Preliminary engineering report for wastewater treatment facilities for the Crandon Project: scope ID 93C049. 1998

Foth and Van Dyke and Associates, Inc.
Green Bay, Wisconsin: Foth and Van Dyke, 1998

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Nicolet Minerals COMPANY

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September 30, 1999

Mr. Paul Luebke
Wisconsin Department of Natural Resources
Bureau of Watershed Management
101 South Webster Street
P.O. Box 7921
Madison, WI 53707-7921

Dear Mr. Luebke:

Re: Crandon Project - *Preliminary Engineering Report for Wastewater Treatment Facilities*

Nicolet Minerals Company (NMC) is pleased to submit the enclosed updated pages for the Crandon Project's *Preliminary Engineering Report for Wastewater Treatment Facilities* (PER). The update has been prepared on behalf of NMC by Foth & Van Dyke and Associates, Inc.

NMC has distributed the 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 of the updates to their appropriate staff members.

The enclosed pages are considered to be an update to the project's PER according to Items 4 through 7 on the attached reference list. Items 1 through 3 were submitted previously. The reference list serves as a log and reference identifying changes made to the PER by NMC throughout the permitting process. If additional revisions are made, they will be added to the attached list in sequential order, and the list will be forwarded with the changes.

filed 10/12/99 NS

[cer1\GBAPP\10000]j:\scopes\99C018\perup999

If you or your staff have any questions regarding these updates, please contact me at (715) 478-3393.

Sincerely,

Gordon Reid
Manager of Engineering
Nicolet Minerals Company

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April 9, 1999

Mr. Paul Luebke
Wisconsin Department of Natural Resources
Bureau of Watershed Management
101 South Webster Street
P.O. Box 7921
Madison, WI 53707-7921

Dear Mr. Luebke:

Re: Crandon Project - *Preliminary Engineering Report for Wastewater Treatment Facilities*

Nicolet Minerals Company (NMC) is pleased to submit the enclosed updated pages for the Crandon Project's *Preliminary Engineering Report for Wastewater Treatment Facilities* (PER). The update has been prepared on behalf of NMC by Foth & Van Dyke and Associates, Inc.

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The enclosed pages are considered to be an update to the project's PER according to Items 1 through 3 on the attached reference list. The reference list serves as a log and reference identifying changes made to the PER by NMC throughout the permitting process. If additional 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 these updates, please contact me at (715) 478-3393.

Sincerely,

Gordon Reid
Manager of Engineering
Nicolet Minerals Company

GR:cer1
Enclosures

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Crandon Project Preliminary Engineering Report for Wastewater Treatment Facilities (1998 Update)
Log of Updates and Additional Information

Entry Number	Date Revision Issued	Page(s)	Document/ Section Number	Description
1	4/9/99	1-5	Distribution List	Updated
2	4/9/99	1	Log of Updates	Addition - place behind Distribution List
3	4/9/99	2	Section 1.1	Updated Project Ownership
4	9/30/99	1-5	Distribution List	Updated
5	9/30/99	1	Log of Updates	Place behind Distribution List
6	9/30/99	(D-89)	Appendix D Drawing No. 7	Updated - 1580 foot contour
7	9/30/99	D-490 through D-492	Appendix D	Calculations revised to reflect the correct 20-foot pipe spacing

Nicolet Minerals COMPANY

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November 24, 1998

Mr. Paul Luebke
Wisconsin Department of Natural Resources
Bureau of Watershed Management
101 South Webster Street
P.O. Box 7921
Madison, WI 53707-7921

40473069

Ms. Char Hauger
U.S. Army Corps of Engineers
St. Paul District
190 5th Street East
St. Paul, MN 55101-1638

Dear Mr. Luebke and Ms. Hauger:

Re: Crandon Project - *Preliminary Engineering Report for Wastewater Facilities*

Nicolet Minerals Company (NMC) is pleased to submit the attached updated report titled *Preliminary Engineering Report for Wastewater Treatment Facilities* for its Crandon Project. This report has been prepared in accordance with Chapter NR 108, Wis. Admin. Code, and is submitted in conjunction with two additional updated documents relating to surface water management. The first is a *WPDES Permit Application for the Crandon Project*. The second is a *Notice of Intent for Storm Water Discharges Associated with the Crandon Project*. The two documents have been prepared pursuant to Chapter 147, Wis. Stat., and Chapter NR 216, Wis. Admin. Code, respectively.

The report includes a brief description of the project, an identification of water and wastewater streams associated with the project, and a discussion of how each of the streams will be managed. Attached as appendices are three reports describing completed treatability studies which provide data used in designing the project's wastewater treatment facility. The final appendix includes a preliminary engineering report for the project's proposed soil absorption system.

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The *Preliminary Engineering Report for Wastewater Treatment Facilities* has been prepared on behalf of NMC by Foth & Van Dyke and Associates, Inc. As noted on the attached distribution list, NMC 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 to their appropriate staff members.

NMC is requesting that the WDNR review this report as expeditiously as possible such that permitting activities associated with the project can continue in a timely manner.

Sincerely,

Gordon Reid
Manager of Engineering
Nicolet Minerals Company

GR:cer1:lmc

Preliminary Engineering Report for Wastewater Treatment Facilities for the Crandon Project

Scope ID: 93C049

Prepared for

Nicolet Minerals Company

7 North Brown Street, 3rd Floor

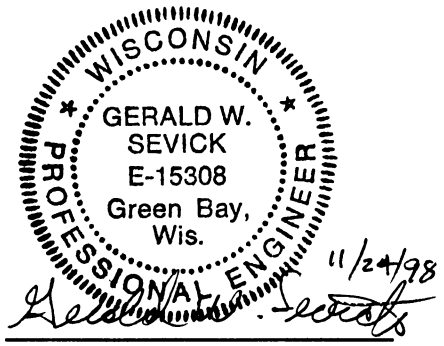
Rhinelander, Wisconsin 54501-3161

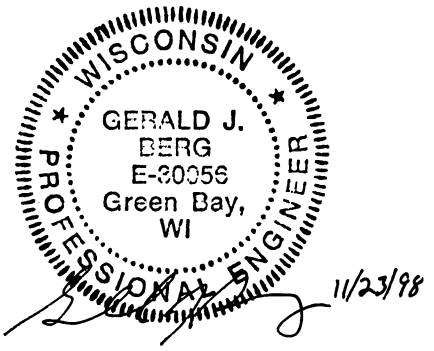
Prepared by

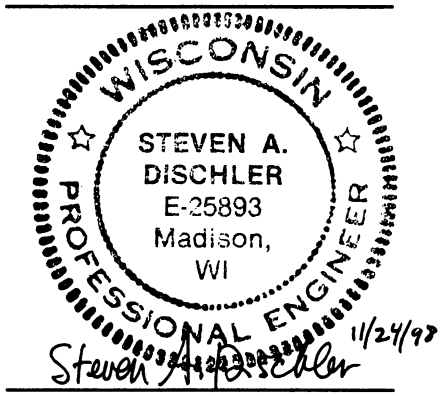
Foth & Van Dyke and Associates Inc.

Originally Issued September 1995

Updated November 1998







Foth & Van Dyke 1998

2737 S. Ridge Road, P.O. Box 19012, Green Bay, Wisconsin 54304, 414/497-2500, FAX: 414/497-8516

Nicolet Minerals Company
Preliminary Engineering Report for
Wastewater Treatment Facilities for the Crandon Project

Executive Summary

Introduction

Nicolet Minerals Company (NMC) plans to discharge treated water from its Crandon Project to a soil absorption system located approximately 2 miles northeast of the project's plant site. Under normal operating conditions, approximately 375 gallons per minute of treated mine water will be discharged to the system. All discharged water will be treated and tested prior to discharge to meet strict standards set by the Wisconsin Department of Natural Resources (WDNR). This document describes the water management and water treatment systems that will be used to comply with these strict standards.

Overview of Water Management Program

NMC's proposed water management program involves the reuse and recycling of water at the project site to the maximum extent possible. Treatment facilities have been designed to protect surface water and groundwater environments during construction, operation, and closure of the project.

Detailed water balances which reflect water inflow and outflow at each water management facility on the project site have been developed. The water balances were prepared using meteorological data, planned operating conditions, and expected mine inflow. The water balance calculations consider average, minimum, and maximum conditions. The water balances helped NMC to identify opportunities to maximize water reuse and recycling. The water balances also identified that, despite water reuse and recycling, the project will generate an excess of water which must be treated and discharged to the environment.

Alternatives Analysis

Several alternative discharge locations for treated water were reviewed for the project, including a soil absorption system, Swamp Creek (downstream from Rice Lake), area lakes, the Wisconsin River, and other area water bodies. As part of that process, water quality standards which apply at each location and treatment technologies needed to meet the standards were evaluated. Based on the initial evaluation, the following three alternatives were selected for a more detailed evaluation:

- Discharge to a soil absorption system in the vicinity of the plant site.
- Discharge to Swamp Creek below Rice Lake.
- Discharge to the Wisconsin River at Hat Rapids Dam.

Discharge to a soil absorption system was selected as the recommended alternative based on the following environmental, economic, and social factors:

- A discharge to groundwater would have no significant adverse effects on the environment.
- A discharge to groundwater would avoid direct discharges to an ERW or ORW.
- The groundwater discharge option will assist in the mitigation of mine related drawdown impacts on Swamp Creek.
- Implementation of the groundwater discharge concept would avoid interbasin transfer of water.
- While not the least costly alternative, a discharge to groundwater is cost effective given the other factors described above.

Description of Wastewater Treatment System

NMC evaluated a number of technologies to treat excess mine water for discharge including lime precipitation, sulfide precipitation, ion exchange, reverse osmosis, and evaporation and crystallization. Based on an evaluation of discharge sites, applicable technologies and discharge standards, water treatment by lime and sulfide precipitation followed by filtration, reverse osmosis, evaporation, monitoring and discharge to a soil absorption system was selected as the most appropriate alternative. To confirm the selected technology, testing was conducted which simulated the treatment of the types of waters to be encountered during project operation. This work confirmed that the proposed treatment system will comply with applicable standards for discharge to a soil absorption system and that there will be no significant adverse impact on the environment. The proposed treatment system consists of reliable technology. The planned facility will treat approximately 437 gallons per minute on average and have a maximum capacity of approximately 726 gallons per minute. The treatment process will consist of:

- neutralization by the addition of lime to the wastewater;
- clarification where metals and other suspended solids are removed from the water;
- precipitation where sodium sulfide is added to further remove metals;
- filtration and a pH adjustment;
- advanced treatment through reverse osmosis and evaporation to further remove dissolved metals and other constituents;
- ammonia removal from the evaporation condensate;

- final pH adjustment;
- monitoring of the water to verify that the strict WDNR standards are met; and
- discharge.

Treated water from the plant will be pumped to two ponds. Water in the ponds will be sampled and analyzed to verify compliance with water quality limitations before any discharge to the soil absorption system occurs.

The wastewater treatment system has also been designed to provide mitigation water that meets strict WDNR standards for soft water bodies. Soft water body mitigation water will be produced by the project's proposed evaporation system, followed by ammonia stripping. Because treated mitigation water will be so clean, it will be stored in on-site enclosed tanks prior to use to prevent contamination from dust and precipitation.

Preliminary Engineering Report for Wastewater Treatment Facilities for the Crandon Project

Contents

Page

Page

Page

Tables

Figures

(Note: Figures for the Preliminary Engineering Report Wastewater Treatment Facilities are located at the end of the text, following page 91.)

Appendices

1 Introduction

This document titled *Preliminary Engineering Report for Wastewater Treatment Facilities for the Crandon Project* has been prepared in accordance with Chapter 144.04, Wis. Stat. and Chapter NR 108.04(1), Wis. Admin. Code, which regulate the design and construction of the wastewater treatment facilities. The treatment facilities addressed in this report are part of Nicolet Minerals Company's (NMC) proposed underground zinc/copper mine in Forest County, Wisconsin.

The Crandon Project will have an extensive water management program. The goal of this water management program is to protect the surface water and groundwater environment. Water recycling will be used wherever possible to achieve this goal. Runoff basins and other control measures will be used to control sediment and erosion during construction activities. Mine drainage and runoff during operation that has potential to come in contact with process equipment, materials, and/or chemicals at the plant site will be sent to wastewater storage basins before being treated in a wastewater treatment system (WWTS). The wastewater treatment system will be used for removing metals in the wastewater before the treated wastewater is reused, discharged to the soil absorption system, or used for mitigation. The water management program will result in protection of water resources during construction, operation, and closure of the project.

A number of parallel documents and permit applications have been or will be submitted to the Wisconsin Department of Natural Resources (WDNR) and the 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
- Air Pollution Control Permit Application
- High Capacity Well Permit Application
- Water Regulatory Permit Applications pursuant to Chapters 30 and 31, Wis. Stat.
- Water Regulatory Permit Application 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
- Tailings Management Area Feasibility Report/Plan of Operation
- Wisconsin Pollutant Discharge Elimination System (WPDES) Permit Application

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

The *Mine Permit Application* provides preliminary design and operating information concerning the project, and can be used to understand how wastewater management issues are addressed within the overall context of the project. Other documents such as the *WPDES Permit Application*, the *Storm Water Notice of Intent*, the *Tailings Management Area Feasibility Report/Plan of Operation*, and the applications for *Water Regulatory Permits* associated with wastewater discharge structures, provide information concerning the discharge of wastewaters from project facilities.

1.1 Background

The Crandon deposit was discovered in the mid-1970s using airborne geophysical techniques and exploratory drilling. The deposit is located approximately 5 miles south of Crandon, Wisconsin. Its size and quality of mineralization has been determined by core holes drilled from the surface.

In 1978, Exxon Minerals Company (EMC) submitted to the Wisconsin Department of Natural Resources (WDNR) a Notification of Intent (NOI) to collect data to support a mining permit application for its Crandon zinc and copper deposit. During the mid-1980s, EMC or its successor company submitted the following major documents or applications to the Wisconsin Department of Natural Resources: an Environmental Impact Report (EIR), a Mine Waste Disposal Facility Feasibility Report, a Mine Permit Application, an Air Permit Application, a Wisconsin Pollutant Discharge Elimination System Permit Application, a High Capacity Well Approval Application, a Mine Refuse Disposal Facility Feasibility Report, Chapter 30 and 31 permit applications, and supporting documents. Additional permit applications and plan approvals were submitted by EMC to the Wisconsin Department of Transportation (WisDOT) and local units of government, and to the Public Service Commission of Wisconsin (PSC) by Wisconsin Public Service Corporation (WPSC). In late 1986, the Wisconsin Department of Natural Resources issued a Final Environmental Impact Statement (FEIS) regarding the proposed project. Subsequently, EMC withdrew its permit applications due to depressed metal prices.

In the fall of 1993 the permitting process for the Crandon Project was reinitiated by Crandon Mining Company (CMC), a partnership comprising two subsidiaries of Exxon Corporation and two subsidiaries of Rio Algom Limited. Additional data were collected and all of the required documentation was again submitted to the WDNR and the USCOE. In 1998 the Exxon subsidiaries withdrew and the partnership changed its name to Nicolet Minerals Company (NMC). NMC continues the permitting and development of the Crandon Project.

As described in greater detail in Section 2 of this document, the deposit will be mined and reclaimed in a similar fashion to that proposed in the 1980s, with the primary difference being that the production rate will be reduced to 5,500 TPD. The current project has also been modified to meet or be better than current day environmental standards and to incorporate design changes to improve environmental protection.

2 General Project Description

The main elements of the Crandon Project consist of an underground mine; ore concentrating facilities; wastewater treatment facilities; a tailings management area; a soil absorption system; a surface water mitigation system; and ancillary facilities such as an access road, a railroad spur line, and other service and support facilities. An extensive description of the project is included in the *Mine Permit Application* (Foth & Van Dyke, 1995/1998a). Following is a brief overview describing the entire project. The overview discusses the location of the mining facilities, the geology of the ore body, 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 project location and features are 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

Average 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
Pre-production	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", "soil absorption system", 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, concentrating, wastewater treatment, administrative offices, 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; 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.

- Soil Absorption System (SAS) - The "SAS" is defined as the area within the "mine site" that includes the project's soil absorption cells and treated wastewater discharge pipeline.

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

In addition, the project's wetland compensation site is located outside of the project area in Shawano and Oconto Counties. Design information for the soil absorption system is included as part of the wastewater treatment system engineering report prepared pursuant to Wisconsin Administrative Codes. Design information relative to the wetland compensation 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 *Environmental Impact Report.*

The boundaries of the project area, plant site, TMA, and the SAS are shown on Figure 2-2. The estimated area of disturbance for the plant site, TMA, and SAS are 116, 282, and 90 acres, respectively. The total area of disturbance, including the access road, railroad spur, surface water mitigation system, and other facilities, is approximately 564 acres.

2.1 Site Location

The Crandon ore body 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 5 miles south of the City of Crandon, and approximately 2 miles east of both STH 55 and the Sokoagan Chippewa Indian Reservation. The plant site is approximately ¼ mile north of Little Sand Lake and 1 mile south of Swamp Creek. The plant site will be located north of the ore body. 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 plant site will be connected northeasterly to the existing Wisconsin Central Limited Railroad. The project's TMA will be located approximately 1 mile southeast of the plant site. The project's SAS will be located approximately 2 miles to the northeast of the plant site on land immediately north of Keith Siding Road.

The project area shown in Figure 2-2 includes portions of property which Nicolet Minerals Company has purchased, leased, optioned for purchase, or obtained by easements for use in the development of the plant site, TMA, SAS, access roads, railroad spur line, and buffer areas. The project area excludes publicly-owned land and roads.

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 materials deposited by this volcanic system were 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 ore body is long and tabular with an average width of 100 feet, north-south, and a strike length of 4,900 feet, east-west. Based on the results of drilling, the ore body extends to an approximate depth of 2,200 feet. The interpreted geologic stratigraphy and ore body configuration are shown on Figures 2-4 and 2-5, respectively.

The bedrock in the hanging wall and in the footwall of the ore body 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 ore body. The first of two ventilation shafts will be located east of this main production shaft. Underground lateral development drifts will access the ore body at 200-foot vertical intervals. These level development drifts are designed to provide access to the ore body. 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 typical schematic longitudinal section showing typical mine level intervals and the initial stoping areas of the mine is shown on Figure 2-6.

An underground ramp will also connect some of the 200-foot spaced levels and the 400-foot spaced main shaft stations 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, and construction of a grouting drift at the top of the ore body and installation of grout to reduce groundwater inflow to the mine. This phase is expected to take 19 months to complete.

2. The development of the underground ore handling and crushing 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 expected to take about 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. As required, inert grout will be pumped under pressure through holes in the collar into the rock 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 each shaft sinking will be controlled to less than 10 gallons per minute (gpm) by freezing and/or grouting. All shaft water will be pumped to the surface water storage ponds.

To control mine water inflow over the underground development and operating period, a grouting drift at the 260-foot mining level will be constructed below the crown pillar in the Crandon Formation parallel to the strike of the ore body. This drift will progress westerly from the East Ventilation Shaft. A 25-foot thick cement grout blanket will be constructed at and above the 250-foot mine level by fan drilling in a vertical and horizontal plane from the grouting drift. Primary grouting holes will be spaced at 20-foot intervals, while secondary and tertiary holes may be drilled between these primary grout holes.

2.3.1.2 Phase II Development

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

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 and waste handling systems; and (d) a loadout facility.

2.3.2 Mine Operations

Level development to the stoping areas will be driven at 200-foot vertical intervals. The primary mining method will be blasthole open stoping with delayed backfill. However, other mechanized mining methods, such as cut-and-fill, will also be used. Stopes (Figure 2-7) will average approximately 200 feet high by 75 feet along the strike, and will vary with the width of the ore body. Ore will be drilled in a stoping block, then blasted and removed. Top hammer or down-the-hole drills will be used to drill blastholes on approximately 10-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 8 inches, will be conveyed to a skip loading pocket and hoisted to the surface.

A typical stope will contain approximately 170,000 tons of ore. At a 2,000,000-ton annual production rate, approximately 12 stopes will be mined out each year, which exposes less than 5 percent of the footwall and hanging wall area of the ore body 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 of a minimum of 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 surficial weathering, mechanized cut-and-fill mining will 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 will be backfilled with cemented paste tailings prior to mining the next upper lift. Less than 10 percent of the ore body will require use of this mining method.

To provide support for the rock walls, a floor for subsequent mucking, and back support for pillar mining, the planned mining methods provide for backfilling all stopes with pyritic paste tailings 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.

Major advances have been made in backfill technology in the past 10 years. These advances will allow the placement of whole tailings in the project's mined-out stopes as a cemented pyritic paste backfill. The whole tailings will consist of pyrite concentrate produced at the mill from a pyrite flotation process. The pyrite concentrate will be dewatered and the resulting paste will be mixed with cement. The pyritic paste backfill will then be transported underground at a density of about 84 percent solids for placement in mined-out stopes. Hydration of the cement, which will be added to the paste at a rate ranging from 1 to 5 percent by weight, will consume the water delivered with the fill, thereby reducing backfill drainage to negligible quantities (i.e., <1 percent). It is estimated that the mined-out stopes will accommodate 75 percent of the total tailings produced by the project.

The very low drainage water flow from the pyritic paste backfill will minimize stope preparation requirements. Timber and shotcrete bulkheads will be constructed as ventilation barriers after the depletion of a stope. Once bulkhead construction has been completed in a given stope, backfilling can commence.

Waste rock will be generated from mine development activities during the pre-production and operating phases of mining. Waste rock generated during pre-production, prior to construction of the first TMA cell, will be hoisted to the surface and temporarily stockpiled on a lined pad at the plant site. The stockpiled waste rock will be used later for construction inside of the TMA as riprap, as the grading layer beneath the final cover system, or placed in the TMA as general fill. Waste rock which is generated during the operating phase and after construction of the first TMA cell will be transported directly to the TMA.

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 the pre-production and mining phases, a grouting drift (Figure 2-8) will be developed in the Crandon Formation below the crown pillar at the 260-foot mine level. As mine development progresses along the drift, conical drilling techniques will be used to advance a 25-foot thick horizontal grout blanket. The grout blanket will be keyed into the moderately weathered bedrock and will serve to control inflow of groundwater to the mine.

Groundwater seepage that is not controlled by grouting will infiltrate the mine workings and ultimately be recovered in the main sumps along with mine utility water and very small amounts of backfill drainage.

Normal mine drainage collection will begin on each mine level where groundwater seepage and utility water drainage will be ditched to small local sumps. 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.

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 will be 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. A pyrite separation circuit will also be included to produce pyritic tailings to be used for underground pyritic paste backfill purposes. The remaining depyritized material, which is called depyritized tailings, will be pumped 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 percent moisture content.

The tailings will range in size from sand to very fine particles. The whole pyrite tailings from the separation circuits will be used to backfill the mined-out stopes. The depyritized 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 wastewater treatment system will be designed to treat tailings pond waters for discharge, if necessary.

2.4 Infrastructure

2.4.1 Wastewater Treatment

A wastewater treatment plant will be constructed as part of project facilities. It will treat mine water and, if needed, process water prior to discharge. Groundwater that enters the mine will be commingled with other mine drainage water, such as the water used for flushing while drilling the blast holes. All of these "contact waters" will be routed through the wastewater treatment plant.

The wastewater treatment plant will include primary and advanced treatment processes. The primary treatment process will include lime and sulfide precipitation with filtration and pH adjustment. Advanced treatment will be used as required to meet water quality discharge limits. A reverse osmosis (RO) system will provide advanced treatment of primary treatment system effluent. High quality effluent from the RO system will be pumped to the discharge holding ponds. Reject wastewater from the RO system will be further concentrated in an evaporator. High quality evaporator condensate water will be either pumped to the discharge holding ponds or to the mitigation storage tanks. Concentrated brine from the evaporator will be pumped to the pyritic paste backfill system for placement underground. Treatment solids from the primary treatment system will be placed along with the depyritized tailings in the TMA. Mine water will be treated and sampled to meet Wisconsin Department of Natural Resources Water Quality Standards before being discharged to groundwater by way of a soil absorption system.

Where required, wastewater treatment plant evaporator condensate will be used for mitigation of nearby lakes impacted by groundwater drawdown associated with mine dewatering activities. Groundwater provided from a small water well will be used for mitigating creeks. A detailed analysis of mitigation requirements is available in the *Crandon Project Surface Water Mitigation Plan* (Foth & Van Dyke, 1998a).

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

Sanitary wastewater will also be generated at the facility. Sanitary wastewater will be handled separately through a package sanitary wastewater treatment plant. The treated wastewater 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, wastewater treatment plant solids, and laboratory wastes.

As discussed in Section 2.4.3 below, waste rock which is generated during pre-production will be hoisted to the surface and temporarily stockpiled. It will later be used for construction purposes within the TMA containment areas, or as general fill in that facility. Waste rock which is hoisted to the surface during operation will be transported directly to containment areas within the TMA to be used as riprap or as general fill. As discussed in Section 2.4.4 below, during the zinc mining phase, approximately 75 percent of the tailings generated by the project will be returned to the mine as backfill, with the remaining 25 percent placed in the TMA.

During 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 primary treatment of project generated wastewaters. These solids will be placed in the TMA with the tailings. Brine generated from advanced treatment of project generated wastewaters will be placed underground with the pyritic paste backfill.

2.4.3 Pre-Production Ore/Waste Rock Storage Areas

As shown in Figure 2-3, a lined pre-production ore storage area will be located to the north of the main production shaft to stockpile pre-production ore and waste rock hoisted to the surface during development of the mine. Prior to the commencement of underground crushing and the start of mill operations, approximately 1.24 million tons of ore and waste rock of a maximum size of 24 inches will be hoisted and temporarily stockpiled on this lined area. An unlined construction storage area is to be located adjacent to and east of the ore/waste rock storage area (Figure 2-3). This area will be used for various construction staging activities. This unlined area may also be used to temporarily stockpile waste rock which is tested and shown to have very low potential to generate acidic runoff.

Within the land area, a ridge will divide the pre-production ore from the waste rock stockpile on a north-south line. 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 composite liner system having a geomembrane overlying a geosynthetic clay liner. A protective soil layer will be placed over the geomembrane. Once ore or waste rock is placed on the storage pad surface, water from the area will be drained to a wastewater storage basin. The wastewater storage basin and delivery system will be sized to hold the volume of water from a 100-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 wastewater 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 a surface water runoff basin. Water from this basin will be discharged to natural site drainageways.

2.4.4 Tailings Management Area

Depyritized tailings, hoisted waste rock, wastewater treatment plant solids, and a small amount of laboratory wastes will be placed in the TMA. The TMA has been designed to provide long-term, environmentally-safe containment. Low sulfide 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 2-11 and 2-12, the TMA will consist of three cells, each of which will consist of a composite liner at the base and along the sidewalls of the facility and will include a leachate collection system. The three cells, referred to as TMA 1, TMA 2, and TMA 3, will each be constructed and operated sequentially in two stages. An internal berm will be constructed to separate TMA 1A and TMA 1B. TMA 1 is designed to contain the depyritized tailings from processing the zinc ore. TMA 2 and TMA 3 will be used for the copper ore depyritized 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	6	16
TMA 2	4	6
TMA 3	4	6
Total	14	28

Prepared by: SAD2
Checked by: JWS

TMA cell development and operation will first involve constructing and filling TMA 1A. As the tailings in TMA 1A approach the design elevation, TMA 1B will be built. As the tailings approach the design elevation of TMA 1B, the second stage of TMA 1 will be built. When approximately 1 to 2 years of capacity remain in the second stage of TMA 1, construction of the first stage of TMA 2 will begin. After consolidation, reclamation of TMA 1 will begin, while filling in the first stage of TMA 2 progresses. The same process will continue for the second stage of TMA 2 and for TMA 3.

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 Statutes and administrative codes which are written to protect the public health and welfare. Key TMA design features include:

- An average 37-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 extending up the interior sidewalls of each cell.
- A reclaimed final composite cover consisting of the following components from top to bottom.
  - topsoil
  - rooting layer
  - biotic layer
  - drainage layer
  - cushioning geotextile
  - geomembrane (60 mil HDPE) liner
  - geosynthetic clay liner (GCL)
  - low permeability (P40) soil layer
  - 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 3 miles long and consist of bituminous concrete with gravel shoulders. The TMA access road will be approximately 1 mile long and will be gravel-surfaced. Pipelines for tailings and reclaim water transport 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 rail car 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) via 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 Soil Absorption System

An in-ground soil absorption system will be constructed to provide for groundwater discharge of treated mine water from the advanced wastewater treatment system. The soil absorption system will be located approximately 2 miles to the northeast of the plant site. A multiple cell, pressure distribution system will be used. A treated water discharge pipeline will be constructed primarily within the railroad spur line corridor from the treated water discharge lagoons to the soil absorption system. The location of the pipeline and the soil absorption system is shown on Figure 2-13.

2.4.9 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
Laboratory facilities
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

2.4.10 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 wastewater 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.

2.4.11 Wetland Compensation

Although mine facilities have been designed to minimize impacts on wetlands, as part of project construction activities, approximately 26.7 acres of wetlands will be either excavated or filled. To compensate, NMC 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.

2.4.12 Surface Water Mitigation

Potential impacts due to mining on nearby lakes and streams were assessed by a regional groundwater flow model. A mitigation framework was developed from an assessment of these potential impacts. The framework consists of a hierarchial system of classifying streams and lakes based on the degree of potential impact. A Level I water body will require the construction of a mitigation facility prior to commencement of mining, while a Level II water body will require that detailed engineering work be completed as part of project permitting, such that the mitigation system could be installed quickly if a need were to arise. Level III and IV water bodies would require proportionally less planning since the potential for impacts would be appreciably less.

2.4.13 Mine Reclamation

Topsoil will be salvaged from disturbed areas for use in reclamation activities. Reclamation of the mining site will occur on an ongoing basis during construction and operation, and at 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, these 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 wastewater treatment plant and associated pipelines will be removed after they are no longer required. Salvageable equipment will be transported off-site. Treatment solids will be placed in the TMA prior to closure of the final cell or disposed of in an approved landfill after the TMA has been closed. Buried segments of pipelines will be flushed, the ends capped, and the pipeline left in place. Above-grade pipelines will be removed. The wastewater treatment plant area and pipeline routes will be graded and revegetated.

The soil absorption system will be reclaimed after there is no further need to discharge treated wastewater. The ends of the piping to the soil absorption system will be capped and the pipeline will be left in place.

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 an approved disposal facility. 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 Description of Wastewater Sources and Characteristics

As designed, the Crandon Project will have an extensive water management program. Figures 3-1 and 3-2 show the locations in the vicinity of the plant site and TMA of the basins and other facilities included in the water management program. Wastewater streams will be generated during construction, operation, and closure of the Crandon Project. Each of the major sources of wastewater are discussed in more detail below. The design of facilities to be used for collection, treatment and disposal of these wastewaters are discussed in Section 6. Water chemistry data referred to in the following discussion is contained in the *Environmental Impact Report for the Crandon Project* (Foth & Van Dyke, 1995/1998a).

3.1 Site Water Balance

Three detailed water balances have been developed for the operational phase of the project. An "average" water balance was developed to identify flow rates on an annual average basis assuming long-term annual average weather conditions over a 30-year period, the best engineering judgement concerning expected groundwater inflow to the mine, expected annual average facility operating conditions, and long-term average operating conditions at the TMA. A "maximum" water balance was developed to identify the maximum flow rates on an annual average basis assuming weather conditions which would occur for an extreme wet year, the high range groundwater inflow to the mine, expected annual average facility operating conditions, and long-term average operating conditions at the TMA. A "minimum" water balance was developed to identify the minimum flow rates on an annual average basis assuming weather conditions which would occur during an extreme drought year, the low range groundwater inflow to the mine, expected annual average facility operating conditions, and long-term average operating conditions at the TMA.

The three site water balances are shown on Figures 3-3, 3-4, and 3-5. The flow rates in the water balances are based on the mine and mill operating normally at an ore production rate of two million tons per year, having the largest tailings cell in service, and the assumptions shown in Table 3-1.

Water flows associated with precipitation and runoff from non-contact areas of the site to the runoff basins have been excluded from the water balances because these flows are solely dependent on precipitation and will be routed to natural drainageways at the site. The small amounts of evapotranspiration from the site have been excluded from the site water balances because these flows are minor compared to the other water flows described previously, and would not significantly affect the site water balances.

Table 3-1

Assumptions for Site Water Balance

Factor	Water Balance Assumptions		
	Minimum Condition	Average Condition	Maximum Condition
Precipitation rate (inches/year)	17.4[1]	30.4[1]	45[1]
Evaporation rate (inches/year)	39[3]	26[2]	15[4]
Total groundwater inflow to the mine (gallons per minute) [5]	250[6]	452[7]	600 [8]

[1] Based on flow data from a 30-year period (1961-1990) at the Pelican Lake Station.
[2] Based on data concerning evaporation by the U.S. Department of Commerce (1992) for lake evaporation rates.
[3] Maximum annual evaporation rate assumed to be 150 percent of the average annual evaporation rate.
[4] Minimum annual evaporation rate assumed to be approximately 60 percent of the average annual evaporation rate.
[5] Model values from HSI GeoTrans (1998).
[6] Based on Low Range Mine Inflow Estimate.
[7] Based on Best Engineering Judgement Mine Inflow Estimate.
[8] Based on High Range Mine Inflow Estimate.

Prepared by: HJA
Checked by: JJF1

3.2 Water Management During Operation

Water sources and characteristics, facilities which collect, use, and treat water and wastewater, facilities for disposal of wastewater, and discharge locations during operation are discussed below.

3.2.1 Mine Drainage

Sources of water inflow to the mine will include groundwater infiltration into the mine, water vapor contained in ventilation air entering the mine, well water used as a supply of potable water, and water contained in the backfill. The flows from the mine will include mine drainage, water vapor contained in ventilation air exiting the mine, and water retained in the ore hoisted to the surface for processing in the mill. Water present in the pyritic paste backfill will be substantially retained in the backfill; therefore, backfill drainage flows are anticipated to be less than 1 gpm. Part of the mine drainage water will be used for utility water and for reuse in the mill as required.

Mine drainage water will primarily consist of groundwater that seeps into the mine and is eventually collected in the mine sumps (mine contact water). The characteristics of the mine drainage will be impacted by partial reuse of mine contact water for utility water purposes within the mine. Groundwater inflow will initially consist of the drainage of water currently stored in the available pore space within the ore body and bedrock. Stored water removal will be conducted in a controlled fashion during the initial years of mining. The second component of groundwater inflow will be a combination of water that moves vertically from the glacial overburden through the till and massive saprolite into the mine workings and water that migrates through the bedrock laterally into the mine workings. This component of inflow will increase over time as mining is extended laterally along the strike and also as mining moves into the weathered ore in the upper mining levels. As discussed in the project's *Mine Permit Application* (Foth & Van Dyke, 1995/1998b) mine grouting techniques will be used to limit the inflow of groundwater into the mine.

In addition to the above, groundwater inflow will occur both from the development of the main shaft access to the mine and the development of the grouting drift. The inflow from shaft development is expected to be less than 10 gallons per minute per shaft. This water will be pumped continuously out of the shafts and directed to wastewater storage basins 6 and 7 and the reclaim pond. The development of the 260 foot mine level grouting drift is expected to have an average inflow over the period of drift development of approximately 75 gpm. This water will also be pumped to the wastewater storage basins and the reclaim pond.

The predicted annual average rate of groundwater inflow to the mine ranges from a low range (LR) value of approximately 250 gallons per minute (gpm) to a high range (HR) value of approximately 600 gpm. For purposes of designing the underground mine water handling systems, the mine will be managed to limit the maximum inflow to the 600 gpm rate. It is not anticipated that this inflow rate will actually be encountered since it is highly unlikely that all the assumptions included in the high range case analysis will be encountered in the field. Also, as

explained in the project's *Mine Permit Application (*Foth & Van Dyke, 1995/1998b), NMC intends to use proven engineering methods to control the rate of groundwater inflow. Figure 3-6 depicts a mine drainage schematic and water balance based on the best engineering judgement (BEJ) groundwater inflow rate of 452 gpm.

Groundwater inflow to the mine will be predominantly through weathered bedrock structures. The intensity and lateral extent of the bedrock weathering diminishes with depth. Initial mine production has been planned for the lower mining levels which are well below the weathered zones. Therefore, groundwater inflows to mine workings during the early years of mine production are expected to be very limited and localized.

During the initial years of mining, ore extraction will take place primarily in weakly weathered and unweathered rock. As such, there will be little water generated in active mining areas during this period. The majority of the inflow to the mine during the initial years of operation is anticipated to occur in the grout drift that is developed for construction of the grout blanket. The grout blanket is designed to restrict vertical percolation of groundwater from the glacial overburden to the mine workings.

Groundwater that seeps into the mine will eventually be collected in the mine sumps located on each mine level. Such water is classified as mine contact water. A portion of the collected mine contact water will be reused as mine utility water. Mine utility water will be used in the mine for dust suppression and to provide drill water for the mining equipment. Utility water will drain to, and be collected in, the mine sumps. Drainage flow from the pyritic paste backfill is anticipated to be less than 1 gpm. This water will also drain to, and be collected in, the mine sumps. The composite contact water/utility/backfill drainage water is referred to as mine drainage. Most of the mine drainage will be pumped to wastewater storage basins 6 and 7, where it will be combined with other waters for treatment. A portion of the mine drainage may also be pumped to the mill process water tank for reuse in the mill process water system as required.

Table 3-2 contains a summary of estimated mine drainage water characteristics for the LR, BEJ and HR mine inflow cases. The composite mine drainage characteristics were developed using a mass balance of the various contributing water sources. The mass of each constituent present in the utility water, the backfill drainage water, and the contact water flows were combined. The total mass for each constituent was then equated to the total mine drainage flow to determine the concentration of the respective constituent in the composite mine drainage. A discussion of the methodology used to develop the characteristics of the utility water, backfill drainage water, and the contact water follows.

Contact water will be groundwater that seeps into the mine and is subsequently collected in mine sumps. Contact water will also contain readily soluble substances, mineral oxidation products, and colloidal materials that will result from the short-term reactions between water and materials within the mine. Based on the current mine plan, it is estimated that 75 percent of the contact water will originate in the ore stopes, with 25 percent originating in the waste development

Table 3-2

Estimated Average Mine Drainage Water Characteristics for LR, BEJ, and HR Mine Inflows

Parameter[1]	@ LR Mine Inflow Condition[2] (mg/L)	@ BEJ Mine Inflow Condition[3] (mg/L)	@ HR Mine Inflow Condition[4] (mg/L)
Antimony	0.0041	0.0030	0.0027
Arsenic	0.065	0.045	0.040
Barium	0.060	0.042	0.037
Beryllium	<0.00006	<0.00006	<0.00006
Boron	N/A[5]	NA[5]	NA[5]
Cadmium	3.4	2.8	2.6
Calcium	80	58	42
Chloride	61	45	41
Chromium	0.018	0.011	0.0095
Copper	78	64	60
Cyanide	<0.0034	<0.0034	<0.0034
Fluoride	0.41	0.30	0.27
Iron	73	54	49
Lead	0.61	0.50	0.47
Magnesium	67	51	46
Manganese	2.4	1.8	1.7
Mercury	0.00041	0.00030	0.00027
Nickel	0.24	0.19	0.18
Nitrate + Nitrite	25	12	9
Nitrogen (Ammonia)	10	5	3.6
Nitrogen (Organic)	NA[6]	NA[6]	NA[6]
Nitrogen (Total)	35	17	13

Table 3-2 *(Continued)*

Parameter[1]	@ LR Mine Inflow Condition[2] (mg/L)	@ BEJ Mine Inflow Condition[3] (mg/L)	@ HR Mine Inflow Condition[4] (mg/L)
Potassium	13.8	9	7.7
Selenium	0.102	0.082	0.076
Silver	0.012	0.0090	0.0081
Sodium	34	22	19
Sulfate	1,643	1,270	1,167
Thallium	0.022	0.017	0.015
Zinc	610	502	471

[1]The parameters listed include the inorganic constituents listed in NR 140, Wis. Admin. Code
[2]Based on a Low Range Mine Inflow Estimate of 250 gpm.
[3]Based on a Best Engineering Judgement Mine Inflow Estimate of 452 gpm.
[4]Based on a High Range Mine Inflow Estimate of 600 gpm.
[5]Data not available.
[6]Data not available. There is no significant source for organic nitrogen in the system.

Prepared by: JJF1
Checked by: HJA

headings. The composition of the contact water is considered to be equivalent to 25 percent of the average of the concentrations of the relevant constituents in the first two leachate samples collected from leaching the Skunk Lake, Rice Lake, Upper Mole Lake and Lower Mole Lake master waste rock composites, plus 75 percent of the average of the concentrations of the relevant constituents in the first two leachate samples collected from leaching the unweathered ore composite.

A portion of the mine contact water will be used in the mine as utility water for dust control and drilling. The collected utility water will contain readily soluble substances, mineral oxidation products, and colloidal materials that will result from the short-term reaction between water and materials in the mine. Based on the current mine plan, it is estimated utility water will primarily originate from waste development headings and ore stopes. The composition of the "first pass" utility water is considered to be equivalent to 75 percent of the average of the concentrations of the relevant constituents in the first two leachate samples collected from leaching the Skunk Lake, Rice Lake, Upper Mole Lake and Lower Mole Lake master waste rock composites, plus 25 percent of the average of the concentrations of the relevant constituents in the first two leachate samples collected from leaching the unweathered ore composite. The use of the results from the first two leaching cycles is considered valid since the majority of utility water will be generated in areas of active mining where fresh rock is continually being encountered. As indicated previously, mine contact water will be collected and reused for utility water. Consequently, the fraction of the spent utility water in the mine contact water which is again reused for mine utility water purposes will be subjected to secondary contact with the mine workings. The quality of this "second pass" utility water was estimated by adding the mass of each constituent in the mine contact water to the mass of the corresponding constituents in the "first pass" utility water. This methodology allows the additional solutes in the utility water due to secondary contact with the mine workings to be accounted for.

Mining operations will include backfilling mined out stopes with cemented pyritic paste tailings. It is anticipated that pyritic paste backfill drainage flows will be less than 1 gpm. The pyritic paste backfill will contain mill process water and brine from the evaporator system that is included in the wastewater treatment system as an advanced treatment step. A mass balance calculation was used to estimate the quality of the composite backfill drainage water by adding the mass of each constituent present in the mill process water to the mass of the corresponding constituents in the evaporator brine flow.

Ammonia and nitrates will also be present in the mine drainage water as byproducts from blasting operations. During initial mine development, years 1 through 3 of construction, prior to removing water from storage or mining in weathered zones, ammonia and nitrate concentrations will each likely approach 20 mg/L to 50 mg/L, expressed as nitrogen. Water collected from the mine during this period will be sent to the wastewater storage basins.

Based on information from another underground mine with an average mine drainage flow rate of 200 gpm, ammonia and nitrate concentrations average approximately 10 mg/L and 25 mg/L as nitrogen, respectively, with a range of minus 75 percent to plus 100 percent. Using this

information, estimated ammonia and nitrate concentrations for the LR, BEJ and HR mine inflow cases were determined. These concentrations are shown in Table 3-3. The average concentrations of ammonia and nitrate shown in Table 3-3 are included in Table 3-2.

Table 3-3

Estimated Ammonia and Nitrate Concentrations in Mine Drainage Water for LR[1], BEJ[2] and HR[3] Mine Inflow

	Concentrations[4]			
	Ammonia (as N)		Nitrate (as N)	
	Average	Range	Average	Range
LR[1]	10.1	3 to 20	25.3	6 to 51
BEJ[2]	5.0	1 to 10	12.5	3 to 25
HR[3]	3.6	1 to 7	9.0	2 to 18

[1] Based on a Low Range Mine Inflow Estimate of 250 gpm.
[2] Based on a Best Engineering Judgement Mine Inflow Estimate of 452 gpm.
[3] Based on a High Rate Mine Inflow Estimate of 600 gpm.
[4] All concentrations are mg/L. Concentrations calculated by using ratio of the total mine drainage flow rate, divided into 200 gpm times 10 mg/L for ammonia (as N) and 25 mg/L for nitrate (as N), respectively. Calculation assumes that mining and blasting rates are similar for the average mine generating 200 gpm of mine water and the Crandon mine.

Prepared by: JJF1
Checked by: HJA

3.2.2 Mill Water Usage

Water will be used in the mill for reagent preparation, seal/gland water, ore grinding, flotation, and other mill processes. It is estimated that an annual average of 3,896 gallons per minute will be required for mill operations. The water leaving the mill will include water retained in the ore concentrates, tailings slurry pumped to the TMA, thickener overflows, and water contained in pyrite concentrate used to produce pyritic paste backfill. Mill process water from the reclaim pond and the thickener overflows will be recycled to a process water tank at the mill to provide most of the water needed for mill processes. However, additional water may be needed to make up for water lost in the concentrates produced by the mill, water lost in the pyritic paste backfill, and for water retained in the depyritized tailings placed in the TMA. Make-up water will be comprised of mine drainage, fresh water, or treated effluent from the wastewater treatment system.

Water recycled from the reclaim pond and the thickener overflows will be the primary source of water for all mill uses including process water, reagent water, and seal/gland water. Water for uses requiring very low suspended solids contents, e.g., seal/gland water, will be filtered prior to use. Normal operation will be for mine drainage water to be used to make up any water deficit at the mill.

The option to use fresh water or wastewater treatment system effluent for mill make-up water may be exercised if higher water quality is required for a given process, e.g., seal/gland water. While the potential will exist to use fresh water from the fresh/fire water tank or effluent from the wastewater treatment system as makeup water to the mill, this is not expected to be required.

The flow rates into and out of the mill under average, maximum, and minimum flow conditions are shown on Figures 3-3, 3-4, and 3-5. Details regarding mill operations are described in the project's *Mine Permit Application (*Foth & Van Dyke, 1995/1998b).

3.2.3 TMA and Reclaim Water Storage Facilities

At the mill, flows into the tailings pump box will include depyritized tailings slurry, wastewater from laboratories and shops in the service building, solids and filter backwash from the lime/sulfide portion of the wastewater treatment system, direct precipitation on that portion of the tailings pipeline containment ditch sloped toward the mill, and treated effluent from the sanitary sewage treatment plant. The tailings slurry and other wastewaters collected in the tailings pump box will be pumped to the tailings pond via the tailings pipeline.

At the TMA, water will be decanted in the tailings pond and pumped to the reclaim pond. The reclaim pond will provide for additional removal of solids from the water by settling, and will also provide surge capacity during periods of imbalance in flow rates between the water from the TMA and the process water needs of the mill. Mill process water will be pumped from the reclaim pond to the process water tank for recycling to the mill.

Mill process water may be routed from the reclaim pond to wastewater storage basins 6 and 7 or to the wastewater treatment plant under the following circumstances:

- When the flow rate into the reclaim pond exceeds the demand for recycled water by the mill process water system for a sustained period. This would occur during periods of wet weather when precipitation on the tailings pond and reclaim pond significantly exceeds evaporation from these ponds.

- In the event that there is a buildup of constituents in the mill process water which interferes with the ore recovery process.

- During reclamation when the final tailings pond and the reclaim pond are being drained of water prior to closure.

Mill process water routed to wastewater storage basins 6 and 7 will be treated by the wastewater treatment system. The treated mill process water may be reused in the mill. Treated mill process water will be discharged only if it meets the New Source Performance Standards, (NSPS) for discharge of mill process water and the applicable WPDES effluent discharge limitations. The NSPS are discussed in Section 4 of this report. Details of the design of the project's TMA are described in the *TMA Feasibility Report* and subsequent addenda (Foth & Van Dyke, 1995, 1996a and b, 1997, 1998a and b).

The anticipated water quality of the reclaim pond effluent is presented in Table 3-4. The estimated characteristics were developed based on information obtained from analyses performed on process water generated as part of the locked cycle tests performed by Lakefield Research, Lakefield, Ontario, and on other information as noted.

3.2.4 Potable Water Supply, Sanitary Wastewater, Laboratory and Shop

The potable water system will be separate from the other water systems at the plant site. A separate well, pump, fresh water tank, and distribution system will be provided for potable water. The Project's *High Capacity Well Permit Application (*Foth & Van Dyke, 1995/1998c) provides more detail on the capacity and operation of the potable water supply well.

Sanitary waste generated by toilets, sinks and showers at the site will be routed to an on-site sewage treatment plant. The site will not have a cafeteria, so wastewaters from food preparation and clean-up will not be generated. Chemical toilets will be used underground in the mine. Containerized waste from the underground mine will be transported to the surface for treatment at the sewage treatment plant. The sanitary wastes from the surface facilities will be transported to the sewage treatment plant via a buried piping system. The flow rate of sanitary wastewater is expected to average approximately 9 gallons per minute. The sewage treatment plant effluent will discharge through a pipeline to the tailings pump box and thence to the TMA. Solids generated in the sewage treatment plant will be removed as necessary by a licensed private contractor for proper disposal.

Wastewater will be generated from the laboratory and shops. The wastewater generated in the laboratory will include small amounts of laboratory chemicals used in ore analysis and in analysis of wastewaters. Wastes generated in the laboratories will either be reused in the mill, disposed of off-site by a qualified contractor, or discharged to the tailings pump box for transport to the TMA. The wastewater generated in the shops will include small amounts of grease and oil, solvents, metal shavings, other particulate materials and wash water. Most of the grease will be captured in traps. These wastewaters are expected to average less than 6 gallons per minute, and will be routed to the tailings pump box.

Table 3-4

Estimated Average Reclaim Pond Effluent Water Characteristics

Parameter	Concentration[1]	Parameter	Concentration[1]
Aluminum[2]	<0.022	Molybdenum[3]	<0.040
Antimony[2]	0.0061	Nickel[2]	0.016
Arsenic[2]	0.0025	Potassium[2]	27
Barium[2]	0.028	Selenium[2]	0.024
Beryllium[2]	<0.00033	Silver[2]	0.00028
Cadmium[2]	0.0018	Sodium[2]	26
Calcium[2]	300	Thallium[3]	<0.003
Chromium[2]	<0.00053	Zinc[2]	1.3
Cobalt[2]	0.030	pH[2]	7.6
Copper[2]	0.0017	Chloride[2]	33
Iron[2]	<0.0023	Cyanide, Total[2]	<0.0034
Fluoride[2]	1.0	Alkalinity as $CaCO_3$[2]	66
Lead[2]	0.0044	Ammonia (as N)[4]	2.8
Magnesium[2]	27	Nitrate (as N)[4]	8.7
Manganese[2]	1.2	Sulfate[2]	901
Mercury[2]	0.0000238	TOC as NPOC[2]	37

[1] All concentrations are mg/L, with the exception of pH which is reported in standard units, and conductivity which is reported as μS/cm. Metal concentration are expressed as the "dissolved" form.

[2] Values from the EnChem, Inc. analysis of a May 20, 1998 water sample from Lakefield locked cycle analyses of the Crandon Project master ore composite performed in February and March, 1998.

[3] Values from the Wisconsin State Laboratory of Hygiene analysis of a June 16, 1994 sample from Lakefield locked cycle analyses of the Crandon Project master ore composite.

[4] Estimated value based on expected average mine drainage concentrations for ammonia and nitrate of 5.0 and 12.5 mg/L (as N), respectively. Estimated values determined by a mass balance calculation at average water balance flow conditions.

Prepared by: JWS
Checked by: GJB1

3.2.5 Runoff from Production Area

During operation, contact runoff will be generated by precipitation on the central runoff drainage area of the plant site. This area is shown on Figure 3-7 and includes the concentrate thickeners, the reagent bulk storage, the lubricant storage, the cold storage, the covered coarse ore storage silo, the roof of the concentrator building, the roof of the wastewater treatment facilities building, the bulk fuel storage area, and other areas in which the runoff could come in contact with process equipment, materials, or chemicals. During operation of the mine and mill, contact runoff will generally contain suspended solids and other substances related to the materials stored in the area, and may also contain oil and grease from the gasoline and diesel fuel storage and handling areas. Based on a 25-year, 24-hour rainfall event, the runoff from this area will be approximately 2.8 million gallons. The annual average flow rates of runoff under average, maximum, and minimum conditions are shown on Figures 3-3, 3-4, and 3-5, respectively. This runoff will be collected and routed to wastewater storage basins 6 and 7. A gravity oil-water separator will be used to treat runoff collected from outdoor areas where gasoline, fuel oil, lubricating oils and other oily materials are stored and handled.

During initial operation of the mine before the start of mill operations, ore and waste rock will be placed in the pre-production ore storage area. Contact runoff will be generated by precipitation on the pre-production ore storage area. This area is also shown on Figure 3-7. This contact runoff will contain suspended solids and other constituents leached from the ore and waste rock by precipitation. Based on a 100-year, 24-hour rainfall event, the runoff from this area will be approximately 1.1 million gallons. The annual average flow rates of runoff under average, maximum, and minimum conditions are shown on Figure 3-3, 3-4, and 3-5, respectively. The runoff from the pre-production ore storage area will be collected in wastewater basin 5. This basin will have pumps to transfer water to the wastewater storage basins 6 and 7. After the mill begins operation and the stored waste rock is placed in the TMA, wastewater storage basin 5 and the pre-production ore storage area may be removed and reclaimed.

A containment ditch shown on Figures 3-1 and 3-7 will be constructed for the tailings pipe and the reclaim pond return pipeline. Wastewater collected in this containment ditch will include contact runoff from rainfall on the pipeline ditch and access road, and may also include materials which have leaked from the pipelines. Based on a 25-year, 24-hour rainfall event, the runoff from this area will be approximately 0.47 million gallons per day. The annual average flow rates of runoff under average, maximum, and minimum conditions are shown on Figures 3-3, 3-4, and 3-5, respectively. The ditch will empty into two drain down basins. One of these is at the mill, while the other, basin 4, will be located adjacent to the tailings pipeline ditch, approximately midway along its length. Basin 4 has been designed to hold two times the volume of that portion of the tailings pipeline drainage to it and the precipitation falling on the ditch and adjacent roadway. During operation, water accumulated in basin 4 will be transferred to the tailings pond.

3.2.6 Wastewater Treatment and Discharge

Wastewater will be stored in wastewater storage basins 6 and 7 prior to treatment in the wastewater treatment system. The primary wastewater treatment system will include lime treatment, clarification, sulfide treatment, filtration, and pH adjustment. This treatment concept has proven to work well at the Flambeau Mine in Ladysmith, Wisconsin, and in the treatability test work conducted on both mine drainage for the Crandon Project, and on an existing mill's process water similar in character to the mill process water expected for the Crandon Project. The results of the primary treatment system treatability testing are summarized in Section 6 of this report.

In order to consistently meet projected water quality limits for discharge to groundwater, for all effluent constituents, advanced wastewater treatment processes will be required. Effluent from the primary treatment system will be routed to a reverse osmosis (RO) system. Rejected wastewater from the RO system will be sent to an evaporator for volume reduction. Concentrated wastewater (brine) from the evaporator system will be combined with the pyritic paste backfill for placement underground in mined-out stopes. The product water (condensate) from the evaporator will receive additional treatment for ammonia nitrogen removal. The evaporator condensate and RO product water (permeate) will then be combined to form a composite effluent which will be pumped to the discharge storage lagoons and eventually to the soil absorption system. Two lined discharge lagoons will be provided. A process flow diagram of the wastewater treatment system is shown on Figures 3-8 and 3-9. Detailed information on the wastewater treatment system is provided in Section 6 of this report.

Where required, treated water from the wastewater treatment system will be used for mitigation of regional lakes impacted by groundwater drawdown associated with mine dewatering activities. Water for mitigation of hard water bodies will be provided by wells and, therefore, this topic is not discussed in this report. A detailed analysis of mitigation requirements is available in the *Crandon Project Surface Water Mitigation Plan* (Foth & Van Dyke, 1998c).

Prior to discharge, the treated wastewater will be tested. If the treated water meets water quality standards, it will be pumped through a pipeline for discharge to groundwater by way of a soil absorption system. When soft water body mitigation is required, evaporator condensate will be pumped directly to mitigation storage tanks, and then to the soft water bodies requiring mitigation.

The effectiveness of an RO system with respect to treatment of effluent from the primary wastewater treatment system was evaluated through a treatability study. The results of the RO system treatability study are described in detail in Section 6 of this report. Briefly, the results demonstrated that an RO system will provide a sufficient level of treatment to meet projected groundwater discharge effluent limits.

Ammonia nitrogen is anticipated to be an effluent constituent which may require the use of an additional treatment process. While ammonia nitrogen is removed by RO systems, it is

anticipated that ammonia nitrogen present in the RO reject water will be volatilized in the evaporator system and be carried over to the evaporator condensate stream. In order to consistently meet ammonia nitrogen effluent limits, an ammonia nitrogen removal process will be added to treat evaporator condensate prior to mixing with the RO permeate or use as mitigation water.

3.2.7 Non-Contact Runoff

During operation of the mine and mill, non-contact runoff will be generated in areas where the runoff will not come in contact with process equipment, materials, or chemicals. Non-contact runoff will be generated in areas such as:

- topsoil storage area;
- the mulch storage area;
- roadways to and from the site;
- railroad lines to and from the site;
- the parking lot;
- the main substation;
- the roof of the service building;
- the area adjacent to the discharge lagoon; and,
- the construction material storage area.

Non-contact runoff includes runoff from the southwest drainage area, the southeast drainage area, the construction material storage drainage area, and the discharge lagoon drainage area at the plant site. These four drainage areas and the accompanying runoff basins 1, 2, 3, and 8 are shown on Figure 3-7. Water from the runoff basins will be discharged to on-site surface water drainageways.

In addition, six runoff basins, numbered consecutively 9 through 14, will be ultimately constructed around the perimeter of the TMA. The outflow from these non-contact basins will be discharged directly to natural drainageways.

3.3 Water Management During Construction

During construction, wastewater will be generated from sinking of the mine shafts. Runoff will also occur from areas of the site disturbed by construction activities. These sources and facilities for collection, treatment, and disposal of wastewater during construction are discussed below.

3.3.1 Shaft Sinking Wastewaters

Minor water inflow will occur during the development period for the main shaft and the east and west ventilation shafts. The inflow for each shaft is expected to be less than 10 gallons per minute, and will be continuously pumped out of the shafts. The shaft water will contain suspended solids. There is also a potential for this water to come in contact with oil. Water

inflow, estimated to be about 75 gpm on average, will also occur during construction of the grouting drift.

The shaft and grouting drift water will be pumped to a temporary oil/water separator for removal of free-floating oil, and then routed to wastewater storage basins 6 and 7 and the TMA reclaim pond. These basins and pond will provide the needed capacity to store mine inflow water generated during the pre-production period before the WWTS comes on-line. Once the WWTS begins operation, the water stored in these basins will be treated and discharged to groundwater by way of the soil absorption system.

3.3.2 Construction Runoff

Activities that will generate runoff include construction of roadways, the TMA, pipelines, railroad lines, mill facilities, above ground mine facilities, ancillary plant site facilities, soil absorption system, and the wetland compensation site. Equipment laydown and materials storage areas used for construction of the mine, mill and TMA will also generate runoff during construction. Typically runoff from disturbed areas will contain suspended solids. In the early stages of construction, erosion will be controlled through the use of silt screens and temporary water detention systems. Inspection, maintenance, and solids removal will be provided for these controls. As the runoff basins are brought on-line, construction runoff will be diverted to these basins. The treated runoff will be discharged from these basins to on-site drainageways. Details regarding the project's erosion control features can be found in the project's *Mine Permit Application* (Foth & Van Dyke, 1995/1998b).

3.4 Water Management During Closure

Following the completion of mining, water will continue to be pumped from the mine until all salvageable equipment has been removed and mine closure operations have been completed. Water pumped from the mine will be treated prior to discharge. Water from the final tailings cell will be pumped to the reclaim pond as in the operational phase of the project. Water will be pumped from the reclaim pond to wastewater storage basins 6 and 7, then pumped to the wastewater treatment system for treatment prior to discharge. The wastewater treatment system and the soil absorption system will continue to operate during reclamation as long as required.

4 Applicable Effluent Discharge Requirements

The treated wastewater effluents that will be discharged during Crandon Project construction, operation, and closure were discussed in Section 3 of this report. The purpose of Section 4 is to review the effluent discharge requirements which are applicable to wastewater effluents from the project. These requirements include the following:

- new source performance standards applicable to mill process wastewater and mine drainage water;
- sanitary wastewater standards applicable to the treated wastewaters from the sewage treatment plant;
- stormwater standards applicable to runoff during construction of the plant site, TMA, and ancillary facilities, and runoff during operation at the plant site;
- water quality standards, and water quality based effluent discharge standards;
- groundwater quality standards applicable to treated wastewaters discharged to groundwater by way of the soil absorption system; and
- water quality antidegradation standards applicable to discharge of treated wastewaters to Exceptional Resource Waters (ERW) and Outstanding Resource Waters (ORW).

4.1 New Source Performance Standards

Mill process wastewater and mine drainage are subject to the New Source Performance Standards (NSPS) for the Ore Mining and Dressing Point Source Category promulgated by the U.S. Environmental Protection Agency (EPA) under 40 CFR 440 and the WDNR under Chapter NR 270, Wis. Admin. Code. The Crandon Project is covered by the NSPS for the copper, lead, zinc, gold, silver, and molybdenum subcategory of the Ore Mine and Dressing Point Source Category.

Mine drainage, as defined in NR 270.002(9), includes any water drained, pumped, or siphoned from a mine. Based on this definition, the groundwater infiltration into the mine, any water released from stope backfill materials, and utility water used in the mine are the project wastewaters which will be subject to the NSPS for mine drainage. NSPS effluent limitations for discharges of mine drainage are shown in Table 4-1.

Table 4-1

NSPS for Mine Drainage[1]

Effluent Characteristic	Effluent Limitations (in mg/L, except pH)	
	Maximum for Any One Day	Average of Daily Values for 30 Consecutive Days
Total Suspended Solids	30.0	20.0
Cadmium	0.10	0.05
Copper	0.30	0.15
Lead	0.6	0.3
Mercury	0.002	0.001
Zinc	1.5	0.75
pH (S.U.)	6.0 - 9.0[2]	6.0 - 9.0[2]

[1] From Chapter NR 270.104, Wis. Admin. Code.

[2] Where the application of neutralization and sedimentation technology to comply with relevant metal limitations results in an inability to comply with the pH range of 6.0 to 9.0, the permit issuer may allow the pH level in the final effluent to slightly exceed 9.0 so that the copper, lead, zinc, mercury, and cadmium limitations will be achieved.

Prepared by: RJC1
Checked by: HJA

As defined in NR 270.002(7), a "Mill" is a preparation facility within which the metal ore is cleaned, concentrated, or otherwise processed before it is shipped. A mill includes all ancillary operations and structures necessary to clean, concentrate, or otherwise process metal ore, such as ore and gangue storage areas and loading facilities. Based on the preceding definition, the following NMC project wastewaters will be subject to the NSPS for mill process wastewaters:

- mill process waters, including tailings slurry;
- contact runoff from production areas and the pre-production ore storage area;
- wastewater from labs and shops; and
- contact runoff from the tailings pipeline ditch and TMA access road.

The sanitary sewage treatment plant effluent will be routed to the tailings pump box and mixed with the tailings slurry for pumping to the tailings pond. Although sanitary sewage does not qualify as mill wastewater by the definition in NR 270.002(7), it will effectively be subject to the NSPS by virtue of its inclusion in the mill process water system.

The NSPS for the mill is no discharge of process wastewaters from the mill to "navigable waters," except as follows:

- In the event that the annual precipitation falling on the treatment facility and the drainage area contributing surface runoff to the treatment facility exceeds the annual evaporation, a volume of water equal to the difference between annual precipitation falling on the treatment facility and the drainage area contributing surface runoff to the treatment facility and annual evaporation may be discharged subject to the effluent limitations in Table 4-1.

- In the event that there is a buildup of contaminants in the recycle water which significantly interferes with the ore recovery process and this interference cannot be eliminated through appropriate treatment of the recycle water, the permitting authority may allow a discharge of process wastewater in an amount necessary to correct the interference problem after installation of appropriate treatment. This discharge shall be subject to the limitations in Table 4-1.

The NSPS also includes the following provision for combining of waste streams:

- In the event that waste streams from various subcategories or segments of the Ore Mining and Dressing point source category are combined for treatment and discharge, the quantity and concentration of each pollutant or pollutant property in the combined discharge that is subject to effluent limitations shall not exceed the quantity and concentration of each pollutant or pollutant property that could have been discharged had each waste stream been treated separately.

4.2 Sanitary Wastewater Discharge Standards

Effluent limitations, performance requirements, and monitoring provisions for facilities which discharge treated sanitary wastewater to surface water are set forth in Chapter NR 210, Wis. Admin. Code. Water quality based effluent limitations are discussed in detail in Section 4.4 of this report. Effluent from sanitary sewage treatment facilities must, at a minimum, meet effluent limitations for 5-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), pH, and fecal coliform bacteria.

Under the proposed NMC facility design, treated sanitary wastewater will be discharged to the tailings pump box. The wastewater, including treated sanitary effluent, entering the TMA will normally be recycled through the reclaim pond to the mill for use as mill process water. Consequently, effluent limitations for treated sanitary wastewater will not normally be applicable. However, the NMC facility design does include an option for sending excess mill process water from the reclaim pond to the wastewater treatment system for treatment and subsequent discharge to groundwater by way of the soil absorption system. The conditions for discharge of excess mill process water were discussed previously in Section 3.2.3 and Section 4.1 of this report.

4.3 Stormwater Standards

Discharge of stormwater runoff is regulated under Chapter NR 216, Wis. Admin. Code. The intent of NR 216 is to "eliminate to the maximum extent practicable the discharge of pollutants carried by stormwater runoff into waters of the state". Pursuant to NR 216, all potential dischargers must obtain a WPDES permit prior to initiation of activities which will potentially result in the discharge of stormwater runoff. Three general categories of runoff are defined in NR 216: municipal stormwater, industrial stormwater, and construction site stormwater. NR 216 exempts non-contact runoff from regulation under the WPDES permit program. In the case of the Crandon Project, only the requirements for industrial stormwater and construction runoff are applicable. These requirements are discussed as follows.

4.3.1 Requirements for Industrial Stormwater Runoff

For the Crandon Project, industrial stormwater will consist of contact runoff during operation and closure. As described previously in Section 4.1, contact runoff must meet the NSPS for mill process wastewaters. Subchapter II of NR 216 contains additional requirements for contact runoff. The primary requirement is the preparation and implementation of a Storm Water Pollution Prevention Plan (SWPPP). The requirements for this plan are identified in NR 216.27.

4.3.2 Requirements for Stormwater Runoff Resulting from Construction

Subchapter III of NR 216 contains requirements for discharges of construction stormwater. A WPDES permit is required for discharges of runoff from any land disturbing construction activity that results in the disturbance of 5 or more acres of total land area. The Crandon Project will initially disturb approximately 400 acres during construction of the project site, plus additional areas for construction of the soil absorption discharge system, the discharge pipeline to the soil absorption system, and for construction at the wetland compensation site. As the project progresses, additional tailings cells will be constructed throughout the life of the project. To obtain a WPDES permit for stormwater discharges associated with land disturbing construction activities, a Notice of Intent must be submitted to the WDNR at least 14 days prior to commencing any land disturbing construction activities. In addition, a Construction Site Erosion Control Plan and a Storm Water Management Plan must be completed prior to submittal of the Notice of Intent.

The Construction Site Erosion Control Plan must address soil erosion and sedimentation during construction and up to the final stabilization of the site. The plan must describe appropriate controls and measures that will be performed at the site to prevent pollutants from reaching waters of the state. All activities required by the plan must be performed, and compliance with the plan must be maintained during construction. The Storm Water Management Plan must address storm runoff after construction is completed. The plan must describe what management practices will be used to control peak flow, pollutants, and runoff volume that will occur after construction operations have been completed. The Crandon Project *Mine Permit Application*

(Foth & Van Dyke, 1995/1998b) includes the information needed to satisfy the requirements for a Construction Site Erosion Control Plan and a Storm Water Management Plan.

When a site has undergone final stabilization and all stormwater discharges associated with construction site activities that were required to have a WPDES permit under NR 216, Subchapter III, have ceased, a Notice of Termination must be submitted to the WDNR.

4.4 Water Quality Standards

Effluent limitations for the wastewater and mitigation waters discharged from the NMC wastewater treatment system will include limitations needed for attainment and maintenance of water quality standards in surface water and groundwater. Water quality standards for surface water and groundwater within the state of Wisconsin have been established by the WDNR in Chapters NR 102, NR 104, NR 105, NR 106, NR 140, and NR 207, Wis. Admin. Code.

The wastewater discharged via the soil absorption system will seep to groundwater and will therefore be regulated by Chapter NR 140, Wis. Admin. Code. Mitigation water will be discharged to surface waters. The mitigation water may also flow directly or indirectly into outstanding resource waters and exceptional resource waters. Mitigation water that originates from the wastewater treatment system will be regulated as a WPDES discharge, for which standards developed under NR 102, NR 104, NR 105, NR 106, and NR 207, Wis. Admin. Code, will be applied.

4.4.1 Groundwater Standards

Effluent limitations for the treated effluent discharged from the soil absorption system will include limitations needed for attainment and maintenance of water quality standards in groundwater. Following is a discussion of the state regulations applicable to a discharge of wastewaters via a soil absorption system.

Chapter NR 140, Wis. Admin. Code, addresses groundwater quality standards for substances entering the groundwater resources of the state. The standards are classified by the following criteria:

- Public Health Groundwater Standards
- Public Welfare Groundwater Standards
- Indicator Parameter Groundwater Standards

The public health and public welfare groundwater standards have enforcement standards and preventative action limits. The indicator parameter groundwater standards have only preventative action limits. The enforcement standards and preventative action limits are numerical values expressing the concentration of a substance in groundwater.

4.4.2 Surface Water Quality Standards

Effluent limitations for the discharge of mitigation waters to soft water bodies include limitations needed for attainment and maintenance of water quality standards in surface water. Water quality standards for surface water within the state of Wisconsin have been established by the WDNR. Following is a discussion of the regulations applicable to surface water quality standards for mitigation water discharges.

Chapters NR 102, NR 104, NR 105, NR 106, and NR 207, Wis. Admin. Code, address water quality standards for surface waters based on the following criteria:

- Acute Toxicity Criteria for Aquatic Life
- Chronic Toxicity Criteria for Aquatic Life
- Wild and Domestic Animal Criteria
- Human Threshold Criteria
- Human Cancer Criteria and Human Threshold Criteria
- Taste and Odor Criteria
- Antidegradation Criteria

For each of the above criteria, the water quality standards vary in stringency depending on the classification of the receiving water.

4.4.3 Outstanding Resource Water and Exceptional Resource Water Standards

Effluent limitations for the discharge of mitigation water that originates from the project's wastewater treatment system include limitations needed for attainment and maintenance of water quality standards in outstanding resource waters (ORW), and exceptional resource waters (ERW). Chapters NR 102 and NR 207, Wis. Admin. Code, address water quality standards for waters classified as either an ORW or an ERW.

5 Alternatives Evaluation

Chapter NR 207, Wis. Admin. Code, requires a new point source discharger to evaluate alternative discharge locations and alternative treatment technologies. The purpose of this section of the report is to summarize the evaluation of alternative discharge locations and alternative treatment technologies for the treated wastewaters to be discharged during operation and closure of the Crandon Project. The section includes a discussion of the following:

- A description of alternative discharge locations and the treatment technologies needed to meet water quality based limitations.
- A comparison of the environmental effects, economic costs, and other considerations for treatment and disposal associated with each alternative discharge location.
- The selected discharge location and the basis for selection.

5.1 Description of Alternative Discharge Locations

Alternative discharge locations considered include discharges to various surface waters and discharge to groundwater via a soil absorption system. Surface waters considered included Lake Metonga, Little Sand Lake, the Wisconsin River, Swamp Creek, Neptune Creek, Haymeadow Creek, Monico Creek, the Pelican River, and the headwaters of several other surface waters in the regions such as the Peshtigo and Oconto Rivers. An initial screening of these alternatives resulted in three potential discharge locations: the Wisconsin River at the Hat Rapids Dam, Swamp Creek below Rice Lake, and a discharge to groundwater via a soil absorption system. The other river surface water locations were eliminated from further consideration because they had low flow rates and thus provided no significant environmental or economic advantages compared to discharging to the Wisconsin River or Swamp Creek. The lakes were eliminated because they discharge to tributaries to the Wolf River and therefore they provided no significant environmental or economic advantage compared to discharging to the Wisconsin River or Swamp Creek. A discussion of the three alternatives remaining after the initial screening follows.

5.1.1 Discharge to Groundwater via Soil Absorption System

For this alternative, treated wastewater would be land applied through the use of a soil absorption system. Applied effluent would infiltrate through the soil, eventually reaching the underlying groundwater aquifer. The absorption system would be located within the Fox-Wolf River drainage basin.

For the evaluation of this discharge alternative, effluent limitations for discharge to the absorption system would be based on groundwater quality standards as promulgated in Chapter NR 140, Wis. Admin. Code. Groundwater standards include Public Health, Public Welfare, and Indicator categories. The public health and public welfare categories in NR 140 include both

Preventative Action Limits (PALs) and Enforcement Standards (ESs). For the indicator category, only PALs are included. ESs are the mandatory groundwater standards which must be met at a compliance boundary determined by the WDNR. Discharged effluent must be, at a minimum, of high enough quality to prevent exceedance of the ESs in the groundwater at the compliance boundary. PALs are more stringent than ESs and serve to inform the WDNR of potential groundwater contamination problems. NR 140 requires that all discharges to groundwater must be regulated to maintain compliance with PALs in the groundwater at the compliance boundary unless it can be shown that compliance is not technically and/or economically feasible. The WDNR may set alternative limits for any groundwater contaminants which have been shown, through data collected during the groundwater sampling program, to naturally occur in the native groundwater at levels exceeding the PALs or ESs. Based on preliminary data, existing ambient groundwater concentrations for a number of NR 140 parameters in the vicinity of the Crandon Project exceed the established PALs. For such substances, an exemption to the PAL may be granted provided that the enforcement standard for that substance is not exceeded and provided that the wastewater treatment facility is designed to provide the lowest possible effluent concentration economically and technically feasible. Indicator standards are based on an allowable increase in the concentration of specified parameters above groundwater background concentrations. Only PALs are established for indicator parameters. Groundwater quality standards are available in NR 140. Final effluent limits for the Crandon Project would be set by the WDNR as part of the WPDES permitting process.

For the purposes of evaluating this alternative, it has been assumed that the treatment system would need to produce an effluent quality that would meet the PALs for all parameters.

5.1.2 Discharge to the Wisconsin River

For the Wisconsin River discharge alternative, treated wastewater would be pumped from the effluent discharge lagoon system at the Crandon Project site to the Wisconsin River via an underground pipeline. The effluent would be discharged into the Wisconsin River at the Hat Rapids Dam. The pipeline would follow existing road rights-of-way throughout its course. The length of the pipeline would be approximately 38.3 miles.

Discharge of wastewater to the Wisconsin River would result in a transfer of water from the Great Lakes drainage basin to the Mississippi River drainage basin. Interbasin diversions are regulated by the State of Wisconsin under Chapter NR 142, Wis. Admin. Code. Criteria for an interbasin transfer applicable to the discharge of effluent from the Crandon Project site to the Wisconsin River are delineated in NR 142.03(3).

The Wisconsin River, in the region of the proposed discharge location, is classified as a Warm Water Sport Fish Community. New dischargers to the river are required to comply with the water quality standards as set forth in Chapter NR 105, Wis. Admin. Code, for Warm Water Sport Fish Communities and the water quality anti-degradation standards as set forth in Chapter NR 207, Wis. Admin. Code. Accordingly, weekly and monthly water quality based effluent

limitations will be set based on one-third of the calculated available assimilative capacity of the Wisconsin River for all substances regulated under the water quality standards. Note that daily maximum limitations are based on acute toxicity criteria which are not based on assimilative capacity and consequently are not subject to the one-third factor used for weekly and monthly average limitations. In addition to water quality based effluent limits, a discharge to the Wisconsin River must meet categorical limits for mine drainage in accordance with New Source Performance Standards as promulgated in Chapter NR 270, Wis. Admin. Code. Where categorical limits are more stringent than water quality based limits, the categorical limits will govern.

In addition to effluent limits based on substances listed in NR 105, the WDNR has proposed regulating discharge of sulfate to the Wisconsin River. While there are currently no water quality standards applicable to discharge of sulfate to the Wisconsin River, the WDNR has indicated that sulfate limits will likely be included in any discharge permit in order to minimize "secondary impacts". The proposed regulation of sulfate is based on concern for wild rice downstream of the Wisconsin River discharge location. Based on preliminary WDNR comments, the sulfate concentration of effluent discharged from the Crandon Project would be regulated to the extent that the sulfate concentration in the Wisconsin River, downstream of the proposed discharge location, would not exceed 10 mg/L under the maximum effluent discharge flow rate and under $Q_{7,10}$ low flow conditions for the river.

Final effluent limitations for the Crandon Project would be set by the WDNR as part of the WPDES permitting process.

5.1.3 Discharge to Swamp Creek

For the Swamp Creek discharge alternative, treated wastewater would be pumped from the effluent discharge lagoon system at the NMC site to Swamp Creek via an underground pipeline. Effluent would be discharged into Swamp Creek at a site located south of County Road M below Rice Lake. The length of the pipeline would be approximately 5 miles.

Swamp Creek is classified as a Warm Water Sport Fish Community and, as such, would be subject to the same effluent limit criteria as described for the Wisconsin River discharge alternative. However, Swamp Creek is also a tributary to the Wolf River, which is classified as an Outstanding Water Resource (ORW). Under Chapter NR 207, Wis. Admin. Code, effluent limitations for ORWs are set equal to background levels as measured in the receiving body of water upstream of the discharge location. Since Swamp Creek is not an ORW itself, effluent limits for discharge to Swamp Creek should not be based directly on background levels in the Wolf River. However, to meet the intent of NR 207, effluent limits for discharge to Swamp Creek should be based on preventing any measurable degradation of the water quality based criteria of the Wolf River. Calculation of effluent limits for discharge to Swamp Creek should therefore take into consideration the background water quality of the Wolf River, the background water quality of Swamp Creek, and the available dilution of discharged effluent prior to reaching

the Wolf River. Additionally, a discharge to Swamp Creek would need to meet all applicable limits based on NR 105 and NR 207 criteria for Warm Water Sport Fish Communities.

Final limitations would be set by the WDNR as part of the WPDES permitting process.

5.1.4 Surface Waters for Mitigation

Water may be required for mitigation of regional streams and/or lakes impacted by groundwater drawdown associated with mine dewatering activities. Treated effluent from the wastewater treatment plant may be used, if required, for the mitigation of soft water bodies, such as lakes. Advanced treatment will be provided, if required, to meet effluent limits for the discharge of mitigation water to soft water bodies. Effluent limits will be set by the WDNR based on applicable sections of the Wisconsin Administrative Code. Water for mitigation of hard water bodies will be provided by wells and, therefore, this topic is not discussed in this report.

5.2 Description of Alternative Treatment Technologies

The base wastewater treatment system for the Crandon Project facility will include hydroxide precipitation, clarification, pH adjustment, sulfide precipitation, and filtration. While the base treatment system will produce a high quality effluent, it is anticipated that all three discharge options will require a level of treatment beyond the capability of the base treatment system. Advanced treatment will sequentially follow the base system to provide treated wastewater that consistently meets water quality standards. The advanced treatment system will include reverse osmosis (RO) and evaporation.

With the exception of sulfate, all of the effluent limitations for discharge to the Wisconsin River can be met using the base treatment system. Advanced treatment would only be required to reduce effluent sulfate concentrations. In order to meet anticipated sulfate limits, approximately 50 percent of the base treatment system effluent would need to be treated by advanced treatment consisting of the RO and evaporation technologies; with the remaining base treatment system effluent bypassing the advanced treatment system. Figure 5-1 shows a schematic flow diagram of the treatment and disposal processes for this alternative.

The effluent limitations anticipated for the Swamp Creek and the groundwater soil absorption system alternatives would also require advanced treatment following the base treatment system. Advanced treatment would be required for reduction of some metals and other effluent constituents. It is anticipated that 100 percent of the base treatment effluent flow would require advanced treatment for these two discharge alternatives. Figures 5-2 and 5-3 show schematic flow diagrams for the treatment and disposal processes for the Swamp Creek and groundwater discharge alternatives, respectively.

For all three discharge alternatives, the treated effluent will be routed to one of two lined discharge lagoons for temporary storage. The lagoon system will allow effluent quality to be verified prior to final discharge. In the event that effluent stored in one of the lagoons does not

meet discharge limitations due to treatment system operational problems, the effluent can be recycled back through the treatment facility or routed to the TMA. Note that the discharge lagoon design is identical for all three discharge alternatives. Design details for the discharge lagoon system are discussed in Section 6 of this report. Following is a discussion of the alternative treatment technologies for the Crandon Project wastewater treatment system.

5.2.1 Base Treatment System

Hydroxide precipitation is a well established, relatively inexpensive technology commonly used to remove heavy metals from wastewater. For the Crandon Project wastewater treatment system, lime will be used for neutralization and for precipitation of heavy metals. Most operating metallic mines are currently operating similar systems for treatment of mine wastewaters. Acidity in the wastewater is neutralized as illustrated below:

Eq. 1a $2H^{+} + Ca(OH)_2 \rightleftharpoons Ca^{+2} + 2H_2O$

Eq. 1b $2HCO_3^{-} + Ca(OH)_2 \rightleftharpoons Ca^{+2} + 2CO_3^{-2} + 2H_2O$

With lime treatment, metal removal occurs by adjusting the pH of the wastewater to the point where metals exhibit minimum solubilities and precipitate as metal hydroxides. These precipitates can then be removed through clarification. The effectiveness of hydroxide precipitation is dependent on wastewater characteristics such as pH, the form of metal ions present, and the presence of complexing agents. Metal removal for this process is limited by the solubilities of the metal hydroxides generated. The minimum solubilities for most metal hydroxides occur in the pH range of 9 to 11; hence metal precipitation, in general, is optimal within this range. However, each metal hydroxide has a unique point of minimum solubility. At pH values above or below this point, the metal solubility increases. The optimal pH for the lime treatment process, corresponding to the maximum overall removal of heavy metals, was determined for the Crandon Project wastewater through wastewater treatability testing. The treatability test methods and test results for the lime treatment process are summarized in Section 6. Based on the results of the treatability testing, a system operating pH of 10.0 will be used for design and initial operation of the lime treatment process.

The principal precipitation reactions which occur with lime treatment can be represented with the following general equations:

Eq. 2a $M^{+2} + Ca(OH)_2 \rightleftharpoons M(OH)_2\downarrow + Ca^{+2}$

Eq. 2b $2M^{+3} + 3Ca(OH)_2 \rightleftharpoons 2M(OH)_3\downarrow + 3Ca^{+2}$

Eq. 2c $Ca^{+2} + SO_4^{-2} \rightleftharpoons CaSO_4\downarrow$

Eq. 2d $Ca^{+2} + CO_3^{-2} \rightleftharpoons CaCO_3\downarrow$

where M^{+2} includes divalent metals such as copper, zinc, lead, nickel, and cadmium, and M^{+3} includes trivalent metals such as aluminum and iron.

In the lime treatment process, wastewater will be mixed with lime slurry in a lime precipitation tank and will subsequently flow to a solids-contact type clarifier. Precipitation of heavy metals will occur in the tank. Settling of the precipitates will occur within the clarifier, and will result in the formation of metal hydroxide solids in the bottom of the clarifier. A solids inventory will be maintained within the clarifier in order to optimize the settling process. Excess solids generated by the precipitation process will be pumped from the clarifier to the tailings pump box. Note that the lime treatment process design is identical for all three of the discharge alternatives. Design details for the lime treatment process are discussed in Section 6 of this report.

As discussed previously, the effectiveness of lime treatment is limited by the solubility of the metal hydroxides generated in the treatment process. The lime treatment process alone is not expected to be able to meet the effluent limitations for all the proposed discharge alternatives. Nevertheless, the lime treatment process will serve to remove a substantial fraction of the dissolved metals and will reduce the amount of metals removal required of subsequent treatment processes.

Following lime treatment and clarification, pH adjustment of the wastewater can be provided through addition of sulfuric acid. Acid addition will occur in a separate tank prior to sulfide treatment to minimize the potential for generation of hydrogen sulfide gas.

The sulfide treatment process will be used as a further treatment step in the wastewater treatment system. This process will provide additional reduction of heavy metals in the wastewater. With sulfide treatment, metals are precipitated as metal sulfides. The precipitated metals will be subsequently removed through filtration. Typical metal precipitation reactions for the sulfide precipitation process can be represented by the following general equation:

Eq. 3a. $M^{+2} + Na_2S \rightleftharpoons MS\downarrow + 2Na^{+}$

The very low solubility of metal sulfides is the key to the effectiveness of this process. The theoretical solubilities of metal sulfides are several orders of magnitude lower than the corresponding solubilities for metal hydroxides. As with hydroxide precipitation, the extent of metals precipitation for the sulfide process is pH dependent. In general, metal sulfides exhibit minimum solubilities in the pH range of 7 to 11. Operation within this pH range also minimizes the potential for generation of hydrogen sulfide gas. The sulfide dosage for design and initial operation of the sulfide treatment process was determined based on the results of treatability testing. The treatability test methods and test results for the sulfide treatment process are summarized in Section 6.

Following pH adjustment, the lime treated wastewater will flow to a sulfide reaction tank. The wastewater will be mixed with a sodium sulfide solution resulting in the generation of metal sulfide precipitates. Note that the sulfide treatment process design is identical for all three discharge alternatives. Design details for the sulfide treatment process are discussed in Section 6 of this report.

Effluent from the sulfide reaction tank will flow to a filter system. Precipitated metal sulfides will be removed from the effluent by the filters. Filter backwashing will be used to periodically remove the captured solids from the filter. Filter effluent stored in a clearwell will be used to backwash the filters. Backwash water, with the solids removed from the filter media, will normally be routed to the tailings pump box. Note that the filter design is identical for all three discharge alternatives. Design details for the filters are provided in Section 6 of this report.

5.2.2 Advanced Treatment

As shown in Table 5-1, the lime/sulfide treatability testing indicates that a higher level of treatment will be needed to produce an effluent of sufficient quality to meet discharge limitations for the soil absorption system. Consequently, advanced wastewater treatment processes such as reverse osmosis, ion exchange, and/or evaporation will be necessary for further reduction of various constituents prior to discharge.

The selected advanced treatment process involves both two-stage reverse osmosis and evaporation technologies. Reverse osmosis (RO) is a membrane process in which organic and inorganic constituents can be removed from wastewater. The basic principles of operation are as follows. A wastewater feed stream is passed tangentially across the membrane surface and is driven by applied hydrostatic pressure through the membrane. Constituents present in the wastewater are rejected at the membrane surface and become concentrated in the "reject" stream while purified "permeate" passes through the membrane. This process separates the membrane system feed stream into two new aqueous streams, the purified "permeate" stream and the concentrated "reject" stream.

A dual-train reverse osmosis process will be used to produce water suitable for discharge to groundwater. The first stage process will pass approximately 75 percent of the water, creating a 25 percent reject stream. The second stage reject water will be sent back to the front of the reverse osmosis process. The combined losses from the system will be approximately 30 percent.

Between the first and second stage processes, the pH of the water will be automatically controlled to increase the removal efficiency of cyanide. A higher pH in the second stage will not result in increased fouling of the membrane because the feed water will be of much higher quality, containing relatively low concentrations of scale forming constituents such as calcium and sulfate. The water from this process will be suitable for discharge to the proposed soil absorption system or will be sent to the evaporator for further treatment prior to use as mitigation water.

The reject stream from the RO system will need further volume reduction. This reject stream also contains the concentrated materials from the RO system. Evaporation technology was determined to be a feasible process for reducing the volume of the RO reject stream and producing a very high effluent quality that can be used for mitigation water. Using an evaporator system, the RO reject will be reduced in volume by approximately 95 percent. The concentrated

Table 5-1

Comparison of Groundwater Quality Standards and Estimated Lime/Sulfide Treated Effluent Quality

Parameter	Units	Estimated Lime/Sulfide Effluent Quality[1]	Estimated Effluent Limitations	
			PAL[2]	ES[3]
Antimony	mg/L	0.0030	0.0012	0.006
Arsenic	mg/L	0.0040	0.005	0.05
Barium	mg/L	0.040	0.4	2
Beryllium	mg/L	<0.00006	0.0004	0.004
Boron	mg/L	<0.0028	2[4]	—
Cadmium	mg/L	0.0015	0.0005	0.005
Calcium	mg/L	450	5[4]	—
Chloride	mg/L	44	125	250
Chromium	mg/L	0.0050	0.01	0.1
Copper	mg/L	0.010	0.13	1.3
Cyanide	mg/L	<0.0034	0.04	0.2
Fluoride	mg/L	0.29	0.8	4
Iron	mg/L	0.081	0.15	0.3
Lead	mg/L	0.0030	0.0015	0.015
Magnesium	mg/L	50	37[5]	—
Manganese	mg/L	0.064	0.025	0.05
Mercury	mg/L	0.0000005	0.0002	0.002
Nickel	mg/L	0.020	0.02	0.1
Nitrate + Nitrite	mg/L	12	2	10
Nitrogen (Ammonia)	mg/L	4.8	2[5]	—
Nitrogen (Organic)	mg/L	NA	2[4]	—
Potassium	mg/L	8.5	5[4]	—

Table 5-1 *(Continued)*

Parameter	Units	Estimated Lime/Sulfide Effluent Quality[1]	Estimated Effluent Limitations PAL[2]	ES[3]
Selenium	mg/L	0.080	0.01	0.05
Silver	mg/L	0.0010	0.01	0.05
Sodium	mg/L	21	10[4]	
Sulfate	mg/L	1200	125	250
Thallium	mg/L	0.010	0.0004	0.002
Zinc	mg/L	0.020	2.5	5
Alkalinity	mg/L	17	230[5]	
BOD 5	mg/L	<10[6]	25[4]	
Color	color units	NA[7]	7.5	
Conductivity	μmhos	NA[7]	NA[7]	15
COD	mg/L	<10[6]	54[5]	
Foaming Agents	mg/L	NA[7]	0.25	0.50
Odor	mg/L	NA[7]	1.5	3
Total Dissolved Solids	mg/L	1800	370[5]	
Total Hardness	mg/L	1300	225[5]	
pH (field)	S.U.	—[8]	6.7-8.7	

[1] Estimated treated effluent quality is based on treatment of mine water through the lime/sulfide process under BEJ flow conditions. Based on the results of the 1995 Wastewater Treatability Study (Foth & Van Dyke, 1995), and best professional judgement.
[2] NR 140 Preventative Action Limit.
[3] NR 140 Enforcement Standard.
[4] Background water quality data are not currently available for this parameter. Stated value indicates allowable increase in groundwater quality above background levels.
[5] Based on Paul Luebke, WDNR, memorandum of April 2, 1998 (WDNR, 1998a).
[6] Based on engineering judgement.
[7] Data not available.
[8] pH will be controlled in the treatment process.

Prepared by: JJF1
Checked by: HJA

evaporator brine will used as makeup water for the pyritic paste backfill. The cemented backfill will stabilize the concentrated waste materials and provide an acceptable means of handling the reject water.

Ammonia from the reverse osmosis reject water will be volatilized in the evaporator and carried over to the evaporator condensate. After the evaporation process, ammonia concentrations will be reduced by an air stripping process. After ammonia removal, the condensate from the evaporator system will be of high enough quality for groundwater discharge via the seepage cell system or for use in surface water mitigation.

5.3 Evaluation of Treatment and Discharge Alternatives

5.3.1 Environmental Considerations

The treatment systems selected for each discharge alternative would produce treated effluents that would meet all water-quality based effluent limitations. Therefore, wastewater discharges during operation and closure should have no significant adverse environmental effect on surface or groundwater quality for any of these three alternatives.

The discharge pipeline for the Wisconsin River alternative would be constructed entirely on NMC property, existing public road rights-of-way, or on the property of Wisconsin Public Service Corporation at the Hat Rapids Dam. Because the pipeline would be buried, impacts would be minimal and limited to the short period when the pipeline would be constructed. No long-term environmental impacts would be expected from pipeline construction. It is expected that no threatened or endangered species would be disturbed during pipeline construction. The pipeline would discharge into the inlet piping of the turbines at the Hat Rapids Dam, so construction activities in the Wisconsin River would be avoided. Therefore, there would be no significant environmental impact on the Wisconsin River during construction.

Impacts associated with the Swamp Creek discharge pipeline are similar to those associated with the Wisconsin River discharge alternative. However, unlike the Wisconsin River alternative, much of the pipeline corridor to Swamp Creek traverses undisturbed habitat. The Swamp Creek alternative would require an outfall structure at Swamp Creek. Measures would be taken to minimize disturbances to wetlands and to Swamp Creek during pipeline construction. No significant long-term environmental impacts would be expected from construction of the pipeline and outfall structure.

The groundwater alternative would require the construction of the soil absorption system, roadways, and ancillary facilities. The pipeline to the soil absorption system site would be located primarily within the railroad spur disturbance corridor. No long-term environmental impacts would be expected from the soil absorption system and pipeline construction. It is expected that no threatened or endangered species would be disturbed during pipeline construction. The soil absorption system cell locations would be on upland sites, so there would be no disturbance of wetlands during soil absorption system cell construction. During project

closure, when effluent discharge is no longer required, the soil absorption system will be reclaimed. No significant long-term environmental impacts would be expected from construction and reclamation of the soil absorption system.

5.3.2 Economic Considerations

In order to evaluate the relative cost of each discharge alternative, capital and operating costs were developed based on conceptual process designs. These designs were based on satisfying the design wastewater flows, wastewater loads, and effluent limitation requirements. Capital costs include equipment and materials, installation, engineering, and a contingency, and are based on budget quotations from equipment vendors, quantity takeoffs using typical unit prices, and miscellaneous costs typical for construction projects. Operation and maintenance costs are based on estimated requirements for power, labor, chemicals, and maintenance based on vendor information and treatment plant experience.

For each discharge alternative, a present worth cost was determined by calculating the present worth of the operation and maintenance costs and adding this value to the capital cost. An 8 percent per year present worth rate and a 30 year design period were used in the present worth evaluation.

The costs for each of the alternatives include a base treatment system consisting of lime treatment, pH adjustment, sulfide treatment, and filtration. All three alternatives use this identical base treatment system. Additionally, all three discharge alternatives utilize an identical discharge lagoon system. The differences in the costs are associated with the advanced treatment and discharge systems used for each alternative.

For the Wisconsin River alternative, it is projected that the base treatment system, under maximum water balance condition flows, would provide a level of treatment adequate to meet all discharge limitations with the exception of sulfate. Under average water balance flow conditions it is projected that the base treatment system would meet all effluent limits including sulfate. Reverse osmosis (RO) treatment of about one-half of the wastewater flow, under maximum flow conditions, would be required to meet sulfate limits. For the present worth analysis, a RO system was included for the Wisconsin River Alternative. An evaporator system was also included to provide volume reduction of the RO brine flow.

For the groundwater alternative, RO treatment will be required to meet effluent limits. The entire base treatment system effluent flow will require RO treatment. An evaporator would also be needed for volume reduction of the RO brine.

For discharge to Swamp Creek, 100 percent of the base treatment system effluent will require evaporation treatment in order to meet the projected effluent limits. The cost for this alternative includes total evaporation treatment of base treatment system effluent with no RO treatment.

For the Wisconsin River and Swamp Creek alternatives, the costs also include capital and operation and maintenance costs associated with the discharge pipeline. The approximate pipeline distances are 38.3 miles and 5 miles, respectively. For the groundwater discharge alternative, the costs associated with effluent discharge include capital and operation and maintenance costs associated with the discharge pipeline and the soil absorption system. The discharge pipeline will be approximately 3.6 miles long.

The estimated capital, O & M, and present worth costs for each alternative are summarized in Table 5-2.

Table 5-2

Present Worth Analysis for Discharge Alternatives

Discharge Alternative	Capital Cost	Annual O&M Cost	Present Worth Cost
Wisconsin River	$21,760,000	$ 488,000/year	$27,260,000
Swamp Creek	$20,970,000	$1,370,000/year	$36,360,000
Groundwater	$18,490,000	$ 807,000/year	$27,580,000

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5.3.3 Other Considerations

In addition to the present worth analysis, the discharge alternatives were evaluated based on non-economic considerations as described below.

The Wisconsin River discharge alternative would result in a transfer of water from the Great Lakes basin to the Mississippi River basin. While the interbasin transfer is permittable, it has generated significant public debate. While the discharge is allowed because of the small volume of water transferred, the soil absorption and Swamp Creek discharge alternatives would keep the discharge water in the Great Lakes basin.

The Swamp Creek discharge alternative keeps the water in the Wolf River watershed. However, this alternative results in a discharge to a tributary of the Wolf River, which is classified as an Outstanding Resource Water (ORW). The ORW classification provides encouragement to search for an alternate discharge location. While a discharge to Swamp Creek is permittable, the required treated effluent quality would be high, resulting in no measurable impact on the Wolf River.

Discharge of treated effluent by way of the soil absorption system has the potential to mitigate the impact of groundwater drawdown. Various locations were evaluated for the siting of the soil absorption system. Some locations offered greater mitigation potential than others. Site specific soil and geologic conditions, as well as mitigation potential, were considered in the site selection process for a soil absorption system. This system is discussed in Section 6.8.

5.4 Alternative Selection

Based on the evaluation of environmental and economic considerations, a discharge to the groundwater is the recommended alternative. This recommendation was based on the following:

- A discharge to groundwater would have no significant adverse effects on the environment.
- A discharge to groundwater would avoid direct discharges to an ERW or ORW.
- The groundwater discharge option will assist in the mitigation of mine related drawdown impacts on Swamp Creek.
- Implementation of the groundwater discharge concept would avoid interbasin transfer of water.
- While not the least costly alternative, a discharge to groundwater is cost effective given the other factors described above.

6 Wastewater Treatment Facilities Design

A wastewater management system will be provided for the collection, treatment, and discharge of wastewaters generated during construction, operation, and closure of the mine, mill, TMA, and ancillary facilities of the Crandon Project. During construction, the collection and treatment facilities will include drainage ditches and runoff basins for collection and treatment of construction runoff, with discharge of treated construction runoff to on-site drainageways.

During operation, collection and treatment facilities will be used for treatment and recycle/reuse of treated wastewaters in the mill process water system and for collection and treatment of mine drainage and contact runoff, with discharge of the treated wastewaters to groundwater by way of a soil absorption system. The facilities used for treatment and recycle/reuse of the treated wastewaters in the mill process water system will include the tailings ponds, the reclaim pond, the tailings pipeline ditch, the drain down sump, and the sanitary sewage treatment plant. The facilities used for treatment and discharge of mine drainage and contact runoff will include wastewater storage basins 5, 6, and 7, the wastewater treatment system, the treated wastewater discharge lagoons, the discharge pumping facilities, and the discharge soil absorption system and associated conveyance pipeline. Treated wastewater will be used as required for mitigation of surface water bodies (soft water) impacted by groundwater drawdown associated with mine dewatering activities.

As the mine is being closed, water will continue to be pumped until all salvageable equipment has been removed and closure operations have been completed. Water pumped from the mine will continue to be treated at the wastewater treatment plant. Water from the final tailings pond will be pumped to the reclaim pond as in the operational phase of the project. Water will be pumped from the reclaim pond at a controlled rate to wastewater storage basins 6 and 7, then pumped to the wastewater treatment plant for treatment prior to discharge. The wastewater treatment system and discharge soil absorption system will continue to operate during reclamation as long as required.

A detailed discussion of the design of the various facilities included in the Crandon Project WWTS is presented below.

6.1 Mill Process Water Treatment and Recycling/Reuse

6.1.1 Tailings Cells

The depyritized tailings slurry and other wastewaters will be transported from a pump box in the concentrator building to the TMA through an aboveground tailings pipeline located in a lined ditch. Tailings slurry will be discharged by spigots located on the perimeter of the cell with water ponding near the center of the pond. The ponded water will be pumped to the reclaim pond. Leachate will be collected in the sideslope riser sumps of each TMA cell, and will also be pumped to the reclaim pond. Details of design for the tailings pipeline and tailings cells are

presented in the project's *TMA Feasibility Report* and Addenda (Foth & Van Dyke, 1995, 1996a and b, 1997, 1998a and b).

6.1.2 Reclaim Pond

The reclaim pond will receive the clarified tailings water and leachate from the tailings cells for recycling back to the mill. The reclaim pond is located north of the tailings pipeline ditch and west of the TMA as shown on Figure 3-1. The reclaim pond will perform the following functions:

- Provide equalization of flows during short-term imbalances between the flow rate out of the tailings pond and the demand for recycled water by the mill process water system.

- Provide additional removal of total suspended solids by settling.

- Allow additional residence time for natural evaporation, oxidation, and biological processes to occur, thereby reducing concentrations of certain chemical constituents in the water recycled to the mill.

The reclaim pond will have the capacity to hold a minimum of three days of reclaim water at the maximum design flow rate plus a 3 foot depth for solids storage plus 3 feet of freeboard. A plan view and a section view of the reclaim pond are shown on Figure 6-1.

The reclaim pond will be constructed with a composite liner to minimize seepage to groundwater. The composite liner will be constructed as shown on Figure 6-1, and consist of the following from top to bottom:

- riprap along the pond inside side slopes to protect the till cover from erosion;
- a till cover over a geotextile to protect the geomembrane liner;
- a 60 mil geomembrane liner;
- a geosynthetic clay liner (GCL); and
- a low permeable soil over compacted natural soil.

The design of this liner will meet the requirements for wastewater lagoon liners in Subchapter II of Chapter NR 213, Wis. Admin. Code.

The reclaim pond bottom will be sloped toward the pond outlet to allow the pond to be drained, if necessary. A pump station will be provided with two reclaim water pumps for pumping the water from the reclaim pond to the process water tank at the plant site via a reclaim water pipeline. One pump will be a standby unit. This pipeline will be located in the tailings pipeline ditch next to the tailings pipeline. Piping will also be provided from the reclaim water pipeline to wastewater storage basins 6 and 7. This piping will allow excess water to be removed from the mill process water system for treatment by the wastewater treatment system.

6.1.3 Tailings Pipeline Ditch

Although the tailings pipeline and the reclaim water pipeline will be designed to prevent spillage, these pipelines will be installed in a lined ditch so potential spillage is fully contained and recoverable. This ditch will also collect contact runoff from the TMA access road as well as precipitation that falls on the ditch. The location of the TMA access road is shown on Figure 3-1. Details of the ditch design are presented in the project's *TMA Feasibility Report* and Addenda (Foth & Van Dyke, 1995, 1996a and b, 1997, 1998a and b).

Water that collects in the ditch on the plant site will flow to a collection sump at the mill, and be pumped with the tailings slurry water and other wastewaters to the tailings pond via the tailings pipeline. Water that collects in the ditch between the plant site and the TMA will flow to a drain down sump.

6.1.4 Drain down Sump (Basin 4)

The drain down sump, also identified as basin 4, will be located adjacent to and on the south side of the tailings pipeline ditch as shown on Figure 3-1. This basin will have the capacity to contain the following:

- the runoff from a 25-year, 24-hour rainfall event; and
- two volumes of the tailings pipeline.

The basin will also have the capacity to hold 3 feet of accumulated solids, and will have 3 feet of freeboard. A plan view and a section view of the basin are shown on Figure 6-2. The basin will be provided with a composite liner similar to that described in Section 6.1.2 to minimize seepage to groundwater.

An alternative to the proposed design is the construction of a concrete sump with design criteria and a design capacity equal to that proposed for the earthen basin design. Selection of the design concept, i.e., an earthen basin with a liner or a concrete sump, will be made before preparing detailed plans and specifications for basin 4.

The water that accumulates in the basin will be placed in the tailings pond. A small sump is included in the northeast corner of the basin. The basin bottom will be sloped toward this sump to assist in removing the water from the basin.

6.2 Sanitary Wastewater

The sewage treatment plant (STP) will handle sanitary wastes from the surface facilities and the underground mine. The sanitary sewage from the surface facilities will be transported to the STP via buried piping. Containerized waste from underground will be transported to the surface for discharge into the STP. The STP will include an activated sludge sequencing batch reactor process. The STP design will be tailored to the hydraulic, BOD_5, and total suspended solids

loadings expected for the Crandon Project. The STP effluent will be disinfected before being routed to the pump box in the mill for pumping to the TMA along with the mill tailings. A sludge holding tank will be included for collection of waste activated sludge solids from the sequencing batch reactor process. These solids will be occasionally hauled off-site for disposal. Figure 6-3 shows a process flow diagram for the sewage treatment plant.

6.3 Pre-Production Ore Storage Area Runoff Collection

As described previously in Section 3.2.5, runoff will be generated from storage of ore and waste rock in the pre-production ore storage area during construction and initial operation of the mill. During initial construction, runoff from the pre-production ore storage area will be directed to the temporary construction runoff basin located west of wastewater storage basin 5 as shown on Figure 3-1. During the later stages of construction, in conjunction with the placement of ore and waste rock on the lined pad, this runoff will be directed to wastewater storage basin 5 located south of the pre-production ore storage area as shown on Figure 3-2. Wastewater storage basin 5 will continue to be used during the initial operations of the mill. Once ore and waste rock stored on the pre-production ore storage area are removed, use of basin 5 will likely be discontinued and the storage area and basin reclaimed. The design and use of the temporary construction runoff basin is discussed in Section 6.10 below.

Wastewater storage basin 5 will provide storage of runoff from the pre-production ore storage area as well as settling of suspended solids in the runoff. The basin will have the capacity per NR 182, Wis. Admin. Code, to hold the runoff from a 100-year, 24-hour rainfall event plus 3 feet of solids storage and 3 feet of freeboard. A plan view and a section of the basin are shown on Figure 6-4.

The elevation of the top of the berm will be at the same elevation as the berms around the pre-production ore storage area, so events which could result in runoff rates in excess of a 100-year, 24-hour rainfall will result in the excess runoff being retained within the pre-production ore storage area.

A pump station with two pumps, one a standby unit, will be provided to transfer runoff collected in the basin to wastewater storage basins 6 or 7. Each pump will have the capacity to remove the volume of runoff from a 100-year, 24-hour rainfall event within four days, and the capacity to remove a 1-year, 24-hour rainfall event in one day.

The basin will accumulate solids from settling of suspended solids contained in the runoff entering the basin. The solids which accumulate in the basin will be removed as often as necessary and placed in the TMA, or in the mill circuit. Both the pre-production ore storage area and the basin will be provided with a composite liner similar to that described in Section 6.1.2 to minimize seepage to groundwater.

After the mill begins operation the ore stored in the pre-production ore storage area will be processed in the mill, and stored waste rock will be sent to the TMA. At this time wastewater storage basin 5 will be taken out of service and the area reclaimed.

6.4 Contact Runoff Collection System

After initial construction and during operation of the mine and mill, runoff will be generated from the central area of the plant site which has the potential to come in contact with process equipment, materials or chemicals in this area of the site. The management of runoff during the initial construction period is addressed in Section 6.10 below. The central area is identified on Figure 3-7. As discussed previously in Section 3.2.5, contact runoff will consist of the following:

- Runoff from an area where fuels and oil are stored and handled. The runoff from this area may occasionally contain oil and grease.

- Runoff from the remainder of this central area. The runoff from these areas is not likely to contain significant concentrations of oil and grease.

The runoff from the area where gasoline and diesel fuel are stored and handled will be segregated and routed to a gravity oil-water separator for removal of free-floating oil and grease. The oil-water separator will be designed to handle the flow rate from a 25-year, 24-hour rainfall event of runoff from this area. Oil and grease collected in the oil-water separator will be removed for off-site disposal or reprocessing. The oil-water separator will be located near the fuel tanks and bulk fuel storage area at the south end of the plant site. The effluent from the oil-water separator will be collected with the runoff from the remainder of the central area.

6.5 Wastewater Storage Basins 6 and 7

Wastewater storage basins 6 and 7 will receive the following wastewaters:

- water generated during grout drift construction and initial grouting;

- mine drainage;

- runoff from the pre-production ore storage area which is transferred from wastewater storage basin 5;

- contact runoff from the central area of the plant site;

- excess water from the mill process water system;

- wastewaters collected by floor drains in the wastewater treatment facilities building; and
- water from the wastewater treatment system which does not meet water quality standards will be reprocessed and retested before being pumped to the soil absorption system.

These two basins are designed to accomplish the following purposes:

- provide for collection and storage of contact runoff both during construction and operation;

- provide equalization of wastewater flows, including wastewater treatment system effluent which needs reprocessing. This will assist in proper operation of the wastewater treatment system by allowing a steady flow to the wastewater treatment system even when flow rates into the basins are fluctuating;

- provide storage of wastewaters for short periods when the wastewater treatment system is out of service;

- provide blending of wastewaters of differing quality. This will assist in operation of the wastewater treatment system by reducing fluctuations in the quality of the combined wastewater influent to the system; and

- provide for handling of the following when the tailings pipeline is not in service:
  - wastewater treatment system clarifier solids; and
  - filter backwash from the wastewater treatment system filters.

In addition, during the pre-production development of the mine, the wastewater generated from mine shaft dewatering and grouting operations will be collected and stored in wastewater storage basins 6 and 7 and the reclaim pond until the wastewater treatment system, the discharge lagoons, the soil absorption system and associated conveyance pipeline, and ancillary facilities are completed and ready for operation.

Basins 6 and 7 are designed for operation in parallel, i.e., wastewaters can be directed to either or both basins, and one basin can be taken out of service for inspection or maintenance without interfering with the operation of the other basin.

Each basin will provide capacity for storage of a minimum of four days of wastewater based on the maximum flow to the wastewater treatment system. Each basin will also have the capacity for 3 feet of solids storage plus 3 feet of freeboard. The location of the two wastewater storage basins is shown on Figures 3-1 and 3-2. A plan view and a section view of the basins are shown on Figure 6-4.

Each basin will be provided with a composite liner system similar to that described in Section 6.1.2 to minimize seepage to groundwater. The basins will accumulate solids from the settling of suspended solids contained in the runoff and other wastewaters entering the basin. The solids that accumulate in the basins will be removed as often as necessary and placed in the TMA, or in the mill circuit.

6.6 Wastewater Treatment System

A wastewater treatment system will be provided for treatment of the wastewaters collected in wastewater storage basins 6 and 7. The wastewater treatment system will be designed to produce treated effluents which will meet the effluent limitations for discharge to groundwater by way of a soil absorption system and effluent limitations for discharge to soft water mitigation sites. The wastewater treatment facilities will include a base treatment system and an advanced treatment system. The base treatment system will serve to substantially reduce the mass of contaminants present in the raw wastewater. The advanced treatment system will serve as a polishing step to further reduce the concentrations of contaminants in the base treatment system effluent to levels low enough to consistently meet effluent limitations. The advanced treatment system will also serve to remove those contaminants not removed by the base treatment system.

The base wastewater treatment system will include equipment, piping, instrumentation and controls for the following treatment processes:

- addition of lime for neutralization of low pH wastewaters and precipitation of dissolved metals as metal hydroxides;
- removal of metal precipitates and other suspended solids by settling, assisted by the addition of a polymer to aid in settling;
- first stage wastewater pH adjustment with acid as needed to enhance metal sulfide precipitation;
- addition of sodium sulfide for precipitation of dissolved metals remaining in the wastewater as metal sulfides; and
- removal of metal sulfide precipitates and other suspended solids in the wastewater by filtration, assisted by the addition of a polymer to aid in filtration.

The advanced wastewater treatment system will include equipment, piping, instrumentation and controls for the following treatment processes:

- reverse osmosis system to consistently reduce the concentrations of metals and other contaminants in the lime/sulfide treatment system effluent to levels meeting limitations for groundwater discharge;
- evaporator system for concentration and volume reduction of reject brine from reverse osmosis treatment system;
- air stripper system for removal of ammonia present in condensate from the evaporator system, as required, to meet effluent limitations for groundwater discharge;

- pH adjustment systems using acid and/or caustic, as required, to optimize performance of the reverse osmosis, evaporator, and air stripper systems; and

- final wastewater pH adjustment with acid and/or caustic, as required, to achieve the pH effluent limitations for groundwater or soft water mitigation discharges.

Reverse osmosis permeate and evaporator condensate will be pumped to the discharge lagoons and subsequently pumped to the soil absorption system for final discharge. When soft water body mitigation is required, evaporator condensate will be pumped to the mitigation water storage tanks and subsequently pumped to the mitigation sites.

The wastewater treatment system design presented below is based on the following:

- results of a wastewater treatability study for base treatment system;

- results of wastewater treatability studies for the advanced treatment systems;

- anticipated effluent limitations for discharge to groundwater and to soft water mitigation water bodies;

- anticipated wastewater flow rates and untreated wastewater concentrations; and

- typical design criteria for the major equipment in the wastewater treatment system.

6.6.1 Lime/Sulfide Wastewater Treatability Study Results

Wastewater treatability testing, with respect to the lime/sulfide treatment system, was conducted on mine drainage water from the Crandon Project and on mill process water from an operating zinc/copper mine in Canada. The purposes of the wastewater treatability testing were to determine the level of treatment which can be attained with the selected treatment processes; to determine design pH setpoints and design chemical dosages for lime, sodium sulfide and sulfuric acid; and to evaluate the whole effluent toxicity of the treated wastewaters. The test methods and test results of the treatability testing are described in Appendix A of this report. The test results indicate that, with respect to some effluent constituents, advanced treatment will be required to consistently meet effluent limitations based on groundwater standards.

6.6.2 Reverse Osmosis Treatability Study Results

The primary technology for the treatment of mine water is the lime and sulfide chemical/physical treatment process which will reduce metals in the water to levels suitable for discharge to specific surface water bodies. However, not all the cations and anions will be reduced to levels suitable for discharge to groundwater or for use at all potential mitigation sites by the

lime/sulfide process. Therefore, advanced treatment will be provided for the cations and anions of concern such that the treated water will meet the standards set by the WDNR.

A detailed work plan outlining the proposed study was submitted to the WDNR (Foth & Van Dyke, 1998d). A report describing the results of the test work is contained in Appendix B.

Using the estimated effluent concentrations from the lime/sulfide treatment process and the results from the RO treatability study, RO permeate effluent concentrations for a full scale RO system were derived as follows. The first step in the derivation was to calculate a passage rate for each constituent for both the first and second passes in the treatability study. For constituents where data was not available from the treatability study, engineering judgement was used to estimate the passage rates. Passage rates were then increased by 100 percent to account for decreasing performance of the RO membranes as they age. The derived passage rates were then applied to the estimated constituent concentrations for the lime/sulfide effluent to develop the estimate of the full scale RO permeate constituent concentrations.

The results of the reverse osmosis evaluation indicate that the RO system will produce an effluent which meets water quality standards for a groundwater discharge. However, some of the constituent concentrations in the RO effluent may exceed projected effluent limitations for some of the soft water mitigation sites. Evaporation technology may therefore be required to meet effluent limits for some potential soft water mitigation sites. An evaporator treatability study was conducted and is discussed in Section 6.6.3. Projected reverse osmosis effluent quality is discussed in Section 6.6.4 along with projected groundwater discharge limits.

6.6.3 Evaporator Wastewater Treatability Study Results

The reject water from the reverse osmosis system will be pumped to an evaporator for further treatment. The evaporator will produce a high quality condensate stream and a concentrated brine stream. The brine stream will be incorporated into the cemented pyritic paste backfill for ultimate disposal. The primary purpose of the evaporator is to concentrate the solutes present in the reverse osmosis reject stream into a small volume which will be mixed with the pyritic paste backfill for placement underground in mined-out stopes. The second purpose of the evaporator is to provide a high quality water which can be used, as required, for mitigation of soft water bodies impacted by groundwater drawdown associated with mine dewatering activities.

Evaporators typically produce a high quality condensate with low dissolved solids content. However, evaporator condensate will contain small amounts of constituents which are carried through the evaporator's demisting section. Volatile constituents in the feed stream may also be present in the condensate. A study was completed to estimate the amount of constituents which will be present in the condensate and to determine if the condensate quality will meet projected effluent limits for mitigation of soft water bodies.

A detailed work plan for the proposed evaporation study was submitted to the WDNR (Foth & Van Dyke, 1998e). A report describing the results of the test work is contained in Appendix C.

Since the brine will be concentrated to a comparable degree in the full scale evaporation system as used in the treatability study, the evaporation treatability study produced data that can be directly used to estimate the constituent concentrations in condensate produced by a full scale evaporation system. The full scale evaporation system will be designed such that the total dissolved solids in the condensate will be less than the total dissolved solids in the treatability study concentrate. Therefore, treatability study data conservatively predicts full scale evaporation system performance.

Based on the results of the evaporation study, and engineering evaluation of evaporation technology, the evaporator condensate, with the exception of ammonia, will meet effluent limits for potential soft water mitigation bodies. As discussed above, an air stripper is included in the system design to remove ammonia. Projected mitigation limits and projected evaporator condensate quality are discussed further in Section 6.6.4.

6.6.4 Projected Effluent Quality and Effluent Limitations

Treated Crandon Project wastewater will be sampled and, if it meets water quality standards, it will be discharged to groundwater by way of a soil absorption system and/or used for mitigation of soft water bodies impacted by regional groundwater drawdown associated with mining activities. When mitigation is not required, the treated wastewater from the WWTS reverse osmosis and evaporator systems will be discharged to the discharge lagoons and subsequently pumped to the soil absorption system for final discharge. When mitigation is required, condensate flow from the evaporator system will be pumped to the mitigation water storage tanks and subsequently pumped to the soft water bodies requiring mitigation. Reverse osmosis effluent, along with any evaporator condensate not needed for mitigation purposes, will be pumped to the discharge lagoons and ultimately discharged to the soil absorption system.

Effluent quality for the lime/sulfide, reverse osmosis, and evaporator treatment systems have been estimated based on results of the respective treatability studies for each system and on engineering judgement.

Table 6-1 presents a comparison of projected effluent quality for the WWTS reverse osmosis system and projected effluent limitations for groundwater discharge. WWTS effluent quality is shown for the cases where mine drainage is being treated in the WWTS and where mill process water is being treated in the WWTS. Values shown for WWTS effluent quality are based on projected reverse osmosis permeate quality. Table 6-1 indicates that the reverse osmosis permeate quality will meet groundwater discharge limitations when mine water is treated. Note that during times when surface water mitigation is not required, the WWTS effluent will be a composite of reverse osmosis permeate and evaporator condensate. Based on the treatability testing, the quality of the evaporator condensate/reverse osmosis permeate composite effluent will meet groundwater discharge limitations under either case. The data in the table also shows that it may be necessary to process the RO effluent by evaporation at the end of the project when mill process water is treated if antimony in the RO effluent would exceed the PAL.

Table 6-1

Comparison of Estimated Treated Effluent Quality to Estimated Effluent Limitations

		Estimated Treated Effluent Quality[1]		Estimated Effluent Limitations	
Parameter	Units	Mine Water	Mill Process Water	PAL[2]	ES[3]
Antimony	mg/L	0.00077	0.0016[9]	0.0012	0.006
Arsenic	mg/L	0.000064	0.000040	0.005	0.05
Barium	mg/L	<0.0054	<0.00054	0.4	2
Beryllium	mg/L	<0.00006	0.000062	0.0004	0.004
Boron	mg/L	<0.0028	<0.0028	2[4]	—
Cadmium	mg/L	<0.000007	<0.000007	0.0005	0.005
Calcium	mg/L	3.6	3.6	5[4]	—
Chloride	mg/L	<0.14	<0.14	125	250
Chromium	mg/L	0.00015	<0.000047	0.01	0.1
Copper	mg/L	0.0016	0.0011	0.13	1.3
Cyanide	mg/L	<0.0034	<0.0034	0.04	0.2
Fluoride	mg/L	<0.014	<0.014	0.8	4
Iron	mg/L	<0.039	<0.039	0.15	0.3
Lead	mg/L	<0.000025	<0.000025	0.0015	0.015
Magnesium	mg/L	0.35	0.19	37[5]	—
Manganese	mg/L	<0.00043	<0.00043	0.025	0.05
Mercury	mg/L	<0.00000006	<0.00000006	0.0002	0.002
Nickel	mg/L	0.00017	0.00014	0.02	0.1
Nitrate + Nitrite	mg/L	0.21	<0.026	2	10
Nitrogen (Ammonia)	mg/L	0.29	<0.061	2[5]	—
Nitrogen (Organic)	mg/L	NA	NA	2[4]	—
Potassium	mg/L	0.16	0.49	5[4]	—
Selenium	mg/L	0.00067	<0.00033	0.01	0.05

Table 6-1 *(Continued)*

Parameter	Units	Estimated Treated Effluent Quality[1]		Estimated Effluent Limitations	
		Mine Water	Mill Process Water	PAL[2]	ES[3]
Silver	mg/L	0.00042	<0.00032	0.01	0.05
Sodium	mg/L	0.45	0.55	10[4]	—
Sulfate	mg/L	14	11	125	250
Thallium	mg/L	0.00020	0.000059	0.0004	0.002
Zinc	mg/L	<0.0039	<0.0039	2.5	5
Alkalinity	mg/L	6.4	6.4	230[5]	—
BOD 5	mg/L	<10[6]	<10[6]	25[4]	—
Color	color units	NA[7]	NA[7]	7.5	—
Conductivity	μmhos/cm	NA[7]	NA[7]	NA[7]	15
COD	mg/L	<10[6]	<10[6]	54[5]	—
Foaming Agents	mg/L	NA[7]	NA[7]	0.25	0.50
Odor	mg/L	NA[7]	NA[7]	1.5	3
Total Dissolved Solids	mg/L	16	16	370[5]	—
Total Hardness	mg/L	10	9.8	225[5]	—
pH (field)	S.U.	—[8]	—[8]	6.7-8.7	—

[1] Estimated treated effluent quality is based on treatment through the reverse osmosis process under BEJ flow conditions.
[2] NR 140 Preventative Action Limit.
[3] NR 140 Enforcement Standard.
[4] Background water quality data are not currently available for this parameter. Stated value indicates allowable increase in groundwater quality above background levels.
[5] Based on Paul Luebke, WDNR, memorandum of April 2, 1998 (WDNR, 1998a).
[6] Based on engineering judgement.
[7] Data not available.
[8] pH will be controlled in the treatment process.
[9] The mill process water will be treated by evaporation if the treated effluent quality for antimony exceeds the PAL.

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Table 6-2 presents a comparison of projected effluent quality for the WWTS evaporator and projected effluent limitations for soft water body mitigation sites. WWTS effluent quality is shown for the case where mine drainage is being treated in the WWTS. Values shown for WWTS effluent quality are based on projected evaporator condensate quality. The ammonia levels in the projected evaporator condensate reflect ammonia reduction through air stripping following the evaporation process. Table 6-2 shows that evaporator condensate quality will meet discharge limitations for the mitigation sites.

6.6.5 Treatment System Design Basis

An evaluation was conducted to determine the effect of variations in the rate of groundwater inflow to the mine, annual precipitation and evaporation, and reuse of various wastewaters as make-up to the mill process water system on the volumes of wastewater to be generated by the project. Water balances were then developed for the project to determine raw wastewater flows to the wastewater treatment system under average, maximum, and minimum conditions. These three water balances were described in Section 3 and shown on Figures 3-3, 3-4, and 3-5. Based on the evaluation and the resulting three water balances, flow rates to the wastewater treatment system could range from a low of 79 gpm to a high of 726 gpm.

The maximum estimated flow rate to the wastewater treatment system of 726 gpm would occur only if the following conditions were to happen simultaneously:

- the groundwater inflow to the mine were to be at the high range (HR); and
- the maximum precipitation and minimum evaporation rates shown on Figure 3-4 were encountered.

In the unlikely event the combined conditions listed above are exceeded, NMC will implement measures to reduce the flow rate to the wastewater treatment system. These measures will include the following:

- cease transferring excess mill process water from the mill process water system to wastewater storage basins 6 and 7, and temporarily store excess mill process water in the TMA;
- temporarily store wastewaters in the TMA by transferring wastewaters collected in wastewater storage basins 6 and 7 to the TMA. The rate of transfer could be controlled to reduce the wastewater flow rate to below the wastewater treatment system design capacity; and
- grout additional portions of the mine walls to reduce groundwater inflow to a flow rate which can be handled by the WWTS.

Table 6-2

Estimated Water Quality Based Effluent Limitations for Mitigation Waters

Parameter[1]	Units	Estimated Treated Water Quality[2]	Estimated Little Sand Lake Limits[3]	Estimated Duck Lake Limits[4]	Estimated Skunk Lake Limits[4]
Arsenic	mg/L	0.000083	0.0050	0.017	0.017
Cadmium	mg/L	<0.000007	0.000071	0.00010	0.00010
Copper	mg/L	0.00017	0.00098	0.00041	0.00041
Cyanide	mg/L	<0.0034	NA	0.0038	0.0038
Lead	mg/L	<0.000025	0.00045	0.00070	0.00070
Mercury	mg/L	0.000000071	0.0000023	0.0000040	0.0000033
Nickel	mg/L	0.00014	0.030	0.0028	0.0028
Zinc	mg/L	<0.0039	0.022	0.0049	0.0049
Nitrogen (Ammonia)	mg/L	0.05[5]	NA	NA	NA
BOD 5	mg/L	<5[6]	7	5	15

[1] The parameters listed are from the May 20, 1998, Jim Schmidt, WDNR, draft memorandum for Duck Lake and Skunk Lake (WDNR, 1998b).

[2] The estimated treated effluent quality is based on average water balance flows and engineering judgement. Effluent quality based on evaporator system condensate.

[3] The Little Sand Lake limits are set to the maximum background concentrations for the 1994-1995 time period as reported in EIR Table 3.7-36 (Foth & Van Dyke, 1995/1998a).

[4] The Duck Lake and Skunk Lake limits are from the May 20, 1998, Jim Schmidt, WDNR, draft memorandum for Duck Lake and Skunk Lake (WDNR, 1998b). The most stringent of the daily, weekly, or monthly limits are listed in this table.

[5] The ammonia concentration is after the air stripping unit operation.

[6] Based on engineering judgement.

NA = Not available

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To accommodate the range of flow rates, to the WWTS of from 79 to 726 gpm, the WWTS design will consist of two parallel treatment trains, with each train designed to treat up to 50 percent of the maximum estimated flow of wastewater. When both treatment trains are in operation the wastewater treatment system will be able to treat up to 100 percent of the maximum estimated flow of wastewater.

The proposed design WWTS capacity of approximately 730 gpm will provide 170 percent of the capacity required under the average condition of the approximately 440 gpm to the WWTS (see Figure 3-3). The WWTS capacity for one train of approximately 370 gpm will provide 460 percent of the capacity required under the minimum condition of approximately 80 gpm to the WWTS (see Figure 3-5). Under minimum conditions the plant will operate intermittently with wastewater stored in wastewater storage basins 6 and 7.

A process flow diagram of the wastewater treatment system is shown on Figures 3-8 and 3.9. Setpoint pHs and chemical dosages for design and initial operation of the wastewater treatment system are summarized in Table 6-3. Design criteria for the major wastewater treatment system equipment are summarized in Table 6-4. Following is a description of the design and operation of the wastewater treatment system. Although the treatment system will consist of two parallel treatment trains, for ease of understanding only one train will be described, except where equipment will be used in common by both trains.

6.6.6 Wastewater Wet Well and Wastewater Treatment System Feed Pumps

As described previously in Section 6.5, wastewaters to be treated by the wastewater treatment system will be collected in wastewater storage basins 6 and 7. The wastewaters from both basins will flow into a common wet well and will be subsequently pumped to the wastewater treatment system. Wastewater treatment system feed pumps will pump the wastewaters to the lime precipitation tanks. Three pumps will be provided with each pump having a capacity of approximately 50 percent of the WWTS design capacity; one pump will provide back-up service. The wastewater pumping system will have variable flow capacity to allow for flexibility in WWTS operation. Facilities will be provided to continuously measure and record the flow rate and pH of the wastewater entering the lime precipitation tank for process control.

6.6.7 Lime Precipitation Tanks

Lime slurry will be added to the wastewater in the lime precipitation tank for neutralization of wastewaters and precipitation of metals as metal hydroxides. The chemistry of lime treatment was discussed previously in Section 5. The lime precipitation tank will provide mixing of the lime slurry with the raw wastewaters and allow time for pH adjustment and formation of the metal hydroxide precipitates. The tank will have a mixer for mixing of the lime slurry with the raw wastewater. A pH meter and automated pH control system will also be provided to control the feed rate of lime slurry into the tank based on the pH setpoint for the wastewater in the tank. The pH setpoint will be adjustable by the operator.

Table 6-3

Design Setpoint pHs and Chemical Dosages for the Wastewater Treatment System[1]

Treatment Process	Location for Chemical Addition	Wastewater Setpoint pH[2]	Chemical Dosage[2]			
			Chemical	Form	Dosage (mg/L)	
• Neutralization/Metal hydroxide precipitation	Lime precipitation tanks	10.0[3]	Lime	100% $Ca(OH)_2$	820 1000 490	(average) (maximum) (minimum)
• Settling	Solids-contact clarifiers	—	Polymer	100% Polymer	1.0 2.0 0.5	(average) (maximum) (minimum)
• pH adjustment	Prior to sulfide reaction tanks	10.0[4]	Sulfuric acid	93% H_2SO_4	as needed	
• Metal sulfide precipitation	Sulfide reaction tanks	—	Sodium sulfide	60% Na_2S	8.1 40.6 2.0	(average) (maximum) (minimum)
• Filtration	Prior to gravity filters	—	Polymer	100% Polymer	1.0 2.0 0.5	(average) (maximum) (minimum)
• pH adjustment	Prior to 1st Pass Reverse Osmosis	6.0[5]	Sulfuric Acid	Dilute H_2SO_4	as needed	
• Reverse Osmosis	Prior to 1st Pass Reverse Osmosis	—	Antiscalent	100% Antiscalent	5 10 1	(average) (maximum) (minimum)

Table 6-3 *(Continued)*

Treatment Process	Location for Chemical Addition	Wastewater Setpoint pH[2]	Chemical Dosage[2]		
			Chemical	Form	Dosage (mg/L)
• pH adjustment	Prior to 2nd Pass Reverse Osmosis	6.0[6]	Sodium Hydroxide	50% NaOH	as needed
• pH adjustment	Prior to Evaporation	6.5[7]	Sulfuric Acid	93% H_2SO_4	as needed
• pH adjustment	Evaporator condensate prior to air stripping	10.5[8]	Sodium Hydroxide	50% NaOH	as needed
• pH adjustment	Prior to effluent wet well	8.0[9]	Sulfuric acid or Sodium Hydroxide	Dilute H_2SO_4, 50% NaOH	as needed

[1] Based on the results of the treatability testing and experience with other wastewater treatment systems.
[2] For design and initial operation of the wastewater treatment system.
[3] May be adjusted over the range of 9.0 to 10.5 based on results during initial start-up of the WWTS.
[4] May be adjusted over the range of 8.0 to 10.0 based on results during initial start-up of the WWTS.
[5] Adjustment of pH as required to inhibit membrane scaling. May be adjusted over range of 5.5 to 6.5 based on operating conditions.
[6] May be adjusted over range of 5.5 to 8.5 based on operating conditions. Adjustment of pH between RO stages will normally only be used if enhanced cyanide removal is required in second stage RO system.
[7] May vary based on results during start-up of the WWTS. Adjustment of pH as required to minimize concentration of carbonate in evaporator feed.
[8] May be adjusted over range of 10.0 to 11.0 as required for optimization of ammonia stripping process.
[9] May be adjusted over the range of 6.5 to 8.5.

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Table 6-4

Design Criteria for Major Wastewater Treatment System Equipment

Equipment	Design Criteria[1]		
Lime Precipitation Tanks	Detention Time	=	15 minutes
Solids - Contact Clarifiers	Hydraulic Loading Rate	=	0.3 gallons/minute-square foot
Sulfide Reaction Tank 1	Detention Time	=	5 minutes
Sulfide Reaction Tank 2	Detention Time	=	5 minutes
Filters	Hydraulic Loading Rate	=	3.0 gallons/minute-square foot
Clearwells	Total water storage capacity of all clearwells sufficient to backwash one filter, based on the following:		
	- backwash flow rate during water backwash	=	15 gallons/minute-square foot
	- duration of water backwash	=	10 minutes
Reverse Osmosis	Flow Rate	=	100% of filtered water at maximum design flow
Evaporators	Flow Rate	=	100% of reverse osmosis reject at maximum design flow
Air Strippers	Flow Rate	=	100% of evaporator condensate at maximum design flow

[1] Design criteria based on proposed WWTS raw wastewater inflow of 730 gpm.

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Checked by: HJA

6.6.8 Lime Feed System

The treatment system will include a temporary lime feed system which will be constructed at the same time the rest of the treatment system is constructed, and a permanent lime feed system which will be constructed later during construction of the mill. The temporary lime feed system will operate from the start of operation of the treatment system until the permanent lime feed system is in operation.

The permanent lime feed system will use quicklime, i.e., calcium oxide (CaO), as the form of lime used at the wastewater treatment system. The permanent lime feed system will include the following:

- bulk storage of quicklime;
- feeding and slaking of quicklime to form a lime slurry;
- storage of the lime slurry; and
- feeding lime slurry to the lime precipitation tanks.

Lime slurry will be used both in the wastewater treatment system and in the mill. Therefore, the equipment for storage, feeding and slaking of quicklime, storage of lime slurry, and pumping lime slurry in a "milk-of-lime" pipe loop to the points in the mill and wastewater treatment where lime slurry will be used will be in a common system shared by the mill and the wastewater treatment system.

Quicklime will be delivered in bulk and unloaded into a lime silo for storage. The lime silo is located as shown on Figure 3-2. A dry lime feeder will feed quicklime from the lime silo to a lime slaker where water will be mixed with the quicklime to form a lime slurry. The lime slurry will normally contain approximately 15 percent lime (as CaO) by weight. The lime slurry produced by the lime slaker will be stored in a lime feed tank. A mixer will be used to keep the lime slurry in suspension in this tank.

A recirculating system will be used for the lime slurry to maintain a sufficient velocity in the lime slurry feed piping and thus prevent lime solids from settling out and plugging this piping. The recirculating system will consist of two lime feed pumps, one a standby unit. The system will pump lime slurry from the lime feed tank back into the lime feed tank in a mill milk-of-lime pipe loop that will pass near the two lime precipitation tanks. At each lime precipitation tank, a control valve will be located on bleed-off piping from the pipe loop into the lime precipitation tank. Each control valve will automatically control the flow rate of lime slurry through the valve and bleed-off piping into its lime precipitation tank based on the pH of the wastewater in that lime precipitation tank.

The temporary lime feed system will include the following:

- bulk storage of hydrated lime, i.e., calcium hydroxide [$Ca(OH)_2$];
- mixing of hydrated lime and water to form a lime slurry;

- storage of lime slurry; and
- feeding of lime slurry to the lime precipitation tanks.

The temporary lime feed system will be similar to the permanent system, except that because hydrated lime will be used as the lime source, a hydrated lime mixing tank will be used instead of a lime slaker for preparing the lime slurry.

6.6.9 Solids-Contact Clarifiers and Solids Pumps

Wastewater will flow from the lime precipitation tank to a clarifier for removal of metal hydroxide precipitates formed in the lime precipitation tanks and suspended solids present in the raw wastewater. Solids-contact clarifiers are a proven technology for settling of metal hydroxide precipitates, and were selected over other types of clarifiers based on their demonstrated ability to provide excellent performance over a wide range of flow rates and influent concentrations. Polymer will be added to the clarifier as needed to promote flocculation and settling of the metal hydroxide precipitates and other suspended solids in the clarifiers. The polymer feed system will be designed to allow polymer to be added at the clarifier influent piping, the rapid mix zone of the clarifier, or the flocculation zone of the clarifier. Selection of the optimum location for polymer addition will be made based on the results of full-scale testing during system start-up. The polymer feed system is described later in Section 6.6.13.

Solids will accumulate in the clarifiers as a result of settling of the metal precipitates and other suspended solids. A pump will be provided to convey the solids from each clarifier to the tailings pump box in the mill. The solids will be mixed with the tailings slurry in the tailings pump box and then pumped with the tailings slurry to the tailings pond. During construction of the mill, tailings pipeline, and TMA, and whenever the tailings pipeline is out of service during operation of the mill, the pump will convey the solids to wastewater storage basins 6 and 7.

6.6.10 Sulfide Reaction Tanks

Clarified wastewater will flow from the solids contact clarifier through a static mixer. Sulfuric acid will be added, if required, prior to the static mixer and the wastewater will then flow to a series of two sulfide reaction tanks, where a sodium sulfide solution will be added to the wastewater if needed for sulfide precipitation of dissolved metals remaining in the wastewater following lime treatment. The tanks will be in series with the effluent of the first tank entering the second tank. The chemistry of sulfide treatment was discussed previously in Section 5 of this report. Each tank will have a mixer for mixing the sodium sulfide solution with the wastewater. Each tank will be covered and vented outside the WWTS building to protect workers against the potential release of hydrogen sulfide gas.

6.6.11 Sulfide Feed System

The sulfide feed system will include two sulfide solution tanks with mixers for making up and storing sodium sulfide solutions and three sulfide feed pumps for feeding sulfide solutions to the

sulfide reaction tanks. Sodium sulfide is commercially available as a dry solid with a strength of approximately 60 percent as Na_2S. The dry sodium sulfide will be delivered to the WWTS building. The sulfide feed system will be designed so that sodium sulfide solutions can be made up using dry sodium sulfide, and solutions can be fed from either sulfide solution tank. Normally, the wastewater treatment system operators will manually make up concentrated sodium sulfide solutions in one sulfide solution tank, while feeding a previously-prepared solution from the other tank. Each solution tank will have a mixer to promote rapid dissolution of the dry sodium sulfide. Each solution tank will have sufficient capacity to hold the volume of sulfide solution required for one day of treatment at the maximum wastewater flow rate. Treated effluent from the wastewater treatment system will be used for preparing the solutions. The sodium sulfide solution strength will normally be in the range of 1 to 10 percent. The sulfide solution tanks will be covered to minimize the potential release of hydrogen sulfide gas.

In addition to the solution tanks, the sulfide feed system will include two chemical feed pumps. Under normal operation, one pump will be used to feed sodium sulfide solution to each sulfide reaction tank, with the second pump as a standby unit. Each chemical feed pump will be automatically controlled to feed sodium sulfide solution proportional to the raw wastewater flow rate to its train.

Based on the results of the wastewater treatability study, a sulfide dosage of up to 50 mg/L of sodium sulfide as $Na_2S \cdot 9H_2O$ (which is equivalent to 27 mg/L as 60 percent Na_2S) provided effective treatment for metals removal. However, based on experience of facilities operating similar treatment systems, it is anticipated that the operating sulfide dosage will be significantly less than that used in the treatability testing. The actual sulfide dosage will be selected based on full-scale testing during operation.

6.6.12 Gravity Filters

Effluent from the sulfide reaction tanks will flow to gravity filters operating in parallel. Metal sulfide precipitates formed during sulfide treatment will be removed by the filter media as the wastewater flows through the filters. Polymer will be introduced into the wastewater between the sulfide reaction tanks and the gravity filters as needed to promote flocculation of the metal sulfide precipitates and other suspended solids and therefore increase the removal of these solids by the filter media. Details of polymer feed system number two are provided in Section 6.6.13.

Periodic backwashing of the filter media will be required to remove the metal sulfide precipitates and other suspended solids trapped in the media. An air scour and a reverse flow water system using filter effluent will be used for backwashing. Two positive displacement blowers will provide the air required for air scouring during backwash, with one of the blowers as a standby.

During normal operation of the filters, the effluent from the filters will flow into clearwells mounted above the filters. These clearwells are storage compartments which store clean water to be used for backwashing a filter. The clearwells for all the filters will be interconnected so that the clearwells act as a single clean water storage compartment. When the clearwells are filled,

the excess filter effluent will overflow the clearwells and will flow to the reverse osmosis system. When a filter starts to become clogged with solids trapped by the filter media, the water level will build up in the influent piping to that filter. The filter will then be taken out of service for backwashing by closing a valve on the influent to the filter.

The backwash sequence will be as follows. Before backwashing with water, an air blower will blow air into the bottom of the filter to loosen the media and dislodge solids caught on the media. Then the dirty backwash outlet valve on the filter will be opened, the air blower will be turned off, and clean backwash water stored in the clearwells will reverse flow, i.e., up through the filter media, to fluidize the media and wash the solids out of the filter through the dirty backwash outlet piping to the mill tailings pumpbox. After the filter has been backwashed, the dirty backwash outlet valve will be closed and the cleaned filter will be ready for operation. The filters and clearwells will be covered and vented outside the WWTS building to protect workers against the potential release of hydrogen sulfide gas.

6.6.13 Polymer Feed Systems

As described in Sections 6.6.9 and 6.6.12, the wastewater treatment system will include two polymer feed systems, one to assist flocculation and settling in the solids-contact clarifiers, and another to assist flocculation and filtration in the gravity filters. Due to differences in the characteristics of metal hydroxides and metal sulfides, there is the potential that different types of polymers will be used for each application. Consequently, two separate polymer systems will be provided.

The polymer feed system for the solids contact clarifiers will be automatically controlled to feed polymer to each train at a rate proportional to the raw wastewater flow rate to that train. The polymer feed system for the gravity filters will be automatically controlled to feed polymer at a rate proportional to the total wastewater flow rate to the filters.

6.6.14 Acid Feed Systems

As shown in Figures 3-8 and 3-9, sulfuric acid will be used as needed for pH adjustment of wastewater. An acid feed system will be provided for this purpose. This system will include two dilute sulfuric acid storage tanks, acid feed pumps, and pH control instrumentation.

Concentrated sulfuric acid will be delivered to the wastewater treatment system in bulk trucks and unloaded into a sulfuric acid bulk storage tank. This tank will be located outside the WWTS building in an area east of the clarifiers. Sulfuric acid from the bulk storage tank will be fed to dilute sulfuric acid storage tanks and mixed with dilution water. This will be used to supply dilute sulfuric acid used for pH adjustment.

Sulfuric acid will be fed to the following locations:

- The effluent pipeline from each solids contact clarifiers. The pH will be lowered, as required, to minimize metal sulfide solubility.

- The common line feeding the reverse osmosis system. The pH will be lowered, as required, to assist in the prevention of membrane scaling.

- The evaporator feed tanks. The pH will be lowered, as required, to maximize carbonate removal.

- The RO effluent pipeline prior to the effluent wet well. The pH will be lowered, as required, to meet discharge limits.

- The evaporator effluent pipeline. The pH will be lowered, as required, to meet discharge limits.

6.6.15 Caustic Feed System

Sodium hydroxide (caustic) will be used as needed for pH adjustment of wastewater. A caustic feed system will be provided for this purpose. This system will include a caustic storage tank, chemical feed pumps, and pH monitoring and control systems.

Concentrated sodium hydroxide will be delivered to the wastewater treatment system in totes. Since sodium hydroxide will be used for pH adjustment of high purity effluent, it is anticipated that usage rates will be relatively low and tote storage will be sufficient. The totes will be located inside the WWTS building and will be used to supply the concentrated caustic to the chemical feed pumps.

Sodium hydroxide will be fed to the following locations:

- The permeate from the first pass RO system. The pH will be increased, as required, to increase the second pass RO system removal efficiency for certain constituents such as cyanide.

- The condensate stream from the evaporator prior to the air stripper. A high pH is required in the air stripper to optimize ammonia removal.

- The evaporator effluent prior to discharge to the evaporator effluent wet well. As described in Section 6.6.14, an acid feed system will also be installed at this point. Both systems will be available to control the effluent pH.

- The reverse osmosis effluent prior to discharge to the main WWTS effluent wet well. As described in Section 6.6.14, an acid feed system will also be installed at this point. Both systems will be available to control effluent pH.

The caustic chemical feed pumps will be automatically controlled to feed caustic at the rate needed to maintain each pH set point.

6.6.16 Reverse Osmosis Treatment System

Wastewater will flow from the clearwell of the gravity filters to the reverse osmosis system. The reverse osmosis equipment will consist of antiscalent chemical feed equipment, acid feed equipment, prefilters, high pressure feed pumps, reverse osmosis membranes and associated piping, instrumentation, and controls.

The filter effluent water will be conditioned with an antiscalent chemical to assist in preventing the precipitation of salts on the reverse osmosis membrane. Precipitation of salts on the membrane will increase pressure drop across the membrane and may require premature replacement of membranes. An antiscalent feed system will be provided for this purpose. The system will include an antiscalent storage drum, chemical metering pump, and control system. The antiscalent will be pumped from the storage drum to the reverse osmosis feed line using the chemical metering pumps.

The filter effluent water will also be pH adjusted to assist in preventing the precipitation of salts on the reverse osmosis membrane. Dilute sulfuric acid will be used as the pH adjustment chemical.

Prefilters (5 micron) will be placed ahead of the RO membranes to remove any solids present in the filter effluent which may damage the membranes or clog the membrane passages. High-pressure pumps will provide the necessary driving force for operation of the reverse osmosis membranes. The feed water will be pressurized by the high-pressure pumps and enter the first pass reverse osmosis units. The membranes selectively allow certain molecules such as water to pass through the membrane and be collected in a permeate. The feed portion which does not pass through the membrane is the reject water. The reverse osmosis membranes will be configured to operate in series with the permeate from the first in the series (first pass) being the feed for the second in series (second pass).

The reject water from the first pass will be pumped to the evaporators. The pH of the second pass feed may be increased to assist in the removal of cyanide. Sodium hydroxide (caustic) will be used to increase the pH, if necessary. The first pass permeate will be pressurized by high-pressure pumps and enter the second pass reverse osmosis units. The wastewater will be further purified in the second pass membranes. The concentrate from the second pass will be mixed into the feed stream of the first pass unit. The permeate from the second pass will be pH adjusted and then flow to the effluent wet well.

6.6.17 Evaporation Treatment System

The reject water from the reverse osmosis operation will be pumped to an evaporator for further treatment. Prior to entering the evaporator, the pH of the water may be lowered by adding

sulfuric acid. Lowering the pH of the water assists in controlling the fouling of the evaporator heat exchange surfaces. The reverse osmosis reject water is then pumped through a heat exchanger which recovers the heat from the evaporator condensate water. The heated reject water then flows through a deaerator vessel which removes dissolved air from the feed water. The dissolved air is then vented to atmosphere and the feed water flows into the evaporator.

The evaporator concentrates the constituents in the feed water by using the heat generated from a condensing vapor. The evaporator will use heat recovery processes associated with a vapor recompression process and heat exchangers. The recompression process will be driven by electrical compressors. The concentrated brine will collect in the evaporator sump and will be maintained at the proper concentration by bleeding a waste stream from the sump.

The condensate from the evaporator will contain small amounts of constituents which are carried through the evaporator's demisting section. Volatile constituents in the feed stream may also be present in the condensate. The remainder of the constituents from the reverse osmosis reject water will leave the evaporator with the waste brine. The brine will be mixed with pyrite concentrate and cement as a minor part of the pyritic paste backfill for the mine.

6.6.18 Final Stage pH Adjustment

The reverse osmosis permeate and evaporator condensate will be pH adjusted, if required, by injection of either sodium hydroxide or dilute sulfuric acid. Following this addition, an in line static mixer will provide mixing of the base or acid with the treated wastewater. A pH meter and automated pH control system will be provided to control the feed rate of the base or acid based on the pH setpoint for the treated wastewater. The pH setpoint will be adjustable by the operator to maintain compliance with the WPDES discharge permit. Details of the feed systems are discussed in Section 6.6.14 and 6.6.15.

6.6.19 Air Stripper (Ammonia Removal)

Ammonia will be rejected by the reverse osmosis system and concentrated in the RO reject water. This water will be sent to the evaporator for treatment. Due to its relatively high vapor pressure, the ammonia in the evaporator feed water may be volatilized and carry over into the evaporator condensate. In order to meet effluent limits for discharge to groundwater and/or mitigation sites, ammonia must be removed from the evaporator condensate. An air stripper system will be provided for this purpose. The air stripper will include a stripping tower and aeration blowers. Two units will be provided with each unit capable of handling the peak evaporator flow. The air strippers will be designed based on the maximum anticipated ammonia feed concentration and on the maximum design evaporator condensate flow rate. The units will be designed with sufficient turn down to accommodate the design flow range of the evaporator system. Each unit will be provided with a dedicated aeration blower. The pH of the evaporator condensate will be raised prior to the air stripper to optimize ammonia stripping.

6.6.20 Effluent Wet Wells and Effluent Pumps

Effluent from the reverse osmosis system will flow to the RO effluent wet well. Effluent from the evaporator system will flow to the mitigation storage tanks. A small portion of the wastewater in the RO effluent wet well will be reused within the wastewater treatment system for make-up of sulfide solutions, dilution of sulfuric acid, and for other non-potable water needs within the wastewater treatment system.

When surface water mitigation is not required, evaporator condensate will report to the RO wet well and will be pumped to the discharge lagoons. When surface water mitigation is required, evaporator condensate will be pumped to the mitigation storage tanks while RO effluent will be pumped from the RO effluent wet well to the discharge lagoons.

Wastewater treatment system effluent can be pumped from the RO effluent wet well to the mill for reuse in the following applications:

- To the mill for reuse as reagent make-up water.
- To the mill for reuse as seal/gland water for pumps and other equipment.

Pumps will be provided to transfer the reverse osmosis system effluent from the RO effluent wet well to the discharge lagoons or to the mill for reuse. The pumps will be sized based on maximum WWTS flow conditions.

Pumps will be provided to transfer the evaporation system effluent from the mitigation storage tanks to the surface water mitigation sites or to the wastewater treatment storage basins. The pumps will be sized based on maximum WWTS evaporator flow conditions.

6.6.21 Wastewater Treatment System Instrumentation and Controls

The wastewater treatment system will include computerized automated control of the wastewater treatment system components. Displays associated with the computerized automated controls will provide the wastewater treatment system operators with information concerning key wastewater treatment system operating data such as wastewater flow rates and pHs; the levels of the wastewater storage basins, discharge lagoons, and chemical feed tanks; and the operating status of the major wastewater treatment system equipment and alarms. The operator will also be able to control the major wastewater treatment system operating functions, such as starting and stopping equipment, adjusting setpoint pHs and dosage rates for treatment chemicals, and selecting automatic or manual control of key treatment equipment and processes.

6.6.22 Wastewater Treatment System Building

The wastewater treatment system will be housed in a WWTS building located as shown on Figure 3-2. The WWTS building will also include the following:

- A control room where the computerized automated controls and displays will be located.

- An electrical room for the electrical equipment needed for the WWTS.

- A floor drain system with a sump for collecting wastewater generated from leaks and spills in the WWTS building. Two sump pumps, one a standby, will be used to pump the wastewaters collected in the sump to wastewater storage basins 6 and 7 or directly to the lime precipitation tank.

- A non-potable water supply system for various non-potable water uses in the WWTS building, including the following:
  - water for making up sodium sulfide solutions;
  - dilution water for the sulfuric acid feed systems; and
  - water for cleaning, flushing, and other maintenance activities in the WWTS building.

- Building heating, ventilating, fire protection, and lighting systems.

- A system for supplying instrument-quality air where needed in the wastewater treatment system, e.g., for operation of air-actuated valves. The system will include dual instrument air compressors with air filters and dryers.

- Facilities for delivery, handling, and storage of treatment chemicals, including facilities for containment and clean-up of chemical leaks and spills inside the WWTS building.

- With the exception of the reactor clarifiers, the lime silo, and the evaporators, the WWTS equipment will be located in the WWTS building.

6.7 Discharge Lagoons, Discharge Pump Station and Discharge Pipeline

6.7.1 Discharge Lagoons

Treated wastewaters will be pumped from the wastewater treatment system to the two discharge lagoons. The treated wastewaters held in these lagoons will be sampled and analyzed to verify compliance with the effluent limitations before being pumped from the lagoons. The lagoons will be operated on an alternating basis. Treated wastewater will flow into and be held in one lagoon while wastewater which has been sampled and analyzed is being pumped from the other lagoon.

Each lagoon will have the capacity to store 24 hours of treated effluent at a flow rate of 636 gallons per minute, plus 3 feet of freeboard. The location of these two lagoons is shown on Figures 3-1 and 3-2. A plan view and a section view of the lagoons are shown on Figure 6-5.

Each lagoon will be provided with a composite liner to minimize seepage to groundwater. The composite liner will be as shown on Figure 6-5, and will consist of the same components as described in Section 6.1.2. The design of the liner will meet the requirements for wastewater lagoon liners in Subchapter II of Chapter NR 213, Wis. Admin. Code.

Each lagoon bottom will be sloped toward the lagoon outlet to allow the lagoon to be drained. Piping will be provided to allow the wastewater to flow from each lagoon to a discharge wet well.

6.7.2 Discharge Pump Station and Discharge Pipeline

If the treated wastewater in a discharge lagoon meets the effluent limitations, discharge pumps will transfer the treated wastewater from the discharge wet well through the discharge pipeline to the soil absorption system. Facilities will be provided for continuous monitoring of the discharge flow rate and composite sampling of the treated wastewater discharged to the SAS. If analysis shows that the wastewater held in a lagoon will not meet the effluent limitations, this wastewater will be pumped back to wastewater storage basins 6 and 7 using the discharge pumps for reprocessing by the WWTS. The discharge wet well, discharge pumps, and discharge monitoring facilities will be located inside a pump station. The pump station will be located south of the discharge lagoons as shown on Figures 3-2 and 6-5.

The discharge pipeline will begin at the discharge lagoon pump station on the plant site and follow the proposed railroad spur to the north and east to the SAS site. The approximate total length of the proposed pipeline is 3.2 miles. Refer to Figure 2-13 for the pipeline route. The pipeline will be installed in public rights-of-way, easements, or on NMC property.

The pipe will have a nominal diameter of 10 inches and will be buried below frost depth. Most of the pipeline will be installed by the open-cut method of construction. Where wetland and/or stream crossings are required, directional drilling methods will be used.

The pipeline is designed as a sealed system. Once installed and prior to backfilling, the pipeline will be pressure and leak tested using either air or water to verify that all joints and connections are properly sealed and there are no leaks. If water is used, it will either be treated water from the project's wastewater treatment plant or water from a potable source. Water used for testing will be left in the pipe.

During operation, pipeline flow rates will be monitored at the discharge lagoons. Pipeline flow rates will also be monitored at the soil absorption system. The total flow from the discharge lagoons can be compared to the total flow rate to the soil absorption system. If a leak is identified, the system will be shut down and the leak repaired. A leak in the discharge pipeline is highly unlikely during the duration of the project.

6.8 Soil Absorption System

Final treated water from the wastewater treatment system will be discharged to groundwater by way of the soil absorption system. A detailed discussion of the SAS design criteria and description of the SAS facilities is available in the *Preliminary Engineering Report for the Crandon Project Soil Absorption System* (Foth & Van Dyke, 1998f). A copy of this document is provided in Appendix D of this report. A brief description of the SAS facilities is provided below.

Treated wastewater from the WWTS will be transferred to the discharge lagoons. Once the treated wastewater quality has been verified to be in compliance with the WPDES effluent limitations, the treated wastewater will be pumped to the SAS. A pump station, located at the discharge lagoons will pump the effluent to the SAS central distribution station. The treated wastewater will enter the influent channel at the central distribution station and flow by gravity into one of six wet wells. Flow control into the wet wells will be provided by adjustable weirs. Each of the six wet wells is designated to discharge to one of six soil absorption cells. Flow from the wet wells to the seepage cells will be by gravity.

Up to six absorption cells will be provided for distribution of treated wastewater. Each cell will include a pipe distribution network to provide even distribution of the treated wastewater across the cell area. Each cell will operate independently of the other cells. This will be accomplished through the use of cell designated water delivery systems. The treated wastewater will discharge into a gravel bed and will then infiltrate down into an underlying highly permeable outwash sand stratum. The distribution piping will be covered with soil to prevent dust and fines from entering the gravel and sand layers and reducing the permeability of these layers. The soil above the piping will also help to insulate the cells and minimize freezing problems.

6.9 Mitigation Treatment System

Wastewater treatment system effluent will be used for mitigation of surface waters impacted by groundwater drawdown associated with mine dewatering activities. A detailed analysis of mitigation requirements is available in the *Crandon Project Surface Water Mitigation Plan* (Foth & Van Dyke, 1998c). Where required, water for mitigation of soft water surface water bodies will be provided from the wastewater treatment system. It is anticipated that the evaporator condensate will be used as the source of mitigation water. The reverse osmosis permeate may also be used as the source of the mitigation water if the permeate meets effluent discharge limits. A blend of the evaporator condensate and the reverse osmosis permeate may also be used as the source of the mitigation water if this blended water meets effluent discharge limits. Based on evaporation treatability testing results, and on engineering evaluation, the evaporation system will produce an effluent meeting mitigation discharge limits

Since the WWTS, as designed to treat mine/mill related wastewaters, will produce an effluent suitable for mitigation purposes, additional treatment processes will not be required specifically for mitigation. Additional facilities associated with soft water body mitigation will primarily be

related to temporary storage of mitigation water and transfer of mitigation water to the discharge sites.

Evaporator condensate will be processed through an air stripper for ammonia removal and will then flow to the mitigation storage tanks or the effluent wet well. Acid/caustic will be added in-line between the air stripper and the storage tanks for final pH adjustment. The effluent will flow to the mitigation storage tanks, if mitigation is required at the time, or flow to the main WWTS effluent wet well for transfer to the discharge lagoons if mitigation is not required at the time.

Multiple mitigation storage tanks will be provided. Each tank will provide storage of one day of peak mitigation flow. The multiple tank arrangement will allow the contents of one tank to be tested for compliance with effluent limits while the second tank is being filled. Once the effluent in the storage tank has been verified to be in compliance with the discharge permit limits, the stored effluent will be discharged to the mitigation site(s).

A mitigation pumping and conveyance system will be constructed for transfer of effluent from the mitigation storage tanks to the mitigation site(s). A detailed description of this system is provided in the *Crandon Project Surface Water Mitigation Plan (*Foth & Van Dyke, 1998c). Additional information on the mitigation facilities is also available in the referenced document.

Any effluent which does not meet discharge permit limits will be pumped back to wastewater storage basins 6 and 7 for reprocessing in the WWTS. The pump will be sized to transfer the contents of one of the storage tanks back to the wastewater basins over a 12-hour period.

6.10 Construction Runoff Control Measures and Treatment

As described in Section 3.3.2, runoff will be generated from the following areas during project construction activities:

- plant site;
- TMA, reclaim pond, and tailings pipeline ditch/access road; and
- other areas, including the plant site access road, railroad spur, wastewater discharge soil absorption system and associated pipeline, and the wetland compensation site.

Control measures and treatment for construction runoff from each of these areas are discussed as follows. Note that the following discussion addresses non-contact runoff generated during the construction period. As discussed in Sections 6.3, 6.4 and 6.5, contact runoff generated during construction will be directed to the wastewater treatment plant.

6.10.1 Plant Site

As discussed previously in Section 3.3.2 and as shown on Figure 3-7, the plant site will include six drainage areas. Construction runoff from each of these drainage areas will be routed to basins 1, 2, 3, and 8 and the temporary construction runoff basin shown on Figure 3-1. During construction, these basins will remove sediment and other settleable material in the runoff. Basins 1, 2, and 8 will remain as non-contact runoff basins after plant start-up and will therefore be sized, per NR 132, Wis. Admin. Code, to handle the construction runoff from a 25-year, 24-hour rainfall event. Since basin 3 will ultimately receive runoff from the area used to potentially store waste rock, it has been designed, per NR 182, Wis. Admin. Code, to handle runoff from a 100-year, 24-hour rainfall event. During the initial stages of construction prior to placement of ore and/or waste rock on the pre-production ore storage area and prior to startup of the wastewater treatment plant, non-contact construction runoff generated in the central runoff drainage area and pre-production ore storage area will be directed to the temporary construction runoff basin. Once ore and/or waste rock are placed on the pre-production ore storage area and the wastewater treatment plant comes on-line, the use of the temporary construction runoff basin will be discontinued and the basin area will be converted to use as a construction lay down area. Since this basin will receive non-contact runoff, it has been designed per NR 132, Wis. Admin. Code, for runoff from a 25-year, 24-hour rainfall event. Sediment which accumulates in the basins during construction will be removed from the basins as often as necessary and reused during construction, if possible, or placed on the soil stockpile at the plant site for reuse during reclamation.

During construction, runoff from the basins will be discharged to on-site drainageways via the outfalls as shown in Table 6-5. Runoff basins 1, 2, 3, and 8 and the temporary construction runoff basin will be constructed of compacted till. The inlets and outlets of these basins will be riprapped for erosion protection. Figures 6-6 and 6-7 show a section view of the basins.

Several areas of the plant site outside these six drainage areas will also be disturbed during construction. In these areas, silt fences, hay bales, or other control measures will be used to minimize the amount of sediment and other settleable solids contained in the runoff. Details of the control measures to be taken for these areas are presented in the project's *Mine Permit Application (*Foth & Van Dyke, 1995/1998b).

6.10.2 TMA, Reclaim Pond, and Tailings Pipeline Ditch/Access Road

As discussed previously in Section 3.3.2 and as shown on Figure 3-7, runoff will occur from a drainage area associated with the tailings pipeline ditch and access road. This construction runoff will be routed to the drain down sump (basin 4). During construction, this basin will remove sediment and other settleable material in the runoff. The basin will be able to handle the construction runoff from a 25-year, 24-hour rainfall event. The design of basin 4 was described previously in Section 6.1.4. During construction, runoff from this basin will be discharged to on-site drainageways via outfall 004. After plant start-up, basin 4 will handle runoff from the TMA access road and the tailings pipeline ditch. Collected runoff will be pumped to the TMA.

Table 6-5

Construction Runoff Discharges

Runoff Drainage Area	Routed to Basin Number	Discharged to Outfall Number[1]
Plant site - southwest area	1	001
Plant site - southeast area	2	002
Plant site - construction material storage area	3	003
Tailings pipeline ditch/TMA access road[2]	4	004
Plant site - pre-production ore storage area[3]	TCRB	005
Plant site - central area[3]	TCRB	005
Plant site - northwest area	8	008
TMA site - discharge lagoon	9	009
TMA site - southern area	10	010
TMA site - east area	11	011
TMA site - northeast area	12	012
TMA site - northern area	13	013
TMA site - northwest area	14	014

[1] Outfall 007 is the discharge to the soil absorption system of treated wastewaters generated during operation and closure of the mine and mill. The project does not include an outfall 006.

[2] During operation, runoff from this drainage area will not be discharged to the outfall shown. Instead, the runoff will be collected and routed to the TMA.

[3] During operation, runoff from this drainage area will not be discharged to the outfall shown. Instead, the runoff will be collected and routed to the wastewater treatment system, with discharge of the treated effluent to the soil absorption system via outfall 007.

TCRB = Temporary construction runoff basin.

Prepared by: PAE
Checked by: JWS

As discussed previously in Section 3.3.2, runoff will occur during construction of the reclaim pond and each of the TMA cells. Construction runoff from the six TMA drainage areas listed in Table 6-5 will be routed to runoff basins 9, 10, 11,12, 13, and 14. During construction, these basins will remove sediment and other settleable solids in the runoff. Each basin is designed, per NR 182, Wis. Admin. Code, to handle the construction runoff from a 100-year, 24-hour rainfall event. Details of the design of runoff basins 9 through 14 are presented in Addendum No. 5 to the project's *TMA Feasibility Report* (Foth & Van Dyke, 1998b). During construction, runoff from these six basins will be discharged to on-site drainageways via the outfalls listed in Table 6-5.

The outside slopes of the tailings pipeline ditch and the TMA access road will also be disturbed during construction. In these areas silt fences, hay bales, or other temporary control measures will be used to minimize the amount of sediment and other settleable solids contained in the runoff. Details of the control measures to be taken for these areas are presented in the project's *Mine Permit Application* (Foth & Van Dyke, 1995/1998b).

6.10.3 Other Areas

Other areas will be disturbed during construction. These areas include the plant site access road, the railroad spur, and the wastewater discharge soil absorption system and associated conveyance pipeline. In these areas silt fences, hay bales, or other temporary control measures will be used to minimize the amount of sediment and other settleable solids contained in the runoff. Details of the control measures to be taken for these areas are also presented in the project's *Mine Permit Application* (Foth & Van Dyke, 1995/1998b).

6.11 Non-Contact Runoff Collection and Discharge During Operation

As described in Section 3.2.7, runoff will also be generated during operation from areas of the plant site and TMA which will not come in contact with raw materials, intermediate products, finished products, by-products, or waste materials from the plant site. As discussed in Section 4.3, this "non-contact" runoff will not require a WPDES permit. Non-contact runoff basins 1, 2, 3, 8, and 9 through 14 may be retained after construction is complete, if required. See Section 6.10 for a description of the design of these basins.

7 Wastewater Treatment Facilities Operation and Maintenance

This section addresses operation and maintenance for the Crandon Project wastewater treatment facilities. Issues discussed include operation, maintenance, and staffing.

7.1 Operation

Proper operation of the wastewater treatment facilities will be essential to consistently producing a high quality effluent which meets the discharge limitations. Efficient facilities operation will also be essential in minimizing operating costs. The general duties associated with operation will include:

- Monitor the operating status of wastewater treatment processes and equipment.
- Monitor the wastewater influent and effluent quality and make necessary process adjustments to maintain the required level of treatment.
- Collect samples for testing.
- Daily inspection of equipment.
- Record keeping.
- Coordination of routine maintenance or repairs.
- Troubleshooting.
- Facilities management.

7.2 Maintenance

Preventative maintenance will be a priority for the project. The treatment facilities will only perform as designed if equipment is maintained in good working order. Additionally, maintenance of equipment can, in the long term, lead to reduced operating costs. Facility systems which will require routine maintenance include the following:

- Monitoring/Control instrumentation.
- Chemical storage, handling, and feeding systems.
- Electrical distribution system.
- Plant utilities, e.g., heating, ventilating, instrument air, non-potable water.
- Pumps and process equipment.

7.3 Wastewater Treatment Facilities Staffing

An estimate of the staffing needs for the Crandon Project wastewater treatment facilities was based on staffing needs reported for existing facilities of similar size and design. Staffing requirements will include personnel for operation, maintenance, supervision, clerical work, and laboratory analysis. These requirements are discussed below.

7.3.1 Operation of Facilities

Plant operators will be available whenever the wastewater treatment system is operating. The operators will be State certified and will have comprehensive training in the processes used in the wastewater treatment system. Operators will need to monitor the performance of treatment equipment and processes, make adjustments as needed to maintain satisfactory treatment system performance, and confirm that the wastewater is adequately treated prior to discharge. They will also need to coordinate with the mill in regard to chemical or water recycle needs. Supervisory duties will be handled within the mill organizational structure.

7.3.2 Laboratory

Laboratory analysis will be required for each shift, seven days per week for analysis of wastewater and solids samples.

7.3.3 Maintenance

The operation staff will be available to meet routine plant operation and maintenance needs. Additional personnel will be periodically required to assist in labor intensive maintenance or repair work. Due to the infrequency of the need for additional maintenance personnel, an additional full time employee will not be needed. Required personnel can be drawn from the surface facilities maintenance pool for this need as necessary.

8 Schedule

Construction of the wastewater treatment facilities described in Section 6 will be carried out so that these facilities will be available for use when needed during construction, operation, and closure of the mine, mill, TMA, and ancillary facilities.

The following is a description of the schedule for construction and operation of the wastewater treatment facilities in relation to construction, operation, and closure of the mine, mill, and TMA. Additional information concerning the schedule for other facilities and activities during construction, operation, and closure are presented in the project's *Mine Permit Application* (Foth & Van Dyke, 1995/1998b).

8.1 Initial Plant Site Construction

During initial plant site construction, the wastewater generated will be limited to construction runoff. Therefore, initial site construction activities will include construction of runoff basins 1, 2, 3, and 8, and wastewater storage basin 6. These five basins will be used to treat non-contact plant site construction runoff from areas of the plant site disturbed during initial construction. The runoff from these runoff basins will be discharged to on-site drainageways via outfalls 001, 002, 003, 006, and 008. Wastewater storage basin 7 will also be constructed during initial plant construction so that it is completed prior to the initiation of mine shaft sinking.

8.2 Mine Shaft Sinking

During sinking of the mine shafts, water from mine shaft dewatering will be collected and stored in wastewater storage basins 6 and 7 while the following wastewater treatment facilities are being constructed:

- the wastewater treatment system and WWTS building;
- the two discharge lagoons;
- the wastewater pumping facilities, discharge pumping facilities, discharge monitoring facilities, and the pump station used to enclose these facilities;
- the soil absorption system; and
- the discharge pipeline to the soil absorption system.

During mine shaft sinking, a temporary oil/water separator will be used to remove oil that comes in contact with the shaft water. Any oil removed by the oil/water separator will be disposed of off-site. Waste rock from the development of the mine shafts will be placed on the lined pre-production ore storage area. Runoff from this area will be collected in runoff basin 5 and

pumped to basins 6 and 7. Construction of the pre-production ore storage area berms and lining will be completed prior to initiation of shaft sinking.

8.3 Mine Development

During mine development, mine drainage will be pumped to wastewater storage basins 6 and 7 and then to the wastewater treatment system for treatment and discharge to the soil absorption system. Therefore, the wastewater treatment system, the two discharge lagoons, the pumping and monitoring facilities in the pump station, the soil absorption system, and the discharge pipeline to the soil absorption system will be completed prior to beginning mine level development.

Ore produced during mine development will be stored in the pre-production ore storage area. Prior to commencing storage of ore in the pre-production ore storage area, the discharge pipe from wastewater storage basin 5 to on-site drainageways will be closed, and the discharges to outfall 005 will cease. At approximately the same time, production activities associated with handling of ore will occur in the central area of the plant site, i.e., the area that drains runoff to wastewater storage basin 6. Because contact runoff will result from precipitation on this area, the discharge pipe from wastewater storage basin 6 to on-site drainageways will also be closed and the discharges to outfall 006 will cease. Beginning at that time, runoff collected in wastewater storage basin 5 will be transferred to wastewater collection basins 6 and 7 and mixed with the contact runoff and mine drainage collected in basins 6 and 7. The combined wastewaters collected in basins 6 and 7 will then be pumped to the wastewater treatment system for treatment and discharge to the soil absorption system.

Therefore, during mine development, the following wastewaters will be treated and discharged to the soil absorption system via outfall 007:

- mine shaft dewatering wastewaters collected in wastewater storage basin 7 during shaft sinking;
- mine drainage generated during mine development;
- runoff from the pre-production ore storage area; and
- contact runoff from the central area of the plant site.

8.4 Mill and TMA Development

Development of the mill, TMA, tailings pipeline, reclaim pond, and associated facilities will overlap with the development of the mine. During this time, the drain down sump (basin 4) will be constructed and used to treat construction runoff from the tailings pipeline ditch and access road, with the treated runoff from the sump discharged to on-site drainageways adjacent to the sump via outfall 004.

Construction of cell 1 of the TMA will result in construction runoff. Therefore, initial construction activities at the TMA will include construction of runoff basin 9. This basin will be used to collect construction runoff from cell 1 of the TMA. The runoff from this basin will be discharged to on-site drainageways at the TMA via outfall 009.

8.5 Plant Operation

After completing construction of the mill, TMA, tailings pipeline, reclaim pond, and associated facilities, the mill will begin operation. Wastewater may be used as a source of water for initial testing and start-up of the mill process water system. Prior to commencing use of the tailings pipeline, the discharge pipe from the drain down sump to on-site drainageways will be closed, and discharges to outfall 004 will cease. Beginning at that time, wastewater collected in the drain down sump will be stored in the sump until it can be pumped to the TMA. Prior to initial start-up of the mill, the wastewater treatment facilities and mill process water recycle facilities will have been completed and in full operation.

8.6 Surface Water Mitigation

Surface waters impacted by regional groundwater drawdown associated with mine dewatering activities will be mitigated as required. A mitigation system will be constructed as required. Details on mitigation requirements, and construction of the mitigation system, are provided in the *Crandon Project Surface Water Mitigation Plan* (Foth & Van Dyke, 1998c).

8.7 Site Closure

At the end of operation of the mine and mill, water will remain in the mill process water circuit which will need to be treated. Additionally, precipitation falling on the TMA, the reclaim pond, and the plant site, prior to final reclamation, will result in generation of contact water which will require treatment. These wastewaters will be routed to the wastewater treatment system for treatment and discharge to the soil absorption system. Therefore, the wastewater treatment system, the soil absorption system, and the discharge pipeline to the soil absorption system will remain in operation until after the final cover has been placed on the TMA and TMA drainage is discontinued, and until the plant site and TMA have been reclaimed.

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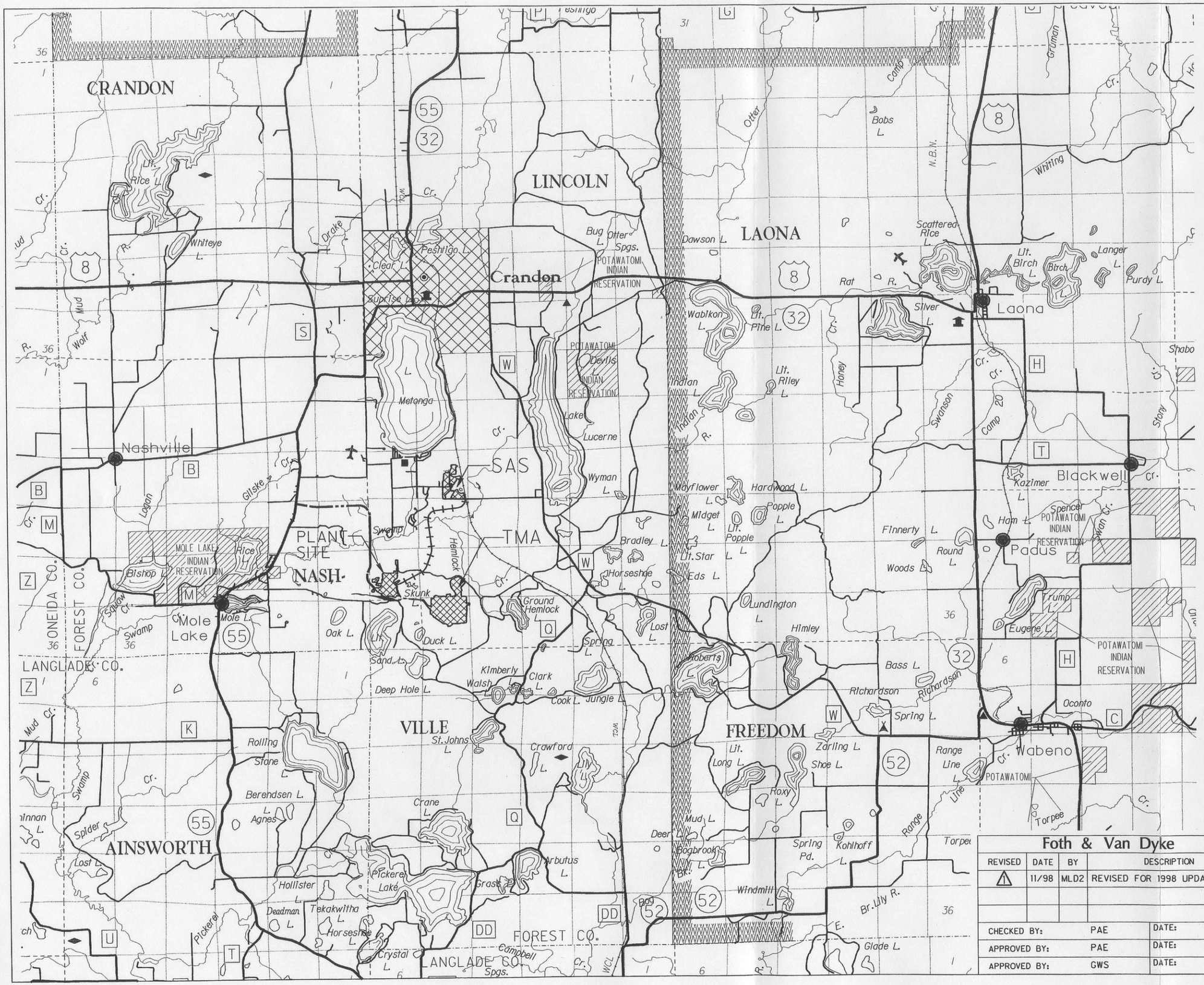
FIGURES FOR THE PRELIMINARY ENGINEERING REPORT FOR WASTEWATER TREATMENT FACILITIES



LEGEND

- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- (8) U.S. HWY NO.
- (47) STATE HWY NO.
- [W] COUNTY HIGHWAY LETTER
- NATIONAL & STATE FOREST BOUNDARY
- CORPORATE LIMITS
- UNINCORPORATED VILLAGE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

N

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.
3. ADDITIONAL POTAWATOMI LANDS LOCATED TO THE EAST OF MAP COVERAGE.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	11/98	MLD2	REVISED FOR 1998 UPDATE

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

Nicolet Minerals COMPANY

Mining for the Future Commitment

FIGURE 2-1

SITE LOCATION

Scale: 0 5,000' 10,000' Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: JRB2 | 93C049

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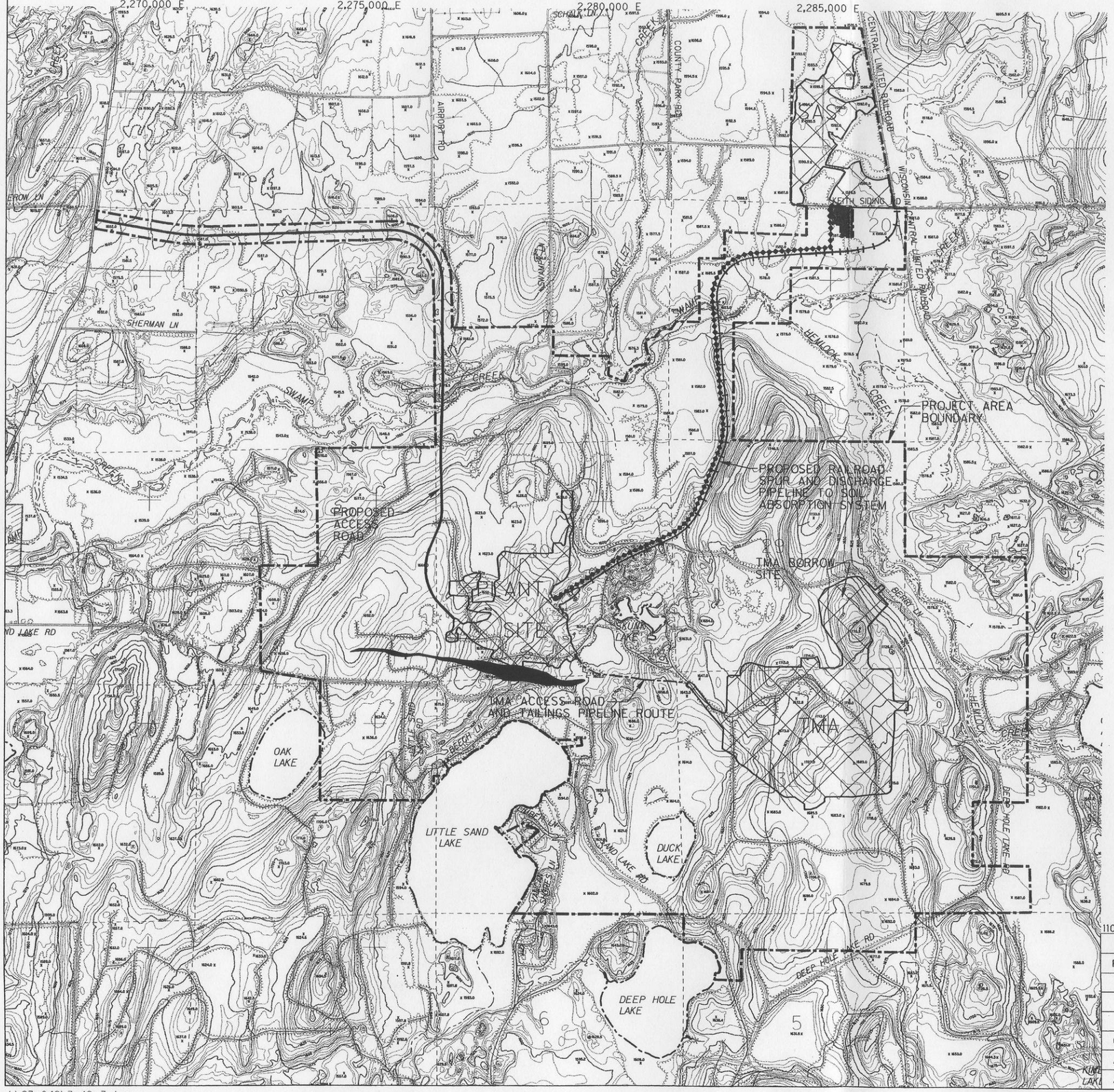

LEGEND

- 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
- PROJECT AREA BOUNDARY
- PROPOSED SOIL ABSORPTION SYSTEM PIPELINE
- PROPERTY NOT INCLUDED WITHIN PROJECT AREA

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 5 FEET.
4. SECTION 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
1	11/98	MLD2	REVISED FOR 1998 UPDATE

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

Nicolet Minerals COMPANY

Mining for the Future Commitment

FIGURE 2-2

PROJECT AREA

Scale: 0 1200' 2400' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: JRB2 | 93C049

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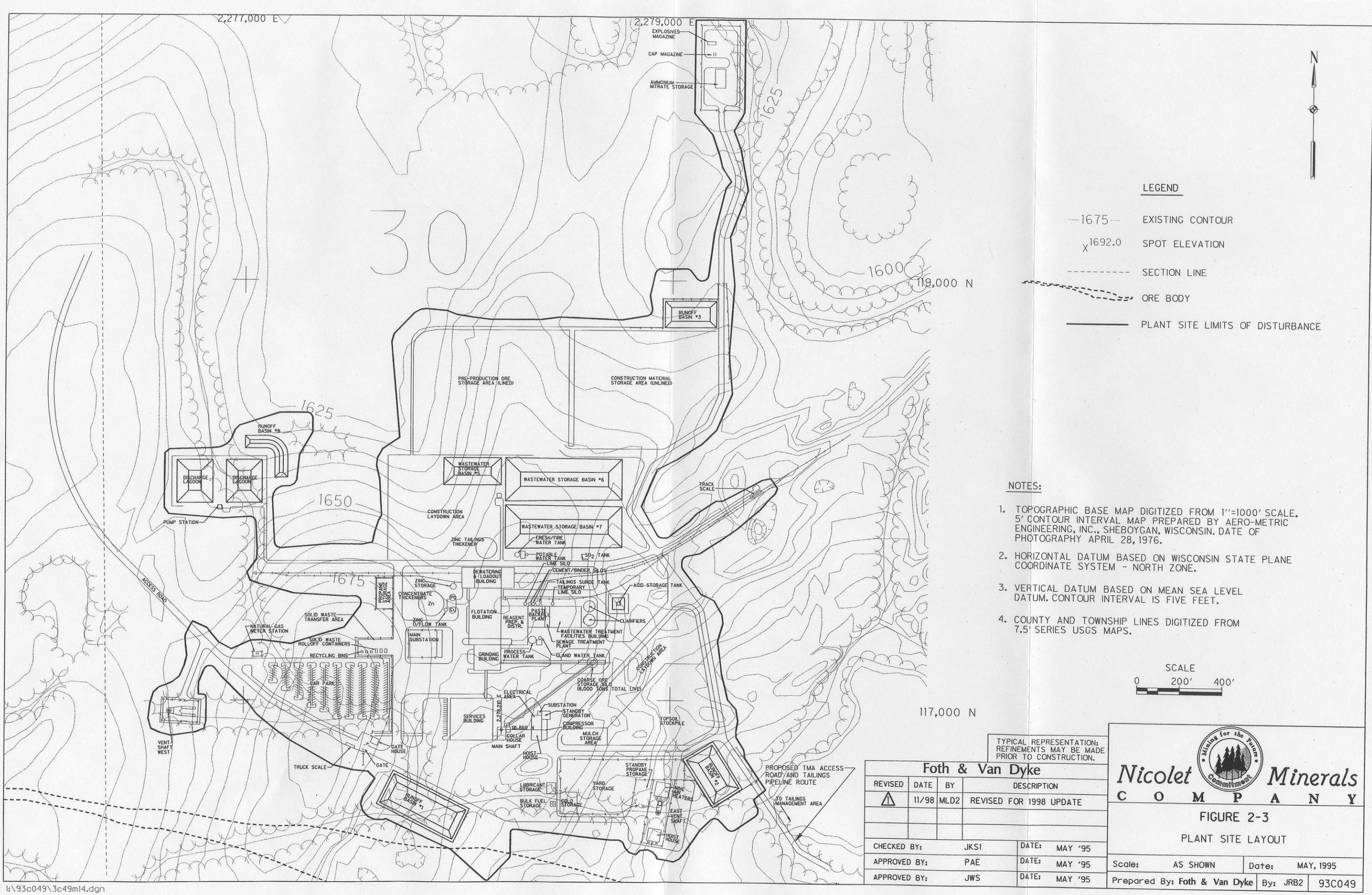

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	11/98	MLD2	REVISED FOR 1998 UPDATE

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

Nicolet Minerals COMPANY

Mining for the Future Tomorrow

FIGURE 2-3

PLANT SITE LAYOUT

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By: Foth & Van Dyke	By: JRB2		93C049

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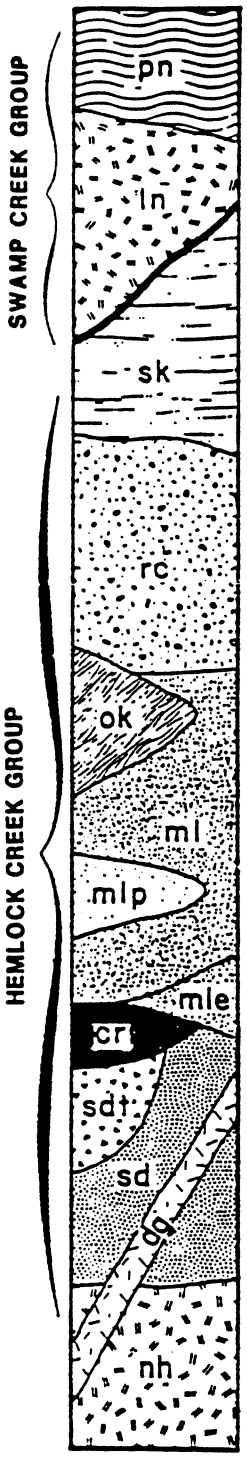

PINE FORMATION (pn)

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
1	11/98	MLD2	REVISED FOR 1998 UPDATE

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

Nicolet Minerals COMPANY

FIGURE 2-4

STRATIGRAPHIC COLUMN

Scale: NOT TO SCALE		Date: MARCH, 1995	
Prepared By: Foth & Van Dyke		By: BSH	93C049

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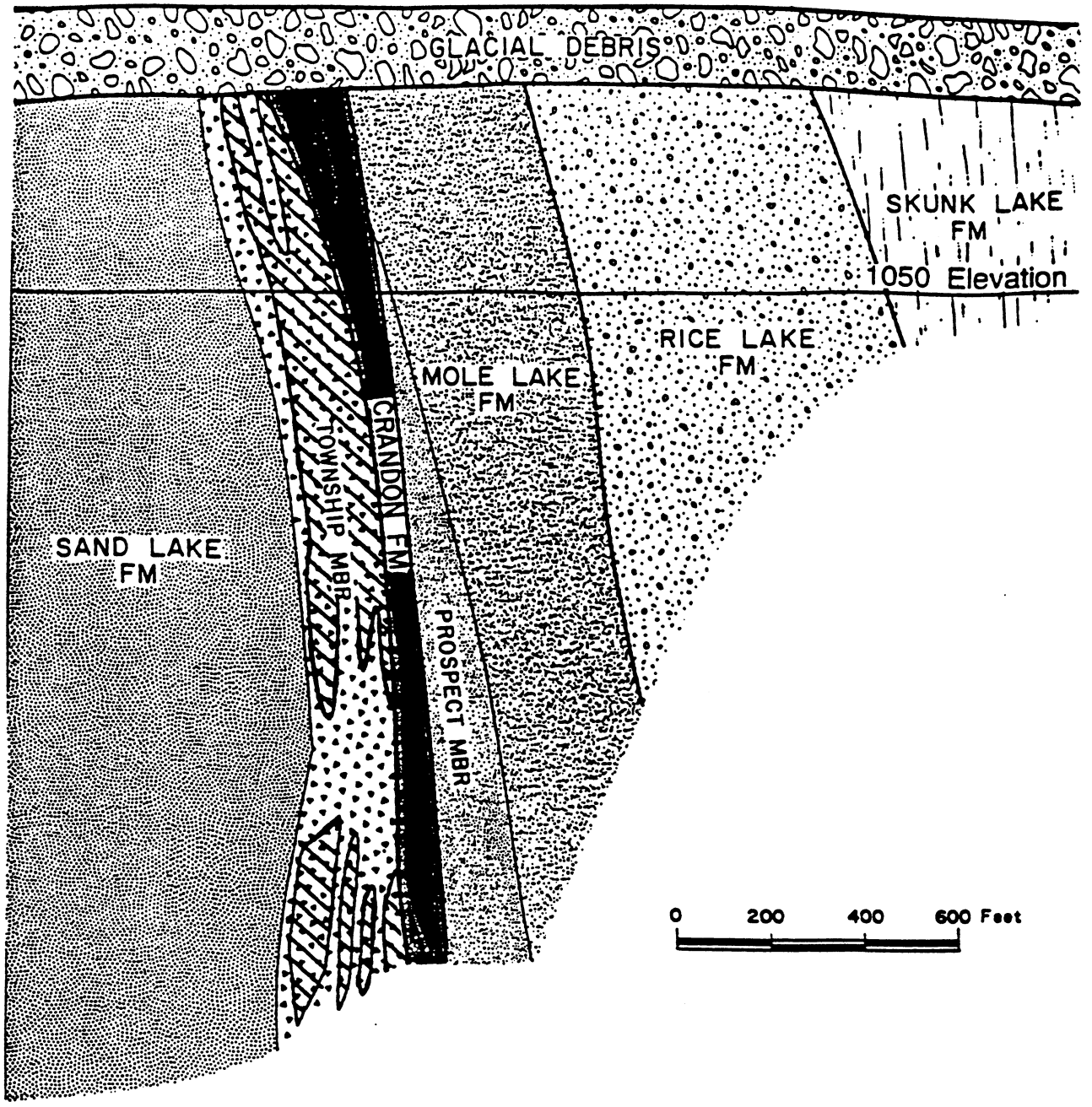
LOOKING WEST



ZINC ORE

COPPER ORE

Foth & Van Dyke			
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1	11/98	MLD2	REVISED FOR 1998 UPDATE

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

Nicolet Minerals COMPANY

Mining for the Future Commitment

FIGURE 2-5

GENERALIZED GEOLOGIC CROSS SECTION C-C

Scale: NOT TO SCALE		Date: MARCH, 1995	
Prepared By: Foth & Van Dyke		By: BSH	93C049

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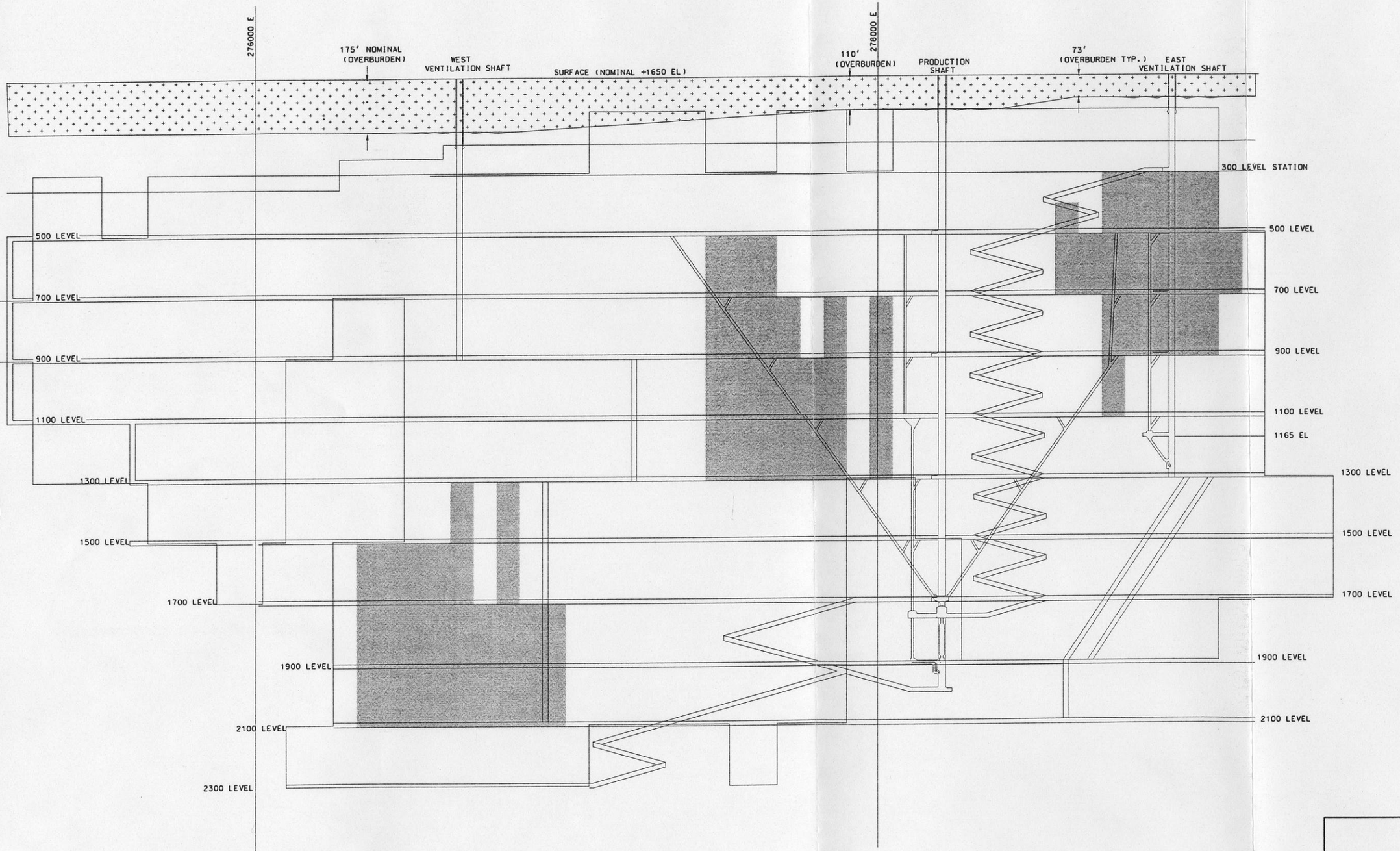

LEGEND

EARLY PRODUCTION AREAS

Foth & Van Dyke					
REVISED	DATE	BY	DESCRIPTION		
1	11/98	MLD2	REVISED FOR 1998 UPDATE		
CHECKED BY:	JKSI		DATE:	APR. '95	
APPROVED BY:	PAE		DATE:	APR. '95	
APPROVED BY:	GWS		DATE:	APR. '95	

Nicolet Minerals COMPANY

FIGURE 2-6

SCHEMATIC LONGITUDINAL SECTION (LOOKING NORTH)

Scale: NOT TO SCALE	Date: APRIL, 1995		
Prepared By: Foth & Van Dyke	By: BSH	93C049	

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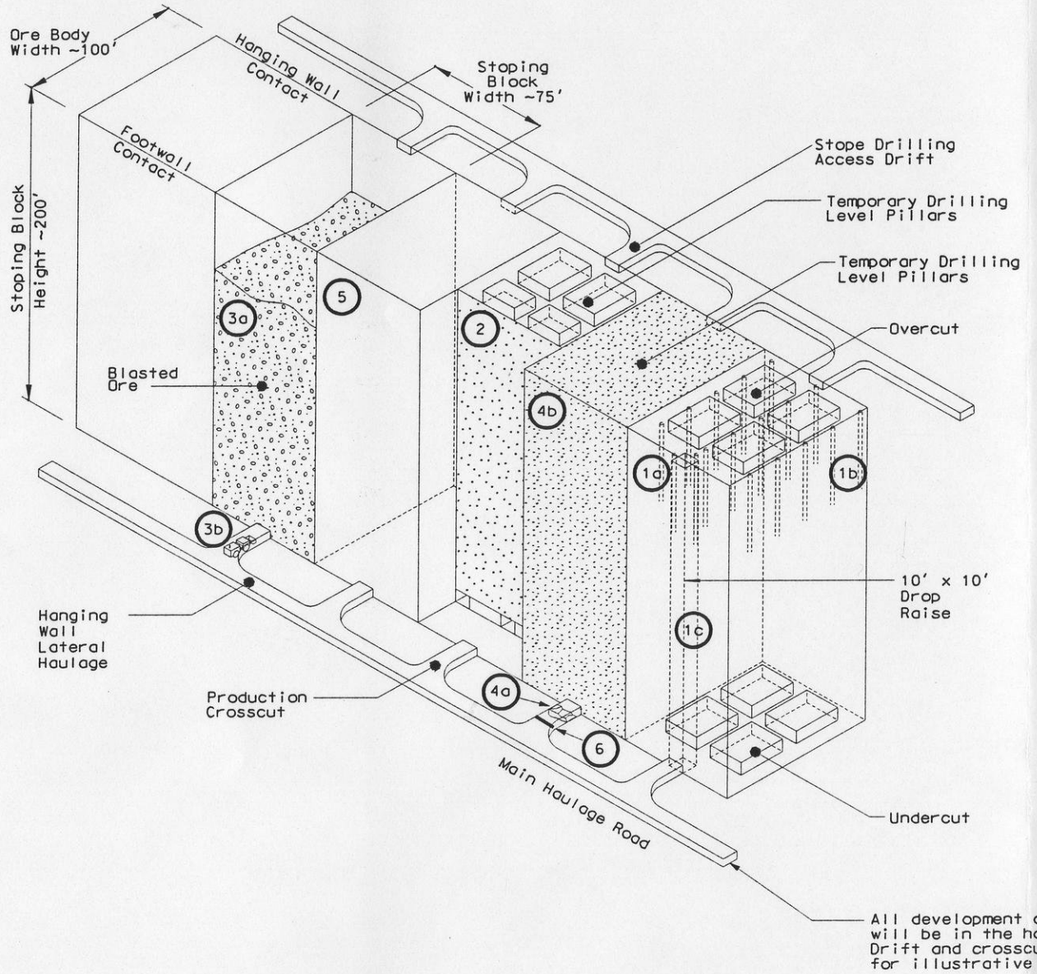

LEGEND

(1a) Develop overcut and undercut.

(1b) Drill off stope using all downholes from overcut.

(1c) Open drop raise and muck out.

(2) Open slot around drop raise until 30% to 50% void space has been achieved. muck out.

(3a) Blast rest of stope in one blast.

(3b) Muck out stope using remote control for final cleanup.

(4a) Block access to undercut with waste rock.

(4b) Backfill stope from overcut with paste backfill.

(5) Alternate stoping block/pillar to be mined after backfilling adjacent stopes.

(6) Establish ventilation stoppage top and bottom to inhibit oxygen transfer into stope.

Foth & Van Dyke

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1	11/98	MLD2	REVISED FOR 1998 UPDATE

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

Nicolet Minerals COMPANY

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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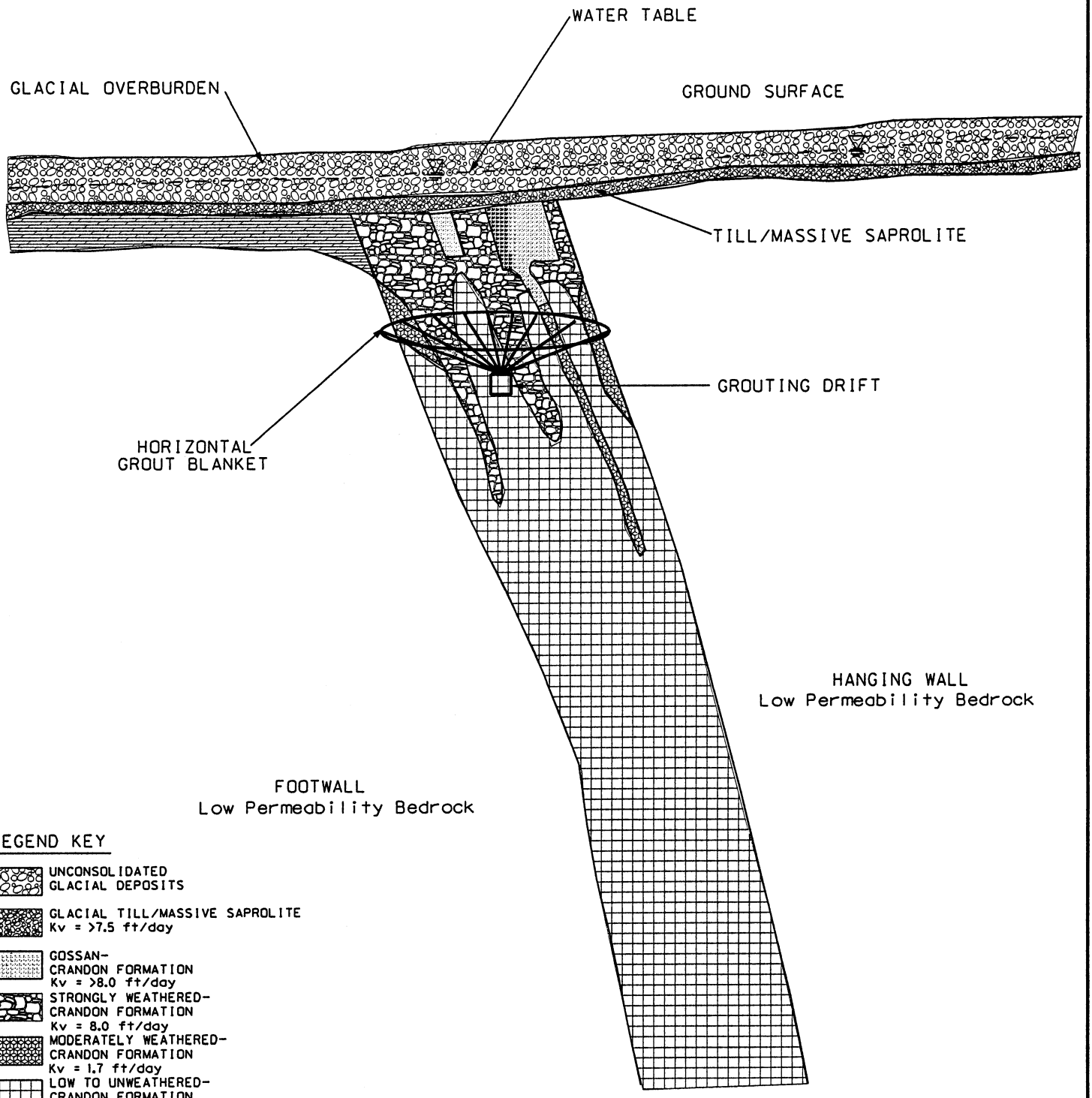

LEGEND KEY

- UNCONSOLIDATED GLACIAL DEPOSITS
- GLACIAL TILL/MASSIVE SAPROLITE Kv = >7.5 ft/day
- GOSSAN-CRANDON FORMATION Kv = >8.0 ft/day
- STRONGLY WEATHERED-CRANDON FORMATION Kv = 8.0 ft/day
- MODERATELY WEATHERED-CRANDON FORMATION Kv = 1.7 ft/day
- LOW TO UNWEATHERED-CRANDON FORMATION Kv = <0.012 ft/day
- STRONGLY WEATHERED-FOOTWALL Kv = 0.23 ft/day
- LOW PERMEABILITY-FOOTWALL AND HANGING WALL Kv = <0.048 ft/day

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	MLD2	DATE: NOV. '98
APPROVED BY:	TWS	DATE: NOV. '98
APPROVED BY:	GWS	DATE: NOV. '98

Nicolet Minerals COMPANY

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FIGURE 2-8

TYPICAL GROUT BLANKET FAN

Scale:	NOT TO SCALE	Date:	NOVEMBER, 1998
Prepared By: Foth & Van Dyke	By: JRB2	93C049	

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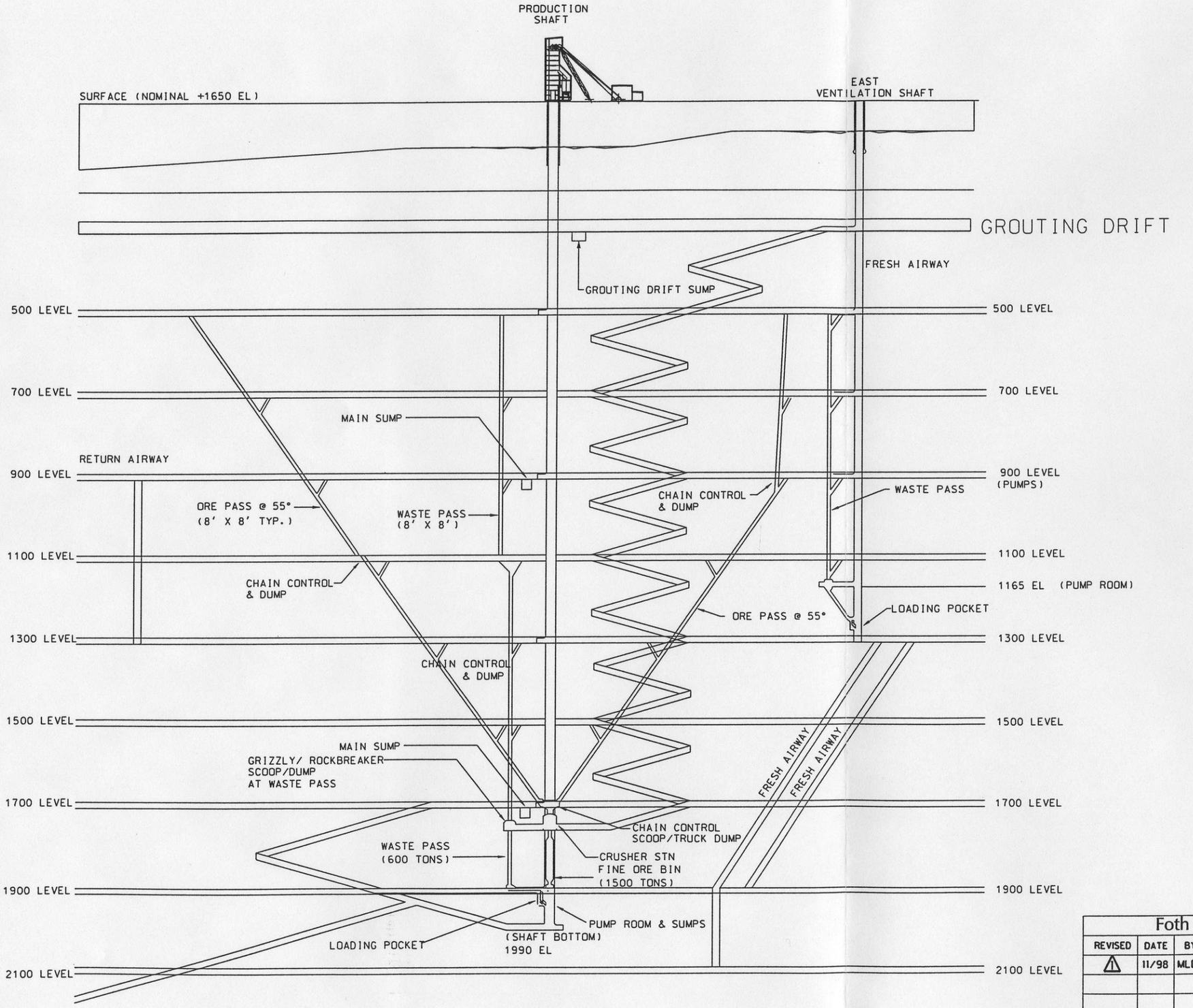

Foth & Van Dyke				
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1	11/98	MLD2	REVISED FOR 1998 UPDATE	
CHECKED BY:		JKSI	DATE:	APR. '95
APPROVED BY:		PAE	DATE:	APR. '95
APPROVED BY:		GWS	DATE:	APR. '95

Nicolet Minerals COMPANY

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FIGURE 2-9

MINE DRAINAGE SCHEMATIC

Scale: NOT TO SCALE	Date: APRIL, 1995	
Prepared By: Foth & Van Dyke	By: BSH	93C049

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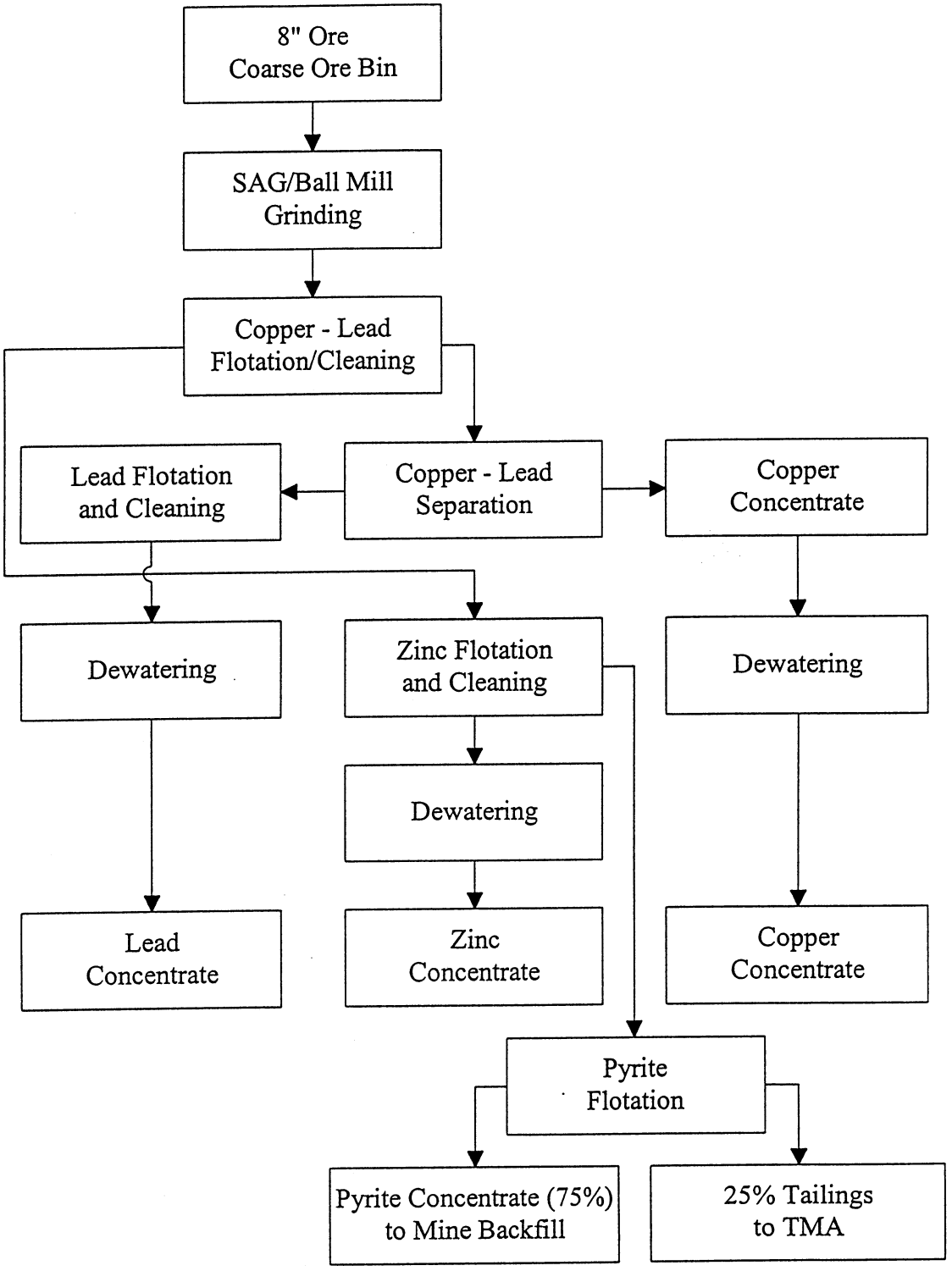

Foth & Van Dyke			
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1	11/98	MLD2	REVISED FOR 1998 UPDATE

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

Nicolet Minerals COMPANY

FIGURE 2-10

CONCENTRATOR PROCESS FLOWSHEET

Scale: NOT TO SCALE	Date: MARCH, 1995	
Prepared By: Foth & Van Dyke	By: BSH	93C049

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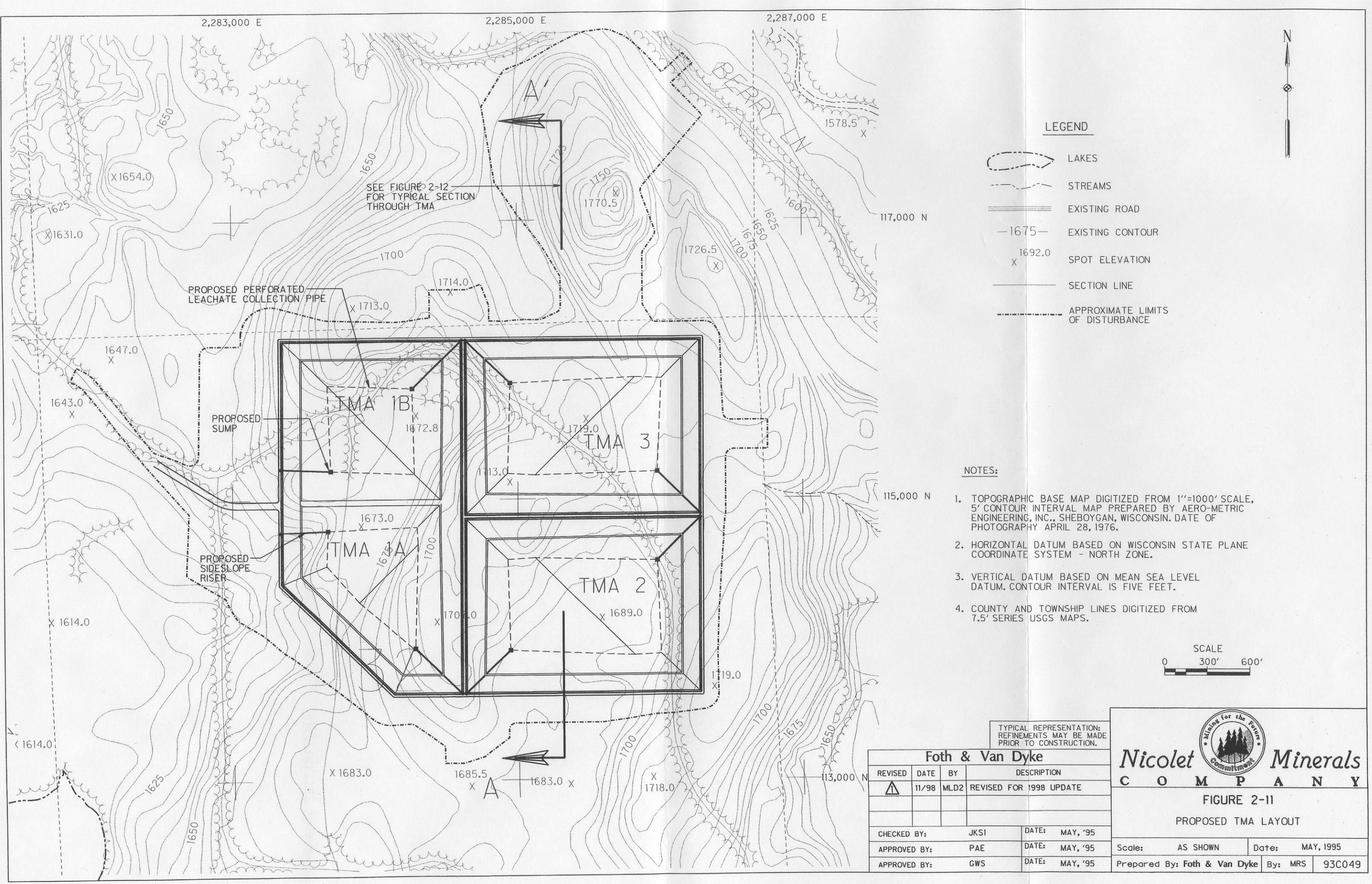

LEGEND

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

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
1	11/98	MLD2	REVISED FOR 1998 UPDATE

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

Nicolet Minerals COMPANY

FIGURE 2-11

PROPOSED TMA LAYOUT

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By: Foth & Van Dyke	By: MRS		93C049

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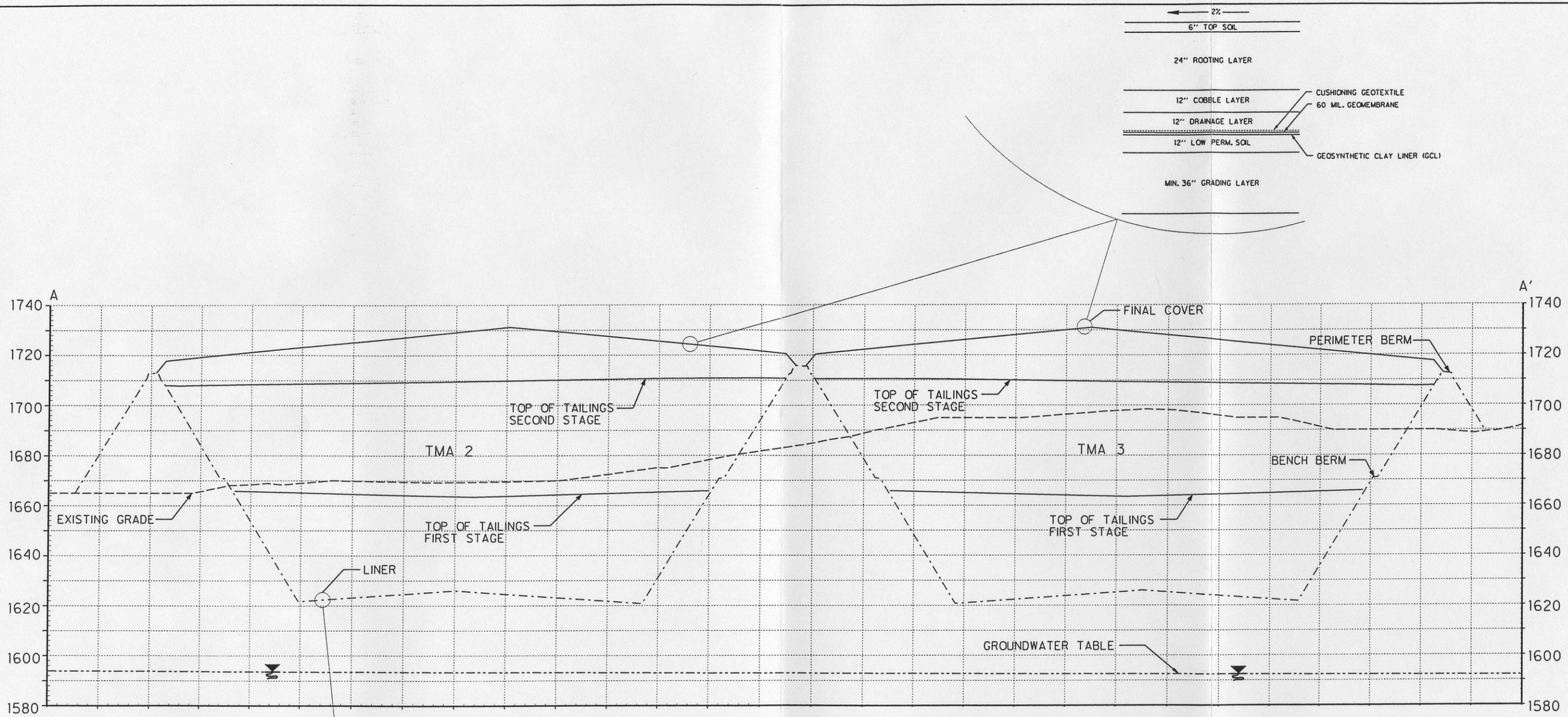
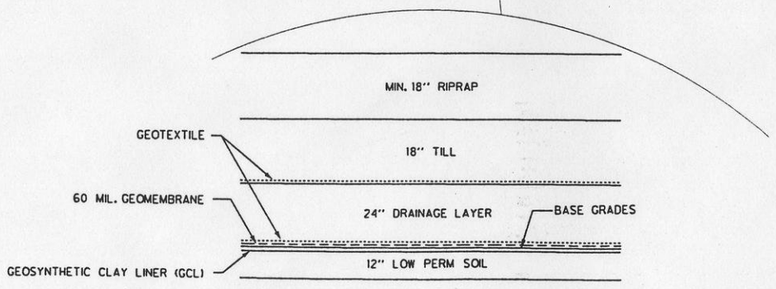
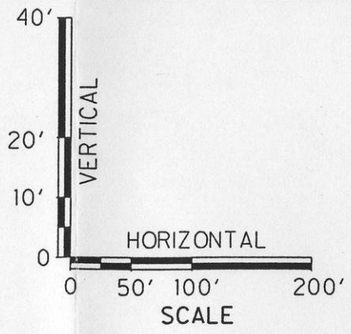


NOTE: VERTICAL SCALE IS EXAGGERATED



TYPICAL CROSS SECTION A-A' THROUGH TMA



TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	11/98	MLD2	REVISED FOR 1998 UPDATE

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

Nicolet Minerals COMPANY

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FIGURE 2-12

TYPICAL CROSS SECTION THROUGH TMA

Scale: AS SHOWN		Date: MAY, 1995	
Prepared By: Foth & Van Dyke	By: MRS	93C049	

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2,280,000 E

2,285,000 E

2,290,000 E

130,000 N

125,000 N

LAKE METONGA

SCHALK LN

ROHR LN

COUNTY PARK RD

OUTLET CREEK

APPROXIMATE LIMITS OF SOIL ABSORPTION SYSTEM SITE

Z16 (NORTH)

A

B

C

D

E

F

T4

CREEK 17-13

Z16 (CENTRAL)

EXCAVATED DITCH

LAKE 17-16

Z16 (SOUTH)

KEITH SIDING RD

SWAMP CREEK

HEMLOCK CREEK

WISCONSIN CENTRAL LIMITED RAILROAD

PROPOSED RAILROAD SPUR

PROPOSED PIPELINE ROUTE

N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- 1675 EXISTING CONTOUR
- SWAMP/WETLAND
- TRAILS
- TREES
- RAILROAD
- WETLANDS
- A PROPOSED SOIL ABSORPTION SYSTEM LOCATION
- PROPOSED SAS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- APPROXIMATE LIMITS OF SOIL ABSORPTION SYSTEM SITE
- Z16 WETLAND NAME
- DISTURBED WETLAND AREA NOT PREVIOUSLY DELINEATED AS A WETLAND

NOTES:

1. SAS TOPOGRAPHY AND WETLAND SPOT ELEVATIONS NORTH OF KEITH SIDING ROAD FROM SURVEY COMPLETED BY FOTH & VAN DYKE IN LATE SUMMER, 1998. CONTOUR INTERVAL IS ONE FOOT.
2. TOPOGRAPHY, WATER BODIES, WETLANDS, ETC. OUTSIDE SAS AREA BASED ON TOPOGRAPHIC BASE MAP DIGITIZED FROM THE 1" = 1000' SCALE 5 FOOT CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING INC., SHEBOYGAN, WI. DATE OF PHOTOGRAPHY APRIL 28, 1976.
3. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
4. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

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APPROVED BY:	GWS	DATE:	NOV. '98

Nicolet Minerals COMPANY

Mining for the Future Commitment

FIGURE 2-13

DISCHARGE PIPELINE AND SOIL ABSORPTION SYSTEM

Scale: 0 500' 1000' Date: NOVEMBER, 1998

Prepared By: Foth & Van Dyke By: JOW 93C049

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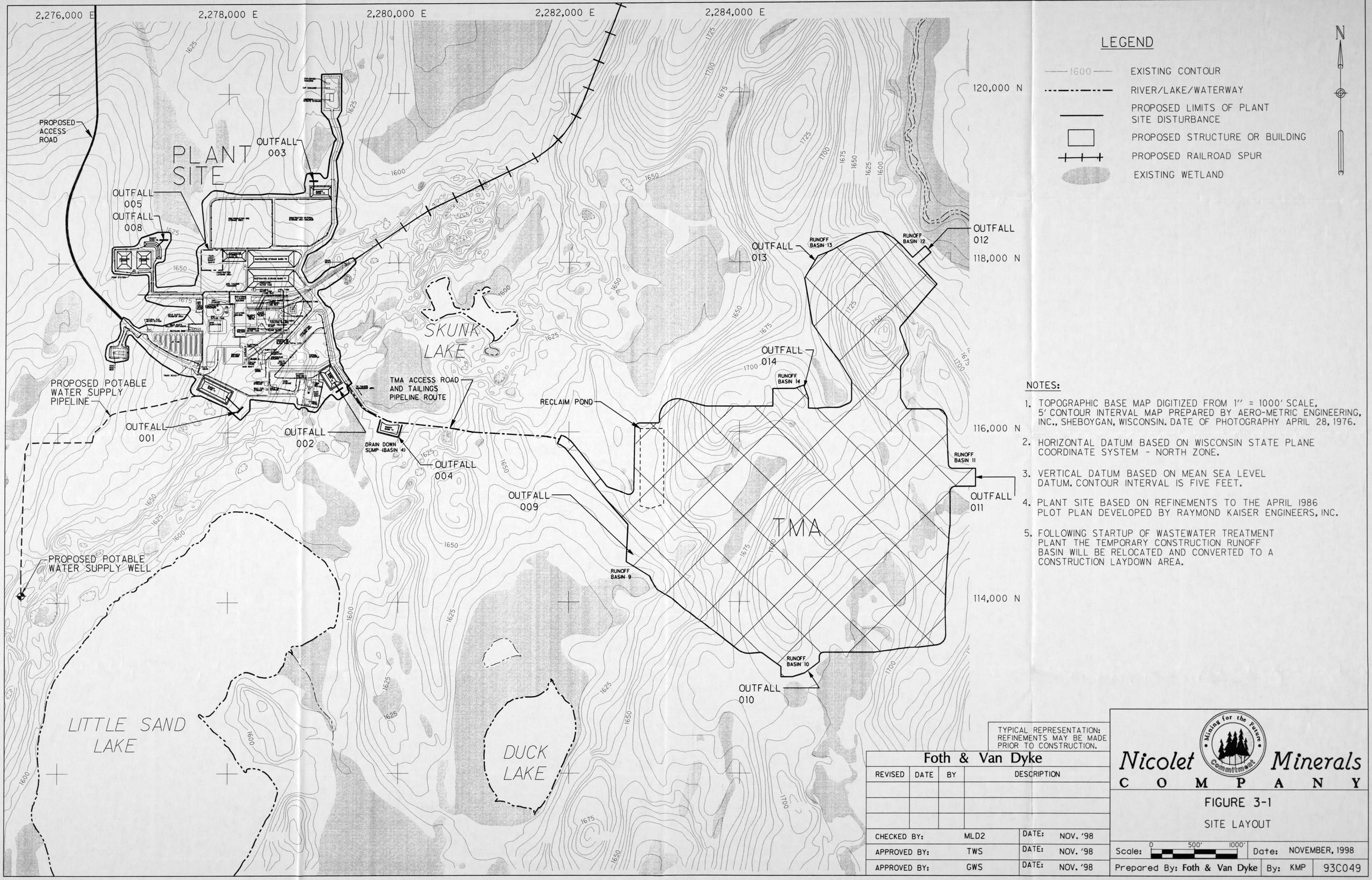

LEGEND

- EXISTING CONTOUR (1600)
- RIVER/LAKE/WATERWAY
- PROPOSED LIMITS OF PLANT SITE DISTURBANCE
- PROPOSED STRUCTURE OR BUILDING
- PROPOSED RAILROAD SPUR
- EXISTING WETLAND

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. PLANT SITE BASED ON REFINEMENTS TO THE APRIL 1986 PLOT PLAN DEVELOPED BY RAYMOND KAISER ENGINEERS, INC.
5. FOLLOWING STARTUP OF WASTEWATER TREATMENT PLANT THE TEMPORARY CONSTRUCTION RUNOFF BASIN WILL BE RELOCATED AND CONVERTED TO A CONSTRUCTION LAYDOWN AREA.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	MLD2	DATE:	NOV. '98
APPROVED BY:	TWS	DATE:	NOV. '98
APPROVED BY:	GWS	DATE:	NOV. '98

Nicolet Minerals COMPANY

FIGURE 3-1

SITE LAYOUT

Scale: 0 500' 1000' | Date: NOVEMBER, 1998

Prepared By: Foth & Van Dyke | By: KMP | 93C049

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23 NOV 98 kmb

2,277,000 E

2,279,000 E

EXPLOSIVES MAGAZINE

CAP MAGAZINE

AMMONIUM NITRATE STORAGE

30

119,000 N

RUNOFF BASIN #3

PRE-PRODUCTION ORE STORAGE AREA

CONSTRUCTION MATERIAL STORAGE AREA (UNLINED)

RUNOFF BASIN #8

DISCHARGE LAGOON

DISCHARGE LAGOON

PIPELINE ROUTE

PUMP STATION

WASTEWATER STORAGE BASIN #5

WASTEWATER STORAGE BASIN #6

WASTEWATER STORAGE BASIN #7

CONSTRUCTION LAYDOWN AREA

ZINC TAILINGS THICKENER

FRESH/FIRE WATER TANK

POTABLE WATER TANK

SO_2 TANK

LIME SILO

CEMENT/BINDER SILOS

TAILINGS SURGE TANK

TEMPORARY LIME SILO

ACID STORAGE TANK

DEWATERING & LOADOUT BUILDING

ZINC STORAGE

CONCENTRATE THICKENERS

Zn

Pb

Cu

ZINC O/FLOW TANK

FLOTATION BUILDING

REAGENT PREP. & DISTR.

PASTE BACKFILL PLANT

CLARIFIERS

WASTEWATER TREATMENT FACILITIES BUILDING

SEWAGE TREATMENT PLANT

GLAND WATER TANK

PROCESS WATER TANK

GRINDING BUILDING

MAIN SUBSTATION

PROPANE GAS LINE AREA

SOLID WASTE TRANSFER AREA

NATURAL GAS METER STATION

SOLID WASTE ROLLOFF CONTAINERS

RECYCLING BINS

CAR PARK

ACCESS ROAD

COARSE ORE STORAGE SILO (8,000 TONS TOTAL LIVE)

CONSTRUCTION LAYDOWN AREA

ELECTRICAL AREA

SUBSTATION

STANDBY GENERATOR

COMPRESSOR BUILDING

SERVICES BUILDING

2,278,210 E

116,860 N

COLLAR HOUSE

MAIN SHAFT

HOIST HOUSE

MULCH STORAGE AREA

TOPSOIL STOCKPILE

VENT SHAFT WEST

GATE HOUSE

GATE

TRUCK SCALE

TRACK SCALE

PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE

TO TAILINGS MANAGEMENT AREA

117,000 N

STANDBY PROPANE STORAGE

RUNOFF BASIN #2

LUBRICANT STORAGE

BULK FUEL STORAGE

COLD STORAGE

YARD STORAGE

MINE AIR HEATERS

EAST VENT SHAFT

HOIST HOUSE

RUNOFF BASIN #1

N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- SECTION LINE
- ORE BODY

NOTES:

1. 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.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	MLD2	DATE:	NOV. '98
APPROVED BY:	TWS	DATE:	NOV. '98
APPROVED BY:	GWS	DATE:	NOV. '98

Nicolet Minerals COMPANY

Mining for the Future Commitment

FIGURE 3-2

PLANT SITE LAYOUT - BUILDING IDENTIFICATION

Scale: 0 200' 400'		Date:	NOVEMBER, 1998
Prepared By: Foth & Van Dyke	By: JRB2		93C049

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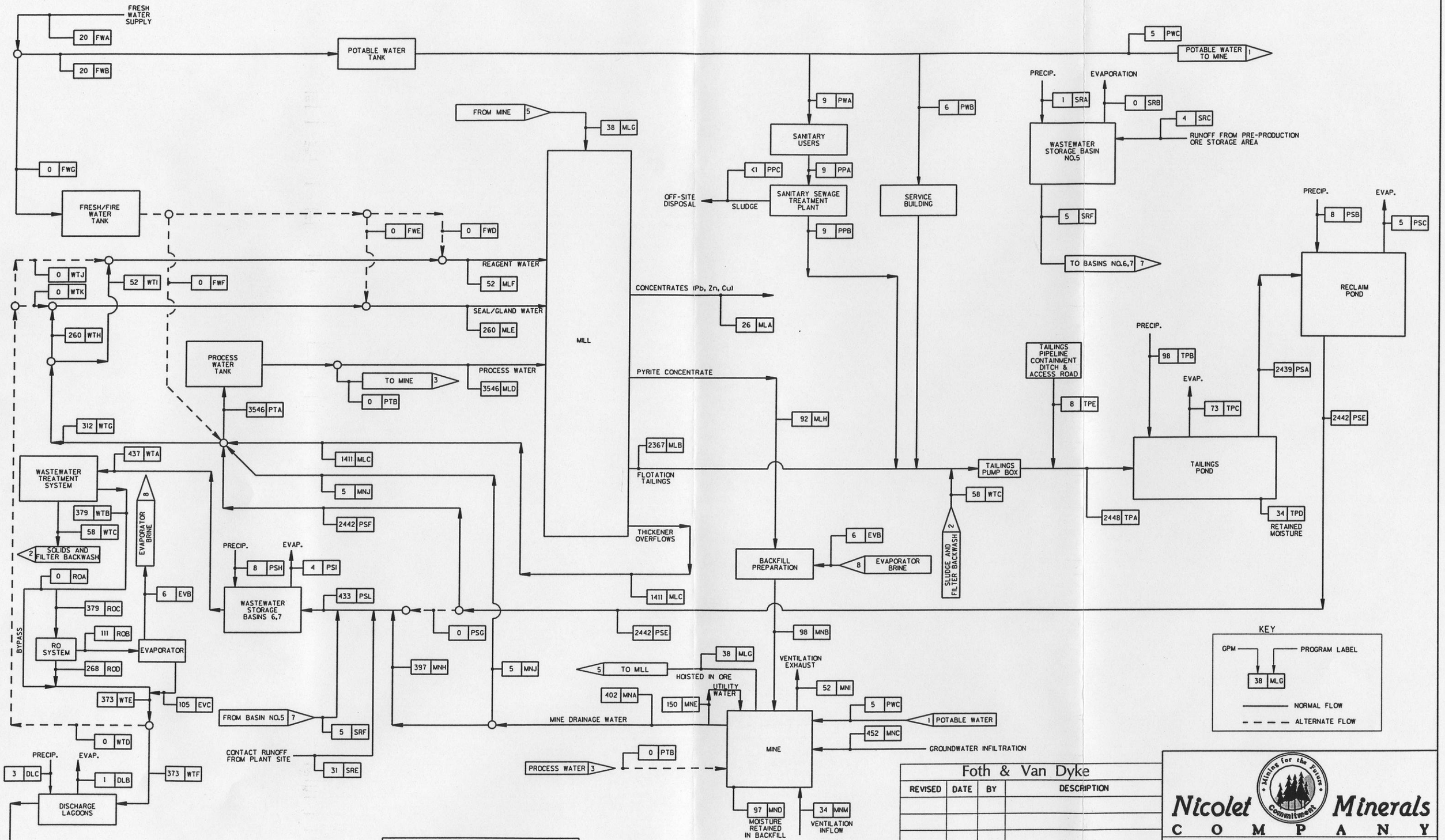

BEJ MINE INFLOW
AVERAGE WEATHER CONDITIONS

KEY

GPM — PROGRAM LABEL

38 MLG

NORMAL FLOW

ALTERNATE FLOW

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	HJA	DATE: NOV. '98
APPROVED BY:	TWS	DATE: NOV. '98
APPROVED BY:	GWS	DATE: NOV. '98

Nicolet Minerals COMPANY

Mining for the Future Commitment

FIGURE 3-3

OVERALL MILL WATER BALANCE
(AVERAGE CONDITIONS)

Scale: NOT TO SCALE		Date: NOVEMBER, 1998	
Prepared By: Foth & Van Dyke	By: GJB	93C049	

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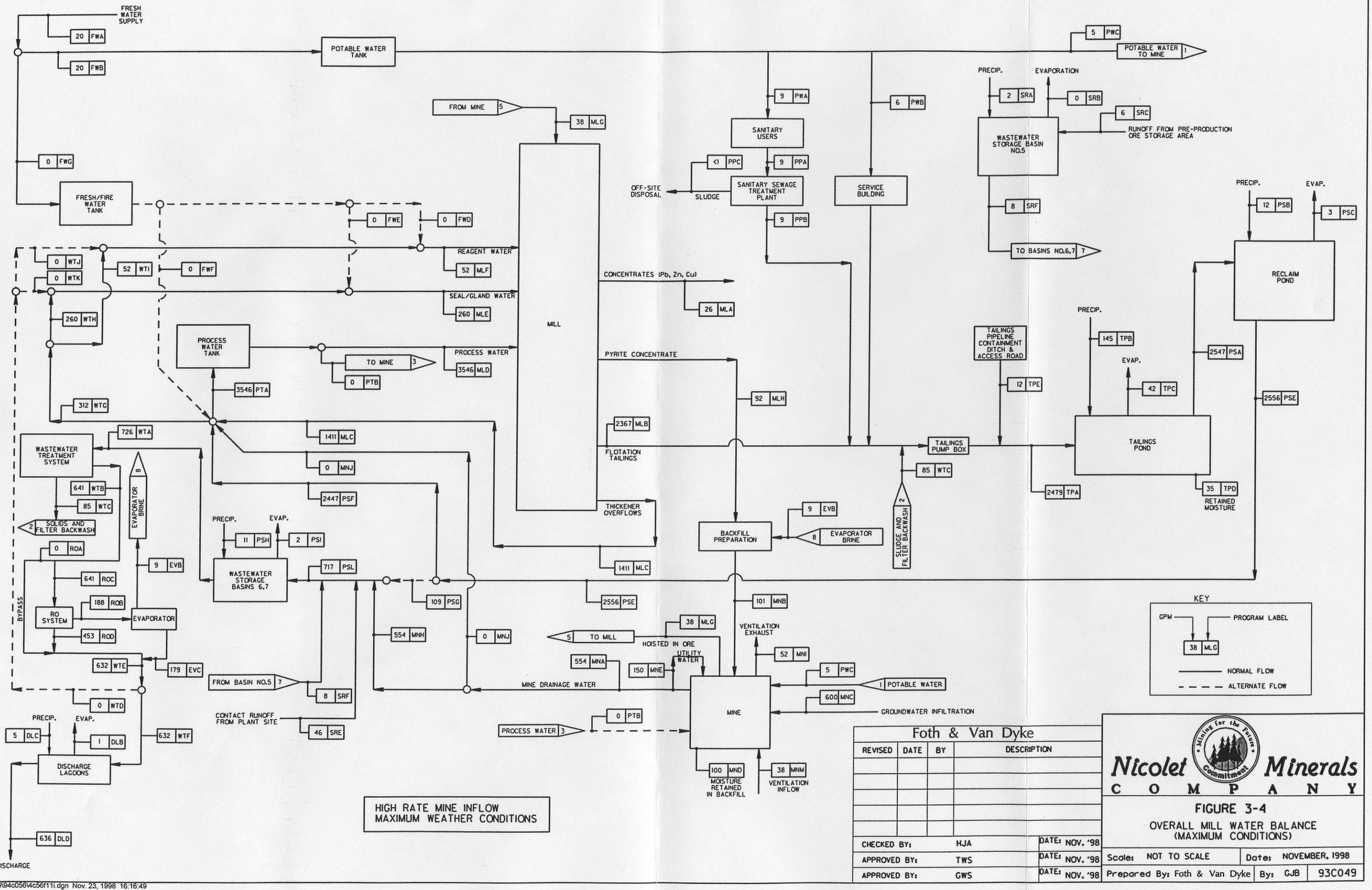

HIGH RATE MINE INFLOW
MAXIMUM WEATHER CONDITIONS

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	HJA	DATE: NOV. '98
APPROVED BY:	TWS	DATE: NOV. '98
APPROVED BY:	GWS	DATE: NOV. '98

Nicolet Minerals COMPANY

Mining for the Future Commitment

FIGURE 3-4

OVERALL MILL WATER BALANCE
(MAXIMUM CONDITIONS)

Scale: NOT TO SCALE	Date: NOVEMBER, 1998	
Prepared By: Foth & Van Dyke	By: GJB	93C049

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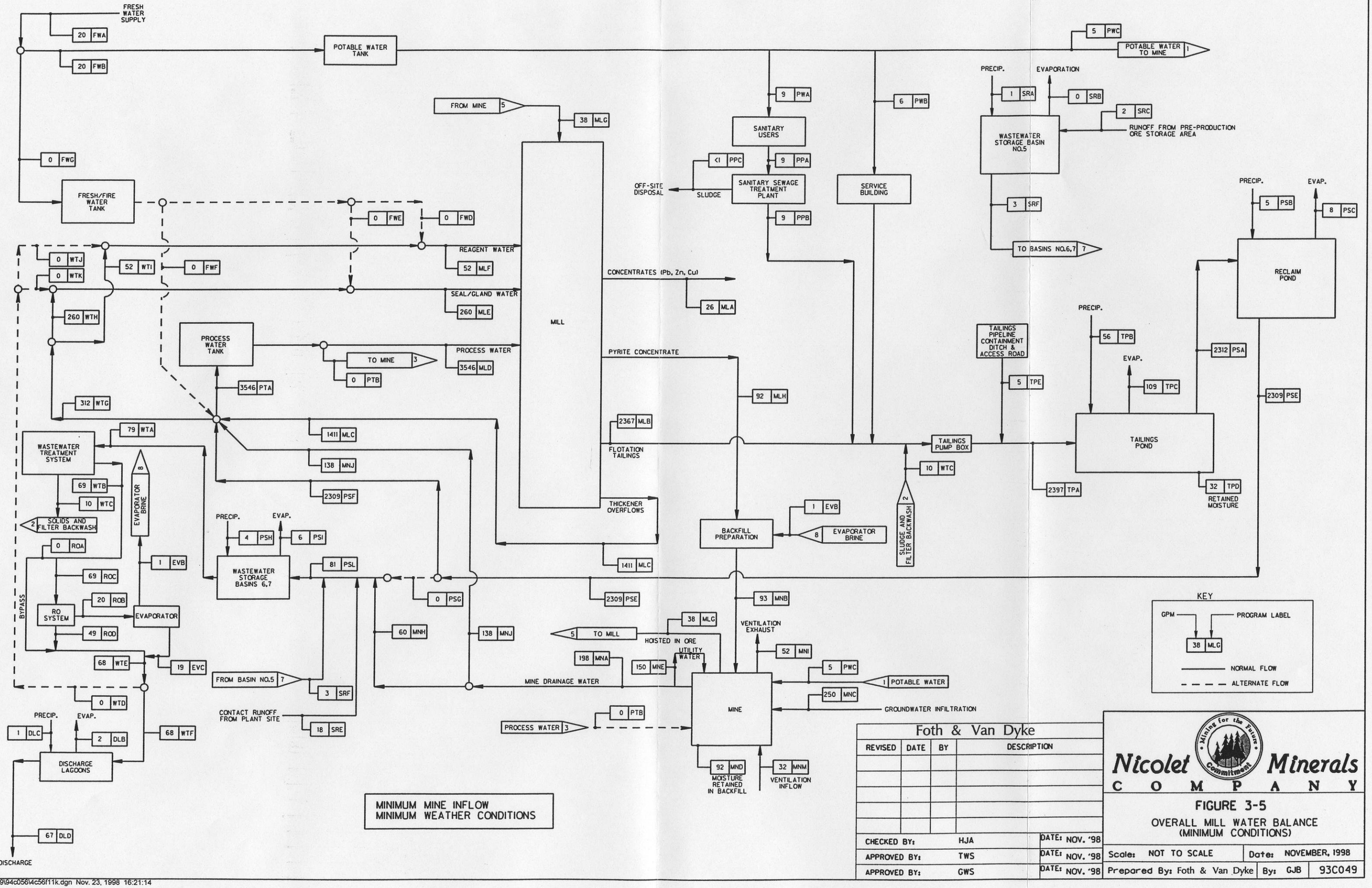

MINIMUM MINE INFLOW
MINIMUM WEATHER CONDITIONS

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	HJA	DATE: NOV. '98
APPROVED BY:	TWS	DATE: NOV. '98
APPROVED BY:	GWS	DATE: NOV. '98

Nicolet Minerals COMPANY

Mining for the Future • Commitment

FIGURE 3-5

OVERALL MILL WATER BALANCE
(MINIMUM CONDITIONS)

Scale: NOT TO SCALE		Date: NOVEMBER, 1998	
Prepared By: Foth & Van Dyke	By: GJB		93C049

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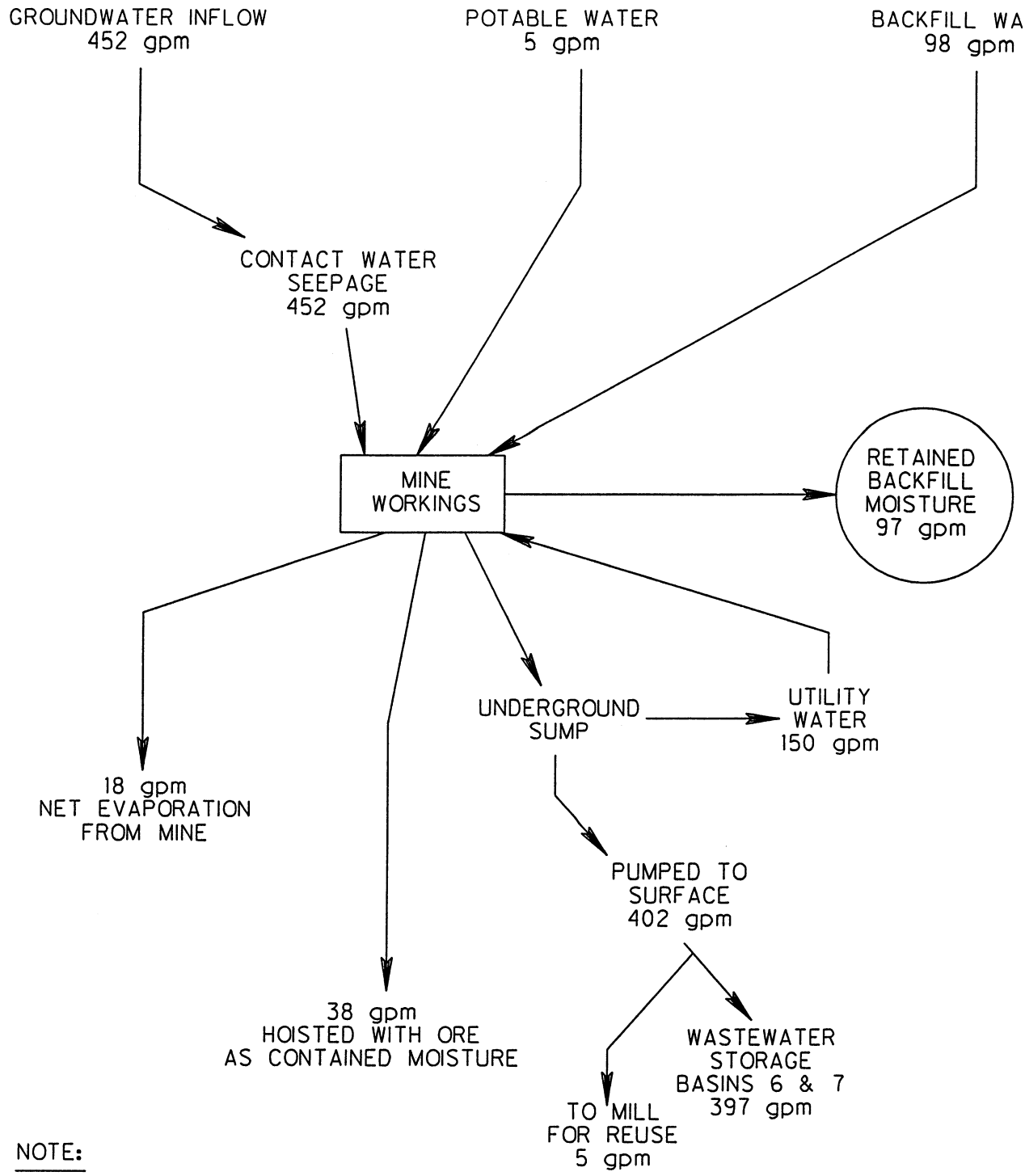


NOTE:

FLOW RATES SHOWN ARE BASED ON THE ROUNDED BEST ENGINEERING JUDGEMENT ESTIMATE FOR GROUNDWATER INFLOW AND AVERAGE FLOW CONDITIONS FOR OTHER FLOWS.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	HJA	DATE: NOV '98
APPROVED BY:	TWS	DATE: NOV '98
APPROVED BY:	GWS	DATE: NOV '98

Nicolet Minerals COMPANY

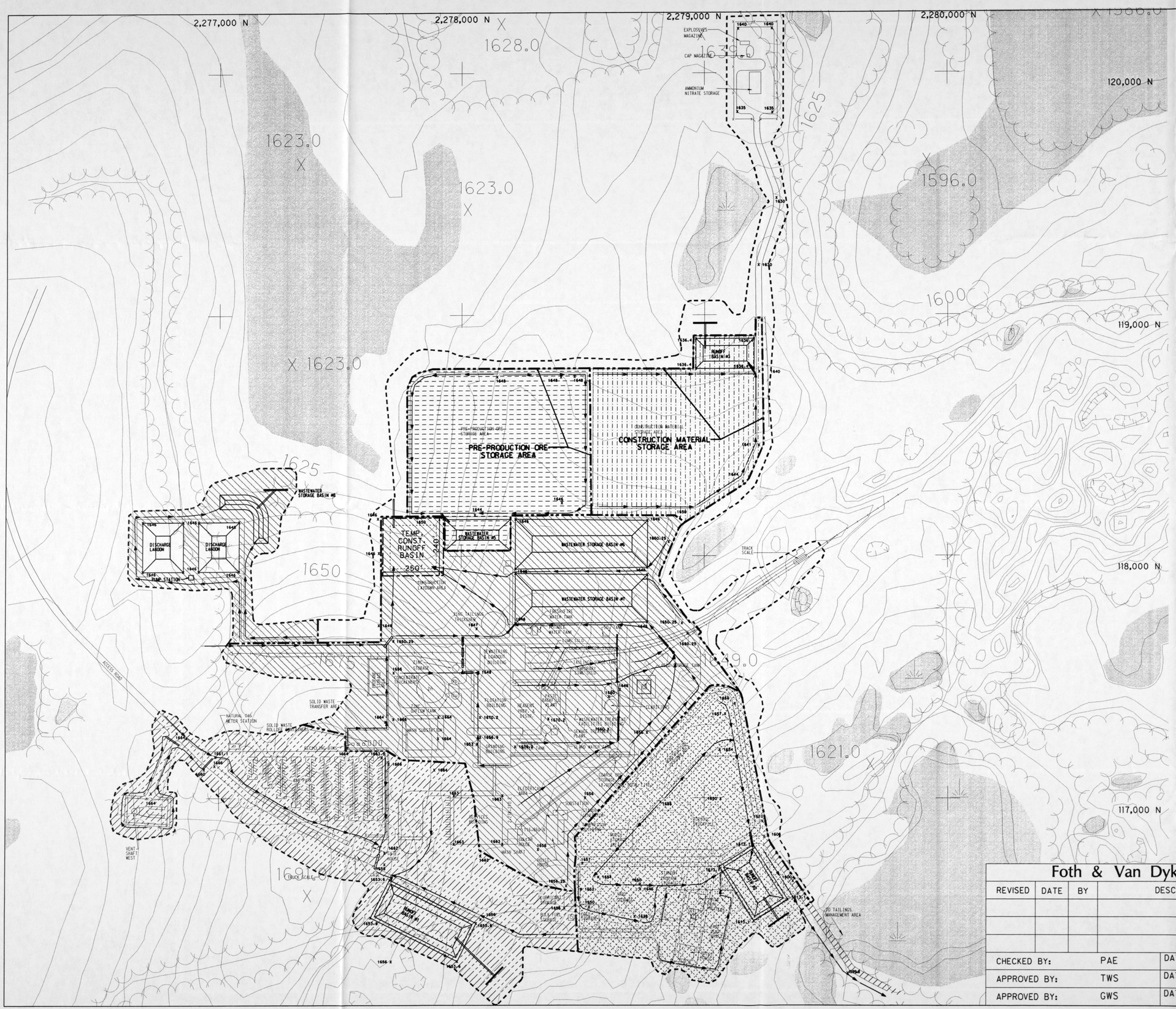
Mining for the Future • Commitment

FIGURE 3-6

MINE DRAINAGE SCHEMATIC & WATER BALANCE

Scale: NOT TO SCALE		Date: NOVEMBER, 1998	
Prepared By: Foth & Van Dyke		By: JOW	93C049

I:\93c049\94c062\4c62f65.dgn Nov. 21, 1998 12:59:37



LEGEND

- EXISTING CONTOUR (1600)
- EXISTING SPOT ELEVATION (x 1677.0)
- EXISTING TRAIL
- EXISTING TREELINE
- EXISTING WETLANDS
- PROPOSED LIMITS OF PLANT SITE DISTURBANCE
- PROPOSED LIMITS OF SURFACE WATER DRAINAGE
- PROPOSED STRUCTURE OR BUILDING
- PROPOSED RAILROAD SPUR
- PROPOSED DRAINAGE DITCH
- PROPOSED CULVERT
- PROPOSED SPOT ELEVATION (x 1648)
- SOUTHWEST RUNOFF DRAINAGE AREA - TO BASIN 1
- SOUTHEAST RUNOFF DRAINAGE AREA - TO BASIN 2
- CONSTRUCTION MATERIAL STORAGE RUNOFF DRAINAGE AREA - TO BASIN 3
- PREPRODUCTION ORE STORAGE RUNOFF DRAINAGE AREA - TO BASIN 5
- CENTRAL RUNOFF DRAINAGE AREA - TO BASINS 6 & 7
- TAILINGS PIPELINE TO DITCH/ACCESS ROAD DRAINAGE AREA - TO BASIN 4 (DRAIN DOWN SUMP)

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. SLIGHT REVISIONS IN THE PLANT SITE FACILITIES MAY OCCUR DURING FINALIZATION OF THE MINE PERMIT APPLICATION. HOWEVER DISCHARGE AREAS FOR EACH BASIN SHOULD REMAIN RELATIVELY UNCHANGED.
5. APPROXIMATE DRAINAGE AREAS:

BASIN NO. 1	24.7 ACRES
BASIN NO. 2	17.9 ACRES
BASIN NO. 3	12.8 ACRES
BASIN NO. 5	11.5 ACRES
BASIN NO. 6 & 7	35.6 ACRES
BASIN NO. 8	9.3 ACRES

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APPROVED BY:	GWS	DATE:	NOV. '98

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FIGURE 3-7

PLANT SITE RUNOFF AREAS

Scale: 0 200' 400'

Date: NOVEMBER, 1998

Prepared By: Foth & Van Dyke | By: JRB2 | 93C049

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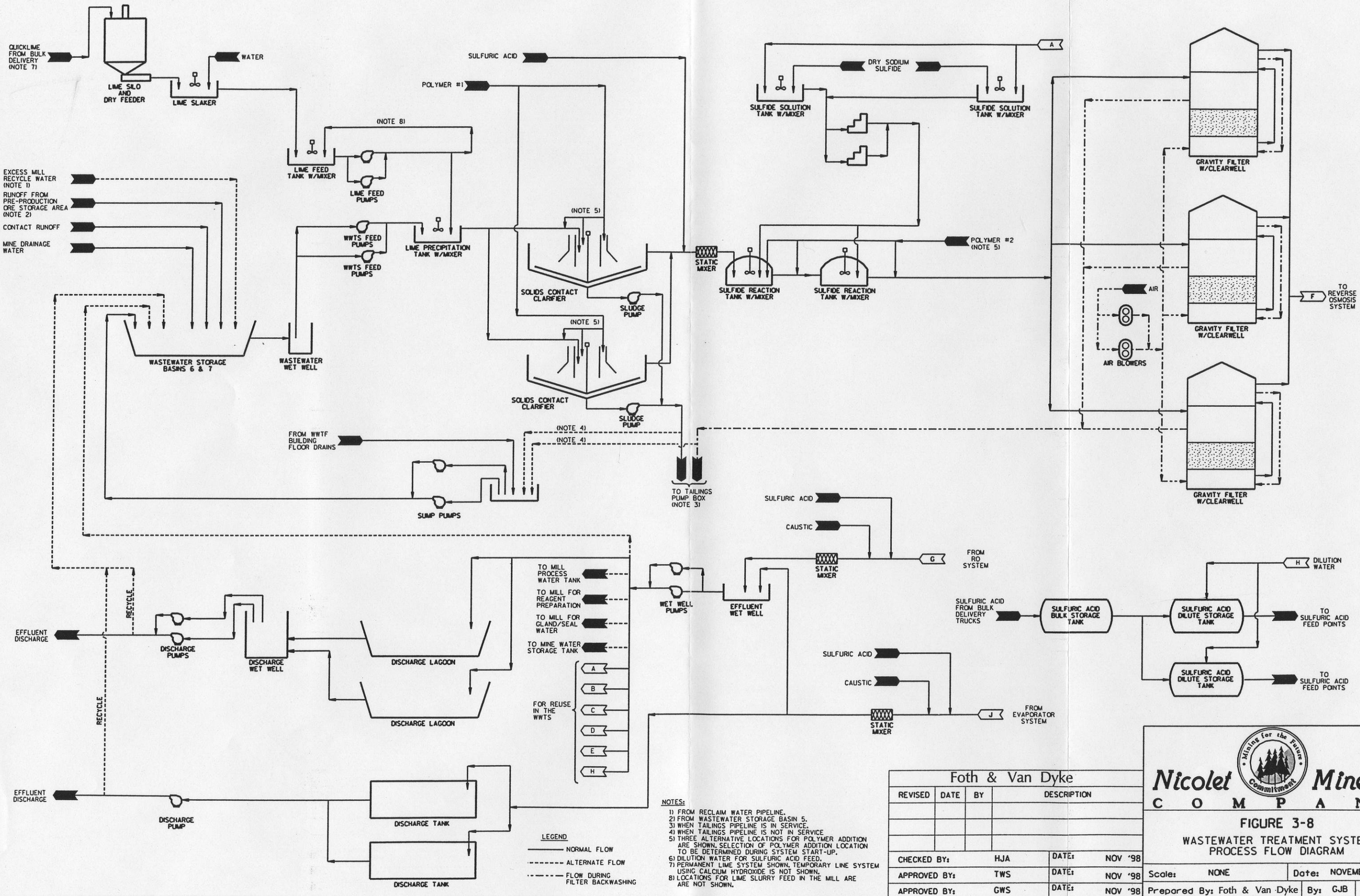
23 NOV 98 kmb



NOTES:

1) FROM RECLAIM WATER PIPELINE.
2) FROM WASTEWATER STORAGE BASIN 5.
3) WHEN TAILINGS PIPELINE IS IN SERVICE.
4) WHEN TAILINGS PIPELINE IS NOT IN SERVICE
5) THREE ALTERNATIVE LOCATIONS FOR POLYMER ADDITION ARE SHOWN. SELECTION OF POLYMER ADDITION LOCATION TO BE DETERMINED DURING SYSTEM START-UP.
6) DILUTION WATER FOR SULFURIC ACID FEED.
7) PERMANENT LIME SYSTEM SHOWN. TEMPORARY LINE SYSTEM USING CALCIUM HYDROXIDE IS NOT SHOWN.
8) LOCATIONS FOR LIME SLURRY FEED IN THE MILL ARE ARE NOT SHOWN.

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APPROVED BY:	TWS	DATE:	NOV '98
APPROVED BY:	GWS	DATE:	NOV '98

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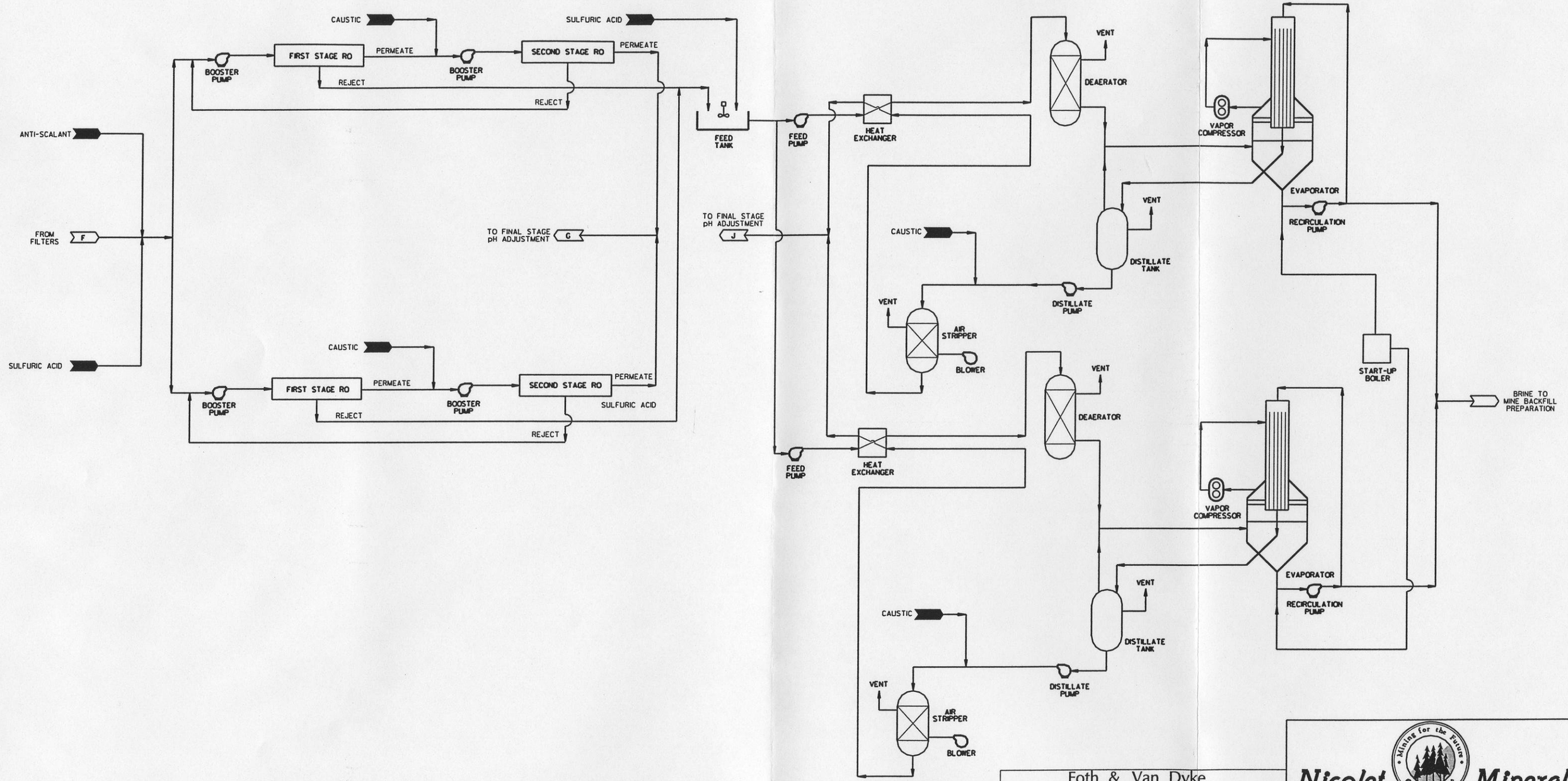
FIGURE 3-8

WASTEWATER TREATMENT SYSTEM PROCESS FLOW DIAGRAM

Scale: NONE		Date: NOVEMBER, 1998	
Prepared By: Foth & Van Dyke	By: GJB		93C049

I:\93c049\94c056\4c56f18.dgn Nov. 21, 1998 13:10:12



Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	HJA	DATE:	NOV '98
APPROVED BY:	TWS	DATE:	NOV '98
APPROVED BY:	GWS	DATE:	NOV '98

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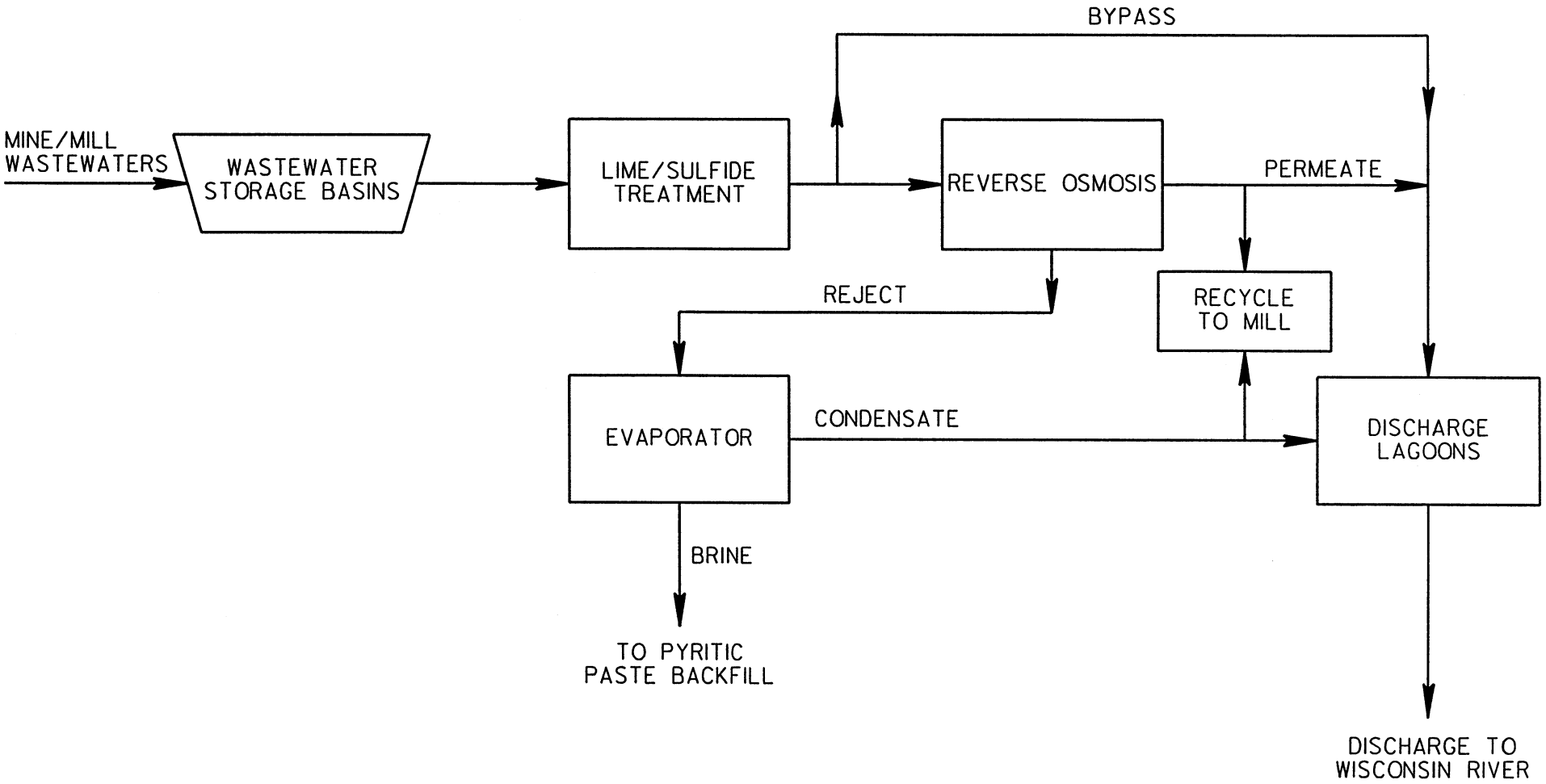
FIGURE 3-9

WASTEWATER TREATMENT SYSTEM
PROCESS FLOW DIAGRAM

Scale: NONE		Date: NOVEMBER, 1998	
Prepared By: Foth & Van Dyke		By: GJB	93C049

I:\93c049\94c056\4c56f36.dgn Nov. 21, 1998 13:15:20



Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION
CHECKED BY:	HJA	DATE: NOV '98	
APPROVED BY:	TWS	DATE: NOV '98	
APPROVED BY:	GWS	DATE: NOV '98	

Nicolet Minerals COMPANY

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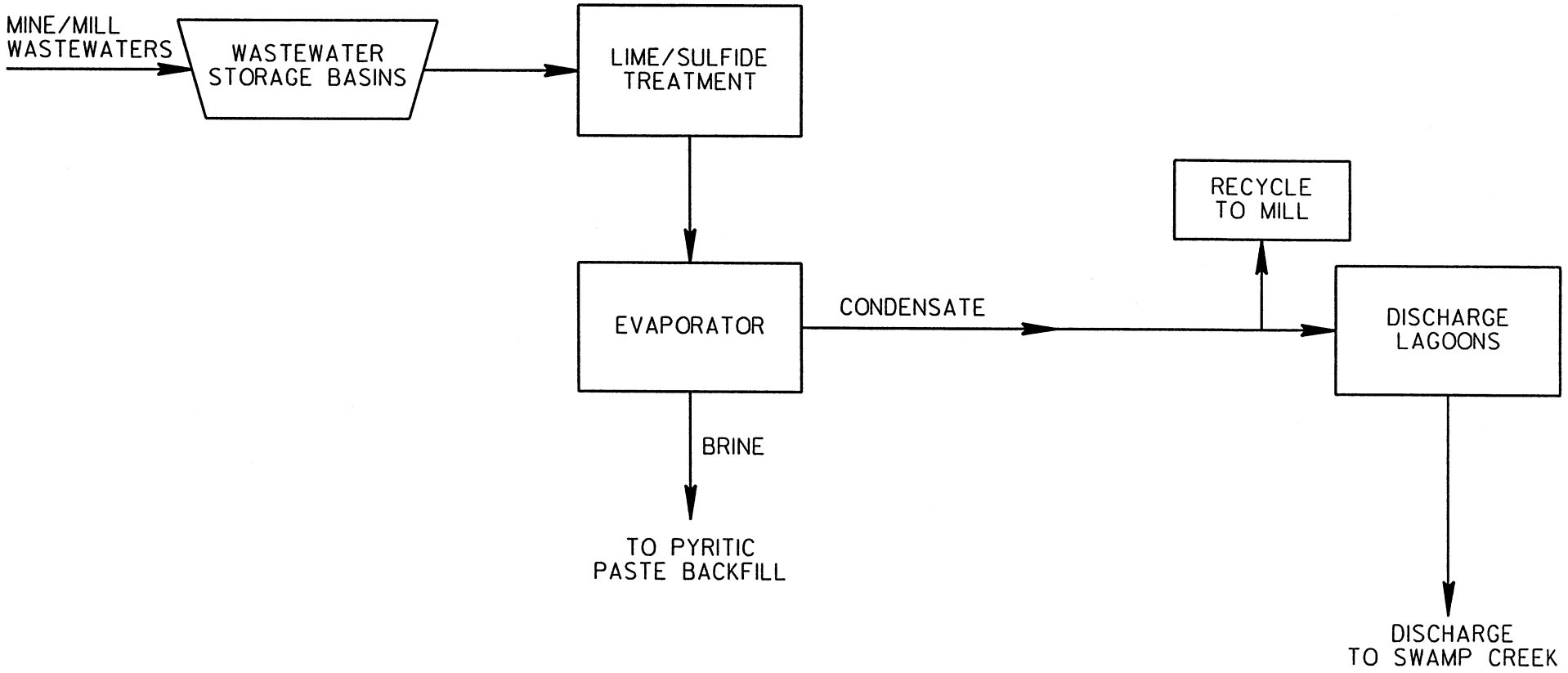
FIGURE 5-1

TREATMENT TECHNOLOGY FOR WISCONSIN RIVER DISCHARGE

Scale: NOT TO SCALE	Date: NOVEMBER, 1998	
Prepared By: Foth & Van Dyke	By: JRB2	93C049

I:\93c049\94c056\4c56f83.dgn Nov. 21, 1998 13:16:34



Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	HJA	DATE: NOV '98
APPROVED BY:	TWS	DATE: NOV '98
APPROVED BY:	GWS	DATE: NOV '98

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FIGURE 5-2

TREATMENT TECHNOLOGY FOR
SWAMP CREEK DISCHARGE

Scale: NOT TO SCALE		Date: NOVEMBER, 1998	
Prepared By: Foth & Van Dyke	By: JRB2	93C049	

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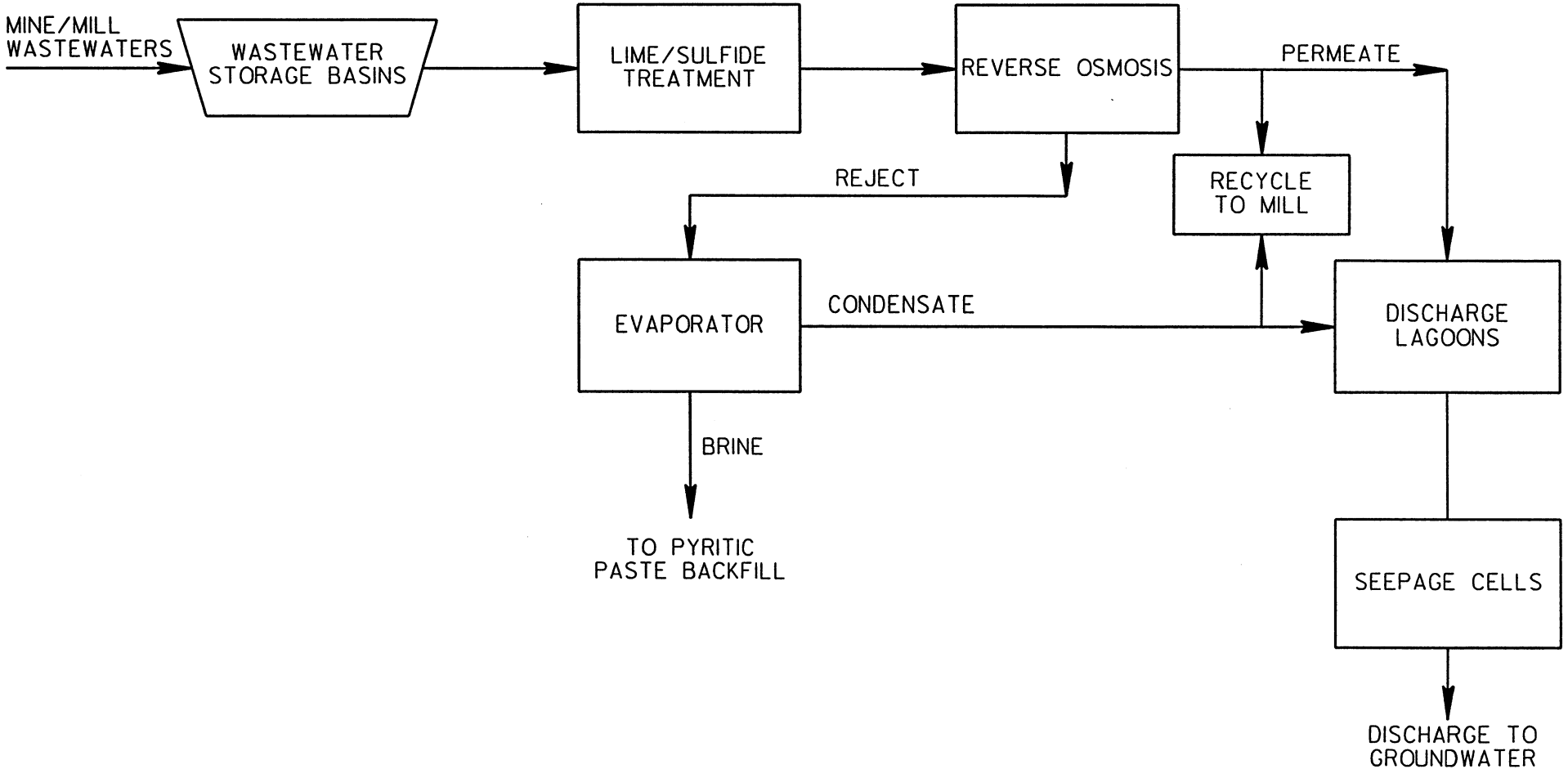

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CHECKED BY:	HJA	DATE: NOV '98
APPROVED BY:	TWS	DATE: NOV '98
APPROVED BY:	GWS	DATE: NOV '98

Nicolet Minerals COMPANY

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FIGURE 5-3

TREATMENT TECHNOLOGY FOR GROUNDWATER DISCHARGE

Scale: NOT TO SCALE		Date: NOVEMBER, 1998	
Prepared By: Foth & Van Dyke	By: JRB2		93C049

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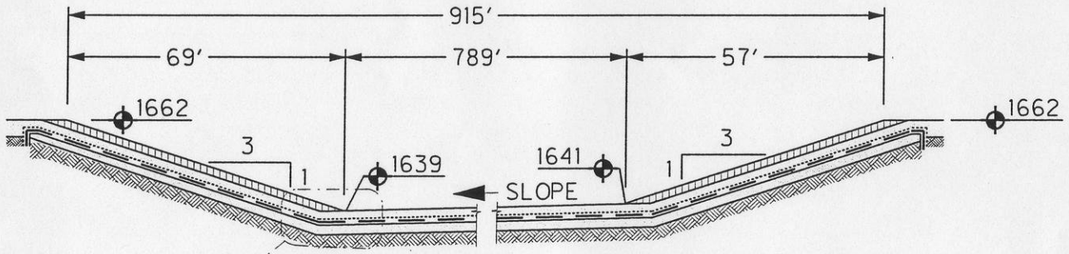
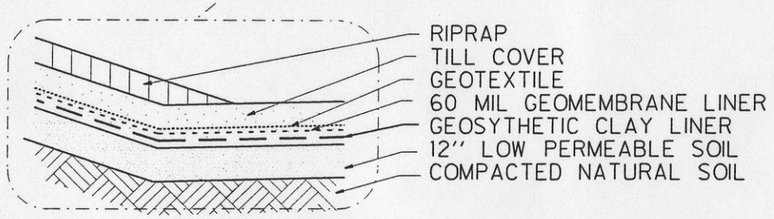
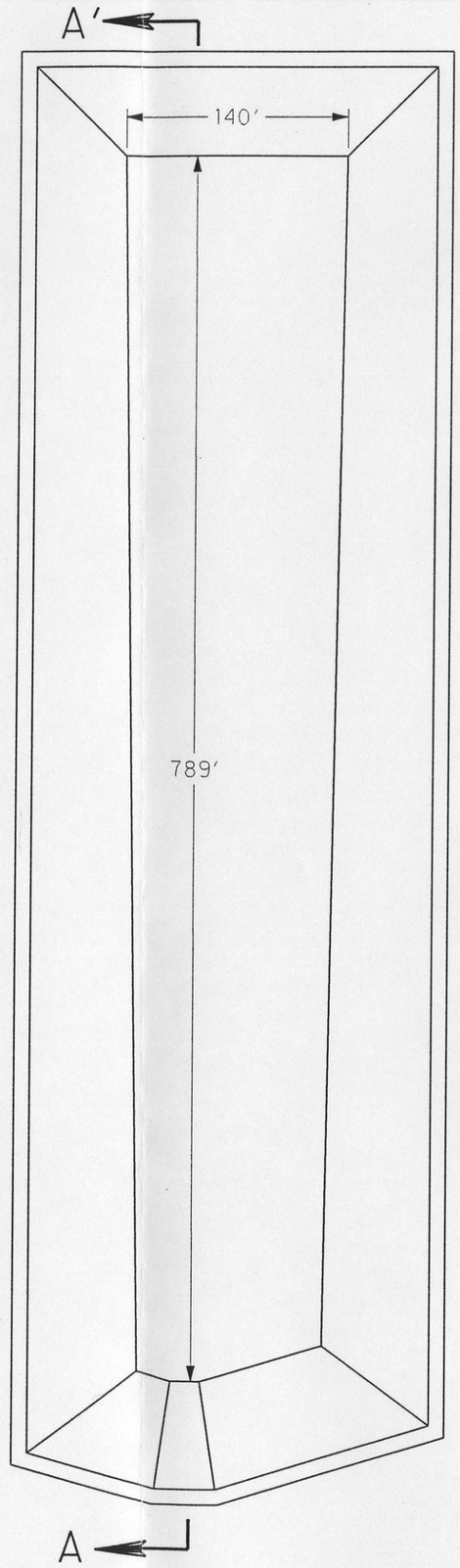




SECTION A - A'

NOT TO SCALE



PLAN

SCALE: 1'' = 100'

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	DMR	DATE:	NOV. '98
APPROVED BY:	TWS	DATE:	NOV. '98
APPROVED BY:	GWS	DATE:	NOV. '98

Nicolet Minerals COMPANY

FIGURE 6-1

RECLAIM POND
PLAN AND SECTION

Scale: 0 50' 100' | Date: NOVEMBER, 1998

Prepared By: Foth & Van Dyke | By: JRB2 | 93C049

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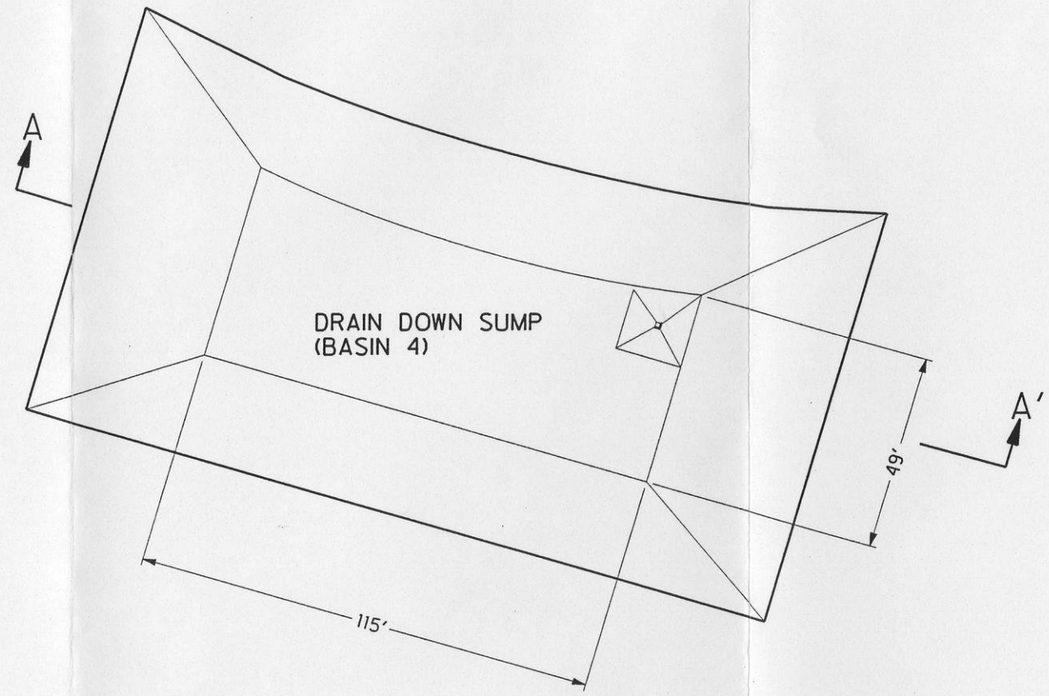
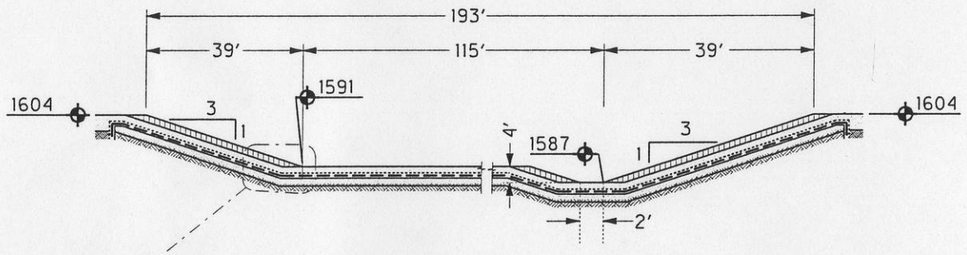


PLAN

0 20' 40'



SECTION A - A'

NOT TO SCALE

TYPICAL REPRESENTATION:
REFINEMENTS MAY BE MADE
PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	DMR	DATE:	NOV '98
APPROVED BY:	TWS	DATE:	NOV '98
APPROVED BY:	GWS	DATE:	NOV '98

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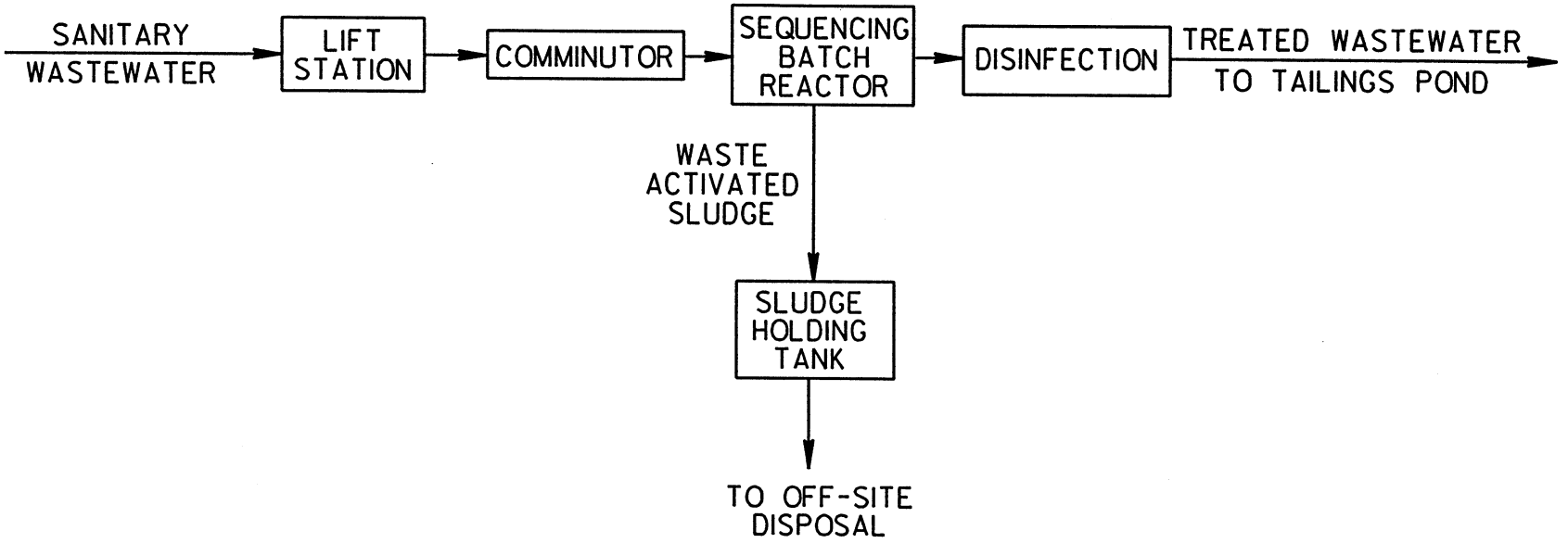
FIGURE 6-2

DRAIN DOWN SUMP (BASIN 4)
PLAN AND SECTION

Scale: NOT TO SCALE		Date: NOVEMBER, 1998	
Prepared By: Foth & Van Dyke	By: JOW	93C049	

I:\93c049\per-plan\3c49f6-2.3d Nov. 24, 1998 15:06:54



Foth & Van Dyke

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CHECKED BY:	JJFI	DATE: NOV '98
APPROVED BY:	TWS	DATE: NOV '98
APPROVED BY:	GWS	DATE: NOV '98

Nicolet Minerals COMPANY

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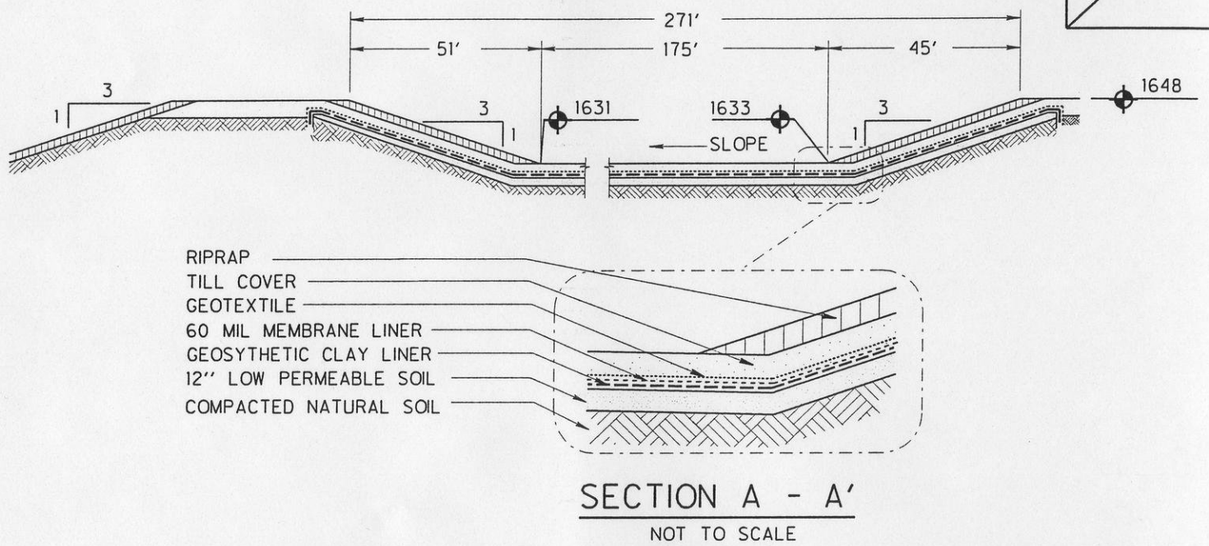
FIGURE 6-3

SEWAGE TREATMENT PLANT
SCHEMATIC FLOW DIAGRAM

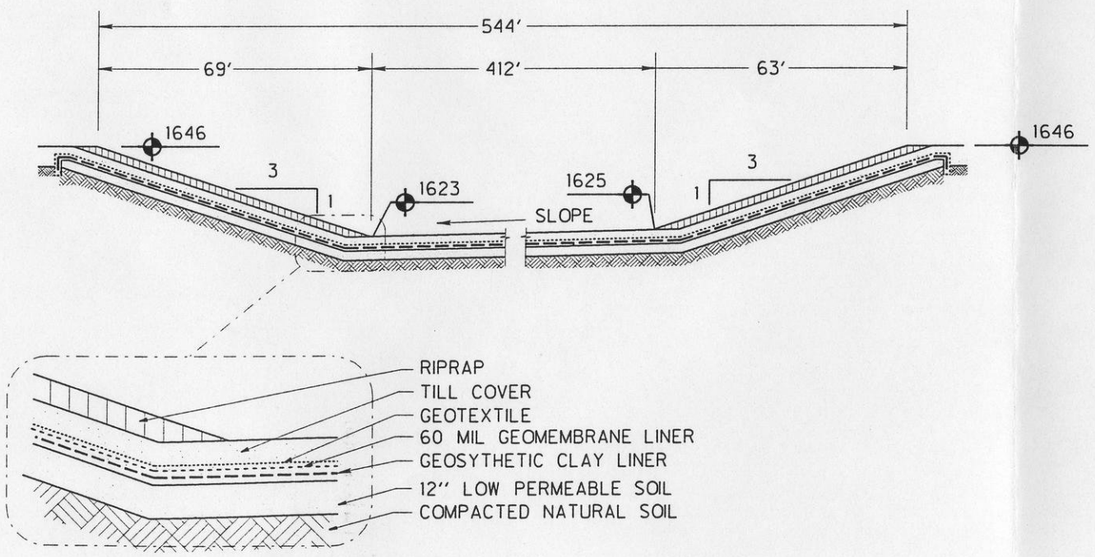
Scale: NOT TO SCALE		Date: NOVEMBER, 1998	
Prepared By: Foth & Van Dyke	By: JRB2		93C049

I:\93c049\94c056\4c56f82.dgn Nov. 24, 1998 14:56:34



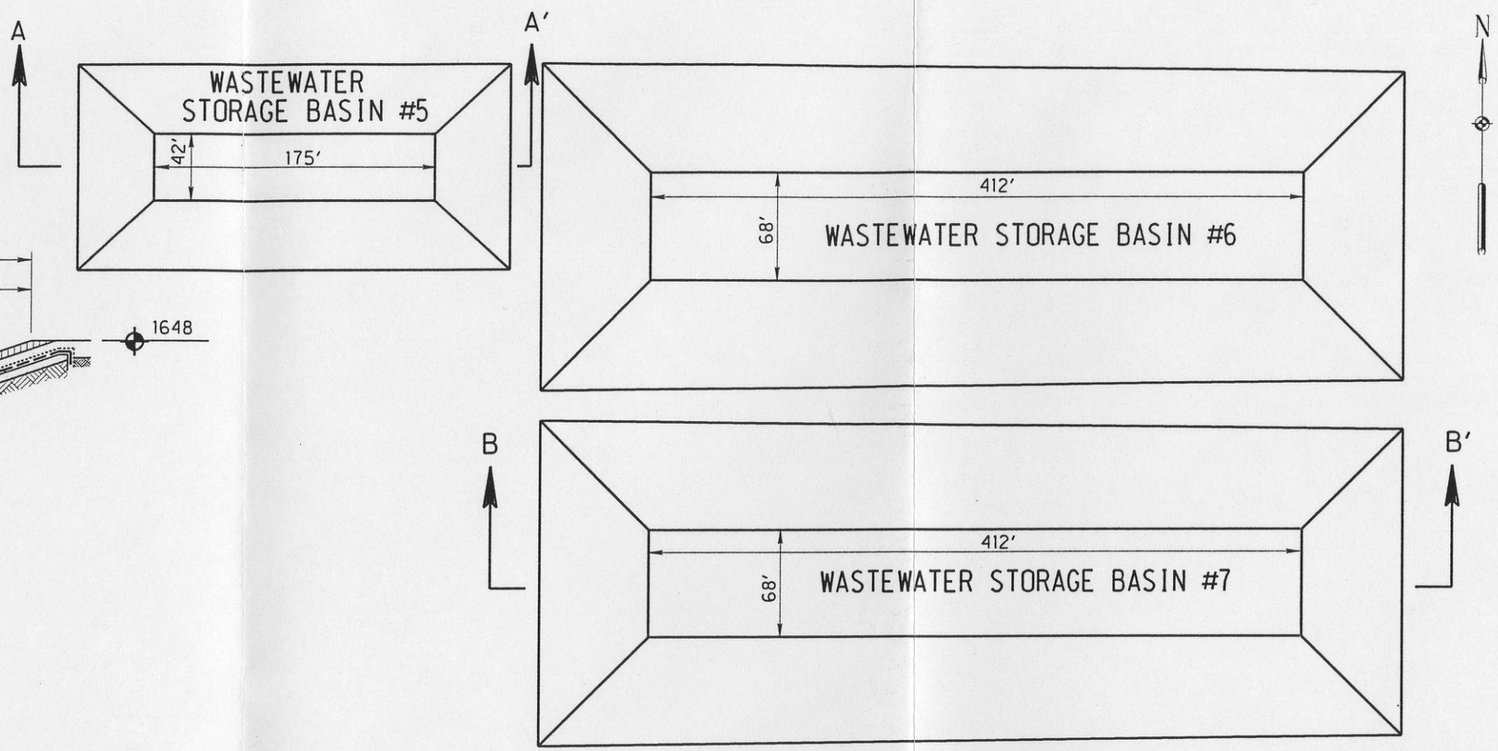
SECTION A - A′

NOT TO SCALE



SECTION B - B′

NOT TO SCALE



PLAN

0 5′ 10′

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

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APPROVED BY:	TWS	DATE:	NOV. '98
APPROVED BY:	GWS	DATE:	NOV. '98

Nicolet Minerals COMPANY

FIGURE 6-4

WASTEWATER STORAGE BASINS 5, 6 AND 7
PLAN AND SECTIONS

Scale: NOT TO SCALE		Date: NOVEMBER, 1998	
Prepared By: Foth & Van Dyke	By: JRB2		93C049

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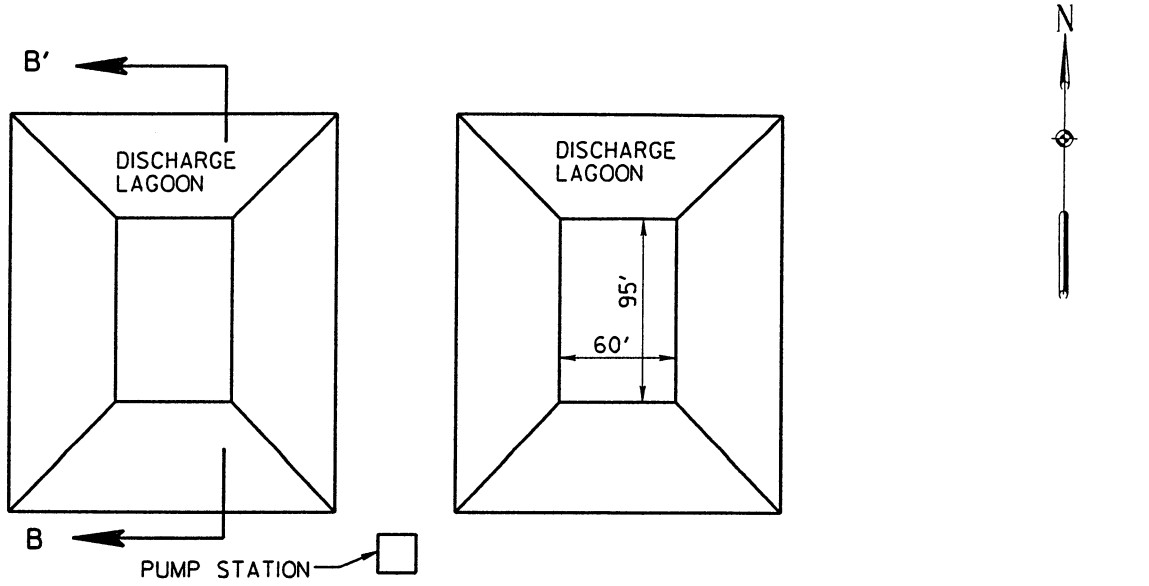
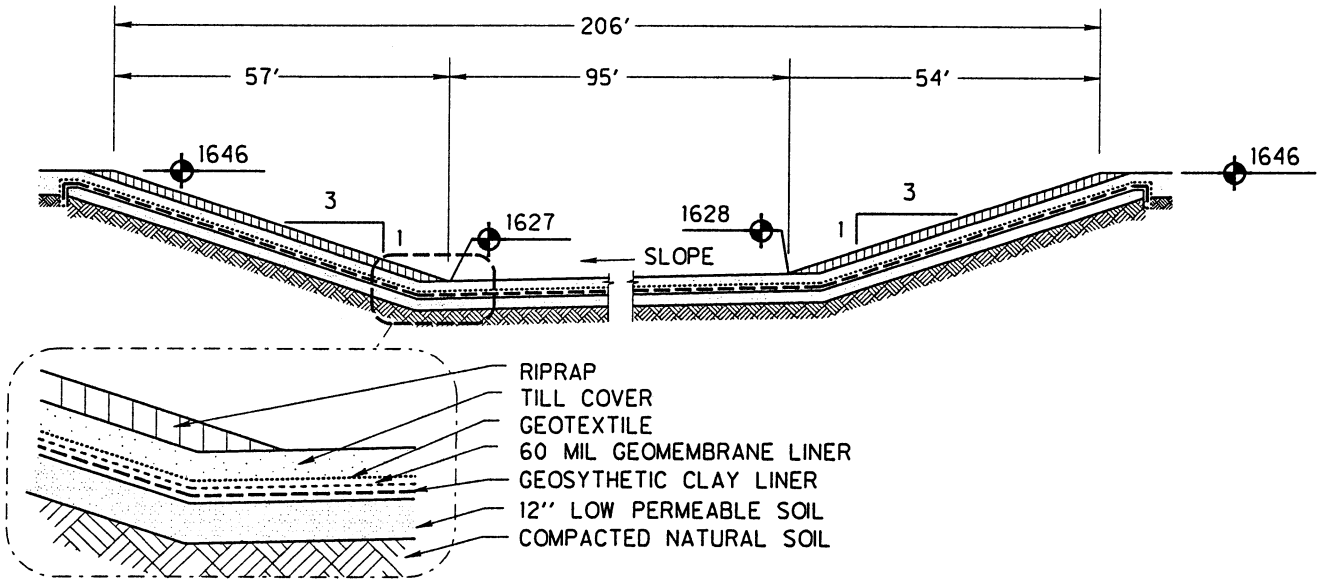


PLAN

0 5' 10'



SECTION B - B'

NOT TO SCALE

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	HJA	DATE: NOV '98
APPROVED BY:	TWS	DATE: NOV '98
APPROVED BY:	GWS	DATE: NOV '98

Nicolet Minerals COMPANY

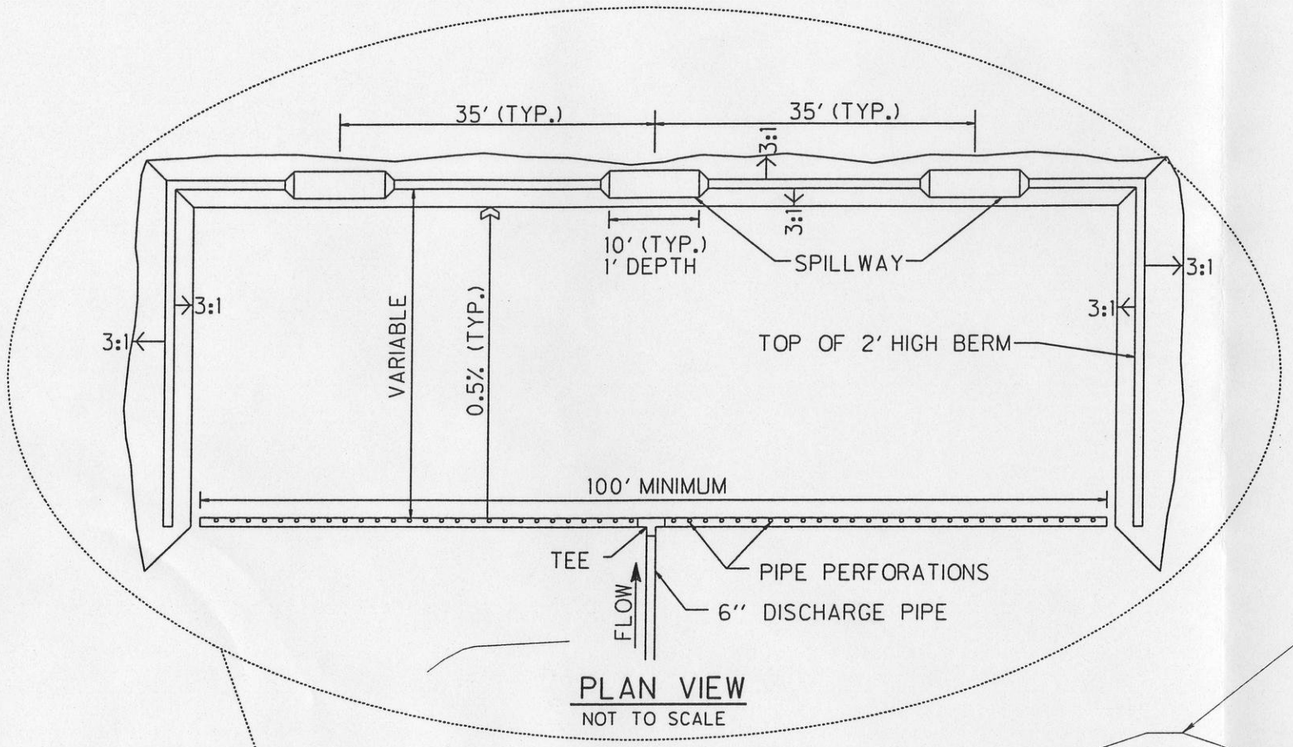
Mining for the Future Commitment

FIGURE 6-5

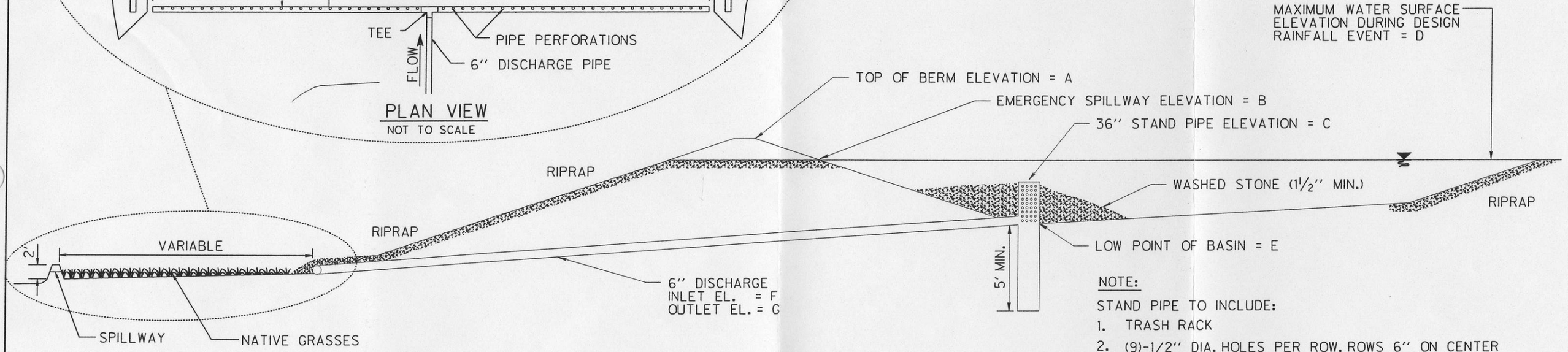
DISCHARGE LAGOON
PLAN AND SECTION

Scale: NOT TO SCALE		Date: NOVEMBER, 1998	
Prepared By: Foth & Van Dyke		By: JRB2	93C049

I:\93c049\per-plan\3c49f6-4.3d Nov. 21, 1998 13:25:53



PLAN VIEW
NOT TO SCALE



NOTE:

STAND PIPE TO INCLUDE:

1. TRASH RACK
2. (9)-1/2" DIA. HOLES PER ROW, ROWS 6" ON CENTER
3. WRAP WITH AKZO ENKADRAIN 9120 OR EQUAL

PLANT SITE RUNOFF BASINS

NOT TO SCALE

	DESIGN STORM EVENT (24 HOUR)	A	B	C	D	E	F	G
RUNOFF BASIN 1	25 YR.	1656.00	1653.00	1651.50	1653.00	1646.00	1646.00	1644.00
RUNOFF BASIN 2	25 YR.	1615.00	1612.80	1610.50	1612.71	1605.00	1605.00	1603.00
RUNOFF BASIN 3	100 YR.	1639.00	1636.90	1634.50	1636.87	1629.00	1629.00	1627.00
RUNOFF BASIN 8	25 YR.	1646.00	1644.20	1643.50	1644.14	1639.00	1639.00	1637.00

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

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REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	HJA	DATE:	NOV '98
APPROVED BY:	PAE	DATE:	NOV '98
APPROVED BY:	GWS	DATE:	NOV '98

Nicolet Minerals COMPANY

FIGURE 6-6

RUNOFF BASINS 1, 2, 3, & 8

Scale: NOT TO SCALE		Date: NOVEMBER, 1998	
Prepared By: Foth & Van Dyke	By: JOW	93C049	

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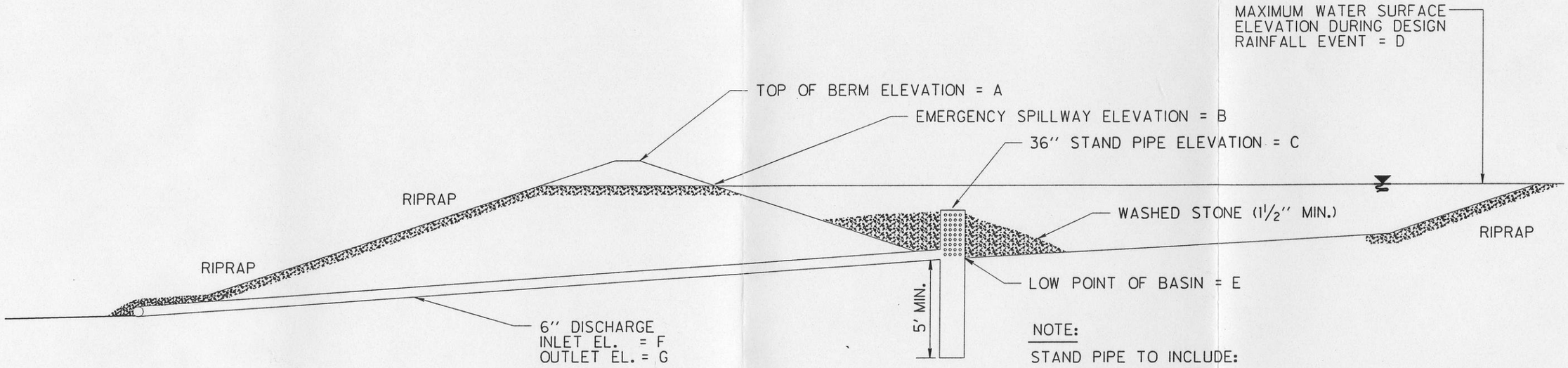

TEMPORARY CONSTRUCTION RUNOFF BASIN

NOT TO SCALE

	DESIGN STORM EVENT (24 HOUR)	A	B	C	D	E	F	G
TEMPORARY RUNOFF BASIN	25 YR.	1646.00	1644.5	1641.50	1644.27	1636.00	1636.00	1633.00

NOTE:

STAND PIPE TO INCLUDE:

1. TRASH RACK
2. (9)-1/2'' DIA. HOLES PER ROW, ROWS 6'' ON CENTER
3. WRAP WITH AKZO ENKADRAIN 9120 OR EQUAL
4. TEMPORARY CONSTRUCTION RUNOFF BASIN FOR PREPRODUCTION ORE STORAGE RUNOFF DRAINAGE AREA AND CENTRAL RUNOFF DRAINAGE AREA PRIOR TO CONTACT CONDITIONS DEVELOPING.
5. FOLLOWING STARTUP OF WASTEWATER TREATMENT PLANT THE TEMPORARY CONSTRUCTION RUNOFF BASIN WILL BE RELOCATED AND CONVERTED TO A CONSTRUCTION LAYDOWN AREA.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

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REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	HJA	DATE:	NOV '98
APPROVED BY:	SRB	DATE:	NOV '98
APPROVED BY:	PAE	DATE:	NOV '98

Nicolet Minerals COMPANY

FIGURE 6-7

TEMPORARY CONSTRUCTION RUNOFF BASIN

Scale: NOT TO SCALE	Date: NOVEMBER, 1998		
Prepared By: Foth & Van Dyke	By: JOW	93C049	

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Appendix A

Wastewater Treatability Study for the Crandon Project

Wastewater Treatability Study 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.

September 1995

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

Appendix A

Wastewater Treatability Study for the Crandon Project

Contents

Tables

Page

Figures

Appendix A

Wastewater Treatability Study for the Crandon Project

A.1 Introduction

Crandon Mining Company intends to develop an underground mining facility near Crandon, Wisconsin. Engineering efforts associated with development of the Crandon Project have indicated that mine drainage, intercepted groundwater, and excess mill process water will be discharged from the project site.

The proposed discharge site for treated wastewater is the Wisconsin River. Wastewaters discharged from the project site will be required to meet effluent limitations that will be set by the Wisconsin Department of Natural Resources (WDNR) for discharge to the Wisconsin River. To meet these limitations, wastewater will require treatment prior to discharge. Based on the estimated characteristics of the mine drainage and mill process water, and on estimated effluent limitations for discharge to the Wisconsin River, a treatment system process design was selected. The treatment system will include lime precipitation, gravity settling, sulfide precipitation, filtration, and pH adjustment. To evaluate the treatment processes selected for the Crandon Project, a wastewater treatability study was conducted. This Appendix provides a summary of the test procedures and their results.

The data presented in this Appendix are designed to demonstrate the effectiveness of the proposed treatment system. All treatability testing was conducted at the Foth & Van Dyke Green Bay offices. Analytical testing of wastewater samples was performed by Pace Incorporated of Minneapolis, Minnesota, and Northern Lakes Service, Inc. of Crandon, Wisconsin. Whole effluent toxicity testing was performed by Integrated Paper Services, Inc. of Appleton, Wisconsin.

A.2 Overview of the Wastewater Treatability Study

The processes for treatment of wastewaters generated at the Crandon Project includes lime precipitation, gravity settling, sulfide precipitation, filtration, and pH adjustment. The primary objectives of the wastewater treatment system are neutralization and the removal of heavy metals and suspended solids present in the wastewater. The present study was designed to evaluate the adequacy and efficiency of the treatment processes for these purposes.

The wastewater treatability study included three separate phases. In the first phase, the selected treatment processes were evaluated for treating mine drainage. The evaluation included optimization of the lime precipitation process, and optimization of the sulfide precipitation process. Additionally, the effectiveness of the combined treatment process and the whole effluent toxicity of the treated effluent were evaluated. Phase II of the treatability study further evaluated the selected treatment processes when treating mine drainage. The purpose of this phase was to further optimize the sulfide precipitation process, to verify the results of Phase I,

and to obtain additional information on whole effluent toxicity of the treated mine wastewater effluent. Phase III of the treatability study evaluated the selected treatment processes when treating mill process wastewater. Phase III included sulfide optimization and whole effluent toxicity testing of the treated mill process water.

A.2.1 Wastewater Treatability Study - Phase I

Phase I of the wastewater treatability study simulated each step of the treatment process when treating mine drainage, sequencing the various treatment processes in the order in which they are planned to occur. Effluent samples were analyzed after each level of treatment to determine the treatment capabilities of each individual treatment process. The level of treatment for each treatment process was optimized before proceeding to evaluation of the next treatment process. This sequencing of optimization was followed throughout the Phase I testing. Thus, each level of treatment was built upon the optimal performance of the previous treatment process.

The following discussion described the four steps completed as part of Phase I of the treatability study. The first step in the study was generation of wastewater to be used in the evaluation of the selected treatment processes. Steps II, III, and IV involved testing of the lime precipitation, the sulfide precipitation, and the filtration processes, respectively.

A.2.1.1 Step I - Wastewater Generation

Because mining activities have not commenced, the wastewater used for Phase I of this study was generated in the laboratory following the leaching procedures used in the waste characterization evaluation as described in Chapter 4.3.16 of the Crandon Project's February 1994 *Notification of Intent to Collect Data & Detailed Scope of Study* and as described in a number of letters subsequently forwarded to the WDNR. Details regarding the leaching procedures used were also discussed with the WDNR prior to initiation of the process and during the performance of the leaching effort. WDNR personnel were present during the performance of some portions of the treatability studies. WDNR personnel also took part in the selection of materials to be used in the generation of contact waters.

Engineering efforts associated with development of the mine plan for the Crandon Project have identified the following as major sources of inflow to the mine:

- Contact water - Groundwater which will come in contact with weathered and unweathered bedrock and ore. Based on waste characterizations studies, contact water will be a composite of groundwater coming in contact with unweathered ore, groundwater coming in contact with unweathered Type II waste rock, and water coming into contact with weathered bedrock and ore.

- Utility Water - A portion of the intercepted groundwater referred to as utility water used in the mine for dust control and equipment operation.

- Cemented backfill drainage - Drainage water from cemented backfilled stopes.

- Uncemented backfill drainage - Drainage water from uncemented backfilled stopes.

Five separate streams, generated in the laboratory, were used to prepare the composite mine drainage water used in the Phase I treatability study. The relative proportions of each

wastewater were calculated from the average water balance. For the purposes of the treatability study, utility water was assumed to be chemically equivalent to contact water. The proportions of the five streams used to prepare the composite were:

- Contact Water
  - Weathered Bedrock and Ore 8%
  - Unweathered Ore 36%
  - Unweathered Type II Waste Rock 36%
- Uncemented Backfill Drainage 8%
- Cemented Backfill Drainage 12%

The unweathered ore wastewaters and unweathered Type II waste rock wastewaters were generated over a period of weeks and were refrigerated until used for treatability testing. The weathered bedrock and ore wastewaters and backfill drainage wastewaters were generated the day prior to use in the treatability study. The untreated composite mine drainage water generated for each step of the Phase I treatability study was made up fresh on each day of testing from those wastewaters.

A.2.1.2 Step II - Lime Treatment

The first stage of the treatment process is lime treatment. This process results in the precipitation of heavy metals as metal hydroxides. The extent of precipitation is dependent on the characteristic solubilities of metal hydroxides at a given wastewater pH. Optimal removal of metals for this process generally occurs in the pH range of 9 to 10 where many metal hydroxides exhibit minimum solubilities. The objective of this step of the bench test was to determine the pH, and the corresponding lime dosage, at which the highest overall removal of heavy metals occurs for the mine drainage water.

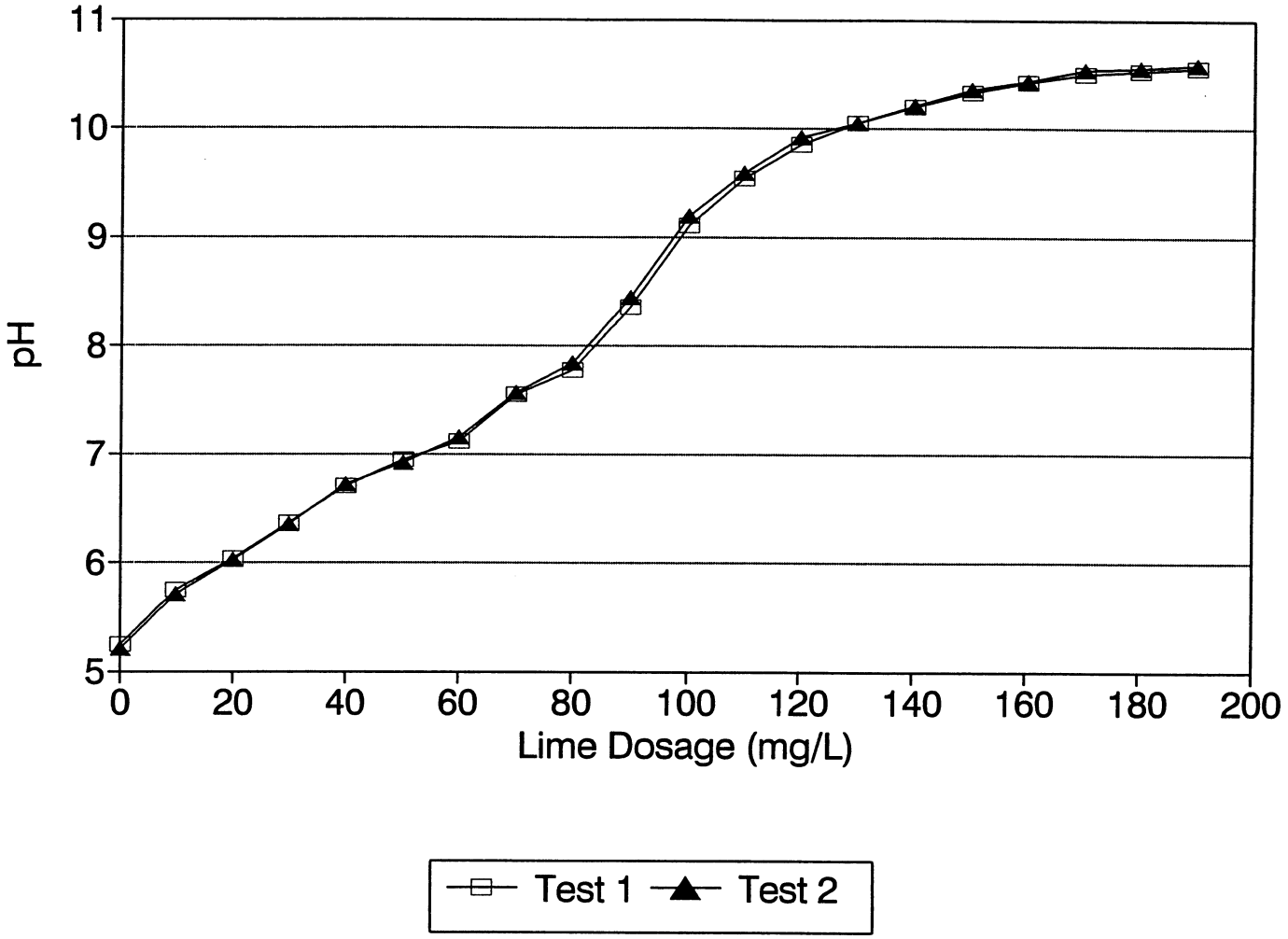
The first task in this step of the treatability study was the development of a lime titration curve. This curve was used to delineate the buffering characteristics of the wastewater and to determine the relationship between lime dosage and pH. The procedures used were as follows.

A 500 ml glass beaker was filled with 250 ml of wastewater. The sample was continuously stirred while increments of 0.5 percent lime solution were added. A low strength lime solution was used in this step to provide sensitivity in pH adjustment. After each addition of lime solution, the pH of the sample was measured and recorded. The titration was conducted over a pH range of 5.5 (raw wastewater pH) to 11.0. The titration procedure was repeated to verify the results. The resulting titration curves are presented in Figure A-1.

After the lime titration curves were developed, the next task was to determine the effectiveness of lime treatment at pH values of 9.0, 9.5, and 10.0. Following is a description of the procedures used for this task.

A. A series of four, two-liter glass beakers were set up. Each beaker was filled with 1.8 liters of wastewater. Wastewater for this test was drawn from a 30 gallon plastic tank used for make up and temporary storage of the wastewater. Prior to the withdrawal of samples, the contents of the tank were thoroughly mixed so that sample uniformity was achieved.

Figure A-1
Step II - Lime Titration Curve



B. Each of the four samples was continuously stirred while increments of a one percent lime solution were added to raise the pH of the samples to the desired level. Mixing was provided by magnetic stir plates and teflon-coated stir bars. All four samples were adjusted to an identical pH level. Four separate samples were used in order to obtain a sufficient volume of treated wastewater for chemical analysis. The volumes of lime solution required to raise the pH of the various samples to the desired level are reported in Table A-1.

   All lime solutions used in the treatability study were prepared using calcium hydroxide [$Ca(OH)_2$] obtained from The Cutler-Magner Company and deionized water. A one percent lime solution was used in this step of the treatability study to allow for sensitivity in pH adjustment.

C. After the desired solution pH was established, a 10 minute reaction time was allowed. Samples were continuously stirred during this time using magnetic stir plates and teflon-coated stir bars. The reaction time used in the lime treatment test reflects proposed operating parameters for the full scale wastewater treatment facility.

D. After the reaction period, the samples were allowed to settle. Supernatant from the settled samples was subsequently filtered through a 0.45 μm filter using a vacuum filtration apparatus. Sample filtering was performed to determine the fraction of metals remaining in solution. While filtering does not precisely reflect the actual treatment process, the objective of this step is only to evaluate the ability for soluble metals to react with hydroxide to form insoluble metal hydroxide precipitates.

   After filtering, the four samples were combined into a single composite sample. Samples for analytical testing were then withdrawn from the composite sample. The lime solids generated during this step of the treatability study were dewatered through gravity settling and retained for future analysis.

   It should be noted that it was not necessary to evaluate polymers as part of this test because the lime floc readily settled, resulting in a visually clear supernatant.

E. Four sets of samples were sent to the lab for analysis. These were a raw wastewater sample and wastewater samples treated at pH values of 9.0, 9.5, and 10.0.

F. The results of the laboratory analysis were evaluated to determine the pH level, and the corresponding lime dosage, which resulted in the optimal treatment efficiency.

Table A-1 shows the average lime dosage required to obtain wastewater pH values of 9.0, 9.5, and 10.0 respectively. Table A-2 shows the analytical results for the four wastewater water samples tested. Figures A-2 and A-3 are plots of selected heavy metal concentrations versus pH. These figures illustrate the variability in the lime treatment process as a function of treatment pH.

The results from the laboratory analysis were evaluated and it was determined that a pH level of 10.0 provided the optimal level of heavy metals removal. The calculated removal efficiencies at pH 10 are reported in Table A-3.

Table A-1

Phase I Treatability Study
Step II - Raw Wastewater Lime Demand[1,2]

Sample No.	Adjusted pH	Lime Solution Added (ml)[3]
1a	9.0	16.9
1b	9.0	17.0
1c	9.0	17.0
1d	9.0	16.9
2a	9.5	18.1
2b	9.5	18.2
2c	9.5	18.1
2d	9.5	18.1
3a	10.0	19.7
3b	10.0	19.8
3c	10.0	19.8
3d	10.0	19.9

[1]A 0.5 percent lime solution was used in this step.
[2]Wastewater pH was measured at 5.5 S.U. prior to addition of lime solution.
[3]Lime solution added to 1.8 L of wastewater.

Table A-2

Phase I Treatability Study
Step II - Lime Treatment[1,2]

Parameter	Units	Untreated Wastewater	Lime Treated Wastewater		
			pH 9.0	pH 9.5	pH 10.0
Antimony	mg/L	<0.05	<0.050	<0.05	<0.050
Arsenic	mg/L	0.920	0.0076	0.0054	0.0055
Beryllium	mg/L	<0.01	<0.010	<0.01	<0.010
Cadmium	mg/L	0.160	0.035	0.009	<0.003
Chromium, Total	mg/L	0.018	<0.005	<0.005	<0.005
Copper	mg/L	12	0.089	0.088	0.068
Cyanide	mg/L	<0.02	<0.020	<0.020	<0.020
Lead	mg/L	0.180	<0.050	0.075	<0.050
Mercury	mg/L	0.0018	<0.0002	<0.0002	<0.00020
Nickel	mg/L	0.053	<0.030	<0.030	<0.030
Selenium	mg/L	0.250	0.210	0.210	0.210
Silver	mg/L	0.018	<0.010	<0.01	<0.010
Thallium	mg/L	0.015	0.012	<0.01	<0.010
Zinc	mg/L	42	0.690	0.350	0.270

[1]All lime treated samples were filtered through a 0.45 μm filter prior to analysis.
[2]Raw wastewater was not filtered prior to analysis.

Table A-3

Phase I Removal Efficiencies for Lime Treatment Process
Step II - Treatment pH at 10.0

Parameter	Removal Efficiency
Antimony	BADL[1]
Arsenic	99.4%
Beryllium	BADL[1]
Cadmium	> 98.1%[2]
Chromium, Total	> 72.2%[2]
Copper	99.4%
Cyanide	BADL[1]
Lead	> 72.2%[2]
Mercury	> 88.9%[2]
Nickel	> 43.4%[2]
Selenium	16%
Silver	> 44.4%[2]
Thallium	> 33.3%[2]
Zinc	99.4%

[1] BADL indicates parameter for raw wastewater was determined to be below the analytical level of detection used by the laboratory for this analysis.

[2] For efficiencies reported in greater than form (">"), value indicated is minimum removal efficiency. For these parameters, lime treated wastewater was below analytical level of detection used by the laboratory for this analysis. Consequently actual treatment efficiency may be higher than indicated for these parameters.

Figure A-2
Step II - Lime Treatment, Cd & Cu

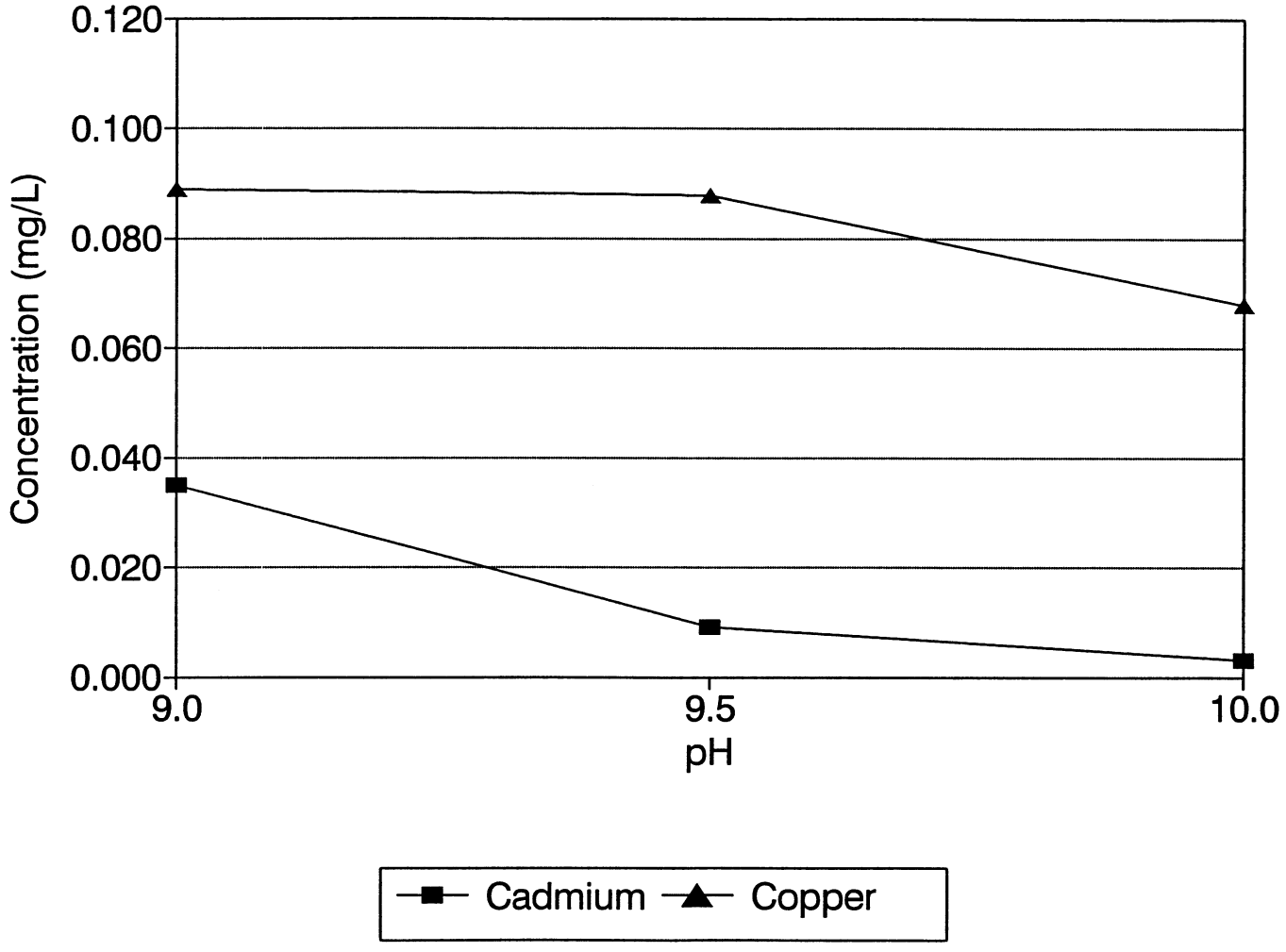
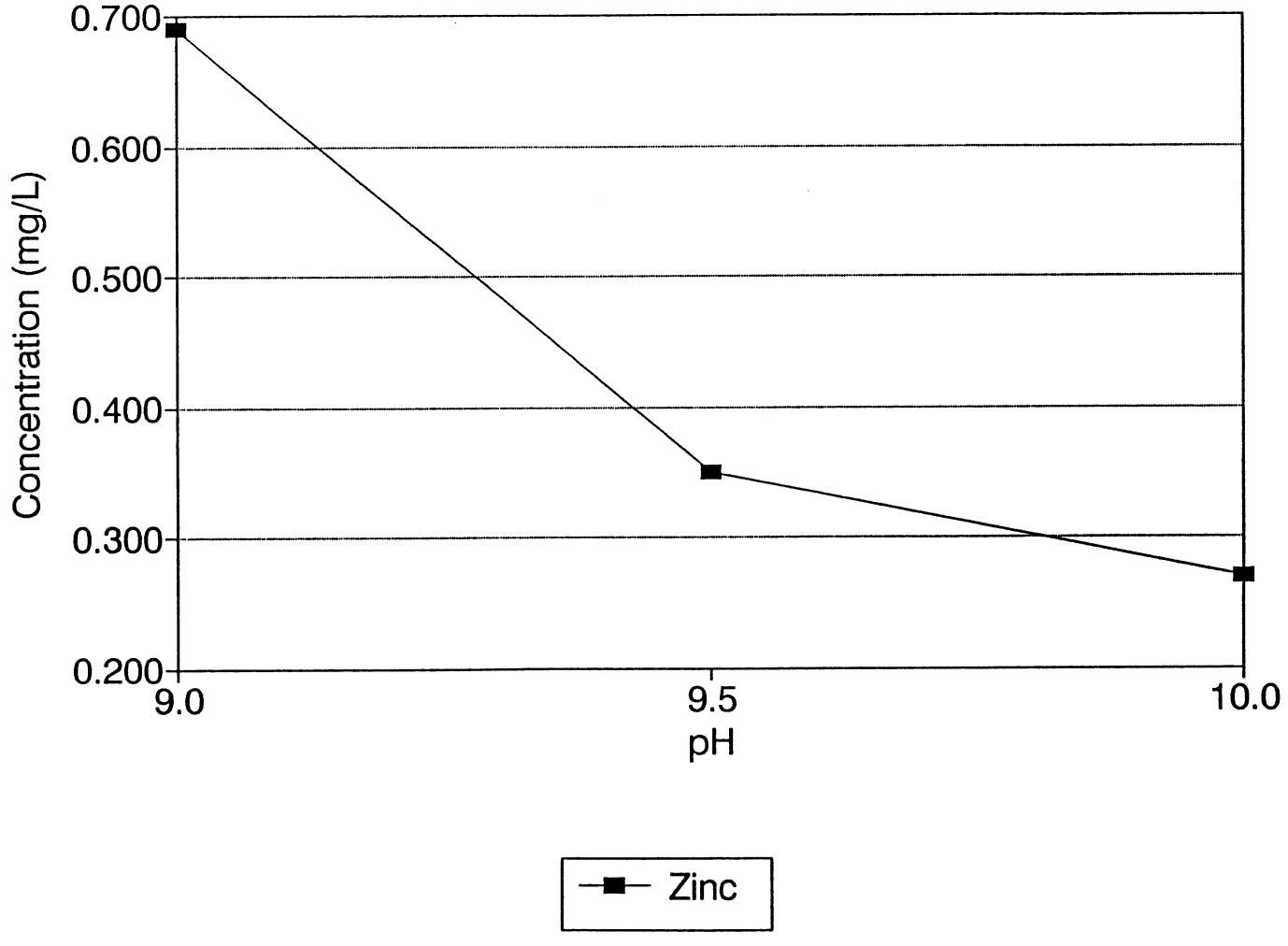


Figure A-3
Step II - Lime Treatment, Zinc



A.2.1.3 Step III - Sulfide Precipitation

The soluble sulfide (Na_2S) process will be used for the Crandon Project wastewater treatment system. In this process, the sulfide ion reacts with metal ions to form metal sulfide precipitates. In general, metal sulfides exhibit minimum solubilities in the pH range of 7 to 10.

The objective of this step of the Phase I treatability study was to determine the sulfide dosage which provided the highest level of overall metal removal. Sulfide treatment was initially evaluated at dosages of 3.5, 7.0, and 14.0 mg/L as $Na_2S \cdot 9H_2O$. Analysis of treated samples indicated that minimal levels of treatment were provided at these sulfide dosages. Consequently, the procedure was repeated using dosages of 100, 250, and 400 mg/L as $Na_2S \cdot 9H_2O$. Note that the sulfide is approximately 13 percent of the total weight of hydrated sodium sulfide. Therefore, a dosage rate of 400 mg/L hydrated sodium sulfide is equivalent to approximately 53 mg/L of sulfide ion. A detailed description of the procedures used to evaluate the sulfide precipitation process is presented below.

A. The first task in this step of the treatment process was the generation of a sufficient quantity of lime treated wastewater with which to conduct the sulfide precipitation evaluation. Nine liters of raw wastewater were made up in a five gallon plastic tank. The raw wastewater used for Phase I, Step III testing was based on the following proportions of the five streams used to prepare the composite:

• Contact Water	
- Weathered Bedrock and Ore	8.4%
- Unweathered Ore	33.55%
- Unweathered Type II Waste Rock	33.55%
• Uncemented Backfill Drainage	9.8%
• Cemented Backfill Drainage	14.7%

These proportions were selected to more closely reflect the proportions of utility water, contact water, and backfill drainage predicted by the water balance under the annual average conditions.

The wastewater was continuously stirred while five percent lime solution was added to reach the optimum pH level of 10.0 as determined in Step II of the Phase I treatability study. A ten minute reaction period was then provided with continuous stirring. After the reaction period, the wastewater was allowed to settle for 3 hours. The reaction time and settling time used in this step were selected based on design criteria planned for the full scale treatment system. After settling, the supernatant was decanted into a second five gallon plastic tank using a peristaltic pump. Care was taken so that the settled solids were not disturbed during the decanting procedure. The solids remaining after decanting were dewatered by gravity settling and saved for future analysis.

B. The pH of the lime treated wastewater was adjusted to 7.0 using commercial grade sulfuric acid. Thirty milliliters of 0.09 normal sulfuric acid were added to six liters of wastewater to lower the pH to 7.0. One liter of the pH adjusted wastewater was removed for analysis.

C. A fresh one percent stock solution of sodium sulfide was prepared by dissolving ten grams of reagent grade sodium sulfide ($Na_2S \cdot 9H_2O$) in 700 milliliters of deionized water and then diluting to 1000 milliliters. This allowed the addition of one milliliter of sulfide solution to the wastewater with an equivalent weight of ten milligrams of hydrated sodium sulfide.

D. 1.2 liters of treated wastewater generated in task B was transferred from the five gallon pH adjustment tank to a two liter glass beaker. The supernatant in the five gallon tank was thoroughly mixed prior to sample withdrawal so that each sample withdrawn was equal in physical and chemical characteristics. The contents of the beaker were continuously stirred while stock sodium sulfide solution was added to attain the desired sulfide dosage.

   A 15 minute reaction time, with continuous stirring, was then provided to allow for formation of metal sulfides. Mixing was provided using a magnetic stir plate. The length of the reaction time was based on design criteria planned for the full scale treatment system. After the reaction period, the wastewater was filtered through a 0.45 μm filter using a vacuum filtration apparatus. Sample filtering was performed to determine the fraction of metals remaining in solution. While filtering does not precisely reflect the actual treatment process, the objective of this step was only to evaluate the ability of soluble metals to react with sulfide to form insoluble precipitates. Step IV evaluates the filtration process for removal of solids.

E. Step D was repeated for three separate sulfide dosages. The dosages used were 100, 250, and 400 mg/L as $Na_2S \cdot 9H_2O$.

F. The three sulfide treated samples and a lime treated control sample were sent to a laboratory for metals analysis. The results of the analysis are reported in Table A-4.

G. The results from the laboratory data were evaluated to determine which sulfide dosage resulted in the optimum removal of heavy metals.

Table A-4 shows the analytical results of the sulfide treatment process. Figure A-4 shows the effluent concentrations of selected metals as a function of sulfide dosage. This figure illustrates the variability of the sulfide treatment process effectiveness as a function of sulfide dosage. Based on evaluation of the lab data provided in Table A-4, a sulfide dosage of 250 mg/L was selected for Step IV of Phase I of the treatability study.

It should be noted that the levels of selenium in the composite mine drainage water used for testing during this stage were excessive as a result of the method by which the backfill drainage water was generated. Simulated mine drainage was made up in the lab through the addition of selenium and other chemicals. Excessive amounts of selenium were added at this point. Waste characterization studies have shown that the level of selenium will be much less than shown in this test run.

Figure A-4
Step III - Sulfide Treatment

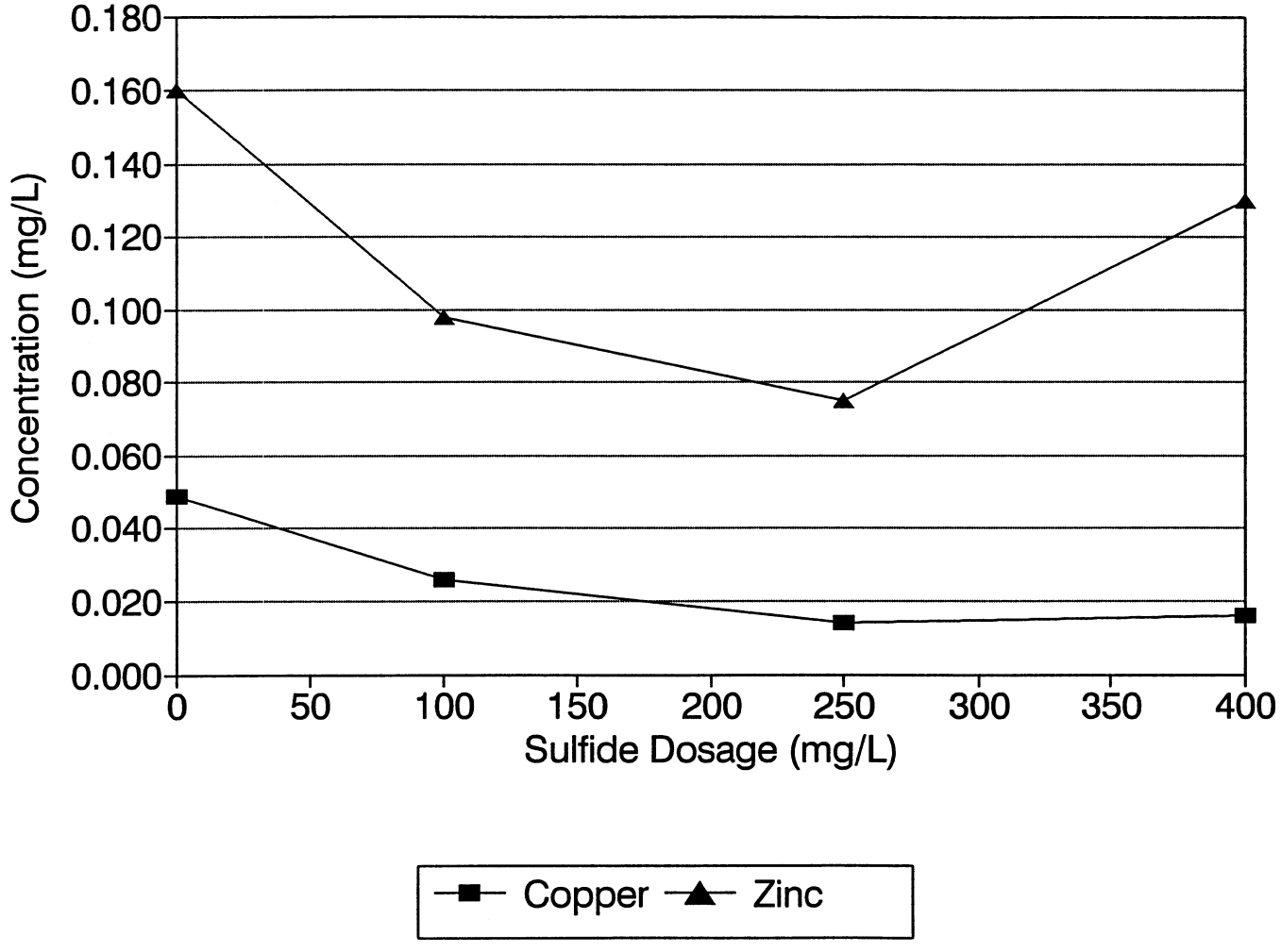


Table A-4

Phase I Treatability Study
Step III - Sulfide Treatment[1]

Parameter	Unit	Lime Treated Wastewater[2]	Sodium Sulfide Dosage[3]		
			100 Na_2S	250 Na_2S	400 Na_2S
Antimony	mg/L	0.056	0.063	<0.050	0.120
Arsenic	mg/L	0.0043	<0.004	0.0041	<0.004
Beryllium	mg/L	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	0.0027	0.0013	0.00095	0.0017
Chromium,Total	mg/L	<0.005	<0.005	<0.005	<0.005
Copper	mg/L	0.049	0.026	0.014	0.016
Lead	mg/L	0.0045	<0.003	0.0031	<0.003
Mercury	mg/L	<0.0002	<0.0002	<0.0002	<0.0002
Nickel	mg/L	<0.020	<0.020	<0.020	<0.020
Selenium	mg/L	0.690[4]	0.690[4]	0.670[4]	0.680[4]
Silver	mg/L	<0.00030	<0.00030	<0.00030	<0.00030
Thallium	mg/L	<0.010	<0.010	<0.010	<0.010
Zinc	mg/L	0.160	0.098	0.075	0.130
pH	S.U.	7.1	9.84	10.45	10.78

[1] All samples were filtered through a 0.45 μm filter prior to analysis.
[2] Sample analyzed after adjusting the pH of the lime-treated wastewater with sulfuric acid.
[3] Sodium sulfide dosages shown are in mg/L as $Na_2S \cdot 9H_2O$.
[4] Concentration of selenium shown is not representative of the concentrations anticipated in mine drainage during mine operation. See text of Appendix A for a discussion concerning the selenium concentrations in the raw wastewater used in this step.

A.2.1.4 Step IV - Filtration

Filtration will be used in the wastewater treatment system to remove the solids present in the wastewater after the sulfide precipitation process. The objective of this step of the treatability study was to evaluate both the performance of the filtration process and the efficiency of the overall treatment process train.

The laboratory filter used for the treatability study was constructed using a plexiglass column with a four inch inside diameter. The filter media consisted of a six inch layer of filter grade gravel (1/4" x 1/8") followed by a four and one half foot layer of filter grade sand with an effective sand size of 0.6-0.65 mm. Approximately two feet of head space remained in the column after the gravel and sand were in place. The gravel and sand were both obtained from Red Flint Sand and Gravel.

Although a laboratory unit was used for the filtration test, the loading rate approximated actual design criteria planned for the full scale system. A detailed description of the procedures used in evaluation of the sand filter follows.

A. The gravel used in the filter test was thoroughly rinsed with deionized water prior to placement in the column. After the gravel was loaded into the column, deionized water was allowed to continuously flow into the column while sand was gradually added. This procedure allowed uniform settling of the sand and minimized the formation of air voids in the sand column. After the gravel and sand beds were in place, deionized water was flushed through the column for seven and one half hours at a rate of approximately one liter per minute. At the end of the filter flush cycle, filter effluent was collected for analysis. This sample served as a filter blank and was used to verify that wastewater did not pick up contaminants while passing through the filter media. The results of filter blank analysis are presented in Table A-5.

B. A 95 liter sample of mine wastewater was made up in a 30 gallon plastic tank. This wastewater was made up using the proportions of contact waters and backfill drainage used in the Phase I, Step III testing. Seven liters of this wastewater were removed for analysis.

C. The remaining 88 liters of wastewater was stirred continuously while 125 ml of a five percent lime solution was added. This raised the wastewater pH to the optimum level of 10.0 as determined in Step II. Following a ten-minute reaction time with continuous stirring, the wastewater was allowed to settle for three hours. Both the reaction time and the settling time were selected to approximate actual design criteria planned for the full scale treatment facility.

   Following the settling period, supernatant from the lime treatment process was decanted into two 15-gallon plastic tanks. The supernatant was decanted using two siphon tubes. Of the 88 liters of wastewater subjected to lime treatment, 78 liters were recovered as supernatant while ten liters was left in the tank with the lime solids. After the decanting process, a glass beaker was used to equalize the volume of supernatant in the two tanks. After volume equalization, the volume of supernatant in each tank was about 39 liters. The lime solids remaining in the 30 gallon tank after the decanting process were dewatered by gravity settling and saved for analysis. The results of the solids analysis are presented in Table A-6.

Table A-5

Phase I Treatability Study
Step IV - Full Treatment[1]

Parameter	Unit	Raw Wastewater	Lime Treated	Sulfide Treated Filter Effluent[2]	Filter Blank
Antimony	mg/L	<0.050	0.057	<0.050	<0.064
Arsenic	mg/L	0.400	0.0069	0.0048	<0.004
Beryllium	mg/L	<0.005	<0.005	<0.005	<0.005
Cadmium	mg/L	0.062	0.0019	0.0013	<0.001
Chromium, Total	mg/L	0.015	0.009	<0.005	<0.005
Copper	mg/L	6	0.110	0.005	<0.005
Cyanide	mg/L	<0.020	<0.020	0.026	N/A
Lead	mg/L	0.840	0.011	0.0055	<0.003
Mercury	mg/L	0.000558	<0.0002	<0.0002	<0.0002
Nickel	mg/L	0.210	<0.020	<0.020	<0.020
Selenium	mg/L	0.120	0.130	0.120	<0.005
Silver	mg/L	0.0064	0.0049	0.00097	0.0011
Thallium	mg/L	0.011	<0.010	<0.010	<0.010
Zinc	mg/L	17	0.220	<0.020	<0.020
Suspended Solids	mg/L	N/A	N/A	8.0	N/A
BOD_5	mg/L	<3	5	32	N/A
COD	mg/L	15	<10	33	N/A
TKN	mg/L	0.8	0.8	0.8	N/A
Sulfide	mg/L	<0.4	0.6	17	N/A
pH	S.U.	6.5	7.2[3]	10.5[4]	N/A

N/A = No Test Performed.

[1] All values for metals expressed as "total" metal.

[2] Except for pH, the sulfide treated wastewater was not analyzed prior to filtration during Step IV of the treatability study. Refer to Table A-4 for analysis of sulfide treated wastewater for Step III of study.

[3] After pH adjustment with sulfuric acid. The pH prior to acid addition was 10.0.

[4] After sulfide addition and metals precipitation, but before filtration.

Table A-6

Phase I Treatability Study
Step IV Lime Solids Analysis

Parameter	Unit	Concentration in Lime Solids
Antimony	mg/kg	<5
Arsenic	mg/kg	90
Beryllium	mg/kg	<0.5
Cadmium	mg/kg	6.6
Chromium, Total	mg/kg	2.3
Copper	mg/kg	640
Cyanide	mg/kg	0.2
Lead	mg/kg	110
Nickel	mg/kg	2.5
Selenium	mg/kg	<7
Silver	mg/kg	1.2
Thallium	mg/kg	<8
Zinc	mg/kg	1,700
Suspended Solids	mg/L	56,000

D. The pH of the lime treatment supernatant was adjusted from 10.0 to 7.2 using commercial grade sulfuric acid. Thirty milliliters of 0.43 normal sulfuric acid solution were added to each of the tanks to effect the pH adjustment. After the pH adjustment procedure, three liters of supernatant were removed from each of the two tanks for analysis.

E. Ninety milliliters of ten percent hydrated sodium sulfide stock solution, prepared fresh one day prior to use, were added to each tank to achieve the optimum sulfide dose of 250 mg/L as determined in Step III. The total volume of sulfide treated wastewater was about 72 liters with the volume being split equally between the two tanks. Following sulfide addition, a ten minute reaction period with continuous stirring was provided. Six liters of the sulfide treated wastewater were removed for analysis after the reaction period.

F. The sulfide treated wastewater generated in Step E was filtered through the sand filter. A diaphragm hand pump was used to transfer the wastewater from the sulfide reaction tanks to the sand column. The flow rate of the wastewater through the sand column was determined to be approximately one liter per minute. The first 33 liters of sulfide treated wastewater were used to flush the filter. This portion of the filter effluent was discarded. The following 33 liters of effluent were collected for chemical analysis and for whole effluent toxicity testing. Samples were split with WDNR representatives who were present during this step of the treatability study. The chemical analyses for wastewater samples from this step of the treatability study are presented in Table A-5. It should be noted that effluent from the sand filter had a distinct yellow coloration. Since effluent from the sulfide treatment process did not exhibit any observable color, it is probable that the yellow coloration of the filter effluent was caused by leaching of the filter media. Evaluation of the analysis of the final effluent indicated that no apparent increase in the concentration of chemical parameters were measured as a result of the effluent discoloration.

A.2.1.5 Results - Phase I

Based on evaluation of the results obtained in Steps II, III, and IV of Phase I of the treatability study, the following conclusions were reached.

- Based on the results of Step II, an operating pH of 10.0 resulted in the most effective overall removal of metals from the raw mine wastewater by lime treatment.

- Based on the results of Step III, the removal efficiencies for cadmium, copper, and zinc were enhanced through sulfide treatment. The remaining metals were below detection limits after lime treatment or showed no significant improvement with subsequent sulfide treatment. The laboratory analyses indicate that a sulfide dosage of 250 mg/L resulted in the greatest increase in removal for copper, cadmium, and zinc.

- From the analysis of the final effluent in Step I, it can be seen that both BOD_5 and COD in the final effluent were significantly higher than in the raw wastewater. The increase in these parameters is believed to the result of the relatively high residual concentration of sulfide in the final effluent.

- Whole effluent toxicity tests were performed by in accordance with U.S. EPA effluent toxicity test protocols. The tests on the final effluent showed acute toxicity in 100 percent effluent, but also showed no chronic toxicity at all dilutions up to 10 percent effluent. It is believed that the acute toxicity at 100 percent effluent may have been caused by the relatively high concentration of residual sulfide in the final effluent. It is also important to note that acute toxicity testing was conducted only with 50 percent and 100 percent effluent, and therefore does not therefore reflect a realistic allowance for a zone of initial dilution. To further address the whole effluent toxicity of the treated effluent, whole effluent toxicity tests were performed for the final effluent generated for Phase II of the treatability study.

A.2.2 Wastewater Treatability Study - Phase II

In Phase II of the wastewater treatability study the performance of the selected treatment processes when treating mine drainage was further evaluated. The objectives of Phase II were to further optimize the sulfide treatment process, and to verify the results of Phase I. Another objective of Phase II was to obtain information on the whole effluent toxicity of the treated effluent under conditions which more nearly simulated the expected discharge from the full-scale system than the conditions used in Phase I.

Phase II of the wastewater treatability study included three steps. These were wastewater generation, sulfide optimization, and complete wastewater treatment including the lime, sulfide, and filtration processes. The following discussion contains a description of the three steps completed as part of Phase II of the treatability study.

A.2.2.1 Step I - Wastewater Generation

For the sulfide optimization step of Phase II, the proportions used to generate the raw mine wastewater were identical to that used in Phase I, Step III. However, due to the limited availability of tailing materials used to generate cemented and uncemented backfill drainage, it was necessary to make minor adjustments to the composite mine wastewater recipe for the full treatment step of Phase II. Specifically, the relative contributions of the cemented and uncemented backfill drainage components of the composite mine wastewater were reduced. The modified composite mine wastewater recipe used for the full treatment step of Phase II was based on the following proportions:

- Contact Water
  - Weathered Bedrock and Ore 8.4%
  - Unweathered Ore 39.0%
  - Unweathered Type II Waste Rock 39.0%
- Uncemented Backfill Drainage 5.4%
- Cemented Backfill Drainage 8.2%

It should be noted that the above modifications to the wastewater recipe did not significantly impact the chemical characteristics of the composite mine wastewater. The concentrations of metals and inorganics in the wastewater generated using the modified proportions for the full treatment step of Phase II were within the range of values reported for the various batches of mine wastewater generated during Phase I of the treatability study. The only significant change noted in the chemical character of the wastewater was a pH of 3.3 compared to the pH of 6.5 observed for the composite mine wastewater generated in Step IV of Phase I. This difference in

pH can be accounted for by the decreased contribution of the high pH cemented backfill drainage component to the composite wastewater.

Fresh wastewater was generated for both the sulfide optimization and the full treatment steps of Phase II of the treatability study. As in Phase I, the weathered bedrock and ore and backfill wastewaters were generated on the day prior to testing and the other contact waters were taken from a composite tank containing water generated over a period of weeks. The composite wastewater was made up on the day of testing.

A.2.2.2 Step II - Sulfide Optimization

The objective of Step II of Phase II was to further define the relationships between sulfide dosage, treatment pH, and effluent quality when treating mine wastewater. The general approach used in this evaluation was to adjust the pH of lime treated wastewater to various pH levels and then treat the wastewater at various sulfide dosages. Ten different pH-sulfide dosage combinations were evaluated covering the pH range of 8.0 to 10.0 and covering sulfide dosages from 10 to 400 mg/L as $Na_2S \cdot 9H_2O$. This methodology is illustrated in Figure A-5.

A. The first task in Step II of the sulfide optimization process was the generation of a sufficient quantity of lime treated wastewater with which to conduct the sulfide treatment evaluation. Fifteen liters of raw composite mine wastewater was made up in a five-gallon plastic tank. The wastewater was continuously stirred while a five percent lime solution was added to reach the optimum treatment pH level of 10.0 as determined in Phase I of the treatability study. A ten minute reaction period was then provided with continuous stirring. After the reaction period, the wastewater was allowed to settle for three hours. The reaction time and settling time used in this step are consistent with design criteria planned for the full scale treatment facility. After settling, the lime supernatant was decanted into another five-gallon plastic tank using plastic siphon tubing. Gravity decanting was used. Care was taken so that the settled solids were not disturbed during the decant process.

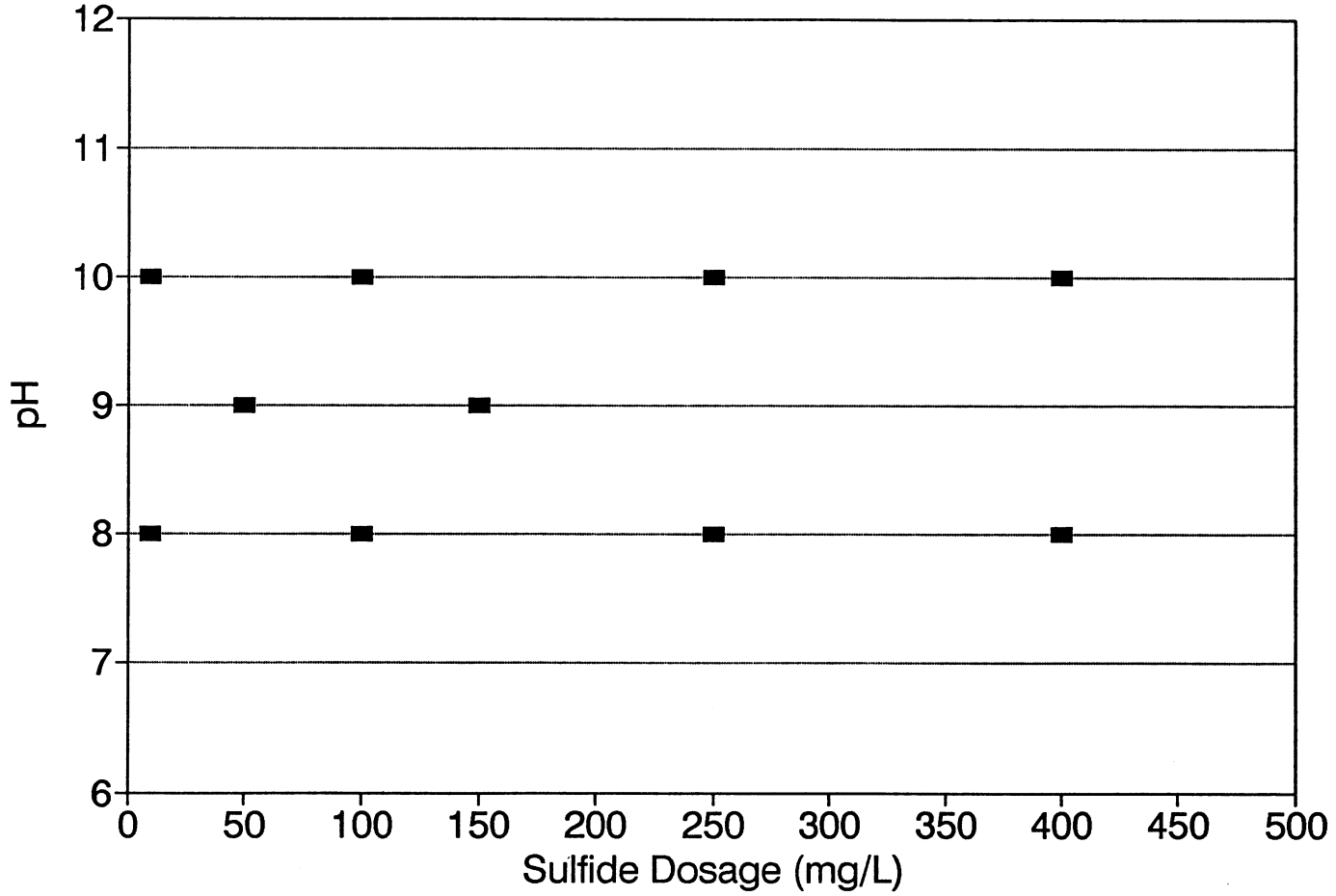
B. A fresh one percent stock solution of sodium sulfide was prepared by dissolving ten grams of reagent grade hydrated sodium sulfide ($Na_2S \cdot 9H_2O$) in 700 milliliters of deionized water and then diluting to 1000 milliliters.

C. 1.0 liter of lime supernatant generated in Task A was transferred from the five-gallon tank into a two-liter glass beaker. The supernatant in the five-gallon plastic tank was thoroughly mixed prior to sample withdrawal so that each sample withdrawn was equal in physical and chemical characteristics.

D. The pH of the wastewater was adjusted to the desired pH using 0.09 normal sulfuric acid.

E. A one percent sodium sulfide stock solution was added to the wastewater to achieve the desired sulfide dosage. A fifteen minute reaction period, with continuous stirring, was then provided to allow formation of metal sulfides. Mixing was provided using a magnetic stir plate.

Figure A-5
pH & Sulfide Dosage Points Evaluated



F. After the reaction period, the wastewater was filtered through a 0.45 μm filter using a vacuum filtration apparatus. Sample filtering was performed to determine the fraction of metals remaining in solution after sulfide treatment. While filtering does not precisely reflect the actual treatment process, the objective of this step was only to evaluate the ability for soluble metals to react with sulfide to form insoluble metal sulfide precipitates. Step III of Phase II of the treatability study evaluated the filtration process for removal of suspended solids.

G. Tasks C through F were repeated for ten different pH-sulfide dosage combinations covering the pH range of 8.0 to 10.0 and sulfide dosages ranging from 10 to 400 mg/L as illustrated on Figure A-5. Note that pH on Figure A-5 refers to the adjusted wastewater pH after lime treatment, but prior to sulfide addition.

H. All ten sulfide treated wastewater samples were sent to a laboratory and analyzed for zinc, copper, and cadmium. Additionally, a sample of raw wastewater and lime treatment decant were analyzed. The results of the analyses are shown in Table A-7.

From the sample analyses presented in Table A-7, it can be seen that the highest level of treatment was provided by treatment adjusting the wastewater pH to 10 and feeding sulfide at a dosage of 400 mg/L. However, the level of treatment at a dosage of 50 mg/L was not significantly different than at 400 mg/L. Therefore a pH of 10.0 and a sulfide dosage of 50 mg/L as $Na_2S \cdot 9H_2O$ was selected for full treatment of Phase II.

Table A-7

Phase II Treatability Study
Step II - Sulfide Optimization

Sample	pH[1]	Sulfide Dosage (mg/L)[2]	Wastewater Concentrations (mg/L)[3]		
			Copper	Zinc	Cadmium
Raw Wastewater	5.9	N/A	11	26	0.110
Lime Treated	10	N/A	0.13	0.29	0.0023
Sulfide Treated	10	10	0.069	0.20	0.0015
Sulfide Treated	10	100	0.077	0.28	0.0017
Sulfide Treated	10	250	0.047	0.23	0.0012
Sulfide Treated	10	400	0.013	0.12	<0.0010
Sulfide Treated	9	50	0.059	0.23	0.0015
Sulfide Treated	9	150	0.067	0.26	0.0016
Sulfide Treated	8	10	0.052	0.14	0.0012
Sulfide Treated	8	100	0.065	0.22	0.0016
Sulfide Treated	8	250	0.048	0.22	0.0014
Sulfide Treated	8	400	0.024	0.16	<0.0010

N/A = No Test Performed.
[1] pH shown for sulfide treated samples is the adjusted pH prior to sulfide addition.
[2] Sulfide dosages stated as $Na_2S \cdot 9H_2O$.
[3] All samples, with exception of raw wastewater, were filtered through a 0.45 μm filter prior to analysis.

A.2.2.3 Step III - Full Treatment

The objectives of the full treatment step of Phase II of the wastewater treatability study were to verify the results obtained in Phase I and to develop more detailed data on the whole effluent toxicity of the treated effluent. With the following exceptions, the procedures used in the full treatment step of Phase II were essentially identical to Step IV of Phase I.

- The pH of the lime treated wastewater was not adjusted with sulfuric acid prior to sulfide treatment. Omission of the pH adjustment step was based on the results of the sulfide optimization step of Phase II which indicated that sulfide treatment was as or more effective at higher pH levels.

- A sulfide dosage of 50 mg/L as $Na_2S \cdot 9H_2O$ was used. This dosage was selected for several reasons. First, the results of the sulfide optimization step indicate that a dosage of 50 mg/L should be sufficient to provide the level of treatment needed to meet the estimated effluent limitations. Second, the results of the whole effluent toxicity testing in Phase I suggest that high residual levels of sulfide in the treated effluent may contribute to acute toxicity. Consequently, it will be advantageous to use the minimum sulfide dosage required to consistently meet effluent limitations. This would reduce the potential for the treated effluent to cause toxicity in the acute whole effluent toxicity test results. Third, based on the experience of operating mine wastewater treatment facilities treating similar wastewaters, it is anticipated that the dosage of sulfide required to provide effective wastewater treatment will be less than 50 mg/L.

- The final effluent from the filter was held in a refrigerator for 24 hours to reflect the holding time the treated effluent will receive in the effluent lagoons at the full scale treatment facility before discharge.

The tasks used in Step III, full treatment, were as follows:

A. A 106 liter sample of raw mine wastewater was made up in a 30-gallon plastic tank using the proportions as described in Section A.2.2.1. Six liters of wastewater were removed for analysis.

B. The raw wastewater was continuously stirred while 280 milliliters of a five percent lime solution was added. This raised the wastewater pH to the optimum level of 10.0 as determined in Phase I of the treatability study. The volume of wastewater treated was about 100 liters. Following a ten minute reaction time with continuous stirring, the wastewater was allowed to settle for three hours. Both the reaction time and settling time were selected to approximate the design criteria planned for the full scale facility.

C. Following the settling period, approximately 84 liters of supernatant from the lime treatment process was decanted into two 15-gallon plastic tanks. Decanting was by gravity using two plastic siphon tubes. Care was taken during the decanting process so that settled solids were not disturbed. Samples of the lime decant were removed and retained for analysis. After sampling, the volume of wastewater in the two decant tanks was equalized using a glass beaker.

D. Twenty-one milliliters of a 10 percent stock sodium sulfide solution was then added to each 15-gallon tank resulting in an applied dosage of 50 mg/L as $Na_2S \cdot 9H_2O$. The total volume of sulfide treated wastewater was about 84 liters with the volume being split equally between the two tanks. Following the sulfide addition, a 15 minute reaction time was provided during which the wastewater was continuously stirred.

E. The sulfide treated wastewater was then filtered through a sand filter. The sand filter used in Phase I of the treatability study was reused in this phase. A physical description of the sand filter can be found in Section A.2.1.4.

Prior to filtration of treated wastewater, the sand filter was flushed with deionized water for a period of 4.5 hours. At the end of the deionized water flush cycle, filter effluent was sampled. This control sample was sent to the lab for metals analysis.

After the deionized water filter flush cycle, sulfide treated effluent was filtered through the sand filter. The first 42 liters of wastewater served as a filter flush. This portion of the effluent was discarded. The second 42 liters of filter effluent was collected and a portion was sent for chemical analysis. The remainder of the filter effluent was then held for approximately 24 hours to simulate the full-scale treatment system, which will hold the treated effluent in a discharge lagoon for one day before discharge. After this 24-hour holding period, samples of the filter effluent were sent for whole effluent toxicity testing.

A.2.2.4 Results - Phase II

The laboratory analytical results for the raw mine wastewater, the supernatant from the lime treatment process, the final effluent, and the sand filter control are presented in Table A-8. In general, the concentrations of metals in the final effluent are equal to or lower than those reported for the final effluent from Phase I of the treatability study. Additionally, BOD_5 levels in the final effluent are below the level of detection and COD levels are at the level of detection.

The results of the acute and chronic whole effluent toxicity testing of the treated effluent from the Phase II full treatment are summarized in Tables A-9, A-10, A-11, and A-12. Acute and chronic toxicity were evaluated with respect to both aquatic invertebrates and aquatic vertebrates. Acute toxicity in these tests was defined as greater than 50 percent mortality in *Ceriodaphnia dubia* or *Daphnia magna* at 48 hours exposure, or to *Pimephales promelas* at 96 hour exposure. Chronic toxicity is determined using the U.S. EPA IC_{25} endpoint and is defined as a 25 percent reduction, from control, in *Ceriodaphnia dubia* reproduction or in *Pimephales promelas* growth as measured using linear interpolation. Controls used in the whole effluent toxicity testing included Wisconsin River water obtained at the Hat Rapids Dam and lab culture water. Acute toxicity was evaluated at 100%, 75%, 50%, 25%, 10%, and 1% effluent dilutions. Chronic toxicity was evaluated at 10.0%. 5.0%, 2.5%, 1.25%, and 0.6% effluent dilutions. Dilutions were made using Wisconsin River water.

The results showed that the treated effluent is not toxic, with $\geq$ 90 percent acute survival for all species in 100 percent effluent, all chronic test effluent dilutions passing all the chronic toxicity criteria.

Table A-8

Phase II Treatability Study
Step III - Full Treatment[1]

Parameter	Unit	Raw Wastewater	Lime Treated	Filter Effluent	Filter Control
Arsenic	mg/L	0.15	<0.004	<0.004	<0.004
Cadmium	mg/L	0.13	<0.005	<0.005	<0.005
Calcium	mg/L	110	180[2]	170[2]	0.11[2]
Chromium, Total	mg/L	0.007	<0.005	<0.005	<0.005
Copper	mg/L	8.4	0.043	<0.005	<0.005
Cyanide	mg/L	N/A	N/A	<0.01	N/A
Hardness	mg/L	700	640	640	N/A
Iron	mg/L	19	0.056	<0.020	0.022
Lead	mg/L	0.64	<0.003	<0.003	<0.003
Magnesium	mg/L	39	33	32	0.040
Mercury	mg/L	0.0002	<0.0002	<0.0002	<0.0002
Nickel	mg/L	0.030	<0.020	<0.020	<0.020
Selenium	mg/L	0.064	0.052	0.055	0.0066[2]
Silver	mg/L	<0.005	<0.005	<0.005	<0.005
Sulfate	mg/L	460	460	500	N/A
Total Dissolved Solids	mg/L	880	N/A	860	<10
Zinc	mg/L	33	0.20	<0.020	<0.02
Total Suspended Solids	mg/L	75	N/A	<10	<10
BOD_5	mg/L	<6	N/A	<6	N/A
COD	mg/L	<10	<10	10	<10
Sulfide	mg/L	<0.4	0.6	1.6	N/A
pH	S.U.	3.3	10.0	10.5	N/A

N/A = No Test Performed.
[1]All values for metals expressed as "total" metal.
[2]Parameter found in the laboratory blank as well as in the sample.

Table A-9

Phase II Treatability Study
Step III - Summary of Bioassay Acute Toxicity Test Data for Full Treatment Step[1]

Organism	Test Solution	Mean % Survival
Ceriodaphnia dubia	Secondary Control[2]	100
	Primary Control[3]	100
	1% Effluent[4]	100
	10% Effluent[4]	100
	25% Effluent[4]	100
	50% Effluent[4]	100
	75% Effluent[4]	100
	100% Effluent[4]	95
Daphnia magna	Secondary Control[2]	100
	Primary Control[3]	100
	1% Effluent[4]	100
	10% Effluent[4]	100
	25% Effluent[4]	100
	50% Effluent[4]	100
	75% Effluent[4]	100
	100% Effluent[4]	90
Pimephales promelas	Secondary Control[2]	90
	Primary Control[3]	100
	1% Effluent[4]	100
	10% Effluent[4]	100
	25% Effluent[4]	100
	50% Effluent[4]	95
	75% Effluent[4]	100
	100% Effluent[4]	100

[1]Tests conducted in accordance with EPA protocols for acute toxicity testing.
[2]Flow through lab culture water.
[3]Wisconsin River water from Hat Rapids Dam.
[4]Effluent mixed with Wisconsin River water in proportion indicated.

Table A-10

Phase II Treatability Study
Step III - *Ceriodaphnia dubia* Chronic Test Data
(Third-Brood Endpoint Reproduction Data)
for Full Treatment Step[1]

Test Solution	Mean Neonates[2]
Secondary Control[3]	31.7
Primary Control[4]	27.9
0.6% Effluent[5]	23.9
1.25% Effluent[5]	24.3
2.5% Effluent[5]	28.2
5.0% Effluent[5]	31.3
10% Effluent[5]	29.8

[1]Tests conducted in accordance with EPA protocols for chronic toxicity testing.
[2]Ten replicates per test.
[3]Flow through lab culture water.
[4]Wisconsin River water from Hat Rapids Dam.
[5]Effluent mixed with Wisconsin River water in proportion indicated.

Table A-11

Phase II Treatability Study
Step III - *Pimephales promelas* Chronic Test
(Mean Biomass Data)
for Full Treatment Step[1]

Test Solution	Mean Biomass[2]
Secondary Control[3]	0.36
Primary Control[4]	0.32
0.6% Effluent[5]	0.34
1.25% Effluent[5]	0.33
2.5% Effluent[5]	0.34
5.0% Effluent[5]	0.37
10% Effluent[5]	0.38

[1] Tests conducted in accordance with EPA protocols for chronic toxicity testing.
[2] Four replicates per test. Mean Biomass = (total replicate dry weight/number larvae used to initiate the replicate).
[3] Flow through lab culture water.
[4] Wisconsin River water from Hat Rapids Dam.
[5] Effluent mixed with Wisconsin River water in proportion indicated.

Table A-12

Phase II Treatability Study
Step III - *Pimephales promelas* Chronic Test
(Mean Survival Data)
for Full Treatment Step[1]

Test Solution	% Survival[2]
Secondary Control[3]	98
Primary Control[4]	98
0.6% Effluent[5]	98
1.25% Effluent[5]	98
2.5% Effluent[5]	98
5.0% Effluent[5]	100
10% Effluent[5]	100

[1]Tests conducted in accordance with EPA protocols for chronic toxicity testing.
[2]Four replicates per test.
[3]Flow through lab culture water.
[4]Wisconsin River water from Hat Rapids Dam.
[5]Effluent mixed with Wisconsin River water in proportion indicated.

A.2.3 Wastewater Treatability Study - Phase III

Phase III of the wastewater treatability study evaluated the performance of the selected treatment processes when treating mill process water. Under normal operating conditions, mill process water will not be discharged. However, the New Source Performance Standards allow mill process water to be discharged during periods when rainfall exceeds precipitation or in the event that buildup of contaminants in the process water significantly interferes with the ore recovery milling process. In addition, mill process water remaining in the TMA and reclaim pond at the time the Crandon Project permanently ceases milling activities will be treated and discharged to the Wisconsin River.

The following discussion contains a description of the various steps completed as part Phase III of the wastewater treatability study. These steps include collection of the process water, lime treatment, optimization of the sulfide treatment process, evaluation of polymers, and full treatment.

A.2.3.1 Step I - Collection of Process Water

The process water used for this phase of the treatability study was obtained from the Inmet Mining Corporation's operating zinc/copper mine located in Winston Lake, Ontario, Canada. The decision to use process water from the Inmet mine for the Crandon Project treatability study was based on similarities between the Inmet ore and milling processes and the proposed Crandon Project. It is believed that Inmet process water simulates the actual Crandon Project mill process water sufficiently for purposes of treatability testing. Process water was sampled in the Inmet mill at the return pipeline from the tailings pond. Sampling at this location simulates the Crandon Project, where process water will be treated after decanting in the TMA, stored in the reclaim pond, and then stored in wastewater storage basins 6 and 7 before being treated at the project's wastewater treatment facility. The process wastewater was collected in 25 five-gallon plastic containers and transported back to the Foth & Van Dyke Green Bay offices where it was stored in a walk-in refrigerator until use.

A.2.3.2 Step II - Lime Treatment

An optimization study of the lime treatment process was not conducted for this phase of the treatability study. The operating pH for the lime treatment process was selected based on data from a treatability study conducted by the Canadian mine from which the wastewater was obtained. Based on this data a pH of 10 was selected for lime treatment. The treatment efficiency of the lime treatment process was evaluated based on samples generated during the sulfide optimization and full treatment steps of this phase of the treatability study. This information is presented later in this report.

A.2.3.3 Step III - Sulfide Optimization

The objective of this step of Phase III was to define the relationships between sulfide dosage, treatment pH, and effluent quality when treating mill process water. The general approach used in this evaluation was to adjust the pH of lime treated wastewater to various pH levels and then treat the wastewater at various sulfide dosages. Ten different pH-sulfide dosage combinations were evaluated covering the pH range of 8.0 to 10.0 and covering sulfide dosages from 10 to 400 mg/L as $Na_2S \cdot 9H_2O$. This methodology is identical to that used previously in Phase II, and is illustrated in Figure A-5.

A. The first task in this step of the sulfide optimization process was the generation of a sufficient quantity of lime treated wastewater with which to conduct the sulfide treatment evaluation. Three liters of mill process water were withdrawn from each of six of the water containers brought back from the Canadian mine for a total of 18 liters. This water was placed in a five gallon plastic tank. The contents of the water containers were thoroughly mixed prior to sample withdrawal to resuspend settled solids and to provide sample uniformity.

B. The wastewater was continuously stirred while a five percent lime solution was added to reach the selected treatment pH of 10. A ten minute reaction period was then provided with continuous stirring. After the reaction period, the wastewater was allowed to settle for three hours. The reaction period and settling time used in this step are consistent with design criteria planned for the full scale treatment facility.

C. At the end of the settling time it was noted that there were few settled solids on the bottom of the tank and that a substantial amount of solids were still in suspension. Because the presence of these solids, in the concentrations observed, would interfere with evaluation of the sulfide treatment process, it was decided to filter out the suspended solids prior to the sulfide optimization step. The lime treated wastewater was filtered using a vacuum filtration apparatus. Although filtration does not accurately reflect the actual treatment process, the goal of this step was only to evaluate removal of dissolved metals in the sulfide treatment process. The use of polymers to enhance solids settling in the lime treatment process was evaluated in the next step of Phase III.

D. A fresh one percent stock solution of sodium sulfide was prepared by dissolving ten grams of reagent grade hydrated sodium sulfide ($Na_2S \cdot 9H_2O$) in 700 milliliters of deionized water and then diluting to 1000 milliliters.

E. 1.0 liter of filtered wastewater from the lime treatment process was placed into a two-liter glass beaker. The pH of the wastewater was then adjusted to the desired pH using 0.09 normal sulfuric acid.

F. Sodium sulfide stock solution was added to the wastewater to achieve the desired sulfide dosage. A fifteen minute reaction period, with continuous stirring, was then provided to allow formation of metal sulfides.

G. After the reaction period, the wastewater was filtered through a 0.45 μm filter using a vacuum filtration apparatus. Sample filtering was performed to determine the fraction of metals remaining in solution after sulfide treatment. While filtering does not precisely reflect the actual treatment process, the objective of this step was only to evaluate the ability of soluble metals to react with sulfide to form insoluble metal sulfide precipitates. Step IV of this phase of the treatability study evaluated the filtration process for removal of suspended solids.

H. Tasks E through G were repeated for ten different pH-sulfide dosage combinations covering the pH range of 8.0 to 10.0 and sulfide dosages ranging from 10 to 400 mg/L as illustrated in Figure A-5. Note that pH on Figure A-5 refers to the adjusted wastewater pH after lime treatment, but prior to sulfide addition.

I. All ten sulfide treated wastewater samples were sent to a laboratory and analyzed for zinc, copper, and cadmium. Additionally, a sample of raw wastewater and lime treated decant were analyzed. The results of the analysis are shown in Table A-13.

As can be seen in Table A-13, the raw process water contained relatively low concentrations of zinc, copper, and cadmium prior to any treatment. After lime treatment, both cadmium and copper were both below analytical levels of detection. Consequently, only zinc concentrations were available for comparative purposes. Based on the zinc data, the highest level of treatment appears to have been provided at the higher sulfide concentrations (400 mg/L). However, the difference between the level of treatment at the highest and lowest sulfide dosages is minor. Additionally, based on the available data, it appears that the sulfide treatment was typically more effective at a pH level of 10.0.

Table A-13

Phase III Treatability Study
Step III - Sulfide Optimization

Sample	pH[1]	Sulfide Dosage (mg/L)[2]	Wastewater Concentrations (mg/L)[3]		
			Copper	Zinc	Cadmium
Raw Wastewater	7.2	N/A	0.017	0.34	0.013
Lime Treated	10	N/A	<0.005	0.048	<0.001
Sulfide Treated	10	10	<0.005	0.051	<0.001
Sulfide Treated	10	100	<0.005	0.035	<0.001
Sulfide Treated	10	250	0.005	0.044	<0.001
Sulfide Treated	10	400	<0.005	0.033	<0.001
Sulfide Treated	9	50	<0.005	0.047	<0.001
Sulfide Treated	9	150	<0.005	<0.020	<0.001
Sulfide Treated	8	10	0.005	0.066	<0.001
Sulfide Treated	8	100	<0.005	0.069	<0.001
Sulfide Treated	8	250	<0.005	0.056	<0.001
Sulfide Treated	8	400	<0.005	0.045	<0.001

N/A = No Test Performed.
[1]pH shown for sulfide treated samples is adjusted pH prior to sulfide addition.
[2]Sulfide dosages stated as $Na_2S \cdot 9H_2O$.
[3]All samples, with exception of raw wastewater, were filtered through 0.45 μm filter prior to analysis.

A.2.3.4 Step IV - Evaluation of Polymers

As previously indicated, the solids generated during lime treatment of the process water exhibited poor settling characteristics. In the full scale treatment system, polymer will be fed to the wastewater prior to settling as needed to assist in the settling process. The objective of this step of the treatability study was to provide a preliminary evaluation of polymers which could serve this purpose.

Two polymers were evaluated, including a low charge anionic polymer (POL E-Z-2706) and a high charge anionic polymer (POL E-Z-8736). The polymers were obtained from the Calgon Corporation in the emulsion form. Both polymers were evaluated at dosages of 0.5, 1.0, 2.5, and 5.0 mg/L. The following is a description of the tasks used in the evaluation:

A. Dilute (0.1 percent volume/volume) solutions of each polymer were made up in accordance with Calgon polymer solution preparation instructions. The polymer solutions were made up on the day of use.

B. Ten liters of raw process water was placed in a five-gallon plastic tank and a five percent lime solution was added to raise the pH to 10.0. A ten minute reaction period, with continuous stirring was then provided. One liter of the lime treated wastewater was then removed from the tank and placed into a two liter glass beaker. The settling characteristics of this sample were observed and compared with polymer treated samples.

C. The contents of the lime treatment tank were thoroughly mixed and one liter of wastewater was transferred into each of four glass beakers. Dilute polymer solution was then added to each beaker while the contents of the beakers were continuously stirred. Stirring was provided by magnetic stir plates. Polymer dosages of 0.5, 1.0, 2.5, and 5.0 mg/L were evaluated. After polymer addition, the wastewater was mixed at a high stir rate for three minutes and at a slow stir rate for an additional two minutes.

D. Mixing of the wastewater was then discontinued and the settling characteristics of the solids were observed over a thirty minute settling time. After the thirty minute settling time, thirty milliliters of supernatant was pipetted from each glass beaker, placed into a glass vial, and allowed to settle. The quantity of settled solids in the bottom of each vial of supernatant were visually evaluated at the end of 24 hours.

E. Tasks C and D were performed for both of the polymers evaluated.

F. Polymer effectiveness was based on a visual assessment of the quantity of solids which settled during the 30 minute settling phase, on the clarity of the supernatant after the thirty minute settling time, and on the quantity of settled solids in the supernatant sample after 24 hours.

Based on the results of this preliminary polymer evaluation the following comments can be made.

- All polymer treated samples showed some increase in the quantity of settled solids relative to the lime treated sample without polymer.

- For both polymers evaluated, the clarity of the sample after polymer addition appeared to increase with polymer dosage. In both cases, the greatest difference in clarity occurred between the 0.5 and 1.0 mg/L polymer dosages.

- There was no distinguishable difference noted in the settling rates of any of the polymer treated samples relative to the sample without polymer.

A.2.3.5 Step V - Full Treatment

The objective of this step in Phase III of the wastewater treatability study was to evaluate both the performance of the filtration process and the performance of the overall treatment process. The procedures used in the full treatment step of Phase III were similar to those used in Phase II of the treatability study, with the major exceptions being the source of the wastewater and the addition of polymer based on the results of Step IV. The tasks followed for the full treatment step are as follows.

A. A 106 liter sample of raw process water was made by transferring water from seven of the water containers brought back from the Canadian mine referenced in Section A.2.3.1 into a 30-gallon plastic tank. The water containers were thoroughly mixed to resuspend settled solids prior to transfer to the tank. Six liters of process water were removed for analysis.

B. The raw process water was continuously stirred while 65 milliliters of a five percent lime solution were added. This raised the water pH to the selected level of 10.0. The volume of water treated was about 100 liters. A ten minute reaction period with continuous stirring was provided.

C. Calgon polymer POL E-Z-2706 was used to make up a 0.1 percent polymer solution following Calgon procedures. Following the lime reaction period, 100 ml of 0.1 percent polymer solution was added to the wastewater. After the polymer was added, a two minute rapid mix period and an eight minute slow mix period were provided.

D. Following polymer addition, a three hour settling period was provided.

E. After the settling period, supernatant from the lime treatment process was decanted into two 15-gallon plastic tanks. Decanting was by gravity using two plastic siphon tubes. Care was taken during the decanting process so that settled solids were not disturbed. Samples of the lime decant were removed and retained for analysis. After sampling, the volume of wastewater in the two decant tanks was equalized using a glass beaker.

F. Nineteen and one half milliliters of a 10 percent stock sodium sulfide solution was then added to each 15-gallon tank resulting in a dosage of 50 mg/L as $Na_2S \cdot 9H_2O$. The total volume of sulfide treated wastewater was about 78 liters, with the volume being split equally between the two tanks. Following the sulfide addition, a 15 minute reaction period was provided during which the wastewater was continuously stirred.

G. The sulfide treated wastewater was then filtered through a sand filter. The sand filter used in Phase I and II of the treatability study was reused in this phase. A physical description of the sand filter can be found in Section A.2.1.4.

The sand filter was flushed with deionized water for a period of three hours prior to filtration of treated wastewater. At the end of the deionized water flush cycle, filter effluent was sampled. This control sample was sent to the lab for chemical analysis. After the deionized water filter flush cycle, sulfide treated effluent was filtered through the sand filter. The first 39 liters of wastewater served as a filter flush. This portion of the effluent was discarded. The second 39 liters of filter effluent was collected and saved for chemical analysis and whole effluent toxicity testing.

A.2.3.6 Results - Phase III

The laboratory analytical results for the raw process water, the supernatant from the lime treatment process, the final effluent, and the sand filter control sample are presented in Table A-14.

The results of the acute and chronic whole effluent toxicity testing of the treated effluent from full treatment in Phase III are summarized in Tables A-15, A-16, A-17, and A-18. Acute and chronic toxicity were evaluated with respect to both aquatic invertebrates and aquatic vertebrates. Acute toxicity in these tests was defined as greater than 50% mortality in *Ceriodaphnia dubia* or *Daphnia magna* at 48 hours exposure, or to *Pimephales promelas* at 96 hour exposure. Chronic toxicity was determined using the EPA IC_{25} endpoint and is defined as a 25 percent reduction, from control, in *Ceriodaphnia dubia* reproduction or in *Pimephales promelas* growth as measured using linear interpolation. Controls used in the whole effluent toxicity testing included Wisconsin River water obtained at the Hat Rapids Dam and lab culture water. Acute toxicity was evaluated at 100%, 75%, 50%, 25%, 10%, 1% effluent dilutions. Chronic toxicity was evaluated at 10.0%, 5.0%, 2.5%, 1.25%, and 0.6% effluent dilutions. Dilutions were made using Wisconsin River water.

The treated wastewater exhibited no chronic toxicity at any of the effluent dilutions tested. The acute toxicity results on daphnids showed no toxicity. The fathead minnow acute toxicity test indicated marginal survival at 75 percent effluent and significant toxicity (10 percent survival) in 100 percent effluent. Minimal toxicity was noted at 50 percent effluent. The cause of the acute toxicity at the 100 percent and 75 percent effluent concentrations was uncertain. However, the concentration of ammonia in the final effluent was relatively high at about 6 mg/L (as N), and may have contributed to the acute effluent toxicity.

Table A-14

Phase III Treatability Study
Step V - Full Treatment Step[1]

Parameter	Unit	Raw Process Water	Lime Treated	Filter Effluent	Filter Control
Ammonia (as N)	mg/L	6.6	N/A	N.A	N/A
Arsenic	mg/L	0.0064	<0.004	<0.004	<0.004
Cadmium	mg/L	<0.006[2]	0.005	<0.005	<0.005
Calcium	mg/L	580	540	520	0.79
Chromium, Total	mg/L	<0.005	<0.005	<0.005	<0.005
Copper	mg/L	0.028[2]	0.015	<0.005	<0.005
Cyanide	mg/L	<0.010	<0.010	<0.010	<0.010
Hardness	mg/L	1,400	1,500	1,500	N/A
Iron	mg/L	0.915[2]	0.260	<0.020	<0.020
Lead	mg/L	<0.003	<0.003	<0.003	<0.003
Magnesium	mg/L	12	11	13	0.073
Mercury	mg/L	<0.0002	<0.0002	<0.0002	<0.0002
Nickel	mg/L	<0.020	<0.020	<0.020	<0.020
Nitrate + Nitrite (as N)	mg/L	6.6	N/A	5.5	N/A
Selenium	mg/L	0.097[2]	0.093	0.076	<0.005
Silver	mg/L	<0.005	<0.005	<0.005	<0.005
Sulfate	mg/L	1,200	1,500	1,600	N/A
Total Dissolved Solids	mg/L	2,600	2,600	2,700	<10
Zinc	mg/L	0.44[2]	0.29	0.023	<0.020
Total Suspended Solids	mg/L	<10	<10	<10	<10
TKN	mg/L	6.7	N/A	7.7	N/A
BOD_5	mg/L	8	N/A	N/A	N/A
COD	mg/L	23	18	20	<10
Sulfide	mg/L	N/A	1.1	1.5	1.4
pH	S.U.	7.1[2]	10.0	9.8	N/A

N/A = No Test Performed.
[1]All values for metals expressed as "total" metal.
[2]Average of analyses for samples collected on two separate days prior to beginning full treatment.

Table A-15

Phase III Treatability Study
Step V - Summary of Bioassay Acute Toxicity Test Data for Full Treatment Step[1]

Organism	Test Solution	Mean % Survival
Ceriodaphnia dubia	Secondary Control[2]	95
	Primary Control[3]	100
	1% Effluent[4]	95
	10% Effluent[4]	100
	25% Effluent[4]	100
	50% Effluent[4]	95
	75% Effluent[4]	100
	100% Effluent[4]	85
Daphnia magna	Secondary Control[2]	100
	Primary Control[3]	100
	1% Effluent[4]	100
	10% Effluent[4]	100
	25% Effluent[4]	100
	50% Effluent[4]	100
	75% Effluent[4]	100
	100% Effluent[4]	100
Pimephales promelas	Secondary Control[2]	100
	Primary Control[3]	95
	1% Effluent[4]	95
	10% Effluent[4]	100
	25% Effluent[4]	95
	50% Effluent[4]	85
	75% Effluent[4]	55
	100% Effluent[4]	10

[1]Tests conducted in accordance with EPA protocols for acute toxicity testing.
[2]Flow through lab culture water.
[3]Wisconsin River water from Hat Rapids Dam.
[4]Effluent mixed with Wisconsin River water in proportion indicated.

Table A-16

Phase III Treatability Study
Step V - *Ceriodaphnia dubia* Chronic Test
(Third-Brood Endpoint Reproduction Data)
for Full Treatment[1]

Test Solution	Mean Neonates[2]
Secondary Control[3]	26.5
Primary Control[4]	31.7
0.6% Effluent[5]	34.4
1.25% Effluent[5]	32.8
2.5% Effluent[5]	35.0
5.0% Effluent[5]	39.7
10% Effluent[5]	31.6

[1]Tests conducted in accordance with EPA protocols for chronic toxicity testing.
[2]Ten replicates per test.
[3]Flow through lab culture water.
[4]Wisconsin River water from Hat Rapids Dam.
[5]Effluent mixed with Wisconsin River water in proportion indicated.

Table A-17

Phase III Treatability Study
Step V - *Pimephales promelas* Chronic Test
(Mean Biomass Data)
for Full Treatment[1]

Test Solution	Mean Biomass[2]
Secondary Control[3]	0.36
Primary Control[4]	0.35
0.6% Effluent[5]	0.26
1.25% Effluent[5]	0.36
2.5% Effluent[5]	0.39
5.0% Effluent[5]	0.37
10% Effluent[5]	0.39

[1] Tests conducted in accordance with EPA protocols for chronic toxicity testing.
[2] Four replicates per test. Biomass = (total replicate dry weight/number larvae used to initiate the replicate).
[3] Flow through lab culture water.
[4] Wisconsin River water from Hat Rapids Dam.
[5] Effluent mixed with Wisconsin River water in proportion indicated.

Table A-18

Phase III Treatability Study
Step V - *Pimephales promelas* Chronic Test
(Mean Survival Data)
for Full Treatment[1]

Test Solution	% Survival[2]
Secondary Control[3]	95
Primary Control[4]	92
0.6% Effluent[5]	100
1.25% Effluent[5]	100
2.5% Effluent[5]	100
5.0% Effluent[5]	100
10% Effluent[5]	100

[1]Tests conducted in accordance with EPA protocols for chronic toxicity testing.
[2]Four replicates per test.
[3]Flow through lab culture water.
[4]Wisconsin River water from Hat Rapids Dam.
[5]Effluent mixed with Wisconsin River water in proportion indicated.

A.3 Summary and Conclusions

The wastewater treatability study was conducted to evaluate the effectiveness of the treatment processes selected for treatment of wastewaters generated by the Crandon Project. The study included three separate phases. The first two phases evaluated treatment of mine drainage water and the third phase evaluated treatment of mill process water. The following provides a summary of the results of the treatability study.

A.3.1 Mine Drainage Water

Phase I of the wastewater treatability study evaluated the selected treatment processes when treating mine drainage water. The first step in this phase was the generation of mine drainage water. This wastewater was generated in the laboratory of Foth & Van Dyke using geologic materials obtained from the Crandon Project site. The second step was optimization of the lime treatment process with respect to the overall removal of heavy metals. The third step was optimization of the sulfide treatment process with respect to the overall removal of heavy metals. Finally, the effectiveness of the full treatment process, including lime treatment, sulfide treatment, and filtration, was evaluated. At each step of Phase I of the treatability study, wastewater samples were analyzed for metals and other inorganic constituents both before and after treatment. Additionally, a sample of the final effluent from the full treatment step was sent to a laboratory for assessment of whole effluent toxicity of the treated effluent.

In Phase II of the wastewater treatability study, the selected treatment processes were evaluated further for treatment of mine drainage water. The objectives of this phase were to further evaluate optimization of the sulfide treatment process, to verify the results obtained in Phase I, and to obtain more information on the whole effluent toxicity of the treated effluent. In the sulfide optimization step of this phase, the impact of both treatment pH and sulfide dosage were evaluated. The full treatment step of Phase II re-evaluated the efficiency of the entire treatment process with several modifications to the treatment used in Phase I. Modifications used in the full treatment step of Phase II included omission of the pH adjustment step following lime treatment and the use of a lower sulfide dosage. Whole effluent toxicity testing of the treated effluent was expanded to evaluate toxicity at a wider range of effluent dilutions. Following is a discussion of the results from Phases I and II of the treatability study.

Phase I of the treatability study evaluated lime treatment at treatment pH levels of 9.0, 9.5, and 10.0. Based on the results obtained during this step, lime treatment for the mine drainage water was most effective, with respect to the overall removal of metals, at a treatment pH of 10.0.

Optimization of the sulfide treatment process was evaluated in both Phase I and II of the treatability study. The impact of both treatment pH and sulfide dosage were evaluated. Ten different pH-sulfide dosage combinations were evaluated covering the pH range from 8.0 to 10.0 and covering sulfide dosages ranging from 10 to 400 mg/L as $Na_2S \cdot 9H_2O$. The results of the optimization process indicate that sulfide treatment is generally more effective at higher pH levels. The results of the optimization process also indicated that a higher level of metals removal resulted at the higher sulfide dosages evaluated. However, based on the results of this study, it is anticipated that the level of treatment required to meet the estimated effluent limitations can be produced at sulfide dosages of 50 mg/L or lower. It is also important to note that operating mines, treating mine wastewater in full scale facilities, have reported effective metals removals at sulfide dosages of less than 10 mg/L as $Na_2S \cdot 9H_2O$.

Full treatment of mine wastewater was evaluated in both Phase I and Phase II of the treatability study. In Phase I, the full treatment process included lime treatment at a pH of 10.0, pH adjustment to 7.3 with sulfuric acid after lime treatment and settling, sulfide treatment at 250 mg/L as $Na_2S \cdot 9H_2O$, and filtration. In Phase II, the full treatment process included lime treatment at a pH of 10.0, sulfide treatment at 50 mg/L $Na_2S \cdot 9H_2O$, and filtration. The omission of the pH adjustment step in Phase II was based on the results of the sulfide optimization step in Phase II which indicated that treatment was more effective at higher pH levels. The use of a lower sulfide dosage in Phase II was based on establishing a balance between treatment effectiveness and effluent toxicity. Results from the whole effluent toxicity tests performed on treated effluent from Phases I and II suggest that the acute effluent toxicity observed in Phase I may have been the result of a high residual sulfide concentration in the effluent. Consequently, the sulfide dosage for Phase II was adjusted to provide a level of treatment adequate to meet estimated discharge limitations while minimizing the potential for effluent toxicity due to residual sulfide.

The analyses of the various effluents generated in the full treatment steps of Phases I and II are reported in Table A-19. Comparing this data and the estimated effluent limitations for a discharge to the Wisconsin River at a discharge flow rate of 1,200 gallons per minute as shown in Table 6-1, it can be seen that the lime treatment process alone will produce an effluent that will meet the estimated effluent limitations for all parameters with the possible exceptions of copper and cadmium. The data also shows that the effectiveness of the lime treatment process is relatively independent of the concentrations of the parameters in the raw wastewater. This conclusion is reached by comparing the range of analytical results for the raw wastewater and the lime treated effluent. The comparison shows considerable variation in the concentrations of parameters in the raw wastewater, while relatively little variation is seen the effluent from the lime treatment process.

The effluent data in Table A-19 represents the mine wastewater subjected to full treatment including lime treatment, sulfide treatment, and filtration. The results of the full treatment tests indicate that the selected treatment processes can produce an effluent that meets or exceeds the estimated effluent limitations for the Wisconsin River. It is important to note that the estimated limitation for mercury is 0.000014 mg/L while the reported detection level is 0.0002 mg/L. This level of detection is based on the approved analytical method for mercury which is to be used for effluent monitoring in the WPDES permit program. Consequently, the effluent limitation for mercury is effectively equivalent to the level of detection for the currently accepted analytical method. Based on the use of the currently accepted analytical method for mercury detection, the concentration of mercury in the final effluent meets the anticipated effluent limitations.

Treated effluents from both Phase I and Phase II were evaluated for whole effluent toxicity in accordance with EPA testing protocols. Acute and chronic toxicity were evaluated with respect to both aquatic invertebrates and aquatic vertebrates. Controls used in the whole effluent toxicity included Wisconsin River water obtained from the Hat Rapids Dam and lab culture water. Acute toxicity for the Phase I effluent was evaluated at 100 percent and 50 percent effluent dilutions. Acute toxicity for the Phase II effluent was evaluated at 100%, 75%, 50%, 25%, 10%, and 1% effluent dilutions. Chronic toxicity, for both Phase I and II effluents, was evaluated at 10%, 5%, 2.5%, 1.25%, and 0.6% effluent dilutions. Dilutions were made using Wisconsin River water.

For Phase I effluent, all acute toxicity tests showed that the effluent would be toxic, i.e., with <5 percent survival in 100 percent effluent for all species tested. Chronic toxicity tests showed no

toxicity for both species within the range of effluent dilutions evaluated. Results of the Phase I whole effluent toxicity testing suggest that the relatively high sulfide residual in the effluent may have been the principal effluent component contributing to effluent toxicity. Consequently, the full treatment step, including whole effluent toxicity testing of the effluent, was repeated in Phase II with the sulfide dosage in Phase II lowered to 50 mg/L as $Na_2S \cdot 9H_2O$. This dosage was selected to provide a level of treatment adequate to meet effluent limitations while minimizing the potential for whole effluent toxicity.

For the effluent from Phase II of the treatability study, all results showed no toxicity, with >90 percent acute survival for all species in 100 percent effluent, and with no chronic toxicity at any of the effluent dilutions tested. These results indicate that the selected treatment processes are capable of generating a final effluent which will meet estimated whole effluent toxicity requirements. Additionally, these results suggest that effluent toxicity observed in effluent generated in Phase I of the treatability study was due to a relatively high concentration of residual sulfide contained in the treated effluent resulting from a high sulfide treatment dosage. Because Phase II of this study demonstrated that the estimated effluent limitations can be met at lower sulfide dosages, it is anticipated that the estimated whole effluent toxicity requirements of the WPDES permit can be met for the discharge of treated mine drainage water from the Crandon Project.

A.3.2 Mill Process Water

Phase III of the wastewater treatability study evaluated the selected treatment processes when treating mill process water. The first step in this phase was the collection of mill process water from an operating zinc/copper mine in Canada similar to that planned for the Crandon Project. The second step was optimization of the sulfide treatment process with respect to the overall removal of heavy metals. Finally, the effectiveness of the entire treatment process, including lime treatment, sulfide treatment and filtration was evaluated. At each step of the Phase III treatability study, wastewater samples were analyzed for metals and other inorganic constituents both before and after treatment. Additionally, a sample of the effluent from the full treatment step was tested for whole effluent toxicity. Following is a discussion of the results from Phase III of the treatability study.

Optimization of the lime treatment process was not conducted for this phase of the treatability study. The lime treatment operating pH was selected based on the results of treatability studies conducted by, and actual operating experience of, the Canadian mine from which the process water was obtained. However, the sulfide treatment process was optimized. The impact of both treatment pH and sulfide dosage on metals removal were evaluated. Ten different pH-sulfide dosage combinations were evaluated covering the pH range from 8.0 to 10.0 and covering sulfide dosages ranging from 10 to 400 mg/L as $Na_2S \cdot 9H_2O$. The results of the optimization process indicated that sulfide treatment was generally more effective at higher pH levels. The results of the optimization process also indicated that a higher level of metals removal resulted at the higher sulfide dosages evaluated. However, based on the results of this study, it is anticipated that the level of treatment required to meet the estimated effluent limitations can be produced at sulfide dosages of 50 mg/L $Na_2S \cdot 9H_2O$ or lower.

In the final step of this phase of the treatability study, full treatment of mill process water was evaluated. The full treatment process included lime treatment at a pH of 10.0, sulfide treatment at 50 mg/L $Na_2S \cdot 9H_2O$, and filtration. From the analyses of the wastewaters generated during full treatment, it can be seen that the lime treatment process alone will produce an effluent that

will meet the estimated effluent limitations for all parameters, with the possible exception of cadmium.

The filter effluent data in Table A-14 represents the process water subjected to full treatment including lime treatment, sulfide treatment, and filtration. The results of the full treatment tests indicate that the selected treatment processes can produce an effluent that meets the estimated effluent limitations for the Wisconsin River.

The effluent was evaluated for whole effluent toxicity. Whole effluent toxicity testing was performed as described previously for the mine wastewater. Chronic tests showed that the effluent is not toxic at any of the effluent dilutions tested. Daphnid acute toxicity tests showed no toxicity. The Pimephales promelas acute test indicated marginal survival at 75 percent effluent and acute toxicity in 100 percent effluent. However, 85 percent Pimephales survival was observed at an effluent dilution of 50 percent and greater than 95 percent survival was observed for the 25%, 10%, and 1% dilutions. The cause of the observed acute toxicity at the higher effluent dilutions was uncertain. The concentration of ammonia in the final effluent was relatively high at about 6 mg/L (as N) and may have contributed to the acute effluent toxicity.

A test which shows that the effluent is toxic should be defined as acute toxicity at the percent effluent which would occur at the edge of the zone of initial dilution or chronic toxicity at less than the instream waste concentration. For the maximum discharge to the Wisconsin River of 1,200 gallons per minute and a $Q_{7,10}$ of 304 cfs, a 3.5 percent effluent dilution would occur at the edge of the zone of initial dilution, and a 0.9 percent effluent dilution would be the instream waste concentration. The proposed discharge location for treated wastewater from the Crandon Project is the Wisconsin River at the Hat Rapids Dam, so a zone of initial dilution is applicable for the Crandon Project. Given the small flow of wastewater relative to the flow of river water through the dam and given the rapid and extensive degree of mixing which will occur under the turbulent flow patterns characteristic of dam hydraulic systems, the wastewater will be substantially diluted before it is discharged from the dam into the river. Consequently, acute toxicity for the treated wastewater should be evaluated on a criterion of significantly less than a 100 percent effluent dilution. Using a conservative effluent dilution of ten percent for the acute toxicity criterion, the effluent generated in Phase III of the treatability study would be not be considered toxic.

Table A-19

Treatability Study
Summary of Results for Phases I and II[1]

Parameter	Unit	Raw Wastewater[2]	Lime Treated[2]	Effluent[3]
Antimony	mg/L	<0.050	<0.057	<0.050
Arsenic	mg/L	0.150-0.400	<0.004-0.0069	<0.004-0.0048
Beryllium	mg/L	<0.005	<0.005	<0.005
Cadmium	mg/L	0.062-0.130	<0.005	<0.005
Chromium, Total	mg/L	0.007-0.015	<0.005-0.009	<0.005
Copper	mg/L	6-8.4	0.043-0.110	<0.005-0.005
Cyanide	mg/L	<0.020	<0.020	<0.010-0.026
Lead	mg/L	0.640-0.840	<0.003-0.011	<0.003-0.0055
Mercury	mg/L	0.0002-0.000558	<0.0002	<0.0002
Nickel	mg/L	0.030-0.210	<0.020	<0.020
Selenium	mg/L	0.064-0.120	0.052-0.130	0.055-0.120
Silver	mg/L	<0.005-0.0064	<0.005	<0.005-0.00097
Thallium	mg/L	0.011	<0.010	<0.010
Zinc	mg/L	17-33	0.200-0.220	<0.020
Total Suspended Solids	mg/L	8-75	N/A	<10

N/A = No Test Performed.

[1] All values for metals expressed as "total" metal.

[2] Based on analysis of wastewater generated in Step IV of Phase I and Step III of Phase II.

[3] Based on analysis of fully treated wastewater with a sulfide dosage of 250 mg/L as $Na_2S \cdot 9H_2O$ from Step IV of Phase I and a sulfide dosage of 50 mg/L as $Na_2S \cdot 9H_2O$ from Step III of Phase II.

Appendix B

Reverse Osmosis Treatability Study for the Crandon Project

Reverse Osmosis Treatability Study for the Crandon Project

Scope ID: 93C049

Prepared for
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November 1998

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Reverse Osmosis Treatability Study for the Crandon Project

Contents

Tables

Appendices

1 Introduction

Nicolet Minerals Company (NMC) is planning to develop a zinc/copper mine near Crandon, Wisconsin. As part of project operations, treated effluent from the mine will need to be discharged to waters of the state. The Wisconsin Department of Natural Resources (WDNR) will establish specific standards that the discharge waters will need to meet. These standards are specific to discharge type and location. A discharge to a stream may be assigned different standards than a discharge to groundwater or to a mitigation site. Standards for discharging to each selected water body will be set individually by the WDNR.

The primary technology proposed for the treatment of mine water is a lime/sulfide filtration treatment process which will reduce metals in the water to levels suitable for discharge to specific surface water bodies. However, not all the cations and anions will be reduced by the lime/sulfide process to levels suitable for discharge to groundwater or for use at all potential mitigation sites. Therefore, advanced treatment may be necessary to provide additional treatment for the cations and anions of concern such that the treated water will meet the standards set by the WDNR. One of the treatment technologies under consideration by NMC is reverse osmosis (RO). A bench scale treatability study has been completed to assess the ability of the RO technology to meet WDNR standards. The implementation of this study does not preclude techniques that may replace or complement the RO technology.

A detailed work plan outlining the proposed study was submitted to the WDNR on May 8, 1998. This document is titled *Bench Scale Evaluation of Reverse Osmosis Method for Wastewater Treatment.* A detailed report describing the completed study is presented in this document. Section 2 of this report provides background information pertaining to treatability studies previously completed for the project. Section 3 of this report discusses feed water generation for the study. Section 4 discusses the treatability protocol and the treatability results. Section 5 presents information relating to the planned use of the generated data.

2 Previous Treatability Studies

Previous studies evaluating the performance of lime/sulfide treatment were presented in the *Preliminary Engineering Report* (PER) (Foth & Van Dyke, 1995/1998) completed for the Crandon Project. This evaluation characterized the untreated wastewater which is anticipated from the proposed project and evaluated the ability of the lime/sulfide process to treat wastewater to levels acceptable for discharge to the Wisconsin River. These previous studies were not intended to be used to demonstrate the ability of lime/sulfide treatment to meet groundwater discharge standards or standards for discharge to surface waters needing mitigation.

3 Feed Water Preparation

The RO system treatability study was undertaken to assess the ability of RO treatment technology to produce an effluent suitable for discharge to groundwater or for use as mitigation water. The feed water used for the test was prepared (Table 3-1) based on the maximum anticipated concentration for each individual constituent that may be present in the effluent from the lime/sulfide treatment process. Due to the solubility of individual constituents, and the ionic strength of the total solution, the final concentrations in the feed water of some of the constituents are likely not achievable due to precipitation. The feed water was produced by mixing the reagents listed in Table 3-1 with deionized water or water that has been passed through an RO system.

Osmonics, Inc., Minneapolis, Minnesota, a manufacturer of RO membranes and treatment systems, completed the RO treatability test. The procedure involved two batch tests. The first involved a single pass through the RO system. The second involved a double pass through the RO system. Two separate batches of feed water, approximately 55 gallons each, were generated at EnChem, Inc., a Green Bay, Wisconsin, commercial laboratory, and transported to Osmonics' Minneapolis facility in new 5 gallon plastic containers by Foth &Van Dyke.

A sample of the prepared feed water from each batch was analyzed for the analytes listed in Table 3-1 to document their concentration in the feed water and to use as a basis of comparison to other samples taken for analysis during the performance of the test. The samples were forwarded to EnChem, Inc. for analytical testing. The majority of the testing was performed by EnChem, Inc. Low level metal and sulfate analyses were performed on behalf of EnChem, Inc. by the Battelle Marine Science Lab, Sequim, Washington, and Commercial Testing & Engineering Company, Denver, Colorado, respectively. The feed water sample for each test batch was collected at the Osmonics facility after emptying the 5 gallon containers for each batch into a separate 55 gallon container which was used as the feed source for the RO apparatus. The sample was collected as described in Appendix A. The analytical results are shown in Table 3-1.

Differences in Table 3-1 between target concentrations and actual feed water concentrations are likely attributable to the effects discussed above. A much higher level of mercury was noted in the feed water. An investigation found that a greater quantity of $HgSO_4$ was inadvertently added during the feed water preparation. Sulfate levels were approximately one half of the target concentration. The investigation into this matter showed that less Na_2SO_4 was added to the feed water than desired. The actual concentrations of sodium and chloride are respectively 70% and 130% higher than the target concentrations for the batch 2 feed water. The additional concentration of sodium chloride may likely have originated from either equipment contamination or an error in the makeup of the feed water. Since the data produced by the tests provides removal efficiency information which can be used to project full scale effluent quality, the differences do not impact the value of the pilot test.

Table 3-1

Feed Water Preparation

Parameter	Target Concentrations (mg/l)	Batch 1 Actual Feed Water Concentrations (mg/l)	Batch 2 Actual Feed Water Concentrations (mg/l)	Chemical Additive
Antimony	0.01	0.000213	0.000336	$SbCl_3$
Arsenic	0.01	<0.0033	0.0089	As_2O_3
Barium	0.16	0.026	0.014	$BaSO_4$
Cadmium	0.002	0.00225	0.0023	$3CdSO_4 \cdot 8H_2O$
Chromium	0.01	0.00609	0.00234	$CrCl_3 \cdot 6H_20$
Copper	0.08	0.0694	0.0664	$CuSO_4 \cdot 5H_2O$
Lead	0.006	0.00563	0.0046	$PbSO_4$
Mercury	0.000040	0.000424	0.000245	$HgSO_4$
Nickel	0.04	0.0392	0.0339	$NiSO_4 \cdot 6H_2O$
Selenium	0.29	0.28	0.24	SeO_2
Silver	0.002	0.0032	0.0021	Ag_2SO_4
Thallium	0.02	0.0182	0.0161	$Tl(NO_3)_3 \cdot 3H_2O$
Iron	0.081	0.054	0.015	$FeSO_4 \cdot 7H_2O$
Manganese	0.064	0.087	0.086	$MnSO_4 \cdot 4H_20$
Zinc	0.1	0.11	0.1	$ZnSO_4 \cdot 7H_20$
Ammonia	7	4.5	4.1	$(NH_4)_2\ SO_4$
Calcium	190	150	190	$CaSO_4$
Magnesium	87	45	73	$MgSO_4$
Potassium	14	14	24	K_2SO_4
Sodium	51	16	87	—[1]
Chloride	47	<0.14	110	—[2]
Sulfate	1246	641	639	Na_2SO_4[3]

Table 3-1 *(Continued)*

Parameter	Target Concentrations (mg/l)	Batch 1 Actual Feed Water Concentrations (mg/l)	Batch 2 Actual Feed Water Concentrations (mg/l)	Chemical Additive
Cyanide	0.13	0.12	0.12	NaCN
Fluoride	0.21	0.24	2.4	NaF
Nitrate + Nitrite	11	6.1	NR	$NaNO_3$
Nitrite	11	—	—	$NaNO_2$
Alkalinity	17	23	170	$NaHCO_3$

[1] Na is added with Na_2SO_4, NaCN, NaF, $NaNO_3$, $NaNO_2$, and $NaHCO_3$.
[2] Cl is added with $SbCl_3$ and $CrCl_3 \cdot 6H_20$. The synthetic concentration of Cl is less than the target concentration because adding additional Cl will cause a corresponding cation (Na) increase above the cation (Na) target level. The target concentration of Cl is already below the PAL concentration without the RO treatment, therefore, the control of chloride is not a relevant issue to the RO performance test.
[3] SO_4 is added with various other chemicals. Na_2SO_4 is added to increase the SO_4 to the target level.

NR = No results

Prepared by: JJF1/MLD2
Checked by: JJF1

4 Treatability Study Protocol

The RO manufacturer, Osmonics, completed the treatability study in conjunction with Foth & Van Dyke. The treatability study was completed in phases at the Osmonics site. The study included evaluation of single pass and multiple pass RO processes to reach the desired water quality. The first phase was a single pass through an RO system. The second phase was a double pass through an RO system.

Foth & Van Dyke collected the necessary samples for analytical testing and coordinated shipment to EnChem, Inc. Since the levels of detection needed for this evaluation were below those normally used, Foth & Van Dyke used clean techniques for the collection, preservation and handling of the samples. The sample collection and handling procedures are presented in Appendix A. Two representatives of the WDNR were in attendance at Osmonics during the RO treatability study.

4.1 Facility Preparation

The Osmonics testing facility was prepared for the study by reducing potential sources of contamination such as airborne dust. The ventilation to the test room was turned off and the ventilation ducts were sealed with plastic. The subsequent reduction in air movement lowered the possibility of dust particles contaminating the permeate samples.

As a further precaution, a plastic cover was placed over the permeate container and was partially removed only during sampling. Plastic was also placed over the floor near the permeate and bench staging area, and plastic was placed over the test facility working bench.

4.2 Phase 1, Single Pass RO Evaluation

A preliminary evaluation was completed to determine the optimum operating level of RO reject/permeate versus effluent quality, and technical and economic feasibility. The RO membrane used in this evaluation was an Osmonics Model No. 192T-MS12 polyamide thin film composite membrane. The study involved the collection of samples for laboratory analyses. Sample size, preservation methods, and laboratory analytical methods are contained in Tables 4-1 and 4-2.

Before the tests commenced, a new membrane was installed in the RO unit and a citric acid solution was run through it for 20 minutes to clean the unit. Deionized water was then run through the RO test unit for 105 minutes to further flush out potential contaminates. The source of the deionized water was RO permeate generated at the Osmonics facility from another RO unit. The RO unit generating the deionized water used city water as the feed. Samples from the permeate of this blank run were taken and analyzed for possible contamination. The analytical results are presented in Table 4-3. The sample was labeled NMC-RO-1.

Table 4-1

Reverse Osmosis Complete Chemical Characterization Testing Schedule

A) Parameter List

Parameter	Detection Limit	Units	Method	Laboratory
Antimony	0.006	µg/l	SW 846-1638	Battelle
Arsenic	0.0021	mg/l	206.2	EnChem
Barium	0.00040	mg/l	EPA 200.7	EnChem
Cadmium	0.000006	mg/l	SW 846-1638	Battelle
Chromium (Total)	0.0003	mg/l	SW 846-1638	Battelle
Copper	0.000030	mg/l	SW 846-1638	Battelle
Cyanide (Total)	0.0034	mg/l	EPA 335.4	EnChem
Fluoride	0.075	mg/l	SM 4500FC	EnChem
Lead	0.000002	mg/l	SW 846-1638	Battelle
Nickel	0.00003	mg/l	SW 846-1638	Battelle
Mercury	0.10	ng/l	SW 846-1631	Battelle
Nitrate + Nitrite	0.026	mg/l	EPA 353.2	EnChem
Selenium	0.0023	mg/l	EPA 270.2	EnChem
Silver	0.0020	mg/l	EPA 272.2	EnChem
Thallium	0.0033	µg/l	SW 846-1638	Battelle
Chloride	0.14	mg/l	EPA 200.7	EnChem
Iron	0.025	mg/l	EPA 200.7	EnChem
Manganese	0.00024	mg/l	EPA 200.7	EnChem
Sulfate	1	mg/l	SM4500 SO_4 C (Gravimetric)	CTE
Zinc	0.0035	mg/l	EPA 200.7	EnChem
Alkalinity	6.4	mg/l	EPA 310.2	EnChem
Ammonia Nitrogen	0.061	mg/l	EPA 350.3	EnChem

Table 4-1 *(Continued)*

Parameter	Detection Limit	Units	Method	Laboratory
Boron	0.076	mg/l	EPA 200.7	EnChem
Calcium	0.016	mg/l	EPA 200.7	EnChem
Conductivity	10	mg/l	EPA 120.1	EnChem
Total Hardness	0.3	mg/l	EPA 200.7	EnChem
Magnesium	0.0056	mg/l	EPA 200.7	EnChem
Organic Nitrogen	0.061	mg/l	EPA 350.3/351.4	EnChem
pH	—	SU	EPA 150.1	EnChem
Potassium	0.012	mg/l	EPA 200.7	EnChem
Sodium	0.260	mg/l	EPA 200.7	EnChem
Total Dissolved Solids	2.0	mg/l	EPA 160.1	EnChem
Total Nitrogen	0.053	mg/l	EPA 351.4	EnChem
Total Phosphorus	0.005	mg/l	EPA 365.1	EnChem

B. Sample Size and Preservation Requirements

Metals, Hardness
1000 ml plastic preserved with nitric acid to pH<2

Cyanide
250 ml preserved with sodium hydroxide and ascorbic acid to pH>12

Fluoride, Chloride, Sulfate, Conductivity, Alkalinity, Total Dissolved Solids, pH
1000 ml unpreserved

Nitrate + Nitrite Nitrogen, Ammonia Nitrogen, Organic Nitrogen, Total Nitrogen, Total Phosphorus
1000 ml preserved with sulfuric acid to pH<2

Prepared by: RTJ
Checked by: GJB1/JJF1

Table 4-2

Reverse Osmosis Partial Chemical Characterization Testing Schedule

Parameter	Detection Limit	Units	Method	Laboratory
Cyanide	0.0034	mg/l	EPA 335.4	EnChem
Nitrate + Nitrite	0.026	mg/l	EPA 353.2	EnChem
Selenium	0.0023	mg/l	EPA 270.2	EnChem
Thallium	0.0033	μg/l	EPA 1638N SW 846-1638	Battelle
Sulfate	1	mg/l	SM4500 SO_4-C (Gravimetric)	CTE
Calcium	0.016	mg/l	EPA 200.7	EnChem
Magnesium	0.0056	mg/l	EPA 200.7	EnChem
Barium	0.00040	mg/l	EPA 200.7	EnChem
TDS	2.0	mg/l	EPA 160.1	EnChem
Conductivity	10	mg/l	EPA 120.1	EnChem
Antimony	0.006	μg/l	SW 846-1638	Battelle
Cadmium	0.000006	mg/l	SW 846-1638	Battelle
Chromium (Total)	0.0003	mg/l	SW 846-1638	Battelle
Copper	0.000030	mg/l	SW 846-1638	Battelle
Lead	0.000002	mg/l	SW 846-1638	Battelle
Nickel	0.00003	mg/l	SW 846-1638	Battelle

Prepared by: RTJ
Checked by: GJB1/JJF1

Table 4-3

Phase 1 Laboratory Analytical Data

Parameter	Blank NMC-RO-1 (mg/l)	Feed Water NMC-RO-2 (mg/l)	50% Recovery NMC-RO-3 (mg/l)	70% Recovery NMC-RO-4 (mg/l)	75% Recovery NMC-RO-5 (mg/l)	80% Recovery NMC-RO-6 (mg/l)
Antimony	0.0000569	0.000213	0.0000271 [1]	0.0000325	0.0000413	0.0000405
Arsenic	0.0035	<0.0033	NR	NR	NR	0.004
Barium	0.00051	0.026	<0.00015	<0.00015	<0.00015	<0.00015
Cadmium	0.00000971	0.00225	0.00000719 [1]	0.00000818	0.00000949	<0.000007
Chromium	0.00138	0.00609	0.0000502 [1]	<0.000047	<0.000047	0.000123
Copper	0.000263	0.0694	0.00918 [1]	0.0137	0.0193	0.00953
Lead	0.000105	0.00563	<0.0000296 [1]	<0.000025	<0.000025	<0.000025
Mercury	0.00000154	0.000424	NR	NR	NR	0.0000116 [1]
Nickel	0.00441	0.0392	0.000282	0.000452	0.000594	0.000363
Selenium	<0.00044	0.28	0.0017	0.0024	0.0033	0.0014
Silver	<0.00058	0.0032	NR	NR	NR	<0.00058
Thallium	<0.0000013	0.0182	0.000617 [1]	0.00108	0.0016	0.000595
Iron	<0.0023	0.054	NR	NR	NR	<0.0023
Manganese	0.0015	0.087	NR	NR	NR	0.0006

Table 4-3 *(Continued)*

Parameter	Blank NMC-RO-1 (mg/l)	Feed Water NMC-RO-2 (mg/l)	50% Recovery NMC-RO-3 (mg/l)	70% Recovery NMC-RO-4 (mg/l)	75% Recovery NMC-RO-5 (mg/l)	80% Recovery NMC-RO-6 (mg/l)
Zinc	0.002	0.11	NR	NR	NR	<0.00095
Ammonia	<0.061	4.5	NR	NR	NR	0.18
Calcium	0.26	150	0.4	0.57	0.9	0.35
Magnesium	0.082	45	0.12	0.18	0.28	0.11
Potassium	0.0098	14	NR	NR	NR	0.46
Sodium	0.23	16	NR	NR	NR	0.66
Chloride	1.4	<0.14	NR	NR	NR	<0.14
Sulfate	2	641	2	3	7	3
Cyanide	<0.0034	0.12	0.034	0.038	0.044	0.027
Fluoride	<0.014	0.24	NR	NR	NR	<0.014
Nitrate + Nitrite	0.11	6.1	0.23	0.34	0.48	0.22
Alkalinity	<6.4	23	NR	NR	NR	<6.4

NR = No Test Performed.

[1] Replicate data is averaged

Prepared by: MLD2
Checked by: JJF1

After completion of the blank run, 50 gallons of batch 1 feed water was added to the feed tank for the RO test unit. An antiscalent, 0.39 ml of Flowcon 260, was added to simulate a full scale production dosage of approximately 5 ppm. A makeup quantity of lead consisting of 104 ml of 10,000 ppb of lead as lead sulfate was also added. The lead was added to correct a feed water shortage of lead.

A sample of the feed water was taken from the feed tank. A complete chemical characterization as per Table 4-1 was completed on the sample. The analysis results are presented in Table 4-3. The sample was labeled NMC-RO-2.

Following sample collection, the reverse osmosis pumps were turned on and the feed water was pumped through the reverse osmosis unit. At the 50% recovery point, a sample of the permeate was taken from the permeate collection hose. A partial chemical characterization as per Table 4-2 was completed on the sample. The analytical results are presented in Table 4-3. The sample was labeled NMC-RO-3.

The reverse osmosis pumps continued to run, and at the 70% recovery point a sample of the permeate was again taken from the permeate collection hose. A partial chemical characterization as per Table 4-2 was completed on the sample. The analytical results are presented in Table 4-3. The sample was labeled NMC-RO-4.

The reverse osmosis pumps continued to run, and at the 75% recovery point a sample of the permeate was taken from the permeate collection hose. A partial chemical characterization as per Table 4-2 was completed on the sample. The analytical results are presented in Table 4-3. The sample was labeled NMC-RO-5.

The reverse osmosis pumps continued to run, and at the 80% recovery point the pumps were shut down. A sample of the composite permeate was taken from the permeate collection tank. A complete chemical characterization as per Table 4-1 was completed on the sample. The analytical results are presented in Table 4-3. The sample was labeled NMC-RO-6. This concluded the Phase 1 testing. A summary of the Phase 1 testing is presented in Table 4-4.

4.3 Phase 2, Multiple Pass RO Evaluation

The RO membrane used in this evaluation was the same as that used for the Phase 1 testing, an Osmonics Model No. 192T-MS12 polyamide thin film composite membrane. Deionized water was run through the RO test unit for 10 minutes. The source of the deionized water was RO permeate generated at the Osmonics facility from another RO unit. The RO unit generating the deionized water used city water as the feed.

After completion of the blank run, 50 gallons of batch 2 feed water were added to the feed tank for the RO test unit. An antiscalent, 0.40 ml of Flowcon 260, was added to simulate a full scale production dosage of approximately 5 ppm. A makeup quantity of lead consisting of 104 ml of 10,000 ppb of lead as lead sulfate was also added. The lead was added to correct a feed water shortage of lead.

Table 4-4

Phase 1 Sample Descriptions

Sample ID	Testing	Description
NMC-RO-1	Complete, per Table 4-1	Blank Permeate: The sample is from the composite permeate using deionized water as the feed.
NMC-RO-2	Complete, per Table 4-1	Synthetic wastewater: The sample is from the feed tank after mixing all of the Batch 1 feed water samples in the feed tank.
NMC-RO-3	Partial, per Table 4-2	Permeate, 50% recovery: The sample is from the permeate hose at the 50% recovery point of Phase 1 testing.
NMC-RO-4	Partial, per Table 4-2	Permeate, 70% recovery: The sample is from the permeate hose at the 70% recovery point of Phase 1 testing.
NMC-RO-5	Partial, per Table 4-2	Permeate, 75% recovery: The sample is from the permeate hose at the 75% recovery point of Phase 1 testing.
NMC-RO-6	Complete, per Table 4-1	Composite permeate, 80% recovery: The sample is from the permeate collection tank at the 80% recovery point of Phase 1 testing.

Prepared by: JJF1
Checked by: HJA

A sample of the feed water was taken from the feed tank. A complete chemical characterization as per Table 4-1 was completed on the sample. The analytical results are presented in Table 4-5. The sample was labeled NMC-RO-7.

The reverse osmosis pumps were turned on and the synthetic wastewater was pumped through the unit. The pumps were shut down at the 75% recovery point. A sample of the composite permeate was taken from the permeate collection tank. A complete chemical characterization as per Table 4-1 was completed on the sample. The analytical results are presented in Table 4-5. The sample was labeled NMC-RO-8.

The permeate from the first pass was set aside and the reverse osmosis membrane was replaced with the same Model No. 192T-MS12 poly amide thin film composite membrane. Deionized water was then run through the RO test unit for 66 minutes. Samples from this blank run were taken and analyzed for possible contamination. A complete chemical characterization as per Table 4-1 was completed on the sample. The analytical results are presented in Table 4-5. The sample was labeled NMC-RO-9.

The remaining RO deionized water used to rinse the system and to test for membrane leakage after membrane replacement was removed from the feed tank. The permeate from the first pass was then pumped into the feed tank. The transfer pump and hose were previously cleaned with citric acid and deionized water before the first pass permeate was transferred into the feed tank.

The second pass was then run to 80% recovery. Duplicate samples of the composite permeate were taken from the permeate collection tank. A complete chemical characterization as per Table 4-1 was completed on the samples. The analytical results are presented in Table 4-5. The samples were labeled NMC-RO-10 and NMC-R-11. This concluded the Phase 2 testing. A summary of the Phase 2 testing is presented in Table 4-6.

Table 4-5

Phase 2 Laboratory Analytical Data

Parameter	Feed Water NMC-RO-7 (mg/l)	1st Pass Permeate NMC-RO-8 (mg/l)	Blank NMC-RO-9 (mg/l)	2nd Pass Permeate NMC-RO-10 (mg/l)	2nd Pass Duplicate NMC-RO-11 (mg/l)
Antimony	0.000336	0.0000518	0.0000367	0.0000221	0.0000312
Arsenic	0.0089	0.000155	0.0000512	0.0000355	0.0000338
Barium	0.014	<0.000067	<0.000067	<0.000067	<0.000067
Cadmium	0.0023	<0.000007	0.0000231	0.00000773	0.00000993
Chromium	0.00234	<0.000047	0.000329	0.00029	0.000307
Copper	0.0664	0.00523	0.00077	0.00266	0.00272
Lead	0.0046	<0.000025	0.0000315	<0.000025	<0.000025
Mercury	0.000245	0.0000316	0.00000333	0.00000256	0.00000212
Nickel	0.0339	0.000196	0.000827	0.000559	0.000565
Selenium	0.24	0.0015	0.0018	0.0005	0.0005
Silver	0.0021	<0.00059	<0.00059	<0.00059	<0.00059
Thallium	0.0161	0.000475	0.000407	0.00008	0.0000754
Iron	0.015	<0.0028	<0.0028	<0.0028	<0.0028
Manganese	0.086	<0.00014	0.00055	<0.00014	<0.00014

Table 4-5 *(Continued)*

Parameter	Feed Water NMC-RO-7 (mg/l)	1st Pass Permeate NMC-RO-8 (mg/l)	Blank NMC-RO-9 (mg/l)	2nd Pass Permeate NMC-RO-10 (mg/l)	2nd Pass Duplicate NMC-RO-11 (mg/l)
Zinc	0.1	0.0011	0.0023	0.0035	0.0014
Ammonia	4.1	0.25	0.12	<0.061	<0.061
Calcium	190	0.45	1.3	0.38	0.37
Magnesium	73	0.18	0.48	0.13	0.14
Potassium	24	0.61	0.45	0.11	0.096
Sodium	87	2.1	1.5	0.46	0.4
Chloride	110	<0.14	<0.14	<0.14	<0.14
Sulfate	639	<1	4	<1	1
Cyanide	0.12	0.021	0.011	0.012	0.013
Fluoride	2.4	<0.014	<0.014	<0.014	<0.014
Nitrate + Nitrate	NR	NR	NR	NR	<0.026
Alkalinity	170	<6.4	<6.4	<6.4	<6.4

NR = No Results

Prepared by: MLD2
Checked by: JJF1

Table 4-6

Phase 2 Sample Description

Sample ID	Testing	Description
NMC-RO-7	Complete, per Table 4-1	Synthetic wastewater: The sample is from the feed tank after mixing all of the Batch 2 feed water samples in the feed tank.
NMC-RO-8	Complete, per Table 4-1	Composite permeate, 75% recovery: The sample is from the permeate collection tank at the 75% recovery point of Phase 2, first pass testing.
NMC-RO-9	Complete, per Table 4-1	Blank Permeate: The sample is from the composite permeate using deionized water as the feed. This blank run was completed after a new membrane was installed at the end of the first pass.
NMC-RO-10	Complete, per Table 4-1	Composite permeate, 80% recovery: The sample is from the permeate collection tank at the 80% recovery point of Phase 2, second pass testing.
NMC-RO-11	Complete, per Table 4-1	Duplicate composite permeate, 80% recovery: The sample is from the permeate collection tank at the 80% recovery point of Phase 2, second pass testing.

Prepared by: JJF1
Checked by: GJB1

5 Data Use

The data generated from the RO treatability study can be used to calculate system passage rates. The passage rates can then be used to estimate effluent characteristics for a full scale RO system. These calculations and estimates are presented in Section 6 of the project's *Preliminary Engineering Report for Wastewater Treatment Facilities for the Crandon Project* (Foth & Van Dyke, 1995/1998).

6 References

Foth & Van Dyke, September 1995/1998. *Preliminary Engineering Report for Wastewater Treatment Facilities for the Crandon Project.*

Foth & Van Dyke, May 1998. *Bench Scale Evaluation of Reverse Osmosis Method for Wastewater Treatment.*

Appendix A

Treatability Study Analytical Sampling and Testing Protocol

Treatability Study Analytical Sampling and Testing Protocol

The intent of this detailed sampling procedure is to prevent contamination from being introduced into the samples prior to analysis. It is the responsibility of the sample collection team to continuously look for potential sources of contamination and eliminate them.

A.1 Sampling Considerations - Low-Level Metals

A.1.1 Equipment

The primary concern for equipment is cleanliness. Clothing and equipment used in this study should be dedicated to the study. If equipment or clothing becomes soiled, it must be replaced.

Sample bottles, preservatives, and other associated equipment will be supplied by the laboratory. The laboratory is responsible for proper preparation of the equipment. The sample bottles and other equipment will be sealed in plastic bags. These bags must not be opened until the time of sample collection.

A.1.2 Sample Area Preparation

A clean area for sample handling is to be established by eliminating sources of contamination and by laying down plastic in the area where the study is conducted and where samples are collected and prepared for shipment to the laboratory.

A.1.3 Personnel Preparation

The sampling program will require, at a minimum, two team members: one to act as a sampler; the other will assist. The sampler will don clean outer garments. One set of shoulder-length gloves will be put on by both the assistant and the sampler. A second set of shoulder-length gloves will be donned by the sampler. After the gloves are on, the team members must only touch clean items. If the sampler touches anything that is not clean, the outer pair of gloves shall be removed and replaced with a clean set of gloves. If the assistant has to leave the clean area, a new pair of gloves shall be donned when returning.

A.1.4 Sampling Procedure

It is the intent to collect all samples by hand with a gloved person. The assistant shall pick up a double-bagged sample bottle and open the outer bag. The sampler shall reach into the outer bag and open the inner bag, removing the sample bottle. The cap for the sample bottle shall remain securely closed until the actual sample is collected. At the time of sample procurement, the cap is removed and the sample bottle is filled. The sample bottle will then be immediately recapped. The contents shall be shaken and then discarded. The sample bottle will then be

refilled to approximately 90% of its volume to allow for the introduction of the preservative. The sampler will recap the bottle and proceed to the clean area where the preservative will be added. The assistant will then open the outer bag for the preservative vials, allowing the sampler to reach in and open the inner bag, removing the appropriate preservative. The sampler will remove the bottle cap (placing it in a contaminant-free area), add the preservative to the sample, and recap the sample. The single bottle will be placed into the inner bag of the double bag system and the inner bag will be closed by the sampler. The bag and bottle will then be put into the outer bag and closed by the assistant. The bottle will then be put into a cooler and iced.

A.2 Sampling Considerations - Standard Analytes

There will be minor differences between the methods for sampling low-level metals and those used for standard analytes. The methods described for low-level metals will be followed for the standard analytes except as provided below.

A.2.1 Sampling Bottles

The sampling bottles and preservatives are to be provided by the laboratories completing the analyses. The sample containers and preservative vials will not be double bagged. The bottles will be sealed and the integrity maintained by keeping them in the coolers provided by the laboratory.

A.2.2 Personnel Preparation

As with the sampling program for low level metals, two team members will work together to complete the sampling. However, in the case of standard parameters, this is for convenience, not because of the need to have one of the team members isolated from potential contamination.

The sampling team members may wear one set of shoulder length gloves for protection and to provide cleanliness during the sampling. There will be no need to have the sampling personnel wear two sets of gloves. If the sampler were to touch anything that was not clean, such as the ground or vegetation, while entering a stream, the pair of gloves are to be removed and replaced with a clean set of gloves.

A.2.3 Sampling Procedure

It is the intent to collect all of the samples by hand with a gloved person. There will be no need to double bag sample bottles; therefore, the addition of preservatives will be completed utilizing the coolers as a clean work surface. All other sampling procedures will remain the same.

A.3 Sample Documentation

Personnel shall use only bound field logbooks for the maintenance of field records. Other bound logbooks, such as bound surveyors logbooks, are acceptable so long as pages cannot be removed without tearing them out.

A log book will be dedicated to this project. The field technician's name, project name, and project code will be entered on the inside of the front cover of the logbook. All entries will be dated and time of entry recorded. At the end of each day's activity, or entry of a particular event if appropriate, the field technician will draw a diagonal line at the conclusion of the entry and initial indicating the conclusion of the entry or the day's activity.

All aspects of sample collection and handling as well as visual observations shall be documented in the field logbooks. All sample collection equipment (where appropriate), field analytical equipment, and equipment used to make physical measurements shall be identified in the field logbooks. All calculations, results, and calibration data for field sampling, field analytical, and field physical measurement equipment shall also be recorded in the field logbooks. All field analyses and measurements must be traceable to the specific piece of field equipment used and to the field investigator collecting the sample, making the measurement, or analyses.

All entries in field logbooks shall be dated, shall be legible, and shall contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language will be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and must be maintained as part of project files.

A.4 Sample Preservation

Table A-1 indicates the parameter, container type, minimum sample volume, preservation requirements and holding times.

Those samples requiring thermal preservation will be cooled with wet ice to reduce/maintain the sample container environment at 4°C. The ice should be wetted ice that is in full contact with the sample containers. (Blue ice is not acceptable.) For samples which require pH adjustment as a means of preservation, EnChem, Inc. will provide sample containers with preservatives and sufficient additional preservative from the same source such that the field sampler can add additional preservatives if necessary. The pH of the sample will be checked by removing an aliquot of the sample, checking the pH with pH paper and adjusting the pH by adding additional preservative (if necessary). If equipment blanks are to be collected, the same amount of acid is added to the blank as to the sample.

If the samples arrive at the laboratory with water and ice remaining in the cooler, the laboratory can assume that the sample temperature is 4°C. If no ice remains, the laboratory shall make a temperature reading and record the temperature reading.

A.5 Sample Dispatch

Samples collected are to be placed into insulated shipping containers and prepared for delivering to the laboratory. The sample containers, within the shipping container, shall be placed such that there was no movement of sample containers. Samples requiring thermal preservation shall be transported with wet ice. Strapping tape is to be used to seal the containers along with numbered seals to provide sample security. Containers shall be appropriately labeled for shipment.

Shipment containers shall be delivered to the laboratory by the sampling team, shipped via courier or shipped via common carrier to the laboratory for analysis. Copies of the chain-of-custody form and any shipping forms shall accompany the samples. The laboratory is to be notified in advance of the forthcoming shipment.

Table A-1

Sample Container, Preservation Methods, Holding Times

Parameter	Sample Container Type	Volume (ml)	Preservative[2,3]	Holding Time[4]
Alkalinity	P, G	100	cool, 4°C	14 dy
Bicarbonate Alkalinity	P, G	100	cool, 4°C	14 dy
Carbonate Alkalinity	P, G	100	cool, 4°C	14 dy
Chloride	P, G	50	none	28 dy
Cyanide	P, G	250	NaOH,pH>12[1]	14 dy
Fluoride	P, G	300	none	28 dy
Hardness	P, G	100	HNO_3,pH<2 cool, 4°C	6 mo.
Nitrogen				
Ammonia	P, G	500	H_2SO_4,pH<2 cool, 4°C	28 dy
Kjeldahl	P, G	500	H_2SO_4,pH<2 cool, 4°C	28 dy
Nitrate	P, G	50	cool, 4°C	48 hr
pH	P, G	25	none	immediate
Phosphorous				
total	P, G	100	H_2SO_4,pH<2 cool, 4°C	28 dy
Solids				
total	P, G	100	cool, 4°C	7 dy
suspended	P, G	100	cool, 4°C	7 dy
dissolved	P, G	100	cool, 4°C	7 dy
Sulfate	P, G	100	cool, 4°C	28 dy
Turbidity	P, G	100	cool, 4°C	48 hr

Table A-1 *(Continued)*

Parameter	Sample Container Type	Volume (ml)	Preservative[2,3]	Holding Time[4]
Metals				
total	P	2000	HNO_3, pH <2	6 mo
Mercury	P	500	HNO_3, pH <2	28 dy

Prepared by: RTJ
Checked by: GJB1

P = Plastic
PE = Pre-extraction
G = Glass
C = Completion
HNO_3 = Nitric Acid
HCl = Hydrochloric Acid
NaOH = Sodium Hydroxide

[1] If residual chlorine is present, 0.6 gm ascorbic acid will be added; if sulfide is present, samples must be pretreated in the field or must be shipped unpreserved at 4°C to the laboratory for analysis within 24 hours.

[2] Sample preservation will be performed immediately upon sample collection. For composite chemical samples, each aliquot will be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.

[3] When any sample is to be shipped by common carrier or sent through the United States Mails, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of Table II, the Office of the Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials Regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentrations of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); and Sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weight or less (pH about 12.30 or less).

[4] Samples will be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show that this is necessary to maintain sample stability. See § 136.3(e) for details.

Appendix C

Evaporation Treatability Study for the Crandon Project

Evaporation Treatability Study for the Crandon Project

Scope ID: 93C049

Prepared for
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November 1998

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Evaporation Treatability Study for the Crandon Project

Contents

Tables

Appendices

1 Introduction

Nicolet Minerals Company (NMC) is planning to develop a zinc/copper mine near Crandon, Wisconsin. As part of project operations, treated effluent from the mine will need to be discharged to waters of the state. The Wisconsin Department of Natural Resources (WDNR) will establish specific standards that the discharge waters will need to meet. These standards are specific to discharge type and location. A discharge to a stream may be assigned different standards than a discharge to groundwater or to a mitigation site. Standards for discharging to each selected water body will be set individually by the WDNR.

The primary technology proposed for the treatment of mine water is a lime/sulfide filtration treatment process which will reduce metals in the water to levels suitable for discharge to specific surface water bodies. However, not all the cations and anions will be reduced by the lime/sulfide process to levels suitable for discharge to groundwater or for use at all potential mitigation sites. Therefore, advanced treatment may be necessary to provide additional treatment for the cations and anions of concern such that the treated water will meet the standards set by the WDNR. One of the treatment technologies under consideration by NMC is evaporation. A bench scale treatability study has been completed to assess the ability of the evaporation technology to meet WDNR effluent standards. The implementation of this study does not preclude techniques that may replace or complement the evaporation technology.

A detailed work plan outlining the proposed study was submitted to the WDNR on August 17, 1998 (Foth & Van Dyke, 1998). This document is titled *Bench Scale Evaluation of Evaporation Method for Wastewater Treatment.* A detailed report describing the completed study is presented in this document. Section 2 of this report provides background information pertaining to treatability studies previously completed for the project. Section 3 of this report discusses feed water generation for the study. Section 4 discusses the treatability study protocol and the treatability study results. Section 5 presents information relating to the planned use of the generated data.

2 Previous Treatability Studies

Previous studies evaluating the performance of lime/sulfide treatment were presented in the Preliminary Engineering Report (PER) (Foth & Van Dyke, 1995/1998) completed for the Crandon Project. This evaluation characterized the untreated wastewater which is anticipated from the proposed project and evaluated the ability of the lime/sulfide process to treat wastewater to levels acceptable for discharge to the Wisconsin River. These previous studies were not intended to be used to demonstrate the ability of lime/sulfide treatment to meet groundwater discharge standards or standards for discharge to surface waters needing mitigation.

3 Feed Water Preparation

The evaporation system treatability study was undertaken to assess the ability of evaporation treatment technology to produce an effluent suitable for discharge to groundwater or for use as mitigation water. The feed water used for the test was prepared (Table 3-1) based on the maximum anticipated concentration for each individual constituent that may be present in the effluent from the lime/sulfide treatment process. Due to the solubility of individual constituents and the ionic strength of the total solution, the final concentrations in the feed water of some of the constituents are likely not achievable due to precipitation. The effluent was produced by mixing the reagents listed in Table 3-1 with deionized water.

U.S. Filter/HPD, Plainfield, Illinois, a manufacturer of evaporation treatment systems, completed the evaporation treatability test. A total of 40 gallons of feed water was generated for the study. This consisted of two water batches: Recipe 1 and Recipe 2. Twenty gallons of feed water was generated in accordance with Table 3-1. This batch is referred to as "Recipe 1". An additional 20 gallons of feed water was generated by increasing the target constituent concentrations in Table 3-1 by a factor of 10. This batch is referred to as "Recipe 2". The rationale for using two different feed water batches is discussed in Section 4. The feed water was shipped to U.S. Filter/HPD in new plastic containers. Preparation of feed water was coordinated by Foth & Van Dyke.

A sample of the Recipe 1 feed water was analyzed to document its composition and to provide data for use as a basis of comparison to other samples taken during the test. The sample was analyzed at EnChem, Inc., a Green Bay, Wisconsin, commercial laboratory. The majority of the testing was performed by EnChem, Inc. Low level metal and sulfate analyses were performed on behalf of EnChem, Inc., by Battelle Marine Science Lab, Sequim, Washington, and Commercial Testing & Engineering, Denver, Colorado, respectively. The sample was collected as described in Appendix A at the evaporator manufacturers' facility from the Recipe 1 container during the test run, as described in Section 4.

Differences in Table 3-1 between target concentrations and actual feed water concentrations are likely attributable to the effects discussed above.

Table 3-1

Feed Water Preparation

Parameter	Target Concentrations (mg/l)	Recipe 1 Actual Feed Water Concentrations (mg/l)	Chemical Additive
Antimony	0.01	0.00113	$SbCl_3$
Arsenic	0.01	0.00232	As_2O_3
Barium	0.16	0.022	$BaSO_4$
Cadmium	0.002	0.00119	$3CdSO_4 \cdot 8H_2O$
Chromium	0.01	0.00182	$CrCl_3 \cdot 6H_20$
Copper	0.08	0.0365	$CuSO_4 \cdot 5H_2O$
Lead	0.006	0.000967	$PbSO_4$
Mercury	0.000040	0.00000671	$HgSO_4$
Nickel	0.04	0.0329	$NiSO_4 \cdot 6H_2O$
Selenium	0.29	0.23	SeO_2
Silver	0.002	0.0013	Ag_2SO_4
Thallium	0.02	0.0127	$Tl(NO_3)_3 \cdot 3H_2O$
Iron	0.081	<0.039	$FeSO_4 \cdot 7H_2O$
Manganese	0.064	0.074	$MnSO_4 \cdot 4H_20$
Zinc	0.1	0.11	$ZnSO_4 \cdot 7H_20$
Ammonia	7	4.5	$(NH_4)_2\ SO_4$
Calcium	190	150	$CaSO_4$
Magnesium	87	40	$MgSO_4$
Potassium	14	14	K_2SO_4
Sodium	51	200	—[1]
Chloride	47	<0.14	—[2]

Table 3-1 *(Continued)*

Parameter	Target Concentrations (mg/l)	Recipe 1 Actual Feed Water Concentrations (mg/l)	Chemical Additive
Sulfate	1246	938	Na_2SO_4[3]
Cyanide	0.13	0.032	NaCN
Fluoride	0.21	0.030	NaF
Nitrate + Nitrite	22	5.8	$NaNO_3$
Alkalinity	17	16	$NaHCO_3$

[1] Na is added with Na_2SO_4, NaCN, NaF, $NaNO_3$, $NaNO_2$, and $NaHCO_3$.
[2] Cl is added with $SbCl_3$ and $CrCl_3 \cdot 6H_20$. The synthetic concentration of Cl is less than the target concentration because adding additional Cl will cause a corresponding cation (Na) increase above the cation (Na) target level.
[3] SO_4 is added with various other chemicals. Na_2SO_4 is added to increase the SO_4 to the target level.

Prepared by: JJF1
Checked by: HJA

4 Treatability Study Protocol

U.S. Filter/HPD completed the treatability study evaluation in conjunction with Foth & Van Dyke. The treatability study was completed at the U.S. Filter/HPD Plainfield, Illinois, site. Operation and monitoring of the evaporation equipment was conducted by U.S. Filter/HPD personnel. The equipment consisted of a standard stirred tank treatability study evaporator system.

Foth & Van Dyke collected the necessary samples for analytical testing and coordinated shipment to EnChem, Inc. Since the levels of detection needed for this evaluation were below those normally used, Foth & Van Dyke used clean techniques for the collection, preservation, and handling of the samples. The sample collection and handling procedures are presented in Appendix A. Two representatives of the WDNR were in attendance at the U.S. Filter/HPD facility for portions of the evaporation treatability study.

The U.S. Filter/HPD testing facility was prepared for the test by reducing potential sources of contamination such as airborne dust. A plastic enclosure was built around the treatability study evaporator. The isolation of the test apparatus lowered the possibility of dust particles contaminating the samples.

U.S. Filter/HPD cleaned the bench scale equipment with citric and hydrochloric acid, followed by rinsing with deionized water prior to the start of the testing. The distillate collection containers were new HDPE containers rinsed with deionized water.

A "blank" run of the evaporator system was conducted for quality control purposes. Deionized water was used as the feed for the blank run. The blank run was conducted using the same equipment planned for use with feed water. A sample of the deionized feed water was collected and analyzed. The sample was labeled NMC-Evap-1. The analytical test methods are listed in Table 4-1. The analytical results are presented in Table 4-2.

The evaporator was initially operated for ten hours using the deionized water as the feed. Sufficient condensate was generated during the blank run to meet the testing sample volume requirements defined in Table 4-1. The condensate was collected and stored in a sealed HDPE container. Samples of the condensate were taken from the HDPE container and analyzed per the procedures identified in Table 4-1. The results are presented in Table 4-2. The sample was labeled NMC-Evap-2.

After the blank run, the concentrated feed water (Recipe 2) was used as the feed for the evaporator unit to shorten the time required to produce a concentrated brine in the evaporation unit so the actual test using Recipe 1 could proceed. The evaporator was operated with Recipe 2 feed water until the unit obtained a concentration factor representative of the estimated full scale operating conditions. For this portion of the test, the volume of Recipe 2 feed water was reduced

by a concentration factor of 15. Since Recipe 1 is a factor of 10, less concentrated than Recipe 2, the volume reduction factor would be 150 when the test is performed on Recipe 1 feed water.

Recipe 1 feed water was then used as the feed for the evaporator unit. The test was performed at a steady state by maintaining the same concentration of solids in the evaporator. The evaporator was operated at these steady state conditions for an additional 24 hours. The condensate from this one-day operational check period was discarded. After the initial 24-hour period, the evaporator continued to operate at steady state conditions using the Recipe 1 feed water. The condensate from this run was collected in an HDPE container. By running the evaporator at a steady state condition, with a concentrated brine solution in the heated chamber, the concentration of the brine solution becomes the controlling factor in the performance of the system. This means that for two different feed water flow rates, if the mass loading to the evaporation system is the same, the flow rate to the system will not affect condensate quality. In other words, the condensate quality will be the same if high volumes of lime/sulfide treatment effluent were fed directly to a system, versus lower volumes of reject water from an RO system used to further treat the effluent from the same lime/sulfide system. This also allows for the use of the data collected from the test in the evaluation of evaporation for treatment of RO reject water.

As part of the test, samples of Recipe 1 feed water were collected and analyzed. The samples were collected from the feed water container which was used to feed the evaporator. The sample was labeled NMC-Evap-3. The analytical results are presented in Table 4-2. After a total of 30 hours of operation with Recipe 1 feed water, samples of the condensate were collected and also analyzed. The sample was labeled NMC-Evap-4. The analytical results are presented in Table 4-2.

Table 4-1

Evaporation Study Laboratory Analytical Test Methods

A) Parameter List

Parameter	Detection Limit	Units	Method	Laboratory
Antimony	0.006	µg/l	SW 846-1638	Battelle
Arsenic	0.00246	µg/l	EPA 1638M	Battelle
Barium	0.00040	mg/l	EPA 200.7	EnChem
Cadmium	0.000006	mg/l	SW 846-1638	Battelle
Chromium (Total)	0.0003	mg/l	SW 846-1638	Battelle
Copper	0.000030	mg/l	SW 846-1638	Battelle
Cyanide (Total)	0.0034	mg/l	EPA 335.4	EnChem
Fluoride	0.075	mg/l	SM 4500FC	EnChem
Lead	0.000002	mg/l	SW 846-1638	Battelle
Nickel	0.00003	mg/l	SW 846-1638	Battelle
Mercury	0.10	ng/l	SW 846-1631	Battelle
Nitrate + Nitrite	0.026	mg/l	EPA 353.2	EnChem
Selenium	0.0023	mg/l	EPA 272.2	EnChem
Silver	0.0020	mg/l	EPA 272.2	EnChem
Thallium	0.0033	µg/l	SW 846-1638	Battelle
Chloride	0.14	mg/l	EPA 325.1	EnChem
Iron	0.025	mg/l	EPA 200.7	EnChem
Manganese	0.00024	mg/l	EPA 200.7	EnChem
Sulfate	1	mg/l	SM4500 SO_4 C (Gravimetric)	CTE
Zinc	0.0035	mg/l	EPA 200.7	EnChem
Alkalinity	6.4	mg/l	SM2320B	EnChem
Ammonia Nitrogen	0.061	mg/l	EPA 350.3	EnChem

Table4-1 *(Continued)*

Parameter	Detection Limit	Units	Method	Laboratory
Nickel	0.000016	mg/l	SW 846-1638	Battelle
Boron	0.076	mg/l	EPA 200.7	EnChem
Calcium	0.016	mg/l	EPA 200.7	EnChem
Conductivity	10	mg/l	EPA 120.1	EnChem
Total Hardness	0.3	mg/l	EPA 200.7	EnChem
Magnesium	0.0056	mg/l	EPA 200.7	EnChem
Organic Nitrogen	0.061	mg/l	EPA 350.3/351.4	EnChem
pH	—	SU	EPA 150.1	EnChem
Potassium	0.012	mg/l	EPA 200.7	EnChem
Sodium	0.260	mg/l	EPA 200.7	EnChem
Total Dissolved Solids	2.0	mg/l	EPA 160.1	EnChem
Total Nitrogen	0.053	mg/l	EPA 351.4	EnChem
Total Phosphorus	0.005	mg/l	EPA 365.1	EnChem

B. Sample Size and Preservation Requirements

Metals, Hardness
1000 ml plastic preserved with nitric acid to pH<2

Cyanide
250 ml preserved with sodium hydroxide and ascorbic acid to pH>12

Fluoride, Chloride, Sulfate, Conductivity, Alkalinity, Total Dissolved Solids, pH
1000 ml unpreserved

Nitrate + Nitrite Nitrogen, Ammonia Nitrogen, Organic Nitrogen, Total Nitrogen, Total Phosphorus
1000 ml preserved with sulfuric acid to pH<2

Prepared by: RTJ
Checked by: GJB1/JJF1

Table 4-2

Evaporation Study Laboratory Analytical Data

Parameter	Blank Feed NMC-Evap-1 (mg/l)	Blank Condensate NMC-Evap-2 (mg/l)	Recipe 1 Feed Water NMC-Evap-3 (mg/l)	Condensate NMC-Evap-4 (mg/l)
Antimony	0.0000122	0.000017	0.00113	0.0000163
Arsenic	0.000015	<0.00000246	0.00232	0.0000825
Barium	<0.00054	<0.00054	0.022	<0.00054
Cadmium	0.0000074	0.00001	0.00119	0.00000659
Chromium	0.00006	0.00007	0.00182	N/A[1]
Copper	0.0000246	0.0000533	0.0365	0.000167
Lead	0.0000129	0.0000441	0.000967	0.0000219
Mercury	0.00000071	0.0000107	0.00000671	0.000148[2]
Nickel	0.0000242	0.0000790	0.0329	N/A[1]
Selenium	<0.00033	<0.00033	0.23	<0.00033
Silver	<0.00032	<0.00032	0.0013	<0.00032
Thallium	0.0000025	0.0000030	0.0127	0.0000144
Iron	<0.039	<0.039	<0.039	<0.039
Manganese	0.00051	0.00050	0.074	<0.00043
Zinc	<0.0039	<0.0039	0.110	<0.0039
Ammonia	<0.061	<0.061	4.5	9.1
Calcium	0.041	0.057	150	1.6
Magnesium	0.018	0.013	40	0.27
Potassium	0.031	0.040	14	0.023
Sodium	0.13	0.14	200	<0.37
Chloride	<0.14	<0.14	<0.14	<0.14
Sulfate	9	1	938	<1

Table 4-2 *(Continued)*

Parameter	Blank Feed NMC-Evap-1 (mg/l)	Blank Condensate NMC-Evap-2 (mg/l)	Recipe 1 Feed Water NMC-Evap-3 (mg/l)	Condensate NMC-Evap-4 (mg/l)
Cyanide	<0.0034	<0.0034	0.032	0.035
Fluoride	0.095	0.089	0.030	<0.014
Nitrate + Nitrite	<0.026	<0.026	5.8	7.1
Alkalinity	4.0	2.0	16	16

[1]N/A = Results not available due to laboratory quality assurance rejection.
[2]Increases in mercury are presumed to be caused by manometer contamination of equipment.

Prepared by: JJF1
Checked by: HJA

5 Data Use

The data generated from the evaporation treatability study can be used to predict the condensate quality of a full scale operation. These predictions are presented in Section 6 of the project's *Preliminary Engineering Report for Wastewater Treatment Facilities for the Crandon Project* (Foth & Van Dyke, 1995/1998).

6 References

Foth & Van Dyke, September 1995/1998. *Preliminary Engineering Report for Wastewater Treatment Facilities for the Crandon Project.*

Foth & Van Dyke, August 1998. *Bench Scale Evaluation of Evaporation Method for Wastewater Treatment.*

Appendix A

Treatability Study Analytical Sampling and Testing Protocol

Treatability Study Analytical Sampling and Testing Protocol

The intent of this detailed sampling procedure is to prevent contamination from being introduced into the samples prior to analysis. It is the responsibility of the sample collection team to continuously look for potential sources of contamination and eliminate them.

A.1 Sampling Considerations - Low-Level Metals

A.1.1 Equipment

The primary concern for equipment is cleanliness. Clothing and equipment used in this study should be dedicated to the study. If equipment or clothing becomes soiled, it must be replaced.

Sample bottles, preservatives, and other associated equipment will be supplied by the laboratory. The laboratory is responsible for proper preparation of the equipment. The sample bottles and other equipment will be sealed in plastic bags. These bags must not be opened until the time of sample collection.

A.1.2 Sample Area Preparation

A clean area for sample handling is to be established by eliminating sources of contamination and by laying down plastic in the area where the study is conducted and where samples are collected and prepared for shipment to the laboratory.

A.1.3 Personnel Preparation

The sampling program will require, at a minimum, two team members: one to act as a sampler; the other will assist. The sampler will don clean outer garments. One set of shoulder-length gloves will be put on by both the assistant and the sampler. A second set of shoulder-length gloves will be donned by the sampler. After the gloves are on, the team members must only touch clean items. If the sampler touches anything that is not clean, the outer pair of gloves shall be removed and replaced with a clean set of gloves. If the assistant has to leave the clean area, a new pair of gloves shall be donned when returning.

A.1.4 Sampling Procedure

It is the intent to collect all samples by hand with a gloved person. The assistant shall pick up a double-bagged sample bottle and open the outer bag. The sampler shall reach into the outer bag and open the inner bag, removing the sample bottle. The cap for the sample bottle shall remain securely closed until the actual sample is collected. At the time of sample procurement, the cap is removed and the sample bottle is filled. The sample bottle will then be immediately recapped. The contents shall be shaken and then discarded. The sample bottle will then be

refilled to approximately 90% of its volume to allow for the introduction of the preservative. The sampler will recap the bottle and proceed to the clean area where the preservative will be added. The assistant will then open the outer bag for the preservative vials, allowing the sampler to reach in and open the inner bag, removing the appropriate preservative. The sampler will remove the bottle cap (placing it in a contaminant-free area), add the preservative to the sample, and recap the sample. The single bottle will be placed into the inner bag of the double bag system and the inner bag will be closed by the sampler. The bag and bottle will then be put into the outer bag and closed by the assistant. The bottle will then be put into a cooler and iced.

A.2 Sampling Considerations - Standard Analytes

There will be minor differences between the methods for sampling low-level metals and those used for standard analytes. The methods described for low-level metals will be followed for the standard analytes except as provided below.

A.2.1 Sampling Bottles

The sampling bottles and preservatives are to be provided by the laboratories completing the analyses. The sample containers and preservative vials will not be double bagged. The bottles will be sealed and the integrity maintained by keeping them in the coolers provided by the laboratory.

A.2.2 Personnel Preparation

As with the sampling program for low level metals, two team members will work together to complete the sampling. However, in the case of standard parameters, this is for convenience, not because of the need to have one of the team members isolated from potential contamination.

The sampling team members may wear one set of shoulder length gloves for protection and to provide cleanliness during the sampling. There will be no need to have the sampling personnel wear two sets of gloves. If the sampler were to touch anything that was not clean, such as the ground or vegetation, while entering a stream, the pair of gloves are to be removed and replaced with a clean set of gloves.

A.2.3 Sampling Procedure

It is the intent to collect all of the samples by hand with a gloved person. There will be no need to double bag sample bottles; therefore, the addition of preservatives will be completed utilizing the coolers as a clean work surface. All other sampling procedures will remain the same.

A.3 Sample Documentation

Personnel shall use only bound field logbooks for the maintenance of field records. Other bound logbooks, such as bound surveyors logbooks, are acceptable so long as pages cannot be removed without tearing them out.

A log book will be dedicated to this project. The field technician's name, project name, and project code will be entered on the inside of the front cover of the logbook. All entries will be dated and time of entry recorded. At the end of each day's activity, or entry of a particular event if appropriate, the field technician will draw a diagonal line at the conclusion of the entry and initial indicating the conclusion of the entry or the day's activity.

All aspects of sample collection and handling as well as visual observations shall be documented in the field logbooks. All sample collection equipment (where appropriate), field analytical equipment, and equipment used to make physical measurements shall be identified in the field logbooks. All calculations, results, and calibration data for field sampling, field analytical, and field physical measurement equipment shall also be recorded in the field logbooks. All field analyses and measurements must be traceable to the specific piece of field equipment used and to the field investigator collecting the sample, making the measurement, or analyses.

All entries in field logbooks shall be dated, shall be legible, and shall contain accurate and inclusive documentation of an individual's project activities. Since field records are the basis for later written reports, language will be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and must be maintained as part of project files.

A.4 Sample Preservation

Table A-1 indicates the parameter, container type, minimum sample volume, preservation requirements and holding times.

Those samples requiring thermal preservation will be cooled with wet ice to reduce/maintain the sample container environment at 4 °C. The ice should be wetted ice that is in full contact with the sample containers. (Blue ice is not acceptable.) For samples which require pH adjustment as a means of preservation, EnChem, Inc. will provide sample containers with preservatives and sufficient additional preservative from the same source such that the field sampler can add additional preservatives if necessary. The pH of the sample will be checked by removing an aliquot of the sample, checking the pH with pH paper and adjusting the pH by adding additional preservative (if necessary). If equipment blanks are to be collected, the same amount of acid is added to the blank as to the sample.

If the samples arrive at the laboratory with water and ice remaining in the cooler, the laboratory can assume that the sample temperature is 4°C. If no ice remains, the laboratory shall make a temperature reading and record the temperature reading.

A.5 Sample Dispatch

Samples collected are to be placed into insulated shipping containers and prepared for delivering to the laboratory. The sample containers, within the shipping container, shall be placed such that there was no movement of sample containers. Samples requiring thermal preservation shall be transported with wet ice. Strapping tape is to be used to seal the containers along with numbered seals to provide sample security. Containers shall be appropriately labeled for shipment.

Shipment containers shall be delivered to the laboratory by the sampling team, shipped via courier or shipped via common carrier to the laboratory for analysis. Copies of the chain-of-custody form and any shipping forms shall accompany the samples. The laboratory is to be notified in advance of the forthcoming shipment.

Table A-1

Sample Container, Preservation Methods, Holding Times

Parameter	Sample Container Type	Volume (ml)	Preservative[2,3]	Holding Time[4]
Alkalinity	P, G	100	cool, 4°C	14 dy
Bicarbonate Alkalinity	P, G	100	cool, 4°C	14 dy
Carbonate Alkalinity	P, G	100	cool, 4°C	14 dy
Chloride	P, G	50	none	28 dy
Cyanide	P, G	250	NaOH,pH>12[1]	14 dy
Fluoride	P, G	300	none	28 dy
Hardness	P, G	100	HNO_3,pH<2 cool, 4°C	6 mo.
Nitrogen				
Ammonia	P, G	500	H_2SO_4,pH<2 cool, 4°C	28 dy
Kjeldahl	P, G	500	H_2SO_4,pH<2 cool, 4°C	28 dy
Nitrate	P, G	50	cool, 4°C	48 hr
pH	P, G	25	none	immediate
Phosphorous				
total	P, G	100	H_2SO_4,pH<2 cool, 4°C	28 dy
Solids				
total	P, G	100	cool, 4°C	7 dy
suspended	P, G	100	cool, 4°C	7 dy
dissolved	P, G	100	cool, 4°C	7 dy
Sulfate	P, G	100	cool, 4°C	28 dy
Turbidity	P, G	100	cool, 4°C	48 hr

Table A-1 *(Continued)*

Parameter	Sample Container Type	Volume (ml)	Preservative[2,3]	Holding Time[4]
Metals				
total	P	2000	HNO_3, pH <2	6 mo
Mercury	P	500	HNO_3, pH <2	28 dy

P = Plastic
PE = Pre-extraction
G = Glass
C = Completion
HNO_3 = Nitric Acid
HCl = Hydrochloric Acid
NaOH = Sodium Hydroxide

Prepared by: RTJ
Checked by: GJB1

[1] If residual chlorine is present, 0.6 gm ascorbic acid will be added; if sulfide is present, samples must be pretreated in the field or must be shipped unpreserved at 4°C to the laboratory for analysis within 24 hours.

[2] Sample preservation will be performed immediately upon sample collection. For composite chemical samples, each aliquot will be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.

[3] When any sample is to be shipped by common carrier or sent through the United States Mails, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of Table II, the Office of the Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials Regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentrations of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); and Sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weight or less (pH about 12.30 or less).

[4] Samples will be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show that this is necessary to maintain sample stability. See § 136.3(e) for details.

Appendix D

Preliminary Engineering Report for the Crandon Project Soil Absorption System

Preliminary Engineering Report for the Crandon Project Soil Absorption System

Scope ID: 93C049

Prepared for

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November 1998

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Nicolet Minerals Company
Preliminary Engineering Report for the
Crandon Project Soil Absorption System

Executive Summary

Nicolet Minerals Company (NMC) plans to discharge the treated Crandon Project wastewaters to groundwater via a soil absorption system. This report describes the investigation results and preliminary design of the soil absorption system. After evaluation of several alternative locations in and around the project area, NMC has selected Area H as the preferred site for the soil absorption system. Area H is located north of Swamp Creek, approximately 2 miles northeast of the plant site.

On-site investigations included topographic mapping, wetland delineation and mapping, subsurface characterization, hydrologic characterization, and archaeological survey. Subsurface investigations included test pits, borings, hand auger borings, groundwater monitoring wells and piezometers, and sand points. Staff gages were installed to evaluate surface water features on and adjacent to the site. Field testing included aquifer response and infiltrometer tests. Laboratory testing included soils and preliminary groundwater characterization.

The subsurface investigations showed that soil and groundwater conditions at Area H are suitable for construction of a soil absorption system. Unconsolidated deposits include a thin mantle of topsoil and loess (generally less than 3 feet thick), underlain by at least 70 feet of fine and coarse outwash sand. Groundwater is generally present within approximately 10 feet of the surface and flows to the east-southeast toward Swamp Creek. Archaeological surveys did not determine the presence of historic resources on the site, and no additional archaeological investigations are recommended in the proposed area of the soil absorption system.

The data collected at Area H were then used as follows to prepare a conceptual model of the hydrogeologic and surface water conditions at the site to confirm the suitability of Area H for construction of a soil absorption system. Under current conditions, water enters the groundwater system primarily through precipitation. Infiltrating water readily moves vertically through the unsaturated zone into the outwash aquifer. In the aquifer, groundwater flows east-southeast toward areas of lower hydraulic head. Under seasonal high groundwater conditions, the Z16 wetland complex to the east of the proposed soil absorption system acts as a point of discharge for groundwater on a transient basis. An exception to this condition is the spring located in the northern areas of wetland Z16, which functions as a permanent regional discharge point. During operation of the soil absorption system, the infiltrated water will increase the water table in the vicinity of the absorption system. Downgradient of the system, the water table will rise and discharge into the Z16 wetland complex, where it will then drain through the wetland system and adjoining culverts into Creek 17-13 and Swamp Creek.

The conceptual model was then used to assist with selection of appropriate parameters for design of the soil absorption system. The soil absorption system is laid out to include six cells with a

combined area of approximately 7 acres. The cells are designed to handle the maximum flows anticipated to be discharged from the wastewater treatment plant, with adequate safety factors. Under average conditions, the predicted discharge is 375 gpm, with a maximum flow of 636 gpm. The capacity of the six cells is conservatively estimated at 714 gpm.

Surface water modeling was performed to evaluate the anticipated changes to on-site and off-site surface water flow rates and depths of flow due to operation of the soil absorption system. This modeling showed that the amount of flow that will be discharged due to operation of the soil absorption system is very small in comparison to the existing drainage basin runoff to the wetlands. As a result, surface water hydrology in wetland Z16 and Swamp Creek will not be detrimentally affected by operation of the soil absorption system. No measurable increase to the Swamp Creek floodplain is expected to occur as a result of operation of the soil absorption system.

Wastewater will be treated at the project's wastewater treatment plant to meet groundwater quality standards. Therefore, on-site soils are not used to further treat the water. As a result, the key design feature of the soil absorption system requires that the treated effluent be evenly distributed to the outwash aquifer. To accomplish even distribution, the water distribution system in each cell includes a network of subsurface, perforated piping. The piping system will be placed underground to allow for year-round operation. The effluent is pumped from the storage lagoon at the plant site to the soil absorption system via approximately 3.2 miles of 10-inch diameter pipeline. Once at the soil absorption site, the effluent flows through a water distribution chamber which allows each soil absorption cell to receive the appropriate hydraulic loading under gravity flow. Each cell can be operated independently of the others to allow for flexibility to handle reduced flows which are expected under normal operating conditions.

Nicolet Minerals Company
Preliminary Engineering Report for the
Crandon Project Soil Absorption System

Contents

Contents *(continued)*

Page

Page

Tables

Figures

(Note: Figures and Drawings for the Preliminary Engineering Report for the Crandon Project Soil Absorption System are located at the end of the text following page 68.)

Drawings

Page

Appendices

1 Introduction

Nicolet Minerals Company (NMC) plans to discharge the Crandon Project's treated wastewater into soil absorption cells which discharge into groundwater. Several other improvements to the project have also been made, including the following:

- NMC's decision to construct a 25-foot thick grout blanket at the base of the crown pillar of the Crandon formation has resulted in a reduction in groundwater inflow to the mine. This reduced mine inflow has allowed NMC to re-evaluate its treatment and discharge options as described in the *Preliminary Engineering Report for Wastewater Treatment Facilities* (Foth & Van Dyke, 1995/1998a).

- Pyrite removal from the tailings and backfilling of the pyritic tailings underground in a cemented paste form.

- Placement of depyritized tailings in the project's tailings management area (TMA).

These changes, along with several improvements to the groundwater flow model, have significantly improved the water budget for the proposed mine. The end result of these changes is that the maximum amount of water, according to the modeling, to be discharged has been reduced by almost 50 percent to 636 gpm. Details of these changes in the water budget are provided in the update to the *Preliminary Engineering Report for Wastewater Treatment Facilities* (Foth & Van Dyke, 1995/1998a).

1.1 Purpose and Scope

NMC is submitting this report titled *Preliminary Engineering Report for the Crandon Project Soil Absorption System*, to describe the investigation results and preliminary design of the soil absorption system. This report has been prepared in accordance with the requirements of Chapters NR 108 and NR 132, Wis. Admin. Code. Area H is proposed as the discharge site for treated mine water from the Crandon Project's wastewater treatment plant (WWTP). Figure 1-1 shows the location of Area H in relation to the proposed plant site. Area H is comprised of approximately 200 acres owned by NMC (see Drawings No. 2 and 3).

The purpose of this report is to provide the information necessary to satisfy the requirements of NR 108 and NR 132, including providing the results of the Phase I and Phase II geotechnical investigations performed at Area H. This report also provides the preliminary design, layout, construction, and operation of the proposed soil absorption system. The report is accompanied by engineering drawings (Drawings No. 1 through 10) which contain the required geotechnical and engineering information to design the proposed soil absorption system.

1.2 Background Information

NMC has evaluated several alternatives for discharging treated mine wastewater as part of the Crandon Project's wastewater management system. The preferred alternative is discharge to groundwater through the use of a soil absorption system. Other alternatives which were evaluated include discharge into Swamp Creek, discharge into the Wisconsin River, and discharge to other surface water bodies in the vicinity of the project. These alternatives are described in the project's *Preliminary Engineering Report for Wastewater Treatment Facilities* (Foth & Van Dyke, 1995/1998a).

In accordance with work plans submitted to the WDNR, NMC has completed several preliminary evaluations of potential soil absorption sites by performing Phase I and Phase II geotechnical investigations as shown on Figure 1-2. Archaeological investigations were also completed at these sites, as discussed in Section 4.4.

1.3 Summary of Alternative Soil Absorption Sites

A total of 12 areas, including Area H, have been investigated for suitability as potential soil absorption sites for disposal of treated Crandon Project wastewater. This section includes a brief description of the sites that are not currently planned to be carried forward for further evaluation. Soil boring and test pit logs for the seven sites evaluated in 1998 which are not considered suitable for development into a soil absorption system are provided in the project's updated *Environmental Impact Report* (EIR) (Foth & Van Dyke, 1995/1998b). Figure 1-2 shows the locations of the sites that were investigated.

1.3.1 Area A

Area A was initially investigated in the fall of 1994, with follow-up work performed in the spring and summer of 1998. The investigations consisted of excavating 38 test pits and drilling nine soil borings. Monitoring wells and piezometers were not installed in Area A. In 1994 and in the spring of 1998, these investigations focused on a drumlin feature which was shown to have a relatively thick deposit (i.e., approximately 30 to greater than 50 feet) of till over outwash soil. The thick till present on the drumlin minimizes the potential construction of a soil absorption system, since the till soils would require removal to allow for infiltration to occur into the outwash.

In the late summer of 1998, the area north of the drumlin at Area A (Area A North) was also investigated. The investigation identified the following subsurface conditions:

- Late Wisconsinan till (Nashville Member, Copper Falls Formation) having a thickness up to 22.5 feet overlies an upper outwash deposit.
- The underlying upper outwash is relatively thin, ranging from 4 to 30 feet thick.

- Beneath the upper outwash is a second layer of till (Late Wisconsinan till, Mapleview Member, Horicon Formation) which is on the order of 20 feet thick.

- Beneath the lower till is lower outwash, which is present to the top of Pre- to Early Wisconsinan till.

- The groundwater table is generally present in the upper outwash or the top of the lower Late Wisconsinan till.

After additional evaluation, the area north of the drumlin at Area A was eliminated from further consideration because of thin outwash and high groundwater.

1.3.2 Areas B, C, and D

Areas B, C, and D were investigated in late 1994 and early 1995 as part of the initial investigation of alternatives for discharge of the Crandon Project's treated mine wastewater. Areas B, C, and D were eliminated from consideration because of the predominance of low permeability, glacial till soils over much of the areas.

1.3.3 Area E

A Phase I and Phase II investigation was completed on Area E, which is located north of the plant site and Swamp Creek. The site investigations completed on Area E consisted of the following activities:

- Excavation and logging of 62 test pits.

- Drilling and continuous sampling (in the outwash) of 18 test borings.

- Installation of six groundwater table wells.

- Completion of well development and aquifer response tests on six groundwater monitoring wells.

- Completion of five double-ring infiltrometer tests.

- Survey of the location and elevation of all field test locations.

- Completion of soil laboratory grain size analysis and hydraulic conductivity testing.

A preliminary evaluation of the site has determined that Area E is suitable for use as a soil absorption system. This conclusion is based on the following general characteristics of Area E:

- Outwash sand exists at or near the ground surface. In the southern portions of Area E the outwash thickness is between 20 and 35 feet thick.

- Based on visual classification of the soil samples, the outwash sand is generally a clean sand with a P200 typically less than 5 percent.

- Aquifer response and infiltrometer tests confirm the clean, high permeability nature of the outwash sands.

- Groundwater is located approximately up to 35 feet below the existing ground surface, and discharges into Swamp Creek.

- A preliminary soil absorption system layout indicates that sufficient, suitable areas exist to accept the discharge of the Crandon Project's treated wastewater.

1.3.4 Area G

A Phase I investigation was completed on Area G during the summer of 1998, and included excavation of 15 test pits and three borings. Area G has been eliminated from further consideration because of the inadequate thickness of acceptable outwash soils, the cemented nature of much of the outwash soils, and high groundwater conditions.

1.3.5 Area J

A Phase I investigation of Area J was completed in June 1998, and consisted of the excavation of five test pits. Area J was eliminated from consideration due to the presence of restrictive soil layers, high groundwater, and lack of suitable outwash soils.

1.3.6 Area K

The Phase I investigation of Area K included the drilling of two borings in July 1998. Area K was eliminated from consideration because of the high groundwater conditions which exist at the site.

1.3.7 Areas XB and XC

Areas XB and XC are located northeast of the plant site and south of Swamp Creek. The investigations on these properties included completing five backhoe test pits on Area XB and eight backhoe test pits on Area XC. These two sites were eliminated from consideration because of the high groundwater table and the presence of restrictive soils in the upper soil horizons.

1.3.8 Area XF

Area XF is located outside of the project area, just south of U.S. Route (USR) 8 and east of County Trunk Highway (CTH) W and is not shown on Figure 1-2. The investigation was completed in an area which is presently being used for the extraction of sand and gravel. Five backhoe test pits were excavated on Area XF. This site was eliminated from consideration because the outwash is interbedded with restrictive layers of sandy till.

2 Regulatory Requirements

Section 2 has been prepared pertaining to the preferred soil absorption site which is known as Area H. The methods and procedures described for Area H were also used for the other sites investigated. Details regarding the investigations completed for these sites are contained in the project's updated *Environmental Impact Report* (EIR) (Foth & Van Dyke, 1995/1998b).

The WDNR has determined that NR 214, Wis. Admin. Code, does not apply to the proposed soil absorption system for the Crandon Project, since that chapter regulates only "a system that utilizes the physical, chemical and biological abilities of the soil to decompose pollutants in the waste". NMC will not be relying on the soil to treat its discharge in any way, but will instead treat the discharge at the wastewater treatment plant to meet NR 140 groundwater quality standards, including Preventative Action Limits (PALs). Thus, this document has been prepared under the requirements of NR 108 and NR 132.

2.1 Technical Procedures

The procedures used in the field and laboratory testing of soils and groundwater were in accordance with American Society of Testing and Materials (ASTM) and/or standards required or acceptable to the Wisconsin Department of Natural Resources (WDNR). The test methods or procedures used were as follows.

- Soil Sampling/Drilling
  - ASTM D 1586-84 method for standard penetration test and split-barrel sampling of soils.
  - ASTM D 1452 practice for soil investigation and sampling by auger borings.
  - ASTM D 2488 practice for description and identification of soils (visual-manual procedure).
- Groundwater Monitoring Well Installation/Construction/Development
  - Wis. Admin. Code, NR 140, Groundwater Quality.
  - Wis. Admin. Code, NR 141, Groundwater Monitoring Well Requirements.
- Laboratory Soil Testing
  - ASTM D 422 method for particle-size analysis of soils (sieve and hydrometer).
  - ASTM D 1140 test method for amount of material in soil finer than the No. 200 (75 um).

- ASTM D 2216 method for moisture content determination of soils.
- ASTM D 2325-68 standard method for capillary-moisture relationships for coarse- and medium-textured soils by porous-plate apparatus.
- ASTM D 2434 test method for permeability of granular soils (constant head).
- ASTM D 2487 classification of soils for engineering purposes.

- Field Testing Methods
  - ASTM D 3385 standard test method for infiltration rate of soils in field using double-ring infiltrometer.
  - Bouwer, H. and Rice, R. C., 1976. A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Partially Penetrating Wells. *Water Resources Research*, Vol. 12, No. 3.
  - Bouwer, H., 1989. The Bouwer and Rice Slug Test - An Update. *Groundwater*, Vol. 27, No. 3, pp. 304-309.
  - U.S. Department of Agriculture, 1988. *Soil Taxonomy.*

2.2 Methods of Investigation

Following is a general description of the methods of investigation used at Area H.

2.2.1 Test Pits

The test pit investigations consisted of the excavation of test pits using a hydraulic excavator. The soil scientist entered the pit to carefully examine the soil profile for the first several feet of depth. After that depth, safety regulations and considerations precluded entering the pits, so samples were analyzed and obtained from the bucket of the excavator. The objective of excavating the test pits was to define the extent of potential layering of less permeable soils to determine the effects of these characteristics on the ability of the soils to accept hydraulic loading. In addition, the soil profile in each pit was carefully examined for mottling and other indications of high or fluctuating groundwater conditions. Test pit logs are provided in Appendix A. Upon completion of the evaluation, all test pits were backfilled and reclaimed. A log of each pit was completed and representative samples of the outwash soils were collected, when possible, at an elevation below the proposed base of the soil absorption system. Samples of the soils above the outwash were not collected, since these soils would be removed prior to construction of the soil absorption system.

2.2.2 Soil Borings and Monitoring Wells

Soil borings and monitoring wells were constructed using an all-terrain or truck mounted drill rig with hollow stem auger drilling techniques. The boreholes were drilled with 4¼-inch inside diameter hollow stem augers. Samples were obtained by driving a 2-, 2½-, or 3-inch split spoon sampler with a 300-pound hammer. The larger diameter samplers were used to obtain larger samples for laboratory soil tests and to allow for better examination of the soil horizons. All borings were continuously sampled in the upper 30 or more feet. Representative soil samples of each split spoon sampler were bagged for possible use in laboratory testing and for the review of the field logs. Each sample was examined as it was removed from the split spoon sampler and described, including its structure, mottling, voids, layering, lenses, and geologic origin. The drilling, soil sampling, and well construction techniques conform with the standards listed in Sections 2.1 and 2.2 of this report. Upon completion of drilling and sampling, all borings were abandoned in accordance with the requirements of NR 141, Wis. Admin. Code (Groundwater Monitoring Well Requirements). WDNR Boring Logs (Form 4400-122) and Borehole Abandonment Report (Form 3300-5B) forms which document the procedures used are included in Appendix B.

Eight monitoring wells and three piezometers were installed in Area H using the appropriate procedures listed above. The wells and piezometers were developed on August 27 and 28, 1998. The details of this work are provided in the WDNR Well Construction Reports (Forms 3300-113A and 3300-113B) provided in Appendix B.

2.2.3 Methods for Soil Description

This report uses two soil classification systems for describing the soils encountered in test borings and test pit excavations. The soil classification used for the soil borings and monitoring wells is the Unified Soil Classification System (USCS) according to ASTM Standard D 2487. Using the USCS system is required by NR 141, Wis. Admin. Code. Similarly, soil classification and other tests (e.g., grain size and hydrometer analysis, ASTM D 422) which were used to classify soils and measure other soil properties required for the soil absorption system analysis and design are based on the USCS.

The logs developed to describe the soils in the backhoe test pits used the Soil Conservation Service (SCS) classification system. The SCS system is typically used for the description of soils proposed for use in the treatment of industrial, municipal, and private wastewater treatment systems. The SCS classification system allows the soil scientist to better describe the upper soil horizons in a potential treatment area including the origin and presence of features such as mottles and restrictive layers. In the text which follows, the SCS system is used only to describe the soil profiles of the test pits. All other soil descriptions use the USCS. Further discussion on the use of both soil classification systems is addressed in Section 3.3.

2.3 Site Location Criteria

The location criteria applicable for this subsurface soil absorption system are included in NR 132.18(1)(a) through (g). Table 2-1 lists these criteria along with the status of the Area H compliance with each location criteria.

Table 2-1

Summary of NR 132.18(1) Location Criteria - Area H

Criteria	Compliance	Reason or Evidence
NR 132.18(1)(a) - Within areas identified as unsuitable in NR 132.03(25).	Complies	Refer to Section 2.3
NR 132.18(1)(b) - Within 1,000 feet of any navigable lake, pond, or flowage.	Exemption Requested	Refer to Section 2.3, Drawing No. 2
NR 132.18(1)(c) - Within 300 feet of a navigable stream.	Exemption Requested	Refer to Section 2.3, Drawing No. 2
NR 132.18(1)(d) - Within a flood plain.	Complies	Refer to Section 2.3, Drawing No. 2
NR 132.18(1)(e) - Within 1,000 feet of a highway right-of-way, public park, screened from view, etc.	Complies	Refer to Section 2.3, Drawing No. 2
NR 132.18(1)(f) - Within wetlands, except pursuant to the criteria in NR 132.06(4).	Complies	Refer to Drawing No. 2
NR 132.18(1)(g) - Within areas so that noncompliance will not result in noncompliance with other applicable federal and state laws and regulations.	Complies	Refer to Section 2.3

Prepared by: REM
Checked by: SAD2

Drawing No. 2 shows the distance from the proposed soil absorption sites to the applicable location criteria. The narrative which follows explains the compliance with the location criteria which are not shown on Drawing No. 2.

- NR 132.18(1)(a) requires that a mine-related structure not be located within an area defined as unsuitable in NR 132.03(25). The following lists the criteria which define unsuitability under NR 132.03(25), along with an explanation of the Area H compliance with each criteria.

  (25) "Unsuitability" means that the land proposed for surface mining is not suitable for such activity because the surface mining activity itself may reasonably be expected to destroy or irreparably damage either of the following:

  (a) Habitat required for survival of species of vegetation or wildlife as designated in ch. NR 27, if such endangered species cannot be firmly reestablished elsewhere.

  The soil absorption system for Area H is located on farm land which is not a habitat required for survival of any endangered species of wildlife. Additional baseline monitoring of the flora and fauna is planned prior to final design, as discussed in Section 9.3.

  (b) Unique features of the land, as determined by state or federal designation as any of the following, which cannot have their unique characteristic preserved by relocation or replacement elsewhere:

  1. *Wilderness areas designated by statute or administrative rule.*
  2. *Wild and scenic rivers designated by statute or administrative rule.*
  3. *National or state parks designated by statute or administrative rule.*
  4. *Wildlife refuges and areas designated by statute or administrative rule.*
  5. *Historical landmarks, sites and archaeological areas designated by the state historical society.*

  Area H does not contain, and is not adjacent to, any of the areas listed above.

  6. *Scientific areas as follows:* (not listed for brevity)

  Area H is not located in or near to any of the scientific areas listed under NR 132.03(25)(b)(6).

- NR 132.18(1)(d) - As shown on Drawing No. 2, the proposed soil absorption site is not located within a floodplain.

- NR 132.18(1)(e) - The proposed soil absorption site complies with all of the 1,000-foot setbacks established in NR 132.18(1)(e). Based on conversation with Mr. Frank Loreti of the Wisconsin Department of Transportation, Rhinelander, it has been determined that Keith Siding Road, adjacent to Area H, is not a major collector road, and therefore not eligible for federal funds. Since Keith Siding Road is not eligible for federal funds, the 1,000-foot setback from the highway right-of-way does not apply, and the criteria of NR 132.18(1)(e) is met.

- NR 132.18(1)(f) - As shown on Drawing No. 2, the proposed soil absorption system is not located within wetlands.

- NR 132.18(1)(g) - The soil absorption system proposed for Area H is not anticipated to result in noncompliance with other applicable federal and state laws and regulations.

As described in the preceding section and summarized in Table 2-1, the soil absorption system proposed at Area H complies with all of the applicable location criteria except NR 132.18(1)(b) and (c). The narrative which follows requests exemptions from these location criteria and provides the justification for granting of these exemptions. Final requests for these exemptions are provided in the project's updated *Mine Permit Application* (MPA) (Foth & Van Dyke, 1995/1998c).

As shown on Drawing No. 2, the 1,000-foot setback distance identified in NR 132.18(1)(b) appears not to be met for Lake 17-16. The ordinary high water mark (OHWM) around Lake 17-16 has been field delineated by the WDNR. However, the OHWM shown on Drawing No. 2 is approximate, since survey of the OHWM was not completed at the time of submission of this document.

The circumstances which justify an exemption for the location of the soil absorption system within 1,000 feet from the OHWM of Lake 17-16 are as follows:

- The proposed discharge water will be treated to NR 140 PALs, which would have no adverse impact on the water quality of Lake 17-16.

- Lake 17-16 is entirely on private land (owned by NMC).

- Lake 17-16 is not known to be used for recreational purposes or as a fishery.

In addition, a portion of the proposed discharge pipeline from the plant site to the soil absorption site is within 1,000 feet from Lake 17-16. The route selected is shown in Drawing No. 2. The chosen route follows the proposed railroad spur to a point just west of the Wisconsin Central

Limited Railroad, then north where it crosses Keith Siding Road. From here, the pipeline continues north to an existing snowmobile trail which bisects wetland Z16 south. An exemption from NR 132.18(1)(b) is also requested for the discharge pipeline.

As shown on Drawing No. 2, the setback between soil absorption cell D and Creek 17-13 is less than 300 feet. In addition, the setback between cells B and C and the small feeder spring to Creek 17-13 emanating from the northern portion of wetland Z-16 is less than 300 feet. The circumstances which justify granting of an exemption from NR 132.18(1)(c) are the same as those stated in the previous discussion requesting an exemption from NR 132.18(1)(b).

Since the selected discharge pipeline route follows the proposed alignment of the railroad spur, it will be constructed within 300 feet of Swamp Creek. Impacts to wetlands and Swamp Creek will be minimized by keeping both the railroad spur and discharge pipeline together. Therefore, an exemption from NR 132.18(1)(c) is also requested for the proposed discharge pipeline in the vicinity of Swamp Creek.

3 Regional Geology

The project area is located, as defined by Olcott (1968), in the Fox-Wolf River Hydrologic Basin. On a regional scale, the geologic conditions in the study area consist of metavolcanic Precambrian bedrock, which hosts the ore body (Figure 3-1), and is overlain by deposits of glacial till and outwash. These components are described below.

3.1 Regional Bedrock Geology

The Precambrian bedrock in northern Wisconsin is similar to, and is the southern extension of, a province of the Canadian Shield, referred to as the Southern Province (Figure 3-1). This province is one of seven Canadian Shield rock provinces consisting of rocks ranging in age from 960 to 3,200 million years (Palmer, 1983).

Volcanic rocks are found within the Southern Province as irregularly shaped belts surrounded by granitic and gneissic rock. These belts are comprised of volcanic flows and pyroclastics with interbedded sedimentary rocks such as shale, sandstone, and conglomerate. Locally, the volcanic belts are intruded by large masses of granite or granodiorite.

In Wisconsin, three major ages of Precambrian rocks are exposed. Of these, the Middle Precambrian rocks, which are described below, are of interest in the study area.

- Early Precambrian (Archean, older than 2,500 million years)

  Rocks in the Early Precambrian are among the oldest in North America. Most of the rock is granitic gneiss, 3,200 million years old, containing minor amounts of volcanic rock that has been folded and intruded by granite (Sims, 1976; Sims and Peterman, 1976).

- Middle Precambrian (Early Proterozoic, 1,600 to 2,500 million years)

  Beginning about 2,100 million years ago, sediments began to accumulate in northeastern Wisconsin. Well-known sediments deposited during this period are the iron formations which host the iron ore of the Gogebic and Florence areas (James, et al., 1968). To the south, flows and volcanic sediments were deposited in a large trough extending across Wisconsin from Ladysmith to Marinette. It is within this volcanic belt that the massive sulfide ore deposits at Ladysmith (Flambeau and Thornapple), Rhinelander (Lynn and Pelican) and Crandon are found. About 1,800 million years ago, during the Penokean Orogeny, this volcanic belt was faulted and folded and intruded by granite (Goldich, 1972; Maas, et al., 1977). Erosion followed, and quartz-rich sandstone was deposited to the south and west in the vicinity of Rusk and Barron counties.

- Late Precambrian (600 to 1,600 million years)

  During this period, quartz-rich sandstone continued to be deposited in western Wisconsin. About 1,500 million years ago, a large body of granite, the Wolf River batholith, was emplaced in east-central Wisconsin (Van Schmus, et al., 1975). The northernmost area of Precambrian rock in Wisconsin is composed of a sequence of basaltic flows with interbedded sedimentary rocks. These basalt flows accumulated in a large trough or rift, which formed about 1,100 million years ago and extended from Lake Superior into Kansas; a distance of over 1,000 miles (Sims, 1976). Deposits of copper occur in some of these rocks in the Upper Peninsula of Michigan.

There has been no major folding, fault, or igneous activity in the Southern Province of the Canadian Shield since the Precambrian era.

3.2 Regional Pleistocene Geology

The majority of unconsolidated sediments in the study region, and across Northern Wisconsin, consist of glacial drift estimated to be approximately 100 to 300 feet in thickness, based on regional bedrock elevation data presented in Section 3.5 of the EIR (Foth & Van Dyke, 1995/ 1998b). Deposits from a number of major glacial advances have been recognized in Wisconsin. In the study region, the majority of the unconsolidated sediments were deposited during the Wisconsinan Age. Sediments of Pre-Wisconsinan Age are present locally above the bedrock. The Pre-Wisconsinan sediments are generally buried by Wisconsinan Age sediments.

The unconsolidated Pre-Wisconsinan deposits of the Forest County area include undifferentiated sediments of the Marathon Formation. Pleistocene units younger than the Marathon Formation are Pre- to Early Wisconsinan undifferentiated sediments of the Lincoln Formation, and the Wisconsinan Mapleview Member of the Horicon Formation. The youngest Pleistocene unit in Forest County is the Nashville Member of the Copper Falls Formation. The Nashville Member, deposited by the Langlade Lobe, is considered the stratigraphic equivalent of the Green Bay Lobe Mapleview Member of the Horicon Formation. In Forest County, the Nashville Member overlies and truncates the Mapleview Member.

The Marathon Formation, a dark brown calcareous till, underlies the Lincoln Formation and the Mapleview Member of the Horicon Formation (Simpkins, et al., 1987). The Marathon and Lincoln Formations are the oldest glacial units of the region. The Marathon Formation contains till and associated sand and gravel. This unit generally thickens northward. The extent of the formation below the Copper Falls Formation and Horicon Formation is not known (Mickelson, et al., 1984).

The Marathon Formation typically contains a pebbly loam to clay loam till which is frequently thin (less than 10 meters) and found directly overlying bedrock, grussified bedrock or saprolitic bedrock-weathering residuum (Mickelson, et al., 1984). Organic material overlying the youngest member of the younger Lincoln Formation has been radiocarbon dated at 40,800 ± 2,000 years

BP (beyond reliable radiocarbon dating range), making the Marathon Foundation presumably Pre- or Early Wisconsinan in age.

Overlying the Marathon Formation are discontinuous deposits of sediments belonging to the Lincoln Formation. In the Forest County region, these sediments are undifferentiated. The Pre- or Early Wisconsinan Lincoln Formation includes red-brown sandy loam till and associated sand and gravel (Mickelson, et al., 1984). This formation also may directly overlie saprolite or bedrock. The Lincoln Formation in the area is generally greater than 40,800 ± 2,000 years BP, making the formation Early to Mid-Wisconsinan. The Lincoln Formation probably makes up the majority of sediments found below the Late Wisconsinan deposits.

The Mapleview Member of the Horicon Formation overlies the Marathon and Lincoln Formations. The Mapleview Member of the Horicon Formation was deposited by ice from the Green Bay Lobe in Late Wisconsinan time around 15,000 or 14,000 B.P. (Mickelson, et al., 1984). The Mapleview Member consists mainly of cobbly, pebbly, silty sand till with boulders and associated sand and gravel (Mickelson, et al., 1984). According to Mickelson, et al. (1984), the Mapleview Member is at least partly contemporaneous with the Nashville Member of the Copper Falls Formation deposited by the Langlade Lobe. In the vicinity of the site, the Mapleview Member is truncated and overlain by the Nashville Member of the Copper Falls Formation.

The majority of the surficial sediments in the Forest County Region belong to the Nashville Member of the Copper Falls Formation. The Nashville Member consists of a pebbly, cobbly sandy loam till with numerous sand lenses and associated sand and gravel (Mickelson, et al., 1984). Till of the Nashville Member, in Forest County, is generally exposed at the surface in drumlins clustered on upland areas (Simpkins, et al., 1987). The associated meltwater sands and gravels have filled in low areas around the uplands in pitted and unpitted outwash plains. In the region, the Nashville Member is of Late Wisconsinan Age and stratigraphically equivalent to the Horicon Formation. Locally it is overlain by post-Pleistocene sediments, consisting of windblown silts and fine sand, organic deposits of grass-sedge, moss and woody peat, and modern alluvium (Simpkins, et al., 1987).

3.3 Soil Survey Information

The United States Department of Agriculture, Soil Conservation Service (SCS) has not yet published the final Soil Survey for Forest County, Wisconsin. Figure 3-2 is a reproduction of the draft soil map for Area H and the surrounding area. Area H has five mapped soil units (see Appendix C) which include the following:

- Mapping Unit-20D, Goodman-Wabeno Complex, 15 to 35 percent slopes which are described as sloping, well-drained soils formed in silty deposits and in the underlying loamy or sandy glacial till. The lower horizons of this unit are fine sandy loams and silt loams with USCS of ML, CL-ML, SM, and SM-SP. Refer to the Soil Mapping sheet 20D in Appendix C for additional information.

- Mapping Unit-103A, Whisklake (Worchester) Silt Loam, 0 to 3 percent slopes which are described as nearly level and gently sloping, poorly-drained soils formed in silty and loamy deposits underlain by sand and gravelly coarse sand glacial outwash. The lower horizons are gravelly sands or sandy gravels with USCS of SP, SP-SM, GP, and GP-GM. Refer to Soil Mapping sheet 103A in Appendix C.

- Mapping Unit-113A, Manitowish Sandy Loam, 0 to 3 percent slopes which are described as nearly level and gently sloping, moderately well-drained soils formed in loamy deposits and underlain by stratified sand and gravelly coarse sand glacial outwash. The lower horizons are poorly graded sands and gravels with USCS of SP and GP. Refer to Soil Mapping sheet 113A in Appendix C.

- Mapping Unit-111B, Pence Sandy Loam, 0 to 6 percent slopes which are described as nearly level and gently sloping, well-drained soils in loamy deposits and in the underlying sand and gravelly coarse sand glacial outwash. The lower soil horizons are primarily poorly graded sands and gravel, USCS SP and GP. Refer to Soil Mapping sheet 111B in Appendix C.

- Mapping Unit-707, Seelyeville and Cathro Soils, 0 to 1 percent slopes which are described as nearly level, very poorly drained soils formed in organic material more than 51 inches thick or underlain by loamy glacial till or lacustrine deposits at depth of 16 to 51 inches. The uppermost and lower soils in this profile are classified as muck with an USCS classification of PT. Refer to Soil Mapping Sheet 707 in Appendix C.

It is apparent from a review of Figure 3-2 that Mapping Unit 111B, Pence Sandy Loam, is the predominant soil type in the area proposed for the soil absorption system. The estimated soil properties from the soil map sheet for the Pence Sandy Loam are similar to the properties discovered during NMC's field investigation and laboratory testing program associated with Area H.

3.4 Regional Hydrogeology

The project area is located in the Fox-Wolf River Hydrologic Basin (Olcott, 1968). On a regional scale, the hydrogeologic conditions around the project area generally consist of saturated glacial till and outwash overlying Precambrian bedrock. Groundwater in the vicinity of the project area occurs within two primary hydrostratigraphic units. These units consist of the Precambrian bedrock and the glacial overburden. The glacial overburden can be subdivided into glacial till and outwash. Regionally, the water table resides within the glacial deposits. The bulk of the Precambrian bedrock, although locally fractured and showing secondary permeability features, typically yields only small amounts of water to wells. As such, it does not fit the conventional definitions (Freeze and Cherry, 1979) of an aquifer.

The glacial aquifer consists of saturated deposits of glacial till and glacial outwash. The glacial till typically is low to moderately permeable, and typically would not be used as an aquifer except where embedded lenses of sand and gravel exist. Based on the work of Simpkins, et al. (1987), the outwash deposits are relatively prolific on a regional scale, and are the dominant unconsolidated unit at the site proposed for the soil absorption system. These outwash deposits are typically sand and gravel, and therefore are permeable enough to yield significant amounts of water. As such, the outwash deposits form the primary regional aquifer for domestic and municipal water supplies.

The depth to groundwater within the glacial deposits is quite variable. This is attributed to the considerable topographic relief in the vicinity of the project area. Near groundwater discharge areas such as streams, lakes, and riparian wetlands, the depth to groundwater is on the order of several feet. In groundwater recharge areas located at topographic highs, or in upland areas, the depth to groundwater can be more than 100 feet.

Groundwater flow occurs primarily within the glacial till and outwash deposits, with the majority of flow occurring within the more permeable outwash deposits that dominate the site. Flow within the outwash can typically be characterized as occurring under unconfined conditions. However, semi-confined conditions may occur locally within the outwash due to the presence of lacustrine clay lake beds overlying the outwash, or in instances where the outwash deposits are overlain by less permeable glacial till.

On a regional scale, groundwater flows from areas of high hydraulic head to areas of low hydraulic head or from potentiometric highs to potentiometric lows. The potentiometric surface is defined as the as the height to which water will rise in a well tapping a confined aquifer and is the water table under unconfined conditions. Thus under unconfined conditions, areas of high hydraulic head correspond to topographic highs in the regional water table. Similarly, areas of low hydraulic head correspond to topographic lows in the regional water table. Under unconfined conditions the potentiometric surface and water table are essentially the same except in areas where strong vertical gradients exists, such as would occur near discharge points and some head-dependant seepage lakes.

High water table elevations occur within upland areas and around upland lakes and wetlands. Low water table elevations occur in lowland areas associated with streams, wetlands, or lakes. Groundwater is replenished in recharge areas defined as an area where the net vertical component of flow is downward. Recharge areas are typically associated with upland areas, upland lakes, and high water table elevations. Groundwater discharge areas are defined as areas where the net vertical component of flow is upwards. Groundwater discharge areas are typically restricted to a narrow band around streams, wetlands, and/or lakes. Thus recharge to the glacial aquifer occurs over much of the regional study area.

A regional potentiometric surface map, shown in Figure 3-3, was prepared from water levels taken in the study area in February 1982, and from additional data on regional groundwater elevations available from the USGS (Foth & Van Dyke, 1995/1998b). The map covers a large

geographic area encompassing Lakes Metonga and Lucerne to the north; Roberts and Lost Lakes to the east; Pickerel, Crane, and Rolling Stone Lakes to the south; and Bishop Lake to the west.

The potentiometric surface map is roughly equivalent to the regional water table, depicting the change in the water table elevation and the horizontal hydraulic gradient on a regional scale. Areas where the potentiometric surface map would not be equivalent to the water table would be in the vicinity of upland lakes, such as Little Sand Lake, that are hydraulically connected to the regional groundwater system. In these localized areas a mounded water table exists due to the occurrence of low permeability lacustrine clay and silt lake beds which create semi-confined conditions in the underlying glacial till and outwash. The regional scale potentiometric surface map does not reflect these small localized mounded systems. Rather, in the vicinity of the upland lakes, the regional potentiometric surface map represents the potentiometric surface in the semi-confined underlying glacial till and outwash.

The regional potentiometric surface map (Figure 3-3) shows a well defined groundwater flow system constrained by a network of creeks and lakes. The near project area controlling surface water features, moving clockwise from the north, are Lake Metonga, Swamp Creek, Hemlock Creek, Ground Hemlock Lake, Crane Lake, Pickerel Lake, Rolling Stone Lake, Pickerel Creek, Mole Lake, Rice Lake, and Gliske Creek. Groundwater flows from water table highs located in upland areas to discharge areas controlled by the above referenced surface water features.

The regional groundwater high of about 1,640 feet is located in the vicinity of Lake Lucerne. The groundwater divide for the hydrologic basin is located just to the north of Lake Metonga and to the east of Lake Lucerne (Olcott, 1968). South and east of this divide groundwater flows into Lake Metonga or Swamp Creek. South and west of Lake Metonga groundwater flows into Outlet Creek, Swamp Creek, Rice Lake, or Gliske Creek. Outlet Creek, which drains Lake Metonga, is a tributary of Swamp Creek. In the vicinity of the area proposed for the soil absorption system, regional groundwater flow is to the southeast toward Swamp Creek.

A second groundwater divide exists south of Swamp Creek in the vicinity of the proposed TMA. Flow north of this divide is to Swamp and Hemlock Creeks and Ground Hemlock Lake. South of this divide, flow is southeasterly and southwesterly toward Crane, Pickerel, and Rolling Stone Lakes, and Pickerel Creek between Rolling Stone and Mole Lakes.

3.5 Regional Groundwater Quality

Information on the regional water quality was obtained from Olcott (1968). Within the glacial overburden, the groundwater typically has a dissolved solids content ranging from 200 to 300 mg/l. However the concentration of dissolved solids can be quite variable and locally can be as high as 400 mg/l. Water within the glacial till and outwash is of the calcium magnesium bicarbonate type. It is moderately hard with high iron concentrations, a common occurrence in much of the area.

3.6 Climatology-Meteorology

The climate of the region is continental, modified slightly by Lake Michigan, which is located approximately 80 miles to the east, and Lake Superior located approximately 90 miles to the north. The region has moderately warm summers with prevailing westerly winds and long cold winters. Summer temperatures rarely exceed 95 degrees Fahrenheit (°F) during the day, while night temperatures range between 50°F to 60°F. Winter temperatures range from 0°F to 25°F during the day, and occasionally will fall below -30°F at night.

Historical monthly temperature and precipitation data, averaged from 1961 to 1990, were obtained from the State Climatologist (Anderson, 1995) for the North Pelican Lake Station, located approximately 15 miles west of the plant site. Data from the North Pelican Lake Station was used due to its relatively close proximity to the project area. The data, presented in Table 3-1, shows that during the period of 1961 to 1990 the highest average temperature at the North Pelican Lake station, 77.2°F, occurs in the month of July. The lowest average temperature, 0.1°F, occurs in January. The highest actual temperature on record for the North Pelican Lake station over the period of 1950-1994 was 98°F in July 1955. In February 1967, the lowest actual temperature, -44°F, was recorded.

Average historical monthly precipitation at the North Pelican Lake station, as shown in Table 3-1 ranges from approximately 1 to 4 inches. The greatest monthly average, 4.14 inches, occurs in the month of August. The least precipitation occurs in February with an average of 0.82 inches. In total, the historical average annual precipitation at the North Pelican Lake station is 30.36 inches. Snow fall in the region averages between 40 and 60 inches per year.

Table 3-1

Meteorological Data

Parameter	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Temperature Data (°F)													
State Climatologist[1]													
Average High	20.1	25.8	36.9	51.9	66.2	73.2	77.2	73.6	64.4	54.0	37.8	24.1	50.4
Average Low	0.1	2.6	15.0	28.8	40.1	49.7	54.9	53.0	45.4	35.3	23.2	6.9	29.6
Precipitation (in)													
State Climatologist[1]													
Normal	1.08	0.82	1.62	2.35	3.18	3.58	3.73	4.14	3.99	2.46	1.96	1.45	30.36

[1] Monthly averages for 30-year period (1961-1990) as measured at North Pelican Lake.

Prepared by: SVD1
Checked by: REM

4 Results of Investigation

The investigation of Area H for use as the proposed soil absorption site consisted of the following:

- topographic mapping;
- wetland delineation and mapping;
- subsurface characterization;
- archaeological survey; and
- groundwater quality sampling.

These are described further in the following sections. The archaeological investigation is discussed in Section 4.4.

4.1 Field Topographic Mapping

In August 1998, a detail topographic survey was completed on the accessible (i.e., non-wetland) portions of Area H. The purpose of this survey was to provide a topographic map with a 1-foot contour interval in the areas proposed for siting the soil absorption system. The on-site survey work also included establishing the location and surface elevation of the test pits, test borings, water table wells, piezometers, sand points, and staff gages. Drawing No. 3 shows the information obtained during the field surveys. The topography and other features on Drawing No. 3 outside of the surveyed area were obtained from the 1976 aerial mapping completed by Aero-Metric Engineering, Inc. The wetland boundaries around the site, which were field delineated, were also surveyed. In addition, spot elevations were established in the wetlands bordering the site to the east.

4.2 Wetland Delineation

On August 17, 1998, a wetland delineation/verification survey was conducted at Area H. Prior to conducting the field investigation, the Crandon Project's 1995 EIR (Foth & Van Dyke, 1995/1998b) was reviewed. In addition, aerial photographs, topographical maps and the historical wetland maps for the site were also reviewed. According to the information presented in the 1995 EIR, two wetlands were previously identified in the vicinity of Area H by Normandeau Associates, Inc. and Interdisciplinary Environmental Planning, Inc. These wetlands, known as T4 and Z16, were previously inventoried and are both described as coniferous swamp.

Following the literature review, a site visit was conducted and a formal wetland delineation in accordance with the *Corps of Engineers Wetland Delineation Manual* (USCOE, 1987) was completed. A technical memorandum describing the 1998 delineation work is provided in Appendix D. Each identified wetland was field delineated by walking several transects across the wetland/non-wetland gradient. Observed vegetation, hydrology and soil characteristics were recorded on Routine Wetland Determination Forms. Based on the data collected, numbered flags

were placed along the perimeter of the wetland boundary. The flags were then surveyed and the resulting wetland boundary is shown on Drawing No. 3. It should be noted that the entire boundaries of wetlands T4 and Z16 were not delineated. The delineation only covered the wetland/upland boundary nearest to the proposed soil absorption area north of Keith Siding Road and west of the Wisconsin Central Limited railroad tracks, as shown on Drawing No. 3.

The information obtained from the literature review is generally consistent with the conditions observed on site. The delineated western boundary of T4 generally follows the same boundary as reported in the 1995 EIR. However, the wetland map presented in the 1995 EIR shows an upland break between wetland T4 and Z16. This area, historically shown as upland, appears to have been significantly affected by clearing and agricultural activities. It appears that the area was cleared and drained for agricultural purposes. An 8-inch diameter corrugated metal culvert pipe (CMCP) is present between T4 and Z16, as shown on Drawing No. 3. The CMCP was not conveying water during the field work performed in August and September 1998. Evidence of hydric soils and hydrophytic vegetation does exist in this area, and it appears to be in the process of reverting back to wetland. Therefore, it was included as wetland in the most recent delineation.

4.3 Subsurface Investigations

4.3.1 General

The subsurface investigations at Area H were completed in three phases during the summer of 1998. The locations of these investigations are shown on Drawing No. 3 and Figure 1-2. The initial investigation was performed during July 1998, at which time three test borings numbered BH-01, BH-03, and BH-05, and four test pits numbered TPH-01 through TPH-04, were completed in Area H South (located south of Keith Siding Road). These holes were drilled to obtain a preliminary assessment of the suitability of the southern portions of Area H South.

A second preliminary investigation and a Phase II investigation were completed in early August 1998 and late August/early September 1998, respectively, on the northern portions of Area H. The following activities were completed as a part of these investigations (locations are shown on Drawing No. 3):

• 104 test pits (98 locations)	TPH-5 through TPH-98
• 16 test borings	BH-2, BH-4, and BH-6 through BH-19
• 8 water table monitoring wells	MWH-09, -10, -11, -13, -14, -15, -16, and MWH-19
• 3 piezometers	MWH-09P, MWH-10P, and MWH-11P
• 6 shallow sand points	SPH-01 through SPH-06

♦	16 test borings	BH-2, BH-4, and BH-6 through BH-19
♦	4 deep sand points	SPH-01A through SPH-04A
♦	2 staff gages	SGH-01 and SGH-02
♦	8 hand auger borings	HAH-01 through HAH-08

Infiltrometer tests were performed at five of the test pit locations. In addition, laboratory soils testing was completed on representative samples. Two rounds of groundwater sampling are in the process of being completed on three wells to obtain a preliminary assessment of existing groundwater quality. The results of this sampling in addition to baseline environmental and biological monitoring data at the site will be provided in a future update to the Crandon Project's EIR (Foth & Van Dyke, 1995/1998b) (see Section 9.3).

Test pits were completed to delineate the soils that will form the base of the seepage cells. Test pit data are used to aid in the design of the cells with respect to soil layers that may restrict the infiltrative capacity of a cell and would thus warrant removal during construction.

The soil borings were completed to characterize the lithology and thickness of the dominant hydro-stratigraphic units that form the aquifer system at the site. The thickness of the aquifer and potential confining layers are a key site feature that will affect the transmissivity of the local aquifer and the ability to transmit infiltrated water to a local groundwater discharge area.

Water table and piezometer wells were installed to define the water table elevation across the site and the groundwater flow field. Monitoring wells were also used to conduct slug tests to assess the hydraulic conductivity of the local aquifer.

Sand points and staff gages were installed to aid in the assessment of groundwater interaction with local surface features such as wetlands T4 and Z16, Lake 17-16 and its associated dredge canal, and Creek 17-13 and its associated diffuse spring that exists in the northern portion of wetland Z16 where staff gage SGH-02 is located. Hand auger borings were completed in wetland Z16 to assess the nature of the shallow soil strata beneath the wetland organic layer that could affect the ability for groundwater to discharge into the wetland.

4.3.2 Test Pits

A total of 104 soil test pits (TPH-5 through TPH-98) were dug by backhoe on the property during the evaluations at locations shown in Drawing No. 3 to characterize the soils at Area H. At some locations, additional test pits were excavated adjacent to the original test pit to confirm soil conditions. At these locations, the test pit designations are followed by letters (A, B, C, etc.) as appropriate. Detailed test pit logs are included in Appendix A. Standard SCS formats were used to record the data and interpretations. Therefore, the terms used to describe soil texture (particle size distribution) are those presented in *Soil Taxonomy* (USDA, 1988), rather than those used in the Unified Soil Classification System (USCS). A non-standard symbol (→) has been

used to indicate "grades to". In addition, two non-standard terms are used in the descriptions to describe the cementation (Ce) and/or compaction (Cp) observed in some of the soil horizons. Wherever possible, the test pits were extended into the saturated zone.

Representative soil grab samples were collected from the test pits for reference and for laboratory testing. In addition, several undisturbed soil cores were collected from selected test pits for bulk density determination.

The upland (i.e., non-wetland) portion of Area H consists of six parcels, or fields, identified by crop and location. These fields, shown on Drawing No. 3, include: 1) a medium size pasture planted in grass in the northeastern corner of the property; 2) a medium size alfalfa field north of the driveway and west of the access road; 3) a small alfalfa field north of the driveway and east of the access road; 4) a small parcel of land south of the driveway and east of Keith Siding Road planted in oats; 5) a medium size alfalfa field north of Keith Siding Road in the southeast portion of the property; and, 6) a medium size parcel west and south of Keith Siding Road which contains a potato crop. Similarities and differences in the soils encountered in these fields are discussed below.

Most of the soils encountered at Area H have limited horizon development, and contain only minor evidence of translocation of materials within the horizons and/or alterations of parent materials. The surficial soils evaluated have been plowed for crop production and original A horizons have been incorporated with portions of the underlying, weakly developed B horizons thereby producing Ap horizons (plow layer) with moderate values and chromas (typically 10YR4/1-3).

Most of the soils on the site are entisols (soils having no diagnostic pedogenic horizons and therefore minimal horizon development). A minor portion of the soils encountered at the site are spodosols [soils with subsurface alluvial accumulations of organic matter (Bh) and compounds of aluminum and usually iron (Bs)]. The spodisols range from containing traces of (see TPH-24), to a distinct (see TPH-9) E horizon and underlying B2s or B2hs-B2s horizons. There may have been a greater proportion of spodosols at the site prior to the onset of agricultural activities during which former E and B2 horizons may have been incorporated into the Ap horizon thus making it nearly impossible to recognize some of the original spodosols. It was observed in some test pits that the Ap horizon truncates E-B2hs-Bs horizons (see TPH-51 and TPH-62) and/or cradle knoll sequences of these horizons (see TPH-40 and TPH-82) which have resulted from the clearing and working of the formerly forested site.

The greatest development of spodosols at the site is in the potato field (Field 6) where, due to the high groundwater levels and seasonal groundwater fluctuations, they are probably aquods (see TPH-23 and TPH-26). This combination of entisols and spodosols, with entisols predominating, was also encountered at the other sites (e.g., Areas E, G, etc.). However, the other sites were forested and the proportion of spodosols to entisols was generally greater at the other sites than at Area H.

The soils at the site have developed in a surficial deposit of loess overlaying medium to coarse outwash sands. The loess consists primarily of silt loam (sil) and sandy loam (sl) materials. In general, the soils in Fields 1 and 2 have the widest range in thickness of the loess material and greater overall loess thicknesses than the soils in the other fields.

In some test pits a thin layer of glacial till, consisting of primarily of sandy clay loam (scl) material, was found between the loess and outwash. About one-third of the test pits in Fields 1 and 2, and about two-thirds of the test pits in Field 4, contain a layer of till between the loess and outwash. Very few of the test pits in Fields 3, 5 and 6 contain a till layer. About two-thirds of the till encountered in all test pits showed signs of having been at least partially reworked resulting in a material with a sandy loam (sl) texture. These reworked tills are referred to as sandy tills in the individual soil descriptions.

The thickness of the loess/till surficial soils ranges from approximately 0 to 4 feet (average about 1½ to 2 feet) across the site. These materials would be expected to have a lower infiltrative capacity and will be removed from the base of the absorption system and replaced with clean sands, as discussed in Section 6.

The soils beneath the surficial soils consist of layers of mainly medium to coarse sands, with subordinate amounts of medium and fine sand, all of which would be expected to have a high infiltrative capacity due to the lack of fine materials (silt plus clay). The upper foot of sand in most of the pits contains small thin, very discontinuous layers of fine material (fsl), and small discontinuous seams of fine gravel ± very coarse sand (grvcos). The stratification between the sand layers is not distinct, which reduces the potential for lateral flow of water applied to these soils.

The outwash sands in some of the test pits contained fragments of till ranging in size from 2 inches by 2 inches to 6 to 8 inches by several feet along the interface between the upper and lower sands. These materials are more common in the outwash in Fields 1 and 2, are less common in the outwash in Fields 3 and 4, and were rarely observed in the outwash in Fields 5 and 6.

Portions of the horizons developed in the loess and/or till are partially cemented and/or compacted. In addition, at some locations the upper 1 foot or so of the outwash show the same characteristics. These horizons are designated as partially cemented/compacted in the remarks section of the detailed descriptions (e.g., TPH-11 and TPH-29). This feature has led to the development of peds having a firm (mfi) consistence in some of the test pit soils (e.g., TPH-11). However, individual peds in some of the test pit soil horizons crush quite easily and have a consistency of friable or even very friable (mfr or mvfr, e.g., TPH-29). It appears that the cementation/compaction developed first as an interpedal feature and later expanded to also become an intrapedal feature. These features were more common in soils in Fields 3 and 5, and were the least common in soils in Field 6. These cemented and/or compact materials are obvious when excavating the soil and will be removed during construction of the system.

As previously mentioned, test pits were extended into the saturated zone when possible. The outwash sands in most of the pits contain horizontal mottling (streaks) near the zone of saturation, indicating that the seasonal fluctuation of the water table is low and that groundwater flow beneath the site is mainly horizontal in nature. However, the relationship between the mottling, normally considered to represent seasonal high groundwater, and the depth of the zone of saturation is not consistent. These test pits were dug at the end of a dry summer and it would be expected that the zone of saturation would be near its lowest level. The banded mottling in some test pits was found to be above the water table (see TPH-7 and 21) as would be expected. In other pits the mottling was observed to be located at, or within, the zone of saturation (see TPH-50 and 51). Therefore, the depth to maximum seasonal groundwater fluctuation listed in the individual soil test pit descriptions has been assumed to be approximately 1 foot above the top of the observed zone of saturation.

Based on the results of the bulk density determinations, the low fines content of the outwash, and the results of the infiltrometer tests (described below), it is expected that the outwash sands exhibit a suitable infiltration capacity for developing a soil absorption system at a conservative rate of about 5 gallons per day per square foot (gpd/sf). Additional discussion on the design infiltration rate is discussed in Section 6.

4.3.3 Soil Borings

Sixteen soil borings were drilled to characterize the deeper soil conditions at Area H. Soils were sampled continuously using a split spoon sampler in the upper 30 or more feet to define the thickness and characteristics of the soil profile and to obtain samples for laboratory analysis. Below approximately 30 feet in depth, soil borings were sampled at approximate 5-foot intervals. Table 4-1 provides a summary of the elevations of the soil borings, wells, piezometers, sand points, and staff gages installed at the site. The soil borings were also used to determine the thickness of the aquifer in the vicinity of Area H and the occurrence, if any, of confining layers that could affect the ability of the aquifer to transmit infiltrated water to a local point of discharge.

The soil borings and wells were completed primarily on lands presently used for agricultural purposes or at the fringes of these agricultural fields. The upper soil horizons (topsoil) are developed in a surficial deposit of loess which directly overlies outwash sands. In isolated cases there is a thin veneer of Late Wisconsinan till between the topsoil/loess and the outwash. The topsoil generally consists of black to dark-grey sandy silt or silty sand, Unified Soil Classification System (USCS) - OL which ranges in thickness from 0.2 feet to 1.0 foot. The topsoil was thickest where the soil structure has not been disturbed by agricultural activities along the margins of the agricultural lands.

The topsoil is underlain in most borings by a yellowish-brown to light-brown silty fine sand or fine sandy silt (ML or SM) which is believed to a loess deposit. The topsoil and loess soil are mixed at locations of past agricultural use due to tillage of the soil which has occurred over the years resulting in a soil classified as (OL-ML) and referred to in the boring logs (Appendix B) as

Table 4-1

Boring/Well/Sand Point/Staff Gage Construction Summary

Boring/ Well ID	Surface Elevation	Top of PVC Casing Elevation	Top of Screen Elevation	Bottom of Screen Elevation	Bottom of Borehole Elevation
BH-01	~1585.00[a]	—	—	—	~1505.00
BH-02	1593.40	—	—	—	1561.40
BH-03	~1585.00[a]	—	—	—	~1555.00
BH-04	1591.68	—	—	—	1541.68
BH-05	~1585.00[a]	—	—	—	~1521.00
BH-06	1590.20	—	—	—	1564.20
BH-07	1588.48	—	—	—	1558.48
BH-08	1586.19	—	—	—	1560.19
BH-09	1591.66	—	—	—	1561.66
BH-10	1592.33	—	—	—	1560.33
MWH-10	1592.46	1595.62	1585.5	1575.5	1574.50
MWH-10P	1592.37	1595.48	1560.4	1555.4	1554.40
BH-11	1585.07	—	—	—	1555.07
MWH-11	1585.00	1588.16	1581.0	1571.0	1570.00
MWH-11P	1584.87	1588.02	1555.9	1550.9	1549.90
BH-12	1591.43	—	—	—	1559.43
BH-13	1594.03	—	—	—	1523.03
MWH-13	1594.42	1597.54	1589.4	1579.4	1578.40
BH-14	1588.36	—	—	—	1522.36
MWH-14	1588.69	1591.92	1583.7	1573.7	1572.70
BH-15	1588.63	—	—	—	1556.63
MWH-15	1588.76	1591.73	1583.8	1573.8	1572.80
BH-16	1592.44	—	—	—	1560.44
MWH-16	1592.92	1596.02	1587.9	1577.9	1576.90

Table 4-1 *(Continued)*

Boring/ Well ID	Surface Elevation	Top of PVC Casing Elevation	Top of Screen Elevation	Bottom of Screen Elevation	Bottom of Borehole Elevation
BH-17	1585.38	—	—	—	1553.38
BH-18	1586.42	—	—	—	1554.42
BH-19	1586.55	—	—	—	1556.55
MWH-19	1586.24	1589.38	1581.2	1571.2	1570.20
MWH-09	1591.23	1594.34	1587.2	1577.2	1576.20
MWH-09P	1591.22	1594.44	1562.2	1557.2	1556.20
SPH-01	1581.52	1583.69[b]	1578.4	1575.4	—
SPH-01A	1581.42	1585.95[b]	1570.3	1567.3	—
SPH-02	1581.95	1583.89[b]	1578.6	1575.6	—
SPH-02A	1581.83	1584.36[b]	1568.5	1565.5	—
SPH-03	1591.08	1593.37[b]	1588.2	1585.2	—
SPH-03A	1591.21	1594.49[b]	1578.5	1575.5	—
SPH-04	1590.76	1593.18[b]	1587.9	1584.9	—
SPH-04A	1590.79	1594.88[b]	1579.2	1576.2	—
SPH-05	1580.45	1581.51[b]	1571.2	1568.2	—
SPH-06	1584.15	1587.18	1582.7	1579.7	—
SGH-01	1577.88[c]	—	—	—	—
SGH-02	1577.41[c]	—	—	—	—

[a] Borings located south of Keith Siding Road. Elevation estimated from the topographic map.
[b] Top of 1¼ inch galvanized steel pipe.
[c] Elevation of zero "0" point on the staff gage.
BH = Borings - Area H
MWH = Monitoring wells - Area H
SPH = Sand points - Area H
SGH = Staff Gages - Area H
~ = Approximately
Note: All elevations in feet (mean sea level).

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a plagen. A plagen is defined as a soil that has been disturbed by agricultural activities and contains evidence of plowing or spading and manuring. A plagen soil condition was observed in borings BH-07, BH-08, BH-09, and BH-10. The till layer was encountered only in borings BH-02, BH-04, BH-05, BH-06, BH-11, BH-13, and BH-15. BH-05 was drilled in Area H South which is not under consideration for use as part of the soil absorption system. In the other borings where till was encountered, located along the east wetland agricultural field margins, the till is classified as a brown, dense, fine sandy silt with variable amounts of gravel and clay (SM or ML). In these borings, the till ranges in thickness from 0.5 feet in BH-02 to 3.6 feet in BH-13. In BH-13 the till is slightly reworked with lenses of silt (ML) and clay (CL). These deposits were also encountered in the northeast corner of the site at the wetland margin at BH-13. At BH-15 the reworked till was encountered again with lenses of silts and clays from a depth of 1.2 to 5 feet.

In general, outwash soils were encountered directly underlying the loess and/or till soils at depths ranging from 1 foot in BH-18 to 5.6 feet in BH-13. In the regional analysis of the unconsolidated deposits at the Crandon Project, the outwash soils have been referred to regionally as fine and coarse outwash based on the predominate grain size of the soil strata. The uppermost outwash (on the order of 20 to 30 feet thick) at Area H was considered coarse outwash and generally classified as a light-brown to brown fine to medium sand (SP) which was typically structureless. Some stratification of the coarse outwash was present at some locations. In many borings, this coarse outwash has lenses or layers of medium to coarse sand and/or fine to coarse gravel. These gravels and coarser sand layers generally appear in the soil profile at depths ranging from 4 feet to a maximum of 16 feet and typically occur intermittently with some occurrences throughout the entire boring depth. In many instances, these coarser layers are located at or very near the water table. In general, fine outwash predominates at depth, being primarily fine and fine to medium grained sands (SP) which generally become more grey in color. The geologic cross-sections provided in Drawings No. 4, 5, and 6 show the soil profiles to the depths of the borings.

Five borings were drilled to depths greater than 30 feet to assess the thickness of the outwash deposit and establish the continuity of the outwash below the groundwater table. These borings are as follows (see Figure 1-2 and Drawing No. 3):

- BH-01 was drilled approximately 450 feet north of Swamp Creek in the southernmost portion of Area H South. At this location, outwash was continuous to a depth of approximately 63 feet where the outwash was interbedded with glaciofluvial deposits consisting of thin (⅛- to ¼-inch thick) lenses of silt (ML) and clay (CL). These layers did not predominate, but rather occurred intermittently in the soil profile to the terminus of the boring at 80 feet.

- BH-05 was also drilled in Area H South, approximately 800 feet north of Swamp Creek. At this location, outwash was continuous to a depth of approximately 62 feet where the outwash became interbedded with glaciofluvial deposits consisting of silty fine sand (SM) and fine sandy silt (ML) to a depth of 64 feet.

- BH-04 is located in the northeastern portion of Area H, approximately 800 feet west of Swamp Creek. BH-04 was drilled to a depth of 50 feet and encountered outwash soil for the entire depth of the boring.

- BH-13 was drilled in the northern corner of Area H approximately 2,200 feet northwest of Swamp Creek. BH-13 was drilled to a depth of 71 feet and outwash deposits were encountered between 5.6 and 71 feet.

- BH-14 was drilled in the southwest portion of Area H, approximately 1,700 feet north of Swamp Creek. BH-14 was drilled to a depth of 66 feet and outwash deposits were encountered between 2 and 66 feet.

The outwash is continuous at depth in all areas beneath and downgradient of the proposed facility. The outwash was further characterized by completing grain size and hydrometer analyses on samples at various depths in the outwash. The results of these tests are discussed further in Section 4.3.8.

4.3.4 Monitoring Wells

Groundwater table monitoring wells (e.g., MWH-09), piezometers (e.g., MWH-09P), sand points (e.g., SPH-01 and SPH-01A), and staff gages (e.g., SGH-01) were installed at the northern portions of Area H at the locations shown on Drawing No. 3. Table 4-1 contains a list of the elevations for each well. Well construction and well development reports are provided in Appendix B. All installations were completed in accordance with the applicable standards as discussed in Sections 2.1 and 2.2.

The groundwater monitoring wells, piezometers, sand points, and staff gages were used to determine the groundwater flow characteristics of the outwash aquifer at Area H. The following is a list of tests or measurements taken from these devices and an indication of where in the report the results are discussed.

- Groundwater elevations were measured at all monitoring locations. The results of these measurements are provided in Table 4-2. Drawing No. 7 (Low Groundwater Table Elevation Contours and Surface Water Elevations) and Drawing No. 8 (Potentiometric Surface Contours and Elevations) were prepared using the measurements obtained on September 25, 1998.

- Vertical gradients were calculated using the groundwater level data from the groundwater table wells and associated piezometers. Vertical gradient calculations are provided in Appendix E. The significance of the vertical gradients are discussed in Section 5.

Table 4-2

Groundwater Elevations - Area H

Monitoring Point[1]	Elevation to Top of PVC[2]	9/11/98		9/15/98		9/24/98		9/25/98		10/15/98	
		Depth to Groundwater	Groundwater Elevation	Depth to Groundwater	Groundwater Elevation	Depth to Groundwater	Groundwater Elevation	Depth to Groundwater	Groundwater Elevation	Depth to Groundwater	Groundwater Elevation
MWH-09	1594.34	7.70	1586.64	7.72	1586.62	7.86	1586.48	7.86	1586.48	7.59	1586.75
MWH-09P	1594.44	8.18	1586.26	8.20	1586.24	8.32	1586.12	8.32	1586.12	8.02	1586.42
MWH-10	1595.62	13.49	1582.13	13.49	1582.13	13.62	1582.00	13.64	1581.98	13.59	1582.03
MWH-10P	1595.48	14.01	1581.47	14.01	1581.47	14.12	1581.36	14.12	1581.36	13.90	1581.58
MWH-11	1588.16	7.38	1580.78	7.39	1580.77	7.50	1580.66	7.50	1580.66	7.26	1580.90
MWH-11P	1588.07	7.19	1580.88	7.21	1580.86	7.30	1580.77	7.30	1580.77	7.08	1580.99
MWH-13	1597.54	9.33	1588.21	9.38	1588.16	9.53	1588.01	9.60	1587.94	9.52	1588.02
MWH-14	1591.92	11.08	1580.84	11.10	1580.82	11.24	1580.68	11.24	1580.68	10.97	1580.95
MWH-15	1591.73	9.54	1582.19	9.58	1582.15	9.72	1582.01	9.72	1582.01	9.46	1582.27
MWH-16	1596.02	13.79	1582.23	13.84	1582.18	13.97	1582.05	13.97	1582.05	13.98	1582.04
MWH-19	1589.38	9.48	1579.90	9.48	1579.90	9.58	1579.80	9.58	1579.80	9.37	1580.01
SPH-01	1583.69	—	—	—	—	3.71	1579.98	3.71	1579.98	2.96	1580.73
SPH-01A	1585.95	—	—	—	—	5.44	1580.51	5.44	1580.51	5.22	1580.73
SPH-02	1583.89	—	—	—	—	3.33	1580.56	3.35	1580.54	3.19	1580.70
SPH-02A	1584.36	—	—	—	—	3.92	1580.44	3.88	1580.48	3.70	1580.66
SPH-03	1593.37	—	—	—	—	5.70	1587.67	5.68	1587.69	4.96	1588.41
SPH-03A	1594.49	—	—	—	—	6.07	1588.42	5.90	1588.59	5.52	1588.97
SPH-04	1593.18	—	—	—	—	DRY	—	DRY	—	6.20	1586.98
SPH-04A	1594.88	—	—	—	—	8.06	1586.82	8.20	1586.68	7.78	1587.10

Table 4-2 *(Continued)*

Monitoring Point[1]	Elevation to Top of PVC[2]	9/11/98		9/15/98		9/24/98		9/25/98		10/15/98	
		Depth to Groundwater	Groundwater Elevation	Depth to Groundwater	Groundwater Elevation	Depth to Groundwater	Groundwater Elevation	Depth to Groundwater	Groundwater Elevation	Depth to Groundwater	Groundwater Elevation
SPH-05	1581.51	—	—	—	—	0.95	1580.56	0.95	1580.56	0.80	1580.71
SHP-06	1587.18	—	—	—	—	4.40	1582.78	4.36	1582.82	4.03	1583.15
SGH-01	1578.19[3]	—	—	—	—	—		1.92	1580.41	2.12	1580.61
SGH-02	1577.29[3]	—	—	—	—	—		3.92	1581.21	3.96	1581.25

[1] SGH-01 = staff gage
SPH-02 = sand point
MWH-09 = monitoring well
MWH-09P = piezometer

[2] Top of 1¼ inch galvanized pipe for sand points (e.g., SPH-01).

[3] Represents zero "0" mark on staff gage.

Note: All elevations in feet (mean sea level).

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- Aquifer response tests were completed on all groundwater table monitoring wells and piezometers. The results are discussed in Section 4.3.5.

4.3.5 Infiltrometer Tests

Three methods were used to measure the infiltration rate and hydraulic conductivity of the outwash soils:

- double-ring field infiltrometer tests at seven locations (ASTM D 3385) to test the infiltration rate of native soils that will be present beneath the soil absorption system;
- slug tests (Bouwer, 1989) completed in the eight on-site wells and three piezometers; and
- laboratory hydraulic conductivity tests completed on remolded outwash samples (ASTM D 2434) to assess the hydraulic conductivity of engineered soils placed beneath the soil absorption cells.

This section will discuss the results of the double-ring infiltrometer tests (DRI tests). The other tests completed will be discussed later in this report. The results of all tests are evaluated in Section 5, which includes the rationale for selecting the design values of vertical and horizontal hydraulic conductivity.

Seven DRI tests were conducted at the locations shown on Drawing No. 3. The tests were performed by excavating through the upper soil horizons with a backhoe to the elevation near the top of the outwash. The infiltrometer rings were then set by tapping the rings in place with a sledgehammer and wood blocking. Appendix F contains the field data forms and the graphs of the infiltrometer tests results which include the depth of each of the rings for each test. Each test was run well beyond the point at which steady state (i.e., saturated) flow occurred, as evidenced by the straight line portion of each graph prior to termination of the tests. Water from the Flannery Construction Company well, located on CTH W south of USR 8, was used for all tests. Table 4-3 contains a summary of the seven tests performed along with other relevant data. The infiltration values listed in Table 4-3 were chosen by selecting a typical infiltration value from the graphs in Appendix F.

After each infiltrometer test was completed, the test area was excavated with a backhoe to determine the flow path of the water from the rings. Excavation in the test area revealed that water flow in the unsaturated zone was primarily vertical with negligible evidence of horizontal flow. The wetting front typically extends vertically below the test area to the groundwater table. This observation indicates that the primary flow path for water from a soil absorption system in Area H will be vertical and restrictive layers which may cause horizontal flow are not prevalent.

Table 4-3
Field Infiltrometer Tests

Test Pit Surface Elevation	Infiltration Rate (ft/d)	(in/ hr)	(cm/sec)	(g/d/sf)	Elevation (Depth) (feet)	Soil Description
TPH-38B 1594.2	61	31	$2.2x10^{-2}$	464	1590.0 (4.2)	Fine to med. sand (SP), outwash
TPH-8D* 1592.0	18	9.0	$6.4x10^{-3}$	135	1588.5 (3.5)	Outwash sand directly overlying rafted till soils and/or other restrictive soils
TPH-42B 1589.9	160	80.0	$5.6x10^{-2}$	1197	1587.4 (2.5)	Fine to med. sand (SP), outwash
TPH-47 1591.9	78	39.0	$2.8x10^{-2}$	584	1586.9 (5.0)	Med. to fine sand (SP), outwash
TPH-53 1593.1	32	16.0	$1.1x10^{-2}$	239	1589.0 (4.0)	Fine to med. sand (SP), outwash
TPH-06B 1593.5	80	40.0	2.81_2x10^{-}	599	1591.5 (2.0)	Med. to coarse sand (SP), outwash
TPH-33B* 1593.1	1.2	0.6	$4.2x10^{-4}$	9.0	1588.6 (4.5)	Outwash sand directly overlying rafted till soils and/or other restrictive soils
Mean (Outwash)	82.4	41.2	$2.9x10^{-2}$	616		

ft/d = feet per day
in/hr = inches per hour
cm/sec = centimeters per second
g/d/sf = gallons per day per square foot
Note: Elevations/depths in feet (mean sea level).
*Tests performed in restrictive soils are not included in mean, since they will be removed prior to installation of the soil absorption system.

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To confirm the observed wetting front described above, soil grab samples were systematically collected for moisture content analysis at and beneath the infiltrative surfaces from the infiltrometer test sites conducted at TPH-6B, TPH-47, and TPH-53. The results of the analyses are included in Appendix H-2. Figures 1 through 3 in Appendix H-2 show contoured distributions of soil moisture contents (as percent volume) for the three test sites. These figures show that the highest moisture contents are concentrated vertically beneath the infiltrometer rings, with the greatest moisture contents in the 1- to 4-foot depth range below the infiltrative surface. These results confirm the field observations of the apparent wetting front and vertical nature of infiltration, as discussed above.

4.3.6 Aquifer Response Tests

In-field hydraulic conductivity tests were performed on the eight wells and three piezometers installed on the northern sections of Area H. Tests on water table wells were performed by measuring the rate at which the water level in the well rises after the static water level has been instantaneously lowered by removing a volume of water. Tests on the piezometers were performed by using both the rising and falling head method of testing. The recovery data was analyzed according to a method described by Bouwer and Rice (1976) and Bouwer (1989). The graphics of these tests are provided in Appendix G, and results are summarized in Table 4-4. Each hydraulic conductivity was analyzed using the AQTESOLV™ program.

The values for hydraulic conductivity values presented in Table 4-4 range from 105 to 12 feet per day, which is a relatively high value indicative of a clean granular deposit such as the outwash at Area H.

4.3.7 Hand Auger Borings

On October 15, 1998, eight hand auger borings were completed in the wetlands east of the proposed soil absorption area. The purpose of these borings was to determine the nature of the soils in the wetlands. Either a 4½-inch or a 3½-inch bucket-type hand auger was used, depending on the subsurface conditions. The locations of the hand auger borings, numbered HAH-01 through HAH-08, are shown on Drawing No. 3. The depth of these borings was limited to a maximum of approximately 6 feet due to the caving nature of the soils in the wetlands. The logs from the hand auger borings are included in Appendix B. In general, the soils encountered in these borings can be described as follows:

- The uppermost soil strata is a black, fibrous, very soft, saturated peat (Pt) with a maximum thickness of greater than 6.2 feet in HAH-01, HAH-03, HAH-07, and HAH-08, and a minimum thickness of 3 feet in HAH-06.

Table 4-4

Aquifer Response Tests

Well No.	Hydraulic Conductivity		
	feet/min	feet/day	cm/sec
MWH-09	$2.2x10^{-2}$	33	$1.2x10^{-2}$
MWH-09P	$3.7x10^{-2}$	53	$1.9x10^{-2}$
MWH-10	$8.0x10^{-3}$	12	$4.1x10^{-3}$
MWH-10P	$3.8x10^{-2}$	55	$1.9x10^{-2}$
MWH-11	$3.5x10^{-2}$	50	$1.8x10^{-2}$
MWH-11P	$7.3x10^{-2}$	105	$3.7x10^{-2}$
MWH- 13	$2.0x10^{-2}$	28	$1.0x10^{-3}$
MWH-14	$3.0x10^{-2}$	43	$1.5x10^{-2}$
MWH-15	$2.9x10^{-2}$	41	$1.5x10^{-2}$
MWH-16	$1.1x10^{-2}$	16	$5.5x10^{-3}$
MWH-19	$1.7x10^{-2}$	24	$8.5x10^{-3}$

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- The peat (Pt) is underlain in HAH-02, HAH-04, HAH-05, and HAH-06 by a mixture of grey firm, silty sand, fine sand, and clayey fine to medium sand containing coarse gravel and cobbles. This strata is best described as a thin veneer of mixed outwash and till layers. This soil layer varied in thickness in these borings from 0.9 feet in HAH-05 to greater than 1 foot in HAH-06 and HAH-04 where the total thickness could not be penetrated with the hand auger due to caving conditions.

- Clean outwash described as a brown, loose, medium to coarse sand (SP) was encountered below the till/outwash layer in HAH-05 where 0.9 feet of outwash was penetrated below the till.

It is expected that outwash will occur universally below the peat and till/outwash at the other locations.

4.3.8 Soil Laboratory Testing

Soil laboratory testing was performed by Nummelin Testing Services, Inc. (NTS) of Stevens Point, Wisconsin, and by Thresher & Son, Inc. of Madison, Wisconsin. NTS completed sieve and hydrometer analysis (ASTM D 422) and constant head permeability tests (ASTM D 2434) on representative samples of outwash from the borings and test pits at Area H. The laboratory data sheets are provided in Appendix H-1. Thresher & Son completed density (ASTM D 2216) determinations on relatively undisturbed samples of outwash sand taken from the base of the selected test pits and moisture contents of the soil samples around and below selected infiltrometer tests. These data are included in Appendix H-2. The laboratory test data from NTS are summarized in Tables 4-5 and 4-6. The bulk density tests are summarized in Table 4-7.

The outwash soils can be described as predominantly fine to medium grained sands, USCS-SP, having a percent passing the number 200 sieve ranging from 0.2 to 16.8 (see Table 4-5). Of the total 71 outwash soil samples tested, six outwash samples had P200 greater than 5 percent. These atypical samples are described in the paragraph that follows. When these six samples are excluded, the average P200 value for 65 outwash samples is 1.4 percent. The outwash soils have a coefficient of uniformity (C_u) less than 6 and are therefore classified as SP. The fine- and medium-grained sizes predominate, with the coarse sand fraction typically being 10 percent or less.

Table 4-6 lists the soils tested which are not representative of the typical outwash soils at Area H. These are generally soils which classify finer or coarser than the typical outwash soil. The soils which classify finer are fine sands with silts (SP-SM) and silty fine sands (SM). These soils are atypical of the outwash and typically occur at depth within the outwash. The soils which classify coarser than the typical outwash are gravelly fine to medium sand and fine to medium sands with gravel. These classifications result from compositing a sampling interval from a split spoon or test pit where the interval contained a coarse sand or gravel lense.

Table 4-5

Laboratory Data - Typical Outwash Soils

Test Pit/ Boring ID	Depth (Feet)	Percent Gravel	Percent Sand	Percent Passing No. 200 Sieve	Percent Silt	Percent Clay	Density (lb/cf)	USCS	SMHC	Laboratory Permeability (cm/sec)	$\frac{C_U}{C_C}$
Borings											
BH-02	12.0-14.0	3.4	94.1	2.5	1.8	0.7	—	SP	—	—	$\frac{2.10}{0.94}$
BH-04	6.0-8.0	30.7	67.5	1.8	0.4	1.4	—	SP	—	—	$\frac{7.60}{0.47}$
BH-06	12.0-14.0	4.3	92.7	3.0	0.7	2.3	—	SP	—	—	$\frac{2.30}{0.96}$
BH-07	6.0-8.0	1.7	96.7	1.6	0.2	1.4	—	SP	—	—	$\frac{2.10}{1.05}$
BH-08	14.0-16.0	0.2	98.0	1.8	0.9	0.9	—	SP	—	—	$\frac{2.20}{1.06}$
BH-09	8.0-10.0	3.3	92.7	4.0	0.6	3.4	—	SP	—	2.4×10^{-3}	$\frac{2.40}{1.08}$
BH-10	14.0-16.0	8.9	88.5	2.6	1.6	1.0	—	SP	—	1.8×10^{-2}	$\frac{3.40}{0.74}$
BH-11	10.0-12.0	43.2	55.0	1.8	1.3	0.5	—	SP	—	2.2×10^{-2}	$\frac{29.2}{0.14}$
BH-12	14.0-16.0	3.7	92.2	4.1	2.5	1.6	—	SP	—	—	$\frac{2.20}{1.07}$
BH-13	10.0-12.0	6.5	91.3	2.2	0.6	1.6	—	SP	—	—	$\frac{3.00}{0.89}$
BH-13	54.0-56.0	0.0	96.6	3.4	2.2	1.2	—	SP	—	—	$\frac{2.30}{1.06}$
BH-14	8.0-10.0	10.2	88.1	1.7	1.1	0.6	—	SP	—	—	$\frac{3.40}{0.78}$

Table 4-5 *(Continued)*

Test Pit/ Boring ID	Depth (Feet)	Percent Gravel	Percent Sand	Percent Passing No. 200 Sieve	Percent Silt	Percent Clay	Density (lb/cf)	USCS	SMHC	Laboratory Permeability (cm/sec)	$\frac{C_U}{C_C}$
BH-14	64.0-66.0	2.4	85.5	12.1	9.5	2.6	—	SM	—	—	4.10/1.98
BH-14	36.0-38.0	2.6	96.7	0.7	0.5	0.2	—	SP	—	—	2.30/0.88
BH-15	26.0-28.0	1.8	84.8	13.4	11.5	1.9	—	SM	—	—	2.60/0.80
BH-15	10.0-12.0	4.6	93.5	1.9	1.0	0.9	—	SP	—	—	2.80/0.76
BH-16	10.0-12.0	2.5	96.5	1.0	0.8	0.2	—	SP	—	—	2.80/0.84
BH-17	18.0-20.0	0.0	83.2	16.8	15.4	1.4	—	SM	—	—	2.80/0.74
BH-18	22.0-24.0	9.3	89.3	1.4	1.1	0.3	—	SP	—	—	4.00/0.82
BH-19	14.0-15.5	17.7	80.1	2.2	1.2	1.0	—	SP	—	—	4.60/0.66
Monitoring Wells											
MWH-09P	32.0-34.0	0.3	90.0	9.7	3.9	5.8	—	SP-SM	—	$1.5x10^{-2}$	4.50/1.80
MWH-10P	34.0-36.0	0.3	92.9	6.8	4.1	2.7	—	SP-SM	—	—	3.60/1.32
MWH-11P	32.0-34.0	0.0	98.3	1.7	0.9	0.8	—	SP	—	$1.8x10^{-2}$	2.90/0.89
Test Pits											
TPH-05	10.0	0.9	97.6	1.5	0.6	0.9	—	SP	—	—	2.20/1.04
TPH-12	6.0	3.3	96.2	0.5	0.1	0.4	—	SP	—	—	2.80/0.75

Table 4-5 *(Continued)*

Test Pit/ Boring ID	Depth (Feet)	Percent Gravel	Percent Sand	Percent Passing No. 200 Sieve	Percent Silt	Percent Clay	Density (lb/cf)	USCS	SMHC	Laboratory Permeability (cm/sec)	$\frac{C_U}{C_C}$
TPH-13	4.5	0.2	99.1	0.7	0.3	0.4	—	SP	—	—	2.30 / 0.88
TPH-14	6.0	0.7	98.7	0.6	0.2	0.4	—	SP	—	—	2.10 / 0.86
TPH-15	5.0	0.3	99.2	0.5	0.3	0.2	—	SP	—	—	1.90 / 1.00
TPH-16	8.0	2.4	97.3	0.3	0.1	0.2	—	SP	—	—	1.90 / 0.99
TPH-17	5.0	0.9	98.7	0.4	0.2	0.2	—	SP	—	—	2.10 / 0.90
TPH-28	8.0	3.3	95.6	1.1	0.2	0.9	—	SP	—	—	1.90 / 1.00
TPH-29	4.5	0.0	97.7	2.3	0.3	2.0	—	SP	—	—	2.90 / 1.14
TPH-30	4.5	0.5	98.8	0.7	0.7*		—	SP	—	—	1.80 / 0.98
TPH-31	9.0	4.1	95.5	0.4	0.2	0.2	—	SP	—	—	3.70 / 0.99
TPH-32	5.0	10.1	88.6	1.3	0.2	1.1	—	SP	—	—	5.10 / 0.85
TPH-33C	5.0	0.0	90.5	9.5	7.1	2.4	—	SP-SM	—	—	2.30 / 1.37
TPH-35	3.0	2.7	96.1	1.2	1.0	0.2	—	SP	—	—	2.10 / 1.02
TPH-36	5.0	0.0	98.4	1.6	0.8	0.8	—	SP	—	—	2.20 / 1.05
TPH-37	3.0	5.8	93.3	0.9	0.5	0.4	—	SP	—	—	2.20 / 0.89
TPH-38B	5.0	0.1	97.9	2.0	0.1	1.9	—	SP	—	—	2.00 / 1.15

Table 4-5 *(Continued)*

Test Pit/ Boring ID	Depth (Feet)	Percent Gravel	Percent Sand	Percent Passing No. 200 Sieve	Percent Silt	Percent Clay	Density (lb/cf)	USCS	SMHC	Laboratory Permeability (cm/sec)	$\frac{C_U}{C_C}$
TPH-42B	7.5	0.0	99.8	0.2	0.0	0.2	—	SP	—	—	$\frac{1.70}{0.95}$
TPH-43	3.3	1.7	97.7	0.6	0.0	0.6	—	SP	—	—	$\frac{1.80}{1.01}$
TPH-48	5.5	0.8	98.7	0.5	0.1	0.4	—	SP	—	—	$\frac{5.10}{0.90}$
TPH-48	3.0	4.6	94.7	0.7	0.3	0.4	—	SP	—	—	$\frac{3.70}{0.74}$
TPH-51	4.2	0.7	98.6	0.7	0.7*		—	SP	—	—	$\frac{2.00}{9.30}$
TPH-54	1.8	0.3	97.1	2.6	0.2	2.4	—	SP	—	—	$\frac{2.80}{1.32}$
TPH-67	4.0	0.0	97.9	2.1	0.7	1.4	—	SP	—	—	$\frac{2.70}{1.31}$
TPH-70	5.0	4.8	94.3	0.9	0.9*		—	SP	—	—	$\frac{2.00}{1.10}$
TPH-72	5.8	0.1	99.7	0.2	0.2*		—	SP	—	—	$\frac{1.60}{1.01}$
TPH-73	3.0	0.1	99.6	0.3	0.3*		—	SP	—	—	$\frac{1.70}{0.90}$
TPH-74	1.5-5.6	4.2	94.6	1.2	0.3	0.9	—	SP	—	—	$\frac{2.50}{0.91}$
TPH-74	0.8-1.5	19.1	76.8	4.1	1.4	2.7	—	SP	—	—	$\frac{4.70}{0.61}$
TPH-76	4.6-5.7	10.0	89.5	0.5	0.1	0.4	—	SP	—	—	$\frac{2.90}{0.74}$
TPH-76	1.5-4.6	10.1	89.3	0.6	0.6*		—	SP	—	—	$\frac{2.70}{0.81}$
TPH-80	4.4-6.5	30.0	69.5	0.5	0.5*		—	SP	—	—	$\frac{8.70}{0.36}$

Table 4-5 *(Continued)*

Test Pit/ Boring ID	Depth (Feet)	Percent Gravel	Percent Sand	Percent Passing No. 200 Sieve	Percent Silt	Percent Clay	Density (lb/cf)	USCS	SMHC	Laboratory Permeability (cm/sec)	$\frac{C_U}{C_C}$
TPH-80	1.8-4.4	9.1	90.0	0.9	0.5	0.4	—	SP	—	—	3.30/0.95
TPH-81	3.7-6.1	2.9	95.9	1.2	1.2*		—	SP	—	—	3.60/0.86
TPH-81	1.7-3.7	16.1	79.5	4.4	2.5	1.9	—	SP	—	—	5.10/0.84
TPH-85	4.2	1.0	98.6	0.4	0.4*		—	SP	—	—	1.60/0.91
TPH-87	5.0	1.2	98.2	0.6	0.2	0.4	—	SP	—	—	1.80/1.02
TPH-88	4.5	2.2	97.3	0.5	0.1	0.4	—	SP	—	—	2.70/0.81
TPH-89	6.1	0.3	99.3	0.4	0.4*		—	SP	—	—	2.90/0.77
TPH-92	2.0-4.3	14.9	83.8	1.3	0.1	1.2	—	SP	—	—	3.90/0.75
TPH-92	4.3-6.1	8.8	90.5	0.7	0.3	0.4	—	SP	—	—	2.10/1.00
TPH-94	2.6	0.4	98.9	0.7	0.3	0.4	—	SP	—	—	4.00/0.80
TPH-97	1.9	15.9	83.1	1.0	0.4	0.6	—	SP	—	—	4.40/0.76

lb/cf = pounds per cubic foot
USCS = Unified Soil Classification System
SMHC = Soil Moisture Holding Capacity
cm/sec = centimeters per second
C_u = Coefficient of Uniformity
C_c = Coefficient of Curvature

* Value represents total P200 percent since insufficient fines existed to separate the silt and clay fractions.

Prepared by: REM
Checked by: TJC

Table 4-6

Laboratory Data - Non-Typical Outwash Soils

Boring	Depth (feet)	% P200	% Gravel	Classification	(USCS)
BH-04	6.0-8.0	1.8	30.7	Gravelly Fine to Medium Sand	(SP)
BH-11	10.0-12.0	1.8	43.2	Gravelly Fine to Medium Sand	(SP)
BH-14	64.0-66.0	12.1	2.4	Sand with Silt	(SM)
BH-15	26.0-28.0	13.4	1.8	Sand with Silt	(SM)
BH-17	18.0-20.0	16.8	0.0	Silty Fine Sand	(SM)
BH-19	14.0-15.5	2.2	17.7	Fine to Medium Sand with Gravel	(SP)
MWH-09P	32.0-34.0	9.7	0.3	Silty Fine Sand with Silt	(SP-SM)
MWH-10P	34.0-36.0	6.8	0.3	Fine to Medium Sand with Silt	(SP-SM)
TPH-33C	5.0	9.5	0.0	Fine Sand with Silt	(SP-SM)
TPH-74	0.8-1.5	4.1	19.1	Fine to Medium Sand with Gravel	(SP)
TPH-80	4.4-6.5	0.5	30.0	Gravelly Fine to Medium Sand	(SP)
TPH-81	1.7-3.7	4.4	16.1	Fine to Medium Sand with Gravel	(SP)
TPH-92	2.0-4.3	1.3	14.9	Fine to Medium Sand with Gravel	(SP)
TPH-97	1.9	1.0	15.9	Fine to Medium Sand with Gravel	(SP)

Prepared by: REM
Checked by: TJC

Table 4-7

Bulk Density Tests

Test Pit	Sample Depth	Bulk Density (g/cm^3)	Bulk Density Pounds per Cubic Foot
TPH-5	52 inches	1.49	92.9
TPH-13	54 inches	1.53	95.4
TPH-21	48 inches	1.54	96.0
TPH-32	60 inches	1.49	92.9
TPH-38A	42 inches	1.55	96.6
	Average	1.52	94.8

Prepared by: REM
Checked by: SAD2

Laboratory hydraulic conductivity tests were also performed on representative samples of outwash at the approximate elevation of the screened interval for the three wells and two piezometers (Table 4-8). These tests were completed by compacting the outwash to a density of 100 pounds per cubic foot and determining the hydraulic conductivity using constant head (ASTM D 2434) test procedures.

These tests were performed to assess the hydraulic conductivity of recompacted outwash. Outwash will be borrowed from a portion of the site to build the absorption cells (see Section 7.2). The laboratory test data indicates that recompacted soils will possess a sufficiently high hydraulic conductivity to allow for the infiltration of discharged water.

Table 4-8

Recompacted Outwash Lab Permeabilities

Well	Laboratory		Field	
	cm/sec	ft/day	cm/sec	ft/day
MWH-09	$2.4x10^{-3}$	7	$1.2x10^{-2}$	33
MWH-09P	$1.5x10^{-2}$	42	$1.9x10^{-2}$	53
MWH-10 (BH-10)	$1.8x10^{-2}$	51	$4.1x10^{-3}$	12
MWH-11 (BH-11)	$2.2x10^{-2}$	62	$1.8x10^{-2}$	50
MWH-11P	$1.8x10^{-2}$	51	$3.7x10^{-2}$	105

Prepared by: REM
Checked by: MLD2

4.4 Archaeological Surveys

4.4.1 General

During the period from May through August 1998, archaeological field crews from the University of Wisconsin-Milwaukee Historic Resource Management Services (HRMS) conducted archaeological investigations in Forest County, Wisconsin. Archaeological field work was conducted in association with the field investigations to generate data on potential soil absorption sites. Field work was conducted on several tracts, including Area H, identified as potential sites for soil absorption system construction as described in Section 1.3. Following is a brief summary of the archaeological investigations which were performed as part of the soil absorption field studies. A complete report on the archaeological investigations will be provided in the update to the project's EIR (Foth & Van Dyke, 1995/1998b).

Archaeological investigations were designed in accordance with Wisconsin Archaeological Survey (WAS) guidelines endorsed by the State Historical Society of Wisconsin. Specific work plans were developed in consultation with Foth & Van Dyke, Nicolet Minerals Company, HRMS, and the U.S. Army Corps of Engineers, St. Paul District.

Archaeological investigations included literature and archival research to identify any known historic resources in the affected areas at each selected soil absorption site. Archaeological field investigations included pedestrian survey and archaeological monitoring of backhoe excavated soil test pits. Backhoe excavations were documented by line drawings of exposed soil profiles, color and black-and-white photographs, and video recordings. Pedestrian survey techniques were largely restricted to shovel probing by the presence of extensive ground cover in the

affected areas. However, surface survey and visual inspection was occasionally possible in those areas where erosional surfaces were exposed.

The entire acreage comprising Areas E, G, J, K, XB, and XC (Area H is discussed in Section 4.4.2) was subjected to archaeological survey. Survey at Area XF was restricted to those locales directly affected by the engineering studies. In these cases, archaeological survey was conducted along access routes, at test pit investigation sites, and associated staging areas.

A total of eight potential soil absorption pond sites was subjected to archaeological investigations in 1998. Sites investigated include Areas E, G, H, J, K, XB, XC, and XF (Area A was previously investigated as part of the 1980s site work, and Areas B, C, and D were previously evaluated as part of the 1994 and 1995 studies on alternative soil absorption sites). Results of the archival investigations indicate that no previously reported historic properties are present within or adjacent to any of the affected areas. Field investigations did not document the presence of previously unreported historic resources in Areas E, H, J, K, XB, XC, and XF. A single late 19th century/early 20th century site was identified in Area G.

4.4.2 Area H Archaeological Investigations

The archaeological investigations at Area H were completed in August and September 1998. Area H was divided into four separate parcels identified during the archaeological field investigations as South, Northeast, Northwest, and West. These areas are identified in the associated engineering studies as Fields 1, 2, 3, 4, 5, and 6 (see Drawing No. 3 and Figure 1-2). The Northwest archaeological survey area includes Fields 1, 2, 3, and 4. Field 5 is coincident with the Northeast area and Field 6 is located within the West area. Field identifications were not assigned to acreage comprising the South area.

Fields 1, 2, 3, 4, and 5 were subjected to a 15 meter interval shovel probe survey. Within Field 6, an archaeological survey was conducted according to a modified protocol that targets only those locations directly affected by the engineering test pit investigations. Consequently, archaeological survey within Field 6 was restricted to 13 acres coincident with specific impact areas and access routes. Survey within the remainder of Field 6 was deferred pending evaluation of the engineering data from this portion of Area H. Backhoe excavations in all portions of Area H were archaeologically monitored and documented by a combination of field drawings, color slides, and black-and-white photographs.

No previously reported archaeological sites are present within or adjacent to Area H. Two separate scatters of recent and modern cultural debris were noted in Area H. One scatter located in the Northwest (Field 2) parcel includes fragments of canning jars, window glass, and modern nails. The locus represents a disturbed scatter of recently deposited materials. The second scatter was identified in the Northeast (Field 5) parcel and includes aluminum tubing, a four-pronged fork, broken white ware and clinkers. This area represents a scatter of recent materials and is not associated with a structure or any surficial remains. Neither scatter is considered an archaeological site locus and no additional investigations are recommended in the archaeologically surveyed portions of Area H.

5 Hydrogeological Interpretation

The ability of the site to operate as a soil absorption system is a function of the infiltrative capacity of the soils relative to the discharge rate and the ability of the aquifer to transmit the water to a point of groundwater discharge. Thus, the infiltration rate of the soils, the transmissivity of the aquifer, and the distance to the point of groundwater discharge are the key parameters that will control the design capacity of the site and the degree of groundwater mounding beneath the soil absorption system. The following description of the hydrogeology of the site focuses on these key site characteristics that are then factored into the design analysis described in Section 6.

5.1 Hydrostratigraphic Units

Based on geomorphological characteristics of the topography surrounding the proposed soil absorption system, the area is inferred to be a broad outwash plain that extends roughly from the southern end of Lake Metonga to just south of Swamp Creek. The soils encountered during the soil boring and test pit program and the accompanying soil grain size data are consistent with this interpretation. Cross sections displayed in Drawings No. 4 to 6 show a thick deposit of coarse and fine grained outwash to a depth of approximately 70 feet or more. Based on the soil boring data described in Section 4, it is estimated that the thickness of the outwash is a minimum of 70 feet thick. Although not fully penetrated in the soil boring program, it is expected that the outwash overlies the Pre- to Early Wisconsinan till which has been consistently encountered during other soil boring programs for the Crandon Project. Bedrock at the site is estimated to reside at an elevation of approximately 100 to 150 feet below ground surface based on available bedrock contour information presented in the Crandon Project's EIR (Foth & Van Dyke, 1995/1998b). As such, the thickness of the Pre- to Early Wisconsinan till is likely to vary from 30 to 80 feet in the vicinity of the site.

Together, the outwash and glacial till form the primary hydrostratigraphic units at the site. Due to the lower permeability of the Pre- to Early Wisconsinan till, estimated to be about 2 feet per day (ft/d) (HSI GeoTrans, Inc. 1998a, 1998b), the outwash will dominate transmission of water from the soil absorption site to the point of groundwater discharge. Accordingly, the following discussion on hydrogeologic conditions focuses on the outwash aquifer.

5.2 Aquifer Hydraulic Conductivity

Based on slug test data, the hydraulic conductivity of the outwash has been measured to be in the range between 12 ft/d and 105 ft/d. Discounting the high and low measurements, the average hydraulic conductivity as determined via slug tests is approximately 50 ft/d. The slug test data vary by less than an order of magnitude indicating rather uniform hydraulic properties of the aquifer. This is consistent with the grain size data which shows that the outwash sands consistently exhibit a low fines content.

The hydraulic conductivity measurements obtained from the slug tests represent a conservative estimate of hydraulic conductivity. As described by Bradbury and Muldoon (1990), hydraulic conductivity measurements are dependent on the scale of the test being conducted and should be viewed in the context of the scale of the problem. Slug tests measure the hydraulic conductivity of a rather small volume of the aquifer relative to the size of the soil absorption system. Based on data from Bradbury and Muldoon (1990), the data from the slug tests are likely to be lower than the large scale hydraulic conductivity of the aquifer by at least a factor of two. Thus the hydraulic conductivity of the outwash aquifer at the site is likely to be closer to 100 ft/d.

5.3 Soil Infiltration Rates

Seven double-ring infiltrometer (DRI) tests were completed on Area H. The results of these tests along with the soil classification were used to determine the infiltration capacity of outwash soils. Of the seven DRI tests completed, two tests were completed in restrictive soil conditions which do not reflect the conditions anticipated for the soil absorption system. The infiltrometer tests completed at TPH-8D and 33B were performed in outwash soils that were directly overlying rafted till soils. The infiltration rates determined by these tests were an order of magnitude lower than the other test results. In addition, the tests were located in areas outside the proposed system boundaries. For the stated reasons, these data are not included in the data used to select the design value.

The sieve and hydrometer analysis completed on samples in the vicinity of the infiltrometer tests show that the upper most outwash soils are typically structureless, loose, brown, fine to medium sands USCS (SP) with trace amounts of silt and clay size particles (i.e., P200). The P200 of these soils is typically less than 3 percent, and the grain size analysis for the sand fraction shows that fine sand predominates, being typically 40 to 80 percent of the sand size particles. The grain size, lack of fines, and loose nature of the deposit correlate well with the values measured by the infiltrometer tests. The post infiltrometer test pit excavation showed that water from the test cells moved primarily vertically downward to the groundwater table with little or no horizontal movement. The vertical movement is evidence that few restrictive layers exist in the outwash soil profile and water movement from the soil absorption system to the groundwater table is expected to be primarily vertical.

The infiltration value used for design was determined by calculating the average value of the five tests completed in outwash soils which is approximately 40 in/hr (80 ft/d). For the initial design infiltration rate, a safety factor of over 150 was applied, which results in using an infiltration rate of 0.25 in/hr (0.5 ft/d). This is very conservative since the Crandon Project treated wastewater will be non-organic and have very low or no suspended solids. As a result, clogging of soil pores is not a concern. Note that the potential for groundwater mounding reduced the final design infiltration rate further, at some locations, to a value of less than 0.5 ft/d, as discussed in Section 6.

5.4 Groundwater Flow Characteristics

The devices used to determine the groundwater flow characteristics at Area H consist of nine groundwater table wells, three piezometers, six shallow (water table) sand points, four deep sand points, and two staff gages on adjacent water bodies at the locations shown on Drawing No. 3. Drawing No. 7 shows the low groundwater table contours for September 25, 1998. Because of the dry conditions during the preceding summer months, these contours likely represent typical low groundwater elevations at Area H. However, based on the soil mottling observations in the test pits, groundwater table fluctuations are likely to range between 1 foot and 2 feet. Table 4-2 contains a listing of the dates and groundwater elevations recorded at the monitoring locations shown on Drawing No. 3.

The water table map shown in Drawing No. 7 shows that the local groundwater flow system is consistent with the regional potentiometric surface map shown in Figure 3-3. The water table at the site displays a rather uniform flow field with groundwater flowing to the southeast towards the adjacent Z16 wetland complex, Creek 17-13, and Swamp Creek. Based on staff gage measurements and concurrent groundwater elevation measurements, the water levels in the dredge canal and Lake 17-16 are an expression of the local groundwater table. As such, the lake is characterized as a groundwater flow through lake in which the stage is controlled by the surrounding water table. This condition may be affected by surface water runoff during periods of high precipitation or snow melt. Other than the canal, there are no well defined inlets or outlets to the lake.

Very weak vertical gradients have been measured at the site. Therefore, the potentiometric surface map shown in Drawing No. 8 mirrors the water table contour map. At the time of the groundwater level measurements, no groundwater discharge was observed in wetland Z16 central and Z16 south. However, a groundwater spring exists in wetland Z16 north and discharges through a culvert pipe beneath the Wisconsin Central Limited Railroad bed to Creek 17-13. As such, wetland Z16 north can be expected to act as a point of groundwater discharge for absorption cells A, B, and C located immediately west of the wetland (see Drawing No. 9).

Wetlands Z16 central and Z16 south exhibited a water table on September 25, 1995, that was approximately several inches to 1 foot beneath the wetland surface. Under high water table conditions, as would be induced by the operation of the soil absorption system, the groundwater table will be expressed in these wetlands. Under high water table conditions, surface water and groundwater discharging to wetland Z16 south and the southern half of wetland Z16 central (south of the canal) is conveyed through a series of culverts beneath the snowmobile trail that bisects the wetland and then through a culvert beneath Keith Siding Road. From this point, surface water then drains through additional wetlands to Swamp Creek.

Given the above, the wetlands to the east of Area H currently act on a permanent to transient basis as areas of groundwater discharge. With the exception of the far northern half of wetland Z16 north (north and upgradient from all of the soil absorption cells), the Z16 wetland complex has outlets and functions as permanent or ephemeral tributaries to Creek 17-13 and Swamp

Creek. The discharge of treated water from the soil absorption system will increase the water table elevation and increase the amount of groundwater discharge to the wetlands. The soil absorption system will also increase the amount of surface water that flows through the wetlands to Creek 17-13 and Swamp Creek. The dredge canal will be regraded to achieve land contours to allow for surface drainage from all of Z16 central to Z16 south. With this restoration of surface drainage across the canal, wetland Z16 central, as well as Z16 north and Z16 south will function as a discharge point for groundwater during the operation of the soil absorption system and thus function as a boundary condition that will affect the response of the water table at Area H.

The degree to which the wetlands allow groundwater discharge to take place is also a function of the permeability of the wetland base. Based on the hand auger borings, the soils beneath the wetland are a mixture of organic soils (peat), outwash, and lenses of glacial till. Therefore, the vertical permeability of the wetland base can reasonably be expected to range between 0.5 ft/d and 5 ft/d based on prior studies (GeoTrans, Inc.; 1996, HSI GeoTrans, Inc., 1998a, 1998b, 1998c).

The elevation of these wetlands was evaluated by surveyed spot elevations. For design purposes, the elevation of wetland Z16 south and Z16 north is approximately 1580.5 feet MSL. Wetland Z16 north resides at an elevation of approximately 1581 feet MSL.

5.5 High and Low Groundwater Elevations

The groundwater elevations collected to date are from the months of September and October 1998. These elevations may reflect low groundwater conditions, since the summer of 1998 has been dry with below-normal precipitation. The high groundwater conditions were estimated by reviewing the historical fluctuations in a well of similar hydrogeologic setting and by soil mottling observed in the test pits. Well DMA-48 (Foth & Van Dyke, 1995/1998b) was selected for this comparison since it has a long historical record and is located in outwash deposits adjacent to a wetland complex that has a shallow water table. Based on the data from DMA-48, it is estimated that the high water table at Area H is likely to be only about 2 feet higher than the low water table. This makes hydrogeologic sense since the site is composed of permeable outwash deposits and is not located near a local groundwater divide (e.g., the TMA). Thus the groundwater elevation is not likely to be recharge sensitive. Moreover, the wetlands will intercept the high water table and drain the water towards Swamp Creek. This boundary condition affect will tend to limit the increase in the water table. In the fall of 1998, the water table was several inches to about 1 foot below the wetland that surrounds Lake 17-16 and the canal. Given the above, a 2-foot increase in the current water table is a reasonable expectation under high water table conditions. Therefore, the current low groundwater contours beneath the proposed soil absorption system area should be increased by 2 feet to represent high groundwater elevations. These higher elevations were used in the design of the system (see Section 6).

5.6 Conceptual Model

A qualitative description of the groundwater flow system, or conceptual model, for the soil absorption system consists of the following. Under current conditions, water enters the groundwater system primarily through precipitation. Infiltrating water readily moves vertically through the unsaturated zone into the saturated zone in the outwash aquifer. After water enters the saturated zone, it flows east-southeast toward areas of lower hydraulic head. Under seasonal high groundwater elevations, the Z16 wetland complex to the east of the proposed soil absorption site acts as a point of discharge for groundwater and thus functions as a local groundwater discharge point on a transient basis. An exception to this condition is the spring in wetland Z16 north which functions as a permanent groundwater discharge point that feeds Creek 17-13. Farther downgradient or east of the Z16 wetland complex lies Swamp Creek which functions as a permanent regional groundwater discharge point. Lake 17-16 is a groundwater flow through lake, with no well defined outlet, that appears to exhibit some influence on the groundwater elevations around the lake during periods of low groundwater as shown on Drawing No. 7.

During operation of the soil absorption system, the infiltrated water will increase the water table in the vicinity of the absorption system. Downgradient of the system, the water table will rise and discharge into the Z16 wetland complex where it will then drain through the wetland system and adjoining culverts into Creek 17-13 and Swamp Creek. The degree to which the wetlands will allow the discharge of water to the surface will in turn control the water table increase beneath the soil absorption system and the degree to which the wetlands will function as the primary point of groundwater discharge.

6 Preliminary Design of Soil Absorption System

6.1 Design Requirements

Design and construction standards for land treatment of industrial wastewater are found in NR 214, Wis. Admin. Code. NR 214 is written for wastewater that requires treatment by the soil prior to entering the groundwater. Since the wastewater from the Crandon Project does not require supplementary soil treatment, the WDNR has determined that NR 214 is not applicable to the Crandon Project soil absorption system.

6.2 Wastewater Treatment Process

Details of the proposed wastewater treatment for the Crandon Project are described in the *Preliminary Engineering Report for Wastewater Treatment Facilities* (PER) (Foth & Van Dyke, 1995/1998a). The treatment process includes the following:

- Base Wastewater Treatment System
  - Lime treatment and pH control for metal hydroxide formation.
  - Clarification for metal removal.
  - Sulfide treatment and pH control for metal sulfide formation.
  - Filtration for metal sulfide removal.
- Advanced Wastewater Treatment System
  - Reverse osmosis to remove remaining metals and anions.
  - Evaporator system for volume reduction of the reject brine from the reverse osmosis process.
  - Air stripper for ammonia removal from evaporator condensate.
  - Final pH adjustment to achieve compliance with groundwater discharge standards.

Treated wastewater will be stored in a holding pond for testing prior to discharge. A pump station will pump treated water to the soil absorption system site.

6.3 Discharge Water Quantity and Quality

The project's PER (Foth & Van Dyke 1995/1998a) contains information regarding the expected water quality for the treatment plant effluent. The wastewater treatment plant will discharge 540,000 gpd (375 gpm) under average conditions. This flow will vary from a low of 96,480 gpd (67 gpm) to a high of 915,840 gpd (636 gpm). The soil absorption system is designed to handle the maximum flow rate anticipated.

The treated effluent will be treated at the wastewater treatment plant to have near zero suspended solids and organic material. This will minimize vertical and horizontal flow restrictions in the soil due to physical and biological clogging. Since groundwater standards for PALs will be met in the effluent prior to discharge to the soil absorption system, there will be no need to rely on the soil for further treatment.

6.4 Design Approach

6.4.1 Rapid Infiltration Design

The treated effluent will be discharged through the use of infiltration cells. In the vicinity of Area H, the infiltrated water will discharge to wetland Z16 and ultimately be conveyed to Swamp Creek via natural surface water drainage features. The critical design feature for the soil absorption system is the ability of the underlying aquifer to transmit the treated mine effluent to the discharge area.

To determine the aquifer capacity, a subsurface model was used. The standard model for rapid infiltration design used in the State of Wisconsin is presented in the USEPA's *Process Design Manual for Land Treatment of Municipal Wastewater* (USEPA, 1981). While the water quality for the Crandon Project will be much different than municipal wastewater, use of the USEPA model for subsurface drainage is still appropriate for design purposes. Design calculations using the USEPA equation are provided in Appendix I.

However, to aid in the design of the infiltration system, a two-dimensional finite difference model was also used. The technical memorandum in Appendix J describes the modeling that was performed to aid in: 1) a preliminary evaluation of the site to handle the infiltrated water; 2) appropriate parameter selection for use in the USEPA design equation; and 3) verifying the design layout. As described in the memorandum in Appendix J, the preliminary analysis with the cross sectional model indicated that the site hydrogeologic conditions are conducive for operating a soil absorption system. Furthermore, the analysis confirms that the proposed layout of the system, based on USEPA subsurface drainage model equations, is compatible with the aquifer systems capacity to transmit the infiltrated water to the local areas of groundwater discharge.

The USEPA equation, as used for design of the subsurface drainage system is as follows (see Appendix I for calculations):

$$W = \frac{KDH}{dL}$$

where

W = total width of infiltration area in the direction of groundwater flow (ft).
K = permeability of aquifer in the direction of groundwater flow (ft/day).
D = average thickness of aquifer below the water table and perpendicular to the direction of flow (ft).
H = elevation difference between the water level of the discharge point and the maximum allowable water table below the application area (ft).
d = lateral flow distance from infiltration area to the discharge point (ft).
L = annual hydraulic loading rate (ft/day).

Using the above equation, K, D, and L were determined from field data and the finite difference conceptual model. The design value for K was conservatively selected at 75 ft/day from on-site slug tests. The design value for D was conservatively selected at 30 feet. The modeling presented in Appendix J shows that the full 70 feet of outwash conveys water to the wetland, but a more conservative value of 30 feet was selected for design. The value for L could be as high as 80 ft/day based on field infiltrometer tests, but a maximum value of 0.5 ft/day was selected to avoid excessive mounding beneath the absorption system.

The value for H is calculated by determining the difference between the groundwater elevation at the discharge area and the maximum watertable beneath the application area, including mounding.

The distance "d" is measured from the center of the application area to the discharge area, selected to be 50 feet beyond the edge of the wetland. Where the edge of the wetland varies, the average distance was selected.

The first design step, using the above equation, is to determine the maximum width and length of each soil absorption cell. The calculations show maximum cell widths from 100 feet to 150 feet. The length of each cell is then optimized to provide a cell of maximum length perpendicular to groundwater flow with no change in grade at the base. The resulting cell lengths vary from 250 to 750 feet. Earthwork considerations were also evaluated when laying out the individual soil absorption cells.

The second design step evaluates groundwater mounding under the soil absorption cells. USEPA (1981) contains a design procedure for determining the groundwater mound underneath a soil absorption cell. A maximum mound height was determined by allowing 5 feet of separation from the bottom of the distribution piping to the highest groundwater mound. The allowable mound value is calculated by subtracting the maximum groundwater elevation beneath the absorption cell without mounding from the maximum mound elevation. The cell width and the application rate are then adjusted to determine the proper design that meets the maximum mound condition.

Appendix I contains the engineering calculations used to determine the maximum cell width and the groundwater mound for each cell in the system. Drawing No. 9 shows the preliminary system layout based on the calculations. Cells A through F have a capacity of 714 gpm. This exceeds the maximum design flow rate of 636 gpm by approximately 12 percent and exceeds the average flow rate by approximately 90 percent. Cells will be constructed in a staged sequence according to actual and projected requirements.

Table 6-1 summarizes the soil absorption cell design, as shown on Drawing No. 9.

Table 6-1

Soil Absorption Cell Design

Cell	Width (ft)	Length (ft)	Max Flow (gpm)	Pipe Elevation (ft)	Max GW Elevation (ft)	Max GW Elevation w/ Mounding (ft)	Max Mound (ft)
A	150	250	84	1597	1587	1592	5
B	150	250	97	1597	1586	1592	6
C	150	300	117	1595	1585	1590	5
D	100	300	78	1591	1582	1586	4
E	100	730	167	1592	1583	1587	4
F	100	750	171	1592	1583	1587	4

GW = groundwater

Prepared by: PAK
Checked by: SAD2

As noted above, the design value for the aquifer thickness was selected to be 30 feet. The finite difference model (Appendix J) indicated that the full aquifer thickness could be used to transmit water to the discharge point. An upper bound on the site capacity was performed using an aquifer thickness of 60 feet, with all other parameters unchanged. With a 60-foot thick aquifer, the absorption cells would be larger and have a total capacity of well over 1,000 gpm (see Appendix J). While the design using 60 feet of aquifer depth may be allowed by the conceptual model, a more conservative design of 30 feet of aquifer depth will be used which still provides sufficient capacity beyond the peak design flow.

6.4.2 Soil Absorption System Design

The soil absorption system is designed for discharging treated effluent to the groundwater. As shown on Drawing No. 9, the system is laid out in six individual cells. Each cell is designed to apply treated effluent evenly through the use of distribution laterals which are laid out at a

uniform elevation over the entire cell. Beneath the laterals, 6 inches of gravel will be placed which will further help to distribute water evenly over the cell surface. The highly permeable outwash sand will be located beneath the gravel bed. Details of the proposed soil absorption cells are provided on Drawing No. 10. The sand to be used in cell construction will either be in situ or will be backfilled with outwash from a nearby borrow source located at the southeastern corner of the site (see Drawing No. 9). Topsoil and other finer soils (i.e., loess and till, where present) above the outwash sand will be removed and replaced with outwash soils from the borrow area.

The finer soil above the piping will be prevented from migrating into the sand and gravel layers (and reducing the permeability in those layers) through the use of a non-woven geotextile. The soil and vegetation above the piping will insulate the soil absorption cells and allow the system to function all year without freezing.

The distribution piping will be 1½-inch or 2-inch PVC with ¼-inch diameter orifices. Normal domestic wastewater can cause clogging of this piping, but the high purity water from the Crandon Project wastewater treatment plant will not clog the piping system. A filtration system ($^1/_{16}$-inch diameter) is included at the discharge end of the effluent storage lagoon, and will remove larger particles that may enter the storage pond prior to discharge to the soil absorption system. For these reasons, cleanouts will not be included for each of the laterals. Should a lateral become plugged, the piping ends can be exposed and the cap removed for cleaning.

Each soil absorption cell will operate independently from the others. This will be accomplished by having a separate discharge system for each cell. Water from the wastewater treatment plant will be pumped to a central distribution chamber which feeds each dosing station proportionately to the capacity of each cell. The dosing tank will be designed to meet the conditions for each cell. A dosing siphon will be used to discharge flow to each cell. This will require the distribution chamber to be built 10 to 15 feet above the highest absorption cell. This elevation allows for a pressurized discharge to the absorption cells without pumps. Drawing No. 10 shows the distribution system and dosing siphon layout. The total discharge capacity of the six dosing stations is 1,958 gpm. The maximum discharge from the treatment plant is 636 gpm. With the large distribution capacity at the soil absorption system, additional treated wastewater storage is not required beyond the dosing tanks.

The piping system for each cell has been designed to provide even distribution over the entire cell. This was accomplished by following the pressure distribution design procedures in the *Design Manual for Onsite Wastewater Treatment and Disposal Systems* (USEPA, 1980). The laterals and manifolds have been sized to have head loss from one end to the other that is less than 10 percent of the head loss at each orifice. This design limits the variation in flow from one cell orifice to another resulting in even flow distribution. Each lateral will have orifices spaced at 10 feet on center. The laterals will be 20 feet apart. This arrangement will allow for good distribution without excessive piping and flow requirements.

The dosing siphons have been designed based on ¼-inch diameter orifices pressurized at 3 feet of head. This allows 1.28 gpm per orifice. The dosing volume is designed for 12 times the volume of the distribution piping to provide even distribution over the entire bed. The proposed piping system has about 15,000 feet of distribution laterals with 1,500 orifices.

6.5 Discharge Pipeline

The proposed discharge pipeline route from the plant site to the soil absorption site is shown on Drawing No. 2. The approximate 3.2-mile pipeline route runs adjacent to the proposed railroad spur to a point just west of the main Wisconsin Central Limited Railroad line. From here, the pipeline runs north and crosses under Keith Siding Road. At this point, the pipeline extends to, and crosses, the snowmobile trail and ends at the distribution chamber located near the center of the proposed cells. This route was selected over alternative routes to minimize construction impacts to wetlands.

The proposed discharge pipeline begins at the effluent lagoons at the plant site. A pump station at the effluent lagoons will pump directly to the soil absorption system distribution chamber. The pump flow rate will be approximately 650 gpm and the pipe size will be 10 inches. The pipe material will be single walled PVC or HDPE, rated at a minimum pressure of 100 psi. To prevent pipeline freezing, the discharge pipeline will be buried below the frost line.

7 Soil Absorption System Construction and Operation

7.1 Construction

Proper construction techniques for the soil absorption system are important for good long-term performance. Compaction and mixing of the outwash with fines must be avoided. Soil compaction will be minimized by using low pressure vehicles for construction. Each cell will be marked to avoid traffic and unnecessary construction related activities on the soil absorption system.

The outwash sand at the base of the soil absorption cells will be protected from wind blown silt, or other fine particles that might migrate into the clean sand. If necessary, excavated soils will be kept moist during construction to minimize wind blown soils from reaching the soil absorption beds. Soil stockpiles will be separated from the absorption beds and silt fencing will be installed to avoid soils transported via surface water run-on from reaching the absorption beds. There will also be limits on the length of time the outwash sand can be exposed to minimize dust and other contaminants from falling on the sand. These features will aid in keeping the high natural permeability of the soil after construction is complete.

Detailed construction plans and specifications will be prepared as part of the final design of the soil absorption system.

7.2 Soil Borrow Area

Soil excavated from each cell will be stockpiled adjacent to the absorption cell it was excavated from. When the absorption cell is completed, the stockpiled soil will be placed over the absorption cell and seeded. This procedure will eliminate hauling soil off-site. The proposed design for the soil absorption system requires that outwash soils be imported to build up the elevations of the cells to provide for 5 feet of vertical separation from the bottom of the distribution piping to the operational high groundwater elevation. As indicated earlier in this report, pre-operational high groundwater has been established as the existing low groundwater contours plus 2 feet.

As shown on Drawing No. 9, the proposed outwash sand borrow area is located in the southeastern parcel of Area H (Field No. 5 on Drawing No. 3). Drawing No. 3 also shows the location of test pits, borings, and wells completed on this parcel. Composite samples of the upper 1.5 to 6.5 feet of the outwash were obtained from test pits TPH-74, TPH-76, TPH-80, TPH-81, and TPH-92 for the purpose of determining if outwash from this parcel is suitable for use as a borrow source for the proposed soil absorption system cells. Grain size analyses were completed on these composite samples with the results summarized in Table 4-5. The test results are generally as follows:

- P200 values are all less than 5 percent ranging from a high of 4.4 percent to a low of 0.5 percent, with the average being 1.5 percent.

- The outwash has a percentage of gravel ranging from 4.2 percent at 1.5 to 5.6 feet in TPH-74 to 30 percent at 4.4 to 6.5 feet in TPH-80 with the average gravel content (i.e., > no. 4 sieve) being approximately 12 percent.

- All samples have USCS designation of SP.

It is apparent that the borrow area has outwash soils which are very similar to the outwash soils in the area of the soil absorption system. Therefore, the outwash borrow soils are suitable for use as backfill in the absorption system without further processing.

The sand placed in the soil absorption system cells needs to be placed at a loose density close to the in situ density of the existing in-situ outwash soils. To determine the typical soil densities, relatively undisturbed samples were collected with beveled-edged rings which were driven into the outwash soil surface in the test pits at the desired depth. Thresher & Son, Inc. completed this sampling and the laboratory density determinations using ASTM D 2216 and Society of Soil Scientists of America (SSSA) 13-2 procedures. The results of these tests are summarized in Table 4-7 with the laboratory data sheets included in Appendix H. Five moisture/density determinations were completed on outwash samples from TPH-5, TPH-13, TPH-21, TPH-32, and TPH-38A. Table 4-7 shows that the average density of these samples is 94.8 pounds per cubic foot (pcf). As shown from the data in Appendix H, the average moisture content was 5.6 percent.

The following will be included in the final design specifications for the project:

- The required outwash soils will be obtained from the borrow area outlined on Drawing No. 9.

- The P200 of all outwash borrow soils shall be < 5 percent. Processing of soil is not required for soils with P200 of less than 5 percent.

- The outwash shall be placed at a density of 95 pcf or less.

- Care shall be taken during construction such that the loess soils used to cover the outwash do not migrate into the outwash soils below.

7.3 Earthwork Balance

Appendix I contains calculations completed to identify the quantity of outwash soil required to construct the soil absorption cells. These estimates assume an average 2-foot fill in each bed and an average 2-foot cut required to excavate the topsoil, loess, and/or till above the outwash. These assumptions are reasonable given the site conditions. Based on these assumptions and the present cell configuration, the preliminary grading plan and estimated earthwork quantities are as follows:

- The topsoil, loess, and/or till and any other restrictive soil layer will be removed from below each cell to a depth at which clean outwash sands are reached in the excavation.

- The excavation shall be carried out at a 2:1 (H to V) slope from the outside toe of the fill slope for each soil absorption cell. These excavated materials will be temporarily segregated and stockpiled for later use to mound over the cells. The quantity of unsuitable soils required to be cut from cells A through F is estimated at approximately 24,000 cubic yards in-place.

- The excavated area will be backfilled with outwash soils obtained from the borrow area in Field 5 shown on Drawings No. 3 and 9.

  - The borrow area has a surface area of approximately 9 acres.

  - Assuming an average thickness of topsoil, loess, and/or till of 2 feet in the borrow area, approximately 30,000 cubic yards must be excavated and stockpiled adjacent to the borrow area before outwash soils can be removed. Following removal of the needed outwash, stockpiled soils will be backfilled in the borrow area with positive drainage maintained.

  - The total borrow volume required for construction of the soil absorption cells includes approximately 24,000 cubic yards to replace the unsuitable soils excavated from the cells and approximately 23,000 cubic yards of above grade outwash fill for a total of 47,000 cubic yards in-place.

  - The average in-place outwash density has been determined to be 94.8 pcf, therefore outwash soils will be placed at a density less than or equal to 95 pcf. Since the density in the borrow area will be duplicated in the fill area, it is not necessary to apply shrinkage or swell factors.

The previous section contains a list of specifications and precautions required for proper handling of the outwash soils during construction. The listed items will be incorporated into the final project specifications.

7.4 Erosion Control

The erosion control methods described in the *Mine Permit Application* (MPA) (Foth & Van Dyke, 1995/1998c) will be implemented during the construction, operation, and reclamation of the soil absorption system cells and soil borrow area.

Drawing No. 9 shows that the temporary stockpiles of topsoil and loess/till will be located to the northwest of the soil absorption system cells and adjacent to Keith Siding Road away from the wetlands and Lake 17-16. The stockpile locations along with implementation of the erosion

control methods described in the MPA will mitigate potential impacts to on-site wetlands and water bodies from soil borrow and handling activities.

7.5 Operation

Treated effluent will be pumped from the discharge lagoon to the soil absorption system site. As shown on Drawing No. 10, the treated effluent will enter a flow distribution structure which will split the flow proportionately to separate soil absorption cell dosing systems. Each dosing system will operate by a dosing siphon which has a fixed on/off elevation matching the required volume at the design flow rate to each soil absorption cell. The operator will select the number of cells to operate by opening the appropriate valves or gates to route flow to the appropriate cell. Normal operation (375 gpm) will require only three or four of the six cells to operate at any given time. This will allow the cells to be rested for a prescribed period of time. At maximum flows (636 gpm), a minimum of five cells will be used.

The requirements for flow rate and dose volume to maintain even flow distribution will result in the delivery of water to the soil absorption cells in pulses. At peak flow, each dosing siphon will cycle at intervals of 40 to 80 minutes of which about 30 percent of the time is actual discharging. This provides for drainage of the gravel bed underneath the piping after each dosing cycle.

Filters will be installed at the effluent storage lagoon at the plant site prior to discharge to the soil absorption cells. These will prevent large particles that may enter the water in the mill effluent storage pond from entering the cells and plugging the orifices. These filters will be cleaned regularly. Pressure drop indicators will be provided with the filters to alert operators of the need to clean them.

The water distribution system will be enclosed in a heated building to prevent above ground pipes and tanks from freezing. The final design will determine the dosing siphon size for each cell. Since dosing siphons operate automatically without electric controls, backup siphons are not required.

The soil cover on the soil absorption cells will provide insulation and allow the cells to operate under winter conditions. Perennial grasses will be planted on the soil absorption cells to prevent soil erosion and provide additional winter insulation. Vegetation on the absorption cells will be mowed on a regular basis to keep woody plants from being established on the cells. The longer roots of woody plants could cause root damage to the distribution piping.

The effluent discharged to the soil absorption system will be treated at the project's wastewater treatment plant to meet NR 140 PALs. Since the effluent will be treated to meet PALs, additional treatment by the soils is not anticipated or required. It is recommended that the separation between the base of the soil absorption system and the water table be maintained at a minimum of 3 feet (USEPA, 1981). Therefore, even though the system has been designed for a 5-foot separation from the operational groundwater mound, the operating separation distance

could be as low as 3 feet. Impacts to existing groundwater quality are not anticipated to occur by maintaining a minimum of a 3-foot separation from operational high groundwater.

7.6 Reclamation

The reclamation plan for the soil absorption system will include the following:

- Procedures for site restoration including landscaping of the soil absorption system cells and appurtenant structures.
- Procedures for proper abandonment of groundwater and other monitoring devices.
- Procedures for long-term care of the restored area.

The information noted above is detailed in the reclamation plan of the project's *Mine Permit Application* (Foth & Van Dyke, 1995/1998c).

8 Environmental Monitoring

The soil absorption system monitoring plan is addressed in the *Mine Permit Application* (Foth & Van Dyke, 1995/1998c).

9 Additional Studies

9.1 Surface Water Drainage Evaluation

As part of the restoration process for the canal adjacent to Lake 17-16, the land surface will be graded to restore surface water drainage between the northern and the southern half of wetland Z16 central. This will allow for groundwater which is discharged to the wetland to drain through the wetland complex and culverts that convey drainage to Swamp Creek.

With the discharge from the soil absorption system entering the Z16 wetlands, the impact of the soil absorption system on the hydrology and surface water flow of the Z16 wetlands was investigated. Also investigated was the potential impact of the soil absorption system discharge on the floodplain of Swamp Creek. These hydrological analyses are included in Appendix K.

The analyses showed that surface water elevation increases as a direct result of the soil absorption system discharge will be minimal. Under predicted base flow conditions during operation of the soil absorption system (i.e., with no surface water component and 100 percent discharge from the soil absorption system), a 0.10-foot increase is predicted to occur in the upstream vicinity of the culvert in the north wetland. At the south wetland, the post-soil absorption system operation base flow predicts an increase in elevation of 0.6 feet in the upgradient vicinity of the culvert which crosses Keith Siding Road.

The biggest increase to on-site flow depths across wetland valley sections during storm events is 0.01 foot. Any increase at wetland Z16 north will occur only at the upstream side of the railroad culvert due to the presence of the railroad berm. Similarly, increases at the wetland Z16 south culvert will only extend upstream on NMC property due to the road grade of Keith Siding Road.

No changes to the Swamp Creek floodplain elevation occur as a result of the soil absorption system. As such, floodplain issues are not relevant.

Based upon the information contained in Appendix K, it has been shown that the amount of flow that will be discharged from the soil absorption system is very small in comparison to the existing drainage basin runoff to each wetland. As a result, surface water hydrology in wetland Z16 and Swamp Creek will not be detrimentally affected by soil absorption system operation.

9.2 Preliminary Groundwater Monitoring

NMC is currently in the process of completing two rounds of groundwater quality monitoring at three wells to assess existing groundwater quality conditions at the site. This and additional baseline environmental monitoring data and impact analysis will be submitted to the WDNR in the spring of 1999 as an update to the project's EIR (Foth & Van Dyke, 1995/1998b).

The wells selected for preliminary monitoring include MWH-10, MWH-11, and MWH-13. The groundwater quality parameter list for the first round of groundwater quality monitoring includes:

Hardness	Total Dissolved Solids
Metals	Fluoride
Cyanide	Herbicides
Total Kjeldahl Nitrogen	Aldicarb
Chemical Oxygen Demand	Organic Chlorine Pesticides
NO_2 and NO_3	

The parameter list for the second round of groundwater quality sampling includes, in addition to the above parameters, the following groups of priority pollutants:

Volatile Organic Compounds	Base/Neutral Compounds
Metals	Pesticides/PCBs
Acid Extractable Compounds	Total Cyanide/Total Phenols

In addition, field conductivity was measured on all wells and piezometers at Area H North during the second round. The monitoring data will be used to assess existing groundwater quality and the potential impact of the soil absorption system on possible pre-existing groundwater quality conditions.

9.3 Environmental Assessment

As discussed in the previous sections of this report, significant data related to geology, hydrogeology, and wetlands have been collected to date at Area H. Since the hydrogeological and geological information collected show that Area H is a suitable site for construction of a soil absorption system, it has been determined that the collection of additional site-specific baseline environmental data would also be desirable at Area H. These data will be used by the WDNR in the preparation of the Environmental Impact Statement for the Crandon Project. The primary focus of the additional data collection will be on flora and fauna, and surface water resources on and in the vicinity of Area H. A work plan describing the additional data collection activities is included in Appendix L.

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FIGURES FOR THE PRELIMINARY ENGINEERING REPORT FOR THE CRANDON PROJECT SOIL ABSORPTION SYSTEM

2,270,000 E
2,275,000 E
2,280,000 E
2,285,000 E
125,000 N
120,000 N
115,000 N
110,000 N

PROJECT AREA BOUNDARY
PROPOSED RAILROAD SPUR AND DISCHARGE PIPELINE TO SOIL ABSORPTION SYSTEM
PROPOSED ACCESS ROAD
PLANT SITE
TMA BORROW SITE
TMA
TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
SAP
SAND SIDING
CENTRAL LIMITED RAILROAD
WISCONSIN CENTRAL LIMITED RAILROAD
AIRPORT RD
COUNTY PARK RD
SHERMAN LN
SWAMP LN
OUTLET
SWAMP
CREEK
HEMLOCK
DEEP HOLE LAKE RD
SAND LAKE RD
OAK LAKE
LITTLE SAND LAKE
DUCK LAKE
SKUNK LAKE
DEEP HOLE LAKE

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
- PROJECT AREA BOUNDARY
- PROPOSED SOIL ABSORPTION SYSTEM PIPELINE
- PROPERTY NOT INCLUDED WITHIN PROJECT AREA

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 5 FEET.
4. SECTION 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:	REM	DATE:	NOV. '98
APPROVED BY:	SAD2	DATE:	NOV. '98
APPROVED BY:	GWS	DATE:	NOV. '98

Nicolet Minerals COMPANY

Mining for the Future Commitment

FIGURE 1-1

PROJECT AREA

Scale: 0 1200' 2400' Date: NOVEMBER, 1998

Prepared By: Foth & Van Dyke By: JRB2 93C049

...\98c040\sap-design\8c40m3.dgn Nov. 18, 1998 14:49:13

2,275,000 E

2,280,000 E

2,285,000 E

2,290,000 E

N

130,000 N

125,000 N

120,000 N

115,000 N

110,000 N

LAKE METONGA

Water

AREA E

AREA K (WEST)

AREA K (EAST)

AREA H (NORTH)

SAS

AREA H (NORTH) SEE DRAWING NO. 3 FOR BOREHOLE, TEST PIT AND WELL LOCATIONS.

AREA H (NORTH)

AREA H (SOUTH)

AREA G

AREA XB

AREA XC

AREA B

AREA A

PLANT SITE

SKUNK LAKE

AREA J-4

AREA J

TMA

GROUND HEMLOCK LAKE

OAK LAKE

LITTLE SAND LAKE

DUCK LAKE

AREA C

AREA D

DEEP HOLE LAKE

BE-01 BE-02 BE-03 BE-04 BE-05 BE-06 BE-07 BE-08 BE-09 BE-10 BE-11 BE-12 BE-13 BE-14 BE-15 BE-16 BE-17

MWE-04 MWE-08 MWE-11 MWE-14 MWE-16 MWE-18

TPE-9B TPE-15 TPE-16 TPE-17 TPE-18 TPE-19 TPE-20 TPE-21 TPE-22 TPE-23 TPE-24 TPE-24B TPE-25 TPE-26 TPE-27 TPE-28 TPE-29 TPE-30 TPE-30B TPE-31 TPE-32 TPE-33 TPE-34 TPE-35 TPE-36 TPE-37 TPE-38 TPE-39 TPE-40 TPE-41 TPE-42 TPE-43 TPE-44 TPE-45 TPE-46 TPE-47 TPE-48 TPE-49 TPE-50 TPE-51 TPE-52 TPE-53 TPE-54 TPE-55 TPE-56 TPE-57 TPE-58 TPE-59 TPE-60 TPE-61 TPE-62

TPG-1 TPG-2 TPG-3 TPG-4 TPG-5 TPG-6 TPG-7 TPG-8 TPG-09 TPG-10 TPG-11 TPG-12 TPG-16 TPG-17 TPG-18

TPXB-1 TPXB-2 TPXB-3 TPXB-4 TPXB-5

TPXC-1 TPXC-2 TPXC-3 TPXC-4 TPXC-5 TPXC-6 TPXC-7 TPXC-8

TPH-01 TPH-02 TPH-03 TPH-04 TPH-22 TPH-23 TPH-24 TPH-25 TPH-26

BH-01 BH-03 BH-05

TPJ-1 TPJ-2 TPJ-3 TPJ-4 TPJ-5

BG-01 BG-02 BG-03 BG-09

BA-02 BA-03 BA-05 BA-06 BA-07 BA-08 BA-09

TPA-1A TPA-10A TPA-11A TPA-13A TPA-19 TPA-20 TPA-21 TPA-22 TPA-23 TPA-24 TPA-25 TPA-26 TPA-27 TPA-28 TPA-29 TPA-30 TPA-31 TPA-32 TPA-33 TPA-34 TPA-35 TPA-36 TPA-37 TPA-38 TPA-6A

1624.0 X

1624.6 X

1633.0 X

1591.8 X

LEGEND

- TREES/BRUSH
- UNPAVED ROAD/TRAIL
- PAVED ROAD
- x 1542.0 EXISTING SPOT ELEVATION
- 1600 EXISTING CONTOUR
- CREEKS/RIVERS/LAKES
- PROPOSED ACCESS ROAD
- BE-08 SOIL BORING NUMBER AND LOCATION
- MWE-08 MONITORING WELL NUMBER AND LOCATION
- TPE-9 TEST PIT NUMBER AND LOCATION
- SECTION LINE
- ORE BODY
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

0 800' 1600'

BAR SCALE

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 5 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. FLANNERY PROPERTY AREA TEST PITS TPXF-1 THROUGH TPXF-5 (NOT SHOWN) ARE LOCATED IN NW1/4, SECTION 33 T36N, R13E.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	REM	DATE: NOV. '98
APPROVED BY:	SAD2	DATE: NOV. '98
APPROVED BY:	GWS	DATE: NOV. '98

Nicolet Minerals COMPANY

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FIGURE 1-2

TEST PIT, SOIL BORING AND WELL LOCATIONS FOR 1998 SOIL ABSORPTION SITE INVESTIGATION

Scale:	SEE BAR SCALE	Date:	NOVEMBER, 1998
Prepared By:	Foth & Van Dyke	By:	DAT

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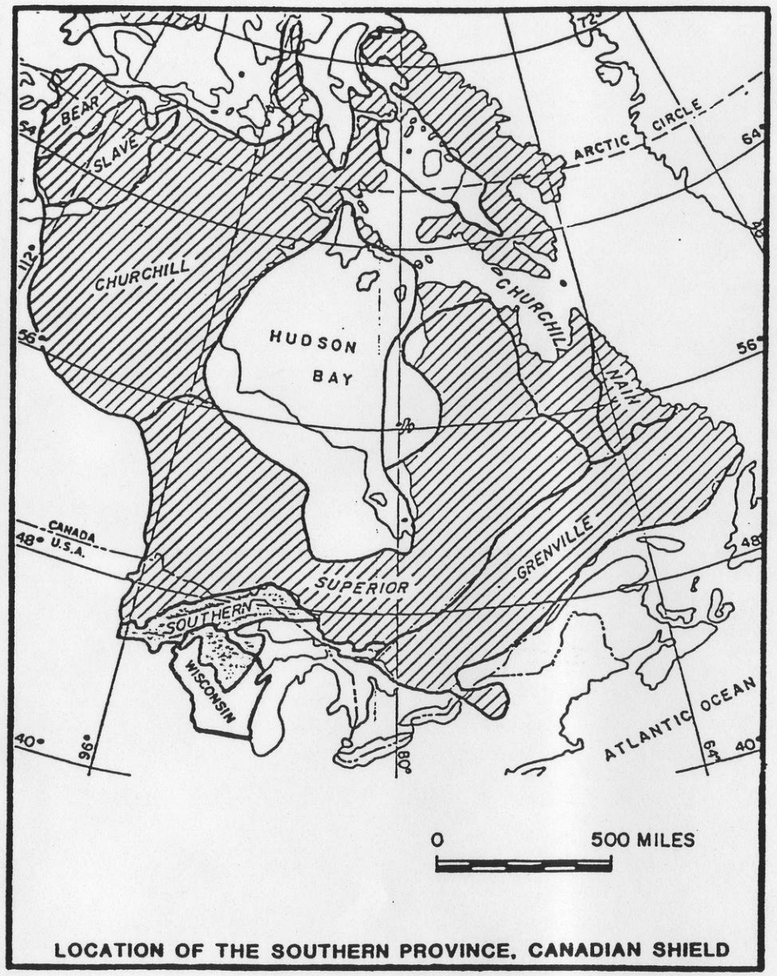
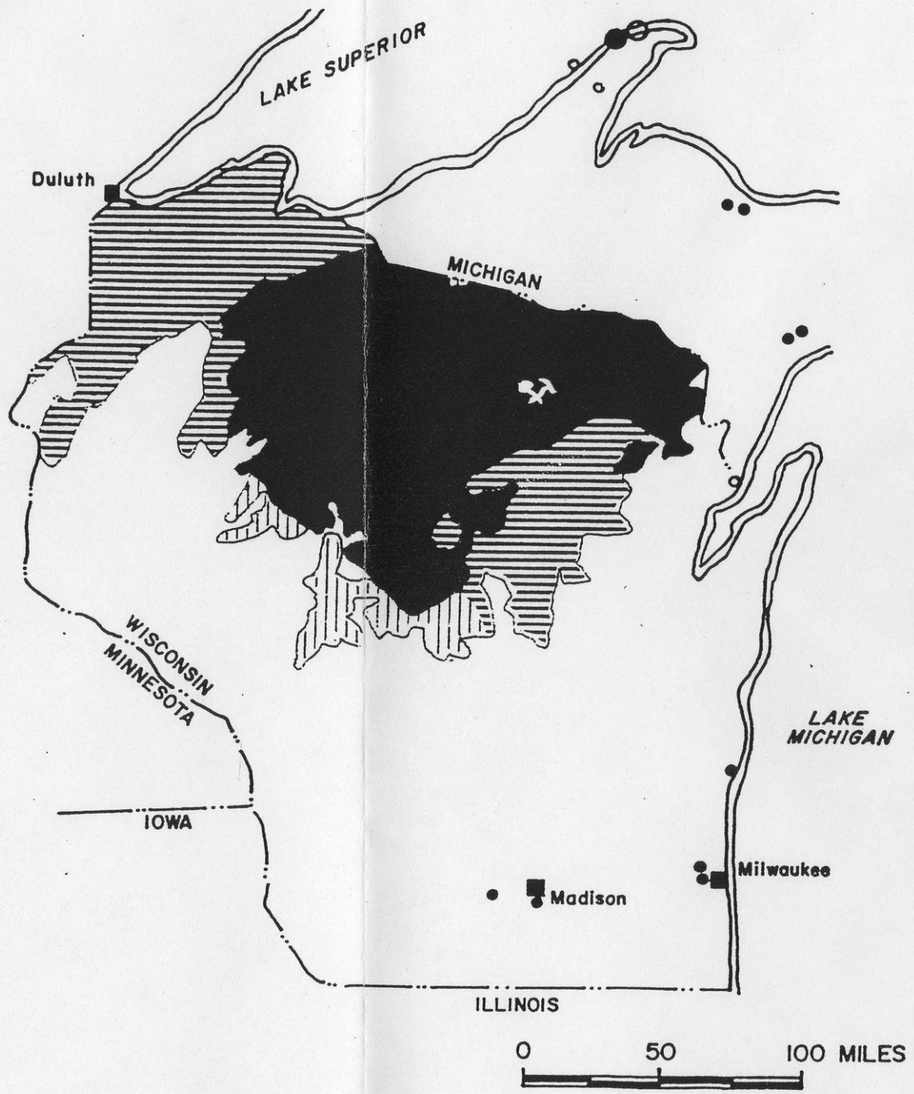
18 NOV 98 jow



LOCATION OF THE SOUTHERN PROVINCE, CANADIAN SHIELD



EXPLANATION:

- PALEOZOIC SEDIMENTARY ROCKS
- LATE PRECAMBRIAN: 600-1600 M.Y.
- MIDDLE PRECAMBRIAN: 1600-2500 M.Y.
- EARLY PRECAMBRIAN: 2500 M.Y. AND OLDER

REFERENCE:

1. U.S.G.S. AND AAPG, 1962.
2. SIMS, 1976.
3. DOCEKAL, 1970.
4. KING AND ZIETZ, 1971.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	SVDI	DATE:	NOV. '98
APPROVED BY:	SAD2	DATE:	NOV. '98
APPROVED BY:	GWS	DATE:	NOV. '98

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FIGURE 3-1

GEOLOGY MAP

Scale: 0 100' 200'	Date: NOVEMBER, 1998		
Prepared By: Foth & Van Dyke	By: DAT	93C049	

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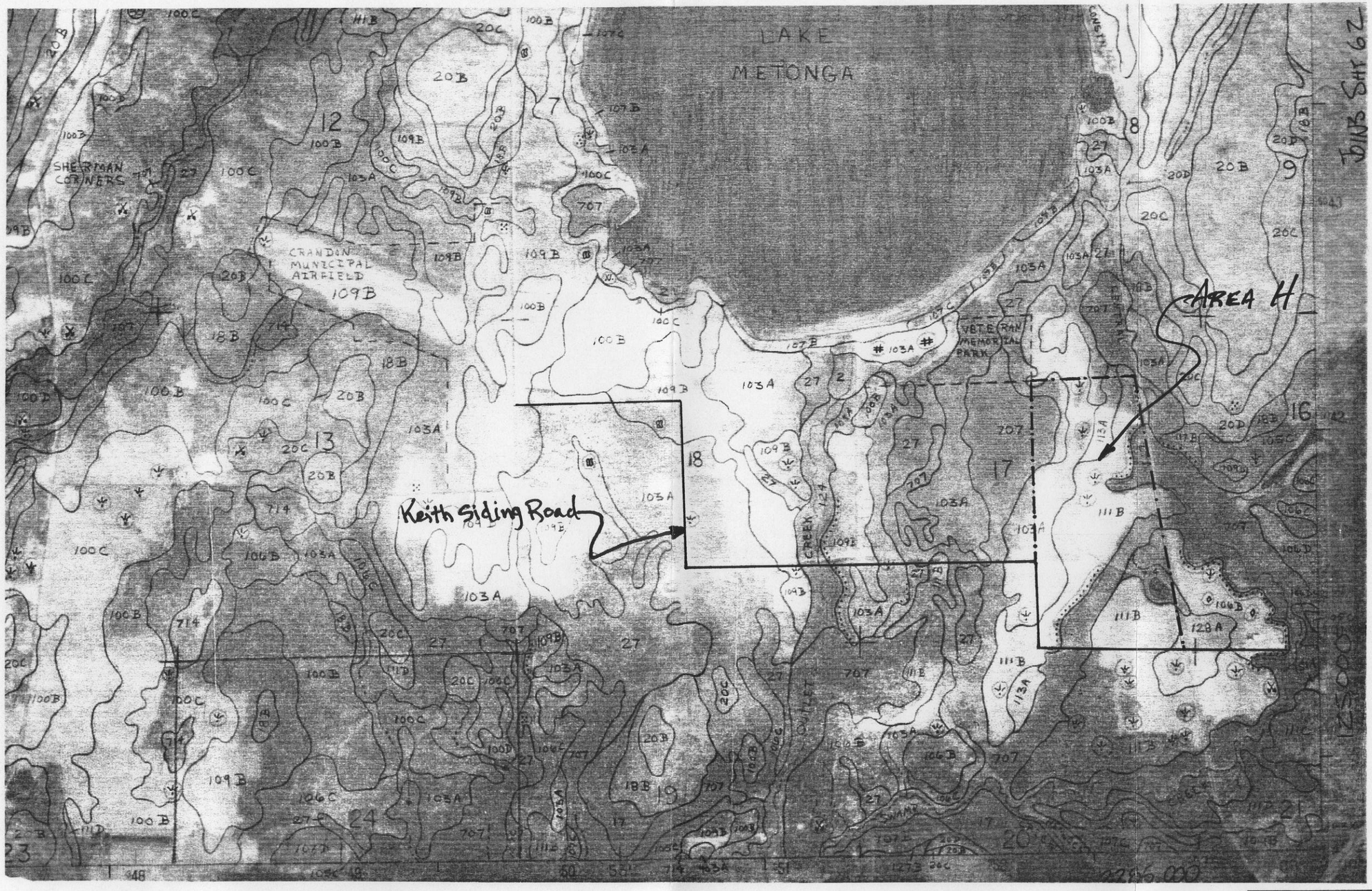

NOTES:
1. SOURCE - DRAFT SOIL SURVEY OF FOREST COUNTY, WISCONSIN
   USDA SOIL CONSERVATION SERVICE
2. REFER TO APPENDIX C FOR SOIL UNIT DESCRIPTIONS

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	SVDI	DATE: NOV.'98
APPROVED BY:	SAD2	DATE: NOV.'98
APPROVED BY:	GWS	DATE: NOV.'98

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FIGURE 3-2
SCS SOIL SURVEY MAP
FOREST COUNTY SOIL SURVEY
MAP SHEET NO. 63

Scale: ~ 1" = 1/3 MILE	Date: NOVEMBER, 1998	
Prepared By: Foth & Van Dyke	By: DAT	93C049

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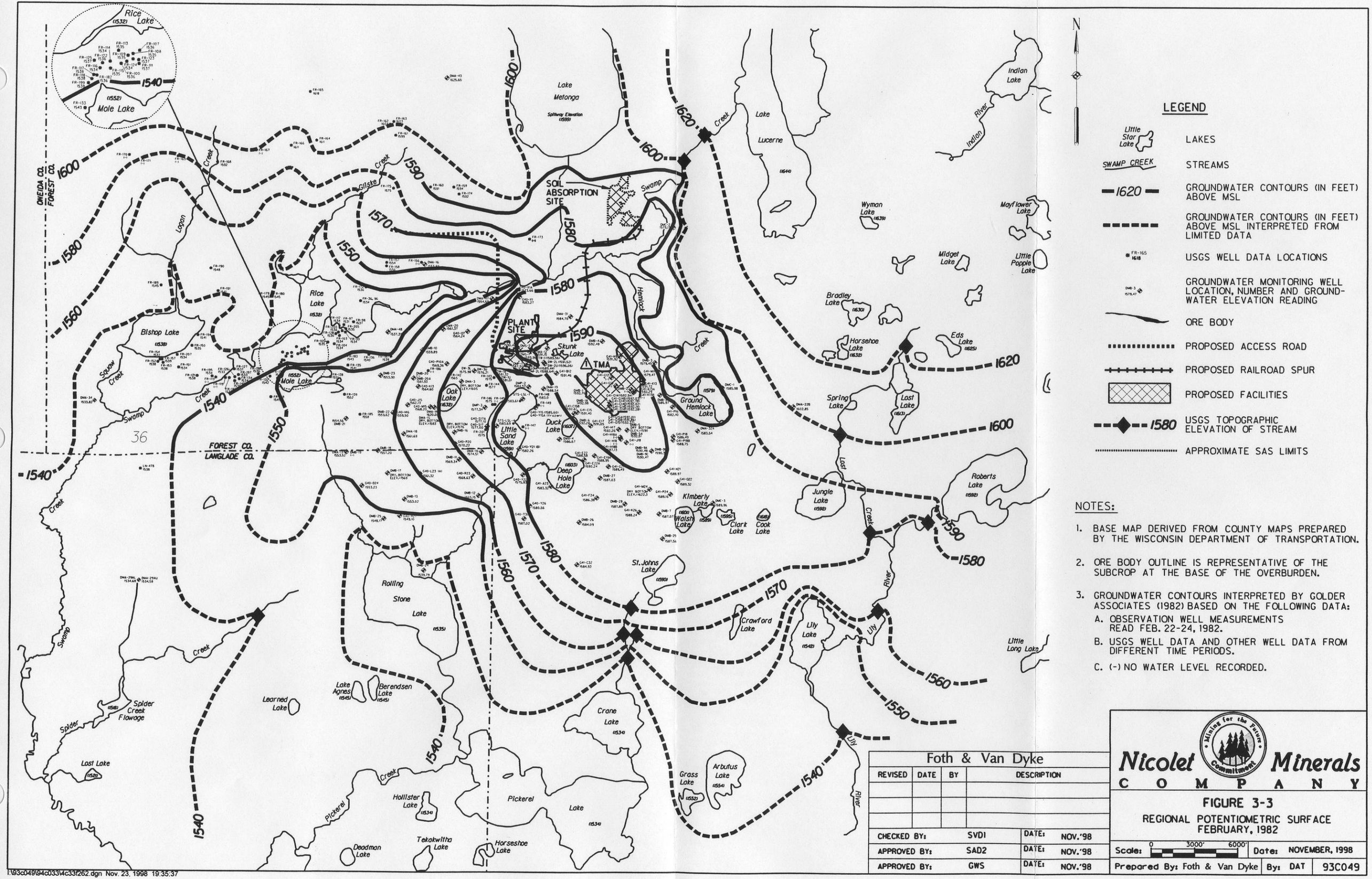

N

LEGEND

- LAKES (Little Star Lake)
- STREAMS (SWAMP CREEK)
- GROUNDWATER CONTOURS (IN FEET) ABOVE MSL (1620)
- GROUNDWATER CONTOURS (IN FEET) ABOVE MSL INTERPRETED FROM LIMITED DATA
- USGS WELL DATA LOCATIONS (FR-165 1618)
- GROUNDWATER MONITORING WELL LOCATION, NUMBER AND GROUND-WATER ELEVATION READING (DMB-3 1579.47)
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- USGS TOPOGRAPHIC ELEVATION OF STREAM (1580)
- APPROXIMATE SAS LIMITS

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.
3. GROUNDWATER CONTOURS INTERPRETED BY GOLDER ASSOCIATES (1982) BASED ON THE FOLLOWING DATA:
   A. OBSERVATION WELL MEASUREMENTS READ FEB. 22-24, 1982.
   B. USGS WELL DATA AND OTHER WELL DATA FROM DIFFERENT TIME PERIODS.
   C. (-) NO WATER LEVEL RECORDED.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	SVDI	DATE:	NOV.'98
APPROVED BY:	SAD2	DATE:	NOV.'98
APPROVED BY:	GWS	DATE:	NOV.'98

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FIGURE 3-3

REGIONAL POTENTIOMETRIC SURFACE
FEBRUARY, 1982

Scale: 0 3000' 6000'		Date:	NOVEMBER, 1998
Prepared By: Foth & Van Dyke	By: DAT		93C049

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DRAWINGS FOR THE PRELIMINARY ENGINEERING REPORT FOR THE CRANDON PROJECT SOIL ABSORPTION SYSTEM

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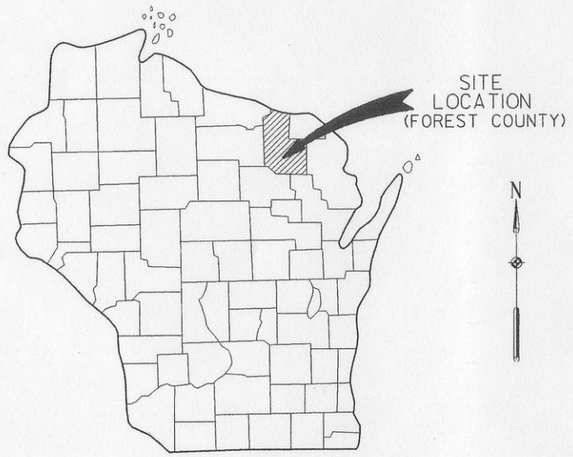
CRANDON PROJECT
PRELIMINARY ENGINEERING REPORT
FOR THE SOIL ABSORPTION SYSTEM

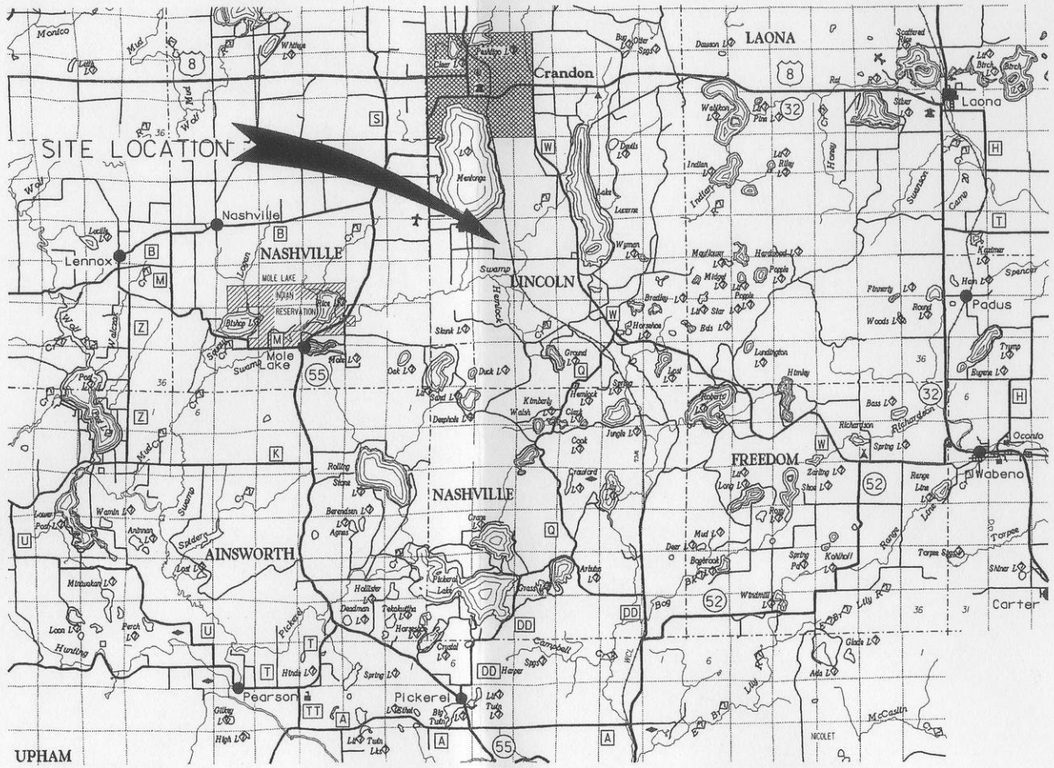
FOREST COUNTY, WISCONSIN

NOVEMBER, 1998

Foth & Van Dyke



COUNTY LOCATION MAP



SITE LOCATION MAP

APPROX. SCALE: 1"=10,000'

INDEX	
DRAWING NO.	DESCRIPTION
1	TITLE SHEET
2	EXISTING CONDITIONS PLAN SHOWING SETBACK
3	SOIL BORING, TEST PIT AND WELL LOCATIONS
4	GEOLOGIC CROSS SECTIONS A-A' AND B-B'
5	GEOLOGIC CROSS SECTION C-C'
6	GEOLOGIC CROSS SECTIONS D-D' AND E-E'
7	LOW GROUNDWATER TABLE ELEVATION CONTOURS AND SURFACE WATER ELEVATIONS SEPTEMBER 25, 1998
8	PONTENTIOMETRIC SURFACE CONTOURS AND ELEVATIONS SEPTEMBER 25, 1998
9	PRELIMINARY SOIL ABSORPTION SYSTEM LAYOUT
10	PREMILINARY ENGINEERING DETAILS

2,280,000 E

2,285,000 E

2,290,000 E

130,000 N

125,000 N

N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- 1675 EXISTING CONTOUR
- 1702.0 X EXISTING SPOT ELEVATION
- SWAMP/WETLAND
- TRAILS
- TREES
- RAILROAD
- T. Perry, et ux — APPROXIMATE PROPERTY BOUNDARY AND OWNER
- 9299 — APPROXIMATE LOCATION OF PRIVATE WATER SUPPLY WELL AND FIRE NUMBER
- 1000' RADIUS SETBACK FROM SURFACE WATER FEATURES, PUBLIC AREAS
- Z16 — WETLANDS
- A — PROPOSED SOIL ABSORPTION SYSTEM LOCATION
- 300' SETBACK FROM CREEK
- PROPOSED PIPELINE ROUTE
- PROPOSED RAILROAD SPUR

NOTES:

1. TOPOGRAPHY ON FIELDS 1 THROUGH 5 AND WETLAND SPOT ELEVATIONS NORTH OF KEITH SIDING ROAD FROM SURVEY COMPLETED BY FOTH & VAN DYKE IN LATE SUMMER, 1998.
2. TOPOGRAPHY, WATER BODIES, WETLANDS, ETC. OUTSIDE SOIL ABSORTION AREA BASED ON TOPOGRAPHIC BASE MAP DIGITIZED FROM THE 1" = 1000 SCALE 5 FOOT CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING INC., SHEBOYGAN, WI. DATE OF PHOTOGRAPHY APRIL 28, 1976.
3. BORING NUMBERS BH-01, BH-03, BH-05 AND TEST PITS TPH-01 THROUGH TPH-04 ARE SHWON ON FIGURE NO. 1-2
4. THE LOCATION OF THE SPRING IN WETLAND Z16 AND THE ORDINARY HIGH WATER MARK AROUND LAKE 17-16 ARE APPROXIMATE.

0 600' 1200'

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TITLE

EXISTING CONDITIONS PLAN SHOWING SETBACKS

SCALE AS SHOWN	STATE: WISCONSIN		COUNTY FOREST		
DRAWN BY JOW	DATE NOV. '98	CHECKED BY REM	DATE NOV. '98		
APPROVED BY SAD2	DATE NOV. '98	APPROVED BY GWS	DATE NOV. '98		
APPROVED BY	DATE NOV. '98	NICOLET MINING COMPANY	DATE NOV. '98		
DRAWING NO. 2	SHEET 2 OF 10	REVISION NO.			

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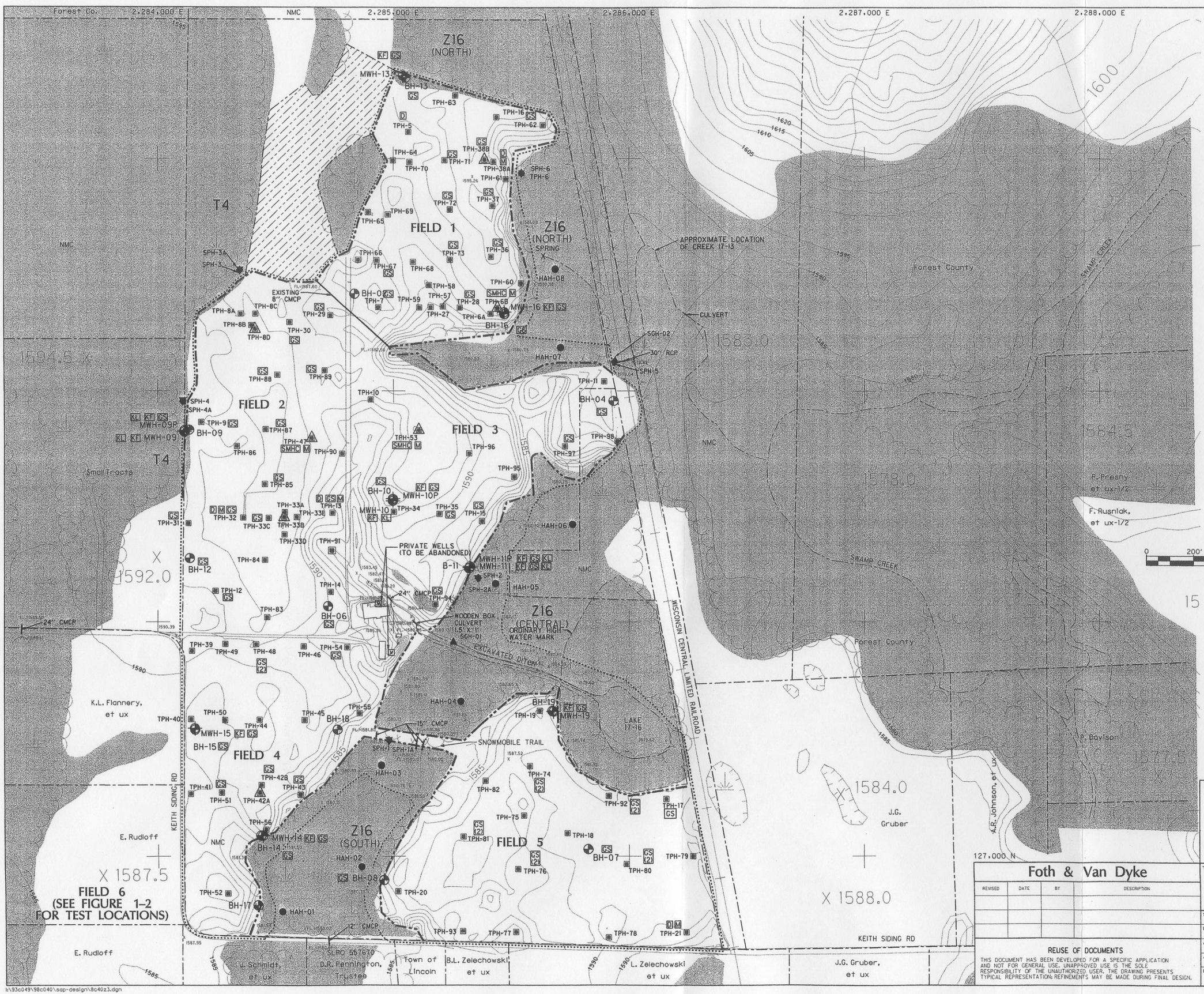

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- 1675 EXISTING CONTOUR
- 1702.0 X EXISTING SPOT ELEVATION
- SWAMP/WETLAND
- TRAILS
- TREES
- RAILROAD
- NMC APPROXIMATE PROPERTY BOUNDARY AND OWNER
- X 1582.17 WETLAND SPOT ELEVATIONS
- BH-09 SOIL BORING NUMBER AND LOCATION
- HAH-01 HAND AUGER BORING NUMBER AND LOCATION
- MWH-09 MONITORING WELL NUMBER AND LOCATION
- MWH-09P PIEZOMETER NUMBER AND LOCATION
- SPH-1 SAND POINT NUMBER AND LOCATION
- SGH-01 STAFF GAUGE NUMBER AND LOCATION
- TPH-59 TEST PIT NUMBER AND LOCATION
- Z16 WETLAND NAMES REPORTED IN THE 1995 EIR
- TPH-47 FIELD INFILTROMETER TEST NUMBER AND LOCATION
- M PRIVATE WELL
- 12" CMCP FL.=1583.02 / FL.=1580.61 CULVERT SIZE AND FLOWLINE ELEVATION
- 1998 WETLAND DELINEATION FIELD VERIFIED AND SURVEYED, SEPTEMBER, 1998
- DISTURBED WETLAND AREA NOT PREVIOUSLY DELINEATED AS A WETLAND
- APPROXIMATE LIMITS OF DETAILED TOPOGRAPHIC SURVEY (SEE NOTE NO. 1)
- LABORATORY SOIL TEST
- GS - GRAIN SIZE/HYDROMETER
- KL - HYDRAULIC CONDUCTIVITY (LAB)
- KF - HYDRAULIC CONDUCTIVITY (FIELD)
- SMHC - SOIL MOISTURE HOLDING CAPACITY
- D - DENSITY DETERMINATION
- M - MOISTURE CONTENT

NOTES:

1. TOPOGRAPHY ON FIELDS 1 THROUGH 5 AND WETLAND SPOT ELEVATIONS NORTH OF KEITH SIDING ROAD FROM SURVEY COMPLETED BY FOTH & VAN DYKE IN LATE SUMMER, 1998.
2. TOPOGRAPHY, WATER BODIES, WETLANDS, ETC. OUTSIDE SOIL ABSORPTION AREA BASED ON TOPOGRAPHIC BASE MAP DIGITIZED FROM THE 1" = 1000 SCALE 5 FOOT CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING INC., SHEBOYGAN, WI. DATE OF PHOTOGRAPHY APRIL 28, 1976.
3. BORING NUMBERS BH-01, BH-03, BH-05 AND TEST PITS TPH-01 THROUGH TPH-04 ARE SHOWN ON FIGURE NO. 1-2.
4. THE LOCATION OF THE SPRING IN WETLAND Z16 AND THE ORDINARY HIGH WATER MARK AROUND LAKE 17-16 ARE APPROXIMATE.

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TITLE

SOIL BORING, TEST PIT AND WELL LOCATIONS

SCALE AS SHOWN	STATE: WISCONSIN		COUNTY FOREST		
DRAWN BY JOW	DATE NOV.'98	CHECKED BY REM	DATE NOV. '98		
APPROVED BY SAD2	DATE NOV.'98	APPROVED BY GWS	DATE NOV. '98		
APPROVED BY	DATE NOV.'98	NICOLET MINING COMPANY	DATE NOV. '98		
DRAWING NO. 3	SHEET 3 OF 10	REVISION NO.			

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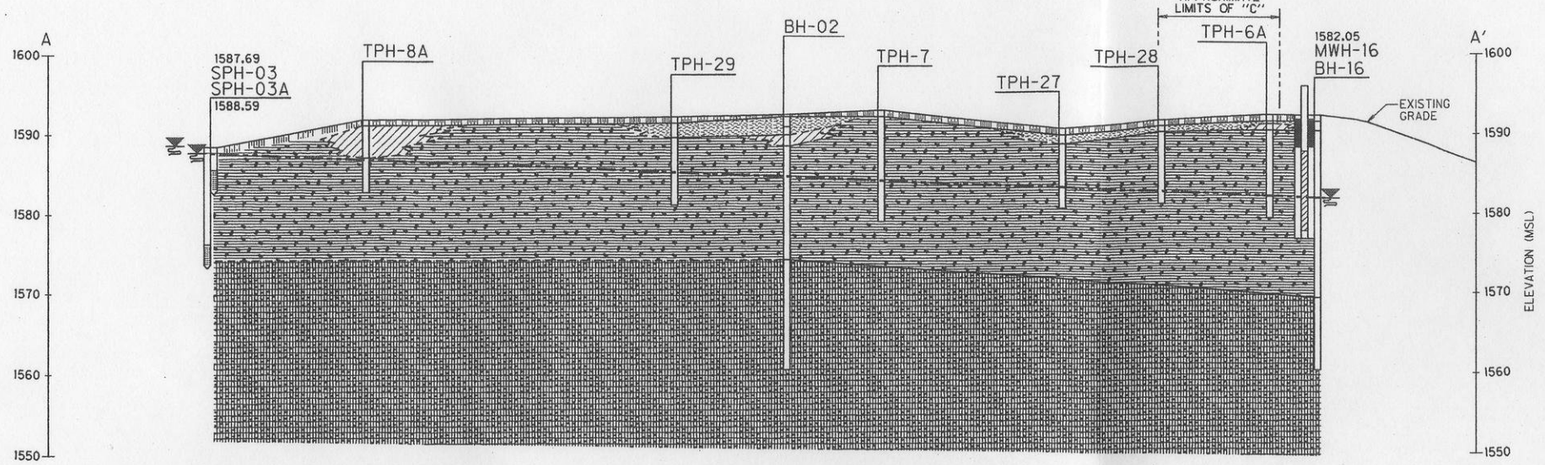
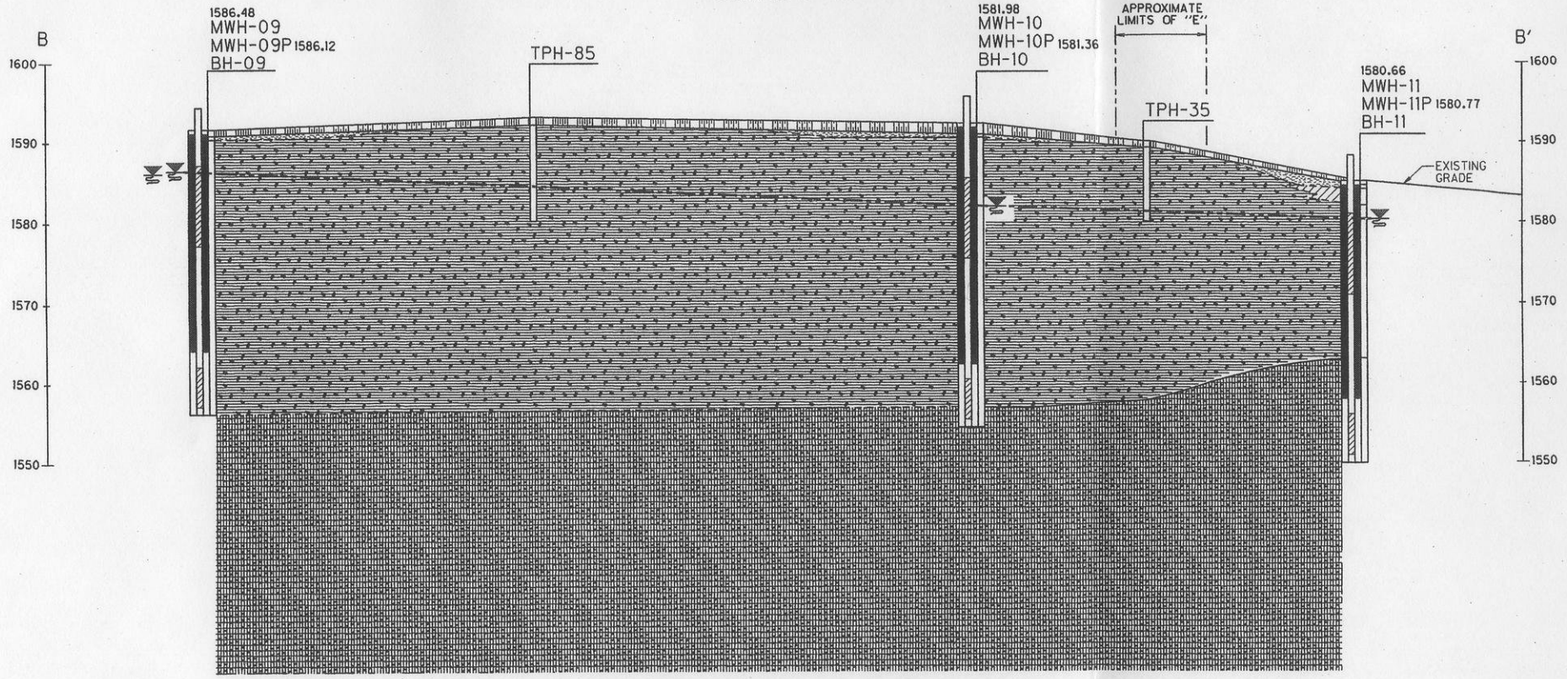
SECTION A - A'

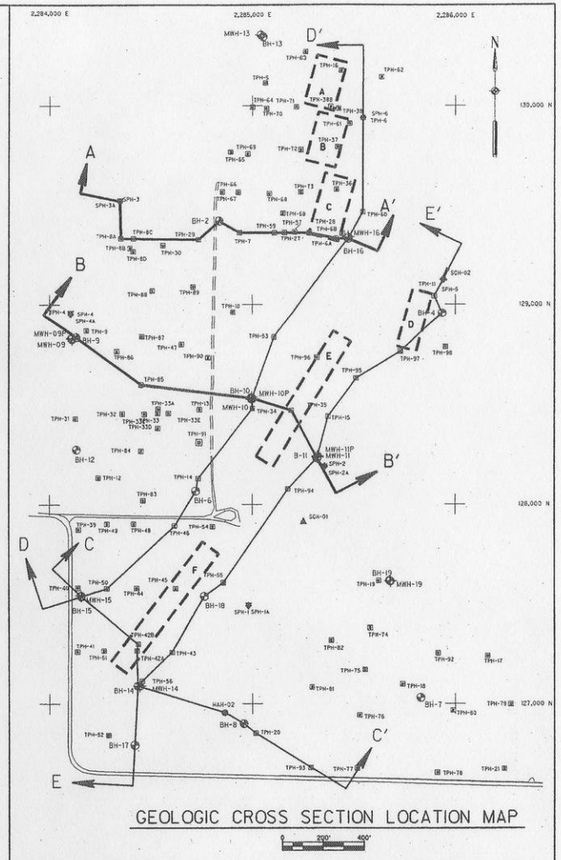


SECTION B - B'



Boring ID	Depth (ft)		% Gravel	% Sand	% Silt	% Clay	USCS	Other
TPH-29	4.5	0.0	97.7	0.3	2.0		SP	--
BH-02	12-14	3.4	94.1	1.8	0.7		SP	--
TPH-28	8.0	3.3	95.6	0.2	0.9		SP	--
MWH-16	10-12	2.5	96.5	0.8	0.2		SP	Kf = 5.5x10-3
MWH-09	8-10	3.3	92.7	0.6	3.4		SP	KL = 2.4x10-3, Kf = 1.2x10-2
MWH-09P	32-34	0.3	90.0	3.9	5.8		SP-SM	Kf = 1.9x10-2, KL = 1.5x10-2
TPH-85	4.2	1.0	98.6	--	0.4		SP	--
MWH-10	14-16	8.9	88.5	1.6	1.0		SP	Kf = 4.1x10-3, KL = 1.8x10-2
MWH-10P	34-36	0.3	92.9	4.1	2.7		SP-SM	Kf = 1.9x10-2
TPH-35	3	2.7	96.1	1.0	0.2		SP	--
MWH-11	10-12	43.2	55.0	1.3	0.5		SP	Kf = 1.8x10-2, KL = 2.2x10-2
MWH-11P	32-34	0.0	98.3	0.9	0.8		SP	Kf = 3.7x10-2, KL = 1.8x10-2

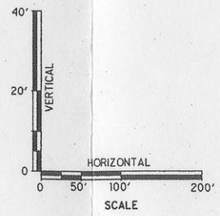
Kf = Field Parameter, cm/sec
KL = Laboratory Permeability, cm/sec (Recompact Sample)
DRI = Double Ring Infiltrometer Test, cm/sec



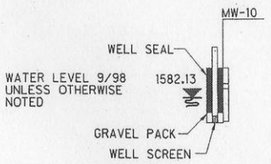
GEOLOGIC CROSS SECTION LOCATION MAP

LEGEND

- TOPSOIL
- LATE WISCONSIN TILL
- LOESS
- FINE OUTWASH
- COARSE OUTWASH
- GEOLOGIC CONTACT
- INFERRED FACIES CHANGE AND HORIZONTAL EXTENT OF NON-CONTINUOUS STRATA IS DEPICTED WITH A JAGGED LINE TYPE
- GROUNDWATER TABLE - 9/25/98



WELL CONSTRUCTION DIAGRAM



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TITLE
GEOLOGIC CROSS SECTIONS
A-A' AND B-B'

SCALE AS SHOWN	STATE: WISCONSIN		COUNTY FOREST		
DRAWN BY JOW	DATE NOV.'98	CHECKED BY REM.	DATE NOV. '98		
APPROVED BY SAD2	DATE NOV.'98	APPROVED BY GWS	DATE NOV. '98		
APPROVED BY	DATE NOV.'98	NICOLET MINING COMPANY	DATE NOV. '98		
DRAWING NO. 4	SHEET 4 OF 10	REVISION NO.			

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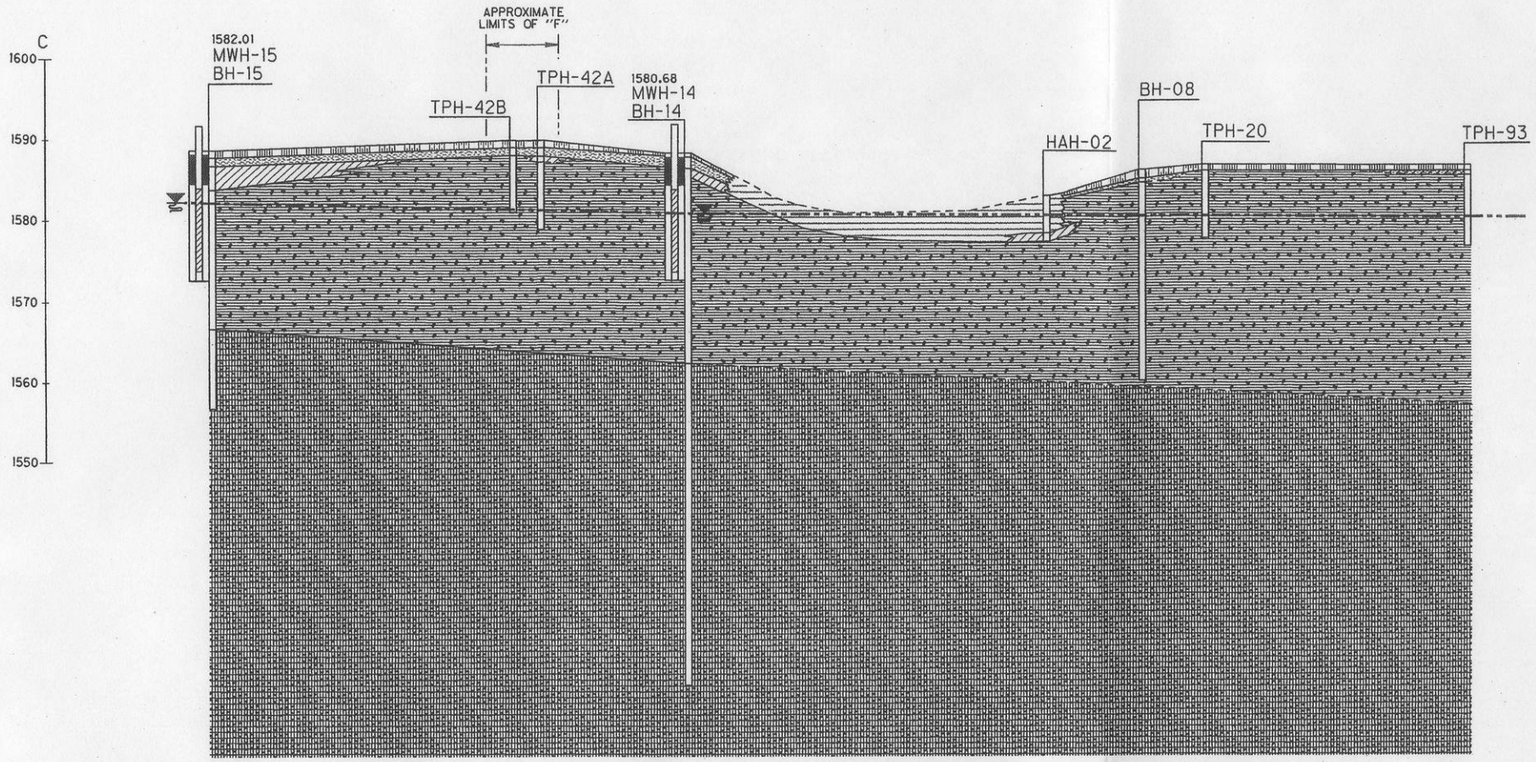
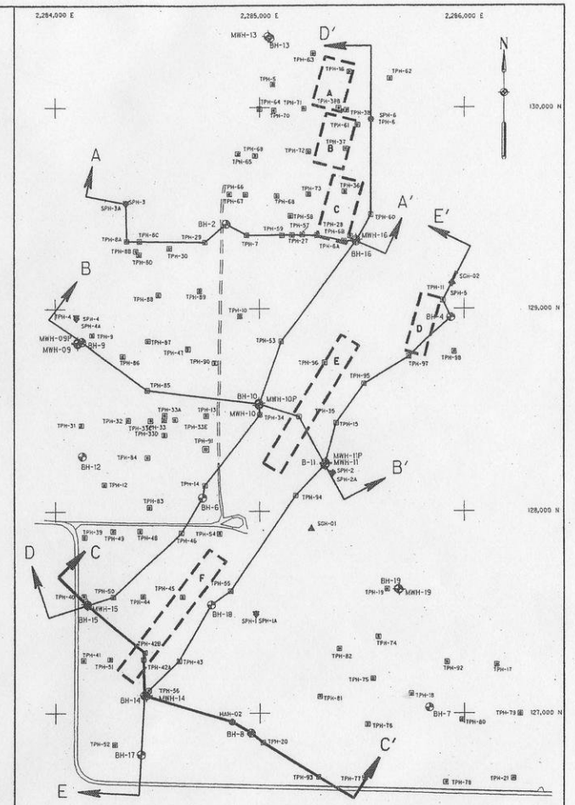
SECTION C - C''



Boring ID	Depth (ft)	% Gravel	% Sand	% Silt	% Clay	USCS	Other
BH-15	26-28	1.8	84.8	11.5	1.9	SM	--
BH-15	10-12	4.6	93.5	1.0	0.9	SP	--
MWH-15	--	--	--	--	--	SP	Kf = 1.5x10-2
TPH-42B	7.5	0.0	99.8	0.0	0.2	SP	DRI = 5.6x10-2
MWH-14	--	--	--	--	--	SP	Kf = 1.5x10-2
BH-08	14-16	0.2	98.0	0.9	0.9	SP	--
BH-14	8-10	10.2	88.1	1.1	0.6	SP	--
BH-14	36-38	2.6	96.7	0.5	0.2	SP	--
BH-14	64-66	2.4	85.5	9.5	2.6	SM	--

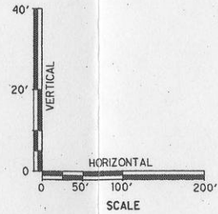
Kf = Field Parameter, cm/sec
KL = Laboratory Permeability, cm/sec (Recompact Sample)
DRI = Double Ring Infiltrometer Test, cm/sec



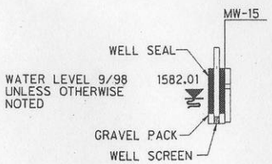
GEOLOGIC CROSS SECTION LOCATION MAP

LEGEND

- PEAT
- TOPSOIL
- LATE WISCONSIN TILL
- LOESS
- FINE OUTWASH
- COARSE OUTWASH
- GEOLOGIC CONTACT
- INFERRED FACIES CHANGE AND HORIZONTAL EXTENT OF NON-CONTINUOUS STRATA IS DEPICTED WITH A JAGGED LINE TYPE
- GROUNDWATER TABLE - 9/25/98



WELL CONSTRUCTION DIAGRAM



Foth & Van Dyke

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TITLE

GEOLOGIC CROSS SECTION C-C'

SCALE: AS SHOWN	STATE: WISCONSIN		COUNTY: FOREST		
DRAWN BY: JOW	DATE: NOV.'98	CHECKED BY: REM	DATE: NOV. '98		
APPROVED BY: SAD2	DATE: NOV.'98	APPROVED BY: GWS	DATE: NOV. '98		
APPROVED BY:	DATE: NOV.'98	NICOLET MINING COMPANY	DATE: NOV. '98		
DRAWING NO.: 5	SHEET 5 OF 10	REVISION NO.			

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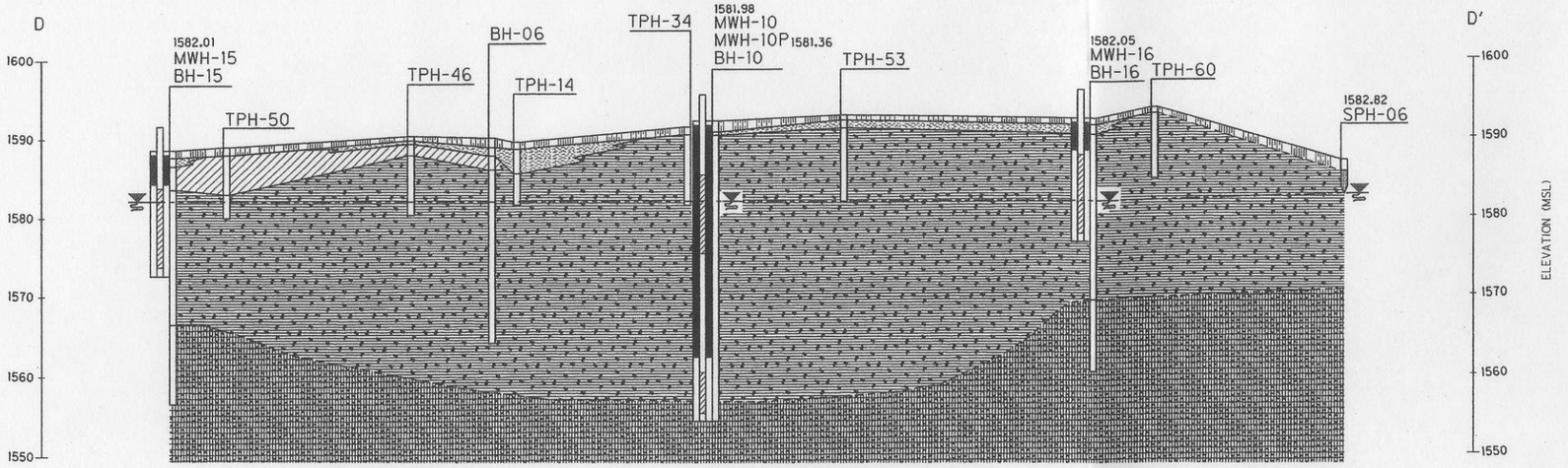
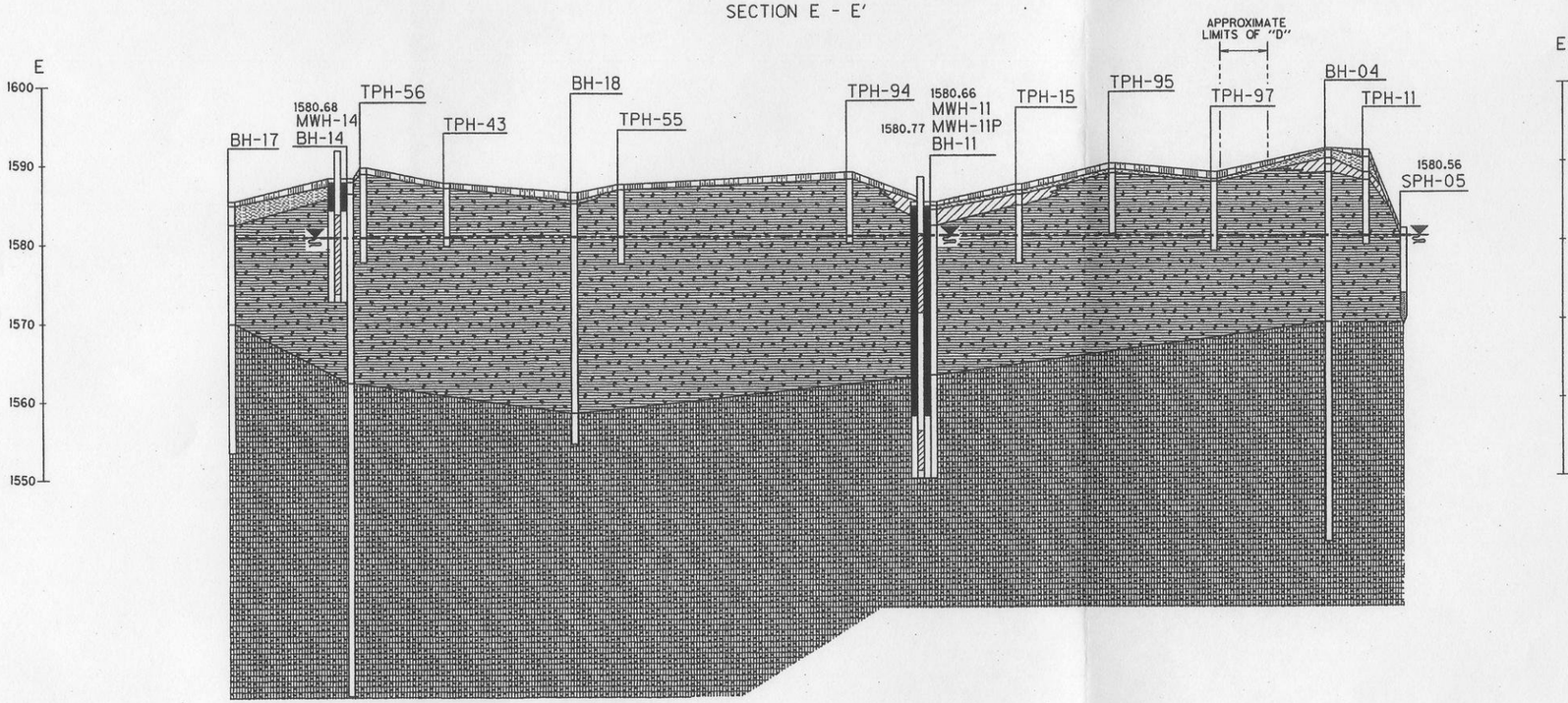
SECTION D - D'



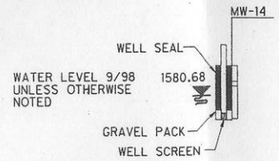
SECTION E - E'

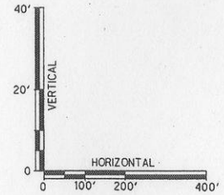


Boring ID	Depth (ft)		% Gravel	% Sand	% Silt	% Clay	USCS	Other
MWH-15	--	--	--	--	--	--		Kf = 1.5x10-2
BH-15	26-28		1.8	84.8	11.5	1.9	SM	--
BH-15	10-12		4.6	93.5	1.0	0.9	SP	--
BH-06	12-14		4.3	92.7	0.7	2.3	SP	--
MWH-10	--	--	--	--	--	--		Kf = 4.1x10-3
MWH-10P	--	--	--	--	--	--		Kf = 1.9x10-2
BH-10	14-16		8.9	88.5	1.6	1.0	SP	KL = 1.8x10-2
TPH-53	--	--	--	--	--	--		DRI = 1.1x10-2
MWH-16	--	--	--	--	--	--		Kf = 5.5x10-3
BH-16	10-12		2.5	96.5	0.8	0.2	SP	--
MWH-14	--	--	--	--	--	--		Kf = 1.5x10-2
BH-14	8-10		10.2	88.1	1.1	0.6	SP	--
TPH-43	3.3		1.7	97.7	0.0	0.6	SP	--
TPH-94	2.6		0.4	98.9	0.3	0.4	SP	--
MWH-11	10-12		43.2	55.0	1.3	0.5	SP	Kf = 1.8x10-2, KL = 2.2x10-2
MWH-11P	32-34		0.0	98.3	0.9	0.8	SP	Kf = 3.7x10-2
TPH-15	5.0		0.3	99.2	0.3	0.2	SP	--
TPH-97	1.9		15.9	83.1	0.4	0.6	SP	--
BH-04	6-8		30.7	67.5	0.4	1.4	SP	--
BH-14	36-38		2.6	96.7	0.5	0.2	SP	--
BH-14	64-66		2.4	85.5	9.5	2.6	SM	--

Kf = Field Parameter, cm/sec
KL = Laboratory Permeability, cm/sec (Recompact Sample)
DRI = Double Ring Infiltrometer Test, cm/sec

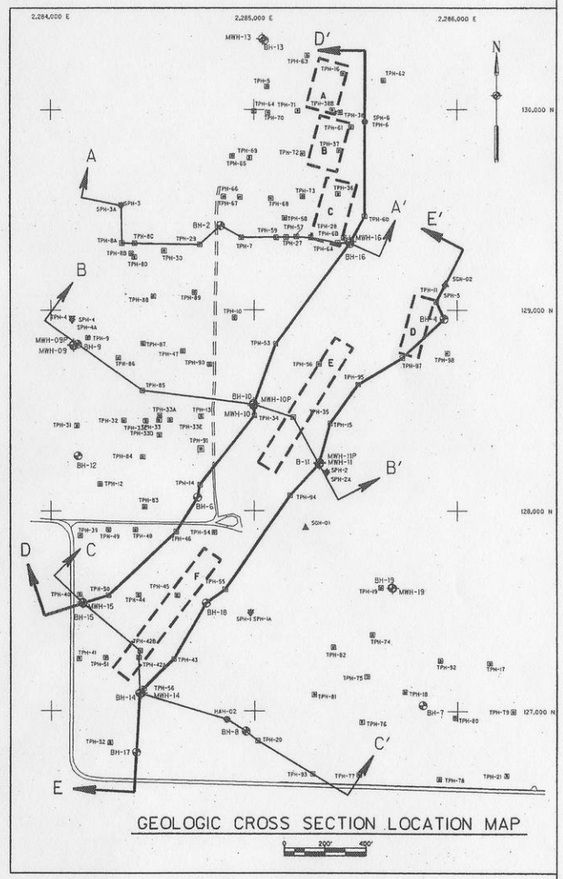
WELL CONSTRUCTION DIAGRAM





LEGEND

- TOPSOIL
- LATE WISCONSIN TILL
- LOESS
- FINE OUTWASH
- COARSE OUTWASH
- GEOLOGIC CONTACT
- INFERRED FACIES CHANGE AND HORIZONTAL EXTENT OF NON-CONTINUOUS STRATA IS DEPICTED WITH A JAGGED LINE TYPE
- GROUNDWATER TABLE - 9/25/98



GEOLOGIC CROSS SECTION LOCATION MAP

0 200' 400'

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

REUSE OF DOCUMENTS

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Nicolet Minerals COMPANY

Mining for the Future • Commitment

TITLE

GEOLOGIC CROSS SECTIONS
D-D' AND E-E'

SCALE: AS SHOWN	STATE: WISCONSIN	COUNTY: FOREST	
DRAWN BY: JOW	DATE: NOV. '98	CHECKED BY: REM	DATE: NOV. '98
APPROVED BY: SAD2	DATE: NOV. '98	APPROVED BY: GWS	DATE: NOV. '98
APPROVED BY:	DATE: NOV. '98	NICOLET MINING COMPANY	DATE: NOV. '98
DRAWING NO.: 6	SHEET 6 OF 10		REVISION NO.

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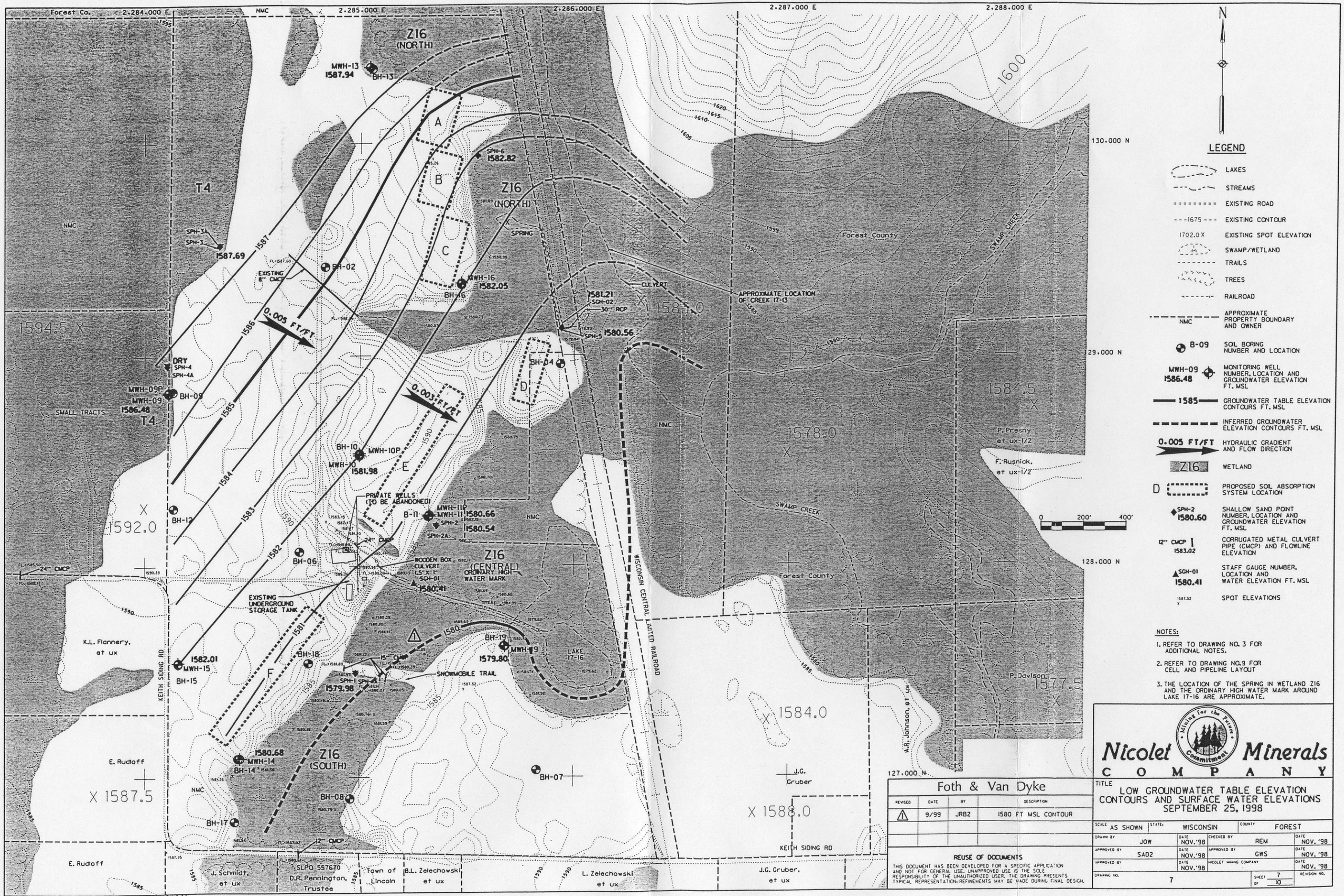

NOTES:

1. REFER TO DRAWING NO. 3 FOR ADDITIONAL NOTES.
2. REFER TO DRAWING NO.9 FOR CELL AND PIPELINE LAYOUT
3. THE LOCATION OF THE SPRING IN WETLAND Z16 AND THE ORDINARY HIGH WATER MARK AROUND LAKE 17-16 ARE APPROXIMATE.

Nicolet Minerals COMPANY

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	9/99	JRB2	1580 FT MSL CONTOUR

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TITLE

LOW GROUNDWATER TABLE ELEVATION CONTOURS AND SURFACE WATER ELEVATIONS SEPTEMBER 25, 1998

SCALE AS SHOWN	STATE: WISCONSIN	COUNTY: FOREST	
DRAWN BY: JOW	DATE: NOV. '98	CHECKED BY: REM	DATE: NOV. '98
APPROVED BY: SAD2	DATE: NOV. '98	APPROVED BY: GWS	DATE: NOV. '98
APPROVED BY:	DATE: NOV. '98	NICOLET MINING COMPANY	DATE: NOV. '98
DRAWING NO. 7	SHEET 7 OF 10		REVISION NO.

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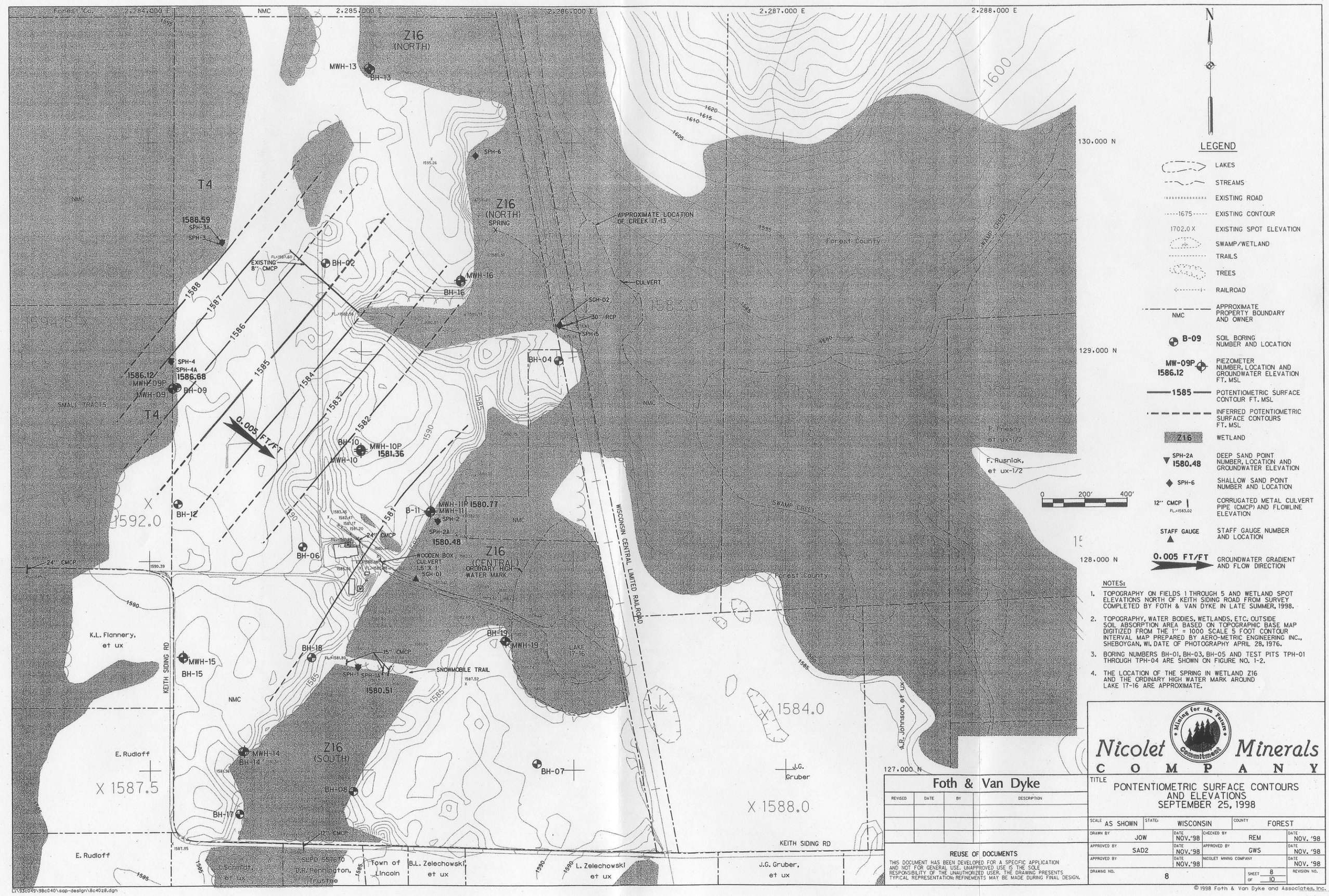

NOTES:

1. TOPOGRAPHY ON FIELDS 1 THROUGH 5 AND WETLAND SPOT ELEVATIONS NORTH OF KEITH SIDING ROAD FROM SURVEY COMPLETED BY FOTH & VAN DYKE IN LATE SUMMER, 1998.
2. TOPOGRAPHY, WATER BODIES, WETLANDS, ETC. OUTSIDE SOIL ABSORPTION AREA BASED ON TOPOGRAPHIC BASE MAP DIGITIZED FROM THE 1" = 1000 SCALE 5 FOOT CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING INC., SHEBOYGAN, WI. DATE OF PHOTOGRAPHY APRIL 28, 1976.
3. BORING NUMBERS BH-01, BH-03, BH-05 AND TEST PITS TPH-01 THROUGH TPH-04 ARE SHOWN ON FIGURE NO. 1-2.
4. THE LOCATION OF THE SPRING IN WETLAND Z16 AND THE ORDINARY HIGH WATER MARK AROUND LAKE 17-16 ARE APPROXIMATE.

Nicolet Minerals COMPANY

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

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TITLE: PONTENTIOMETRIC SURFACE CONTOURS AND ELEVATIONS SEPTEMBER 25, 1998

SCALE: AS SHOWN	STATE: WISCONSIN		COUNTY: FOREST		
DRAWN BY: JOW	DATE: NOV.'98	CHECKED BY: REM	DATE: NOV. '98		
APPROVED BY: SAD2	DATE: NOV.'98	APPROVED BY: GWS	DATE: NOV. '98		
APPROVED BY	DATE: NOV.'98	NICOLET MINING COMPANY	DATE: NOV. '98		
DRAWING NO.: 8	SHEET 8 OF 10	REVISION NO.			

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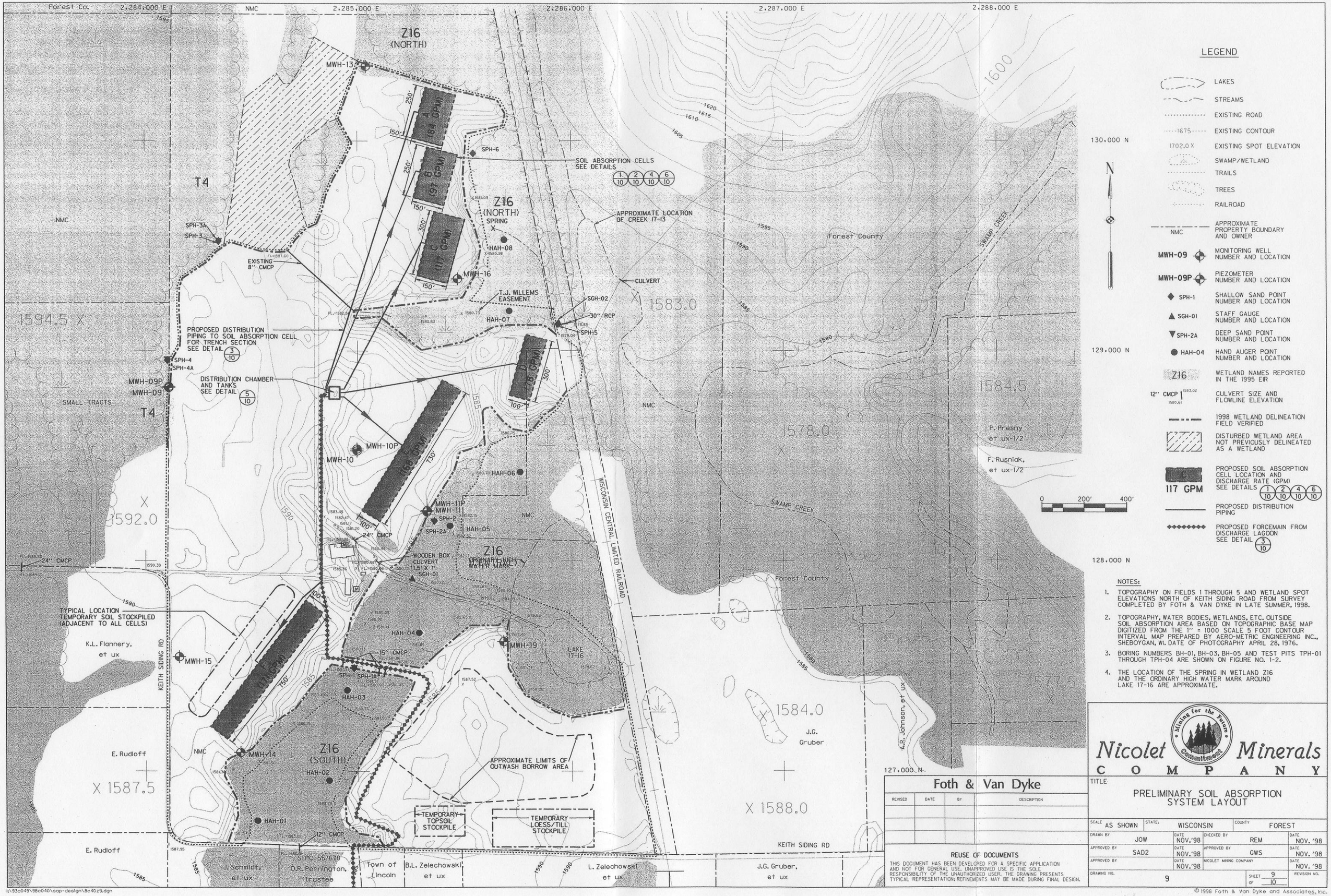

NOTES:

1. TOPOGRAPHY ON FIELDS 1 THROUGH 5 AND WETLAND SPOT ELEVATIONS NORTH OF KEITH SIDING ROAD FROM SURVEY COMPLETED BY FOTH & VAN DYKE IN LATE SUMMER, 1998.
2. TOPOGRAPHY, WATER BODIES, WETLANDS, ETC. OUTSIDE SOIL ABSORPTION AREA BASED ON TOPOGRAPHIC BASE MAP DIGITIZED FROM THE 1" = 1000 SCALE 5 FOOT CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING INC., SHEBOYGAN, WI. DATE OF PHOTOGRAPHY APRIL 28, 1976.
3. BORING NUMBERS BH-01, BH-03, BH-05 AND TEST PITS TPH-01 THROUGH TPH-04 ARE SHOWN ON FIGURE NO. 1-2.
4. THE LOCATION OF THE SPRING IN WETLAND Z16 AND THE ORDINARY HIGH WATER MARK AROUND LAKE 17-16 ARE APPROXIMATE.

Nicolet Minerals COMPANY

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

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TITLE

PRELIMINARY SOIL ABSORPTION SYSTEM LAYOUT

SCALE AS SHOWN	STATE: WISCONSIN		COUNTY FOREST		
DRAWN BY JOW	DATE NOV. '98	CHECKED BY REM	DATE NOV. '98		
APPROVED BY SAD2	DATE NOV. '98	APPROVED BY GWS	DATE NOV. '98		
APPROVED BY	DATE NOV. '98	NICOLET MINING COMPANY	DATE NOV. '98		
DRAWING NO. 9	SHEET 9 OF 10	REVISION NO.			

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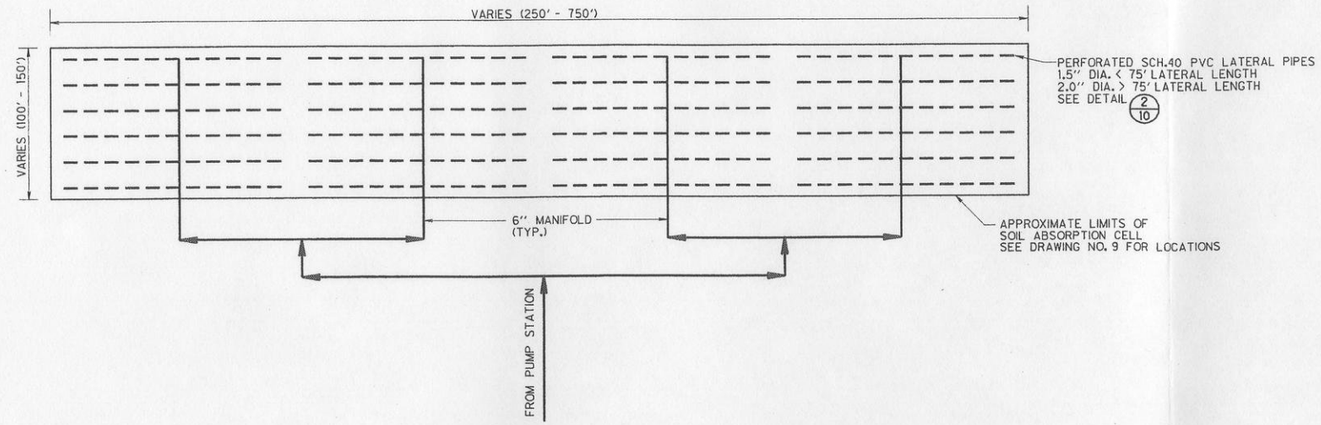
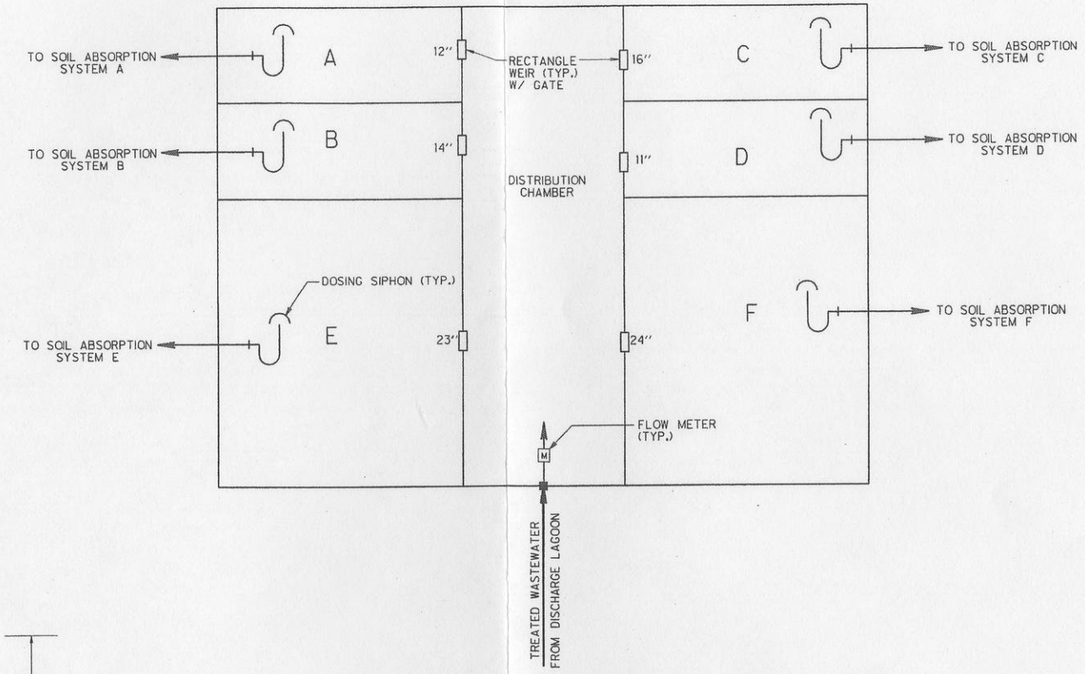


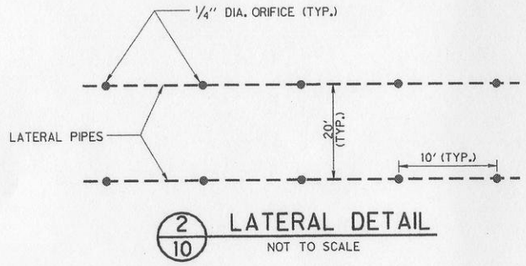
1/10 SOIL ABSORPTION SYSTEM - PLAN SECTION

NOT TO SCALE



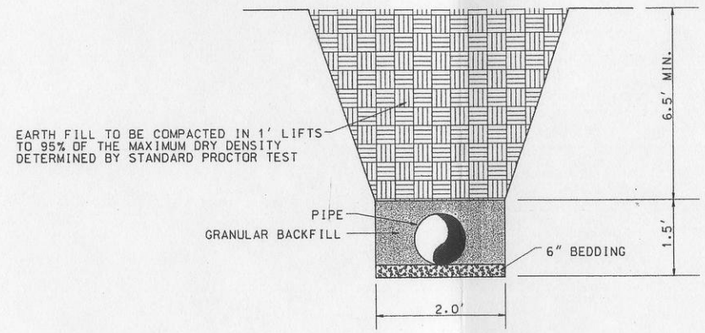
5/10 DISTRIBUTION CHAMBER AND TANKS

NOT TO SCALE



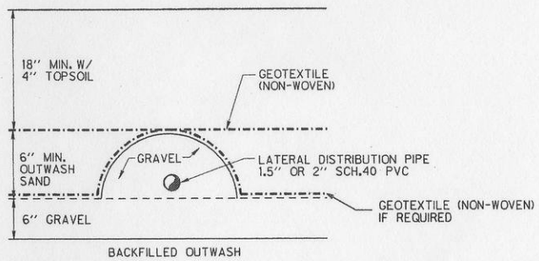
2/10 LATERAL DETAIL

NOT TO SCALE



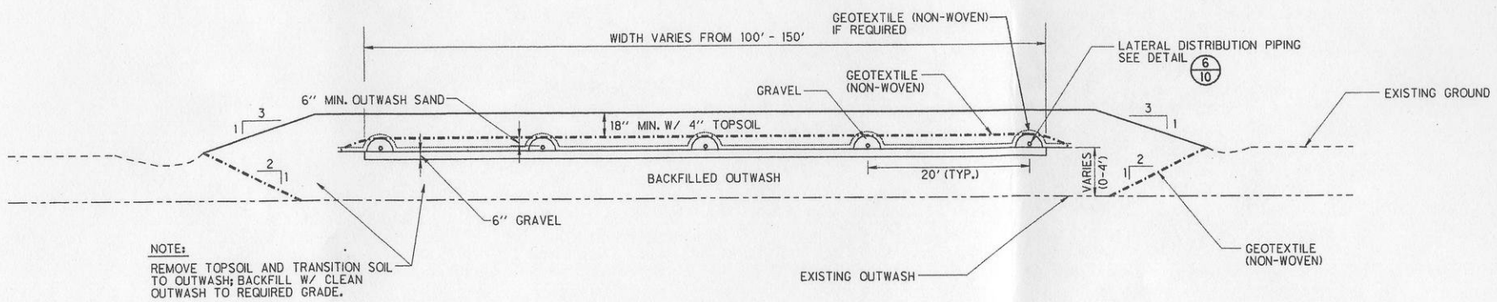
3/10 TYPICAL TRENCH SECTION - BURIED PIPELINES

NOT TO SCALE



6/10 LATERAL DISTRIBUTION PIPING DETAIL

NOT TO SCALE



4/10 SOIL ABSORPTION SYSTEM - TYPICAL SECTION

NOT TO SCALE

Nicolet Minerals COMPANY

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

TITLE: DETAILS

SCALE: AS SHOWN	STATE: WISCONSIN		COUNTY: FOREST		
DRAWN BY: JOW	DATE: NOV.'98	CHECKED BY: REM	DATE: NOV. '98		
APPROVED BY: SAD2	DATE: NOV.'98	APPROVED BY: GWS	DATE: NOV. '98		
APPROVED BY:	DATE: NOV.'98	NICOLET MINING COMPANY	DATE: NOV. '98		
DRAWING NO.: 10	SHEET: 10 OF 10	REVISION NO.			

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Appendix A

Test Pit Logs

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-1

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	072198	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 54"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
NE¼, T35N R13E, Section 20			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Materials	Cementation, Ce Compaction, Cp
1 (A)	0-3	10YR4/3	-	sil	1msbk	d-mvfr	1f-c	as	loess	none
2 (E/B)	3-6	10YR6/2	-	sl	1msbk	d-mvfr	1f-c	cs	loess	none
3 (B)	6-17	10YR6/4	-	sl-sil	0-1fgr	d-mvfr	1f-c	cs	loess	none
4 (2C)	17-72+	10YR6/4	> 54" ccd 10YR5/8	m-cos	0-1csbk → sg	mvfr → ml	0-1f → 0	-	outwash	none

Remarks:

a. Pit extended to approximately 7', soil similar to that encountered in horizon 4. b. Soil saturated below 6½'.

c. Horizon 4 contains few thin (< ½" thick) discontinuous 7.5YR4/4 fsl strata between 17-34".

d. Horizon 4 becomes gleyed (color → 10YR7/1-2) below 67".

Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

10/4/98
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-2

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	072198	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 46"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
NE¼, T35N R13E, Section 20			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Materials	Cementation, Ce Compaction, Cp
1 (A)	0-8	10YR3/1	-	sl	2f-mgr	d-mvfr	3f,1mc	as	loess	none
2 (B1)	8-16	10YR5/4	-	sil	1f-csbk	d-mvfr	0-1f	cs	loess	none
3 (B2)	16-28	7.5YR5/3 (v)	-	sl	0-1m-csbk	d-mvfr	0	cw	loess	none
4 (2C)	28-60+	10YR6/4	> 46" see remarks	m-cos → ms	0-1csbk → sg	mvfr → ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 8', soil similar to that encountered in horizon 4. b. Soil saturated below 7'.

c. Horizon 4 contains few thin (< 3" thick) layers of grcos and fs.

d. Horizon 4 contains ccd → mcd 10YR5/6 mottling below 46". Color of horizon → 10YR6/3 below 46".

Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

10/14/98
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-3

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	072198	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 84"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
NE¼, T35N R13E, Section 20			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Materials	Cementation, Ce Compaction, Cp
1 (A)	0-4	10YR3/1	-	sl	2mgr	d-mfr	2f,1mc	aw	loess	none
2 (E)	4-6	10YR7/1-2	-	sl-sil	2cgr	d-mfr	0-1f	aw	loess	none
3 (B2)	6-19	10YR5/6	-	sl-sil	0-1vfgr	d-mfr	1f	cs	loess	none
4 (B3)	19-24	7.5YR4/6	-	sl	1msbk	mvfr	0-1f	cs	loess	none
5 (2C1)	24-72+	10YR5/4 (v)	-	f-ms	0-1csbk → sg	mvfr-ml	0-1f-c	-	outwash	none
5 (2C1)	72-84	10YR5/4 (v)	-	f-ms	sg	ml	0	cs	outwash	none
6 (2C2)	84-96	10YR5/3	ccd 7.5YR5/6	cos	sg	w-ml	0	cs	outwash	none
7 (2C3)	96-120+	10YR5/4	-	mf	sg	w-ml	0	-	outwash	

Remarks:

a. Pit extended to approximately 10', soil as described above. b. Soil saturated below 9'.

c. Horizon 5 contains few thin (< 4" thick) discontinuous grscl-sl strata (sandy till?).

Limiting Factors/Depth

John E. Thresher, Jr., CST No. 228796

10/4/98
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-4

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	072198	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 61"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
NE¼, T35N R13E, Section 20			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Materials	Cementation, Ce Compaction, Cp
1 (A)	0-5	10YR2/1	-	sl	1vfgr	mvfr	3f,1mc	aw	loess	none
2 (E)	5-8	5YR7/1	-	sil	1vfgr	d-mvfr	0-1f	ai	loess	none
3 (B2hs)	8-13	5YR4/4	-	sil	1mgr	mvfr	1f-c	cw	loess	none
4 (B2s)	13-21	10YR5/4	-	sl	2msbk	mfr	1f-c	cs	loess	none
5 (B3)	21-33	10YR6/6	-	lfs	0-1msbk	mvfr	1mc	cs	outwash	none
6 (2C)	33-70+	10YR6/4	> 61" see remarks	ms → fs	sg	ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 9', soil similar to that encountered in horizon 6. b. Soil saturated below 8'.

c. Horizon 6 contains few thin (< ¼" thick) discontinuous 7.5YR5/4 fsl strata.

d. Horizon 6 also contains ccp 5YR3/4-4/6 banded mottles below 61". Color of horizon → 10YR5/4 below 64".

Limiting Factors/Depth

John E. Thresher, Jr., CST No. 229796

10/4/98
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-5

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	073098	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 84"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description		**System Geometry and Depth**	
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR4/1	-	sil	1mgr	d-mvfr	2f	as	loess	none
2 (B21)	9-17	10YR4/6	-	sil	2msbk	d-mvfr	0-1f	as	loess	none
3 (B22)	17-24	7.5YR4/6	-	sl	2msbk	d-mvfr	0-1f	aw	sandy till	none
4 (2C1)	24-49	10YR4/6-5/6	-	m-cos	1csbk	mvfr	0	aw	outwash	none
5 (2C2)	49-64+	10YR6/4	-	m-cos	0-1csbk	mvfr	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10', soil similar to that encountered in horizon 5. b. Soil saturated below 8'.

c. Collected grab sample at 10'.

d. Horizon 4 contains few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata and few thin (<1" thick) 7.5YR5/6 vcos+gr seams.

prob. seasonal sat'n > 84"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

092898
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-6A

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	073098	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 120"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR5/3	-	sil	2mgr	d-mvfr	1f	as	loess	none
2 (B21)	10-14	10YR6/3	-	sil	2f-msbk	d-mfr	0-1f	as	loess	none
3 (2B22)	14-24	7.5YR4/4	-	scl-sl	2msbk	mfi	0-1f	aw	till	partially Ce/Cp
4 (3C1)	24-47	10YR4/4	-	m-cos	0-1csbk	mvfr	0	aw	outwash	none
5 (3C2)	47-64+	10YR6/4	-	ms	1csbk	mfr	0	-	outwash	none
5 (3C2)	64-96	10YR6/4	-	ms	0-1csbk	mvfr	0	cs	outwash	none
6 (3C3)	96-156+	10YR6/4	-	vcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 13', soil changes as noted above. b. Soil saturated below 11'.

c. Portions of horizon 3 are partially cemented/compacted.

prob. seasonal sat'n > 120"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

092898
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-6B

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082898	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 84"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR4/2-3	-	sil-sl	2m-csbk	mfr	2f,1mc	as	loess	none
2 (B)	9-15	10YR5/3-4	-	sil-sl	2f-msbk	mfr	1f	cw	loess	none
3 (2C1)	15-48+	10YR6/6 (v)	> 84" see remarks	m-cos	1csbk	mvfr	0-1f	-	outwash	none
3 (2C1)	48-96	10YR6/6 (v)	see remarks	m-cos	1csbk → sg	mvfr → ml	0	cs	outwash	none
4 (2C2)	96-108+	10YR5/4	-	grvcos	sg	w-ml	0	-	outwash	none

D-100

Remarks:

a. Pit extended to approximately 9', soil similar to that encountered in horizon 3. b. Soil saturated below 8'.

c. Horizon 3 contains few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata and very few thin 1" thick) grvcos seams.

d. Horizon 3 also contains ccd 7.5YR5/6 banded mottling above the waster table.

e. Pit was constructed to conduct a double-ring infiltrometer test. The tested infiltration surface was at 24". Grab samples were collected at the infiltration surface beneath the rings, and at 2' and 4' north and south of the rings. Additional grab samples were collected at depths of 1½', 3' and 4½' beneath the infiltration surface.

prob. seasonal sat'n > 84"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

092898
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-7

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	073098	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 120"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR5/3	-	sil-sl	2mgr-sbk	d-mfr	1f	as	loess	none
2 (2B21)	10-14	5YR4/4	-	sl	2mgr	d-mvfr	0-1f	as	outwash	none
3 (2B22)	14-28	7.5YR5/6-8	-	m-cos	2msbk	mvfr	0	cs	outwash	none
4 (2C)	28-78+	10YR5/4-6/4	-	m-cos	1msbk	mvfr	0	-	outwash	none
4 (2C)	78-168+	10YR5/4-6/4	> 120" see remarks	m-cos	1msbk	w-mvfr	0	-	outwash	none

D-101

Remarks:

a. Pit extended to approximately 14', soil similar to that encountered in horizon 4. b. Soil saturated below 11'.

c. Horizon contains ccd 7.5YR5/6-8 banded mottling above the water table.

prob. seasonal sat'n > 120"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-8A

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	073198	alfalfa	fill over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 40"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-6	10YR3/2	-	sil-sl	2msbk	d-mvfr	2f	as	fill	
2 (B1)	6-12	10YR5/2	-	sl	0-1fgr	d-mvfr	0-1f	as	fill	
3 (B2)	12-20	2.5Y7/6	-	sl	2msbk	mfr-mfi	0-1f	aw	fill	partially Ce/Cp
4 (B3)	20-59	2.5Y7/6	> 40" see remarks	sl	sg	ml	0	aw	fill	
5 (2Eb)	59-72	2.5Y4/1-2		m-cos	sg	w-ml	0	as	outwash	
6 (2Bhsb)	72-74	10YR2/1		m-cos	3csbk	w-mvfi	0	cs	outwash	strongly Ce
7 (2Bsb)	74-86+	7.5YR5/4		m-cos	1csbk	w-mfr	0	-	outwash	

Remarks:

a. Description is for profile on north wall of pit. Soil on the south side of the pit is similar to that encountered in TPE-8B.

b. Horizon 3 contains ffd 7.5YR5/8 intrapedal mottles. Portions of horizon 3 are partially cemented/compacted.

c. Horizon 4 contains ccp → mcp 5YR5/8-7/5YR5/8 and vfvfp 5YR3/2 (accumulation) and ccp 10YR5/3 (depletion) mottles.

d. Pit was dug in an area where fill was used to cover a strongly developed aquod.

e. Horizons 5-7 appear to be saturated.

strongly cemented > 40"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

072898
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-8B

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	073198	alfalfa	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 54"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-8	10YR3/2	-	sil	2csbk	d-mvfr	2f	as	loess	none
2 (2AC)	8-56	7.5YR4/4	> 24", see remarks	sl-scl	0-1csbk	mfr-mfi	0-1f	cw	till	none
3 (3C)	56-64+	10YR5/4	?	m-cos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 9', soil similar to that encountered in horizon 3. b. Soil saturated below 5½'-6'.

c. Horizon 2 contains fmd 10YR4/6 → mcd 7.5YR4/6 and ffp → cfp 10YR3/1-2 (accumulation), and fmd 10YR6/2 → ccd 10YR6/2 (depletion) mottles.

d. Mottling in horizon 2 becomes banded below 50".

prob. seasonal sat'n > 54"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-8C

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082698	alfalfa	glacial sediments
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161			
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1	0-									
2										
3										
4										
5										
6										
7										

Remarks:

a. Pit was dug to prepare a platform for conducting a double-ring infiltrometer test. The soils were found to consist of fill materials and the pit was therefore abandoned and the test was moved to TPH-8D.

Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-8D

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082698	alfalfa	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161			
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1	0-									
2										
3										
4										
5										
6										
7										

Remarks:

a. An infiltration test using a double-ring infiltrometer was conducted in the upper part of the sandy soils in this test pit. At termination of the test the pit was extended and it was found that a large rafted till fragment (7.5YR4/4, scl, 1csbk, mfr), about 4-12" thick and 6' long, was located a few inches beneath the base of the infiltrometer. The upper surface of the till fragment slopes to the north. The relative moisture content of the sand surrounding, and beneath, the till fragment indicated that most of the infiltrating water migrated along the upper surface of the fragment and entered the underlying sand to the north of the fragment. It also appears that small portion of the infiltration percolated through the till fragment.

Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-9

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	073198	alfalfa	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 48"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR3/2	-	sil	2m-csbk	d-mfr	2f,1m	as	colluvial	none
2 (Ab)	10-10½±¼	10YR2/1	-	-	-	d-mfr	-	as	-	none
3 (Eb)	10½-13	10YR7/1-2	-	sl-sil	2f-msbk	d-mvfr	0-1f	cs	loess	none
4 (2B2b)	13-24	10YR5/4	-	sl-scl	2csbk	d-mfr-mfi	0-1f	cs	till	none
5 (3C1b)	24-33	10YR5/4 (v)	-	m-cos	1csbk	mvfr	0-1f	cs	outwash	none
6 (3C2b)	33-54+	10YR5/3	> 44" see remarks	m-cos	1csbk	w-mvfr	0	-	outwash	none

Remarks:

a. Pit extended to approximately 8', soil similar to that encountered in horizon 6.

b. Soil is wet to saturated below 5'.

c. Horizon 4 contains cmd 7.5YR4/6-5/8 textural mottling.

d. Horizon 6 contains ccd 7.5YR5/6-8 banded mottling above the water table.

prob. seasonal sat'n > 48"
Limiting Factors/Depth

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Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-10

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	073198	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 90"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-13	10YR4/2	-	sil	1m-csbk-gr	d-mfr	1-2f	as	loess	none
2 (2B)	13-21	7.5YR4/4 (v)	-	sl-ls	2msbk → 0-1msbk	d-mfi-mfr	0-1f	as	outwash	none
3 (2C)	21-60+	10YR6/4	-	m-cos	0-1csbk → sg	mfr → ml	0-1f	-	outwash	none
3 (2C)	60-120+	10YR6/4	> 84" see remarks	m-cos	sg	w-ml	0	-	outwash	none

D-107

Remarks:

a. Pit extended to approximately 10', soil similar to that encountered in horizon 3. b. Soil saturated below 8½'.

c. Horizon 3 contains fvcd 7.5YR4/6-5/8 root mottles.

d. Horizon 3 also contains cvcd 7.5YR5/6-8 banded mottling above the water table.

prob. seasonal sat'n > 84"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
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Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-11

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	073198	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 108"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-11	10YR4/1	-	sil	2f-mgr	d-mvfr	2f	as	loess	none
2 (B2)	11-33	10YR6/2-3	-	sl-sil	2f-msbk	d-mfi	0-1f	cw	loess	partially Ce/Cp
3 (2C1)	33-45	7.5YR4/6 (v)	-	sl	0-1csbk	mfr	1f-m	cw	till	partially Ce/Cp
4 (3C2)	45-64+	10YR6/4	-	m-cos	0-1csbk	mvfr	0	-	outwash	none

Remarks:

a. Pit extended to approximately 12', soil similar to that encountered in horizon 4. b. Soil saturated below 10'.

c. Horizon 2 contains fmd 10YR6/6 → fvcp 7.5YR3/4 textural mottles.

d. Portions of horizon 2 and 3 are partially cemented/compacted.

prob. seasonal sat'n > 108"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-12

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080398	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9½	10YR4/2	-	sil	2msbk	d-mfr	2f,1mc	as	loess	none
2 (B2)	9½-25±8	7.5YR5/4 (v)	-	sl-sil	1msbk	d-mvfr	0-1f	cw	loess	partially Ce/Cp
3 (2C1)	25-44	7.5YR4/6	-	m-vcos	0-1csbk	mvfr	0-1f-m	cs	outwash	none
4 (2C2)	44-64+	10YR5/4	-	m-cos	1csbk → sg	mfr → ml	0-1f	-	outwash	none

D-109

Remarks:

a. Pit extended to approximately 10', soil similar to that encountered in horizon 4. b. Soil saturated below 7'.

c. Collected grab sample at 6'.

d. Horizon 2 contains common thin (<1" thick) 10YR6/3 sil strata.

e. Portions of horizon 2 are partially cemented/compacted.

e. Horizons 3 and 4 contain vfcp 7.5YR5/8 root mottles.

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-13

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080398	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 78"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/2	-	sl-sil	1f-mgr	d-mvfr	2f-m	aw	loess	none
2 (B2)	10-19	7.5YR4/4 (v)	-	sil	2m-csbk	d-mfr	0-1f	cw	loess	none
3 (2C1)	19-29	7.5YR5/4	-	sl	0-1csbk	d-mvfr	0-1f	cs	sandy till	none
4 (2C2)	29-46	7.5YR4/4 (v)	-	sl-scl	2csbk	d-mfi-mvfi	0-1f	cs	till	none
5 (3C3)	46-66+	10YR6/4	-	m-cos	sg	ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil similar to that encountered in horizon 5. b. Soil saturated below 7½'.

c. Collected grab sample at 4½'.

prob. seasonal sat'n > 78"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-14

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080398	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-11	10YR3/2	-	sil	1fgr	d-mvfr	2f,1mc	as	loess	none
2 (B21)	11-23	10YR6/3	-	sil	1mgr-sbk	d-mvfr	1f-c	as	loess	partially Ce/Cp
3 (B22)	23-35	10YR6/3	-	ls	1mgr	mvfr	1f	cw	loess	none
4 (B3)	35-48	7.5YR4/4	-	sl-ls	1csbk	mfr	0-1f	cw	loess	partially Ce/Cp
5 (2C)	48-64+	10YR5/3	-	ms	0-1csbk	mvfr	0-1f	-	outwash	none
5 (2C)	64-96+	10YR5/3	> 72" see remarks	ms → m-cos	0-1csbk	w-mvfr	0	-	outwash	none

Remarks:

a. Pit extended to approximately 8', soil similar to that encountered in horizon 5. b. Soil saturated below 7'.

c. Collected grab sample at 6'.

d. Portions of horizons 2 and 4 are partially cemented/compacted.

e. Horizon 5 contains ccd 10YR5/8-6/8 banded mottling above the water table.

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-15

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080398	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 48"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/2-3		sil	1msbk	d-mvfr	2f,1m	as	loess	none
2 (B1)	10-12	10YR6/4		sil	1msbk	d-mvfr	1f	as	loess	none
3 (2B2)	12-32	7.5YR4/4 (v)		sl-scl	2mgr	mfr	1f	as	till	none
4 (3C)	32-48+	10YR6/4	> 38" see remarks	m-cos	1csbk	mvfr	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10', soil similar to that encountered in horizon 4. b. Soil saturated below 5'.

c. Collected grab samples at 3½' and 5'.

d. Horizon 4 contains ccd 7.5YR5/6-8 and ffp 2.5YR3/4-5YR3/4 banded mottles above the water table.

prob. seasonal sat'n > 48"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-16

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080398	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 132"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR4/2	-	sil	2csbk	d-mfr-mfi	2f	as	loess	none
2 (B2)	9-14	10YR5/6	-	sil	2msbk	d-mfi	0-1f	as	loess	partially Ce/Cp
3 (2C1)	14-30	7.5YR4/4 (v)	-	ms → grcos	sg	d-ml	0-1f	cs	outwash	none
4 (2C2)	30-41	7.5YR5/6	-	ms	1csbk	mfr	0	as	outwash	none
5 (2C3)	41-63+	10YR6/4	-	m-cos	0-1csbk	mvfr	0	-	outwash	none

D-113

Remarks:

a. Pit extended to approximately 13', soil similar to that encountered in horizon 5. b. Soil saturated below 12'.

c. Collected grab samples at 4½' and 8'.

d. Portions of horizon 2 are partially cemented/compacted.

e. Horizon 4 contains few thin (<¼" thick) very discontinuous 7.5YR4/4 fsl strata.

prob. seasonal sat'n > 132"
Limiting Factors/Depth

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608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-17

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080398	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 108"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/3	-	sil	2m-csbk	d-mfr	1-2f	as	loess	none
2 (B2)	10-21	10YR6/4	-	sl-sil	2mgr-sbk	d-mfr	0-1f	as	loess	none
3 (2C1)	21-34	7.5YR5/6	-	ms → cos	0-1msbk	d-mvfr	0-1f	as	outwash	none
4 (2C2)	34-72+	10YR6/4	-	m-cos	0-1csbk → sg	mvfr → ml	0-1f	-	outwash	none
4 (2C2)	72-96	10YR6/4	-	m-cos	sg	ml	0	cs	outwash	none
5 (2C3)	96-144+	10YR5/3	-	grcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 12', soil as described above. b. Soil saturated below 10'.

c. Collected grab sample at 5'.

d. Horizon 3 contains few thin (<¾" thick) discontinuous 7.5YR4/4 fsl strata.

e. Horizon 4 contains few thin (<¼" thick) very discontinuous 7.5YR4/4 fsl strata and few thin (<4" thick) vcos seams.

prob. seasonal sat'n > 108"
Limiting Factors/Depth

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Madison, WI 53705
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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-18

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080398	alfalfa	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 96"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR4/2	-	sil	2msbk	d-mfi	2f,1m	as	loess	partially Ce/Cp
2 (2B2)	9-27	10YR6/4	-	sl-ls	1mgr	d-mvfr	0-1f	cw	sandy till	partially Ce/Cp
3 (3C1)	27-46	7.5YR4/4	-	ms → fgr	sg → 1csbk	ml → mfr	0	as	outwash	none
4 (3C2)	46-74+	10YR6/4 (v)	-	m-cos	0-1csbk → sg	mvfr → ml	0	-	outwash	none
4 (3C2)	74-108	10YR6/4 (v)	> 102" see remarks	m-cos	sg	w-ml	0	cs	outwash	none
5 (3C3)	108-132+	10YR5/3	gleyed (?)	grcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil as described above. b. Soil saturated below 9'.

c. Collected grab sample of ms at 4' (finest grained material in the outwash).

d. Portions of horizons 1 and 2 are partially cemented/compacted.

e. Horizon 3 contains few thin (<¼" thick) discontinuous 7.5YR4/4 fsl strata.

f. Horizon 4 contains cvcd 7.5YR5/6-8 banded mottles above the gleyed horizon

prob. seasonal sat'n > 96"
Limiting Factors/Depth

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Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-19

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080498	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-8	10YR4/1-2	-	sil	2mgr-sbk	d-mfr	2f,1mc	as	loess	none
2 (2B2)	8-22	7.5YR4/4	-	sl → m-cos	2mgr → 1mgr	d-mfr → mvfr	0-1f	cw	outwash	partially Ce/Cp
3 (2C1)	22-64+	10YR6/4	-	m-cos	0-1csbk → sg	mvfr →ml	0-1f	-	outwash	none
3(2C1)	64-72	10YR6/4	-	m-cos	sg	ml	0	cs	outwash	none
4 (2C2)	72-132+	10YR5/3-4	> 78" see remarks	vcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil as described above. b. Soil saturated below 7'.

c. Collected grab sample at 4'.

d. Portions of horizon 2 are partially cemented/compacted.

e. Horizon 3 contains few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata and very few thin (<6" thick) grm-cos seams.

f. Horizon 4 contains cvcp 7.5YR5/8 banded mottles above the water table.

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Madison, WI 53705
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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-20

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080498	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 60"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/2	-	sil	2csbk	d-mfi	1f	as	loess	partially Ce/Cp
2 (2B2)	10-22	5YR4/6	-	grm-cos	2msbk → sg	d-mfr → ml	0-1f	cw	outwash	partially Ce/Cp
3 (2C)	22-54+	7.5YR5/4 → 10YR6/4	-	m-cos	0-1csbk → sg	mvfr → ml	0-1f-m	-	outwash	none
3 (2C)	54-108+	10YR6/4	> 66" see remarks	m-cos	sg	w-ml	0	-	outwash	none

D-117

Remarks:

a. Pit extended to approximately 9', soil as described above. b. Soil saturated below 6'.

c. Collected grab sample at 4'.

d. Portions of horizons 1 and 2 are partially cemented/compacted.

e. Horizon 3 contains ff-cd 7.5YR5/8 root mottles above 48", and few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata and few thin (<4" thick) grvcos seams.

f. Horizon 3 also contains ccd 7.5YR5/6-8 banded mottling above the water table.

prob. seasonal sat'n > 60"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-21

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080498	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 90"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR4/2	-	sil	2f-msbk	d-mfr	2f,1mc	as	loess	partially Ce/Cp
2 (B2)	9-15	10YR6/4	-	sil	2msbk	d-mfi	0-1f	cw	loess	partially Ce/Cp
3 (2B31)	15-20	7.5YR5/4	-	grvcos	1msbk	d-mfr	0-1f	cs	outwash	partially Ce/Cp
4 (2B32)	20-35	10YR5/4	-	ls-ms	2msbk → 0-1msbk	mfr → mvfr	0-1f	cw	outwash	none
5 (2C1)	35-63+	10YR6/4	-	ms	1csbk	mvfr	0	-	outwash	none
5 (2C1)	63-84	10YR6/4	-	ms	0-1csbk	mvfr	0	cs	outwash	none
6 (2C2)	84-132+	10YR6/4	> 96" see remarks	m-cos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil as described above. b. Soil saturated below 8½'.

c. Collected grab samples at 4' and 9'. d. Portions of horizons 1-3 are partially cemented/compacted.

e. Horizon 4 contains few thin (<½" thick) very discontinuous 7.5YR4/4 strata.

f. Horizon 6 contains fvcd 7.5YR5/6 banded mottles above the water table.

prob. seasonal sat'n > 90"
Limiting Factors/Depth

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Madison, WI 53705
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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-22

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080498	potatoes	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 0.0"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
NW¼, T35N R13E, Section 20			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-5	10YR3/2	ffp 2.5YR3/6	sl-sil	1f-mgr	mvfr	1f-m	aw	loess	none
2 (A)	5-10	10YR3/1	cfp 2.5YR3/4-6	sl	2mgr	mvfr	0-1f	aw	loess	none
3 (2B2)	10-14	10YR4/4	ccp 7.5YR4/1-2 + ccp 7.5YR4/6	scl	1csbk	mfr-mfi	0-1f	aw	till	none
4 (3C1)	14-22	7.5YR5/3	fcd 7.5YR4/6	m-cos	1msbk	w-ml	0	cs	outwash	none
5 (3C2)	22-40+	10YR5/3-4	fcp 7.5YR4/6	m-cos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 7', soil similar to that encountered in horizon 5. b. Soil saturated below 3'.

c. Collected grab sample at 3'.

prob. seasonal sat'n at 0"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-23

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080498	potatoes	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 15"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
NW¼, T35N R13E, Section 20			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-15±5	10YR3/2-3	?	sil-sl	1f-cgr	mvfr	2f,1mc	ai	fill	none
2 (Eb)	15-19±4	7.5YR5/2-6/2	fmp 5YR4/4	ms	0-1mgr	mvfr	0-1f	ai	outwash	none
3 (B2hsb)	19-22±3	2.5YR2.5/4	?	m-cos	2msbk	mfi	0-1f	cw	outwash	partially Ce/Cp
4 (B2sb)	22-30±3	7.5YR3/4	fmp 5YR3/4	m-cos	1msbk	mfr	0-1f	cs	outwash	none
5 (B3)	30-36	7.5YR5/3	cmd 7.5YR5/8	ms	1msbk	mfr	0	cs	outwash	none
6 (C1)	36-42	10YR5/6	mvcd 7.5YR4/6	m-cos	0-1msbk	w-mvfr	0	cs	outwash	none
7 (C2)	42-74+	10YR4/2-5/2	gleyed	m-cos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 7', soil similar to that encountered in horizon 7. b. Soil saturated below 40".

c. Collected grab sample at 6'.

d. Portions of horizon 3 are partially cemented/compacted.

e. Horizons 4 and 5 contain vfvcp 2.5YR2.5/2-3 root mottles.

prob. seasonal sat'n > 15"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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2828 Regent St.
Madison, WI 53705
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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-24

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080498	potatoes	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 0" (?)	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
NW¼, T35N R13E, Section 20			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-11	10YR3/3	ffp 5YR4/4 (?)	sl	2csbk	mfr	0-1f	as	fill	none
2 (B2)	11-17	10YR6/4	cmd 7.5YR4/4	sil-sl	2msbk	mvfr	0	as	loess	none
3 (2C1)	17-43	7.5YR5/3	see remarks	m-cos	1m-csbk	mfr	0	cs	outwash	none
4 (2C2)	43-46+	5YR3/1-4/1 (v)	gleyed	m-cos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 6', soil similar to that encountered in horizon 4. b. Soil saturated below 5'.

c. Horizon 1 mottling may be an inherited feature of the fill material.

d. Horizon 2 contains a few thin (<½" thick) sections of a 10YR6/1 Eb horizon.

e. Horizon 3 contains cvcd 5YR4/4 banded mottling above the gleyed horizon.

prob. seasonal sat'n > 0"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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2828 Regent St.
Madison, WI 53705
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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-25

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080498	potatoes	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 13"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
NW¼, T35N R13E, Section 20			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9±3	10YR3/3	-	sl	2msbk	mfr	2f,1mc	ai	fill	none
2 (B21)	9-20	10YR5/4	> 13" cmd 7.5YR5/8 + ccp 7.5YR6/1	sil-sl	2msbk	mfr	0-1f	cs	loess	none
3 (B22)	20-25	7.5YR4/4	cmd 7.5YR5/8 ccp 7.5YR6/1-2	sil-sl	1msbk	mfr	0	cs	loess	none
4 (2C1)	25-43	7.5YR5/6	see remarks	m-cos	1csbk	mfr	0	cs	outwash	none
5 (2C2)	43-48+	10YR5/2	gleyed	m-cos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 8', soil similar to that encountered in horizon 5. b. Soil saturated below 4'.

c. Horizon 4 contains cvcp 5YR4/6 banded mottling above the gleyed horizon.

prob. seasonal sat'n > 13"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-26

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080498	potatoes	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 35"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
NW¼, T35N R13E, Section 20			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (A)	0-32±4	none	-	var.	var.	var.	yes	ai	fill	none
2 (Eb)	32-35	10YR5/1-2	-	m-cos	1msbk	w-mfr-mfi	0	cs	outwash	none
3 (2B2hb)	35-45	10YR4/2	gleyed (?)	m-cos	2csbk	w-mfr	0	cw	outwash	none
4 (2C1b)	45-59±12	2.5Y5/1-2	gleyed	m-cos	1msbk	w-mfr	0	cvw	outwash	none
5 (2C2b)	59-96+	2.5Y4/2	gleyed	m-cos	1msbk	w-mfr	0	-	outwash	none

Remarks:

a. Pit extended to approximately 8', soil similar to that encountered in horizon 5. b. Soil saturated below 4'.

c. Pit was dug in a low area that was partially filled with trees and soil during land clearing. Soils contain a strong H_2S odor.

prob. seasonal sat'n > 35"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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2828 Regent St.
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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-27

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080498	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/2	-	sl	1mgr-sbk	d-mvfr	1f-m	as	loess	none
2 (B2)	10-23	10YR6/4	-	sl	1csbk	d-mfr	0-1f	cs	loess	partially Ce/Cp
3 (2C1)	23-53	10YR5/4 (v)	-	mixed	1m-csbk	mfr	0	cs	outwash	none
4 (2C2)	53-66+	7.5YR4/4	> 63" see remarks	msl	1msbk	w-mfr	0	cs	outwash	none
5 (2C3)	66-120+	7.5YR5/3	see remarks	m-cos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10', soils as described above. b. Soil saturated below 7'.

c. Portions of horizon 2 are partially cemented/compacted.

d. Horizon 3 consists of mixed ms, cos and grcos and contains few thin (<¾" thick) very discontinuous 7.5YR4/4 fsl strata.

e. Horizon 4 contains ccp 7.5YR6/1 patches (depletion) and cfd 7.5YR5/8 bands (accumulation) mottles.

f. Horizon 5 contains ccd 7.5YR5/8 banded mottling above the water table.

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-28

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080498	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 96"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR3/3	-	sil	2msbk	d-mfr	2f,1m	as	loess	none
2 (B2)	9-18	10YR6/4	-	sl	2msbk	d-mfr	0-1f	cs	loess	partially Ce/Cp
3 (2C1)	18-32	5YR4/4-6 (v)	-	grm-cos → ms	0-1csbk → sg	mfr → ml	0-1f	cs	outwash	partially Ce/Cp
4 (2C2)	32-40	7.5YR5/4	-	fls	2csbk	mfr	0	as	outwash	none
5 (2C3)	40-63+	10YR6/4	-	m-cos	0-1csbk	mvfr	0	-	outwash	none
5 (2C3)	63-126+	10YR6/4	> 102" see remarks	m-cos	0-1csbk → sg	mvfr → w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10½', soil as described above. b. Soil saturated below 9'.

c. Collected grab sample at 8'. d. Portions of horizons 2 and 3 are partially cemented/compacted.

e. Horizon 3 contains cmf 7.5YR4/6 textural mottles.

f. Horizon 4 contains fvcp 10YR6/4 (cores) with fmp 5YR2.5/2-3/3 (rims) root mottles.

g. Horizon 5 contains cvcd 7.5YR5/6-8 banded mottles below 8½'.

prob. seasonal sat'n > 96"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

080898
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-29

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080498	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 96"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/2	-	sil-sl	1f-cgr	d-mvfr	2f,1mc	ai	loess	none
2 (B1)	10-17	7.5YR5/6	-	sl-sil	1mgr	d-mvfr	1f-m	cs	loess	partially Ce/Cp
3 (B2)	17-31	7.5YR6/4-6	-	sl	2mgr-sbk	d-mfr	0-1f	cs	loess	partially Ce/Cp
4 (2C1)	31-41	7.5YR5/6	-	grm-cos	1csbk	mfr	0	as	outwash	none
5 (2C2)	41-61+	10YR6/4	-	m-cos	1csbk	mfr	0	-	outwash	none
5 (2C2)	61-132+	10YR6/4	> 102" see remarks	m-cos	1csbk → sg	mfr → w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 11' soil as described above. b. Soil saturated below 9'.

c. Collected grab samples at 4½' and 7'.

d. Portions of horizons 2 and 3 are partially cemented/compacted.

e. Horizon 4 contains few thin (<½" thick) discontinuous 7.5YR4/4 fsl strata.

f. Horizon 5 contains cvcd 7.5YR5/6 banded mottling.

prob. seasonal sat'n > 96"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-30

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080598	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 36"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/2	-	sil	2f-msbk	d-mvfr	2f,1mc	as	loess	none
2 (B1)	10-12	10YR8/1	-	cl	0	d-mfi	0	as	cemented loess	strong Ce
3 (B2)	12-44	7.5YR4/4	> 28" see remarks	sl	1csbk	mvfr	0-1f	cw	loess	none
4 (2C)	44-62+	5YR6/4	?	m-cos	0-1csbk	w-mvfr	0	-	outwash	none

D-127

Remarks:

a. Pit extended to approximately 10', soil similar to that encountered in horizon 4. b. Soil saturated below 4'. c. Collected grab sample at 4½'.

d. Horizon 2 was a sil material which is being cemented with calcium carbonate precipitates due to the upward migration of capillary water during dry weather.

e. Horizon 3 contains few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata.

f. Horizon 3 also contains cf-mp 7.5YR4/6 root mottles above 36".

g. Horizon 3 also contains cmp 5YR5/8 (accumulation) and ccp 2.5YR6/2 (depletion) mottles between 28-38", below 38" it contains cvcd 7.5YR5/6-8 banded mottling.

prob. seasonal sat'n > 36"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-31

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080598	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/2	-	sil	2m-csbk	d-mvfr	2f,1mc	as	loess	none
2 (E)	10-12½±1	10YR7/1	-	fsl	1fgr	mvfr	0-1f	cs	loess	none
3 (B2hs)	12½-22	7.5YR4/4	-	sl-sil	2csbk	mfr	0-1f	cw	loess	partially Ce/Cp
4 (2B2s)	22-43	7.5YR6/6	-	m-cos	0-1csbk	mvfr	0	cs	outwash	none
5 (2C)	43-54+	10YR6/4	-	m-cos	1csbk	mvfr	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10', soil similar to that encountered in horizon 5. b. Soil saturated below 7'.

c. Collected grab sample at 9'.

d. Horizon 2 is a native E horizon which is now accumulating calcium carbonate precipitates from upward migrating capillary water similar to horizon 2 in TPH-30.

e. Portions of horizon 3 are partially cemented/compacted.

f. Horizon 4 contains few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata.

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

09'28'98
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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-32

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080598	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 78"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/1	-	sil-sl	2msbk	d-mvfr	1f-c	as	loess	none
2 (B)	10-27	7.5YR4/4	-	sil	1m-csbk	d-mvfr	0-1f-m	cw	loess	partially Ce/Cp
3 (2C)	27-63+	7.5YR4/6	-	m-cos	0-1csbk → sg	mvfr → ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil similar to that encountered in horizon 3. b. Soil saturated below 7½'.

c. Collected grab sample at 5'.

d. Portions of horizon 2 are partially cemented/compacted.

e. Horizon 3 contains very few thin (<½" thick), very discontinuous and irregular in shape 7.5YR4/4 fsl strata, and few thin (<4" thick fgr-grcos seams.

prob. seasonal sat'n > 78"
Limiting Factors/Depth

John E. Thresher, Jr.
John E. Thresher, Jr., CST No. 223796

09'2898
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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-33A

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080598	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 90"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-11	10YR4/1	-	sil-sl	2msbk	d-mfr	2f,1mc	as	loess	none
2 (B2)	11-21	10YR7/4	-	sil	1msbk	d-mfr	0-1f	cs	loess	partially Ce/Cp
3 (2C1)	21-33	5YR4/4	-	grm-cos	1csbk	d-mfr	0-1f	cs	outwash	none
4 (2C2)	33-48±7	7.5YR5/6	-	grm-cos	1csbk	mvfr	0-1f	aw	outwash	none
5 (2C3)	48-57±7	7.5YR4/4	-	fsl	3fabk	mfr	0	aw	outwash	none
6 (2C4)	57-65+	10YR6/4	-	m-cos	0-1csbk	mvfr	0	-	outwash	none

Remarks:

a. Pit extended to approximately 12', soil similar to that encountered in horizon 6. b. Soil saturated below 8½'.

c. Portions of horizon 2 partially cemented/compacted.

d. Horizon 5 contains fmd 7.5YR5/8 (accumulation) and fmd 7.5YR5/3 (depletion) mottles.

prob. seasonal sat'n > 90"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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2828 Regent St.
Madison, WI 53705
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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-33B

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082898	alfalfa	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 96"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-11	10YR4/2	-	sil	2msbk	mvfr	2f,1mc	as	loess	none
2 (B1)	11-22	10YR5/4(v)	-	sl	1fsbk	mfr	0-1f	gs	loess	partially Ce/Cp
3 (B2)	22-37	10YR6/4(v)	-	sl	1msbk	mfr	0-1f	cs	loess	partially Ce/Cp
4 (2C1)	37-59	7.5YR4/4(v)	-	scl-sl	sg-1csbk	ml-mfi	0-1f	cs	sandy till	none
5 (3C2)	59-70+	10YR6/4	-	m-cos	1csbk	mvfr	0	-	outwash	none
5 (3C2)	70-120	10YR6/4		m-cos	1csbk → sg	mvfr → (w)ml	0	cs	outwash	none
6 (3C3)	120-120+	10YR5/3	-	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10½', soil similar to that encountered in horizon 5. b. Soil saturated below 9'.

b. Structures in horizons 2 and 3 overprinted on 3c geologic layering.

c. Portions of horizons 2 and 3 are partially cemented/compacted.

d. Horizon 3 contains ffp 7.5YR5/6 textural mottles.

e. Horizon 5 contains very few thin (<½" thick) discontinuous 7.5YR4/4 fsl strata.

prob. seasonal sat'n > 96"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-33C

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083198	alfalfa	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161			
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1	0-9			sil					loess	
2	9-22			sil					loess	
3	22-31			sl-scl					sandy till	
4	31-52			scl					till	
5	52-64+			ms					outwash	

Remarks:

a. Horizon 4 pendants and clay balls along its lower boundary and appears to be a large rafted till fragment.

b. Collected grab sample at 60".

c. Pit was dug to determine the distribution of rafted till fragments.

Limiting Factors/Depth

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Madison, WI 53705
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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-33D

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083198	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161			
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	cementation, Ce Compaction, Cp
1	0-14			sil-sl					loess	
2	14-47			m-cos					outwash	
3	47-65+			m-cos					outwash	

Remarks:

a. Pit was dug to determine the distribution of rafted till fragments.

Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-33E

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083198	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161			
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1	0-11			sl-sil					loess	
2	11-40			m-cos					outwash	
3	40-56+			m-cos					outwash	

Remarks:

a. Horizon 2 is partially cross bedded.

b. Pit was dug to determine the distribution of rafted till fragments.

Limiting Factors/Depth

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Madison, WI 53705
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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-34

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080598	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 96"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/1-2	-	sil	2m-csbk	d-mvfr	2f	as	loess	none
2 (2B)	10-26	7.5YR5/6 (v)	-	grm-cos	0-1mgr	mvfr	0-1f	cw	outwash	partially Ce/Cp
3 (2C1)	26-33	10YR5/6	-	m-cos	0-1msbk	mvfr	0	cs	outwash	none
4 (2C2)	33-43	10YR5/6	-	fsl	2msbk	mvfr	0	cs	outwash	none
5 (2C3)	43-68+	10YR6/4	-	m-cos	0-1csbk	mvfr	0	-	outwash	none
5 (2C3)	68-120+	10YR6/4	> 96" see remarks	m-cos	0-1csbk → sg	mvfr → w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10', soil as described above. b. Soil saturated below 9'. c. Collected grab sample at 5'.

d. Portions of horizon 2 are partially cemented/compacted.

e. Horizon 2 contains few thin (<½" thick) irregular and very discontinuous 7.5YR4/4 fsl strata.

f. Horizon 4 contains few thin (<½" thick) irregular and discontinuous 7.5YR4/4 fsl strata at the top and base of the horizon.

g. Horizon 5 contains cvcd 7.5YR5/6-8 banded mottling below 8'.

prob. seasonal sat'n > 96"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

09'28'98
Date Signed

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2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-35

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080598	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	.Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR4/2	-	sil	2m-csbk	d-mfr	1f	as	loess	none
2 (2AC)	9-17	7.5YR5/6 (v)	-	f-ms	0-1mgr	d-mvfr	0-1f	cs	outwash	partially Ce/Cp
3 (2C1)	17-29	10YR6/6	-	ms	2csbk	mfr	0-1f	cs	outwash	none
4 (2C2)	29-61+	10YR6/4	-	m-cos	0-1csbk → sg	mvfr → ml	0	-	outwash	none
4 (2C2)	61-120+	10YR6/4	> 72" see remarks	m-cos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10', soil as described above. b. Soil saturated below 7'.

c. Collected grab sample at 3'.

d. Portions of horizon 2 are partially cemented/compacted.

e. Horizon 3 contains few thin (<¾" thick) very discontinuous 7.5YR4/4 fsl strata.

f. Horizon 4 contains fcd 7.5YR5/6-8 banded mottling below 6'.

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Madison, WI 53705
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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-36

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080598	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 96"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-11	10YR4/2	-	sil	2f-csbk	d-mvfr	2f	as	loess	none
2 (B1)	11-19	10YR5/4-6/4	-	sl	0-1mgr	d-mvfr	0-1f	cs	loess	partially Ce/Cp
3 (B21)	19-25	10YR5/4	-	sil	2msbk	mvfr	0-1f	cw	loess	partially Ce/Cp
4 (B22)	25-36	7.5YR4/4 (v)	-	sil-sl	2msbk	mvfr	0-1f	cw	?	none
5 (2C)	36-72+	10YR6/4 (v)	-	m-cos	1csbk	mvfr	0	-	outwash	none

D-137

Remarks:

a. Pit extended to approximately 11', soil similar to that encountered in horizon 5. b. Soil saturated below 9'.

c. Collected grab sample of the finest grained material within the horizon at 5'.

d. Portions of horizons 2 and 3 are partially cemented/compacted.

e. Horizon 2 contains fmp 5YR5/8-7.5YR5/8 root mottles.

f. Horizons 2-4 contain fmd 7.5YR5/6-10YR5/6 textural mottles.

g. Horizon 4 contains ffp 10YR2/1 and ffd 7.5YR5/6 intrapedal mottles.

prob. seasonal sat'n > 96"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-37

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080598	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 96"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-11	10YR4/2	-	sil	2f-csbk	d-mfr	1f-m	as	loess	none
2 (B2)	11-14	7.5YR6/4	-	sl-sil	2f-msbk	d-mfr	0-1f	aw	loess	partially Ce/Cp
3 (2C1)	14-29	7.5YR3/4	-	m-cos	sg → 1csbk	ml → mfr	0	cs	outwash	none
4 (2C2)	29-56+	10YR5/4	-	m-cos	1csbk → sg	mvfr → ml	0	-	outwash	none
4 (2C2)	56-132+	10YR5/4	> 96" see remarks	m-cos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil as described above. b. Soil saturated below 9'. c. Collected grab sample at 3'.

d. Portions of horizon 2 partially cemented/compacted.

e. Horizon 3 contains few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata.

f. Horizon 4 contains very few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata, and few thin (<2" thick) fgr-fgrvcos discontinuous seams.

g. Horizon 4 contains cvcd 7.5YR5/6-8 banded mottling below 8'.

prob. seasonal sat'n > 96"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-38A

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	080598	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 96"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR4/2	-	sil	2m-csbk	d-mfi	1f-m	as	loess	none
2 (2AC)	9-30	7.5YR5/6	-	m-cos	1msbk	mfr-mvfr	0	as	outwash	partially Ce/Cp
3 (2C1)	30-35	10YR5/4	-	fsl	2mabk	mfr	0	as	outwash	none
4 (2C2)	35-54+	10YR6/4	-	m-cos	1csbk	mvfr	0	-	outwash	none
4 (2C2)	54-120+	10YR6/4	> 96" see remarks	m-cos	1csbk → sg	mvfr → w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10', soil as described above. b. Soil saturated below 9'.

c. Collected grab sample at 3½'.

d. Portions of horizon 2 are partially cemented/compacted.

e. Horizon 3 contains fmd 5YR4/6 textural mottles.

f. Horizon 4 contains cvcd 7.5YR5/6-8 banded mottling below 8'.

prob. seasonal sat'n > 96"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-38B

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082698	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 96"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR4/2-3	-	sil	2msbk	d-mfi	1f-m	as	loess	none
2 (2B1)	9-28	7.5YR5/6	-	m-cos	1csbk	mfr-mvfr	0	as	outwash	partially Ce/Cp
3 (2B2)	28-31	10YR5/4	-	fsl	2mabk	mfr	0	as	outwash	none
4 (2C)	31-66+	10YR6/4	-	m-cos	1csbk	mvfr	0	-	outwash	none

Remarks:

a. Pit was constructed to conduct a double-ring infiltrometer test. The tested infiltration surface was at 45". A grab sample was collected beneath the infiltrometer rings at a depth of 60" the day following the conclusion of the infiltrometer test.

prob. seasonal sat'n > 96"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-39

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082698	oats	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	7.5YR3/2	-	sl	1mgr	mvfr	1f-m	as	loess	none
2 (B2hs)	10-13	7.5YR4/6	-	sl	1msbk	mvfr	0-1f	aw	loess	none
3 (B2s)	13-18	10YR4/4	-	sl	2msbk	mvfr	0-1f	cs	loess	none
4 (2B31)	18-22	7.5YR4/6	-	sl-ms	0-1msbk	ml-mvfr	0-1f	aw	sandy till	none
5 (3B32)	22-32	10YR6/6	-	ms	2msbk	mvfr	0	as	outwash	none
6 (3B33)	32-38	10YR5/4	-	fs-fsl	2msbk	mfr	0	aw	outwash	none
7 (3C1)	38-47	variegated	-	vcos	sg	d-ml	0	cs	outwash	none
8 (3C2)	47-56+	10YR6/4	-	ms	1csbk	mvfr	0	-	outwash	none
8 (3C2)	56-72	10YR6/4	-	ms	1csbk	mvfr	0	cs	outwash	none
9 (3C3)	72-132+	10YR5/4 (v)	-	m-cos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil as described above. b. Soil saturated below 7'. c. A <1" thick band of textural mottling was found between horizons 4, 5 and 6.

d. Many small (<10" long) rafted till fragments (7.5YR4/4, scl-cl) were found between 30-72" in the west wall of the pit which contained 5YR5/8 and 10B6/1 textural mottling.

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-40

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082698	oats	glacial sediments
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 56"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-14	10YR3/2	-	sl	2msbk	mvfr	1f	as	loess	none
2 (sB)	14-35	10YR5/6	-	ms-mls	0-1msbk	mvfr-ml	0-1f	cs	outwash	none
3 (3C1)	35-51±4	7.5YR4/4	-	scl-sl	0-1csbk	mvfr-mfi	0	cw	till	none
4 (4C2)	51-61	10YR6/4	-	m-cos	1-2csbk	mfr-mvfr	0	cw	outwash	none
5 (4C3)	61-72+	10YR5/4 (v)	> 84" see remarks	cos-grvcos	sg	w-ml	0	-	outwash	none

D-142

Remarks:

a. Pit extended to approximately 11', soil similar to that encountered in horizon 5. b. Soil saturated below 68".

c. Horizon 2 contains few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata.

d. Horizon 2 also contains few truncated cradle knoll spodosol horizons (up to 22' thick).

e. Horizon 3 contains fcp 5YR5/6 (accumulation) and 10YR6/1-2 (depletion) textural mottles.

prob. seasonal sat'n > 56"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-41

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082698	oats	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR3/3	-	sil	2csbk	mfr	1f-m	as	loess	none
2 (2Bs)	10-14	7.5YR4/4	-	scl-sl	2csbk	mfr	0-1f	cs	till	partially Ce/Cp
3 (3C1)	14-31	7.5YR4/4 (v)	-	m-cos	1csbk	mfr-mfi	0-1f	cs	outwash	partially Ce/Cp
4 (3C2)	31-54	10YR6/4	-	m-cos	2csbk	mfr	0	cs	outwash	partially Ce/Cp
5 (3C3)	54-66+	10YR6/4	> 64" see remarks	ms	1csbk	mfr	0	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil similar to that encountered in horizon 5. b. Soil saturated below 7'.

c. Portions of horizons 2, 3 and 4 are partially cemented/compacted.

d. Horizon 3 contains fmp 10YR3/2 root channels and few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata.

e. Horizon 4 contains very few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata.

f. Horizon 5 contains fcp 7.5YR5/6-8 root mottles with fmp 10RP4/12 cores (probably strengite precipitates).

g. Horizon 5 also contains fcd 10YR5/6 → ccd 10YR5/8 banded mottling below 64". Mottling extended to approximately 120".

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-42A

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082698	oats	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 84"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-11	7.5YR3/2	-	sil	2csbk	mvfr	1f-m	as	loess	none
2 (B21s)	11-16	7.5YR4/6	-	sil	1mgr	mvfr	0-1f	as	loess	none
3 (B22)	16-24	7.5YR5/4	-	sl-ls	2csbk	mfr-mfi	0-1f	aw	loess	partially Ce/Cp
4 (2B3)	24-33	7.5YR4/6 (v)	-	cosl	2csbk	mfr-mvfr	0-1f	cs	sandy till	partially Ce/Cp
5 (3C1)	33-53	7.5YR5/4 (v)	-	vcos	0-1csbk	mvfr-mfr	0	cs	outwash	none
6 (3C2)	53-63	10YR6/4	-	cos	sg	ml	0	as	outwash	none
7 (3C3)	63-65+	10YR6/4	-	ms	1csbk	mfr	0	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil similar to that encountered in horizon 7. b. Soil saturated below 8'.

c. Horizon 2 contains few scattered, thin (< 2" thick/horizon), truncated remnants of A, E and Bhs horizons.

d. Portions of horizons 3 and 4 are partially cemented/compacted.

e. Horizon 7 contains ccd 7.5YR5/6-8 banded mottling below 9'.

prob. seasonal sat'n > 84"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-42B

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082698	oats	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 78"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR3/2	-	sil	2csbk	mvfr	1f	as	loess	none
2 (A)	9-11	10YR2/2	-	sil	1msbk	mvfr	0-1f	as	loess	none
3 (2B2)	11-23	7.5YR5/4	-	scl-sl	2csbk	mfr-mfi	0-1f	cs	till	none
4 (3C1)	23-36	7.5YR4/6 (v)	-	ms-sl	1csbk	mfr	0-1f	cs	outwash	none
5 (3C2)	36-60	10YR6/4	-	m-cos	0-1csbk	mvfr	0	-	outwash	none

Remarks:

a. Pit was extended to approximately 9', soil similar to that encountered in horizon 5. b. Soil saturated below 90".

c. Pit was constructed to conduct a double-ring infiltrometer test. Tested infiltration surface was at 30'.

d. Visual observations following the infiltrometer test revealed that the outwash contained higher moisture contents within a 4' radius of the infiltrometer rings, and the maximum water contents were within a 2' radius of the infiltrometer rings.

e. The top of horizon 3 contains thin scattered traces of former E and Bs horizons.

prob. seasonal sat'n > 78"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-43

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082698	oats	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 66"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-8	7.5YR2.5/2	-	sl-sil	2msbk	mfr	2f,1m	ai	loess	none
2 (B2hs → B2s)	8-14	5YR3/4 → 7.5YR5/6	-	m-cosl	1mgr	mvfr	0-1f	cw	outwash	none
3 (2B3)	14-19	10YR5/4	-	fsl	2msbk	mfr	0-1f	cw	outwash	none
4 (2C1)	19-27	10YR6/4	-	m-cos	0-1msbk	mvfr	0	as	outwash	none
5 (2C2)	27-32	10YR5/3	-	fsl	3msbk	mfr	0	as	outwash	none
6 (2C3)	32-61+	10YR6/4	-	m-cos	0-1csbk	mvfr	0	-	outwash	none
6 (2C3)	61-84	10YR6/4	> 72" see remarks	m-cos	sg	ml	0	cs	outwash	none
7 (2C4)	84-96+	10YR5/3	see remarks	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 8', soil as described above. b. Soil saturated below 6½'. c. Collected grab sample at 40".

d. Horizon 2 contains few thin remnants of a 5YR3/4, mfi-mvfi, Bhs horizon.

e. Horizon 5 contains cfd 7.5YR5/6 textural mottling at the base of the horizon.

f. Horizons 6 and 7 contain ccd 7.5YR5/6-8 banded mottling from 72-90".

prob. seasonal sat'n > 66"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-44

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082698	oats	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR3/2	-	sil-sl	2csbk	mfr	1f-m	as	loess	none
2 (B2s)	9-17	7.5YR4/6 (v)	-	sl-sil	1mgr-sbk	mvfr	0-1f	cs	loess	partially Ce/Cp
3 (2B31)	17-27	7.5YR5/6	-	sl-scl	1-3csbk	mfr-mfi	0-1f	cs	sandy till	partially Ce/Cp
4 (2B32)	27-41	10YR6/3	-	fsl-cl	2f-msbk	mvfr	0	cs	till	none
5 (3C1)	41-51	7.5YR6/4 (v)	-	m-cosl	2msbk	mfr	0	as	outwash	none
6 (3C2)	51-60+	10YR6/4	> 78" see remarks	m-cos	1csbk	mvfr	0	-	outwash	none

D-147

Remarks:

a. Pit extended to approximately 11', soil similar to that encountered in horizon 6. b. Soil saturated below 7'.

c. Portions of horizons 2 and 3 are partially cemented/compacted.

d. Horizon 2 contains few thin truncated remnants of E, Bhs and Bs horizons at the top of the horizon.

e. Horizon 4 contains ffd 7.5YR5/6 textural mottles.

f. Horizons 5 and 6 contain few 7.5YR4/4 clay balls (2" diameter) and few 2" x 4" 7.5YR4/4 scl slabs with a variety of orientations along the boundary between the horizons.

g. Horizon 6 contains ccd 7.5YR5/6-8 banded mottling from 78-90".

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-45

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082698	oats	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 84"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9½	10YR3/3	-	sl-sil	2msbk	mvfr	1f	as	loess	none
2 (A/C)	9½-15	10YR6/4	-	sl	1fgr	mvfr	0-1f	cs	loess	partially Ce/Cp
3 (C1)	15-25	7.5YR5/4	-	sl	1mgr	mvfr	0-1f	cs	loess	partially Ce/Cp
4 (2C2)	25-32	7.5YR6/4	-	ms	0-1msbk	mvfr-ml	0	cs	sandy till	none
5 (3C3)	32-42	10YR6/4	-	ms	0-1msbk	mvfr-ml	0	cs	outwash	none
6 (3C4)	42-52	10YR5/3	-	fsl	2msbk	mvfr	0	cs	outwash	none
7 (3C5)	52-63	10YR6/4	-	m-cos	1csbk	mvfr	0	as	outwash	none
8 (3C6)	63-67+	10YR6/4	> 90" see remarks	cos	sg	ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10', soil similar to that encountered in horizon 8. b. Soil saturated below 8'.

c. Portions of horizons 2 and 3 are partially cemented/compacted. d. Horizon 4 contains few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata.

d. Horizon 5 contains very few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata.

e. Horizon 8 contains ccd 7.5YR5/6-8 banded mottling from approximately 90-108".

prob. seasonal sat'n > 84"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-46

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082698	oats	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 84"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-7	10YR4/3	-	sil-sl	2f-msbk	mfr	1f-m	as	loess	none
2 (B2)	7-12	10YR5/3-4/3	-	sil	2msbk	mfr	0-1f	as	loess	partially Ce/Cp
3 (2B3)	12-29	7.5YR5/3 (v)	-	grm-cos	1csbk-gr	mfr-mvfr	0-1f	as	sandy till	partially Ce/Cp
4 (3C1)	29-46	10YR5/3	-	m-cos	1csbk	mvfr	0	as	outwash	none
5 (3C2)	46-65+	10YR6/4	-	m-cos	1csbk	mvfr	0	-	outwash	none
5 (3C2)	65-96	10YR6/4	-	m-cos	1csbk → sg	mvfr → ml	0	cs	outwash	none
6 (3C3)	96-120+	10YR5/3	-	grvcos	sg	w-ml	0	-	outwash	none

D-149

Remarks:

a. Pit extended to approximately 10', soil as described above. b. Soil saturated below 8'.

c. Portions of horizons 2 and 3 are partially cemented/compacted.

d. Horizon 5 contains a 8" x 6' rafted till fragment in one pit wall at the top of the horizon.

prob. seasonal sat'n > 84"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-47

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082798	alfalfa	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 84"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR3/2-4/2	-	sl-sil	2msbk	mvfr	1f-c	as	loess	none
2 (B2)	9-13	7.5YR5/6	-	sil	0-1f-msbk	mvfr	0-1f-c	cs	loess	none
3 (B3)	13-28	10YR6/4	-	sil	1msbk	mfr	0-1f-m	cs	loess	partially Ce/Cp
4 (2C1)	28-58	variegated	-	sl-scl	0-2msbk	mfr-mfi	0-1f-m	cs	sandy till	partially Ce/Cp
5 (3C2)	58-63+	10YR6/4	-	ms	1msbk	mvfr	0	-	outwash	none
5 (3C2)	63-104	10YR6/4	-	ms	1msbk → sg	mvfr → ml	0	cs	outwash	none
6 (3C3)	104-108+	10YR5/3	-	cos	sg	w-ml	0	-	outwash	none

D-150

Remarks:

a. Pit extended to approximately 9', soil as described above. b. b. Soil saturated below 8'.

c. Portions of horizons 3 and 4 are partially cemented/compacted.

d. Horizon 3 contains ff-md 7.5YR5/6 textural mottling in the lower 3" of the horizon.

e. Horizon 5 contains few thin (<¼" thick) very discontinuous 7.5YR4/4 fsl strata.

f. Pit was constructed to conduct a double-ring infiltrometer test. The tested infiltration surface was at 60". Grab samples were collected at the infiltration surface beneath the rings and at 2' east, and at 2' and 4' west. Additional grab samples were collected at depths of 1½' and 3' beneath the infiltration surface.

prob. seasonal sat'n > 84"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-48

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082798	oats	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 96"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-7	7.5YR3/2	-	sil-sl	2mgr	mvfr	1f-m	as	loess	none
2 (2B)	7-19	7.5YR5/4 (v)	-	sl-scl	1csbk	mfr-mfi	0-1f	cs	sandy till	partially Ce/Cp
3 (3C1)	19-26	10YR5/3	-	cos	1-2csbk	mfr	0-1f-m	cs	outwash	none
4 (3C2)	26-58+	10YR6/4	> 96" see remarks	m-cos	1csbk	mvfr	0	-	outwash	none

D-151

Remarks:

a. Pit extended to approximately 12', soil similar to that encountered in horizon 4. b. Soil saturated below 9'.

c. Portions of horizon 2 partially cemented/compacted.

d. Horizon 3 contains few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata.

e. Collected grab samples at 36" and at 66".

f. Horizon 4 contains ccd 7.5YR5/6-8 banded mottling between 96-120".

prob. seasonal sat'n > 96"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-49

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082798	oats	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-8	10YR3/2	-	sil-sl	2csbk	mvfr	1f-m	as	loess	none
2 (B2)	8-17	10YR5/4 (v)	-	sl-sil	1f-msbk	mvfr	0-1f	cs	loess	none
3 (2C1)	17-32	10YR5/4 (v)	-	m-cos	0-1csbk	mvfr-mfr	0-1f	as	outwash	partially Ce/Cp
4 (2C2)	32-61+	10YR6/4	-	m-cos	0-1csbk	mvfr	0	-	outwash	none
4 (2C2)	61-96	10YR6/4	> 78" see remarks	m-cos	0-1csbk → sg	mvfr → ml	0	cs	outwash	none
5 (2C3)	96-132+	10YR5/3	-	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil as described above. b. Soil saturated below 7'.

c. Portions of horizon 3 partially cemented/compacted.

d. Horizon 3 contains few thin (<¾" thick) very discontinuous 7.5YR4/4 fsl strata.

e. Horizon 4 contains very few thin (<¼" thick) very discontinuous 7.5YR4/4 fsl strata.

f. Horizon 4 also contains ccd 7.5YR5/6-8 banded mottling from 78-96".

prob. seasonal sat'n > 72"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-50

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082798	oats	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 60"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-12	10YR3/2	-	sl	2msbk	mvfr	0-1f-m	as	outwash	none
2 (2B2)	12-20	7.5YR4/6 (v)	-	ls	2mgr	mvfr	0-1f	cs	sandy till	none
3 (2C1)	20-57+	7.5YR4/4	-	cl-scl-sl	1m-csbk	mfr	0	-	mixed till	none
3 (2C1)	57-72	7.5YR4/4	> 66" see remarks	cl-scl-sl	1m-csbk	mfr	0	cs	mixed till	none
4 (3C2)	72-108+	10YR5/3	see remarks	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 9', soil as described above. b. Soil saturated below 6'.

c. Horizon 2 contains few thin, truncated fragments of former E, Bhs and Bs horizons at the top of the horizon.

d. The cl portions of horizon 3 contain cm-cd 7.5YR5/6-8 (accumulation) and 10YR5/2 (depletion) textural mottles above 6'.

e. Horizons 3 and 4 contain ccd 7.5YR5/6-8 banded mottling from 66-84".

prob. seasonal sat'n > 60"
Limiting Factors/Depth

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-51

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082798	oats	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 60"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR3/3	-	sl-sil	2msbk	mvfr	2f,1m	as	loess	none
2 (B2)	10-22	10YR6/4	-	sil-sl	3msbk	mfr	0-1f	cs	loess	partially Ce/Cp
3 (2B3)	22-35	7.5YR5/4 (v)	-	m-cos	2csbk	mfr	0-1f	cs	outwash	partially Ce/Cp
4 (2C1)	35-65+	10YR6/3 → 10YR6/4	-	f-ms → ms	1csbk → 0-1csbk	mfr → mvfr	0	-	outwash	none
4 (2C1)	65-78	10YR6/4	> 72" see remarks	ms	0-1csbk → sg	mvfr → w-ml	0	cs	outwash	none
5 (2C2)	78-120"	10YR5/3	see remarks	m-cos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10', soil as described above. b. Soil saturated below 6'.

c. Horizon 2 contains few truncated fragments of former E, Bhs and Bs horizons at the top of the horizon.

d. Portions of horizons 2 and 3 are partially cemented/compacted.

e. Horizon 3 contains few thin (<¼" thick) very discontinuous 7.5YR4/4 fsl strata.

f. Collected grab sample at 50". g. Horizons 4 and 5 contain ccd 7.5YR5/6-8 banded mottling from 72-96".

prob. seasonal sat'n > 60"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-52

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082798	oats	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-8	10YR4/3-3/3	-	sl	0-1m-csbk	mvfr	1f	cs	loess	none
2 (B2)	8-13	10YR5/4	-	sl-sil	1-2msbk	mfr	0-1f	cw	loess	none
3 (2C1)	13-24	7.5YR5/4 (v)	-	grm-cos	0-1csbk	mfr-mfi	0-1f	cs	sandy till	partially Ce/Cp
4 (3C2)	24-40	10YR5/3 (v)	-	m-cos	1csbk	mfr	0	as	outwash	partially Ce/Cp
5 (3C3)	40-49	10YR5/4 (v)	-	fsl	3msbk	mfr	0	as	outwash	none
6 (3C4)	49-63+	10YR6/4	-	m-cos	1csbk	mvfr	0	-	outwash	none
6 (3C4)	63-96	10YR6/4	-	m-cos	1csbk → sg	mvfr → w-ml	0	cs	outwash	none
7 (3C5)	96-132+	10YR5/3 (v)	-	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil as described above. b. Soil saturated below 7'.

c. Portions of horizons 3 and 4 are partially cemented/compacted.

d. Horizon 4 contains few fine (<½ thick) very discontinuous 7.5YR4/4 fsl strata. The horizon also contains a thin (<3" thick) grcos seam at the base of the horizon.

prob. seasonal sat'n > 72"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-53

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082798	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 96"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-8	10YR4/2-3	-	sil	2m-csbk	mvfr	1f-c	as	loess	none
2 (B2)	8-14	7.5YR4/6	-	sl	1msbk	mvfr	0-1f	cs	loess	none
3 (B3)	14-20	10YR5/6	-	sl	0-1mgr	mvfr	0-1f	cw	loess	none
4 (2C1)	20-48+	10YR6/4	-	ms	1csbk	mvfr	0-1f	-	outwash	partially Ce/Cp
5 (2C2)	48-120	10YR6/4	>96" see remarks	ms → m-cos	1csbk → sg	mvfr → w-ml	0	cs	outwash	none
6 (2C3)	120-132+	10YR5/3	-	grcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil as described above. b. Soil saturated below 9'.

c. Horizon 2 contains truncated fragments of former E and Bhs horizons at the top of the horizon.

d. Portions of horizon 4 are partially cemented/compacted. e. Horizon 4 contains small irregular patches of rafted till fragments (7.5YR4/4, scl-fsl) in lower 12" of horizon.

f. Horizon 4 contains also contains few thin (<¼" thick) very discontinuous 7.5YR4/4 fsl strata. g. Horizon 5 contains ccd 7.5YR5/6-8 banded mottling from 96-120".

h. Pit was constructed to conduct a double-ring infiltrometer test. The tested infiltration surface was at 48". Grab samples were collected at the infiltration surface beneath the rings and at 2' and 4' east, and at 2' west. Additional grab samples were collected at depths of 1½' and 3' beneath the infiltration surface.

prob. seasonal sat'n > 96"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-54

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082798	oats	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 54"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-7	10YR4/3	-	sl	2csbk	mfr	1f-m	as	loess	none
2 (2B)	7-14	7.5YR5/4 (v)	-	vcos	1csbk	mfr-mvfr	0-1f-c	as	outwash	none
3 (2C1)	14-47+	10YR6/3	-	m-cos	1csbk	mvfr	0-1f-c	-	outwash	none
3 (2C1)	47-66	10YR6/3	> 60" see remarks	m-cos	1csbk → sg	mvfr → ml	0-1f	cs	outwash	none
4 (2C2)	66-108+	10YR5/4	see remarks	grvcos	sg	w-ml	0	-	outwash	none

D-157

Remarks:

a. Pit extended to approximately 9', soil as described above. b. Soil saturated below 5½'.

c. Horizons 2 and 3 contain fmp 10YR2/2 and fcd 7.5YR5/4-6 root mottles.

d. Collected grab sample at 22".

prob. seasonal sat'n > 54"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-55

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082798	oats	glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 60"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-8	7.5YR3/3	-	sl-ls	2csbk	mfr	1f-c	ai	outwash	none
2 (A/C)	8-30	7.5YR5/6 (v)	-	m-cos	1csbk	mvfr	0-1f-m	cw	outwash	none
3 (C1)	30-54+	10YR6/4	-	m-cos	1-2csbk	mfr	0-1m	-	outwash	none
3 (C1)	54-72	10YR6/4	> 66" see remarks	m-cos	1csbk → sg	mfr → ml	0	cs	outwash	none
4 (C2)	72-120+	10YR5/3	see remarks	grvcos	sg	w-ml	0	-	outwash	none

D-158

Remarks:

a. Pit extended to approximately 10', soil as described above. b. Soil saturated below 6'.

c. Horizon 2 contains few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata.

d. Horizons 2 and 3 contain fcd 7.5YR5/6 root mottles.

e. Horizon 3 also contains a small wedge of cross bedded cos and grcos.

prob. seasonal sat'n > 60"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-56

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082798	oats	glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	7.5YR3/2	-	sl-ls	2csbk	mfr	1f-m	cw	outwash	none
2 (B2s)	10-17	7.5YR4/6	-	sl	2msbk	mvfr	0-1f	cw	outwash	none
3 (C1)	17-34	7.5YR5/6	-	sl-ls	sg → 1msbk	ml-mvfr	0-1f	cw	outwash	none
4 (C2)	34-42	7.5YR5/6-5YR5/6	-	grms	1csbk	mvfr	0-1f	cw	outwash	none
5 (C3)	42-48+	10YR6/4	-	m-cos	1csbk	mvfr	0	-	outwash	none
5 (C3)	48-108	10YR6/4	-	m-cos	1csbk → sg	mvfr → w-ml	0	cs	outwash	none
6 (C4)	108-144+	10YR5/3	-	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 12', soil as described above. b. Soil saturated below 7'.

c. Horizon 2 contains truncated fragments of a very few cradle knoll sequences of E, Bhs and Bs horizons.

prob. seasonal sat'n > 72"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-57

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082898	grass	glacial sediments
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR3/3-4/3	-	sl	2m-csbk	mvfr	2f,1mc	as	outwash	none
2 (A/B)	9-31	7.5YR4/6 → 10YR5/6	-	lcos	0-1csbk	mvfr	0-1f	cs	outwash	partially Ce/Cp
3 (2B2)	31-41	7.5YR4/4 (v)	-	sl-scl	1-2f-msbk	mfr	0-1f	cw	sandy till	partially Ce/Cp
4 (2C1)	41-49	7.5YR4/4	-	m-cos	0-1msbk	mvfr	0	cw	outwash	none
5 (2C2)	49-57	7.5YR4/4 (v)	-	scl-sl	1-2msbk	mfr	0	cw	sandy till	none
6 (3C3)	57-65+	10YR5/4	-	cos	0-1csbk	mvfr	0	-	outwash	none
6 (3C3)	65-84	10YR5/4	> 72" see remarks	cos → vcos	0-1csbk → sg	mvfr → ml	0	cs	outwash	none
7 (3C4)	84-102+	10YR5/3	see remarks	grvcos	sg	w-ml	0	-	outwash	none

D-160

Remarks:

a. Pit extended to approximately 8½', soil as described above. b. Soil saturated below 7'. c. Portions of horizons 2 and 3 are partially cemented/compacted.

d. Horizon 3 contains mcp 7.5YR6/2 (depletion) and fcd 7.5YR5/6 (accumulation) textural mottles. d. Horizon 5 contains f-ccp 7.5YR7/1 (depletion) and f-ccd 7.5YR5/6 (accumulation) textural mottles. f. Horizons 6 and 7 contain ccd 7.5YR5/6-8 banded mottling below 72".

prob. seasonal sat'n > 72"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-58

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082898	grass	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR4/2-3	-	sl	2m-csbk	mfr	2f,1mc	cs	loess	none
2 (B2)	9-30	10YR5/3-6/4	-	sl-sil	1-2msbk	mfr	0-1f-m	gw	loess	partially Ce/Cp
3 (2B3)	30-51	7.5YR4/4 (v)	-	scl-sl	1-2msbk	mfr	0-1f	cw	sandy till	none
4 (3C1)	51-72+	10YR5/4	-	m-cos	1csbk	mvfr	0	-	outwash	none
4 (3C1)	72-96	10YR5/4	> 72" see remarks	m-cos	1csbk → sg	mvfr → w-ml	0	cs	outwash	none
5 (3C2)	96-120+	10YR5/3	see remarks	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10', soil as described above. b. Soil saturated below 7'.

c. Portions of horizon 2 are partially cemented/compacted.

d. Horizon 3 contains fcp 7.5YR6/2 (depletion) and fmd 7.5YR5/6 (accumulation) textural mottles.

e. The color, texture, structure, and consistence of horizons 2 and 3 are highly variable.

f. Horizons 4 and 5 contain ccd 7.5YR5/6-8 banded mottling below 72".

prob. seasonal sat'n > 72"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-59

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082898	grass	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-8	10YR3/3	-	sl-sil	2m-csbk	mfr	1f-m	as	loess	none
2 (B2)	8-28	7.5YR5/6 → 10YR5/4	-	sil-sl	2msbk → 1csbk	mvfr	0-1f	cs	loess	none
3 (2B3)	28-52	7.5YR4/4	-	sl-scl	1csbk	mfr	0-1f	cw	sandy till	none
4 (3C1)	52-61+	10YR5/4	-	cos	1csbk	mvfr	0	-	outwash	none
4 (3C1)	61-90	10YR5/4	> 72" see remarks	cos	0-1csbk	ml-mvfr	0	cs	outwash	none
5 (3C2)	90-132+	10YR5/3	-	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil as described above. b. Soil saturated below 7'.

c. Horizon 4 contains ccd 7.5YR5/6-8 banded mottling from 72-90".

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr.
John E. Thresher, Jr., CST No. 223796

092898
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-60

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082898	grass	glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 78"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR4/4	-	sl	2m-csbk	mvfr-mfr	1f-m	as	outwash	none
2 (B2)	9-14	7.5YR5/4	-	f-ms	1csbk	mvfr	0-1f	cs	outwash	none
3 (B3)	14-48	10YR6/6 (v)	-	m-cos	1-2csbk	mvfr	0-1f	as	outwash	none
4 (C1)	48-55+	10YR6/4	-	ms	1csbk	mvfr	0	-	outwash	none
4 (C1)	55-102	10YR6/4	> 80" see remarks	ms	1csbk → sg	mvfr → w-ml	0	cs	outwash	none
5 (C2)	102-108+	10YR5/4	-	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 9', soil as described above. b. Soil saturated below 7½'.

c. Horizon 3 contains few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata, and vfm-cp 10YR3/2 root mottles/channels.

d. Horizon 4 contains ccd 7.5YR5/6-8 banded mottling from 80-102".

prob. seasonal sat'n > 78"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-61

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082898	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 78"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-8	10YR4/3	-	sl-sil	2csbk	mvfr	2f,1m	as	loess	none
2 (2B2)	8-25	10YR6/3 (v)	-	sl-grcos	2msbk-sg	mfr-ml	1-2f-m	cs	outwash	partially Ce/Cp
3 (2C1)	25-51+	10YR6/4	-	m-cos	1csbk	mvfr	0-1f-m	-	outwash	none
3 (2C1)	51-102	10YR6/4	> 78" see remarks	m-cos	1csbk → sg	mvfr → w-ml	0-1f → 0	cs	outwash	none
4 (2C2)	102-108+	10YR5/3	see remarks	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 9', soil as described above. b. Soil saturated below 7½'.

b. Portions of horizon 2 partially cemented/compacted.

c. Horizons 2 and 3 contain ccp 10YR3/2 root mottles/channels.

d. Horizon 3 also contains very few thin (<¼" thick) very discontinuous 7.5YR4/4 fsl strata.

e. Horizons 3 and 4 contain ccd 7.5YR5/6-8 banded mottling below 78".

prob. seasonal sat'n > 78"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-62

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082998	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 96"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	7.5YR3/2	-	sl	1msbk	mvfr	2f,1mc	as	loess	none
2 (B2)	10-18±4	7.5YR5/4-4/6	-	sl-l	2m-csbk	mvfr	0-1f	cw	loess	none
3 (2C1)	18-31	7.5YR5/6-8 (v)	-	grcosl	sg	ml	0-1f	cs	outwash	none
4 (2C2)	31-52	7.5YR5/6 (v)	-	m-cos	1csbk	mvfr	0	cs	outwash	none
5 (2C3)	52-55+	7.5YR6/6	-	m-cos	sg	ml	0	-	outwash	none

D-165

Remarks:

a. Pit extended to approximately 11', soils similar to that encountered in horizon 5. b. Soil saturated below 9'.

c. Horizon 2 contains few truncated fragments of former E, Bhs and Bs horizons at the top of the horizon.

d. Horizon 2 also contains fcf 7.5YR5/6-7 (accumulation) and ccd 7.5YR6/2 (depletion) textural mottles, and ffp 10YR2/1 intrapedal mottles.

e. Horizon 4 contains few thin (<½" thick) discontinuous 7.5YR4/4 fsl strata.

prob. seasonal sat'n > 96"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-63

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082998	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 84"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR3/3-4/3	-	sil-sl	1m-cgr	mvfr	1f,1m	as	loess	none
2 (B2)	9-16	10YR5/4	-	sil	2m-csbk	mvfr	0-1f	cs	loess	partially Ce/Cp
3 (2C1)	16-40	7.5YR6/4 (v)	-	m-cos	0-1csbk	mvfr-ml	0-1f	cs	outwash	partially Ce/Cp
4 (2C2)	40-71+	10YR6/4	> 96" see remarks	m-cos	1csbk → sg	mvfr → ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil similar to that encountered in horizon 4. b. Soil saturated below 8'.

c. Portions of horizons 2 and 3 are partially cemented/compacted.

d. Horizon 3 contains few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata.

e. Horizon 4 contains very few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata. f. Horizon 4 also contains ccd 7.5YR5/6-8 banded mottling from 96-114".

g. On one side of the pit there are several rafted till fragments (7.5YR4/4, scl-sl) ranging in size from 2" x 2" to 1½' x 1½' along the interface between horizons 3 and 4.

prob. seasonal sat'n > 84"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-64

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082998	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 84"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR3/3	-	sl-sil	1-2m-csbk	mvfr	2f,1m	as	loess	none
2 (B2s)	10-26	7.5YR4/4	-	sil	2msbk	mvfr	0-1f	cs	loess	partially Ce/Cp
3 (2B3)	26-54	10YR6/4 (v)	-	m-cos	1csbk-sg	mfr-ml	0-1f	cs	outwash	partially Ce/Cp
4 (2C1)	54-64+	10YR6/4	-	m-cos	0-1csbk	mvfr-ml	0	-	outwash	none
4 (2C1)	64-96	10YR6/4	-	m-cos	0-1csbk	mvfr-ml	0	-	outwash	none
5	96-120+	see remarks	?						outwash	none

Remarks:

a. Pit extended to approximately 10', soil as described above. b. Soil saturated below 8'.

c. Portions of horizons 2 and 3 are partially cemented/compacted.

d. Horizon 3 contains very few thin (<½ thick) discontinuous 7.5YR4/4 fsl strata, and few thin (<2" thick) grcos seams.

e. Horizon 5 consists of a buried sequence of aquod horizons including an O, E, and a thick Bhs/Bs horizon. The Bhs horizon is partially cemented and contains banded colors of black, reddish brown, orangish brown, and yellowish brown m-cos (from top to bottom). Similar to TPH-8A.

strongly cemented > 96"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-65

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082998	grass	glacial sediments
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR3/2-4/2	-	sl	2m-csbk	mfi-mfr	1f-m	as	loess (fill ?)	none
2 (B2)	10-20	7.5YR4/3 (v)	-	scl-cl → ms	3mabk → 1msbk	mfi → mvfr	1f → 0	cw	sandy till (fill ?)	partially Ce/Cp
3 (C)	20-34+	10YR6/4	see remarks	m-cos	1csbk	mfr	0	-	outwash (fill ?)	partially Ce/Cp
3 (C)	34-84	10YR6/4	see remarks	m-cos	1csbk	mfr	0	cs	outwash (fill ?)	partially Ce/Cp
4	84-132+	see remarks	?	m-cos			0	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil as described above. b. Soil saturated below 7'.

c. Horizon 2 contains several truncated fragments of former E, Bhs and Bs horizons at the top of the horizon.

d. Portions of horizons 2 and 3 are partially cemented/compacted.

e. Horizon 3 contains mcd 7.5YR5/6-8, cfp 5YR4/6 and fcp 2.5YR3/4-6 banded mottling.

f. Horizon 5 consists of a buried sequence of aquod horizons including an O, e, and a thick Bhs/Bs horizon. The Bhs/Bs horizon is partially cemented and contains banded colors of black, reddish brown, orangish brown, and yellowish brown (from top to bottom). Similar to TPH-64.

strongly cemented > 84"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-66

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082998	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 66"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-8	10YR3/2	-	sil-sl	2m-csbk	mfr	2f,1mc	as	loess	none
2 (A)	8-13	10YR4/2	-	sil	1f-msbk	mvfr	0-1f	cs	loess	none
3 (E)	13-21	10YR5/2	-	sil	2f-msbk	mfr	0-1f	cs	loess	partially Ce/Cp
4 (B2)	21-44	10YR6/2 (v)	-	sil	1msbk → 2msbk	mfr-mfi	0-1f	cw	loess	partially Ce/Cp
5 (2C1)	44-61	10YR5/4 (v)	-	m-cos	sg-1csbk	ml-mvfr	0	cs	outwash	partially Ce/Cp
6 (2C2)	61-75+	10YR5/4	see remarks	m-cos	1csbk	mvfr	0	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil similar to that encountered in horizon 6. b. Soil saturated below 6½'.

c. Portions of horizons 3-5 are partially cemented/compacted.

d. Horizon 5 contains few thin (<½" thick) discontinuous 7.5YR4/4 fsl strata and few thin (<2" thick) grcos seams.

e. Horizon 6 contains ccd 7.5YR5/6-8 banded mottling from 61-71". The banded mottling appears to be dipping to the north, towards the wetland.

prob. seasonal sat'n > 66"
Limiting Factors/Depth

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-67

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082998	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 84"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR4/2	-	sl-sil	2msbk	mvfr	1f-m	as	loess	none
2 (B2)	9-24±4	10YR5/4	-	sil	1m-csbk	mvfr	0-1f	cw	loess	none
3 (2B3)	24-36±3	10YR5/6 (v)	-	grm-cos	1csbk	mvfr	0	cw	outwash	none
4 (2C1)	36-63+	10YR6/4	-	ms	1csbk → sg	mvfr → ml	0	-	outwash	none
4 (2C1)	63-120	10YR6/4	> 84" see remarks	ms	sg	w-ml	0	cs	outwash	none
5 (2C2)	120-126	10YR5/3	-	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10½', soils as described above. b. Soil saturated below 8'.

c. Horizon 3 contains few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata.

d. Horizon 4 contains very few thin (<¼" thick) very discontinuous 7.5YR4/4 fsl strata.

e. Horizon also contains ccd 7.5YR5/6-8 banded mottling from 84-108".

f. Collected grab sample at 48".

prob. seasonal sat'n > 84"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-68

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082998	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR4/2	-	sil-sl	2msbk	mfr	2f,1m	as	loess	none
2 (A/E)	9-27±8	10YR5/4 → 10YR5/2	-	sil	2msbk → 1msbk	mfr → mvfr	0-1f	cvw	loess	none
3 (2C1)	27-61	10YR6/6 (v)	-	grm-cos	1csbk	mvfr	0	cw	outwash	none
4 (2C2)	61-74+	10YR6/4	-	m-cos	0-1csbk	mvfr	0	-	outwash	none
4 (2C2)	74-96	10YR6/4	> 84" see remarks	m-cos	0-1csbk → sg	mvfr → w-ml	0	cs	outwash	none
5 (2C3)	96-132+	10YR5/4	see remarks	grvcos	sg	w-ml	0	-	outwash	none

D-171

Remarks:

a. Pit extended to approximately 11', soils as described above. b. Soil saturated below 7'.

c. Horizon 3 contains several rafted till fragments (7.5YR4/4 scl-sl) ranging in size from 2" in diameter to 12' x 36" slabs along the base of the horizons. The till fragments contain fmp 7.5YR7/2 (depletion) and ffd 7.5YR5/6 (accumulation) textural mottles.

d. Horizons 4 and 5 contain ccd 7.5YR5/6-8 banded mottling below 84".

prob. seasonal sat'n > 72"
Limiting Factors/Depth

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-69

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082998	grass	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 90"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR4/2	-	sl-sil	1m-csbk	mvfr	2f,1mc	as	loess	none
2 (2B)	9-35±5	7.5YR4/4 (v)	-	grcosl → scl	0-1csbk → 2m-csbk	mvfr → mfr	0-1f	cvw	sandy till → till	none
3 (3C1)	35-66	10YR6/4	-	m-cos	1csbk	mvfr	0	cs	outwash	none
4 (3C2)	66-70+	10YR5/4 (v)	-	grvcos	sg	ml	0	-	outwash	none
4 (3C2)	70-90	10YR5/4 (v)	-	grvcos	sg	ml	0	as	outwash	none
5 (3C3)	90-108	10YR6/4	see remarks	fsl	3mabk	w-mfr	0	as	outwash	none
6 (3C4)	108-120+	10YR6/4	see remarks	m-cos	sg	w-ml	0	-	outwash	none

D-172

Remarks:

a. Pit extended to approximately 10', soils as described above. b. Soil saturated below 9'.

c. The lower part of horizon 2 (scl) contains mcd 10YR6/3 (depletion) mottles. The upper parts of horizon 3 beneath the convex-up portions of the horizon 2 base contains mcd 7.5YR5/8 (accumulation) mottles.

d. Horizon 3 also contains large (up to 10" x 30") irregular fragments of till (7.5YR4/4, scl).

e. Horizon 5 contains mcd 7.5YR5/6-8 banded mottling, and horizon 6 contains ccd 7.5YR5/6-8 banded mottling.

prob. seasonal sat'n > 96"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-70

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082998	grass	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	7.5YR3/3	-	sl-sil	1-2msbk	mfr	2f,1m	as	loess	none
2 (B2s)	10-16	7.5YR4/4	-	sl	1msbk	mvfr	0-1f	cw	loess	none
3 (2C1)	16-23	7.5YR5/4 (v)	-	grcosl	0-1csbk-sg	mvfr-ml	0-1f	cw	sandy till	none
4 (3C2)	23-45	10YR5/3 (v)	-	ms → m-cos	1csbk	mvfr	0	cw	outwash	none
5 (3C3)	45-64+	10YR6/4	-	m-cos	1csbk	mvfr	0	-	outwash	none

Remarks:

a. Pit extended to approximately 9', soil similar to that encountered in horizon 5. b, Soil saturated below 7'.

c. Horizon 4 contains few thin (<¼" thick) very discontinuous 7.5YR4/4 fsl strata.

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-71

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082998	grass	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 84"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	7.5YR3/2	-	sl-sil	1m-csbk	mvfr	2f,1m	as	loess	none
2 (B2)	10-23	10YR5/4	-	sil	2msbk	mvfr	0-1f	cw	loess	none
3 (B31)	23-34±3	7.5YR5/4	-	sl-sil	1mgr	mvfr	0-1f	cw	loess	none
4 (2B32)	34-50±6	7.5YR4/4	-	scl-sl	1-2csbk	mfr	0	cw-i	till	none
5 (3C)	50-64+	10YR6/4	-	ms	1csbk	mvfr	0	-	outwash	none

D-174

Remarks:

a. Pit extended to approximately 11', soil similar to that encountered in horizon 5. b. Soil saturated below 8'. c. Collected grab sample at 60".

d. Lower 4" of horizon 3 contains fcd 7.5YR5/6 (banded, accumulation) and ccp 7.5YR6/2 (depletion) mottles.

e. Upper 3" of horizon 4 contains fm-cd 7.5YR5/8 banded mottling.

f. The base of horizon 4 contains several till pendants which extend into horizon 5. The upper part of horizon 5 contains many small (<2" in diameter) till fragments. It appears that horizon 4 is part of a large rafted till fragment.

prob. seasonal sat'n > 84"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

082898
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-72

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082998	grass	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 96"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/2-3	-	sl	2msbk	mvfr	1f-m	as	loess	none
2 (A/B)	10-16	10YR6/4	-	sl-sil	1f-msbk	mvfr	0-1f	cs	loess	none
3 (B)	16-21	7.5YR5/4-6	-	sl	1f-msbk	mvfr	0-1f	cw	loess	none
4 (2C1)	21-32	7.5YR5/3	-	cosl	1-2msbk	mfr	0	cw	sandy till	none
5 (3C2)	32-61+	10YR6/4	> 84" see remarks	ms	1csbk → sg	mfr → ml	0	-	outwash	none

D-175

Remarks:

a. Pit extended to approximately 10', soil similar to that encountered in horizon 5. b. Soil saturated below 9'. c. Collected grab sample at 70".

d. Horizon 5 contains several rafted till fragments (7.5YR4/4, scl) ranging from 2" x 2" to 24" x 60" above 63". The entire horizon contains very few thin (<¼" thick) very discontinuous 7.5YR4/4 fsl strata.

e. Above the rafted till fragments horizons 4 and 5 contain fmd 7.5YR5/6 textural mottles.

f. Horizon 5 also contains ccd 7.5YR5/6-8 banded mottling below 84".

prob. seasonal sat'n > 96"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-73

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	082998	grass	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 84"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-12	10YR4/2	-	sil-sl	1f-msbk	d-mvfr	2f,1m	as	loess	none
2 (B2)	12-20	10YR6/3-4	-	sil	2msbk	d-mvfr	0-1f	cw	loess	none
3 (2C1)	20-27	7.5YR6/4-6	-	grcos	0-1csbk	mvfr	0-1m	cw	outwash	none
4 (2C2)	27-70+	10YR6/4	> 84" see remarks	m-cos	1csbk → sg	mvfr → ml	0-1m → 0	-	outwash	none

Remarks:

a. Pit extended to approximately 10', soil similar to that encountered in horizon 4. b. Soil saturated below 8'.

c. Horizons 3 and 4 contain vfcp 10YR2/1-3 root channels.

d. Horizon 4 contains few thin (<½" thick) discontinuous 7.5YR4/4 fsl strata.

e. Collected grab sample at 36".

f. Horizon 4 also contains ccd 7.5YR5/6-8 banded mottling below 84".

prob. seasonal sat'n > 84"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-74

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083098	alfalfa	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 60"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/2	-	sil	2msbk	mvfr	2f,1m	as	loess	none
2 (2A/C)	10-18	7.5YR4/4	-	grvcos	1m-csbk	mvfr	0-1f	cs	sandy till	partially Ce/Cp
3 (3C1)	18-30	7.5YR6/4	-	ms	2msbk	mfr	0-1f	cs	outwash	partially Ce/Cp
4 (3C2)	30-67+	10YR6/4	-	m-cos	1msbk	mvfr	0	-	outwash	none
4 (3C2)	67-84	10YR6/4	> 72" see remarks	m-cos	1msbk → sg	mvfr → w-ml	0	cs	outwash	none
5 (3C3)	84-108+	10YR5/4	see remarks	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 9', soil as described above. b. Soil saturated below 6'.

c. Collected 2 composite samples: 10-18" and 18-67". d. Portions of horizons 2 and 3 are partially cemented/compacted.

e. Horizon 3 contains few thin (<½" thick) discontinuous 7.5YR4/4 fsl strata.

f. Horizon 4 contains few thin (<¾" thick) 7.5YR4/4 fsl strata, and few thin (<1" thick) grvcos seams.

g. Horizon 4 and 5 contain ccd 7.5YR5/6-8 banded mottling below 72".

prob. seasonal sat'n > 60"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-75

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083098	alfalfa	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 66"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/2	-	sil	1msbk	mvfr	2f,1m	as	loess	none
2 (B2)	10-14	10YR6/6 (v)	-	sil	2msbk	mfr-mfi	1f	cw	loess	partially Ce/Cp
3 (2C1)	14-38±6	7.5YR4/6 (v)	-	grcosl	sg	ml	0-1f	cw	sandy till	partially Ce/Cp
4 (3C2)	38-65+	10YR6/4	-	m-cos	sg-1csbk	ml-mvfr	0	-	outwash	none
4 (3C2)	65-96	10YR6/4	see remarks	m-cos	sg	w-ml	0	cs	outwash	none
5 (3C3)	96-102+	10YR5/4	see remarks	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 8¼', soil as described above. b. Soil saturated below 6½'.

c. Portions of horizons 2 and 3 are partially cemented/compacted.

d. Horizon 3 contains few thin (<¼" thick) very discontinuous 7/5YR4/4 fsl strata.

e. Horizons 4 and 5 contain ccd 7.5YR5/6-8 banded mottling below 65".

prob. seasonal sat'n > 66"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-76

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083098	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 56"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR4/2 (v)	-	sl-sil	1csbk	mvfr	2f,1mc	as	loess	none
2 (A/B)	9-15	10YR6/4	-	sil	1msbk	mvfr	1f	cw	loess	none
3 (B2)	15-18	7.5YR4/4	-	sl-sil	2msbk	mvfr-mfi	1f	cw	loess	partially Ce/Cp
4 (2C1)	18-55	7.5YR5/4 (v)	-	grcos	1csbk → sg	mvfr → ml	0-1f	as	outwash	partially Ce/Cp
5 (2C2)	55-68+	10YR5/4-6/4	> 65" see remarks	m-cos	1csbk	mvfr	0	-	outwash	none
5 (2C2)	68-96	10YR5/4-6/4	see remarks	m-cos	1csbk → sg	mvfr → w-ml	0	cs	outwash	none
6 (2C3)	96-108+	10YR5/3	see remarks	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 9', soil as described above. b. Soil saturated below 68". c. Collected 2 composite samples: 18-55" and 55-68".

d. Portions of horizons 3 and 4 are partially cemented/compacted. e. Horizon 3 contains mmd 7.5YR6/2 (depletion) mottles.

f. Horizon 4 contains very few thin (<¼" thick) very discontinuous 7.5YR4/4 fsl strata, and few thin (<3" thick) grvcos seams (some contain ccd 7.5YR5/6-8 textural mottles).

g. Horizons 5 contains ccd 7.5YR5/6-7 banded mottling, and horizon 6 contains fcd 7.5YR5/6-8 banded mottling.

prob. seasonal sat'n > 56"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-77

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083098	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 32"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/2-3	-	sl	2m-csbk	mfr	2f,1mc	as	loess	none
2 (2A/C)	10-32	7.5YR5/6 (v)	?	grcos	0-1csbk	mvfr-mfr	1f	cw	outwash	partially Ce/Cp
3 (2C1)	32-50	10YR5/4-6/4	c-mvcd 7.5YR5/6-8	m-cos	sg-1csbk	ml-mfr	0-1f	cs	outwash	none
4 (2C2)	50-59+	10YR4/3	gleyed	m-cos	1csbk	w-mvfr	0	-	outwash	none
4 (2C2)	59-72	10YR4/3	gleyed	m-cos	1csbk → sg	mvfr → w-ml	0	cs	outwash	none
5 (2C3)	72-84+	10YR4/3	gleyed	grvcos	sg	w-ml	0	-	outwash	none

D-180

Remarks:

a. Pit extended to approximately 7', soil as described above. b. Soil saturated below 50".

c. Portions of horizon 2 are partially cemented/compacted.

prob. seasonal sat'n > 32"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-78

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083098	alfalfa	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 96"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-8	10YR4/2	-	sl-sil	1msbk	mvfr	2f,1mc	as	loess	none
2 (B2s)	8-14±2	7.5YR5/4	-	sl-sil	2msbk	mvfr	1f	cw	loess	partially Ce/Cp
3 (2B/C)	14-31	7.5YR6/6 → 7.5YR5/4	-	m-cos	1csbk	mvfr-mfr	0-1f	cs	outwash	none
4 (2C1)	31-67+	10YR6/4 → 10YR5/4	-	m-cos	1csbk → sg	mvfr → ml	0	-	outwash	none
4 (2C1)	67-114	10YR5/4	> 102" see remarks	m-cos	sg	w-ml	0	cs	outwash	none
5 (2C2)	114-126+	10YR5/4	see remarks	grvcos	sg	w-ml	0	-	outwash	none

D-181

Remarks:

a. Pit extended to approximately 10½, soil as described above. b. Soil saturated below 9'. c. Portions of horizon 2 are cemented/compacted.

d. Horizon 2 contains a small truncated cradle knoll sequence of E, Bhs and Bs horizons at the top of the horizon.

e. Horizon 3 contains few thin (<¼" thick) very discontinuous 7.5YR4/4 fsl strata.

f. Horizon 4 contains few thin (<½" thick) discontinuous 7.5YR4/4 fsl strata. g. Horizons 4 and 5 contain ccd 7.5YR5/6-8 banded mottling below 102".

prob. seasonal sat'n > 96"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-79

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083098	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 60"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/2	-	sil-sl	1m-csbk	mfr	2f,1mc	as	loess	none
2 (A/C)	10-26±6	10YR5/4	-	sil	0-1msbk	ml-mvfr	0-1f	cw	loess	partially Ce/Cp
3 (2C1)	26-54	7.5YR5/6 → 10YR5/4	-	grcos	0-1csbk	ml-mfr	0-1f	cs	outwash	partially Ce/Cp
4 (2C2)	54-63+	10YR6/4	-	m-cos	1csbk	mvfr	0	-	outwash	none
4 (2C2)	63-96	10YR6/4	> 66" see remarks	m-cos	1csbk → sg	mvfr → w-ml	0	cs	outwash	none
5 (2C3)	96-120+	10YR5/4	see remarks	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10', soil as described above. b. Soil saturated below 6'.

c. Portions of horizons 2 and 3 are partially cemented/compacted.

d. Horizons 4 and 5 contain ccd 7.5YR5/6-8 banded mottling below 66".

prob. seasonal sat'n > 60"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-80

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083098	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR3/2	-	sil-sl	1m-csbk	mvfr	2f,1mc	as	loess	none
2 (A/C)	10-22±3	10YR6/4	-	sl-sil	0-1f-msbk	mvfr	0-1f	cw	loess	partially Ce/Cp
3 (2C1)	22-53	7.5YR5/6 (v)	-	grcos	sg-1csbk	ml-mvfr	0-1f	cs	outwash	partially Ce/Cp
4 (2C2)	53-78+	10YR5/4	> 72" see remarks	grm-cos	1csbk → sg	mvfr → ml	0	-	outwash	none
4 (2C2)	78-96	10YR5/4	see remarks	grm-cos	sg	w-ml	0	cs	outwash	none
5 (2C3)	96-108+	10YR5/3	-	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 9', soil as described above. b. Soil saturated below 7'. c. Collected composite 2 samples from: 22-53" and 53-78".

d. Portions of horizons 2 and 3 are partially cemented/compacted.

e. Horizon 3 contains very few thin (<¼" thick) discontinuous 7.5YR4/4 fsl strata.

f. Horizon 4 contains few thin (<½" thick) discontinuous 7.5YR4/4 fsl strata, and very few thin (<2" thick) grcos seams.

g. Horizon 4 contains ccd 7.5YR5/6-8 banded mottling below 72".

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

09'28'98
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-81

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083098	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/2-3	-	sil	1f-msbk	mvfr	2f,1m	as	loess	none
2 (B2)	10-20±5	7.5YR5/6 → 7.5YR6/4	-	sil	2f-msbk	mvfr	0-1f-m	cw	loess	none
3 (2C1)	20-44	7.5YR6/4	-	grm-cos	sg-1csbk	ml-mfr	0-1f-m	cs	outwash	partially Ce/Cp
4 (2C2)	44-73+	10YR6/4	> 60" see remarks	m-cos	1csbk → sg	mvfr → ml	0	-	outwash	none
4 (2C2)	73-114	10YR6/4	see remarks	m-cos	sg	w-ml	0	cs	outwash	none
5 (2C3)	114-122+	10YR5/3	-	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 12', soil as described above. b. Soil saturated below 7'. c. Collected 2 composite samples from: 20-44" and 44-73".

d. Portions of horizon 3 are partially cemented/compacted.

e. Horizon 3 contains few thin (<½" thick) discontinuous 7.5YR4/4 fsl strata, and very few thin (<2" thick) grcos seams.

f. Horizon 4 contains very few thin (<½" thick) discontinuous 7.5YR4/4 fsl strata.

g. Horizon 4 also contains ccd 7.5YR5/6-8 banded mottling below 60".

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-82

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083098	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 58"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-8	10YR3/2	-	sil-sl	1f-msbk	mvfi	2f,1mc	as	loess	none
2 (2B2s)	8-31±6	7.5YR4/4 → 7.5YR5/4	-	vcosl	sg-1csbk	ml-mfr	0-1f	cw	outwash	partially Ce/Cp
3 (2C1)	31-71+	7.5YR6/4	> 44" see remarks	m-cos	1csbk	mvfr	0-1f	-	outwash	none
3 (2C1)	71-96	7.5YR6/4	see remarks	m-cos	1csbk	w-mvfr	0	cs	outwash	none
4 (2C2)	96-120+	10YR5/3	-	grvcos	sg	w-ml	0	-		

Remarks:

a. Pit extended to approximately 10', soil as described above. b. Soil saturated below 70".

c. Portions of horizon 2 are partially cemented/compacted.

d. Horizon 2 contains several truncated cradle knoll sequences of former E, Bhs and Bs horizons at the top of the horizon.

e. Horizon 3 contains ccd 7.5YR5/6-8 banded mottling below 44".

prob. seasonal sat'n > 58"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

092898
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-83

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083098	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	7.5YR4/2	-	sl	2csbk	mfr	2f,1mc	as	loess	none
2 (2A/C)	10-43	7.5YR5/6 → 10YR6/4	-	cosl	sg-1csbk	ml-mfr	0-1f-m	cs	outwash	partially Ce/Cp
3 (2C1)	43-49	10YR6/4 (v)	-	vcos	sg	ml	0	cs	outwash	none
4 (2C2)	49-62+	10YR6/4	> 72" see remarks	ms	1csbk	mvfr	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10', soil similar to that encountered in horizon 4. b. Soil saturated below 7'. c. Collected grab samples at 20" and at 70".

d. Portions of horizon 2 are partially cemented/compacted.

e. Horizon 3 contains few thin (<½" thick) discontinuous 7.5YR4/4 fsl strata.

f. Horizon 4 contains very few thin (<¼" thick) very discontinuous 7.5YR4/4 fsl strata.

g. Horizon 4 contains ccd 7.5YR5/6-8 banded mottling below 72".

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

092898
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-84

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083098	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 60"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/3	-	sil	1f-msbk	mvfr	2f,1mc	as	loess	none
2 (2B2s)	10-42	7.5YR5/6 → 10YR6/4	-	cosl	sg-1csbk	d-ml-mfr	0-1f-c	cs	outwash	partially Ce/Cp
3 (2C1)	42-48	10YR6/4	-	m-cos	sg	ml	0-1f-m	as	outwash	none
4 (2C2)	48-55	10YR6/4	-	vfsl	2-3mabk	mfr	0	as	outwash	none
5 (2C3)	55-64+	10YR6/4	> 60" see remarks	ms	1csbk	mvfr	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10', soil similar to that encountered in horizon 5. b. Soil saturated below 6'.

c. Portions of horizon 2 are partially cemented/compacted. d. Horizon 2 contains few truncated cradle knoll sequences of E, Bhs and Bs horizons at the top of the horizon.

d. Horizon 2 also contains few thin (<½ thick) discontinuous 7.5YR4/4 fsl strata, and few thin (<3" thick) grvcos seams.

e. Horizon 5 contains very few thin (<½" thick) discontinuous 7.5YR4/4 fsl strata. g. Horizon 5 also contains ccd 7.5YR5/6-8 banded mottling below 60".

prob. seasonal sat'n > 60"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-85

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083098	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 96"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-12	10YR4/3	-	sil	2f-msbk	d-mvfr	2f,1mc	as	loess	none
2 (2A/C)	12-36	7.5YR5/4-6 (v)	-	m-cos	1csbk	mvfr-mfr	1f-m	cs	outwash	partially Ce/Cp
3 (2C1)	36-73+	10YR6/4	-	m-cos	1csbk	mvfr	0-1m	-	outwash	none
3 (2C1)	73-132	10YR6/4	> 96" see remarks	m-cos	1csbk → sg	mvfr → w-ml	0	cs	outwash	none
4 (2C2)	132-156+	10YR5/3	see remarks	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 13', soil as described above. b. Soil saturated below 9'. c. Collected grab sample at 50".

d. Portions of horizon 2 are partially cemented/compacted.

e. Horizon 2 contains few thin (<½" thick) discontinuous 7.5YR4/4 fsl strata.

f. Horizon 3 contains very few thin (<¼" thick) discontinuous 7.5YR4/4 fsl strata, and minor cross bedding in the sands.

g. Horizon 3 and 4 also contain ccd 7.5YR5/6-8 banded mottling below 96".

prob. seasonal sat'n > 96"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223706

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-86

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083098	alfalfa planted but short grasses and weeds growing	glacial sediments

Customer Address	Estimated Shallowest Groundwater Depth	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		

County	Tax Parcel No.	
Forest	Crandon Mine Site	

Lot Legal Description		
SE¼, T35N R13E, Section 17		

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (A)	0-36	variegated	-	fill						
2 (C)	36-48	dk gray-white	gleyed	sandy fill						
3 (Oeb)	48-60	black	-	-						
4 (Eb)	60-66+	dk gray	-	sand						

Remarks:

a. Pit dug in the center of a 60' diameter low area in which alfalfa does not grow.

b. Did not enter pit due to H_2S fumes, less odor than at THP-26.

c. Base of horizon 2 and top of horizon 3 contain large decomposing wood fragments.

Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-87

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083198	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/3	-	sil-sl	1f-msbk	d-mvfr	2f,1mc	as	loess	none
2 (A/C)	10-13	7.5YR6/4	-	sil-sl	1fgr	d-mvfr	0-1f	cw	loess	none
3 (2C1)	13-26±12	7.5YR4/4 (v)	-	grcosl	sg-1csbk	ml-mvfr	0-1f-c	cw	outwash	partially Ce/Cp
4 (2C2)	26-68+	7.5YR6/4-10YR6/4	-	m-cos	1csbk	mvfr	0-1f-m	-	outwash	none
4 (2C2)	68-120	10YR6/4	-	m-cos	1csbk → sg	mvfr → w-ml	-	cs	outwash	none
5 (2C3)	120-132+	10YR5/4	-	grvcos	sg	w-ml	-	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil as described above. b. Soil saturated below 7'. c. Collected grab sample at 60".

d. Portions of horizon 3 are partially cemented/compacted.

e. Horizon 4 contains few thin (<1" thick) discontinuous 7.5YR4/4 fsl strata which appears to have 2mabk, mfr features.

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-88

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083198	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 60"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/2	-	sil	2f-csbk	d-mvfr	2f,1mc	as	loess	none
2 (B2)	10-23	10YR6/4	-	sil-sl	2f-msbk → 1mgr	d-mvfr	0-1f-m	cs	loess	partially Ce/Cp
3 (2C1)	23-34	7.5YR5/4 (v)	-	grm-cos	sg-1csbk	ml-mfr	0-1f	cs	outwash	partially Ce/Cp
4 (2C2)	34-64+	10YR6/4	> 59" see remarks	m-cos	1csbk	mvfr	0-1f	-	outwash	none
4 (2C2)	64-84	10YR6/4	see remarks	m-cos	1csbk → sg	mvfr → w-ml	0	cs	outwash	none
5 (2C3)	84-120+	10YR5/4	-	vcos	sg	w-ml	0	-	outwash	none

D-191

Remarks:

a. Pit extended to approximately 10', soil as described above. b. Soil saturated below 6'. c. Collected grab sample at 54".

d. Portions of horizons 2 and 3 are partially cemented/compacted. e. Horizon 3 contains few thin (<¼" thick) very discontinuous 7.5YR4/4 fsl strata.

f. Horizon 4 contains very few thin (<¾" thick) very discontinuous 7.5YR4/4 fsl strata.

g. Horizon 4 also contains ccd 7.5YR5/6-8 banded mottling below 59".

prob. seasonal sat'n > 60"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-89

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083198	alfalfa	loess over glacial till and outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 63"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-11	10YR4/2-3	-	sil-sl	1f-msbk	d-mvfr	2f,1mc	as	loess	none
2 (B2)	11-23	10YR6/4	-	sil	1msbk	d-mvfr	0-1f	cw	loess	none
3 (2B3)	23-58±10	7.5YR4/4	-	scl-sl	2m-csbk	mvfr-mfi	0-1f-m	cw	till	partially Ce/Cp
4 (3C)	58-78+	10YR5/4	-	m-cos	1csbk	w-mvfr	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10', soil similar to that encountered in horizon 4. b. Soil saturated below 75". c. Collected grab sample at 73".

d. Pit contains several large root channels extending from 23-75" which are filled with sil.

e. Portions of horizon 3 are partially cemented/compacted.

f. Horizon 3 is a large rafted till fragment with many pendants of till extending into the top of horizon 4.

prob. seasonal sat'n > 63"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-90

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	083198	alfalfa	loess over glacial till and outwash

Customer Address	Estimated Shallowest Groundwater Depth	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161	> 53"	

County	Tax Parcel No.		
Forest	Crandon Mine Site		

Lot Legal Description		
SE¼, T35N R13E, Section 17		

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/3	-	sl-sil	1f-mgr	d-mvfr	2f,1mc	as	loess	none
2 (A/C)	10-17	10YR6/6	-	sl-sil	1fgr	mvfr	0-1f-m	cw	loess	none
3 (C1)	17-37±5	10YR6/3 (v)	-	sl	1msbk	mvfr	0-1f-m	cw	loess	none
4 (2C2)	37-50±13	7.5YR4/4 (v)	-	grscl-sl	1csbk	mfr	0-1f-m	cw	till	partially Ce/Cp
5 (3C3)	50-73+	10YR6/6	-	ms	2csbk	mvfr	0	-	outwash	none

Remarks:

a. Pit extended to approximately 8½', soil similar to that encountered in horizon 5. b. Soil saturated below 65".

c. One side of the pit contains a large (about 5' thick) truncated cradle knoll sequence of A, E, Bhs, and Bs horizons below the Ap horizon.

d. Portions of horizon 4 are partially cemented/compacted. e. Horizon 4 is a large rafted till fragment with many pendants extending into the top of horizon 5.

f. Horizon 5 contains several clay (scl) balls (about 2-3" in diameter) in the upper part of the horizon. These features have mcp 7.5YR5/2-3 (depletion) and 5YR4/6-7.5YR4/6 (accumulation) textural mottling similar to that observed in TPH-89.

prob. seasonal sat'n > 53"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-91

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	090198	alfalfa planted but short grasses and weeds growing	fill over glacial till

Customer Address	Estimated Shallowest Groundwater Depth
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161	

County	Tax Parcel No.
Forest	Crandon Mine Site

Lot Legal Description
SE¼, T35N R13E, Section 17

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	variegated		sil-sl					fill	
2 (C)	10-20	variegated		sil-sl					fill	
3 (Oib)	20-34	5YR2.5/2		-						
4 (C1b)	34-40	5GY5/1-5Y5/1	gleyed	scl					till	
5 (C2b)	40-44+	7.5YR5/2	gleyed	cl					till	

Remarks:

a. Pit dug in a drainageway in which alfalfa does not grow.

b. Entered pit for only a short time due to mild H_2S fumes, less odor than at TPH-86.

c. Base of horizon 2 and top of horizon 3 contain large decaying wood fragments.

Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-92

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	090198	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-11	10YR4/2-3	-	sil-sl	2m-csbk	d-mfr	2f,1mc	as	loess	none
2 (B2)	11-24	10YR5/4 → 10YR6/4	-	sil-sl	2msbk → 1f-msbk	mfr → mvfr	0-1f	cs	loess	partially Ce/Cp
3 (2C1)	24-51	7.5YR6/4 → 7.5YR5/6	-	grm-cos	sg-0-1csbk	ml-mvfr	0-1f	cs	outwash	partially Ce/Cp
4 (2C2)	51-73+	10YR6/4	> 61" see remarks	m-cos	1csbk	mvfr	o	-	outwash	none
4 (2C2)	73-90	10YR6/4	see remarks	m-cos	1csbk	w-mvfr	o	cs	outwash	none
5 (2C3)	90-108"	10YR5/4	-	grvcos	sg	w-ml	o	-	outwash	none

Remarks:

a. Pit extended to approximately 9', soil as described above. b. Soil saturated below 7'.

c. Portions of horizons 2 and 3 are partially cemented/compacted.

d. Horizon 4 contains ccd 7.5YR5/6-8 banded mottling below 61".

e. A large rafted till fragment (scl, 7.5YR4/4) was found on the opposite side of the pit between 43-63". Banded mottling beneath the rafted till is mcp 2.5YR3/6-4/8.

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-93

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	090198	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 61"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR4/2-3	-	sil-sl	2m-csbk	d-mvfr	2f,1mc	as	loess	none
2 (B2)	9-16	10YR5/4	-	sil	2msbk → 1fsbk	d-mvfr	0-1f-m	cs	loess	partially Ce/Cp
3 (2C1)	16-36	10YR6/4 (v)	-	m-cos	1csbk	mvfr	0-1f	cs	outwash	none
4 (2C2)	36-73+	7.5YR6/3	> 52" see remarks	m-cos	1csbk	w-mvfr	0-1f	-	outwash	none
4 (2C2)	73-78	7.5YR6/3	see remarks	m-cos	1csbk	w-mvfr	0	cs	outwash	none
5 (2C3)	78-90	10YR6/4	see remarks	f-ms	1csbk	w-mvfr	0	cs	outwash	none
6 (2C4)	90-120+	10YR5/3	-	grvcos	sg	w-ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 10', soil as described above. b. Soil saturated below 73".

c. Portions of horizon 2 are partially cemented/compacted.

d. Horizon 3 contains few thin (<½" thick) irregular and discontinuous 7.5YR4/4 fsl strata.

e. Horizon 4 contains fcp 10YR2/2-7.5YR5/6 root channels and mottles. Horizon 4 also contains ccd 7.5YR5/6-8 banded mottling below 52".

prob. seasonal sat'n > 61"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-94

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	090198	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-11	10YR4/3-5/3	-	sil	1f-msbk	mvfr	2f,1m	as	loess	none
2 (2C1)	11-15	10YR6/4	-	ls	sg-1mgr	ml-mvfr	0-1f	cs	outwash	none
3 (2C2)	15-51	10YR6/4 (v)	-	grm-cos	1csbk	mvfr	0-1f	cs	outwash	none
4 (2C3)	51-65+	10YR6/4 (v)	> 67" see remarks	grm-cos	sg	ml	0	-	outwash	none

Remarks:

a. Pit extended to approximately 9', soil similar to that encountered in horizon 4. b. Soil saturated below 7'. c. Collected grab sample at 31".

d. Horizon 3 contains few thin (<½" thick) discontinuous 7.5YR4/4 fsl strata and a 6" x 24" lens of fsl (2msbk).

e. Horizon 4 contains ccd 7.5YR5/6-8 banded mottling below 67".

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

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Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-95

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	090198	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR4/2-3	-	sl	1m-csbk	mfr-mvfr	2f,1m	as	loess	none
2 (B2)	9-15	7.5YR4/4	-	sil-sl	2msbk	mfr	0-1f	cs	loess	none
3 (2C1)	15-27	7.5YR5/4	-	grm-cos	2csbk	mfr-mvfr	0-1f	cs	outwash	partially Ce/Cp
4 (2C2)	27-70+	10YR6/4	> 70" see remarks	grm-cos	1csbk	mvfr	0-1f	-	outwash	none

Remarks:

a. Pit extended to approximately 9', soil similar to that encountered in horizon 4. b. Soil saturated below 7'.

c. Portions of horizon 3 are partially cemented/compacted.

d. Horizon 3 contains few thin (<½" thick) irregular very discontinuous 7.5YR4/4 fsl strata.

e. Horizon 4 contains few thin (<1" thick) very discontinuous 7.5YR4/4 fsl strata and vfcp 10YR2/2-7.5YR5/6 root channels and mottles above 70".

f. Horizon 4 also contains ccd 7.5YR5/6-8 banded mottling below 70".

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

092898
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-96

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	090198	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 68"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-9	10YR4/2-3	-	sil	1f-csbk	d-mvfr	2f,1mc	as	loess	none
2 (A/C)	9-13	10YR5/4	-	sil	1fgr	d-mvfr	1f	as	loess	none
3 (2C1)	13-34	7.5YR5/4	-	m-cos	0-1csbk	mvfr	0-1f-m	cs	outwash	partially Ce/Cp
4 (2C2)	34-80+	10YR6/4	> 65" see remarks	m-cos	1csbk	mvfr	0-1f-m	-	outwash	none

Remarks:

a. Pit extended to approximately 11', soil similar to that encountered in horizon 4. b. Soil saturated below 80".

c. Portions of horizon 3 are partially cemented/compacted.

d. Horizon 3 contains few thin (<¼" thick) very discontinuous 7.5YR4/4 fsl strata.

e. Horizon 4 contains few thin (<¾" thick) discontinuous 7.5YR4/4 fsl strata.

f. Horizon 4 also contains ccd 7.5YR5/6 banded mottling between 65-96".

prob. seasonal sat'n > 68"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

092898
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-97

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	090198	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 68"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-11	10YR4/2-3	-	sil	2m-csbk	d-mfr	2f,1mc	as	loess	none
2 (B2)	11-15	7.5YR5/4	-	sil-sl	2msbk	d-mvfr	1f	cw	loess	none
3 (2C1)	15-39	7.5YR4/6 (v)	-	grm-cos	1csbk	mfr-mvfr	0-1f	cs	outwash	partially Ce/Cp
4 (2C2)	39-81+	10YR6/4	> 69" see remarks	grm-cos	1csbk	mvfr	0-1f	-	outwash	none

Remarks:

a. Pit extended to approximately 10', soil similar to that encountered in horizon 4. b. Soil saturated below 80". c. Collected grab sample at 23".

d. Portions of horizon 3 are partially cemented/compacted.

e. Horizon 3 contains very few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata.

f. Horizon 4 contains very few thin (<½" thick) very discontinuous 7.5YR4/4 fsl strata, and very few thin (<4" thick) grvcos seams.

g. Horizon 4 also contains ccd 7.5YR5/8 banded mottling between 69-108".

prob. seasonal sat'n > 68"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 223796

092898
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

SOIL DESCRIPTION REPORT

Soil Test Pit: TPH-98

Customer Name	Soil Evaluation Date	Current Land Use or Vegetative Cover	Parent Materials
Nicolet Minerals Company	090198	alfalfa	loess over glacial outwash
Customer Address		**Estimated Shallowest Groundwater Depth**	
7 N. Brown Street, 3rd Floor, Rhinelander, WI 54501-3161		> 72"	
County	**Tax Parcel No.**		
Forest	Crandon Mine Site		
Lot Legal Description			
SE¼, T35N R13E, Section 17			

Horizon	Depth (in.)	Dominant Color	Mottles Qu,Sz,Co,Color	Texture	Structure Gr,Sz,Sh	Consistence	Roots	Boundary	Parent Material	Cementation, Ce Compaction, Cp
1 (Ap)	0-10	10YR4/2	-	sil	2m-csbk	d-mvfr	1f-c	as	loess	none
2 (2A/C)	10-44	7.5YR5/4 (v)	-	grm-cos	sg-1csbk	ml-mfr	0-1f	cs	outwash	partially Ce/Cp
3 (2C)	44-71+	10YR6/4	> 65" see remarks	m-cos	1csbk	mvfr	0-1f	-	outwash	none

D-201

Remarks:

a. Pit extended to approximately 8', soil similar to that encountered in horizon 3. b. Soil saturated below 7'.

c. Portions of horizon 2 are partially cemented/compacted.

d. Horizon 3 contains ccd 7.5YR5/6-8 banded mottling between 65-96".

prob. seasonal sat'n > 72"
Limiting Factors/Depth

John E. Thresher, Jr., CST No. 229796

012898
Date Signed

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

Appendix B

Boring Logs, Borehole Abandonment Forms, Hand Auger Logs, and Well Construction Forms

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☑ Other Mitigation Site

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Crandon Project - SAP II - Area H		BH-01

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Pat Jensen	07/20/98	07/20/98	HSA-0'-16' 16'-80' MND Rotary

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				~1585 Feet MSL	4¼" IB, 8" OD, 3⅞" Tri-Cone

Boring Location
State Plane ____ N, ____ E S/C/N Lat
NE 1/4 of NE 1/4 of Section 20, T 35 N, R 13 E Long

Local Grid Location (if applicable)
Feet ____ N Feet ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow* Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
1	18"	1/1/2		0 - .2', dk-red-brown silty fine sand, tr organics .2' - 2', lt-brn (10YR5/4) fine to med sand tr silt, loose (outwash)										2" SS
2	18"	2/2/5	2	2' - 4', lt-brn (10YR6/4) fine to med sand, tr silt, loose (outwash)	SM/ SP									3" SS
3	10"	2/2/5	4	4' - 6', brn (7.5YR4/3) med and coarse sand, tr silt, loose (outwash)	SP									2.5" SS
4	20	3/3/9	6	6' - 8', brn (7.5YR4/3) fine to med sand, tr silt saturated, loose (outwash)	SP									2" SS
5	17"	2/2/5	8	8' - 9.3', brn (10YR5/3) med to coarse sand w/ fine	SP									3" SS
				9.3' - 10', lt-brn (10YR6/1) fine to med sand with fine gravel, fine sand stained black	SP									2.5" SS
6	NR	1/1/2	10	10' - 12', No recovery	--									2" SS
7	13"	2/1/2	12	12' - 14', brn (10YR5/3) fine to med sand tr silt w/ fine gravel (outwash)	SP									3" SS
8	6"	2/2/8	14	14' - 16', lt-grey (10YR5/2) fine sand, tr silt (outwash)	SP									18" Blowup 3 ⅞" Tri-cone
9	10"	2/2/4	16	16' - 18', lt grey (10YR5/2) fine to med sand, tr silt and fine gravel (outwash)	SP									3" SS
10	13"	2/2/4	18	18' - 19', lt-grey (10YR5/2) fine sand, tr gravel	SP									3" SS
				19' - 20', grey, med to coarse sand w/ fine gravel (outwash)										
11	13"	2/2/6	20	20' - 22', lt-grey (10YR5/2) fine sand	SP									3" SS
				21.5' - 22', grey, med to coarse sand w/ fine gravel (outwash)										
12	12"	1/2/5	22	22' - 24', grey (10YR5/1) fine to med sand w/ fine to coarse gravel (outwash)	SP									3" SS

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Ron Meister Firm: Foth & Van Dyke

This form is authorized by Chapters 114.147 and 162, Wis. Stats. Completion of this report is mandatory.
Penalties: Forfeit not less than $10 nor more then $5,000 for each violation. Fined not less than $10 or more than $100 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss 114.06, Wis. Stats.

DML\LMC\93C049\GBAPP\65745.61\14000

SAMPLE No.	SAMPLE Rec (in)	Blow* Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
13	15"	2/2/7	24	24' - 25.5', very loose, grey (10YR5/1) med to coarse sand w/ fine gravel	SP									3" SS
				25.5' - 26', fine sand (outwash)										
14	14"	2/3/8	26	26' - 27', med to coarse sand (10YR5/1)	SP									3" SS
				27' - 28', fine sand (outwash)										
15	16"	1/2/3	28	28' - 29.5', grey, loose, fine sand w/ fine gravel	SP									3" SS
				29.5' - 30' , med to coarse sand w/ fine gravel										
16	10"	1/2/5	30	30' - 32', grey, loose, fine to med sand w/ fine gravel, tr silt (outwash)	SP									3" SS
			32											3" SS
17	10"	2/2/8	34	34' - 36', grey (10YR5/1) loose fine to med sand, tr fine gravel (outwash)	SP									3" SS
			36											3" SS
18	17"	4/4/10	38	38' - 40', grey (10YR5/2) loose fine sand, tr silt (outwash)	SP									3" SS
			40											3" SS
19		5/5/11	42	42' - 44', grey (10YR5/2) loose, fine sand tr silt (outwash)	SP									3" SS
			44											3" SS
20		5/5/12	46	46' - 48', grey (10YR5/2) loose, fine sand tr silt and fine gravel (outwash)	SP									3" SS
			48											3" SS
21	15"	5/5/13	50	51' - 53', grey (10YR5/2) loose, fine sand, tr silt (outwash)	SP									3" SS
			52											
			54											
			56											
22	15"	8/9/20	58	58' - 60', grey (10YR5/2) firm, fine sand, tr silt (outwash)	SP									3" SS
			60											
23		7/19/13	62	63' - 65', pale red (10YR6/2) firm, fine sand, tr silt w/ ⅛" to ¼" laminae of red-brn silty clay & grey clayey silt (lacustrine outwash)	CL, ML, SP									3" SS
			64											
			66											
24	18"	4/6/26	68	68' - 68.5', laminated (¼"- ⅛") dk-grey (10YR5/3) fine, sandy silt & silty fine sand w/ laminae of clay (5YR5/4) (rd-brn)	SM, ML, CL									3" SS
				68.5' - 70', brn (10YR5/4) fine sand, tr silt	SP									3" SS
			70											
			72											

State of Wisconsin
Department of Natural Resources
BORING NUMBER: BH-01

Route to:

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

SAMPLE No.	SAMPLE Rec (in)	Blow* Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
			74											3" SS
			76		SP									
25	16"	7/7/16	78	78' - 80', layered ¼" dk-grey (10YR5/3) clay silt (4") grey, very fine, sandy (ML) 1½" silty fine sand (SM) remainder is brn (10YR5/4) fine sand w/ silt (SP) (lacustrine/outwash)	ML, SM, SP									3" SS
			80	80' E,O,B,										

*Blow counts are for a 300 lb hammer

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☑ Other Mitigation Site

SOIL BORING LOG INFORMATION
Form 4400-122 7-91
Drilling Rig Arrives 12:45

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Crandon Project - SAP II - Area H		BH-02

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear/Mike Miller	08/03/98	08/03/98	4¼ inch HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1593.40	8"

Boring Location
State Plane 129420.85 N, 2284835.2 E S/C/N Lat
NW 1/4 of SE 1/4 of Section 17, near TPH-07 T N, R E Long

Local Grid Location (if applicable)
Feet ____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
														4¼" HSA
				0-3", bl (10YR4/2) fine, sandy silt topsoil	OL									3" SS
				3" - 2', fine, sandy silt, lt-yel brn, loess	ML									
1	20"	4/5/10	2	2 - 3½', lt-yel to gray-brown, fine sandy silt	ML									2½" SS
		3/5/7		3½ - 4', brn (10YR6/2), fine sandy silt w/ gravel and clay (till)	SC/ ML									2" SS
2	17"		4	4 - 6', brn (10YR6/4), fine to med sand w/coarse sand and fine gravel (outwash)	SP									3" SS
3	15"	2/2/15	6	6 - 7½', lt-brn (10YR6/6), fine sand w/ fine gravel, streaked red-brn & bl	SP									2½" SS
				7½ - 8', lt-brn med sand (outwash)										
4	17"	3/4/10	8	8 - 10', brn fine and fine to med sand w/ fine gravel, saturated @ 9' (outwash)	SP									2" SS
5	17"	2/2/11	10	10 - 12', brn (10YR6/4) fine to med sand	SP									3" SS
				11½ - 12', med to coarse sand (outwash)										
6	17"	3/3/8	12	12 - 14', brn (10YR6/4) layered brn fine to med and med to coarse sand w/ gravel	SP									3" SS
7	15"	4/4/4	14	14 - 16', brn (10YR6/2) layered fine to med and fine sand, tr fine gravel	SP									2½" SS
8	16"	2/2/4	16	16 - 18', brn (10YR6/2) med to coarse sand w/ fine gravel (outwash)	SP									3" SS
9	9"													
10	13"	2/1/2	18	18 - 20', lt-brn to grey (10YR6/2) fine and fine to med sand w/ fine to med gravel (outwash)	SP									2" SS
11	NR	1/1/2	20	20 - 22', no recovery	SP									3" SS
12	13"	3/1/3	22	22 - 24', lt-grey (10YR6/1) fine to med sand w/ fine gravel, tr silt (outwash)	SP									2" SS
			24	24 - 26', lt-grey & brn (10YR6/2) fine to med sand & fine sand w/ fine gravel, tr silt (outwash)										
13	13"	4/3/3	26	26 - 27½', lt-grey (10YR6/2), fine sand tr silt	SP									3" SS
				27½ - 28', fine sand silt, grey, saturated										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
Ken Mentor	Foth & Van Dyke

This form is authorized by Chapters 114.147 and 162, Wis. Stats. Completion of this report is mandatory.
Penalties: Forfeit not less than $10 nor more then $5,000 for each violation. Fined not less than $10 or more than $100 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss 114.06, Wis. Stats.

State of Wisconsin
Department of Natural Resources
BORING NUMBER: BH-02

Route to:

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
14	12"	1/1/2	28	28 - 29½', grey, fine sand, tr silt	SP/ GP									2" SS
				29½ - 30', med to coarse sand w/ fine to med gravel (outwash)										
15	9"	2/1/2	30	30 - 32', grey (10YR6/1) fine and fine to med sand layered w/ fine gravel (outwash)	SP/ GP									3" SS
16	10"		32	E.O.B. - 32'	SP									2" SS

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Crandon Project - SAP II - Site H		BH-03

Boring Drilled by (Firm name and name of crew chief)	Date Started	Date Completed	Drilling Method
Boart Longyear Pat Jensen	MM/DD/YY 07/21/98	MM/DD/YY 07/21/98 Wire finish 8	HSA - 4¼" ID

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1586 Feet MSL	8 inches

Boring Location	Local Grid Location (if applicable)
State Plane ____ N, ____ E S/C/N Lat NE 1/4 of NE 1/4 of Section 20, T35N, R13E Long	____ N ____ E Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	Rec (in)	Blow" Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
1	24"	1/1/2	-	0 - .2': organic silt (topsoil)	OL									2" SS
			-	.2' - .4': h gr (10YR7/1) fine sandy silt (loess)	ML									
			-	.4' - 1.5': yel-brn (10YR6/1) silty fine sand (loess)	SM									
			-	1.5' - 2': yel-brn (10YR5/6) fine to med sand w/ silt (outwash)	SP									
2	15"	1/2/2	- 2	2' - 4': yel-brn (10YR6/6) fine to med sand w/ silt loose (outwash)	SP									3" SS
3		1/1/4	- 4	4' - 6': lt-brn (10YR6/4) fine to med sand w/ silt, loose (outwash)	SP									2½" SS
4	12"	2/2/2	- 6	6' - 8': lt-brn (10YR6/4) fine to med sand w/ silt, loose (outwash) saturated @ 6'	SP									2" SS
5	12"	9/10/10	- 8	8' - 10': brn (10YR6/4) fine to med sand w/ silt, loose (outwash)	SP									3" SS
6	12"	1/1/2	- 10	10' - 11': brn (10YR6/2) fine to med sand w/ silt, loose	SP									3" SS
			-	11' - 12': (10YR6/2) grey-brn fine to med sand w/ silt										
7	12"	1/1/2	- 12	12' - 14': brn (10YR6/2) med to coarse sand w/ fine tr silt, loose (outwash)	SP									2½" SS
8	10"	1/1/3	- 14	14' - 16': grey-brn (10YR6/2) fine to med sand, tr silt loose (outwash)	SP									2" SS
9	9"	4/4/4	- 16	16' - 18': grey-brn (10YR6/2) layered very fine and fine sand, tr silt, loose (outwash)	SP									3" SS
10	4"	1/1/2	- 18	18' - 20': grey-brn (10YR6/2) very fine sand, tr. silt loose (outwash)	SP									3" SS
11	4"	1/1/2	- 20	20' - 22': grey-brn (10YR6/2) very fine & fine sand tr silt, loose (outwash)	SP									3" SS
12	3"	1/1/1	- 22	22' - 24': same as above, fine sand	SP									3" SS
13	12"	1/1/3	- 24	24' - 26': fine to med sand, tr silt, loose (outwash)	SP									2" SS

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Tom Mentor | Firm: Foth & Van Dyke

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State of Wisconsin
Department of Natural Resources
BORING NUMBER: BH-03

Route to:

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

SAMPLE No.	SAMPLE Rec (in)	Blow* Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
14	8"	4/2/6	26	26' - 28': fine & very fine sand, grey-brn (10YR6/2) loose (outwash)	SP									2" SS
	NR	1/1/1	28	28' - 30': auger sample (no recover y from SS)										2" SS
				E.O.B. 30'										
				*Blow counts are for a 300 lb hammer										

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - SAP II - Area H		BH-04

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Miller	08/03/98	08/03/98	4¼"

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1591.68	8"

Boring Location
State Plane 128957.10 N, 2285934.77 E S/C/N Lat
NW 1/4 of SE 1/4 of Section 17, T N, R E Long

Local Grid Location (if applicable)
____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
			-	0-3", black (10YR4/2) fine sandy silt w/ clay	OL									3" SS
			-	3-15", light yel-brown (10YR4/2) blocky fine sandy (loess)	ML									
1	24"	4/5/10	-	15"-2', brown (10YR6/2) fine sandy silt w/ fine to gravel (till)	SM-ML									2½" SS
2	24"	12/14/28	- 2	2-3', brown (10YR6/2) siltly fine sand w/ fine to gravel (reworked till)	SM									2" SS
			-	3-4', light brown, fine sand, tr. silt (outwash)	SP									3" SS
3	11"	8/10/27	- 4	4-6', light brown fine sand w/ fine to med gravel, tr. silt	SP									2½" SS
			-	5½-6', med to coarse sand (outwash)										
4	16"	5/3/6	- 6	6-8', layered brown fine sand, tr. silt & fine to med sand w/ fine to coarse gravel (outwash)	SP									2" SS
5	14"	4/5/7	- 8	8-10', brown (10YR6/4) fine sand w/ fine to coarse gravel, saturated (outwash)	SP									3" SS
6	14"	2/2/4	- 10	10-12', brown to grey, fine sand, tr. silt, then med to coarse sand w/ fine gravel, saturated (outwash)	SP									2" SS
7	6"	1/1 1/1	- 12	12-14', brown (10YR5/4) med to coarse sand w/ gravel & cobbles, rock in shoe, structureless, wet, loose (outwash)	SP									2" SS
8	4"	3/3 1/2	- 14	14-16', as above, push cobble	SP									2" SS
9	22"	8/2 4/7	- 16	16-18', brown (10YR5/4) fine to med sand with coarse sand & gravel lenses, stratified, structureless, wet, loose (outwash)	SP									2" SS
10	18"	4/7 9/13	- 18	18-20', as above at 20', outwash changes to grey (2.5Y5/1) w/ limestone clasts	SP									2" SS

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
	Foth & Van Dyke

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DMW\93C049\GBAPP\67954.61\14000

State of Wisconsin Route to: SOIL BORING LOG INFORMATION
Department of Natural Resources Form 4400-122 7-91
BORING NUMBER: BH-04

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
11	4"	2/2 2/2	20	20-22', brown (10YR5/4) outwash as above	SP									2" SS
12	12"	6/6 4/6	22	22-24', grey brown (10YR5/1) fine sand	SP									2" SS
13	10"	5/7 8/12	24	24-26', grey (10YR4/1) med to coarse sand w/ gravel, stratified, structureless, wet (outwash)	SP									2" SS
14	10"	6/6 4/6	26	26-28', as above	SP									2" SS
15	12"	5/5 3/4	28	28-30', as above	SP									3" SS
16	5"	3/3 3/2	30	30-32', as above	SP									2" SS
17	15"	6/4 4/3	32	32-34', as above	SP									2" SS
18	10"	5/5 4/4	34	34-36', grey brown (10YR5/2) fine to med sand, weakly stratified, structureless, wet, loose (outwash)	SP									2" SS
19	12"	3/3 3/3	36	36-38', as above w/ gravel lense at 38'	SP									3" SS
20	14"	2/3 5/4	38	38-40', as above	SP									2" SS
21	4"	0/0 0/0	40	40-42', fine sand, as above	SP									2" SS
22	12"	2/3 5/5	42	42-44', med to coarse sand w/ gravel, as above	SP									2" SS
23	12"	16/3 4/16	44	44-46', as above, fine sand w/ coarse sand & gravel lenses	SP									2" SS
24	12"	10/10 10/10	46	46-48', as above, more dense and tighter	SP									2" SS
25	5"	2/4 6/8	48	48-50', as above	SP									2" SS
			50	E.O.B. 50'										
			52											
			54											
			56											
			58											
			60											
			62											
			64											

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☑ Other Mitigation Site

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
Crandon Project - SAP II - Area H		BH-05

Boring Drilled by (Firm name and name of crew chief)	Date Started	Date Completed	Drilling Method
Boart Longyear Pat Jensen	MM/DD/YY 07/20/98	MM/DD/YY 07/21/98	4¼" HSA & Mud Rotary

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				~1585	8"

Boring Location	Local Grid Location (if applicable)
State Plane ____ N, ____ E S/C/N Lat NE ¼ of NE ¼ of Section 20, T35N, R13E Long	____ N ____ E Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow" Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
1	20"	1/1/4	-	0-.3', black organic silt loam topsoil	OL									2" SS
			-	.3'-2', brn-yel (10YR6/8) silty fine sand w/ gravel (till)	SM									
2			- 2	2'-3', as above	SM									3" SS
			-	3'-4', (10YR6/6) very fine sand, tr silt, loose (outwash)	SP									
3	24"	7/8/17	- 4	4'-6', (10YR6/6) lt-brn, fine to med. sand, tr silt, loose (outwash)	SP									2½" SS
4	18"	7/10/7	- 6	6'-8', (10YR4/6) brn, 4" fine sand, 9" med sand, saturated @ 7½" in layers then fine sand and med and coarse sand, loose (outwash)	SP									2" SS
5	18"	1/1/4	- 8	8'-10', brn (10YR5/4) fine sand, tr silt, loose (outwash) saturated	SP									3" SS
6	14"	1/2/4	- 10	10'-12', brn (10YR5/4) fine sand w/ some layers of med to coarse sand, loose, saturated (outwash)	SP									2½" SS
7		1/2/5	- 12	12'-14', grey-brn (10YR5/2) fine to med sand some coarse sand, loose (outwash)	SP									2" SS
8		1/1/2	- 14	14'-16', grey-brn (10YR5/2) fine to med sand, tr of coarse sand, loose (outwash)	SP									3" SS
9	16"	1/2/5	- 16	16'-18', grey-brn (10YR5/2) fine to med sand, tr silt, loose (outwash)	SP									
10	17"	2/2/3	- 18	18'-20', grey-brn (10YR6/3) fine & very fine sand, tr silt, loose (outwash)	SP									

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
Ken Meister	Foth & Van Dyke

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State of Wisconsin Route to: SOIL BORING LOG INFORMATION

DML\DMW\93C049\GBAPP\65757.61\14000

SAMPLE No.	SAMPLE Rec (in)	Blow* Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
11	12"	3/2/5	20	20'-22', grey-brn (10YR6/2) med to coarse sand w/ fine to med gravel, tr silt, loose (outwash)	SP									3" SS
12	12"	1/1/4	22	22'-24', same as above, change to (sample fine sand only) grey-brn (10YR6/3) fine & very fine sand, tr silt (23'-24'), loose (outwash)										3" SS
13	12"	1/2/3	24	24'-26', grey-brn (10YR6/3) fine sand, tr silt, loose (outwash)	SP									3" SS
14	7"	2/3/7	26	26'-28', grey-brn (10YR6/2) fine to med sand w/ fine gravel and silt, loose (outwash)	SP									3" SS
15	18"	2/3/8	28	28'-30', grey-brn (10YR6/2) layered fine sand & fine to med sand w/ fine gravel, loose (outwash)	SP									3" SS
			30											3" SS
16	12"	5/3/8	32	32'-34', grey-brn (10YR6/2) fine to med sand w/ fine gravel and silt, loose (outwash)	SP									3" SS
			34											3" SS
17	15"	4/4/8	36	36'-38', grey-brn (10YR6/2) fine sand, tr silt, loose (outwash)	SP									3" SS
18	16"	4/4/11	38	38'-40', grey-brn (10YR5/2) fine sand, tr silt & fine to med gravel, dense (outwash)	SP									3" SS
			40											3" SS
19	16"	4/5/11	42	43'-43.5', grey-brn (10YR5/2) fine to med sand, tr silt	SP									
				43.5'-45', grey-brn (10YR5/2) fine to very fine sand, tr silt, dense (outwash)	SP									
			44											3" SS
			46											3" SS
20	16"	5/6/14	48	48'-50', Grey-brn alternating ½" to 1½" layer of very fine sand and fine to med sand, dense (outwash)	SP									3" SS
			50											
			52											
			54											
			56											

State of Wisconsin | Route to: | SOIL BORING LOG INFORMATION

Department of Natural Resources | Form 4400-122 | 7-91

BORING NUMBER: BH-05 | Page 3 of 3

SAMPLE No.	SAMPLE Rec (in)	Blow* Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
			58											
			60											
21	17"		62	62'-63.5', (10YR5/4) grey-brn, fine sand, tr. silt outwash grading to silty fine sand	SP									3" SS
				63.5'-64', fine sandy silt, grey-brn (10YR4/2)	ML									
			64	E.O.B. 64'										

*Blow counts are for a 300 lb hammer.

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - SAP II - Area H		BH-06

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/04/98	08/04/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1590.20	8 ¼"

Boring Location
State Plane 128067.11 N, 2284720.66 ES/C/N Lat
SW ¼ of SE ¼ of Section 17, T35 N, R13 E Long

Local Grid Location (if applicable)
Feet ____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/Comm
1	23	3/5 7/12		0-1.2', brown (10YR5/2) fine sand silt with organics, plagen, disturbed	ML-OL									3" SS
				1.2-1.7', lt-brown (10YR6/3) fine sandy silt to silty sand, moderate med platy str dry (loess)	ML-									
2	20	7/12 10/10	2	1.7-2', brown (10YR6/4) fine sand with silt and minor gravel, fragipan, hard dense strong coarse blocky structure to massive, dense 2-4', as above	SP-SM									2½" SS
3	18	5/6 7/9	4	4-6', lt-brown (10YR7/4) fine sand, structureless, weakly oxidized damp, loose (outwash)	SP									2" SS
4	18	4/5 4/5	6	6-8', brown (10YR5/4) fine to med sand, structureless, stratified, wet, loose (outwash) coarse sand with gravel lense 7.8-8.0, wet at 6.2'	SP									3" SS
5	22	5/4 4/5	8	8-10', as above, slightly coarser	SP									2 ½" SS
6	14	3/4 4/6	10	10-12', brown (10YR5/5) fine to med sand, structureless, stratified, wet, loose	SP									2" SS
7	20	1/1 1/1	12	12-14', brown (10YR5/5) fine to med sand as above with minor gravel lenses	SP									2" SS
8	4	4/3 3/3	14	14-16', as above	SP									2" SS
9	9	0/1 0/1	16	16-18', as above with coarse sand lenses	SP									2" SS
10	2	0/1 0/1	18	18-20', as above	SP									2" SS

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature Firm Foth & Van Dyke

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LMC\93C049\GBAPP\67394.61\14000

State of Wisconsin
Department of Natural Resources
BORING NUMBER: BH-06

Route to:

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
11	2	0/0 0/1	20	20-22', as above	SP									2" SS
12	8	2/2 2/2	22	22-24', as above	SP									2" SS
13	16	1/1 1/2	24	24-26', as above	SP									2" SS
			26	E.O.B. 26'										

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - SAP II - Area H		BH-07

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/04/98	08/04/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1588.48	8¼"

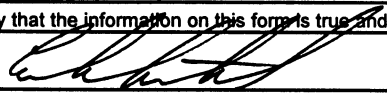
Boring Location
State Plane 127029.86 N, 2285829.03 E S/C/N Lat Long
SE ¼ of SE ¼ of Section 17, T 35 N, R 13 E

Local Grid Location (if applicable)
____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
1	23	2/5 7/11		0-1.1', lt-brown (10YR4/2) sandy silt with organics, plagen, disturbed	OL-ML									3" SS
				1.1-1.5', brown (10YR6/2) fine, sandy silt with minor gravel, w/ fine, blocky structure day (loess)	ML									
2	20	7/7 9/12	2	1.5-2.1', lt-brown (10YR6/1) fine silty sand with gravel, cemented, massive, dense, hard, dry	ML-SM									2½" SS
				2-4', brown (10YR6/3) fine-med sand with gravel, stratified, loose; sl. damp, (outwash)	SP									
3	16	7/7 7/11	4	4-6', brown (10YR6/2) fine-med sand with coarse sand lenses, damp, structureless, loose, very damp near tip of spoon	SP									2" SS
4	18	11/5 5/5	6	6-8', as above, wet at ~6.8', color (10YR4/4) minor gravel & coarse sand lenses	SP									3" SS
5	18	4/5 4/5	8	8-10', brown (10YR4/4) coarse sand with gravel and cobbles, structureless, stratified, wet (outwash)	SP-GP									2½" SS
6	0	2/1 1/1	10	10-12', no recovery	-									2" SS
7	8	4/3 3/3	12	12-14', as above with fine-med sand lenses	SP									3" SS
8	13	3/2 1/1	14	14-16', as above	SP									2" SS
9	2	0/0 0/1	16	16-18', as above, less gravel	SP									2" SS

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature  Firm Foth & Van Dyke

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State of Wisconsin Route to: SOIL BORING LOG INFORMATION

Department of Natural Resources Form 4400-122 7-91

BORING NUMBER: BH-07

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
10	8	2/2 2/2	18	18-20', as above, less gravel	SP									2" SS
11	17	1/2 2/3	20	20-22', as above, med Sand	SP									2" SS
12	18	1/1 1/1	22	22-24', as above	SP									2" SS
13	8	1/2 2/3	24	24-26', grey (2.5YR4/1) med sand, structureless stratified, wet (outwash)	SP									2" SS
14	2	1/2 3/3	26	26-28', as above, poor recovery, fine-med sand	SP									2" SS
15	10	2/2 3/3	28	28-30', as above, fine-med grey sand	SP									2" SS
			30	E.O.B. 30'										

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - SAP II - Area H		BH-08

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/05/98	08/05/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1586.19	8¼"

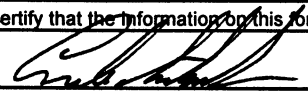
Boring Location
State Plane 126899.53 N, 2284956.62 E S/C/N Lat
SW ¼ of SE1/4 of Section 17, T 35 N, R 13 E Long

Local Grid Location (if applicable)
____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln TWP

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/Comm
1	22	6/7 8/10	-	0-1.2', lt-Brown (10YR5/3) fine sandy silt with organic m+l, plagen, disturbed, moderate med blocky structure, dry	OL-ML									300 lb hammer 3" s.s
			-	1.2-1.7', lt-brown (7.5YR6/2) fine sandy silt, with fine, blocky structure, dry, soft (loess)	ML									
			-	1.7-2', brown (7.5YR6/3) fine sand with minor silt and gravel										
2	22	5/7 9/13	- 2	2-4', brown (10YR6/3) fine-med sand with very minor gravel, damp, stratified with coarse sand lenses, loose, (outwash)	SP									2" SS
3	12	3/3 5/8	- 4	4-6', brown (10YR5/5) fine-med sand as above, wet at 5.1', locally oxidized	SP									2" SS
4	19	2/1 1/1	- 6	6-8', as above, med to slightly finer sand	SP									2" SS
5	16	0/1 1/1	- 8	8-10', as above	SP									2" SS
6	10	0/1 1/1	- 10	10-12', as above	SP									2" SS
7	10	2/2 2/2	- 12	12-14', as above with gravel	SP									2" SS
8	22	3/4 3/7	- 14	14-16', as above, less gravel, grey at tip	SP									2" SS
9	8	0/1 1/1	- 16	16-18', as above	SP									2" SS

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature  Firm Foth & Van Dyke

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LMC\DMW\93C049\GBAPP\67413.61\14000

State of Wisconsin Route to: SOIL BORING LOG INFORMATION

Department of Natural Resources Form 4400-122 7-91

BORING NUMBER: BH-08

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
10	14	1/1 1/2	- 18	18-20', brown (10YR3/4) fine sand with med sand lenses, stratified, wet, (outwash)	SP									2" SS
11	12	1/1 1/1	- 20	20-22', as above	SP									2" SS
12	13	4/4 3/5	- 22	22-24', as above	SP									2" SS
13	6	1/1 2/2	- 24	24-26', brown (10YR4/4) fine sand (outwash)	SP									2" SS
			- 26	E.O.B. 26'										

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - SAP II - Area H		BH-09

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/05/98	08/05/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1591.66	8¼ in

Boring Location
State Plane 128830.78 N, 2284131.85 E S/C/N Lat
NW 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E Long

Local Grid Location (if applicable)
Feet ___ N Feet ___ E
Feet ___ S Feet ___ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/Comm
1	23	6/6 5/4		0-1.3', grey (2.5YR4/1) sandy silt with minor gravel (plagen) distrurbed, mod med platy structure	CL-ML									300 lb hammer
				1.3-1.6', brown (10YR5/2) sandy silt, cemented, hard, dry, locally oxidized	ML									3" s.s
				1.6-2', brown (7.5YR6/3) fine-med sand with gravel, damp, structureless (outwash)										
2	23	6/6 7/10	2	2-3', as above	SP									2½" SS
				3-4', brown (10YR4/4) fine to med with coarse sand lenses, stratified, wet at ~3.5'	SP									
3	23	4/5 7/9	4	4-6', as above	SP									2" SS
4	6	2/1 2/2	6	6-8', as above, slightly finer	SP									2" SS
5	20	3/3 3/4	8	8-10', grey-brown (10YR4/2) med to coarse sand w/ fine sand and coarse sand with gravel lenses, stratified, structureless, wet, loose	SP									3" SS
6	12	0/1 0/1	10	10-12', grey-brown, fine to med sand as above	SP									2" SS
7	11	0/1 0/1	12	12-14', as above with coarse sand lenses	SP									2" SS
8	6	3/3 3/4	14	14-16', as above	SP									2" SS
9	14	3/4 4/5	16	16-18', as above	SP									2" SS

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature [signature] Firm Foth & Van Dyke

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LMC\DMW\93C049\GBAPP\67420.61\14000

State of Wisconsin
Department of Natural Resources
BORING NUMBER: BH-09

Route to:

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
10	12	0/1 1/1	18	18-20', as above with lenses of coarse sand 19.5-20'	SP									2" SS
11	14	1/1 2/2	20	20-22', brown (10YR4/2) fine to med sand as above, wet (outwash)	SP									2" SS
12	17	1/1 2/3	22	22-24', as above w/ coarse sand lenses	SP									2" SS
13	11	1/1 1/3	24	24-26', as above	SP									2" SS
14	10	0/1 0/1	26	26-28', as above	SP									2" SS
15	14	3/2 2/3	28	28-30'. as above	SP									3" SS
			30	E.O.B. 30'										

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - SAP II - Area H		BH-10

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/05/98	08/05/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1592.33	8¼ in

Boring Location
State Plane 128530.22 N, 2284998.06 E S/C/N Lat
NW 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E Long

Local Grid Location (if applicable)
Feet ____ N Feet ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
1	22	4/6 6/7		0-1.4', lt-brown (10YR6/2) fine sandy silt, disturbed, dry, soft	OL-ML									3" SS
				1.4-1.8', lt-brown (10YR6/2) fine sandy silt, cemented, dense, hard, minor gravel, dry	ML									
				1.8-2', brown (7.5YR6/3) fine to med sand with gravel, oxidized, structureless, damp, loose										
2	20	7/8 8/8	2	2-4', brown (10YR6/3) fine to med sand with gravel, stratified, damp, loose	SP									2½" SS
				3.7-4', fine sand, loose (outwash)										
3	17	4/4 5/5	4	4-6', lt-brown (10YR7/3) fine sand with med sand lenses, stratified, damp, loose (outwash)	SP									2" SS
4	18	5/4 5/4	6	6-8', lt-brown (10YR7/8) fine to med sand with coarse sand lenses & minor gravel, stratified, very damp, loose (outwash)	SP									3" SS
5	20	3/1 2/3	8	8-10', brown (10YR5/4) fine to med sand with coarse sand & gravel lense at 9.6', stratified, wet, loose (outwash), wet at 8.2'	SP									2½ SS
6	14	1/2 2/2	10	10-12', brown (7.5YR5/4) med to coarse sand with fine sand lenses, stratified, wet, loose (outwash)	SP									2" SS
7	12	3/2 1/1	12	12-14', as above	SP									2" SS
8	23	1/1 2/2	14	14-16', as above	SP									2" SS

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LMC\93C049\GBAPP\67422.61\14000

State of Wisconsin Route to: SOIL BORING LOG INFORMATION

Department of Natural Resources Form 4400-122 7-91

BORING NUMBER: BH-10

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
9	16	1/1 1/1	16	16-18', as above	SP									2" SS
10	22	1/2 2/3	18	18-20', as above, slightly coarser	SP									2" SS
11	0	0/1 0/1	20	20-22', no recovery	-									2" SS
12	0	0/0 0/1	22	22-24', no recovery	-									2" SS
13	5	1/1 1/1	24	24-26', brown (10YR5/4) fine to med sand as above	SP									3" SS
14	14	4/3 3/2	26	26-28', as above	SP									2" SS
15	8	2/3 3/3	28	28-30', as above, slightly finer sand	SP									2" SS
16	13	1/1 1/2	30	30-32', as above	SP									3" SS
			32	E.O.B. 32'										

State of Wisconsin
Department of Natural Resources

Route to:
- ☐ Solid Waste
- ☐ Emergency Response
- ☐ Wastewater
- ☐ Haz. Waste
- ☐ Underground Tanks
- ☐ Water Resources
- ☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		MWH-10P

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/26/98	08/27/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1592.37	8¼ in

Boring Location
State Plane 128534.44 N, 2284996.57 E S/C/N Lat
NW 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E Long

Local Grid Location (if applicable)
Feet ____ N / S Feet ____ E / W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
				0-38 Blind drill, see boring log BH-10										
			5											
			10											
			15											
			20											
			25											
			30											
1	12	2/2 2/2	35	Grey (10YR4/2) fine-med. Sand, stratified, wet	SP									
				E.O.B. 38'										
			40											

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
[illegible]	Foth & Van Dyke

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State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		BH-11

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/24/98	08/24/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1585.07	8¼ in

Boring Location
State Plane 128232.29 N, 2285320.44 E S/C/N Lat
NE 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E Long

Local Grid Location (if applicable)
____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
1	19	2/2 3/4	-	0-0.1', 0-Horizon										3" SS
			-	0.1-0.5', brown (7.5YR3/4) organic topsoil, w/ med granular structure, damp, soft	OL									
			-	0.5-0.8', yel-brown (7.5YR5/6) fine to med sand, structureless, loose	SP									2½" SS
			-	0.8-2', brown (10YR3/4) silty fine sand with gravel, massive, cemented (till)	SM									
2	16	3/1 1/2	- 2	2-3', lt-brown (7.5YR5/5) silty fine sand with gravel as above (till)	SM									2½" SS
			-	3-4', strong yel-brown (7.5YR5/6) fine to med sand with minor gravel, structureless, stratified, damp, loose (outwash) oxidized, molted	SP									
3	13	6/7 3/5	- 4	4-6', brown (7.5YR4/3) fine to med sand, stratified wet at 4', minor oxidation, fine sand & coarse sand lenses abundant (outwash)	SP									2" SS
4	12	3/5 5/7	- 6	6-8', brown (7.5YR4/5) fine to med sand with gravel & silt, massive, wet, soft, (reworked till)	SP-SM									2" SS
5	2	2/2 4/4	- 8	8-10', brown (10YR4/3) fine to med sand with abundant gravel (outwash)	SP									3" SS
6	14	11/8 3/2	- 10	10-12', brown (10YR4/3) fine to med sand with coarse sand and gravel lense, abundant (outwash)	SP-GP									2" SS
7	13	3/1 1/4	- 12	12-14', brown (10YR5/2) med to coarse sand with gravel, stratified, wet, loose (outwash)	SP									2" SS

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State of Wisconsin Route to: SOIL BORING LOG INFORMATION
Department of Natural Resources Form 4400-122 7-91
BORING NUMBER: BH-11

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
8	23	3/3 5/4	14	14-16', as above	SP									2" SS
9	14	2/3 3/3	16	16-18', as above - slightly finer	SP									2" SS
10	16	1/1 1/1	18	18-20', as above - med to fine sand (outwash)	SP									2" SS
11	6	1/1 1/1	20	20-22', as above, poor recovery	SP									2" SS
12	10	1/1 1/1	22	22-24', lt-brown (10YR5/2) fine to med sand with stratified, wet, loose (outwash)	SP									2" SS
13	14	1/1 1/1	24	24-26', as above with minor med sand lenses	SP									2" SS
14	13	1/1 1/4	26	26-28', as above	SP									2" SS
15	9	1/1 1/3	28	28-30', as above	SP									2" SS
			30	E.O.B. 30'										

LMC\DMW\93C049\GBAPP\67424.61\14000

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Lincoln Area H		BH-12

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/24/98	08/24/98	4¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1591.43	8¼ in

Boring Location
State Plane 128274.90 N, 2284134.29 E S/C/N Lat
NW 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E Long

Local Grid Location (if applicable)
Feet ____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
1	24	1/2 2/3	-	0-0.9', dark-brown (7.5YR3/2) orgainc topsoil, with med subangular blocky structure, damp, soft (silt loam)	OL									3" SS
			-	0.9-1.1', brown (7.5YR5/6) silty fine sand (loamy sand) w/ med blocky structure, dry, slightly hard	SM									
			-	1.1-2', brown (7.5YR5/5) fine to med sand, oxidized layers, slightly coarser, dry, soft (outwash)	SP									
2	24	1/2 3/2	- 2	2-4', as above	SP									2½" SS
3	24	4/4 4/5	- 4	4-6', yel-brown (7.5YR5/6) fine to med sand, stratified, slightly damp, loose (outwash)	SP									2" SS
4	18	2/2 3/4	- 6	6-6.6', as above	SP									2" SS
			-	6.6-8', brown (10YR4/4) med sand with coarse sand lenses, stratified, wet, loose (outwash)										
5	17	1/2 4/3	- 8	8-10', as above with fine sand lenses, minor gravel in coarse sand lenses	SP									2" SS
6	6	1/2 1/2	- 10	10-12', as above, gravel lenses	SP									2" SS
7	22	2/2 1/1	- 12	12-14', brown (10YR4/4) med sand with fine sand lenses, minor gravel, stratified, wet, loose, (outwash)	SP									2" SS
8	23	0/1 4/4	- 14	14-16', lt-brown (10YR6/4) fine to med sand with fine sand and coarse sand lenses, stratified, wet, loose	SP									2" SS
9	19	2/2 2/2	- 16	16-18', grey-brown (7.5YR5/2) fine to med sand with med to coarse sand lenses, stratified, wet, loose (outwash)	SP									2" SS

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LMC\DMW\93C049\GBAPP\67429.61\14000

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
10	6	0/1 1/1	18	18-20', as above	SP									2" SS
11	6	0/1 1/1	20	20-22', as above, fine grey sand lenses	SP									2" SS
12	11	1/1 1/1	22	22-24', as above	SP									2" SS
13	6	1/0 1/1	24	24-26', as above, bottom of spoon grey (10YR4/2) silty fine sand, massive, wet, soft	SP-SM									2" SS
				blowup 3rd attempt										3" SS
14	16	0/1 1/2	26	26-28', grey-brown (10YR4/2) med to coarse sand with gravel, structureless (outwash)	SP									
15	0	2/1 1/5	28	28-30', no recovery, fine sand ran out of spoon	--									2" SS
16	12	1/1 3/4	30	30-32', as above	SP									2" SS
			32	E.O.B. 32'										
			34											
			36											
			38											
			40											

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		BH-13

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/25/98	08/25/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1594.03	8¼ in

Boring Location
State Plane 130347.91 N, 2285052.06 E S/C/N Lat
SW 1/4 of NE 1/4 of Section 17, T 35 N, R 13 E Long

Local Grid Location (if applicable)
____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
1	19	2/3 4/6		0-1.1', dark brown (10YR3/2) organic topsoil (sandy silt loam) med, blocky structure	OL									3" SS
				1.1-1.4', light grey-brown (10YR6/2) silty sand (sandy loam) with minor gravel, structureless, dry, loose	SM									
				1.4-2', brown (7.5YR4/5) fine-med sand with silt and gravel, w/ fine platy structure, damp, loose	SP-SM									2½" SS
2	0	4/4 5/6	2	2-4', no recovery	--									
3	15	1/1 2/6	4	4-4.6', brown (10YR4/5) silty sand with gravel & clay lenses, molted, massive, damp	SM									2" SS
				4.6-5.6', grey (2.5Y5/1) silty clay oxidized, massive, damp	CL									2" SS
				5.6-6', brown (10YR5/6) fine to med sand, stratified, damp (wet at 5.9') loose	SP									
4	16	1/1 2/2	6	6-8', as above	SP									2" SS
				6.4', lt brown (10YR5/2) fine to med sand lenses (outwash)										
5	12	1/1 1/1	8	8-10', grey (10YR4/1) very fine sand with very minor silt & med sand lenses, stratified, wet, massive	SP									2" SS
6	20	1/1 1/1	10	10-12', grey-brown (10YR5/2) med to coarse sand, stratified, wet, loose	SP									2" SS
7	14	1/1 2/3	12	12-14', lt grey-brown (10YR5/2) med to coarse sand as above	SP									2" SS
8	8	5/4 3/4	14	14-16', as above, fine sand lense at tip of spoon	SP									2" SS
9	15	3/1 1/4	16	16-18', brown (10YR5/3) med sand as above	SP									2" SS

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Signature  Firm Foth & Van Dyke

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LMC\DMW\93C049\GBAPP\67440.61\14000

State of Wisconsin Route to: SOIL BORING LOG INFORMATION
Department of Natural Resources Form 4400-122 7-91
BORING NUMBER: BH-13

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
10	14	1/1 1/1	- 18	18-20', brown (10YR4/3) med sand, weakly stratified, wet, loose (outwash)	SP									2" SS
11	22	1/1 1/1	- 20	20-22', as above with minor coarse sand lenses	SP									2" SS
12	21	1/2 1/1	- 22	22-24', as above										2" SS
13	6	4/4 5/6	- 24	24-26', as above, poor recovery, blowup	SP									2" SS
14	18	4/5 3/8	- 26	26-28', as above	SP									2" SS
15	6	1/2 1/1	- 28	28-30', as above	SP									2" SS
16	10	1/2 1/1	- 30	30-32', as above	SP									2" SS
17	0	1/1 1/1	- 32	32-34', no recovery, fine sand ran out of spoon	--									2" SS
18	0	1/1 2/2	- 34	34-36'	--									2" SS
19	5	1/2 3/1	- 36	36-38', brown (10YR4/4) fine to med sand, weakly stratified, weak oxidation at top, wet, loose (outwash)	SP									2" SS
			- 38	Note: moved to 2.5' sample interval										
20	10	1/3 1/1	-	39-41', brown (10YR4/4) fine to med sand, weakly stratified, wet, no gravel, loose (outwash)	SP									2" SS
			- 40											
21	6	1/1 1/5	- 42	42-44', brown (10YR4/4) fine to med sand, wet, loose (outwash)	SP									2" SS
			- 44											
22	12	1/2 1/5	-	45-46.6', brown (10YR4/4) same	SP									2" SS
			- 46	46.6-47', brown (10YR4/3) fine to coarse sand, wet, little gravel, loose, (outwash)	SP									
23	0	10/11 8/6	- 48	48-49.5', no recovery										
			- 50	(1.5' sand in auger cleaned w/ 3" SS)										
24	15	2/6 8/5	-	51-53', brown (10YR4/4) fine to med sand, w/ coarse sand lenses, 1" coarse gravelly sand at base, wet, loose (outwash)	SP									2" SS
			- 52											
25	16	3/1 1/6	- 54	54-56', brown (10YR/4) fine to med sand, wet, loose (outwash)	SP									2" SS

State of Wisconsin Route to: SOIL BORING LOG INFORMATION

Department of Natural Resources Form 4400-122 7-91

BORING NUMBER: BH-13

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
			56											
26	12	1/1 2/4		57-59', same as above	SP									2" SS
			58											
27	20	3/4 4/4	60	60-62', same as above except finer, BTM 6", weakly stratified	SP									2" SS
			62											
28	10	2/2 4/8		63-65', brown (10YR4/4) fine to med sand, weakly stratified w/ 2" coarse, gravelly sand near base, wet, loose (outwash)	SP									2" SS
			64											
29	19	2/2 3/5	66	66-68', brown (10YR4/4) fine to med sand, weakly stratified, wet, loose (outwash)	SP									2" SS
			68											
30	10	1/2 1/4		69-71', brown (10YR4/4) fine to med sand, weakly stratified, few gravel, wet, loose (outwash)	SP									2" SS
			70											
			72	E.O.B. 71'	SP									2" SS

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		BH-14

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Todd Schmanfelt	08/26/98	08/26/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1588.36	8¼ in

Boring Location
State Plane 127088.44 N, 2284436.56 E S/C/N Lat Long
SW 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E

Local Grid Location (if applicable)
Feet ___ N Feet ___ E
Feet ___ S Feet ___ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/Comm
1	24	2/2 3/4		0-0.2', brown (7.5YR3/3) fine to med sand with organics and minor silt	SP									140 lb hammer
				0.2-0.5', brown (10YR2/2) organic topsoil (sandy loam) w/fine granular structure, dry	OL									2" SS
				0.5-2', yel-brown (7.5YR5/6) fine sand with silty, highly oxidized (sandy loam) w/ fine granular structure (loess)	SP-SM									
2	16	3/4 2/4	2	2-2.5', lt brown (7.5YR6/2) fine to med sand, stratified, damp, loose, (outwash)	SP									2" SS
				2.5-4', lt brown (7.5YR6/2) med to coarse sand, stratified, damp, loose (outwash)	SP									
3	20	2/3 3/4	4	4-6', as above										2" SS
4	22	1/2 3/4	6	6-8', as above, brown (10YR5/3), wet at 6' oxidized, fine-med sand lense at 6.6'	SP									2" SS
5	22	1/1 3/3	8	8-9.2', as above	SP									2" SS
				9.2-10', brown (10YR6/2) fine sand w/ med sand lense, minor oxidation, wet, loose (outwash)	SP									
6	24	1/1 1/1	10	10-12', as above, alternating 4-8" lenses of fine to med and med to coarse sand, wet, (outwash)	SP									2" SS
7	23	3/4 4/5	12	12-14', brown (10YR5/2) fine to med sand, stratified w/ coarse sand lenses, wet, loose (outwash)	SP									2" SS
8	14	1/1 1/1	14	14-16', brown (10YR5/2) fine sand with coarse sand lenses as above	SP									2" SS
9	23	2/3 4/4	16	16-18', as above, coarse sand lense 16-16.4'	SP									2" SS

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature [signature] Firm Foth & Van Dyke

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Penalties: Forfeit not less than $10 nor more then $5,000 for each violation. Fined not less than $10 or more than $100 or imprisoned not less than 30 days, or both for each violation. Each day of continued violation is a separate offense, pursuant to ss 114.06, Wis. Stats.

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SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
10	12	1/2 2/3	18	18-20', brown (10YR4/4) med sand, stratified, wet, loose (outwash)	SP									2" SS
11	23	1/1 1/1	20	20-22', brown (10YR4/4) med sand, stratified, wet, soft	SP									2" SS
12	18	2/3 4/4	22	22-24', as above	SP									2" SS
13	12	2/2 3/4	24	24-26'. as above	SP									2½" SS
14	12	2/2 3/3	26	26-28', grey (2.5Y4/2) med sand with coarse sand lenses, stratified, wet, loose (outwash)	SP									2" SS
15	18	3/3 5/6	28	28-30', as above with fine sand lense 28.2-29'	SP									2" SS
16	20	4/4 5/6	30	30-32', grey (2.5Y4/1) fine sand w/ med & coarse sand lenses, wet, loose, stratified (outwash)	SP									2" SS
			32											
17	0	4/5 5/6		33-35', no recovery, fine sand running out of spoon (outwash?? 2½" SS also no recovery)	SP									2" SS
			34											
18	20	2/4 4/5	36	36-38', grey (3.5Y4/1) med to coarse sand with fine sand lenses stratified, wet, loose (outwash)	SP									2" SS
			38											
19	18	3/4 4/4		39-41', as above, slightly more fine sand lenses	SP									2" SS
			40											
20	22	2/4 4/5	42	42-44', as above, slightly finer, fine sand lenses, thicker	SP									2" SS
			44											
21	8	5/5 6/6		45-47', as above	SP									2" SS
			46											
22	4	5/5 6/7	48	48-50', as above	SP									2" SS
			50											
				51-53', as above										2" SS
23	18	4/4 5/6	52											
24	14	5/6 6/7	54	54-56', as above										2" SS

State of Wisconsin
Department of Natural Resources
BORING NUMBER: BH-14

Route to:

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

SAMPLE					USCS	Graph Log	Well Diag	PID/ FID	Soil Properties					
No.	Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit					Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
			56											
25	16	4/5 7/7		57-59', as above										2" SS
			58											
			60											
			62											
26	18	4/5 6/6	64	64-66', as above										2" SS
			66	E.O.B 66'										

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		BH-15

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Todd Schmanfelt	08/27/98	08/27/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1583.63	8¼ in

Boring Location
State Plane 127537.17 N, 2284157.65 E S/C/N Lat Long
SW 1/4 of SE 1/4 of Section 1, T 35 N, R 13 E

Local Grid Location (if applicable)
Feet ___ N ___ S Feet ___ E ___ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
1		1/2 2/3	-	0-0.9, dk brown (7.5YR3/2) organic topsoil (sandy silt loam) w/ fine granular structure, dry, soft	OL									140 lb hammer 2" SS
			-	0.9-1.2, yel-brown (7.5YR5/7) silty fine sand (loamy sand) oxidized, damp (loess)	SP-SM									2" SS
			-	1.2-2, yel-brown (7.5YR5/3) fine sand, damp, soft, mottled (loess)	SP									
2	14	2/3 3/3	- 2	2-4, (7.5YR5/3) fine sand with gravel and grey clay and silt lenses mixed, very strong mottles (till)	SP (ML									2" s.s
3	14	2/4 6/6	- 4	4-5, as above	CL)									
			-	5-6, yel-brown (7.5YR5/5) med to coarse sand stratified w/fine sand	SP									2" SS
4	18	2/4 4/5	- 6	6-8, brown (7.5YR4/4) fine to med sand, stratified w/ coarse sand lenses, wet, loose (outwash)	SP									2" SS
5	17	4/5 6/6	- 8	8-10, brown (7.5YR5/4) med sand with fine sand and coarse sand lenses, stratified, wet (outwash)	SP									2" SS
6	21	2/3 4/5	- 10	10-12, brown (7.5YR5/4) med to coarse sand with gravel, stratified, wet, loose (outwash)	SP									2" SS
7	16	1/1 2/1	- 12	12-14, brown (7.5YR4/4) fine to med sand, stratified w/ coarse sand lenses, wet, loose (outwash)	SP									2" SS
8	20	2/2 3/4	- 14	14-16, as above with oxidized very fine sand lenses 14.6-14.8	SP									2" SS
9	23	1/1 1/1	- 16	16-18, brown (7.5YR5/3) fine sand with minor med to coarse sand, stratified, wet, soft (outwash)	SP									2" SS
10	17	1/1 1/1	- 18	18-20, as above, more med sand	SP									2" SS

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State of Wisconsin
Department of Natural Resources
BORING NUMBER: BH-15

Route to:

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
11	22	1/2 1/1	20	20-21, as above 21-22, brown (7.I5YR5/4) very fine sand, stratified, wet, soft (outwash)	SP									2" SS
12	16	4/2 4/4	22	22-24, grey (2.5Y5/1) very fine sand with coarse sand lenses at 23.5, stratified, wet, soft (outwash)	SP									2" SS
13	11	4/5 5/6	24	24-26, grey (2.5Y5/1) fine to med sand with minor gravel, stratified, wet, soft (outwash)	SP									
14	24	4/3 2/4	26	26-28, grey (2.5Y4/1) very fine to fine sand, with stratified, wet, soft (outwash)	SP									
15	18	2/4 3/3	28	28-30, grey (10YR5/2) fine sand w/ stratified, wet, soft (outwash)	SP									
16	19	5/4 4/5	30	30-32, as above	SP									
			32	E.O.B. 32'										

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		BH-16

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Todd Schmanfelt	08/27/98	08/27/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1592.44	8¼ in

Boring Location
State Plane 129334.33 N, 2285471.98 E S/C/N Lat
SW 1/4 of NE 1/4 of Section17, T 35 N, R 13 E Long

Local Grid Location (if applicable)
Feet ____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
1	19	3/3 4/5		0-0.9 Dr. brown (10YR2/2) orgainc topsoil (sandy silt loam) dry	OL									140 lb hammer
				0.9-2 Strong yellow brown (7.5YR5/6) fine sand with minor silt, dry	SP									2" SS
2	24	4/4 4/4	2	2-2.5 As above 2.5-4 Yellow brown (10YR6/5) fine sand with minor gravel, damp, soft, stratified (outwash)	SP									2" SS
3	23	2/2 3/4	4	4-6 As above, mottled lt yellow brown	SP									2" SS
4	16	2/3 4/4	6	6-8 (10YR6/4) fine to med sand stratified w/ coarse sand lenses, very damp, gravel, mottled (outwash)	SP									2" SS
5	22	2/2 4/5	8	8-10 As above, wet at ~9	SP									2" SS
6	17	2/2 3/3	10	10-12 Yellow brown (10YR5/4) med to coarse sand with gravel, stratified, wet, loose (outwash)	SP									2" SS
7	24	1/1 1/2	12	12-13 As above										2" SS
				13-14 Dk yellow brown (10YR3/4) coarse Sand with gravel, wet, soft, (outwash) (weathered rock)	SP									2" SS
8	23	2/2 1/1	14	14-16 As above, very dark in color, weathered, coarse, zone?	SP									2" SS
9	4	4/4 5/6	16	16-18 Dk grey brown (2.5YR4/2) coarse sand with gravel, stratified, wet, loose	SP									2" SS
10	6	1/1 1/1	18	18-20 Grey brown (10YR4/2) coarse sand with gravel, stratified, wet, loose (outwash)	SP									2" SS

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Signature [signature] Firm Foth & Van Dyke

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State of Wisconsin Route to: SOIL BORING LOG INFORMATION

Department of Natural Resources Form 4400-122 7-91

BORING NUMBER: BH-16

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
11	7	1/1 1/1	20	20-22 As above	SP									2" SS
12	13	2/1 3/3	22	22-24 As above, med to coarse sand	SP									2" SS
13	6	2/2 2/1	24	24-26 No recovery	--									
14	14	2/2 2/1	26	26-28 Grey brown (10YR4/2) med sand, wet, stratified (outwash)	SP									2" SS
15	19	2/3 3/4	28	28-30 As above with fine sand lenses	SP									2" SS
16	6	1/2 2/2	30	30-32 As above	SP									2" SS
			32	E.O.B. 32'										

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		BH-17

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Todd Schmanfelt	08/27/98	08/27/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1585.38	8¼ in

Boring Location
State Plane 126791.61 N, 2284420.79 E S/C/N Lat
SW 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E Long

Local Grid Location (if applicable)
____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
				0-0.7 Dk brown (10YR2/2) organic topsoil (sandy silt loam)	OL									140 lb hammer
				0.7-2 Yellow brown (7.5YR5/6) fine sand with silt (sandy loam) highly oxidized mottled	SP-SM									2" SS
1	12	2/2 4/5	2	2-3 As above	SP									2" SS
				3-4 Lt. brown (10YR7/3) fine to med sand, stratified with coarse sand lenses (outwash) wet at 3.9	SP									
2	12	2/2 2/4	4	4-6 Brown (10YR5/3) med to coarse sand w/ fine sand lenses, stratified, wet, loose (outwash)	SP									2" SS
3	20	4/3 2/2	6	6-8 As above	SP									2" SS
4	23	1/1 2/2	8	8-10 As above with oxidized lenses 7.9-9.4, slightly finer	SP									2" SS
5	24	1/2 2/2	10	10-11 Brown yellow (10YR6/8) fine to med sand, stratified, wet, loose (outwash)	SP									2" SS
				11-12 Brown (10YR5/3) med to coarse sand stratified, wet, loose (outwash)	SP									
6	20	2/4 4/5	12	12-14 As abaove with minor gravel	SP									2" SS
7	16	2/2 3/4	14	14-15.5 As above	SP									2" SS
				15.5-16 Grey brown (10YR5/2) very fine sand, wet, soft, massive, (outwash)	SP									
8	24	2/1 3/4	16	16-18 Grey brown (10YR5/2) fine sand, stratified w/ very fine sand lenses, wet, soft, (outwash)	SP									2" SS
9	22	2/4 4/5	18	18-20 As above	SP									2" SS

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LMC\93C049\GBAPP\67522.61\14000

State of Wisconsin Route to: SOIL BORING LOG INFORMATION

Department of Natural Resources Form 4400-122 7-91

BORING NUMBER: BH-17

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
			20											
10	23	4/3 4/5		21-23 As above	SP									2" SS
			22											
			24											
11	6	3/2 2/1		25-27 As above, slightly coarser, fine to med w/ fine sand lenses	SP									2" SS
			26											
12	20	3/2 1/3		27-29 Grey (10YR5/2) fine to med sand w/ coarse sand lenses, stratified, wet, loose (outwash)	SP									2" SS
			28											
13		3/1 1/2	30	30-32 As above (10YR4/2) with fine sand, minor silt lense 31.5-31.7 31.7-32 Grey med sand as above	SP (SP-SM)									2" SS
			32	E.O.B. 32'										

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		BH-18

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Todd Schmanfelt	08/27/98	08/27/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1586.42	8¼ in

Boring Location
State Plane 127537.98 N, 2284761.83 E S/C/N Lat
SW 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E Long

Local Grid Location (if applicable)
Feet ____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
1	22	2/2 3/4	0	0-1 Dk brown (2.5YR2/2) organic topsoil (sandy loam) 1-1.4 Yellow brown (7.5YR4/6) silty sand, oxidized (sandy loam) 1.4-2 Yellow brown (7.5YR5/4) fine to med sand, oxidized, few faint mottles, wet, slightly blocky structure, damp, soft (outwash)	OL SP-SM SP									140 lb hammer 2" SS
2	19	1/2 3/2	2	2-2.4 Yellow brown (7.5YR1/4) fine-med sand w/ minor gravel, stratified, damp, soft (outwash 2.4-4 Yellow brown (7.5YR6/3) fine to med sand as above	SP SP									2" SS
3	18	3/4 4/5	4	4-6 Lt brown (10YR7/2) med to coarse sand, mottle at 5.5-5.7, wet at 5.7, wet color (10YR6/3) stratified w/ fine sand lenses (outwash)	SP									2" SS
4	20	2/3 3/4	6	6-8 Brown (10YR5/3) fine to med sand, stratified w/coarse sand lenses, few faint mottles, wet, soft (outwash)	SP									2" SS
5	23	1/1 3/3	8	8-10 As above, minor gravel	SP									2" SS
6	24	1/2 2/3	10	10-12 Brown (10YR4/3) med to coarse sand stratified w/fine sand lenses, wet, loose, (outwash)	SP									2" SS
7	17	1/1 1/1	12	12-14 As above, slightly more fine sand lenses	SP									2" SS
8	0	2/3 4/5	14	14-16 No recovery - fine sand ran out of spoon	--									2" SS
9	12	1/1 1/1	16	16-18 Brown (10YR4/3) med to coarse sand w/fine sand lenses as above	SP									2" SS
10	16	2/4 2/2	18	18-20 Brown (10YR5/3) coarse sand with gravel stratified w/ med and minor fine sand lenses, wet, loose (outwash)	SP									2" SS

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SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
11	11	1/2 2/2	20	20-22 As above	SP									2" SS
12	12	6/4 4/6	22	22-24 Grey (2.5Y5/1) coarse sand with gravel stratified, wet, loose	SP									2" SS
13	14	2/3 4/4	24	24-26 Grey (2.5Y4/1) med to coarse sand stratified, minor gravel, wet, loose	SP									2" SS
14	13	2/7 3/6	26	26-28 As above	SP									2" SS
15	14	1/1 3/2	28	28-30 Grey (2.5Y5/1) fine to med sand w/ coarse sand lense, wet, stratified (outwash)	SP									2" SS
16	13	1/1 2/2	30	30-32 As above	SP									2" SS
			32	E.O.B. 32'										
			34											
			36											
			38											
			40											

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		BH-19

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/26/98	08/26/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1586.55	8¼ in

Boring Location
State Plane 127616.63 N, 2285675.31 E S/C/N Lat
SE 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E Long

Local Grid Location (if applicable)
Feet ____ N ____ S Feet ____ E ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
1	21	1/2 3/4	-	0-0.8 Dk. brown (10YR3/2) organic topsoil (silt loam), w/ med blocky structure, damp, soft 0.8-2 Yellow brown (7.5YR5/4) fine to med sand w/gravel, damp, structureless, stratified, fine, few mottles (outwash)	OL SP									300 lb hammer 3" SS
2	16	1/1 2/3	- 2	2-4 As above, oxidized	SP									2½" SS
3	13	1/1 ½	- 4	4-6 Yellow brown (10YR5/4) fine to med sand w/ gravel, coarse sand lenses, stratified, damp, loose (outwash)	SP									2" SS
4	5	½ 2/2	- 6	6-8 Brown (10YR4/4) med sand with gravel, stratified, wet at 6', loose (outwash)	SP									2" SS
5	12	½ 2/1	- 8	8-10 As above	SP									2" SS
6	14	1/1 1/1	- 10	10-12 Brown (10YR4/4) fine to med sand with minor gravel and coarse sand lenses, stratified, wet, loose	SP									2" SS
7	12	1/1 1/1	- 12	12-14 As above	SP									2" SS
8	14	4/4 12/-	- 14	Pound spoon 18" had ~1' blowup in augers 14-15.5 Brown (10YR5/4) fine & med sand with minor gravel, stratified, wet, soft	SP									2" SS
9	17	2/2 5/10	- 16	16-18 As above	SP									2" SS
10	4	0/1 0/1	- 18	18-20 Grey brown (10Y5/2) fine sand w/ med sand lenses, stratified, wet, very soft	SP									2" SS
11	3	0/1 1/2	- 20	20-22 As above, fine sand running out of spoon	SP									2" SS

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature [signature] Firm Foth & Van Dyke

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State of Wisconsin Route to: SOIL BORING LOG INFORMATION

Department of Natural Resources Form 4400-122 7-91

BORING NUMBER: BH-19

SAMPLE					USCS				Soil Properties					
No.	Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit		Graph Log	Well Diag	PID/ FID	Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
12	9	0/1 1/2	22	22-24 As above with coarse sand lense at 24.6	SP									2" SS
13	14	1/2 4/6	24	24-26 As above, w/ coarse sand lenses (outwash)	SP									2" SS
14	9	1/1 1/3	26	26-28 As above	SP									2" SS
15	6	0/1 1/1	28	28-30 As above	SP									2" SS
			30	E.O.B. 30'										

LMC\93C049\GBAPP\67550.61\14000

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		MWH-09

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/26/98	08/26/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1591.23	8¼ in

Boring Location
State Plane 128827.63 N, 2284111.34 E S/C/N Lat
NW 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E Long

Local Grid Location (if applicable)
Feet ____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
			0	0-15 Blind drill, see boring log BH-9										
			2											
			4											
			6											
			8											
			10											
			12											
			14											
				E.O.B. 15'										
			16											

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature Firm Foth & Van Dyke

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State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		MWH-09P

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/26/98	08/26/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1591.22	8¼ in

Boring Location
State Plane 128827.77 N, 2284111.79 E S/C/N Lat Long
NW 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E

Local Grid Location (if applicable)
Feet ___ N ___ E
Feet ___ S ___ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln TWP

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
				0-35 Blind drill, see boring log BH-9										
1	18	1/1 1/1	35	32-34 Grey (10YR5/1) fine Sand (outwash)	SP									
				E.O.B. 35'										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature [signature] Firm Foth & Van Dyke

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State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		MWH-10

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/26/98	08/26/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1592.46	8¼ in

Boring Location
State Plane 128524.62 N, 2284996.76 E S/C/N Lat
NW 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E Long

Local Grid Location (if applicable)
Feet ____ N ____ S Feet ____ E ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
			2	0-18 Blind drill, see boring log BH-10										
			4											
			6											
			8											
			10											
			12											
			14											
			16											
			18	E.O.B. 18'										

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State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		MWH-11

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/27/98	08/27/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1585.0	8¼ in

Boring Location
State Plane 128234.40 N, 2285323.43 E S/C/N Lat Long
NE 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E

Local Grid Location (if applicable)
Feet ____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
			2	0-15 Blind drill, see boring log BH-11										
			4											
			6											
			8											
			10											
			12											
			14											
				E.O.B. 15'										
			16											

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State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		MWH-11P

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/27/98	08/27/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
					8¼ in

Boring Location
State Plane 128240.76 N, 2285325.07 E S/C/N Lat
NE 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E Long

Local Grid Location (if applicable)
____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
			5	0-36 Blind drill, see boring log BH-11										
			10											
			15											
			20											
			25											
			30											
			35											
				E.O.B. 36'										
			40											

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State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		MWH-13

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/27/98	08/27/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1594.42	8¼ in

Boring Location
State Plane 130355.72 N, 2285041.29 E S/C/N Lat Long
SW 1/4 of NE 1/4 of Section 17, T 35 N, R 13 E

Local Grid Location (if applicable)
Feet ____ N ____ S Feet ____ E ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
			2	0-16 Blind drill, see boring log BH-13										
			4											
			6											
			8											
			10											
			12											
			14											
			16	E.O.B. 16'										

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State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		MWH-14

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Todd Schmanfelt	08/26/98	08/26/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1588.69	8¼ in

Boring Location
State Plane 127088.73 N, 2284444.46 E S/C/N Lat
SW 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E Long

Local Grid Location (if applicable)
Feet ___ N ___ S Feet ___ E ___ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
			2	0-16 Blind drill, see boring log BH-14										
			4											
			6											
			8											
			10											
			12											
			14											
			16	E.O.B. 16'										

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State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Page 1 of 1

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		MWH-15

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Todd Schmanfelt	08/27/98	08/27/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1588.76	8¼ in

Boring Location
State Plane 127542.29 N, 2284156.78 E S/C/N Lat Long
SW 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E

Local Grid Location (if applicable)
Feet ____ N ____ E
Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
			2	0-16 Blind drill, see boring log BH-15										
			4											
			6											
			8											
			10											
			12											
			14											
			16	E.O.B. 16'										

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State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		MWH-16

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/27/98	08/27/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1592.92	8¼ in

Boring Location
State Plane 129341.85 N, 2285471.77 E S/C/N Lat
SW 1/4 of NE 1/4 of Section 17, T 35 N, R 13 E Long

Local Grid Location (if applicable)
Feet ____ N ____ S Feet ____ E ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
			2	0-16 Blind drill, see boring log BH-16										
			4											
			6											
			8											
			10											
			12											
			14											
			16	E.O.B. 16'										

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LMC\93C049\GBAPP\67568.61\14000

State of Wisconsin
Department of Natural Resources

Route to:
☐ Solid Waste ☐ Haz. Waste
☐ Emergency Response ☐ Underground Tanks
☐ Wastewater ☐ Water Resources
☐ Other

SOIL BORING LOG INFORMATION
Form 4400-122 7-91

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		MWH-19

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Boart Longyear Mike Mueller	08/26/98	08/26/98	4 ¼ ID HSA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1586.24	8¼ in

Boring Location
State Plane 127614.63 N, 2285679.80 E S/C/N Lat Long
SE 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E

Local Grid Location (if applicable)
Feet ___ N ___ E
Feet ___ S Feet ___ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Town of Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
			2 4 6 8 10 12 14 16	0-16 Blind drill, see boring log BH-19 E.O.B. 16'										

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LMC\93C049\GBAPP\67569.61\14000

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-01
County: Forest
____ 1/4 of ____ 1/4 of Sec. ____ ; T. ____ N; R. ____ ☐ E ☐ W
(If Applicable)
_____ Gov't Lot _____ Grid Number
Grid Location
_____ ft. ☐ N. ☐ S., _____ ft. ☐ E. ☐ W.
Civil Town Name
Street Address of Well
City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known)
Present Well Owner: Crandon Mine
Street or Route
City, State, Zip Code: Crandon, WI
Facility Well No. and/or Name (If Applicable): BH-01
WI Unique Well No.
Reason For Abandonment: Test Boring
Date of Abandonment: 07/20/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On
(Date) _____

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) _____

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) _____ (From groundsurface)
Casing Diameter (in.) _____
Casing Depth (ft.) _____

Lower Drillhole Diameter (in.) _____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? _____ Feet

(4) Depth to Water (Feet) _____

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain _____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☐ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☒ Granular Bentonite
☐ Bentonite-Cement Grout

(7)

Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Benonite Grout	Surface	8.0	3 Bags	

(8) Comments _____

(9) Name of Person or Firm Doing Sealing Work
BOART LONGYEAR

Signature of Person Doing Work: [signature]
Date Signed: 7-28-98

Street or Route: 101 ALDERSON ST., P.O. BOX 109
Telephone Number: 715-359-7090

City, State, Zip Code: SCHOFIELD, WI 54476

D-256

(10) DNR OR COUNTY USE ONLY

Date Received	District/County
Reviewer/Inspector	☐ Complying Work ☐ Non-complying Work
Follow-up Needed	

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-02
County: Forest
____ 1/4 of ____ 1/4 of Sec. ____ ; T. ____ N; R. ____ ☐ E ☐ W
(If Applicable) ____ Gov't Lot ____ Grid Number
Grid Location ____ ft. ☐ N. ☐ S., ____ ft. ☐ E. ☐ W.
Civil Town Name:
Street Address of Well:
City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known):
Present Well Owner: Crandon Mine
Street or Route:
City, State, Zip Code: Crandon, WI
Facility Well No. and/or Name (If Applicable): BH-02
WI Unique Well No.:
Reason For Abandonment: Test Boring
Date of Abandonment: 08/03/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On (Date) ____

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) ____

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) ____ Casing Diameter (in.) ____ Casing Depth (ft.) ____

Lower Drillhole Diameter (in.) ____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? ____ Feet

(4) Depth to Water (Feet) ____

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain ____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7)

Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	32.0	7 Bags	

(8) Comments ____

(9) Name of Person or Firm Doing Sealing Work: BOART LONGYEAR
Signature of Person Doing Work
Date Signed: 8-11-98
Street or Route: 101 ALDERSON ST., P.O. BOX 109
Telephone Number: 715-359-7090
City, State, Zip Code: SCHOFIELD, WI 54476

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County
Reviewer/Inspector	☐ Complying Work ☐ Noncomplying Work
Follow-up Necessary	

D-257

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-03
County: Forest

____ 1/4 of ____ 1/4 of Sec. ____ ; T. ____ N; R. ____ ☐ E ☐ W
(If Applicable)
____ Gov't Lot ____ Grid Number

Grid Location
____ ft. ☐ N. ☐ S., ____ ft. ☐ E. ☐ W.

Civil Town Name

Street Address of Well

City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known)

Present Well Owner: Crandon Mine

Street or Route

City, State, Zip Code: Crandon, WI

Facility Well No. and/or Name (If Applicable): BH-03
WI Unique Well No.

Reason For Abandonment: Test Boring

Date of Abandonment: 07/21/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On
(Date) ____

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) ____

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) ____ Casing Diameter (in.) ____
Casing Depth (ft.) ____

Lower Drillhole Diameter (in.) ____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? ____ Feet

(4) Depth to Water (Feet) ____

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain ____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7)

Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	30.0	12 Bags	

(8) Comments ____

(9) Name of Person or Firm Doing Sealing Work
BOART LONGYEAR

Signature of Person Doing Work: [signature] Date Signed: 7-28-98

Street or Route: 101 ALDERSON ST., P.O. BOX 109
Telephone Number: 715-359-7090

City, State, Zip Code: SCHOFIELD, WI 54476

D-258

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County
Reviewer/Inspector	☐ Complying Work ☐ Non-complying Work
Follow-up Needed	

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-04
County: Forest
____ 1/4 of ____ 1/4 of Sec. ____ ; T. ____ N; R. ____ ☐ E ☐ W
(If Applicable) ____ Gov't Lot ____ Grid Number
Grid Location ____ ft. ☐ N. ☐ S., ____ ft. ☐ E. ☐ W.
Civil Town Name:
Street Address of Well:
City, Village: Crandon

(2) FACILITY NAME Crandon Mine
Original Well Owner (If Known):
Present Well Owner: Crandon Mine
Street or Route:
City, State, Zip Code: Crandon, WI
Facility Well No. and/or Name (If Applicable): BH-04
WI Unique Well No.:
Reason For Abandonment: Test Boring
Date of Abandonment: 08/03/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On (Date) ____

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) ____

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) ____ Casing Diameter (in.) ____ Casing Depth (ft.) ____

Lower Drillhole Diameter (in.) ____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? ____ Feet

(4) Depth to Water (Feet) ____

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain ____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7)

Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	50.0	11 Bags	

(8) Comments ____

(9) Name of Person or Firm Doing Sealing Work: BOART LONGYEAR
Signature of Person Doing Work: [signature] Date Signed: 8-11-98
Street or Route: 101 ALDERSON ST., P.O. BOX 109 Telephone Number: 715-359-7090
City, State, Zip Code: SCHOFIELD, WI 54476

D-259

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County
Reviewer/Inspector	☐ Complying Work ☐ Noncomplying Work
Follow-up Necessary	

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-05
County: Forest
___ 1/4 of ___ 1/4 of Sec. ___ ; T. ___ N; R. ___ ☐ E ☐ W
(If Applicable)
___ Gov't Lot ___ Grid Number
Grid Location
___ ft. ☐ N. ☐ S., ___ ft. ☐ E. ☐ W.
Civil Town Name
Street Address of Well
City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known)
Present Well Owner: Crandon Mine
Street or Route
City, State, Zip Code: Crandon, WI
Facility Well No. and/or Name (If Applicable): BH-05
WI Unique Well No.
Reason For Abandonment: Test Boring
Date of Abandonment: 07/20/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On
(Date) ___

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) ___

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) ___ Casing Diameter (in.) ___ Casing Depth (ft.) ___

Lower Drillhole Diameter (in.) ___

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? ___ Feet

(4) Depth to Water (Feet) ___

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain ___

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7) Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	64.0	12 Bags	

(8) Comments ___

(9) Name of Person or Firm Doing Sealing Work
BOART LONGYEAR
Signature of Person Doing ~~Work~~
Date Signed: 7-28-98
Street or Route: 101 ALDERSON ST., P.O. BOX 109
Telephone Number: 715-359-7090
City, State, Zip Code: SCHOFIELD, WI 54476

D-260

(10) FOR DNR OR COUNTY USE ONLY
Date Received/Inspected
District/County
Reviewer/Inspector
☐ Complying Work
☐ Noncomplying Work
Follow-up Necessary

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-06
County: Forest

____ 1/4 of ____ 1/4 of Sec. ____ ; T. ____ N; R. ____ ☐ E ☐ W
(If Applicable)
____ Gov't Lot ____ Grid Number

Grid Location
____ ft. ☐ N. ☐ S., ____ ft. ☐ E. ☐ W.

Civil Town Name

Street Address of Well

City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known)

Present Well Owner: Crandon Mine

Street or Route

City, State, Zip Code: Crandon, WI

Facility Well No. and/or Name (If Applicable): BH-06
WI Unique Well No.

Reason For Abandonment: Test Boring

Date of Abandonment: 08/03/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On (Date) ____

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) ____

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) ____ Casing Diameter (in.) ____ Casing Depth (ft.) ____

Lower Drillhole Diameter (in.) ____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? ____ Feet

(4) Depth to Water (Feet) ____

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain ____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7) Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	26.0	6 Bags	

(8) Comments ____

(9) Name of Person or Firm Doing Sealing Work: BOART LONGYEAR
Signature of Person Doing Work: [signature] Date Signed: 8-11-98
Street or Route: 101 ALDERSON ST., P.O. BOX 109 Telephone Number: 715-359-7090
City, State, Zip Code: SCHOFIELD, WI 54476

(10) FOR DNR OR COUNTY USE ONLY	
Date Received/Inspected	District/County
Reviewer/Inspector	☐ Complying Work ☐ Noncomplying Work
Follow-up Necessary	

D-261

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-07
County: Forest
___ 1/4 of ___ 1/4 of Sec. ___ ; T. ___ N; R. ___ ☐ E ☐ W
(If Applicable)
___ Gov't Lot ___ Grid Number
Grid Location
___ ft. ☐ N. ☐ S., ___ ft. ☐ E. ☐ W.
Civil Town Name
Street Address of Well
City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known)
Present Well Owner: Crandon Mine
Street or Route
City, State, Zip Code: Crandon, WI
Facility Well No. and/or Name (If Applicable): BH-07
WI Unique Well No.
Reason For Abandonment: Test Boring
Date of Abandonment: 08/04/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On
(Date) ___

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) ___

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) ___ Casing Diameter (in.) ___ Casing Depth (ft.) ___

Lower Drillhole Diameter (in.) ___

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? ___ Feet

(4) Depth to Water (Feet) ___

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain ___

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7)

Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	30.0	6 Bags	

(8) Comments ___

(9) Name of Person or Firm Doing Sealing Work
BOART LONGYEAR

Signature of Person Doing Work: [signature]
Date Signed: 8-11-98

Street or Route: 101 ALDERSON ST., P.O. BOX 109
Telephone Number: 715-359-7090

City, State, Zip Code: SCHOFIELD, WI 54476

D-262

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County
Reviewer/Inspector	☐ Complying Work ☐ Noncomplying Work
Follow-up Necessary	

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-08
County: Forest
____ 1/4 of ____ 1/4 of Sec. ____ ; T. ____ N; R. ____ ☐ E ☐ W
(If Applicable) _____ Gov't Lot _____ Grid Number
Grid Location _____ ft. ☐ N. ☐ S., _____ ft. ☐ E. ☐ W.
Civil Town Name
Street Address of Well
City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known)
Present Well Owner: Crandon Mine
Street or Route
City, State, Zip Code: Crandon, WI
Facility Well No. and/or Name (If Applicable): BH-08
WI Unique Well No.
Reason For Abandonment: Test Boring
Date of Abandonment: 08/05/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On
(Date) _____

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) _____

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) _____
Casing Diameter (in.) _____
Casing Depth (ft.) _____

Lower Drillhole Diameter (in.) _____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? _____ Feet

(4) Depth to Water (Feet) _____

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain _____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7)

Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	26.0	7 Bags	

(8) Comments _____

(9) Name of Person or Firm Doing Sealing Work: BOART LONGYEAR
Signature of Person Doing Work
Date Signed: 8-11-98
Street or Route: 101 ALDERSON ST., P.O. BOX 109
Telephone Number: 715-359-7090
City, State, Zip Code: SCHOFIELD, WI 54476

D-263

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County
Reviewer/Inspector	☐ Complying Work ☐ Noncomplying Work
Follow-up Necessary	

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-09
County: Forest
____ 1/4 of ____ 1/4 of Sec. ____ ; T. ____ N; R. ____ ☐ E ☐ W
(If Applicable) ____ Gov't Lot ____ Grid Number
Grid Location ____ ft. ☐ N. ☐ S., ____ ft. ☐ E. ☐ W.
Civil Town Name
Street Address of Well
City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known)
Present Well Owner: Crandon Mine
Street or Route
City, State, Zip Code: Crandon, WI
Facility Well No. and/or Name (If Applicable): BH-09
WI Unique Well No.
Reason For Abandonment: Test Boring
Date of Abandonment: 08/05/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On (Date) ____

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) ____

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) ____ Casing Diameter (in.) ____ Casing Depth (ft.) ____

Lower Drillhole Diameter (in.) ____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? ____ Feet

(4) Depth to Water (Feet) ____

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain ____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7) Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	30.0	6 Bags	

(8) Comments ____

(9) Name of Person or Firm Doing Sealing Work: BOART LONGYEAR
Signature of Person Doing Work
Date Signed: 8-11-98
Street or Route: 101 ALDERSON ST., P.O. BOX 109
Telephone Number: 715-359-7090
City, State, Zip Code: SCHOFIELD, WI 54476

D-264

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County
Reviewer/Inspector	☐ Complying Work ☐ Noncomplying Work
Follow-up Necessary	

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-10
County: Forest
____ 1/4 of ____ 1/4 of Sec. ____ ; T. ____ N; R. ____ ☐ E ☐ W
(If Applicable)
____ Gov't Lot ____ Grid Number
Grid Location
____ ft. ☐ N. ☐ S., ____ ft. ☐ E. ☐ W.
Civil Town Name
Street Address of Well
City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known)
Present Well Owner: Crandon Mine
Street or Route
City, State, Zip Code: Crandon, WI
Facility Well No. and/or Name (If Applicable): BH-10
WI Unique Well No.
Reason For Abandonment: Test Boring
Date of Abandonment: 08/05/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On (Date) ____

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) ____

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) ____ Casing Diameter (in.) ____ Casing Depth (ft.) ____

Lower Drillhole Diameter (in.) ____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? ____ Feet

(4) Depth to Water (Feet) ____

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain ____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7) Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	32.0	8 Bags	

(8) Comments ____

(9) Name of Person or Firm Doing Sealing Work: BOART LONGYEAR
Signature of Person Doing Work: [signature] Date Signed: 8-11-98
Street or Route: 101 ALDERSON ST., P.O. BOX 109 Telephone Number: 715-359-7090
City, State, Zip Code: SCHOFIELD, WI 54476

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County
Reviewer/Inspector	☐ Complying Work ☐ Noncomplying Work
Follow-up Necessary	

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-11
County: Forest
____ 1/4 of ____ 1/4 of Sec. ____ ; T. ____ N; R. ____ ☐ E ☐ W
(If Applicable)
____ Gov't Lot ____ Grid Number
Grid Location
____ ft. ☐ N. ☐ S., ____ ft. ☐ E. ☐ W.
Civil Town Name
Street Address of Well
City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known)
Present Well Owner: Crandon Mine
Street or Route
City, State, Zip Code: Crandon, WI
Facility Well No. and/or Name (If Applicable): BH-11
WI Unique Well No.
Reason For Abandonment: Test Boring
Date of Abandonment: 08/24/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On (Date) ____

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) ____

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) ____ Casing Diameter (in.) ____ Casing Depth (ft.) ____

Lower Drillhole Diameter (in.) ____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? ____ Feet

(4) Depth to Water (Feet) 4.0

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain ____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7)

Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	30.0	6 Bags	

(8) Comments ____

(9) Name of Person or Firm Doing Sealing Work: BOART LONGYEAR
Signature of Person Doing Work
Date Signed: 9-1-98
Street or Route: 101 ALDERSON ST., P.O. BOX 109
Telephone Number: 715-359-7090
City, State, Zip Code: SCHOFIELD, WI 54476

D-266

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County
Reviewer/Inspector	☐ Complying Work ☐ Noncomplying Work
Follow-up Necessary	

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-12
County: Forest

____ 1/4 of ____ 1/4 of Sec. ____ ; T. ____ N; R. ____ ☐ E ☐ W
(If Applicable)
____ Gov't Lot ____ Grid Number

Grid Location
____ ft. ☐ N. ☐ S., ____ ft. ☐ E. ☐ W.

Civil Town Name:

Street Address of Well:

City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known):

Present Well Owner: Crandon Mine

Street or Route:

City, State, Zip Code: Crandon, WI

Facility Well No. and/or Name (If Applicable): BH-12
WI Unique Well No.:

Reason For Abandonment: Test Boring

Date of Abandonment: 08/24/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On (Date): ____

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) ____

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) ____ Casing Diameter (in.) ____ Casing Depth (ft.) ____

Lower Drillhole Diameter (in.) ____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? ____ Feet

(4) Depth to Water (Feet) 7.0

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain ____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7)

Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	32.0	7 Bags	

(8) Comments ____

(9) Name of Person or Firm Doing Sealing Work: BOART LONGYEAR

Signature of Person Doing Work: [signature] Date Signed: 9-1-98

Street or Route: 101 ALDERSON ST., P.O. BOX 109
Telephone Number: 715-359-7090

City, State, Zip Code: SCHOFIELD, WI 54476

D-267

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County
Reviewer/Inspector	☐ Complying Work ☐ Noncomplying Work
Follow-up Necessary	

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-13
County: Forest
____ 1/4 of ____ 1/4 of Sec. ____ ; T. ____ N; R. ____ ☐ E ☐ W
(If Applicable) ____ Gov't Lot ____ Grid Number
Grid Location ____ ft. ☐ N. ☐ S., ____ ft. ☐ E. ☐ W.
Civil Town Name:
Street Address of Well:
City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known):
Present Well Owner: Crandon Mine
Street or Route:
City, State, Zip Code: Crandon, WI
Facility Well No. and/or Name (If Applicable): BH-13
WI Unique Well No.:
Reason For Abandonment: Test Boring
Date of Abandonment: 08/25/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On (Date) ____

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) ____

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) ____ Casing Diameter (in.) ____ Casing Depth (ft.) ____

Lower Drillhole Diameter (in.) ____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? ____ Feet

(4) Depth to Water (Feet) ____

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain ____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7) Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	71.0	12 Bags	

(8) Comments ____

(9) Name of Person or Firm Doing Sealing Work: BOART LONGYEAR
Signature of Person Doing Work: [signature] Date Signed: 9-1-98
Street or Route: 101 ALDERSON ST., P.O. BOX 109 Telephone Number: 715-359-7090
City, State, Zip Code: SCHOFIELD, WI 54476

D-268

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County
Reviewer/Inspector	☐ Complying Work ☐ Noncomplying Work
Follow-up Necessary	

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-14
County: Forest

____ 1/4 of ____ 1/4 of Sec. ____ ; T. ____ N; R. ____ ☐ E ☐ W
(If Applicable)
____ Gov't Lot ____ Grid Number

Grid Location
____ ft. ☐ N. ☐ S., ____ ft. ☐ E. ☐ W.

Civil Town Name:

Street Address of Well:

City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known):

Present Well Owner: Crandon Mine

Street or Route:

City, State, Zip Code: Crandon, WI

Facility Well No. and/or Name (If Applicable): BH-14
WI Unique Well No.:

Reason For Abandonment: Test Boring

Date of Abandonment: 08/26/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On
(Date) _____

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available?
☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) _____

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) _____
Casing Diameter (in.) _____
Casing Depth (ft.) _____

Lower Drillhole Diameter (in.) _____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? _____ Feet

(4) Depth to Water (Feet) _____

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain _____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7) Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	66.0	10 Bags	

(8) Comments _____

(9) Name of Person or Firm Doing Sealing Work
BOART LONGYEAR

Signature of Person Doing Work: [signature]
Date Signed: 9-1-98

Street or Route: 101 ALDERSON ST., P.O. BOX 109
Telephone Number: 715-359-7090

City, State, Zip Code: SCHOFIELD, WI 54476

D-269

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County
Reviewer/Inspector	☐ Complying Work ☐ Noncomplying Work
Follow-up Necessary	

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-15
County: Forest
___ 1/4 of ___ 1/4 of Sec. ___ ; T. ___ N; R. ___ ☐ E ☐ W
(If Applicable)
___ Gov't Lot ___ Grid Number
Grid Location
___ ft. ☐ N. ☐ S., ___ ft. ☐ E. ☐ W.
Civil Town Name:
Street Address of Well:
City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known):
Present Well Owner: Crandon Mine
Street or Route:
City, State, Zip Code: Crandon, WI
Facility Well No. and/or Name (If Applicable): BH-15
WI Unique Well No.:
Reason For Abandonment: Test Boring
Date of Abandonment: 08/27/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On (Date) ___

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) ___

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) ___ Casing Diameter (in.) ___ Casing Depth (ft.) ___

Lower Drillhole Diameter (in.) ___

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? ___ Feet

(4) Depth to Water (Feet) ___

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain ___

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7) Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	32.0	10 Bags	

(8) Comments ___

(9) Name of Person or Firm Doing Sealing Work: BOART LONGYEAR
Signature of Person Doing Work: [signature] Date Signed: 9-1-98
Street or Route: 101 ALDERSON ST., P.O. BOX 109 Telephone Number: 715-359-7090
City, State, Zip Code: SCHOFIELD, WI 54476

D-270

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County
Reviewer/Inspector	☐ Complying Work ☐ Noncomplying Work
Follow-up Necessary	

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-16
County: Forest

____ 1/4 of ____ 1/4 of Sec. ____ ; T. ____ N; R. ____ ☐ E ☐ W
(If Applicable)
____ Gov't Lot ____ Grid Number

Grid Location
____ ft. ☐ N. ☐ S., ____ ft. ☐ E. ☐ W.

Civil Town Name:

Street Address of Well:

City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known):

Present Well Owner: Crandon Mine

Street or Route:

City, State, Zip Code: Crandon, WI

Facility Well No. and/or Name (If Applicable): BH-16
WI Unique Well No.:

Reason For Abandonment: Test Boring

Date of Abandonment: 08/26/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On
(Date) ____

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) ____

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) ____
Casing Diameter (in.) ____
Casing Depth (ft.) ____

Lower Drillhole Diameter (in.) ____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? ____ Feet

(4) Depth to Water (Feet) ____

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain ____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7) Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	32.0	7 Bags	

(8) Comments ____

(9) Name of Person or Firm Doing Sealing Work
BOART LONGYEAR

Signature of Person Doing Work: [signature]
Date Signed: 9-1-98

Street or Route: 101 ALDERSON ST., P.O. BOX 109
Telephone Number: 715-359-7090

City, State, Zip Code: SCHOFIELD, WI 54476

D-271

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County
Reviewer/Inspector	☐ Complying Work ☐ Noncomplying Work
Follow-up Necessary	

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-17
County: Forest

____ 1/4 of ____ 1/4 of Sec. ____ ; T. ____ N; R. ____ ☐ E ☐ W
(If Applicable)
____ Gov't Lot ____ Grid Number

Grid Location
____ ft. ☐ N. ☐ S., ____ ft. ☐ E. ☐ W.

Civil Town Name

Street Address of Well

City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known)

Present Well Owner: Crandon Mine

Street or Route

City, State, Zip Code: Crandon, WI

Facility Well No. and/or Name (If Applicable): BH-17
WI Unique Well No.

Reason For Abandonment: Test Boring

Date of Abandonment: 08/26/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On
(Date) ____

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) ____

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) ____
Casing Diameter (in.) ____
Casing Depth (ft.) ____

Lower Drillhole Diameter (in.) ____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? ____ Feet

(4) Depth to Water (Feet) ____

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain ____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7)

Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	32.0	7 Bags	

(8) Comments ____

(9) Name of Person or Firm Doing Sealing Work
BOART LONGYEAR

Signature of Person Doing Work: [signature] Date Signed: 9-1-98

Street or Route: 101 ALDERSON ST., P.O. BOX 109
Telephone Number: 715-359-7090

City, State, Zip Code: SCHOFIELD, WI 54476

D-272

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County
Reviewer/Inspector	☐ Complying Work ☐ Noncomplying Work
Follow-up Necessary	

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-18
County: Forest
____ 1/4 of ____ 1/4 of Sec. ____ ; T. ____ N; R. ____ ☐ E ☐ W
(If Applicable) ____ Gov't Lot ____ Grid Number
Grid Location ____ ft. ☐ N. ☐ S., ____ ft. ☐ E. ☐ W.
Civil Town Name:
Street Address of Well:
City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known):
Present Well Owner: Crandon Mine
Street or Route:
City, State, Zip Code: Crandon, WI
Facility Well No. and/or Name (If Applicable): BH-18
WI Unique Well No.:
Reason For Abandonment: Test Boring
Date of Abandonment: 08/27/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On (Date) ____

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) ____

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) ____ Casing Diameter (in.) ____ Casing Depth (ft.) ____

Lower Drillhole Diameter (in.) ____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? ____ Feet

(4) Depth to Water (Feet) ____

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain ____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7)

Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	32.0	5 Bags	

(8) Comments ____

(9) Name of Person or Firm Doing Sealing Work: BOART LONGYEAR
Signature of Person Doing Work: [signature] Date Signed: 9-1-98
Street or Route: 101 ALDERSON ST., P.O. BOX 109 Telephone Number: 715-359-7090
City, State, Zip Code: SCHOFIELD, WI 54476

D-273

DNR/COUNTY

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County
Reviewer/Inspector	☐ Complying Work ☐ Noncomplying Work
Follow-up Necessary	

State of Wisconsin
Department of Natural Resources

WELL/DRILLHOLE/BOREHOLE ABANDONMENT
Form 3300-5B Rev. 4-97

All abandonment work shall be performed in accordance with the provisions of Chapters NR 811, NR 812 or 141, Wis. Admin. Code, whichever is applicable.

(1) GENERAL INFORMATION

Well/Drillhole/Borehole Location: BH-19
County: Forest
____ 1/4 of ____ 1/4 of Sec. ____ ; T. ____ N; R. ____ ☐ E ☐ W
(If Applicable) ____ Gov't Lot ____ Grid Number
Grid Location ____ ft. ☐ N. ☐ S., ____ ft. ☐ E. ☐ W.
Civil Town Name:
Street Address of Well:
City, Village: Crandon

(2) FACILITY NAME Crandon Mine

Original Well Owner (If Known):
Present Well Owner: Crandon Mine
Street or Route:
City, State, Zip Code: Crandon, WI
Facility Well No. and/or Name (If Applicable): BH-19
WI Unique Well No.:
Reason For Abandonment: Test Boring
Date of Abandonment: 08/26/98

WELL/DRILLHOLE/BOREHOLE INFORMATION

(3) Original Well/Drillhole/Borehole Construction Completed On (Date) ____

☐ Monitoring Well
☐ Water Well
☐ Drillhole
☒ Borehole

Construction Report Available? ☒ Yes ☐ No

Construction Type:
☒ Drilled ☐ Driven (Sandpoint) ☐ Dug
☐ Other (Specify) ____

Formation Type:
☒ Unconsolidated Formation ☐ Bedrock

Total Well Depth (ft) (From groundsurface) ____ Casing Diameter (in.) ____ Casing Depth (ft.) ____

Lower Drillhole Diameter (in.) ____

Was Well Annular Space Grouted? ☐ Yes ☐ No ☐ Unknown
If Yes, To What Depth? ____ Feet

(4) Depth to Water (Feet) ____

Pump & Piping Removed?	☐ Yes	☐ No	☒ Not Applicable
Liner(s) Removed?	☐ Yes	☐ No	☒ Not Applicable
Screen Removed?	☐ Yes	☐ No	☒ Not Applicable
Casing Left in Place?	☒ Yes	☐ No	

If No, Explain ____

Was Casing Cut Off Below Surface?	☐ Yes	☐ No
Did Sealing Material Rise to Surface?	☒ Yes	☐ No
Did Material Settle After 24 Hours?	☐ Yes	☒ No
If Yes, Was Hole Retopped?	☐ Yes	☐ No

(5) Required Method of Placing Sealing Material
☒ Conductor Pipe - Gravity ☐ Conductor Pipe - Pumped
☐ Dump Bailer ☐ Other (Explain)

(6) Sealing Materials
☐ Neat Cement Grout
☐ Sand-Cement (Concrete) Grout
☐ Concrete
☐ Clay-Sand Slurry
☐ Bentonite-Sand Slurry
☒ Chipped Bentonite

For monitoring wells and monitoring well boreholes only
☐ Bentonite Pellets
☐ Granular Bentonite
☐ Bentonite-Cement Grout

(7) Sealing Material Used	From (Ft.)	To (Ft.)		Mix Ratio or Mud Weight
Bentonite Chips	Surface	30.0	5 Bags	

(8) Comments ____

(9) Name of Person or Firm Doing Sealing Work: BOART LONGYEAR
Signature of Person Doing Work: [signature] Date Signed: 9-1-98
Street or Route: 101 ALDERSON ST., P.O. BOX 109 Telephone Number: 715-359-7090
City, State, Zip Code: SCHOFIELD, WI 54476

D-274

(10) FOR DNR OR COUNTY USE ONLY

Date Received/Inspected	District/County
Reviewer/Inspector	☐ Complying Work ☐ Noncomplying Work
Follow-up Necessary	

DNR/COUNTY

State of Wisconsin
Department of Natural Resources

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☐
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

MONITORING WELL CONSTRUCTION

Form 4400-113A Rev. 4-90

Facility/Project Name NMC - Area H	Local Grid Location of Well ☐ N. ☐ E. _____ ft. ☐ S. _____ ft. ☐ W.	Well Name MWH-09
Facility License, Permit or Monitoring Number _____	Grid Origin Location Lat. _____ Long. _____ or St. Plane 128822.63 ft N., 2284111.34 ft E.	Wis. Unique Well Number DNR Well Number _____ ___
Type of Well Water Table Observation Well ☑ 11 Piezometer ☐ 12	Section Location of Waste/Source ☐ E. _¼ of _ ¼ of Sec. _, T. _ N, R._ ☐ W.	Date Well Installed 0 8/2 6/9 8 m m d d y y
Distance Well Is From Waste/Source Boundary ft.	Location of Well Relative to Waste/Source u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known	Well Installed By: (Person's Name and Firm) Mike Mueller Boart-Longyear
Is Well A Point of Enforcement Std. Application? ☐ Yes ☐ No		

A. Protective pipe, top elevation 1594.40 ft MSL

B. Well casing, top elevation 1594.34 ft MSL

C. Land surface elevation 1591.2 ft MSL

D. Surface seal, bottom 1590.7 ft. MSL or _0.5 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☑
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis attached? ☐ Yes ☑ No

14. Drilling method used: Rotary ☐ 50
Hollow Stem Auger ☑ 41
Other ☐

15. Drilling fluid used: Water ☐ 02 Air ☐ 01
Drilling Mud ☐ 03 None ☑ 99

16. Drilling additives used? ☐ Yes ☐ No
Describe _____

17. Source of water (attach analysis):
_____

E. Bentonite seal, top 1590.7 ft. MSL or _0.5 ft.

F. Fine sand, top _____ ft. MSL or _____ ft.

G. Filter pack, top 1587.7 ft. MSL or _3.5 ft.

H. Screen joint, top 1587.2 ft. MSL or _4.0 ft.

I. Well bottom 1577.2 ft. MSL or _14.0 ft.

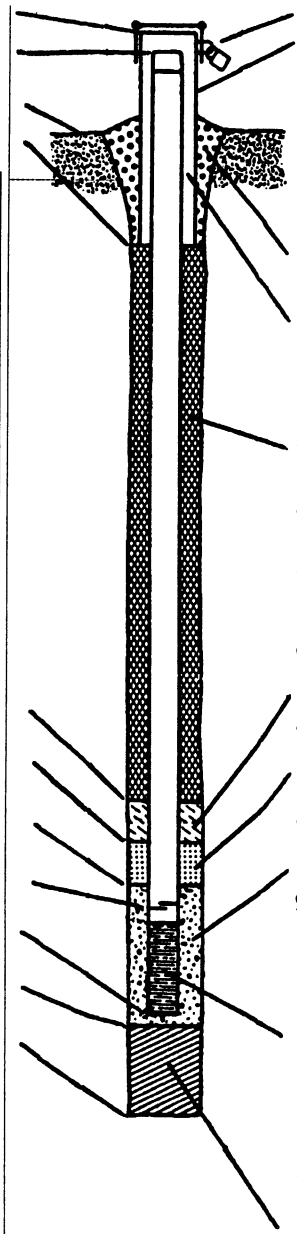
J. Filter pack, bottom 1576.2 ft. MSL or _15.0 ft.

K. Borehole, bottom 1576.2 ft. MSL or _15.0 ft.

L. Borehole, diameter _8.3 in.

M. O.D. well casing _2.38 in.

N. I.D. well casing _1.87 in.



1. Cap and lock? ☑ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: 4.0 in.
b. Length: 5.0 ft.
c. Material: Steel ☑ 04
_____ Other ☐
d. Additional protection? ☐ Yes ☐ No
If yes, describe: _____
3. Surface seal: Bentonite ☑ 30
Concrete ☐ 01
Native Other ☑
4. Material between well casing and protective pipe:
Bentonite ☐ 30
Annular space seal ☐
#30 Sand Other ☑
5. Annular space seal: a. Chipped Bentonite ☑ 33
b. _____ Lbs/gal mud weight Bentonite-sand slurry ☐ 35
c. _____ Lbs/gal mud weight .... Bentonite slurry ☐ 31
d. _____ % Bentonite .... Bentonite-cement grout ☐ 50
e. 1.5 Ft^3 volume added for any of the above
f. How installed: Tremie ☐ 01
Tremie pumped ☐ 02
Gravity ☑ 08
6. Bentonite seal: a. Bentonite granules ☐ 33
b. ☐ ¼ in. ☑ ⅜ in. ☐ ½ in. Bentonite chips ☑ 32
c. _____ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
a. Badger Mining BB#7
b. Volume added 0.0 ft^3
8. Filter pack material: Manufacturer, product name and mesh size
a. Red Flint #30
b. Volume added 2.4 ft^3
9. Well casing: Flush threaded PVC schedule 40 ☐ 23
Flush threaded PVC schedule 80 ☑ 24
_____ Other ☐
10. Screen material: PVC
a. Screen Type: Factory cut ☑ 11
Continuous slot ☐ 01
_____ Other ☐
b. Manufacturer Northern Air
c. Slot size: 0.010 in.
d. Slotted length: 10.0 ft.
11. Backfill material (below filter pack): None ☑ 14
_____ Other ☐

I hereby certify that the information on this form is true and correct to the bast of my knowledge.

Signature _____ Firm Foth & Van Dyke

Please complete both sides of this form and return to the appropriate DNR off listed at the top of this form as required by chs. 144, 147 and 160, Wis. Stat., and ch. NR 141, Wis. Ad. Code. In accordance with ch. 144, Wis Stats., failure to file this form may result in a forfeiture of not less than $10, nor more than $5000 for each day of violation. In accordance with ch. 147, Wis. Stat., failure to file this form may result in a forfeiture of not more than $10,000 for each day of violation. NOTE: Shaded areas are for DNR use only. See instructions for more information including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

MONITORING WELL DEVELOPMENT
Form 4400-113B Rev. 4-90

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☑
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

Facility/Project Name	County Name	Well Name
Nicolet Minerals Co - Area H	Forest	MWH-09

Facility License, Permit or Monitoring Number	County Code	Wis.Unique Well Number	DNR Well Number
0 0 0 0 0 0 0	2 1	0 0 0 0 0 0	0 0 0

		Before Development	After Development
1. Can this well be purged dry?	☐ Yes ☑ No		
2. Well development method			
surged with bailer and bailed	☐ 4 1		
surged with bailer and pumped	☐ 6 1		
surged with block and bailed	☐ 4 2		
surged with block and pumped	☑ 6 2		
surged with block, bailed and pumped	☐ 7 0		
compressed air	☐ 2 0		
bailed only	☐ 1 0		
pumped only	☐ 5 1		
pumped slowly	☐ 5 0		
Other _____	☐		
3. Time spent developing well	7 5 min.		
4. Depth of well (from top of well casing)	1 7 1 ft.		
5. Inside diameter of well	1 8 7 in.		
6. Volume of water in filter pack and well casing	8 5 gal.		
7. Volume of water removed from well	8 5 0 gal.		
8. Volume of water added (if any)	0 0 gal.		
9. Source of water added N/A			
10. Analysis performed on water added? (If yes, attach results)	☐ Yes ☑ No		
11. Depth to Water (from top of well casing)	a.	7 4 9 ft.	7 9 6 ft.
Date	b.	0 8/2 8/9 8 m m d d y y ☑ a.m.	0 8/2 8/9 8 m m d d y y ☑ a.m.
Time	c.	0 7:1 0 ☐ p.m.	0 8:2 5 ☐ p.m.
12. Sediment in well bottom		0 0 inches	0 0 inches
13. Water clarity		Clear ☐ 1 0 Turbid ☑ 1 5 (Describe) Turbid - Brown	Clear ☑ 2 0 Turbid ☐ 2 5 (Describe)
Fill in if drilling fluids were used and well is at solid waste facility:			
14. Total suspended solids		____.__ mg/l	____.__ mg/l
15. COD		____.__ mg/l	____.__ mg/l

16. Additional comments on development:

Well developed by: Person's Name and Firm

Name: Scott Janssen

Firm: Foth & Van Dyke

I hereby certify that the above information is true and correct to the best of my knowledge.

Signature: [signature]

Print Initials: EAS

Firm: Foth & Van Dyke

NOTE: Shaded areas are for DNR use only. See instructions for more information including a list of county codes.

State of Wisconsin
Department of Natural Resources

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☐
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

MONITORING WELL CONSTRUCTION

Form 4400-113A Rev. 4-90

Facility/Project Name NMC - Area H	Local Grid Location of Well ☐ N. _____ ft. ☐ S. ☐ E. _____ ft. ☐ W.	Well Name MWH-09P
Facility License, Permit or Monitoring Number _____	Grid Origin Location Lat. _____ Long. _____ or St. Plane 128827.77 ft N. 2284111.79 ft E.	Wis. Unique Well Number DNR Well Number _____ ___
Type of Well Water Table Observation Well ☐ 11 Piezometer ☑ 12	Section Location of Waste/Source _¼ of _ ¼ of Sec. _, T. _ N, R._ ☐ E. ☐ W.	Date Well Installed 0 8/2 6/9 8 m m d d y y
Distance Well Is From Waste/Source Boundary ft.	Location of Well Relative to Waste/Source u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known	Well Installed By: (Person's Name and Firm) Mike Mueller Boart-Longyear
Is Well A Point of Enforcement Std. Application? ☐ Yes ☐ No		

A. Protective pipe, top elevation 1594.50 ft. MSL

B. Well casing, top elevation 1594.44 ft. MSL

C. Land surface elevation 1591.2 ft. MSL

D. Surface seal, bottom 1590.7 ft. MSL or 0.5 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☑
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis attached? ☐ Yes ☑ No

14. Drilling method used: Rotary ☐ 50
Hollow Stem Auger ☑ 41
Other ☐

15. Drilling fluid used: Water ☐ 02 Air ☐ 01
Drilling Mud ☐ 03 None ☑ 99

16. Drilling additives used? ☐ Yes ☐ No
Describe _____

17. Source of water (attach analysis):
_____

E. Bentonite seal, top 1590.7 ft. MSL or 0.5 ft.

F. Fine sand, top 1566.2 ft. MSL or 25.0 ft.

G. Filter pack, top 1564.2 ft. MSL or 27.0 ft.

H. Screen joint, top 1562.2 ft. MSL or 29.0 ft.

I. Well bottom 1557.2 ft. MSL or 34.0 ft.

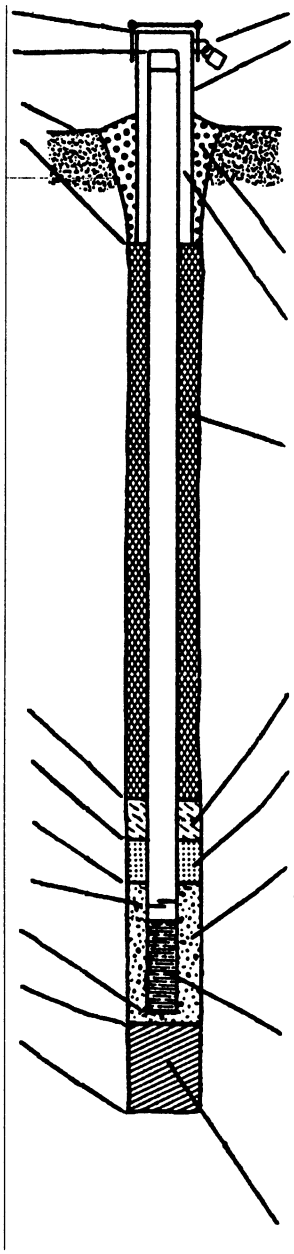
J. Filter pack, bottom 1556.2 ft. MSL or 35.0 ft.

K. Borehole, bottom 1556.2 ft. MSL or 35.0 ft.

L. Borehole, diameter 8.3 in.

M. O.D. well casing 2.38 in.

N. I.D. well casing 1.87 in.



1. Cap and lock? ☑ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: 4.0 in.
b. Length: 5.0 ft.
c. Material: Steel ☑ 04
_____ Other ☐
d. Additional protection? ☐ Yes ☐ No
If yes, describe: _____
3. Surface seal: Bentonite ☑ 30
Concrete ☐ 01
Native Other ☑
4. Material between well casing and protective pipe:
Bentonite ☐ 30
Annular space seal ☐
#30 Sand Other ☑
5. Annular space seal: a. Chipped Bentonite ☑ 33
b. _____ Lbs/gal mud weight Bentonite-sand slurry ☐ 35
c. _____ Lbs/gal mud weight .... Bentonite slurry ☐ 31
d. _____ % Bentonite .... Bentonite-cement grout ☐ 50
e. 5.6 Ft^3 volume added for any of the above
f. How installed: Tremie ☐ 01
Tremie pumped ☐ 02
Gravity ☑ 08
6. Bentonite seal: a. Bentonite granules ☐ 33
b. ☐ ¼ in. ☑ ⅜ in. ☐ ½ in. Bentonite chips ☑ 32
c. _____ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
a. Badger Mining BB#7
b. Volume added 0.5 ft^3
8. Filter pack material: Manufacturer, product name and mesh size
a. Red Flint #30
b. Volume added 2.0 ft^3
9. Well casing: Flush threaded PVC schedule 40 ☐ 23
Flush threaded PVC schedule 80 ☑ 24
_____ Other ☐
10. Screen material: PVC
a. Screen Type: Factory cut ☑ 11
Continuous slot ☐ 01
_____ Other ☐
b. Manufacturer Northern Air
c. Slot size: 0.010 in.
d. Slotted length: 5.0 ft.
11. Backfill material (below filter pack): None ☑ 14
_____ Other ☐

I hereby certify that the information on this form is true and correct to the bast of my knowledge.

Signature _____ Firm Foth & Van Dyke

Please complete both sides of this form and return to the appropriate DNR off listed at the top of this form as required by chs. 144, 147 and 160, Wis. Stat., and ch. NR 141, Wis. Ad. Code. In accordance with ch. 144, Wis Stats., failure to file this form may result in a forfeiture of not less than $10, nor more than $5000 for each day of violation. In accordance with ch. 147, Wis. Stat., failure to file this form may result in a forfeiture of not more than $10,000 for each day of violation. NOTE: Shaded areas are for DNR use only. See instructions for more information including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

MONITORING WELL DEVELOPMENT
Form 4400-113B Rev. 4-90

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☐
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

Facility/Project Name	County Name	Well Name
Nicolet Minerals Co - Area H	Forest	MWH-09P

Facility License, Permit or Monitoring Number	County Code	Wis.Unique Well Number	DNR Well Number
0 0 0 0 0 0 0	2 1	0 0 0 0 0 0	0 0 0

1. Can this well be purged dry? ☐ Yes ☑ No

2. Well development method

surged with bailer and bailed	☐ 4 1
surged with bailer and pumped	☐ 6 1
surged with block and bailed	☐ 4 2
surged with block and pumped	☑ 6 2
surged with block, bailed and pumped	☐ 7 0
compressed air	☐ 2 0
bailed only	☐ 1 0
pumped only	☐ 5 1
pumped slowly	☐ 5 0
Other _____	☐

3. Time spent developing well: 1 0 0 min.

4. Depth of well (from top of well casing): 3 8.0 ft.

5. Inside diameter of well: 1.8 7 in.

6. Volume of water in filter pack and well casing: 9.9 gal.

7. Volume of water removed from well: 1 0 0.0 gal.

8. Volume of water added (if any): 0.0 gal.

9. Source of water added: N/A

10. Analysis performed on water added? ☐ Yes ☐ No
(If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing)	a. 7.9 7 ft.	8.3 8 ft.
Date	b. 0 8/2 7/9 8 m m d d y y ☑ a.m.	0 8/2 7/9 8 m m d d y y ☑ a.m.
Time	c. 0 7:1 0 ☐ p.m.	0 8:2 5 ☐ p.m.
12. Sediment in well bottom	0.0 inches	0.0 inches
13. Water clarity	Clear ☐ 1 0 Turbid ☐ 1 5 (Describe) Brown-Moderate Turbid	Clear ☑ 2 0 Turbid ☐ 2 5 (Describe)
Fill in if drilling fluids were used and well is at solid waste facility:		
14. Total suspended solids	____.__ mg/l	____.__ mg/l
15. COD	____.__ mg/l	____.__ mg/l

16. Additional comments on development:

Well developed by: Person's Name and Firm

Name: Scott Janssen

Firm: Foth & Van Dyke

I hereby certify that the above information is true and correct to the best of my knowledge.

Signature: [signature]

Print Initials: E A S

Firm: Foth & Van Dyke

NOTE: Shaded areas are for DNR use only. See instructions for more information including a list of county codes.

State of Wisconsin
Department of Natural Resources

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☐
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

MONITORING WELL CONSTRUCTION

Form 4400-113A Rev. 4-90

Facility/Project Name NMC - Area H	Local Grid Location of Well ☐N. _____ft. ☐S. ☐E. _____ft. ☐W.	Well Name MWH-10
Facility License, Permit or Monitoring Number _____	Grid Origin Location Lat. _____ Long. _____ or St. Plane 128524.62 ft N 2284996.76 ft E.	Wis. Unique Well Number DNR Well Number _____ ___
Type of Well Water Table Observation Well ☑ 11 Piezometer ☐ 12	Section Location of Waste/Source ☐E. _¼ of _ ¼ of Sec. _, T. _ N, R._ ☐W.	Date Well Installed 0 8/2 6/9 8 m m d d y y
Distance Well Is From Waste/Source Boundary ft.	Location of Well Relative to Waste/Source u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known	Well Installed By: (Person's Name and Firm) Mike Mueller Boart-Longyear
Is Well A Point of Enforcement Std. Application? ☐ Yes ☐ No		

A. Protective pipe, top elevation 1595.69 ft. MSL

B. Well casing, top elevation 1595.62 ft. MSL

C. Land surface elevation 1592.5 ft. MSL

D. Surface seal, bottom 1592.0 ft. MSL or 0.5 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☑
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis attached? ☐ Yes ☑ No

14. Drilling method used: Rotary ☐ 50
Hollow Stem Auger ☑ 41
Other ☐

15. Drilling fluid used: Water ☐ 02 Air ☐ 01
Drilling Mud ☐ 03 None ☑ 99

16. Drilling additives used? ☐ Yes ☐ No
Describe _____

17. Source of water (attach analysis):
_____

E. Bentonite seal, top 1592.0 ft. MSL or 0.5 ft.

F. Fine sand, top 1587.5 ft. MSL or 5.0 ft.

G. Filter pack, top 1586.5 ft. MSL or 6.0 ft.

H. Screen joint, top 1585.5 ft. MSL or 7.0 ft.

I. Well bottom 1575.5 ft. MSL or 17.0 ft.

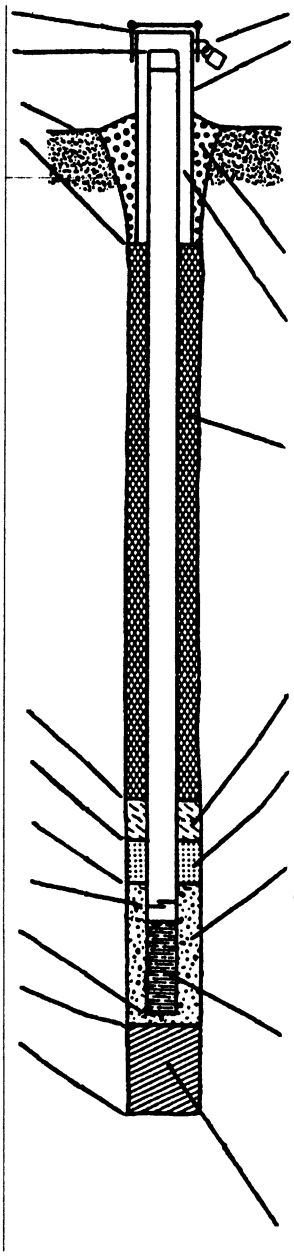
J. Filter pack, bottom 1574.5 ft. MSL or 18.0 ft.

K. Borehole, bottom 1574.5 ft. MSL or 18.0 ft.

L. Borehole, diameter 8.3 in.

M. O.D. well casing 2.38 in.

N. I.D. well casing 1.94 in.



1. Cap and lock? ☑ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: 4.0 in.
b. Length: 7.0 ft.
c. Material: Steel ☑ 04
_____ Other ☐
d. Additional protection? ☐ Yes ☐ No
If yes, describe: _____
3. Surface seal: Bentonite ☑ 30
Concrete ☐ 01
Native Other ☑
4. Material between well casing and protective pipe:
Bentonite ☐ 30
Annular space seal ☐
#30 Red Flint Filter Other ☑
5. Annular space seal: a. Chipped Bentonite ☑ 33
b. _____Lbs/gal mud weight Bentonite-sand slurry ☐ 35
c. _____Lbs/gal mud weight .... Bentonite slurry ☐ 31
d. _____% Bentonite .... Bentonite-cement grout ☐ 50
e. 1.8 Ft^3 volume added for any of the above
f. How installed: Tremie ☐ 01
Tremie pumped ☐ 02
Gravity ☑ 08
6. Bentonite seal: a. Bentonite granules ☐ 33
b. ☐ ¼ in. ☑ ⅜ in. ☐ ½ in. Bentonite chips ☑ 32
c. _____ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
a. Badger Mining BB#7 Fine Silica
b. Volume added 0.5 ft^3
8. Filter pack material: Manufacturer, product name and mesh size
a. Red Flint #30
b. Volume added 2.7 ft^3
9. Well casing: Flush threaded PVC schedule 40 ☐ 23
Flush threaded PVC schedule 80 ☑ 24
_____ Other ☐
10. Screen material: PVC
a. Screen Type: Factory cut ☑ 11
Continuous slot ☐ 01
_____ Other ☐
b. Manufacturer Northern Air
c. Slot size: 0.010 in.
d. Slotted length: 10.0 ft.
11. Backfill material (below filter pack): None ☑ 14
_____ Other ☐

I hereby certify that the information on this form is true and correct to the bast of my knowledge.

Signature	Firm
	Foth & Van Dyke

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State of Wisconsin
Department of Natural Resources

MONITORING WELL DEVELOPMENT
Form 4400-113B Rev. 4-90

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☑
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

Facility/Project Name	County Name	Well Name	
Nicolet Minerals Co - Area H	Forest	MWH-10	
Facility License, Permit or Monitoring Number	**County Code**	**Wis.Unique Well Number**	**DNR Well Number**
0 0 0 0 0 0 0	2 1	0 0 0 0 0 0	0 0 0

1. Can this well be purged dry? ☐ Yes ☑ No

2. Well development method
   - surged with bailer and bailed ☐ 4 1
   - surged with bailer and pumped ☐ 6 1
   - surged with block and bailed ☐ 4 2
   - surged with block and pumped ☑ 6 2
   - surged with block, bailed and pumped ☐ 7 0
   - compressed air ☐ 2 0
   - bailed only ☐ 1 0
   - pumped only ☐ 5 1
   - pumped slowly ☐ 5 0
   - Other _____ ☐ [ ]

3. Time spent developing well __65 min.

4. Depth of well (from top of well casing) _203 ft.

5. Inside diameter of well _1.87 in.

6. Volume of water in filter pack and well casing __6.2 gal.

7. Volume of water removed from well _650 gal.

8. Volume of water added (if any) __0.0 gal.

9. Source of water added N/A

10. Analysis performed on water added? ☐ Yes ☑ No
(If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing)	a. _13.27 ft.	_14.10 ft.
Date	b. 08/27/98 m m d d y y ☑ a.m.	08/27/98 m m d d y y ☑ a.m.
Time	c. 08:30 ☐ p.m.	09:30 ☐ p.m.
12. Sediment in well bottom	_0.0 inches	_0.0 inches
13. Water clarity	Clear ☐ 10 Turbid ☑ 15 (Describe) Brown Very High Turbidity	Clear ☑ 20 Turbid ☐ 25 (Describe)

Fill in if drilling fluids were used and well is at solid waste facility:

14. Total suspended solids	____._ mg/l	____._ mg/l
15. COD	____._ mg/l	____._ mg/l

16. Additional comments on development:

Well developed by: Person's Name and Firm

Name: Scott Janssen

Firm: Foth & Van Dyke

I hereby certify that the above information is true and correct to the best of my knowledge.

Signature: [signature]

Print Initials: EMS

Firm: Foth & Van Dyke

NOTE: Shaded areas are for DNR use only. See instructions for more information including a list of county codes.

State of Wisconsin
Department of Natural Resources

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☐
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

MONITORING WELL CONSTRUCTION

Form 4400-113A Rev. 4-90

Facility/Project Name NMC - Area H	Local Grid Location of Well ☐N. ☐E. _____ft. ☐S. _____ft. ☐W.	Well Name MWH-10P
Facility License, Permit or Monitoring Number _____	Grid Origin Location Lat. _____ Long. _____ or St. Plane 128534.44 ft N. 2284996.57 ft E.	Wis. Uniqe Well Number DNR Well Number _____ ___
Type of Well Water Table Observation Well ☐ 11 Piezometer ☑ 12	Section Location of Waste/Source ☐E. _¼ of _¼ of Sec. _, T. _N, R._ ☐W.	Date Well Installed 0 8/2 7/9 8 m m d d y y
Distance Well Is From Waste/Source Boundary ft.	Location of Well Relative to Waste/Source u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known	Well Installed By: (Person's Name and Firm) Mike Mueller Boart-Longyear
Is Well A Point of Enforcement Std. Application? ☐ Yes ☐ No		

A. Protective pipe, top elevation 1595.54 ft. MSL

B. Well casing, top elevation 1595.48 ft. MSL

C. Land surface elevation 1592.4 ft. MSL

D. Surface seal, bottom 1591.9 ft. MSL or _0.5 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☑
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis attached? ☐ Yes ☑ No

14. Drilling method used: Rotary ☐ 50
Hollow Stem Auger ☑ 41
Other ☐

15. Drilling fluid used: Water ☐ 02 Air ☐ 01
Drilling Mud ☐ 03 None ☑ 99

16. Drilling additives used? ☐ Yes ☐ No
Describe _____

17. Source of water (attach analysis):
_____

E. Bentonite seal, top 1591.9 ft. MSL or __0.5 ft.

F. Fine sand, top 1564.4 ft. MSL or _28.0 ft.

G. Filter pack, top 1562.4 ft. MSL or _30.0 ft.

H. Screen joint, top 1560.4 ft. MSL or 32.0 ft.

I. Well bottom 1555.4 ft. MSL or _37.0 ft.

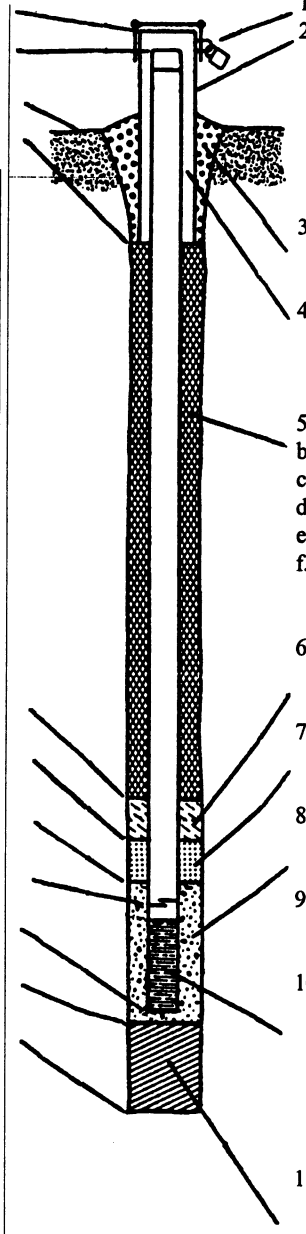
J. Filter pack, bottom 1554.4 ft. MSL or 38.0 ft.

K. Borehole, bottom 1554.4 ft. MSL or _38.0 ft.

L. Borehole, diameter _8.3 in.

M. O.D. well casing _2.38 in.

N. I.D. well casing _1.87 in.



1. Cap and lock? ☑ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: _4.0 in.
b. Length: _7.0 ft.
c. Material: Steel ☑ 04
_____ Other ☐
d. Additional protection? ☐ Yes ☐ No
If yes, describe: _____
3. Surface seal: Bentonite ☑ 30
Concrete ☐ 01
Native Other ☑
4. Material between well casing and protective pipe:
Bentonite ☐ 30
Annular space seal ☐
#30 Sand Other ☑
5. Annular space seal: a. Chipped Bentonite ☑ 33
b. _____Lbs/gal mud weight Bentonite-sand slurry ☐ 35
c. _____Lbs/gal mud weight .... Bentonite slurry ☐ 31
d. _____% Bentonite .... Bentonite-cement grout ☐ 50
e. 6.0 Ft³ volume added for any of the above
f. How installed: Tremie ☐ 01
Tremie pumped ☐ 02
Gravity ☑ 08
6. Bentonite seal: a. Bentonite granules ☐ 33
b. ☐ ¼ in. ☑ ⅜ in. ☐ ½ in. Bentonite chips ☑ 32
c. _____ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
a. Badger Mining BB#7
b. Volume added 0.6 ft³
8. Filter pack material: Manufacturer, product name and mesh size
a. Red Flint #30
b. Volume added 2.1 ft³
9. Well casing: Flush threaded PVC schedule 40 ☐ 23
Flush threaded PVC schedule 80 ☑ 24
_____ Other ☐
10. Screen material: PVC
a. Screen Type: Factory cut ☑ 11
Continuous slot ☐ 01
_____ Other ☐
b. Manufacturer Northern Air
c. Slot size: 0.010 in.
d. Slotted length: 5.0 ft.
11. Backfill material (below filter pack): None ☑ 14
_____ Other ☐

I hereby certify that the information on this form is true and correct to the bast of my knowledge.

Signature _____ Firm Foth & Van Dyke

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State of Wisconsin
Department of Natural Resources

MONITORING WELL DEVELOPMENT
Form 4400-113B Rev. 4-90

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☑
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

Facility/Project Name	County Name	Well Name
Nicolet Minerals Co - Area H	Forest	MWH-10P

Facility License, Permit or Monitoring Number	County Code	Wis.Unique Well Number	DNR Well Number
0 0 0 0 0 0 0	2 1	0 0 0 0 0 0	0 0 0

1. Can this well be purged dry? ☐ Yes ☑ No

2. Well development method
   - surged with bailer and bailed ☐ 4 1
   - surged with bailer and pumped ☐ 6 1
   - surged with block and bailed ☐ 4 2
   - surged with block and pumped ☐ 6 2
   - surged with block, bailed and pumped ☑ 7 0
   - compressed air ☐ 2 0
   - bailed only ☐ 1 0
   - pumped only ☐ 5 1
   - pumped slowly ☐ 5 0
   - Other _____ ☐ [redacted]

3. Time spent developing well __ __ 9 5 min.

4. Depth of well (from top of well casing) __ 4 0 . 1 ft.

5. Inside diameter of well __ 1 . 8 7 in.

6. Volume of water in filter pack and well casing __ __ 9 . 3 gal.

7. Volume of water removed from well __ 9 5 0 gal.

8. Volume of water added (if any) __ __ 0 . 0 gal.

9. Source of water added N/A

10. Analysis performed on water added? ☐ Yes ☑ No
(If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing)	a. __ 1 3 . 9 1 ft.	__ 1 4 . 3 2 ft.
Date	b. 0 8/2 7/9 8 m m d d y y ☑ a.m.	0 8/2 7/9 8 m m d d y y ☑ a.m.
Time	c. 0 8 : 3 0 ☐ p.m.	0 9 : 4 0 ☐ p.m.
12. Sediment in well bottom	__ 0 . 0 inches	__ 0 . 0 inches
13. Water clarity	Clear ☐ 1 0 Turbid ☑ 1 5 (Describe) Light Brown Slightly Turbid	Clear ☑ 2 0 Turbid ☐ 2 5 (Describe)
Fill in if drilling fluids were used and well is at solid waste facility:		
14. Total suspended solids	_ _ _ _ . _ mg/l	_ _ _ _ . _ mg/l
15. COD	_ _ _ _ . _ mg/l	_ _ _ _ . _ mg/l

16. Additional comments on development:

Well developed by: Person's Name and Firm

Name: Scott Janssen

Firm: Foth & Van Dyke

I hereby certify that the above information is true and correct to the best of my knowledge.

Signature: [signature]

Print Initials: EAS

Firm: Foth & Van Dyke

NOTE: Shaded areas are for DNR use only. See instructions for more information including a list of county codes.

State of Wisconsin
Department of Natural Resources

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☐
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

MONITORING WELL CONSTRUCTION
Form 4400-113A Rev. 4-90

Facility/Project Name NMC - Area H	Local Grid Location of Well ☐ N. ☐ E. _____ ft. ☐ S. _____ ft. ☐ W.	Well Name MWH-11
Facility License, Permit or Monitoring Number _____	Grid Origin Location Lat. _____ Long. _____ or St. Plane 128234.40 ft N. 2285323.43 ft E.	Wis. Unique Well Number DNR Well Number _____ ___
Type of Well Water Table Observation Well ☐ 11 Piezometer ☑ 12	Section Location of Waste/Source ☐ E. _¼ of _ ¼ of Sec. _, T. _ N, R._ ☐ W.	Date Well Installed 0 8/2 7/9 8 m m d d y y
Distance Well Is From Waste/Source Boundary ft.	Location of Well Relative to Waste/Source u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known	Well Installed By: (Person's Name and Firm) Mike Mueller Boart-Longyear
Is Well A Point of Enforcement Std. Application? ☐ Yes ☐ No		

A. Protective pipe, top elevation 1588.25 ft. MSL

B. Well casing, top elevation 1588.16 ft. MSL

C. Land surface elevation 1585.0 ft. MSL

D. Surface seal, bottom 1584.5 ft. MSL or _0.5 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☑
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis attached? ☐ Yes ☑ No

14. Drilling method used: Rotary ☐ 50
Hollow Stem Auger ☑ 41
Other ☐ __

15. Drilling fluid used Water ☐ 02 Air ☐ 01
Drilling Mud ☐ 03 None ☑ 99

16. Drilling additives used? ☐ Yes ☐ No
Describe _____

17. Source of water (attach analysis):
_____

E. Bentonite seal, top 1584.5 ft. MSL or _0.5 ft.

F. Fine sand, top ____.- ft. MSL or _-.- ft.

G. Filter pack, top 1581.5 ft. MSL or _3.5 ft.

H. Screen joint, top 1581.0 ft. MSL or _4.0 ft.

I. Well bottom 1571.0 ft. MSL or 14.0 ft.

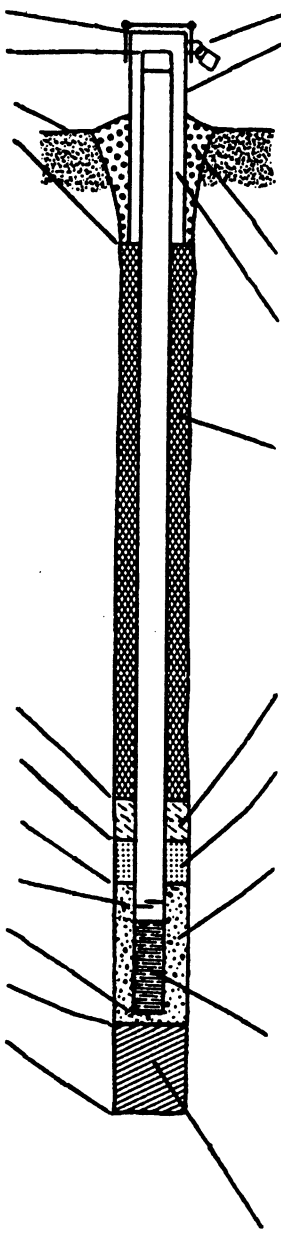
J. Filter pack, bottom 1570.0 ft. MSL or 15.0 ft.

K. Borehole, bottom 1570.0 ft. MSL or _15.0 ft.

L. Borehole, diameter _8.3 in.

M. O.D. well casing _2.38 in.

N. I.D. well casing _1.87 in.



1. Cap and lock? ☑ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: 4.0 in.
b. Length: 5.0 ft.
c. Material: Steel ☑ 04
_____ Other ☐ __
d. Additional protection? ☐ Yes ☐ No
If yes, describe: _____
3. Surface seal: Bentonite ☑ 30
Concrete ☐ 01
Native Other ☑ __
4. Material between well casing and protective pipe:
Bentonite ☐ 30
Annular space seal ☐ __
#30 Sand Other ☑ __
5. Annular space seal: a. Chipped Bentonite ☑ 33
b. _____ Lbs/gal mud weight Bentonite-sand slurry ☐ 35
c. _____ Lbs/gal mud weight .... Bentonite slurry ☐ 31
d. _____ % Bentonite .... Bentonite-cement grout ☐ 50
e. 1.3 Ft³ volume added for any of the above
f. How installed: Tremie ☐ 01
Tremie pumped ☐ 02
Gravity ☑ 08
6. Bentonite seal: a. Bentonite granules ☐ 33
b. ☐ ¼ in. ☑ ⅜ in. ☐ ½ in. Bentonite chips ☑ 32
c. _____ Other ☐ __
7. Fine sand material: Manufacturer, product name & mesh size
a. Badger Mining BB#7 __
b. Volume added 0.0 ft³
8. Filter pack material: Manufacturer, product name and mesh size
a. Red Flint #30 __
b. Volume added 2.4 ft³
9. Well casing: Flush threaded PVC schedule 40 ☐ 23
Flush threaded PVC schedule 80 ☑ 24
_____ Other ☐ __
10. Screen material: PVC __
a. Screen Type: Factory cut ☑ 11
Continuous slot ☐ 01
_____ Other ☐ __
b. Manufacturer Northern Air
c. Slot size: 0.010 in.
d. Slotted length: 10.0 ft.
11. Backfill material (below filter pack): None ☑ 14
_____ Other ☐ __

I hereby certify that the information on this form is true and correct to the bast of my knowledge.

Signature _____ Firm Foth & Van Dyke

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State of Wisconsin
Department of Natural Resources

MONITORING WELL DEVELOPMENT
Form 4400-113B Rev. 4-90

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☑
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

Facility/Project Name	County Name	Well Name
Nicolet Minerals Co - Area H	Forest	MWH-11

Facility License, Permit or Monitoring Number	County Code	Wis.Unique Well Number	DNR Well Number
0 0 0 0 0 0 0	2 1	0 0 0 0 0 0	0 0 0

1. Can this well be purged dry? ☐ Yes ☑ No

2. Well development method
   - surged with bailer and bailed ☐ 4 1
   - surged with bailer and pumped ☐ 6 1
   - surged with block and bailed ☐ 4 2
   - surged with block and pumped ☑ 6 2
   - surged with block, bailed and pumped ☐ 7 0
   - compressed air ☐ 2 0
   - bailed only ☐ 1 0
   - pumped only ☐ 5 1
   - pumped slowly ☐ 5 0
   - Other _____ ☐ [redacted]

3. Time spent developing well __ 7 0 min.

4. Depth of well (from top of well casing) __ 1 7.0 ft.

5. Inside diameter of well __ 1.8 7 in.

6. Volume of water in filter pack and well casing __ __ 8.7 gal.

7. Volume of water removed from well __ 9 0.0 gal.

8. Volume of water added (if any) __ __ 0.0 gal.

9. Source of water added N/A

10. Analysis performed on water added? ☐ Yes ☑ No
(If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing)	a. __ 7.2 9 ft.	__ 9.1 8 ft.
Date	b. 0 8/2 8/9 8 (m m d d y y) ☑ a.m.	0 8/2 8/9 8 (m m d d y y) ☑ a.m.
Time	c. 1 0:0 0 ☐ p.m.	1 1:1 0 ☐ p.m.
12. Sediment in well bottom	__ 0.0 inches	__ 0.0 inches
13. Water clarity	Clear ☐ 1 0 Turbid ☑ 1 5 (Describe) Brown Very High Turbidity	Clear ☑ 2 0 Turbid ☐ 2 5 (Describe)

Fill in if drilling fluids were used and well is at solid waste facility:

14. Total suspended solids	_____ mg/l	_____ mg/l
15. COD	_____ mg/l	_____ mg/l

16. Additional comments on development:

Well developed by: Person's Name and Firm

Name: Scott Janssen

Firm: Foth & Van Dyke

I hereby certify that the above information is true and correct to the best of my knowledge.

Signature: [signature]

Print Initials: E A S

Firm: Foth & Van Dyke

NOTE: Shaded areas are for DNR use only. See instructions for more information including a list of county codes.

State of Wisconsin
Department of Natural Resources

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☐
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

MONITORING WELL CONSTRUCTION

Form 4400-113A Rev. 4-90

Facility/Project Name	Local Grid Location of Well	Well Name
NMC - Area H	☐ N. ☐ E. _____ ft. ☐ S. _____ ft. ☐ W.	MWH-11P
Facility License, Permit or Monitoring Number	**Grid Origin Location**	**Wis. Unique Well Number DNR Well Number**
_____	Lat. _____ Long. _____ or	_____ ___
Type of Well Water Table Observation Well ☑ 11	St. Plane 128240.76 ft N. 2285325.07 ft E.	**Date Well Installed**
Piezometer ☐ 12	**Section Location of Waste/Source**	0 8/2 7/9 8 (m m d d y y)
Distance Well Is From Waste/Source Boundary	☐ E. _¼ of _ ¼ of Sec. _, T. _ N, R._ ☐ W.	**Well Installed By: (Person's Name and Firm)**
ft.	**Location of Well Relative to Waste/Source**	Mike Mueller
Is Well A Point of Enforcement Std. Application?	u ☐ Upgradient s ☐ Sidegradient	Boart-Longyear
☐ Yes ☐ No	d ☐ Downgradient n ☐ Not Known	

A. Protective pipe, top elevation 1588.07 ft. MSL

B. Well casing, top elevation 1588.02 ft. MSL

C. Land surface elevation 1584.9 ft. MSL

D. Surface seal, bottom 1584.4 ft. MSL or _0.5 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☑
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis attached? ☐ Yes ☑ No

14. Drilling method used: Rotary ☐ 50
Hollow Stem Auger ☑ 41
Other ☐

15. Drilling fluid used: Water ☐ 02 Air ☐ 01
Drilling Mud ☐ 03 None ☑ 99

16. Drilling additives used? ☐ Yes ☐ No
Describe _____

17. Source of water (attach analysis):
_____

E. Bentonite seal, top 1584.4 ft. MSL or __0.5 ft.

F. Fine sand, top 1559.9 ft. MSL or 25.0 ft.

G. Filter pack, top 1557.9 ft. MSL or 27.0 ft.

H. Screen joint, top 1555.9 ft. MSL or 29.0 ft.

I. Well bottom 1550.9 ft. MSL or 34.0 ft.

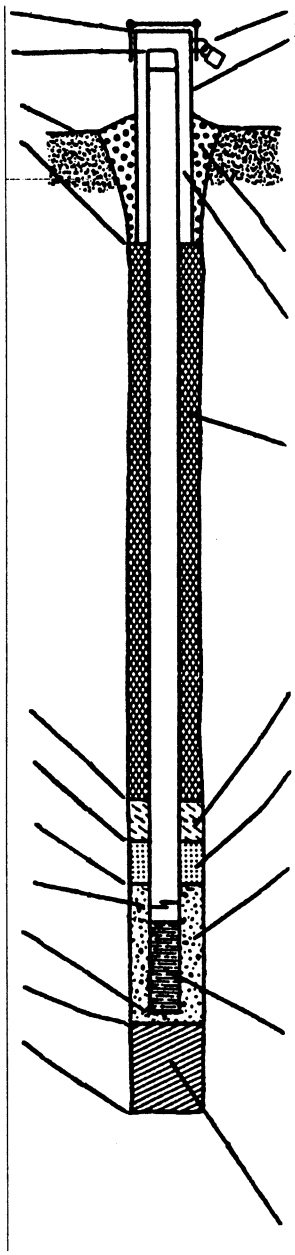
J. Filter pack, bottom 1549.9 ft. MSL or 35.0 ft.

K. Borehole, bottom 1549.9 ft. MSL or _35.0 ft.

L. Borehole, diameter _8.3 in.

M. O.D. well casing _2.38 in.

N. I.D. well casing _1.87 in.



1. Cap and lock? ☑ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: 4.0 in.
b. Length: 5.0 ft.
c. Material: Steel ☑ 04
_____ Other ☐
d. Additional protection? ☐ Yes ☐ No
If yes, describe: _____
3. Surface seal: Bentonite ☑ 30
Concrete ☐ 01
Native Other ☑
4. Material between well casing and protective pipe:
Bentonite ☐ 30
Annular space seal ☐
#30 Sand Other ☑
5. Annular space seal: a. Chipped Bentonite ☑ 33
b. _____ Lbs/gal mud weight Bentonite-sand slurry ☐ 35
c. _____ Lbs/gal mud weight .... Bentonite slurry ☐ 31
d. _____ % Bentonite .... Bentonite-cement grout ☐ 50
e. 5.8 Ft³ volume added for any of the above
f. How installed: Tremie ☐ 01
Tremie pumped ☐ 02
Gravity ☑ 08
6. Bentonite seal: a. Bentonite granules ☐ 33
b. ☐ ¼ in. ☑ ⅜ in. ☐ ½ in. Bentonite chips ☑ 32
c. _____ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
a. Badger Mining BB#7
b. Volume added 0.49 ft³
8. Filter pack material: Manufacturer, product name and mesh size
a. Red Flint #30
b. Volume added 1.4 ft³
9. Well casing: Flush threaded PVC schedule 40 ☐ 23
Flush threaded PVC schedule 80 ☑ 24
_____ Other ☐
10. Screen material: PVC
a. Screen Type: Factory cut ☑ 11
Continuous slot ☐ 01
_____ Other ☐
b. Manufacturer Northern Air
c. Slot size: 0.010 in.
d. Slotted length: 5.0 ft.
11. Backfill material (below filter pack): None ☑ 14
_____ Other ☐

I hereby certify that the information on this form is true and correct to the bast of my knowledge.

Signature	Firm
	Foth & Van Dyke

Please complete both sides of this form and return to the appropriate DNR off listed at the top of this form as required by chs. 144, 147 and 160, Wis. Stat., and ch. NR 141, Wis. Ad. Code. In accordance with ch. 144, Wis Stats., failure to file this form may result in a forfeiture of not less than $10, nor more than $5000 for each day of violation. In accordance with ch. 147, Wis. Stat., failure to file this form may result in a forfeiture of not more than $10,000 for each day of violation. NOTE: Shaded areas are for DNR use only. See instructions for more information including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

MONITORING WELL DEVELOPMENT
Form 4400-113B Rev. 4-90

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☑
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

Facility/Project Name	County Name	Well Name
Nicolet Minerals Co - Area H	Forest	MWH-11P

Facility License, Permit or Monitoring Number	County Code	Wis.Unique Well Number	DNR Well Number
0 0 0 0 0 0 0	2 1	0 0 0 0 0 0	0 0 0

1. Can this well be purged dry? ☐ Yes ☑ No

2. Well development method
   - surged with bailer and bailed ☐ 4 1
   - surged with bailer and pumped ☐ 6 1
   - surged with block and bailed ☐ 4 2
   - surged with block and pumped ☑ 6 2
   - surged with block, bailed and pumped ☐ 7 0
   - compressed air ☐ 2 0
   - bailed only ☐ 1 0
   - pumped only ☐ 5 1
   - pumped slowly ☐ 5 0
   - Other _____ ☐ ..

3. Time spent developing well 7 5 min.

4. Depth of well (from top of well casing) 3 7.0 ft.

5. Inside diameter of well 1.8 7 in.

6. Volume of water in filter pack and well casing 9.9 gal.

7. Volume of water removed from well 1 0 0 0 gal.

8. Volume of water added (if any) 0.0 gal.

9. Source of water added N/A

10. Analysis performed on water added? ☐ Yes ☑ No
    (If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing)	a. 7.1 2 ft.	7.3 9 ft.
Date	b. 0 8/2 8/9 8 (m m d d y y)	0 8/2 8/9 8 (m m d d y y)
Time	c. 1 0:0 0 ☑ a.m. ☐ p.m.	1 1:1 5 ☑ a.m. ☐ p.m.
12. Sediment in well bottom	0.0 inches	0.0 inches
13. Water clarity	Clear ☐ 1 0 Turbid ☑ 1 5 (Describe) Brown Moderate Turbidity	Clear ☑ 2 0 Turbid ☐ 2 5 (Describe)

Fill in if drilling fluids were used and well is at solid waste facility:

14. Total suspended solids	____.__ mg/l	____.__ mg/l
15. COD	____.__ mg/l	____.__ mg/l

16. Additional comments on development:

Well developed by: Person's Name and Firm

Name: Scott Janssen

Firm: Foth & Van Dyke

I hereby certify that the above information is true and correct to the best of my knowledge.

Signature: [signature]

Print Initials: EAS

Firm: Foth & Van Dyke

NOTE: Shaded areas are for DNR use only. See instructions for more information including a list of county codes.

State of Wisconsin
Department of Natural Resources

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☐
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

MONITORING WELL CONSTRUCTION

Form 4400-113A Rev. 4-90

Facility/Project Name NMC - Area H	Local Grid Location of Well ☐ N. _____ ft. ☐ S. ☐ E. _____ ft. ☐ W.	Well Name MWH-13
Facility License, Permit or Monitoring Number _____	Grid Origin Location Lat. _____ Long. _____ or St. Plane 130355.72 ft N. 2285041.29 ft E.	Wis. Unique Well Number DNR Well Number _____ ___
Type of Well Water Table Observation Well ☑ 11 Piezometer ☐ 12	Section Location of Waste/Source ☐ E. _¼ of _ ¼ of Sec. _, T. _ N, R._ ☐ W.	Date Well Installed 0 8/2 7/9 8 m m d d y y
Distance Well Is From Waste/Source Boundary ft.	Location of Well Relative to Waste/Source u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known	Well Installed By: (Person's Name and Firm) Mike Mueller Boart-Longyear
Is Well A Point of Enforcement Std. Application? ☐ Yes ☐ No		

A. Protective pipe, top elevation 1597.60 ft. MSL

B. Well casing, top elevation 1597.54 ft. MSL

C. Land surface elevation 1594.4 ft. MSL

D. Surface seal, bottom 1593.9 ft. MSL or _0.5 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☑
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis attached? ☐ Yes ☑ No

14. Drilling method used: Rotary ☐ 50
Hollow Stem Auger ☑ 41
Other ☐

15. Drilling fluid used: Water ☐ 02 Air ☐ 01
Drilling Mud ☐ 03 None ☑ 99

16. Drilling additives used? ☐ Yes ☐ No
Describe _____

17. Source of water (attach analysis):
_____

E. Bentonite seal, top 1593.9 ft. MSL or __0.5 ft.

F. Fine sand, top ____. ft. MSL or __.__ ft.

G. Filter pack, top 1589.9 ft. MSL or __4.5 ft.

H. Screen joint, top 1589.4 ft. MSL or __5.0 ft.

I. Well bottom 1579.4 ft. MSL or _15.0 ft.

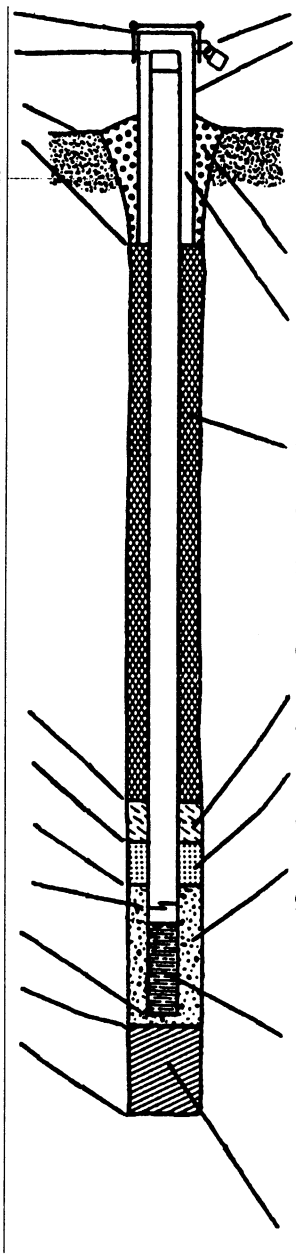
J. Filter pack, bottom 1578.4 ft. MSL or _16.0 ft.

K. Borehole, bottom 1578.4 ft. MSL or _16.0 ft.

L. Borehole, diameter _8.3 in.

M. O.D. well casing _2.38 in.

N. I.D. well casing _1.87 in.



1. Cap and lock? ☑ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: 4.0 in.
b. Length: 7.0 ft.
c. Material: Steel ☑ 04
_____ Other ☐
d. Additional protection? ☐ Yes ☐ No
If yes, describe: _____
3. Surface seal: Bentonite ☑ 30
Concrete ☐ 01
Native Other ☑
4. Material between well casing and protective pipe:
Bentonite ☐ 30
Annular space seal ☐
#30 Sand Other ☑
5. Annular space seal: a. Chipped Bentonite ☑ 33
b. _____ Lbs/gal mud weight Bentonite-sand slurry ☐ 35
c. _____ Lbs/gal mud weight .... Bentonite slurry ☐ 31
d. _____ % Bentonite .... Bentonite-cement grout ☐ 50
e. 1.3 Ft³ volume added for any of the above
f. How installed: Tremie ☐ 01
Tremie pumped ☐ 02
Gravity ☑ 08
6. Bentonite seal: a. Bentonite granules ☐ 33
b. ☐ ¼ in. ☑ ⅜ in. ☐ ½ in. Bentonite chips ☑ 32
c. _____ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
a. Badger Mining BB#7
b. Volume added 0.0 ft³
8. Filter pack material: Manufacturer, product name and mesh size
a. Red Flint #30
b. Volume added 2.5 ft³
9. Well casing: Flush threaded PVC schedule 40 ☐ 23
Flush threaded PVC schedule 80 ☑ 24
_____ Other ☐
10. Screen material: PVC
a. Screen Type: Factory cut ☑ 11
Continuous slot ☐ 01
_____ Other ☐
b. Manufacturer Northern Air
c. Slot size: 0.010 in.
d. Slotted length: 10.0 ft.
11. Backfill material (below filter pack): None ☑ 14
_____ Other ☐

I hereby certify that the information on this form is true and correct to the bast of my knowledge.

Signature _____ Firm Foth & Van Dyke

Please complete both sides of this form and return to the appropriate DNR off listed at the top of this form as required by chs. 144, 147 and 160, Wis. Stat., and ch. NR 141, Wis. Ad. Code. In accordance with ch. 144, Wis Stats., failure to file this form may result in a forfeiture of not less than $10, nor more than $5000 for each day of violation. In accordance with ch. 147, Wis. Stat., failure to file this form may result in a forfeiture of not more than $10,000 for each day of violation. NOTE: Shaded areas are for DNR use only. See instructions for more information including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

MONITORING WELL DEVELOPMENT
Form 4400-113B Rev. 4-90

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☑
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

Facility/Project Name	County Name	Well Name	
Nicolet Minerals Co - Area H	Forest	MWH-13	
Facility License, Permit or Monitoring Number	**County Code**	**Wis.Unique Well Number**	**DNR Well Number**
0 0 0 0 0 0 0	2 1	0 0 0 0 0 0	0 0 0

		Before Development	After Development
1. Can this well be purged dry?	☐ Yes ☑ No		
2. Well development method			
surged with bailer and bailed	☐ 4 1		
surged with bailer and pumped	☐ 6 1		
surged with block and bailed	☐ 4 2		
surged with block and pumped	☑ 6 2		
surged with block, bailed and pumped	☐ 7 0		
compressed air	☐ 2 0		
bailed only	☐ 1 0		
pumped only	☐ 5 1		
pumped slowly	☐ 5 0		
Other _____	☐		
3. Time spent developing well	6 5 min.		
4. Depth of well (from top of well casing)	1 7.9 ft.		
5. Inside diameter of well	1.8 7 in.		
6. Volume of water in filter pack and well casing	7.8 gal.		
7. Volume of water removed from well	8 0 0.0 gal.		
8. Volume of water added (if any)	0.0 gal.		
9. Source of water added N/A			
10. Analysis performed on water added? (If yes, attach results)	☐ Yes ☑ No		
11. Depth to Water (from top of well casing)		a. 9.1 6 ft.	1 1.4 8 ft.
Date		b. 0 8/2 8/9 8 m m d d y y ☑ a.m.	0 8/2 8/9 8 m m d d y y ☐ a.m.
Time		c. 1 1:3 5 ☐ p.m.	1 2:4 0 ☑ p.m.
12. Sediment in well bottom		0.0 inches	0.0 inches
13. Water clarity		Clear ☐ 1 0 Turbid ☑ 1 5 (Describe) Brown Very High Turbidity	Clear ☑ 2 0 Turbid ☐ 2 5 (Describe)
Fill in if drilling fluids were used and well is at solid waste facility:			
14. Total suspended solids		____.__ mg/l	____.__ mg/l
15. COD		____.__ mg/l	____.__ mg/l

16. Additional comments on development:

Well developed by: Person's Name and Firm

Name: Scott Janssen

Firm: Foth & Van Dyke

I hereby certify that the above information is true and correct to the best of my knowledge.

Signature: [signature]

Print Initials: EAS

Firm: Foth & Van Dyke

NOTE: Shaded areas are for DNR use only. See instructions for more information including a list of county codes.

State of Wisconsin
Department of Natural Resources

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☐
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

MONITORING WELL CONSTRUCTION
Form 4400-113A Rev. 4-90

Facility/Project Name	Local Grid Location of Well	Well Name
NMC - Area H	☐ N. ☐ E. _____ ft. ☐ S. _____ ft. ☐ W.	MWH-14
Facility License, Permit or Monitoring Number	**Grid Origin Location**	**Wis. Unique Well Number DNR Well Number**
_____	Lat. _____ Long. _____ or	_____ ___
Type of Well Water Table Observation Well ☑ 11	St. Plane 127088.73 ft N. 2284444.46 ft E.	**Date Well Installed**
Piezometer ☐ 12	**Section Location of Waste/Source**	0 8/2 6/9 8 (m m d d y y)
Distance Well Is From Waste/Source Boundary	☐ E.	**Well Installed By: (Person's Name and Firm)**
ft.	_¼ of _ ¼ of Sec. _, T. _ N, R._ ☐ W.	Todd Schmanfelt
Is Well A Point of Enforcement Std. Application?	**Location of Well Relative to Waste/Source**	Boart-Longyear
☐ Yes ☐ No	u ☐ Upgradient s ☐ Sidegradient	
	d ☐ Downgradient n ☐ Not Known	

A. Protective pipe, top elevation 1591.85 ft. MSL

B. Well casing, top elevation 1591.92 ft. MSL

C. Land surface elevation 1588.7 ft. MSL

D. Surface seal, bottom 1588.2 ft. MSL or _0.5 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☑
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis attached? ☐ Yes ☑ No

14. Drilling method used: Rotary ☐ 50
Hollow Stem Auger ☑ 41
Other ☐

15. Drilling fluid used: Water ☐ 02 Air ☐ 01
Drilling Mud ☐ 03 None ☑ 99

16. Drilling additives used? ☐ Yes ☐ No
Describe _____

17. Source of water (attach analysis):
_____

E. Bentonite seal, top 1588.2 ft. MSL or __0.5 ft.

F. Fine sand, top ____. ft. MSL or __.__ ft.

G. Filter pack, top 1584.2 ft. MSL or __4.5 ft.

H. Screen joint, top 1583.7 ft. MSL or __5.0 ft.

I. Well bottom 1573.7 ft. MSL or _15.0 ft.

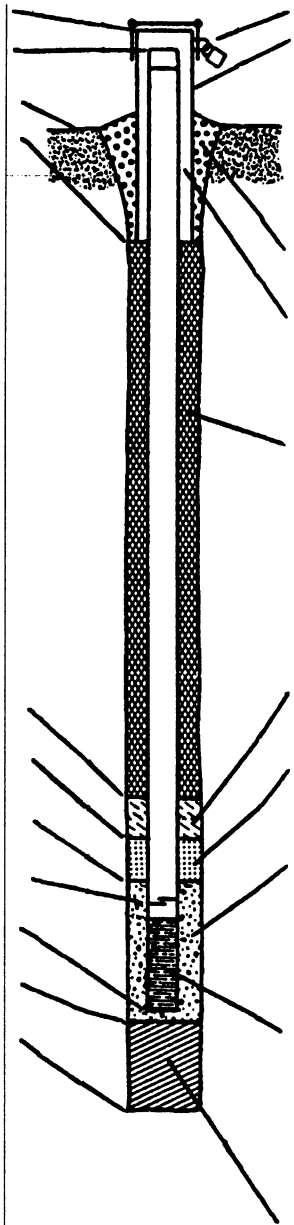
J. Filter pack, bottom 1572.7 ft. MSL or _16.0 ft.

K. Borehole, bottom 1572.7 ft. MSL or _16.0 ft.

L. Borehole, diameter _8.3 in.

M. O.D. well casing _2.38 in.

N. I.D. well casing _1.87 in.



1. Cap and lock? ☑ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: 4.0 in.
b. Length: ___. ft.
c. Material: Steel ☑ 04
_____ Other ☐
d. Additional protection? ☐ Yes ☐ No
If yes, describe: _____
3. Surface seal: Bentonite ☑ 30
Concrete ☐ 01
Native Other ☑
4. Material between well casing and protective pipe:
Bentonite ☐ 30
Annular space seal ☐
#30 Sand Other ☑
5. Annular space seal: a. Chipped Bentonite ☑ 33
b. _____Lbs/gal mud weight Bentonite-sand slurry ☐ 35
c. _____Lbs/gal mud weight .... Bentonite slurry ☐ 31
d. _____% Bentonite .... Bentonite-cement grout ☐ 50
e. 1.3 Ft³ volume added for any of the above
f. How installed: Tremie ☐ 01
Tremie pumped ☐ 02
Gravity ☑ 08
6. Bentonite seal: a. Bentonite granules ☐ 33
b. ☐ ¼ in. ☑ ⅜ in. ☐ ½ in. Bentonite chips ☑ 32
c. _____ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
a. Badger Mining BB#7
b. Volume added _____ ft³
8. Filter pack material: Manufacturer, product name and mesh size
a. Red Flint #30
b. Volume added 3.5 ft³
9. Well casing: Flush threaded PVC schedule 40 ☐ 23
Flush threaded PVC schedule 80 ☑ 24
_____ Other ☐
10. Screen material: PVC
a. Screen Type: Factory cut ☑ 11
Continuous slot ☐ 01
_____ Other ☐
b. Manufacturer Northern Air
c. Slot size: 0.010 in.
d. Slotted length: 10.0 ft.
11. Backfill material (below filter pack): None ☑ 14
_____ Other ☐

I hereby certify that the information on this form is true and correct to the bast of my knowledge.

Signature	Firm
	Foth & Van Dyke

Please complete both sides of this form and return to the appropriate DNR off listed at the top of this form as required by chs. 144, 147 and 160, Wis. Stat., and ch. NR 141, Wis. Ad. Code. In accordance with ch. 144, Wis Stats., failure to file this form may result in a forfeiture of not less than $10, nor more than $5000 for each day of violation. In accordance with ch. 147, Wis. Stat., failure to file this form may result in a forfeiture of not more than $10,000 for each day of violation. NOTE: Shaded areas are for DNR use only. See instructions for more information including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

MONITORING WELL DEVELOPMENT
Form 4400-113B Rev. 4-90

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☑
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

Facility/Project Name	County Name	Well Name	
Nicolet Minerals Co - Area H	Forest	MWH-14	
Facility License, Permit or Monitoring Number	**County Code**	**Wis.Unique Well Number**	**DNR Well Number**
0 0 0 0 0 0 0	2 1	0 0 0 0 0 0	0 0 0

		Before Development	After Development
1. Can this well be purged dry?	☐ Yes ☑ No		
2. Well development method			
surged with bailer and bailed	☐ 4 1		
surged with bailer and pumped	☐ 6 1		
surged with block and bailed	☐ 4 2		
surged with block and pumped	☑ 6 2		
surged with block, bailed and pumped	☐ 7 0		
compressed air	☐ 2 0		
bailed only	☐ 1 0		
pumped only	☐ 5 1		
pumped slowly	☐ 5 0		
Other _____	☐		
3. Time spent developing well	__ 4 5 min.		
4. Depth of well (from top of well casing)	__ 1 8.2 ft.		
5. Inside diameter of well	__ 1.8 7 in.		
6. Volume of water in filter pack and well casing	__ __ 6.4 gal.		
7. Volume of water removed from well	__ 6 5.0 gal.		
8. Volume of water added (if any)	__ __ 0.0 gal.		
9. Source of water added N/A			
10. Analysis performed on water added? (If yes, attach results)	☐ Yes ☑ No		
11. Depth to Water (from top of well casing)	a.	1 0.9 9 ft.	1 1.2 2 ft.
Date	b.	0 8/2 7/9 8 m m d d y y	0 8/2 7/9 8 m m d d y y
Time	c.	1 7:1 5 ☐ a.m. ☑ p.m.	1 8:0 0 ☐ a.m. ☑ p.m.
12. Sediment in well bottom		__ 0.0 inches	__ 0.0 inches
13. Water clarity		Clear ☐ 1 0 Turbid ☑ 1 5 (Describe) Brown Very High Turbidity	Clear ☑ 2 0 Turbid ☐ 2 5 (Describe)
Fill in if drilling fluids were used and well is at solid waste facility:			
14. Total suspended solids		_____ mg/l	_____ mg/l
15. COD		_____ mg/l	_____ mg/l

16. Additional comments on development:

Well developed by: Person's Name and Firm

Name: Scott Janssen

Firm: Foth & Van Dyke

I hereby certify that the above information is true and correct to the best of my knowledge.

Signature: [signature]

Print Initials: EAS

Firm: Foth & Van Dyke

NOTE: Shaded areas are for DNR use only. See instructions for more information including a list of county codes.

State of Wisconsin
Department of Natural Resources

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☐
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

MONITORING WELL CONSTRUCTION
Form 4400-113A Rev. 4-90

Facility/Project Name	Local Grid Location of Well	Well Name
NMC - Area H	☐ N. ☐ E. _____ ft. ☐ S. _____ ft. ☐ W.	MWH-15
Facility License, Permit or Monitoring Number	**Grid Origin Location**	**Wis. Unique Well Number DNR Well Number**
_____	Lat. _____ Long. _____ or	_____ _____
Type of Well Water Table Observation Well ☑ 11	St. Plane 127542.29 ft N. 2284156.78 ft E.	**Date Well Installed**
Piezometer ☐ 12	**Section Location of Waste/Source**	0 8/2 7/9 8
Distance Well Is From Waste/Source Boundary	☐ E.	m m d d y y
ft.	_¼ of _ ¼ of Sec. _, T. _ N, R._ ☐ W.	**Well Installed By: (Person's Name and Firm)**
Is Well A Point of Enforcement Std. Application?	**Location of Well Relative to Waste/Source**	Todd Schmanfelt
☐ Yes ☐ No	u ☐ Upgradient s ☐ Sidegradient	Boart-Longyear
	d ☐ Downgradient n ☐ Not Known	

A. Protective pipe, top elevation 1591.63 ft. MSL

B. Well casing, top elevation 1591.73 ft. MSL

C. Land surface elevation 1588.8 ft. MSL

D. Surface seal, bottom 1588.3 ft. MSL or _0.5 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☑
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis attached? ☐ Yes ☑ No

14. Drilling method used: Rotary ☐ 50
Hollow Stem Auger ☑ 41
Other ☐

15. Drilling fluid used: Water ☐ 02 Air ☐ 01
Drilling Mud ☐ 03 None ☑ 99

16. Drilling additives used? ☐ Yes ☐ No
Describe _____

17. Source of water (attach analysis):
_____

E. Bentonite seal, top 1588.3 ft. MSL or _-.- ft.

F. Fine sand, top ____. ft. MSL or _-.- ft.

G. Filter pack, top 1584.3 ft. MSL or _4.5 ft.

H. Screen joint, top 1583.8 ft. MSL or _5.0 ft.

I. Well bottom 1573.8 ft. MSL or 15.0 ft.

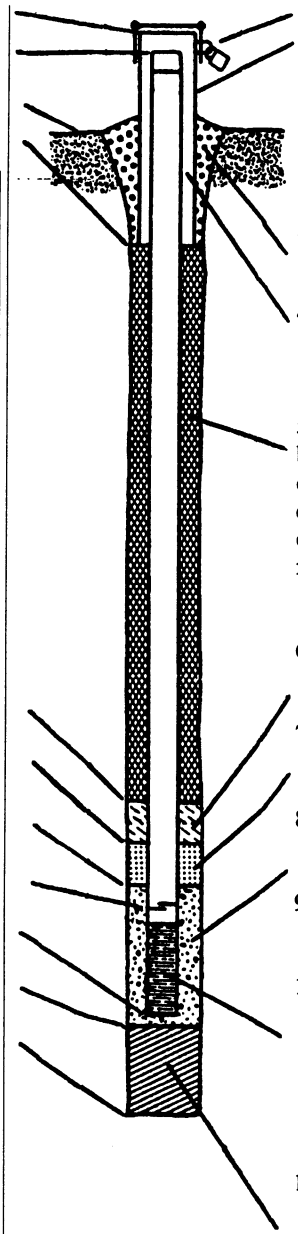
J. Filter pack, bottom 1572.8 ft. MSL or 16.0 ft.

K. Borehole, bottom 1572.8 ft. MSL or _16.0 ft.

L. Borehole, diameter _8.3 in.

M. O.D. well casing _2.38 in.

N. I.D. well casing _1.87 in.



1. Cap and lock? ☑ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: _4.0 in.
b. Length: _7.0 ft.
c. Material: Steel ☑ 04
_____ Other ☐
d. Additional protection? ☐ Yes ☐ No
If yes, describe: _____
3. Surface seal: Bentonite ☑ 30
Concrete ☐ 01
Native Other ☑
4. Material between well casing and protective pipe:
Bentonite ☐ 30
Annular space seal ☐
#30 Sand Other ☑
5. Annular space seal: a. Chipped Bentonite ☑ 33
b. _____ Lbs/gal mud weight Bentonite-sand slurry ☐ 35
c. _____ Lbs/gal mud weight .... Bentonite slurry ☐ 31
d. _____ % Bentonite .... Bentonite-cement grout ☐ 50
e. 1.8 Ft³ volume added for any of the above
f. How installed: Tremie ☐ 01
Tremie pumped ☐ 02
Gravity ☑ 08
6. Bentonite seal: a. Bentonite granules ☐ 33
b. ☐ ¼ in. ☑ ⅜ in. ☐ ½ in. Bentonite chips ☑ 32
c. _____ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
a. Badger Mining BB#7
b. Volume added _____ ft³
8. Filter pack material: Manufacturer, product name and mesh size
a. Red Flint #30
b. Volume added 2.4 ft³
9. Well casing: Flush threaded PVC schedule 40 ☐ 23
Flush threaded PVC schedule 80 ☑ 24
_____ Other ☐
10. Screen material: PVC
a. Screen Type: Factory cut ☑ 11
Continuous slot ☐ 01
_____ Other ☐
b. Manufacturer Northern Air
c. Slot size: 0.010 in.
d. Slotted length: 10.0 ft.
11. Backfill material (below filter pack): None ☑ 14
_____ Other ☐

I hereby certify that the information on this form is true and correct to the bast of my knowledge.

Signature _____ Firm Foth & Van Dyke

Please complete both sides of this form and return to the appropriate DNR off listed at the top of this form as required by chs. 144, 147 and 160, Wis. Stat., and ch. NR 141, Wis. Ad. Code. In accordance with ch. 144, Wis Stats., failure to file this form may result in a forfeiture of not less than $10, nor more than $5000 for each day of violation. In accordance with ch. 147, Wis. Stat., failure to file this form may result in a forfeiture of not more than $10,000 for each day of violation. NOTE: Shaded areas are for DNR use only. See instructions for more information including where the completed form should be sent.

State of Wisconsin
Department of Natural Resources

MONITORING WELL DEVELOPMENT
Form 4400-113B Rev. 4-90

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☑
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

Facility/Project Name	County Name	Well Name
Nicolet Minerals Co - Area H	Forest	MWH-15

Facility License, Permit or Monitoring Number	County Code	Wis.Unique Well Number	DNR Well Number
0 0 0 0 0 0 0	2 1	0 0 0 0 0 0	0 0 0

1. Can this well be purged dry? ☐ Yes ☑ No

2. Well development method
   - surged with bailer and bailed ☐ 41
   - surged with bailer and pumped ☐ 61
   - surged with block and bailed ☐ 42
   - surged with block and pumped ☑ 62
   - surged with block, bailed and pumped ☐ 70
   - compressed air ☐ 20
   - bailed only ☐ 10
   - pumped only ☐ 51
   - pumped slowly ☐ 50
   - Other _____ ☐ ..

3. Time spent developing well __55 min.

4. Depth of well (from top of well casing) _18.2 ft.

5. Inside diameter of well _1.87 in.

6. Volume of water in filter pack and well casing __7.8 gal.

7. Volume of water removed from well _800.0 gal.

8. Volume of water added (if any) __0.0 gal.

9. Source of water added N/A

10. Analysis performed on water added? ☐ Yes ☑ No
    (If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing)	a. _9.40 ft.	_9.75 ft.
Date	b. 08/27/98 mm dd yy ☐ a.m.	08/27/98 mm dd yy ☐ a.m.
Time	c. 18:05 ☑ p.m.	19:00 ☑ p.m.
12. Sediment in well bottom	_0.0 inches	_0.0 inches
13. Water clarity	Clear ☐ 10 Turbid ☑ 15 (Describe) Brown Very High Turbidity	Clear ☑ 20 Turbid ☐ 25 (Describe)
Fill in if drilling fluids were used and well is at solid waste facility:		
14. Total suspended solids	____._ mg/l	____._ mg/l
15. COD	____._ mg/l	____._ mg/l

16. Additional comments on development:

Well developed by: Person's Name and Firm

Name: Scott Janssen

Firm: Foth & Van Dyke

I hereby certify that the above information is true and correct to the best of my knowledge.

Signature: [signature]

Print Initials: EAS

Firm: Foth & Van Dyke

NOTE: Shaded areas are for DNR use only. See instructions for more information including a list of county codes.

State of Wisconsin
Department of Natural Resources

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☐
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

MONITORING WELL CONSTRUCTION
Form 4400-113A Rev. 4-90

Facility/Project Name	Local Grid Location of Well	Well Name
NMC - Area H	☐N. ☐E. _____ft. ☐S. _____ft. ☐W.	MWH-16
Facility License, Permit or Monitoring Number	**Grid Origin Location**	**Wis. Unique Well Number DNR Well Number**
_____	Lat. _____ Long. _____ or	_____ _____
Type of Well Water Table Observation Well ☑ 11	St. Plane 129341.85 ft N. 2285471.77 ft E.	**Date Well Installed**
Piezometer ☐ 12	**Section Location of Waste/Source**	08/27/98 (m m d d y y)
Distance Well Is From Waste/Source Boundary	☐E. _¼ of _¼ of Sec. _, T. _N, R._ ☐W.	**Well Installed By: (Person's Name and Firm)**
ft.	**Location of Well Relative to Waste/Source**	Mike Mueller
Is Well A Point of Enforcement Std. Application?	u ☐ Upgradient s ☐ Sidegradient	Boart-Longyear
☐ Yes ☐ No	d ☐ Downgradient n ☐ Not Known	

A. Protective pipe, top elevation 1596.08 ft. MSL

B. Well casing, top elevation 1596.02 ft. MSL

C. Land surface elevation 1592.9 ft. MSL

D. Surface seal, bottom 1592.4 ft. MSL or 0.5 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☑
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis attached? ☐ Yes ☑ No

14. Drilling method used: Rotary ☐ 50
Hollow Stem Auger ☑ 41
Other ☐

15. Drilling fluid used: Water ☐ 02 Air ☐ 01
Drilling Mud ☐ 03 None ☑ 99

16. Drilling additives used? ☐ Yes ☐ No
Describe _____

17. Source of water (attach analysis):
_____

E. Bentonite seal, top 1592.4 ft. MSL or 0.5 ft.

F. Fine sand, top ____ ft. MSL or ___ ft.

G. Filter pack, top 1588.4 ft. MSL or 4.5 ft.

H. Screen joint, top 1587.9 ft. MSL or 5.0 ft.

I. Well bottom 1577.9 ft. MSL or 15.0 ft.

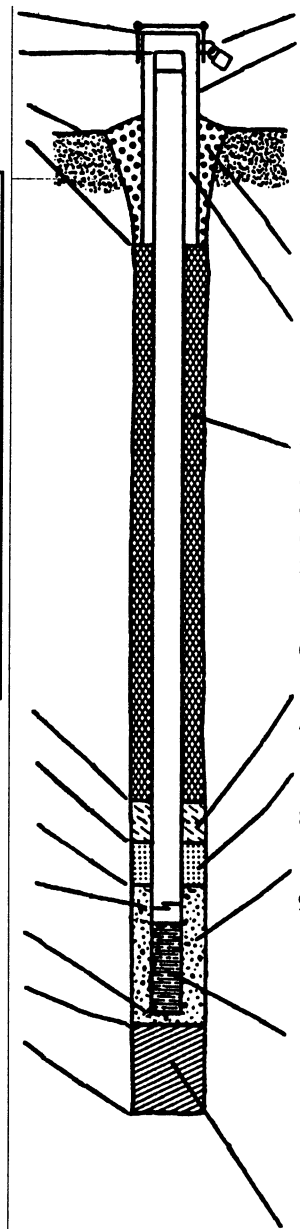
J. Filter pack, bottom 1576.9 ft. MSL or 16.0 ft.

K. Borehole, bottom 1576.9 ft. MSL or 16.0 ft.

L. Borehole, diameter 8.3 in.

M. O.D. well casing 2.38 in.

N. I.D. well casing 1.87 in.



1. Cap and lock? ☑ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: 4.0 in.
b. Length: 7.0 ft.
c. Material: Steel ☑ 04
_____ Other ☐
d. Additional protection? ☐ Yes ☐ No
If yes, describe: _____
3. Surface seal: Bentonite ☑ 30
Concrete ☐ 01
Native Other ☑
4. Material between well casing and protective pipe:
Bentonite ☐ 30
Annular space seal ☐
#30 Sand Other ☑
5. Annular space seal: a. Chipped Bentonite ☑ 33
b. _____Lbs/gal mud weight Bentonite-sand slurry ☐ 35
c. _____Lbs/gal mud weight .... Bentonite slurry ☐ 31
d. _____% Bentonite .... Bentonite-cement grout ☐ 50
e. 1.5 Ft³ volume added for any of the above
f. How installed: Tremie ☐ 01
Tremie pumped ☐ 02
Gravity ☑ 08
6. Bentonite seal: a. Bentonite granules ☐ 33
b. ☐ ¼ in. ☑ ⅜ in. ☐ ½ in. Bentonite chips ☑ 32
c. _____ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
a. Badger Mining BB#7
b. Volume added – ft³
8. Filter pack material: Manufacturer, product name and mesh size
a. Red Flint #30
b. Volume added 2.6 ft³
9. Well casing: Flush threaded PVC schedule 40 ☐ 23
Flush threaded PVC schedule 80 ☑ 24
_____ Other ☐
10. Screen material: PVC
a. Screen Type: Factory cut ☑ 11
Continuous slot ☐ 01
_____ Other ☐
b. Manufacturer Northern Air
c. Slot size: 0.010 in.
d. Slotted length: 10.0 ft.
11. Backfill material (below filter pack): None ☑ 14
_____ Other ☐

I hereby certify that the information on this form is true and correct to the bast of my knowledge.

Signature _____ Firm Foth & Van Dyke

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State of Wisconsin
Department of Natural Resources

MONITORING WELL DEVELOPMENT
Form 4400-113B Rev. 4-90

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☑
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

Facility/Project Name	County Name	Well Name
Nicolet Minerals Co - Area H	Forest	MWH-16
Facility License, Permit or Monitoring Number	**County Code**	**Wis.Unique Well Number** / **DNR Well Number**
0 0 0 0 0 0 0	2 1	0 0 0 0 0 0 / 0 0 0

		Before Development	After Development
1. Can this well be purged dry?	☐ Yes ☑ No		
2. Well development method			
surged with bailer and bailed	☐ 41		
surged with bailer and pumped	☐ 61		
surged with block and bailed	☐ 42		
surged with block and pumped	☑ 62		
surged with block, bailed and pumped	☐ 70		
compressed air	☐ 20		
bailed only	☐ 10		
pumped only	☐ 51		
pumped slowly	☐ 50		
Other _____	☐		
3. Time spent developing well	30 min.		
4. Depth of well (from top of well casing)	179 ft.		
5. Inside diameter of well	1.87 in.		
6. Volume of water in filter pack and well casing	3.8 gal.		
7. Volume of water removed from well	400.0 gal.		
8. Volume of water added (if any)	0.0 gal.		
9. Source of water added N/A			
10. Analysis performed on water added? (If yes, attach results)	☐ Yes ☑ No		
11. Depth to Water (from top of well casing)	a.	13.65 ft.	14.46 ft.
Date	b.	08/28/98 mm dd yy ☐ a.m.	08/28/98 mm dd yy ☐ a.m.
Time	c.	12:45 ☑ p.m.	13:15 ☑ p.m.
12. Sediment in well bottom		0.0 inches	0.0 inches
13. Water clarity		Clear ☐ 10 Turbid ☑ 15 (Describe) Brown Very High Turbidity	Clear ☑ 20 Turbid ☐ 25 (Describe)
Fill in if drilling fluids were used and well is at solid waste facility:			
14. Total suspended solids		____.__ mg/l	____.__ mg/l
15. COD		____.__ mg/l	____.__ mg/l

16. Additional comments on development:

Well developed by: Person's Name and Firm

Name: Scott Janssen

Firm: Foth & Van Dyke

I hereby certify that the above information is true and correct to the best of my knowledge.

Signature: [signature]

Print Initials: EAS

Firm: Foth & Van Dyke

NOTE: Shaded areas are for DNR use only. See instructions for more information including a list of county codes.

State of Wisconsin
Department of Natural Resources

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☐
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

MONITORING WELL CONSTRUCTION

Form 4400-113A Rev. 4-90

Facility/Project Name NMC - Area H	Local Grid Location of Well ☐ N. _____ ft. ☐ S. ☐ E. _____ ft. ☐ W.	Well Name MWH-19
Facility License, Permit or Monitoring Number _____	Grid Origin Location Lat. _____ Long. _____ or St. Plane 127614.65 ft N. 2285679.80 ft E.	Wis. Unique Well Number DNR Well Number _____ ___
Type of Well Water Table Observation Well ☑ 11 Piezometer ☐ 12	Section Location of Waste/Source _¼ of _ ¼ of Sec. _, T. _ N, R._ ☐ E. ☐ W.	Date Well Installed 0 8/2 6/9 8 m m d d y y
Distance Well Is From Waste/Source Boundary ft.	Location of Well Relative to Waste/Source u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known	Well Installed By: (Person's Name and Firm) Mike Mueller Boart-Longyear
Is Well A Point of Enforcement Std. Application? ☐ Yes ☐ No		

A. Protective pipe, top elevation 1589.37 ft. MSL

B. Well casing, top elevation 1589.38 ft. MSL

C. Land surface elevation 1586.2 ft. MSL

D. Surface seal, bottom 1585.7 ft. MSL or 0.5 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☑
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis attached? ☐ Yes ☑ No

14. Drilling method used: Rotary ☐ 50
Hollow Stem Auger ☑ 41
Other ☐

15. Drilling fluid used Water ☐ 02 Air ☐ 01
Drilling Mud ☐ 03 None ☑ 99

16. Drilling additives used? ☐ Yes ☐ No
Describe _____

17. Source of water (attach analysis):
_____

E. Bentonite seal, top 1585.7 ft. MSL or 0.5 ft.

F. Fine sand, top ____.- ft. MSL or -.- ft.

G. Filter pack, top 1581.7 ft. MSL or 4.5 ft.

H. Screen joint, top 1581.2 ft. MSL or 5.0 ft.

I. Well bottom 1571.2 ft. MSL or 15.0 ft.

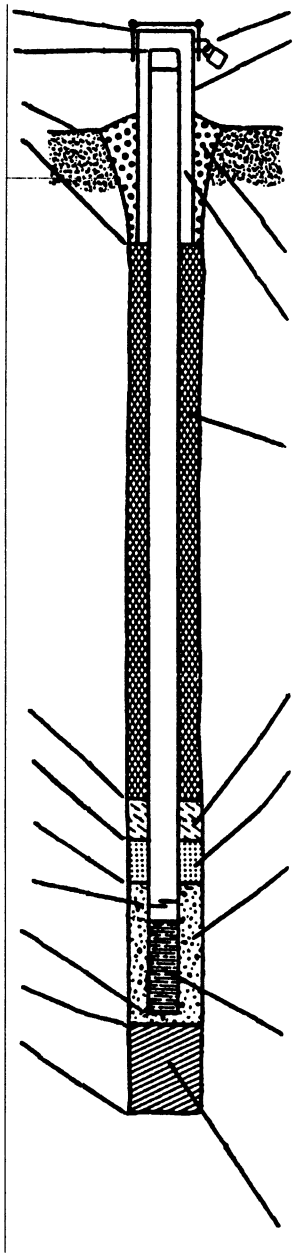
J. Filter pack, bottom 1570.2 ft. MSL or 16.0 ft.

K. Borehole, bottom 1570.2 ft. MSL or 16.0 ft.

L. Borehole, diameter 8.3 in.

M. O.D. well casing 2.19 in.

N. I.D. well casing 1.94 in.



1. Cap and lock? ☑ Yes ☐ No
2. Protective cover pipe:
a. Inside diameter: 4.0 in.
b. Length: 7.0 ft.
c. Material: Steel ☑ 04
_____ Other ☐
d. Additional protection? ☐ Yes ☐ No
If yes, describe: _____
3. Surface seal: Bentonite ☑ 30
Concrete ☐ 01
Native Other ☑
4. Material between well casing and protective pipe:
Bentonite ☐ 30
Annular space seal ☐
#30 Sand Other ☑
5. Annular space seal: a. Chipped Bentonite ☑ 33
b. _____ Lbs/gal mud weight Bentonite-sand slurry ☐ 35
c. _____ Lbs/gal mud weight .... Bentonite slurry ☐ 31
d. _____ % Bentonite .... Bentonite-cement grout ☐ 50
e. 1.6 Ft³ volume added for any of the above
f. How installed: Tremie ☐ 01
Tremie pumped ☐ 02
Gravity ☑ 08
6. Bentonite seal: a. Bentonite granules ☐ 33
b. ☐ ¼ in. ☑ ⅜ in. ☐ ½ in. Bentonite chips ☑ 32
c. _____ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
a. Badger Mining BB#7
b. Volume added – ft³
8. Filter pack material: Manufacturer, product name and mesh size
a. Red Flint #30
b. Volume added 2.7 ft³
9. Well casing: Flush threaded PVC schedule 40 ☑ 23
Flush threaded PVC schedule 80 ☐ 24
_____ Other ☐
10. Screen material: PVC
a. Screen Type: Factory cut ☑ 11
Continuous slot ☐ 01
_____ Other ☐
b. Manufacturer Northern Air
c. Slot size: 0.010 in.
d. Slotted length: 10.0 ft.
11. Backfill material (below filter pack): None ☑ 14
_____ Other ☐

I hereby certify that the information on this form is true and correct to the bast of my knowledge.

Signature	Firm
	Foth & Van Dyke

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State of Wisconsin
Department of Natural Resources

MONITORING WELL DEVELOPMENT
Form 4400-113B Rev. 4-90

Route to: Solid Waste ☐ Haz. Waste ☐ Wastewater ☑
Env.Response & Repair ☐ Underground Tanks ☐ Other ☐ _____

Facility/Project Name	County Name	Well Name
Nicolet Minerals Co - Area H	Forest	MWH-19
Facility License, Permit or Monitoring Number	**County Code**	**Wis.Unique Well Number** / **DNR Well Number**
0 0 0 0 0 0 0 0	2 1	0 0 0 0 0 0 / 0 0 0

1. Can this well be purged dry? ☐ Yes ☑ No

2. Well development method
   - surged with bailer and bailed ☐ 41
   - surged with bailer and pumped ☐ 61
   - surged with block and bailed ☐ 42
   - surged with block and pumped ☑ 62
   - surged with block, bailed and pumped ☐ 70
   - compressed air ☐ 20
   - bailed only ☐ 10
   - pumped only ☐ 51
   - pumped slowly ☐ 50
   - Other _____ ☐ ..

3. Time spent developing well __55 min.

4. Depth of well (from top of well casing) _179 ft.

5. Inside diameter of well _1.87 in.

6. Volume of water in filter pack and well casing __7.6 gal.

7. Volume of water removed from well _750 gal.

8. Volume of water added (if any) __0.0 gal.

9. Source of water added N/A

10. Analysis performed on water added? ☐ Yes ☑ No
    (If yes, attach results)

	Before Development	After Development
11. Depth to Water (from top of well casing)	a. _94.0 ft.	102.9 ft.
Date	b. 08/27/98 mm dd yy	08/27/98 mm dd yy
Time	c. 16:15 ☑ p.m. ☐ a.m.	17:10 ☑ p.m. ☐ a.m.
12. Sediment in well bottom	_0.0 inches	_0.0 inches
13. Water clarity	Clear ☐ 10 Turbid ☑ 15 (Describe) Brown Highly Turbid	Clear ☑ 20 Turbid ☐ 25 (Describe)

Fill in if drilling fluids were used and well is at solid waste facility:

14. Total suspended solids	_____ mg/l	_____ mg/l
15. COD	_____ mg/l	_____ mg/l

16. Additional comments on development:

Well developed by: Person's Name and Firm

Name: Scott Janssen

Firm: Foth & Van Dyke

I hereby certify that the above information is true and correct to the best of my knowledge.

Signature: [signature]

Print Initials: EAS

Firm: Foth & Van Dyke

NOTE: Shaded areas are for DNR use only. See instructions for more information including a list of county codes.

State of Wisconsin
Department of Natural Resources

GROUNDWATER MONITORING WELL INFORMATION FORM
Chapter 144, Wis. Stats.
Form 4400-89 Rev. 1-90

Facility Name	Facility ID Number	Date	Completed By (Name and Firm)
Crandon Project - Soil Absorbtion System - Area H		10-20-98	Stephen V. Donohue SVD Foth & Van Dyke

Well Name	DNR Well ID Number	Well Location	N	S	E	W	Date Established	Well Casing Diam.	Well Casing Type	Elevations Top of Well Casing	Elevations Ground Surface	Reference MSL (✓)	Reference Site Datum (✓)	Screen Length	Well Depth	Type of Well (✓) PIEZ	OW	PW	LYS	Other	Aban-doned	Enf.Stds. Apply	Gradient U, S, D or N
SPH-1		127,491	✓				9/15/98	1.25"	G	1583.69	1581.5	✓		3'	8.29					Sand Point		NA	NA
		2,284,980			✓																		
SPH-1A		127,495	✓				9/16/98	1.25"	G	1585.95	1581.4	✓		3'	18.65					Sand Point		NA	NA
		2,284,981			✓																		
SPH-2		128,190	✓				9/16/98	1.25"	G	1583.89	1581.9	✓		3'	8.29					Sand Point		NA	NA
		2,285,360			✓																		
SPH-2A		128,191	✓				9/16/98	1.25"	G	1584.36	1581.8	✓		3'	18.86					Sand Point		NA	NA
		2,285,357			✓																		
SPH-3		129,521	✓				9/16/98	1.25"	G	1593.37	1591.1	✓		3'	8.17					Sand Point		NA	NA
		2,284,348			✓																		
SPH-3A		129,524	✓				9/16/98	1.25"	G	1594.49	1591.2	✓		3'	18.99					Sand Point		NA	NA
		2,284,350			✓																		
SPH-4		128,954	✓				9/16/98	1.25"	G	1593.18	1590.8	✓		3'	8.28					Sand Point		NA	NA
		2,284,105			✓																		
SPH-4A		128,960	✓				9/16/98	1.25"	G	1594.88	1590.8	✓		3'	18.68					Sand Point		NA	NA
		2,284,105			✓																		
SPH-5		129,127	✓				9/16/98	1.25"	G	1581.51	1580.5	✓		3'	13.31					Sand Point		NA	NA
		2,285,939			✓																		
SPH-6		129,940	✓				9/16/98	1.25"	G	1587.18	--	✓		3'	7.48					Sand Point			
		2,285,545			✓																		

Location Coordinates Are:

☐ Local Grid System (preferred) ☑ State Plane Coordinate
☑ Northern
☐ Central

Remarks:
NA = Not Applicable
G = Galvanized Pipe

PSS Use:
File Maint. Completed: _____
Other: _____

D-297

DMW\93C049\GBAPP\68820.61\10000

HAND AUGER LOG

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - SAS - AREA H		HAH-01

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Foth & Van Dyke	10/15/98	10/15/98	4½" HA to 4' 3½" HA to 6'

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				~1580.5	

Boring Location	Local Grid Location (if applicable)
State Plane ____ N, ____ E S/C/N Lat SW 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E Long	Feet ____ N ____ S Feet ____ E ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
			0	0-4.5, black, 7.5YR2/0, fibrous peat, wet, soft (root mat 8"-0.2')										
AS-1			1-2											
			3											
			4	4.5-6.2, dusty red, 10YR5/2, coarse, fibrous peat w/ wood pieces, saturated, very soft	PT									
			5											
			6	EOB 6.2'										
				3.3', hole caved with water										
				Note: Hole caving during drilling - could retrieve a sample from below 5.5'										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
Kay Munter	Foth & Van Dyke

HAND AUGER LOG

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - SAS - AREA H		HAH-02

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Foth & Van Dyke	10/15/98	10/15/98	3½" HA to 0' - 5.5'

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				~1580.5	

Boring Location	Local Grid Location (if applicable)
State Plane ____ N, ____ E S/C/N Lat SW 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E Long	____ N ____ E Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
				Humhocky surface - drilled in depression										
			0	0-4, black, 7.5YR2/0, fibrous peat, saturated, very soft (root mat 0-0.2')	PT									
AS-1			0-2											
AS-2			2-4											
			4	4-5, dusky red, coarse, fibrous peat, wet, very soft	PT									
AS-3			5	4.5-5.5, grey-brown, 10YR5/2, silty sand w/ fine to coarse gravel and clay, saturated, loose to firm (till)	SM-SC									
				EOB 5.5'										
				5.5' refusal - cobble										
				Notes: 1. Hole caving during drilling 2. Water level - 1.0' after boring										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
Roy Mewster	Foth & Van Dyke

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HAND AUGER LOG

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - SAS - Area H		HAH-03

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Foth & Van Dyke	10/15/98	10/15/98	4½" HA to 0'-4' 3½" HA to 4'-6.2'

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				~1580.5	

Boring Location	Local Grid Location (if applicable)
State Plane ____ N, ____ E S/C/N Lat SW ¼ of SE ¼ of Section 17, T 35 N, R 13 E Long	____ N Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
			0	0-0.2, root mat (spagnum)										
				0.2-3.5, black, 7.5YR2/0, fibrous peat, saturated very soft	PT									
			1											
			2											
			3											
				3.5-4, black to dark red-brown, 10YR3/1, peat w/ spruce logs, branches, etc., saturated, very soft	PT									
			4	4-6, black, 75YR2/0, peat, wet, very soft (could not retrieve auger sample below 4.5')										
			5											
			6											
				E.O.B. 6.2'										
				1.7', hole caved in with water										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
Lon Meister	Foth & Van Dyke

HAND AUGER LOG

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - SAS - Area H		HAH - 04

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Foth & Van Dyke	10/15/98	10/15/98	4½" HA to 4.5' 3½" HA to 6.2'

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				~1582	

Boring Location	Local Grid Location (if applicable)
State Plane ____ N, ____ E S/C/N Lat SE 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E Long	____ N Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
				0-1, root mat (spagnum) and roots w/ peat, wet	PT									
			1	1-4, black, 10YR2/1, fibrous peat, saturated, very soft	PT									
			2											
			3											
			4	4-5, dark red-brown, 5YR5/3, fibrous peat, saturated, very soft	PT									
			5	5-5.2, fine to coarse gravel (no auger recovery)										
AS-1			5.2-6	Grey-brown, 10YR5/2, silty fine to med sand w/ fine to coarse gravel & clay w/ layer of dark red-brown, 5YR5/3, peat (till)	SM/ SC									
			6											
				E.O.B. - 6.2'										
				Water level - 3.3' after boring										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
Ron Meister	Foth & Van Dyke

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HAND AUGER LOG

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - SAS - Area H		HAH-05

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Foth & Van Dyke			4½" HA - 0-4' 3½" HA - 4-6'

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				~1582	

Boring Location	Local Grid Location (if applicable)
State Plane ____ N, ____ E S/C/N Lat SE 1/4 of NE 1/4 of Sectio 17, T 35 N, R 13 E Long	Feet ____ N ____ E Feet ____ S ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
				0-1, root mat (spagnum) roots and peat	PT									
			1	1-4, black, 7.5YR2/0, fibrous peat, very soft, wet	PT									
ST-1			0.8 - 2.8'											
			2											
AS-2			2.8 - 3.8'											
			3											
			4	4-5.1, gray 10YR5/1, silty clayey fine to medium sand w/ fine to coarse gravel, trace of organics, firm (till)	SC									
			5	5.1-6, grey-brown, 10YR5/2, medium to coarse sand w/ layer of fine to coarse gravel, water-bearing, loose (outwash)	SP									
			6	E.O.B. - 6'										
				Water level - 2' after boring										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: Ron Meister — Firm: Foth & Van Dyke

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HAND AUGER LOG

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - SAS - Area H		HAH-06

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Foth & Van Dyke	10/15/98	10/15/98	4½" HA to 0' - 4' 3½" HA to 4' - 6'

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				~1581	

Boring Location	Local Grid Location (if applicable)
State Plane ____ N, ____ E S/C/N Lat NE 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E Long	____ Feet ____ N S ____ Feet ____ E W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
				0-1, root mat and spagnum w/ peat, black, fibrous	PT									
			1	water entering hole at 1'										
				1-3, black, 7.5YR2/0, fibrous peat, saturated, very soft	PT									
			2											
			3	3-3.7, grey-brown, 10YR5/1, silty or clayey fine to med sand w/ fine to coarse gravel & cobbles, wet, dense (till)	SM/ SC									
				3.7, auger refusal, cobble										
				E.O.B. 3.7'										
				Water level - 0.9' after boring										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
Ron Mentes	Foth & Van Dyke

HAND AUGER LOG

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - SAS - Area H		HAH-07

Boring Drilled by (Firm name and name of crew chief)	Date Started MM/DD/YY	Date Completed MM/DD/YY	Drilling Method
Foth & Van Dyke	10/15/98	10/15/98	4½" HA

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1581	

Boring Location	Local Grid Location (if applicable)
State Plane ____ N, ____ E S/C/N Lat NE 1/4 of SE 1/4 of Section 17, T 35 N, R 13 E Long	Feet ____ N ____ E Feet ____ S ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
				0-1, root mat w/ peat	PT									
			1	1-4.5, black, 7.5YR2/0, fibrous peat, wet, very soft	PT									
ST-1	9		1-2											
			2											
			3											
			4	4.5 - 6.2, dark brown, 5YR5/2, peat w/ wood & twigs, wet, very soft	PT									
			5											
			6	E.O.B. - 6.2										
				Water level - 1.9' after boring										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
Ron Mentzer	Foth & Van Dyke

HAND AUGER LOG

Facility/Project Name	License/Permit/Monitoring Number	Boring Number
NMC - Area H		HAH-08

Boring Drilled by (Firm name and name of crew chief)	Date Started	Date Completed	Drilling Method
Foth & Van Dyke	MM/DD/YY	MM/DD/YY	4½" HA to 0' - 4' 3½" HA to 4' - 6.2'

DNR Facility Well No.	WI Unique Well No.	Common Well Name	Final Static Water Level	Surface Elevation	Borehole Diameter
				1581	

Boring Location	Local Grid Location (if applicable)
State Plane ____ N, ____ E S/C/N Lat SE 1/4 of NE 1/4 of Section 17, T 35 N, R 13 E Long	____ N Feet ____ S Feet ____ W

County	DNR County Code	Civil Town/City/or Village
Forest	21	Lincoln

SAMPLE No.	SAMPLE Rec (in)	Blow Counts	Depth in Feet	Soil/Rock description and geologic origin for each major unit	USCS	Graph Log	Well Diag	PID/ FID	Soil Properties: Std Pntr	Mst Cont	Liq Lim	Plas Lim	P 200	RQD/ Comm
				(Hole located ~10' N of flowing stream in the wetland)										
				0-0.9, root mat and peat	PT									
				0.9-3.5, black, 7.5YR5/0, fibrous peat w/ wood	PT									
			1											
AS-1			1-2											
			2											
			3	3.5-6.2, black to dark red-brown, 5YR5/2, fibrous peat w/ thin (1/16 -1/8") partings of grey fine sand	PT									
			4											
			5											
			6											
				E.O.B. - 6.2'										
				Water level - 1.1' after boring										

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
Ken Hunter	Foth & Van Dyke

Appendix C

Soil Survey Data

SOIL DESCRIPTION REPORT

FOREST COUNTY, WISCONSIN

Map Unit Symbol	Map unit name / Description
2	FORDUM LOAM, 0 TO 2 PERCENT SLOPES Nearly level, poorly drained and very poorly drained soil formed primarily in loamy alluvium over sand and gravelly sand. This map unit is not highly erodible. The land capability classification is 4W. This map unit is hydric.
17	CABLE MUCK, 0 TO 2 PERCENT SLOPES, STONY Nearly level, poorly drained and very poorly drained soil formed in silty deposits and in the underlying loamy or sandy glacial till. This map unit is not highly erodible. The land capability classification is 6W. This map unit is prime farmland where drained and stones removed. This map unit is hydric.
18B	MONICO SILT LOAM, 1 TO 6 PERCENT SLOPES, STONY Nearly level and gently sloping, somewhat poorly drained soil formed in silty deposits and in the underlying loamy or sandy glacial till. This map unit is not highly erodible. The land capability classification is 6S. It is 2W where stones are removed. This map unit is prime farmland where drained and stones removed. This map unit may have hydric inclusions.
19B	WABENO-MONICO COMPLEX, 1 TO 15 PERCENT SLOPES, STONY Nearly level to gently sloping, moderately well drained soil formed in silty deposits and in the underlying loamy or sandy glacial till; and nearly level and gently sloping, somewhat poorly drained soil formed in silty deposits and in the underlying loamy or sandy glacial till. This map unit is potentially highly erodible. The land capability classification is 6S. It is 3E where stones are removed. This map unit may have hydric inclusions.
19D	WABENO-MONICO COMPLEX, 1 TO 35 PERCENT SLOPES, STONY Moderately steep and steep, well drained soil formed in silty deposits and in the underlying loamy or sandy glacial till; and nearly level and gently sloping, somewhat poorly drained soil formed in silty deposits and in the underlying loamy or sandy glacial till. This map unit is highly erodible. The land capability classification is 7S. It is 6E where stones are removed. This map unit may have hydric inclusions.

Map Unit Symbol	Map unit name / Description
20B	GOODMAN-WABENO COMPLEX, 1 TO 6 PERCENT SLOPES, STONY Nearly level and gently sloping, moderately well drained soils formed in silty deposits and in the underlying loamy or sandy glacial till. This map unit is potentially highly erodible. The land capability classification is 6S. It is 2E where stones are removed. This map unit is prime farmland where stones are removed.
20C	GOODMAN-WABENO COMPLEX, 6 TO 15 PERCENT SLOPES, STONY Sloping, moderately well drained soils formed in silty deposits and in the underlying loamy or sandy glacial till. This map unit is potentially highly erodible. The land capability classification is 6S. It is 3E where stones are removed.
20D	GOODMAN-WABENO COMPLEX, 15 TO 35 PERCENT SLOPES, STONY Moderately steep and steep, well drained soils formed in silty deposits and in the underlying loamy or sandy glacial till. This map unit is highly erodible. The land capability classification is 7S. It is 6E where stones are removed.
22B	SARONA-WABENO COMPLEX, 1 TO 6 PERCENT SLOPES, STONY Nearly level and gently sloping, moderately well drained soils formed in loamy deposits and in the underlying loamy or sandy glacial till. This map unit is not highly erodible. The land capability classification is 6S. It is 2E where stones are removed. This map unit is prime farmland where stones are removed.
22C	SARONA-WABENO COMPLEX, 6 TO 15 PERCENT SLOPES, STONY Sloping, well drained soils formed in loamy deposits and in the underlying loamy and sandy glacial till. This map unit is potentially highly erodible. The land capability classification is 6S. It is 3E where stones are removed.
22D	SARONA-WABENO COMPLEX, 15 TO 35 PERCENT SLOPES, STONY Moderately steep and steep, well drained soil formed in loamy deposits and in the underlying loamy and sandy glacial till. This soil is highly erodible. The land capability classification is 7S. It is 6E where stones are removed.

Map Unit Symbol	Map unit name / Description
23D	MICHIGAMME-ROCK OUTCROP COMPLEX, 4 TO 60 PERCENT SLOPES, STONY Gently sloping to very steep, well drained soil formed in loamy deposits and in the underlying loamy or sandy glacial till underlain by igneous or metamorphic bedrock with areas of exposed bedrock at the surface. This map unit is potentially highly erodible. The land capability classification is 7E.
26E	ELDERON GRAVELLY SANDY LOAM, 20 TO 45 PERCENT SLOPES, STONY Steep and very steep, somewhat excessively drained soil formed in thin loamy deposits and in the underlying cobbly and gravelly sandy glacial drift. This map unit is highly erodible. The land capability classification is 7S.
27	MINOCQUA MUCK, 0 TO 2 PERCENT SLOPES Nearly level, poorly drained and very poorly drained soil formed in loamy deposits underlain by sand and gravelly sand glacial outwash. This map unit is not highly erodible. The land capability classification is 6W. This map unit is hydric.
30B	RUBICON SAND, 0 TO 6 PERCENT SLOPES Nearly level and gently sloping, excessively drained soil formed in sandy glacial outwash. This map unit is not highly erodible. The land capability classification is 6S.
30C	RUBICON SAND, 6 TO 15 PERCENT SLOPES Sloping, excessively drained soil formed in sandy glacial outwash. This map unit is potentially highly erodible. The land capability classification is 6S.
30D	RUBICON LOAMY SAND, 15 TO 35 PERCENT SLOPES Moderately steep and steep, excessively drained soil formed in sandy glacial outwash. This map unit is potentially highly erodible. The land capability classification is 7S.
51B	PADUS-WABENO COMPLEX, 1 TO 6 PERCENT SLOPES, STONY Nearly level and gently sloping, well drained soil formed in silty and loamy deposits and in the underlying stratified sand and gravelly sand glacial outwash, and moderately well drained soil formed in silty and loamy deposits and in the underlying loamy or sandy glacial till. This map unit is potentially highly erodible. The land capability classification is 6S. It is 2E where stones are removed. This map unit is prime farmland where stones are removed. This map unit may have hydric inclusions.

Map Unit Symbol	Map unit name / Description
51C	PADUS-WABENO COMPLEX, 6 TO 15 PERCENT SLOPES, STONY Sloping, well drained soil formed in silty and loamy deposits and in the underlying stratified sand and gravelly sand glacial outwash, and moderately well drained soil formed in silty and loamy deposits and in the underlying loamy or sandy glacial till. This map unit is potentially highly erodible. The land capability classification is 6S. It is 3E where stones are removed. This map unit may have hydric inclusions.
51D	PADUS-WABENO COMPLEX, 15 TO 35 PERCENT SLOPES, STONY Moderately steep and steep, well drained soil formed in silty and loamy deposits and in the underlying straitified sand and gravelly sand glacial outwash, and well drained soil formed is silty and loamy deposits and in the underlying loamy or sandy glacial till. This map unit is highly erodible. The land capability classification is 7S. It is 6E where stones are removed. This map unit may have hydric inclusions.
100B	STAMBAUGH SILT LOAM, 0 TO 6 PERCENT SLOPES Nearly level and gently sloping, well drained soil formed in silty deposits overlying stratified sand and gravelly coarse sand glacial outwash. This map unit is potentially highly erodible. The land capability classification is 2E. This map unit is prime farmland.
100C	STAMBAUGH SILT LOAM, 6 TO 15 PERCENT SLOPES Sloping, well drained soil formed in silty deposits overlying stratified sand and gravelly coarse sand glacial outwash. This map unit is potentially highly erodible. The land capability classification is 3E.
100D	STAMBAUGH SILT LOAM, 15 TO 25 PERCENT SLOPES Sloping, well drained soil formed in silty deposits overlying stratified sand and gravelly coarse sand glacial outwash. This map unit is highly erodible. The land capability classification is 6E.
103A	WORCESTER SILT LOAM, 0 TO 3 PERCENT SLOPES Nearly level and gently sloping, somewhat poorly drained soil formed in silty and loamy deposits underlain by sand and gravelly coarse sand glacial outwash. The land capability classification is 2W. This map unit is prime farmland where drained. This map unit may have hydric inclusions.

Map Unit Symbol	Map unit name / Description
105B	PADUS FINE SANDY LOAM, 0 TO 6 PERCENT SLOPES Nearly level and gently sloping, well drained soil formed in loamy deposits and in the underlying stratified sand and gravelly sand glacial outwash. This map unit is not highly erodible. The land capability classification is 2E. This map unit is prime farmland.
105C	PADUS FINE SANDY LOAM, 6 TO 15 PERCENT SLOPES Sloping, well drained soil formed in loamy deposits and in the underlying stratified sand and gravelly sand glacial outwash. This map unit is potentially highly erodible. The land capability classification is 3E.
105D	PADUS FINE SANDY LOAM, 15 TO 35 PERCENT SLOPES Moderately steep and steep, well drained soil formed in loamy deposits and in the underlying stratified sand and gravelly sand glacial outwash. This map unit is highly erodible. The land capability classification is 6E.
106B	PADUS-PENCE COMPLEX, 0 TO 6 PERCENT SLOPES Nearly level and gently sloping, well drained soils formed in loamy deposits and in the underlying stratified sand and gravelly sand glacial outwash. This map unit is potentially highly erodible. The land capability classification is 3E.
106C	PADUS-PENCE COMPLEX, 6 TO 15 PERCENT SLOPES Sloping, well drained soils formed in loamy deposits and in the underlying straified sand and gravelly sand glacial outwash. This map unit is potentially highly erodible. The land capability classification is 4E.
106D	PADUS-PENCE COMPLEX, 15 TO 35 PERCENT SLOPES Moderately steep and steep, well drained soils formed in loamy deposits and in the underlying stratified sand and gravelly sand glacial outwash. This map unit is highly erodible. The land capability classification is 7E.
107B	PENCE-VILAS COMPLEX, 0 TO 6 PERCENT SLOPES Nearly level and gently sloping, well drained soil formed in loamy deposits and in the underlying stratified sand and gravelly coarse sand glacial outwash, and excessively drained soil formed in sandy glacial outwash. This map unit is potentially highly erodible. The land capability classification is 3E.

Map Unit Symbol	Map unit name / Description
107C	PENCE-VILAS COMPLEX, 6 TO 15 PERCENT SLOPES Sloping, well drained soil formed in loamy deposits and in the underlying stratified sand and gravelly coarse sand glacial outwash, and excessively drained soil formed in sandy glacial outwash. This map unit is potentially highly erodible. The land capability classification is 4E.
107D	PENCE-VILAS COMPLEX, 15 TO 35 PERCENT SLOPES Moderately steep and steep, well drained soil formed in loamy deposits and in the underlying stratified sand and gravelly coarse sand glacial outwash, and excessively drained soil formed in sandy glaciual outwash. This map unit is highly erodible. The land capability is 7E.
109B	STAMBAUGH SILT LOAM, MODERATELY WET, 0 TO 4 PERCENT SLOPES Nearly level and gently sloping, moderately well drained soil formed in silty deposits overlying stratified sand and gravelly coarse sand glacial outwash. This map unit is not highly erodible. The land capability classification is 2E. This map unit is prime farmland.
111B	PENCE SANDY LOAM, 0 TO 6 PERCENT SLOPES Nearly level and gently sloping, well drained soil formed in loamy deposits and in the underlying stratified sand and gravelly coarse sand glacial outwash. This map unit is potentially highly erodible. The land capability classification is 3E.
111C	PENCE SANDY LOAM, 6 TO 15 PERCENT SLOPES Sloping, well drained soil formed in loamy deposits and in the underlying stratified sand and gravelly coarse sand glacial outwash. This map unit is potentially highly erodible. The land capability classification is 4E.
111D	PENCE SANDY LOAM, 15 TO 35 PERCENT SLOPES Moderately steep and steep, well drained soil formed in loamy deposits and in the underlying stratified sand and gravelly coarse sand glacial outwash. This map unit is highly erodible. The land capability classification is 7E.

Map Unit Symbol	Map unit name / Description
113A	MANITOWISH SANDY LOAM, 0 TO 3 PERCENT SLOPES nearly level and gently sloping, moderately well drained soil formed in loamy deposits and in the underlying stratified sand and gravelly coarse sand glacial outwash. This map unit is not highly erodible. The land capability classification is 3S.
115B	VILAS LOAMY SAND, 0 TO 6 PERCENT SLOPES Nearly level and gently sloping, excessively drained soil formed in sandy glacial outwash. This map unit is not highly erodible. The land capability classification is 4S.
115C	VILAS LOAMY SAND, 6 TO 15 PERCENT SLOPES Sloping, excessively drained soil formed in sandy glacial outwash. This map unit is potentially highly erodible. The land capability classification is 6S.
117B	PADUS FINE SANDY LOAM, MODERATELY WET, 0 TO 6 PERCENT SLOPES Nearly level and gently sloping, moderately well drained soil formed in loamy deposits and in the underlying stratified sand and gravelly sand glacial outwash. This map unit is not highly erodible. The land capability classification is 2E. This map unit is prime farmland.
117X	PADUS FINE SANDY LOAM, LOAMY SUBSTRATUM, 0 TO 6 PERCENT SLOPES Nearly level and gently sloping, moderately well drained soil formed in loamy deposits and in the underlying stratified sand and gravelly sand glacial outwash underlain by loamy glacial till or lacustrine deposits. This map unit is not highly erodible. The land capability classification is 2E. This map unit is prime farmland.
124	KINROSS MUCK, 0 TO 2 PERCENT SLOPES Nearly level, poorly drained soil formed in mucky and sandy deposits overlying sandy glacial outwash. This map unit is not highly erodible. The land capability classification is 6W. This map unit is hydric.
126A	AU GRES LOAMY SAND, 0 TO 2 PERCENT SLOPES Nearly level, somewhat poorly drained soil formed in sandy glacial outwash. This map unit is not highly erodible. The land capability classification is 4W. This map unit may have hydric inclusions.

Map Unit Symbol	Map unit name / Description
126X	AU GRES LOAMY SAND, LOAMY SUBSTRATUM, 0 TO 3 PERCENT SLOPES Nearly level and gently sloping, somewhat poorly drained soil formed in sandy glacial outwash over loamy glacial till or lacustrine deposits. This map unit is not highly erodible. The land capability classification is 4W. This map unit may have hydric inclusions.
127B	CROSWELL LOAMY SAND, 0 TO 3 PERCENT SLOPES Nearly level and gently sloping, moderately well drained soil formed in sandy glacial outwash. This map unit is not highly erodible. The land capability classification is 4S.
127X	CROSWELL LOAMY SAND, LOAMY SUBSTRATUM, 0 TO 3 PERCENT SLOPES Nearly level and gently sloping, moderately well drained soil formed in sandy glacial outwash over loamy glacial till or lacustrine deposits. This map unit is not highly erodible. The land capability classification is 4S.
150B	ALCONA SILT LOAM, 0 TO 6 PERCENT SLOPES Nearly level and gently sloping, moderately well drained soil formed in silty and loamy deposits underlain by stratified silty, loamy and sandy lacustrine deposits. This map unit is not highly erodible. The land capability classification is 2E. This map unit is prime farmland.
151A	GAASTRA SILT LOAM, 0 TO 3 PERCENT SLOPES Nearly level, somewhat poorly drained soil formed in silty deposits underlain by stratified silty, loamy and sandy lacustrine deposits. This map unit is not highly erodible. The land capability classification is 2W. This map unit is prime farmland where drained. This map unit may have hydric inclusions.
707	SEELYEVILLE AND CATHRO SOILS, 0 TO 1 PERCENT SLOPES Nearly level, very poorly drained soils formed in organic material more than 51 inches thick or underlain by loamy glacial till or lacustrine deposits at depths of 16 to 51 inches. This map unit is not highly erodible unless drained. The land capability classification is 6W. This map unit is hydric.

Map Unit Symbol	Map unit name / Description
714	LOXLEY AND BESEMAN SOILS, 0 TO 1 PERCENT SLOPES Nearly level, very poorly drained soils formed in acid organic material more than 51 inches thick or underlain by loamy glacial till or lacustrine deposits at depths of 16 to 51 inches. This map unit is not highly erodible unless drained. The land capability classification is 6W. This map unit is hydric.

SECTION II-A

SOIL LEGEND

FOREST COUNTY, WISCONSIN

Map Symbol	Map Unit Name
2	FORDUM LOAM, 0 TO 2 PERCENT SLOPES
17	CAPITOLA MUCK, 0 TO 2 PERCENT SLOPES, VERY STONY
18B	MUDLAKE SILT LOAM, 1 TO 6 PERCENT SLOPES, VERY STONY
19B	WABENO-MUDLAKE SILT LOAMS, 1 TO 15 PERCENT SLOPES, VERY STONY
19D	SOPERTON-MUDLAKE SILT LOAMS, 1 TO 35 PERCENT SLOPES, VERY STONY
20B	WABENO-GOODWIT SILT LOAMS, 1 TO 6 PERCENT SLOPES, VERY STONY
20C	WABENO-GOODMAN SILT LOAMS, 6 TO 15 PERCENT SLOPES, VERY STONY
20D	SOPERTON-GOODMAN SILT LOAMS, 15 TO 35 PERCENT SLOPES, VERY STONY
22B	ARGONNE-SARWET SANDY LOAMS, 1 TO 6 PERCENT SLOPES, VERY STONY
22C	LAONA-SARONA SANDY LOAMS, 6 TO 15 PERCENT SLOPES, VERY STONY
22D	LAONA-SARONA SANDY LOAMS, 15 TO 35 PERCENT SLOPES, VERY STONY
23D	METONGA-ROCK OUTCROP COMPLEX, 4 TO 60 PERCENT SLOPES, VERY STONY
26E	PELISSIER GRAVELLY SANDY LOAM, 20 TO 45 PERCENT SLOPES, STONY
27	MINOCQUA MUCK, 0 TO 2 PERCENT SLOPES
30D	RUBICON LOAMY SAND, 15 TO 35 PERCENT SLOPES
51B	PADUS-WABENO SILT LOAMS, 1 TO 6 PERCENT SLOPES, VERY STONY
51C	PADUS-WABENO SILT LOAMS, 6 TO 15 PERCENT SLOPES, VERY STONY
51D	PADUS-SOPERTON, SILT LOAMS, 15 TO 35 PERCENT SLOPES, VERY STONY
100B	STAMBAUGH SILT LOAM, 0 TO 6 PERCENT SLOPES
100C	STAMBAUGH SILT LOAM, 6 TO 15 PERCENT SLOPES
100D	STAMBAUGH SILT LOAM, 15 TO 25 PERCENT SLOPES
103A	WHISKLAKE SILT LOAM, 0 TO 3 PERCENT SLOPES

SOIL LEGEND

FOREST COUNTY, WISCONSIN

Map Symbol	Map Unit Name
103X	WORMET SANDY LOAM, 0 TO 3 PERCENT SLOPES
105B	PADUS SANDY LOAM, 0 TO 6 PERCENT SLOPES
105C	PADUS SANDY LOAM, 6 TO 15 PERCENT SLOPES
105D	PADUS SANDY LOAM, 15 TO 35 PERCENT SLOPES
106B	PADUS-PENCE SANDY LOAMS, 0 TO 6 PERCENT SLOPES
106C	PADUS-PENCE SANDY LOAMS, 6 TO 15 PERCENT SLOPES
106D	PADUS-PENCE SANDY LOAMS, 15 TO 35 PERCENT SLOPES
107B	PENCE-VILAS COMPLEX, 0 TO 6 PERCENT SLOPES
107C	PENCE-VILAS COMPLEX, 6 TO 15 PERCENT SLOPES
107D	PENCE-VILAS COMPLEX, 15 TO 35 PERCENT SLOPES
109B	VANZILE SILT LOAM, 0 TO 6 PERCENT SLOPES
111B	PENCE SANDY LOAM, 0 TO 6 PERCENT SLOPES
111C	PENCE SANDY LOAM, 6 TO 15 PERCENT SLOPES
111D	PENCE SANDY LOAM, 15 TO 35 PERCENT SLOPES
113A	MANITOWISH SANDY LOAM, 0 TO 3 PERCENT SLOPES
115B	VILAS LOAMY SAND, 0 TO 6 PERCENT SLOPES
115C	VILAS LOAMY SAND, 6 TO 15 PERCENT SLOPES
117A	TIPLER SANDY LOAM, 0 TO 3 PERCENT SLOPES
117X	PADWOOD SANDY LOAM, 0 TO 6 PERCENT SLOPES
124	KINROSS MUCK, 0 TO 2 PERCENT SLOPES
126A	AU GRES LOAMY SAND, 0 TO 2 PERCENT SLOPES
126X	FLINK LOAMY SAND, 0 TO 3 PERCENT SLOPES
127B	CROSWELL LOAMY SAND, 0 TO 3 PERCENT SLOPES

SECTION II-A

SOIL LEGEND

FOREST COUNTY, WISCONSIN

Map Symbol	Map Unit Name
127X	CUBLAKE LOAMY SAND, 0 TO 3 PERCENT SLOPES
150B	FENCE SILT LOAM, 0 TO 6 PERCENT SLOPES
151A	GAASTRA SILT LOAM, 0 TO 3 PERCENT SLOPES
403A	WORCESTER SANDY LOAM, 0 TO 3 PERCENT SLOPES
707	LUPTON, CATHRO, AND MARKEY MUCKS, 0 TO 1 PERCENT SLOPES
714	LOXLEY, BESEMAN, AND DAWSON PEATS, 0 TO 1 PERCENT SLOPES
Pt	PITS, GRAVEL
ZZ901	WATER LESS THAN 40 ACRES

SECTION II-A

SOIL LEGEND

FOREST COUNTY, WISCONSIN

Map Symbol	Map Unit Name
2	FORDUM LOAM, 0 TO 2 PERCENT SLOPES
17	CABLE MUCK, 0 TO 2 PERCENT SLOPES, STONY
18B	MONICO SILT LOAM, 1 TO 6 PERCENT SLOPES, STONY
19B	WABENO-MONICO COMPLEX, 1 TO 15 PERCENT SLOPES, STONY
19D	WABENO-MONICO COMPLEX, 1 TO 35 PERCENT SLOPES, STONY
20B	GOODMAN-WABENO COMPLEX, 1 TO 6 PERCENT SLOPES, STONY
20C	GOODMAN-WABENO COMPLEX, 6 TO 15 PERCENT SLOPES, STONY
20D	GOODMAN-WABENO COMPLEX, 15 TO 35 PERCENT SLOPES, STONY
22B	SARONA-WABENO COMPLEX, 1 TO 6 PERCENT SLOPES, STONY
22C	SARONA-WABENO COMPLEX, 6 TO 15 PERCENT SLOPES, STONY
22D	SARONA-WABENO COMPLEX, 15 TO 35 PERCENT SLOPES, STONY
23D	MICHIGAMME-ROCK OUTCROP COMPLEX, 4 TO 60 PERCENT SLOPES, STONY
26E	ELDERON GRAVELLY SANDY LOAM, 20 TO 45 PERCENT SLOPES, STONY
27	MINOCQUA MUCK, 0 TO 2 PERCENT SLOPES
30B	RUBICON SAND, 0 TO 6 PERCENT SLOPES
30C	RUBICON SAND, 6 TO 15 PERCENT SLOPES
30D	RUBICON LOAMY SAND, 15 TO 35 PERCENT SLOPES
51B	PADUS-WABENO COMPLEX, 1 TO 6 PERCENT SLOPES, STONY
51C	PADUS-WABENO COMPLEX, 6 TO 15 PERCENT SLOPES, STONY
51D	PADUS-WABENO COMPLEX, 15 TO 35 PERCENT SLOPES, STONY
100B	STAMBAUGH SILT LOAM, 0 TO 6 PERCENT SLOPES
100C	STAMBAUGH SILT LOAM, 6 TO 15 PERCENT SLOPES
100D	STAMBAUGH SILT LOAM, 15 TO 25 PERCENT SLOPES

SOIL LEGEND

FOREST COUNTY, WISCONSIN

Map Symbol	Map Unit Name
103A	WORCESTER SILT LOAM, 0 TO 3 PERCENT SLOPES
105B	PADUS FINE SANDY LOAM, 0 TO 6 PERCENT SLOPES
105C	PADUS FINE SANDY LOAM, 6 TO 15 PERCENT SLOPES
105D	PADUS FINE SANDY LOAM, 15 TO 35 PERCENT SLOPES
106B	PADUS-PENCE COMPLEX, 0 TO 6 PERCENT SLOPES
106C	PADUS-PENCE COMPLEX, 6 TO 15 PERCENT SLOPES
106D	PADUS-PENCE COMPLEX, 15 TO 35 PERCENT SLOPES
107B	PENCE-VILAS COMPLEX, 0 TO 6 PERCENT SLOPES
107C	PENCE-VILAS COMPLEX, 6 TO 15 PERCENT SLOPES
107D	PENCE-VILAS COMPLEX, 15 TO 35 PERCENT SLOPES
109B	STAMBAUGH SILT LOAM, MODERATELY WET, 0 TO 4 PERCENT SLOPES
111B	PENCE SANDY LOAM, 0 TO 6 PERCENT SLOPES
111C	PENCE SANDY LOAM, 6 TO 15 PERCENT SLOPES
111D	PENCE SANDY LOAM, 15 TO 35 PERCENT SLOPES
113A	MANITOWISH SANDY LOAM, 0 TO 3 PERCENT SLOPES
115B	VILAS LOAMY SAND, 0 TO 6 PERCENT SLOPES
115C	VILAS LOAMY SAND, 6 TO 15 PERCENT SLOPES
117B	PADUS FINE SANDY LOAM, MODERATELY WET, 0 TO 6 PERCENT SLOPES
117X	PADUS FINE SANDY LOAM, LOAMY SUBSTRATUM, 0 TO 6 PERCENT SLOPES
124	KINROSS MUCK, 0 TO 2 PERCENT SLOPES
126A	AU GRES LOAMY SAND, 0 TO 2 PERCENT SLOPES
126X	AU GRES LOAMY SAND, LOAMY SUBSTRATUM, 0 TO 3 PERCENT SLOPES
127B	CROSWELL LOAMY SAND, 0 TO 3 PERCENT SLOPES

SECTION II-A

SOIL LEGEND

FOREST COUNTY, WISCONSIN

Map Symbol	Map Unit Name
127X	CROSWELL LOAMY SAND, LOAMY SUBSTRATUM, 0 TO 3 PERCENT SLOPES
150B	ALCONA SILT LOAM, 0 TO 6 PERCENT SLOPES
151A	GAASTRA SILT LOAM, 0 TO 3 PERCENT SLOPES
707	SEELYEVILLE AND CATHRO SOILS, 0 TO 1 PERCENT SLOPES
714	LOXLEY AND BESEMAN SOILS, 0 TO 1 PERCENT SLOPES
Pt	PITS, GRAVEL
ZZ800	WATER LESS THAN 40 ACRES

20D GOODMAN-WABENO COMPLEX, 15 TO 35 PERCENT SLOPES, STONY

Moderately steep and steep, well drained soils formed in silty deposits and in the underlying loamy or sandy glacial till. This map unit is highly erodible. The land capability classification is 7S. It is 6E where stones are removed.

Component Name: WABENO, WELL DRAINED — This map unit has 2 components, and 2 interpretation sheet.
Classification: ALFIC FRAGIORTHODS, COARSE-LOAMY, MIXED, FRIGID

ESTIMATED SOIL PROPERTIES

Depth	USDA Texture	Classification Unified	Classification AASHTO	>10 In.	3-10 Inches	Percent < 3 in. passing sieve No 4	No.10	No.40	No.200	Clay % <.002 mm
0- 6	SIL	ML CL-ML	A-4	1-5	5-20	90-100	85-100	75-100	60- 90	3-10
6-27	SIL L FSL	ML CL-ML SM SC-SM	A-4	0-5	0-20	90-100	85-100	60-100	35- 90	4-12
27-47	SL GR-SL LS	SM SC SP-SM SC-SM	A-1 A-2	0-5	0-30	70-100	65- 95	30- 65	10- 35	6-16
47-60	LS SL GR-LS	SM SC-SM SP-SM	A-1 A-2	0-5	0-30	70- 90	65- 90	30- 65	10- 25	3-10

Depth (In)	Liquid Limit	Plasticity Index	Moist Bulk Density g/cc	Permeability In/hr	Available Water Capacity (In./in)	Soil Reaction (pH)	CEC (me/100g)	CaCO3 Pct	Organic Matter Pct	Shrink Swell Potential	Erosion Factor K
0- 6	<25	NP-6	1.2-1.5	0.6-2.	0.14-0.23	3.6- 6.	0- 1	-	1.- 2.	LOW	0.37
6-27	<25	NP-7	1.3-1.5	0.6-2.	0.17-0.24	3.6- 6.	0- 1	-	0.5- 1.	LOW	0.43
27-47	<30	NP-10	1.8- 2.	0.2-0.6	0.08-0.12	3.6- 6.	0- 1	-	0.-0.5	LOW	0.28
47-60	<23	NP-6	1.8- 2.	0.6-2.	0.03-0.05	4.5-6.5	0- 1	-	0.-0.5	LOW	0.28

Flooding Frequency	Flooding Duration	Flooding Months	Water Table-(feet) Depth	Water Table Kind	Water Table Months	Bedrock-(in) Depth	Bedrock Hard.	HYD GRP	T Fact.	Wind Erod. Index	Risk of Corrosion Uncoated Steel	Risk of Corrosion Concrete	Potential Frost Action
NONE	-	-	>6.0	-	-	>60		B	4	48	MODERATE	HIGH	MODERATE

SANITARY FACILITIES	RATING	RESTRICTIVE FEATURE(S)		
Septic Tank Absorption Fields	SEVERE	Percs Slowly	Slope	
Daily Cover for Landfill	POOR	Small Stones	Slope	

BUILDING SITE DEVELOPMENT	RATING	RESTRICTIVE FEATURE(S)		
Shallow Excavations	SEVERE	Cutbanks Cave	Slope	
Dwellings Without Basements	SEVERE	Slope		
Dwellings With Basements	SEVERE	Slope		
Small Commercial Buildings	SEVERE	Slope		
Local Streets and Roads	SEVERE	Slope		
Lawns, Landscaping, and Golf Fairways	SEVERE	Slope		

CONSTRUCTION MATERIAL	RATING	RESTRICTIVE FEATURE(S)		
Roadfill	POOR	Slope		
Sand	IMPROBABLE	Excess Fines		
Gravel	IMPROBABLE	Excess Fines		
Topsoil	POOR	Large Stones	Area Reclaim	Slope

WATER MANAGEMENT	RATING	RESTRICTIVE FEATURE(S)		
Pond Reservoir Area	SEVERE	Slope		
Embankments, Dikes and Levees	SEVERE	Seepage		
Drainage	LIMITATION	Deep To Water		
Irrigation	LIMITATION	Slope	Large Stones	Rooting Depth
Terraces and Diversions	LIMITATION	Slope	Large Stones	Erodes Easily
Grassed Waterways	LIMITATION	Large Stones	Slope	Erodes Easily

RECREATIONAL DEVELOPMENT	RATING	RESTRICTIVE FEATURE(S)		
Camp Areas	SEVERE	Slope		
Picnic Areas	SEVERE	Slope		
Playgrounds	SEVERE	Large Stones	Slope	
Paths and Trails	SEVERE	Slope		

CROPS AND PASTURE YIELDS

Crop yields in this table are averages for high level management where the crop is commonly grown on the map unit.

Corn Grain bu/a	Corn Silage tons/a	Soybeans bu/a	Wheat bu/a	Oats bu/a	Alfalfa Hay tons/acre	Red Clover Hay tons/acre	Improved Pasture AUM	Permanemt Pasture AUM
								2.6
								1.3

WOODLAND INTERPRETATIONS

WOODLAND ORD. SYB.	EROSION HAZARD	EQUIPMENT LIMITATION	SEEDLING MORTALITY	WIND TH. HAZARD	PLANT COMPETITION	INTERP ASPECT	COMMONLY EXISTING TREES (E) and/or TREES RECOMENDED TO PLANT (P)		SITE INDEX	WOODLAND PRODUCT-IVITY
3R	MODERATE	MODERATE	SLIGHT	MODERATE	MODERATE	NORTH	sugar maple	E	67	3
							yellow birch	E	72	3
							white ash	E	78	5
							American basswood	E	74	5
							eastern hemlock	E	56	
							white spruce	P		
							red pine	P		

For more information contact: Area Resource Soil Scientist, Soil Conservation Service, Hwy 70 E. and Timberland Road, Route 2, Box 2355, Spooner, WI 54801-1403, Phone: 715-635-3505

103A WORCESTER SILT LOAM, 0 TO 3 PERCENT SLOPES

Nearly level and gently sloping, somewhat poorly drained soil formed in silty and loamy deposits underlain by sand and gravelly coarse sand glacial outwash. The land capability classification is 2W. This map unit is prime farmland where drained. This map unit may have hydric inclusions.

Component Name: WORCESTER
Classification: AQUALFIC HAPLORTHODS, COARSE-LOAMY, MIXED, FRIGID

ESTIMATED SOIL PROPERTIES

Depth	USDA Texture	Classification Unified	Classification AASHTO	>10 In.	3-10 Inches	Percent < 3 in. passing sieve No 4	No.10	No.40	No.200	Clay % <.002 mm
0- 6	SIL	ML CL SM SC	A-4	-	0-7	80-100	75-100	65-100	45- 90	6-15
6-17	L SL SIL	SM SC-SM ML CL-ML	A-2 A-4	-	0-7	80-100	75-100	35- 95	12- 80	8-18
17-36	L SL GR-SL	SM SC ML CL	A-2 A-4 A-1	-	0-7	50-100	45-100	25- 95	10- 80	8-18
36-60	S GR-S GRV-S	SP SP-SM GP GP-GM	A-1 A-2 A-3	-	0-7	30-100	25-100	10- 70	1- 12	0- 3

Depth (In)	Liquid Limit	Plasticity Index	Moist Bulk Density g/cc	Permeability In/hr	Available Water Capacity (In./in)	Soil Reaction (pH)	CEC (me/100g)	CaCO3 Pct	Organic Matter Pct	Shrink Swell Potential	Erosion Factor K
0- 6	20-30	3-10	1.4-1.5	0.6-2.	0.16-0.24	4.5-6.5	-	-	1.- 3.	LOW	0.37
6-17	15-20	2-7	1.4-1.7	0.6-2.	0.09-0.22	4.5-6.5	-	-	-	LOW	0.32
17-36	15-25	3-10	1.4-1.7	0.6-2.	0.06-0.19	4.5-6.5	-	-	-	LOW	0.32
36-60	-	NP	1.3- 2.	6.-20.	0.02-0.07	5.1-6.5	-	-	-	LOW	0.15

Flooding Frequency	Flooding Duration	Flooding Months	Water Table-(feet) Depth	Water Table-(feet) Kind	Water Table-(feet) Months	Bedrock-(in) Depth	Bedrock-(in) Hard.	Wind HYD GRP	Wind T Fact.	Wind Erod. Index	Risk of Corrosion Uncoated Steel	Risk of Corrosion Concrete	Potential Frost Action
NONE	-	-	1.0-3.0	APPARENT	NOV-MAY	>60		C	4	56	HIGH	HIGH	HIGH

SANITARY FACILITIES	RATING	RESTRICTIVE FEATURE(S)		
Septic Tank Absorption Fields	SEVERE	Wetness	Poor Filter	
Daily Cover for Landfill	POOR	Seepage	Too Sandy	Small Stones

BUILDING SITE DEVELOPMENT	RATING	RESTRICTIVE FEATURE(S)		
Shallow Excavations	SEVERE	Cutbanks Cave	Wetness	
Dwellings Without Basements	SEVERE	Wetness		
Dwellings With Basements	SEVERE	Wetness		
Small Commercial Buildings	SEVERE	Wetness		
Local Streets and Roads	SEVERE	Frost Action		
Lawns, Landscaping, and Golf Fairways	MODERATE	Large Stones	Wetness	Droughty

CONSTRUCTION MATERIAL	RATING	RESTRICTIVE FEATURE(S)		
Roadfill	FAIR	Wetness		
Sand	PROBABLE			
Gravel	PROBABLE			
Topsoil	POOR	Small Stones	Area Reclaim	

WATER MANAGEMENT	RATING	RESTRICTIVE FEATURE(S)		
Pond Reservoir Area	SEVERE	Seepage		
Embankments, Dikes and Levees	SEVERE	Seepage	Piping	Wetness
Drainage	LIMITATION	Frost Action	Cutbanks Cave	
Irrigation	LIMITATION	Wetness	Droughty	
Terraces and Diversions	LIMITATION	Wetness	Too Sandy	
Grassed Waterways	LIMITATION	Wetness	Droughty	Rooting Depth

RECREATIONAL DEVELOPMENT	RATING	RESTRICTIVE FEATURE(S)			
Camp Areas	SEVERE	Wetness			
Picnic Areas	MODERATE	Wetness			
Playgrounds	SEVERE	Wetness			
Paths and Trails	MODERATE	Wetness			

CROPS AND PASTURE YIELDS

Crop yields in this table are averages for high level management where the crop is commonly grown on the map unit.

Corn Grain bu/a	Corn Silage tons/a	Soybeans bu/a	Wheat bu/a	Oats bu/a	Alfalfa Hay tons/acre	Red Clover Hay tons/acre	Improved Pasture AUM	Permanent Pasture AUM
70	10			70	3.8	3.	6.3	3.4

WOODLAND INTERPRETATIONS

WOODLAND ORD. SYB.	EROSION HAZARD	EQUIPMENT LIMITATION	SEEDLING MORTALITY	WIND TH. HAZARD	PLANT COMPETITION	INTERP ASPECT	COMMONLY EXISTING TREES (E) and/or TREES RECOMENDED TO PLANT (P)		SITE INDEX	WOODLAND PRODUCTIVITY
2W	SLIGHT	SEVERE	SLIGHT	MODERATE	MODERATE	NORTH	balsam fir	E		
							sugar maple	E		
							yellow birch	E		
							red maple	EP	55	2
							white spruce	EP		
							eastern white pine	P		

RECOMMENDED WINDBREAK SPECIES AND EXPECTED HEIGHT AT 20 YEARS

Plant Name	Height	Plant Name	Height	Plant Name	Height	Plant Name	Height
American cranberrybush	10	common ninebark	8	eastern white pine	30	lilac	10
nannyberry viburnum	8	northern whitecedar	15	red maple	30	redosier dogwood	8
silky dogwood	10	silver maple	30	white ash	30	white spruce	20

For more information contact: Area Resource Soil Scientist, Soil Conservation Service, Hwy 70 E. and Timberland Road, Route 2, Box 2355, Spooner, WI 54801-1403, Phone: 715-635-3505

nearly level and gently sloping, moderately well drained soil formed in loamy deposits and in the underlying stratified sand and gravelly coarse sand glacial outwash. This map unit is not highly erodible. The land capability classification is 3S.

Component Name: MANITOWISH
Classification: ENTIC HAPLORTHODS, SANDY, MIXED, FRIGID

ESTIMATED SOIL PROPERTIES

Depth	USDA Texture	Classification Unified	Classification AASHTO	>10 In.	3-10 Inches	Percent < 3 in. passing sieve No 4	No.10	No.40	No.200	Clay % <.002 mm
0- 4	SL	SM ML	A-4	-	0-7	90-100	85-100	50- 85	35- 55	4-10
4-16	SL L FSL	SM SC-SM ML CL-ML	A-4 A-2	-	0-7	85-100	85-100	45- 95	30- 75	5-15
16-22	LCOS GR-LS LFS	SM SC-SM GM GM-GC	A-2 A-1 A-3 A-4	-	0-8	55-100	50-100	20- 90	5- 50	3-12
22-60	COS GR-S GR-COS	SP SP-SM GP GP-GM	A-1 A-3 A-2	-	0-15	50-100	50-100	20- 70	0- 12	0- 3

Depth (In)	Liquid Limit	Plasticity Index	Moist Bulk Density g/cc	Permeability In/hr	Available Water Capacity (In./in)	Soil Reaction (pH)	CEC (me/ 100g)	CaCO3 Pct	Organic Matter Pct	Shrink Swell Potential	Erosion Factor K
0- 4	<21	NP-4	1.3-1.7	2.-6.	0.11-0.18	4.5-6.5	-	-	1.- 3.	LOW	0.24
4-16	<25	NP-7	1.4-1.7	2.-6.	0.1-0.19	4.5-6.5	-	-	-	LOW	0.24
16-22	<25	NP-6	1.5-1.6	2.-6.	0.04-0.12	4.5-6.5	-	-	-	LOW	0.1
22-60	-	NP	1.5-1.7	6.-20.	0.02-0.07	5.6-6.5	-	-	-	LOW	0.1

Flooding Frequency	Flooding Duration	Flooding Months	Water Table (feet) Depth	Water Table Kind	Water Table Months	Bedrock (in) Depth	Bedrock Hard.	Wind Erod. HYD GRP	Wind Erod. T Fact.	Wind Erod. Index	Risk of Corrosion Uncoated Steel	Risk of Corrosion Concrete	Potential Frost Action
NONE	-	-	3.0-6.0	APPARENT	NOV-MAY	>60		B	3	86	LOW	MODERATE	LOW

SANITARY FACILITIES	RATING	RESTRICTIVE FEATURE(S)		
Septic Tank Absorption Fields	SEVERE	Wetness	Poor Filter	
Daily Cover for Landfill	POOR	Seepage	Too Sandy	Small Stones

BUILDING SITE DEVELOPMENT	RATING	RESTRICTIVE FEATURE(S)		
Shallow Excavations	SEVERE	Cutbanks Cave		
Dwellings Without Basements	SLIGHT			
Dwellings With Basements	MODERATE	Wetness		
Small Commercial Buildings	SLIGHT			
Local Streets and Roads	SLIGHT			
Lawns, Landscaping, and Golf Fairways	MODERATE	Droughty	Large Stones	

CONSTRUCTION MATERIAL	RATING	RESTRICTIVE FEATURE(S)		
Roadfill	GOOD			
Sand	PROBABLE			
Gravel	PROBABLE			
Topsoil	POOR	Small Stones	Area Reclaim	Too Sandy

WATER MANAGEMENT	RATING	RESTRICTIVE FEATURE(S)		
Pond Reservoir Area	SEVERE	Seepage		
Embankments, Dikes and Levees	SEVERE	Seepage	Piping	
Drainage	LIMITATION	Deep To Water		
Irrigation	LIMITATION	Droughty	Soil Blowing	
Terraces and Diversions	LIMITATION	Too Sandy	Soil Blowing	
Grassed Waterways	LIMITATION	Droughty		

RECREATIONAL DEVELOPMENT	RATING	RESTRICTIVE FEATURE(S)		
Camp Areas	SLIGHT			
Picnic Areas	SLIGHT			
Playgrounds	MODERATE	Small Stones		
Paths and Trails	SLIGHT			

CROPS AND PASTURE YIELDS

Crop yields in this table are averages for high level management where the crop is commonly grown on the map unit.

Corn Grain bu/a	Corn Silage tons/a	Soybeans bu/a	Wheat bu/a	Oats bu/a	Alfalfa Hay tons/acre	Red Clover Hay tons/acre	Improved Pasture AUM	Permanent Pasture AUM
65	10			60	3.5	3.	5.2	2.6

WOODLAND INTERPRETATIONS

WOODLAND ORD. SYB.	EROSION HAZARD	EQUIPMENT LIMITATION	SEEDLING MORTALITY	WIND TH. HAZARD	PLANT COMPETITION	INTERP ASPECT	COMMONLY EXISTING TREES (E) and/or TREES RECOMENDED TO PLANT (P)		SITE INDEX	WOODLAND PRODUCTIVITY
3S	SLIGHT	MODERATE	MODERATE	SLIGHT	MODERATE	NORTH	sugar maple	E	60	3
							quaking aspen	E		
							red pine	EP	59	7
							eastern white pine	EP		
							jack pine	P		

RECOMMENDED WINDBREAK SPECIES AND EXPECTED HEIGHT AT 20 YEARS

Plant Name	Height	Plant Name	Height	Plant Name	Height	Plant Name	Height
American cranberrybush	10	Amur maple	10	eastern redcedar	15	eastern white pine	30
gray dogwood	8	jack pine	30	lilac	10	manyflower cotoneaster	6
Norway spruce	20	red pine	30	Siberian peashrub	8	silky dogwood	8

For more information contact: Area Resource Soil Scientist, Soil Conservation Service, Hwy 70 E. and Timberland Road, Route 2, Box 2355, Spooner, WI 54801-1403, Phone: 715-635-3505

111B PENCE SANDY LOAM, 0 TO 6 PERCENT SLOPES

Nearly level and gently sloping, well drained soil formed in loamy deposits and in the underlying stratified sand and gravelly coarse sand glacial outwash. This map unit is potentially highly erodible. The land capability classification is 3E.

Component Name: PENCE
Classification: ENTIC HAPLORTHODS, SANDY, MIXED, FRIGID

ESTIMATED SOIL PROPERTIES

Depth	USDA Texture	Classification Unified	Classification AASHTO	>10 In.	3-10 Inches	Percent < 3 in. passing sieve No 4	No.10	No.40	No.200	Clay % <.002 mm
0- 2	SL	SM ML	A-4 A-2 A-1	0	0-15	85-100	75-100	45- 85	20- 55	3-11
2-14	SL L GR-SL	SM ML CL-ML SC-SM	A-4 A-2 A-1	0-4	0-15	55-100	50-100	30- 95	15- 75	2-12
14-20	GR-COS LS S	SM SP-SM GM GP-GM	A-2 A-1 A-3	0-4	0-15	55-100	50-100	25- 75	2- 30	2-10
20-60	GR-COS S SG	SP SM	A-1 A-3 A-2	0-4	0-15	55- 85	50- 75	15- 55	2- 15	0- 4

Depth (In)	Liquid Limit	Plasticity Index	Moist Bulk Density g/cc	Permeability In/hr	Available Water Capacity (In./in)	Soil Reaction (pH)	CEC (me/100g)	CaCO3 Pct	Organic Matter Pct	Shrink Swell Potential	Erosion Factor K
0- 2	<21	NP-4	1.2-1.6	2.-6.	0.1-0.18	4.5-6.5	0- 1	-	1.- 3.	LOW	0.24
2-14	<25	NP-7	1.4-1.5	2.-6.	0.1-0.15	4.5-6.5	0.- 1	-	0.-0.5	LOW	0.24
14-20	-	NP	1.6-1.8	2.-20.	0.05-0.08	4.5-6.5	0.- 1	-	0.-0.5	LOW	0.1
20-60	-	NP	1.4-1.8	6.-20.	0.02-0.05	5.1-6.5	0.- 0	-	0.-0.5	LOW	0.1

Flooding Frequency	Flooding Duration	Flooding Months	Water Table (feet) Depth	Water Table (feet) Kind	Water Table (feet) Months	Bedrock (in) Depth	Bedrock (in) Hard.	HYD GRP	T Fact.	Wind Erod. Index	Risk of Corrosion Uncoated Steel	Risk of Corrosion Concrete	Potential Frost Action
NONE			>6.0	-	-	>60		B	3	86	LOW	MODERATE	LOW

SANITARY FACILITIES	RATING	RESTRICTIVE FEATURE(S)		
Septic Tank Absorption Fields	SEVERE	Poor Filter		
Daily Cover for Landfill	POOR	Seepage	Too Sandy	Small Stones

BUILDING SITE DEVELOPMENT	RATING	RESTRICTIVE FEATURE(S)		
Shallow Excavations	SEVERE	Cutbanks Cave		
Dwellings Without Basements	SLIGHT			
Dwellings With Basements	SLIGHT			
Small Commercial Buildings	SLIGHT			
Local Streets and Roads	SLIGHT			
Lawns, Landscaping, and Golf Fairways	MODERATE	Large Stones	Droughty	

CONSTRUCTION MATERIAL	RATING	RESTRICTIVE FEATURE(S)		
Roadfill	GOOD			
Sand	PROBABLE			
Gravel	PROBABLE			
Topsoil	POOR	Too Sandy	Small Stones	Area Reclaim

WATER MANAGEMENT	RATING	RESTRICTIVE FEATURE(S)		
Pond Reservoir Area	SEVERE	Seepage		
Embankments, Dikes and Levees	SEVERE	Seepage		
Drainage	LIMITATION	Deep To Water		
Irrigation	LIMITATION	Slope	Droughty	
Terraces and Diversions	LIMITATION	Too Sandy	Soil Blowing	
Grassed Waterways	LIMITATION	Droughty	Rooting Depth	

RECREATIONAL DEVELOPMENT	RATING	RESTRICTIVE FEATURE(S)		
Camp Areas	SLIGHT			
Picnic Areas	SLIGHT			
Playgrounds	MODERATE	Slope	Small Stones	
Paths and Trails	SLIGHT			

CROPS AND PASTURE YIELDS

Crop yields in this table are averages for high level management where the crop is commonly grown on the map unit.

Corn Grain bu/a	Corn Silage tons/a	Soybeans bu/a	Wheat bu/a	Oats bu/a	Alfalfa Hay tons/acre	Red Clover Hay tons/acre	Improved Pasture AUM	Permanent Pasture AUM
60	10			55	3.5	2.5	5.	2.5

WOODLAND INTERPRETATIONS

WOODLAND ORD. SYB.	EROSION HAZARD	EQUIPMENT LIMITATION	SEEDLING MORTALITY	WIND TH. HAZARD	PLANT COMPETITION	INTERP ASPECT
3S	SLIGHT	MODERATE	SLIGHT	SLIGHT	SLIGHT	NORTH

COMMONLY EXISTING TREES (E) and/or TREES RECOMENDED TO PLANT (P)		SITE INDEX	WOODLAND PRODUCTIVITY
balsam fir	E		
sugar maple	E	59	3
yellow birch	E		
paper birch	E		
quaking aspen	E		
American basswood	E		
red pine	EP	59	7
eastern white pine	EP	57	8
jack pine	P		

RECOMMENDED WINDBREAK SPECIES AND EXPECTED HEIGHT AT 20 YEARS

Plant Name	Height	Plant Name	Height	Plant Name	Height	Plant Name	Height
American cranberrybush	10	Amur maple	10	eastern redcedar	15	eastern white pine	30
gray dogwood	8	jack pine	30	lilac	10	manyflower cotoneaster	6
Norway spruce	20	red pine	30	Siberian peashrub	8	silky dogwood	8

For more information contact: Area Resource Soil Scientist, Soil Conservation Service, Hwy 70 E. and Timberland Road, Route 2, Box 2355, Spooner, WI 54801-1403, Phone: 715-635-3505

707 SEELYEVILLE AND CATHRO SOILS, 0 TO 1 PERCENT SLOPES

Nearly level, very poorly drained soils formed in organic material more than 51 inches thick or underlain by loamy glacial till or lacustrine deposits at depths of 16 to 51 inches. This map unit is not highly erodible unless drained. The land capability classification is 6W. This map unit is hydric.

Component Name: SEELYEVILLE
Classification: TYPIC BOROSAPRISTS, EUIC

This map unit has 2 components, and 2 interpretation sheet.

ESTIMATED SOIL PROPERTIES

Depth	USDA Texture	Classification Unified	Classification AASHTO	>10 In.	3-10 Inches	Percent < 3 in. passing sieve No 4	No.10	No.40	No.200	Clay % <.002 mm
0-10	MUCK	PT	A-8	0	0	-	-	-	-	-
10-60	MUCK MPT	PT	A-8	0	0	-	-	-	-	-

Depth (In)	Liquid Limit	Plasticity Index	Moist Bulk Density g/cc	Permeability In/hr	Available Water Capacity (In./in)	Soil Reaction (pH)	CEC (me/100g)	CaCO3 Pct	Organic Matter Pct	Shrink Swell Potential	Erosion Factor K
0-10	-	-	0.1-0.3	0.2-6.	0.35-0.45	4.5-7.3	2- 2	-	25.-99.		0.1
10-60	-	-	0.1-0.3	0.2-6.	0.35-0.45	4.5-7.3	2- 2	-	25.-99.		

Flooding Frequency	Flooding Duration	Flooding Months	Water Table-(feet) Depth	Water Table-(feet) Kind	Water Table-(feet) Months	Bedrock-(in) Depth	Bedrock-(in) Hard.	HYD GRP	T Fact.	Wind Erod. Index	Risk of Corrosion Uncoated Steel	Risk of Corrosion Concrete	Potential Frost Action
NONE	-	-	+2-2.0	APPARENT	YEAR-ROUND	>60		A/D	5	134	HIGH	MODERATE	HIGH

SANITARY FACILITIES	RATING	RESTRICTIVE FEATURE(S)		
Septic Tank Absorption Fields	SEVERE	Subsides	Ponding	Percs Slowly
Daily Cover for Landfill	POOR	Ponding	Excess Humus	

BUILDING SITE DEVELOPMENT	RATING	RESTRICTIVE FEATURE(S)		
Shallow Excavations	SEVERE	Excess Humus	Ponding	
Dwellings Without Basements	SEVERE	Subsides	Ponding	Low Strength
Dwellings With Basements	SEVERE	Subsides	Ponding	Low Strength
Small Commercial Buildings	SEVERE	Subsides	Ponding	Low Strength
Local Streets and Roads	SEVERE	Subsides	Ponding	Frost Action
Lawns, Landscaping, and Golf Fairways	SEVERE	Ponding	Excess Humus	

CONSTRUCTION MATERIAL	RATING	RESTRICTIVE FEATURE(S)		
Roadfill	POOR	Wetness		
Sand	IMPROBABLE	Excess Humus		
Gravel	IMPROBABLE	Excess Humus		
Topsoil	POOR	Excess Humus	Wetness	

WATER MANAGEMENT	RATING	RESTRICTIVE FEATURE(S)		
Pond Reservoir Area	SEVERE	Seepage		
Embankments, Dikes and Levees	SEVERE	Excess Humus	Ponding	
Drainage	LIMITATION	Ponding	Subsides	Frost Action
Irrigation	LIMITATION	Ponding	Soil Blowing	
Terraces and Diversions	LIMITATION	Ponding	Soil Blowing	
Grassed Waterways	LIMITATION	Wetness		

RECREATIONAL DEVELOPMENT	RATING	RESTRICTIVE FEATURE(S)	
Camp Areas	SEVERE	Ponding	Excess Humus
Picnic Areas	SEVERE	Ponding	Excess Humus
Playgrounds	SEVERE	Excess Humus	Ponding
Paths and Trails	SEVERE	Ponding	Excess Humus

CROPS AND PASTURE YIELDS

Crop yields in this table are averages for high level management where the crop is commonly grown on the map unit.

Corn Grain bu/a	Corn Silage tons/a	Soybeans bu/a	Wheat bu/a	Oats bu/a	Alfalfa Hay tons/acre	Red Clover Hay tons/acre	Improved Pasture AUM	Permanent Pasture AUM
								4.2
								4.

WOODLAND INTERPRETATIONS

WOODLAND ORD. SYB.	EROSION HAZARD	EQUIPMENT LIMITATION	SEEDLING MORTALITY	WIND TH. HAZARD	PLANT COMPETITION	INTERP ASPECT	COMMONLY EXISTING TREES (E) and/or TREES RECOMENDED TO PLANT (P)		SITE INDEX	WOODLAND PRODUCTIVITY
3W	SLIGHT	SEVERE	SEVERE	SEVERE	SEVERE	NORTH	black ash	E	55	2
							balsam fir	EP	45	6
							tamarack	EP	56	4
							black spruce	EP	34	3
							northern whitecedar	EP	30	3

RECOMMENDED WINDBREAK SPECIES AND EXPECTED HEIGHT AT 20 YEARS

Plant Name	Height	Plant Name	Height	Plant Name	Height	Plant Name	Height
common ninebark	7	golden willow	33	imperial Carolina poplar	50	white willow	33
-		-		-		-	
-		-		-		-	

For more information contact: Area Resource Soil Scientist, Soil Conservation Service, Hwy 70 E. and Timberland Road, Route 2, Box 2355, Spooner, WI 54801-1403, Phone: 715-635-3505

Nearly level, very poorly drained soils formed in organic material more than 51 inches thick or underlain by loamy glacial till or lacustrine deposits at depths of 16 to 51 inches. This map unit is not highly erodible unless drained. The land capability classification is 6W. This map unit is hydric.

Component Name: CATHRO This map unit has 2 components, and 2 interpretation sheet.
Classification: TERRIC BOROSAPRISTS, LOAMY, MIXED, EUIC

ESTIMATED SOIL PROPERTIES

Depth	USDA Texture	Classification Unified	Classification AASHTO	>10 In.	3-10 Inches	Percent < 3 in. passing sieve No 4	No.10	No.40	No.200	Clay % <.002 mm
0-14	MUCK	PT	A-8	0	0	-	-	-	-	-
14-19	MUCK	PT	A-8	0	0	-	-	-	-	-
19-60	L SICL SL	SC-SM CL-ML SC CL	A-4 A-6	0	0-5	80-100	65-100	60-100	35- 90	10-30

Depth (In)	Liquid Limit	Plasticity Index	Moist Bulk Density g/cc	Permeability In/hr	Available Water Capacity (In./in)	Soil Reaction (pH)	CEC (me/ 100g)	CaCO3 Pct	Organic Matter Pct	Shrink Swell Potential	Erosion Factor K
0-14	-	-	0.3-0.4	0.2-6.	0.45-0.55	4.5-7.8	2- 2	-	60.-85.		0.1
14-19	-	-	0.2-0.3	0.2-6.	0.35-0.45	4.5-7.8	2- 2	-	60.-85.		
19-60	20-40	4-20	1.5-1.7	0.2-2.	0.11-0.22	5.6-8.4	0- 1	5-25	0.-0.5	LOW	0.32

Flooding Frequency	Flooding Duration	Flooding Months	Water Table (feet) Depth	Water Table (feet) Kind	Water Table (feet) Months	Bedrock (in) Depth	Bedrock (in) Hard.	HYD GRP	T Fact.	Wind Erod. Index	Risk of Corrosion Uncoated Steel	Risk of Corrosion Concrete	Potential Frost Action
NONE	-	-	+1-1.0	APPARENT	YEAR-ROUND	>60		A/D	5	134	HIGH	LOW	HIGH

SANITARY FACILITIES	RATING	RESTRICTIVE FEATURE(S)		
Septic Tank Absorption Fields	SEVERE	Ponding	Percs Slowly	
Daily Cover for Landfill	POOR	Ponding		

BUILDING SITE DEVELOPMENT	RATING	RESTRICTIVE FEATURE(S)		
Shallow Excavations	SEVERE	Excess Humus	Ponding	
Dwellings Without Basements	SEVERE	Subsides	Ponding	
Dwellings With Basements	SEVERE	Subsides	Ponding	
Small Commercial Buildings	SEVERE	Subsides	Ponding	
Local Streets and Roads	SEVERE	Subsides	Ponding	Frost Action
Lawns, Landscaping, and Golf Fairways	SEVERE	Ponding	Excess Humus	

CONSTRUCTION MATERIAL	RATING	RESTRICTIVE FEATURE(S)		
Roadfill	POOR	Wetness		
Sand	IMPROBABLE	Excess Fines		
Gravel	IMPROBABLE	Excess Fines		
Topsoil	POOR	Excess Humus	Wetness	

WATER MANAGEMENT	RATING	RESTRICTIVE FEATURE(S)		
Pond Reservoir Area	SEVERE	Seepage		
Embankments, Dikes and Levees	SEVERE	Piping	Ponding	
Drainage	LIMITATION	Ponding	Subsides	Frost Action
Irrigation	LIMITATION	Ponding	Soil Blowing	
Terraces and Diversions	LIMITATION	Ponding	Soil Blowing	
Grassed Waterways	LIMITATION	Wetness		

RECREATIONAL DEVELOPMENT	RATING	RESTRICTIVE FEATURE(S)		
Camp Areas	SEVERE	Ponding	Excess Humus	
Picnic Areas	SEVERE	Ponding	Excess Humus	
Playgrounds	SEVERE	Excess Humus	Ponding	
Paths and Trails	SEVERE	Ponding	Excess Humus	

CROPS AND PASTURE YIELDS

Crop yields in this table are averages for high level management where the crop is commonly grown on the map unit.

Corn Grain bu/a	Corn Silage tons/a	Soybeans bu/a	Wheat bu/a	Oats bu/a	Alfalfa Hay tons/acre	Red Clover Hay tons/acre	Improved Pasture AUM	Permanent Pasture AUM
								4.2
								4.

WOODLAND INTERPRETATIONS

WOODLAND ORD. SYB.	EROSION HAZARD	EQUIPMENT LIMITATION	SEEDLING MORTALITY	WIND TH. HAZARD	PLANT COMPETITION	INTERP ASPECT	COMMONLY EXISTING TREES (E) and/or TREES RECOMENDED TO PLANT (P)		SITE INDEX	WOODLAND PRODUCTIVITY
5W	SLIGHT	SEVERE	SEVERE	SEVERE	SEVERE	NORTH	balsam fir	E	40	5
							red maple	E	40	2
							paper birch	E		
							tamarack	E	35	2
							black spruce	E	15	2
							northern whitecedar	E	15	2
							white spruce	EP		

For more information contact: Area Resource Soil Scientist, Soil Conservation Service, Hwy 70 E. and Timberland Road, Route 2, Box 2355, Spooner, WI 54801-1403, Phone: 715-635-3505

Appendix D

Technical Memorandum - Wetland Delineation

Foth & Van Dyke
Memorandum

November 10, 1998

TO: Master File

CC: Gordon Reid, Nicolet Minerals Company
Jerry Sevick, Foth & Van Dyke,
Steve Dischler, Foth & Van Dyke

FR: Brad Helmandollar, Foth & Van Dyke BDH

RE: Crandon Project - Wetland Delineation/Verification for Area H

The following presents an overview of the wetland delineation/verification activities conducted on the property proposed for construction of the soil absorption system. The site is known as Area "H" and is located within the Rudloff property north of Keith Siding Road.

Prior to conducting the field investigation, the May 1995 EIR for the Crandon Project was reviewed. In addition, aerial photographs, topographical maps, and the historical wetland maps for the site were also reviewed. According to the information presented in the EIR, two wetlands were previously identified in the vicinity of Area H by Normandeau Associates, Inc., and Interdisciplinary Environmental Planning, Inc. These wetlands, known as wetland T4 and wetland Z16, were previously inventoried and are both described as coniferous swamp.

After the completion of the literature review, a site visit was conducted and a formal wetland delineation, in accordance with the *1987 Corps of Engineers Wetland Delineation Manual,* was completed. Each identified wetland was field delineated by walking several transects across the wetland/non-wetland gradient. Observed vegetation, hydrology, and soil characteristics were recorded on Routine Wetland Determination Forms. These forms are provided as an attachment to this memorandum. Based on the data collected, numbered flags were placed along the perimeter of the wetland boundary. The flags were then surveyed to tie the delineated area into the site's coordinate system. The site map with the wetland boundaries is attached as Figure 1. It should be noted that the entire boundaries of wetland T4 and Z16 were not delineated. The delineation covered the wetland/upland boundary nearest to the proposed soil absorption area north of Keith Siding Road and west of the Wisconsin Central Limited main line.

The conditions observed on site were generally consistent with the information obtained from the literature review. The delineated western boundary of T4 generally follows the same as reported in the EIR. However, the wetland map presented in the EIR shows an upland break between wetland T4 and Z16 in the northern portion of Area H. This area, historically shown as upland, appears to have been significantly affected by clearing and agricultural activities. It appears that

the area was cleared and drained for agricultural purposes. An 8-inch diameter corrugated metal culvert pipe (CMCP) is present between T4 and Z16. The CMCP was not conveying water during other field work performed in August and September, 1998. Evidence of hydric soils and hydrophytic vegetation does exist in this area and, therefore, it was included as wetland in the most recent delineation.

Conclusions

The attached Figure 1 presents a comparison between the wetland boundaries presented in the 1995 EIR and the verification work completed in 1998. The configuration of the boundaries of wetlands T4 and Z16, adjacent to the proposed soil absorption system, are virtually identical in both mapping efforts. The only exception is the addition, in 1998, of an abandoned agricultural field. This field may have been active during the previous mapping effort and was, therefore, left off of the wetland map.

Based on the 1998 verification, it is concluded that the wetland inventory work completed previously, and as presented in the 1995 EIR, is an accurate representation of the wetland boundaries within the potential area of influence from the proposed soil absorption system.

BDH:cer1

Attachment

2.284.000 E | 2.285.000 E | 2.286.000 E | 2.287.000 E | 2.288.000 E

130.000 N

129.000 N

128.000 N

127.000 N

Z16

T4

NMC

Small Tracts

K.L. Flannery, et ux

E. Rudloff

J. Schmidt, et ux

SLPD 557670 D.R. Pennington, Trustee

Town of Lincoln

B.L. Zelechowski et ux

L. Zelechowski et ux

J.G. Gruber, et ux

P. Fresny et ux-1/2

F. Rusniak, et ux-1/2

Forest County

P. Davison

J.R. Johnson, et ux

J.G. Gruber

1593.0 X

1595.5 X

1594.5 X

1594.0 X

1592.0 X

1590.5 X

1589.5 X

1588.0 X

1587.5 X

1586.0 X

1584.5 X

1584.0 X

1583.0 X

1578.0 X

1577.5 X

1600

1620

1615

1610

1605

1595

1590

1585

1580

APPROXIMATE LOCATION OF CREEK 17-13

SPRING

EXISTING 8" CMCP

CULVERT

30" RCP

PRIVATE WELL (TO BE ABANDONED)

24" CMCP

WOODEN BOX CULVERT 1.5' X 1'

EXCAVATED DITCH

ORDINARY HIGH WATER MARK

PRIVATE WELL (TO BE ABANDONED)

15" CMCP

LAKE 17-16

12" CMCP

SWAMP CREEK

WISCONSIN CENTRAL LIMITED RAILROAD

KEITH SIDING RD

① ② ③ ④ ⑤ ⑥ ⑦

N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- ---1675--- EXISTING CONTOUR
- 1702.0 X EXISTING SPOT ELEVATION
- SWAMP/WETLAND
- TRAILS
- TREES
- RAILROAD
- T. Perry, et ux — APPROXIMATE PROPERTY BOUNDARY AND OWNER
- x 1582.17 WETLAND SPOT ELEVATIONS
- Z16 WETLAND NAMES REPORTED IN THE 1995 EIR
- PRIVATE WELL
- 12" CMCP FL.=1583.02 FL.=1580.61 CULVERT SIZE AND FLOWLINE ELEVATION
- 1998 WETLAND DELINEATION FIELD VERIFIED AND SURVEYED, SEPTEMBER, 1998
- DISTURBED WETLAND AREA NOT PREVIOUSLY DELINEATED AS A WETLAND
- APPROXIMATE LIMITS OF DETAILED TOPOGRAPHIC SURVEY (SEE NOTE NO. 1)
- ① APPROXIMATE LOCATION OF TRANSECTS

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. THE LOCATION OF THE SPRING IN WETLAND Z16 AND THE ORDINARY HIGH WATER MARK AROUND LAKE 17-16 ARE APPROXIMATE.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	BDH	DATE:	NOV. '98
APPROVED BY:	SAD2	DATE:	NOV. '98
APPROVED BY:	SAD2	DATE:	NOV. '98

Nicolet Minerals COMPANY

Mining for the Future Commitment

FIGURE 1

AREA H - WETLAND MAP

Scale: 0 200' 400' | Date: NOVEMBER, 1998

Prepared By: Foth & Van Dyke | By: JRB2 | 93C049

..\98c040\sap-design\8c40z30.dgn Nov. 23, 1998 19:15:11

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: RUDLOFF PROPERTY - CRANDON PROJECT
Applicant/Owner: NMC
Investigator: BHELMANDOLLAR

Date: 8/17/98
County: FOREST
State: WI

Do Normal Circumstances exist on the site? Yes (No)
Is the site significantly disturbed (Atypical Situations? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID: T4
Transect ID: 1
Plot ID: A

VEGETATION

Dominant Plant Species	Stratum	Indicator
1. ALFALFA		
2. TARAXICUM OFFICINALE	FACU	HERB
3. POA SP.		
4.		
5.		
6.		
7.		
8.		

Dominant Plant Species	Stratum	Indicator
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks: WITHIN AN AGRICULTURAL FIELD BORDERING T4

HYDROLOGY

_____ Recorded Data (Describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other

X No Recorded Data Available

Field Observations:

Depth of Surface Water: N/A (in.)
Depth to Free Water in Pit: N/A (in.)
Depth to Saturated Soil: N/A (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
_____ Saturated in Upper 12 inches
_____ Water Marks
_____ Drift Lines
_____ Sediment Deposits
_____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

_____ Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks:

SOILS

Map Unit Name
(Series and Phase) _____ Drainage Class: _____

Field Observations
Taxonomy (Subgroup): _____ Confirm Mapped Type? Yes N

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretic. Structure, etc.
0-10		10YR 4/3			SILTY SAND
10-18		10YR 6/8			SAND

Hydric Soil Indicators:

_____ Histosol
_____ Histic Epipedon
_____ Sulfidic Odor
_____ Aquic Moisture Regime
_____ Reducing Conditions
_____ Gleyed or Low-Chrome Colors
_____ Concretions
_____ High Organic Content in Surface Layer in Sandy Soils
_____ Organic Streaking in Sandy Soils
_____ Listed on Local Hydric Soils List
_____ Listed on National Hydric Soils List
_____ Other (Explain in Remarks)

Remarks: NON HYDRIC SOIL - AREA IN ACTIVE AGRICULTURE

WETLAND DETERMINATION

Hydrophytic Vegetation Present? Yes (No) (Circle)
Wetland Hydrology Present? Yes (No)
Hydric Soils Present? Yes (No)

(Circle)
Is this Sampling Point Within a Wetland? Yes (No)

Remarks:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: RUDLOFF PROPERTY - CRANDON PROJECT
Applicant/Owner: NMC
Investigator: BHELMANDOLLAR

Date: 8/17/98
County: FOREST
State: WI

Do Normal Circumstances exist on the site? Yes (No)
Is the site significantly disturbed (Atypical Situations? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID: T4
Transect ID: 1
Plot ID: B

VEGETATION

Dominant Plant Species	Stratum	Indicator
1. Clintonia borealis	HERB	FACU
2. Populus tremuloides	TREE	FAC
3. Acer rubrum	TREE	FAC
4. Alnus sp		
5. Cornus stolonifera	SHRUB	FACW
6. Eupatorium perfoliatum	HERB	FACW+
7. Phalaris arundinacea	HERB	FACW+
8. Carex sp		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks: AREA HAS BEEN SIGNIFICANTLY AFFECTED BY LOGGING.

HYDROLOGY

_____ Recorded Data (Describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other

X No Recorded Data Available

Field Observations:

Depth of Surface Water: N/D (in.)
Depth to Free Water in Pit: N/D (in.)
Depth to Saturated Soil: N/D (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
_____ Saturated in Upper 12 inches
_____ Water Marks
_____ Drift Lines
_____ Sediment Deposits
X Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

_____ Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks: AREA IS DRY. HOWEVER, IT HAS BEEN A BELOW AVERAGE YEAR FOR RAINFALL.
EVIDENCE OF HYDROLOGY (DEPRESSIONAL AREAS, DRAINAGE ETC) WAS NOTED

SOILS

Map Unit Name
(Series and Phase) _____ Drainage Class: _____

Field Observations

Taxonomy (Subgroup): _____ Confirm Mapped Type? Yes No

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretic. Structure, etc.
0-4		10YR 4/3			SILTY SAND
4-10		10YR 4/3	GLAY 2.5/5B	>25% ORGANIC STREAKING	SAND
10-24		GLAY 2.5/5B	10YR 4/3	<25%	SAND

Hydric Soil Indicators:

____	Histosol	____	Concretions
____	Histic Epipedon	____	High Organic Content in Surface Layer in Sandy Soils
____	Sulfidic Odor	X	Organic Streaking in Sandy Soils
____	Aquic Moisture Regime	____	Listed on Local Hydric Soils List
____	Reducing Conditions	____	Listed on National Hydric Soils List
____	Gleyed or Low-Chrome Colors	____	Other (Explain in Remarks)

Remarks: SOIL WAS NOT SATURATED. HOWEVER, THERE IS EVIDENCE OF PREVIOUSLY SATURATED SOIL.

WETLAND DETERMINATION

		(Circle)
Hydrophytic Vegetation Present?	(Yes)	No
Wetland Hydrology Present?	(Yes)	No
Hydric Soils Present?	(Yes)	No

Is this Sampling Point Within a Wetland? (Yes) No

Remarks:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: RUDLOFF PROPERTY - CRANDON PROJECT
Applicant/Owner: NMC
Investigator: BHELMANDOLLAR

Date: 8/17/98
County: FOREST
State: WI

Do Normal Circumstances exist on the site? Yes (No)
Is the site significantly disturbed (Atypical Situations? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID: T4
Transect ID: 2
Plot ID: A

VEGETATION

Dominant Plant Species	Stratum	Indicator
1. Melilotus alba	HERB	FACU
2. Taraxicum officinale	HERB	FACU
3. ALFALFA		
4.		
5.		
6.		
7.		
8.		

Dominant Plant Species	Stratum	Indicator
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks: WITHIN AGRICULTURAL FIELD ADJACENT TO T4.

HYDROLOGY

_____ Recorded Data (Describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other

X No Recorded Data Available

Field Observations:

Depth of Surface Water: N/A (in.)
Depth to Free Water in Pit: N/A (in.)
Depth to Saturated Soil: N/A (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
_____ Saturated in Upper 12 inches
_____ Water Marks
_____ Drift Lines
_____ Sediment Deposits
_____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

_____ Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks:

SOILS

Map Unit Name
(Series and Phase) _____ Drainage Class: _____

Field Observations
Taxonomy (Subgroup): _____ Confirm Mapped Type? Yes N

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretic. Structure, etc.
0-10		10YR 4/3			SILTY SAND
10-18		10YR 6/8			SAND

Hydric Soil Indicators:

_____	Histosol	_____	Concretions
_____	Histic Epipedon	_____	High Organic Content in Surface Layer in Sandy Soils
_____	Sulfidic Odor	_____	Organic Streaking in Sandy Soils
_____	Aquic Moisture Regime	_____	Listed on Local Hydric Soils List
_____	Reducing Conditions	_____	Listed on National Hydric Soils List
_____	Gleyed or Low-Chroma Colors	_____	Other (Explain in Remarks)

Remarks: NON-HYDRIC SOIL. PLOT IN ACTIVE AGRICULTURAL LAND

WETLAND DETERMINATION

Hydrophytic Vegetation Present?	Yes	(No)	(Circle)
Wetland Hydrology Present?	Yes	(No)	
Hydric Soils Present?	Yes	(No)	

Is this Sampling Point Within a Wetland? Yes (No) (Circle)

Remarks:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: RUDLOFF PROPERTY - CRANDON PROJECT
Applicant/Owner: NMC
Investigator: BHELMANDOLLAR

Date: 8/17/98
County: FOREST
State: WI

Do Normal Circumstances exist on the site? Yes (No)
Is the site significantly disturbed (Atypical Situations? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID: T4
Transect ID: 2
Plot ID: B

VEGETATION

Dominant Plant Species	Stratum	Indicator
1. Solidago gigantea	HERB	OBL
2. Alnus rugosa	SHRUB	OBL
3. ~~Scirpus cyperinus~~	~~HERB~~	~~OBL~~
4. Scirpus cyperinus	HERB	OBL
5. Salix sp.		
6. Juncus effusus		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks: AREA HAS BEEN CLEARED BY AGRICULTURAL LAND. IT APPEARS THAT IT HAS BEEN ABANDONED FOR SEVERAL YEARS.

HYDROLOGY

_____ Recorded Data (Describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other

X No Recorded Data Available

Field Observations:

Depth of Surface Water: N/A (in.)

Depth to Free Water in Pit: N/A (in.)

Depth to Saturated Soil: SURFACE (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
X Saturated in Upper 12 inches
_____ Water Marks
_____ Drift Lines
_____ Sediment Deposits
_____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

_____ Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks:

SOILS

Map Unit Name
(Series and Phase) _____ Drainage Class: _____

Taxonomy (Subgroup): _____ Field Observations
Confirm Mapped Type? Yes No

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretic. Structure, etc.
0-12		10YR 4/2	10YR 6/6	< 20%	SANDY SILT
12-20		10YR 6/6	10YR 4/2 10YR 7/1	< 20%	

Hydric Soil Indicators:

____	Histosol	____	Concretions
____	Histic Epipedon	____	High Organic Content in Surface Layer in Sandy Soils
____	Sulfidic Odor	X	Organic Streaking in Sandy Soils
____	Aquic Moisture Regime	____	Listed on Local Hydric Soils List
____	Reducing Conditions	____	Listed on National Hydric Soils List
X	Gleyed or Low-Chrome Colors	____	Other (Explain in Remarks)

Remarks: SOIL HAS BEEN DISTURBED BY AGRICULTURAL ACTIVITIES. HYDRIC SOIL INDICATORS EVIDENT.

WETLAND DETERMINATION

Hydrophytic Vegetation Present?	(Yes)	No	(Circle)
Wetland Hydrology Present?	(Yes)	No	
Hydric Soils Present?	(Yes)	No	

Is this Sampling Point Within a Wetland? (Yes) No (Circle)

Remarks:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: RUDLOFF PROPERTY - CRANDON PROJECT Applicant/Owner: NMC Investigator: BHELMANDOLLAR	Date: 8/17/98 County: FOREST State: WI
Do Normal Circumstances exist on the site? Yes (No) Is the site significantly disturbed (Atypical Situations? Yes (No) Is the area a potential Problem Area? Yes (No) (If needed, explain on reverse.)	Community ID: T9 Transect ID: 3 Plot ID: 1A

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. TRIFOLIUM AGRARIUM	HERB	FACU	9.		
2. AGROPYRON REPENS			10.		
3.			11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks: WITHIN AG. FIELD

HYDROLOGY

_____ Recorded Data (Describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other

_____ No Recorded Data Available

Field Observations:

Depth of Surface Water: N/A (in.)

Depth to Free Water in Pit: N/A (in.)

Depth to Saturated Soil: N/A (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
_____ Saturated in Upper 12 inches
_____ Water Marks
_____ Drift Lines
_____ Sediment Deposits
_____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

_____ Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks:

SOILS

Map Unit Name
(Series and Phase) _____ Drainage Class: _____

Field Observations
Taxonomy (Subgroup): _____ Confirm Mapped Type? Yes N

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretic. Structure, etc.
0-10		10YR 4/3			SILTY SAND
10-18		10YR 6/8			SAND

Hydric Soil Indicators:

_____	Histosol	_____	Concretions
_____	Histic Epipedon	_____	High Organic Content in Surface Layer in Sandy Soils
_____	Sulfidic Odor	_____	Organic Streaking in Sandy Soils
_____	Aquic Moisture Regime	_____	Listed on Local Hydric Soils List
_____	Reducing Conditions	_____	Listed on National Hydric Soils List
_____	Gleyed or Low-Chrome Colors	_____	Other (Explain in Remarks)

Remarks: NON-HYDRIC SOIL

WETLAND DETERMINATION

Hydrophytic Vegetation Present?	Yes	(No)	(Circle)
Wetland Hydrology Present?	Yes	(No)	
Hydric Soils Present?	Yes	(No)	

Is this Sampling Point Within a Wetland? Yes (No) (Circle)

Remarks:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: RUDLOFF PROPERTY - CRANDON PROJECT Applicant/Owner: NMC Investigator: BHELMANDOLLAR	Date: 8/17/98 County: FOREST State: WI
Do Normal Circumstances exist on the site? Yes (No) Is the site significantly disturbed (Atypical Situations? Yes (No) Is the area a potential Problem Area? Yes (No) (If needed, explain on reverse.)	Community ID: T4 Transect ID: 3 Plot ID: B

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Scirpus americanus	HERB	OBL	9.		
2. Scirpus cyperinus	HERB	OBL	10.		
3. Salix sp			11.		
4. Solidago gigantea	HERB	OBL	12.		
5. Iris versicolor	HERB	OBL	13.		
6. Phalaris arundinacea	HERB	FACW	14.		
7. Juncus effusis			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks: PLOT WITHIN ABANDONED AGRICULTURAL LAND

HYDROLOGY

_____ Recorded Data (Describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other

__X__ No Recorded Data Available

Field Observations:

Depth of Surface Water: N/A (in.)

Depth to Free Water in Pit: N/A (in.)

Depth to Saturated Soil: SURFACE (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
__X__ Saturated in Upper 12 inches
_____ Water Marks
_____ Drift Lines
_____ Sediment Deposits
_____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

_____ Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks:

SOILS

Map Unit Name
(Series and Phase) _____ Drainage Class: _____

Field Observations

Taxonomy (Subgroup): _____ Confirm Mapped Type? Yes N

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretic: Structure, etc.
0-4		10YR3/2			SILTY SAND
4-24		10YR6/8	10YR7/1	50%	

Hydric Soil Indicators:

	Histosol		Concretions
	Histic Epipedon		High Organic Content in Surface Layer in Sandy Soils
	Sulfidic Odor		Organic Streaking in Sandy Soils
	Aquic Moisture Regime		Listed on Local Hydric Soils List
	Reducing Conditions		Listed on National Hydric Soils List
X	Gleyed or Low-Chroma Colors		Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present? (Yes) No (Circle)
Wetland Hydrology Present? (Yes) No
Hydric Soils Present? (Yes) No

(Circle)
Is this Sampling Point Within a Wetland? (Yes) No

Remarks:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: RUDLOFF PROPERTY - CRANDON PROJECT
Applicant/Owner: NMC
Investigator: BHELMANDOLLAR

Date: 8/17/98
County: FOREST
State: WI

Do Normal Circumstances exist on the site? Yes (No)
Is the site significantly disturbed (Atypical Situations? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID: ~~EA~~ Z16
Transect ID: 4
Plot ID: A

VEGETATION

Dominant Plant Species	Stratum	Indicator
1. ALGILG		
2. POA SP.		
3.		
4.		
5.		
6.		
7.		
8.		

Dominant Plant Species	Stratum	Indicator
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks: EDGE OF AGRICULTURAL FIELD.

HYDROLOGY

_____ Recorded Data (Describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other

X No Recorded Data Available

Field Observations:

Depth of Surface Water: N/D (in.)
Depth to Free Water in Pit: N/D (in.)
Depth to Saturated Soil: N/D (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
_____ Saturated in Upper 12 inches
_____ Water Marks
_____ Drift Lines
_____ Sediment Deposits
_____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

_____ Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks:

SOILS

Map Unit Name
(Series and Phase) _____ Drainage Class: _____

Taxonomy (Subgroup): _____ Field Observations
Confirm Mapped Type? Yes N

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretic. Structure, etc.
0-4		10YR3/3			SANDY SILT
4-18		2.5Y 6/4			SANDY SILT

Hydric Soil Indicators:

_____ Histosol
_____ Histic Epipedon
_____ Sulfidic Odor
_____ Aquic Moisture Regime
_____ Reducing Conditions
_____ Gleyed or Low-Chrome Colors
_____ Concretions
_____ High Organic Content in Surface Layer in Sandy Soils
_____ Organic Streaking in Sandy Soils
_____ Listed on Local Hydric Soils List
_____ Listed on National Hydric Soils List
_____ Other (Explain in Remarks)

Remarks: NON-HYDRIC SOIL

WETLAND DETERMINATION

Hydrophytic Vegetation Present? Yes (No) (Circle)
Wetland Hydrology Present? Yes (No)
Hydric Soils Present? Yes (No)

(Circle)
Is this Sampling Point Within a Wetland? Yes (No)

Remarks:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: RUDLOFF PROPERTY - CRANDON PROJECT
Applicant/Owner: NMC
Investigator: BHELLMANDOLLAR

Date: 8/17/98
County: FOREST
State: WI

Do Normal Circumstances exist on the site? (Yes) No
Is the site significantly disturbed (Atypical Situations? Yes (NO)
Is the area a potential Problem Area? Yes (NO)
(If needed, explain on reverse.)

Community ID: ~~TF~~ Z-16
Transect ID: 1
Plot ID: B

VEGETATION

Dominant Plant Species	Stratum	Indicator
1. Fraxinus pennsylvanica	TREE	FACW
2. Abies balsamea	TREE	FACW
3. Athyrium filix-femina	HERB	FAC
4. Onoclea sensibilis	HERB	FACW
5. Acer rubrum	TREE	FAC
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks: WITHIN A DEPRESSION ADJACENT TO AGRICULTURE.

HYDROLOGY

_____ Recorded Data (Describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other

X No Recorded Data Available

Field Observations:

Depth of Surface Water: N/A (in.)

Depth to Free Water in Pit: N/A (in.)

Depth to Saturated Soil: SURFACE (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
X Saturated in Upper 12 inches
X Water Marks
_____ Drift Lines
_____ Sediment Deposits
X Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

_____ Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks:

SOILS

Map Unit Name
(Series and Phase) _____ Drainage Class: _____

Field Observations

Taxonomy (Subgroup): _____ Confirm Mapped Type? Yes No

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretic. Structure, etc.
0-24		10YR 2/1	10YR 4/2	≅ 30%	ORGANIC

Hydric Soil Indicators:

_____	Histosol	_____	Concretions
_____	Histic Epipedon	_____	High Organic Content in Surface Layer in Sandy Soils
X	Sulfidic Odor	_____	Organic Streaking in Sandy Soils
_____	Aquic Moisture Regime	_____	Listed on Local Hydric Soils List
_____	Reducing Conditions	_____	Listed on National Hydric Soils List
_____	Gleyed or Low-Chrome Colors	X	Other (Explain in Remarks)

Remarks: SOIL CONSISTS OF ORGANIC MATERIAL.

WETLAND DETERMINATION

Hydrophytic Vegetation Present?	(Yes)	No	(Circle)
Wetland Hydrology Present?	(Yes)	No	
Hydric Soils Present?	(Yes)	No	

(Circle)

Is this Sampling Point Within a Wetland? (Yes) No

Remarks:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: RUDLOFF PROPERTY - CRANDON PROJECT
Applicant/Owner: NMC
Investigator: BHELMANDOLLAR

Date: 8/17/98
County: FOREST
State: WI

Do Normal Circumstances exist on the site? Yes (No)
Is the site significantly disturbed (Atypical Situations? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID: Z-16
Transect ID: 35
Plot ID: A

VEGETATION

Dominant Plant Species	Stratum	Indicator
1. ALFALFA		
2.		
3.		
4.		
5.		
6.		
7.		
8.		

Dominant Plant Species	Stratum	Indicator
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks: WITHIN AGRICULTURAL FIELD

HYDROLOGY

_____ Recorded Data (Describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other

X No Recorded Data Available

Field Observations:

Depth of Surface Water: N/A (in.)

Depth to Free Water in Pit: N/A (in.)

Depth to Saturated Soil: N/A (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
_____ Saturated in Upper 12 inches
_____ Water Marks
_____ Drift Lines
_____ Sediment Deposits
_____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

_____ Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks:

SOILS

Map Unit Name
(Series and Phase) _____ Drainage Class: _____

Taxonomy (Subgroup): _____ Field Observations
Confirm Mapped Type? Yes N:-

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretic: Structure, etc.
0-10		10YR 4/3			SANDY SILT
10-20		10YR 5/6	10YR 4/3		SANDY SILT

Hydric Soil Indicators:

_____ Histosol
_____ Histic Epipedon
_____ Sulfidic Odor
_____ Aquic Moisture Regime
_____ Reducing Conditions
_____ Gleyed or Low-Chrome Colors
_____ Concretions
_____ High Organic Content in Surface Layer in Sandy Soils
_____ Organic Streaking in Sandy Soils
_____ Listed on Local Hydric Soils List
_____ Listed on National Hydric Soils List
_____ Other (Explain in Remarks)

Remarks: ACTIVE AG. LAND

WETLAND DETERMINATION

Hydrophytic Vegetation Present? Yes (No) (Circle)
Wetland Hydrology Present? Yes (No)
Hydric Soils Present? Yes (No)

(Circle)
Is this Sampling Point Within a Wetland? Yes (No)

Remarks:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: RUDLOFF PROPERTY - CRANDON PROJECT Applicant/Owner: NMC Investigator: BHELMANDOLLAR	Date: 8/17/98 County: FOREST State: WI
Do Normal Circumstances exist on the site? (Yes) No Is the site significantly disturbed (Atypical Situations? Yes (No) Is the area a potential Problem Area? Yes (No) (If needed, explain on reverse.)	Community ID: 2-16 Transect ID: S 5 Plot ID: B

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Cornus Sedericea	SHRUB	FACW	9.		
2. Salix Sp	SHRUB		10.		
3. Onoclea Sensibilis	HERB	FACW	11.		
4. Scirpus Cyperinus	HERB	OBL	12.		
5. Sphagnum			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks: WITHIN DEPRESSION ADJACENT TO AG. LAND

HYDROLOGY

_____ Recorded Data (Describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other

X No Recorded Data Available

Field Observations:

Depth of Surface Water: N/P (in.)

Depth to Free Water in Pit: N/P (in.)

Depth to Saturated Soil: SURFACE (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
X Saturated in Upper 12 inches
X Water Marks
X Drift Lines
X Sediment Deposits
X Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

_____ Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks:

SOILS

Map Unit Name
(Series and Phase) _____ Drainage Class: _____

Field Observations

Taxonomy (Subgroup): _____ Confirm Mapped Type? Yes No

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretic: Structure, etc.
0-4		10YR3/1			ORGANIC
4-24		10YR4/2	10YR 5/1 10YR 7/1		SILT

Hydric Soil Indicators:

	Histosol		Concretions
	Histic Epipedon		High Organic Content in Surface Layer in Sandy Soils
X	Sulfidic Odor		Organic Streaking in Sandy Soils
	Aquic Moisture Regime		Listed on Local Hydric Soils List
	Reducing Conditions		Listed on National Hydric Soils List
X	Gleyed or Low-Chroma Colors		Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present? (Yes) No (Circle)
Wetland Hydrology Present? (Yes) No
Hydric Soils Present? (Yes) No

(Circle)
Is this Sampling Point Within a Wetland? (Yes) No

Remarks:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: RUDLOFF PROPERTY - CRANDON PROJECT Applicant/Owner: NMC Investigator: BHELMANDOLLAR	Date: 8/17/98 County: FOREST State: WI
Do Normal Circumstances exist on the site? Yes (No) Is the site significantly disturbed (Atypical Situations? Yes (No) Is the area a potential Problem Area? Yes (No) (If needed, explain on reverse.)	Community ID: 216 Transect ID: 36 Plot ID: A

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Pteridium aquilinum	HERB	FACU	9.		
2. Poa Sp			10.		
3. Lysimachia alba	HERB	FACU	11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks: EDGE OF CUT FIELD

HYDROLOGY

_____ Recorded Data (Describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other

__X__ No Recorded Data Available

Field Observations:

Depth of Surface Water: N/A (in.)

Depth to Free Water in Pit: N/A (in.)

Depth to Saturated Soil: N/A (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
_____ Saturated in Upper 12 inches
_____ Water Marks
_____ Drift Lines
_____ Sediment Deposits
_____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

_____ Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks:

SOILS

Map Unit Name
(Series and Phase) _____ Drainage Class: _____

Taxonomy (Subgroup): _____ Field Observations
Confirm Mapped Type? Yes No

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretic. Structure, etc.
0-14		10YR 5/3			
14-24		10YR 5/3	10YR 6/8		

Hydric Soil Indicators:

_____ Histosol	_____ Concretions
_____ Histic Epipedon	_____ High Organic Content in Surface Layer in Sandy Soils
_____ Sulfidic Odor	_____ Organic Streaking in Sandy Soils
_____ Aquic Moisture Regime	_____ Listed on Local Hydric Soils List
_____ Reducing Conditions	_____ Listed on National Hydric Soils List
_____ Gleyed or Low-Chrome Colors	_____ Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present? Yes (No) (Circle)
Wetland Hydrology Present? Yes (No)
Hydric Soils Present? Yes (No)

(Circle)
Is this Sampling Point Within a Wetland? Yes (No)

Remarks:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: RUDLOFF PROPERTY - CRANDON PROJECT
Applicant/Owner: NMC
Investigator: BHELMANDOLLAR

Date: 8/17/98
County: FOREST
State: WI

Do Normal Circumstances exist on the site? (Yes) No
Is the site significantly disturbed (Atypical Situations? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID: Z16
Transect ID: B 6
Plot ID: B

VEGETATION

Dominant Plant Species	Stratum	Indicator
1. Alnus Sp.		
2. Fraxinus Pennsylvanica	TREE	FACW
3. ~~Phalaris arundinacea~~	~~HERB~~	~~FACW~~
4. Onoclea Sensibilis	HERB	FACW
5. Abies balsamea	TREE	FACW
6. Acer rubrum	HERB	FAC
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks: WITHIN WETLAND ADJACENT TO AG FIELD

HYDROLOGY

_____ Recorded Data (Describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other

X No Recorded Data Available

Field Observations:

Depth of Surface Water: N/A (in.)
Depth to Free Water in Pit: N/A (in.)
Depth to Saturated Soil: 5 (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
X Saturated in Upper 12 inches
X Water Marks
X Drift Lines
_____ Sediment Deposits
_____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

_____ Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks:

SOILS

Map Unit Name
(Series and Phase) _____ Drainage Class: _____

Taxonomy (Subgroup): _____ Field Observations
Confirm Mapped Type? Yes No

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretic: Structure, etc.
0-8		10YR 5/3	10YR 6/6	<5%	SANDY SILT
8-24		10YR 7/1	10YR 7/8		

Hydric Soil Indicators:

	Histosol	X	Concretions
	Histic Epipedon		High Organic Content in Surface Layer in Sandy Soils
	Sulfidic Odor		Organic Streaking in Sandy Soils
	Aquic Moisture Regime		Listed on Local Hydric Soils List
	Reducing Conditions		Listed on National Hydric Soils List
X	Gleyed or Low-Chrome Colors		Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present?	(Yes)	No	(Circle)
Wetland Hydrology Present?	(Yes)	No	
Hydric Soils Present?	(Yes)	No	

(Circle)
Is this Sampling Point Within a Wetland? (Yes) No

Remarks:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: RUDLOFF PROPERTY - CRANDON PROJECT Applicant/Owner: NMC Investigator: BHELMANDOLLAR	Date: 8/17/98 County: FOREST State: WI
Do Normal Circumstances exist on the site? Yes (No) Is the site significantly disturbed (Atypical Situations? Yes (No) Is the area a potential Problem Area? Yes (No) (If needed, explain on reverse.)	Community ID: 216 Transect ID: 7 Plot ID: A

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Alfalfa			9.		
2. Tragopogon officinale	HERB	FACU	10.		
3. Poa sp			11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks: EDGE OF AG FIELD

HYDROLOGY

_____ Recorded Data (Describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other

__X__ No Recorded Data Available

Field Observations:

Depth of Surface Water: N/A (in.)

Depth to Free Water in Pit: N/A (in.)

Depth to Saturated Soil: N/A (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
_____ Saturated in Upper 12 inches
_____ Water Marks
_____ Drift Lines
_____ Sediment Deposits
_____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

_____ Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks:

SOILS

Map Unit Name
(Series and Phase) _____ Drainage Class: _____

Taxonomy (Subgroup): _____ Field Observations
Confirm Mapped Type? Yes No

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretic: Structure, etc.
0-8		10YR 5/6			
8-24		10YR 6/8			

Hydric Soil Indicators:

_____ Histosol	_____ Concretions
_____ Histic Epipedon	_____ High Organic Content in Surface Layer in Sandy Soils
_____ Sulfidic Odor	_____ Organic Streaking in Sandy Soils
_____ Aquic Moisture Regime	_____ Listed on Local Hydric Soils List
_____ Reducing Conditions	_____ Listed on National Hydric Soils List
_____ Gleyed or Low-Chrome Colors	_____ Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present? Yes (No) (Circle)
Wetland Hydrology Present? Yes (No)
Hydric Soils Present? Yes (No)

Is this Sampling Point Within a Wetland? Yes (No) (Circle)

Remarks:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: RUDLOFF PROPERTY - CRANDON PROJECT
Applicant/Owner: NMC
Investigator: BHEUMANDOLLAR

Date: 8/17/98
County: FOREST
State: WI

Do Normal Circumstances exist on the site? Yes (No)
Is the site significantly disturbed (Atypical Situations? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID: Z-16
Transect ID: E 7
Plot ID: B

VEGETATION

Dominant Plant Species	Stratum	Indicator
1. SCIRPUS CYPERINUS	HERB	OBL
2. POACEA SENSIBILIS	HERB	FACW
3. ACER RUBRUM	TREE	FAC
4.		
5.		
6.		
7.		
8.		

Dominant Plant Species	Stratum	Indicator
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks: EDGE OF AG FIELD

HYDROLOGY

_____ Recorded Data (Describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other

X No Recorded Data Available

Field Observations:

Depth of Surface Water: N/D (in.)

Depth to Free Water in Pit: N/D (in.)

Depth to Saturated Soil: 5 (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
X Saturated in Upper 12 inches
_____ Water Marks
_____ Drift Lines
_____ Sediment Deposits
_____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

_____ Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks:

SOILS

Map Unit Name
(Series and Phase) _____ Drainage Class: _____

Taxonomy (Subgroup): _____ Field Observations
Confirm Mapped Type? Yes N

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretic. Structure, etc.
0-2		10YR 2/1			ORGANIC
2-8		10YR 4/6	10YR 2/1		OM - SANDY
8-24		10R 7/1	10YR 4/1		SANDY SILT

Hydric Soil Indicators:

____	Histosol	____	Concretions
____	Histic Epipedon	X	High Organic Content in Surface Layer in Sandy Soils
____	Sulfidic Odor	X	Organic Streaking in Sandy Soils
____	Aquic Moisture Regime	____	Listed on Local Hydric Soils List
____	Reducing Conditions	____	Listed on National Hydric Soils List
X	Gleyed or Low-Chrome Colors	____	Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present? (Yes) No (Circle)
Wetland Hydrology Present? (Yes) No
Hydric Soils Present? (Yes) No

(Circle)
Is this Sampling Point Within a Wetland? (Yes) No

Remarks:

Appendix E

Vertical Gradient Calculations

Foth & Van Dyke
consultants · engineers · scientists

Client: NMC | Scope I.D.: 93C049
Project: SAP II - AREA H | Page: 1
Prepared By: REM | Date: 9/28/98
Checked By: SVDI | Date: 10/3/98

VERTICAL GRADIENT CALCULATIONS

GIVEN:

VERTICAL GRADIENT (VG) = Elev. of upper well water level − Elevation of lower well water level

* Elevation of water level − Elevation of Midpoint of the gravel pack

* If the gravel pack is entirely submerged midpoint of the gravel pack

Calculate Vertical Gradients

MWH-10 / MWH-10P: $VG = \frac{1581.98 - 1581.36}{1581.98 - 1559.4} = \frac{.62}{22.58} = 0.03$ ↓

MWH-9 / MWH-9P: $VG = \frac{1586.48 - 1586.12}{1586.48 - 1561.2} = \frac{.36}{25.28} = 0.01$ ↓

MWH-11 / MWH-11P: $VG = \frac{1580.66 - 1580.72}{1580.6 - 1554.9} = \frac{-0.06}{25.7} = -0.002$ ↑

** SPH-01 / SPH-01A: $VG = \frac{1579.98 - 1580.51}{1579.98 - 1564.2} = \frac{-0.53}{15.78} = -0.03$ ↑

** SPH-02 / SPH-02A: $VG = \frac{1580.54 - 1580.98}{1580.54 - 1564.2} = \frac{.04}{16.34} = 0.003$ ↓

** SPH-03 / SPH-03A: $VG = \frac{1587.69 - 1588.59}{1587.69 - 1573.7} = \frac{-.90}{13.99} = -0.06$ ↑

** SPH-04 / SPH-04A: $VG = \frac{1588.59 - 1587.28}{1588.59 - 1583.0} = \frac{1.31}{5.59} = 0.234$ ↓

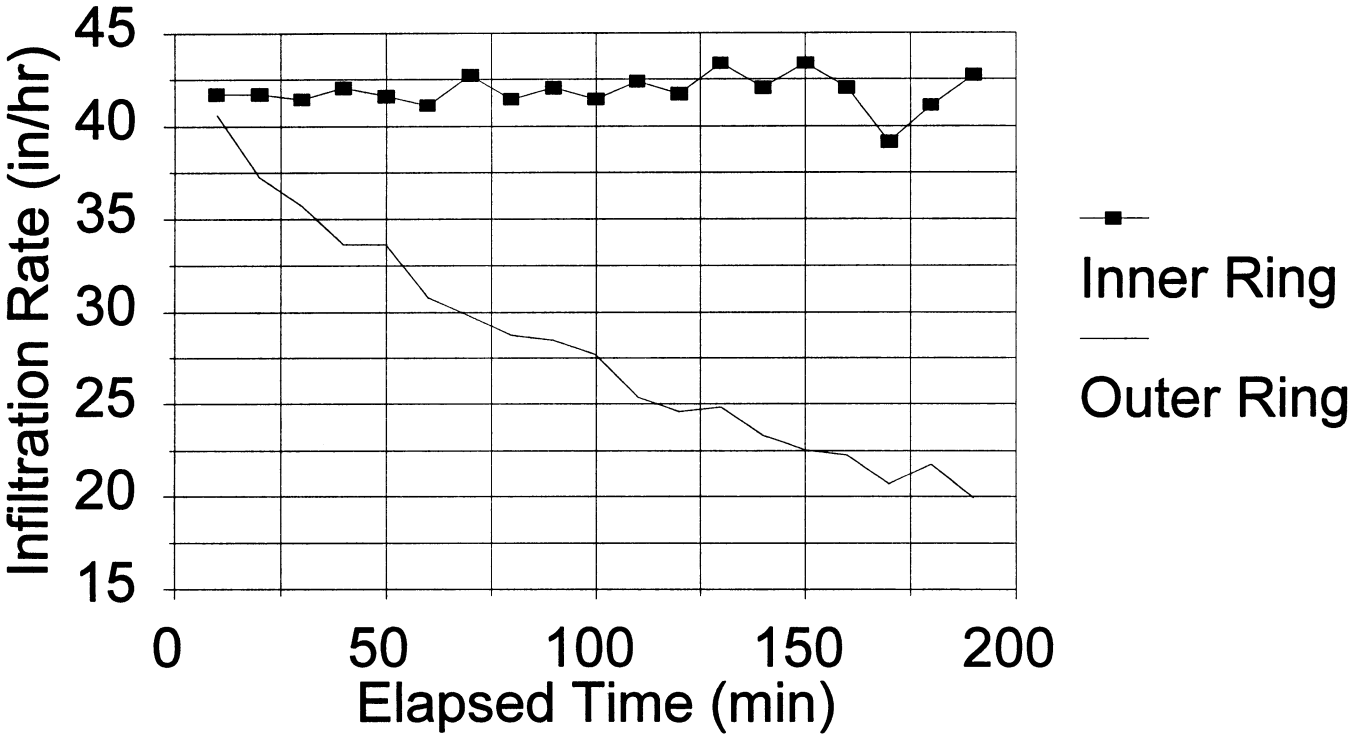
** Top of sand (continuous) to bottom of Sand Point taken as the gravel pack.

Appendix F

Double-Ring Infiltrometer Tests

Infiltration Test

TPH-06B



Data Form for Infiltration Test (ASTM D 3385)

Project: SAPII - Area H
Location: TPH-06B
Water Source: Flannery Shop
Date: August 28, 1998
Estimated Depth to Water Table: Approx. 6 Feet from Ground Surface

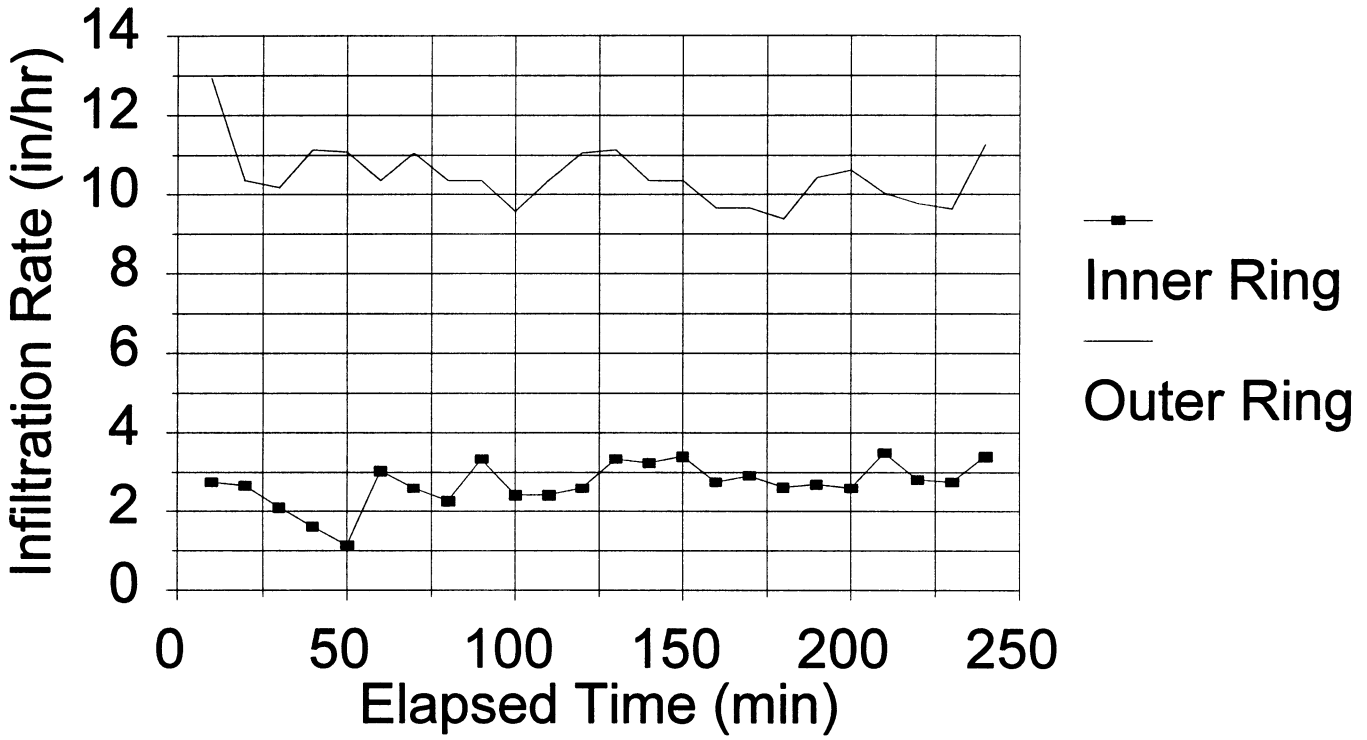
Inner Ring (in2): 113.1
Annular Space (in2): 141.4

Penetration of Rings: Inner: 5.5 inches Outer: 6.5 inches

		Inner Ring		Annular Space		Infiltration Rate	
Trial Number	Time (min.)	Reading (ml)	Flow (in2)	Reading (ml)	Flow (in2)	Inner (in/hr)	Annular (in/hr)
1	10	12900	787.16	15700	958.01	41.76	40.65
2	20	12900	787.16	14400	878.69	41.76	37.29
3	30	12800	781.06	13800	842.08	41.44	35.73
4	40	13000	793.26	13000	793.26	42.08	33.66
5	50	12860	784.72	13000	793.26	41.63	33.66
6	60	12700	774.95	11900	726.14	41.11	30.81
7	70	13200	805.46	11500	701.73	42.73	29.78
8	80	12800	781.06	11100	677.32	41.44	28.74
9	90	13000	793.26	11000	671.22	42.08	28.48
10	100	12800	781.06	10700	652.91	41.44	27.70
11	110	13100	799.36	9800	598.00	42.41	25.37
12	120	12900	787.16	9500	579.69	41.76	24.60
13	130	13400	817.67	9600	585.79	43.38	24.86
14	140	13000	793.26	9000	549.18	42.08	23.30
15	150	13400	817.67	8700	530.87	43.38	22.53
16	160	13000	793.26	8600	524.77	42.08	22.27
17	170	12100	738.34	8000	488.16	39.17	20.71
18	180	12700	774.95	8400	512.57	41.11	21.75
19	190	13200	805.46	7700	469.85	42.73	19.94
20	200	13600	829.87	7700	469.85	44.03	19.94

Infiltration Test

TPH-8D



Data Form for Infiltration Test (ASTM D 3385)

Project: SAPII - Area H
Location: TPH-8D
Water Source: Flannery Shop
Date: August 26, 1998
Estimated Depth to Water Table: Approx. 6 Feet from Ground Surface

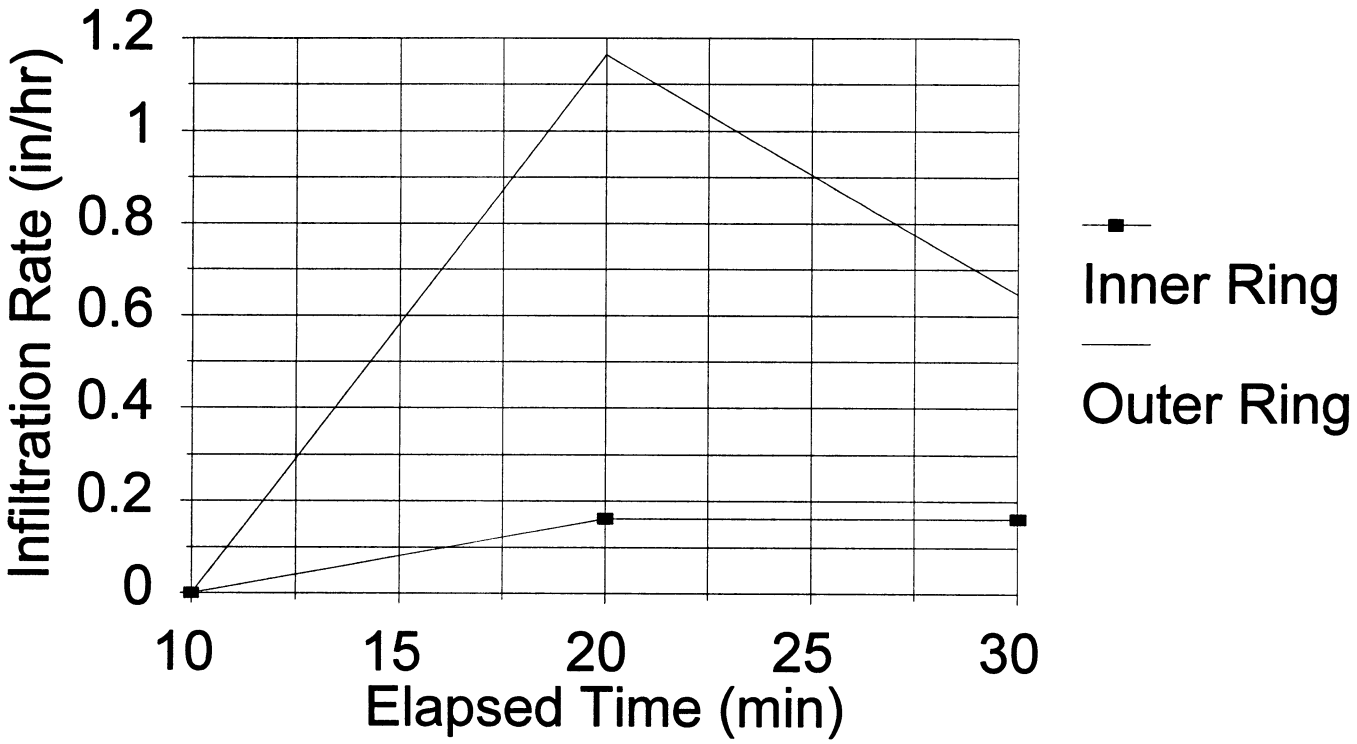
Inner Ring (in2): 113.1
Annular Space (in2): 141.4

Penetration of Rings: Inner: 5.75 inches Outer: 6 inches

		Inner Ring		Annular Space		Infiltration Rate	
Number	Time (min.)	Reading (ml)	Flow (in2)	Reading (ml)	Flow (in2)	Inner (in/hr)	Annular (in/hr)
1	10	850	51.87	5000	305.10	2.75	12.95
2	20	825	50.34	4000	244.08	2.67	10.36
3	30	650	39.66	3930	239.81	2.10	10.18
4	40	500	30.51	4300	262.39	1.62	11.13
5	50	350	21.36	4280	261.17	1.13	11.08
6	60	940	57.36	4000	244.08	3.04	10.36
7	70	800	48.82	4270	260.56	2.59	11.06
8	80	700	42.71	4000	244.08	2.27	10.36
9	90	1030	62.85	4000	244.08	3.33	10.36
10	100	750	45.77	3700	225.77	2.43	9.58
11	110	750	45.77	4000	244.08	2.43	10.36
12	120	800	48.82	4270	260.56	2.59	11.06
13	130	1030	62.85	4300	262.39	3.33	11.13
14	140	1000	61.02	4000	244.08	3.24	10.36
15	150	1050	64.07	4000	244.08	3.40	10.36
16	160	850	51.87	3730	227.60	2.75	9.66
17	170	900	54.92	3730	227.60	2.91	9.66
18	180	810	49.43	3620	220.89	2.62	9.37
19	190	830	50.65	4025	245.61	2.69	10.42
20	200	800	48.82	4100	250.18	2.59	10.62
21	210	1080	65.90	3875	236.45	3.50	10.03
22	220	870	53.09	3775	230.35	2.82	9.77
23	230	850	51.87	3720	226.99	2.75	9.63
24	240	1050	64.07	4350	265.44	3.40	11.26

Infiltration Test

TPH-33B



Data Form for Infiltration Test (ASTM D 3385)

Project: SAPII - Area H
Location: TPH-33B
Water Source: Flannery Shop
Date: August 28, 1998
Estimated Depth to Water Table: Approx. 6 Feet Till

Inner Ring (in2): 113.1
Annular Space (in2): 141.4

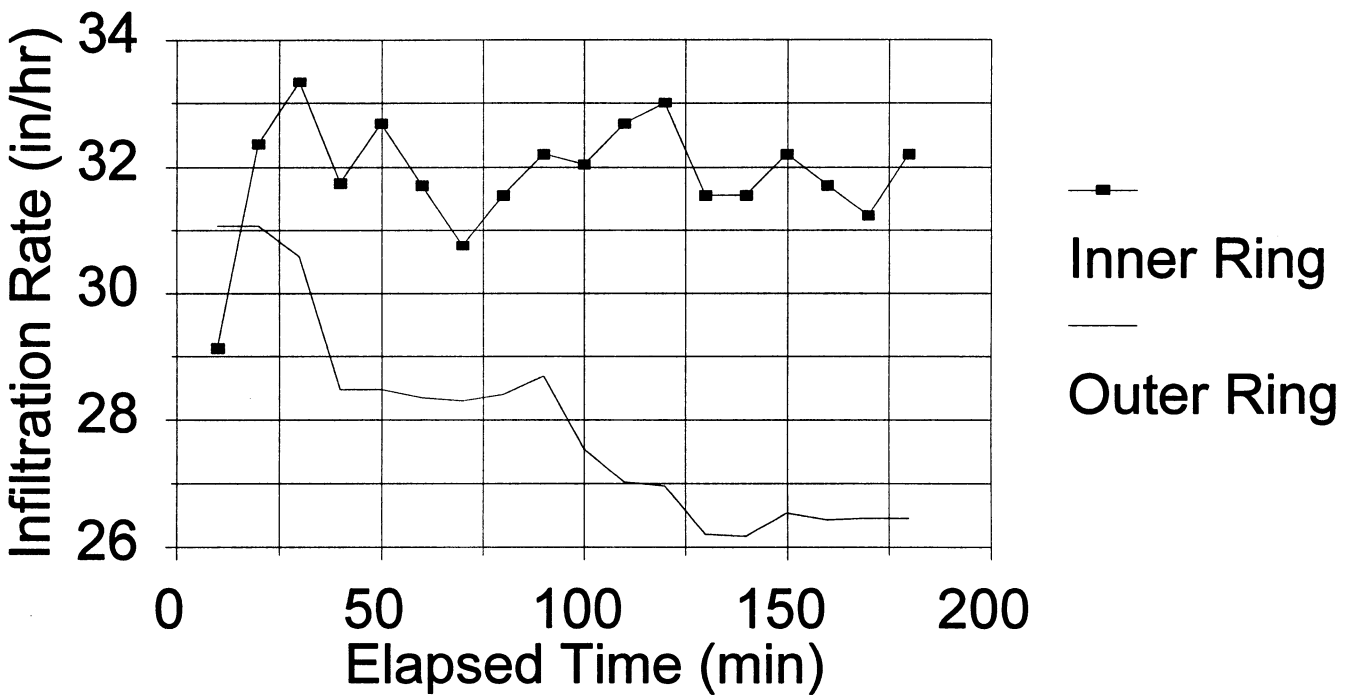
Penetration of Rings: Inner: 5.5 inches Outer: 6 inches

		Inner Ring		Annular Space		Infiltration Rate	
Number	Time (min.)	Reading (ml)	Flow (in2)	Reading (ml)	Flow (in2)	Inner (in/hr)	Annular (in/hr)
1	10	0	0.00	0	0.00	0.00	0.00
2	20	50	3.05	450	27.46	0.16	1.17
3	30	50	3.05	250	15.26	0.16	0.65

J:\SCOPES\93C049\SOILAB~1\INFILAUG.WB2

Infiltration Test

TPH-38B



Data Form for Infiltration Test (ASTM D 3385)

Project: SAPII - Area H
Location: TPH-38B
Water Source: Flannery Shop
Date: August 25, 1998
Estimated Depth to Water Table: Approx. 6.0 feet

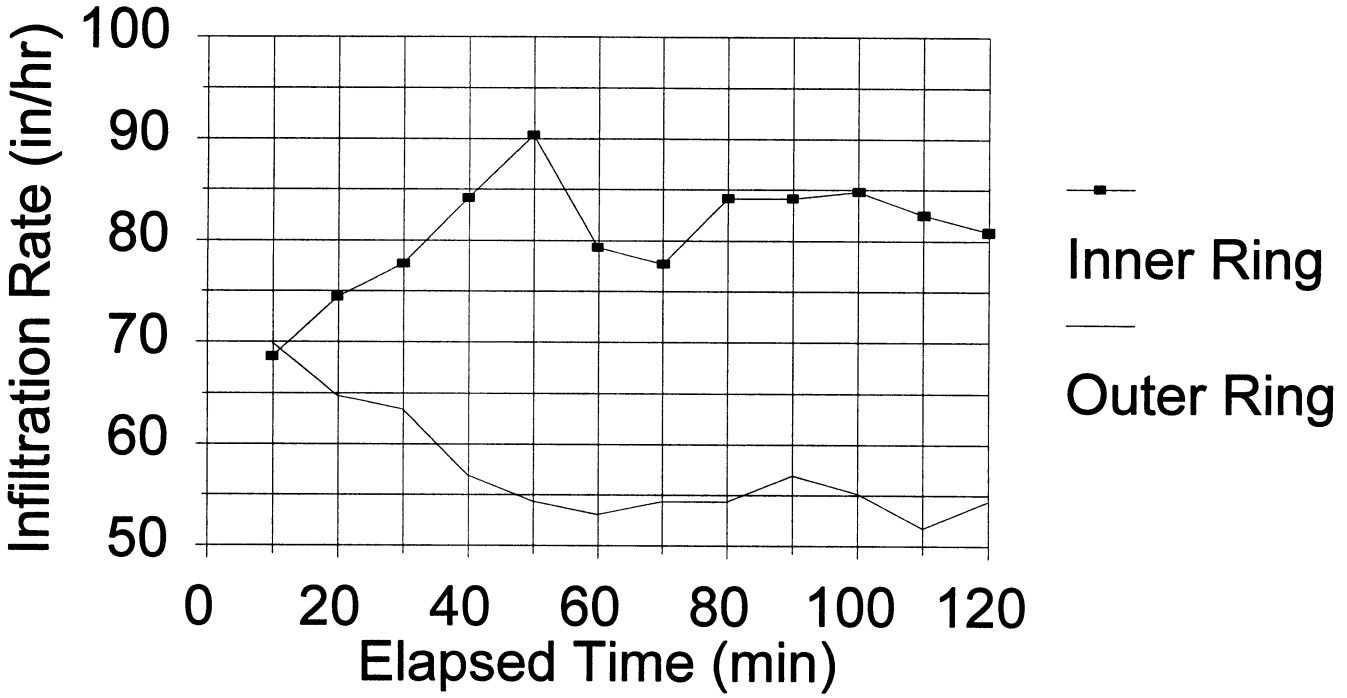
Inner Ring (in2): 113.1
Annular Space (in2): 141.4

Penetration of Rings: Inner: 5 inches Outer: 6 inches

		Inner Ring		Annular Space		Infiltration Rate	
Trial Number	Time (min.)	Reading (ml)	Flow (in2)	Reading (ml)	Flow (in2)	Inner (in/hr)	Annular (in/hr)
1	10	9000	549.18	12000	732.24	29.13	31.07
2	20	10000	610.20	12000	732.24	32.37	31.07
3	30	10300	628.51	11810	720.65	33.34	30.58
4	40	9810	598.61	11000	671.22	31.76	28.48
5	50	10100	616.30	11000	671.22	32.70	28.48
6	60	9800	598.00	10950	668.17	31.72	28.35
7	70	9500	579.69	10930	666.95	30.75	28.30
8	80	9750	594.95	10970	669.39	31.56	28.40
9	90	9950	607.15	11080	676.10	32.21	28.69
10	100	9900	604.10	10635	648.95	32.05	27.54
11	110	10100	616.30	10440	637.05	32.70	27.03
12	120	10200	622.40	10410	635.22	33.02	26.95
13	130	9750	594.95	10120	617.52	31.56	26.20
14	140	9750	594.95	10110	616.91	31.56	26.18
15	150	9950	607.15	10250	625.46	32.21	26.54
16	160	9800	598.00	10210	623.01	31.72	26.44
17	170	9650	588.84	10220	623.62	31.24	26.46
18	180	9950	607.15	10220	623.62	32.21	26.46

Infiltration Test

TPH-42



Data Form for Infiltration Test (ASTM D 3385)

Project: SAPII - Area H
Location: TPH-42
Water Source: Flannery Shop
Date: August 26, 1998
Estimated Depth to Water Table: Approx. 6 feet

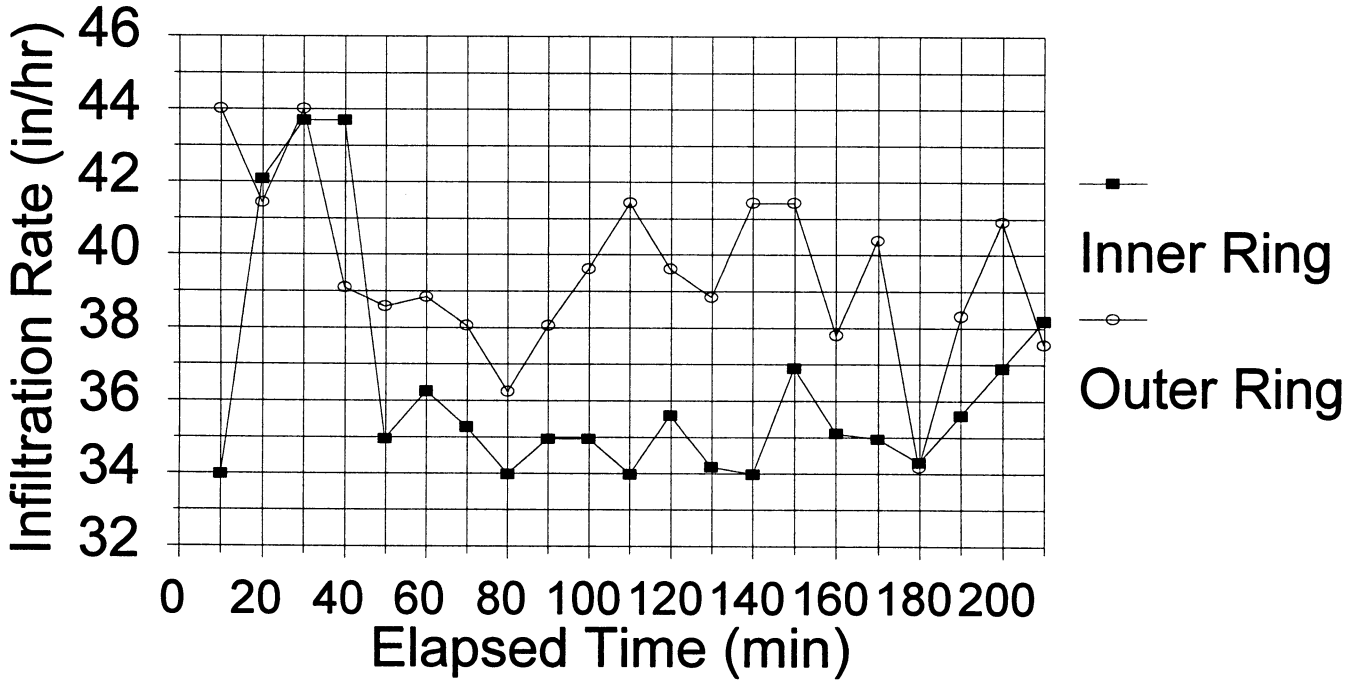
Inner Ring (in2): 113.1
Annular Space (in2): 141.4

Penetration of Rings: Inner: 5.25 inches Outer: 6 inches

		Inner Ring		Annular Space		Infiltration Rate	
Trial Number	Time (min.)	Reading (ml)	Flow (in2)	Reading (ml)	Flow (in2)	Inner (in/hr)	Annular (in/hr)
1	10	21200	1293.62	27000	1647.54	68.63	69.91
2	20	23000	1403.46	25000	1525.50	74.45	64.73
3	30	24000	1464.48	24500	1494.99	77.69	63.44
4	40	26000	1586.52	22000	1342.44	84.17	56.96
5	50	27900	1702.46	21000	1281.42	90.32	54.37
6	60	24500	1494.99	20500	1250.91	79.31	53.08
7	70	24000	1464.48	21000	1281.42	77.69	54.37
8	80	26000	1586.52	21000	1281.42	84.17	54.37
9	90	26000	1586.52	22000	1342.44	84.17	56.96
10	100	26200	1598.72	21300	1299.73	84.81	55.15
11	110	25500	1556.01	20000	1220.40	82.55	51.79
12	120	25000	1525.50	21000	1281.42	80.93	54.37

Infiltration Test

TPH-47



Data Form for Infiltration Test (ASTM D 3385)

Project: SAPII - Area H
Location: TPH-47

Inner Ring (in2): 113.1

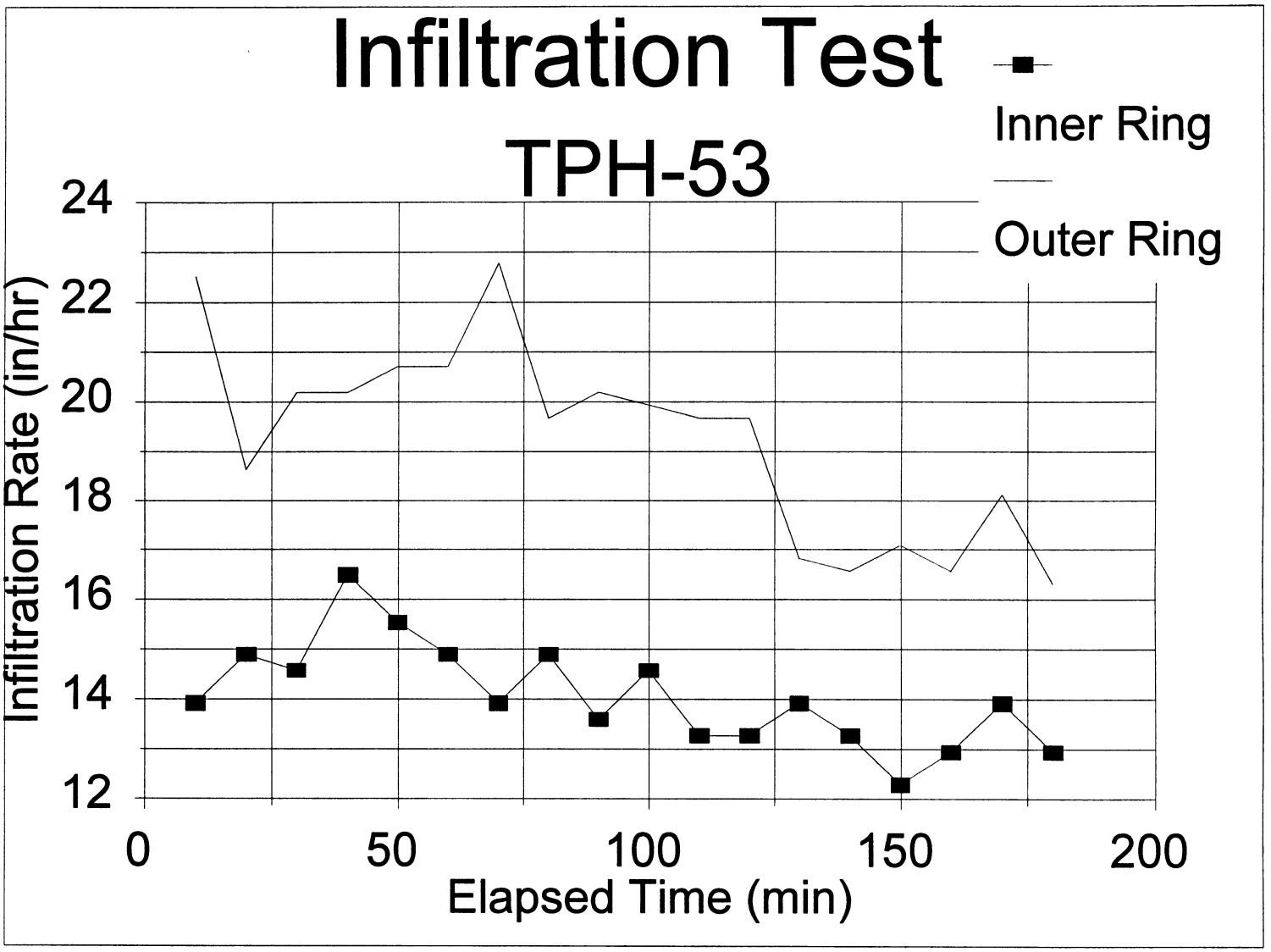
Annular Space (in2): 141.4

Water Source: TW-02 Flannery Shop
Date: August 28, 1998

Penetration of Rings: Inner: 5.25 inches Outer: 6 inches

Estimated Depth to Water Table: Approx. 6 Feet from Ground Surface

		Inner Ring		Annular Space		Infiltration Rate	
Trial Number	Time (min.)	Reading (ml)	Flow (in2)	Reading (ml)	Flow (in2)	Inner (in/hr)	Annular (in/hr)
1	10	10500	640.71	17000	1037.34	33.99	44.02
2	20	13000	793.26	16000	976.32	42.08	41.43
3	30	13500	823.77	17000	1037.34	43.70	44.02
4	40	13500	823.77	15100	921.40	43.70	39.10
5	50	10800	659.02	14900	909.20	34.96	38.58
6	60	11200	683.42	15000	915.30	36.26	38.84
7	70	10900	665.12	14700	896.99	35.28	38.06
8	80	10500	640.71	14000	854.28	33.99	36.25
9	90	10800	659.02	14700	896.99	34.96	38.06
10	100	10800	659.02	15300	933.61	34.96	39.62
11	110	10500	640.71	16000	976.32	33.99	41.43
12	120	11000	671.22	15300	933.61	35.61	39.62
13	130	10560	644.37	15000	915.30	34.18	38.84
14	140	10500	640.71	16000	976.32	33.99	41.43
15	150	11400	695.63	16000	976.32	36.90	41.43
16	160	10850	662.07	14600	890.89	35.12	37.80
17	170	10800	659.02	15600	951.91	34.96	40.39
18	180	10600	646.81	13200	805.46	34.31	34.18
19	190	11000	671.22	14800	903.10	35.61	38.32
20	200	11400	695.63	15800	964.12	36.90	40.91
21	210	11800	720.04	14500	884.79	38.20	37.54


Infiltration Test
TPH-53
Inner Ring
Outer Ring
Infiltration Rate (in/hr)
24
22
20
18
16
14
12
0
50
100
150
200
Elapsed Time (min)

Data Form for Infiltration Test (ASTM D 3385)

Project: SAPII - Area H
Location: TPH-53
Water Source: Flannery Shop
Date: August 27,1998
Estimated Depth to Water Table: Approx. 6 Feet from Ground Surface

Inner Ring (in2): 113.1
Annular Space (in2): 141.4

Pentration of Rings: Inner: 5.20 Inches Outer: 6 Inches

		Inner Ring		Annular Space		Infiltration Rate	
Trial Number	Time (min.)	Reading (ml)	Flow (in2)	Reading (ml)	Flow (in2)	Inner (in/hr)	Annular (in/hr)
1	10	4300	262.39	8700	530.87	13.92	22.53
2	20	4600	280.69	7200	439.34	14.89	18.64
3	30	4500	274.59	7800	475.96	14.57	20.20
4	40	5100	311.20	7800	475.96	16.51	20.20
5	50	4800	292.90	8000	488.16	15.54	20.71
6	60	4600	280.69	8000	488.16	14.89	20.71
7	70	4300	262.39	8800	536.98	13.92	22.79
8	80	4600	280.69	7600	463.75	14.89	19.68
9	90	4200	256.28	7800	475.96	13.60	20.20
10	100	4500	274.59	7700	469.85	14.57	19.94
11	110	4100	250.18	7600	463.75	13.27	19.68
12	120	4100	250.18	7600	463.75	13.27	19.68
13	130	4300	262.39	6500	396.63	13.92	16.83
14	140	4100	250.18	6400	390.53	13.27	16.57
15	150	3800	231.88	6600	402.73	12.30	17.09
16	160	4000	244.08	6400	390.53	12.95	16.57
17	170	4300	262.39	7000	427.14	13.92	18.12
18	180	4000	244.08	6300	384.43	12.95	16.31
19	190	4100	250.18	6500	396.63	13.27	16.83
20	200	4000	244.08	6500	396.63	12.95	16.83

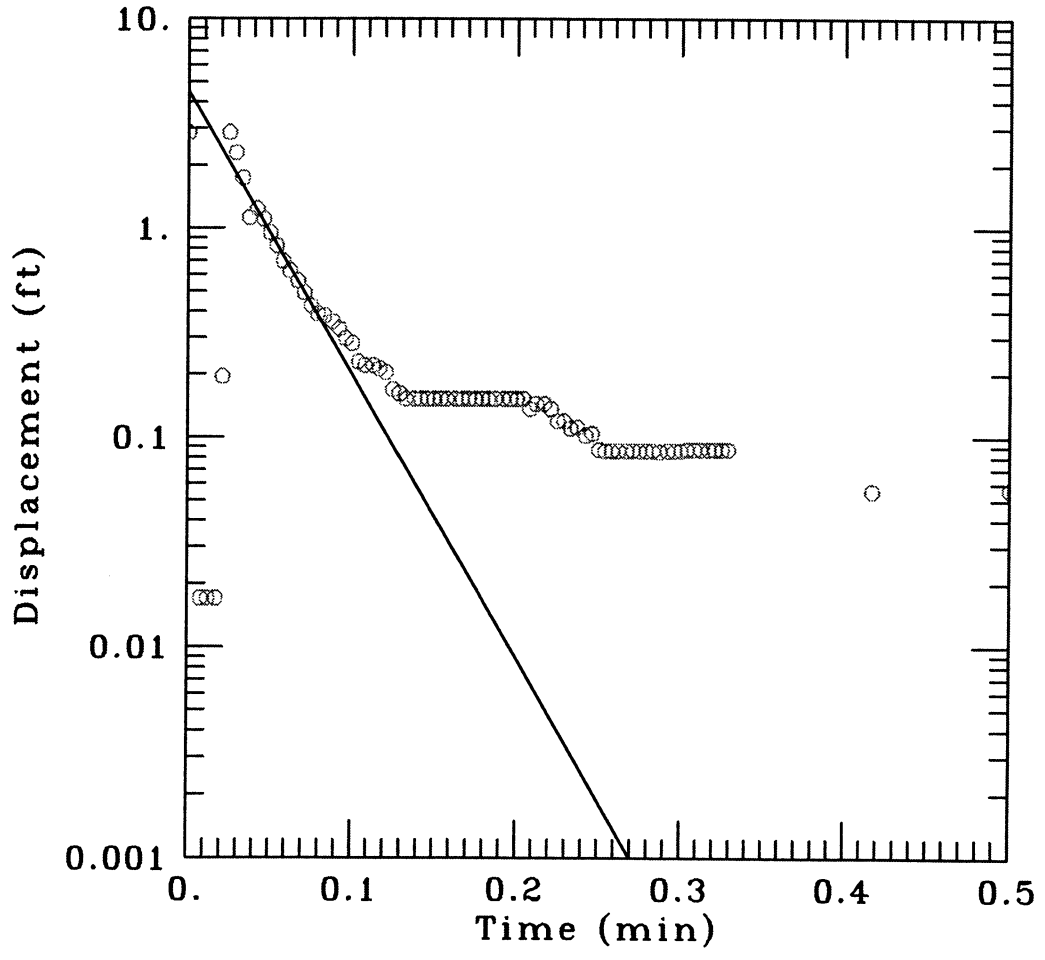
Appendix G

In-Field Hydraulic Conductivity Tests

Note that for well MWH-09P multiple slug-in and slug-out tests were completed to verify the consistency of results. MWH-09P (Test 1) failed due to data logger error. MWH-09P (Test 2) and MWH-09P (Test 4) were slug-in tests. MWH-09P (Test 3) and MWH-09P (Test 5) were slug-out tests. The average of the four tests is reported in Table 4-4 of this report. Slug-out tests were performed on water table wells and MWH-10P. A slug-in test was performed on MWH-11P.

Foth & Van Dyke	
Project No.: 93C049	

MWH-9



DATA SET:
TST13WL1.DAT
09/28/98

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

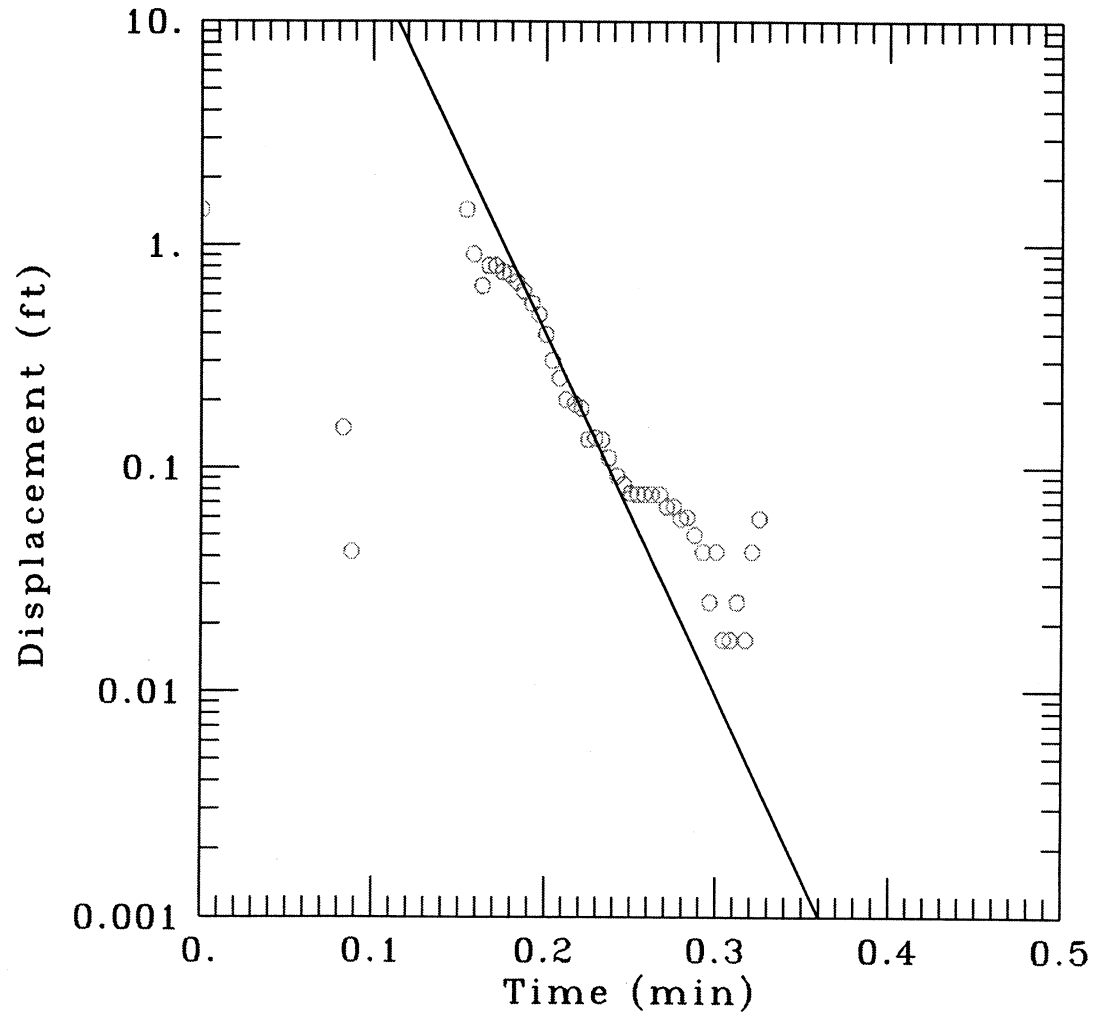
TEST DATE:
September 11, 1998

ESTIMATED PARAMETERS:
K = 0.022 ft/min
y0 = 4.486 ft

TEST DATA:
H0 = 2.863 ft
rc = 0.078 ft
rw = 0.346 ft
L = 10. ft
b = 10.4 ft
H = 9.4 ft

Foth & Van Dyke	
Project No.: 93C049	

MWH-09P (test 2)



DATA SET:
tst15wl1.dat
10/26/98

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
September 11, 1998

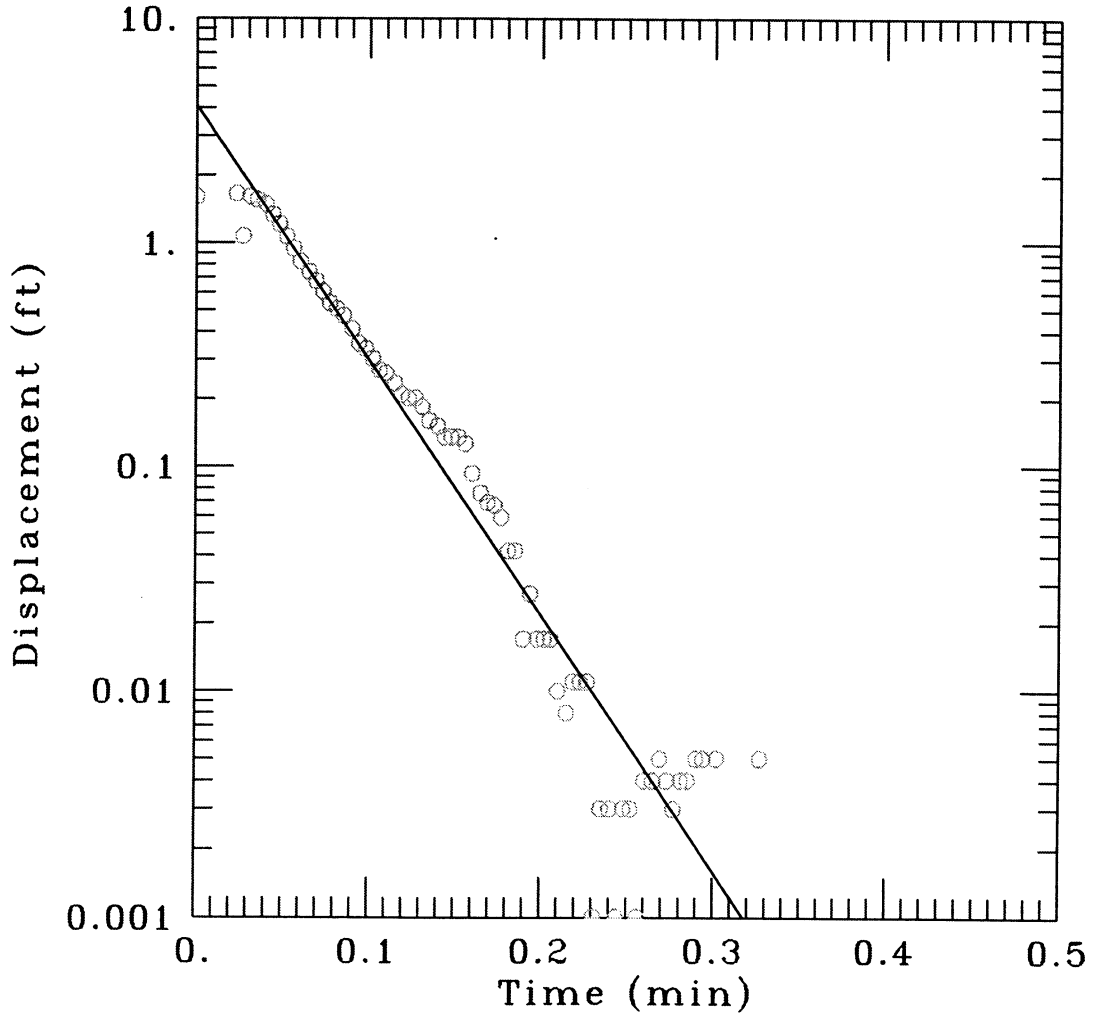
OBS. WELL:
MWH-09P

ESTIMATED PARAMETERS:
K = 0.056 ft/min
y0 = 723.7 ft

TEST DATA:
H0 = 1.437 ft
rc = 0.078 ft
rw = 0.346 ft
L = 5. ft
b = 30.84 ft
H = 29.84 ft

Foth & Van Dyke	
Project No.: 93C049	

MWH-09P (test 3)



DATA SET:
tst16wl1.dat
10/26/98

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
September 11, 1998

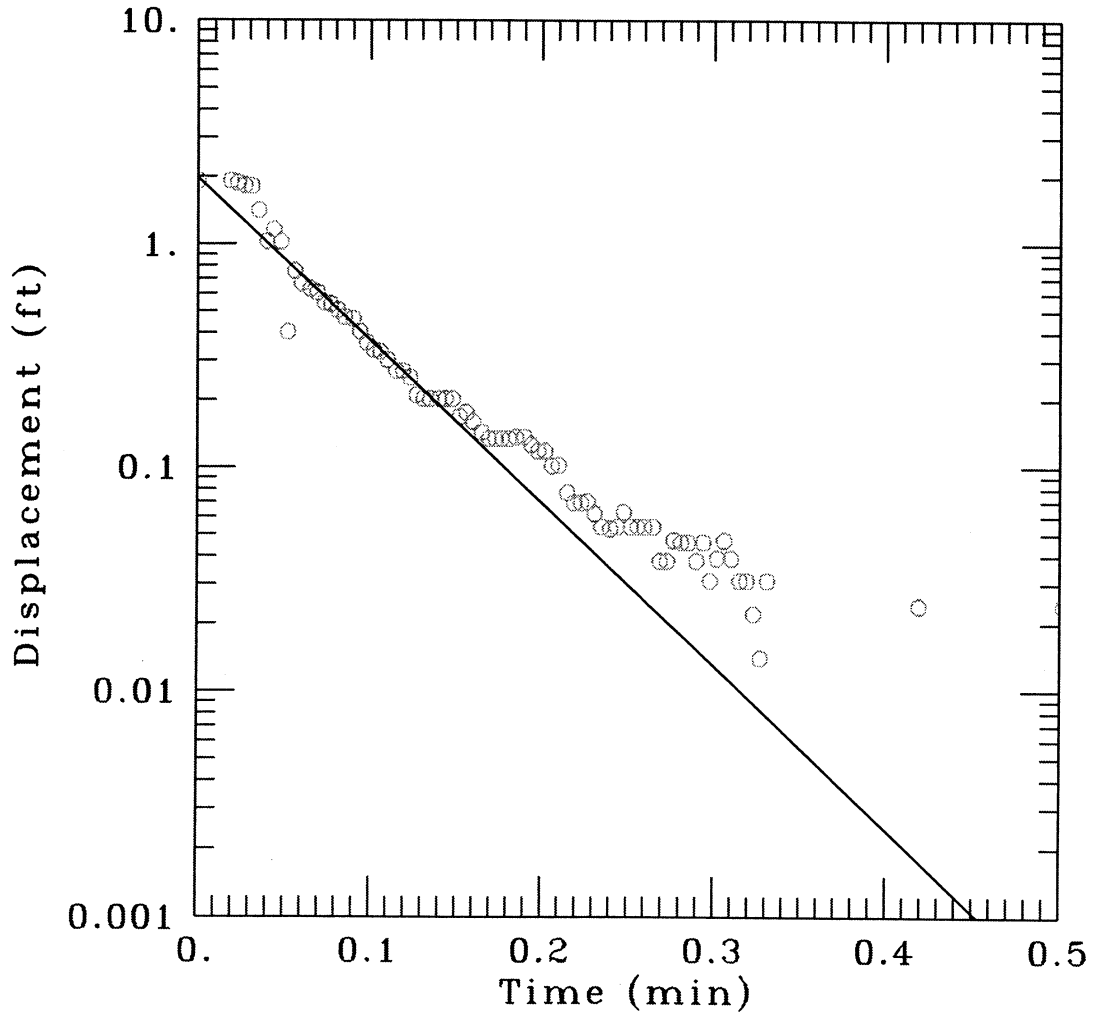
OBS. WELL:
MWH-09P

ESTIMATED PARAMETERS:
K = 0.03906 ft/min
y0 = 4.082 ft

TEST DATA:
H0 = 1.606 ft
rc = 0.078 ft
rw = 0.346 ft
L = 5. ft
b = 30.84 ft
H = 29.84 ft

Foth & Van Dyke	
Project No.: 93C049	

MWH-09P(test 4)



DATA SET:
tst17wl1.dat
09/30/98

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

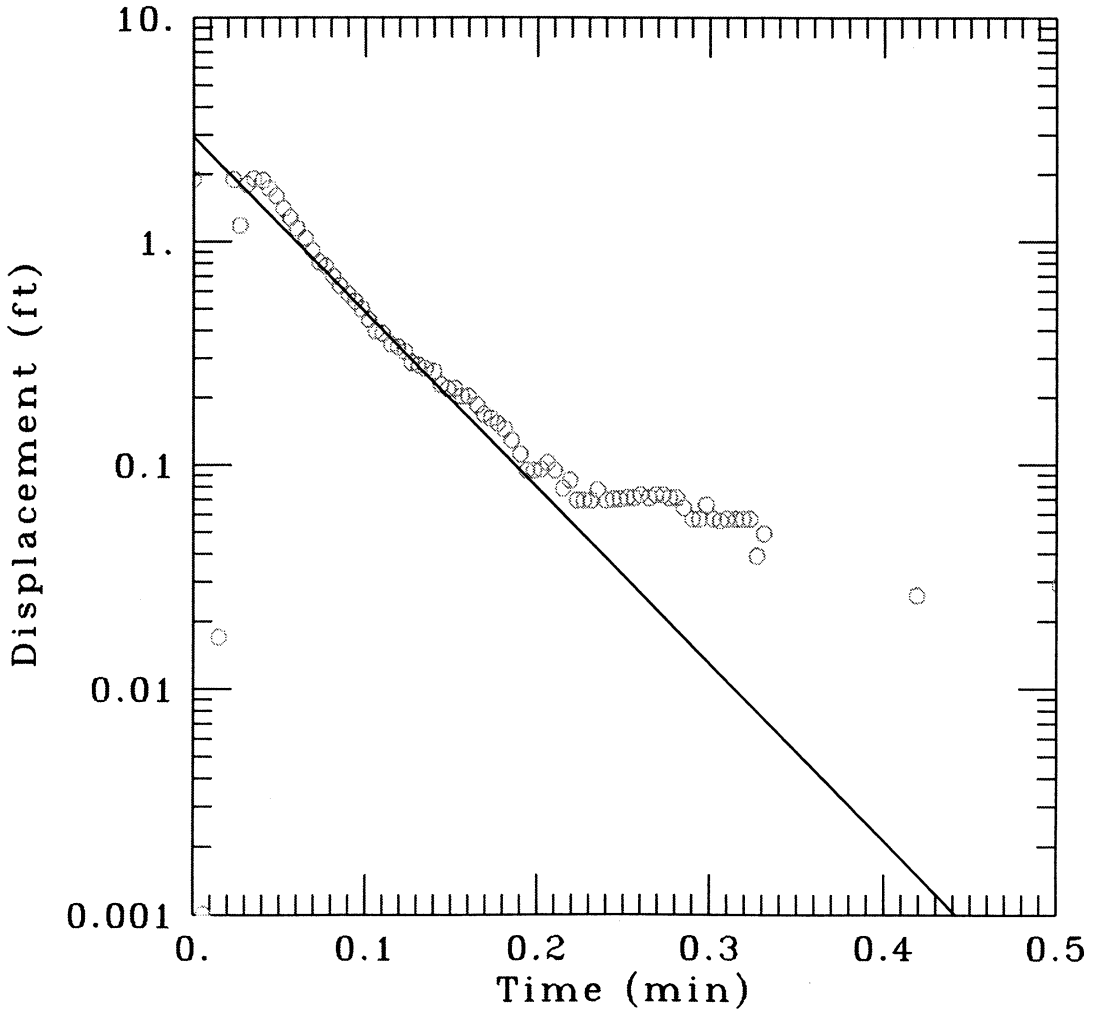
TEST DATE:
September 11, 1998

ESTIMATED PARAMETERS:
K = 0.025 ft/min
y0 = 1.978 ft

TEST DATA:
H0 = 1.915 ft
rc = 0.078 ft
rw = 0.346 ft
L = 5. ft
b = 30.84 ft
H = 29.84 ft

Foth & Van Dyke	
Project No.: 93C049	

MWH-09P (test 5)



DATA SET:
tst18wl1.dat
10/26/98

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

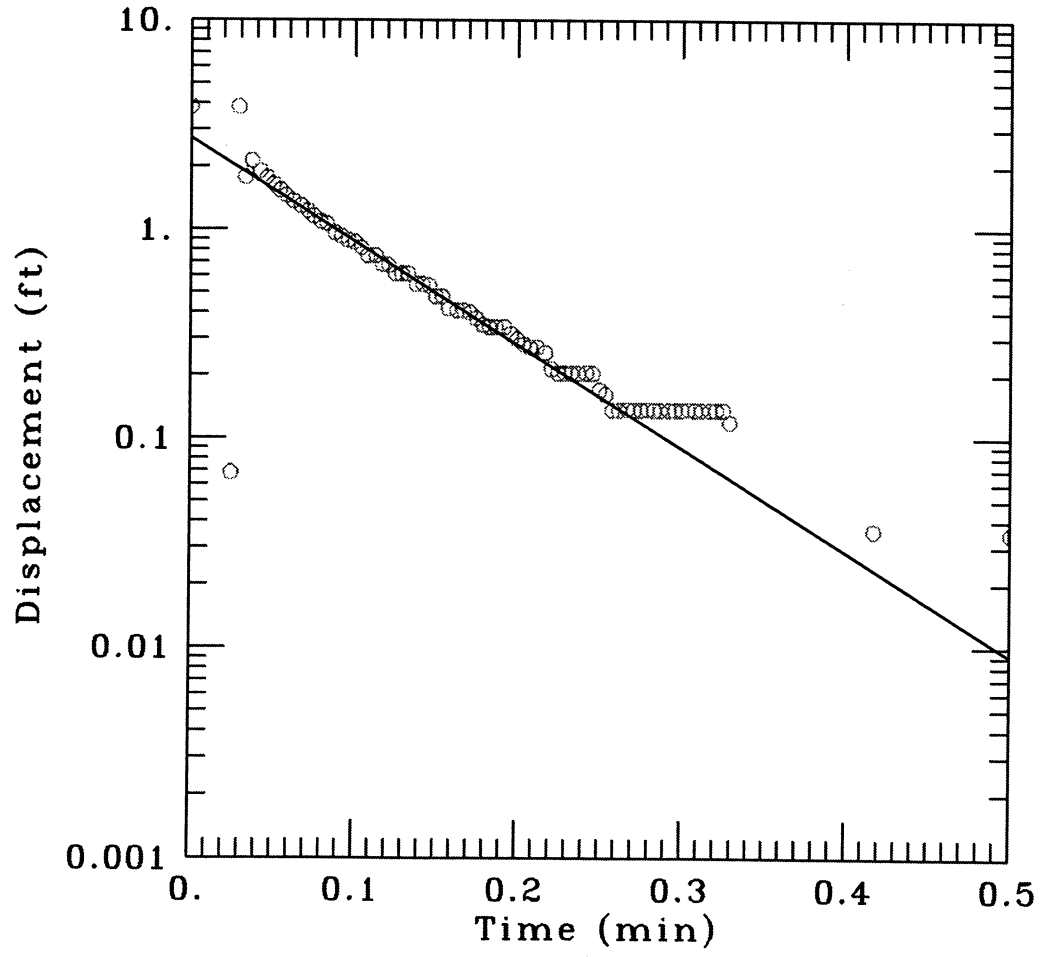
TEST DATE:
September 11, 1998

ESTIMATED PARAMETERS:
K = 0.027 ft/min
y0 = 2.946 ft

TEST DATA:
H0 = 1.909 ft
rc = 0.078 ft
rw = 0.346 ft
L = 5. ft
b = 30.84 ft
H = 29.84 ft

Foth & Van Dyke	
Project No.: 93C049	

MWH-10



DATA SET:
TST10WL1.DAT
09/28/98

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

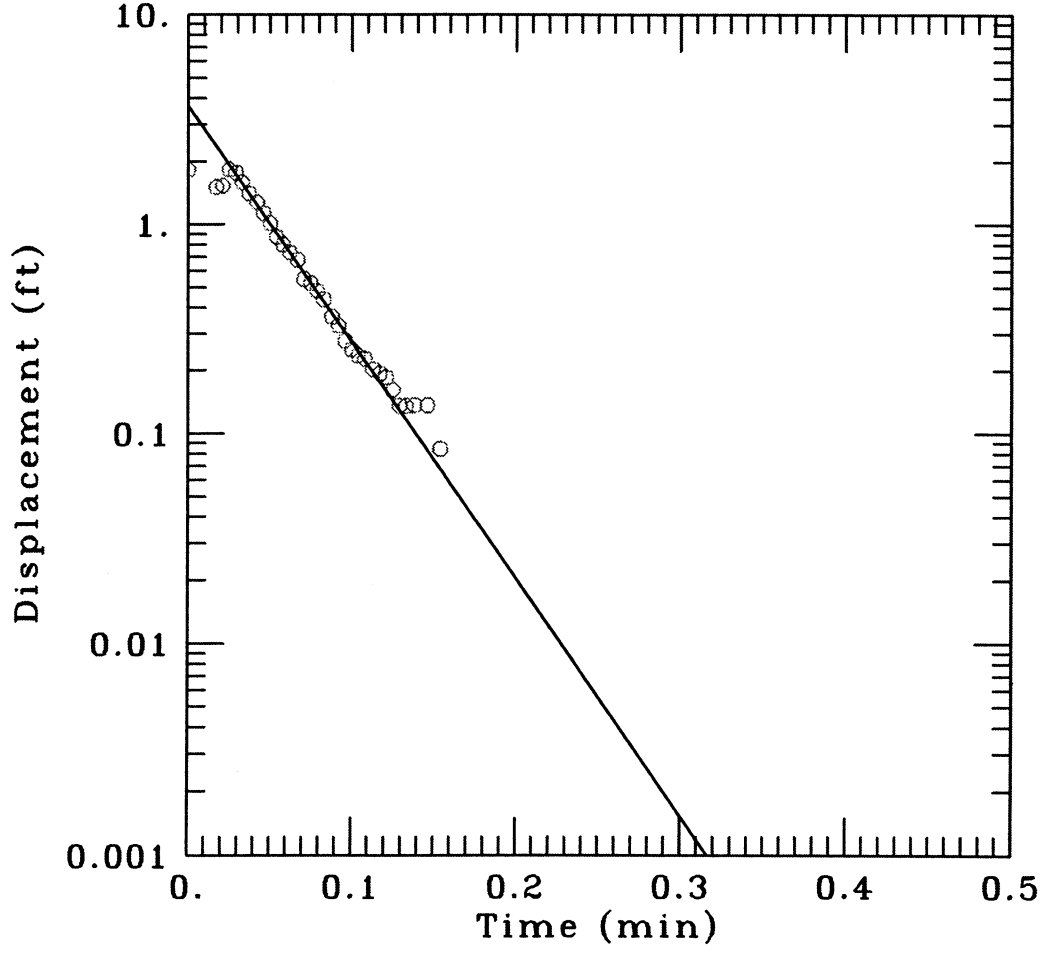
TEST DATE:
September 11, 1998

ESTIMATED PARAMETERS:
K = 0.008 ft/min
y0 = 2.725 ft

TEST DATA:
H0 = 3.834 ft
rc = 0.081 ft
rw = 0.346 ft
L = 10. ft
b = 7.77 ft
H = 6.77 ft

Foth & Van Dyke	
Project No.: 93C049	

MWH-10P



DATA SET:
TST12WL1.DAT
09/28/98

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

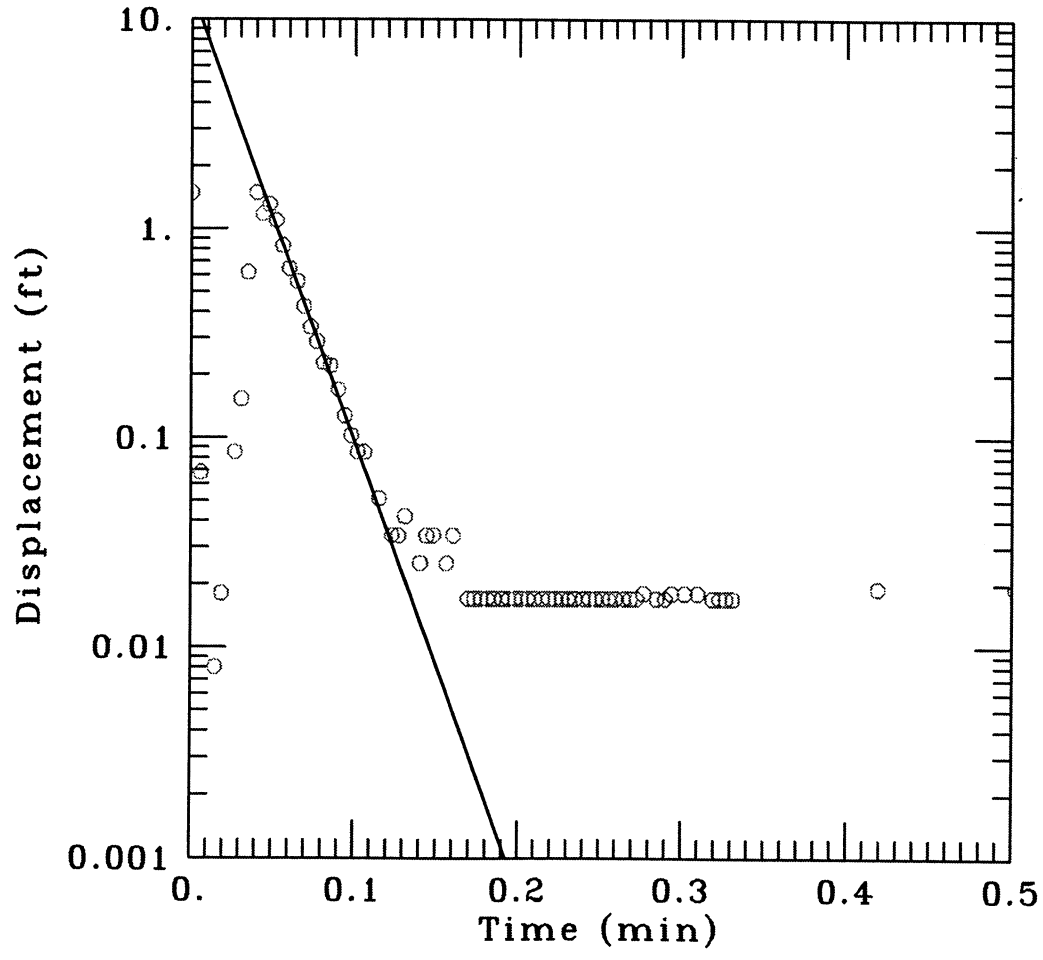
TEST DATE:
September 11, 1998

ESTIMATED PARAMETERS:
K = 0.038 ft/min
y0 = 3.665 ft

TEST DATA:
H0 = 1.824 ft
rc = 0.078 ft
rw = 0.346 ft
L = 5. ft
b = 27.07 ft
H = 26.07 ft

Foth & Van Dyke	
Project No.: 93C049	

MWH-11



DATA SET:
TST07WL1.DAT
09/28/98

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

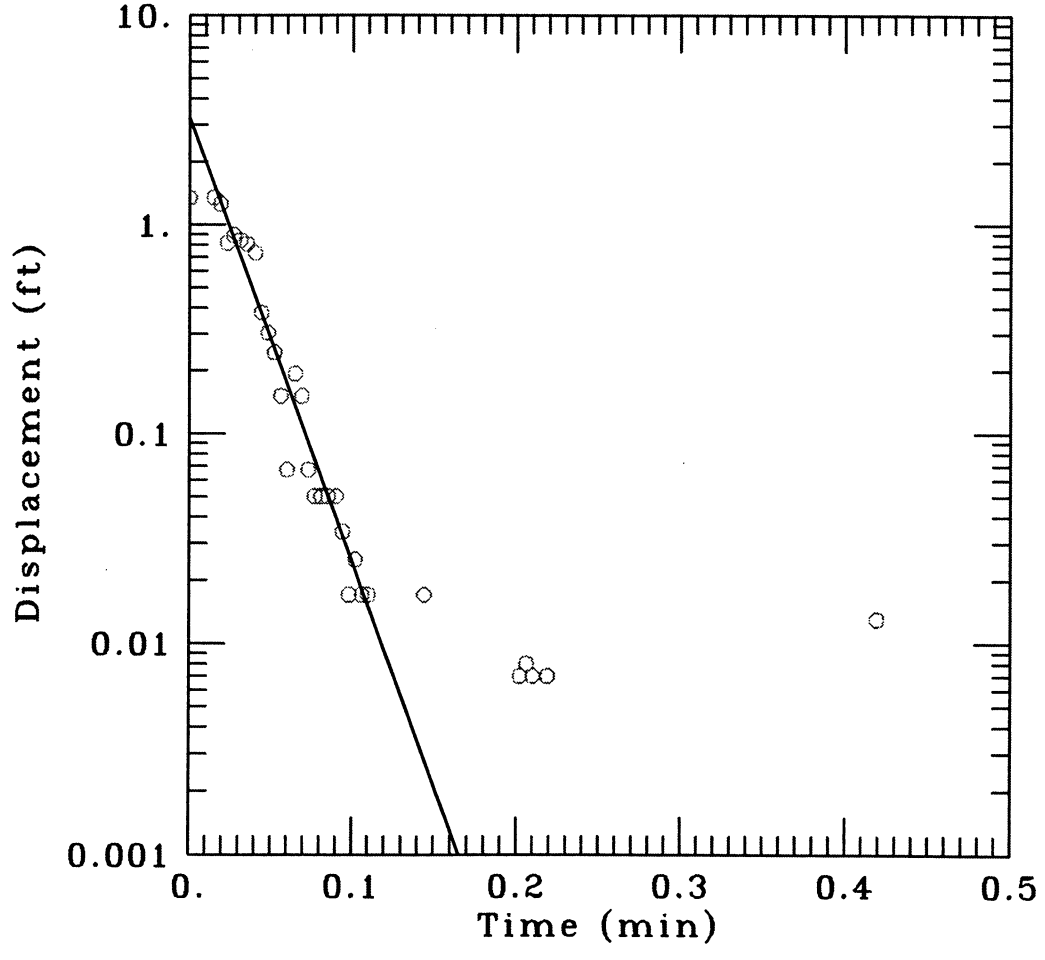
TEST DATE:
September 11, 1998

ESTIMATED PARAMETERS:
K = 0.035 ft/min
y0 = 13.35 ft

TEST DATA:
H0 = 1.481 ft
rc = 0.078 ft
rw = 0.346 ft
L = 10. ft
b = 10.63 ft
H = 9.63 ft

Foth & Van Dyke	
Project No.: 93C049	

MWH-11P



DATA SET:
TST08WL1.DAT
09/28/98

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

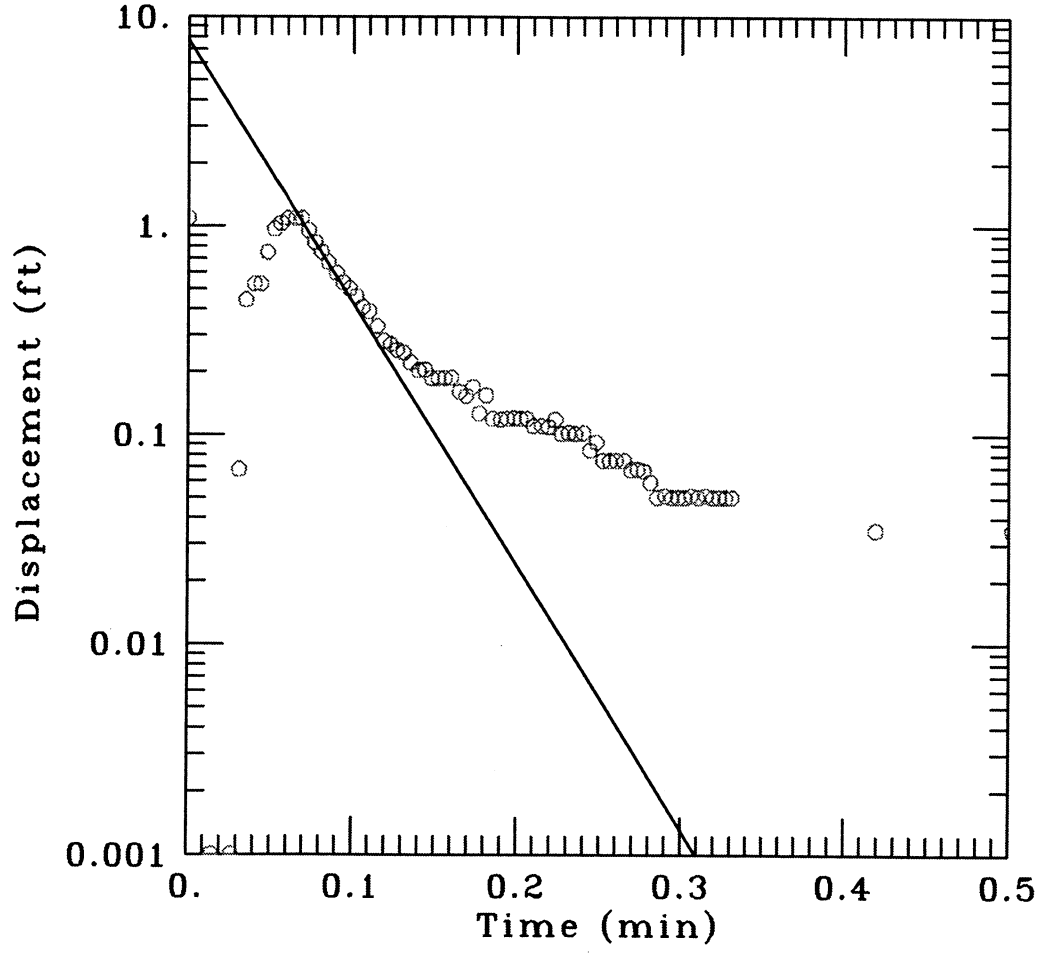
TEST DATE:
September 11, 1998

ESTIMATED PARAMETERS:
K = 0.073 ft/min
y0 = 3.243 ft

TEST DATA:
H0 = 1.345 ft
rc = 0.078 ft
rw = 0.346 ft
L = 5. ft
b = 30.83 ft
H = 29.83 ft

Foth & Van Dyke	
Project No.: 93C049	

MWH-13



DATA SET:
TST04WL1.DAT
09/28/98

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

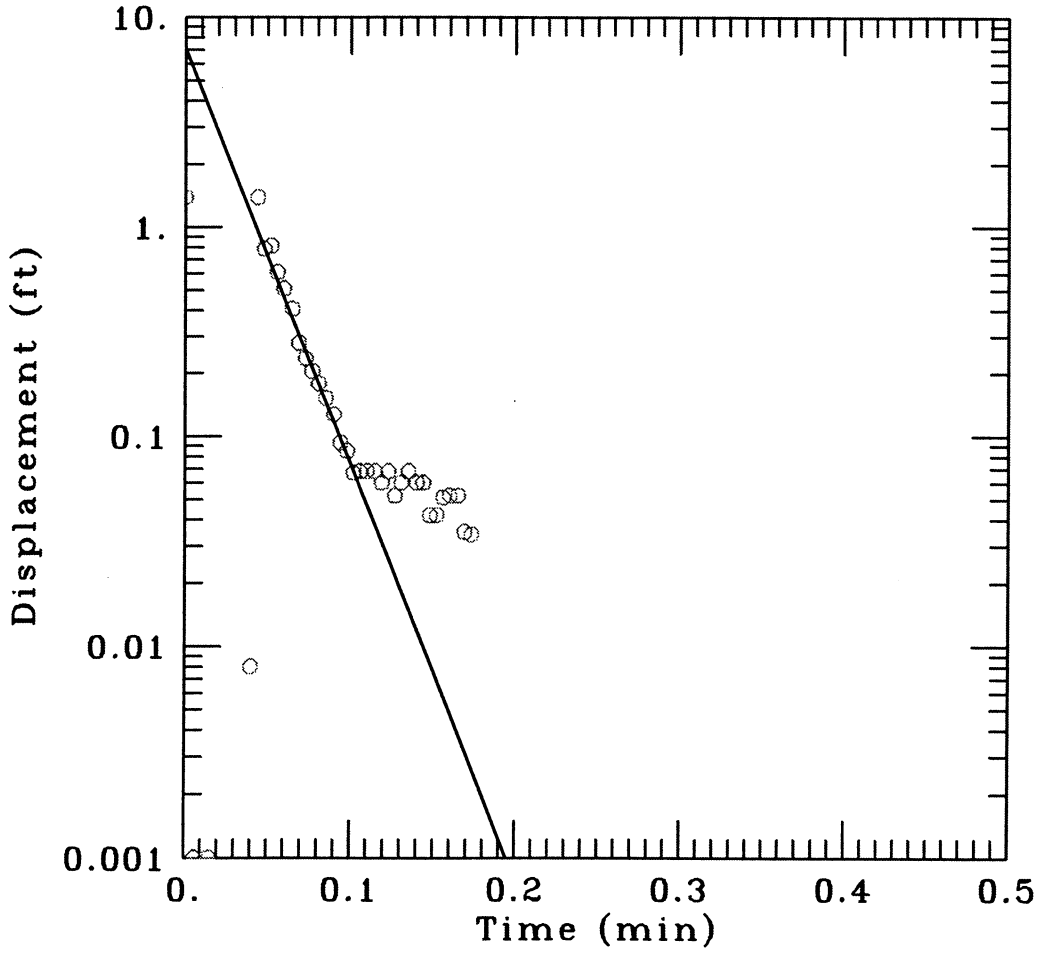
TEST DATE:
September 11, 1998

ESTIMATED PARAMETERS:
K = 0.02 ft/min
y0 = 7.699 ft

TEST DATA:
H0 = 1.086 ft
rc = 0.078 ft
rw = 0.346 ft
L = 10. ft
b = 9.59 ft
H = 8.59 ft

Foth & Van Dyke	
Project No.: 93C049	

MWH-14



DATA SET:
TST02WL1.DAT
09/28/98

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

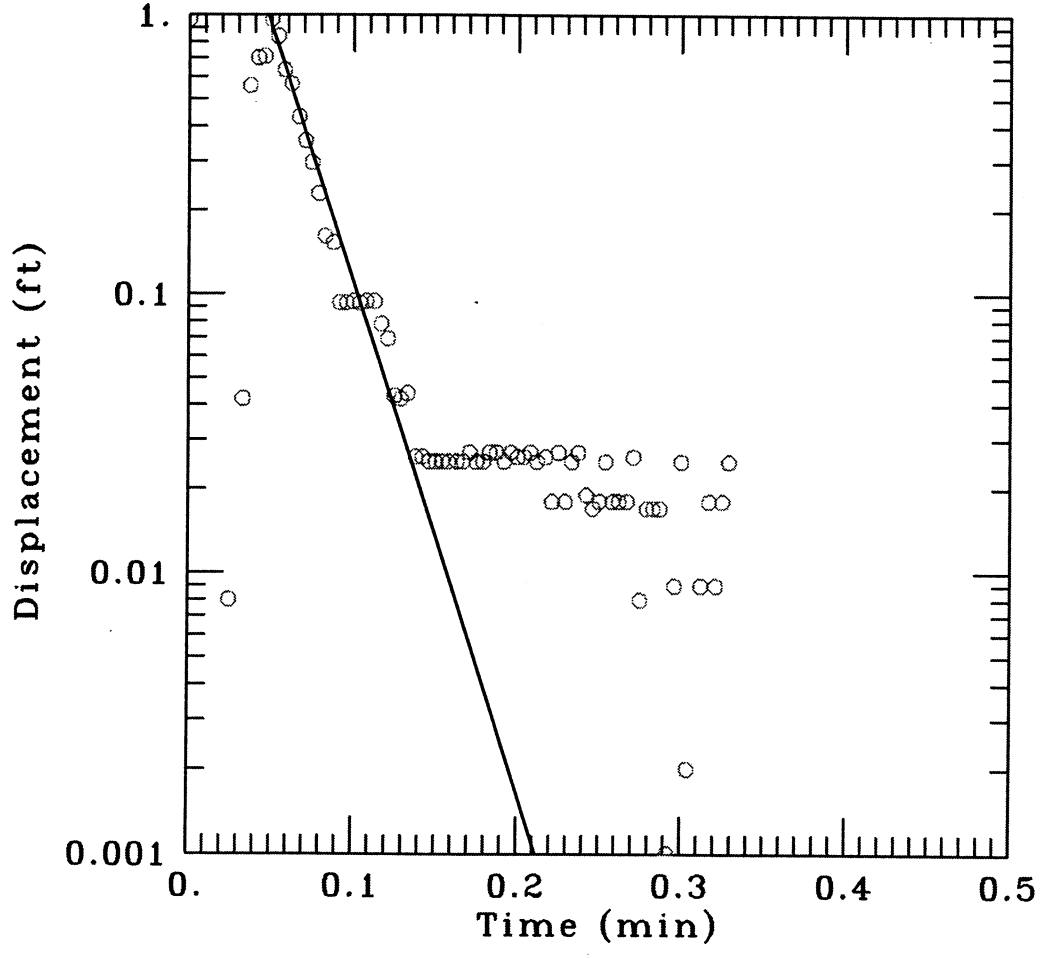
TEST DATE:
September 11, 1998

ESTIMATED PARAMETERS:
K = 0.03 ft/min
y0 = 7.075 ft

TEST DATA:
H0 = 1.388 ft
rc = 0.078 ft
rw = 0.345 ft
L = 10. ft
b = 8.08 ft
H = 7.08 ft

Foth & Van Dyke	
Project No.: 93C049	

MWH-15



DATA SET:
TST03WL1.DAT
09/28/98

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

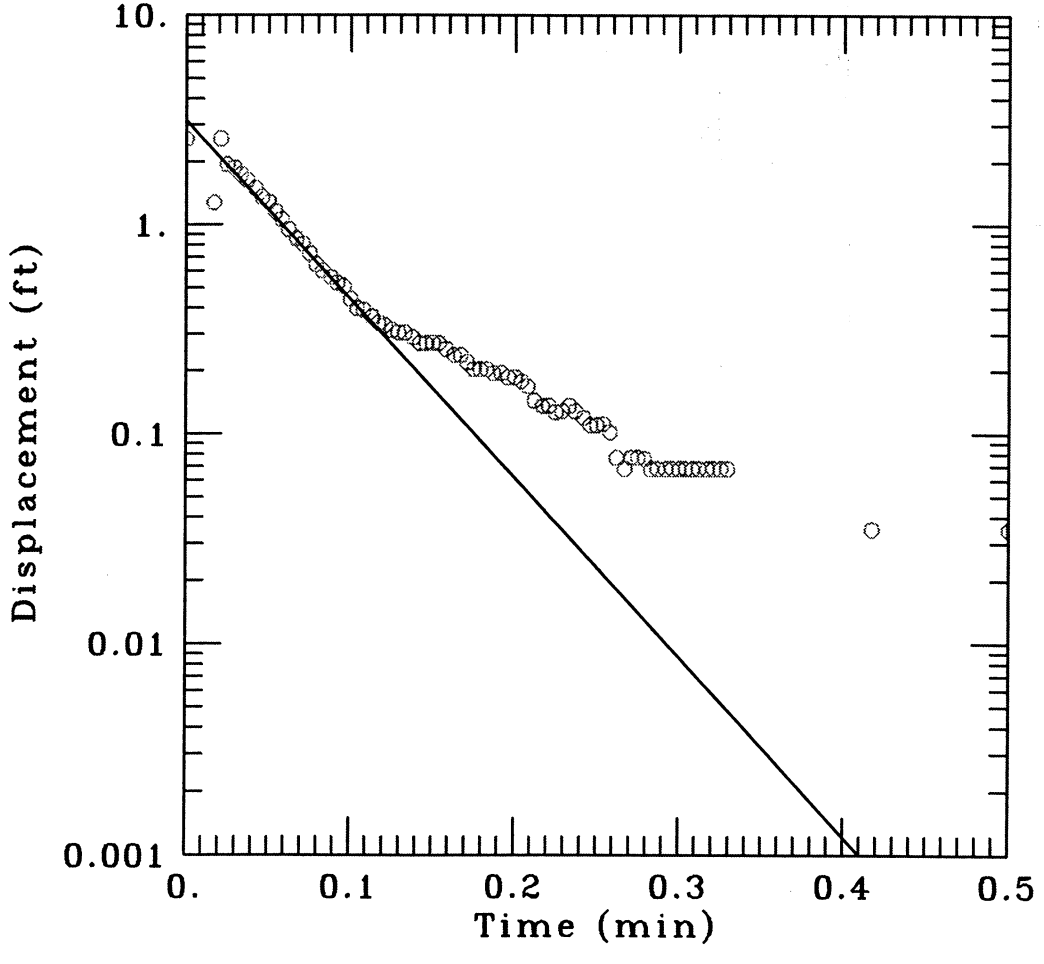
TEST DATE:
September 11, 1998

ESTIMATED PARAMETERS:
K = 0.029 ft/min
y0 = 7.608 ft

TEST DATA:
H0 = 0.964 ft
rc = 0.078 ft
rw = 0.346 ft
L = 10. ft
b = 9.42 ft
H = 8.42 ft

Foth & Van Dyke	
Project No.: 93C049	

MWH-16



DATA SET:
TST05WL1.DAT
09/28/98

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

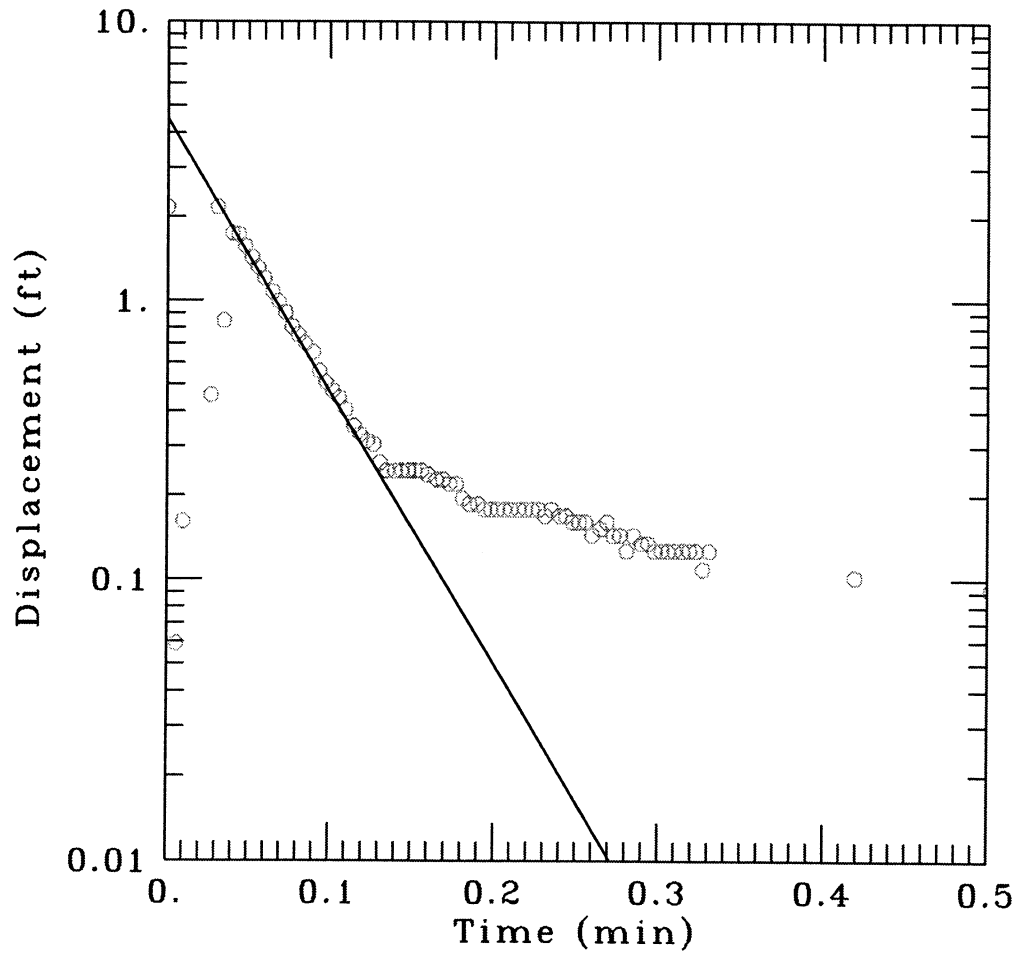
TEST DATE:
September 11, 1998

ESTIMATED PARAMETERS:
K = 0.011 ft/min
y0 = 3.143 ft

TEST DATA:
H0 = 2.566 ft
rc = 0.078 ft
rw = 0.346 ft
L = 10. ft
b = 5.09 ft
H = 4.09 ft

Foth & Van Dyke	
Project No.: 93C049	

MWH-19



DATA SET:
TST01WL1.DAT
09/28/98

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
September 11, 1998

ESTIMATED PARAMETERS:
K = 0.01667 ft/min
y0 = 4.472 ft

TEST DATA:
H0 = 2.166 ft
rc = 0.081 ft
rw = 0.346 ft
L = 10. ft
b = 9.42 ft
H = 8.42 ft

Appendix H

Soil Testing Data

H-1 - Nummelin Testing Services, Inc. Data

H-2 - Thresher & Son, Inc. Test Data

Appendix H-1

Nummelin Testing Services, Inc. Data

NTS NUMMELIN
TESTING SERVICES, INC.

CENTRAL WISCONSIN AREA:
332 N. Georgia Street
Stevens Point, WI 54481
(715) 341-7974 • Fax (715) 341-8654

MADISON AREA:
5620 Woodland Drive
Waunakee, WI 53597
(608) 849-9120 • Fax (608) 849-9122

September 29, 1998

Foth & Van Dyke
2737 South Ridge Road
P.O. Box 19012
Green Bay, WI 54307-9012

Project No. 1154703.lab

Report No. 03

Attention: Mr. Ronald E. Meister, P.G.

Re: Laboratory Analyses
Crandon Project #93C049
SAP II - Area H

Dear Mr. Meister:

Please find enclosed the laboratory test results for the 66 soil samples obtained from your office on September 14, 1998. Grain size distribution, consisting of nested sieves and hydrometer were performed on all 66 samples. Permeability tests were performed on the 5 out of the 8 designated samples, not enough soil was obtained for the 3 perms not performed. All permeability tests were performed at a sample density of 100 lbs/ft^3, as requested. All tests were performed in general conformance with ASTM standards. Due to the small percentages passing the #200 sieve and the accuracy of the hydrometer test, the hydrometer test results do show some variation from the nested sieve results.

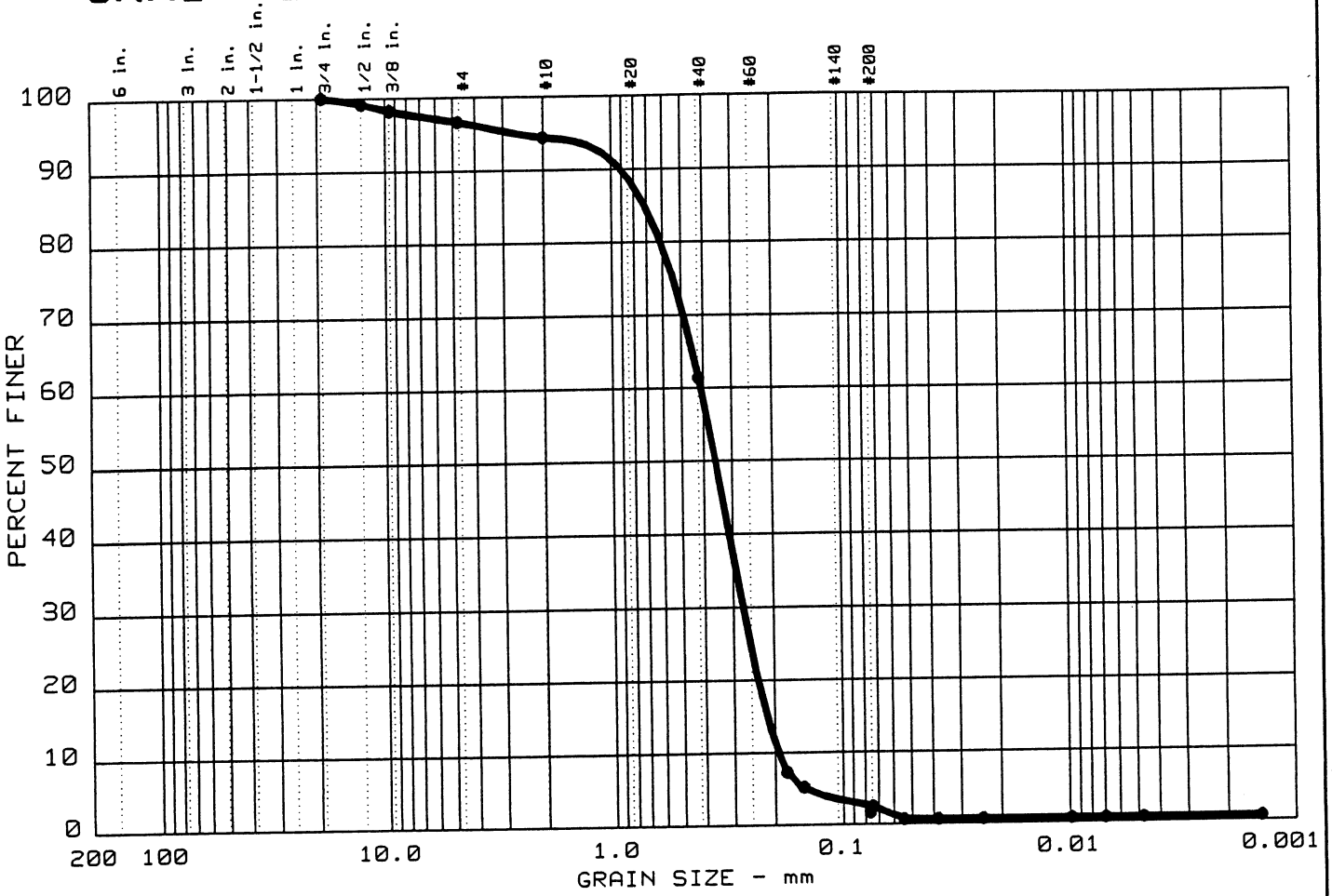
If you have any questions please feel free to call me.

Sincerely,

Bruce Nummelin, President
NUMMELIN TESTING SERVICES, INC.

encl. Grain size graphs, permeability summary, sample list.

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	9	0.0	3.4	94.1	1.8	0.7

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.72	0.41	0.36	0.273	0.2158	0.1932	0.94	2.1

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-02, 12'-14'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-12-98

Remarks:

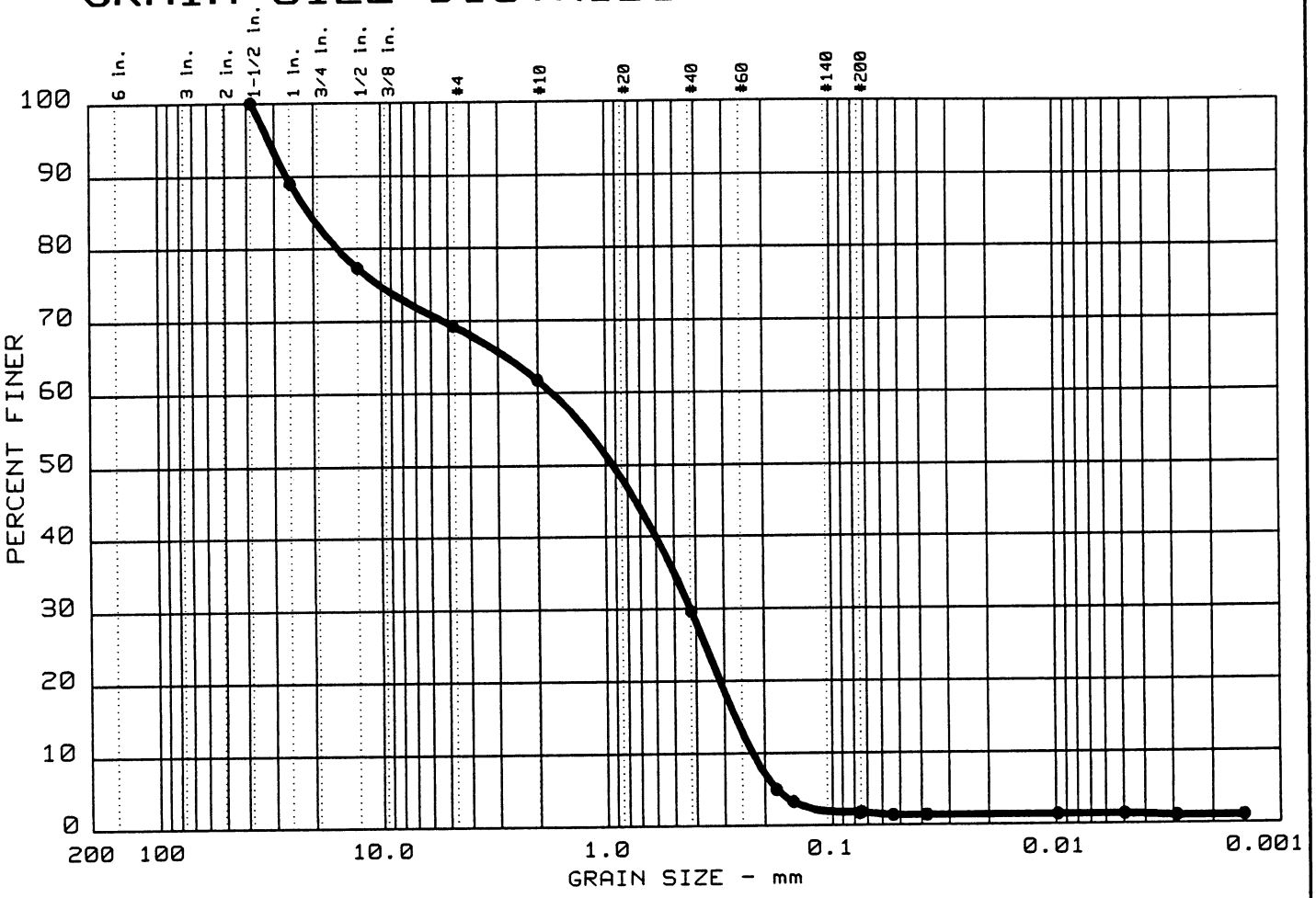
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	5	0.0	30.7	67.5	0.4	1.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			21.11	1.72	0.92	0.425	0.2682	0.2257	0.47	7.6

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-04, 6'-8'	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-10-98

Remarks:

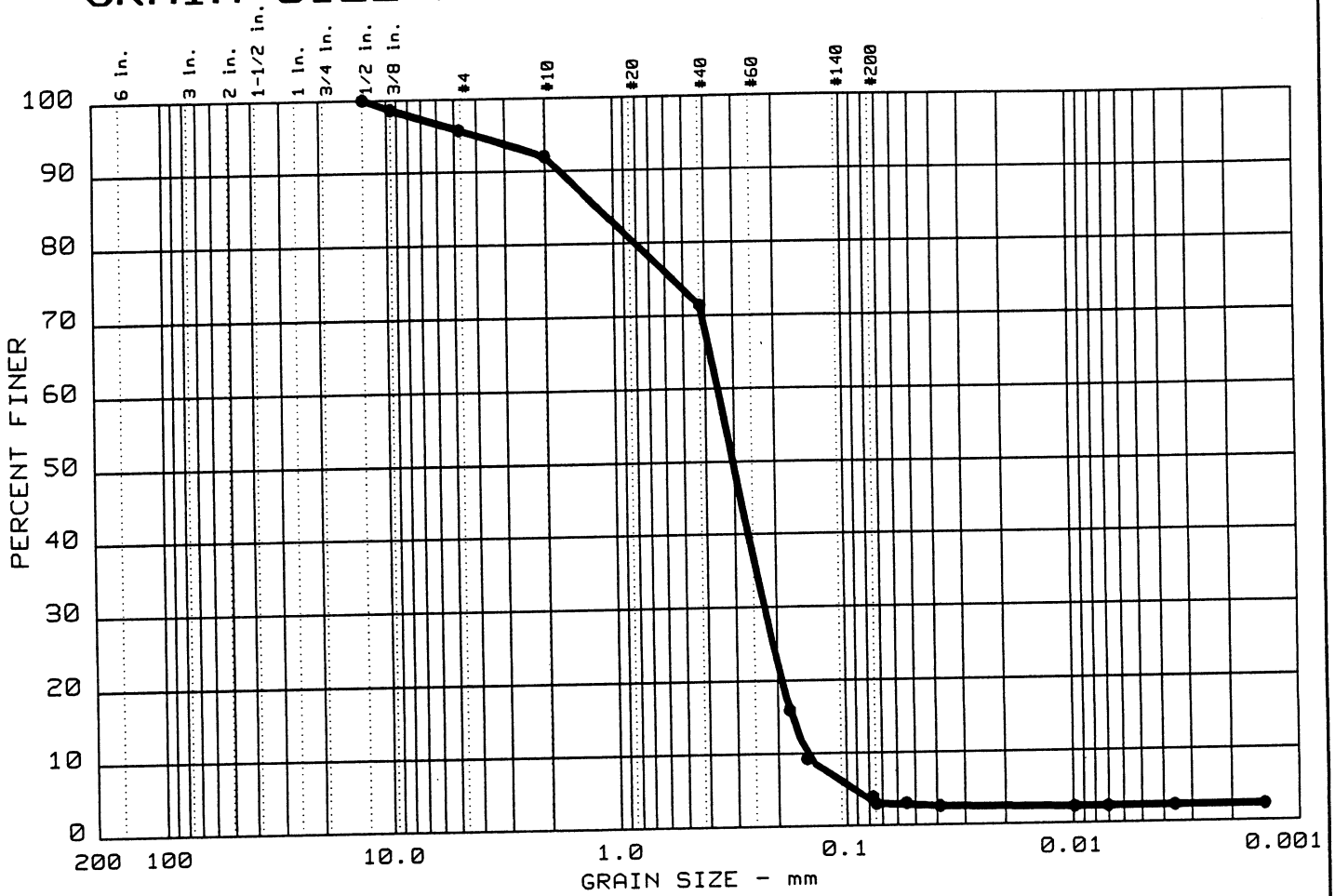
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	4.3	92.7	0.7	2.3

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.17	0.35	0.31	0.226	0.1718	0.1514	0.96	2.3

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-06, 12'-14'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-11-98

Remarks:

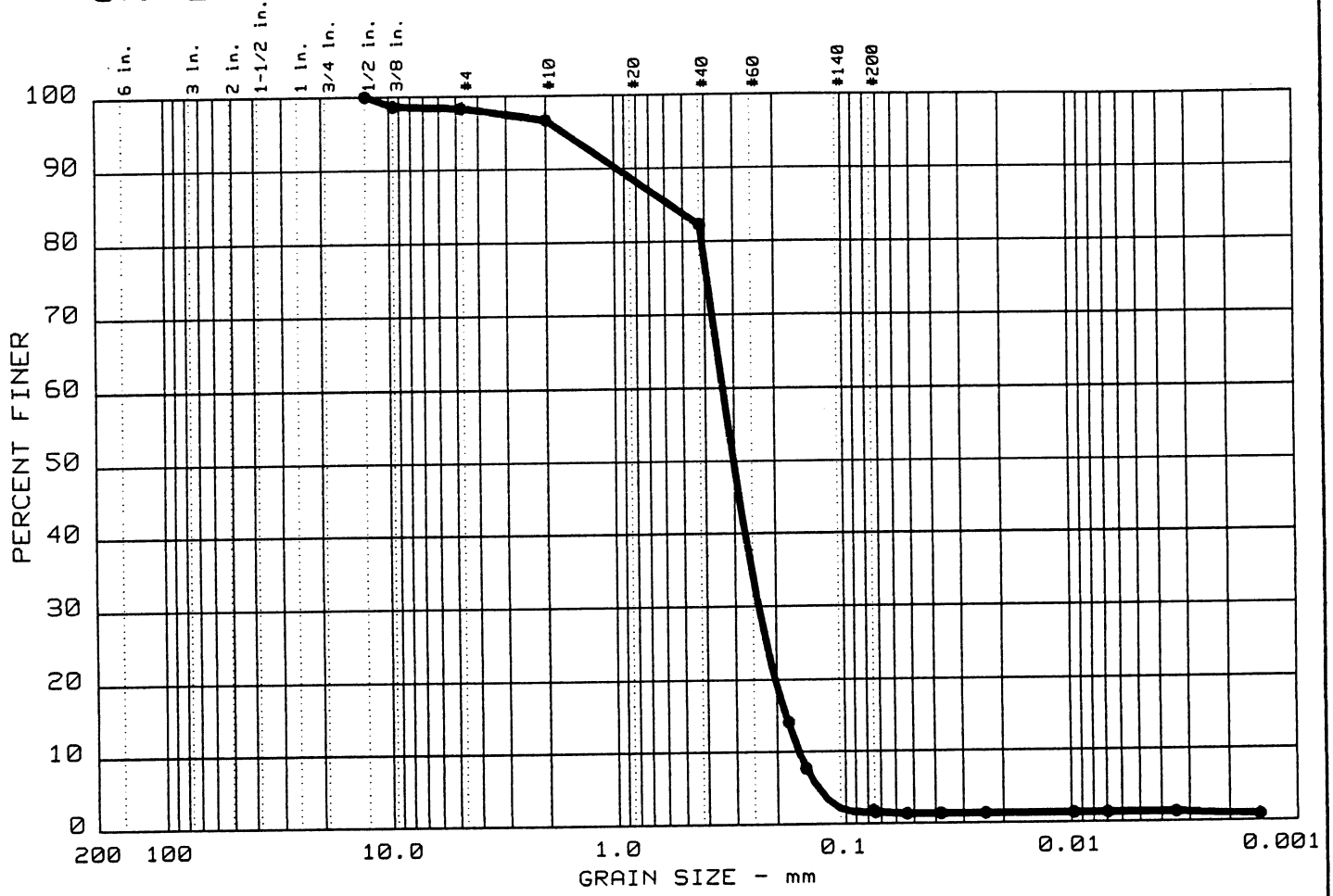
Checked By: BN

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	1.7	96.7	0.2	1.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.56	0.34	0.30	0.239	0.1809	0.1603	1.05	2.1

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-07, 6'-8'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-16-98

Remarks:

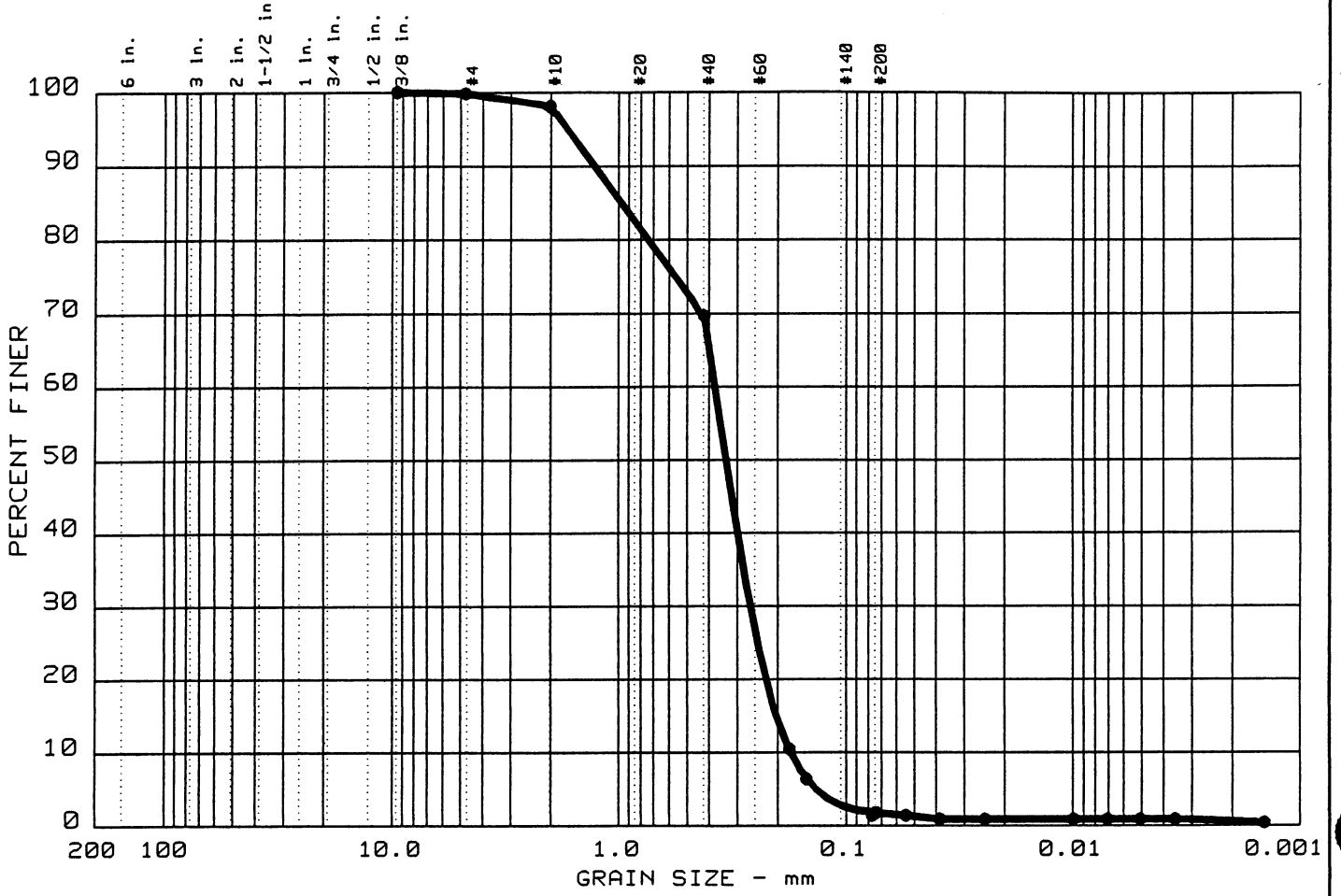
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	6	0.0	0.2	98.0	0.9	0.9

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.97	0.38	0.34	0.264	0.2037	0.1734	1.06	2.2

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-08, 14'-16'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-12-98

Remarks:

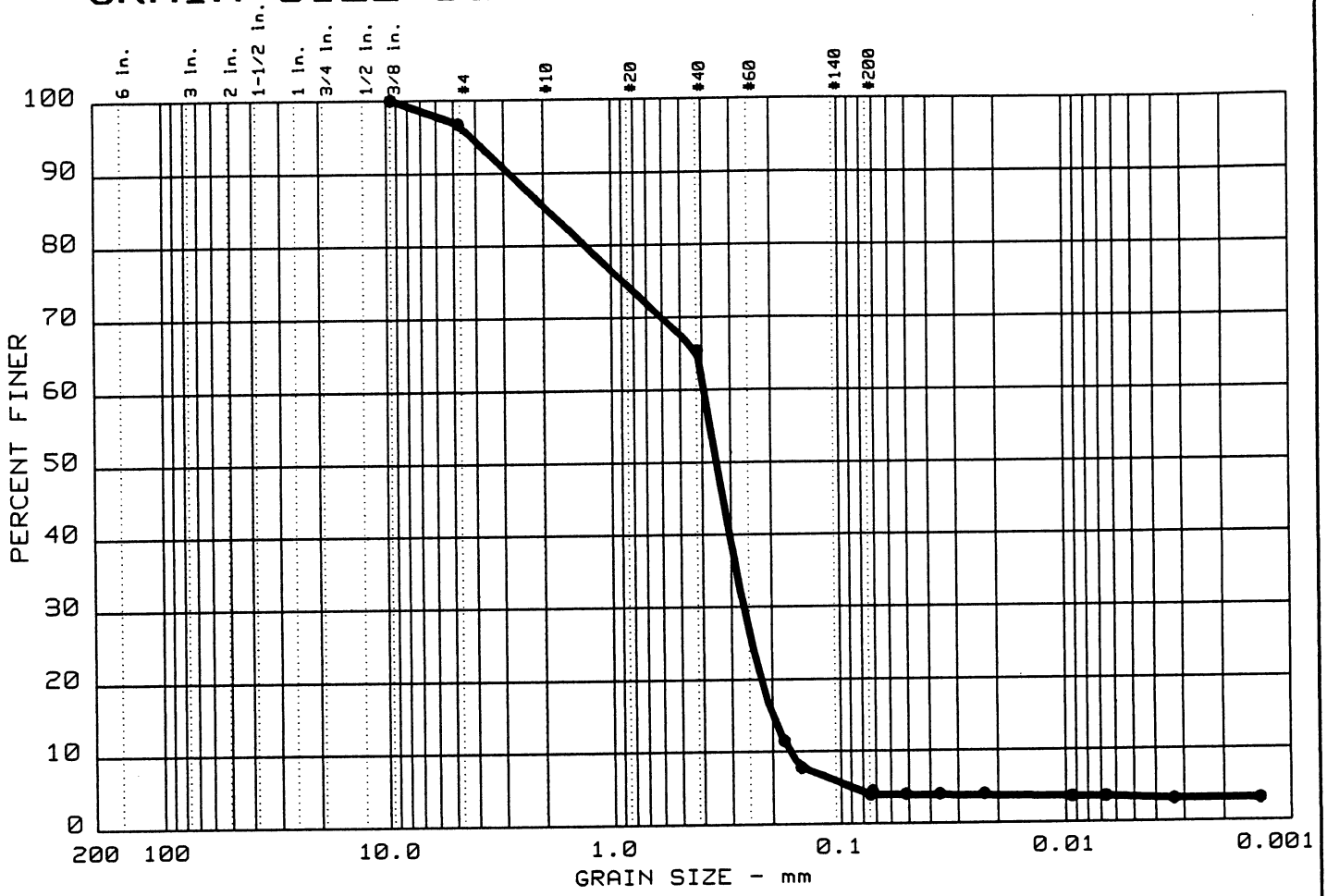
Checked By: BH

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	3.3	92.7	0.6	3.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.91	0.39	0.35	0.266	0.1993	0.1658	1.08	2.4

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-09, 8-10'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

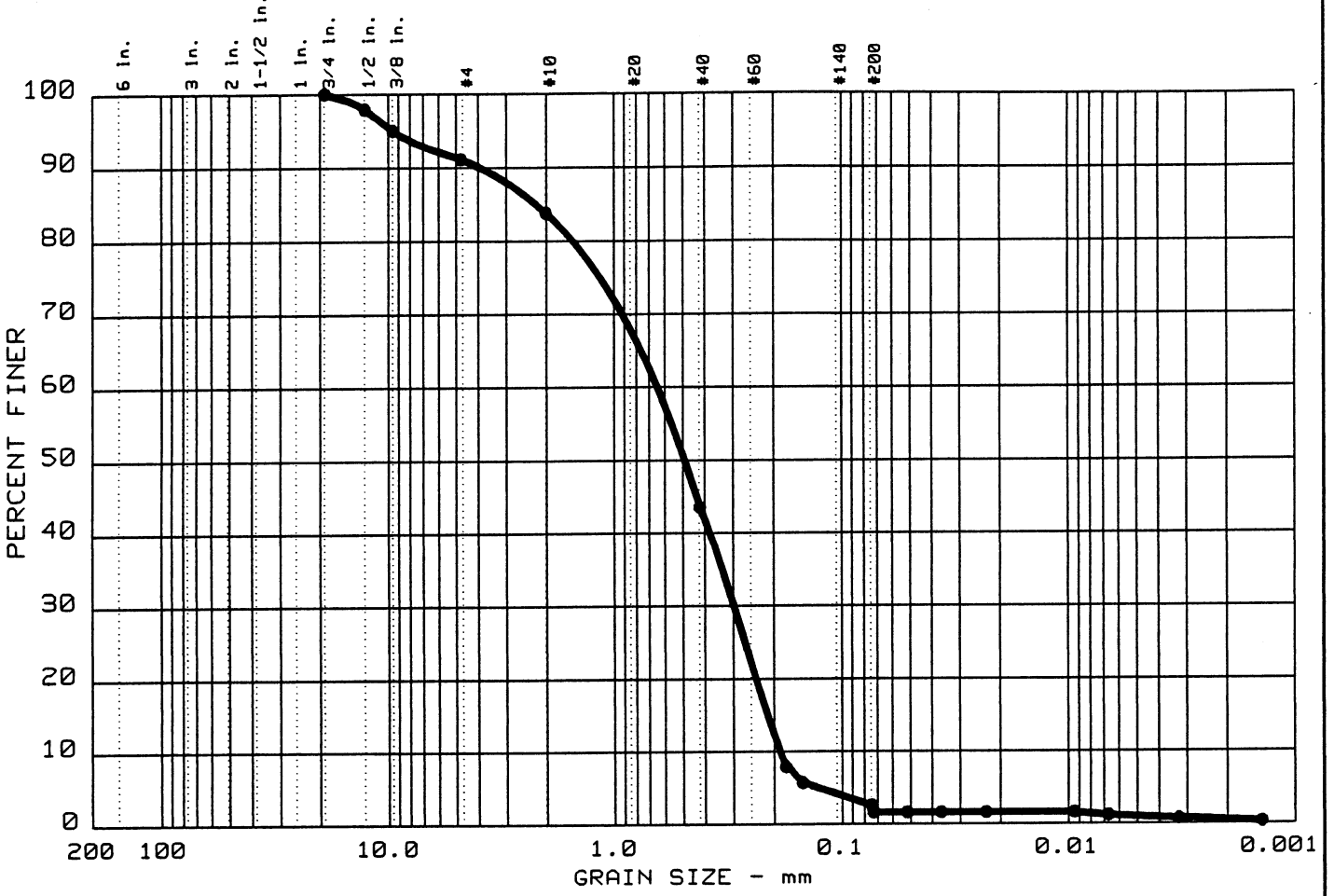
Checked By: BN

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	7	0.0	8.9	88.5	1.6	1.0

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			2.19	0.65	0.49	0.299	0.2133	0.1877	0.74	3.4

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-10, 14-16'	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-16-98

Remarks:

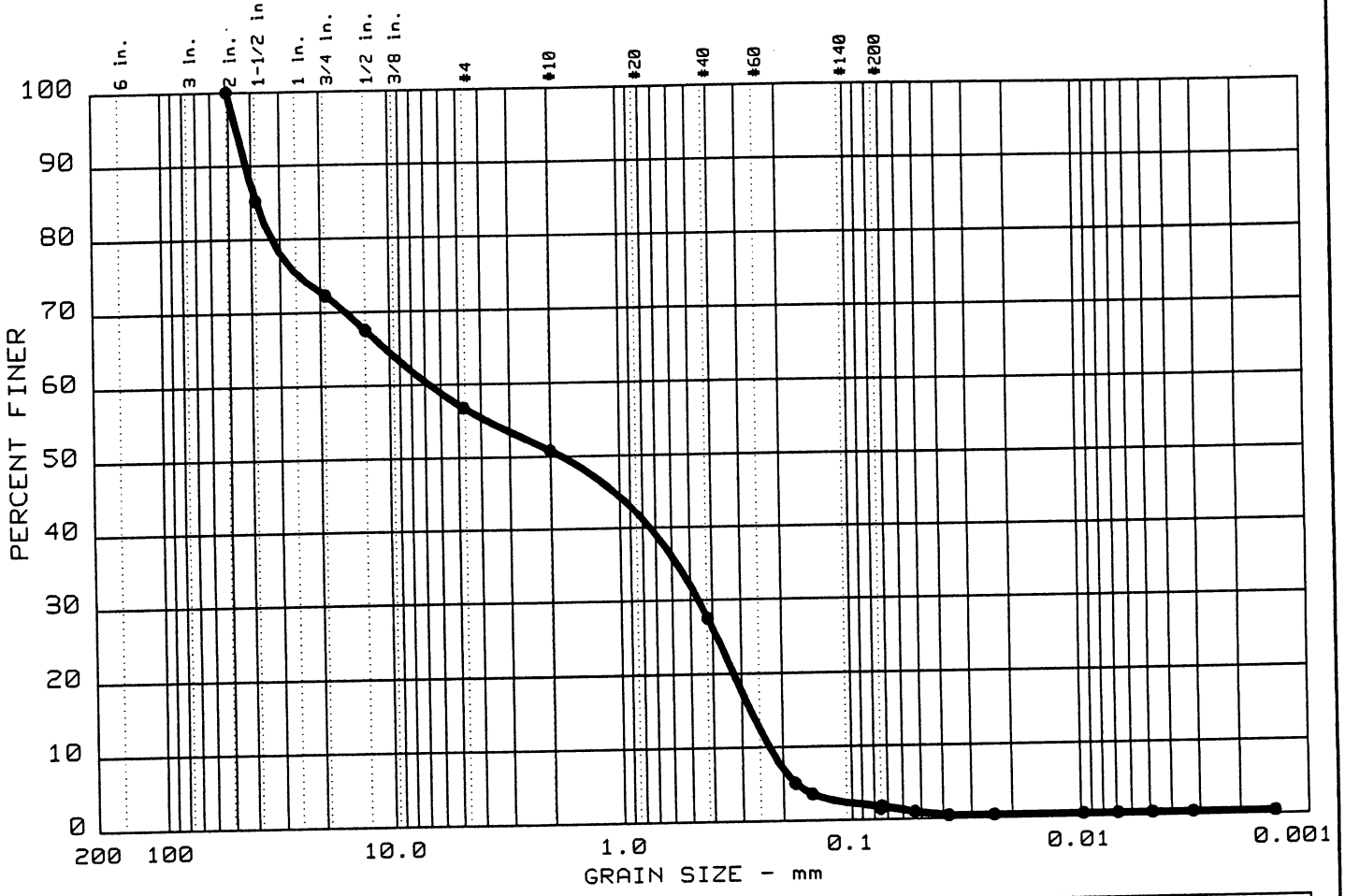
Checked By: BN

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	3	0.0	43.2	55.0	1.3	0.5

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			37.89	6.66	1.77	0.461	0.2745	0.2283	0.14	29.2

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-11, 10'-12'	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-12-98

Remarks:

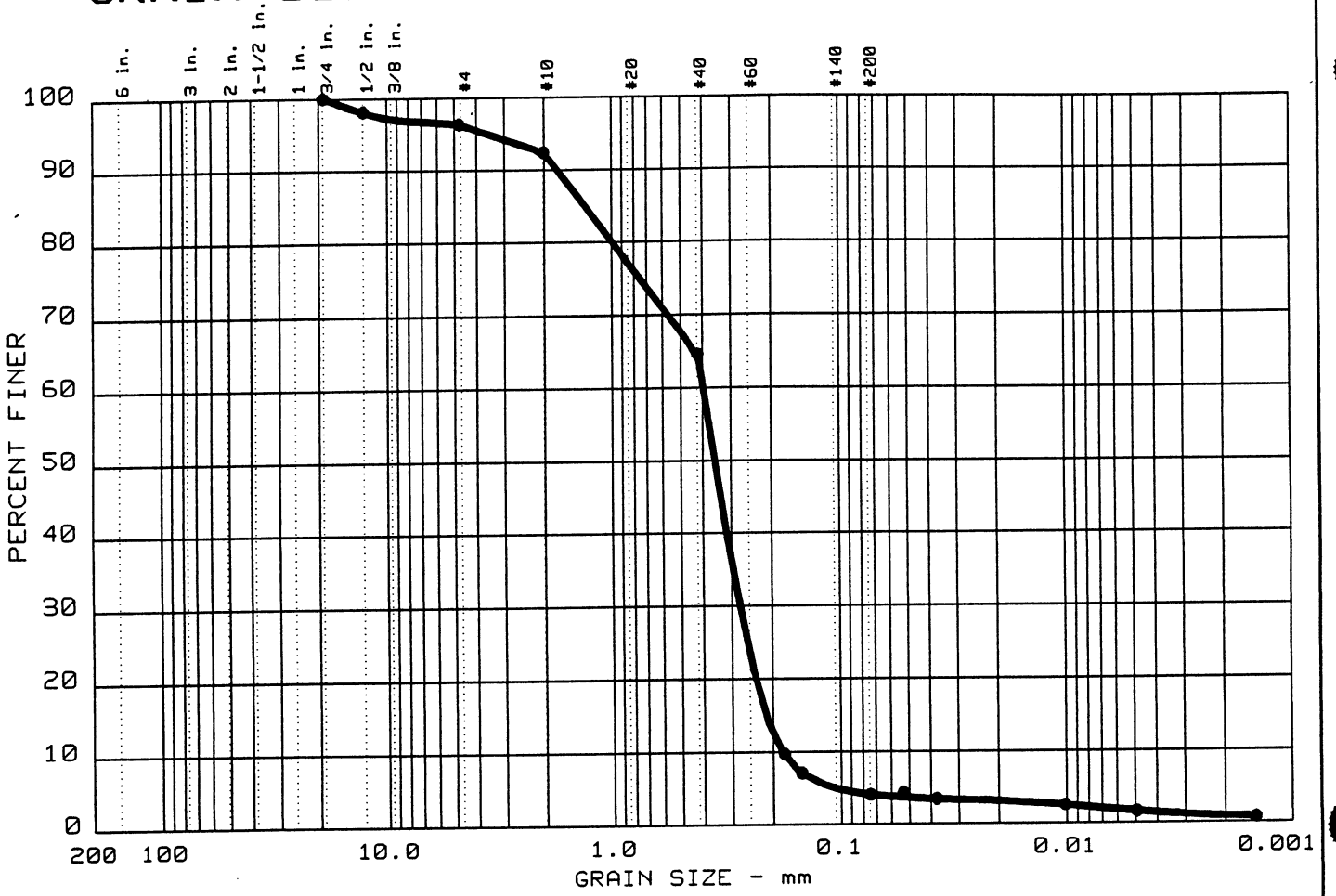
Checked By: BN

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	3.7	92.2	2.5	1.6

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.32	0.40	0.36	0.277	0.2138	0.1799	1.07	2.2

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-12, 14'-16'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-10-98

Remarks:

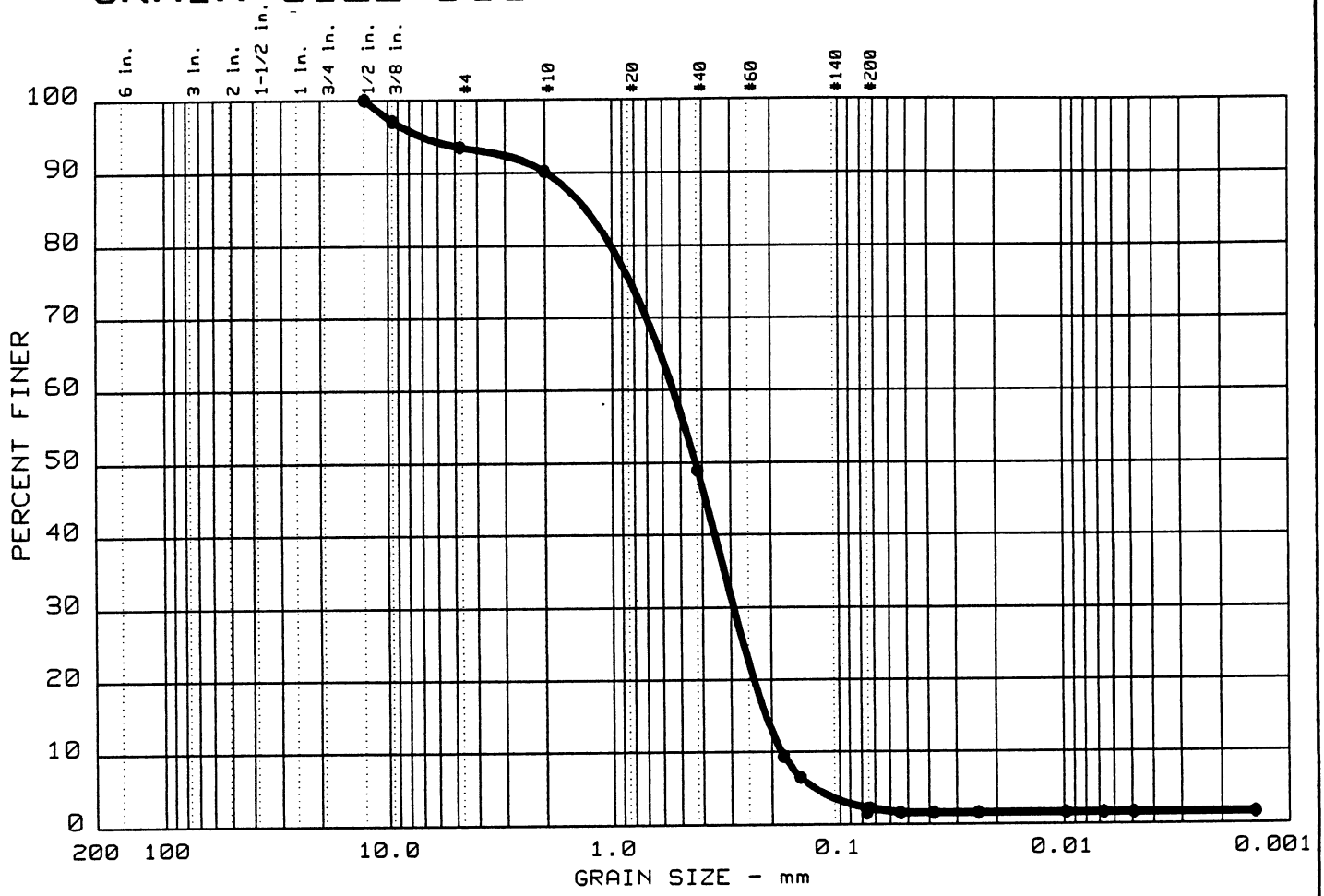
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	10	0.0	6.5	91.3	0.6	1.6

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.30	0.54	0.43	0.293	0.2118	0.1803	0.89	3.0

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-13, 10'-12'	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-12-98

Remarks:

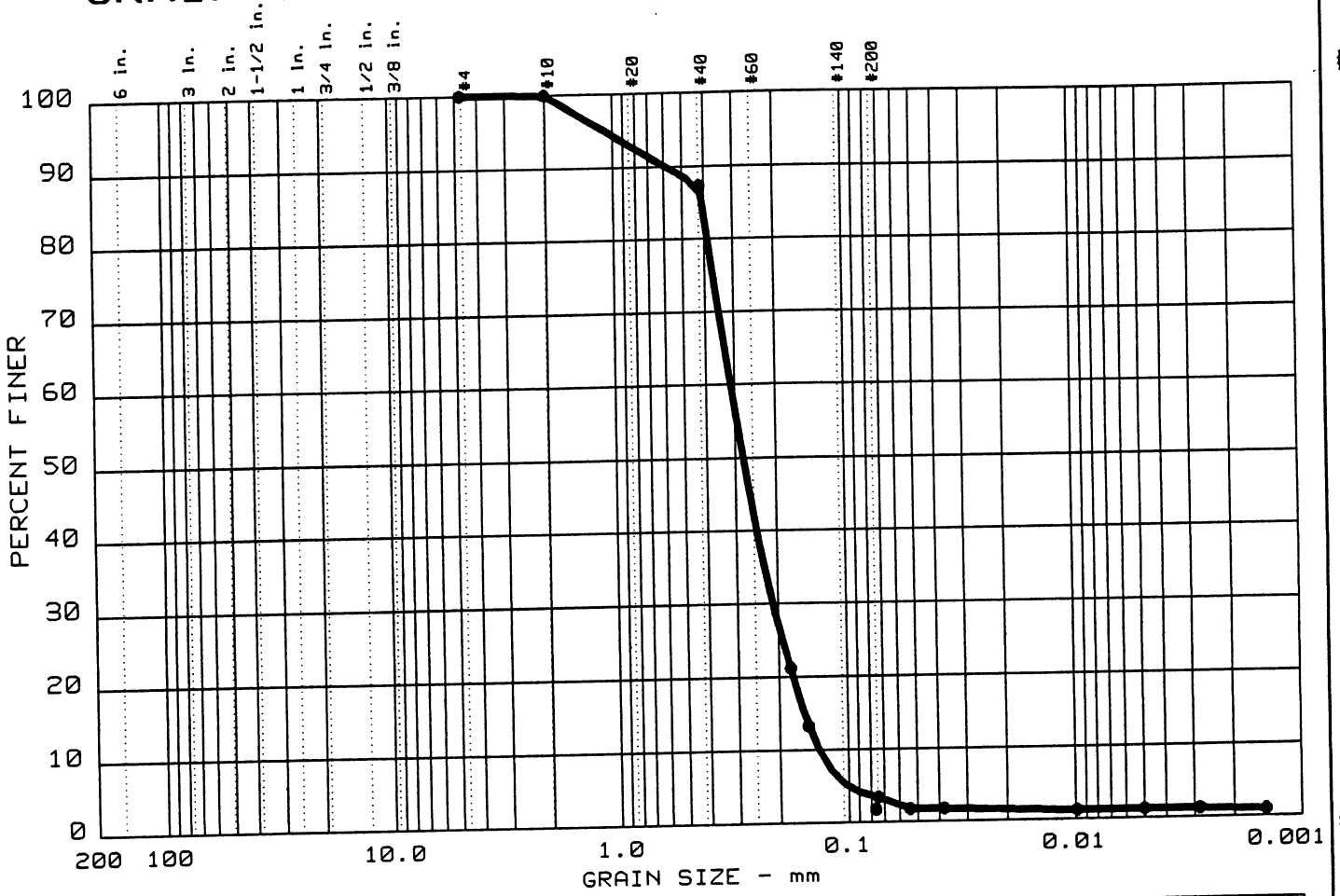
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	3	0.0	0.0	96.6	2.2	1.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.41	0.31	0.28	0.211	0.1556	0.1340	1.06	2.3

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-13, 54'-56'	SP	A-3

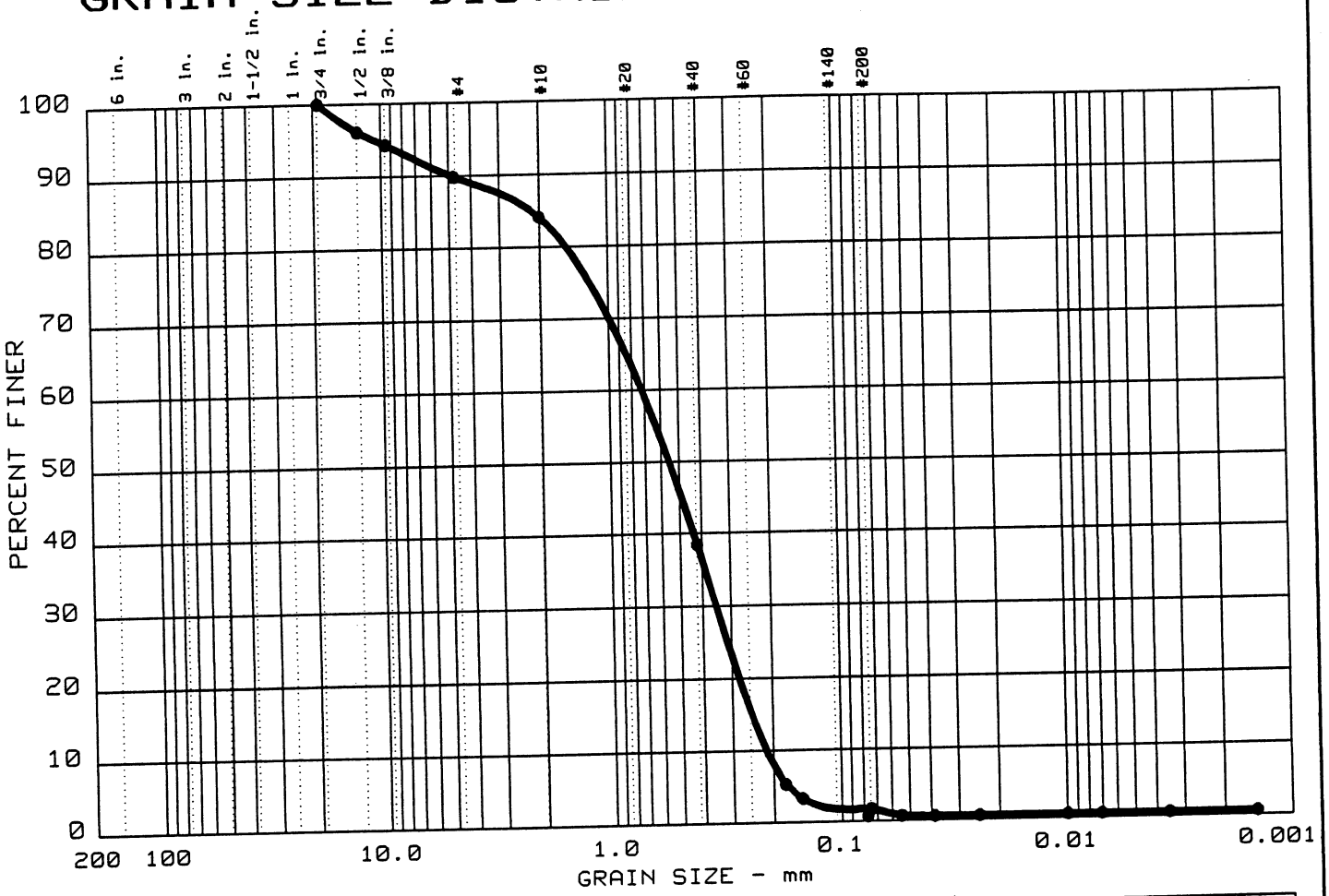
Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-10-98

Remarks:
Checked By: BM
ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT
NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	10.2	88.1	1.1	0.6

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			2.16	0.72	0.55	0.348	0.2466	0.2145	0.78	3.4

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-14, 8'-10'	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-11-98

Remarks:

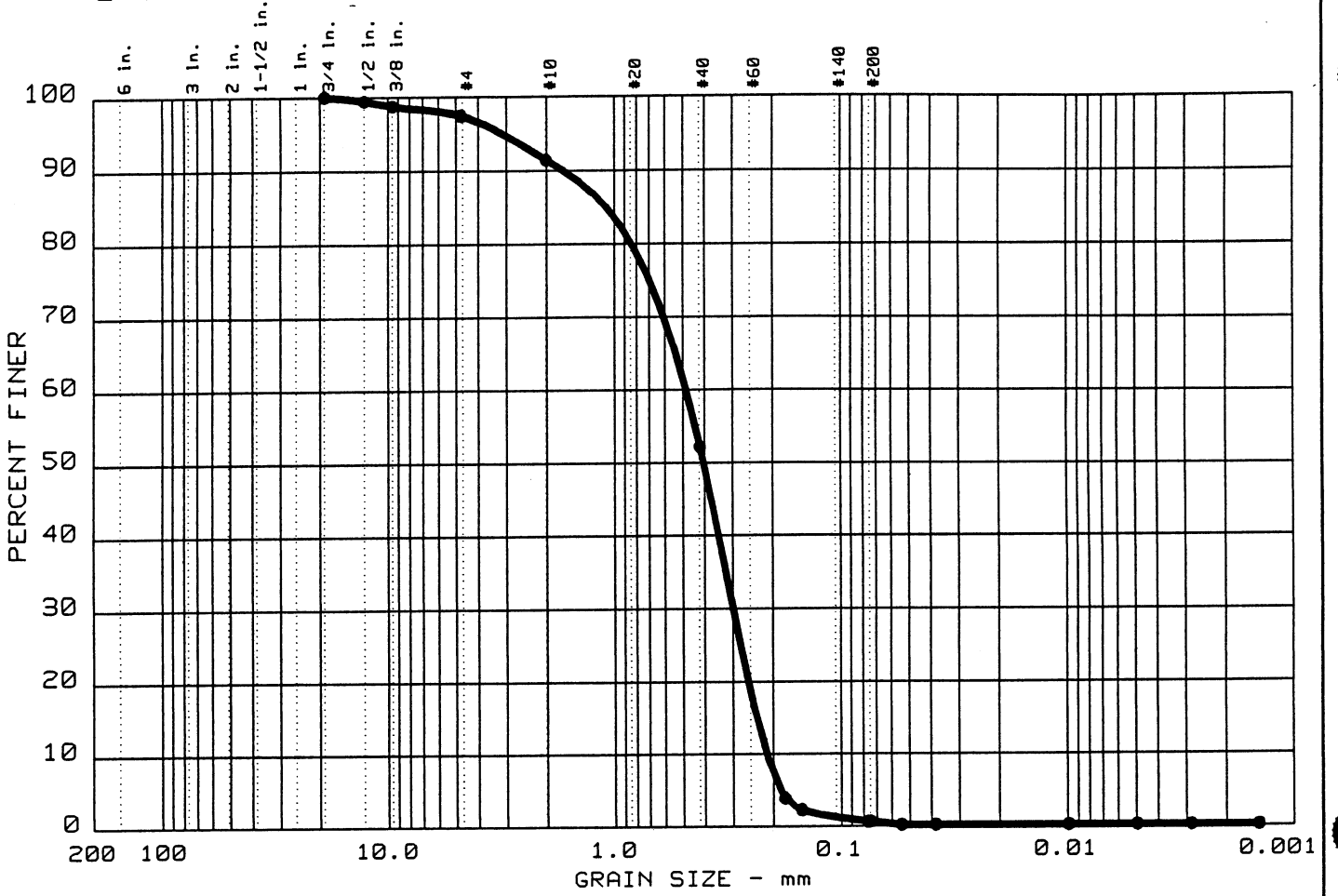
Checked By: BN

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	2	0.0	2.6	96.7	0.5	0.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.08	0.48	0.41	0.300	0.2358	0.2126	0.88	2.3

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-14, 36'-38'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-10-98

Remarks:

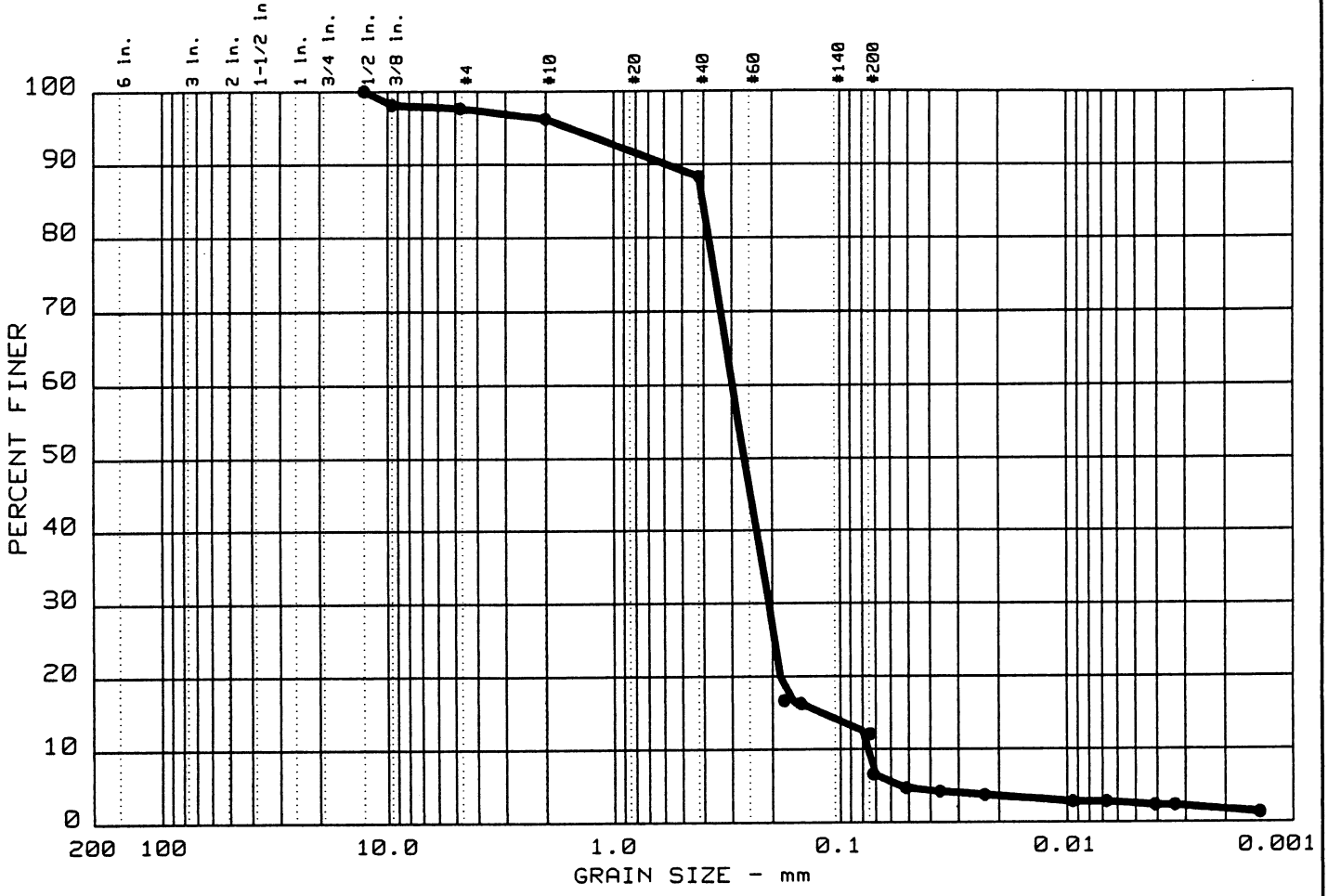
Checked By: BN

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	5	0.0	2.4	85.5	9.5	2.6

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.40	0.30	0.26	0.208	0.1182	0.0730	1.98	4.1

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-14, 64'-66'	SM	A-2-4(0.3)

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

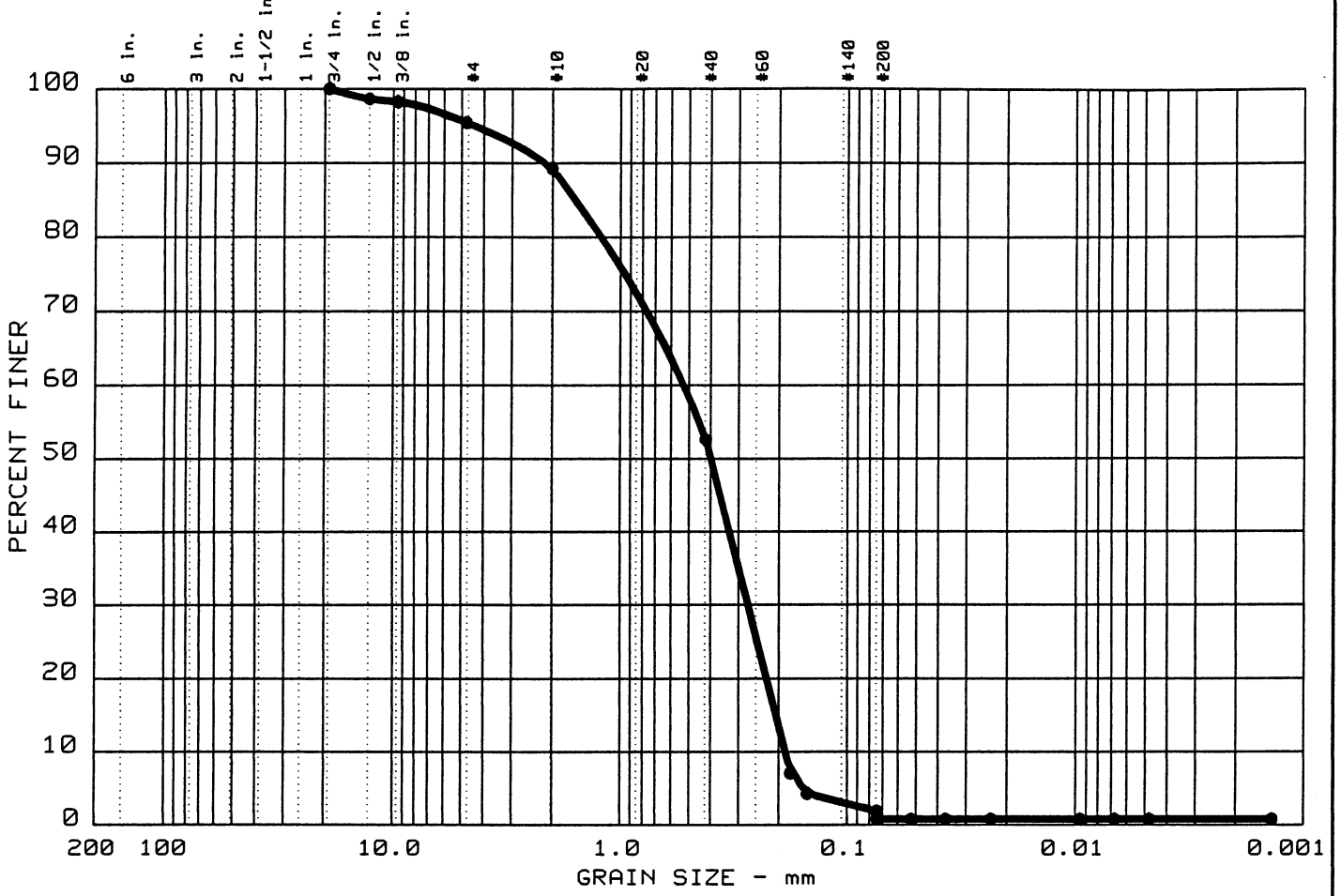
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	3	0.0	4.6	93.5	1.0	0.9

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.58	0.53	0.40	0.273	0.2049	0.1869	0.76	2.8

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-15, 10'-12'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

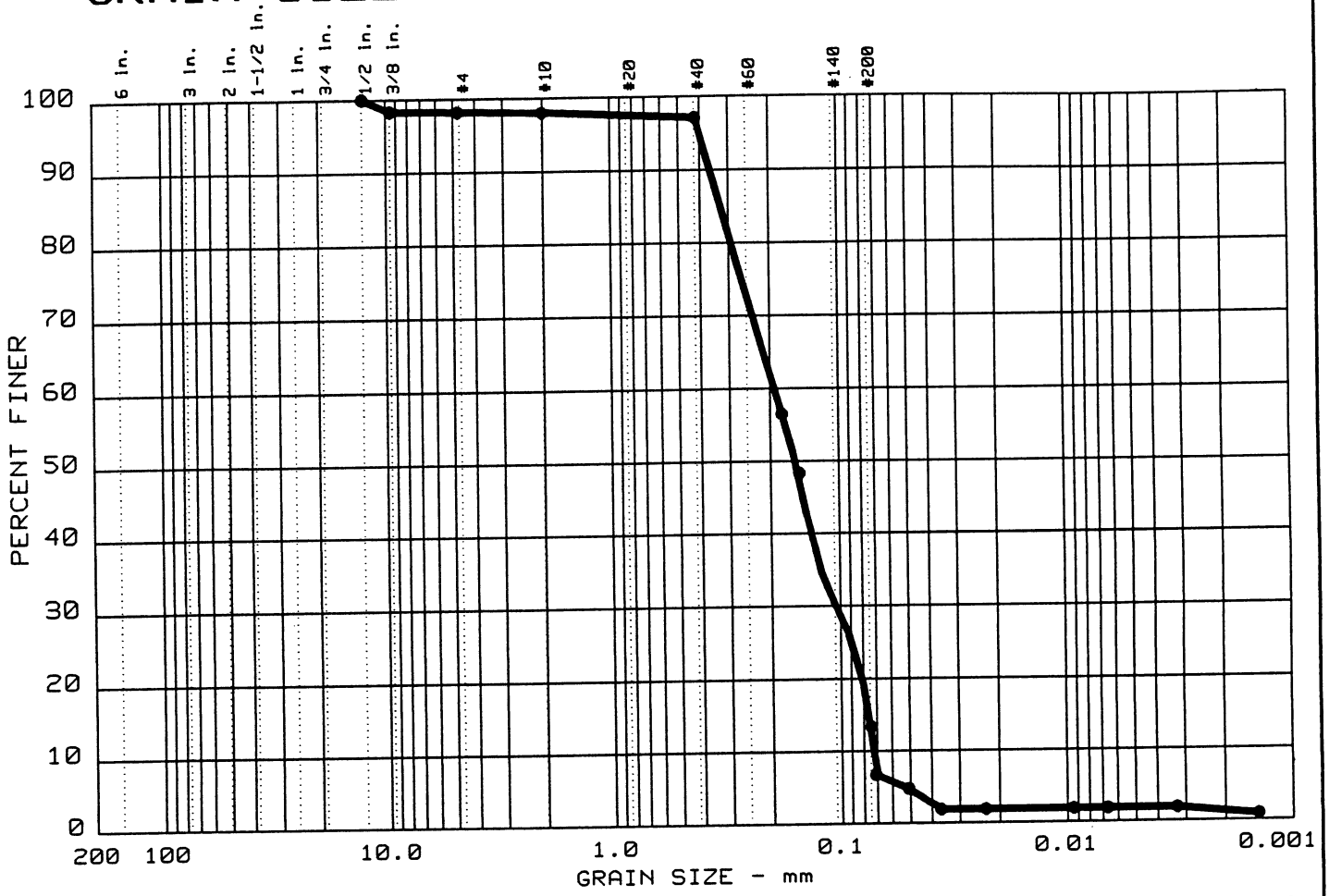
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	3	0.0	1.8	84.8	11.5	1.9

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.33	0.19	0.16	0.105	0.0752	0.0724	0.80	2.6

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-15, 26'-28'	SM	A-2-4(0.2)

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-16-98

Remarks:

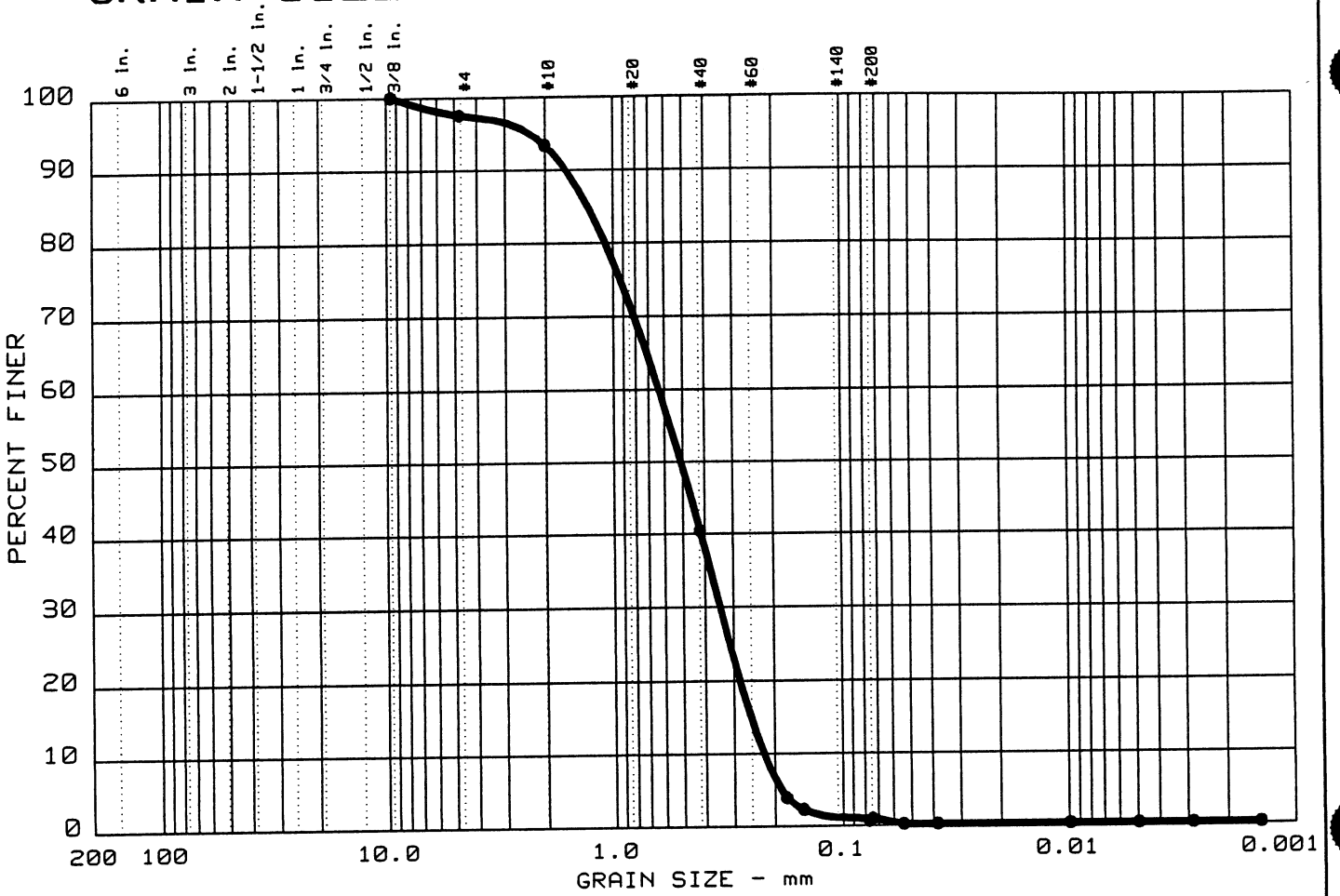
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	2	0.0	2.5	96.5	0.8	0.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.29	0.63	0.51	0.344	0.2532	0.2231	0.84	2.8

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-16, 10'-12'	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-21-98

Remarks:

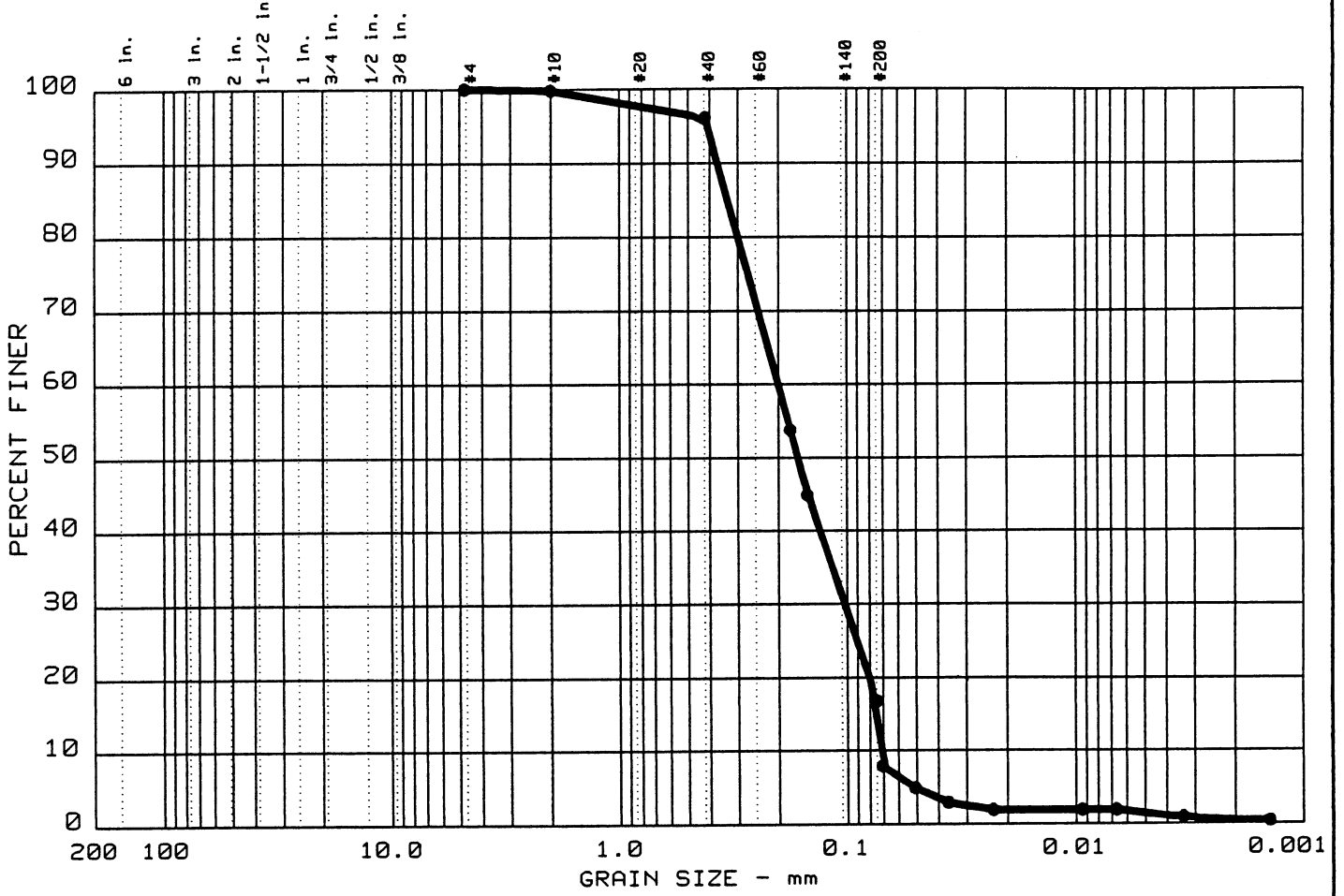
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	3	0.0	0.0	83.2	15.4	1.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.33	0.20	0.16	0.103	0.0732	0.0712	0.74	2.8

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-17, 18-20'	SM	A-2-4(0.0)

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

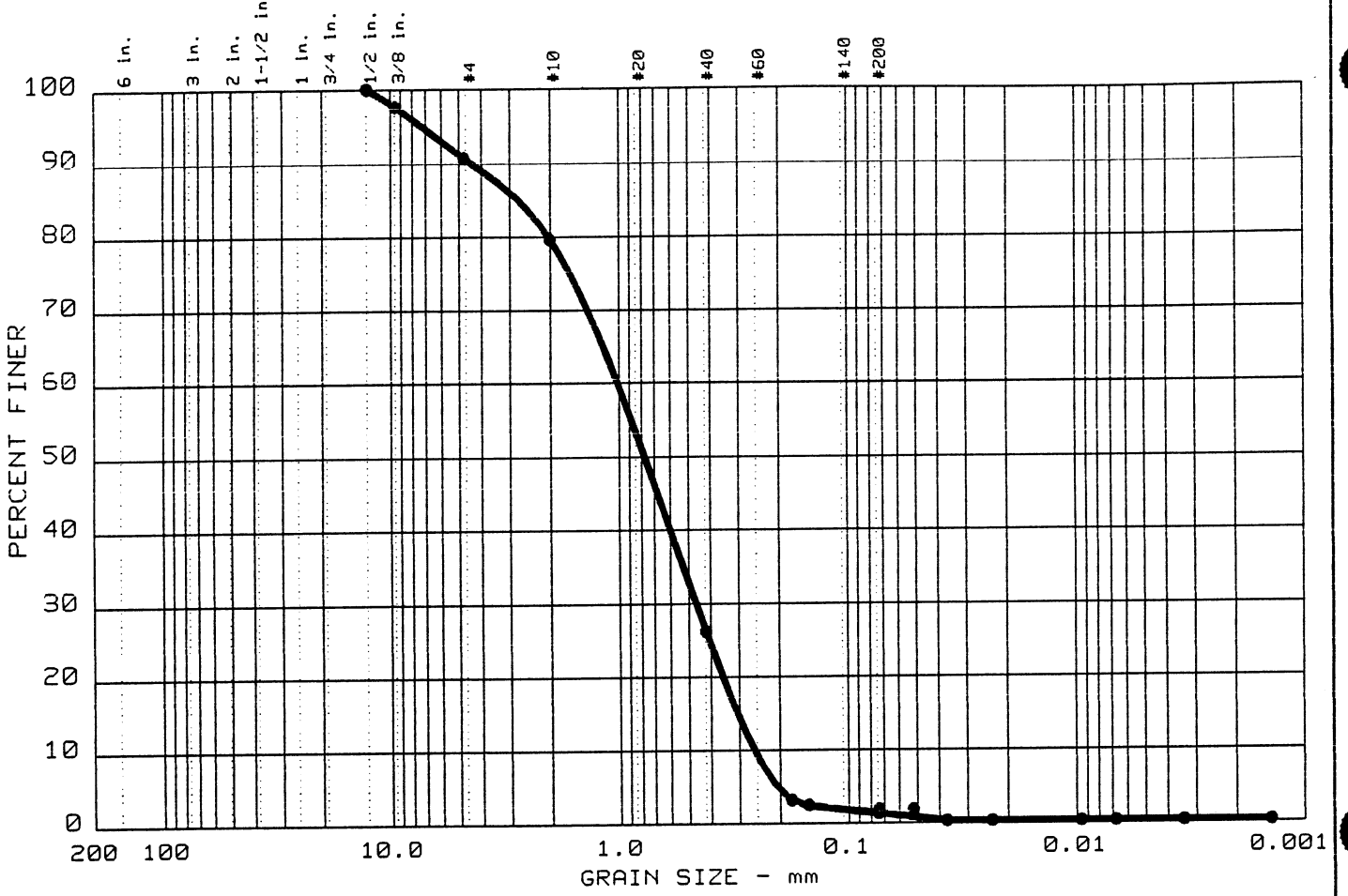
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	2	0.0	9.3	89.3	1.1	0.3

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			2.75	1.02	0.78	0.462	0.3055	0.2570	0.82	4.0

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-18, 22'-24'	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-16-98

Remarks:

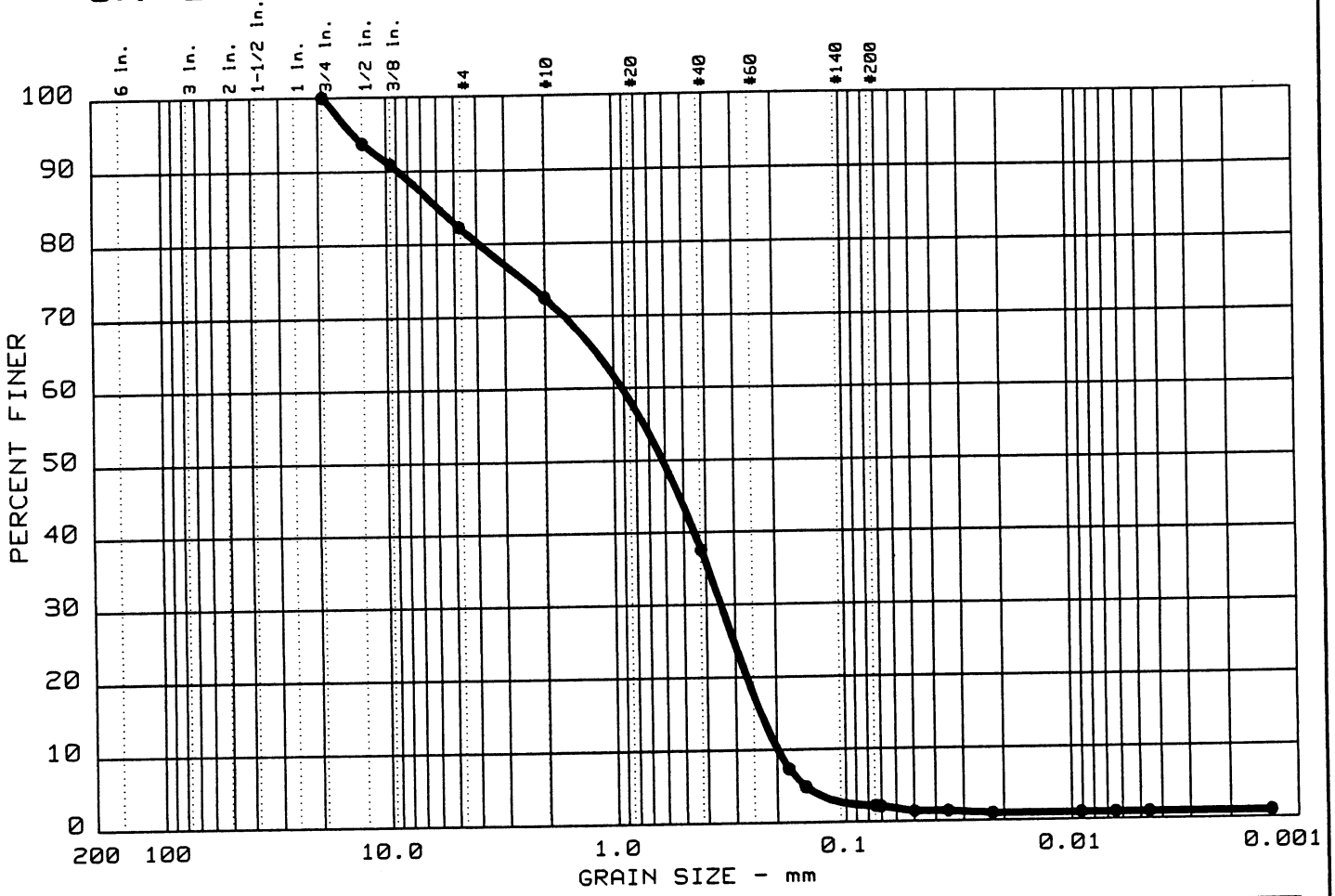
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	17.7	80.1	1.2	1.0

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			5.89	0.91	0.61	0.346	0.2336	0.1982	0.66	4.6

MATERIAL DESCRIPTION	USCS	AASHTO
● BH-19, 14'-15.5'	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

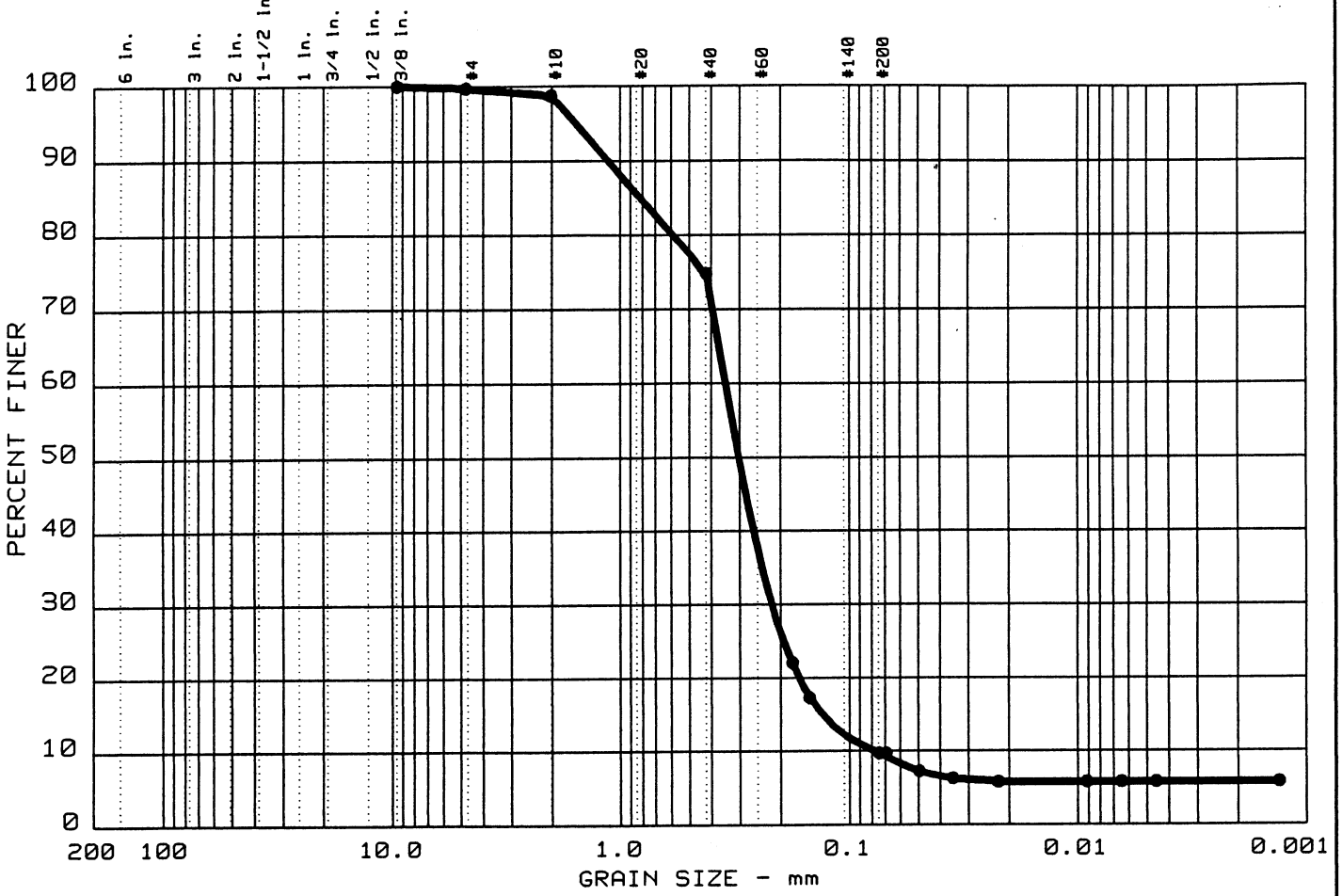
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	2	0.0	0.3	90.0	3.9	5.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.81	0.35	0.30	0.219	0.1305	0.0768	1.80	4.5

MATERIAL DESCRIPTION	USCS	AASHTO
● MWH-09P, 32-34'	SP-SM	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

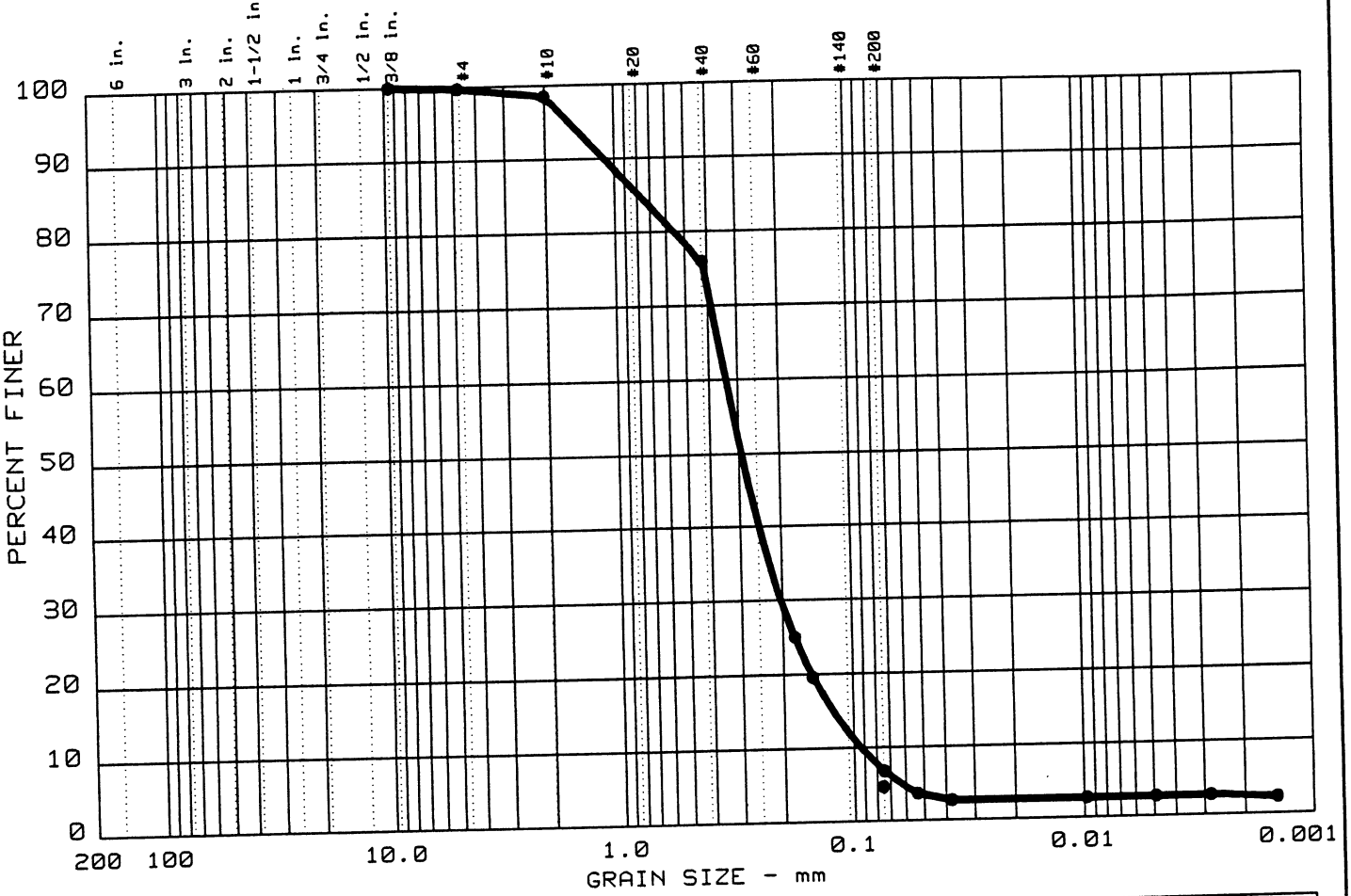
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	0.3	92.9	4.1	2.7

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.79	0.34	0.29	0.204	0.1227	0.0931	1.32	3.6

MATERIAL DESCRIPTION	USCS	AASHTO
● MWH-10P 34'-36'	SP-SM	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-10-98

Remarks:

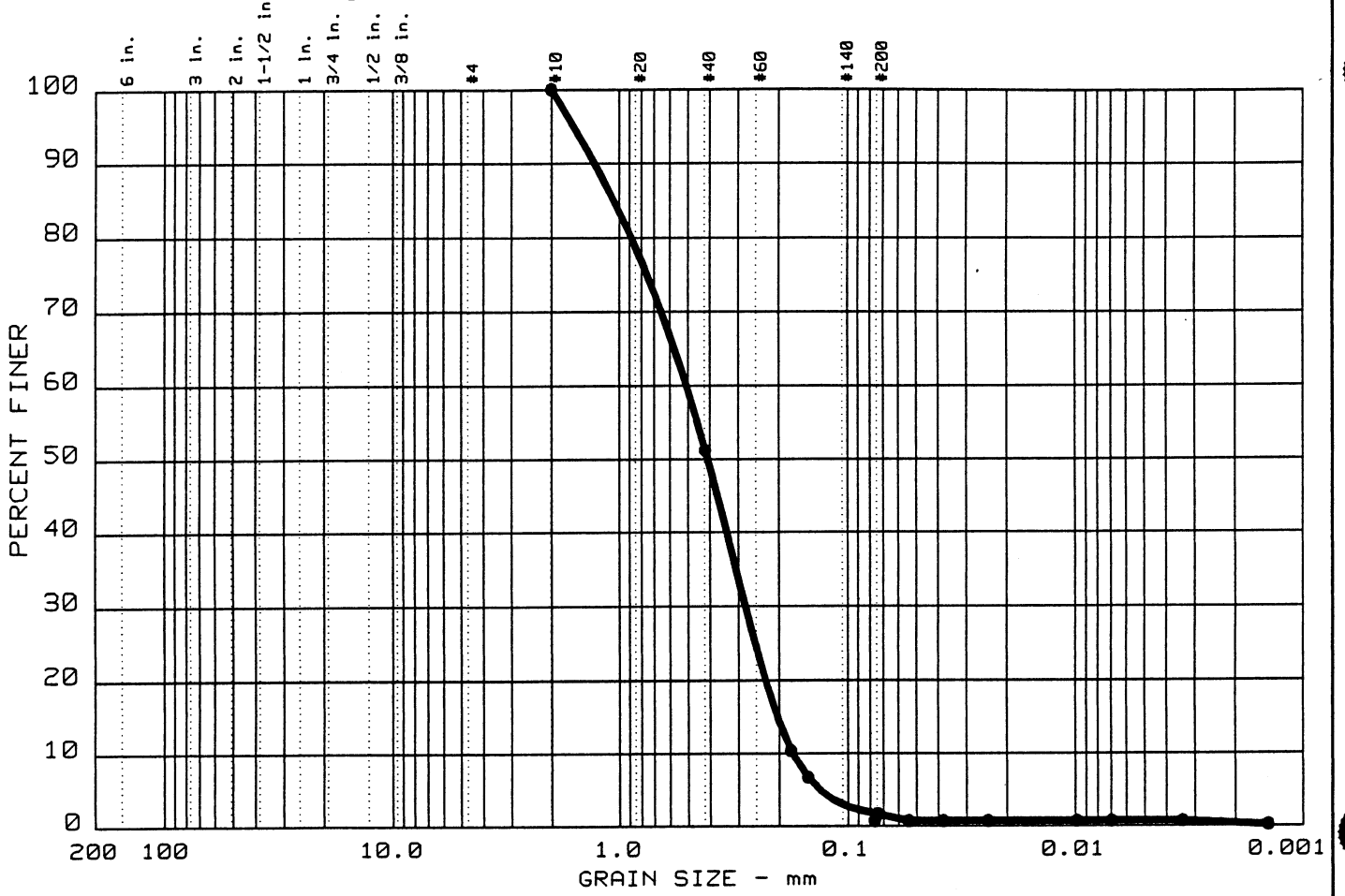
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	3	0.0	0.0	98.3	0.9	0.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.06	0.51	0.41	0.280	0.2030	0.1744	0.89	2.9

MATERIAL DESCRIPTION	USCS	AASHTO
● MWH-11P, 32'-34'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-11-98

Remarks:

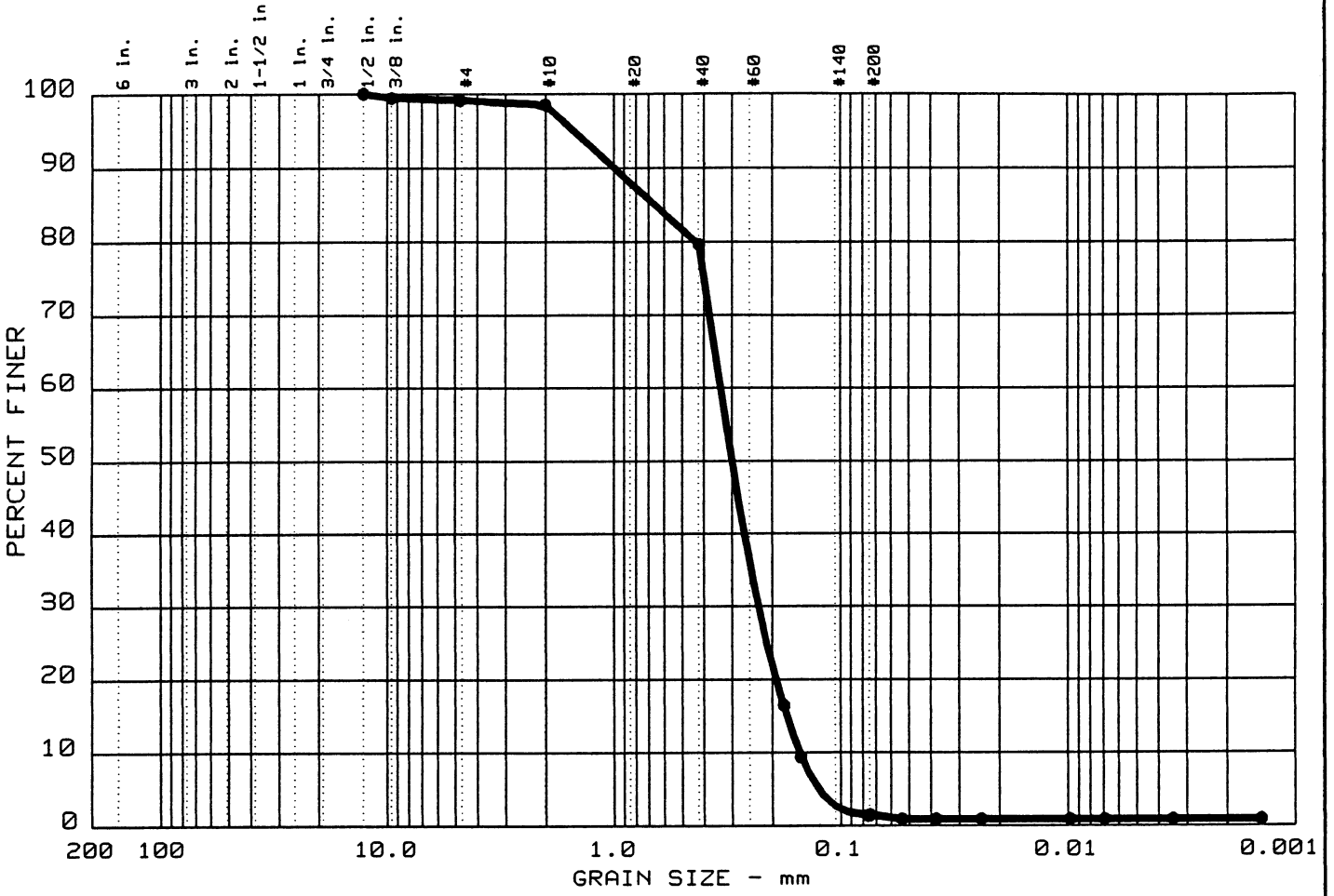
Checked By: BN

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	8	0.0	0.9	97.6	0.6	0.9

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.65	0.34	0.30	0.230	0.1716	0.1512	1.04	2.2

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-5, 10'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

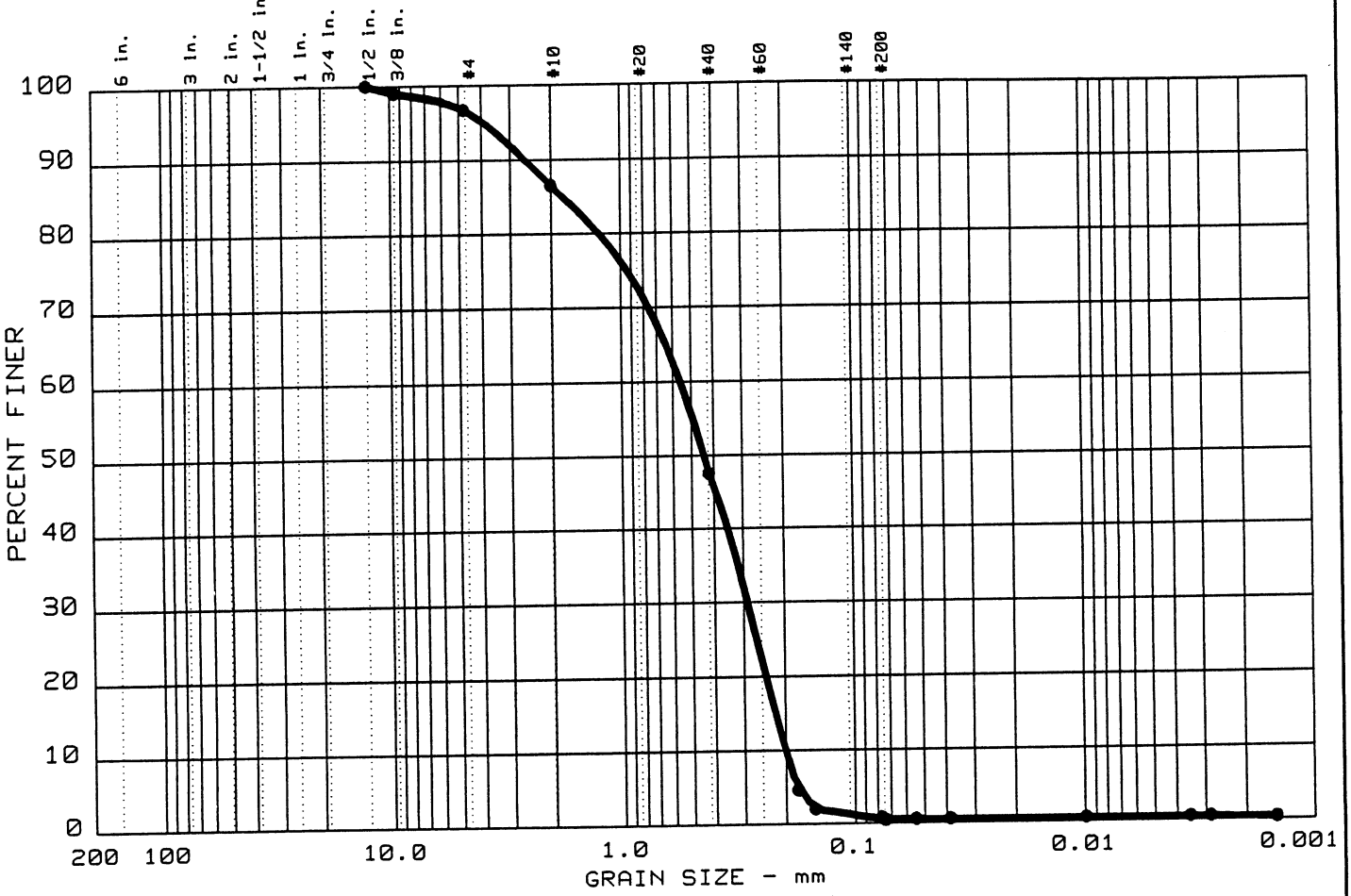
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	2	0.0	3.3	96.2	0.1	0.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.78	0.56	0.44	0.289	0.2205	0.1998	0.75	2.8

MATERIAL DESCRIPTION	USCS	AASHTO
● H-12, 6'	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-10-98

Remarks:

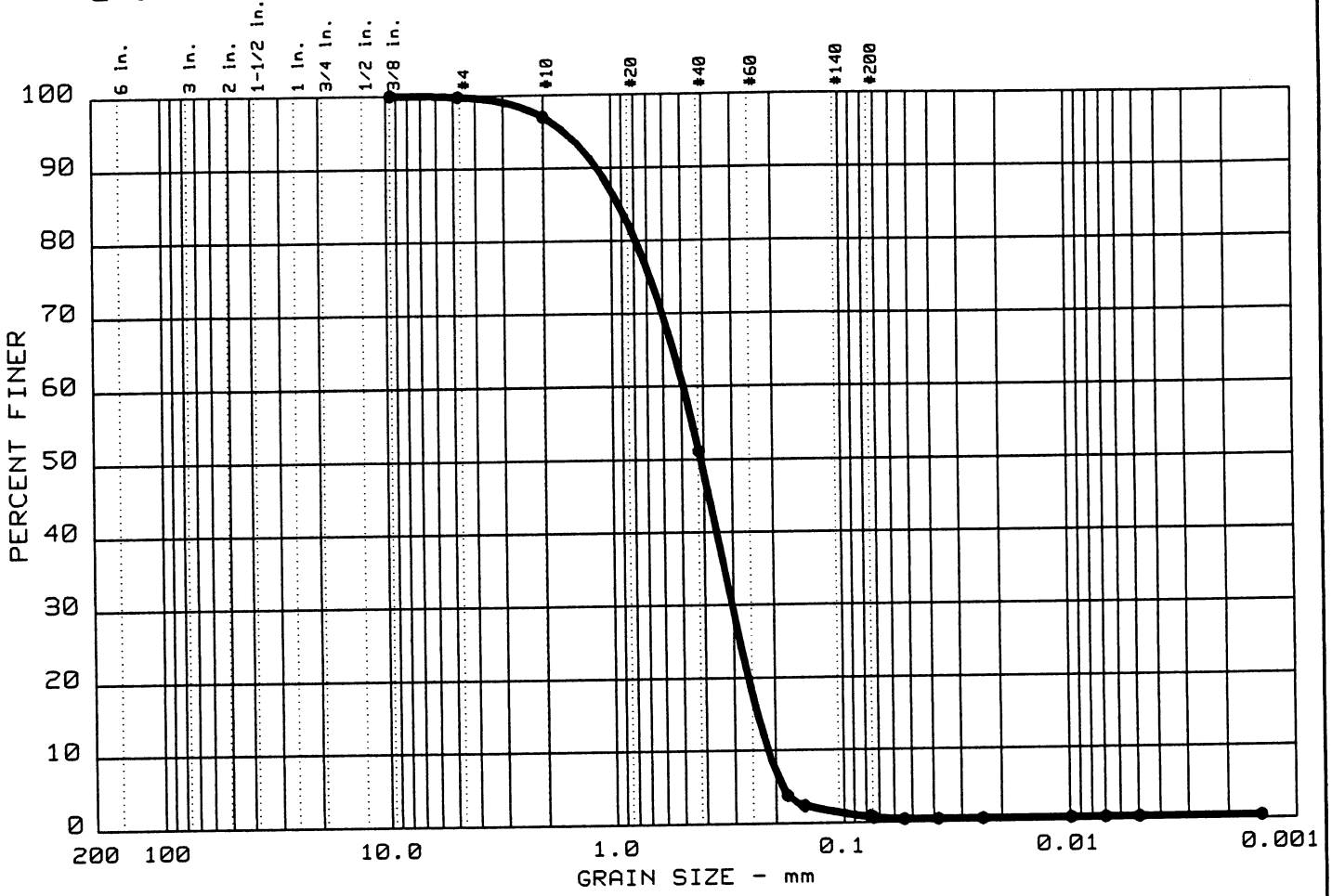
Checked By: BN

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	0.2	99.1	0.3	0.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.93	0.49	0.41	0.305	0.2391	0.2155	0.88	2.3

MATERIAL DESCRIPTION	USCS	AASHTO
● H-13, 4.5'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-21-98

Remarks:

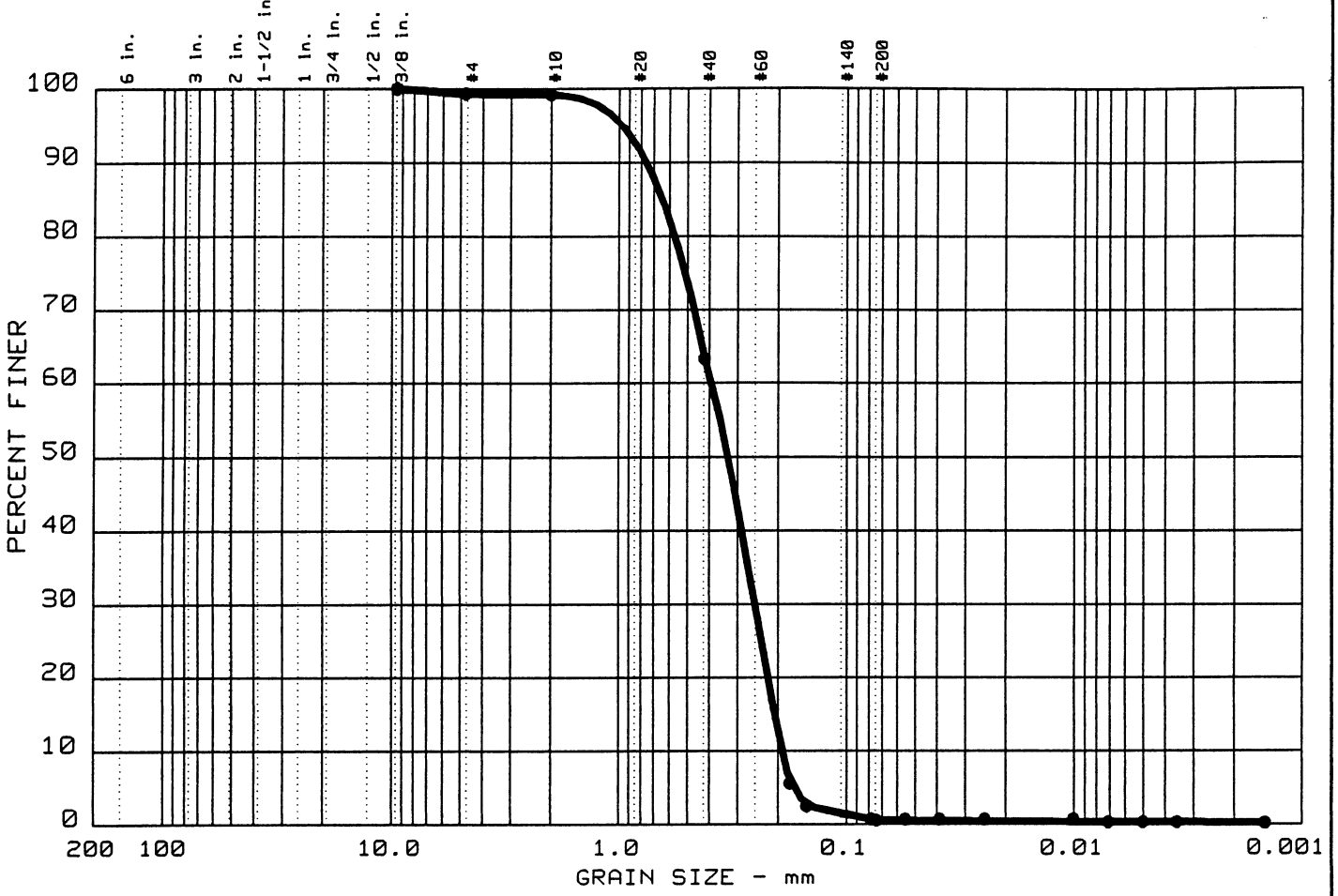
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	6	0.0	0.7	98.7	0.2	0.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.64	0.39	0.33	0.253	0.2056	0.1908	0.86	2.1

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-14, 6'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-12-98

Remarks:

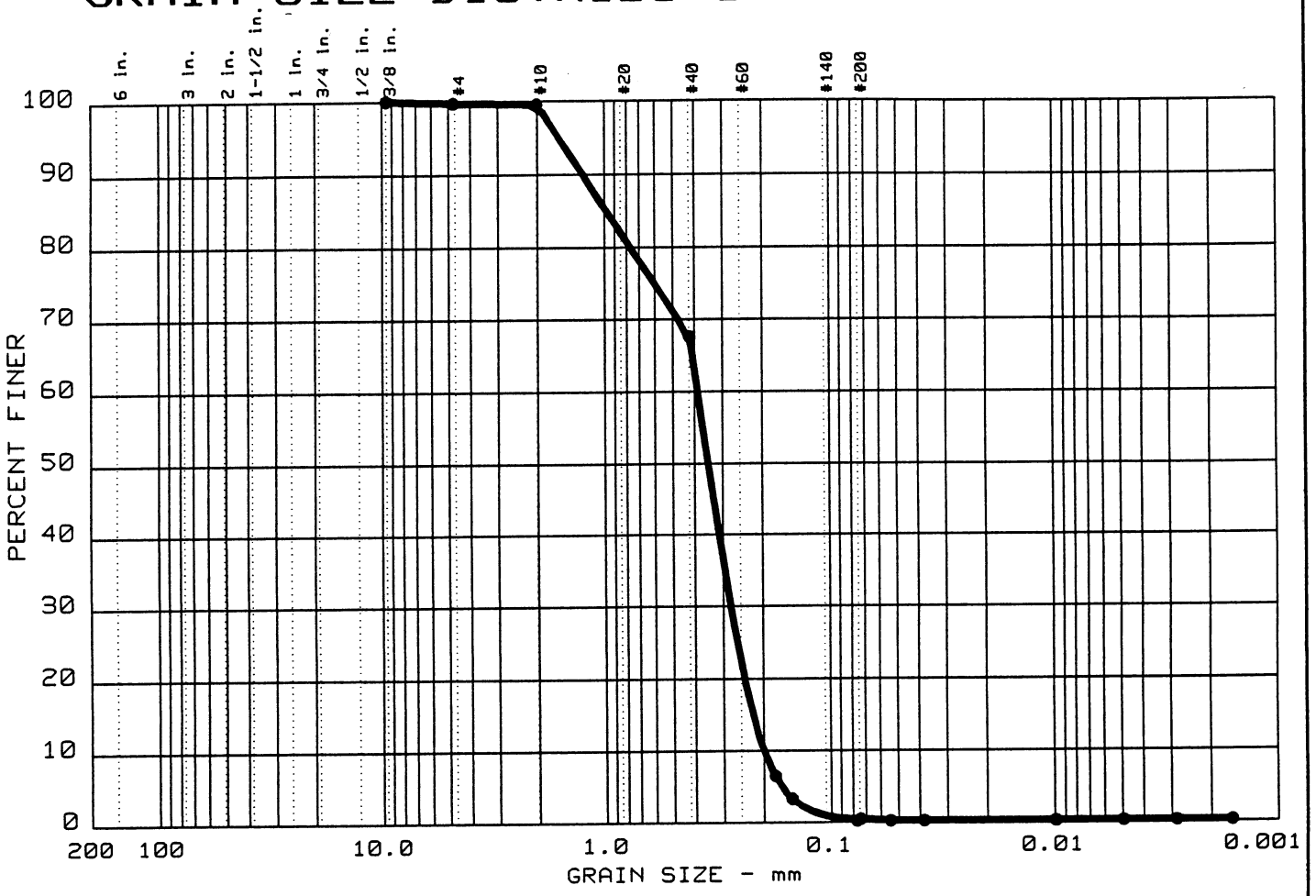
Checked By: BN

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	0.3	99.2	0.3	0.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.98	0.39	0.35	0.279	0.2236	0.2007	1.00	1.9

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-15, 5'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-10-98

Remarks:

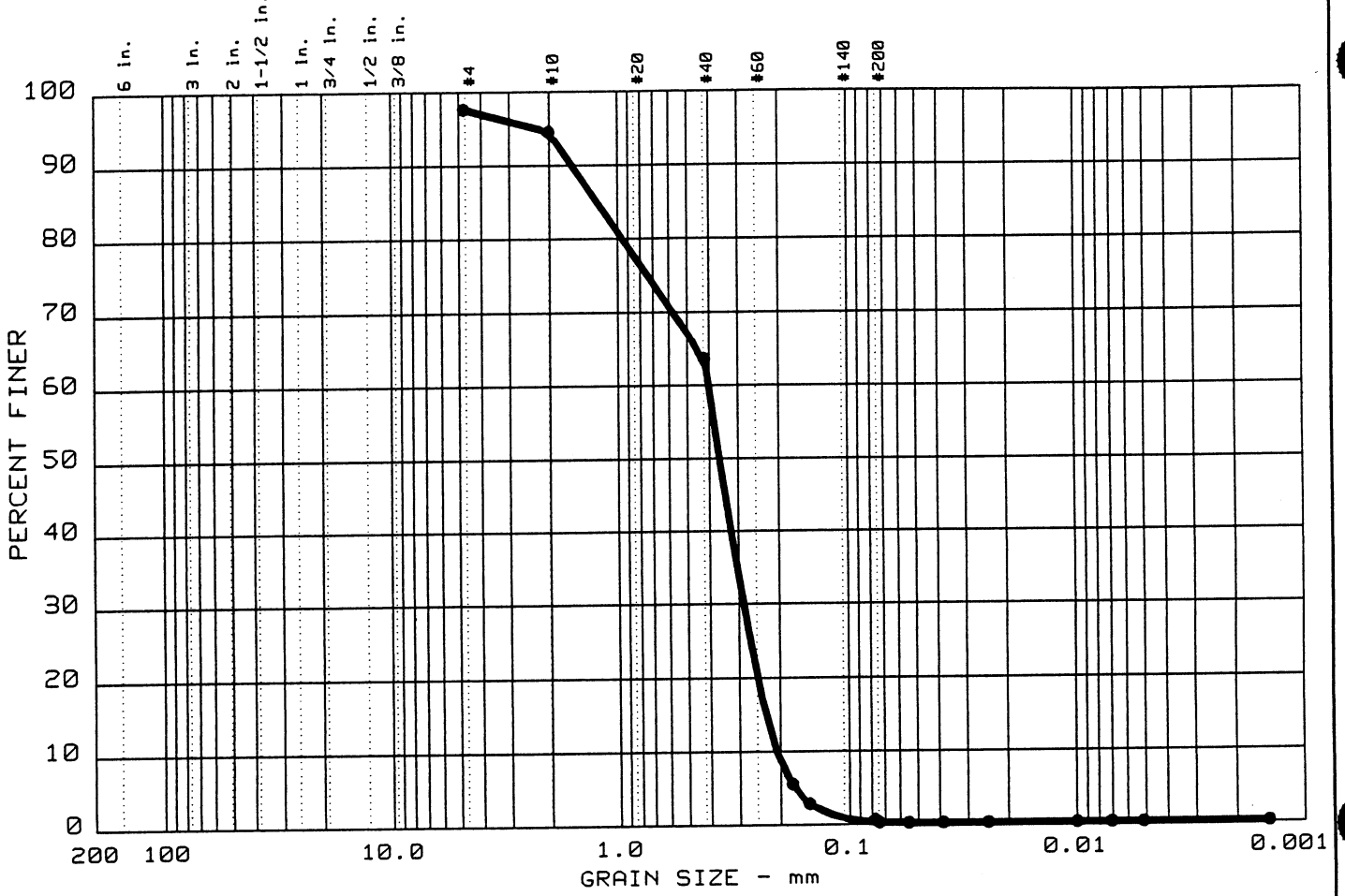
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	8	0.0	2.4	97.3	0.1	0.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.23	0.40	0.36	0.287	0.2304	0.2077	0.99	1.9

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-16, 8'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-12-98

Remarks:

Checked By: BM

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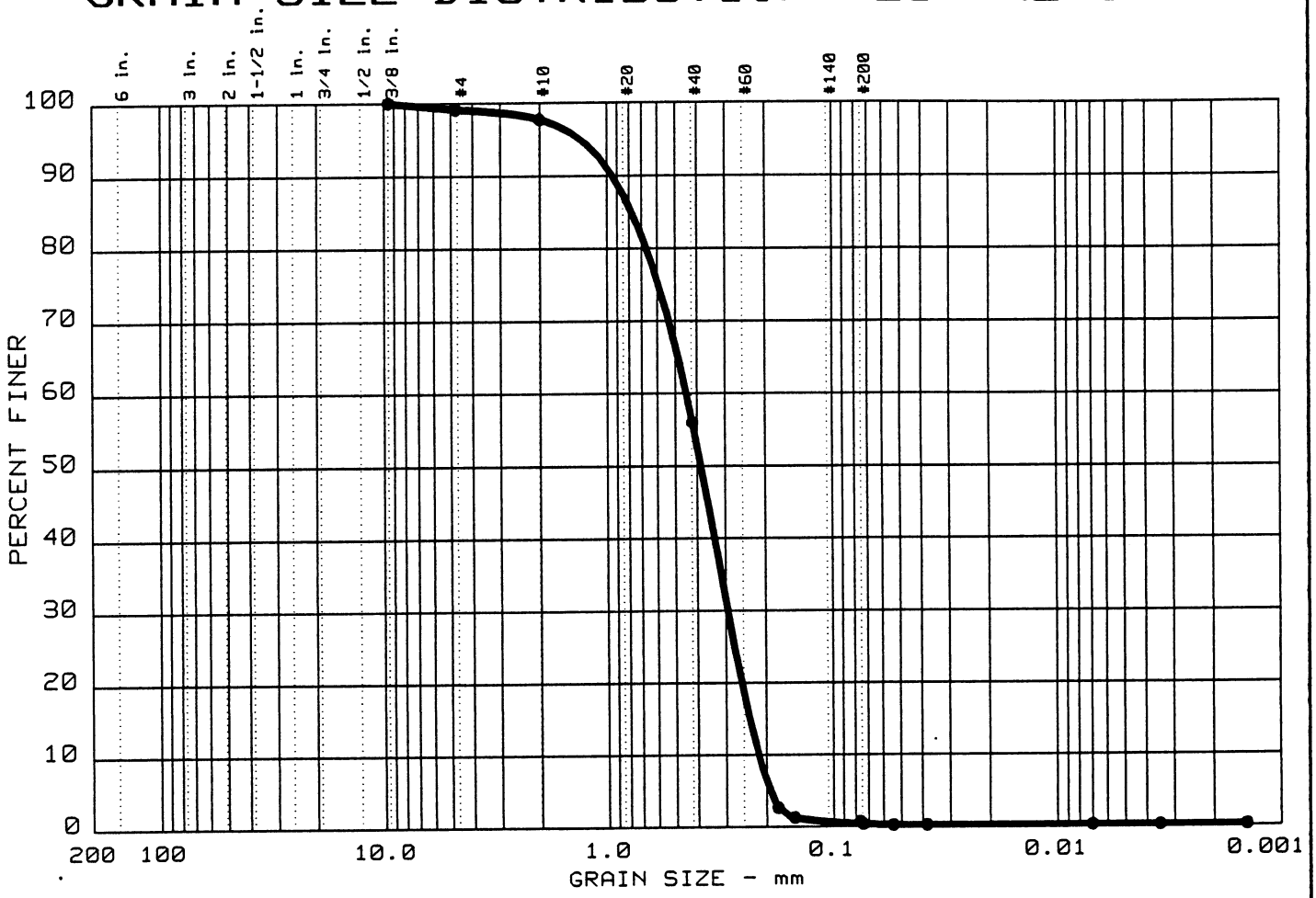
GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	0.9	98.7	0.2	0.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.78	0.45	0.38	0.295	0.2371	0.2163	0.90	2.1

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-17, 5'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-10-98

Remarks:

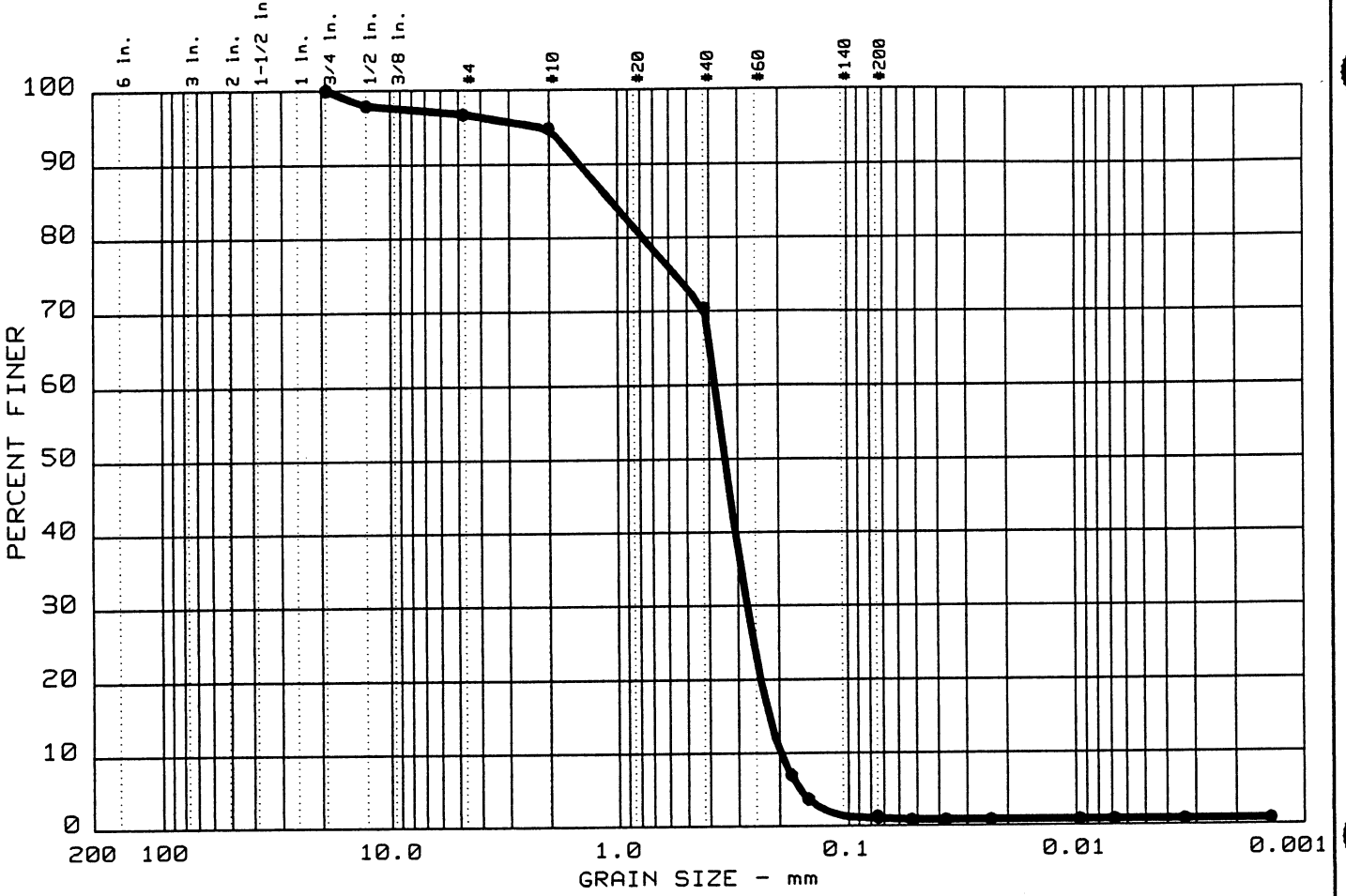
Checked By: BN

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	3.3	95.6	0.2	0.9

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.06	0.38	0.34	0.275	0.2208	0.1984	1.00	1.9

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-28, 8'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

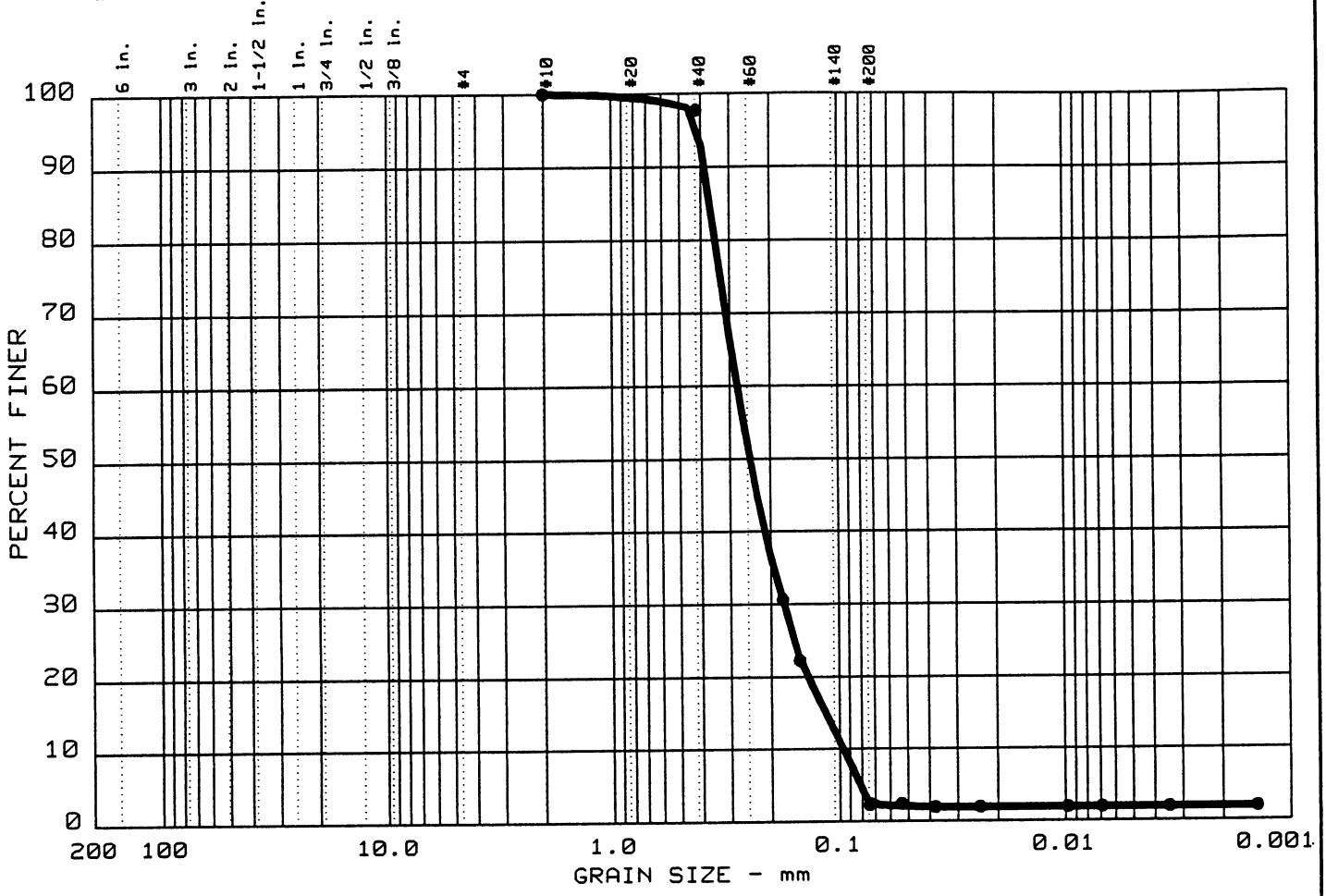
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	7	0.0	0.0	97.7	0.3	2.0

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.37	0.28	0.25	0.175	0.1153	0.0968	1.14	2.9

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-29, 4.5'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

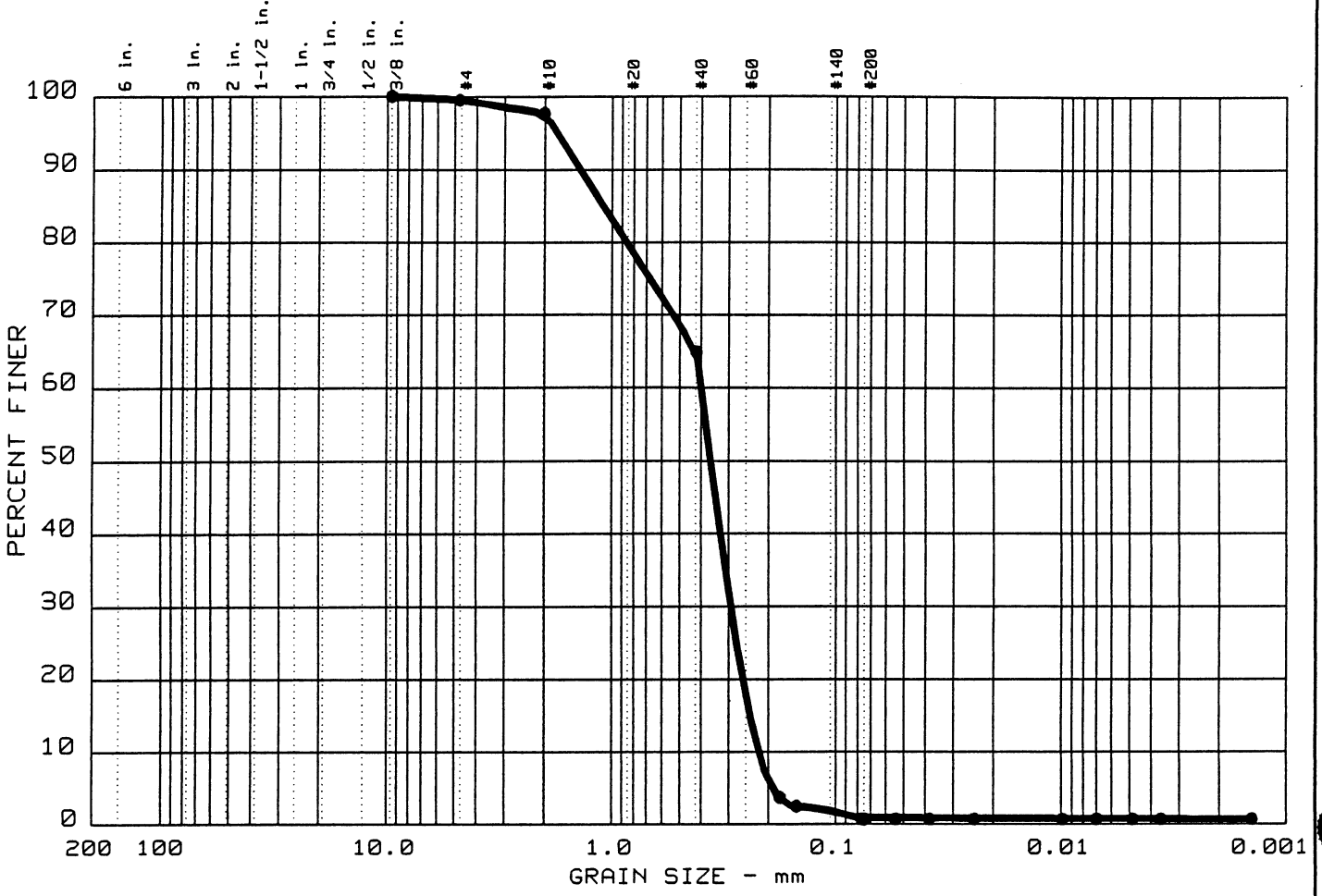
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	7	0.0	0.5	98.8	0.7	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.08	0.40	0.36	0.294	0.2418	0.2205	0.98	1.8

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-30, 4.5'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-12-98

Remarks:

Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

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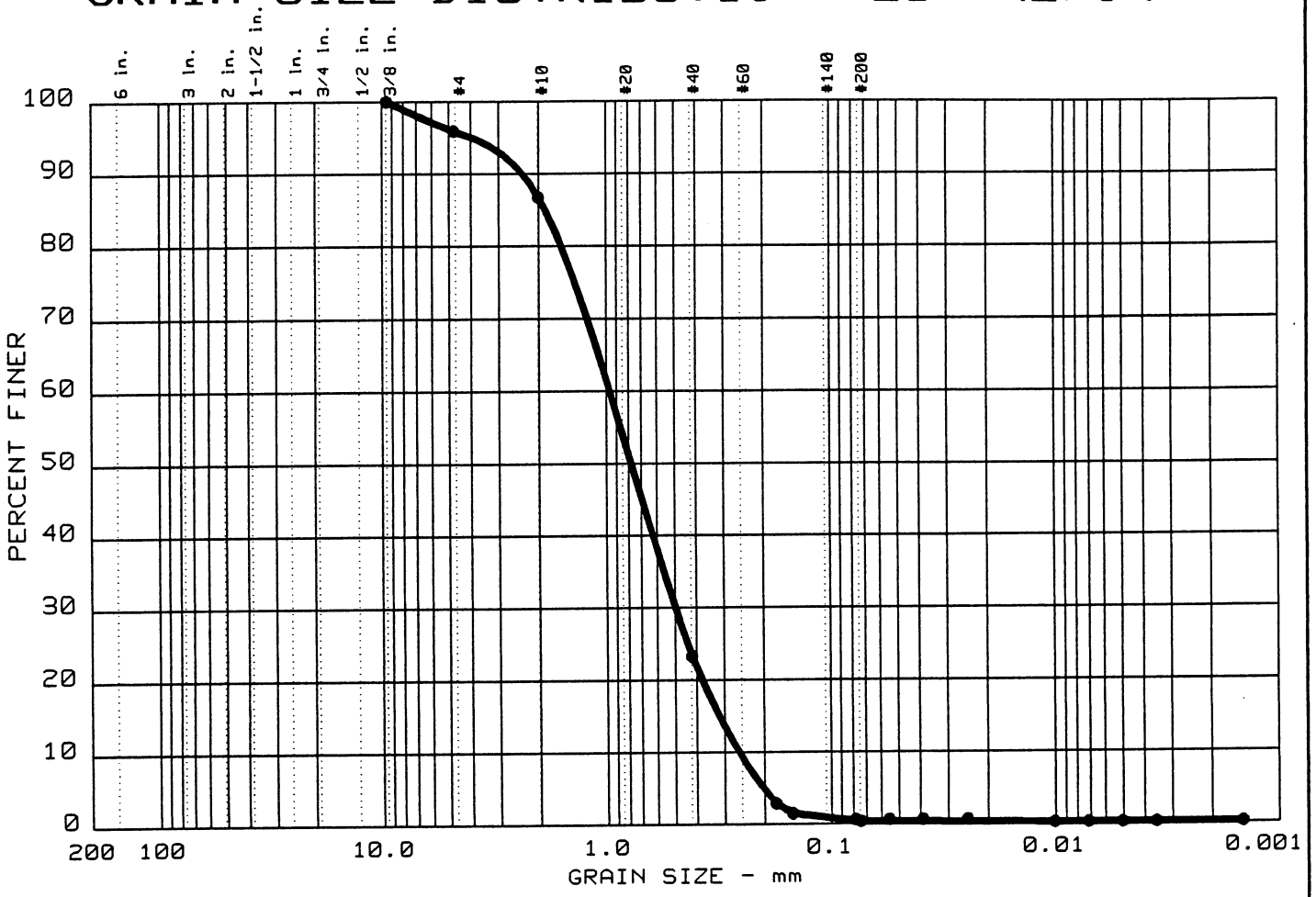


	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	5	0.0	4.1	95.5	0.2	0.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.86	0.97	0.78	0.498	0.3173	0.2579	0.99	3.7

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-31, 9'	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-12-98

Remarks:

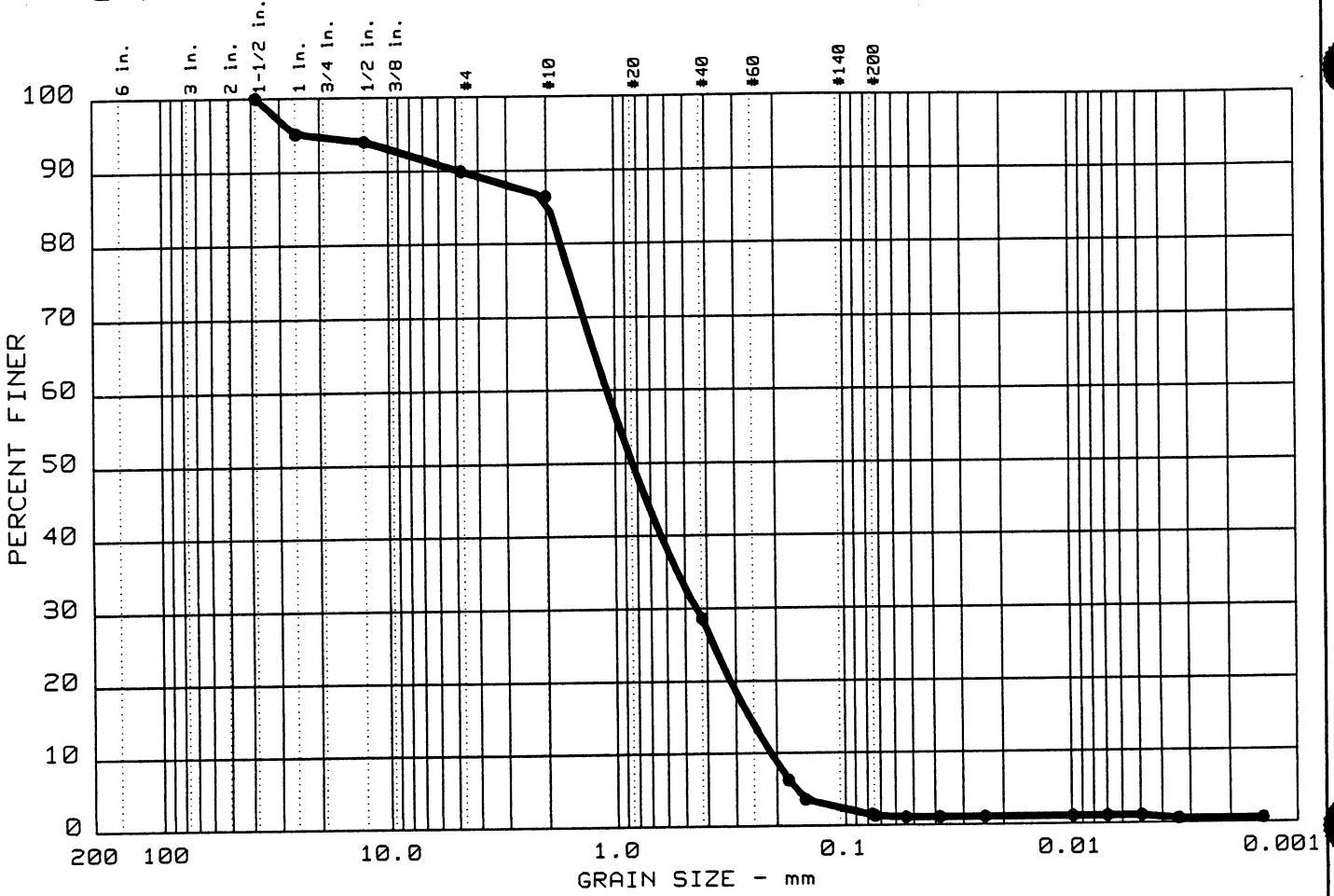
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	10.1	88.6	0.2	1.1

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.94	1.09	0.84	0.443	0.2627	0.2111	0.85	5.1

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-32, 5'	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-12-98

Remarks:

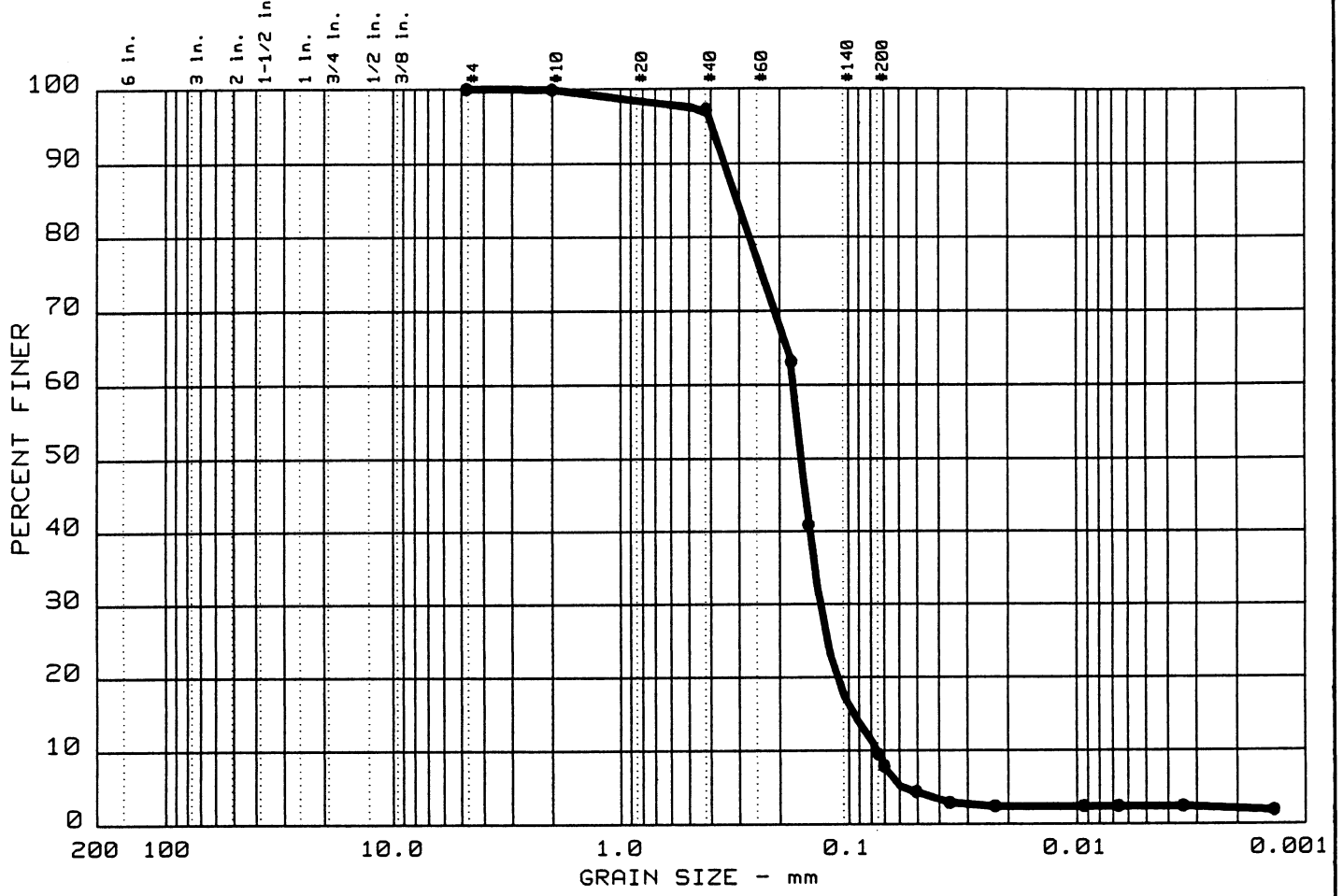
Checked By: Bm

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	2	0.0	0.0	90.5	7.1	2.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.31	0.17	0.16	0.133	0.0954	0.0749	1.37	2.3

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-33C, 60"	SP-SM	A-3

Project No.: 115.47 •
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

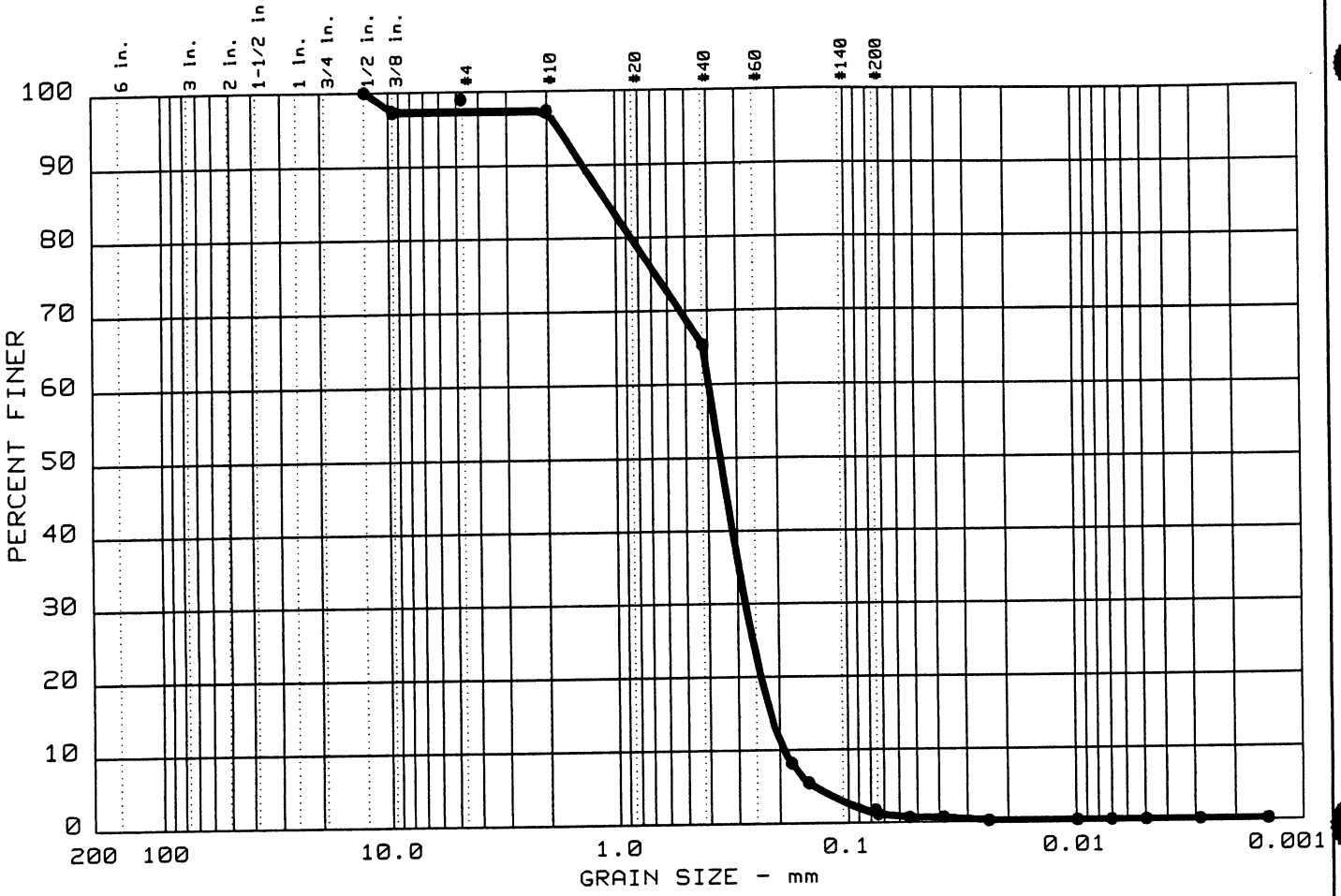
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	2.7	96.1	1.0	0.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.10	0.40	0.35	0.279	0.2188	0.1925	1.02	2.1

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH 35, 3'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-10-98

Remarks:

Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

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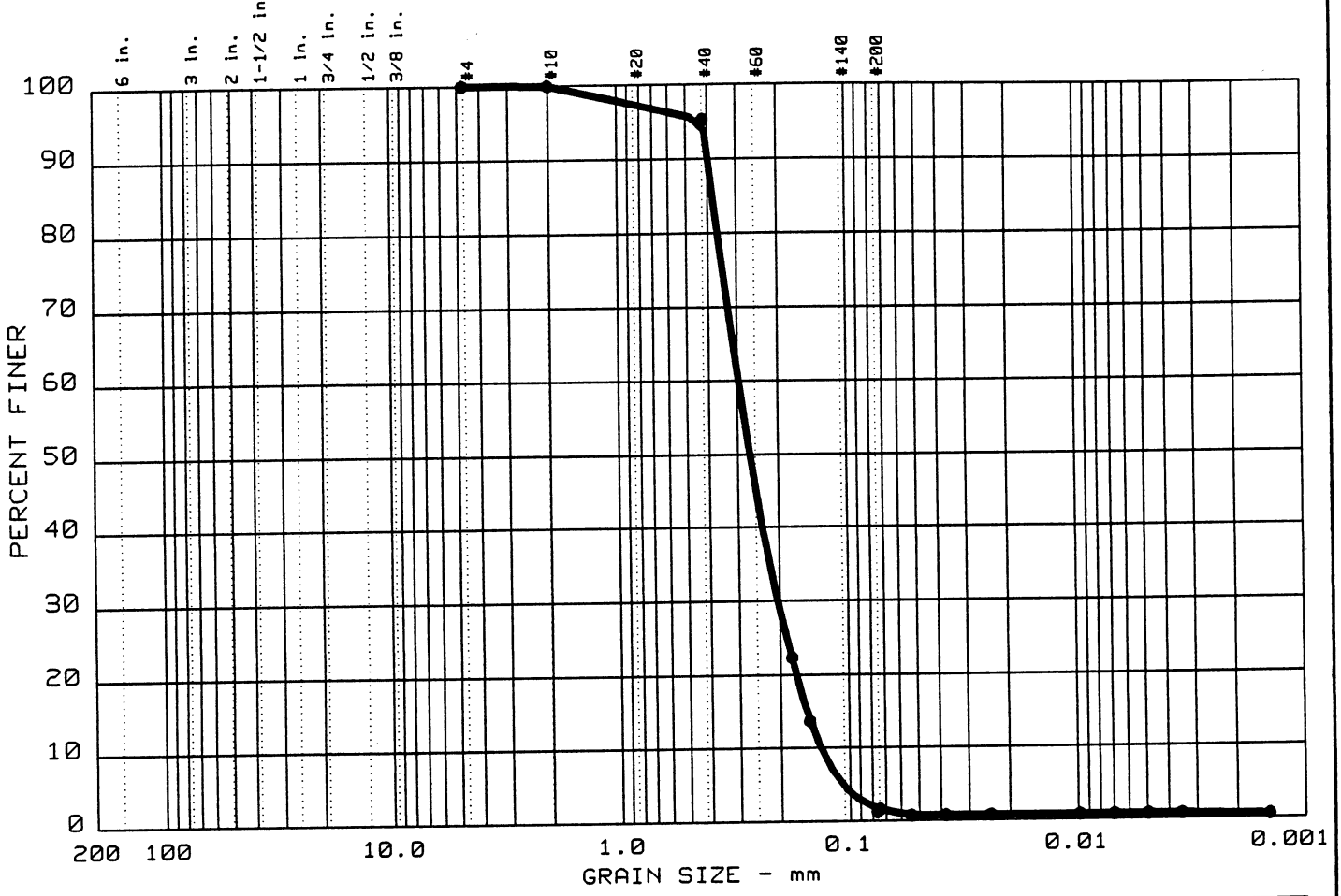


	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	3	0.0	0.0	98.4	0.8	0.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.38	0.30	0.27	0.205	0.1535	0.1337	1.05	2.2

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-36, 5'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-12-98

Remarks:

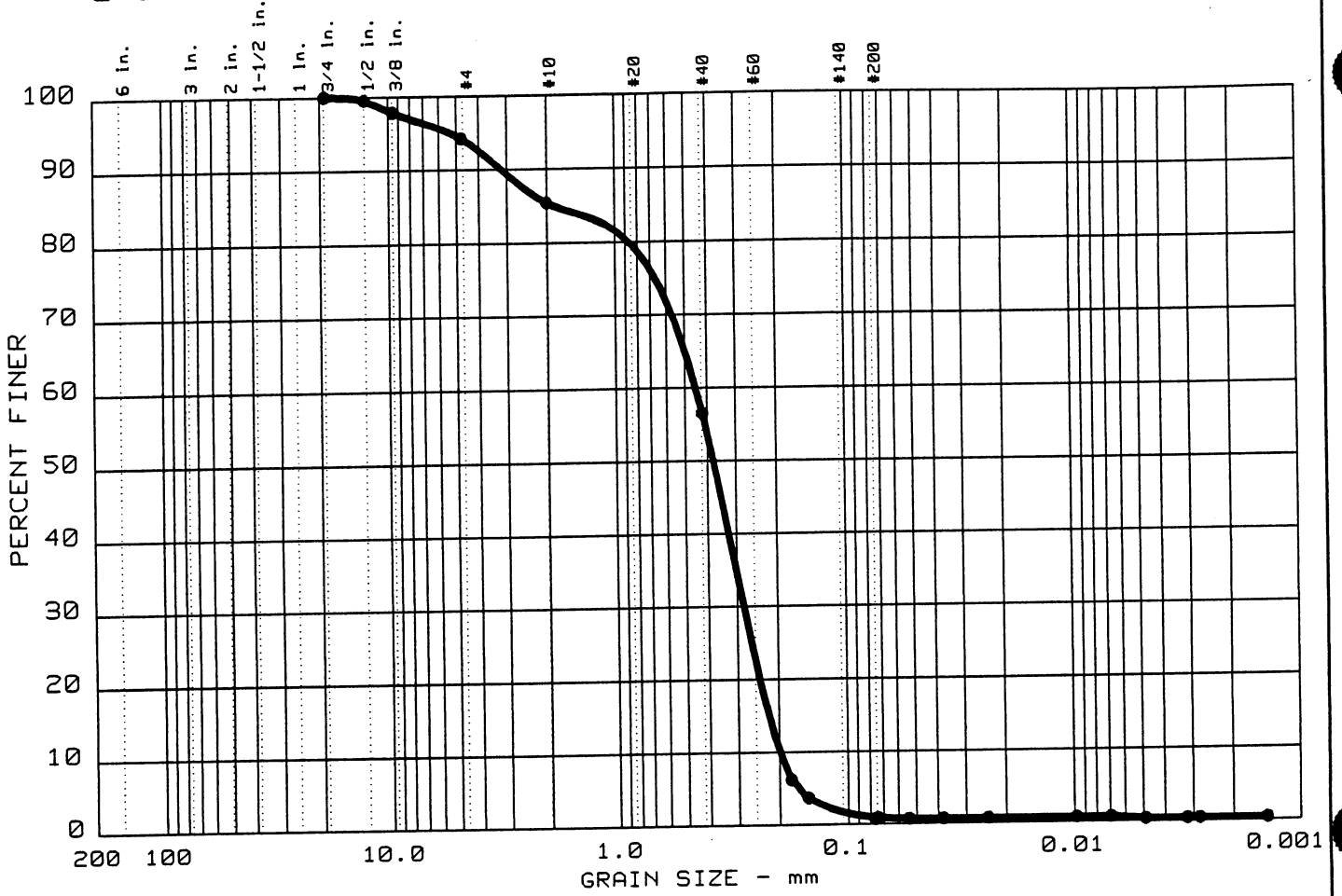
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	2	0.0	5.8	93.3	0.5	0.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.86	0.45	0.38	0.282	0.2208	0.1986	0.89	2.2

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-37, 3'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-12-98

Remarks:

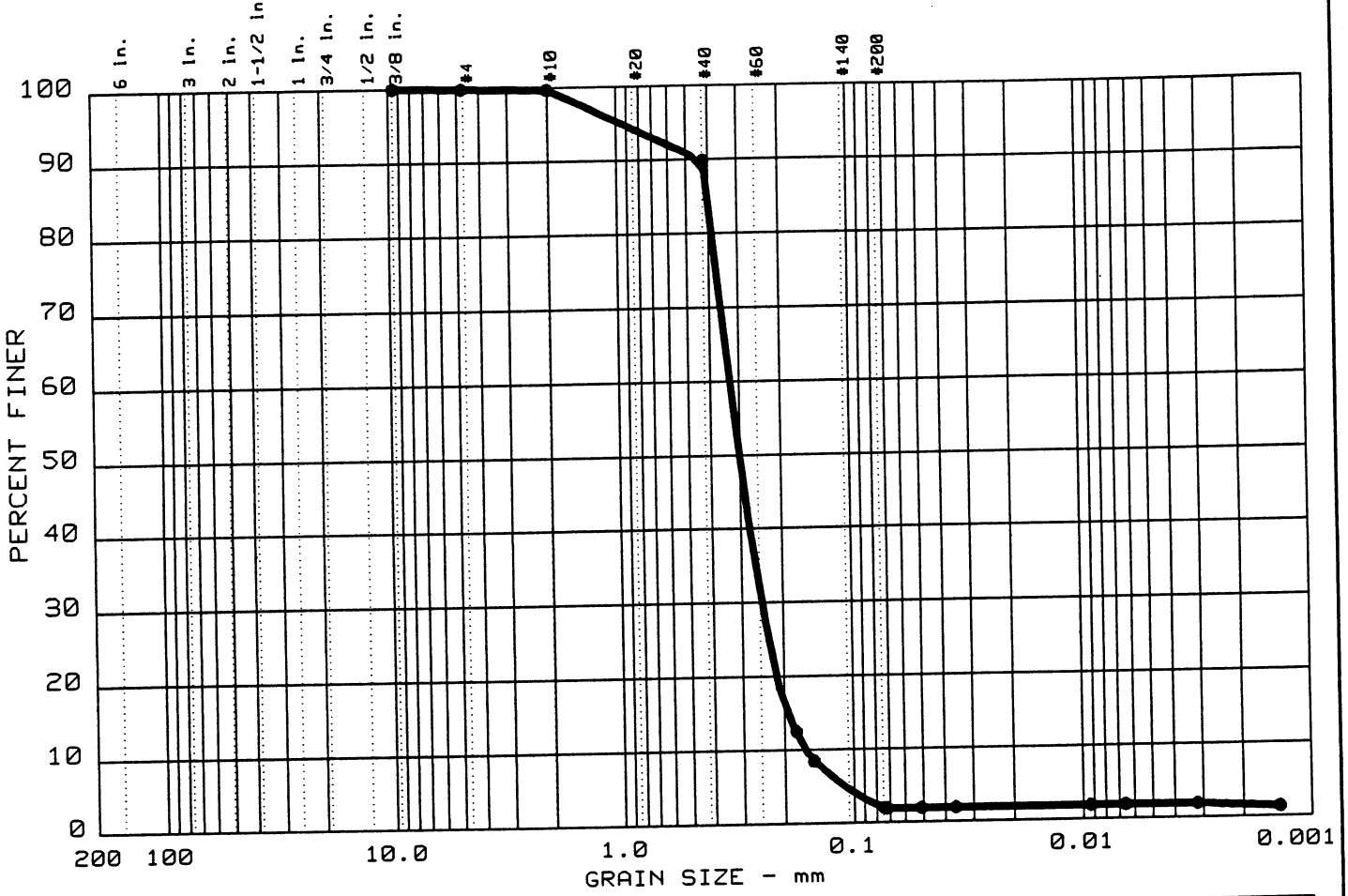
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	0.1	97.9	0.1	1.9

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.40	0.33	0.30	0.247	0.1939	0.1613	1.15	2.0

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-38B, 60"	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-16-98

Remarks:

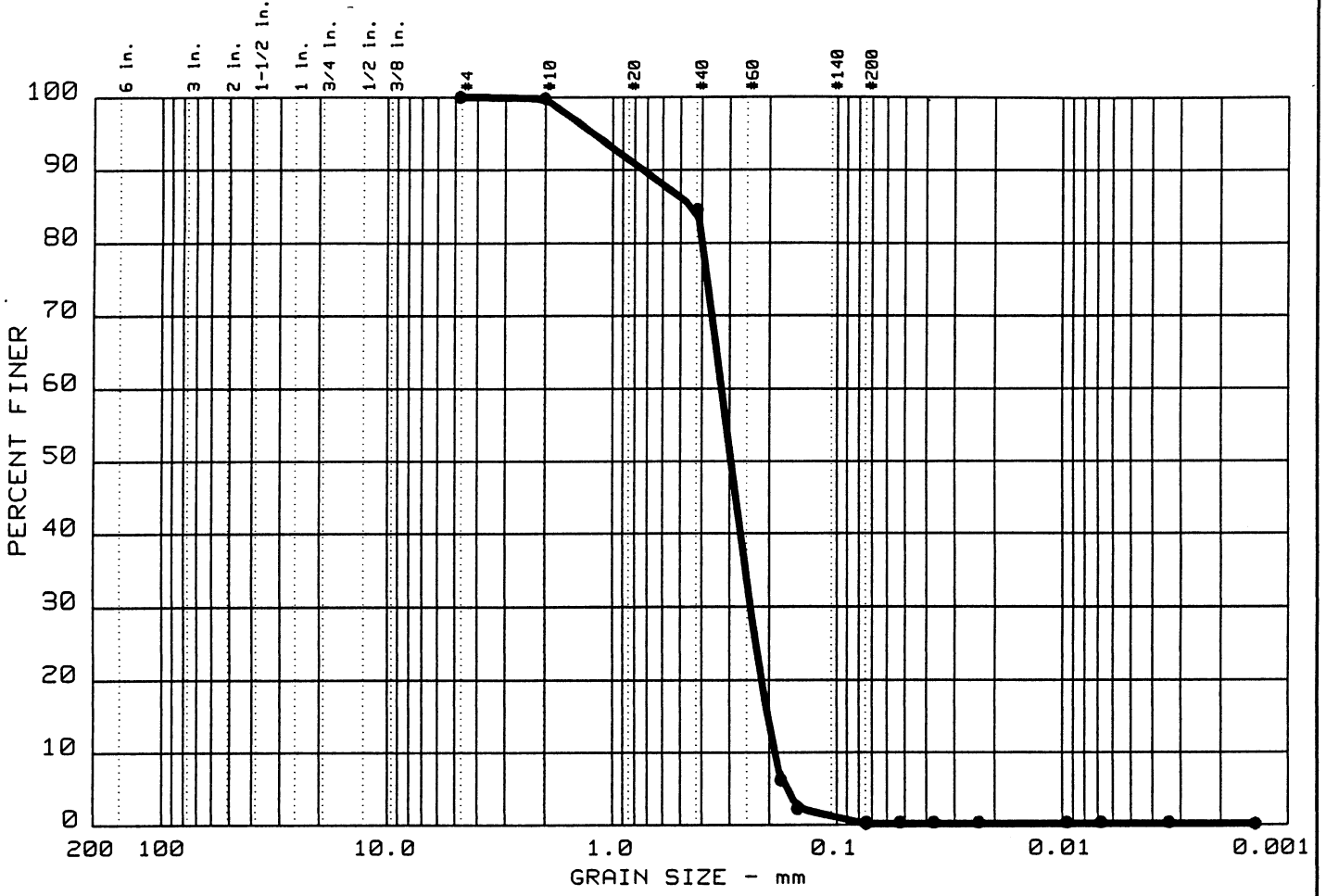
Checked By: BN

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	0.0	99.8	0.0	0.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.44	0.33	0.30	0.242	0.2028	0.1888	0.95	1.7

MATERIAL DESCRIPTION	USCS	AASHTO
● TBH-42B, 90"	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-16-98

Remarks:

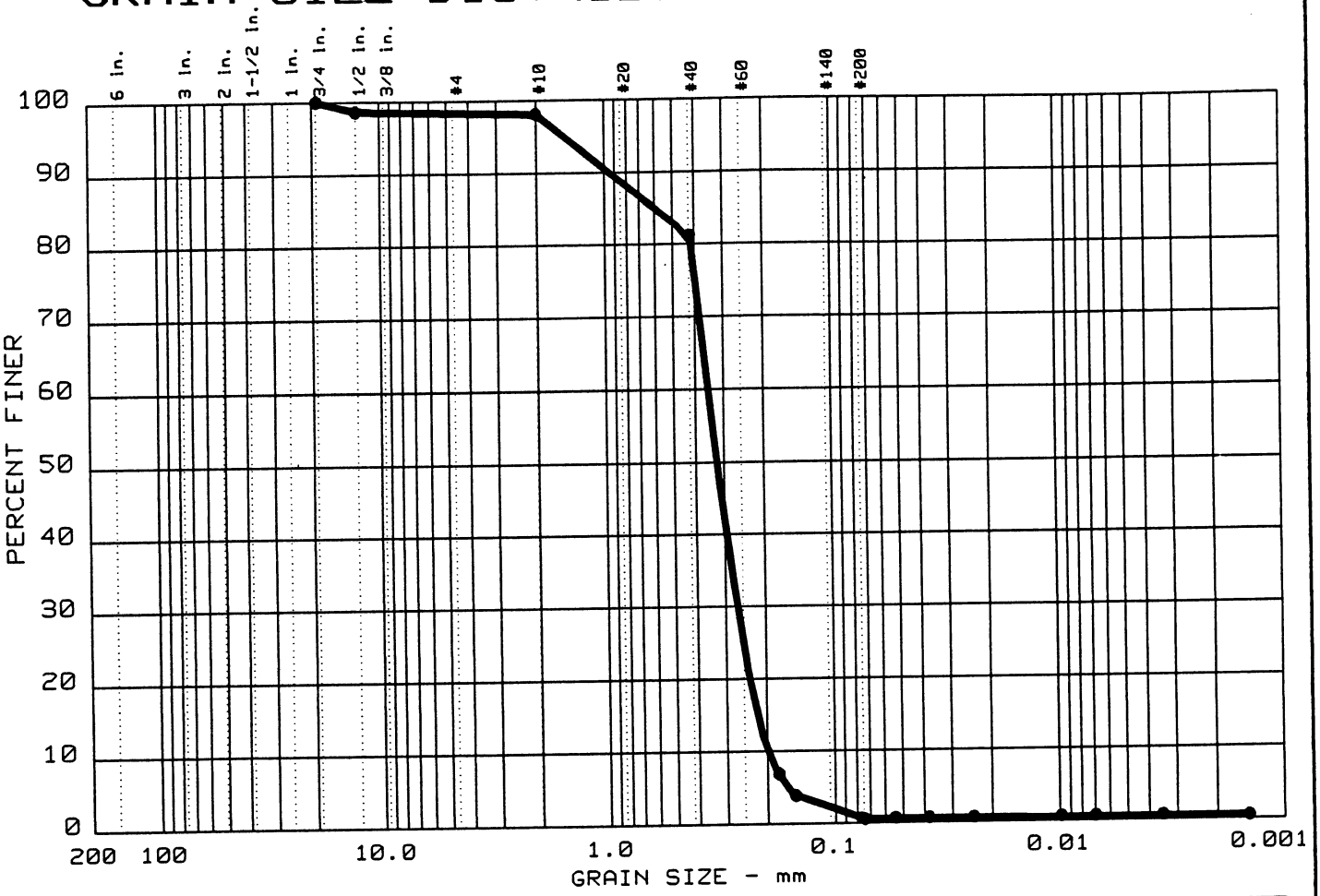
Checked By: BN

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	2	0.0	1.7	97.7	0.0	0.6

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.60	0.35	0.32	0.267	0.2193	0.1991	1.01	1.8

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-43, 40"	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-12-98

Remarks:

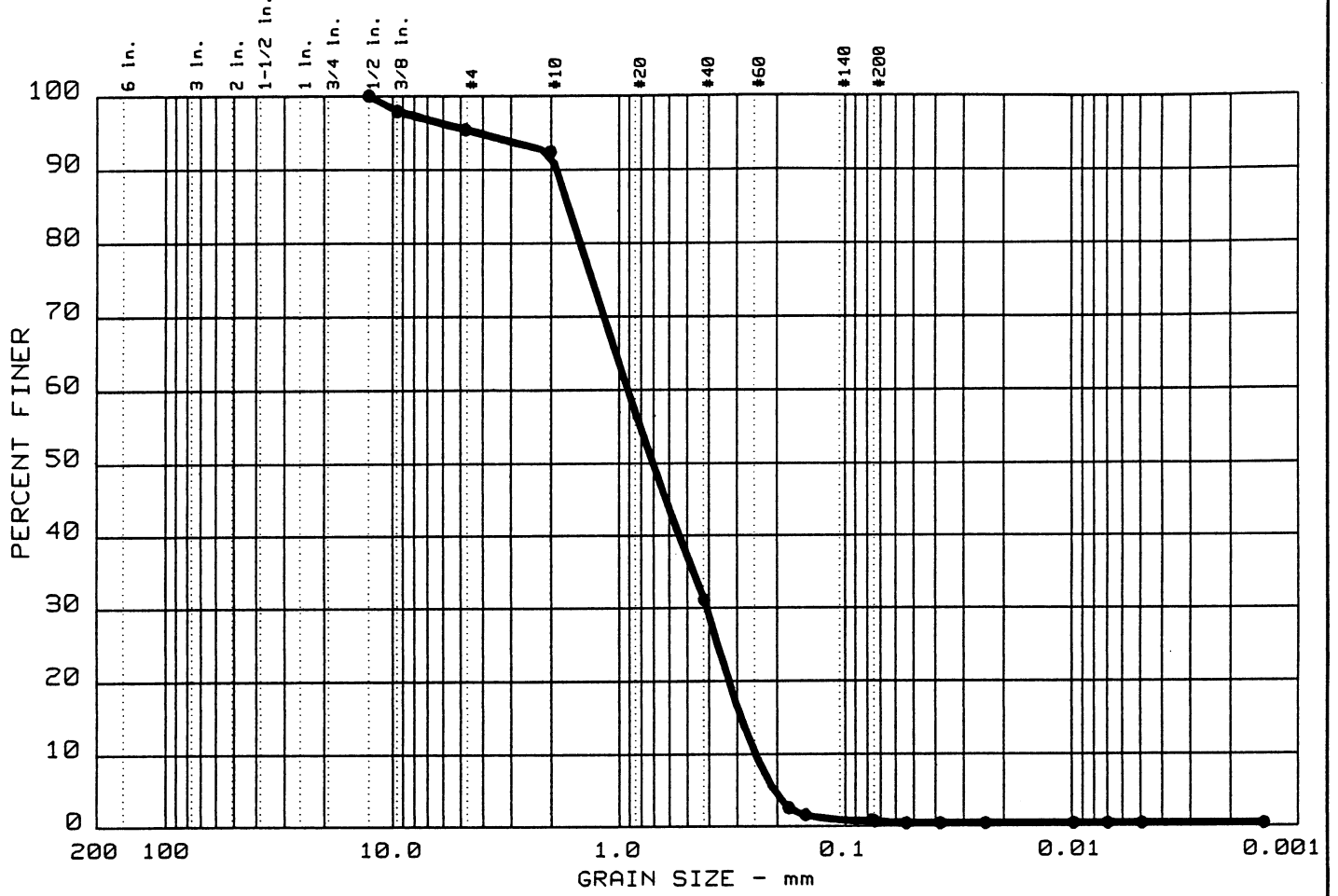
Checked By: BR

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	8	0.0	4.6	94.7	0.3	0.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.68	0.91	0.71	0.410	0.2884	0.2483	0.74	3.7

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-48, 36"	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

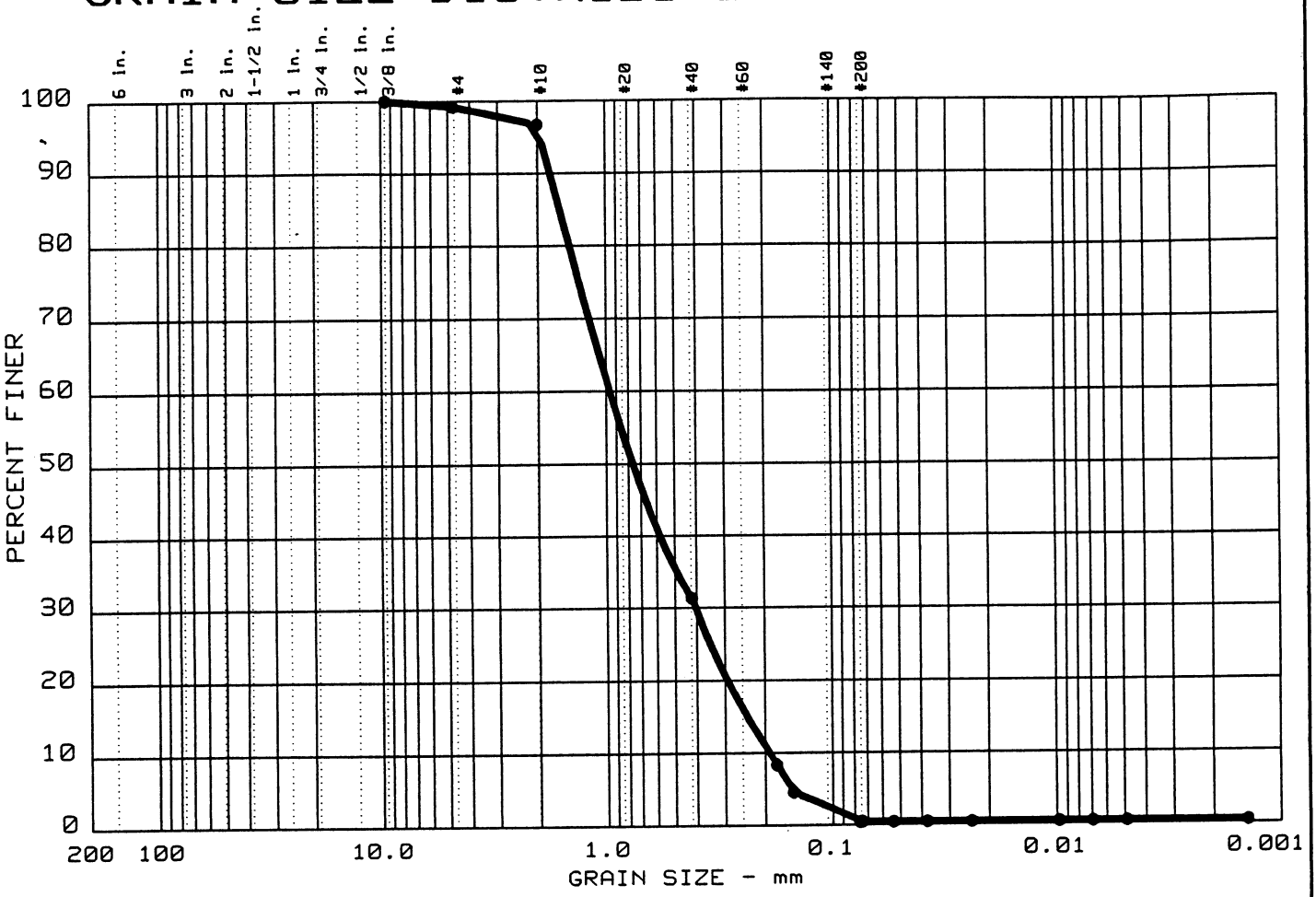
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	0.8	98.7	0.1	0.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.60	0.96	0.76	0.406	0.2388	0.1897	0.90	5.1

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-48, 66"	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

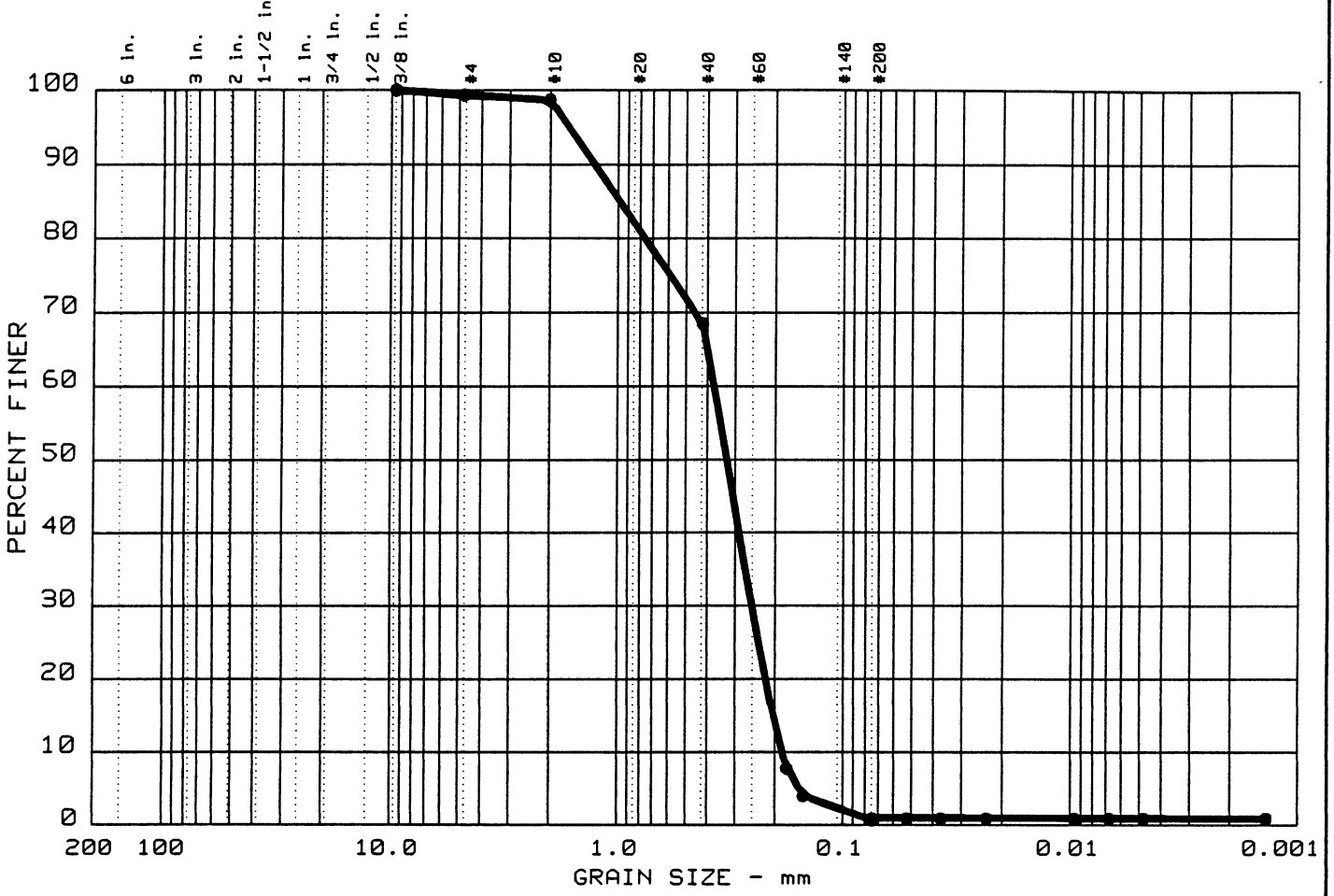
Checked By: BN

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	6	0.0	0.7	98.6	0.7	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.98	0.37	0.33	0.254	0.2030	0.1851	0.93	2.0

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-51, 50"	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

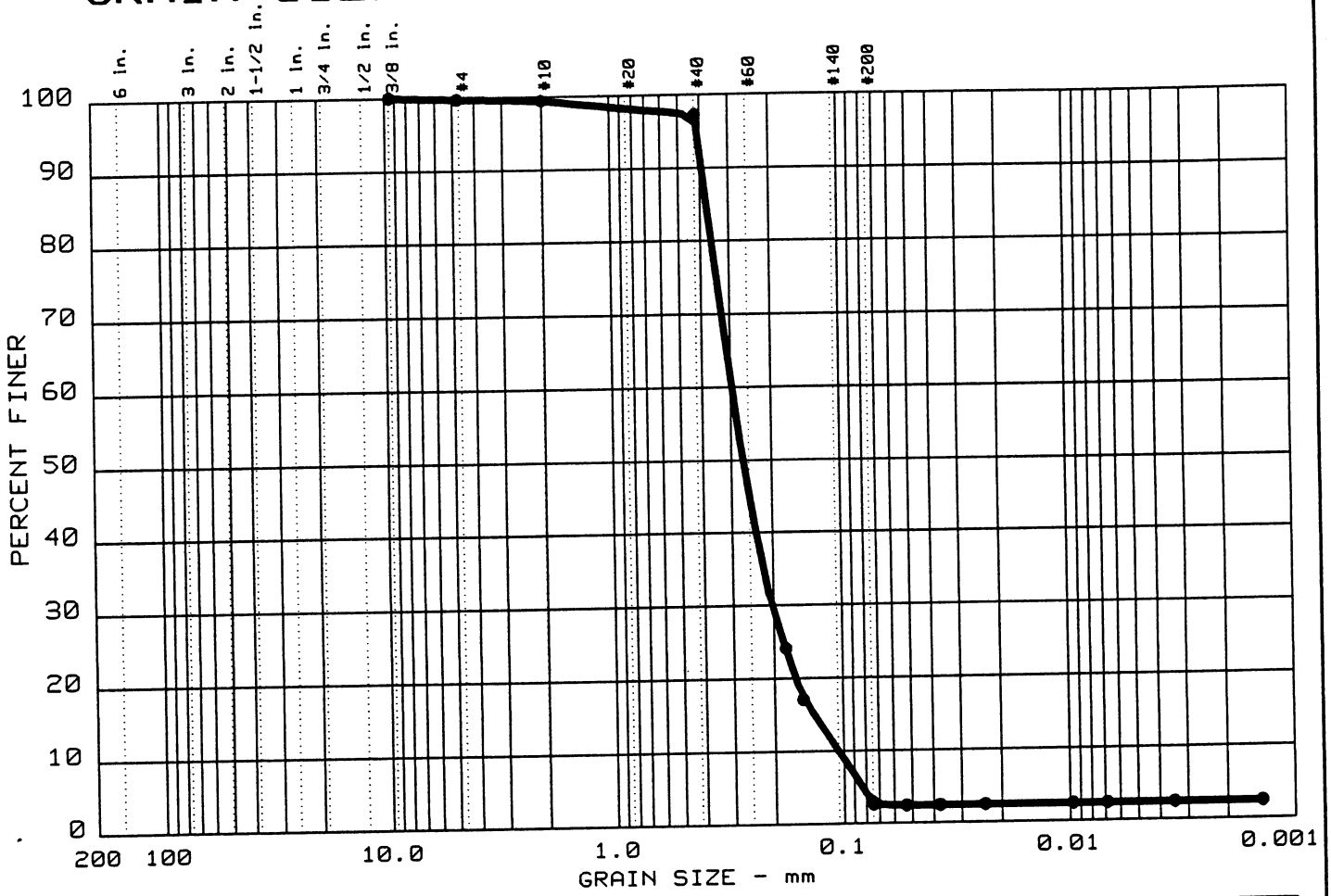
Checked By: BH

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	2	0.0	0.3	97.1	0.2	2.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.38	0.30	0.27	0.203	0.1338	0.1051	1.32	2.8

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-54, 22"	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-16-98

Remarks:

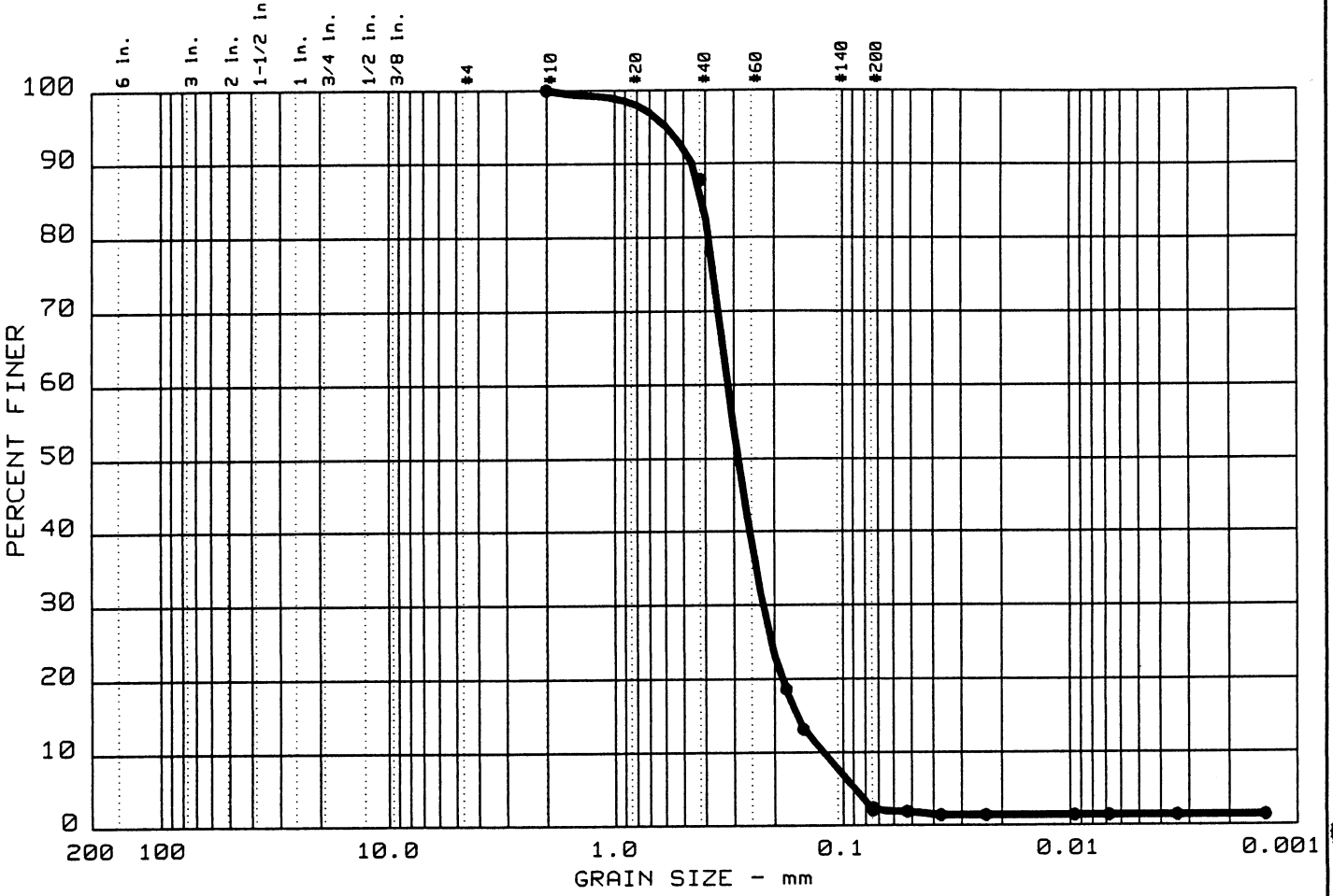
Checked By: BN

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	3	0.0	0.0	97.9	0.7	1.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.41	0.32	0.29	0.225	0.1590	0.1206	1.31	2.7

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-67, 48"	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

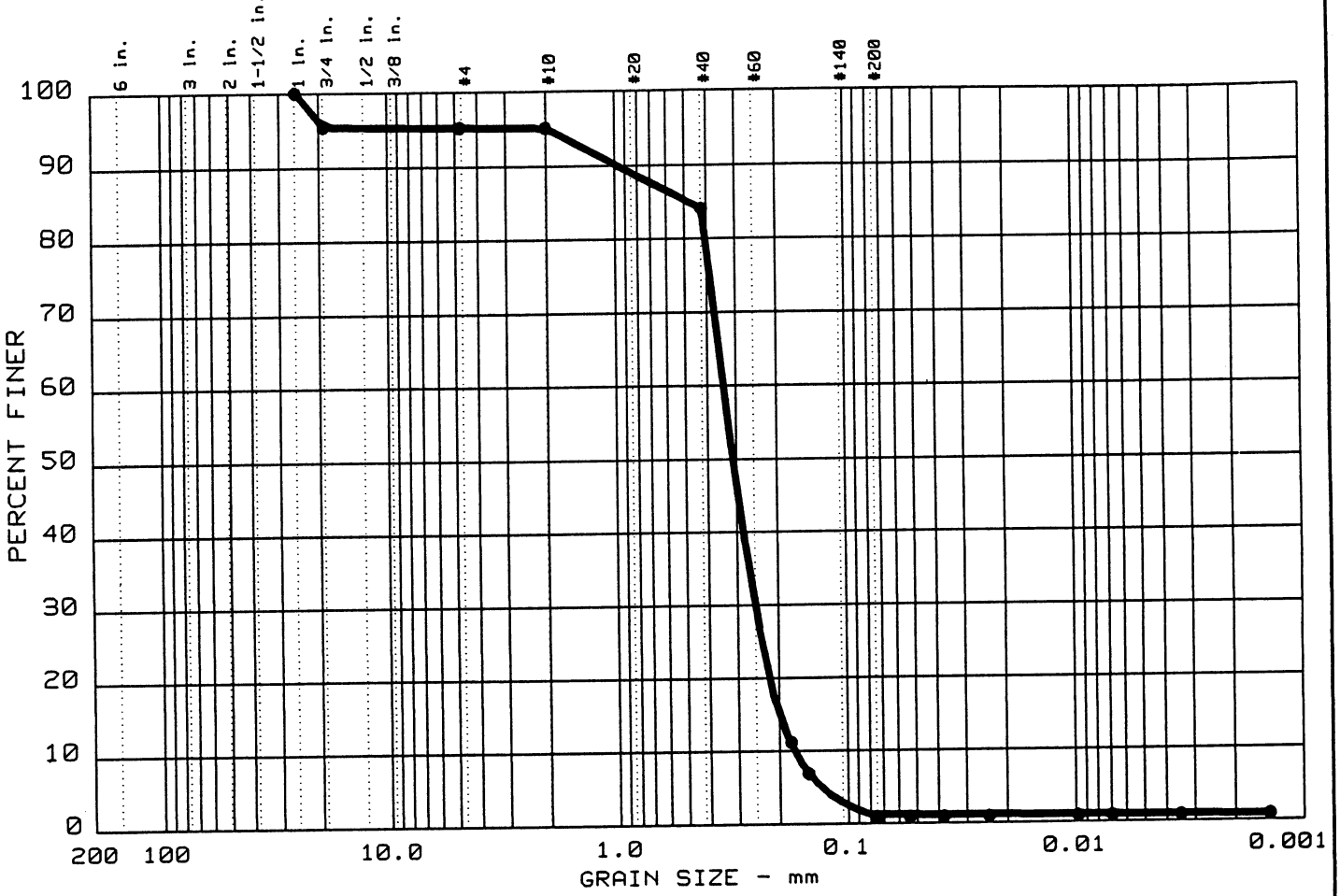
Checked By: _____

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	4.8	94.3	0.9	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.47	0.34	0.31	0.252	0.2000	0.1702	1.10	2.0

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-70, 5'	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

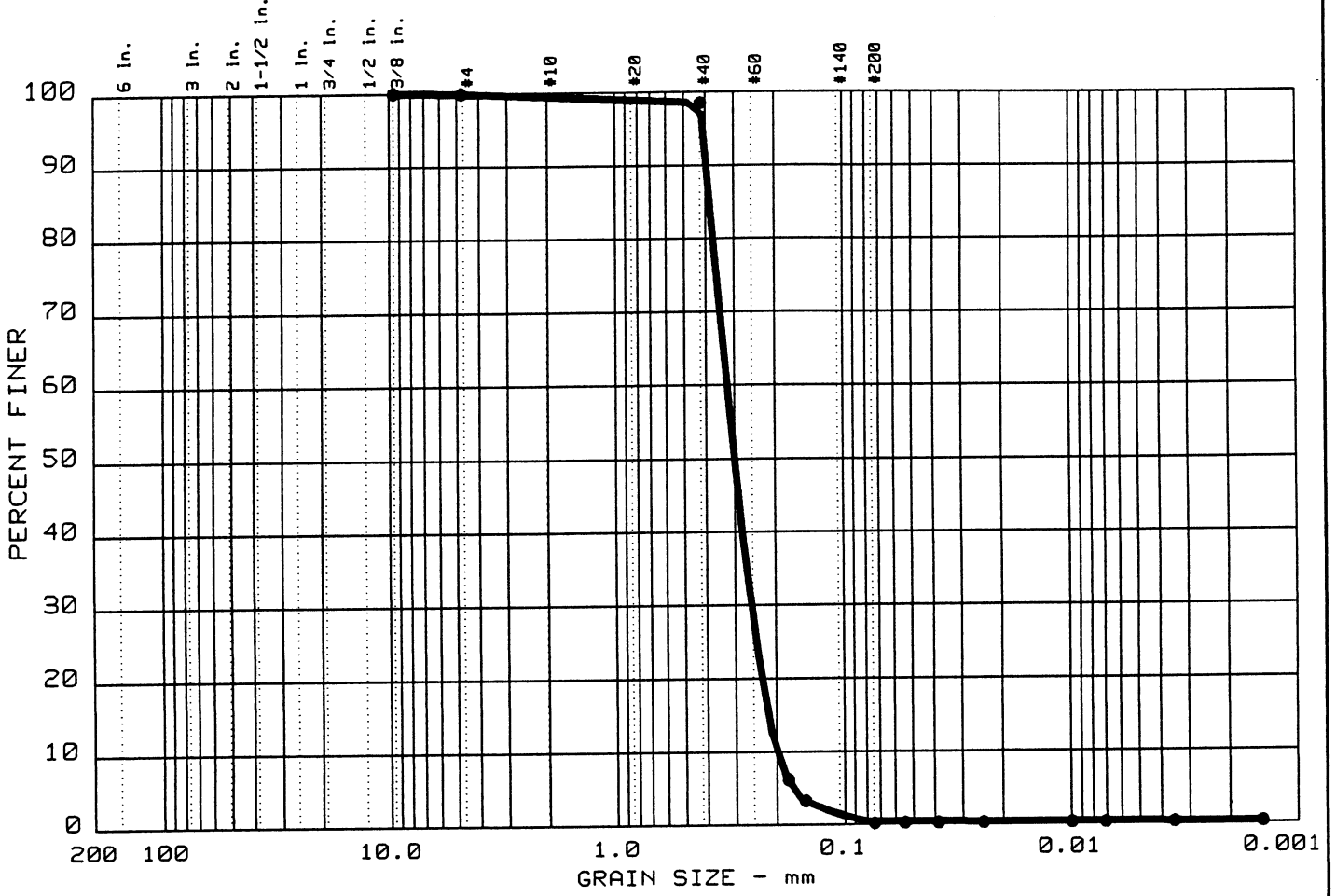
Checked By: BN

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	0.1	99.7	0.2	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.38	0.32	0.30	0.256	0.2168	0.1998	1.01	1.6

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-72, 70"	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

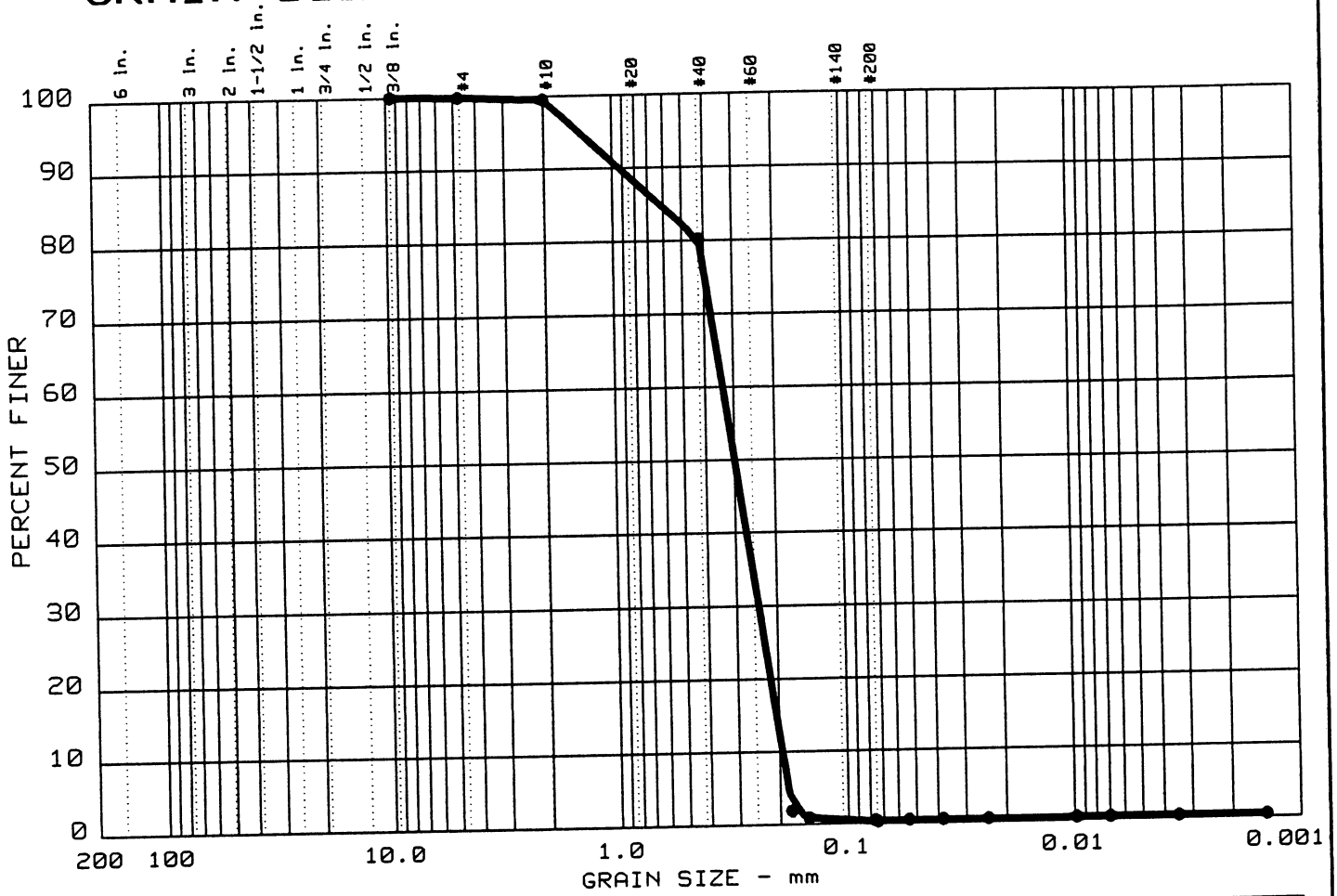
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	7	0.0	0.1	99.6	0.3	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.62	0.34	0.30	0.241	0.2044	0.1934	0.90	1.7

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-73, 36"	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

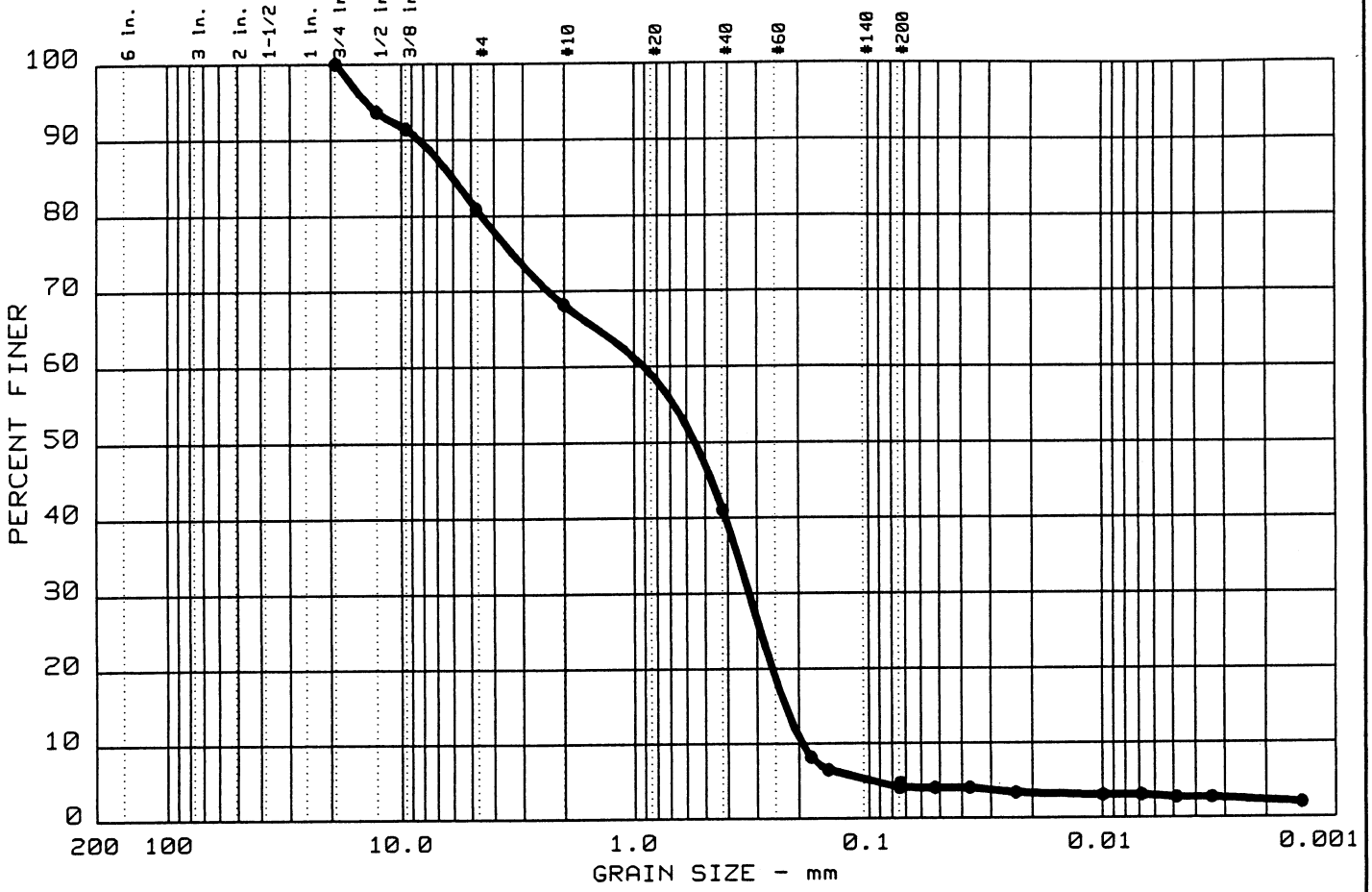
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	19.1	76.8	1.4	2.7

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			5.96	0.90	0.55	0.325	0.2275	0.1934	0.61	4.7

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-74, 10-18"	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

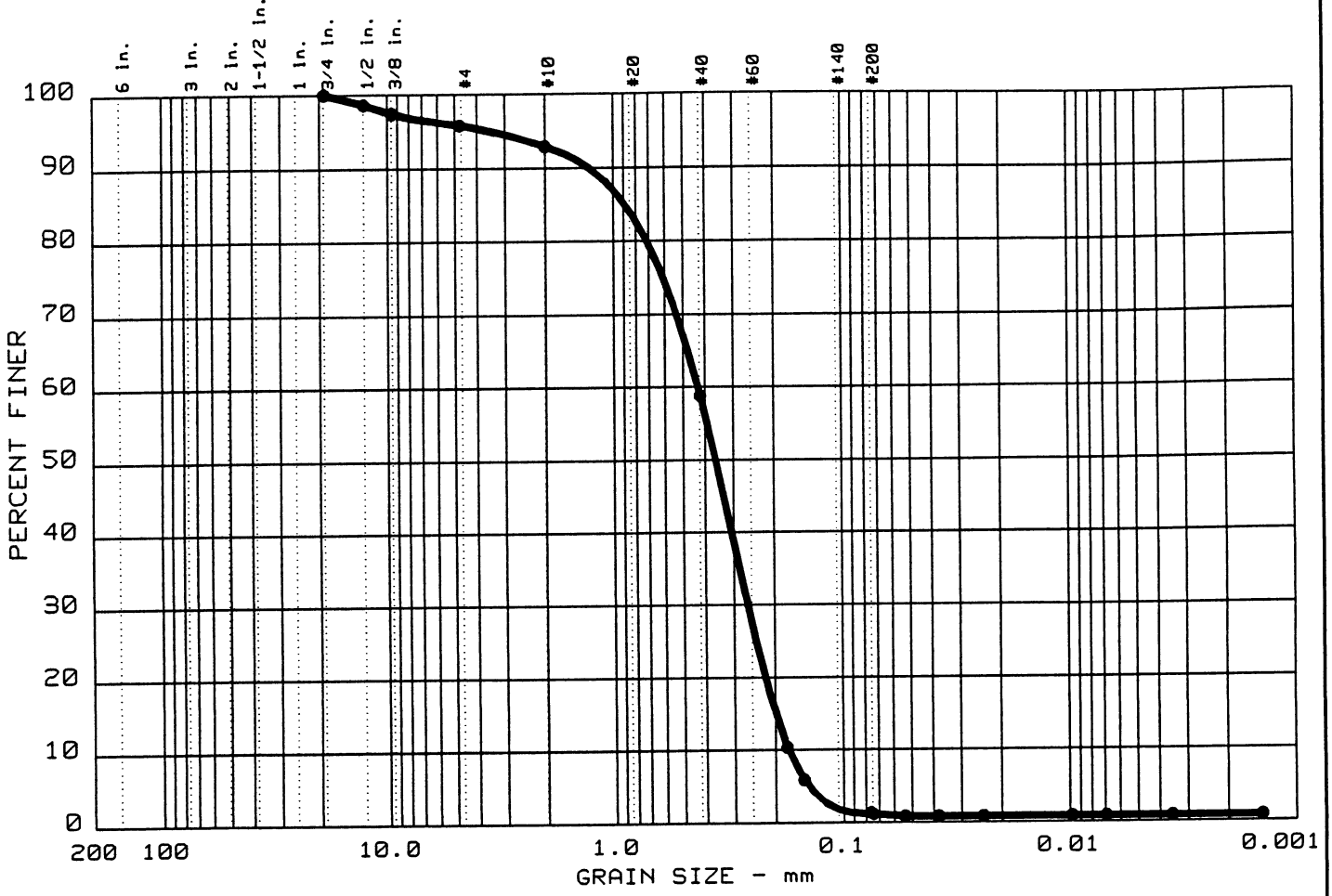
Checked By: Bn

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	4.2	94.6	0.3	0.9

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.89	0.43	0.36	0.262	0.1986	0.1748	0.91	2.5

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-74, 18-67"	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

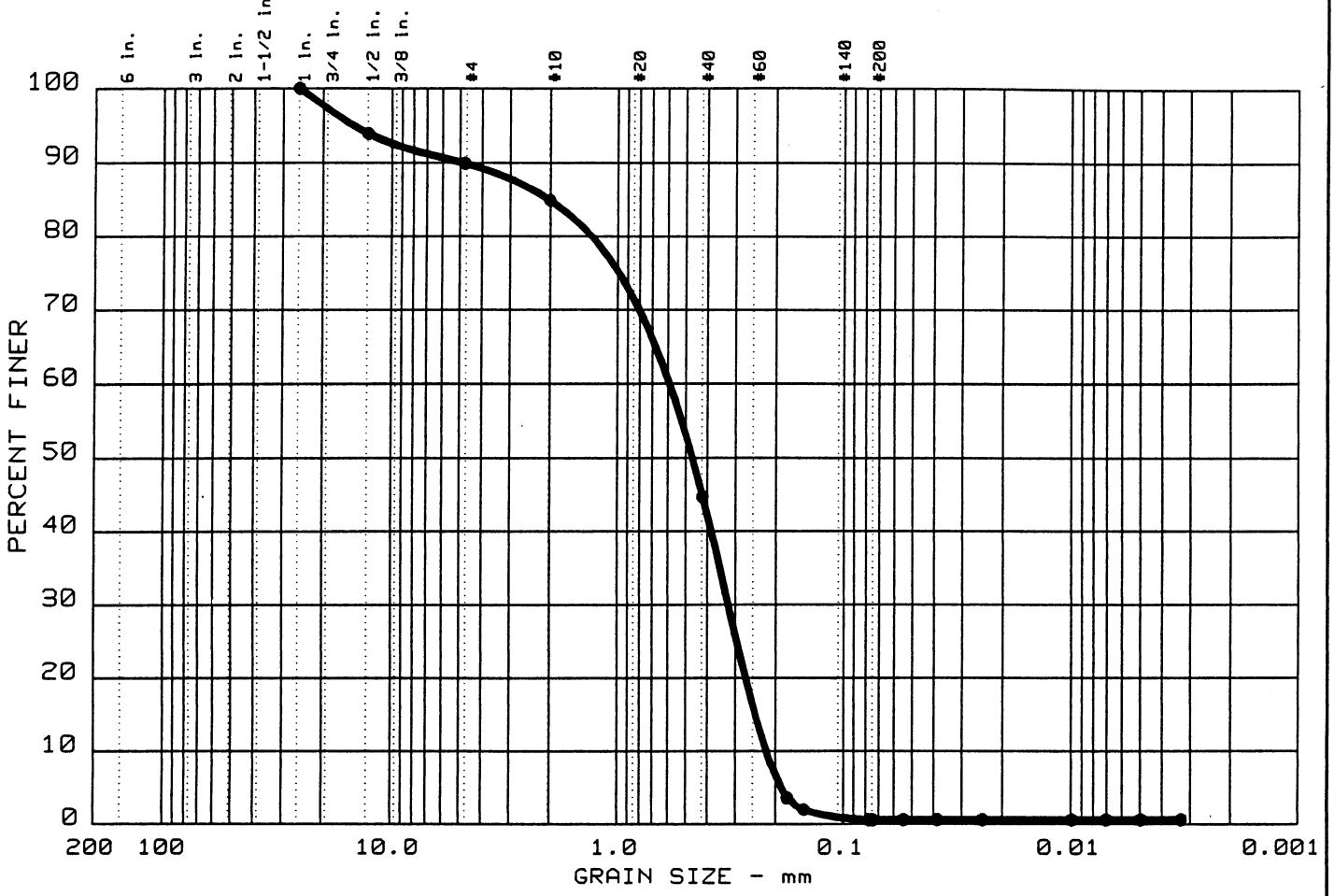
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	2	0.0	10.1	89.3	0.6	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			2.02	0.59	0.47	0.323	0.2449	0.2198	0.81	2.7

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-76, 18-55"	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-21-98

Remarks:

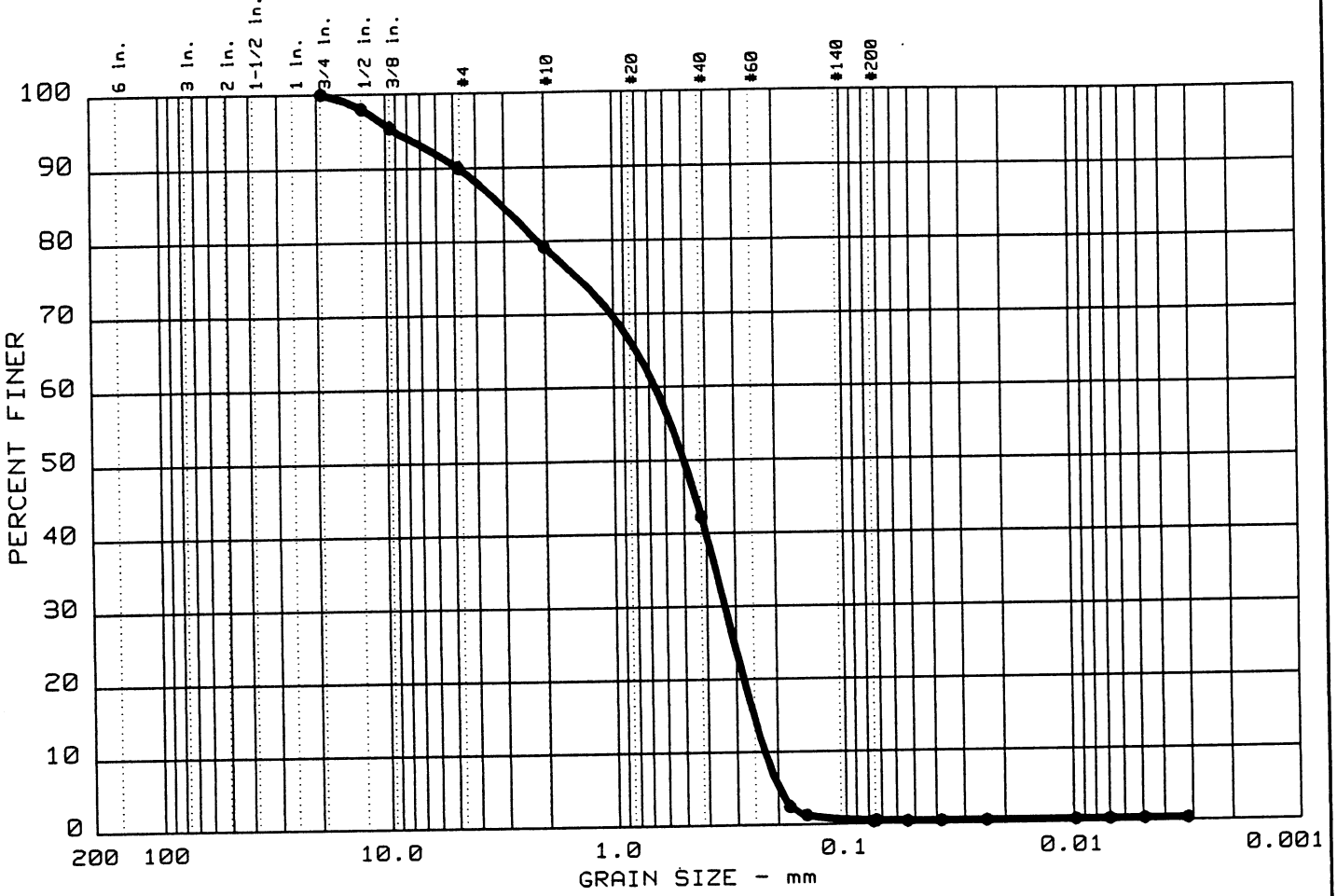
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	10.0	89.5	0.1	0.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			3.09	0.66	0.50	0.335	0.2541	0.2280	0.74	2.9

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-76, 55-68"	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-21-98

Remarks:

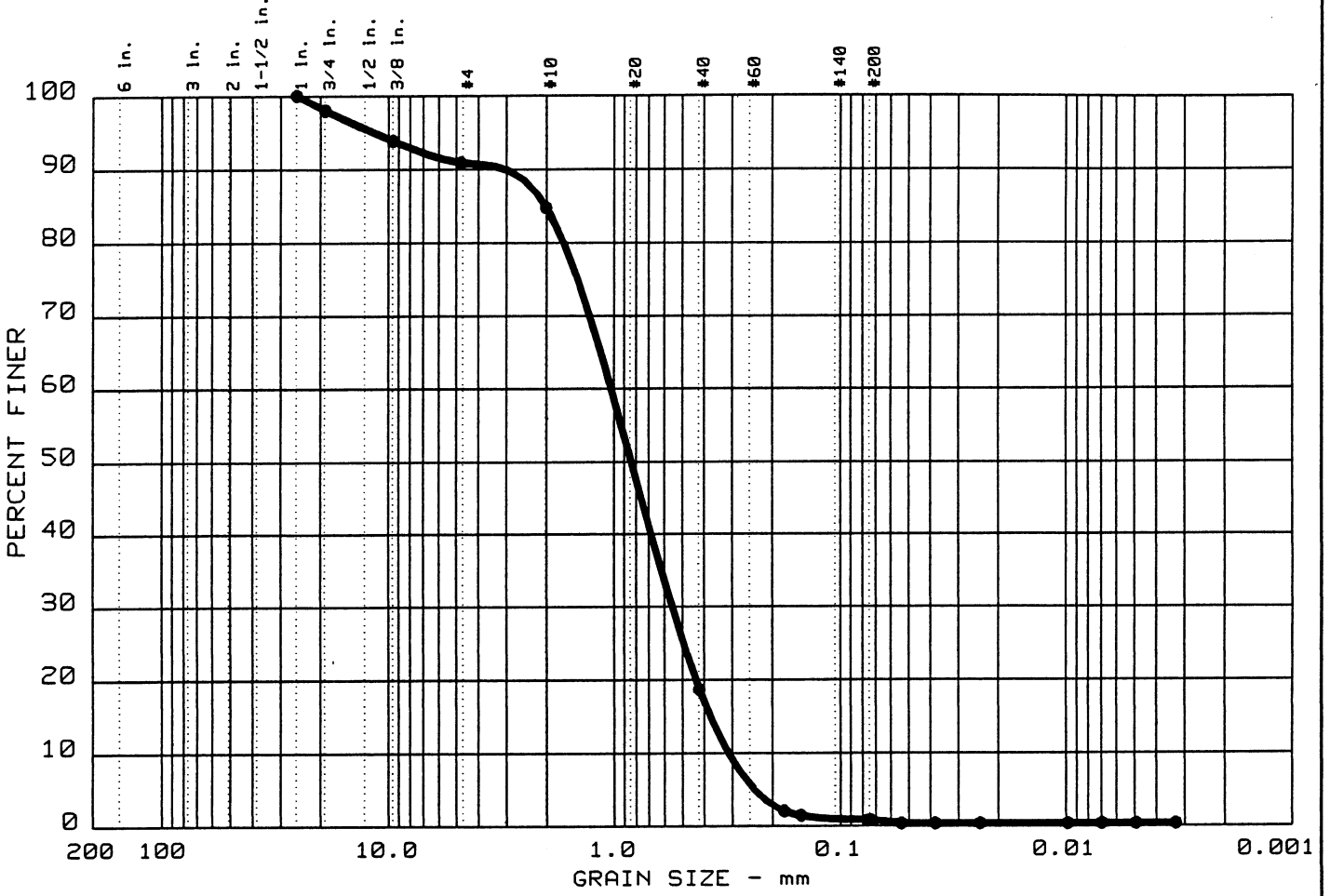
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	9.1	90.0	0.5	0.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			2.00	1.03	0.84	0.554	0.3746	0.3115	0.95	3.3

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-80, 22-53"	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-21-98

Remarks:

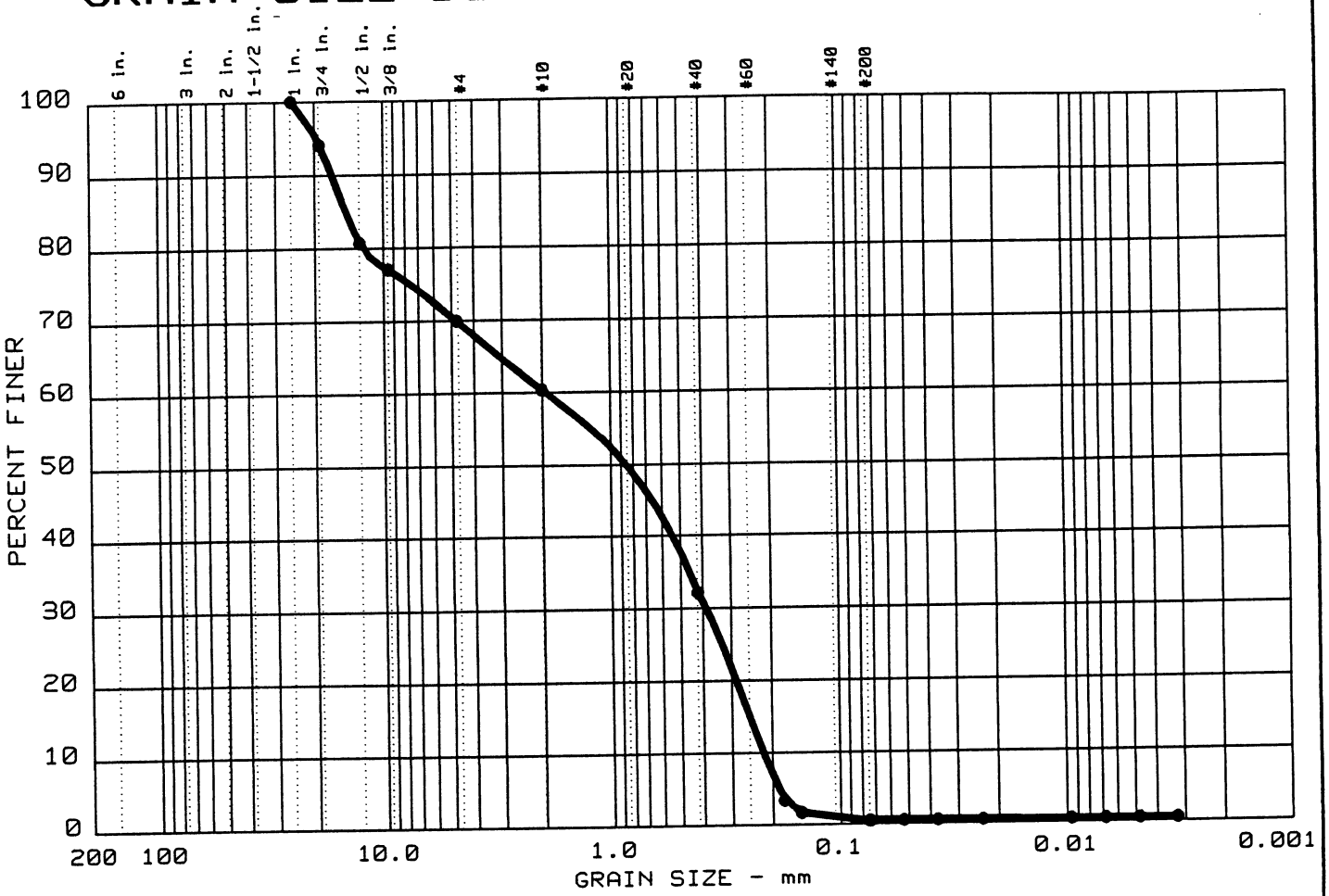
Checked By: Bn

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	30.0	69.5	0.5	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			14.62	1.91	0.85	0.385	0.2509	0.2185	0.36	8.7

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-80, 53-78"	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-21-98

Remarks:

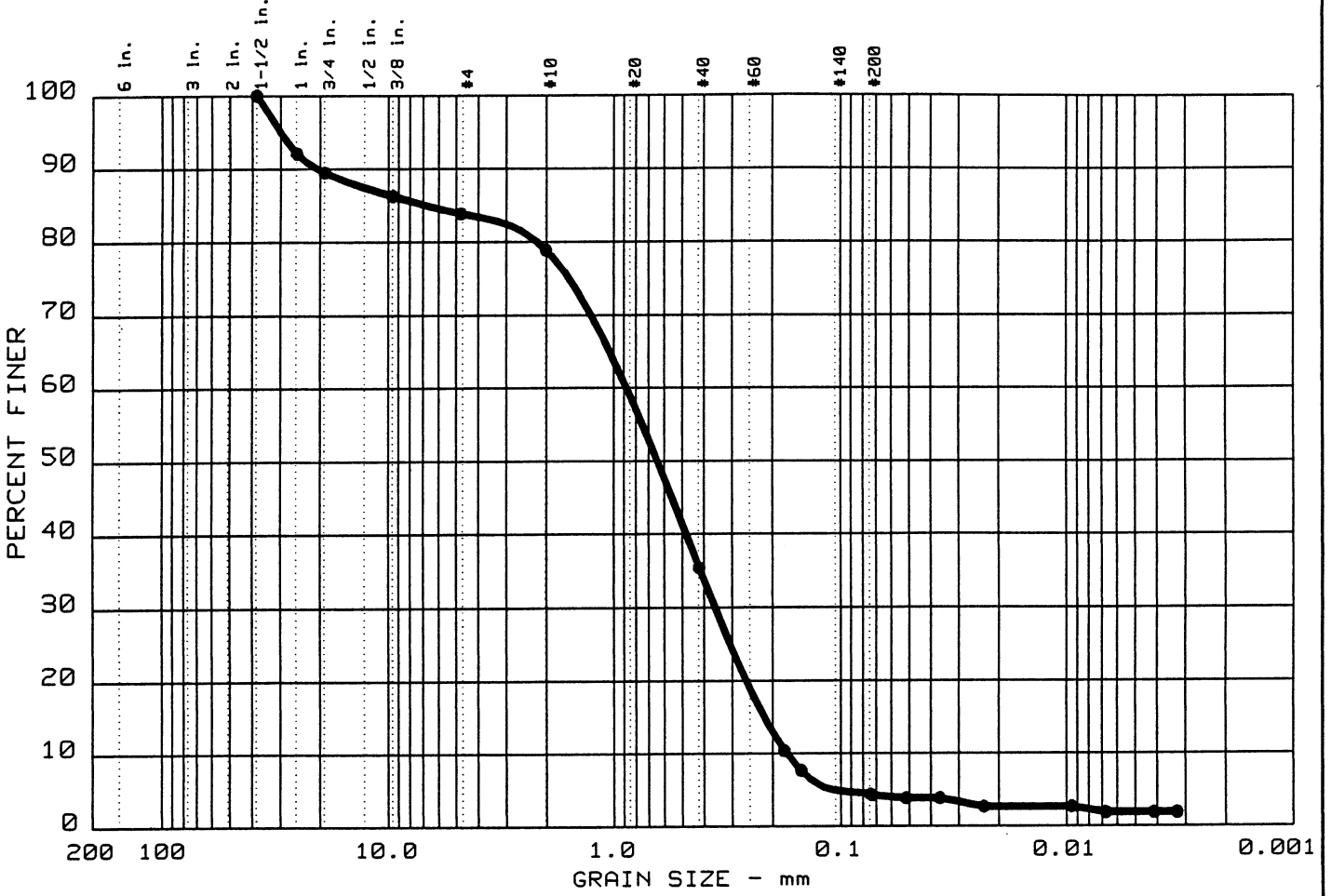
Checked By: Bm

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	3	0.0	16.1	79.5	2.5	1.9

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			6.68	0.88	0.64	0.358	0.2175	0.1728	0.84	5.1

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-81, 20-44"	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-21-98

Remarks:

Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

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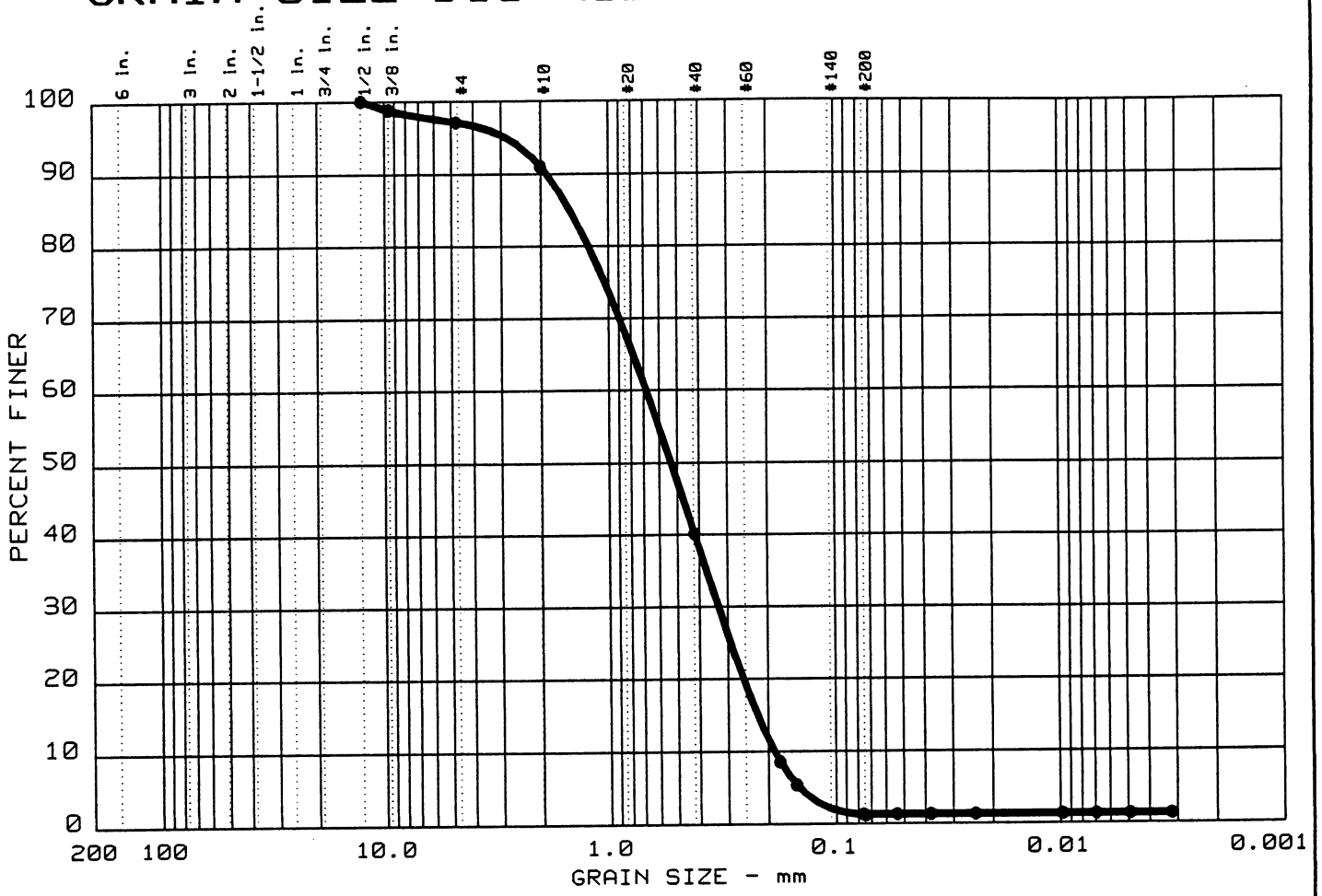
GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	3	0.0	2.9	95.9	1.2	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.48	0.68	0.53	0.331	0.2226	0.1873	0.86	3.6

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-81, 44-73"	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-21-98

Remarks:

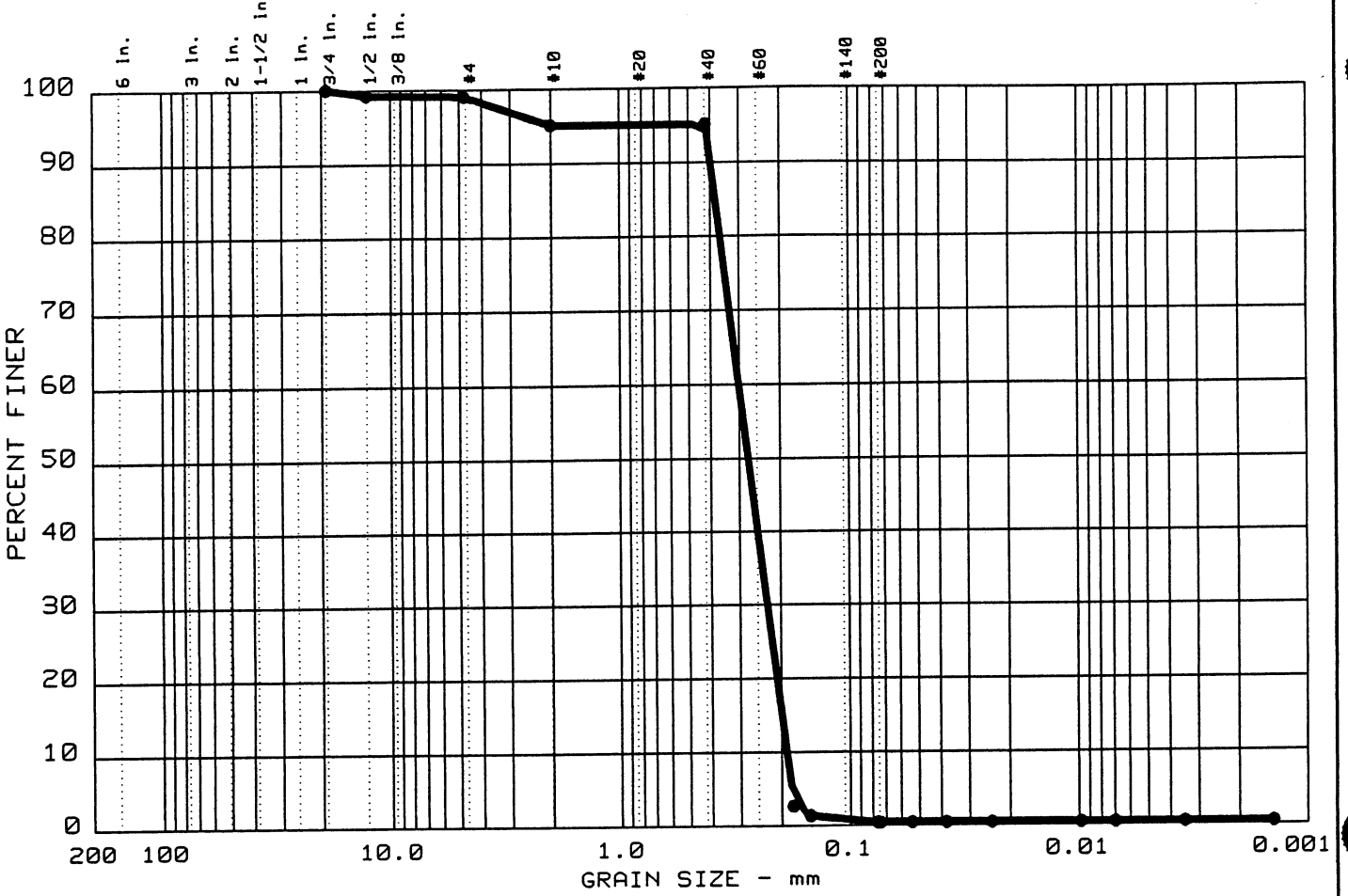
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	2	0.0	1.0	98.6	0.4	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.38	0.30	0.28	0.228	0.1984	0.1895	0.91	1.6

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-85, 50"	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

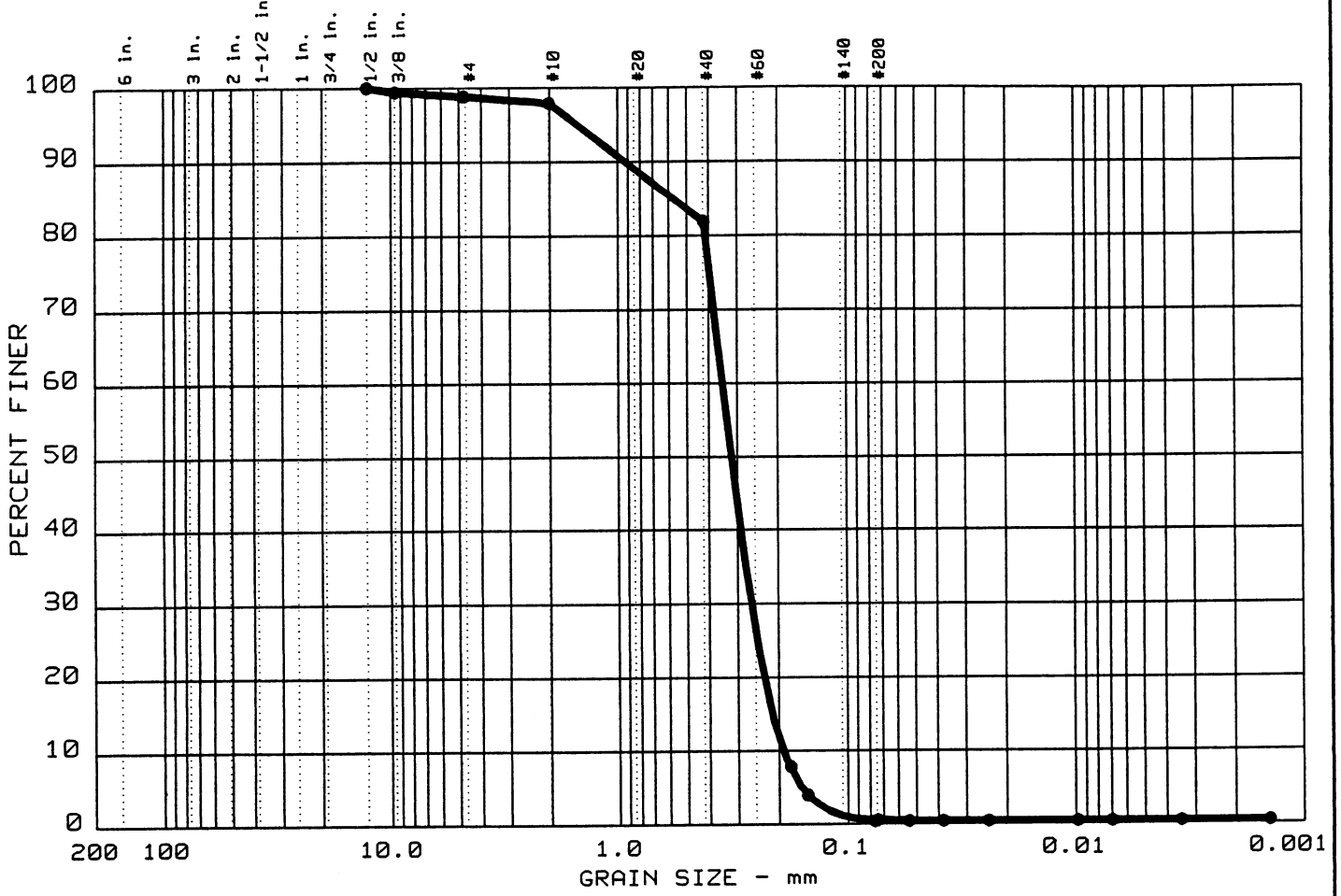
Checked By: BR

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	5	0.0	1.2	98.2	0.2	0.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.56	0.35	0.32	0.262	0.2138	0.1919	1.02	1.8

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-87, 60"	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

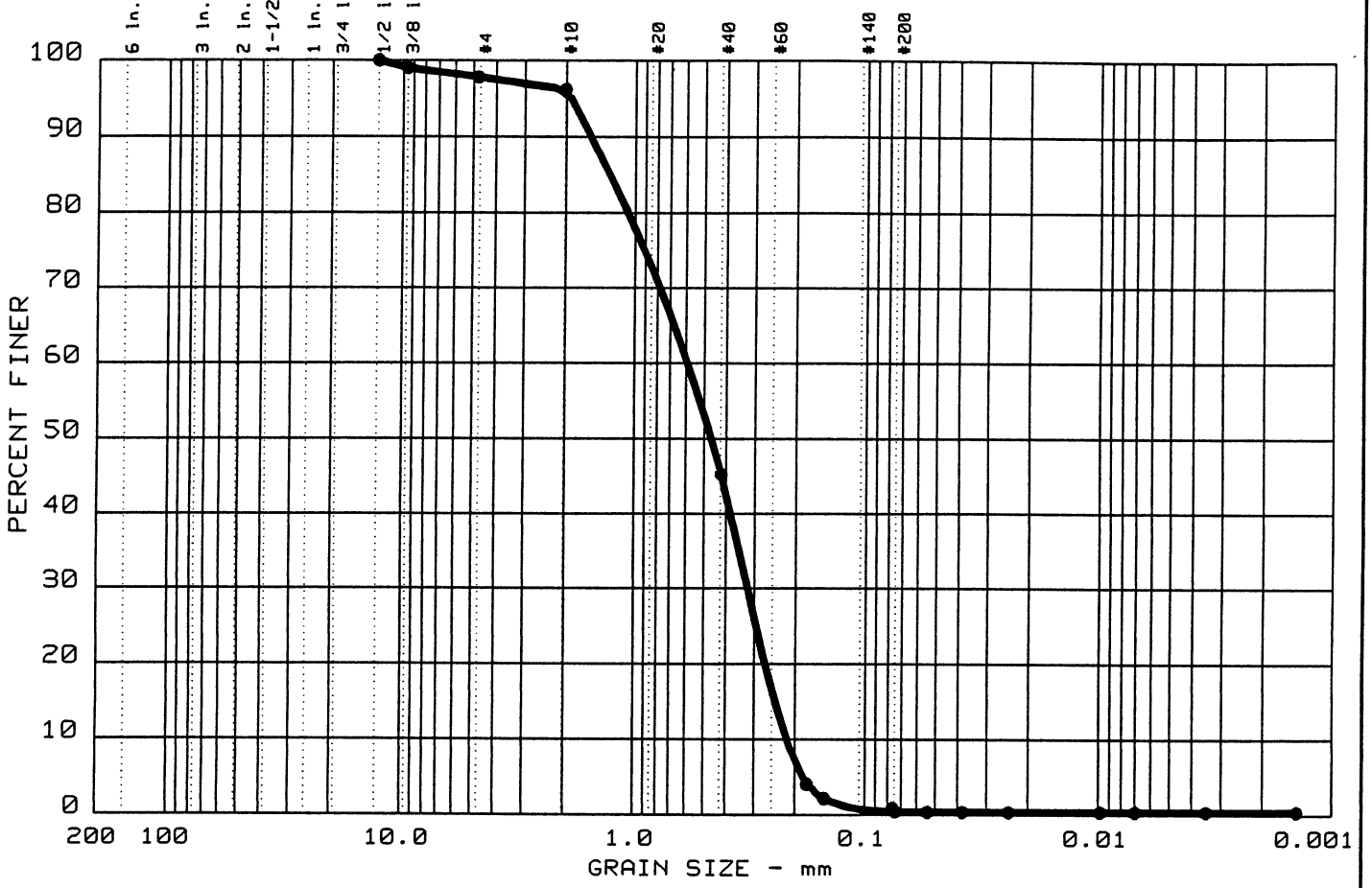
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	6	0.0	2.2	97.3	0.1	0.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.29	0.59	0.47	0.322	0.2438	0.2168	0.81	2.7

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-88, 54"	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

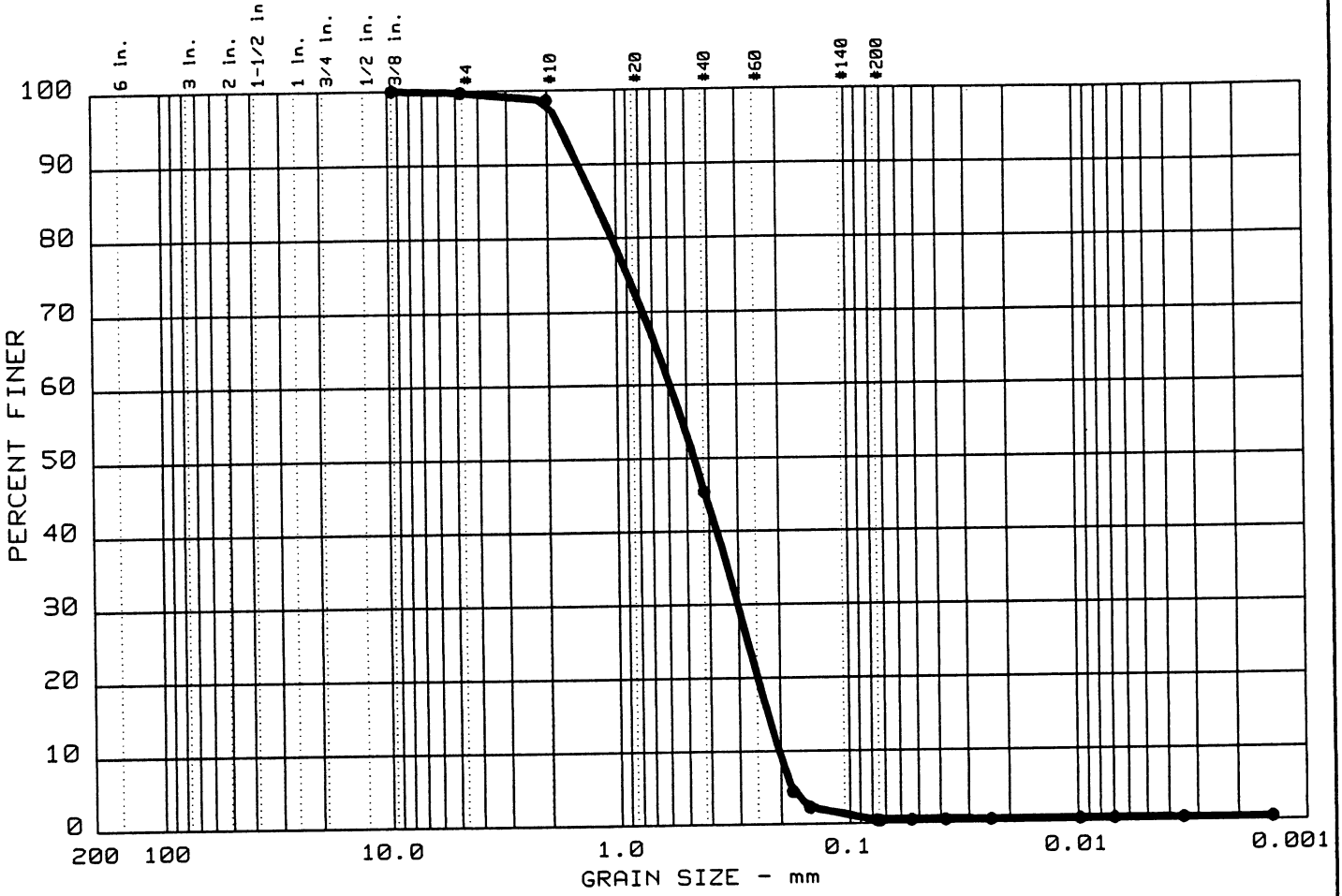
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	0.3	99.3	0.4	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.23	0.59	0.46	0.303	0.2262	0.2032	0.77	2.9

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-89, 73"	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

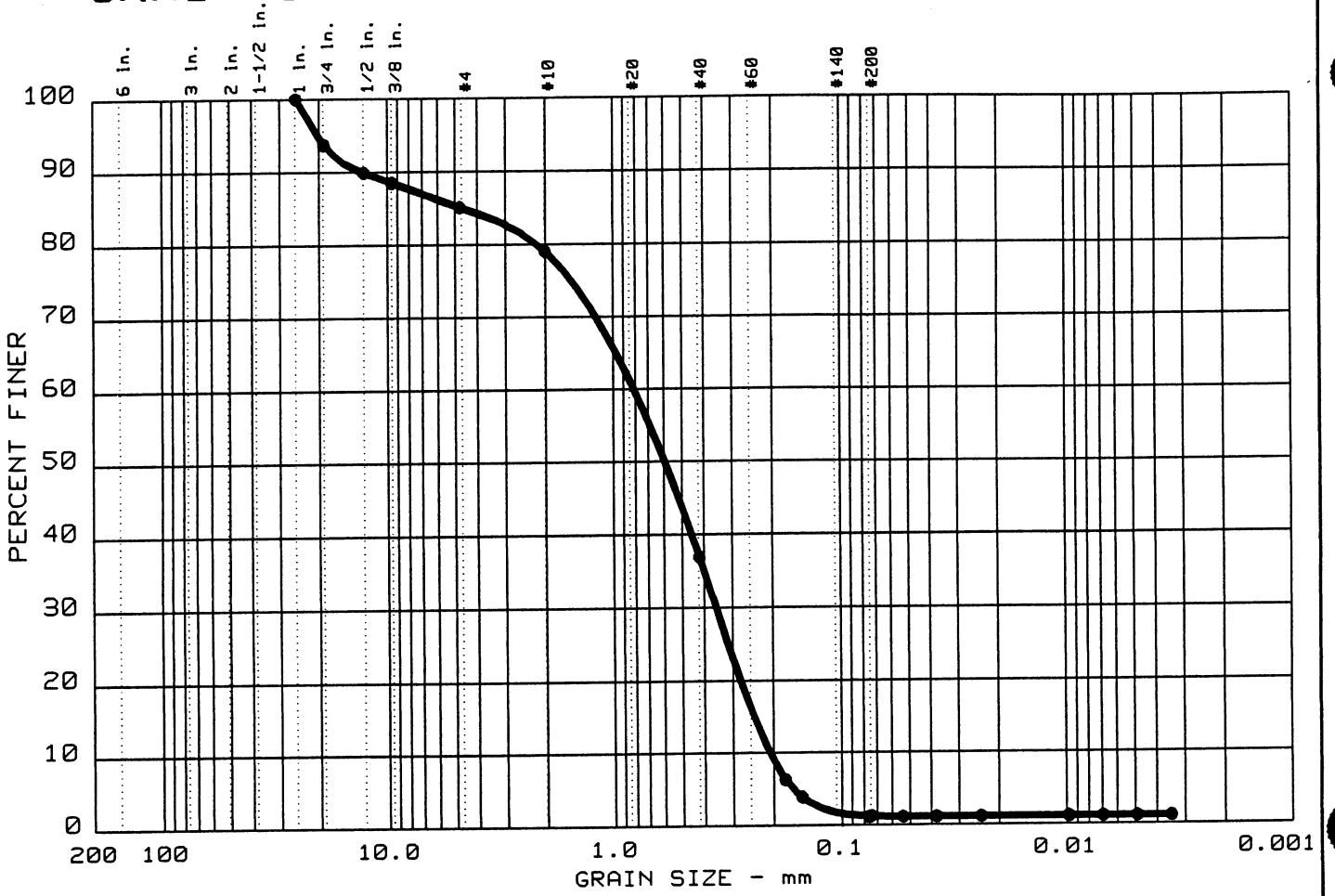
Checked By: Bn

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	14.9	83.8	0.1	1.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			4.62	0.81	0.59	0.354	0.2424	0.2063	0.75	3.9

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-92, 24-51"	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-21-98

Remarks:

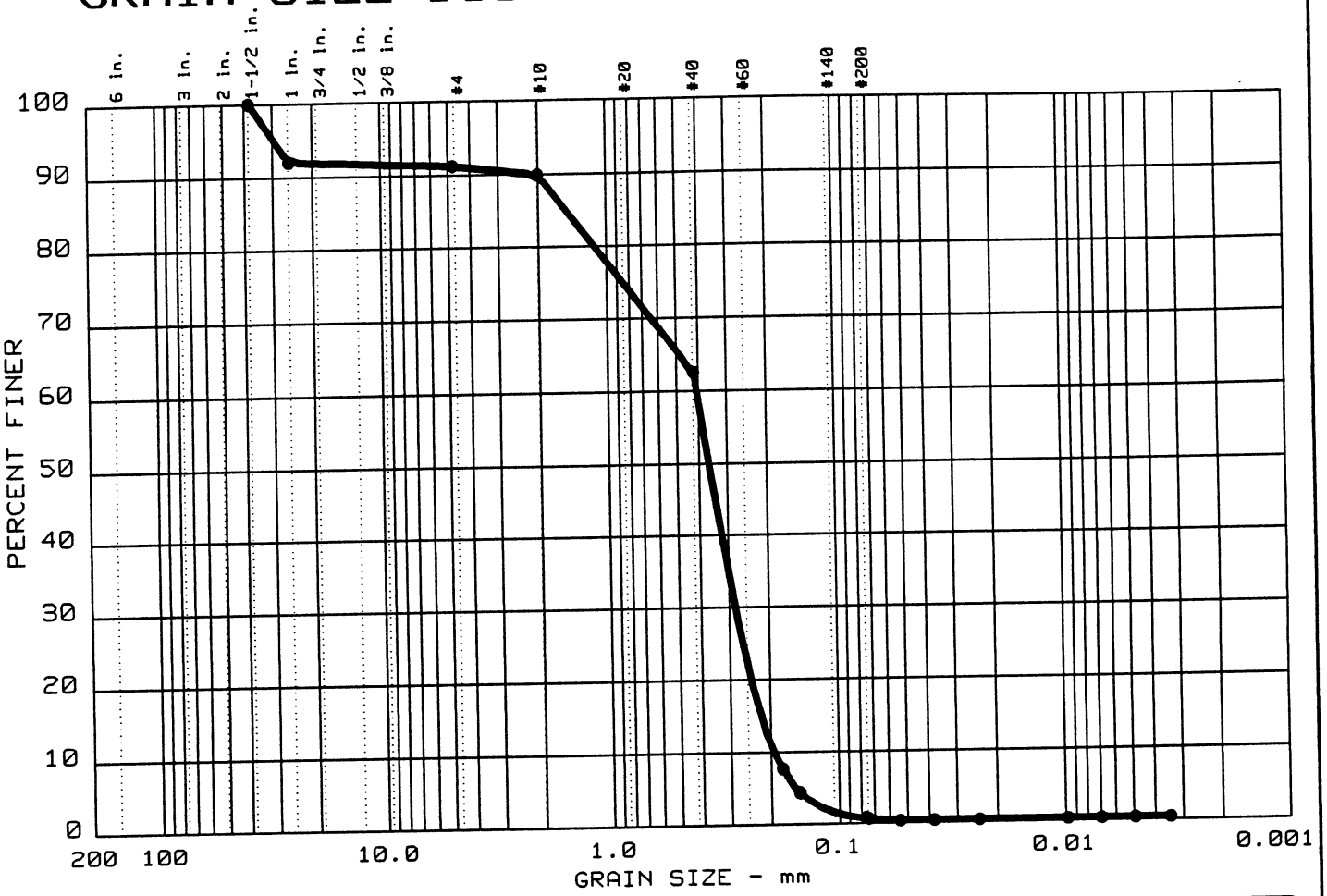
Checked By: Bm

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	2	0.0	8.8	90.5	0.3	0.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.50	0.41	0.36	0.282	0.2208	0.1945	1.00	2.1

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-92, 51-73"	SP	A-3

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-21-98

Remarks:

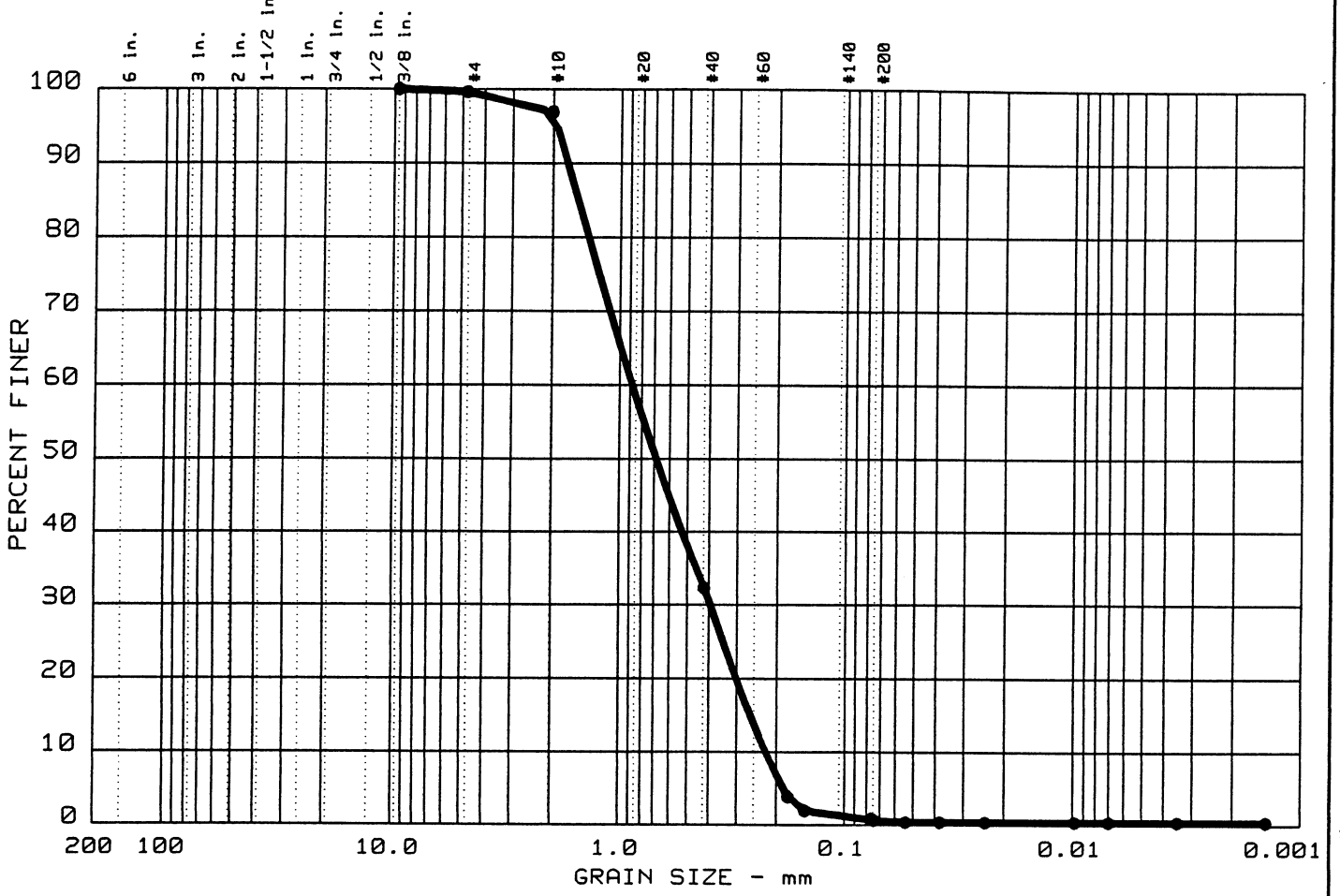
Checked By: BN

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	6	0.0	0.4	98.9	0.3	0.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.55	0.88	0.69	0.395	0.2612	0.2223	0.80	4.0

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-94, 31"	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

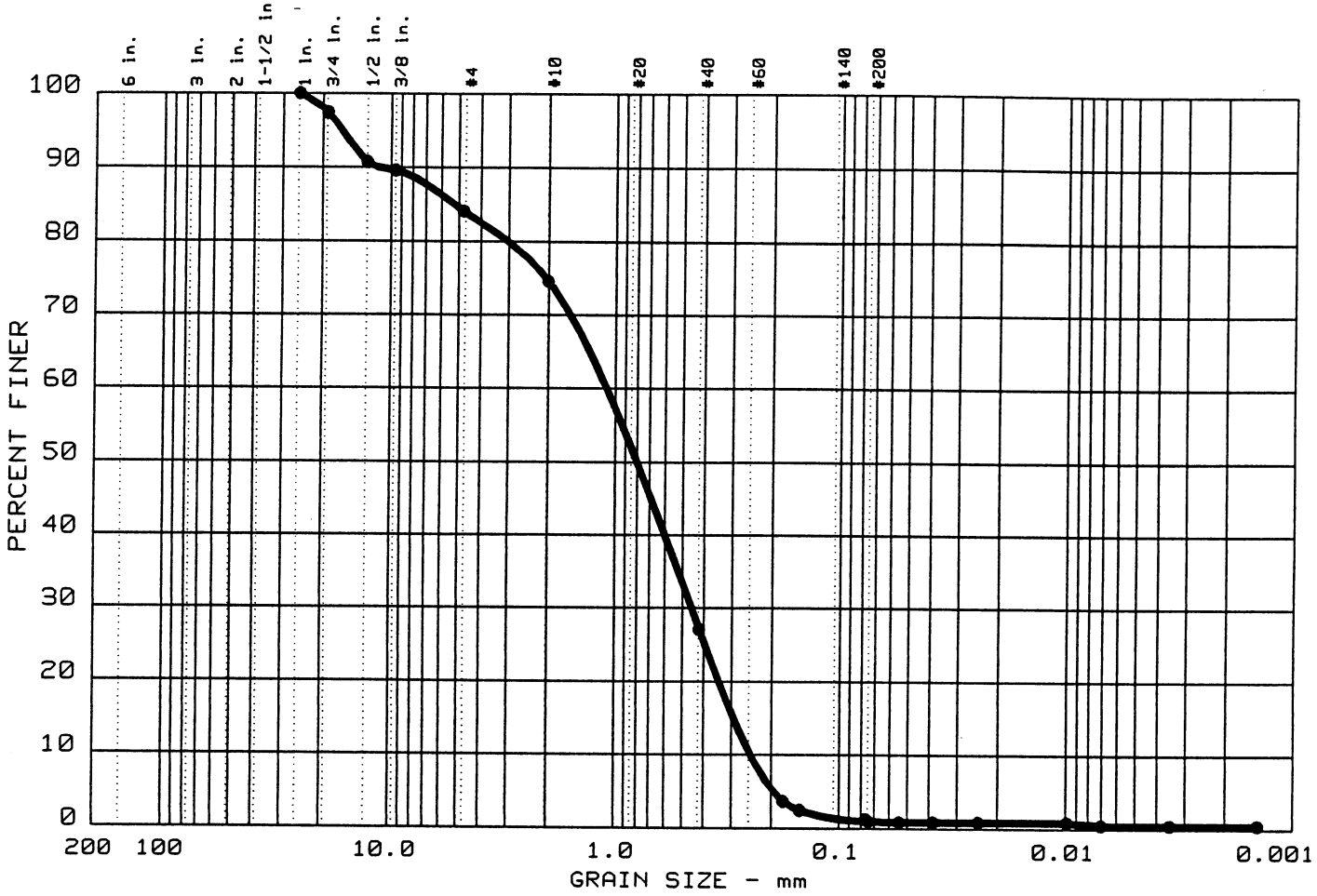
Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	8	0.0	15.9	83.1	0.4	0.6

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			5.19	1.10	0.80	0.455	0.2938	0.2472	0.76	4.4

MATERIAL DESCRIPTION	USCS	AASHTO
● TPH-97, 23"	SP	A-1-b

Project No.: 115.47
Project: Foth & Van Dyke
● Location: Nicolet Minerals Co.

Date: 09-18-98

Remarks:

Checked By: BM

ASTM D1140 & D422

GRAIN SIZE DISTRIBUTION TEST REPORT

NUMMELIN TESTING SERVICES

HYDRAULIC CONDUCTIVITY SUMMARY SHEET
(CONSTANT HEAD)

CLIENT: FOTH & VAN DYKE
PROJECT: NICOLET MINERALS CO.
PROJECT #: 1154702.H
REPORT #: 03

SAMPLE #	SAMPLE DENSITY	NATURAL MOISTURE	FINAL MOISTURE	**HYDRAULIC CONDUCTIVITY**
MWH-11P, 32'-34'	100 lbs/ft^3	17.1%	23.0%	**1.8×10^{-2}**
BH-09, 8'-10'	100 lbs/ft^3	18.7%	21.9%	**2.4×10^{-3}**
BH-11, 10'-12'	100 lbs/ft^3	9.7%	18.2%	**2.2×10^{-2}**
MWH-09P, 32'-34'	100 lbs/ft^3	15.4%	22.1%	**1.5×10^{-2}**
BH-10, 14'-16'	100 lbs/ft^3	16.2%	23.3%	**1.8×10^{-2}**
* BH-14, 8'-10'				
* BH-13, 10'-12'				
* MWH-10P, 34'-36'				

* NOT ENOUGH SAMPLE

1154702H

NTS, INC.

Appendix H-2

Thresher & Son, Inc. Test Data

Thresher & Son, Inc.
Memorandum

6 November 1998

TO: Jerry W. Sevick, Foth & Van Dyke
Steve A. Dischler, Foth & Van Dyke

CC: Gordon Reid, Nicolet Minerals Company
Ken Black, Nicolet Minerals Company
Master File

FR: John E. Thresher, Jr., Thresher & Son, Inc.

RE: Moisture Content of Soils from the Double-Ring Infiltrometer Tests

1 Introduction

Soil grab samples were collected at and beneath the infiltrative surface from three of the double-ring infiltrometer test sites (TPH-6B, TPH-47 and TPH-53) having intermediate infiltrative capacities. These samples were analyzed for their soil moisture content and distribution as recommended in ASTM D 3385.

The calculated volumetric soil moisture contents for each test site were plotted and contoured to show the soil moisture conditions existing at the end of each test. These figures show that the highest moisture contents concentrated vertically beneath the infiltrometer rings, with the greatest moisture contents in the 1- to 4-foot range below the infiltrative surface. These results confirm the field observations of the apparent wetting front and the vertical nature of infiltration beneath the infiltrometer rings.

2 Sample Collection

The soil grab samples collected at and beneath the infiltrative surfaces from the double-ring infiltrometer test sites conducted at TPH-6B, TPH-47 and TPH-53 were stored in double plastic bags and were analyzed in the laboratory for their moisture content and distribution. Water remaining within the double-ring apparatus was allowed to percolate into the soil prior to the removal of the apparatus. A trench intersecting the center of the double-ring location site was then dug by backhoe. Grab samples were collected from the exposed soil surface on the XZ plane intersecting the center of the double-ring location. Sampling was completed within about one-half hour following the termination of each test. The samples collected at the three test sites was as follows:

TPH-6B Sampling. The infiltrative surface at TPH-6B was 24 inches below the land surface. Grab samples were collected at the infiltrative surface beneath the rings, and at 2' and 4' north and south of the rings. Additional grab samples were collected at

depths of 1½', 3' and 4½' beneath the infiltrative surface samples. A total of 20 grab samples were collected from this test site.

TPH-47 Sampling. The infiltrative surface at TPH-47 was 60 inches below the land surface. Grab samples were collected at the infiltrative surface beneath the rings, and at 2' east of, and at 2' and 4' west of the rings. Additional grab samples were collected at depths of 1½' and 3' below the infiltrative surface samples. A total of 12 grab samples were collected from this test site.

TPH-53 Sampling. The infiltrative surface at TPH-53 was 48 inches below the land surface. Grab samples were collected at the infiltrative surface beneath the rings, and at 2' and 4' east of, and at 2' west of the rings. Additional grab samples were collected at depths of 1½' and 3' below the infiltrative surface samples. A total of 12 grab samples were collected from this test site.

3 Laboratory Analyses

Undisturbed core samples were collected from sandy soil horizons in five soil test pits during the Phase I evaluation of Area H, before the double-ring infiltrometer tests were conducted. The bulk density (D_b) and soil moisture content (weight %, θ_m) of the samples were determined using the core method of sample collection and bulk density determination as described by Blake and Hartge (in SSSA 1986, Method 13-2). The results of these analyses were averaged to determine the average site sand bulk density.

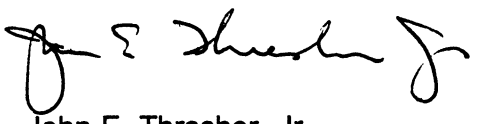
Soil samples were collected on an XZ grid pattern beneath three of the double-ring infiltrometer test sites to determine the soil moisture content (both by % weight, θ_m, and % volume, θ_v) of the samples and the distribution of soil moisture content (θ_v) beneath the test rings. The moisture content (weight %, θ_m) of each samples was determined using ASTM Method D 2216. The volumetric (%) moisture content (θ_v) of each sample collected on the XZ grid was calculated by multiplying the moisture content (weight %, θ_m) by the average site sand bulk density.

4 Results and Discussion

The results of the bulk density and soil moisture (θ_m) determinations of the undisturbed core samples are included in Table 1. The average bulk density of the sands at the site was determined to be 1.52 g/cm^3 (approximately 95 lbs/cf).

The results of the soil moisture (θ_m) determinations and calculations (θ_v) of the grab samples collected at and beneath the infiltrative surface are included in Table 2. The calculated volumetric soil moisture contents (θ_v) of the samples have been plotted and contoured for each test site, as shown in Figures 1 through 3. These figures show that the highest moisture contents are concentrated vertically beneath the infiltrometer rings, especially at TPH-6B (Figure 1). The greatest soil moisture contents at each test site were in the 1- to 4-foot depth range below the infiltrative surface.

Respectfully submitted,



John E. Thresher, Jr.
110697

Reference Cited

Blake, G. R. and K. H. Hartge. 1986. *Bulk Density.* in A. Klute, ed. *Methods of Soil Analysis. Part 1, Physical and Mineralogical Methods.* 2nd edition. Soil Science Society of America Monograph No. 9. Madison, Wisconsin.

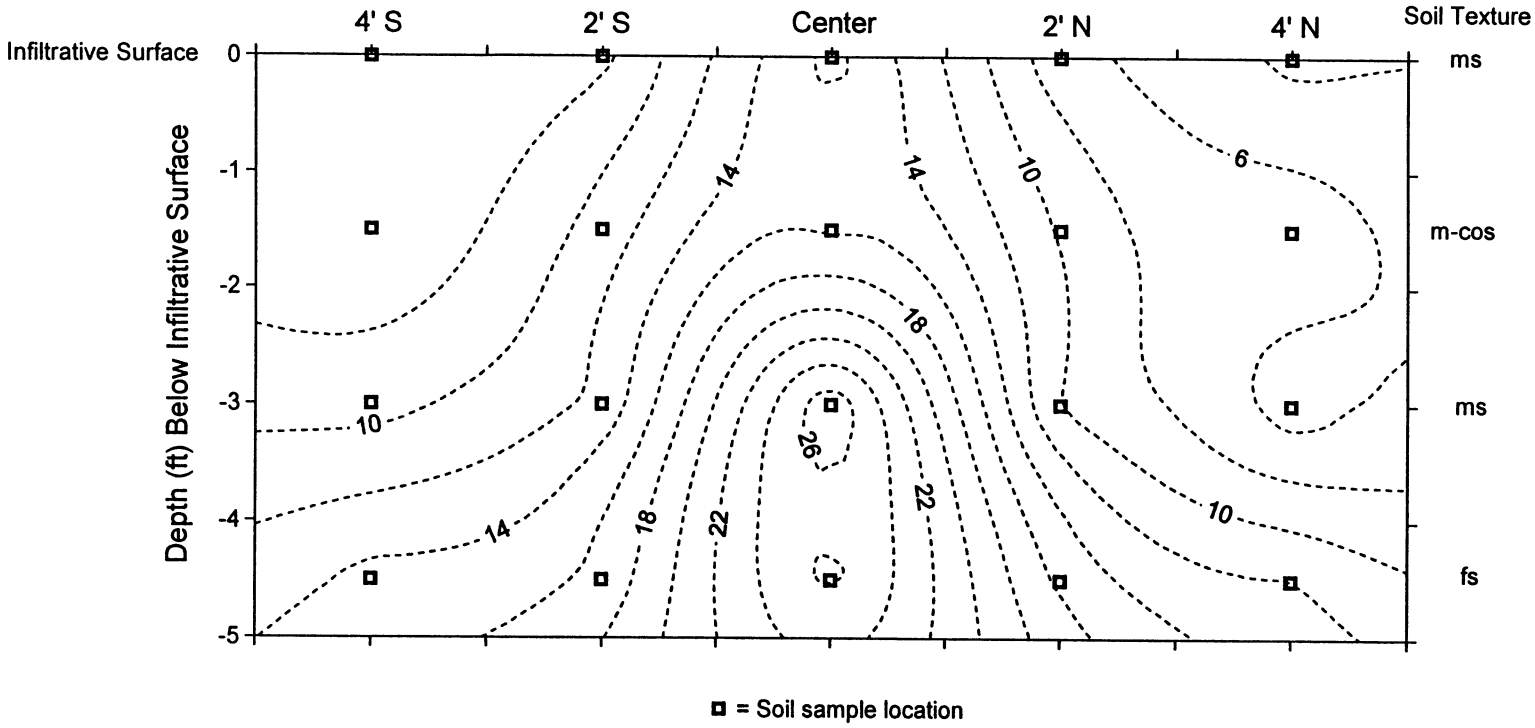


Figure 1. Moisture Content (vol., %) and Soil Texture of Samples Collected Following the Double-Ring Infiltrometer Test at TPH-6B.

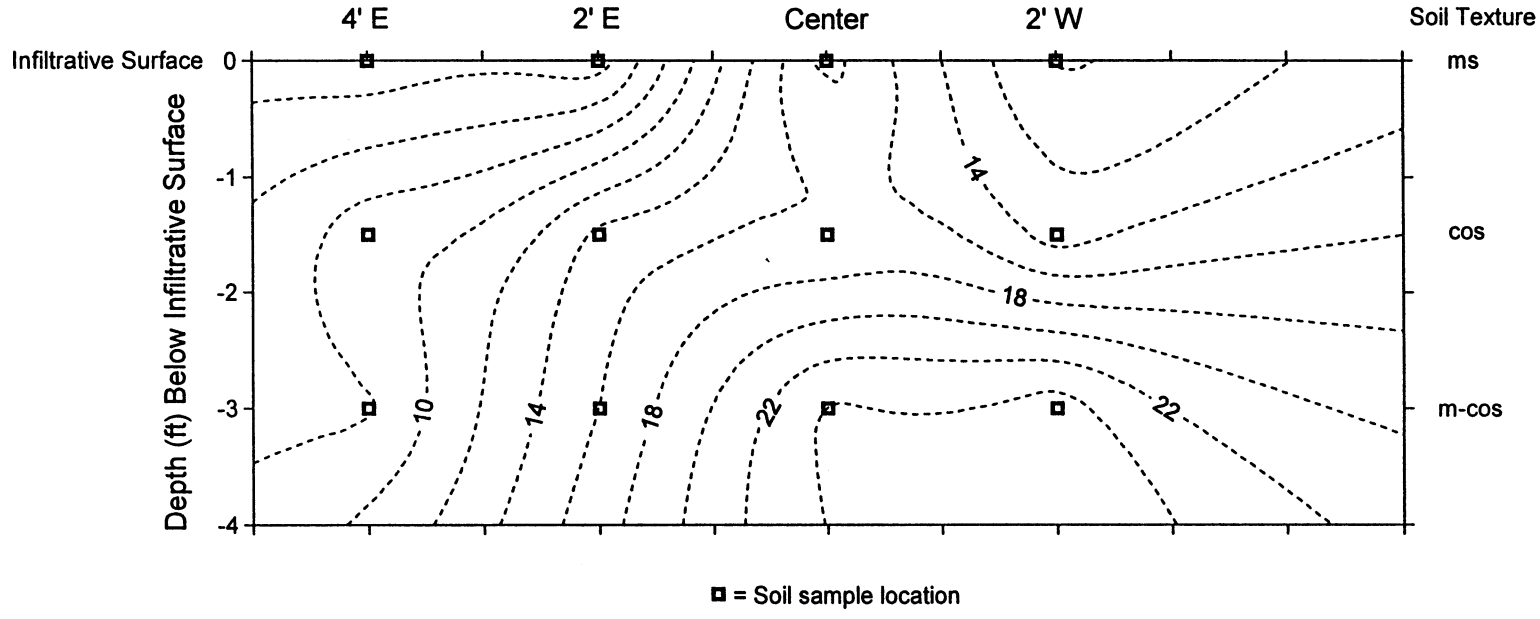


Figure 2. Moisture Content (vol., %) and Soil Texture of Samples Collected Following the Double-Ring Infiltrometer Test at TPH-47.

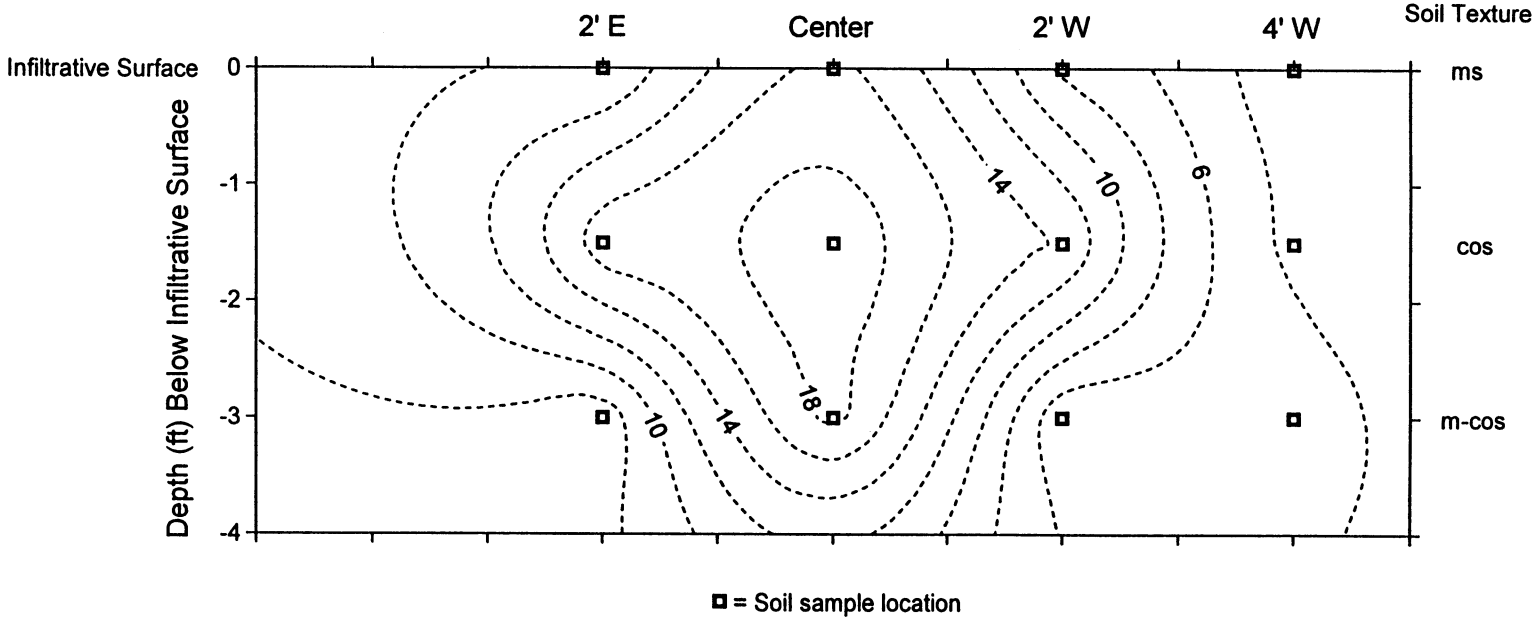


Figure 3. Moisture Content (vol., %) and Soil Texture of Samples Collected Following the Double-Ring Infiltrometer Test at TPH-53.

Table 1. Bulk Density (D_b) and Soil Moisture (θ_m) Determinations of Soil Samples Collected at the Rudloff Property

(SSSA: 13-2 and ASTM: D 2216)

Nicolet Minerals Company, Crandon Wisconsin

Sample	TPH-5, 52"	TPH-13, 54"	TPH-21, 48"	TPH-32, 60"	TPH-38A, 42"		
Ring no.	12	7	4	3	6		
Wt. ring + moist soil (g)	179.14	181.59	181.92	181.27	184.37		
Wt. ring + dry soil (g)	173.93	176.60	177.45	173.87	177.98		
Wt. of ring (g)	73.06	73.02	73.19	72.95	73.04		
Wt. of water (g)	5.21	4.99	4.47	7.40	6.39		
Wt. of dry soil (g)	100.87	103.58	104.26	100.92	104.94		
Bulk Density, D_b (g/cm^3)	1.49	1.53	1.54	1.49	1.55		
Moisture content, θ_m (wt., %)	5.17	4.82	4.29	7.83	6.09		
Soil Texture (SCS, field)	m-cos	m-cos	ms	m-cos	m-cos		

Bulk density, D_b (g/cm^3) = (wt. of dry soil, g) / (vol. of ring, cm^3); ring vol. = 67.7 cm^3

Moisture content, θ_m (wt., %) = [(wt. of water, g) / (wt. of oven dry soil, g)] x 100

Analyzed and prepared by: JET, 090598

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

Table 2. Moisture Content (θ_m and θ_v) of Soil Samples Collected Following the Completion of the Double-Ring Infiltrometer Tests at the Rudloff Property.

(ASTM: D 2216)

Nicolet Minerals Company, Crandon Wisconsin

Sample	TPH-6B C, surf.	TPH-6B C, 1½'	TPH-6B C, 1½'*	TPH-6B C, 3'	TPH-6B C, 4½'	TPH-6B 4S, surf.	TPH-6B 4S, 1½'
Tin No.	35	9	34	22	12	25	29
Wt. Tin + Moist Soil (g)	58.55	61.83	60.00	72.44	64.22	60.39	56.54
Wt. Tin + Dry Soil (g)	54.33	57.73	55.59	63.75	57.02	58.45	54.93
Wt. of Tin (g)	15.51	15.25	15.59	15.41	15.54	15.35	15.53
Wt. of Water (g)	4.22	4.10	4.41	8.69	7.20	1.94	1.61
Wt. of Dry Soil (g)	38.82	42.48	40.00	48.34	41.48	43.10	39.40
Moisture Content, θ_m (wt., %)	10.9	9.65	11.0	18.0	17.4	4.50	4.09
Moisture Content, θ_v (vol. %)	16.6	14.7	16.7	27.4	26.4	6.84	6.22
Soil Texture (SCS)	ms	m-cos	m-cos	ms	fs	ms	m-cos

Moisture content, θ_m (wt., %) = [(wt. of water, g) / (wt. of oven dry soil, g)] x 100

Moisture content, θ_v (vol., %) = θ_m x (bulk density, D_b); av. D_b = 1.52 g/cm^3

* = duplicate sample

Analyzed and prepared by: JET, 090598

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

Table 2 (continued). Moisture Content (θ_m and θ_v) of Soil Samples Collected Following the Completion of the Double-Ring Infiltrometer Tests at the Rudloff Property.

(ASTM: D 2216)

Nicolet Minerals Company, Crandon Wisconsin

Sample	TPH-6B 4S, 3'	TPH-6B 4S, 4½'	TPH-6B 2S, surf.	TPH-6B 2S, surf.*	TPH-6B 2S, 1½'	TPH-6B 2S, 3'	TPH-6B 2S, 4½'
Tin No.	11	32	13	15	1	3	28
Wt. Tin + Moist Soil (g)	60.28	59.51	54.19	56.52	54.42	59.59	58.57
Wt. Tin + Dry Soil (g)	57.70	55.66	52.34	54.61	51.82	56.25	54.34
Wt. of Tin (g)	15.57	15.51	15.29	15.54	15.50	15.56	15.52
Wt. of Water (g)	2.58	3.85	1.85	1.91	2.60	3.34	4.23
Wt. of Dry Soil (g)	42.13	40.15	37.05	39.07	36.32	40.69	38.82
Moisture Content, θ_m (wt., %)	6.12	9.59	4.99	4.89	7.16	8.21	10.9
Moisture Content, θ_v (vol. %)	9.30	14.6	7.58	7.43	10.9	12.5	16.6
Soil Texture (SCS)	ms	fs	ms	ms	m-cos	ms	fs

Moisture content, θ_m (wt., %) = [(wt. of water, g) / (wt. of oven dry soil, g)] x 100

Moisture content, θ_v (vol., %) = θ_m x (bulk density, D_b); av, D_b = 4.52 g/cm^3

* = duplicate sample

Analyzed and prepared by: JET, 090598

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

Table 2 (continued). Moisture Content (θ_m and θ_v) of Soil Samples Collected Following the Completion of the Double-Ring Infiltrometer Tests at the Rudloff Property.

(ASTM: D 2216)

Nicolet Minerals Company, Crandon Wisconsin

Sample	TPH-6B 2N, surf.	TPH-6B 2N, 1½'	TPH-6B 2N, 3'	TPH-6B 2N, 3'*	TPH-6B 2N, 4½'	TPH-6B 2N, 4½'*	TPH-6B 4N, surf.
Tin No.	7	27	14	4	33	30	21
Wt. Tin + Moist Soil (g)	55.56	53.91	58.14	59.35	58.11	62.89	55.97
Wt. Tin + Dry Soil (g)	53.87	51.59	55.48	56.77	54.40	58.25	55.04
Wt. of Tin (g)	15.34	15.51	15.36	15.55	15.53	15.60	15.39
Wt. of Water (g)	1.69	2.32	2.66	2.58	3.71	4.64	0.93
Wt. of Dry Soil (g)	38.53	36.08	40.12	41.22	38.87	42.65	39.65
Moisture Content, θ_m (wt., %)	4.39	6.43	6.63	6.26	9.54	10.9	2.35
Moisture Content, θ_v (vol., %)	6.67	9.77	10.1	9.52	14.5	16.6	3.57
Soil Texture (SCS)	ms	m-cos	ms	ms	fs	fs	ms

Moisture content, θ_m (wt., %) = [(wt. of water, g) / (wt. of oven dry soil, g)] x 100

Moisture content, θ_v (vol., %) = θ_m x (bulk density, D_b); av D_b = 1.52 g/cm^3

* = duplicate sample

Analyzed and prepared by: JET, 090598

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

Table 2 (continued). Moisture Content (θ_m and θ_v) of Soil Samples Collected Following the Completion of the Double-Ring Infiltrometer Tests at the Rudloff Property.

(ASTM: D 2216)

Nicolet Minerals Company, Crandon Wisconsin

Sample	TPH-6B 4N, 1½'	TPH-6B 4N, 3'	TPH-6B 4N, 4½'	TPH-47 C, surf.	TPH-47 C, 1½'	TPH-47 C, 1½'*	TPH-47 C, 3'
Tin No.	36	16	24	19	15	35	3
Wt. Tin + Moist Soil (g)	51.86	63.52	61.77	63.14	67.48	64.20	69.67
Wt. Tin + Dry Soil (g)	50.17	61.97	58.34	57.87	62.43	59.65	62.20
Wt. of Tin (g)	15.61	15.41	15.29	15.47	15.53	15.51	15.56
Wt. of Water (g)	1.69	1.55	3.43	5.27	5.05	4.55	7.47
Wt. of Dry Soil (g)	34.56	46.56	43.05	42.40	46.90	44.14	46.64
Moisture Content, θ_m (wt., %)	4.89	3.33	7.97	12.4	10.8	10.3	16.0
Moisture Content, θ_v (vol. %)	7.43	5.06	12.1	18.8	16.4	15.6	24.3
Soil Texture (SCS)	m-cos	ms	fs	ms	cos	cos	m-cos

Moisture content, θ_m (wt., %) = [(wt. of water, g) / (wt. of oven dry soil, g)] x 100

Moisture content, θ_v (vol., %) = θ_m x (bulk density, D_b); av. D_b = 1.52 g/cm^3

* = duplicate sample

Analyzed and prepared by: JET, 090598

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

Table 2 (continued). Moisture Content (θ_m and θ_v) of Soil Samples Collected Following the Completion of the Double-Ring Infiltrometer Tests at the Rudloff Property.

(ASTM: D 2216)

Nicolet Minerals Company, Crandon Wisconsin

Sample	TPH-47 4E, surf.	TPH-47 4E, 1½'	TPH-47 4E, 3'	TPH-47 2E, surf.	TPH-47 2E, surf.*	TPH-47 2E, 1½'	TPH-47 2E, 3'
Tin No.	22	25	24	4	18	30	14
Wt. Tin + Moist Soil (g)	56.49	59.49	61.65	56.27	54.42	61.13	61.94
Wt. Tin + Dry Soil (g)	55.75	56.93	59.40	55.52	53.69	57.15	57.52
Wt. of Tin (g)	15.41	15.35	15.29	15.55	15.48	15.60	15.37
Wt. of Water (g)	0.74	2.56	2.25	0.75	0.73	3.98	4.42
Wt. of Dry Soil (g)	40.34	41.58	44.11	39.97	38.21	41.55	42.15
Moisture Content, θ_m (wt., %)	1.83	6.16	5.10	1.88	1.91	9.58	10.5
Moisture Content, θ_v (vol. %)	2.78	9.36	7.75	2.86	2.90	14.6	16.0
Soil Texture (SCS)	ms	cos	m-cos	ms	ms	cos	m-cos

Moisture content, θ_m (wt., %) = [(wt. of water, g) / (wt. of oven dry soil, g)] x 100

Moisture content, θ_v (vol., %) = θ_m x (bilk density, D_b); av. D_b = 1.52 g/cm^3

* = duplicate sample

Analyzed and prepared by: JET, 090598

Thresher & Son, Inc.
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Madison, WI 53705
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Table 2 (continued). Moisture Content (θ_m and θ_v) of Soil Samples Collected Following the Completion of the Double-Ring Infiltrometer Tests at the Rudloff Property.

(ASTM: D 2216)

Nicolet Minerals Company, Crandon Wisconsin

Sample	TPH-47 2W, surf.	TPH-47 2W, 1½'	TPH-47 2W, 3'	TPH-53 C, surf.	TPH-53 C, 1½'	TPH-53 C, 3'	TPH-53 C, 3'*
Tin No.	23	16	32	27	7	8	17
Wt. Tin + Moist Soil (g)	58.05	59.48	65.61	62.19	72.37	65.41	69.49
Wt. Tin + Dry Soil (g)	55.47	56.01	58.53	57.59	65.95	60.05	63.49
Wt. of Tin (g)	15.31	15.41	15.51	15.51	15.34	15.59	15.26
Wt. of Water (g)	2.58	3.47	7.08	4.60	6.42	5.36	6.00
Wt. of Dry Soil (g)	40.16	40.60	43.02	42.08	50.61	44.46	48.23
Moisture Content, θ_m (wt., %)	6.42	8.55	16.5	10.9	12.7	12.1	12.4
Moisture Content, θ_v (vol. %)	9.76	13.0	25.1	16.6	19.3	18.4	18.8
Soil Texture (SCS)	ms	cos	m-cos	ms	cos	m-cos	m-cos

Moisture content, θ_m (wt., %) = [(wt. of water, g) / (wt. of oven dry soil, g)] x 100

Moisture content, θ_v (vol. %) = θ_m x (bulk density, D_b); av. D_b = 1.52 g/cm^3

* = duplicate sample

Analyzed and prepared by: JET, 090598

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

Table 2 (continued). Moisture Content (θ_m and θ_v) of Soil Samples Collected Following the Completion of the Double-Ring Infiltrometer Tests at the Rudloff Property.

(ASTM: D 2216)

Nicolet Minerals Company, Crandon Wisconsin

Sample	TPH-53 2E, surf.	TPH-53 2E, 1½'	TPH-53 2E, 3'	TPH-53 2W, surf.	TPH-53 2W, 1½'	TPH-53 2W, 3'	TPH-53 4W, surf.
Tin No.	21	28	1	11	29	36	13
Wt. Tin + Moist Soil (g)	61.12	62.30	57.67	58.36	64.84	58.94	59.02
Wt. Tin + Dry Soil (g)	58.33	57.54	55.91	56.33	60.70	57.73	58.22
Wt. of Tin (g)	15.39	15.53	15.50	15.58	15.53	15.60	15.28
Wt. of Water (g)	2.79	4.76	1.76	2.03	4.14	1.21	0.80
Wt. of Dry Soil (g)	42.64	42.01	40.41	40.75	45.17	42.13	42.94
Moisture Content, θ_m (wt., %)	6.50	11.3	4.36	4.98	9.17	2.87	1.86
Moisture Content, θ_v (vol., %)	9.88	17.2	6.63	7.57	13.9	4.36	2.83
Soil Texture (SCS)	ms	cos	m-cos	ms	cos	m-cos	ms

Moisture content, θ_m (wt., %) = [(wt. of water, g) / (wt. of oven dry soil, g)] x 100

Moisture content, θ_v (vol., %) = θ_m x (bulk density, D_b); av. D_b = 1.52 g/cm^3

* = duplicate sample

Analyzed and prepared by: JET, 090598

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

Table 2 (continued). Moisture Content (θ_m and θ_v) of Soil Samples Collected Following the Completion of the Double-Ring Infiltrometer Tests at the Rudloff Property.

(ASTM: D 2216)

Nicolet Minerals Company, Crandon Wisconsin

Sample	TPH-53 4W, surf.*	TPH-53 4W, 1½'	TPH-53 4W, 3'				
Tin No.	33	34	5				
Wt. Tin + Moist Soil (g)	60.70	63.55	60.28				
Wt. Tin + Dry Soil (g)	59.98	62.48	58.86				
Wt. of Tin (g)	15.53	15.60	15.43				
Wt. of Water (g)	0.72	1.07	1.42				
Wt. of Dry Soil (g)	44.45	46.88	43.43				
Moisture Content, θ_m (wt., %)	1.62	2.28	3.27				
Moisture Content, θ_v (vol., %)	2.46	3.46	4.97				
Soil Texture (SCS)	ms	cos	m-cos				

Moisture content, θ_m (wt., %) = [(wt. of water, g) / (wt. of oven dry soil, g)] x 100

Moisture content, θ_v (vol., %) = θ_m x (bulk density, D_b); av. D_b = 1.52 g/cm^3

* = duplicate sample

Analyzed and prepared by: JET, 090598

Thresher & Son, Inc.
2828 Regent St.
Madison, WI 53705
608-233-0297

Appendix I

Soil Absorption System Design Calculations

CRANDON PROJECT
SOIL ABSORPTION SYSTEM DESIGN

RUDLOFF PROPERTY - AREA H

DESIGN STEP 1 - CALCULATE MAXIMUM CELL WIDTH

W = ((K*D*H)/(d*L))
WHERE:

K = HYDRAULIC CONDUCTIVITY - FT/DAY
D = AQUIFER DEPTH, FT
PIPE ELEVATION = APPLICATION POINT FOR WASTEWATER DISPOSAL
DISCHARGE ELEVATION = MAXIMUM WATER LEVEL IN DISCHARGE WETLAND
MAXIMUM GROUNDWATER MOUND ELEV. = PIPE ELEVATION - 5 FEET
H = VERTICAL GROUNDWATER ELEV.; MAX MOUND - DISCHARGE ELEV., FT
d = DISTANCE FROM CENTER OF APPLICATION SYSTEM TO DISCHARGE POINT, FT
L = HYDRAULIC APPLICATION RATE, FT/DAY
W = ABSORPTION POND MAX WIDTH, FT

CELL	A	B	C	D	E	F
K	75	75	75	75	75	75
D	30	30	30	30	30	30
PIPE ELEV.	1597	1597	1595	1591	1592	1592
DISCHARGE ELEV.	1581	1581	1581	1580.5	1580.5	1580.5
MAX MOUND ELEV.	1592	1592	1590	1586	1587	1587
H	11	11	9	5.5	6.5	6.5
d	300	200	200	200	250	250
L	0.50	0.50	0.50	0.50	0.50	0.50
W	165	248	203	124	117	117
LENGTH	250	250	300	300	730	750

Prepared by: PAK
Checked by: TWS

DESIGN STEP 2 - CALCULATE SIZE AND APPLICATION RATE TO MEET MAXIMUM MOUND RESTRICTIONS

GROUNDWATER MOUNDING FROM "EPA - LAND TREATMENT OF MUNICIPAL WASTEWATER"
MOUND IS DETERMINED GRAPHICALLY IN TEXT BUT CONVERTED TO STRAIGHT LINE EQUATION IN THE TABLES BELOW

W/(4@T)^.5
W = BASIN WIDTH
T = LENGTH OF WASTEWATER APPLICATION, DAYS TO STEADY STATE
T = (d/((K*(H/d))/V))
@ = KD/V
K = HYDRAULIC CONDUCTIVITY
D = AQUIFER THICKNESS
V = SPECIFIC YIELD = 0.25 FOR FINE SAND

CELL	W	T	K	D	V	W/(4@T)^.5
A*	150	27.27	75	30	0.25	0.15
B*	150	12.12	75	30	0.25	0.23
C*	150	14.81	75	30	0.25	0.21
D*	100	24.24	75	30	0.25	0.11
E*	100	32.05	75	30	0.25	0.09
F*	100	32.05	75	30	0.25	0.09

* CELL WIDTH REDUCED FROM MAXIMUM FOR ACTUAL DESIGN

RT
R = I/V
I = INFILTRATION RATE
hO/RT = COMPUTED VALUE BASED ON GRAPHICAL SOLUTION (STRAIGHT LINE)
hO = GROUNDWATER MOUND

CELL	T	I	V	RT	hO/RT	hO	MAX GW EL	MAX MOUND
A	27.27	0.43	0.25	46.91	0.105968	4.97	1587	5
B	12.12	0.50	0.25	24.24	0.158952	3.85	1586	6
C	14.81	0.50	0.25	29.63	0.143777	4.26	1585	5
D	24.24	0.50	0.25	48.48	0.074931	3.63	1582	4
E	32.05	0.44	0.25	56.41	0.065166	3.68	1583	4
F	32.05	0.44	0.25	56.41	0.065166	3.68	1583	4

CELL	GPD	GPM	LENGTH	WIDTH	AREA ACRES
A	120615	84	250	150	0.86
B	140250	97	250	150	0.86
C	168300	117	300	150	1.03
D	112200	78	300	100	0.69
E	240258	167	730	100	1.68
F	246840	171	750	100	1.72
TOTAL	1,028,463	714			6.84

Prepared by: PAK
Checked by: TWS

ALTERNATE DESIGN - 60' AQUIFER DEPTH

CRANDON PROJECT
SOIL ABSORPTION SYSTEM DESIGN

RUDLOFF PROPERTY - AREA H

DESIGN STEP 1 - CALCULATE MAXIMUM CELL WIDTH

W = ((K*D*H)/(d*L))
WHERE:

K = HYDRAULIC CONDUCTIVITY - FT/DAY
D = AQUIFER DEPTH, FT
PIPE ELEVATION = APPLICATION POINT FOR WASTEWATER DISPOSAL
DISCHARGE ELEVATION = MAXIMUM WATER LEVEL IN DISCHARGE WETLAND
MAXIMUM GROUNDWATER MOUND ELEV. = PIPE ELEVATION - 5 FEET
H = VERTICAL GROUNDWATER ELEV.; MAX MOUND - DISCHARGE ELEV., FT
d = DISTANCE FROM CENTER OF APPLICATION SYSTEM TO DISCHARGE POINT, FT
L = HYDRAULIC APPLICATION RATE, FT/DAY
W = ABSORPTION POND MAX WIDTH, FT

CELL	A	B	C	D	E	F
K	75	75	75	75	75	75
D	60	60	60	60	60	60
PIPE ELEV.	1597	1597	1595	1591	1592	1592
DISCHARGE ELEV.	1581	1581	1581	1580.5	1580.5	1580.5
MAX MOUND ELEV.	1592	1592	1590	1586	1587	1587
H	11	11	9	5.5	6.5	6.5
d	300	200	200	200	250	250
L	0.50	0.50	0.50	0.50	0.50	0.50
W	330	495	405	248	234	234
LENGTH	250	250	300	300	730	750

Prepared by: PAK
Checked by: TWS

DESIGN STEP 2 - CALCULATE SIZE AND APPLICATION RATE TO MEET
MAXIMUM MOUND RESTRICTIONS

GROUNDWATER MOUNDING FROM "EPA - LAND TREATMENT OF MUNICIPAL WASTEWATER"
MOUND IS DETERMINED GRAPHICALLY IN TEXT BUT CONVERTED TO STRAIGHT LINE
EQUATION IN THE TABLES BELOW

W/(4@T)^.5
W = BASIN WIDTH
T = LENGTH OF WASTEWATER APPLICATION, DAYS TO STEADY STATE
T = (d/((K*(H/d))/V))
@ = KD/V
K = HYDRAULIC CONDUCTIVITY
D = AQUIFER THICKNESS
V = SPECIFIC YIELD = 0.25 FOR FINE SAND

CELL	W	T	K	D	V	W/(4@T)^.5
A*	180	27.27	75	60	0.25	0.13
B*	300	12.12	75	60	0.25	0.32
C*	240	14.81	75	60	0.25	0.23
D*	150	24.24	75	60	0.25	0.11
E*	130	32.05	75	60	0.25	0.09
F*	130	32.05	75	60	0.25	0.09

* CELL WIDTH REDUCED FROM MAXIMUM FOR ACTUAL DESIGN

RT
R = I/V
I = INFILTRATION RATE
hO/RT = COMPUTED VALUE BASED ON GRAPHICAL SOLUTION (STRAIGHT LINE)
hO = GROUNDWATER MOUND

CELL	T	I	V	RT	hO/RT	hO	MAX GW EL	MAX MOUND
A	27.27	0.50	0.25	54.55	0.089917	4.90	1587	5
B	12.12	0.50	0.25	24.24	0.224792	5.45	1586	6
C	14.81	0.50	0.25	29.63	0.162665	4.82	1585	5
D	24.24	0.50	0.25	48.48	0.079476	3.85	1582	4
E	32.05	0.50	0.25	64.10	0.059904	3.84	1583	4
F	32.05	0.50	0.25	64.10	0.059904	3.84	1583	4

CELL	GPD	GPM	LENGTH	WIDTH	AREA ACRES
A	168300	117	250	180	1.03
B	280500	195	250	300	1.72
C	269280	187	300	240	1.65
D	168300	117	300	150	1.03
E	354926	246	730	130	2.18
F	364650	253	750	130	2.24
TOTAL	1,605,956	1115			9.86

Prepared by: PAK
Checked by: TWS

SOIL ABSORPTION BED DESIGN

ASSUME CELLS A - F OPERATE INDEPENDANTLY

ASSUME "EVEN DISTRIBUTION" OVER EACH CELL TO BE DONE
WITH LATERALS SPACED 20 FEET APART AND WITH
DISCHARGE ORIFICES SPACED 10 FEET APART.

TO PROVIDE EVEN DISTRIBUTION, THE HEAD LOSS ACROSS
THE LATERAL MUST BE <10% OF THE HEAD AT EACH ORIFICE

GIVEN THE ABOVE CONDITIONS, THE MAXIMUM LATERAL LENGTH IS

1.5 INCH PIPE = 1.59" ID	75 FEET (8 ORIFICES)
2 INCH PIPE = 2.047" ID	125 FEET (13 ORIFICES)

CELL A

MAXIMUM AVERAGE FLOW RATE =	84	GPM
DIMENSIONS =	250	LONG
	150	WIDE
LATERAL LENGTH	62.5	FEET
LATERAL DIAMETER	1.59	INCHES
LATERALS PER ROW	4	
ROWS OF LATERALS	8	
TOTAL LATERAL LENGTH =	2000	FEET
NUMBER OF HOLES =	200	
FLOW RATE PER HOLE =	1.28	GPM
TOTAL FLOW RATE =	256	GPM
LATERAL VOLUME =	0.01378166	CU FT/FT
	206	GALLONS
DOSE VOLUME =	2474	GALLONS

CELL B

MAXIMUM AVERAGE FLOW RATE =	97	GPM
DIMENSIONS =	250	LONG
	150	WIDE
LATERAL LENGTH	62.5	FEET
LATERAL DIAMETER	1.59	INCHES
LATERALS PER ROW	4	
ROWS OF LATERALS	8	
TOTAL LATERAL LENGTH =	2000	FEET
NUMBER OF HOLES =	200	
FLOW RATE PER HOLE =	1.28	GPM
TOTAL FLOW RATE =	256	GPM
LATERAL VOLUME =	0.01378166	CU FT/FT
	206	GALLONS
DOSE VOLUME =	2474	GALLONS

Prepared by: PAK
Checked by: TWS

CELL C

MAXIMUM AVERAGE FLOW RATE =	117	GPM
DIMENSIONS =	300	LONG
	150	WIDE
LATERAL LENGTH	75	FEET
LATERAL DIAMETER	1.59	INCHES
LATERALS PER ROW	4	
ROWS OF LATERALS	8	
TOTAL LATERAL LENGTH =	2400	FEET
NUMBER OF HOLES =	240	
FLOW RATE PER HOLE =	1.28	GPM
TOTAL FLOW RATE =	307	GPM
LATERAL VOLUME =	0.01378166	CU FT/FT
	247	GALLONS
DOSE VOLUME =	2969	GALLONS

CELL D

MAXIMUM AVERAGE FLOW RATE =	78	GPM
DIMENSIONS =	300	LONG
	100	WIDE
LATERAL LENGTH	75	FEET
LATERAL DIAMETER	1.59	INCHES
LATERALS PER ROW	4	
ROWS OF LATERALS	5	
TOTAL LATERAL LENGTH =	1500	FEET
NUMBER OF HOLES =	150	
FLOW RATE PER HOLE =	1.28	GPM
TOTAL FLOW RATE =	192	GPM
LATERAL VOLUME =	0.01378166	CU FT/FT
	155	GALLONS
DOSE VOLUME =	1856	GALLONS

CELL E

MAXIMUM AVERAGE FLOW RATE =	167	GPM
DIMENSIONS =	730	LONG
	100	WIDE
LATERAL LENGTH	91.25	FEET
LATERAL DIAMETER	2.047	INCHES
LATERALS PER ROW	8	
ROWS OF LATERALS	5	
TOTAL LATERAL LENGTH =	3650	FEET
NUMBER OF HOLES =	365	
FLOW RATE PER HOLE =	1.28	GPM
TOTAL FLOW RATE =	467	GPM
LATERAL VOLUME =	0.02284246	CU FT/FT
	624	GALLONS
DOSE VOLUME =	7484	GALLONS

Prepared by: PAK
Prepared by: TWS

CELL F

MAXIMUM AVERAGE FLOW RATE =	171	GPM
DIMENSIONS =	750	LONG
	100	WIDE
LATERAL LENGTH	93.75	FEET
LATERAL DIAMETER	2.047	INCHES
LATERALS PER ROW	8	
ROWS OF LATERALS	5	
TOTAL LATERAL LENGTH =	3750	FEET
NUMBER OF HOLES =	375	
FLOW RATE PER HOLE =	1.28	GPM
TOTAL FLOW RATE =	480	GPM
LATERAL VOLUME =	0.02284246	CU FT/FT
	641	GALLONS
DOSE VOLUME =	7689	GALLONS

CELL	FLOW - GPM	% TOT.	DOSE VOL GAL.	% TOT.
A	84	12%	2474	10%
B	97	14%	2474	10%
C	117	16%	2969	12%
D	78	11%	1856	7%
E	167	23%	7484	30%
F	171	24%	7689	31%
	714		24945	

Prepared by: PAK
Checked by: TWS

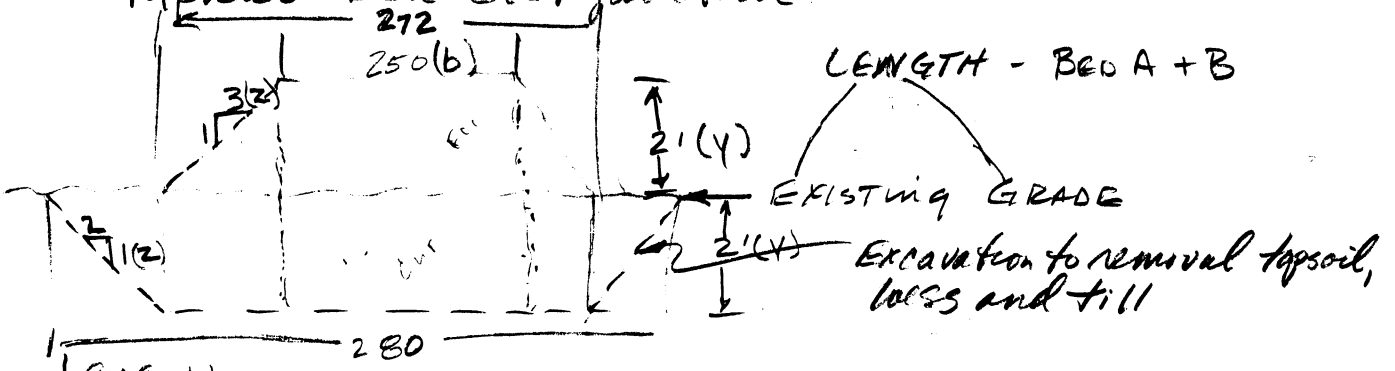
Foth & Van Dyke
consultants · engineers · scientists

Client: NMC Scope I.D.: 93C049
Project: SAS - AREA H Page: 1/4
Prepared By: REM Date: 10/20/98
Checked By: PAH Date: 10/22/98

Estimate EARTH WORK Volumes for SAS CONSTRUCTION ON AREA H

GIVEN:
- TOTAL BED AREA = 6.84 AC
- SAND FROM SOUTHEAST "RUDOFF Property (FIELD 5) AS THE BORROW site
- BED A = 150' x 250 BED C = 150' x 300' BED E = 100' x 730'
  BED B = 150' x 250 BED D = 100' x 300' BED F = 100' x 750'
- No SHRINKAGE from BORROW site since SAND will be place at the natural density

ASSUME:
- Average cut to remove topsoil, loess and till = 2' CUT
- average fill to BOTTOM OF pipe elevation = 2' FILL
- 2' of Topsoil, loess/till to be used to cover the bed
- Typical Bed Configuration



	A	B	C	D	E	F
FILL	(250) 262	(250) 262	(300) 312	(300) 312	(730) 742	(750) 762
CUT	(262) 270	270	320	320	750	770

Calculate AREAS Given $(b+zy)y = A$

	FILL	CUT
A+B	$(250+3(2))2 = 512^{sq'}$	$(270+2(2))2 = 548^{sq'}$
C+D	$(300+3(2))2 = 612^{sq'}$	$(320+2(2))2 = 648^{sq'}$
E	$(730+3(2))2 = 1472^{sq'}$	$(750+2(2))2 = 1508^{sq'}$
F	$(750+3(2))2 = 1512^{sq'}$	$(770+2(2))2 = 1548^{sq'}$

Foth & Van Dyke
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Client: NMC Scope I.D.: 93C049
Project: SAS - AREA H Page: 2/4
Prepared By: REM Date: 10/21/98
Checked By: PAH Date: 10/22/98

Calculate FILL REQUIRED ABOVE GRADE

A+B

512□'x 150' + 12□'x 162' x 1/27 = 2916.44
SAY 2900cy = A
2900cy = B

C

612□'x 150' + 12□' x 162' x 1/27 = 3472
SAY 3500cy = C

D

612□' x 100' + 12□' x 112 x 1/27 = 2316.44
SAY 2300cy = D

E

1472□'x 100' + 12□ x 112 x 1/27 = 5501.63
SAY 5500cy = E

F

1512□'x 100' + 12□'x 112 x 1/27 = 5649.8
SAY 5700cy = F

TOTAL FILL above grade = 22,800

Foth & Van Dyke
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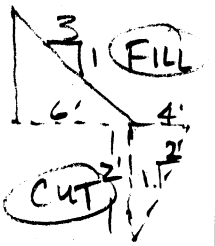
Client: NMC Scope I.D.: 93C049
Project: SAS - AREA 1+ Page: 3/4
Prepared By: REM Date: 10/21/98
Checked By: PHK Date: 10/22/98

	WIDTH A,B+C		WIDTH D,E+F		AREA
FILL	(150)	162	(100)	112	(2)(½)(2)(6) = 12□'
CUT	(162)	166	(112)	116	(2)(½)(2)(4) = 8□'



Calculate Volumes of Cut

A+B

(548□' x 150') + 8□' x 166' x 1/27 = 3094
(1328 CF) x 1/27
SAY 3100CY = A
3100CY = B

C

648□' x 150' + 8□' x 166' x 1/27 = 3649.19
SAY 3,700CY = C

D

648□' x 100' + 8□' x 116' x 1/27 = 2434.37
(928 CF)
SAY 2,400CY = D

E

1508□' x 100' + 8□' x 116 x 1/27 = 5619.56
SAY 5,600CY = E

F

1548□' x 100' + 8□' x 116 x 1/27 = 5767.7
SAY 5,800CY = F

(Topsoil, less FILL) - TOTAL CUT 23,700CY
(Above grade) → FILL 22,800CY
TOTAL FILL → 46,500CY

Check
6.84 AC x 43,560 x 4' x 1/27 = 44,140.8 OKAY

Foth & Van Dyke
consultants · engineers · scientists

Client: NMC Scope I.D.: 93C049
Project: SAS- AREA H Page: 4/4
Prepared By: REM Date: 10/21/98
Checked By: PHM Date: 10/22/98

Determine Stripping and excavation Required for Field 5 Borrow AREA
Average T.S, Loess + Till Thickness from Test Pits + Borings

TPH-74	1.5'
TPH-82	.7'
TPH-81	2.1'
TPH-76	1.5'
TPH-18	2.3'
TPH-80	2.1'
BH-7	2.1'
	12.3'

AV = 1.757 say 2' to be conservative ✓

Determine AREA based on geometric shapes from PAGE 5

A = (550') (400') = 220,000
B = (1/2) (270') (340') = 45,900
C = (1/2) (50') (360') = 9,000
D = (340') (360') = 122,400
397,300 = 9.1

E (400) (250') = 100,000
F = (1/2) (120) (80) = 4800
G = (120) (620) = 74,400
H = (1/2) (170) (100) = 8500
170,700 = 3.9
568,000 13.0 AC

Calculate Stripping Quantity

397,300 □' x 2' x 1/27 = 29,429.63 ✓
Say 29,400 cy

Determine approximate Excavation Depth
Given 46,700 cy of Fill required.

46,500 cy = $\frac{397{,}300\ \square'(x)}{27}$

✓ X = 3.16 say 3.2' of cut over 9.1 AC

Average Existing grade ~1588
Top of Outwash ~1586
~1585
Site Restoration
Bottom of Borrow Exc. ~1583

Appendix J

Technical Memorandum - Design Basis

Foth & Van Dyke
Memorandum

November 6, 1998

TO: Jerry Sevick, Foth & Van Dyke
Steve Dischler, Foth & Van Dyke

CC: Gordon Reid, Nicolet Minerals Company
Ken Black, Nicolet Minerals Company
Master File

FR: Steve Donohue, Foth & Van Dyke SVD
Greg Council, HSI GeoTrans, Inc.
Pete Andersen, HSI GeoTrans, Inc.

RE: Crandon Project - Design Basis Memorandum for Surface Absorption System - Area H

1 Introduction

Nicolet Minerals Company (NMC) is currently evaluating the feasibility of discharging treated mine water via a soil absorption system (SAS). The primary criteria which describes the layout and capacity of the SAS is the ability of the aquifer at the site to accept the required quantity of discharge water. As such, the performance of the proposed system will be dictated by the hydrogeologic conditions at the site.

Area H, located north of Keith Siding Road in the Town of Lincoln, has been investigated as a potential site for locating the SAS. Test pits have been completed to characterize the unsaturated zone beneath the SAS. Soil borings have been completed to define the approximate aquifer thickness. Monitoring wells, sand points, and staff gages have been installed to evaluate groundwater flow characteristics and the interaction of wetlands and surface waters with the local groundwater system. Slug tests and infiltrometer tests have been completed to evaluate the hydraulic conductivity of the outwash aquifer and the soils beneath the proposed soil absorption cells. In addition, survey work has been completed to evaluate the elevation of various wetland areas and culverts that will control, in part, the overall hydrologic response of the system due to the water added via the SAS.

The purpose of this memorandum is to provide a basis upon which to design the dimensions and infiltration capacity of the SAS given hydrogeologic conditions at Area H. Section 2 of this memorandum describes the conceptual model of the hydrogeology at the site and the general response of the system due to the SAS. Utilizing the conceptual model, Section 3 of this memorandum describes a cross-sectional, finite-difference flow model that was developed to

evaluate the capacity of the site to handle the treated mine water based on preliminary design concepts, and to provide guidance for the final design of the SAS. Section 4 of this memorandum describes the use of the cross-sectional model to evaluate the performance of the system based on the final design layout. The purpose of evaluating the final layout of the system via the cross-sectional model is to provide an additional check on the design calculations with respect to system performance and groundwater mounding.

2 Conceptual Model

Area H is located north of the confluence of Swamp Creek and Hemlock Creek. Based on geomorphological characteristics, this area is best described as a broad outwash plain that extends roughly from the southern end of Lake Metonga to just south of Swamp Creek. Based on the regional potentiometric surface map, regional groundwater flow near the site is predominantly to the south and east, with Swamp Creek functioning as a regional groundwater discharge point. Area H is bounded to the east by the Z16 wetland complex that generally follows an erosional channel that conveys runoff and seasonal groundwater discharge down to Swamp Creek. Creek 17-13, located east of wetland Z16 North, is a groundwater fed creek that is a tributary to Swamp Creek. A spring which feeds into Creek 17-13 is located in wetland Z16 North. The layout of the area is shown in Figure 2-1.

Based on the site investigation data, the hydrogeologic characteristics of the site can be summarized as follows:

- The outwash aquifer is approximately 70 ft thick at a minimum, based on soil boring data, and consists of coarse and fine grained outwash sands.

- Based on site groundwater level data and water table contour maps, the hydraulic gradient at the site is likely to range between 0.001 to 0.004 ft/ft with groundwater flow to the east and southeast toward the spring in Wetland Z16 North and Creek 17-13, wetlands Z16 Central and Z16 South, and Swamp Creek.

- Based on slug test data, the field measured hydraulic conductivity of the outwash is approximately 50 ft/d. Accounting for scale dependency, a reasonable conservative estimate of the outwash hydraulic conductivity at the scale of the SAS is 75 ft/d.

- The soils beneath the peat in the adjacent wetland to the east of Area H are underlain by a mixture of clean outwash sands, and lenses of silty sand and clayey sand tills. Based on this, the vertical permeability of the wetland soils are likely to be in the range of 0.5 ft/d (till) to 5 ft/d (outwash). Given the variability of the soils beneath the wetland, an average value of 1 ft/d is considered a reasonable value for design analysis.

- The infiltrometer tests on the soils beneath Area H measured the infiltration capacity of the shallow outwash soils at approximately 80 ft/d. The infiltration capacity of the soils is conservatively estimated to be 10 times lower than this, or approximately 8 ft/d. An

even lower value of 0.5 ft per day (or less) was used in the final design layout of the cells to limit mounding beneath the SAS.

- The elevation of the wetlands east of Area H, which will likely function as a discharge point for some or all of the infiltrated water, range in elevation from about 1580.5 (wetlands Z16 South and Z16 Central) to 1581 (Wetland Z16 North) based on surveyed spot elevations (all elevations are in ft. M.S.L.).

The water table at the site displays a rather uniform flow field with groundwater flowing to the east and southeast toward the adjacent wetland and Swamp Creek. Very weak vertical gradients have been measured at the site. Under high water table conditions, groundwater is likely to be expressed in the wetlands immediately east of the site. An active groundwater spring exists in wetland Z16 North, and is a source of groundwater discharge to Creek 17-13 via a culvert pipe beneath the Wisconsin Central Limited railroad bed. The Z16 Central and Z16 South wetlands that exist to the north and south of the dredge canal exhibit a water table that is several inches to approximately 1 ft beneath the land surface. Under high water table conditions, the water table is likely to be expressed in the wetland. Surface water and groundwater discharge to wetlands Z16 Central and Z16 South is conveyed through a series of culverts beneath a snowmobile trail that bisects the wetland and then through a culvert beneath Keith's Siding Road, where it then drains through additional wetlands to Swamp Creek.

Given the above, the wetlands to the east of Area H act on a permanent (Z16 North) to transient (Z16 Central and Z16 South) basis as areas of groundwater discharge. With the exception of that portion of wetland Z16 Central that is north of the dredge canal, the wetlands have outlets and function as permanent or ephemeral tributaries of groundwater discharge to Creek 17-13 and Swamp Creek. As part of the restoration of the dredge canal and wetland, drainage through Wetland Z16 Central will be reestablished. As such, all of wetland Z16 Central, in addition to the wetlands Z16 South and Z16 North, will act as a potential discharge point for groundwater resulting from the SAS. The discharge of treated water to the SAS will increase the water table elevation, thus increasing the amount of groundwater discharge to the wetlands and the amount of water that flows through the wetlands to Swamp Creek. As such, the wetlands will function as a boundary condition that will affect the response of the water table at Area H in response to the SAS. The probable hydrologic response of the groundwater system is described below. The key question is to what degree the wetlands will function as the controlling boundary condition vs. Swamp Creek, which is further removed from the site.

3 Cross-Sectional Flow Modeling - Scoping Analysis

Using preliminary design concepts for the proposed SAS cells (the approximate locations are shown in Figure 2-1), a scoping analysis was performed to determine: 1) the approximate range of mounding that could be expected beneath each SAS cell; 2) the critical design parameters affecting mounding; and 3) parameter values to be used in calculations made for the final design layout. The scoping analysis was performed with three cross-sectional flow models that

extended from different SAS cells to groundwater discharge points. A separate model was constructed for SAS cells B, E, and F based on a preliminary SAS design. These three models were used in order to capture the range of conditions that would affect groundwater flow and mounding.

3.1 Conceptual Analysis

The conceptual model of groundwater flow is the same for each SAS cell. The hydrogeologic setting is generally coarse- to fine-grained outwash. Groundwater flows from northwest to southeast, approximately perpendicular to the long axis of a proposed rectangular SAS cell. Groundwater eventually discharges into wetland Z16 South, Z16 Central, or Z16 North and associated spring, or Creek 17-13, or directly to Swamp Creek. Precipitation recharge provides a source of groundwater flow in the area.

Additional infiltration from the SAS will cause ambient groundwater elevations to increase. The increase would be most dramatic directly beneath the cell. A properly designed SAS cell will create a mound that is sufficiently below the base of the SAS bed. The conceptual model of groundwater flow near the SAS is illustrated in Figure 3-1.

An analytical solution for groundwater elevation change can be found if the following assumptions are made: 1) the aquifer transmissivity and recharge are constant; 2) the SAS cell is effectively an infinite line source perpendicular to groundwater flow; 3) upgradient flow is unaffected by the SAS flux; 4) the groundwater head is unaffected by the SAS cell at a known downgradient distance (i.e., at a discharge point); and 5) there is no groundwater discharge between the SAS cell and the known constant-head location. In this case, the mounding beneath the SAS cell, Δh, is given by (from Attachment A):

$$\Delta h = \frac{Q'L}{T} \qquad (1)$$

where Q' is the SAS cell infiltration rate per unit length, T is the aquifer transmissivity, and L is the distance from the SAS cell to the constant-head boundary.

This simple analysis was found to be inadequate for designing the SAS cells. If L is chosen as the distance from the SAS cell to the wetland, then the prediction of mounding from equation (1) is low, but it may be inappropriate to assume that the wetland creates a true constant-head boundary. If L is chosen to be a larger distance (e.g., the distance from the SAS cell to Swamp Creek), then the prediction of mounding is large, but the assumption of no discharge at intermediate distances (i.e., at the wetland Z16 complex) is clearly over-restrictive.

While it is inappropriate for use in the final design, equation (1) provides two useful functions. First, it can be used to check the reasonableness of results obtained by a more sophisticated analysis (this is done in Section 4). Second, the analytical analysis shows which parameters are likely to be critical in determining mounding. From equation (1) it is clear that SAS infiltration rate, aquifer transmissivity, and the distance to head controlling boundaries will affect mounding.

Conversely, though included in the derivation (see Attachment A), neither the background recharge rate nor upgradient groundwater flux appear in equation (1). Thus, the degree of mounding is not likely to be sensitive to these rates.

3.2 Modeling Method

In order to factor into the analysis the role of local and regional groundwater discharge points in controlling groundwater mounding at the site, while maintaining the overall simplicity desired for this scoping analysis, 2-D cross-sectional finite-difference models were constructed for cells B, E, and F. Each model followed an approximate groundwater flow path from the SAS cell through wetland Z16 to a regional groundwater discharge point (for cells F and E the regional discharge point was chosen to be Swamp Creek; for cell B it was the spring in wetland Z16 North. The MODFLOW program was used for this modeling (McDonald and Harbaugh, 1988; McDonald and Harbaugh, 1996).

Each section was similarly constructed (as discussed in Section 3.3) with the geometry appropriate for the SAS cell and flow path. Existing conditions were then simulated and model parameters were varied to achieve a reasonable match to observed conditions (Section 3.4). Subsequently, SAS cell seepage was simulated to determine the impact on groundwater heads and flows (Section 3.5). The process of calibration to existing conditions and prediction of condition with SAS infiltration was repeated with different parameter sets to test model sensitivity (Section 3.6). Finally, the results of the models were summarized to complete the scoping analysis (Section 3.7).

Note that the three models presented in this section were based on SAS preliminary design concepts. Section 4 presents models for the final-design layout of SAS cells.

3.3 Model Construction

For each model, the appropriate cross-sectional domain was discretized into rectangular cells and boundary conditions were applied on the model edges. The details of the model construction are presented below for SAS cell F. For cells B and E, the construction is similar, with some dimensions changed to account for different flow paths.

3.3.1 SAS Cell F Model Construction

The cross-sectional model domain for cell F (conceptual design) extends from the northwest (upgradient) edge of the SAS cell to the middle of Swamp Creek, about 3,700 ft (Figure 3-2). Vertically, the model extends from an elevation of 1510 ft (all elevations relative to mean sea level) to the water table, which varies from about 1577 ft at Swamp Creek to about 1581 ft at the SAS cell under current conditions. Horizontally, the domain is discretized into 370 cells of 10-ft width. Vertically, seven layers are used, with the bottom of layer 1 (the top layer) set to a uniform elevation of 1570 ft , and all other layers set to uniform thicknesses of 10 ft. Note that the thickness (and transmissivity) of layer 1 is allowed to vary, depending on the elevation of the

water table. However, for the purpose of setting the vertical leakance between layers 1 and 2, layer 1 is assumed to be 10 ft thick.

The bottom elevation for the model, 1510 ft , was chosen because it approximates the bottom of the transmissive outwash zone. Below this elevation it is assumed that lower-permeability Pre-to Early Wisconsinan till exists. Accordingly, the boundary condition for the model bottom is set to no-flow. The downgradient edge of the model, beneath Swamp Creek, is assumed to approximate a flow divide, meaning that groundwater is not allowed to pass beneath Swamp Creek. This condition is supported by head measurements on both sides of the creek that are higher than the creek elevation. A uniform constant flux condition is imposed on the upgradient edge of the model. This flux represents lateral inflow of groundwater to the aquifer, and its magnitude is adjusted as part of calibration (Section 3.4). This flux condition is incorporated in MODFLOW using wells in all layers in model column 1.

Along the top of the model, several boundary conditions are applied. First, a constant uniform recharge flux is applied at all cells in the top layer. The recharge rate is initially set to 8 in/yr (1.8e-3 ft/d), which is approximately the default rate used in the regional groundwater flow model (HSI GeoTrans, 1998). Swamp Creek is simulated with a head-dependent flux boundary in column 370 of layer 1. The stage of the creek is set to 1577 ft and the conductance of the creekbed is initially set to 10 ft^3/d (per ft perpendicular to the section). This conductance is also based on parameters in the regional flow model: the creekbed vertical conductivity is 1 ft/d, the creekbed thickness is 1 foot, and Swamp Creek is approximately 20 ft wide (half of this width, 10 ft, is used in the model since the groundwater divide is assumed to extend vertically from the center of the creek). The wetland Z16 South is simulated as a drain boundary on the top of the model in columns 28-66 (270 ft to 660 ft from the upgradient edge of the model). The wetland water elevation is 1580.5 ft and the sediment vertical leakance is 0.2 d^{-1}. The leakance is based on a wetland thickness of 5 ft (from the regional flow model) and an initial sediment conductivity of 1 ft/d (estimated from field observations). The total conductance for this wetland is 78 ft^3/d (per ft).

Finally, an additional flux boundary condition is applied in predictive simulations to model infiltration from the SAS cell. The first 10 cells in layer 1 are used to simulate the 100-ft width of SAS cell F. The applied infiltration rate (from preliminary design calculations) is 0.5 ft/d, giving a total inflow of 50 ft^3/d (per ft).

All model simulations are made in steady-state mode. Therefore, the only aquifer parameters required are horizontal and vertical conductivities. For this model, the horizontal conductivity is initially set to 75 ft/d (based on field measurements), and the vertical conductivity is set to 7.5 ft/d. This gives a total aquifer transmissivity of approximately 5250 ft^2/d (variable depending on water table elevation).

3.3.2 Model Construction for SAS Cell E and SAS Cell B

Two similar models were also constructed - one for SAS cell E and one for SAS cell B (conceptual layouts of the cells were used). Note that final design layouts are evaluated below in Section 4. The models differ in length, location, and width of the top-layer boundary conditions, and elevations for the stream and wetland. The differences in the construction of the models are identified in Table 3-1.

SAS cell E is 90 ft wide, with a 320-ft wide wetland Z16 Central located 250 ft from the cell's edge. The middle of Swamp Creek is 2,210 ft from the cell's edge. The wetland and creek elevations are 1580.5 ft and 1578 ft , respectively.

SAS cell B is 130 ft wide, with a 490-ft wide wetland (Z16 North) located 420 ft from the cell's edge. The model ends at the spring at the far edge of the wetland Z16 North, 920 ft from the edge of SAS cell B. The spring is assumed to be hydraulically similar to Swamp Creek. The wetland and spring elevations are 1581 ft and 1579 ft , respectively.

The three models constructed for this scoping analysis simulate groundwater flow from 3 of the original 6 cells in the preliminary SAS design. These 3 cells were chosen to represent a range of conditions that would cover all 6 cells.

3.4 Parameterization and Calibration

Adjustable parameters in the models include: aquifer horizontal conductivity, aquifer vertical conductivity, recharge rate, wetland sediment vertical conductivity, stream sediment vertical conductivity, and upgradient aquifer influx.

The primary calibration target for each model is the observed water table elevation on the upgradient edge of the model (Table 3-1). Several parameter value combinations will achieve acceptable calibration. The process of achieving a set of calibrated parameter values was as follows: 1) reasonable values are chosen for all parameters except the upgradient flux; and 2) the model is run multiple times in calibration mode (no influx from SAS cells), using various upgradient flux values until calibration is achieved.

With the initial values for all other parameters, the calibrated upgradient inflows needed for calibration were 3.5 $ft^3/d/ft$ for cells F and E and 23.1 $ft^3/d/ft$ for cell B. These flows represent horizontal hydraulic gradients of approximately 0.0007 (cells F and E) and 0.004 (cell B) at the model edges. These horizontal gradients are in reasonable agreement with the range of gradients observed near the proposed SAS cells. As discussed in Section 3.6, the actual value of upgradient influx and even the accuracy of the calibration is unimportant for the prediction of mounding beneath the SAS cells.

Additional parameter value sets are simulated as part of the sensitivity analysis discussed in Section 3.6.

3.5 Model Predictions

Using the preliminary design SAS infiltration rate of 0.5 ft/d, each model is run again to calculate the effect of the SAS cells on groundwater heads and flows. The water table predictions are compared to the calibration water table elevations to determine the degree of mounding (Figures 3-3 through 3-5). The greatest mounding occurs at the upgradient edge of the model beneath the SAS cell. Note that the upgradient aquifer flux is held at the calibration value for these simulations, while in reality it would decrease due to the SAS infiltration. Holding the upgradient flux constant is a simplifying assumption that makes the predicted mounding larger than it would be in reality.

Predictive simulation results are listed for all 3 models in Table 3-2. For these base models, the maximum predicted mounding is: 4.6 ft for cell F, 4.8 ft for cell E, and 8.3 ft for cell B. In each model, nearly all of the SAS infiltration is transmitted to the wetland rather than Swamp Creek. The predicted mounding is greatest for SAS cell B because the cell is wider (more infiltration flux) than the other cells, and the controlling outlet is further away (analogous to a larger L in equation (1)).

For the cell F model, particle traces originating at the SAS cell all terminate at the wetland (Figure 3-6). On the way to the wetland, some of the infiltrating water flows to the lowest model layer, indicating that the full aquifer transmissivity is important for predicting mounding. This conclusion was corroborated by a sensitivity simulation in which the conductivities in the lowest 3 layers were reduced by a factor of 10. The maximum mounding for this simulation was 5.6 ft, which is about 1 ft more than was predicted by the base model.

3.6 Model Sensitivity

Early simulations with the cell F model indicated that the model-predicted mounding was most sensitive to two hydraulic parameters: aquifer horizontal conductivity and wetland sediment vertical conductivity. The modeled mounding was much less sensitive to the values used for creekbed conductance, aquifer vertical conductivity, recharge rate, and upgradient aquifer influx. These relative degrees of sensitivity agreed with an earlier analytical analysis (Section 3.1). Early simulations with the cell F model also revealed that the selected level of discretization was appropriate and that it was unimportant whether the aquifer was simulated as confined or unconfined. Also, it was determined that spreading the same infiltration volume over a wider SAS cell would decrease the maximum mounding only slightly.

To test the model sensitivity, multiple simulations were made with a range of values for the two important hydraulic parameters and a range of possible SAS infiltration rates. Aquifer conductivity values of 50 ft/d and 75 ft/d were simulated. Wetland sediment conductivities of 0.5 ft/d, 1 ft/d, and 5.0 ft/d were simulated, and SAS infiltration rates of 0.5 ft/d and 1.0 ft/d were simulated. All 12 possible combinations of these parameter values were simulated with each of the three models, and the predicted maximum mounding was tabulated (Table 3-3). Note that calibration was first achieved for each combination of hydraulic parameter values, and the

calibrated water table surfaces were then compared to the predictive simulation results to compute mounding. Note also that some combination of parameter values (namely high infiltration rates, low conductivities) could cause mounding above land surface (mounding greater than about 9 ft).

3.7 Scoping Analysis Conclusions

The scoping analysis performed here indicates that the mounding beneath the proposed SAS cells will be dependent on the aquifer transmissivity, the wetland sediment conductivity, and the designed infiltration rate. For base parameter values (aquifer conductivity = 75 ft/d, wetland conductivity = 1 ft/d, SAS infiltration = 0.5 ft/d), the model-predicted maximum mounding would be between 4.6 and 8.3 ft, depending on the width of the wetland. For design calculations, the modeling indicates that an aquifer thickness of approximately 70 ft is appropriate since the bottom-most model layers do transmit water from the SAS cell to the wetland.

It is important to note that this modeling method is conservative with respect to predictions of mounding - it does not allow a flattening of the gradient on the upgradient side of the SAS cells and does not allow flow to spread laterally as it moves toward discharge locations. Confining flow to the cross-sectional domain starting at the edge of the SAS cell makes the analysis simpler, but overestimates groundwater mounding. The analysis described above was used to guide the final design layout and infiltration rates for the SAS. The following section describes the analysis of the final SAS design using modified versions of the cross-sectional models described above.

4 Final Design of SAS Cells

Using the scoping analysis of Section 3 and the final engineering design layout calculations, the SAS cells were reconfigured to optimize the SAS capacity. The final layout of the SAS cells is shown in Figure 4-1. The mounding impact of the SAS cells was evaluated using reconfigured versions of the 3 cross-sectional models presented in Section 3 to compare to the results of the final engineering design layout calculations. The results of the models were then checked for reasonableness using analytical calculations.

4.1 Final Design Cross-Sectional Models

Three cross-sectional models were constructed to simulate groundwater flow and head mounding for SAS cells F, E, and B. The conceptual model and modeling method remained the same, as described in Sections 3.1 and 3.2. However, the construction of the models was changed slightly to account for the optimized layout of the SAS cells and a more careful evaluation of the cross-sectional locations. Figure 4-1 shows the location of the three cross-sections in plan view. Figure 4-2 shows how each model differs in extent and placement of boundary conditions. The construction dimensions are listed in Table 4-1, and can be compared to the preliminary model construction dimensions in Table 3-1. For the cell B cross-section, it was noted that the spring may not provide a groundwater divide boundary, so the model was extended to Creek 17-13.

Both the spring and Creek 17-13 are included in the model for cell B.

Parameter values chosen for the final SAS layout were selected from available data and earlier analyses. The parameter values are the initial parameter values of Section 3, including an aquifer hydraulic conductivity of 75 ft/d (horizontal) and a wetland sediment hydraulic conductivity of 1 ft/d (vertical). These conductivities are the most reasonable interpretations of the site-specific field data (Section 2). The parameter values are listed in Table 4-2.

The three models were run, first in calibration mode (to determine the upgradient aquifer flux), then in impact mode with the designed infiltration rates (0.44 ft/d for SAS cells F and E, 0.5 ft/d for SAS cell B). Note that SAS cell B is located near the Z16 North wetland and spring, which forms a well-defined discharge and drainage pathway. As such, the engineering design maximizes the use of this area for infiltration of treated wastewater. Accordingly, the design layout for cell B contains a wider seepage bed and a higher infiltration rate than other SAS cells. Thus, it is expected that the maximum mounding will occur in the vicinity of SAS cell B. The predicted rise in the water table is shown in Figures 4-3 through 4-5, and listed in Table 4-3. Also listed in Table 4-3 is the percentage of flow to the discharge wetland. In all three models, nearly all of the SAS cell water discharges to the wetland.

4.2 Analytical Check of Numerical Model Results

The analytical solution for mounding, explained in Section 3.1, is revisited here for the purpose of checking the reasonableness of the MODFLOW model results. Rearranging the terms of equation (1) yields:

$$L = \frac{\Delta h T}{Q'} \qquad (2)$$

In this equation, L is the distance to a hypothesized constant-head boundary downgradient of the SAS cell, which is a function of aquifer transmissivity, SAS cell infiltration rate, and the mounding beneath the SAS cell.

Though a constant-head aquifer boundary does not truly exist in the numerical models, we do know (from Table 4-3) that the vast majority of the SAS flow discharges into the wetland which has a constant controlling elevation. We would therefore expect that if the MODFLOW-predicted mounding beneath the SAS cell were taken as Δh, then the value of L would likely lie in range between: 1) the distance from the SAS cell to the near edge of the discharge wetland; and 2) the distance from the SAS cell to the far edge of the discharge wetland. Certainly, L should not be shorter than 1) or very much longer than 2) for the results to be valid.

The values of L in equation (2) are computed for the MODFLOW results for all three models. The transmissivity used in the calculations is 5250 ft^2/d. The SAS infiltration flux (calculated as infiltration rate x cell width) is 44 ft^3/d (per ft) for cells F and E, and 75 ft^3/d (per ft) for cell B. The computed values of L, listed in Table 4-3, all lie in the expected range, indicating that the MODFLOW results are reasonable for the conceptual model and parameter values chosen.

4.3 Final Design Assessment

The three models used to evaluate mounding beneath 3 of the 6 proposed SAS cells show maximum mounding of 3.9 ft to 5.9 ft. The three SAS cells modeled were chosen because they represent the range of conditions for all 6 SAS cells. Higher flux rates per unit area, and greater distances to the controlling discharge wetland lead to increased mounding.

The amount of mounding predicted in the cross-sectional models is likely to be an overprediction of actual mounding. The cross-sectional models do not allow the SAS infiltration to spread laterally and do not allow redirection of upgradient groundwater flow around the SAS cells. Both lateral spreading and upgradient groundwater redirection would actually occur as a result of SAS operation, leading to groundwater head mounding that is less than the amounts predicted by this simplified analysis.

For comparison purposes, Table 4-3 compares the results of the predicted mounding from the cross-sectional models to the final engineering design layout calculations. The predicted mounding from the cross-sectional models are very similar to that from the engineering design layout calculations. Overall, the analysis provided by the cross section models, the analytical check on the cross sectional models, and comparison to the engineering design calculations shows that the proposed SAS and hydrologic conditions will provide suitable drainage of infiltrated water.

Table 3-1

Construction Details for the Preliminary Design Cross-Sectional Models

(A) Horizontal dimensions

	Cell F		Cell E		Cell B	
	ft	cells	ft	cells	ft	cells
Width of SAS cell	100	10	90	9	130	13
Distance between SAS cell and wetland	170	17	250	25	420	42
Width of wetland	390	39	320	32	490	49
Distance between wetland and stream	3030	303	1630	163	0	0
(Half) stream width	10	1	10	1	10	1
Total model width	3700	370	2300	230	1050	105

(B) Elevations (ft, M.S.L.)

	Cell F	Cell E	Cell B
Wetland	1580.5	1580.5	1581
Stream	1577	1578	1579
Water table beneath cell	1581	1581.5	1585

Prepared by: GWC
Checked by: SVD1

Table 3-2

Results of Preliminary Cross-Sectional Model Simulations with Initial Parameter Values

	Maximum Mounding (ft)	Discharge to Wetland[1]
Cell F	4.6	99%
Cell E	4.8	97%
Cell B	8.3	95%

[1] Amount of SAS cell infiltration that discharges to the wetland, as a percentage of total SAS cell infiltration.

Prepared by: GWC
Checked by: PFA

Table 3-3

Modeled Mounding (in feet) for Various Combinations of Parameter Values (Scoping Analyses - Preliminary Cell Layout)

SAS Infiltration rate (ft/d)	Aquifer Conductivity (ft/d)	Wetland Conductivity (ft/d)	Cell F	Cell E	Cell B
0.5	50	0.5	7.1	7.4	12.1
		1.0	6.4	6.7	11.4
		5.0	5.6	6.0	10.5
	75	0.5	5.3	5.5	8.9
		1.0	**4.6**	**4.8**	**8.3**
		5.0	3.9	4.2	7.5
1.0	50	0.5	13.4	13.9	22.5
		1.0	12.1	12.6	21.2
		5.0	10.6	11.3	19.7
	75	0.5	10.1	10.5	16.8
		1.0	8.9	9.2	15.6
		5.0	7.5	8.0	14.2

Note: Bolded values indicate results with field estimated values for all parameters.

Prepared by: GWC
Checked by: PFA

Table 4-1

Cross-Sectional Model Construction Details for the Final SAS Design Layout

(A) Horizontal dimensions

	Cell F		Cell E		Cell B[1]	
	ft	cells	ft	cells	ft	cells
Width of SAS cell	100	10	100	10	150	15
Distance between SAS cell and wetland	150	15	150	15	100	10
Width of wetland	390	39	400	40	490	49
Distance between wetland and stream	3050	305	1640	164	200	200
(Half) stream width	10	1	10	1	10	1
Total model width	3700	370	2300	230	950	95

(B) Elevations (ft, M.S.L.)

	Cell F	Cell E	Cell B[1]
Wetland	1580.5	1580.5	1581
Stream	1577	1578	1578.5
Water table beneath cell	1581	1581	1583

[1] For cell B, there is also a small spring located 440 feet from the upgradient edge of the model which is 1 cell (10 feet) wide with an elevation of 1579 ft, M.S.L. Its vertical leakance is assumed to be the same as Swamp Creek.

Prepared by: GWC
Checked by: SVD1

Table 4-2

Parameter Values in the Final SAS Cross-Sectional Models

Parameter		Value
Aquifer horizontal conductivity (ft/d)		75
Aquifer vertical conductivity (ft/d)		7.5
Wetland sediment vertical conductivity (ft/d)		1
Recharge rate (in/yr)		8
Stream sediment vertical conductivity (ft/d)		1
Calibrated upgradient flux ($ft^2/d/ft$)	Cell F	3.5
	Cell E	3.5
	Cell B	23.1

Prepared by: GWC
Checked by: SVD1

Table 4-3

Results of Cross-Sectional Models for Final Design SAS Cells, Compared to Engineering Design Layout Calculations

	Cross-Sectional Models			Engineering Design[4] Calculation 30 ft Thick Aquifer (Mound Ft)	Engineering[4] Design Calculations 60 ft Thick Aquifer (Mound Ft)
	Maximum Mound (ft)	Discharge to Wetland[1]	Length (L) to "constant head"[2] (ft)		
Cell F	3.9	99%	470	4	4
Cell E	3.9	98%	470	4	4
Cell B	5.9	94%[3]	410	6	6

[1] Amount of SAS cell infiltration that discharges to the wetland, as a percentage of total SAS cell infiltration.

[2] Computed from equation (2).

[3] Includes discharge to spring within the wetland.

[4] Engineer design layout calculations from USEPA *Process Design Manual for Land Treatment of Municipal Wastewater* (USEPA, 1981). Calculations were performed assuming 30 ft thick aquifer and 60 ft thick aquifer.

Prepared by: GWC
Checked by: SVD1

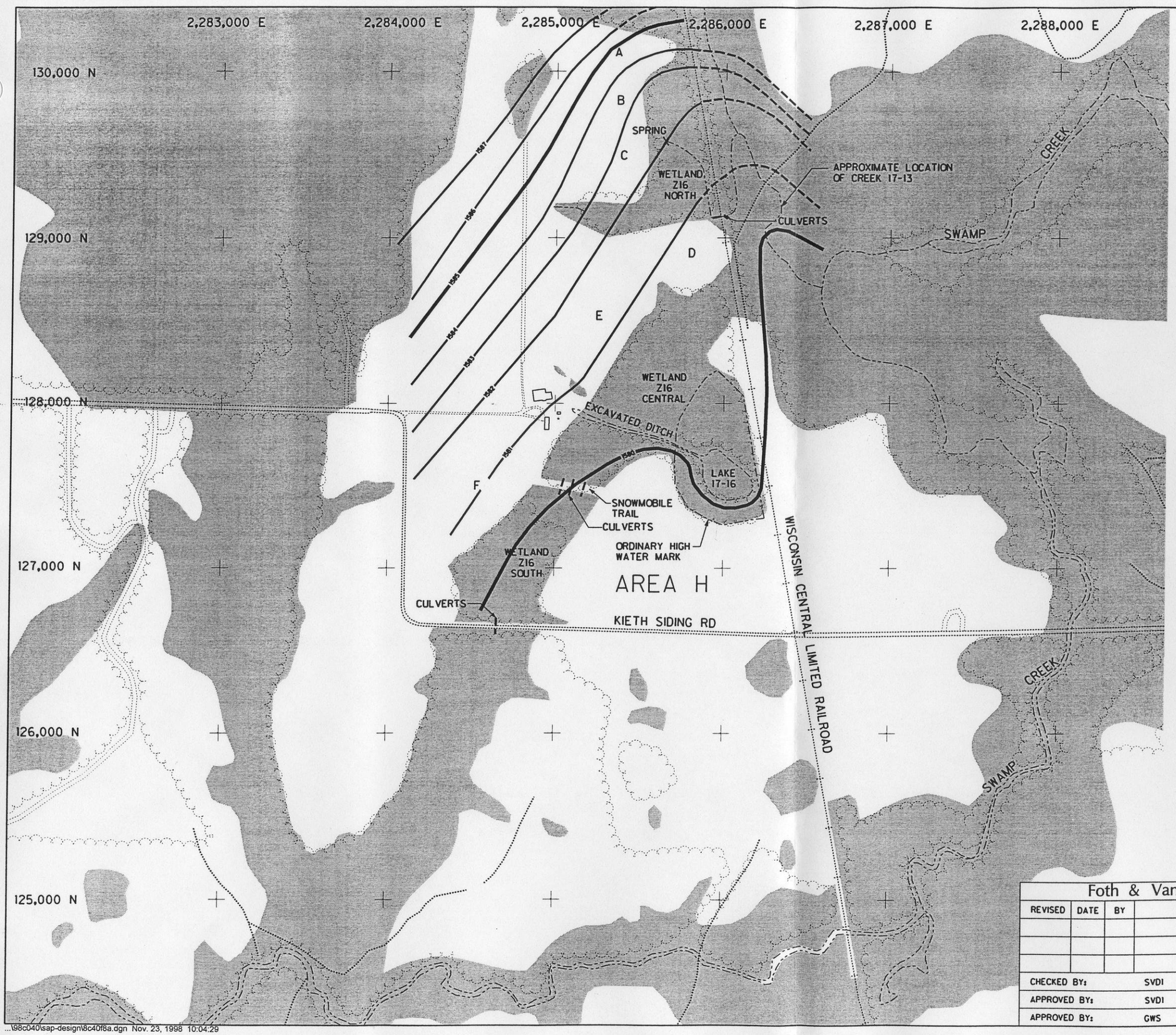
References

HSI GeoTrans, 1998. *Addendum No. 2 to Numerical Simulation of the Effect of Groundwater and Surface Water of the Proposed Zinc and Copper Mine near Crandon, Wisconsin.* Consulting report prepared for Foth & Van Dyke. August 28, 1998.

McDonald, M.G., A.W. Harbaugh, 1988. A modular three-dimensional finite difference groundwater flow model: U.S. Geological Survey Techniques of Water-Resource Investigations, Book 6, Chapter A1.

McDonald, M.G., A.W. Harbaugh, 1996. An update to the U.S. Geological Survey Modular Finite-Difference Ground-Water Flow Model: U.S. Geological Survey Open-File Report 96-485.

United States Environmental Protection Agency, 1981. *Process Design Manual for Land Treatment of Municipal Wastewater.* USEPA 625/1-81-013.



LEGEND

- TRAILS
- LAKES
- STREAMS
- EXISTING ROAD
- TREE/BRUSH
- WETLAND AREA
- 1584 — WATER TABLE ELEVATION CONTOUR FT MSL
- 1584 — INFERRED WATER TABLE ELEVATION CONTOUR FT MSL
- F — APPROXIMATE LOCATIONS OF POTENTIAL SAS CELLS

N

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. THE LOCATION OF THE SPRING IN WETLAND Z16 AND THE ORDINARY HIGH WATER MARK AROUND LAKE 17-16 ARE APPROXIMATE.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	SVDI	DATE:	NOV. '98
APPROVED BY:	SVDI	DATE:	NOV. '98
APPROVED BY:	GWS	DATE:	NOV. '98

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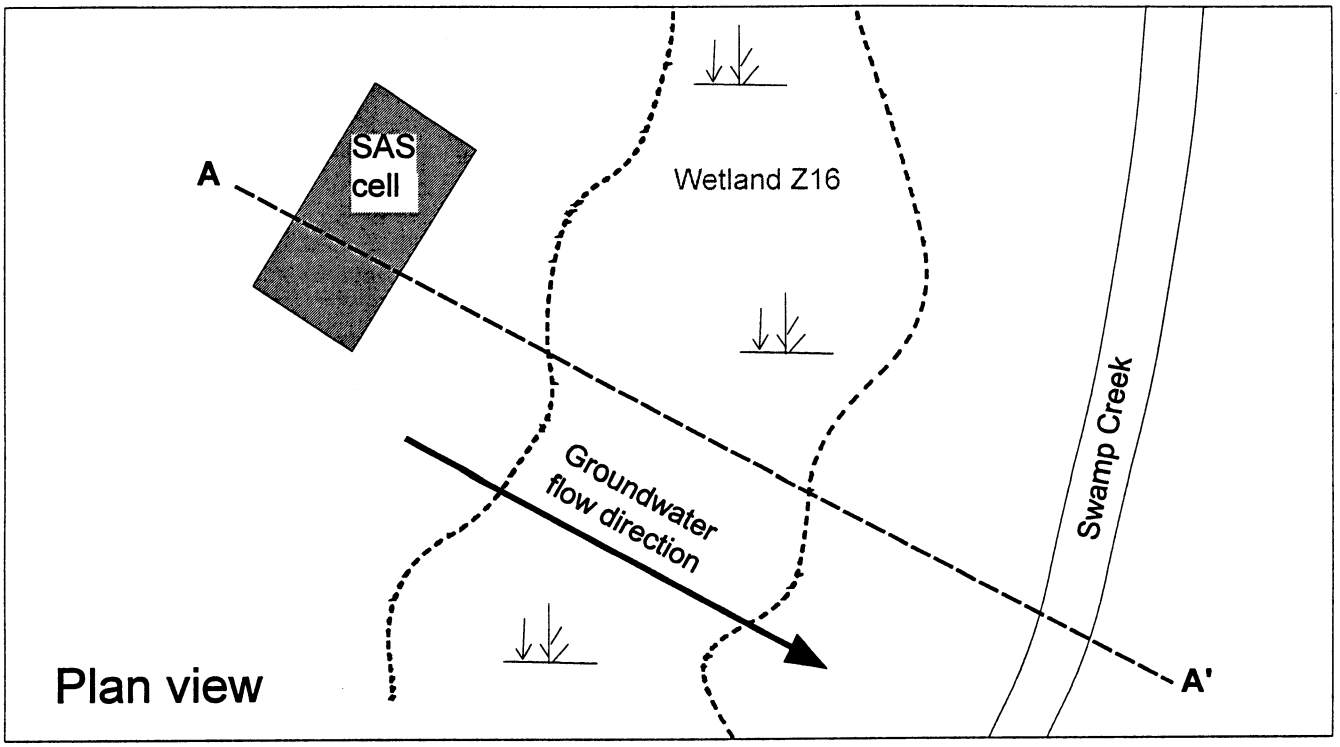
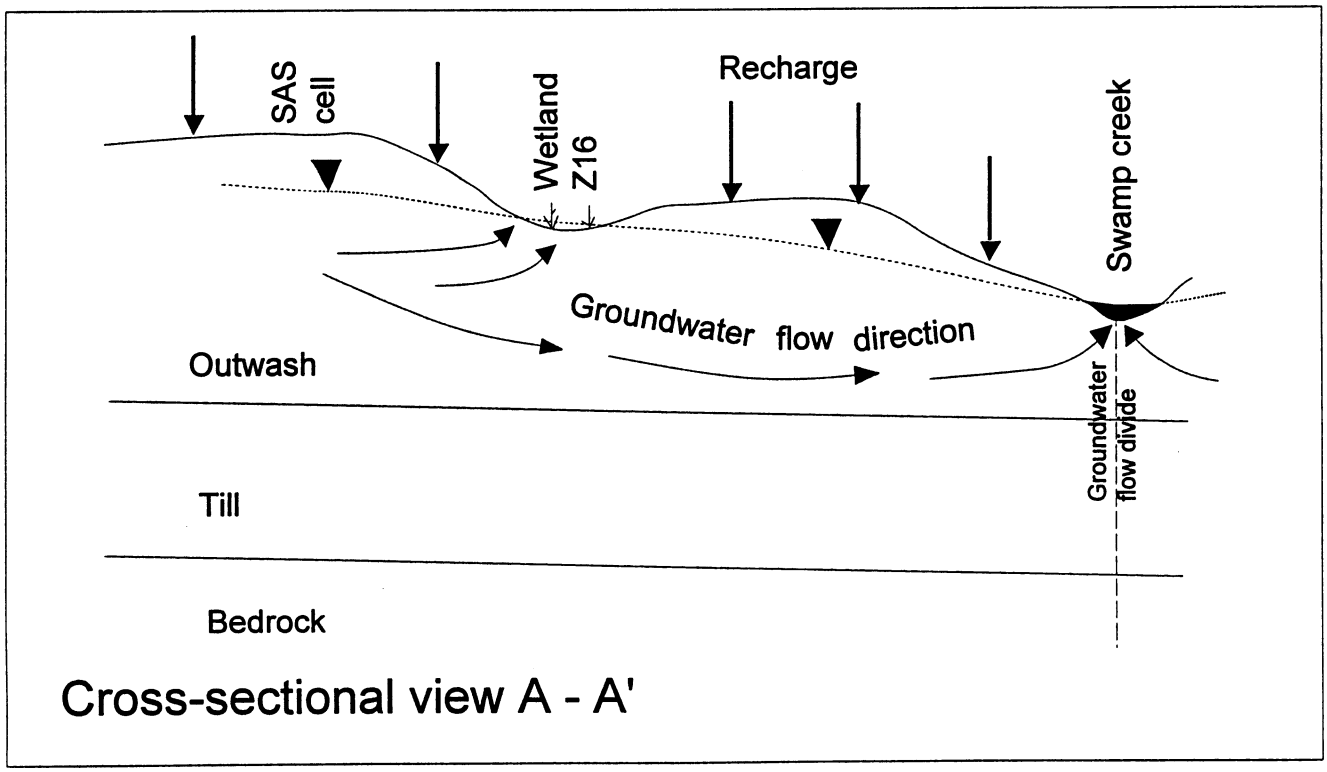
FIGURE 2-1

SITE LOCATION MAP

Scale: 0 300' 600'		Date:	NOVEMBER, 1998
Prepared By: Foth & Van Dyke		By: MJO3	93C049

...\98c040\sap-design\8c40f8a.dgn Nov. 23, 1998 10:04:29





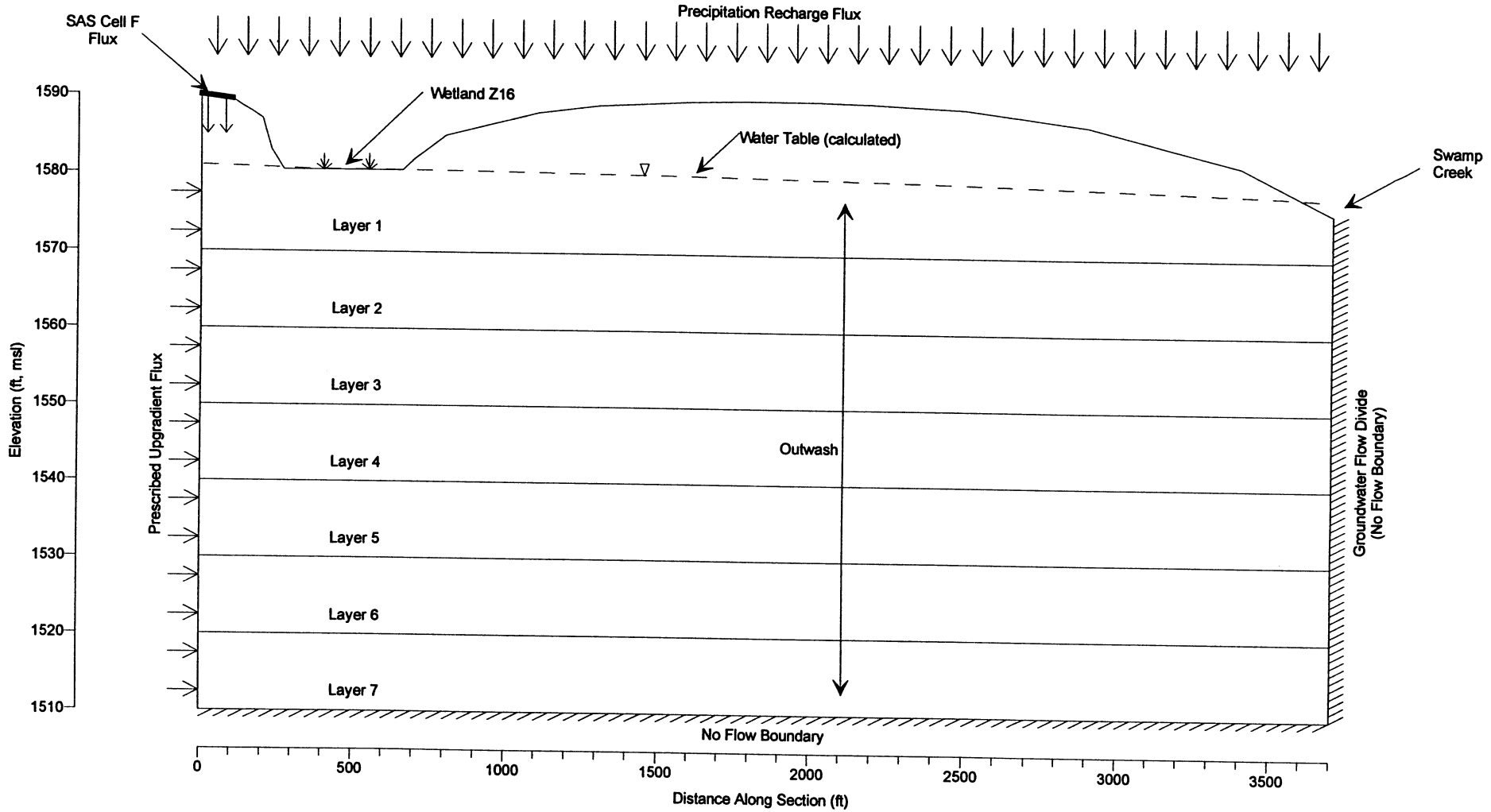
HSI GEOTRANS			
REVISED	DATE	BY	DESCRIPTION
CHECKED BY: GWC			DATE: Oct 98
APPROVED BY: PFA			DATE: Oct 98
APPROVED BY:			DATE:

Nicolet Minerals COMPANY

Figure 3-1
Conceptual model of groundwater flow near the SAS

Scale: no scale	Date: October 1998
Prepared By: HSI GeoTrans	By: PAW

\Crandon\SAPmodel\Surfer\CellF1.srf



D-518

Note:
Horizontal discretization (not shown) is 10 feet (uniform) for 370 columns.

0 500 1000

Horizontal Scale in Feet
(Vertical Exaggeration 25:1)

HSI GEOTRANS

REVISED	DATE	BY	DESCRIPTION

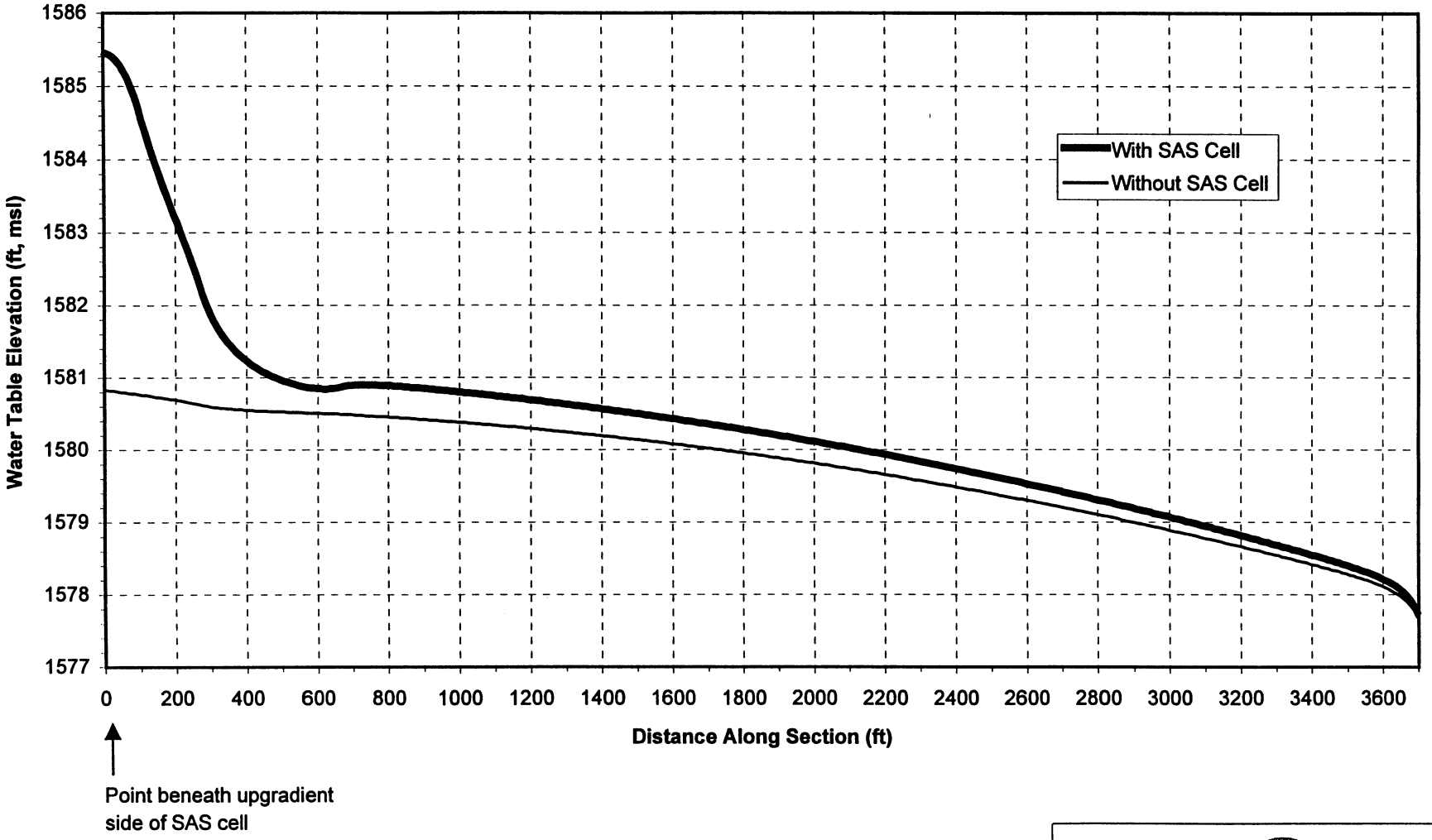
CHECKED BY: KMR	DATE: Nov 98
APPROVED BY: PFA	DATE: Nov 98
APPROVED BY:	DATE:

Nicolet Minerals COMPANY

Figure 3-2
Construction of Cell F
Cross-Sectional Model

Scale: 1" = 500'(h), 20'(v)	Date: Oct. 1998
Prepared By: HSI GeoTrans	By: GWC

Kangaroo\harddisk\Crandon\SAPmodel\Modflow\24b-wt.xls



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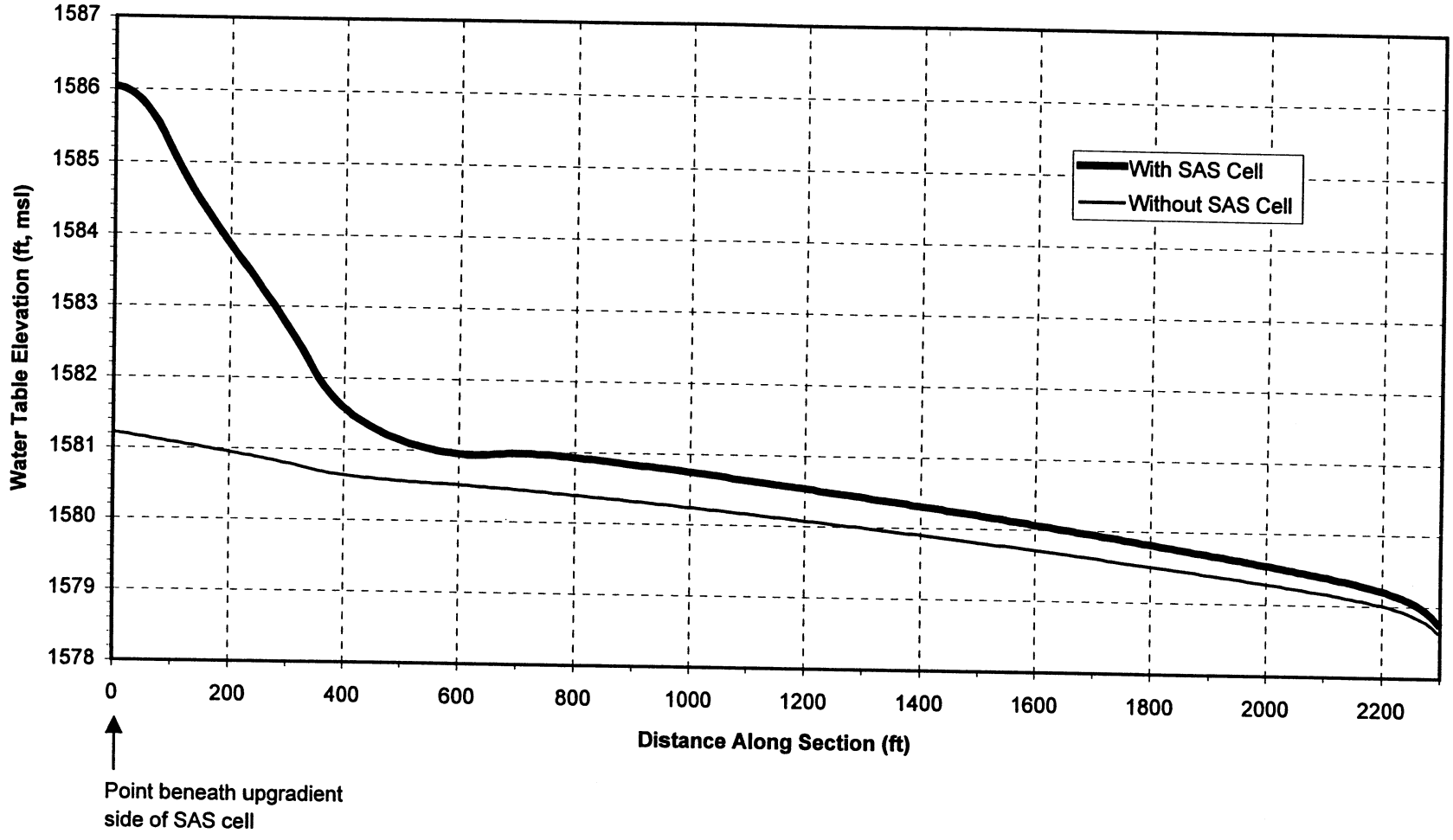
REVISED	DATE	BY	DESCRIPTION	
CHECKED BY: KMR				DATE: Nov 98
APPROVED BY: PFA				DATE: Nov 98
Simulation 24B	APPROVED BY:			DATE:

Nicolet Minerals COMPANY

Figure 3-3
Water Table Mounding with Initial Parameter Values, Cell F

Scale: None	Date: Oct 1998
Prepared By: HSI GEOTRANS	By: GWC



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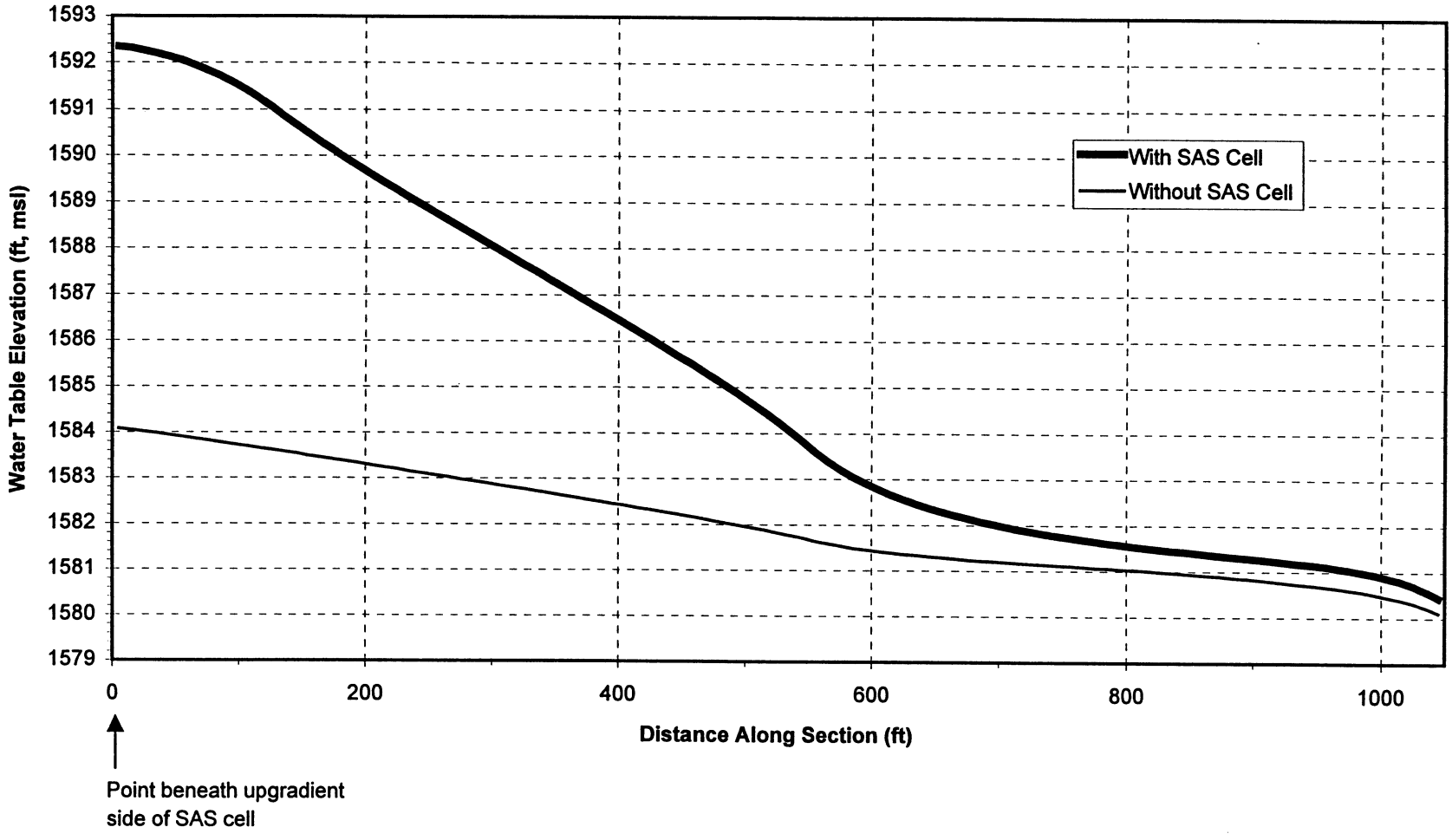
REVISED	DATE	BY	DESCRIPTION	
CHECKED BY: KMR			DATE: Nov 98	
APPROVED BY: PFA			DATE: Nov 98	
Simulation 30B	APPROVED BY:		DATE:	

Nicolet Minerals COMPANY

Figure 3-4
Water Table Mounding with Initial Parameter Values, Cell E

Scale: None	Date: Oct 1998
Prepared By: HSI GEOTRANS	By: GWC



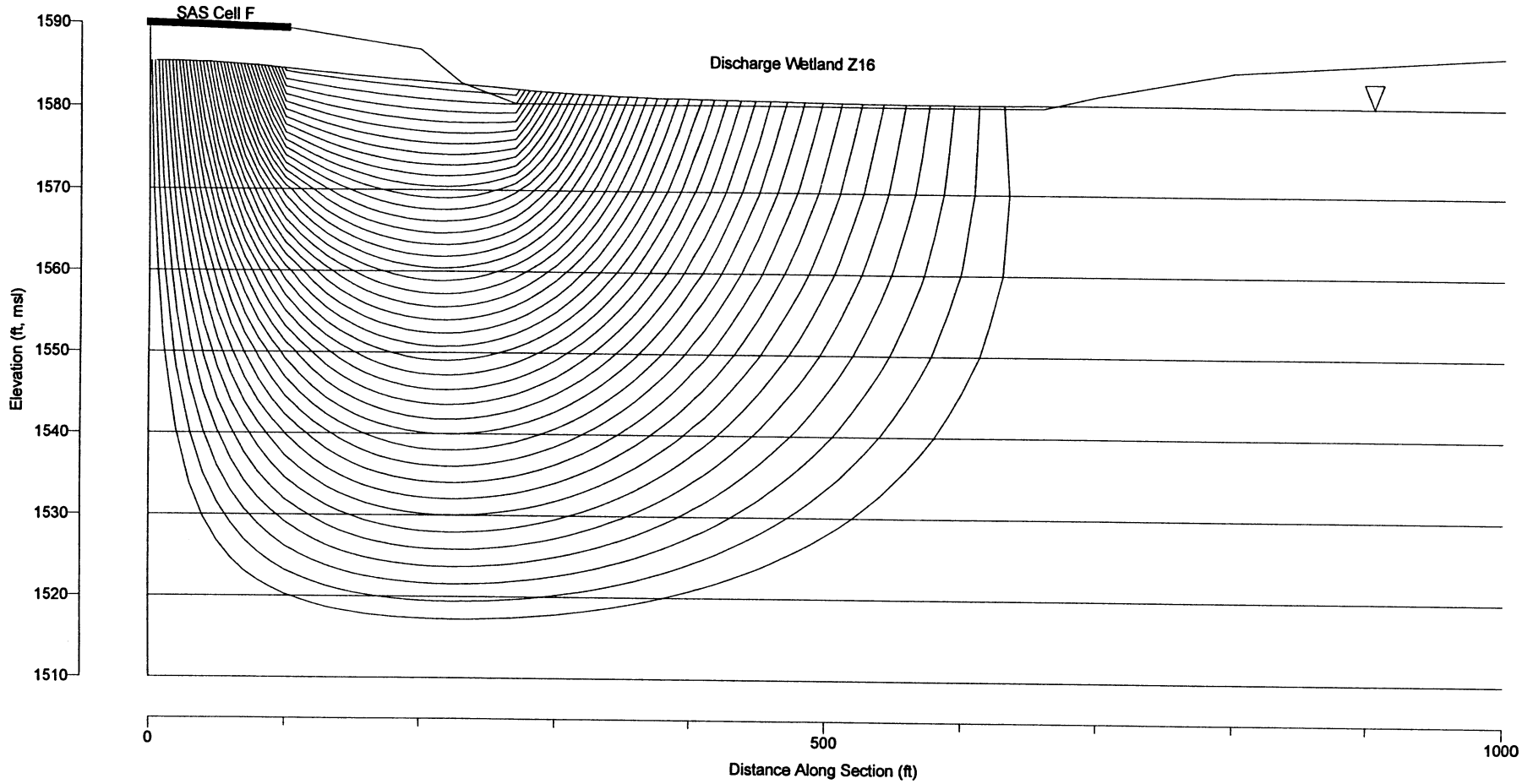
HSI GEOTRANS				
REVISED	DATE	BY	DESCRIPTION	
CHECKED BY: KMR				DATE: Nov 98
APPROVED BY: PFA				DATE: Nov 98
Simulation 36B	APPROVED BY:			DATE:

Nicolet Minerals COMPANY

Figure 3-5
Water Table Mounding with Initial Parameter Values, Cell B

Scale: None	Date: Oct 1998
Prepared By: HSI GEOTRANS	By: GWC

\Crandon\SAPmodel\Surfer\24b-Pth.srf



D-522

0 120 240

Horizontal Scale in Feet
(Vertical Exaggeration 6:1)

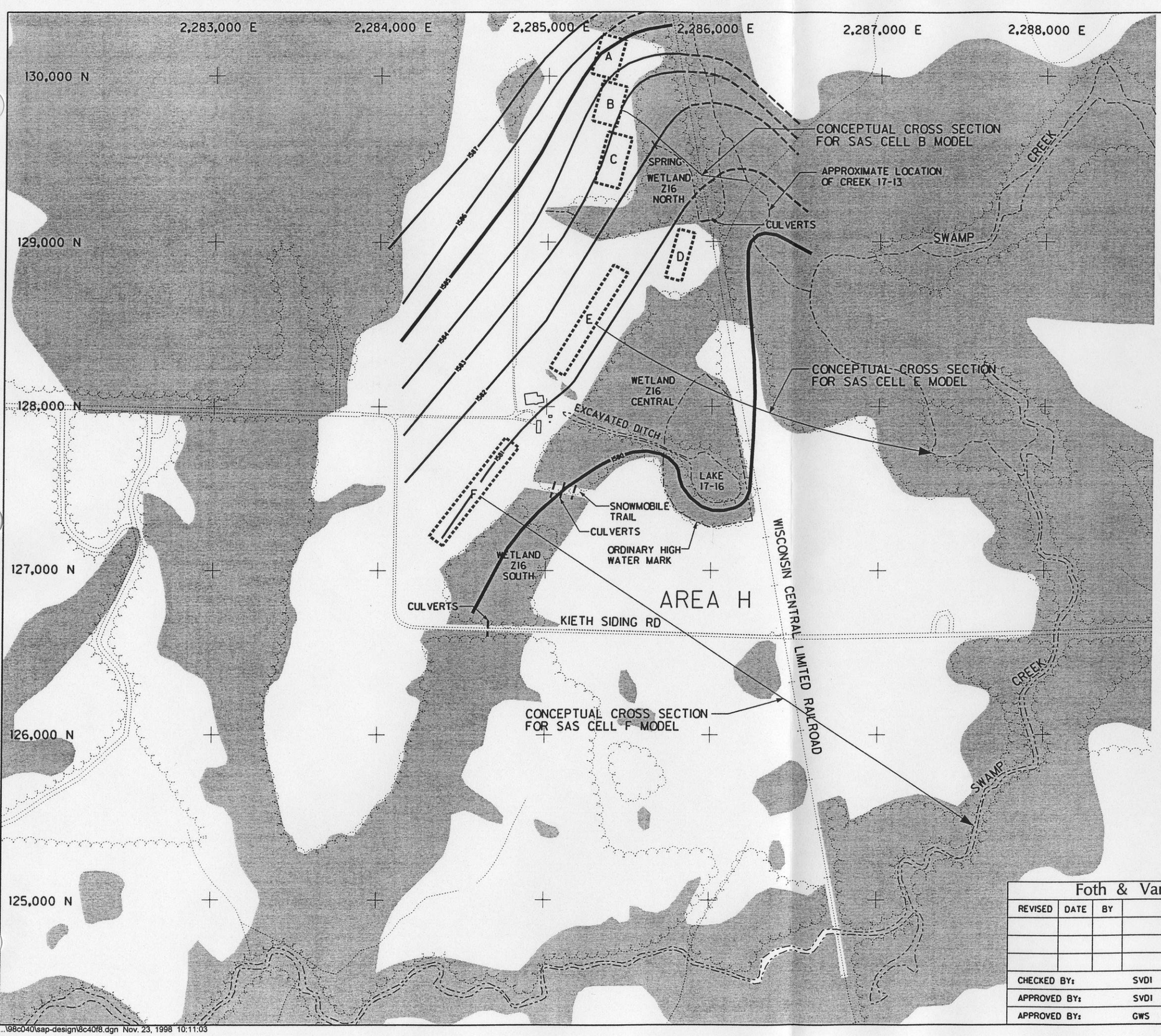
HSI GEOTRANS			
REVISED	DATE	BY	DESCRIPTION

CHECKED BY: KMR	DATE: Nov 98
APPROVED BY: PFA	DATE: Nov 98
APPROVED BY:	DATE:

Nicolet Minerals COMPANY

Figure 3-6
Simulated Particle Traces
Originating at SAS Cell F

Scale: 1" = 120'(h), 20'(v)	Date: Oct. 1998
Prepared By: HSI GeoTrans	By: GWC



N

LEGEND

- TRAILS
- LAKES
- STREAMS
- EXISTING ROAD
- TREE/BRUSH
- WETLAND AREA
- 1584 — WATER TABLE ELEVATION CONTOUR FT MSL
- 1584 — INFERRED WATER TABLE ELEVATION CONTOUR FT MSL
- APPROXIMATE LOCATIONS OF POTENTIAL SAS CELLS

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.
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Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	SVDI	DATE:	NOV. '98
APPROVED BY:	SVDI	DATE:	NOV. '98
APPROVED BY:	GWS	DATE:	NOV. '98

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FIGURE 4 -1

SECTION LOCATIONS FOR FINAL CROSS SECTION MODELS OF SAS CELLS B, E & F

Scale: 0 300' 600'		Date:	NOVEMBER, 1998
Prepared By: Foth & Van Dyke	By: MJO3		93C049

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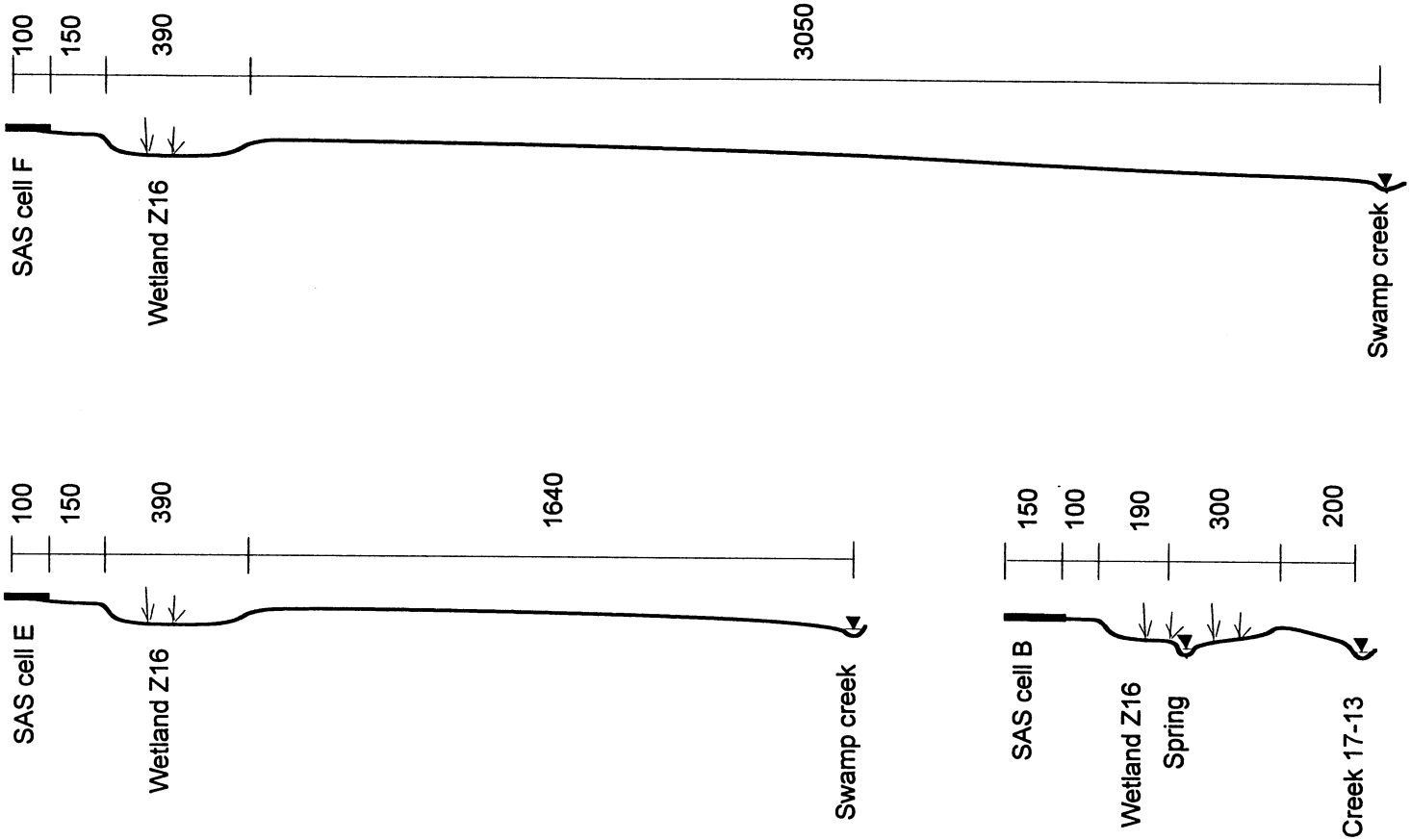


0 500 1000

Scale in Feet (for horizontal only)

HSI GEOTRANS

REVISED	DATE	BY	DESCRIPTION

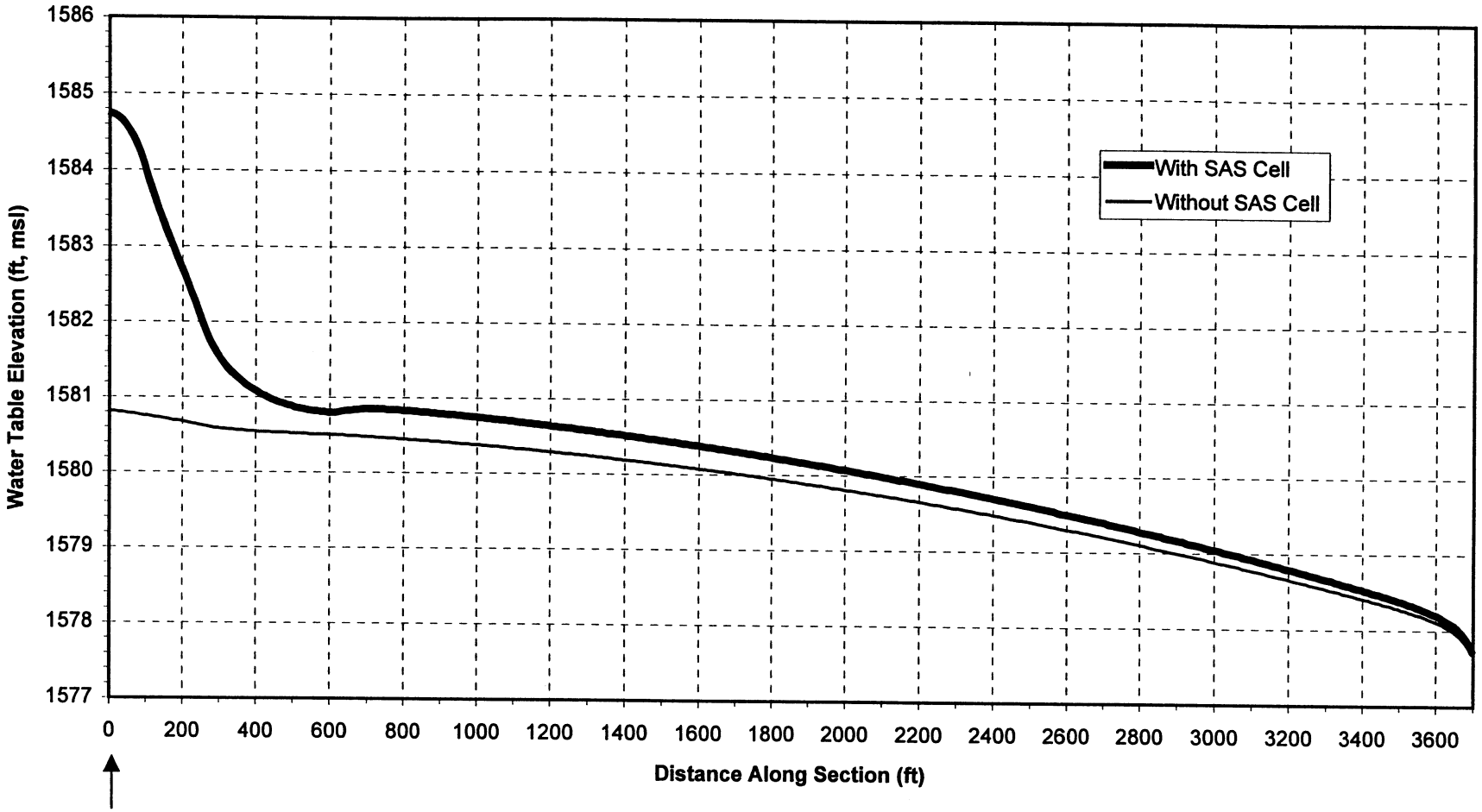
CHECKED BY: GWC	DATE: Oct 98
APPROVED BY: PFA	DATE: Oct 98
APPROVED BY:	DATE:

Nicolet Minerals COMPANY

Figure 4-2
Horizontal dimensions in the three cross-sectional models

Scale: 1 in. = 500 ft. | Date: Oct 1998

Prepared By: HSI GeoTrans | By: PAW



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REVISED	DATE	BY	DESCRIPTION	
CHECKED BY: KMR				DATE: Nov 98
APPROVED BY: PFA				DATE: Nov 98
Simulation 39B	APPROVED BY:			DATE:

Nicolet Minerals COMPANY

Figure 4-3
BEJ Water Table Mounding for SAS Cell F

Scale: None	Date: Oct 1998
Prepared By: HSI GEOTRANS	By: GWC

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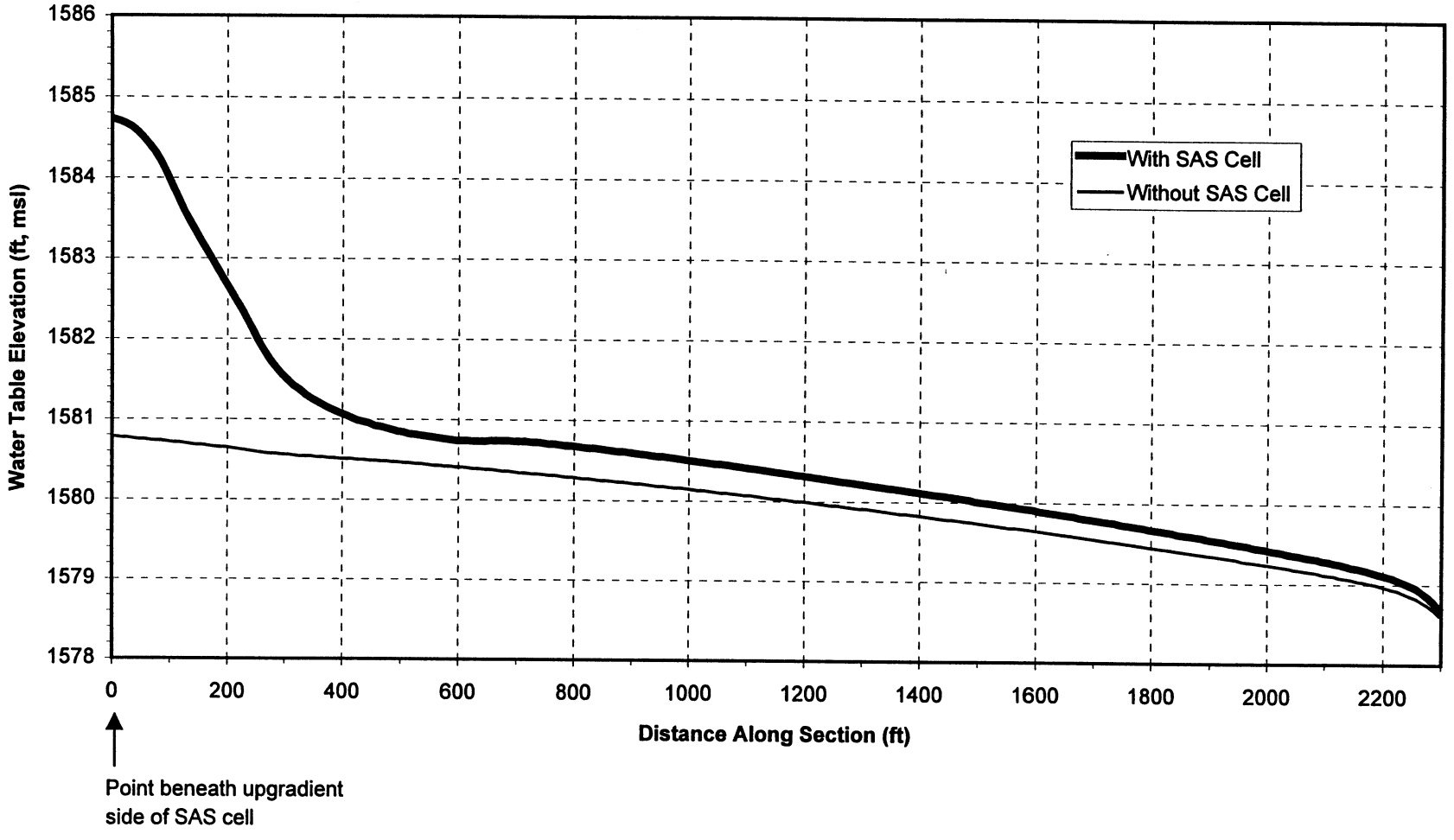

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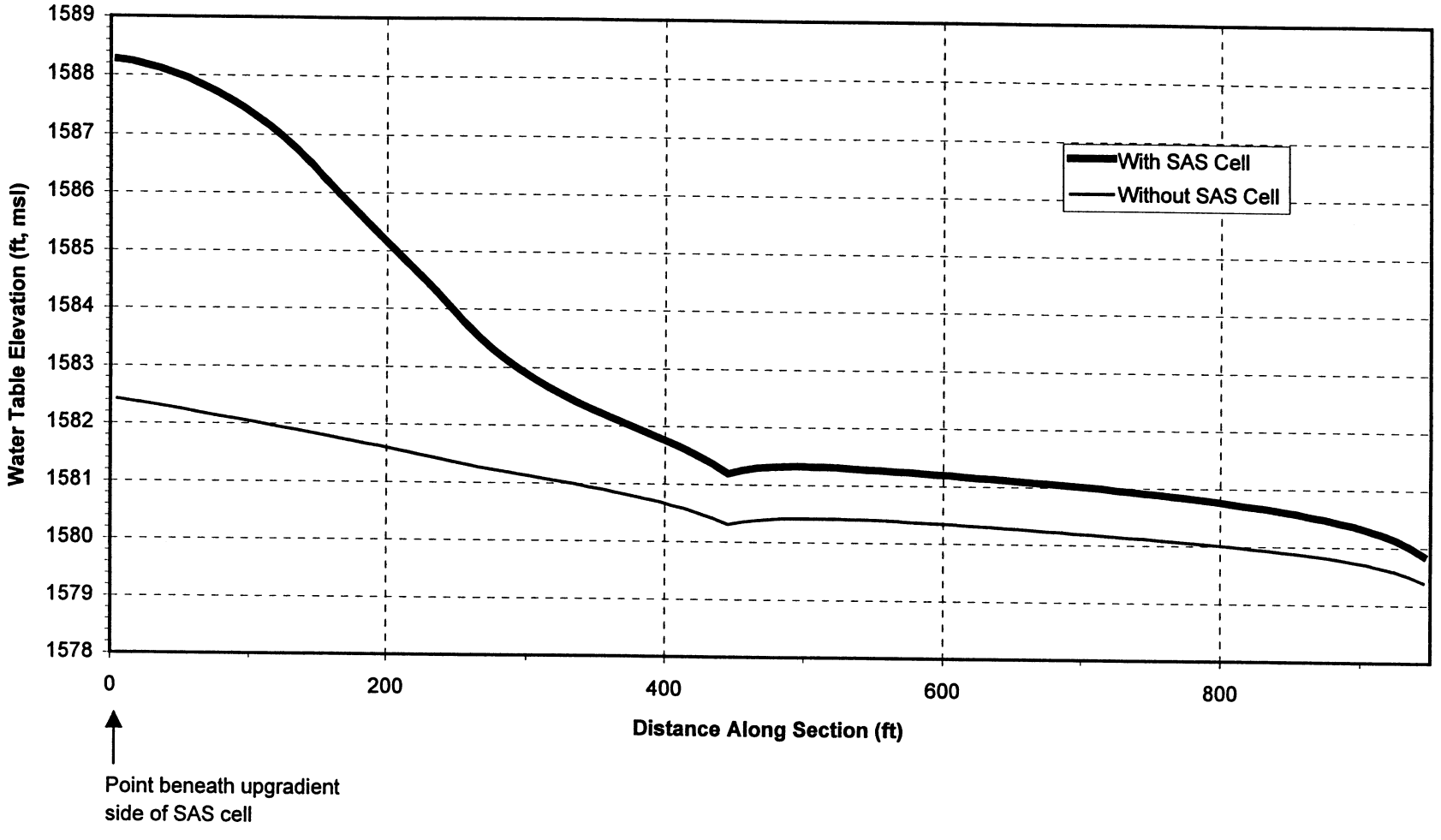
REVISED	DATE	BY	DESCRIPTION	
CHECKED BY: KMR				DATE: Nov 98
APPROVED BY: PFA				DATE: Nov 98
Simulation 41B	APPROVED BY:			DATE:

Nicolet Minerals COMPANY

Figure 4-4
BEJ Water Table Mounding for SAS Cell E

Scale: None	Date: Oct 1998
Prepared By: HSI GEOTRANS	By: GWC



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REVISED	DATE	BY	DESCRIPTION	
CHECKED BY: KMR			DATE: Nov 98	
APPROVED BY: PFA			DATE: Nov 98	
Simulation 47B	APPROVED BY:		DATE:	

Nicolet Minerals COMPANY

Figure 4-5
BEJ Water Table Mounding for SAS Cell B

Scale: None	Date: Oct 1998
Prepared By: HSI GEOTRANS	By: GWC

Attachment A

Analytical Calculations

Attachment A

Analytical Solution for Head Change in a Confined Aquifer Due to a Changing Boundary Flux

Consider the case of a confined aquifer with a uniform transmissivity, T, a constant head boundary, a constant flux boundary, and a uniform recharge source (Figure A.1). The aquifer and boundaries are assumed to extend uniformly and infinitely in the y-direction (perpendicular to the page). The groundwater head (h) equation can be written in its 1-D depth-averaged from for this case:

$$\frac{\partial}{\partial x}\left(T\frac{\partial h}{\partial x}\right) + R = 0 \tag{A-1}$$

With boundary conditions given by:

$$Q = -T\frac{\partial h}{\partial x} \quad \text{at } x = 0 \tag{A-2}$$

$$h = h_L \quad \text{at } x = L \tag{A-3}$$

where T is the aquifer transmissivity [L^2/T], R is the recharge rate [L/T], Q is the left-boundary flux per unit length in the y-direction [L^2/T], and h_L is the constant head elevation [L] on the right boundary. The length of the domain is L.

The solution to equations (A-1) through (A-3) can be found by integrating (A-1) twice and applying (A-2) and (A-3) to determine the integration constants. The result is:

$$h(x) = \frac{R}{2T}\left(L^2 - x^2\right) + \frac{Q}{T}(L - x) + h_L \tag{A-4}$$

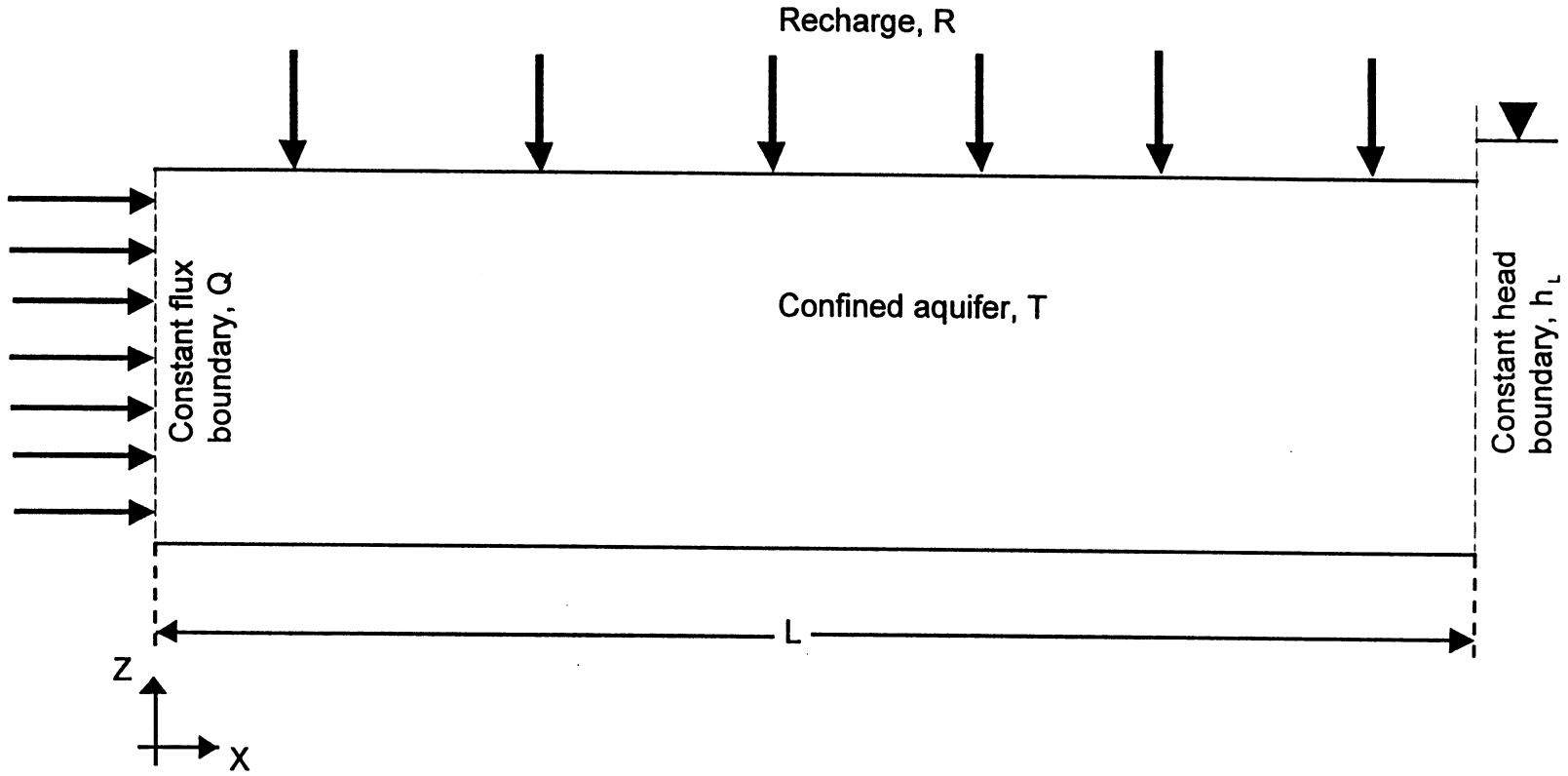
If the left edge flux is increased by an amount Q' (making the left-edge flux equal to $Q+Q'$), then the change in head (Dh) can be expressed as:

$$\Delta h(x) = \frac{Q'}{T}(L - x) \tag{A-5}$$

The change in head is maximized at the left edge:

$$\Delta h = \frac{Q'L}{T} \quad \text{at } x = 0 \tag{A-6}$$

Equation (A-6) is therefore then analytical expression for the maximum change in a confined aquifer due to a change in a confined aquifer due to a change in boundary flux equal to Q'.



HSI GEOTRANS

REVISED	DATE	BY	DESCRIPTION

CHECKED BY: GWC	DATE: Oct 98
APPROVED BY: PFA	DATE: Oct 98
APPROVED BY:	DATE:

Nicolet Minerals COMPANY

Figure A-1
Conceptual model for analytical analysis

Scale: no scale	Date: Oct 1998
Prepared By: HSI GeoTrans	By: PAW

Appendix K

Technical Memorandum
Hydrologic Analysis

Foth & Van Dyke
Memorandum

November 23, 1998

TO: Steve Dischler, Foth & Van Dyke

CC: Steve Donohue, Foth & Van Dyke
Jerry Sevick, Foth & Van Dyke
Gordon Reid, Nicolet Minerals Company
Master File

FR: Michael D. Liebman, P.E., Senior Water Resource Consultant MDL
Steve R. Birr, Water Resource Engineer SRB

RE: Crandon Project - Soil Absorption System Wetland Surface Water Flow Impacts

Introduction

With the discharge from the soil absorption system (SAS) ultimately entering nearby down-gradient wetlands (i.e., Z16 north, central, and south), the impact of the SAS on the hydrology and surface water flow of these wetlands was investigated. Also investigated was the potential impact of the SAS discharge on the floodplain of Swamp Creek.

This memorandum summarizes the results of the surface water flow evaluation. For these analyses, it was assumed that positive surface water drainage is maintained across the dredged canal and snowmobile trail which bisect the wetland body.

Methods of Analyses

The method used to determine the impact of additional water discharges near wetlands was based on Haestad Methods "TR-55" hydrologic software, Mannings formula hydraulics across the wetland valley (Haestad Methods "Flowmaster" software), and culvert nomographs where culverts control hydraulics (adding weir flow where appropriate). An existing or base condition flow was established from various storm events for the drainage areas tributary to each of the Z16 north, central, and south wetlands. A depth of flow associated with each storm event peak flow was calculated using the appropriate hydraulics. Then, the rates of peak discharge from the SAS were added to the existing base flows calculated for each wetland, and new depths of flow were determined. Any increase in depth caused by the SAS discharge could then be determined. To be conservative, it was assumed that all of the additional water from each SAS cell discharges to the respective wetland. Also, to assure conservativeness, discharge from cell D was added to the flow analysis for both the central and north wetlands, as it is not certain to which wetland the flow will pass.

Possible effects of the SAS discharge on the Swamp Creek floodplain were evaluated by calculating the 100-year flood flow of Swamp Creek in this area, and determining the associated depth of flow in Swamp Creek. The flood flow was found using the NRC5 TR20 hydrological program. The associated depth of flow was calculated from a Mannings analysis ("Flowmaster") across a section of the Swamp Creek floodplain. By calculating this depth of flow with the SAS discharge added to the 100-year flow, an increase caused by the SAS could be determined.

Figure 1 illustrates the location of the SAS cells and their peak discharge rates, the location of the conveyance culverts, the location of the wetlands that were investigated, the location of the Swamp Creek cross-section used in the floodplain evaluation, and the location of the other valley sections used in the analysis.

Results

Table 1 illustrates the results of the hydraulic analysis. The north wetland (Area A) has a drainage area of 42.7 acres. To be conservative in terms of base flow comparison, adding SAS flow to a lower base flow would show a greater impact. The approximate 9-acre wetland area that may intermittently drain through the 8 inch agricultural drain tile was excluded from the area which drains to the Z16 north wetland. Using this assumption, Area A contributes from approximately 2 cfs to approximately 24 cfs of runoff for the 2 through 100-year recurrence interval storm events under existing conditions. Surface water flow for this wetland is controlled by the railroad culvert east of the north wetland. A base flow of 0.5 cfs was estimated from field observation of depth and velocity at this culvert. This brings total existing flow to a range from 0.5 cfs (no storm event) to 24.5 cfs (100-year storm event). The proposed peak discharge from the northern SAS cells (A, B, C, and D) is a combined 376 gal/min (0.84 cfs) of discharge, which would give a total flow rate of 3.34 cfs to 25.34 cfs of flow at the wetland for the 2 through 100-year storm events, respectively. Depth of increase of the wetland water surface upgradient from this culvert varied from 0.05 to 0.07 ft for these storm events if the SAS were operating, and showed 0.10 ft increase with SAS flow only.

Similarly, the central wetland (Area B1) has a drainage area of 50 acres. The range of flows for the 2-100 year storm events was found to be approximately 2 cfs to approximately 28 cfs. With the 245 gal/min (0.55 cfs) discharge from the SAS cells D and E, the depth increase based on the wetland valley hydraulics if the SAS were operating was from 0 to 0.01 ft during the storm events, and 0.03 ft with no storm flow.

The south wetland (south of Keith Siding Road - Area B2) has a drainage area of 105 acres, which includes the 50-acre central area (Area B1). This drainage area includes a dredge canal and pond, and contributes from approximately 4 cfs to approximately 53 cfs of runoff for the 2 through 100-year storm events under existing conditions. The proposed peak discharge from the southern SAS cell (F) is 171 gal/min (0.38 cfs) of flow which, when combined with the central area flows (245 gal/min or 0.55 cfs), gives a total flow rate of 4.93 cfs to 53.93 cfs of flow in the wetland when the SAS is operating. For the south wetland, both valley section and culvert crossing hydraulics were evaluated. Depth increase of the wetland water surface at these locations varied from 0.00 ft to 0.01 ft if the SAS were operating during storm events, and 0.6 ft

with only SAS flow. The capacity of the 12-inch CMCP that conveys runoff across Keith Siding Road is only 4 cfs. Therefore, weir flow overtopping of the road is predicted for larger storm events under base flow conditions without the SAS in operation. The weir length was estimated to be 680 ft, which is the width of the wetland at the road (refer to Figure 1). Attachment 1 documents modeling data used in obtaining results illustrated in Table 1.
For Swamp Creek, floodplain impacts were found to be non-existent because the increase in flow caused by the SAS discharge changed the 100-year flow from 277.5 cfs to 278.34 cfs, which makes no detectable difference to the hydraulics of the floodplain.

Conclusion

The wetland surface water elevation increase as a direct result of the SAS discharge was shown to be minimal. Under predicted base flow conditions during operation of the SAS (i.e., with no surface water component and 100% discharge from the SAS), 0.10 ft is predicted to occur in the upstream vicinity of the culvert in the north wetland. At the south wetland, the post-SAS operation base flow predicts an increase in elevation of 0.6 ft in the upgradient vicinity of the culvert which crosses Keith Siding Road.

Referring to the valley section modeling, the biggest increase to onsite flow depths during storm events is 0.01 ft. Any increase at the northern wetland will occur only at the upstream side of the railroad culvert due to the presence of the railroad berm. Similarly, increases at the south area culvert will only extend upstream on NMC property due to the road grade of Keith Siding Road.

No changes to the Swamp Creek floodplain elevation occur as a result of operation of the SAS. As such, floodplain issues are not relevant.

Based upon the information contained on Table 1 and the documentation in Attachment 1, it has been shown that the amount of flow that will be discharged from the SAS is very small in comparison to the existing drainage basin runoff to each wetland and, as a result, surface water hydrology in the Z16 wetland and Swamp Creek will not be significantly affected by SAS operation.

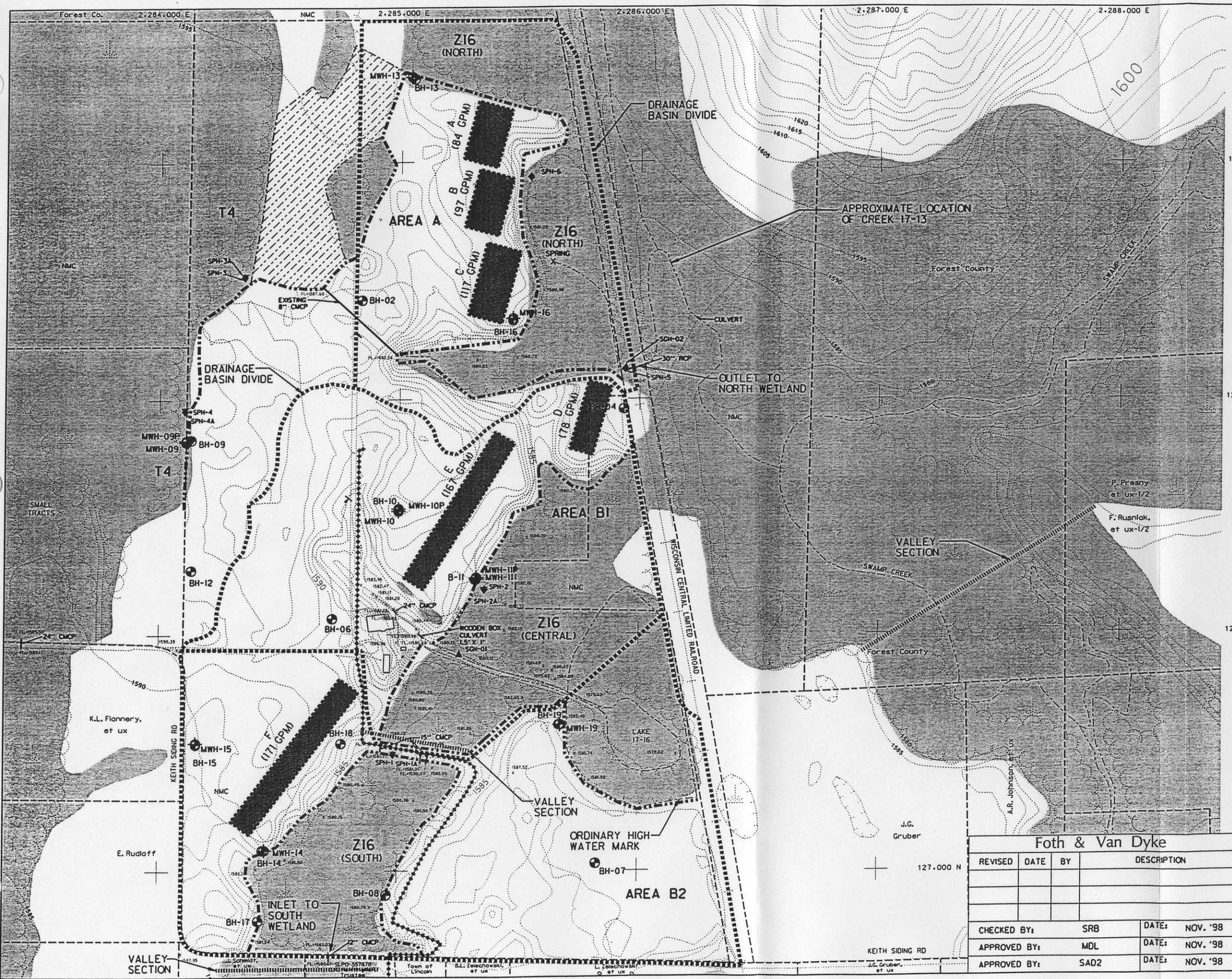
Table 1

Crandon Project - Soil Absorption Sites Surface Flow Analyses

		Storm Events					
North Area (42.7 Acres)		0 Year (Base)	2 Year (2.4")	5 Year (3.1")	10 Year (3.6")	25 Year (4.2")	100 Year (5.0")
Railroad Crossing	Existing Flow	0.5 cfs	2.5 cfs	4.5 cfs	11.5 cfs	16.5 cfs	24.5 cfs
	Existing Depth	1.15 ft	1.30 ft	1.40 ft	1.75 ft	2.10 ft	2.71 ft
	Existing + SAS Flow	1.34 cfs	3.34 cfs	5.34 cfs	12.34 cfs	17.34 cfs	25.34 cfs
	Existing + SAS Depth	1.25 ft	1.35 ft	1.45 ft	1.80 ft	2.17 ft	2.78 ft
Central Area (50 Acres)							
Valley Section[1]	Existing Flow	0 cfs	2 cfs	5 cfs	13 cfs	19 cfs	28 cfs
	Existing Depth	0 ft	0.06 ft	0.10 ft	0.18 ft	0.23 ft	0.29 ft
	Existing + SAS Flow	0.55 cfs	2.55 cfs	5.55 cfs	13.55 cfs	19.55 cfs	28.55 cfs
	Existing + SAS Depth	0.03 ft	0.07 ft	0.11 ft	0.19 ft	0.23 ft	0.29 ft
South Area (105 Acres)							
Valley Section[1]	Existing Flow	0 cfs	4 cfs	9 cfs	24 cfs	36 cfs	53 cfs
	Existing Depth	0 ft	0.06 ft	0.10 ft	0.18 ft	0.24 ft	0.30 ft
	Existing + SAS Flow	0.93 cfs	4.93 cfs	9.93 cfs	24.93 cfs	36.93 ft	53.93 cfs
	Existing + SAS Depth	0.03 ft	0.07 ft	0.11 ft	0.19 ft	0.24 ft	0.30 ft
Keith Siding Road	Existing Flow	0 cfs	4 cfs	9 cfs	24 cfs	36 cfs	53 cfs
	Existing Depth	0 ft	1.70 ft	1.72 ft	1.75 ft	1.77 ft	1.79 ft
	Existing + SAS Flow	0.93 cfs	4.93 cfs	9.93 cfs	24.93 cfs	36.93 cfs	53.93 cfs
	Existing + SAS Depth	0.6 ft	1.71 ft	1.72 ft	1.75 ft	1.77 ft	1.79 ft
Swamp Creek (15 Sq Mi)							
Floodplain Section	Existing Flow	3.5 cfs	66.5 cfs	114.5 cfs	153.5 cfs	204.5 cfs	277.5 cfs
	Existing Depth	0.05 ft	0.31 ft	0.43 ft	0.51 ft	0.61 ft	0.73 ft
	Existing + SAS Flow	4.34 cfs	67.34 cfs	115.34 cfs	154.34 cfs	205.34 cfs	278.34 cfs
	Existing + SAS Depth	0.06 ft	0.31 ft	0.43 ft	0.51 ft	0.61 ft	0.73 ft

[1] Section locations are shown on attached Figure 1.

Prepared by: SRB
Checked by: MDL



LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- ---1675--- EXISTING CONTOUR
- 1702.0 X EXISTING SPOT ELEVATION
- SWAMP/WETLAND
- TRAILS
- TREES
- RAILROAD
- NMC — APPROXIMATE PROPERTY BOUNDARY AND OWNER
- BH-09 — SOIL BORING NUMBER AND LOCATION
- MWH-09 — MONITORING WELL NUMBER AND LOCATION
- MWH-09P — PIEZOMETER NUMBER AND LOCATION
- SPH-1 — SAND POINT NUMBER AND LOCATION
- SGH-01 — STAFF GAUGE NUMBER AND LOCATION
- Z16 — WETLAND NAMES REPORTED IN THE 1995 EIR
- 12" CMCP 1583.02 / 1580.61 — CULVERT SIZE AND FLOWLINE ELEVATION
- 1998 WETLAND DELINEATION FIELD VERIFIED
- DISTURBED WETLAND AREA NOT PREVIOUSLY DELINEATED AS A WETLAND
- C / 117 GPM — PROPOSED SOIL ABSORPTION POND LOCATION AND DISCHARGE RATE (GPM)
- DRAINAGE BASIN DIVIDE
- PROPOSED PIPELINE ROUTE
- VALLEY SECTION

NOTE:

1. THE LOCATION OF THE SPRING IN WETLAND Z16 AND THE ORDINARY HIGH WATER MARK AROUND LAKE 17-16 ARE APPROXIMATE.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	SRB	DATE:	NOV. '98
APPROVED BY:	MDL	DATE:	NOV. '98
APPROVED BY:	SAD2	DATE:	NOV. '98

Nicolet Minerals COMPANY

FIGURE 1

SOIL ABSORPTION SITE LOCATION WITH WETLAND DRAINAGE BASINS

Scale: 0 200' 400'		Date:	NOVEMBER, 1998
Prepared By: Foth & Van Dyke	By:	JRB2	93C049

...\98c040\sap-design\8c40f5.dgn Nov. 23, 1998 10:01:13

Attachment 1

Hydrologic & Hydraulic Modeling Documentation

Quick TR-55 Ver.5.46 S/N:1315430197
Executed: 16:38:52 10-06-1998

NICOLET MINING COMPANY
SOIL ABSORPTION SITE
RUNOFF CURVE NUMBERS FOR WETLANDS
FOTH AND VAN DYKE: 93C049 10/98

RUNOFF CURVE NUMBER SUMMARY

Subarea Description	Area (acres)	CN (weighted)
	42.70	62

Quick TR-55 Ver.5.46 S/N:1315430197
Executed: 16:38:52 10-06-1998

NICOLET MINING COMPANY
SOIL ABSORPTION SITE
RUNOFF CURVE NUMBERS FOR WETLANDS
FOTH AND VAN DYKE: 93C049 10/98

RUNOFF CURVE NUMBER DATA

Composite Area:

SURFACE DESCRIPTION	AREA (acres)	CN	
A1	25.50	50	
A2	17.20	80	
COMPOSITE AREA --->	42.70	62.1	(62)

Quick TR-55 Ver.5.46 S/N:1315430197
Executed: 16:38:17 10-06-1998

NICOLET MINING COMPANY
SOIL ABSORPTION SITE
RUNOFF CURVE NUMBERS FOR WETLANDS
FOTH AND VAN DYKE: 93C049 10/98

RUNOFF CURVE NUMBER SUMMARY

Subarea Description	Area (acres)	CN (weighted)
	105.00	62

Quick TR-55 Ver.5.46 S/N:1315430197
Executed: 16:38:17 10-06-1998

NICOLET MINING COMPANY
SOIL ABSORPTION SITE
RUNOFF CURVE NUMBERS FOR WETLANDS
FOTH AND VAN DYKE: 93C049 10/98

RUNOFF CURVE NUMBER DATA

Composite Area:

SURFACE DESCRIPTION	AREA (acres)	CN	
B1	43.90	50	
B2	36.10	80	
B3	25.00	55	
COMPOSITE AREA --->	105.00	61.5	(62)

Quick TR-55 Ver.5.46 S/N:1315430197
Executed: 17:42:18 10-22-1998

NICOLET MINING COMPANY
SOIL ABSORPTION SITE
RUNOFF CURVE NUMBERS FOR WETLANDS
FOTH AND VAN DYKE: 93C049 10/98

RUNOFF CURVE NUMBER SUMMARY

Subarea Description	Area (acres)	CN (weighted)
	50.00	62

FOR CENTRAL BASIN
B1
(VALLEY SECTION)

Quick TR-55 Ver.5.46 S/N:1315430197
Executed: 17:42:18 10-22-1998

NICOLET MINING COMPANY
SOIL ABSORPTION SITE
RUNOFF CURVE NUMBERS FOR WETLANDS
FOTH AND VAN DYKE: 93C049 10/98

RUNOFF CURVE NUMBER DATA

Composite Area:

SURFACE DESCRIPTION	AREA (acres)	CN	
B1	30.00	50	
B2	20.00	80	
COMPOSITE AREA --->	50.00	62.0	(62)

Quick TR-55 Ver.5.46 S/N:1315430197
Executed: 17:32:48 10-22-1998 NMCSOIL.TCT

NICOLET MINING COMPANY
TIME OF CONCENTRATION (Tc) ESTIMATES
FOR SOIL ABSORPTION SITE: WETLAND ISSUES
FOTH & VAN DYKE: 93C049 10/98

Tc COMPUTATIONS FOR: A

SHEET FLOW (Applicable to Tc only)

Segment ID		A	
Surface description		MEADOW	
Manning's roughness coeff., n		0.2500	
Flow length, L (total < or = 300)	ft	300.0	
Two-yr 24-hr rainfall, P2	in	2.400	
Land slope, s	ft/ft	0.0067	
$T = \frac{.007 * (n*L)^{0.8}}{P2^{0.5} * s^{0.4}}$	hrs	1.06	= 1.06

SHALLOW CONCENTRATED FLOW

Segment ID		B	
Surface (paved or unpaved)?		Unpaved	
Flow length, L	ft	1150.0	
Watercourse slope, s	ft/ft	0.0057	
Avg.V = $Csf * (s)^{0.5}$	ft/s	1.2181	
where: Unpaved Csf = 16.1345			
Paved Csf = 20.3282			
T = L / (3600*V)	hrs	0.26	= 0.26

CHANNEL FLOW

Segment ID			
Cross Sectional Flow Area, a	sq.ft	0.00	
Wetted perimeter, Pw	ft	0.00	
Hydraulic radius, r = a/Pw	ft	0.000	
Channel slope, s	ft/ft	0.0000	
Manning's roughness coeff., n		0.0000	
$V = \frac{1.49 * r^{2/3} * s^{1/2}}{n}$	ft/s	0.0000	
Flow length, L	ft	0	
T = L / (3600*V)	hrs	0.00	= 0.00

::

TOTAL TIME (hrs) 1.32

Quick TR-55 Ver.5.46 S/N:1315430197
Executed: 17:32:48 10-22-1998 NMCSOIL.TCT

NICOLET MINING COMPANY
TIME OF CONCENTRATION (Tc) ESTIMATES
FOR SOIL ABSORPTION SITE: WETLAND ISSUES
FOTH & VAN DYKE: 93C049 10/98

Tc COMPUTATIONS FOR: B

SHEET FLOW (Applicable to Tc only)

Segment ID		A	
Surface description		MEADOW	
Manning's roughness coeff., n		0.2400	
Flow length, L (total < or = 300)	ft	300.0	
Two-yr 24-hr rainfall, P2	in	2.400	
Land slope, s	ft/ft	0.0220	
$T = \frac{.007 * (n*L)^{0.8}}{P2^{0.5} * s^{0.4}}$	hrs	0.64	= 0.64

SHALLOW CONCENTRATED FLOW

Segment ID		B	
Surface (paved or unpaved)?		Unpaved	
Flow length, L	ft	2120.0	
Watercourse slope, s	ft/ft	0.0015	
$Avg.V = Csf * (s)^{0.5}$	ft/s	0.6249	
where: Unpaved Csf = 16.1345			
Paved Csf = 20.3282			
T = L / (3600*V)	hrs	0.94	= 0.94

CHANNEL FLOW

Segment ID			
Cross Sectional Flow Area, a	sq.ft	0.00	
Wetted perimeter, Pw	ft	0.00	
Hydraulic radius, r = a/Pw	ft	0.000	
Channel slope, s	ft/ft	0.0000	
Manning's roughness coeff., n		0.0000	
$V = \frac{1.49 * r^{2/3} * s^{1/2}}{n}$	ft/s	0.0000	
Flow length, L	ft	0	
T = L / (3600*V)	hrs	0.00	= 0.00

::

TOTAL TIME (hrs) 1.58

Quick TR-55 Ver.5.46 S/N:1315430197
Executed: 17:32:48 10-22-1998 NMCSOIL.TCT

NICOLET MINING COMPANY
TIME OF CONCENTRATION (Tc) ESTIMATES
FOR SOIL ABSORPTION SITE: WETLAND ISSUES
FOTH & VAN DYKE: 93C049 10/98

Tc COMPUTATIONS FOR: AREA B1 (CENTL)

SHEET FLOW (Applicable to Tc only)

Segment ID		A	
Surface description		MEADOW	
Manning's roughness coeff., n		0.2400	
Flow length, L (total < or = 300)	ft	300.0	
Two-yr 24-hr rainfall, P2	in	2.400	
Land slope, s	ft/ft	0.0220	
$T = \frac{.007 * (n*L)^{0.8}}{P2^{0.5} * s^{0.4}}$	hrs	0.64	= 0.64

SHALLOW CONCENTRATED FLOW

Segment ID		B	
Surface (paved or unpaved)?		Unpaved	
Flow length, L	ft	1300.0	
Watercourse slope, s	ft/ft	0.0020	
$Avg.V = Csf * (s)^{0.5}$	ft/s	0.7216	
where: Unpaved Csf = 16.1345			
Paved Csf = 20.3282			
T = L / (3600*V)	hrs	0.50	= 0.50

CHANNEL FLOW

Segment ID			
Cross Sectional Flow Area, a	sq.ft	0.00	
Wetted perimeter, Pw	ft	0.00	
Hydraulic radius, r = a/Pw	ft	0.000	
Channel slope, s	ft/ft	0.0000	
Manning's roughness coeff., n		0.0000	
$V = \frac{1.49 * r^{2/3} * s^{1/2}}{n}$	ft/s	0.0000	
Flow length, L	ft	0	
T = L / (3600*V)	hrs	0.00	= 0.00

TOTAL TIME (hrs) 1.14

Quick TR-55 Ver.5.46 S/N:1315430197
Executed: 17:32:48 10-22-1998 NMCSOIL.TCT

SUMMARY SHEET FOR Tc or Tt COMPUTATIONS
(Solved for Time using TR-55 Methods)

NICOLET MINING COMPANY
TIME OF CONCENTRATION (Tc) ESTIMATES
FOR SOIL ABSORPTION SITE: WETLAND ISSUES
FOTH & VAN DYKE: 93C049 10/98

Subarea descr.	Tc or Tt	Time (hrs)
A	Tc	1.32
B	Tc	1.58
AREA B1 (CENTL)	Tc	1.14

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution 2-YEAR
(24 hr. Duration Storm)

Executed: 10-22-1998 17:44:00
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input	Ia/p used
AREA A	42.70	62.0	1.25	0.00	2.40	0.19	.51	.50
AREA B	105.00	62.0	1.50	0.00	2.40	0.19	.51	.50
AREA B1	50.00	62.0	1.25	0.00	2.40	0.19	.51	.50

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 197.70 acres or 0.3089 sq.mi
Peak discharge = 8 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
AREA A	1.32	0.00	1.25	0.00	No	Computed Ia/p > .5
AREA B	1.58	0.00	1.50	0.00	No	Computed Ia/p > .5
AREA B1	1.14	0.00	1.25	0.00	No	Computed Ia/p > .5

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:44:00
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
AREA A	2	13.0
AREA B	4	13.2
AREA B1	2	13.0
Composite Watershed	8	13.2

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:44:00
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
AREA A	0	0	0	0	0	0	0	0	0
AREA B	0	0	0	0	0	0	0	0	0
AREA B1	0	0	0	0	0	0	0	0	0
Total (cfs)	0	0	0	0	0	0	0	0	0

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
AREA A	0	1	1	1	2	2	2	2	1
AREA B	0	1	1	2	3	4	4	4	4
AREA B1	0	1	1	1	2	2	2	2	2
Total (cfs)	0	3	3	4	7	8	8	8	7

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:44:00
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Composite Hydrograph Summary (cfs)

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
AREA A	1	1	1	1	1	1	1	1	1
AREA B	3	3	3	2	2	2	2	2	1
AREA B1	2	1	1	1	1	1	1	1	1
Total (cfs)	6	5	5	4	4	4	4	4	3

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
AREA A	1	0	0	0	0
AREA B	1	1	1	1	0
AREA B1	1	1	1	0	0
Total (cfs)	3	2	2	1	0

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:44:00
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	0	14.8	4
11.1	0	14.9	4
11.2	0	15.0	4
11.3	0	15.1	4
11.4	0	15.2	4
11.5	0	15.3	4
11.6	0	15.4	4
11.7	0	15.5	4
11.8	0	15.6	4
11.9	0	15.7	4
12.0	0	15.8	4
12.1	0	15.9	4
12.2	0	16.0	4
12.3	0	16.1	4
12.4	0	16.2	4
12.5	0	16.3	4
12.6	3	16.4	4
12.7	3	16.5	4
12.8	4	16.6	4
12.9	6	16.7	4
13.0	7	16.8	4
13.1	8	16.9	4
13.2	8	17.0	4
13.3	8	17.1	4
13.4	8	17.2	4
13.5	8	17.3	3
13.6	8	17.4	3
13.7	8	17.5	3
13.8	7	17.6	3
13.9	6	17.7	3
14.0	6	17.8	3
14.1	6	17.9	3
14.2	5	18.0	3
14.3	5	18.1	3
14.4	5	18.2	3
14.5	5	18.3	3
14.6	5	18.4	3
14.7	5	18.5	2

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:44:00
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	2	22.4	1
18.7	2	22.5	1
18.8	2	22.6	1
18.9	2	22.7	1
19.0	2	22.8	1
19.1	2	22.9	1
19.2	2	23.0	1
19.3	2	23.1	1
19.4	2	23.2	1
19.5	2	23.3	1
19.6	2	23.4	1
19.7	2	23.5	1
19.8	2	23.6	1
19.9	2	23.7	1
20.0	2	23.8	1
20.1	2	23.9	1
20.2	2	24.0	0
20.3	2	24.1	0
20.4	2	24.2	0
20.5	2	24.3	0
20.6	2	24.4	0
20.7	2	24.5	0
20.8	2	24.6	0
20.9	2	24.7	0
21.0	2	24.8	0
21.1	1	24.9	0
21.2	1	25.0	0
21.3	1	25.1	0
21.4	1	25.2	0
21.5	1	25.3	0
21.6	1	25.4	0
21.7	1	25.5	0
21.8	1	25.6	0
21.9	1	25.7	0
22.0	1	25.8	0
22.1	1	25.9	0
22.2	1		
22.3	1		

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution 5-YEAR
(24 hr. Duration Storm)

Executed: 10-22-1998 17:44:37
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input	Ia/p used
AREA A	42.70	62.0	1.25	0.00	3.10	0.44	.4	.50
AREA B	105.00	62.0	1.50	0.00	3.10	0.44	.4	.50
AREA B1	50.00	62.0	1.25	0.00	3.10	0.44	.4	.50

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 197.70 acres or 0.3089 sq.mi
Peak discharge = 18 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
AREA A	1.32	0.00	1.25	0.00	No	--
AREA B	1.58	0.00	1.50	0.00	No	--
AREA B1	1.14	0.00	1.25	0.00	No	--

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:44:37
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
AREA A	4	13.0
AREA B	9	13.4
AREA B1	5	13.2
Composite Watershed	18	13.4

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:44:37
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
AREA A	0	0	0	0	0	0	0	0	0
AREA B	0	0	0	0	0	0	0	0	1
AREA B1	0	0	0	0	0	0	0	0	0
Total (cfs)	0	0	0	0	0	0	0	0	1

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
AREA A	1	1	2	3	4	4	4	4	3
AREA B	1	2	3	4	7	8	9	9	9
AREA B1	1	2	2	3	4	5	5	4	4
Total (cfs)	3	5	7	10	15	17	18	17	16

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:44:37
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Composite Hydrograph Summary (cfs)

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
AREA A	3	3	2	2	2	2	2	1	1
AREA B	8	7	6	6	5	4	4	4	3
AREA B1	4	3	3	2	2	2	2	2	2
Total (cfs)	15	13	11	10	9	8	8	7	6

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
AREA A	1	1	1	1	0
AREA B	3	3	3	2	0
AREA B1	1	1	1	1	0
Total (cfs)	5	5	5	4	0

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:44:37
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	0	14.8	10
11.1	0	14.9	10
11.2	0	15.0	10
11.3	0	15.1	10
11.4	0	15.2	10
11.5	0	15.3	9
11.6	0	15.4	9
11.7	0	15.5	9
11.8	0	15.6	9
11.9	0	15.7	9
12.0	0	15.8	8
12.1	0	15.9	8
12.2	0	16.0	8
12.3	0	16.1	8
12.4	1	16.2	8
12.5	3	16.3	8
12.6	5	16.4	8
12.7	7	16.5	8
12.8	10	16.6	8
12.9	12	16.7	8
13.0	15	16.8	7
13.1	16	16.9	7
13.2	17	17.0	7
13.3	18	17.1	7
13.4	18	17.2	7
13.5	18	17.3	6
13.6	17	17.4	6
13.7	16	17.5	6
13.8	16	17.6	6
13.9	16	17.7	6
14.0	15	17.8	5
14.1	14	17.9	5
14.2	14	18.0	5
14.3	13	18.1	5
14.4	12	18.2	5
14.5	12	18.3	5
14.6	11	18.4	5
14.7	11	18.5	5

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:44:37
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	5	22.4	4
18.7	5	22.5	4
18.8	5	22.6	3
18.9	5	22.7	3
19.0	5	22.8	3
19.1	5	22.9	3
19.2	5	23.0	3
19.3	5	23.1	3
19.4	5	23.2	3
19.5	5	23.3	3
19.6	5	23.4	3
19.7	5	23.5	2
19.8	5	23.6	2
19.9	5	23.7	2
20.0	5	23.8	2
20.1	5	23.9	2
20.2	5	24.0	2
20.3	5	24.1	2
20.4	5	24.2	2
20.5	5	24.3	2
20.6	5	24.4	2
20.7	5	24.5	2
20.8	5	24.6	1
20.9	5	24.7	1
21.0	4	24.8	1
21.1	4	24.9	1
21.2	4	25.0	1
21.3	4	25.1	1
21.4	4	25.2	1
21.5	4	25.3	1
21.6	4	25.4	1
21.7	4	25.5	0
21.8	4	25.6	0
21.9	4	25.7	0
22.0	4	25.8	0
22.1	4	25.9	0
22.2	4		
22.3	4		

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution 10-YEAR
(24 hr. Duration Storm)

Executed: 10-22-1998 17:45:20
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input	Ia/p used
AREA A	42.70	62.0	1.25	0.00	3.60	0.66	.34	.30
AREA B	105.00	62.0	1.50	0.00	3.60	0.66	.34	.30
AREA B1	50.00	62.0	1.25	0.00	3.60	0.66	.34	.30

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 197.70 acres or 0.3089 sq.mi
Peak discharge = 46 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
AREA A	1.32	0.00	1.25	0.00	No	--
AREA B	1.58	0.00	1.50	0.00	No	--
AREA B1	1.14	0.00	1.25	0.00	No	--

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:45:20
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
AREA A	11	13.0
AREA B	24	13.2
AREA B1	13	13.0
Composite Watershed	46	13.2

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:45:20
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
AREA A	0	0	0	0	0	0	0	1	2
AREA B	0	0	0	0	0	0	1	2	3
AREA B1	0	0	0	0	0	0	0	1	3
Total (cfs)	0	0	0	0	0	0	1	4	8

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
AREA A	4	6	8	9	11	10	9	7	6
AREA B	6	9	12	16	21	24	23	20	17
AREA B1	4	7	9	11	13	12	10	8	7
Total (cfs)	14	22	29	36	45	46	42	35	30

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:45:20
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Composite Hydrograph Summary (cfs)

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
AREA A	5	4	3	3	2	2	2	2	1
AREA B	15	12	10	8	6	5	5	4	4
AREA B1	6	5	4	3	3	2	2	2	2
Total (cfs)	26	21	17	14	11	9	9	8	7

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
AREA A	1	1	1	1	0
AREA B	3	3	3	2	0
AREA B1	2	1	1	1	0
Total (cfs)	6	5	5	4	0

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:45:20
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	0	14.8	16
11.1	0	14.9	15
11.2	0	15.0	14
11.3	0	15.1	13
11.4	0	15.2	13
11.5	0	15.3	12
11.6	0	15.4	12
11.7	0	15.5	11
11.8	0	15.6	11
11.9	0	15.7	10
12.0	0	15.8	10
12.1	0	15.9	9
12.2	1	16.0	9
12.3	4	16.1	9
12.4	8	16.2	9
12.5	14	16.3	9
12.6	22	16.4	9
12.7	29	16.5	9
12.8	36	16.6	9
12.9	40	16.7	9
13.0	45	16.8	8
13.1	46	16.9	8
13.2	46	17.0	8
13.3	44	17.1	8
13.4	42	17.2	8
13.5	39	17.3	7
13.6	35	17.4	7
13.7	32	17.5	7
13.8	30	17.6	7
13.9	28	17.7	7
14.0	26	17.8	6
14.1	24	17.9	6
14.2	23	18.0	6
14.3	21	18.1	6
14.4	20	18.2	6
14.5	18	18.3	6
14.6	17	18.4	6
14.7	16	18.5	6

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:45:20
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	5	22.4	4
18.7	5	22.5	4
18.8	5	22.6	3
18.9	5	22.7	3
19.0	5	22.8	3
19.1	5	22.9	3
19.2	5	23.0	3
19.3	5	23.1	3
19.4	5	23.2	3
19.5	5	23.3	3
19.6	5	23.4	3
19.7	5	23.5	2
19.8	5	23.6	2
19.9	5	23.7	2
20.0	5	23.8	2
20.1	5	23.9	2
20.2	5	24.0	2
20.3	5	24.1	2
20.4	5	24.2	2
20.5	5	24.3	2
20.6	5	24.4	2
20.7	5	24.5	2
20.8	5	24.6	1
20.9	5	24.7	1
21.0	4	24.8	1
21.1	4	24.9	1
21.2	4	25.0	1
21.3	4	25.1	1
21.4	4	25.2	1
21.5	4	25.3	1
21.6	4	25.4	1
21.7	4	25.5	0
21.8	4	25.6	0
21.9	4	25.7	0
22.0	4	25.8	0
22.1	4	25.9	0
22.2	4		
22.3	4		

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution 25-YEAR
(24 hr. Duration Storm)

Executed: 10-22-1998 17:46:32
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input	Ia/p used
AREA A	42.70	62.0	1.25	0.00	4.20	0.97	.29	.30
AREA B	105.00	62.0	1.50	0.00	4.20	0.97	.29	.30
AREA B1	50.00	62.0	1.25	0.00	4.20	0.97	.29	.30

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 197.70 acres or 0.3089 sq.mi
Peak discharge = 69 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
AREA A	1.32	0.00	1.25	0.00	No	--
AREA B	1.58	0.00	1.50	0.00	No	--
AREA B1	1.14	0.00	1.25	0.00	No	--

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:46:32
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
AREA A	16	13.0
AREA B	36	13.2
AREA B1	19	13.0
Composite Watershed	69	13.2

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:46:32
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
AREA A	0	0	0	0	0	0	1	2	3
AREA B	0	0	0	0	0	0	1	2	5
AREA B1	0	0	0	0	0	0	1	2	4
Total (cfs)	0	0	0	0	0	0	3	6	12

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
AREA A	6	8	11	13	16	15	13	11	9
AREA B	8	13	18	23	31	36	33	30	25
AREA B1	7	10	13	16	19	18	15	12	10
Total (cfs)	21	31	42	52	66	69	61	53	44

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:46:32
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Composite Hydrograph Summary (cfs)

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
AREA A	7	6	5	4	3	3	3	2	2
AREA B	21	17	14	11	9	8	7	6	5
AREA B1	9	7	6	5	4	3	3	3	2
Total (cfs)	37	30	25	20	16	14	13	11	9

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
AREA A	2	2	2	1	0
AREA B	5	4	4	3	0
AREA B1	2	2	2	1	0
Total (cfs)	9	8	8	5	0

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:46:32
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	0	14.8	22
11.1	0	14.9	21
11.2	0	15.0	20
11.3	0	15.1	19
11.4	0	15.2	18
11.5	0	15.3	18
11.6	0	15.4	17
11.7	0	15.5	16
11.8	0	15.6	16
11.9	0	15.7	15
12.0	0	15.8	15
12.1	0	15.9	14
12.2	3	16.0	14
12.3	6	16.1	14
12.4	12	16.2	14
12.5	21	16.3	13
12.6	31	16.4	13
12.7	42	16.5	13
12.8	52	16.6	13
12.9	59	16.7	12
13.0	66	16.8	12
13.1	68	16.9	11
13.2	69	17.0	11
13.3	65	17.1	11
13.4	61	17.2	10
13.5	57	17.3	10
13.6	53	17.4	9
13.7	48	17.5	9
13.8	44	17.6	9
13.9	40	17.7	9
14.0	37	17.8	9
14.1	35	17.9	9
14.2	32	18.0	9
14.3	30	18.1	9
14.4	28	18.2	9
14.5	27	18.3	9
14.6	25	18.4	9
14.7	24	18.5	8

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:46:32
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	8	22.4	4
18.7	8	22.5	4
18.8	8	22.6	4
18.9	8	22.7	4
19.0	8	22.8	4
19.1	8	22.9	4
19.2	8	23.0	4
19.3	8	23.1	4
19.4	8	23.2	4
19.5	8	23.3	3
19.6	8	23.4	3
19.7	8	23.5	3
19.8	8	23.6	3
19.9	8	23.7	3
20.0	8	23.8	3
20.1	8	23.9	3
20.2	8	24.0	2
20.3	8	24.1	2
20.4	7	24.2	2
20.5	7	24.3	2
20.6	7	24.4	2
20.7	7	24.5	2
20.8	7	24.6	2
20.9	7	24.7	2
21.0	6	24.8	2
21.1	6	24.9	1
21.2	6	25.0	1
21.3	6	25.1	1
21.4	6	25.2	1
21.5	6	25.3	1
21.6	6	25.4	1
21.7	5	25.5	1
21.8	5	25.6	0
21.9	5	25.7	0
22.0	5	25.8	0
22.1	5	25.9	0
22.2	5		
22.3	5		

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution 100-YEAR
(24 hr. Duration Storm)

Executed: 10-22-1998 17:47:26
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

>>>> Input Parameters Used to Compute Hydrograph <<<<

Subarea Description	AREA (acres)	CN	Tc (hrs)	* Tt (hrs)	Precip. (in)	Runoff (in)	Ia/p input	Ia/p used
AREA A	42.70	62.0	1.25	0.00	5.00	1.44	.25	.30
AREA B	105.00	62.0	1.50	0.00	5.00	1.44	.25	.30
AREA B1	50.00	62.0	1.25	0.00	5.00	1.44	.25	.30

* Travel time from subarea outfall to composite watershed outfall point.
Total area = 197.70 acres or 0.3089 sq.mi
Peak discharge = 102 cfs

>>>> Computer Modifications of Input Parameters <<<<<

Subarea Description	Input Values Tc (hr)	Input Values * Tt (hr)	Rounded Values Tc (hr)	Rounded Values * Tt (hr)	Ia/p Interpolated (Yes/No)	Ia/p Messages
AREA A	1.32	0.00	1.25	0.00	No	--
AREA B	1.58	0.00	1.50	0.00	No	--
AREA B1	1.14	0.00	1.25	0.00	No	--

* Travel time from subarea outfall to composite watershed outfall point.

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:47:26
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

>>>> Summary of Subarea Times to Peak <<<<

Subarea	Peak Discharge at Composite Outfall (cfs)	Time to Peak at Composite Outfall (hrs)
AREA A	24	13.0
AREA B	53	13.2
AREA B1	28	13.0
Composite Watershed	102	13.2

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:47:26
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Composite Hydrograph Summary (cfs)

Subarea Description	11.0 hr	11.3 hr	11.6 hr	11.9 hr	12.0 hr	12.1 hr	12.2 hr	12.3 hr	12.4 hr
AREA A	0	0	0	0	0	0	1	2	5
AREA B	0	0	0	0	0	0	1	4	7
AREA B1	0	0	0	0	0	0	1	3	6
Total (cfs)	0	0	0	0	0	0	3	9	18

Subarea Description	12.5 hr	12.6 hr	12.7 hr	12.8 hr	13.0 hr	13.2 hr	13.4 hr	13.6 hr	13.8 hr
AREA A	8	12	17	20	24	23	19	16	13
AREA B	13	19	26	34	46	53	49	44	37
AREA B1	10	15	20	23	28	26	23	18	15
Total (cfs)	31	46	63	77	98	102	91	78	65

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:47:26
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Composite Hydrograph Summary (cfs)

Subarea Description	14.0 hr	14.3 hr	14.6 hr	15.0 hr	15.5 hr	16.0 hr	16.5 hr	17.0 hr	17.5 hr
AREA A	11	9	7	6	5	4	4	3	3
AREA B	32	26	21	17	13	11	10	9	8
AREA B1	13	10	9	7	6	5	4	4	4
Total (cfs)	56	45	37	30	24	20	18	16	15

Subarea Description	18.0 hr	19.0 hr	20.0 hr	22.0 hr	26.0 hr
AREA A	3	3	2	2	0
AREA B	7	7	6	5	0
AREA B1	3	3	3	2	0
Total (cfs)	13	13	11	9	0

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:47:26
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

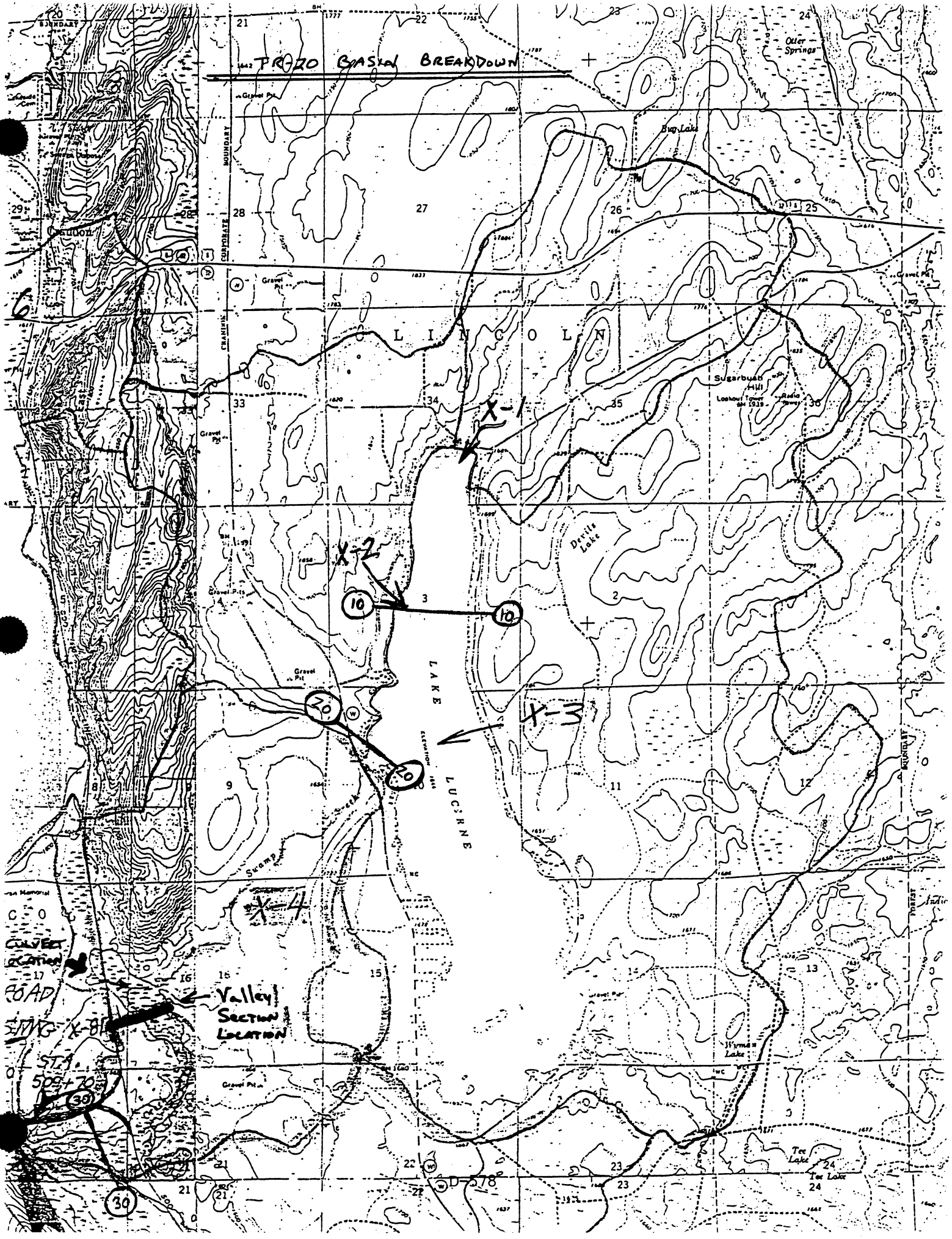
Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
11.0	0	14.8	34
11.1	0	14.9	32
11.2	0	15.0	30
11.3	0	15.1	29
11.4	0	15.2	28
11.5	0	15.3	26
11.6	0	15.4	25
11.7	0	15.5	24
11.8	0	15.6	23
11.9	0	15.7	22
12.0	0	15.8	22
12.1	0	15.9	21
12.2	3	16.0	20
12.3	9	16.1	20
12.4	18	16.2	19
12.5	31	16.3	19
12.6	46	16.4	18
12.7	63	16.5	18
12.8	77	16.6	18
12.9	88	16.7	17
13.0	98	16.8	17
13.1	100	16.9	16
13.2	102	17.0	16
13.3	96	17.1	16
13.4	91	17.2	16
13.5	85	17.3	15
13.6	78	17.4	15
13.7	71	17.5	15
13.8	65	17.6	15
13.9	60	17.7	14
14.0	56	17.8	14
14.1	52	17.9	13
14.2	49	18.0	13
14.3	45	18.1	13
14.4	42	18.2	13
14.5	40	18.3	13
14.6	37	18.4	13
14.7	35	18.5	13

TR-55 TABULAR HYDROGRAPH METHOD
Type II Distribution
(24 hr. Duration Storm)

Executed: 10-22-1998 17:47:26
Watershed file: --> NMCSOIL .WSD
Hydrograph file: --> NMCSOIL .HYD

NICOLET MINING COMPANY
FOTH AND VAN DYKE 93C049
SOIL ABSORPTION SITE AREA A
LOCAL WETLAND IMPACTS 10/98

Time (hrs)	Flow (cfs)	Time (hrs)	Flow (cfs)
18.6	13	22.4	8
18.7	13	22.5	8
18.8	13	22.6	8
18.9	13	22.7	7
19.0	13	22.8	7
19.1	13	22.9	7
19.2	13	23.0	7
19.3	12	23.1	7
19.4	12	23.2	6
19.5	12	23.3	6
19.6	12	23.4	6
19.7	12	23.5	6
19.8	11	23.6	5
19.9	11	23.7	5
20.0	11	23.8	5
20.1	11	23.9	5
20.2	11	24.0	4
20.3	11	24.1	4
20.4	11	24.2	4
20.5	10	24.3	4
20.6	10	24.4	4
20.7	10	24.5	3
20.8	10	24.6	3
20.9	10	24.7	3
21.0	10	24.8	3
21.1	10	24.9	2
21.2	10	25.0	2
21.3	10	25.1	2
21.4	10	25.2	2
21.5	10	25.3	2
21.6	9	25.4	1
21.7	9	25.5	1
21.8	9	25.6	1
21.9	9	25.7	1
22.0	9	25.8	0
22.1	9	25.9	0
22.2	9		
22.3	8		


PROPOSED BASIN BREAKDOWN
X-1
X-2
X-3
X-4
10
10
20
20
30
30
Valley Section Location
CULVERT LOCATION
ROAD
STA. 509+20
LINCOLN
LAKE LUCERNE
Devils Lake
Sugarbush Hill
Bug Lake
Outer Springs
Tee Lake
Wyman Lake
Swamp Creek
D-578

```
**********************************************************************
*                                * TR 20 S/N    :                    *
*                                * HMVersion    :  3.40              *
*            TR 20               * Date         : 10/30/98           *
*                                * Time         : 15:48:44           *
*   Project Formulation Hydrology * Input file   : NMCSOIL.T20        *
*                                * Output file  : NMCSOIL.OUT        *
*                                *                                   *
*                                *                                   *
**********************************************************************
```

```
XXXXXXX  XXXXXX    XXXXX    XXXXX
   X     X     X  X     X  X    XX
   X     X     X        X  X   X X
   X     XXXXXX      X     X  X  X
   X     X   X     X       X X   X
   X     X    X   X        XX    X
   X     X     X  XXXXXXX   XXXXX
```

```
::::::::::::::::::::::::::::::::::::::::::::
::::::::::::::::::::::::::::::::::::::::::::
:::                                      :::
:::  Full Microcomputer Implementation   :::
:::                  by                  :::
:::        Haestad Methods, Inc.         :::
:::                                      :::
::::::::::::::::::::::::::::::::::::::::::::
::::::::::::::::::::::::::::::::::::::::::::
```

37 Brookside Road * Waterbury, Connecticut 06708 * (203) 755-1666

```
******************80-80 LIST OF INPUT DATA FOR TR-20 HYDROLOGY*******************

JOB TR-20                                   PASS=  1          NOPLOTS
TITLE   1 HYDROLOGY FOR SWAMP CREEK AT SAS-NICOLET MINING CO.   10/30/98
TITLE     EXISTING              FILE:NMCSOIL.T20   FOTH & VAN DYKE 93C049
 3 STRUCT      01
 8                             1644.00        0.00        0.00
 8                             1644.10         1.0        2.00
 8                             1644.50         6.0      524.00
 8                             1645.00        10.0     1060.00
 8                             1645.50        13.0     1610.00
 8                             1646.00        15.0     2170.00
 8                             1647.00        19.0     3320.00
 8                             1650.00        50.0     7000.00
 9 ENDTBL
 3 STRUCT      02                                                    METONGA
 8                             1599.00        0.00        0.00
 8                             1599.20         6.0       400.0
 8                             1599.50        23.4      1020.0
 8                             1599.80        47.3      1645.0
 8                             1600.00        65.9      2060.0
 8                             1601.00       185.0      4200.0
 8                             1602.00      3500.0      6350.0
 8                             1605.00     30000.0     12800.0
 9 ENDTBL
 6 RUNOFF 1  10       5          2.06          70       12.51        1       X1
 6 RUNOFF 1  10       6          2.37          75       11.61        1       X2
 6 ADDHYD 4  10    5 6 7                                    1        1
 6 REACH  3  20    7  5            10         0.2        1.31        1
 6 RUNOFF 1  20       7          7.92          82       13.51        1       X3
 6 ADDHYD 4  20    5 7 6                                    1        1
 6 RESVOR 2     1 6   7          1644                       1        1  LUCERNE
 6 REACH  3  30    7  5         21000         1.5       1.251        1
 6 RUNOFF 1  30       6          3.05          74       13.61        1       X4
 6 ADDHYD 4  30    5 6 4                                    1        1
 6 RUNOFF 1  40       7          1.43          74        8.51        1       X9
 6 REACH  3  45    7  5          4000         1.2        1.21        1
 6 RUNOFF 1  45       6          2.99          75       21.71        1      X10
 6 ADDHYD 4  45    5 6 7                                    1        1
 6 REACH  3  50    7  5         10000         1.2        1.21        1
 6 RUNOFF 1  50       7          4.75          73        6.51        1      X11
 6 ADDHYD 4  50    5 7 6                                    1        1
 6 ADDHYD 4  50    4 6 7                                    1        1
   ENDATA
 7 INCREM 6            0.1333333333
 7 COMPUT 7  10    50             0          2.4        1.01 2       1      2YR
   ENDCMP 1
 7 COMPUT 7  10    50             0          3.1        1.01 2       2      5YR
```

```
**********80-80 LIST OF INPUT DATA (CONTINUED)**********

   ENDCMP 1
 7 COMPUT 7  10    50              0        3.6        1.01 2      3     10YR
   ENDCMP 1
 7 COMPUT 7  10    50              0        4.2        1.01 2      4     25YR
   ENDCMP 1
 7 COMPUT 7  10    50              0        5.0        1.01 2      5     100YR
   ENDCMP 1
   ENDJOB 2

**********END OF 80-80 LIST**********
```

FILE NO. 1

COMPUTER PROGRAM FOR PROJECT FORMULATION - HYDROLOGY USER NOTES

THE USERS MANUAL FOR THIS PROGRAM IS THE MAY 1982 DRAFT OF TR-20. CHANGES FROM THE 2/14/74 VERSION INCLUDE:

REACH ROUTING - THE MODIFIED ATT-KIN ROUTING PROCEDURE REPLACES THE CONVEX METHOD. INPUT DATA PREPARED FOR PREVIOUS PROGRAM VERSIONS USING CONVEX ROUTING COEFFICIENTS WILL NOT RUN ON THIS VERSION.

THE PREFERRED TYPE OF DATA ENTRY IS CROSS SECTION DATA REPRESENTATIVE OF A REACH. IT IS RECOMMENDED THAT THE OPTIONAL CROSS SECTION DISCHARGE-AREA PLOTS BE OBTAINED WHENEVER NEW CROSS SECTION DATA IS ENTERED. THE PLOTS SHOULD BE CHECKED FOR REASONABLENESS AND ADEQUACY OF INPUT DATA FOR THE COMPUTATION OF "M" VALUES USED IN THE ROUTING PROCEDURE.

GUIDELINES FOR DETERMINING OR ANALYZING REACH LENGTHS AND COEFFICIENTS (X,M) ARE AVAILABLE IN THE USERS MANUAL. SUMMARY TABLE 2 DISPLAYS REACH ROUTING RESULTS AND ROUTING PARAMETERS FOR COMPARISON AND CHECKING.

HYDROGRAPH GENERATION - THE PROCEDURE TO CALCULATE THE INTERNAL TIME INCREMENT AND PEAK TIME OF THE UNIT HYDROGRAPH HAVE BEEN IMPROVED. PEAK DISCHARGES AND TIMES MAY DIFFER FROM THE PREVIOUS VERSION. OUTPUT HYDROGRAPHS ARE STILL INTERPOLATED, PRINTED, AND ROUTED AT THE USER SELECTED MAIN TIME INCREMENT.

INTERMEDIATE PEAKS - METHOD ADDED TO PROVIDE DISCHARGES AT INTERMEDIATE POINTS WITHIN REACHES WITHOUT ROUTING.

OTHER - THIS VERSION CONTAINS SOME ADDITIONS TO THE INPUT AND NUMEROUS MODIFICATIONS TO THE OUTPUT. USER OPTIONS HAVE BEEN MODIFIED AND AUGMENTED ON THE JOB RECORD, RAINTABLES ADDED, ERROR AND WARNING MESSAGES EXPANDED, AND THE SUMMARY TABLES COMPLETELY REVISED. THE HOLDOUT OPTION IS NOT OPERATIONAL AT THIS TIME.

PROGRAM QUESTIONS OR PROBLEMS SHOULD BE DIRECTED TO HYDRAULIC ENGINEERS AT THE SCS NATIONAL TECHNICAL CENTERS:

CHESTER, PA (NORTHEAST) -- 215-499-3933, FORT WORTH, TX (SOUTH) -- 334-5242 (FTS)
LINCOLN, NB (MIDWEST) -- 541-5318 (FTS), PORTLAND, OR (WEST) -- 423-4099 (FTS)
OR HYDROLOGY UNIT, ENGINEERING DIVISION, LANHAM, MD -- 436-7383 (FTS).

PROGRAM CHANGES SINCE MAY 1982:

12/17/82 - CORRECT PEAK RATE FACTOR FOR USER ENTERED DIMHYD
CORRECT REACH ROUTING PEAK TRAVEL TIME PRINTED WITH FULLPRINT OPTION
5/02/83 - CORRECT COMPUTATIONS FOR ---
1. DIVISION OF BASEFLOW IN DIVERT OPERATION
2. HYDROGRAPH VOLUME SPLIT BETWEEN BASEFLOW AND ABOVE BASEFLOW
3. CROSS SECTION DATA PLOTTING POSITION
4. INTERMEDIATE PEAK WHEN "FROM" AREA IS LARGER THAN "THRU" AREA
5. STORAGE ROUTED REACH TRAVEL TIME FOR MULTIPEAK HYDROGRAPH
6. ORDERING "FLOW-FREQ" FILE FROM SUMMARY TABLE #3 DATA
7. BASEFLOW ENTERED WITH READHYD
8. LOW FLOW SPLIT DURING DIVERT PROCEDURE #2 WHEN SECTION RATINGS START AT DIFFERENT ELEVATIONS
ENHANCEMENTS ---
1. REPLACE USER MANUAL ERROR CODES (PAGE 4-9 TO 4-11) WITH MESSAGES
2. LABEL OUTPUT HYDROGRAPH FILES WITH CROSS SECTION/STRUCTURE, ALTERNATE AND STORM NO'S
09/01/83 - CORRECT INPUT AND OUTPUT ERRORS FOR INTERMEDIATE PEAKS
CORRECT COMBINATION OF RATING TABLES FOR DIVERT
CHECK REACH ROUTING PARAMETERS FOR ACCEPTABLE LIMITS
ELIMINATE MINIMUM REACH TRAVEL TIME WHEN ATT-KIN COEFFICIENT EQUALS ONE

EXECUTIVE CONTROL OPERATION INCREM MAIN TIME INCREMENT = .13 HOURS RECORD ID

EXECUTIVE CONTROL OPERATION COMPUT FROM XSECTION 10 TO XSECTION 50 RECORD ID 2YR
STARTING TIME = .00 RAIN DEPTH = 2.40 RAIN DURATION= 1.00 RAIN TABLE NO.= 1 ANT. MOIST. COND= 2
ALTERNATE NO.= 0 STORM NO.= 1 MAIN TIME INCREMENT = .13 HOURS

OPERATION RUNOFF CROSS SECTION 10

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
23.50	31.27	(RUNOFF)

OPERATION RUNOFF CROSS SECTION 10

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
21.36	54.53	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 10

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
22.00	84.77	(NULL)

*** WARNING REACH 20 ATT-KIN COEFF.(C) GREATER THAN 0.667, CONSIDER REDUCING MAIN TIME INCREMENT ***

*** WARNING - REACH 20 INFLOW HYDROGRAPH VOLUME TRUNCATED ABOVE BASEFLOW AT 9.27 CFS, 10.94 % OF PEAK.

OPERATION REACH CROSS SECTION 20

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
22.00	84.77	(NULL)

OPERATION RUNOFF CROSS SECTION 20

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
22.22	271.79	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 20

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
22.18	356.53	(NULL)

OPERATION RESVOR STRUCTURE 1

*** WARNING-NO PEAK FOUND, MAXIMUM DISCHARGE = 5.60 CFS.

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
39.87	5.60	1644.47

*** WARNING - REACH 30 INFLOW HYDROGRAPH VOLUME TRUNCATED ABOVE BASEFLOW AT 5.60 CFS, 100.00 % OF PEAK.

OPERATION REACH CROSS SECTION 30

*** WARNING-NO PEAK FOUND, MAXIMUM DISCHARGE = 5.27 CFS.

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
39.87	5.27	(NULL)

OPERATION RUNOFF CROSS SECTION 30

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
23.53	60.91	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 30

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
23.71	62.80	(NULL)

OPERATION RUNOFF CROSS SECTION 40

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
18.32	34.73	(RUNOFF)

OPERATION REACH CROSS SECTION 45

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
18.84	34.54	(NULL)

OPERATION RUNOFF CROSS SECTION 45

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
30.01	49.88	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 45

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
26.65	71.28	(NULL)

*** WARNING - REACH 50 INFLOW HYDROGRAPH VOLUME TRUNCATED ABOVE BASEFLOW AT 29.41 CFS, 41.26 % OF PEAK.

OPERATION REACH CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
27.59	70.82	(NULL)

OPERATION RUNOFF CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
16.35	118.06	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
19.24	154.69	(NULL)

OPERATION ADDHYD CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
22.42	212.06	(NULL)

EXECUTIVE CONTROL OPERATION ENDCMP COMPUTATIONS COMPLETED FOR PASS 1 RECORD ID

EXECUTIVE CONTROL OPERATION COMPUT FROM XSECTION 10 TO XSECTION 50 RECORD ID 5YR
STARTING TIME = .00 RAIN DEPTH = 3.10 RAIN DURATION= 1.00 RAIN TABLE NO.= 1 ANT. MOIST. COND= 2
ALTERNATE NO.= 0 STORM NO.= 2 MAIN TIME INCREMENT = .13 HOURS

OPERATION RUNOFF CROSS SECTION 10

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
22.25	59.63	(RUNOFF)

OPERATION RUNOFF CROSS SECTION 10

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
20.70	96.65	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 10

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
21.25	155.00	(NULL)

*** WARNING REACH 20 ATT-KIN COEFF.(C) GREATER THAN 0.667, CONSIDER REDUCING MAIN TIME INCREMENT ***

OPERATION REACH CROSS SECTION 20

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
21.25	155.00	(NULL)

OPERATION RUNOFF CROSS SECTION 20

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
21.68	433.60	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 20

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
21.52	588.29	(NULL)

OPERATION RESVOR STRUCTURE 1

*** WARNING-NO PEAK FOUND, MAXIMUM DISCHARGE = 7.97 CFS.

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
39.87	7.97	1644.75

*** WARNING - REACH 30 INFLOW HYDROGRAPH VOLUME TRUNCATED ABOVE BASEFLOW AT 7.97 CFS, 100.00 % OF PEAK.

OPERATION REACH CROSS SECTION 30

*** WARNING-NO PEAK FOUND, MAXIMUM DISCHARGE = 7.62 CFS.

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
39.87	7.62	(NULL)

OPERATION RUNOFF CROSS SECTION 30

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
22.77	108.32	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 30

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
22.95	110.78	(NULL)

OPERATION RUNOFF CROSS SECTION 40

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
17.77	64.11	(RUNOFF)

OPERATION REACH CROSS SECTION 45

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
18.23	63.83	(NULL)

OPERATION RUNOFF CROSS SECTION 45

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
29.38	86.13	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 45

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
26.14	122.31	(NULL)

*** WARNING - REACH 50 INFLOW HYDROGRAPH VOLUME TRUNCATED ABOVE BASEFLOW AT 48.26 CFS, 39.46 % OF PEAK.

OPERATION REACH CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
27.05	121.72	(NULL)

OPERATION RUNOFF CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
15.87	227.66	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
16.59	286.55	(NULL)

OPERATION ADDHYD CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
19.98	373.07	(NULL)

EXECUTIVE CONTROL OPERATION ENDCMP COMPUTATIONS COMPLETED FOR PASS 2 RECORD ID

EXECUTIVE CONTROL OPERATION COMPUT FROM XSECTION 10 TO XSECTION 50 RECORD ID 10YR
STARTING TIME = .00 RAIN DEPTH = 3.60 RAIN DURATION= 1.00 RAIN TABLE NO.= 1 ANT. MOIST. COND= 2
ALTERNATE NO.= 0 STORM NO.= 3 MAIN TIME INCREMENT = .13 HOURS

OPERATION RUNOFF CROSS SECTION 10

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
21.84	83.69	(RUNOFF)

OPERATION RUNOFF CROSS SECTION 10

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
20.43	130.89	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 10

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
20.90	213.07	(NULL)

*** WARNING REACH 20 ATT-KIN COEFF.(C) GREATER THAN 0.667, CONSIDER REDUCING MAIN TIME INCREMENT ***

OPERATION REACH CROSS SECTION 20

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
20.90	213.07	(NULL)

OPERATION RUNOFF CROSS SECTION 20

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
21.42	558.32	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 20

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
21.25	770.86	(NULL)

OPERATION RESVOR STRUCTURE 1

*** WARNING-NO PEAK FOUND, MAXIMUM DISCHARGE = 9.75 CFS.

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
39.87	9.75	1644.97

*** WARNING - REACH 30 INFLOW HYDROGRAPH VOLUME TRUNCATED ABOVE BASEFLOW AT 9.75 CFS, 100.00 % OF PEAK.

OPERATION REACH CROSS SECTION 30

*** WARNING-NO PEAK FOUND, MAXIMUM DISCHARGE = 9.35 CFS.

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
39.87	9.35	(NULL)

OPERATION RUNOFF CROSS SECTION 30

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
22.44	147.04	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 30

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
22.56	149.98	(NULL)

OPERATION RUNOFF CROSS SECTION 40

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
17.53	88.43	(RUNOFF)

OPERATION REACH CROSS SECTION 45

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
17.95	88.10	(NULL)

OPERATION RUNOFF CROSS SECTION 45

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
29.01	115.14	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 45

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
25.89	162.90	(NULL)

*** WARNING - REACH 50 INFLOW HYDROGRAPH VOLUME TRUNCATED ABOVE BASEFLOW AT 62.82 CFS, 38.56 % OF PEAK.

OPERATION REACH CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
26.75	162.21	(NULL)

OPERATION RUNOFF CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
15.65	320.10	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
16.31	401.58	(NULL)

OPERATION ADDHYD CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
19.30	507.24	(NULL)

EXECUTIVE CONTROL OPERATION ENDCMP COMPUTATIONS COMPLETED FOR PASS 3 RECORD ID

EXECUTIVE CONTROL OPERATION COMPUT FROM XSECTION 10 TO XSECTION 50 RECORD ID 25YR
STARTING TIME = .00 RAIN DEPTH = 4.20 RAIN DURATION= 1.00 RAIN TABLE NO.= 1 ANT. MOIST. COND= 2
ALTERNATE NO.= 0 STORM NO.= 4 MAIN TIME INCREMENT = .13 HOURS

OPERATION RUNOFF CROSS SECTION 10

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
21.47	115.82	(RUNOFF)

OPERATION RUNOFF CROSS SECTION 10

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
20.14	175.34	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 10

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
20.60	289.44	(NULL)

*** WARNING REACH 20 ATT-KIN COEFF.(C) GREATER THAN 0.667, CONSIDER REDUCING MAIN TIME INCREMENT ***

OPERATION REACH CROSS SECTION 20

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
20.60	289.44	(NULL)

OPERATION RUNOFF CROSS SECTION 20

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
21.19	714.87	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 20

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
20.97	1003.36	(NULL)

OPERATION RESVOR STRUCTURE 1

*** WARNING-NO PEAK FOUND, MAXIMUM DISCHARGE = 11.47 CFS.

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
39.87	11.47	1645.24

*** WARNING - REACH 30 INFLOW HYDROGRAPH VOLUME TRUNCATED ABOVE BASEFLOW AT 11.47 CFS, 100.00 % OF PEAK.

OPERATION REACH CROSS SECTION 30

*** WARNING-NO PEAK FOUND, MAXIMUM DISCHARGE = 11.10 CFS.

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
39.87	11.10	(NULL)

OPERATION RUNOFF CROSS SECTION 30

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
22.14	197.40	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 30

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
22.28	200.90	(NULL)

OPERATION RUNOFF CROSS SECTION 40

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
17.28	120.37	(RUNOFF)

OPERATION REACH CROSS SECTION 45

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
17.71	119.97	(NULL)

OPERATION RUNOFF CROSS SECTION 45

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
28.69	152.50	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 45

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
25.70	214.92	(NULL)

*** WARNING - REACH 50 INFLOW HYDROGRAPH VOLUME TRUNCATED ABOVE BASEFLOW AT 81.12 CFS, 37.74 % OF PEAK.

OPERATION REACH CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
26.60	214.15	(NULL)

OPERATION RUNOFF CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
15.46	442.68	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
16.14	550.56	(NULL)

OPERATION ADDHYD CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
18.73	681.98	(NULL)

EXECUTIVE CONTROL OPERATION ENDCMP COMPUTATIONS COMPLETED FOR PASS 4 RECORD ID

EXECUTIVE CONTROL OPERATION COMPUT FROM XSECTION 10 TO XSECTION 50 RECORD ID 100YR
STARTING TIME = .00 RAIN DEPTH = 5.00 RAIN DURATION= 1.00 RAIN TABLE NO.= 1 ANT. MOIST. COND= 2
ALTERNATE NO.= 0 STORM NO.= 5 MAIN TIME INCREMENT = .13 HOURS

OPERATION RUNOFF CROSS SECTION 10

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
21.15	162.88	(RUNOFF)

OPERATION RUNOFF CROSS SECTION 10

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
19.83	239.01	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 10

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
20.33	399.79	(NULL)

*** WARNING REACH 20 ATT-KIN COEFF.(C) GREATER THAN 0.667, CONSIDER REDUCING MAIN TIME INCREMENT ***

OPERATION REACH CROSS SECTION 20

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
20.33	399.79	(NULL)

OPERATION RUNOFF CROSS SECTION 20

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
20.92	931.95	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 20

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
20.68	1330.49	(NULL)

OPERATION RESVOR STRUCTURE 1

*** WARNING-NO PEAK FOUND, MAXIMUM DISCHARGE = 13.51 CFS.

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
39.87	13.51	1645.63

*** WARNING - REACH 30 INFLOW HYDROGRAPH VOLUME TRUNCATED ABOVE BASEFLOW AT 13.51 CFS, 100.00 % OF PEAK.

OPERATION REACH CROSS SECTION 30

*** WARNING-NO PEAK FOUND, MAXIMUM DISCHARGE = 13.21 CFS.

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
39.87	13.21	(NULL)

OPERATION RUNOFF CROSS SECTION 30

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
21.76	269.66	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 30

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
21.93	273.97	(NULL)

OPERATION RUNOFF CROSS SECTION 40

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
17.05	166.49	(RUNOFF)

OPERATION REACH CROSS SECTION 45

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
17.46	165.99	(NULL)

OPERATION RUNOFF CROSS SECTION 45

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
28.40	205.52	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 45

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
25.53	288.41	(NULL)

*** WARNING - REACH 50 INFLOW HYDROGRAPH VOLUME TRUNCATED ABOVE BASEFLOW AT 106.49 CFS, 36.92 % OF PEAK.

OPERATION REACH CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
26.30	287.60	(NULL)

OPERATION RUNOFF CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
15.26	621.19	(RUNOFF)

OPERATION ADDHYD CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
15.97	771.59	(NULL)

OPERATION ADDHYD CROSS SECTION 50

PEAK TIME(HRS)	PEAK DISCHARGE(CFS)	PEAK ELEVATION(FEET)
17.52	939.65	(NULL)

EXECUTIVE CONTROL OPERATION ENDCMP COMPUTATIONS COMPLETED FOR PASS 5 RECORD ID

EXECUTIVE CONTROL OPERATION ENDJOB RECORD ID

SUMMARY TABLE 1 - SELECTED RESULTS OF STANDARD AND EXECUTIVE CONTROL INSTRUCTIONS IN THE ORDER PERFORMED
(A STAR(*) AFTER THE PEAK DISCHARGE TIME AND RATE (CFS) VALUES INDICATES A FLAT TOP HYDROGRAPH
A QUESTION MARK(?) INDICATES A HYDROGRAPH WITH PEAK AS LAST POINT.)

SECTION/ STRUCTURE ID	STANDARD CONTROL OPERATION	DRAINAGE AREA (SQ MI)	RAIN TABLE #	ANTEC MOIST COND	MAIN TIME INCREM (HR)	PRECIPITATION BEGIN (HR)	PRECIPITATION AMOUNT (IN)	PRECIPITATION DURATION (HR)	RUNOFF AMOUNT (IN)	PEAK DISCHARGE * ELEVATION (FT)	PEAK DISCHARGE * TIME (HR)	PEAK DISCHARGE * RATE (CFS)	PEAK DISCHARGE * RATE (CSM)
ALTERNATE 0 STORM 1	2-YEAR												
XSECTION 10	RUNOFF	2.06	1	2	.13	.0	2.40	24.00	.39	---	23.50	31.27	15.2
XSECTION 10	RUNOFF	2.37	1	2	.13	.0	2.40	24.00	.58	---	21.36	54.53	23.0
XSECTION 10	ADDHYD	4.43	1	2	.13	.0	2.40	24.00	.49	---	22.00	84.77	19.1
XSECTION 20	REACH	4.43	1	2	.13	.0	2.40	24.00	.49	---	22.00	84.77	19.1
XSECTION 20	RUNOFF	7.92	1	2	.13	.0	2.40	24.00	.89	---	22.22	271.79	34.3
XSECTION 20	ADDHYD	12.35	1	2	.13	.0	2.40	24.00	.74	---	22.18	356.53	28.9
STRUCTURE 1	RESVOR	12.35	1	2	.13	.0	2.40	24.00	.01	1644.47	39.87?	5.60?	.5
XSECTION 30	REACH	12.35	1	2	.13	.0	2.40	24.00	.01	---	39.87?	5.27?	.4
XSECTION 30	RUNOFF	3.05	1	2	.13	.0	2.40	24.00	.52	---	23.53	60.91	20.0
XSECTION 30	ADDHYD	15.40	1	2	.13	.0	2.40	24.00	.11	---	23.71	62.80	4.1
XSECTION 40	RUNOFF	1.43	1	2	.13	.0	2.40	24.00	.55	---	18.32	34.73	24.3
XSECTION 45	REACH	1.43	1	2	.13	.0	2.40	24.00	.55	---	18.84	34.54	24.2
XSECTION 45	RUNOFF	2.99	1	2	.13	.0	2.40	24.00	.46	---	30.01	49.88	16.7
XSECTION 45	ADDHYD	4.42	1	2	.13	.0	2.40	24.00	.49	---	26.65	71.28	16.1
XSECTION 50	REACH	4.42	1	2	.13	.0	2.40	24.00	.48	---	27.59	70.82	16.0
XSECTION 50	RUNOFF	4.75	1	2	.13	.0	2.40	24.00	.51	---	16.35	118.06	24.9
XSECTION 50	ADDHYD	9.17	1	2	.13	.0	2.40	24.00	.50	---	19.24	154.69	16.9
XSECTION 50	ADDHYD	24.57	1	2	.13	.0	2.40	24.00	.25	---	22.42	212.06	8.6
ALTERNATE 0 STORM 2	5-YEAR												
XSECTION 10	RUNOFF	2.06	1	2	.13	.0	3.10	24.00	.74	---	22.25	59.63	28.9
XSECTION 10	RUNOFF	2.37	1	2	.13	.0	3.10	24.00	1.00	---	20.70	96.65	40.8
XSECTION 10	ADDHYD	4.43	1	2	.13	.0	3.10	24.00	.88	---	21.25	155.00	35.0
XSECTION 20	REACH	4.43	1	2	.13	.0	3.10	24.00	.88	---	21.25	155.00	35.0
XSECTION 20	RUNOFF	7.92	1	2	.13	.0	3.10	24.00	1.40	---	21.68	433.60	54.7
XSECTION 20	ADDHYD	12.35	1	2	.13	.0	3.10	24.00	1.21	---	21.52	588.29	47.6
STRUCTURE 1	RESVOR	12.35	1	2	.13	.0	3.10	24.00	.02	1644.75	39.87?	7.97?	.6
XSECTION 30	REACH	12.35	1	2	.13	.0	3.10	24.00	.01	---	39.87?	7.62?	.6
XSECTION 30	RUNOFF	3.05	1	2	.13	.0	3.10	24.00	.93	---	22.77	108.32	35.5
XSECTION 30	ADDHYD	15.40	1	2	.13	.0	3.10	24.00	.19	---	22.95	110.78	7.2
XSECTION 40	RUNOFF	1.43	1	2	.13	.0	3.10	24.00	.97	---	17.77	64.11	44.8
XSECTION 45	REACH	1.43	1	2	.13	.0	3.10	24.00	.97	---	18.23	63.83	44.6
XSECTION 45	RUNOFF	2.99	1	2	.13	.0	3.10	24.00	.81	---	29.38	86.13	28.8

* MUST ADD BASE FLOW OF 3.5 CFS TO GET TOTAL PEAK FLOW

SUMMARY TABLE 1 - SELECTED RESULTS OF STANDARD AND EXECUTIVE CONTROL INSTRUCTIONS IN THE ORDER PERFORMED
(A STAR(*) AFTER THE PEAK DISCHARGE TIME AND RATE (CFS) VALUES INDICATES A FLAT TOP HYDROGRAPH
A QUESTION MARK(?) INDICATES A HYDROGRAPH WITH PEAK AS LAST POINT.)

SECTION/ STRUCTURE ID		STANDARD CONTROL OPERATION	DRAINAGE AREA (SQ MI)	RAIN TABLE #	ANTEC MOIST COND	MAIN TIME INCREM (HR)	PRECIPITATION BEGIN (HR)	PRECIPITATION AMOUNT (IN)	PRECIPITATION DURATION (HR)	RUNOFF AMOUNT (IN)	PEAK DISCHARGE ELEVATION (FT)	PEAK DISCHARGE TIME (HR)	PEAK DISCHARGE RATE (CFS)	PEAK DISCHARGE RATE (CSM)
ALTERNATE 0 STORM 2														
XSECTION	45	ADDHYD	4.42	1	2	.13	.0	3.10	24.00	.86	---	26.14	122.31	27.7
XSECTION	50	REACH	4.42	1	2	.13	.0	3.10	24.00	.84	---	27.05	121.72	27.5
XSECTION	50	RUNOFF	4.75	1	2	.13	.0	3.10	24.00	.92	---	15.87	227.66	47.9
XSECTION	50	ADDHYD	9.17	1	2	.13	.0	3.10	24.00	.88	---	16.59	286.55	31.2
XSECTION	50	ADDHYD	24.57	1	2	.13	.0	3.10	24.00	.45	---	19.98	373.07	15.2
ALTERNATE 0 STORM 3 10-YEAR														
XSECTION	10	RUNOFF	2.06	1	2	.13	.0	3.60	24.00	1.03	---	21.84	83.69	40.6
XSECTION	10	RUNOFF	2.37	1	2	.13	.0	3.60	24.00	1.34	---	20.43	130.89	55.2
XSECTION	10	ADDHYD	4.43	1	2	.13	.0	3.60	24.00	1.20	---	20.90	213.07	48.1
XSECTION	20	REACH	4.43	1	2	.13	.0	3.60	24.00	1.20	---	20.90	213.07	48.1
XSECTION	20	RUNOFF	7.92	1	2	.13	.0	3.60	24.00	1.79	---	21.42	558.32	70.5
XSECTION	20	ADDHYD	12.35	1	2	.13	.0	3.60	24.00	1.58	---	21.25	770.86	62.4
STRUCTURE	1	RESVOR	12.35	1	2	.13	.0	3.60	24.00	.02	1644.97	39.87?	9.75?	.8
XSECTION	30	REACH	12.35	1	2	.13	.0	3.60	24.00	.02	---	39.87?	9.35?	.8
XSECTION	30	RUNOFF	3.05	1	2	.13	.0	3.60	24.00	1.25	---	22.44	147.04	48.2
XSECTION	30	ADDHYD	15.40	1	2	.13	.0	3.60	24.00	.26	---	22.56	149.98	9.7
XSECTION	40	RUNOFF	1.43	1	2	.13	.0	3.60	24.00	1.30	---	17.53	88.43	61.8
XSECTION	45	REACH	1.43	1	2	.13	.0	3.60	24.00	1.30	---	17.95	88.10	61.6
XSECTION	45	RUNOFF	2.99	1	2	.13	.0	3.60	24.00	1.09	---	29.01	115.14	38.5
XSECTION	45	ADDHYD	4.42	1	2	.13	.0	3.60	24.00	1.16	---	25.89	162.90	36.9
XSECTION	50	REACH	4.42	1	2	.13	.0	3.60	24.00	1.14	---	26.75	162.21	36.7
XSECTION	50	RUNOFF	4.75	1	2	.13	.0	3.60	24.00	1.25	---	15.65	320.10	67.4
XSECTION	50	ADDHYD	9.17	1	2	.13	.0	3.60	24.00	1.19	---	16.31	401.58	43.8
XSECTION	50	ADDHYD	24.57	1	2	.13	.0	3.60	24.00	.61	---	19.30	507.24	20.6
ALTERNATE 0 STORM 4 25-YEAR														
XSECTION	10	RUNOFF	2.06	1	2	.13	.0	4.20	24.00	1.42	---	21.47	115.82	56.2
XSECTION	10	RUNOFF	2.37	1	2	.13	.0	4.20	24.00	1.78	---	20.14	175.34	74.0
XSECTION	10	ADDHYD	4.43	1	2	.13	.0	4.20	24.00	1.61	---	20.60	289.44	65.3
XSECTION	20	REACH	4.43	1	2	.13	.0	4.20	24.00	1.61	---	20.60	289.44	65.3
XSECTION	20	RUNOFF	7.92	1	2	.13	.0	4.20	24.00	2.29	---	21.19	714.87	90.3
XSECTION	20	ADDHYD	12.35	1	2	.13	.0	4.20	24.00	2.04	---	20.97	1003.36	81.2
STRUCTURE	1	RESVOR	12.35	1	2	.13	.0	4.20	24.00	.03	1645.24	39.87?	11.47?	.9
XSECTION	30	REACH	12.35	1	2	.13	.0	4.20	24.00	.02	---	39.87?	11.10?	.9
XSECTION	30	RUNOFF	3.05	1	2	.13	.0	4.20	24.00	1.67	---	22.14	197.40	64.7
XSECTION	30	ADDHYD	15.40	1	2	.13	.0	4.20	24.00	.35	---	22.28	200.90	13.0
XSECTION	40	RUNOFF	1.43	1	2	.13	.0	4.20	24.00	1.74	---	17.28	120.37	84.2

SUMMARY TABLE 1 - SELECTED RESULTS OF STANDARD AND EXECUTIVE CONTROL INSTRUCTIONS IN THE ORDER PERFORMED
(A STAR(*) AFTER THE PEAK DISCHARGE TIME AND RATE (CFS) VALUES INDICATES A FLAT TOP HYDROGRAPH
A QUESTION MARK(?) INDICATES A HYDROGRAPH WITH PEAK AS LAST POINT.)

SECTION/ STRUCTURE ID	STANDARD CONTROL OPERATION	DRAINAGE AREA (SQ MI)	RAIN TABLE #	ANTEC MOIST COND	MAIN TIME INCREM (HR)	PRECIPITATION BEGIN (HR)	PRECIPITATION AMOUNT (IN)	PRECIPITATION DURATION (HR)	RUNOFF AMOUNT (IN)	PEAK DISCHARGE ELEVATION (FT)	PEAK DISCHARGE TIME (HR)	PEAK DISCHARGE RATE (CFS)	PEAK DISCHARGE RATE (CSM)
ALTERNATE 0 STORM 4													
XSECTION 45	REACH	1.43	1	2	.13	.0	4.20	24.00	1.74	---	17.71	119.97	83.9
XSECTION 45	RUNOFF	2.99	1	2	.13	.0	4.20	24.00	1.45	---	28.69	152.50	51.0
XSECTION 45	ADDHYD	4.42	1	2	.13	.0	4.20	24.00	1.54	---	25.70	214.92	48.6
XSECTION 50	REACH	4.42	1	2	.13	.0	4.20	24.00	1.51	---	26.60	214.15	48.4
XSECTION 50	RUNOFF	4.75	1	2	.13	.0	4.20	24.00	1.67	---	15.46	442.68	93.2
XSECTION 50	ADDHYD	9.17	1	2	.13	.0	4.20	24.00	1.59	---	16.14	550.56	60.0
XSECTION 50	ADDHYD	24.57	1	2	.13	.0	4.20	24.00	.81	---	18.73	681.98	27.8
ALTERNATE 0 STORM 5	100-YEAR												
XSECTION 10	RUNOFF	2.06	1	2	.13	.0	5.00	24.00	1.97	---	21.15	162.88	79.1
XSECTION 10	RUNOFF	2.37	1	2	.13	.0	5.00	24.00	2.40	---	19.83	239.01	100.8
XSECTION 10	ADDHYD	4.43	1	2	.13	.0	5.00	24.00	2.20	---	20.33	399.79	90.2
XSECTION 20	REACH	4.43	1	2	.13	.0	5.00	24.00	2.20	---	20.33	399.79	90.2
XSECTION 20	RUNOFF	7.92	1	2	.13	.0	5.00	24.00	2.97	---	20.92	931.95	117.7
XSECTION 20	ADDHYD	12.35	1	2	.13	.0	5.00	24.00	2.69	---	20.68	1330.49	107.7
STRUCTURE 1	RESVOR	12.35	1	2	.13	.0	5.00	24.00	.03	1645.63	39.87?	13.51?	1.1
XSECTION 30	REACH	12.35	1	2	.13	.0	5.00	24.00	.02	---	39.87?	13.21?	1.1
XSECTION 30	RUNOFF	3.05	1	2	.13	.0	5.00	24.00	2.27	---	21.76	269.66	88.4
XSECTION 30	ADDHYD	15.40	1	2	.13	.0	5.00	24.00	.47	---	21.93	273.97	17.8
XSECTION 40	RUNOFF	1.43	1	2	.13	.0	5.00	24.00	2.36	---	17.05	166.49	116.4
XSECTION 45	REACH	1.43	1	2	.13	.0	5.00	24.00	2.35	---	17.46	165.99	116.1
XSECTION 45	RUNOFF	2.99	1	2	.13	.0	5.00	24.00	1.97	---	28.40	205.52	68.7
XSECTION 45	ADDHYD	4.42	1	2	.13	.0	5.00	24.00	2.09	---	25.53	288.41	65.3
XSECTION 50	REACH	4.42	1	2	.13	.0	5.00	24.00	2.05	---	26.30	287.60	65.1
XSECTION 50	RUNOFF	4.75	1	2	.13	.0	5.00	24.00	2.28	---	15.26	621.19	130.8
XSECTION 50	ADDHYD	9.17	1	2	.13	.0	5.00	24.00	2.17	---	15.97	771.59	84.1
XSECTION 50	ADDHYD	24.57	1	2	.13	.0	5.00	24.00	1.10	---	17.52	939.65	38.2

SUMMARY TABLE 2 - SELECTED MODIFIED ATT-KIN REACH ROUTINGS IN ORDER OF STANDARD EXECUTIVE CONTROL INSTRUCTIONS
(A STAR(*) AFTER VOLUME ABOVE BASE(IN) INDICATES A HYDROGRAPH TRUNCATED AT A VALUE EXCEEDING BASE + 10% OF PEAK
A QUESTION MARK(?) AFTER COEFF.(C) INDICATES PARAMETERS OUTSIDE ACCEPTABLE LIMITS, SEE PREVIOUS WARNINGS)

		HYDROGRAPH INFORMATION							ROUTING PARAMETERS									PEAK	
		INFLOW		OUTFLOW		OUTFLOW+ INTERV.AREA		BASE-	VOLUME ABOVE	MAIN TIME	ITER- ATION	Q AND A EQUATION			PEAK RATIO	S/Q @PEAK	ATT- KIN	TRAVEL TIME STOR-	KINE-
XSEC ID	REACH LENGTH (FT)	PEAK (CFS)	TIME (HR)	PEAK (CFS)	TIME (HR)	PEAK (CFS)	TIME (HR)	FLOW (CFS)	BASE (IN)	INCR (HR)	#	COEFF (X)	POWER (M)	FACTOR (K*)	O/I (Q*)	(K) (SEC)	COEFF (C)	AGE (HR)	MATIC (HR)
ALTERNATE 0 STORM 1																			
20	10	85	22.0	85	22.0	357	22.1	0	.49*	.13	0	.200	1.30	.000	1.000	10	1.00?	.00	.00
30	21000	6	39.9	5	39.9	63	23.7	0	.01*	.13	1	1.50	1.25	.109	.941	8606	.05	.00	2.40
45	4000	35	18.3	35	18.8	71	26.7	0	.55	.13	1	1.20	1.20	.019	.995	1585	.26	.53	.44
50	10000	71	26.7	71	27.6	155	19.2	0	.49*	.13	1	1.20	1.20	.034	.993	3516	.13	.93	.98
ALTERNATE 0 STORM 2																			
20	10	155	21.2	155	21.2	588	21.5	0	.88	.13	0	.200	1.30	.000	1.000	8	1.00?	.00	.00
30	21000	8	39.9	8	39.9	111	22.9	0	.02*	.13	1	1.50	1.25	.098	.956	8019	.06	.00	2.23
45	4000	64	17.7	64	18.3	122	26.1	0	.97	.13	1	1.20	1.20	.017	.996	1431	.29	.53	.40
50	10000	122	26.1	122	27.1	287	16.5	0	.86*	.13	1	1.20	1.20	.030	.995	3213	.14	.93	.89
ALTERNATE 0 STORM 3																			
20	10	213	20.9	213	20.9	771	21.2	0	1.20	.13	0	.200	1.30	.000	1.000	8	1.00?	.00	.00
30	21000	10	39.9	9	39.9	150	22.5	0	.02*	.13	1	1.50	1.25	.094	.958	7702	.06	.00	2.14
45	4000	88	17.5	88	18.0	163	25.9	0	1.30	.13	1	1.20	1.20	.017	.996	1357	.30	.53	.38
50	10000	163	25.9	162	26.8	402	16.3	0	1.16*	.13	1	1.20	1.20	.028	.996	3063	.15	.93	.85
ALTERNATE 0 STORM 4																			
20	10	289	20.7	289	20.7	1003	20.9	0	1.61	.13	0	.200	1.30	.000	1.000	7	1.00?	.00	.00
30	21000	11	39.9	11	39.9	201	22.3	0	.03*	.13	1	1.50	1.25	.087	.968	7457	.06	.00	2.07
45	4000	120	17.3	120	17.7	215	25.7	0	1.74	.13	1	1.20	1.20	.016	.997	1289	.31	.40	.36
50	10000	215	25.7	214	26.5	551	16.1	0	1.54*	.13	1	1.20	1.20	.026	.996	2925	.15	.67	.81
ALTERNATE 0 STORM 5																			
20	10	400	20.3	400	20.3	1330	20.7	0	2.20	.13	0	.200	1.30	.000	1.000	7	1.00?	.00	.00
30	21000	14	39.9	13	39.9	274	21.9	0	.03*	.13	1	1.50	1.25	.081	.978	7216	.06	.00	2.01
45	4000	166	17.1	166	17.5	288	25.5	0	2.36	.13	1	1.20	1.20	.016	.997	1221	.33	.40	.34
50	10000	288	25.5	288	26.3	772	16.0	0	2.09*	.13	1	1.20	1.20	.024	.997	2785	.16	.67	.77

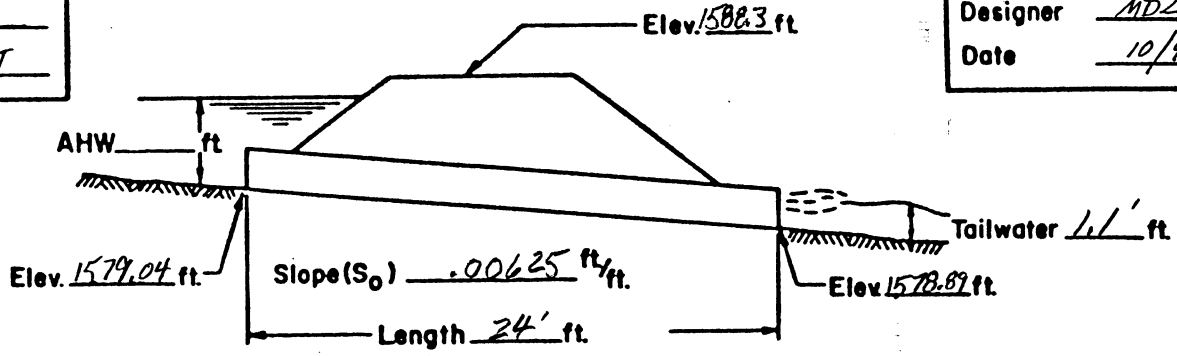
SUMMARY TABLE 3 - DISCHARGE (CFS) AT XSECTIONS AND STRUCTURES FOR ALL STORMS AND ALTERNATES

XSECTION/ STRUCTURE ID	DRAINAGE AREA (SQ MI)	STORM NUMBERS..... 1	2	3	4	5
STRUCTURE 1	12.35					
ALTERNATE 0		5.60	7.97	9.75	11.47	13.51
XSECTION 10	4.43					
ALTERNATE 0		84.77	155.00	213.07	289.44	399.79
XSECTION 20	12.35					
ALTERNATE 0		356.53	588.29	770.86	1003.36	1330.49
XSECTION 30	15.40					
ALTERNATE 0		62.80	110.78	149.98	200.90	273.97
XSECTION 40	1.43					
ALTERNATE 0		34.73	64.11	88.43	120.37	166.49
XSECTION 45	4.42					
ALTERNATE 0		71.28	122.31	162.90	214.92	288.41
XSECTION 50	24.57					
ALTERNATE 0		212.06	373.07	507.24	681.98	939.65

HYDROLOGIC AND CHANNEL INFORMATION

Project NORTH AREA
Culvert Sta. RAILROAD CULVERT

Designer MDL
Date 10/98



Hydrology:

(____ freq.) Q= _____ cfs.

(____ freq.) Q= _____ cfs.

$\frac{L}{100 S_o} = \frac{24}{} = 38.4$

Location comments:

D-602

Culvert			Q	Capacity Charts HW	Inlet Cont.		Outlet Control							Controlling HW	Outlet Velocity	Comments
~~Entrance~~	Material	Size			$\frac{HW}{D}$	HW	K_e	d_c	$\frac{d_c+D}{2}$	h_o*	H	LS_o	**HW			
BASE FLOW	RCP	30"	.5 / 1.34				.9	.1 / .2	1.35 / 1.5	1.35 / 1.35	<.1	.15	1.15 / 1.25			0.10 INCREASE
2-YR.			2.5 / 3.34				.9	.4 / .4	1.4 / 1.5	1.45 / 1.45	<.1	.15	1.3 / 1.35			0.05 INCREASE
5-YR			4.5 / 5.34		0.4 /	1.0 /	.9	.6 / .7	1.55 / 1.6	1.55 / 1.6	<.1	.15	1.4 / 1.45			0.05 INCREASE
10-YR			11.5 / 12.34				.9	1.1 / 1.2	1.8 / 1.85	1.8 / 1.85	.1 / .2	.15	1.75 / 1.88			0.05 INCREASE
25-YR			16.5 / 17.34				.9	1.3 / 1.4	1.9 / 1.95	1.9 / 1.95	.35 / .37	.15	2.1 / 2.17			0.07 INCREASE
100-YR.			24.5 / 25.34		1.0 /	2.5 /	.9	1.7 / 1.8	2.1 / 2.15	2.1 / 2.15	.76 / .78	.15	2.71 / 2.78			0.07 INCREASE

*h_o = The greater of $\frac{d_c+D}{2}$ or TW

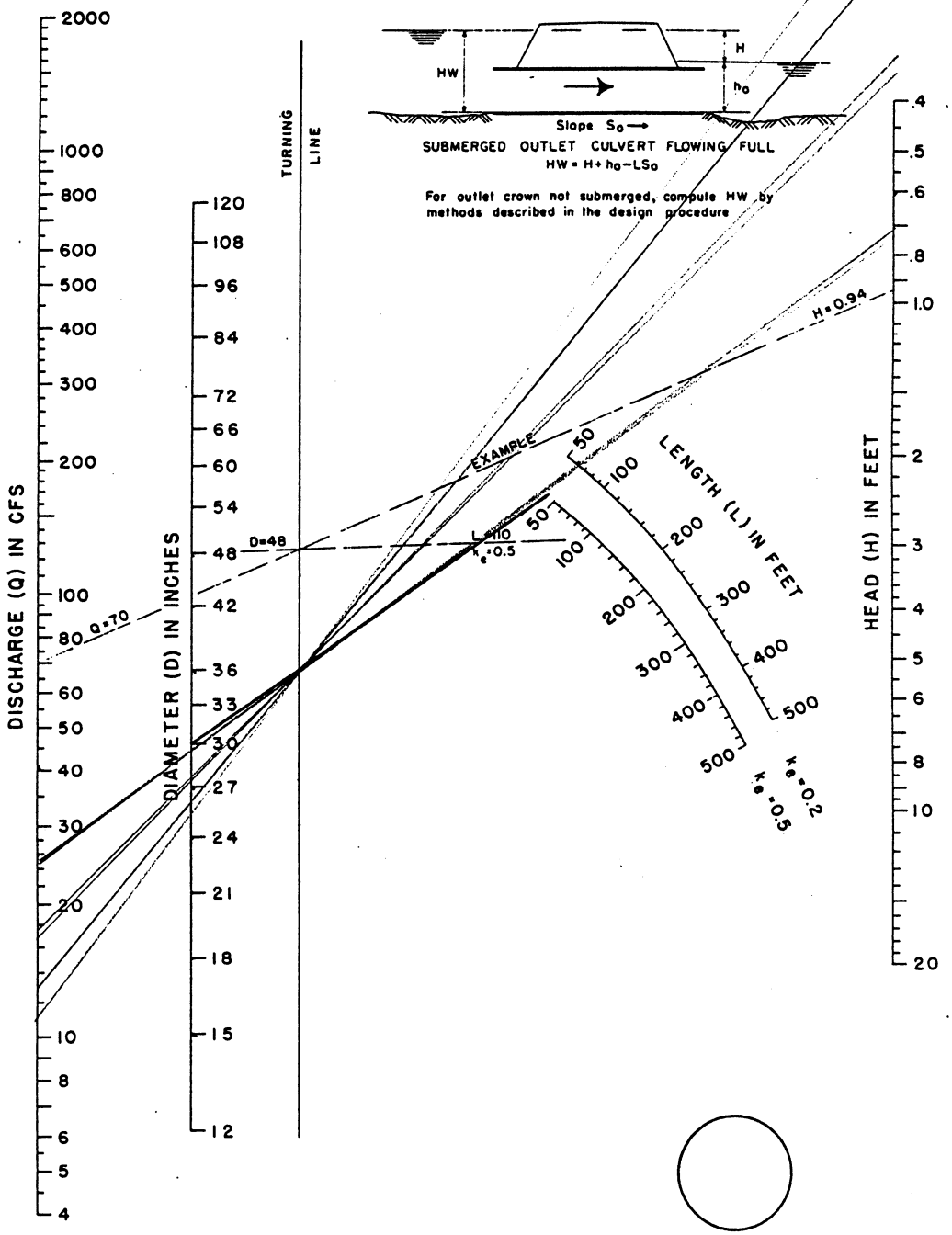
**HW = $H + h_o - LS_o$

Summary & Recommendations:

DRAINAGE

NORTH AREA
RAILROAD CULVERT

CHART 9



INCREASE 0.84 CFS

HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCFLOOD

Comment: CENTRAL VALLEY - BASE CONDITION

Solve For Depth

Given Input Data:

Bottom Width.....	380.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	0.55 cfs

Computed Results:

Depth.....	0.03 ft
Velocity.....	0.05 fps
Flow Area.....	10.35 sf
Flow Top Width...	380.44 ft
Wetted Perimeter.	380.44 ft
Critical Depth...	0.00 ft
Critical Slope...	0.5869 ft/ft
Froude Number....	0.06 (flow is Subcritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCCENT

Comment: CENTRAL VALLEY- EXISTING 2-YR

Solve For Depth

Given Input Data:

Bottom Width.....	380.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	2.00 cfs

Computed Results:

Depth.....	0.06 ft
Velocity.....	0.09 fps
Flow Area.....	22.47 sf
Flow Top Width...	380.94 ft
Wetted Perimeter.	380.95 ft
Critical Depth...	0.01 ft
Critical Slope...	0.4405 ft/ft
Froude Number....	0.06 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCFLOOD

Comment: CENTRAL VALLEY - PROPOSED 2-YR

Solve For Depth

Given Input Data:

Bottom Width.....	380.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	2.55 cfs

Computed Results:

Depth.....	0.07 ft
Velocity.....	0.10 fps
Flow Area.....	26.00 sf
Flow Top Width...	381.09 ft
Wetted Perimeter.	381.10 ft
Critical Depth...	0.01 ft
Critical Slope...	0.4174 ft/ft
Froude Number....	0.07 (flow is Subcritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCCENT

Comment: CENTRAL VALLEY- EXISTING 5-YR

Solve For Depth

Given Input Data:

Bottom Width.....	380.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	5.00 cfs

Computed Results:

Depth.....	0.10 ft
Velocity.....	0.13 fps
Flow Area.....	38.97 sf
Flow Top Width...	381.64 ft
Wetted Perimeter.	381.65 ft
Critical Depth...	0.02 ft
Critical Slope...	0.3594 ft/ft
Froude Number....	0.07 (flow is Subcritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCFLOOD

Comment: CENTRAL VALLEY - PROPOSED 5-YR

Solve For Depth

Given Input Data:

Bottom Width.....	380.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	5.55 cfs

Computed Results:

Depth.....	0.11 ft
Velocity.....	0.13 fps
Flow Area.....	41.49 sf
Flow Top Width...	381.74 ft
Wetted Perimeter.	381.76 ft
Critical Depth...	0.02 ft
Critical Slope...	0.3512 ft/ft
Froude Number....	0.07 (flow is Subcritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCCENT

Comment: CENTRAL VALLEY- EXISTING 10-YR

Solve For Depth

Given Input Data:

Bottom Width.....	380.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	13.00 cfs

Computed Results:

Depth.....	0.18 ft
Velocity.....	0.19 fps
Flow Area.....	69.22 sf
Flow Top Width...	382.90 ft
Wetted Perimeter.	382.93 ft
Critical Depth...	0.03 ft
Critical Slope...	0.2907 ft/ft
Froude Number....	0.08 (flow is Subcritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCFLOOD

Comment: CENTRAL VALLEY - PROPOSED 10-YR

Solve For Depth

Given Input Data:

Bottom Width.....	380.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	13.55 cfs

Computed Results:

Depth.....	0.19 ft
Velocity.....	0.19 fps
Flow Area.....	70.97 sf
Flow Top Width...	382.98 ft
Wetted Perimeter.	383.00 ft
Critical Depth...	0.03 ft
Critical Slope...	0.2880 ft/ft
Froude Number....	0.08 (flow is Subcritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCCENT

Comment: CENTRAL VALLEY- EXISTING 25-YR

Solve For Depth

Given Input Data:

Bottom Width.....	380.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	19.00 cfs

Computed Results:

Depth.....	0.23 ft
Velocity.....	0.22 fps
Flow Area.....	86.99 sf
Flow Top Width...	383.65 ft
Wetted Perimeter.	383.67 ft
Critical Depth...	0.04 ft
Critical Slope...	0.2672 ft/ft
Froude Number....	0.08 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCFLOOD

Comment: CENTRAL VALLEY - PROPOSED 25-YR

Solve For Depth

Given Input Data:

Bottom Width.....	380.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	19.55 cfs

Computed Results:

Depth.....	0.23 ft
Velocity.....	0.22 fps
Flow Area.....	88.50 sf
Flow Top Width...	383.71 ft
Wetted Perimeter.	383.74 ft
Critical Depth...	0.04 ft
Critical Slope...	0.2655 ft/ft
Froude Number....	0.08 (flow is Subcritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCCENT

Comment: CENTRAL VALLEY- EXISITNG 100-YR

Solve For Depth

Given Input Data:

Bottom Width.....	380.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	28.00 cfs

Computed Results:

Depth.....	0.29 ft
Velocity.....	0.25 fps
Flow Area.....	109.89 sf
Flow Top Width...	384.60 ft
Wetted Perimeter.	384.63 ft
Critical Depth...	0.06 ft
Critical Slope...	0.2452 ft/ft
Froude Number....	0.08 (flow is Subcritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCFLOOD

Comment: CENTRAL VALLEY - PROPOSED 100-YR

Solve For Depth

Given Input Data:

Bottom Width.....	380.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	28.55 cfs

Computed Results:

Depth.....	0.29 ft
Velocity.....	0.26 fps
Flow Area.....	111.19 sf
Flow Top Width...	384.65 ft
Wetted Perimeter.	384.69 ft
Critical Depth...	0.06 ft
Critical Slope...	0.2441 ft/ft
Froude Number....	0.08 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSOUT

Comment: SOUTH AREA-BASE CONDITION WITH SAS

Solve For Depth

Given Input Data:

Bottom Width.....	680.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	0.93 cfs

Computed Results:

Depth.....	0.03 ft
Velocity.....	0.05 fps
Flow Area.....	17.90 sf
Flow Top Width...	680.42 ft
Wetted Perimeter.	680.42 ft
Critical Depth...	0.00 ft
Critical Slope...	0.5943 ft/ft
Froude Number....	0.06 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSOUT

Comment: SOUTH AREA-EXISTING 2-YR

Solve For Depth

Given Input Data:

Bottom Width.....	680.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	4.00 cfs

Computed Results:

Depth.....	0.06 ft
Velocity.....	0.09 fps
Flow Area.....	42.97 sf
Flow Top Width...	681.01 ft
Wetted Perimeter.	681.02 ft
Critical Depth...	0.01 ft
Critical Slope...	0.4298 ft/ft
Froude Number....	0.07 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSOUT

Comment: SOUTH AREA-PROPOSED 2-YR

Solve For Depth

Given Input Data:

Bottom Width.....	680.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	4.93 cfs

Computed Results:

Depth.....	0.07 ft
Velocity.....	0.10 fps
Flow Area.....	48.71 sf
Flow Top Width...	681.15 ft
Wetted Perimeter.	681.15 ft
Critical Depth...	0.01 ft
Critical Slope...	0.4102 ft/ft
Froude Number....	0.07 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSOUT

Comment: SOUTH AREA-EXISTING 5-YR

Solve For Depth

Given Input Data:

Bottom Width.....	680.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	9.00 cfs

Computed Results:

Depth.....	0.10 ft
Velocity.....	0.13 fps
Flow Area.....	69.92 sf
Flow Top Width...	681.64 ft
Wetted Perimeter.	681.66 ft
Critical Depth...	0.02 ft
Critical Slope...	0.3589 ft/ft
Froude Number....	0.07 (flow is Subcritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSOUT

Comment: SOUTH AREA-PROPOSED 5-YR

Solve For Depth

Given Input Data:

Bottom Width.....	680.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	9.93 cfs

Computed Results:

Depth.....	0.11 ft
Velocity.....	0.13 fps
Flow Area.....	74.18 sf
Flow Top Width...	681.74 ft
Wetted Perimeter.	681.76 ft
Critical Depth...	0.02 ft
Critical Slope...	0.3511 ft/ft
Froude Number....	0.07 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSOUT

Comment: SOUTH AREA-EXISTING 10-YR

Solve For Depth

Given Input Data:

Bottom Width.....	680.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	24.00 cfs

Computed Results:

Depth.....	0.18 ft
Velocity.....	0.19 fps
Flow Area.....	126.05 sf
Flow Top Width...	682.96 ft
Wetted Perimeter.	682.98 ft
Critical Depth...	0.03 ft
Critical Slope...	0.2886 ft/ft
Froude Number....	0.08 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSOUT

Comment: SOUTH AREA-PROPOSED 10-YR

Solve For Depth

Given Input Data:

Bottom Width.....	680.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	24.93 cfs

Computed Results:

Depth.....	0.19 ft
Velocity.....	0.19 fps
Flow Area.....	128.96 sf
Flow Top Width...	683.03 ft
Wetted Perimeter.	683.05 ft
Critical Depth...	0.03 ft
Critical Slope...	0.2862 ft/ft
Froude Number....	0.08 (flow is Subcritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSOUT

Comment: SOUTH AREA-EXISTING 25-YR

Solve For Depth

Given Input Data:

Bottom Width.....	680.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	36.00 cfs

Computed Results:

Depth.....	0.24 ft
Velocity.....	0.22 fps
Flow Area.....	160.84 sf
Flow Top Width...	683.77 ft
Wetted Perimeter.	683.80 ft
Critical Depth...	0.04 ft
Critical Slope...	0.2638 ft/ft
Froude Number....	0.08 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSOUT

Comment: SOUTH AREA-PROPOSED 25-YR

Solve For Depth

Given Input Data:

Bottom Width.....	680.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	36.93 cfs

Computed Results:

Depth.....	0.24 ft
Velocity.....	0.23 fps
Flow Area.....	163.33 sf
Flow Top Width...	683.83 ft
Wetted Perimeter.	683.86 ft
Critical Depth...	0.05 ft
Critical Slope...	0.2623 ft/ft
Froude Number....	0.08 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSOUT

Comment: SOUTH AREA-EXISTING 100-YR

Solve For Depth

Given Input Data:

Bottom Width.....	680.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	53.00 cfs

Computed Results:

Depth.....	0.30 ft
Velocity.....	0.26 fps
Flow Area.....	202.97 sf
Flow Top Width...	684.76 ft
Wetted Perimeter.	684.80 ft
Critical Depth...	0.06 ft
Critical Slope...	0.2421 ft/ft
Froude Number....	0.08 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSOUT

Comment: SOUTH AREA-PROPOSED 100-YR

Solve For Depth

Given Input Data:

Bottom Width.....	680.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	53.93 cfs

Computed Results:

Depth.....	0.30 ft
Velocity.....	0.26 fps
Flow Area.....	205.11 sf
Flow Top Width...	684.81 ft
Wetted Perimeter.	684.85 ft
Critical Depth...	0.06 ft
Critical Slope...	0.2411 ft/ft
Froude Number....	0.08 (flow is Subcritical)

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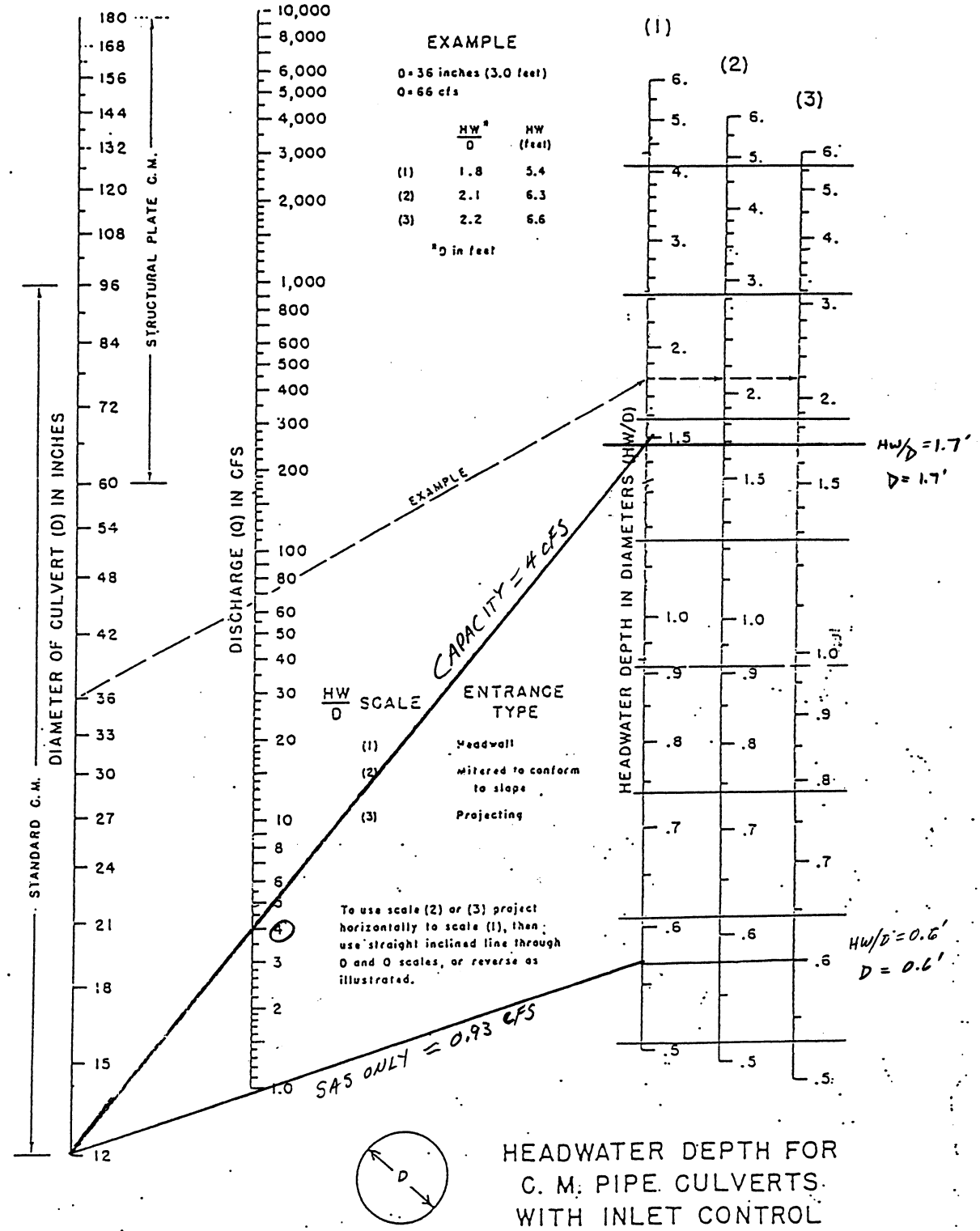
South Area 12" CMCP

CHART 5



5-33

Foth & Van Dyke

Client: NMC Scope I.D.: 93C049
Project: SOIL ABSORPTION SITE Page: 1
Prepared by: SRB Date: 10/7/98
Checked by: MDL Date: 11/12/98

CULVERT + WEIR FLOW

$$Q_{WEIR} = 3LH^{1.5}$$

$$H = \left(\frac{Q}{3L}\right)^{2/3}$$

NORTH AREA

24" CMCP: FL = 1578.9
T/O/RAIL ≈ 1588.3
AVAILABLE HW = 9.4

Capacity of 24" Before Overtop (Based on Inlet Control Nomograph) = 40 CFS

Based on Haestad Methods "TR-55" Hydrologic model, flows for this area, 2-100 year are less than 40 cfs. Therefore, there will be no weir flow. Therefore, refer to Haestad Methods "FLOWMASTER" software along with culvert nomographs for depth of water calculations.

SOUTH AREA

12" CMCP: FL = 1583.0
T/O/ROAD = 1584.7
AVAILABLE HW = 1.7

Capacity of 12" Before Overtop (Based on Inlet Control Nomograph) = 4 CFS

Depth comparison over road based on increase of flow over 4 CFS and 680 foot wide weir (WIDTH OF WETLAND at road).

* $Q = 3LH^{1.5}$, solve for H (DEPTH).

YEAR	EXISTING (Q)	PROPOSED (Q)	EXISTING (H)	PROPOSED (H)
2	4 CFS	4.98 CFS	1.70	1.71
5	10 CFS	10.98 CFS	1.72	1.72
10	27 CFS	27.98 CFS	1.75	1.75
25	40 CFS	40.98 CFS	1.77	1.77
100	60 CFS	60.98 CFS	1.79	1.79

Ex ①: $H = 1.70 + \left(\frac{0.98}{3(680)}\right)^{2/3} = 1.71$

Ex ②: $H = 1.70 + \left(\frac{6.98}{3(680)}\right)^{2/3} = 1.72$

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSWMP

Comment: SWAMP CREEK -EXISTING BASE CONDITION

Solve For Depth

Given Input Data:

Bottom Width.....	800.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	3.50 cfs

Computed Results:

Depth.....	0.05 ft
Velocity.....	0.08 fps
Flow Area.....	42.32 sf
Flow Top Width...	800.85 ft
Wetted Perimeter.	800.85 ft
Critical Depth...	0.01 ft
Critical Slope...	0.4590 ft/ft
Froude Number....	0.06 (flow is Subcritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSWMP

Comment: SWAMP CREEK -PROPOSED BASE CONDITION

Solve For Depth

Given Input Data:

Bottom Width.....	800.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	4.34 cfs

Computed Results:

Depth.....	0.06 ft
Velocity.....	0.09 fps
Flow Area.....	48.15 sf
Flow Top Width...	800.96 ft
Wetted Perimeter.	800.97 ft
Critical Depth...	0.01 ft
Critical Slope...	0.4375 ft/ft
Froude Number....	0.06 (flow is Subcritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSWMP

Comment: SWAMP CREEK -EXSITNG 2-YR

Solve For Depth

Given Input Data:

Bottom Width.....	800.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	66.50 cfs

Computed Results:

Depth.....	0.31 ft
Velocity.....	0.27 fps
Flow Area.....	248.11 sf
Flow Top Width...	804.95 ft
Wetted Perimeter.	804.99 ft
Critical Depth...	0.06 ft
Critical Slope...	0.2386 ft/ft
Froude Number....	0.09 (flow is Subcritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSWMP

Comment: SWAMP CREEK -PROPOSED 2-YR

Solve For Depth

Given Input Data:

Bottom Width.....	800.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	67.34 cfs

Computed Results:

Depth.....	0.31 ft
Velocity.....	0.27 fps
Flow Area.....	249.99 sf
Flow Top Width...	804.98 ft
Wetted Perimeter.	805.02 ft
Critical Depth...	0.06 ft
Critical Slope...	0.2380 ft/ft
Froude Number....	0.09 (flow is Subcritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSWMP

Comment: SWAMP CREEK -EXISTING 5-YR

Solve For Depth

Given Input Data:

Bottom Width.....	800.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	114.50 cfs

Computed Results:

Depth.....	0.43 ft
Velocity.....	0.33 fps
Flow Area.....	344.08 sf
Flow Top Width...	806.85 ft
Wetted Perimeter.	806.91 ft
Critical Depth...	0.09 ft
Critical Slope...	0.2115 ft/ft
Froude Number....	0.09 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSWMP

Comment: SWAMP CREEK -PROPOSED 5-YR

Solve For Depth

Given Input Data:

Bottom Width.....	800.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	115.34 cfs

Computed Results:

Depth.....	0.43 ft
Velocity.....	0.33 fps
Flow Area.....	345.59 sf
Flow Top Width...	806.88 ft
Wetted Perimeter.	806.94 ft
Critical Depth...	0.09 ft
Critical Slope...	0.2112 ft/ft
Froude Number....	0.09 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSWMP

Comment: SWAMP CREEK -EXISTING 10-YR

Solve For Depth

Given Input Data:

Bottom Width.....	800.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	153.50 cfs

Computed Results:

Depth.....	0.51 ft
Velocity.....	0.37 fps
Flow Area.....	410.51 sf
Flow Top Width...	808.17 ft
Wetted Perimeter.	808.23 ft
Critical Depth...	0.10 ft
Critical Slope...	0.1982 ft/ft
Froude Number....	0.09 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSWMP

Comment: SWAMP CREEK -PROPOSED 10-YR

Solve For Depth

Given Input Data:

Bottom Width.....	800.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	154.34 cfs

Computed Results:

Depth.....	0.51 ft
Velocity.....	0.37 fps
Flow Area.....	411.86 sf
Flow Top Width...	808.20 ft
Wetted Perimeter.	808.26 ft
Critical Depth...	0.10 ft
Critical Slope...	0.1979 ft/ft
Froude Number....	0.09 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSWMP

Comment: SWAMP CREEK -EXISTING 25-YR

Solve For Depth

Given Input Data:

Bottom Width.....	800.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	204.50 cfs

Computed Results:

Depth.....	0.61 ft
Velocity.....	0.42 fps
Flow Area.....	487.98 sf
Flow Top Width...	809.70 ft
Wetted Perimeter.	809.78 ft
Critical Depth...	0.13 ft
Critical Slope...	0.1860 ft/ft
Froude Number....	0.10 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSWMP

Comment: SWAMP CREEK -PROPOSED 25-YR

Solve For Depth

Given Input Data:

Bottom Width.....	800.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	205.34 cfs

Computed Results:

Depth.....	0.61 ft
Velocity.....	0.42 fps
Flow Area.....	489.19 sf
Flow Top Width...	809.72 ft
Wetted Perimeter.	809.80 ft
Critical Depth...	0.13 ft
Critical Slope...	0.1858 ft/ft
Froude Number....	0.10 (flow is Subcritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSWMP

Comment: SWAMP CREEK -EXISTING 100-YR

Solve For Depth

Given Input Data:

Bottom Width.....	800.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	277.50 cfs

Computed Results:

Depth.....	0.73 ft
Velocity.....	0.47 fps
Flow Area.....	586.63 sf
Flow Top Width...	811.65 ft
Wetted Perimeter.	811.74 ft
Critical Depth...	0.16 ft
Critical Slope...	0.1738 ft/ft
Froude Number....	0.10 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: NMCSWMP

Comment: SWAMP CREEK -PROPOSED 100-YR

Solve For Depth

Given Input Data:

Bottom Width.....	800.00 ft
Left Side Slope..	8.00:1 (H:V)
Right Side Slope.	8.00:1 (H:V)
Manning's n.....	0.080
Channel Slope....	0.0010 ft/ft
Discharge.....	278.34 cfs

Computed Results:

Depth.....	0.73 ft
Velocity.....	0.47 fps
Flow Area.....	587.70 sf
Flow Top Width...	811.67 ft
Wetted Perimeter.	811.76 ft
Critical Depth...	0.16 ft
Critical Slope...	0.1737 ft/ft
Froude Number....	0.10 (flow is Subcritical)

Open Channel Flow Module, Version 3.21 (c) 1990
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Appendix L

Work Plan for Baseline Environmental Monitoring at Area H

Nicolet Minerals
COMPANY

Rhinelander Office: 7 N. Brown Street, 3rd Floor • Rhinelander, WI 54501-3161 • Ph: 715.365.1450 • Fax: 715.365.1457
Crandon Office: 104 W. Madison Street, P.O. Box 336 • Crandon, WI 54520-0336 • Ph: 715.478.3393 • Fax: 715.478.3641
Web Site: www.crandonmine.com

November 6, 1998

Ms. Char Hauger
U. S. Army Corps of Engineers
St. Paul District
190 5th Street East
St. Paul, MN 55101-1638

Mr. Bill Tans
Wisconsin Department of Natural Resources
Bureau of Integrated Science Services
101 South Webster Street
P.O. Box 7921
Madison, WI 53707-7921

Dear Ms. Hauger and Mr. Tans:

Re: Crandon Project - Environmental Data Collection for Soil Absorption Site - Area H

In early 1998, Nicolet Minerals Company (NMC) reinitiated investigations to determine if a suitable site could be located in the vicinity of its Crandon Project for the installation of a soil absorption system (SAS) to accept treated water from the project's planned wastewater treatment plant. The nature of the investigations was discussed in various work plans previously provided to your agencies. Details regarding the results of the investigations will be presented in a SAS design report to be submitted to the appropriate regulatory agencies and others in the near future.

One of a number of potential sites that shows promise for the development of a soil absorption system is located just north of the intersection of the project's proposed railroad spur and the Wisconsin Central Limited Railroad. This site, referred to as Area H (Figure 1), consists of an approximate 200 acre parcel of land. The site is situated north and west of Swamp Creek.

A significant amount of environmental data related to geology, hydrogeology, wetlands, groundwater quality, etc., has been collected to date for Area H in accordance with the above-referenced work plans. NMC has determined that the collection of additional

site-specific environmental data is desirable. The additional data collection will include flora and fauna, surface water, groundwater and leach tests on and in the vicinity of Area H.

The proposed aquatic investigations will focus on aquatic macrophytes, fish, mussels, and macroinvertebrates. Terrestrial investigations will focus mainly on the plant communities within the surrounding wetlands. Surface water investigations will include water quality monitoring within selected surface water bodies in the vicinity of the site, and measurement of flow in Stream 17-13. Two rounds of sampling and analysis are planned for surface water monitoring sites.

Two rounds of samples have been collected from three on-site groundwater monitoring wells as part of the site investigations performed at Area H. The samples were analyzed for selected metals, inorganic parameters, and priority pollutants, among others. Finally, water leach tests on soils that would be beneath an operating soil absorption system will be conducted to assess the potential to leach agricultural chemicals, if present, and to assess the leachability of anions and cations (especially iron and manganese) from site soils.

NMC is collecting the environmental data specified above to assist the regulatory agencies in their environmental review process and in the preparation of their respective environmental impact statements. Prior to commencement of construction, NMC will conduct additional baseline monitoring related to Area H. A plan for this work will be submitted at a future date.

It should also be noted that, since 1993, NMC has collected appreciable environmental data in and around its proposed project area. Some of that data has been collected near Area H. The data collected specific to Area H is to be used as a supplement to, or in addition to, data previously collected. Finally, data collection and analytical procedures for the work identified in this plan will be performed in accordance with previously submitted protocols for the Crandon Project. Personnel performing the work will be individuals who have completed such work for the project in the past.

A presentation of proposed environmental data collection work elements follows. A listing of planned field events and their proposed schedule are presented in Table 1.

Aquatic Macrophytes

An investigation will be conducted within Swamp Creek from its confluence with Hemlock Creek upstream to Creek 17-13. Creek 17-13 will also be investigated upstream to a point approximately 1,200 ft north of the confluence with the feeder creek

flowing out of wetland Z16. The feeder creek will also be investigated. In addition, an investigation will be conducted on Lake 17-16. The purpose of the investigations will be to identify plant species which may appear on the Natural Heritage Inventory List. The investigations will be scheduled for the low-flow periods of July or August of 1999, depending on field conditions. The aquatic plant search team will consist of Bradley Helmandollar of Foth & Van Dyke and Gary Fewless of the University of Wisconsin Green Bay (UWGB). Voucher specimens of listed species will be collected and retained at the UWGB herbarium for documentation.

Fish

The investigation for fish species will be conducted within the same study area as described in the aquatic macrophyte section. Sampling will take place during early to mid November of 1998. The fish sampling team will consist of Bradley Helmandollar of Foth & Van Dyke and Gregory Seegert of EA Engineering. Following is an overview of sampling locations and procedures.

- The study area will be visually surveyed for brook trout spawning activity. Spawning areas and suitable spawning habitat will be noted.

- Swamp Creek will be sampled in at least two locations to characterize the composition of the fish community and to determine whether state-listed species are present. The two locations will be determined based on the information collected during the trout spawning area identification effort. Each of the two locations will be sampled by electrofishing a 200-meter segment of the stream.

- Creek 17-13 will be sampled using electrofishing equipment or seining (depending on bottom type) at one 150-meter segment.

- Lake 17-16 will be sampled using a 12-foot minishocker. The entire shoreline of the lake will be sampled. According to Steve AveLallemant of the WDNR, the conductivity of Lake 17-16 may reduce the effectiveness of electrofishing. If the mini-shocker is ineffective, a gill net will be used to complete the sampling.

Fish captured during these efforts will be counted and identified. Collection of fish specimens is not anticipated.

Mussels

The investigation for mussels will be conducted within the same study area described in the Aquatic Macrophyte section. Target species for the collection effort will be the

same as those for the sampling effort previously completed in 1994 both downstream on Swamp Creek and on Hemlock Creek, with any additions which may have been made to the Natural Heritage Inventory. Mussel collection activities will be conducted in June 1999 by Donald Helms of Helms & Associates. Because of the relatively shallow depth of Swamp Creek, the search team will likely use snorkel equipment to locate mussels. If deeper water is encountered, divers will be required.

If mussel beds are noted within the study area, a minimum of three beds will be evaluated. A "bed" of mussels may consist of an area of several feet in length or, depending on substrate and other conditions, 300 feet or more in length. If defined beds are located, collectors will randomly pick 20 mussels and place them in a mesh bag or several mesh bags. The mesh bags will be brought to shore, remaining submerged, where a taxonomist will identify the mussels. Collectors will repeat this procedure picking 20 mussels at a time until no new species are found for six replicate picking efforts. If insufficient mussels are encountered within a bed to accomplish this protocol, then the collectors will continue to search for four hours in lieu of completing six replicate collections.

In addition to general reconnaissance and hand picking techniques described above, bank searches will also be conducted. Field technicians will walk designated sections of the river looking for shells which may lie in the shallows or which other animals may have left along the bank. Shells may also be found during other aquatic investigations. These findings will be documented and will supplement the in-stream picking technique.

Live specimens of mussels which have been identified will be returned to the approximate location of their finding and replaced with proper alignment to substrate and flow. Collected voucher specimens will be retained per requirements of the Wisconsin Department of Natural Resources collector's permit.

General Macroinvertebrates

Aquatic macroinvertebrates, including Odonata, will be collected within the study area described in the aquatic macrophyte section of this letter. A search for these species will be conducted in the fall of 1998 and the spring and early summer of 1999. Specific search dates are presented in Table 1. The collection team for this field effort will consist of Mr. William West of Environmental Compliance Consultants, Inc. (ECCI) and Dr. Kenneth Tennessen of the Tennessee Valley Authority (TVA).

Qualitative in-stream sampling efforts of macroinvertebrates other than Odonata will include the use of dip nets to hand pick sections of the creeks selected from general

areas identified to represent a cross section of available micro-habitats (i.e., pool, riffles, detrital masses in slackwater, cut banks with overhanging cover, snags, and various bottom types). Each micro-habitat will be sampled by hand picking for no less than one hour, or until a five minute period produces no new species, whichever is longest. Some organisms such as the nymphs of Ephemeroptera and Plecoptera as well as the larvae of Trichoptera and Coleoptera generally cannot be identified to species. Therefore, sampling for adults using UV light traps and sweep netting will be conducted during the specific known flight seasons of target species (i.e., late spring/early summer).

In addition, a riffle area in each site will be sampled using a surber sampler. Triplicate samples will be taken at each site. Pools with soft bottom substrates will be sampled using an Ekman dredge for collection of infaunal forms. Triplicate samples will be taken at each location. Samples will be washed through a surber net (mesh size 600 - 800) and preserved in formalin. Sampling locations for the general macroinvertebrate collections and Odonata nymphs will be the same as those described for the exuviae collections. Dr. Tennessen will provide specimen verification.

Odonata

The field investigations for Odonata will employ three techniques for collecting Odonata, including collection of exuviae from shoreline habitats, observation and collection of adult specimens, and in stream sampling. Depending on the species of Odonata, one collection technique may be more suited than the other for obtaining information on potential species. For instance, the gomphid dragonflies will be most easily sampled by the collection of exuviae. Exuviae can be found along the banks of streams and lakes and on vegetation or other objects immediately after adults have emerged from the water body in spring and early summer. Because of their relative size, members of the genus *Somatochlora* are best surveyed as adults.

In general, all larval Odonata may be collected using in-stream sampling techniques in either the fall or early spring, while most species are in the late instars or at pre-emergence stages. It should be noted that in-stream sampling techniques may underestimate the numbers of organisms present and may miss some populations altogether. The collection of exuviae is a good technique for obtaining specimens which are uncommon or rare in an area and for determining relative species abundance. It is proposed to collect exuviae in the spring/early summer. A field reconnaissance may be required to determine the specific timing of the emergence. Typically in northern Wisconsin, emergence will occur in late May or the first two weeks of June for the gomphids, although one gomphid (*Stylurus scudderi*) does not emerge until the second week of July. Depending on exuviae abundance, 150 to 300 ft segments of

stream will be searched intensely. Both sides of the stream will be searched. All specimens observed within a collection area will be included in the collection.

Terrestrial Biology

The terrestrial biological investigations will concentrate mainly on the wetland areas to the east of the proposed system and the western and northern shore of Swamp Creek from its confluence with Hemlock Creek upstream to Creek 17-13. The upland areas located within Area H are comprised of active agricultural land and, therefore, will only be briefly investigated.

Two field investigations will be conducted by Bradley Helmandollar of Foth & Van Dyke and Gary Fewless of UWGB. The first will be completed during the fall of 1998 and will consist of walking several transects through the wetlands in the study and documenting the dominant vegetation. This information will be used to further identify the vegetation cover type within each of the wetland areas. In addition, once compiled, this information will be used to identify areas that may potentially contain species listed on the Wisconsin Natural Heritage Inventory List. The second field investigation will be conducted in the late spring and/or early summer of 1999. This investigation will focus on identifying threatened, endangered and/or special concern species within the wetland areas.

No investigations for terrestrial fauna are proposed for this field effort. The potential presence or absence of threatened endangered and/or special concern species within the area of influence can be inferred from the vast data base collected for the mine site and surrounding study area. This assumption will be confirmed based on the vegetation cover type (habitat type) information collected in the fall of 1998.

Surface Waters

Surface water monitoring will consist of gathering two rounds of flow and water quality data at selected locations by Foth & Van Dyke personnel.

Flow data will be recorded at the culvert where the small feeder to Creek 17-13 crosses the Wisconsin Central Limited Railroad tracks. This sampling point is designated as SG-Z16 on Figure 1. Flow data for Creek 17-13 will be recorded at sampling point SG 17-13. Flow data will also be recorded at sampling point SG-KSR where wetland Z16 (south) terminates along Keith Siding Road. Flow data at all three locations will be collected in the fall of 1998, before ice conditions develop, and during the winter ice cover conditions. In the spring of 1999, a site visit will be made during the peak runoff period to observe and document surface water flow patterns in the

vicinity of Area H. If channelized flow is suitable for flow monitoring, velocity and cross-section information will be collected to quantify peak surface water runoff conditions.

Surface water quality samples will be collected from Lake 17-16 and at the following three creek locations as shown on Figure 1: SG-Z16, SG17-13, and SG-5A. The sample results from LG17-16, SG-Z16, and SG-17-13 will characterize surface water quality in the immediate vicinity of Area H. Sample results from SG-5A will provide contemporaneous data for Swamp Creek, immediately downstream of Area H. Two rounds of water quality samples will be collected. The first sampling will occur in the fall of 1998 before ice conditions develop. The second round will occur during the winter after ice conditions develop. Table 2 contains the planned parameter list with expected analytical methods and reporting limits specified.

Groundwater Monitoring

NMC has completed two rounds of groundwater quality sampling at groundwater monitoring wells MWH-10, MWH-11, and MWH-13 (Figure 1) to assess existing groundwater quality conditions at the site. The parameter list for the first round of groundwater quality monitoring includes:

Hardness	Total Dissolved Solids
Metals	Fluoride
Cyanide	Herbicides
Total Kjeldahl Nitrogen	Aldicarb
Chemical Oxygen Demand	Organic Chlorine Pesticides
Nitrate & Nitrite	

The parameter list for the second round of groundwater quality monitoring includes, in addition to the above parameters, the following groups of priority pollutants:

Volatile Organic Compounds	Base/Neutral Compounds
Metals	Pesticides/PCBs
Acid Extractable Compounds	Total Cyanide/Total Phenols

In addition, field conductivity measurements were taken at all on-site groundwater monitoring wells during the second round of sample collection.

Water Leach Testing

Four soil samples (Figure 1) will be collected by Foth & Van Dyke personnel from Area H for the purpose of performing water leach tests to determine the potential for the discharged water to leach agricultural chemicals and other anions and cations from the soil. The samples will be collected for the unsaturated soil horizon below the limit of excavation of the soil absorption system. Testing will be performed using the synthetic precipitation leaching procedure (SPLP) Method 1312, modified as discussed below.

For locations east of the Mississippi River, the SPLP protocol specifies a leachant of Grade A water adjusted to a pH of 4.2 su, using a 60/40 wt percent mixture of sulphuric and nitric acids. This leachant composition has been designed to evaluate the effects of acid rain. Treated Crandon Project effluent, unlike rain, will not pass through the atmosphere, and, therefore, will not have characteristics similar to that of acid rain. The treated effluent pH will be maintained at neutral conditions, and will be characterized by very low solute concentrations. The acidic leachant specified in the SPLP Method 1312 is, therefore, not appropriate for the test conditions associated with Area H soils. A more appropriate leachant for the planned tests is deionized water. Therefore, the proposed tests will be completed with deionized water.

Reporting

Upon completion of 1998 field activities and receipt of laboratory results for samples collected during these field activities, NMC will summarize the work and provide results and interpretations in a report. Following completion of 1999 field work, NMC will submit a supplement to the original report documenting the additional work and interpreting the results.

Should you have any questions regarding this proposed work, please contact me at (715) 478-3393.

Sincerely,

Gordon Reid
Manager of Engineering
Nicolet Minerals Company

GR:cer1

Attachments

cc: Mr. Archie Wilson, Wisconsin Department of Natural Resources
Mr. Larry Lynch, Wisconsin Department of Natural Resources
Mr. Paul Luebke, Wisconsin Department of Natural Resources
Mr. Christopher Carlson, Wisconsin Department of Natural Resources
Mr. Dave Heath, Wisconsin Department of Natural Resources
Mr. John Pohlman, Wisconsin Department of Natural Resources
Mr. Robert Jaeger, U. S. Department of the Interior
Mr. Philip Shopodock, Forest County Potawatomi
Mr. Charlie Fox, Sokaogon Chippewa Community
Apesanahkwat, Menominee Indian Tribe of Wisconsin
Mr. Philip Seem, Menominee Indian Tribe of Wisconsin
Mr. Doug Cox, Menominee Indian Tribe of Wisconsin
Mr. Dan Cozza, U. S. Environmental Protection Agency
Mr. John Coleman, University of Wisconsin-Madison
Mr. Mark Meyers, U. S. Army Corps of Engineers
Ms. Joanne Tacopina, Town of Nashville
Mr. Jerry Sevick, Foth & Van Dyke

Table 1

Proposed Field Investigation Schedule

Field Activity	1998	1999
A) Flora and Fauna		
Aquatic Macrophytes	N/A	July-August
Fish	November	N/A
Mussels	N/A	June
Macroinvertebrates		
Benthos Collections	November	N/A
Light Trapping	N/A	May - June
Odonata	N/A	May - June - July
Exuviae	N/A	June
Terrestrial Cover Types	October-November	June - July
Vegetation	N/A	June - July
B) Surface Waters	November	January - February
C) SPLP Testing	November	N/A

Prepared by: BDH
Checked by: JWS

Table 2

Surface Water Monitoring Program

Analyte	Analytical Method	Reporting Limit
Laboratory Parameters		
Alkalinity, Bicarbonate	SM 2320B	10 mg/l
Alkalinity, Carbonate	SM 2320B	10 mg/l
Alkalinity, Total	SM 2320B	10 mg/l
Aluminum, Total	EPA 200.7	50 μg/l
Antimony, Total	EPA 200.7	5 μg/l
Arsenic (LL)	EPA 1632	0.01 μg/l
Barium, Total	EPA 200.7	5 μg/l
Beryllium, Total	EPA 200.7	1 μg/l
BOD_5	EPA 405.1	2 mg/l
Boron, Total	EPA 200.7	100 μg/l
Cadmium (LL)	EPA 1638	0.02 μg/l
Calcium, Total	EPA 200.7	100μg/l
COD	EPA 410.4	5 mg/l
Chloride	EPA 325.1	2 mg/l
Chlorophyll a	SM 10200H	0.2 mg/1,000L[1]
Chromium (LL)	EPA 1638	0.1 μg/l
Color	EPA 110.2	1 (color unit)
Copper (LL)	EPA 1638	0.02 μg/l
Cyanide, Total	EPA 335.4	0.01 mg/l
Fluoride	SM 4500F-C	0.1 mg/l
Hardness	EPA 200.7	100 μg/l
Iron, Total	EPA 200.7	50 μg/l
Lead (LL)	EPA 1638	0.01 μg/l
Manganese, Total	EPA 200.7	2 μg/l

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Table 2 *(Continued)*

Analyte	Analytical Method	Reporting Limit
Magnesium, Total	EPA 200.7	30 µg/l
Mercury (LL)	EPA 1631	0.0005 µg/l
Molybdenum, Total	EPA 200.7	6 µg/l
Nickel (LL)	EPA 1638	0.03 µg/l
Nitrogen, Ammonia	EPA 350.3	0.1 mg/l
Nitrogen, Kjeldahl	EPA 351.3	0.1 mg/l
Nitrogen, Nitrate	EPA 354.1/353.2	0.05 mg/l
Oil & Grease	EPA 413.1	5 mg/l
pH	EPA 150.1	0.1 SU
Phosphorous, Dissolved	EPA 1638	3 µg/l
Phosphorous (LL)	EPA 1638	3 µg/l
Potassium, Total	EPA 200.7	100 µg/l
Selenium (LL)	EPA 1638	0.6 µg/l
Silver (LL)	EPA 1638	0.01 µg/l
Sodium, Total	EPA 200.7	300 µg/l
TDS	EPA 160.1	20 mg/l
TSS	EPA 160.2	10 mg/l
TVS	EPA 160.4	20 mg/l
Sulfate	EPA 375.2	10 mg/l
Thallium (LL)	EPA 1638	0.01 µg/l
Turbidity	EPA 180.1	0.1 NTU
Zinc (LL)	EPA 1638	0.05 µg/l
Field Parameters		
Conductivity	EPA 120.1	1 umho/cm
Oxygen, Dissolved	SM 4500-0G	1 mg DO/l
pH	EPA 150.1	0.1 SU

Table 2 *(Continued)*

Analyte	Analytical Method	Reporting Limit
Secchi Disk Reading	(A)	0.5 ft
Temperature	SM 2550	1.0°C

[1]Reporting limit dependent on water clarity.
LL = low level analyses by Battelle Marine Sciences.
(A) = see attached procedure.

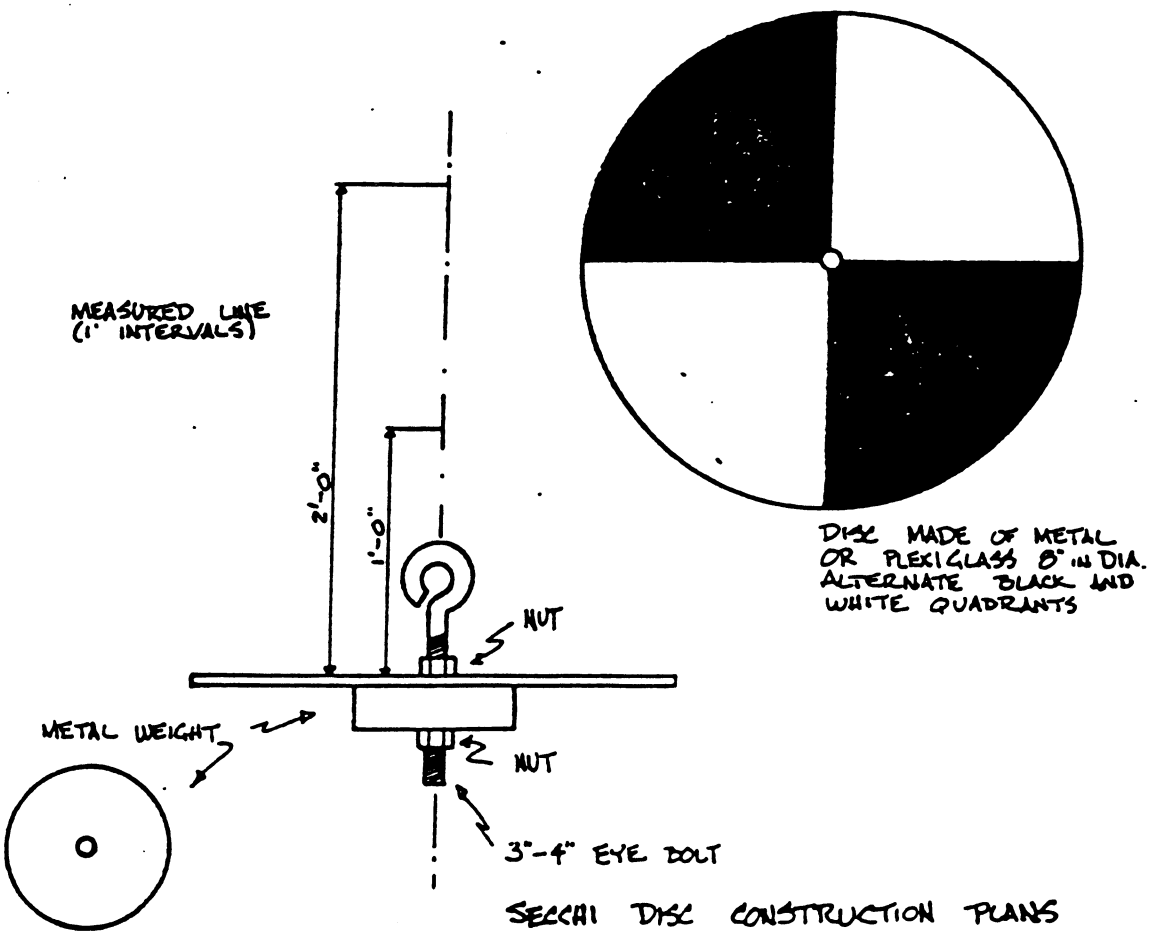
Prepared by: RTJ
Checked by: JWS

THE SECCHI DISC

The Secchi disc is a simple, scientific instrument used to measure water transparency. Secchi disc transparency is a measure of the clarity of the water, and is a quick, simple, and accurate method for estimating lake water quality. Factors which reduce the clarity are algae, zooplankton, water color, and silt. Since algae is usually the most abundant item, one is indirectly measuring the algal population when measuring transparency. This test for transparency is the most frequently collected and commonly used indicator of lake water quality.

Construction

A typical construction plan is shown below.



SECCHI DISC CONSTRUCTION PLANS

Making the Measurements

- Secchi disc measurements should be made on a weekly schedule between May 1 and September 30 of each year. More frequent measurements, i.e. daily, are desirable.

- Disc readings should be taken over the deepest basin (area) of the lake, preferably between 10:00 a.m. and 4:00 p.m. If possible, readings should not be taken during times of the day when the lake is rough or being used by a large number of motor-powered boats which may agitate bottom sediments and reduce clarity. Supplementary readings taken in different areas of the lake, can be valuable if the lake has an irregular configuration or distinct basins or inlet regions.

- Anchor the boat before measuring the transparency to ensure that the Secchi disc is observed straight down, instead of at an angle.

- Disc measurements should be obtained by lowering the disc into the water on the shaded side of the boat. The observer should lean over the side of the boat so that he is directly over the disc as it is lowered. The depth at which the disc just disappears is noted. It is then raised slowly until it again becomes visible and that depth is noted. The point half-way between the two readings is the Secchi disc measurement. The disc should then be raised several feet and the procedure repeated and an average for the two values calculated. Report transparency to the nearest one-half foot.

- Secchi disc readings will vary from day-to-day at different locations within any one lake, so the measurements should be made at the same location for all samples. This will make data comparable from year-to-year or week-to-week.

- After determining the Secchi disc measurement the information is recorded along with any other relevant information such as current weather, a recent runoff event, or heavy motorboat traffic which might affect the reading.

2,280,000 E

2,285,000 E

2,290,000 E

130,000 N

125,000 N

LAKE METONGA

SCHALK LN

ROHR LN

COUNTY PARK RD

OUTLET CREEK

APPROXIMATE LIMITS OF SOIL ABSORPTION SYSTEM

APPROXIMATE LIMITS OF STUDY AREA

Z16 (NORTH) MWH-13

SPLP-1

SG-17-15

Z16 (NORTH)

APPROXIMATE LOCATION OF CREEK 17-13

EXISTING 8" CMCP

SG-Z16

CULVERT 30" RCP

SPLP-2

SPLP-3

MWH-10

24" CMCP

MWH-11

Z16 (CENTRAL)

WOODEN BOX CULVERT 4.5' x 3'

EXCAVATED DITCH

SG 17-16

LAKE (17-16)

15" CMCP

SPLP-4

Z16 (SOUTH)

SG-KSR

12" CMCP

KEITH SIDING RD

SG-5

SWAMP CREEK

HEMLOCK CREEK

PROPOSED RAILROAD SPUR

PROPOSED PIPELINE ROUTE

WISCONSIN CENTRAL LIMITED RAILROAD

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- 1675 EXISTING CONTOUR
- SWAMP/WETLAND
- TRAILS
- TREES
- RAILROAD
- WETLANDS
- PROPOSED SOIL ABSORPTION SYSTEM LOCATION
- PROPOSED PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- MWH-13 MONITORING WELL NUMBER AND LOCATION
- SG-Z16 SURFACE WATER MONITORING LOCATION
- SPLP-1 WATER LEACH TEST SAMPLE COLLECTION POINT
- APPROXIMATE LIMITS OF SOIL ABSORPTION SYSTEM
- APPROXIMATE LIMITS OF STUDY AREA
- Z16 WETLAND NAME
- DISTURBED WETLAND AREA NOT PREVIOUSLY DELINEATED AS A WETLAND

NOTES:

1. SAS TOPOGRAPHY AND WETLAND SPOT ELEVATIONS NORTH OF KEITH SIDING ROAD FROM SURVEY COMPLETED BY FOTH & VAN DYKE IN LATE SUMMER, 1998. CONTOUR INTERVAL IS ONE FOOT.
2. TOPOGRAPHY, WATER BODIES, WETLANDS, ETC. OUTSIDE SAS AREA BASED ON TOPOGRAPHIC BASE MAP DIGITIZED FROM THE 1" = 1000' SCALE 5 FOOT CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING INC., SHEBOYGAN, WI. DATE OF PHOTOGRAPHY APRIL 28, 1976.
3. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
4. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	TWS	DATE: NOV '98
APPROVED BY:	GWS	DATE: NOV '98
APPROVED BY:		DATE:

Nicolet Minerals COMPANY

Mining for the Future Commitment

FIGURE 1

PROPOSED AREA H MONITORING SITES

Scale: 0 500' 1000'		Date: NOVEMBER, 1998	
Prepared By: Foth & Van Dyke	By: JOW	93C049	

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