Final engineering report for wastewater treatment facilities for the Kennecott Flambeau Project. 1989

Green Bay, Wisconsin: Foth & Van Dyke and Associates, Inc., 1989

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December 15, 1989

Kennecott
87K102

Mr. Michael D. Witt
Chief, Industrial Wastewater Section
Wisconsin Department of Natural Resources
101 S. Webster Street
Madison, WI 53707

Dear Mr. Witt:

RE: Flambeau Project
Final Engineering Report for Wastewater Treatment Facilities

Flambeau Mining Company (Flambeau) a wholly owned subsidiary of Kennecott Corporation is pleased to submit to the Wisconsin Department of Natural Resources (WDNR) for review and approval the attached report titled *Flambeau Project - Final Engineering Report for Wastewater Treatment Facilities (FER)*. This document has been prepared in accordance with Wis. Admin. Code ch. NR 108. An application for a wastewater discharge permit under Wis. Stat. ch. 147 has also been submitted to the WDNR.

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. Flows originating from the open pit have been revised in the FER to reflect the results of groundwater modeling work completed for the project in July 1989. Even though the modeling work shows that less flow from the open pit to the wastewater treatment plant will occur than that originally anticipated, the design capacity of the plant has not been changed. To minimize interruptions of mining operations, Flambeau desires to have additional capacity at the plant to process contact water that will accumulate in the pit as a result of storm events.

Attached to the report as an appendix is a report describing the bench scale evaluations completed to provide data to be used in designing the project's wastewater treatment plant and settling ponds. Wastewater treatment plant design and process descriptions referred to in this report have been prepared by Ford, Bacon & Davis Utah, Inc. (formerly Ford, Bacon & Davis, Inc.) of Salt Lake City, Utah.

Review comments from Ms. Percy Mather of the WDNR regarding the Preliminary Engineering Report (PER) were considered in preparing the FER. As an aid in the review process, we have listed her comments below and indicated our responses and/or the location of the response in the FER.

Comment No. 1

Why are there two outfalls for the project? Both of the outfalls will have the same water quality based limits. This will require two sets of analysis. The WDNR would prefer one outfall.

Response No. 1

We agree that one set of analyses would be a cost savings to the project. However, the physical location of the treatment facility and the settling ponds does not allow for the combination of these effluent streams. We will continue to evaluate this idea and if a feasible process for combining the discharges can be developed, we will present this information to the WDNR for an approval prior to implementation.

Comment No. 2

The WDNR would like to see flow proportional 24 hour composite sampling capabilities on both of the discharges.

Response No. 2

Flambeau will construct flow monitoring and sampling stations on outfall 001 which will allow for flow proportional 24 hour composite sampling. Outfall 002 will be monitored with the use of a battery powered flow meter. Samples will be collected manually, since by the nature of the treatment process the effluent characteristics from this outfall are not subject to rapid change. Grab samples will adequately represent the discharge from this outfall. While exact details cannot be listed in the FER until final equipment is purchased, the commitment to the above monitoring is presented in Sections 6.2.3.3 and 6.3.3 of the FER.

Comment No. 3

There was a concern over the fact that the clarifier will not be covered. Ms. Mather indicated that winter operation of the clarifier would be best if it was in a covered facility.

Response No. 3

This treatment system is not a biological process, therefore maintaining a warmer water temperature is not a critical concern for the performance of this treatment system. However, convection currents because of cooling from the outside walls of the clarifier is a concern. As discussed in Section 6.2.3.1 of the FER, Flambeau will be insulating the walls of the clarifier to prevent this from occurring.

Comment No. 4

A condition for approval will be the inclusion of a flocculation chamber in the clarifier.

Response No. 4

A flocculation system will be included in the lime treatment process. Section 6.2.3.1 of the FER discusses the proposed flocculation system.

Comment No. 5

Was a combined sulfide and lime treatment process evaluated in the process determination?

Response No. 5

It is the opinion of Ford, Bacon & Davis Utah, Inc. that a higher quality effluent can be achieved by running the sulfide precipitation process at a pH of 6.0 s.u. Given this fact, it is not possible to combine the sulfide and lime treatment process.

Comment No. 6.

A concern was expressed regarding backup in the event that the settling ponds do not meet effluent limits. What additional treatment would Flambeau propose in the event the settling ponds could not meet the effluent limits?

Response No. 6

It is anticipated that the settling pond will be able to meet the limits as demonstrated in the bench tests. In the event additional treatment is needed, Sections 6.3.1 and 6.3.2 of the FER describe the polymer and/or lime feed steps that will be taken.

Comment No. 7

Flambeau should give consideration to a 24 hour detention basin following the wastewater treatment facility. This will allow Flambeau to monitor the effluent prior to its discharge and allow for the oxidation of sulfides.

Response No. 7

Flambeau has evaluated the need for a detention basin following the wastewater treatment facility. At this time it is felt that this added facility is not needed. In the event plant upsets occur, the runoff and surge ponds can be used to hold water for reprocessing.

Comment No. 8

Truck maintenance wastewater should be collected in a holding tank for off site disposal.

Response No. 8

There will be a gravity separator system installed for the pretreatment of the wastewater generated from the truck maintenance area. The wastewater from this process will be treated at the wastewater treatment facilities and the separated oil and grease will be removed for off site disposal. A description of this process can be found in Section 4.5 of the FER.

Comment No. 9

The following items will be needed for the settling ponds:

A. Operation and Maintenance plan;

B. Hydraulic profile of the settling pond configuration;

C. Piping diagram of the system including the polymer feed system; and

D. A description and/or sketch of the spillway structure.

Response No. 9

A. An operation and maintenance plan was included in the PER, however, the plan has been modified in the FER to include more details. A discussion of the revised operation and maintenance plan can be found in Section 6.3.2 of the FER.

B. An additional drawing (Figure No. 8) has been prepared illustrating the hydraulic profile of the settling ponds.

C. The only piping associated with the settling ponds are the 36 inch outlet structure and the 16 inch discharge structure. A plan view and section showing this piping are included in Figure No's. 3 and 9 of the FER. There are no provisions for polymer feed in the settling ponds at this time. When operated as a retention pond, the polymer will be fed manually, if needed. A more detailed discussion of this process can be found in Sections 6.3.1 and 6.3.2 of the FER.

D. A description of the spillway structure for the settling ponds is included in Section 6.3.2 of the FER.

Comment No. 10

What is the timetable for treatment facilities construction and operation?

Response No. 10

A timetable has been added to Section 2.3 of the FER.

Comment No. 11

If Flambeau is planning to use diffusers in the outfall(s) for the purpose of obtaining a Zone of Initial Dilution (ZID) variance to the water quality based effluent limits, detailed plans will have to be submitted for approval.

Response No. 11

At the present time, Flambeau is not planning to apply for a ZID variance.

Comment No. 12

Are the floor drains in the wastewater treatment facility going to be routed to the head end of the plant for treatment of any wash down water and/or spills?

Response No. 12

Yes, a discussion of this can be found in Section 4.5 of the FER.

As per an agreement developed with the WDNR, it is our understanding that the WDNR will distribute this report to all appropriate state and federal agencies. Flambeau will distribute the document to appropriate local public officials.

Flambeau 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. In reviewing the document, please note that the title blocks for the figures have not been changed to reflect the name of Flambeau Mining Company. Since the document is filed by the Flambeau Mining Company, the fact that this change has not been made is immaterial.

If you have any questions or comments as you review this report, please contact me at your convenience.

Sincerely,

Flambeau Mining Company

Lawrence E Mercando

Lawrence E. Mercando
Vice President

Enclosure

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KFER

FINAL ENGINEERING REPORT
FOR
WASTEWATER TREATMENT FACILITIES
FOR THE
KENNECOTT FLAMBEAU PROJECT

Prepared for:

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Prepared by:

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DECEMBER 1989

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1.0 INTRODUCTION

Numerous federal, state, and local environmental, construction, building and safety permits, and approvals will need to be obtained before Flambeau Mining Company (Flambeau) can commence mining operations for its Flambeau Project. One step in the approval process is the submittal and the Wisconsin Department of Natural Resources (WDNR) approval of a Final Engineering Report (FER) for the wastewater treatment process associated with the project.

The Flambeau Project FER meets the requirements of Wisconsin Stat. Sec. 144.04 and Wis. Admin. Code ch. NR 108. In addition to the FER Flambeau has submitted to the WDNR an application for a WPDES discharge permit under Wisconsin Stat. ch. 147.

This report includes final designs for the proposed wastewater treatment facilities and bench test study results evaluating the treatment processes. The final designs have been prepared by Ford, Bacon and Davis, Inc. of Salt Lake City, Utah. The bench test studies (Appendix A) were completed by Foth & Van Dyke and Associates Inc. at their Green Bay, Wisconsin facilities.

Additional information regarding the planned project and the environment of the project area can be found in the Flambeau Project's Mining Permit Application and Environmental Impact Report.

2.0 GENERAL PROJECT INFORMATION

2.1 Name, Address and Telephone Number of Person Submitting the Final Engineering Report

Lawrence E. Mercando,
Vice President
On Behalf of Flambeau Mining Company
10 East South Temple
P. O. Box 11248
Salt Lake City, Utah 84147
(801) 322-8460

Flambeau Mining Company is a wholly owned subsidiary of Kennecott Corporation.

2.2 Project Location and Topography

Figure No. 1 is a map showing the approximate project location. The project area is located just south of the City of Ladysmith in Rusk County, Wisconsin. Figure No. 2 is a topographic map of the project area.

2.3 Project Timetable

The ultimate timetable for the wastewater treatment facility construction and start up is dependent on the timing of the mining permit approval and other regulatory permit approvals. At the present time the anticipated timetable is as follows. Weather permitting, approximately four weeks after permits are granted, construction of the wastewater treatment plant will commence with clearing and grubbing activities. Over the next 32 week period, plant earthwork including the settling ponds, and the construction of plant facilities will be completed. At the end of this 32 week period a two week start-up process will be commenced. The plant will be operational prior to the need to treat site wastewater. For further information regarding the construction schedule, the reader is referred to Figure No. 4-5 of the Mining Permit Application.

2.4 Property Ownership

The project area as shown on Figure No. 1 will incorporate a total of approximately 300 acres. Legal descriptions of the site and adjoining property, which are owned by Flambeau, are contained in Appendix B.

3.0 DESCRIPTION OF THE PROPOSED PROJECT

3.1 Introduction

The project facilities will consist of an open pit mine; an unlined (Type I) stockpile for storage of overburden, saprolite, sandstone, and waste rock containing very low levels of sulfide mineralization; a lined (Type II) stockpile for storage of saprolite and waste rock containing slightly higher levels of sulfide mineralization; a topsoil stockpile; water control features; a wastewater treatment plant; and ancillary facilities such as an office, railroad spur line, and maintenance building.

Figure No. 3 has been prepared to graphically illustrate the proposed project. The figure is a plan view of the mine area showing the location and relative size of key project elements.

3.2 Geology

3.2.1 Description of Site Geology

Precambrian volcanic rock, Cambrian sandstone, and Quaternary glacial and fluvial sediments are present beneath the project area. The geology has been defined from hundreds of soil borings and core samples drilled on site and from scattered outcrops along the banks of Meadowbrook Creek.

The steeply dipping Precambrian rock has been highly altered during mountain building processes to schist, which was later weathered and further altered. The top ten to 20 feet of Precambrian waste rock has been weathered to a silty-clay rock termed saprolite.

Small amounts of disseminated pyrite have been oxidized below the saprolite to several tens of feet in depth. This rock is termed Type I waste rock, and contains less than one percent sulfur. Type I material has been leach column-tested and found to produce water of quality that can be discharged without treatment. Type II waste rock occurs in the lower levels of the proposed open pit. Because this material contains greater than one percent sulfur, it will be stored on a lined stockpile area.

The Precambrian rock is overlain by Cambrian sandstone which consists of a poorly cemented, fine to coarse-grained quartz sand. Thickness of the sandstone varies from zero to greater than 30 feet within the proposed pit perimeter.

Near-surface materials consist of unconsolidated Quaternary glacial-fluvial sediments. Most of the deposit is covered by a dense, silty-sand glacial till. Glacial-fluvial sand and gravel generally occur in the northwest part of the project area in the vicinity of the abandoned gravel pit.

3.2.2 Deposit Description

The Flambeau deposit is tabular in shape, strikes in a northeast direction, and dips steeply to the northwest. The upper portion of the sulfide mineralization has been enriched in copper as a result of ancient fluctuating groundwater tables to about 225 feet below the present land surface. The deposit to be mined is 2,600 feet long, averages 50 feet wide, and contains approximately 1.9 million tons of material. The upper part of the deposit consists of zero to 30 feet of iron oxide-rich gossan. Below the gossan are varying proportions of chalcocite and bornite (copper sulfide minerals) in a matrix of chert (cryptocrystalline quartz) and pyrite (iron sulfide). No significant or economic amounts of sulfide mineralization have been found by drilling in either direction from the deposit. Sulfide

mineralization occurring beneath the proposed pit has been determined by Flambeau to be uneconomical based upon projected metal prices.

3.3 Description of Key Project Elements

3.3.1 General Mine Plan

Enriched ore will be mined from an oval-shaped open pit designed to cover approximately 32 acres to a maximum pit depth of 225 feet. All excavated materials will be hauled to the surface, which is at about 1,140 feet Mean Sea Level. Ore will be transported by truck to a crushing facility adjacent to the pit and crushed to minus 12 inches for rail shipment to an out-of-state processing facility.

Two open pit mining phases will be used. The first will mine the southwest half of the deposit to the 970-foot elevation. The second mines the balance of the pit to its final lateral limits and extends the pit bottom to the 900-foot elevation. Due to variation in the orebody grades, two ore-mining faces will be available at all times. Hydraulic shovels will operate from 20-foot high benches. The next bench is prepared as soon as working room becomes available to allow for construction of a sump to handle in-pit water flows and for emergency storage during heavy precipitation.

Waste material will be classified in the pit by sulfur content and stored on either lined or unlined storage sites adjacent to the pit. Eventually waste materials from the separate stockpiles will be returned to the pit as backfill. Upon completion of the mining operation, the project site will be contoured and reclaimed. Land owned by Flambeau but not included in the project area will mostly remain in its current use.

3.3.2 Mining Operation

Preproduction activities will take approximately 10 months to develop the open pit, the waste rock stockpiles, and plant facility. Chief tasks will be clearing the site; preproduction stripping; construction of access roads, the railroad spur, powerline, wastewater treatment plant, storage areas, etc. Disturbed soil areas will be stabilized and water control measures installed at that time.

The Flambeau orebody will be mined from the open pit over a period of approximately six years. The pit area at the end of the mine life will embrace an oval-shaped area of approximately 32 acres. The pit will be 2,600 feet long and average about 550 feet wide. Open pit mining will take place five to six days a week, eight hours per day, to produce approximately 320,000 dry short tons of ore per year.

The steeply dipping rocks will accommodate a pit, with slopes at 36 degrees for the glacial till and 50 degrees interramp for rock sections. Twenty-seven-foot wide catch benches will be left at 60-foot intervals for safety considerations. The access ramp has a design width of 60 feet and a gradient of ten percent.

Overburden and waste rock will be excavated from 20-foot high benches and ore from ten-foot benches using conventional mining equipment. The excavated overburden will be transported to the Type I stockpile or to construction areas elsewhere on the project site.

It is anticipated that most of the Cambrian sandstone, all of the saprolite and some of the oxidized waste rock (Type I) can be broken by using a dozer with a ripper blade. However, certain areas of the deposit, such as those portions of the orebody that contain quartz or hard waste rock, will require drilling and blasting. Fresher and harder rock and ore can be expected as the open pit deepens during the first year of full production. Therefore, blasting during preproduction and into the first year of production will likely be performed only on an infrequent basis.

Controlled blasting procedures will be used to minimize the generation of seismic waves and noise. Due to the small scale of the mining method and operations, ore blasts will be relatively small. Blasting is anticipated to occur from one to five times per week. A set of blasting standards will be carefully followed to keep risks of flyrock, ground vibrations, and noise to a minimum.

Two four-cubic yard shovels and a seven-cubic yard loader will be used to load the broken ore and other materials into 35-ton or 50-ton trucks. At first, only four trucks will be required. The truck fleet will be increased to a maximum of seven trucks as the pit deepens and haul distance increases. A 4,000-gallon water truck will wet haul roads and truck unloading areas for dust control.

Anticipated production and operation schedules are found in Table No. 3-1. The tonnages shown in the table are averages since ore and spoils production vary from year to year.

TABLE NO. 3-1

Anticipated Production and Operation Data

Preproduction Stripping	1,500,000 tons
Daily Ore Production	1,300 tons
Annual Ore Production	320,000 tons
Total Ore Production	1,900,000 tons
Total Overburden & Waste Rock	8,000,000 tons
Total Material Moved (Includes Backfill)	17,500,000 tons
Open Pit Size	32 acres
Project Area	300 acres
Total Project Life	8 to 9 years
Preproduction and Construction	1 year
Mining	6 years
Rehabilitation & Backfilling	1 to 2 years
Open Pit Operating Schedule	5 to 6 days/week 8 hours/day, 1 shift
Crushing Plant	5 to 6 days/week 8 hours/day, 1 shift
Employment During Operations	
Initial	56
Peak	61
Average	55

3.3.3 Water Inflow Controls

When topsoil is stripped and excavation begins, control methods will be provided for surface water and groundwater that could flow into the open pit. Hydrologic studies indicate that a simple system of grading and ditching to a series of sumps can capture and control most of the water expected to inflow. The water will then be diverted to settling ponds or to the wastewater treatment plant. A slurry wall of either grout or bentonite clay will be constructed at the end of the pit adjacent to the river to minimize potential inflow from that direction. Detailed geologic mapping will be routinely conducted to identify, monitor, and control any areas of significant water inflow which might develop.

Two water collection systems are planned for the pit. During preproduction stripping, an upper sump will catch surface and groundwater inflows from the glacial overburden and Cambrian sandstone. This water, which will not come into contact with sulfide mineralization, but which could carry suspended solids such as clays, will be pumped to settling ponds to remove suspended materials and colloids. The clear overflow will be discharged to the Flambeau River or possibly used to provide water to an adjacent wetland. A lower sump will collect all groundwater inflow and precipitation that comes into contact with ore and waste rock. Water from the lower sump will be pumped to the wastewater treatment plant, treated, and then separately discharged to the Flambeau River or an adjacent wetland.

A flood control dike will be constructed at the west end of the open pit to prevent overflow of the river into the pit during potential severe flooding conditions (100-year flood). The dike will be constructed using specially selected materials overlying the orebody. The west toe of the flood-control dike would be approximately 70 to 90 feet from the east edge of the current Flambeau River channel. The edge of the open pit will be no closer than 140 feet from east edge of the river channel.

3.3.4 Crushing Facilities

The crushing facility consisting of a crusher, crushed ore stockpile, and railcar loading area will be built on the southwest side of the Type II waste rock stockpile. The crusher will be separated from the Type II stockpile by a retaining wall to contain rock and runoff water. The proximity of the crusher facility and stockpile to the pit minimizes haul distances. The crushing and ore loading areas will be contoured and underlain with a 60-mil HDPE liner to direct water to a runoff catchment pond for transfer to the wastewater treatment plant. All crushing will occur during daylight operations. The crusher will be oriented in a southwest direction to direct noise away from populated areas. The crusher is designed to crush coarse ore to minus 12 inches. A dust suppression spray system will control dust generated by the crusher and conveyor belt discharge point.

The crushing facility is designed for 250 tons per hour and allows for production variations and maintenance. Crushed and bypassed ore will be discharged onto a conveyor belt and transported to the crushed ore stockpile, where a front-end loader will load railroad cars at an average rate of approximately 12 cars per working day. It is planned to ship an average of approximately 24 loaded cars every other operating day.

3.3.5 Infrastructure

3.3.5.1 General

Several buildings will be erected to support the open pit operation and crushing plant. Chief infrastructure components will consist of a wastewater treatment plant, railroad spur, utilities, administrative building and shop, storage tanks, and explosives magazine. Most of these ancillary facilities will be clustered east of the crushing plant.

3.3.5.2 Wastewater Collection and Treatment Plant

The wastewater treatment plant, located southeast of the crushing facility, will be designed to treat water from four sources: 1) pit contact water, 2) ore haul road drainage, 3) Type II waste material storage pad drainage and runoff, and 4) site runoff from the crushing and loadout facilities and other ancillary facilities. Water from these combined sources will average approximately 296 gallons per minute on an annual basis.

A uniform feed of untreated wastewater to the treatment plant aids optimum plant performance. It is important, though, to consider surge capacity in its design, since water volume and metal loading can change with the seasons. Therefore, the wastewater treatment plant design provides for water storage in both a lined runoff catchment pond and a lined wastewater treatment surge reservoir. The open pit will also be used for emergency water storage. A 25-year rainfall event has been used as the design basis for the wastewater treatment system.

The wastewater treatment plant has been designed to process wastewater for acid neutralization and metal removal in a three-stage process. The process consists of lime treatment, sulfide precipitation, and multi-media filtration.

Precipitate handling and treated water disposal make up the final components of the wastewater treatment system. Some of the treated water will be recycled for plant operations, makeup water, washdowns, and dust control with the balance discharged to the Flambeau River or an adjacent wetland. Precipitate at approximately 25 percent solids will be trucked from the treatment plant to the Type II stockpile where it will be stored with the waste rock.

3.3.5.3 Access Roads and Railroad Spur

Two access roads and a railroad spur will be constructed for the project. A new, paved plant site access road will be built from State Highway 27 into the project site. The road will be constructed opposite the intersection of Jansen Road and State Highway 27. A second access road to a visitors' observation platform is planned to be constructed approximately 2,700 feet north of the plant access road.

A single line railroad spur approximately 6,500 feet long will be constructed from the Wisconsin Central Ltd. railroad line southwesterly to the crusher plant site to provide access to railroad cars used for shipping ore. The spur line at the crusher plant site will consist of two parallel tracks for ease in loading and switching railroad cars. The primary route for the railroad spur is north of Jansen Road along a location which avoids as much of existing wetlands as possible.

3.3.5.4 Utilities

The electrical power supply for the Flambeau Project will be delivered at 13.8 Kv from the Northern States Power Company power grid to a main substation adjacent to the wastewater treatment plant. Natural gas will be extended to the site for space heating needs.

A low-capacity potable water well will be drilled to supply water to field offices and shops.

3.3.5.5 Buildings and Shops

A maintenance shop, office building, and guard house will be erected south and east of the crushing plant. The existing utility building east of the pit will be used to house a limited inventory of equipment and supplies. A peripheral security fence will be constructed around the entire plant site and open pit.

3.3.5.6 Mining Materials and Storage Tanks

Two portable magazines will be located in a remote bunkered area north of the Type I stockpile settling ponds. A blasting cap storage building will also be located in the same general area, but separated from the magazines. A 15,000-gallon diesel fuel tank and associated piping will be installed to provide fuel for mining equipment.

3.3.6 Solid Materials Stockpiles

Topsoil, overburden, and Type I and Type II material will be removed and segregated in accordance with their characteristics, then stockpiled in the appropriate location for use in reclamation following the completion of mining.

3.3.6.1 Topsoil Stockpile

The top 12 to 18 inches of soil will be removed from all construction sites and placed in the topsoil stockpile. In some areas, such as the railroad spur cut and fill banks, access road slopes, and exposed berms, the topsoil will be moved to one side and then returned to stabilize and support temporary revegetation of these areas upon completion of construction. Topsoil from the open pit, crusher plant and excess topsoil from the storage areas will be removed and stockpiled. The topsoil stockpile area will be located east of the pit. This stockpile will serve as a visitors' viewing area. Stockpiled topsoil will be used to reclaim the site after mining activities are completed. The topsoil stockpile area will cover approximately seven acres.

3.3.6.2 Overburden/Type I Stockpile

Overburden and Type I material (less than one percent sulfur) will be stored on an unlined area located between the open pit and Blackberry Lane. A bermed swale at the base of the stockpile will contain internal runoff and direct it to the settling ponds. The stockpile will occupy about 40 acres, reach a height of about 60 feet, and have a design capacity of approximately 2.8 million cubic yards.

3.3.6.3 Type II Stockpile

Type II material (more than one percent sulfur) will be stockpiled separately in a lined area located southeast of the open pit and northeast of the crushing plant site. Approximately 27 acres will be required for this stockpile, which has been designed with a capacity of 2.2 million cubic yards. The Type II stockpile will be built with an impervious liner and leachate collection system at its base. A lined berm and runoff containment swale will encircle the area to collect all precipitation that comes into contact with this material. Collected leachate and runoff will ultimately be directed via piping to the surge reservoir and then to the wastewater treatment plant.

Perimeter berms for the Type II stockpile will be constructed using overburden or soil excavated during base grade preparation. A protective layer of coarse-grained soils will be placed over the HDPE liner to protect the liner as waste rock is hauled onto the stockpile. The projected height of the stockpile is approximately 70 feet. The outside of the perimeter berm will be topsoiled and vegetated.

3.3.7 Surface Water Controls

As previously discussed, precipitation falling within the limits of the open pit, Type I and II storage piles, and plant area will be collected and directed to either the settling ponds or the wastewater treatment plant. Some of the surface water drainage originating from outside the active mine area will be intercepted by a series of drainage swales and directed to existing natural drainage features.

3.3.8 Reclamation

Disturbed soil areas will be revegetated and woodlands maintained during the life of the mining project. The open pit will be backfilled once mining is complete. The plan is to return the project site to close to approximate original contours, such that it will be suitable for other land uses. Stockpiled Type II material will be placed at the bottom of the pit, with Type I waste rock placed over it and compacted as part of normal traffic of equipment used for backfilling. Saprolite, followed by sandstone and till will then be placed within the pit over the Type I waste rock. Finally, the pit site will be covered with topsoil and the area revegetated. Surface facilities, including the railroad spur, will be dismantled at the end of mine operations unless a beneficial plan for keeping all or some of the facilities is developed by Flambeau, the WDNR, and local residents.

4.0 WATER SOURCES

Water management will be an important part of the Flambeau Project. During construction, operation, and backfilling, water generated from various sources will be handled in a variety of ways, ranging from channelling water away from the project site to collecting water for treatment prior to discharge. The various sources have been classified into seven different categories. The seven categories are shown on Figure No. 4. Also shown are the origin of the source, projected volumes, where appropriate, and discharge point for each individual category. A discussion of each of the categories follows.

4.1 Category No. 1 - Uncontrolled Non-contact Runoff

Water in this category will be generated in the area of the railroad spur, primarily east of STH 27, and also from the west berm separating the pit area from the Flambeau River. There will be no drainage features constructed to control runoff in these areas. This runoff will be clear water requiring no sediment control. Volume calculations have not been prepared for this category since it is relatively small and need not be controlled. This discharge does not require a permit because it is storm discharge not in contact with the active mine area.

4.2 Category No. 2 - Controlled Non-contact Runoff

This category will primarily consist of runoff from vegetated berms and exterior run-on to constructed drainage ways. This will be water that is collected in drainage diversion features constructed for the project and water which has not come into contact with the active mine area. Discharge points will either be directly to the Flambeau River or to natural drainageways leading to the Flambeau River.

This discharge does not require a permit. Under state law, uncontaminated stormwater runoff is not considered a "point source" and thus does not require a permit, Wis. Stat. s. 147.015(12). Under federal law, stormwater runnoff from mining operations is exempt from permitting requirements, 33 USC s. 1342(L)(2).

Since a permit is not required for this category, volume calculations have not been prepared.

4.3 Category No. 3 - Type I Storage Pile Runoff and Non Contact Pit Water

This category consists of three water sources. The first is runoff from the Type I storage pile. The second is groundwater which is generated during preproduction stripping in Phase I of the open pit and stripping of overburden in Phase II of the open pit. The third is precipitation falling on the open pit during Phase I and II stripping and on a small drainage area located between the open pit and the Type II stockpile. Runoff from this small drainage area will flow into the open pit.

Water in this category will not come into contact with ore or sulfide-bearing waste rock. The water will be directed to settling ponds for removal of sediments prior to discharge to the Flambeau River or Wetland No. 1 on an as-needed basis.

On an annual average basis, storm water runoff from the Type I storage pile is estimated to be equivalent to approximately 29 gallons per minute (gpm). The peak runoff flow based on a 25-year, 24-hour storm is estimated to be approximately 8100 gpm.

For purposes of this discussion the groundwater and precipitation sources to the pit contributing to Category No. 3 have been combined since both will be removed from the pit using the same pumping system. Water from these sources will be directed to the settling ponds during two periods of the mining operation. The first is during Phase I preproduction stripping. The second is during the stripping of Phase II overburden. In both phases, following completion of the stripping process, all water entering the open pit from groundwater inflow and precipitation will be directed to the planned wastewater treatment plant.

Estimates of groundwater inflow used in this report have been taken from the report titled *Groundwater Model for the Kennecott Flambeau Project, Ladysmith, Wisconsin* (Kennecott Model) prepared by Thomas A. Prickett & Associates, Inc. and Engineering Technologies Associates, Inc. The Kennecott Model report was submitted to the WDNR in July of 1989.

During Phase I preproduction stripping which is projected to occur over a four month period, the annual average flow from Category No. 3 to the settling ponds is estimated to be approximately 139 gpm. The 139 gpm figure consists of an average annual precipitation contribution of 19 gpm added to the "best engineering judgement" estimate of the four month average pit inflow rate from Figure 8 of the Kennecott Model. The actual total flows for this category will vary with the stage of the stripping process and with the occurrence of precipitation events. During the first month of the stripping process, the flow rate is projected to be equivalent to 315 gpm. During the fourth and final month of stripping, the flow is expected to be approximately 74 gpm.

The peak flow to the settling ponds from this source is governed by in pit pump capacity and is estimated to be 1,350 gpm. Pump capacity was selected based on an acceptable length of downtime that would be required to remove excess water from the pit during a major storm.

The average annual flow rate to the settling ponds during Phase II stripping is estimated to be less than that during Phase I stripping since: 1) some dewatering of the Phase II overburden will have taken place during Phase I mining; and 2) only a minor portion of the small drainage area between the open pit and Type II stockpile will drain into the Phase II area. Peak flow will be the same, though, since the same size pumps will be used.

4.4 Category No. 4 - Contact Pit Water

This category consists primarily of precipitation and groundwater that collects in the pit and that has come into contact with ore or sulfide-bearing waste rock. In addition, this category contains runoff water from the ore haul road. Such runoff will be directed back into the pit where it will be collected and sent to the wastewater treatment plant. The water in this category will have a pH less than neutral and may contain metals. The water will be treated at the wastewater treatment plant.

Pit area not only increases with time, but also deepens. As a result, the pit inflow rate will vary with time, reaching a peak during preproduction stripping and then declining to a minimum rate shortly after mining commences. As the pit deepens the rate will gradually increase from this minimum, but will not exceed the rate encountered during initial preproduction stripping. The "best engineering judgement" maximum peak inflow rate for post preproduction stripping as estimated in Figure 8 in the Kennecott Model report is 260 gpm. The "best engineering judgement" steady state estimate of annual average pit inflow at the end of mining is 110 gpm (Figure 9, Kennecott Model). Since the maximum pit inflow rate will occur during overburden stripping, and since inflow will decrease thereafter, the maximum contribution of pit inflow to the wastewater treatment plant under the "best engineering judgement" scenario is expected to fall between 113 and 260 gpm.

In addition to pit inflow, precipitation falling on the open pit area and the ore haul road both contribute to Category No. 4 water. The annual average contribution from these two sources is estimated to be 50 gpm and 5 gpm, respectively. Actual flows will vary according to precipitation events. However, since the pit can act as a detention basin, the delivery rate of Category No. 4 water will be based on wastewater treatment plant capacity. That is, the delivery rate will be controlled by the total capacity of the wastewater treatment plant and the volume of water from other sources also being delivered to the plant for treatment at any one given time.

4.5 <u>Category No. 5 - Contact Runoff</u>

This category primarily contains water that will consist of precipitation that has fallen on the ore processing and loading area and plant site. The water quality of this source will be very similar to that discussed in Category No. 4 and will be directed to the wastewater treatment plant. In addition, this category also includes water from inside the truck maintenance area and that collected by floor drains in the wastewater treatment plant.

On an annual average basis water from this category is estimated to be equivalent to 19 gpm. During major storm events, water from this category that cannot be processed immediately at the wastewater treatment plant will be stored in the runoff catchment and surge ponds. As a backup, any additional generated water will be directed to the pit for storage.

Water collected in the truck maintenance shop will receive treatment prior to discharge to the influent structures of the wastewater treatment facilities. A gravity oil and grease separator will be used to remove the oil and grease from this water. The removed oil and grease will be disposed of off site.

Floor drains from the wastewater treatment facility will be routed to the head end of the treatment process. Any wash down or spills that occur will be treated prior to disposal.

The volume of water generated by these last two sources is expected to be in the hundreds of gallons per year range. Therefore, this water volume is negligible in comparison to the major Category No. 5 contributor.

4.6 Category No. 6 - Leachate

This category contains leachate and runoff that will be collected from the Type II storage area. On an annual average basis approximately 47 gpm will be generated by this source. Storage of water from this source will be handled in a fashion similar to that described for Category No. 5.

4.7 Category No. 7 - Sanitary Wastewater

This category will be water that will be generated from domestic activities associated with the mining operation, such as discharges from showers and sanitary facilities. This water will be disposed of via a septic system and drainage field or via a holding tank.

Based on the peak project employment of 61 and a water usage rate of 35 gallons per day per employee (includes showers per Wis. Admin. Code ILHR 83.15(3)(c)2), the maximum volume of water generated from this source will be 2135 gallons per day. Since this volume does not exceed 8000 gallons per day, a permit under NR 200 is not required for this category. Under federal law a permit would not be required because this is not a discharge to a "navigable water." See 33 USC s. 1362 (12).

5.0 SURFACE WATER DATA

5.1 Water Quality Data

As part of the environmental studies supporting the permitting process, the background water quality of the Flambeau River was evaluated. Over a 12-month period in 1987 and 1988, samples of river water were collected on a monthly basis. Two sampling locations were evaluated, one upstream from the mine area, and one downstream from the mine area. This data is intended to establish background water quality for the river. The water quality data generated from this program is included in Table No. 5-1. A more detailed discussion of the surface water monitoring program and its results are contained in Section 3.7 of the Environmental Impact Report prepared for the project.

5.2 Flow Data

River flow records are available for a 36-year period through 1987 from the U.S. Geological Survey gaging station located 2.5 miles downstream from the Thornapple power plant, which is located approximately 6.5 miles below the proposed mining site. Average river discharge at this station for the 36-year period is 1,855 cubic feet per second (cfs). The recorded extremes were 17,600 cfs in April 1986 and 100 cfs in August 1957. The seven-day ten-year low flow value (Q7,10) established for the Flambeau River in the area affected by proposed mining activities is 435 cfs (Holmstrom 1979).

TABLE NO. 5-1

Analytical Results of Surface Water Sampling - Flambeau River

SAMPLING DATE	TOTAL ALKALINITY mg/l as CaCo3			ALUMINUM mg/l			ARSENIC mg/l			BARIUM mg/l			BERYLLIUM mg/l		
	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK
10/14/87	43	43	11	0.066	0.042	0.022	<0.005	<0.005	<0.005	<1	<1	<1	<0.001	<0.001	<0.001
11/04/87	53	53	<10	0.074	0.058	0.013	<0.005	<0.005	<0.005	<0.50	<0.50	<0.05	<0.001	<0.001	<0.001
12/02/87	32	32	<10	(b)	(b)	(b)	<0.005	<0.005	<0.005	<0.50	<0.50	<0.50	<0.001	<0.001	<0.001
1/06/88	50	(a)	<10	0.111	(a)		<0.005	(a)		<0.50	(a)		<0.001	(a)	
2/03/88	50	50	<10	0.045	0.049	<0.011	<0.005	<0.005	<0.005	<0.50	<0.50	<0.50	0.001	<0.001	<0.001
3/01/88	(b)	(b)	(b)	0.074	0.044	0.012	<0.005	<0.005	<0.005	<0.50	<0.50	<0.50	<0.001	<0.001	<0.001
4/08/88	30	30	<10				<0.005	<0.005	<0.005						
5/05/88	31	31	<10				<0.005	<0.005	<0.005						
6/02/88	27	36	<10				<0.005	<0.005	<0.005						
7/07/88	57	43	14				<0.005	<0.005	<0.005						
8/09/88	48	48	<10				<0.005	<0.005	<0.005						
9/08/88	60	60	<10				<0.005	<0.005	<0.005						
AVERAGE	44	43	2.3	0.074	0.050	0.012	0.000	0.000	0.000	0.0	0.0	0.0	0.000	0.000	0.000
MINIMUM	27	30	<10	0.045	0.042	<0.011	<0.005	<0.005	<0.005	<0.5	<0.5	<0.5	<0.001	<0.001	<0.001
MAXIMUM	60	60	14	0.111	0.058	0.022	<0.005	<0.005	<0.005	<1	<1	<1	0.001	<0.001	<0.001

TABLE NO. 5-1 (Cont.)

SAMPLING DATE	BOD mg/l			CADMIUM mg/l			CALCIUM mg/l			CHLORIDE mg/l			CHLOROPHYLL-a mg/l		
	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK
10/14/87	<6	<6	<6	<0.0010	<0.0010	<0.0010	16.0	17.0	0.2	(b)	(b)	(b)	0.005	0.004	
11/04/87	<6	<6	<6	<0.0010	<0.0010	<0.0010	16.0	15.0	<0.2	5.0	5.0	<1	0.002	0.003	<0.001
12/02/87				<0.0010	<0.0010	<0.0010	14.0	13.0	<0.2	(b)	(b)	(b)	<0.001	<0.001	<0.001
1/06/88	9	(a)		<0.0010	(a)	<0.0010	15.0	(a)		7.0	(a)	<1	<0.001	(a)	
2/03/88	<10	<10	<6	(b)	(b)	(b)	15.0	16.0	<0.2	7.0	6.0	<1	<0.001	<0.001	<0.001
3/01/88	<6	<6	<6	(b)	(b)	(b)	16.0	16.0	<0.5	7.0	8.0	<2	<0.001	<0.001	<0.001
4/08/88				<0.0003	<0.0003	<0.0003	9.9	11.0	<0.5	2.0	3.0	<2	0.001	<0.001	<0.001
5/05/88				(b)	(b)	(b)	13.0	12.0	<0.2	2.7	3.4	<2	0.001	<0.001	<0.001
6/02/88				<0.0003	<0.0003	<0.0003	15.0	16.0	<0.5	5.0	5.0	<2	0.003	0.010	<0.001
7/07/88				<0.0003	<0.0003	<0.0003	14.0	16.0	<0.5	8.0	7.0	<2	0.005	0.009	<0.001
8/09/88				(b)	(b)	(b)	17.0	16.0	<0.5	9.0	9.0	<2	0.012	0.007	<0.001
9/08/88				<0.0003	<0.0003	<0.0003	14.0	19.0	0.7	7.0	7.0	<2	0.003	0.003	<0.001
AVERAGE	1.8	0	0	0.0000	0.0000	0.0000	15.0	15.0	0.0	6.0	5.9	0	0.003	0.004	0.000
MINIMUM	<6	<6	<6	<0.0003	<0.0003	<0.0003	9.9	11.0	<0.2	2.0	3.0	<1	<0.001	<0.001	<0.001
MAXIMUM	9	<10	<6	<0.0010	<0.0010	<0.0010	17.0	19.0	0.7	9.0	9.0	<2	0.012	0.010	<0.001

TABLE NO. 5-1 (Cont.)

SAMPLING DATE	HEXAVALENT CHROMIUM mg/l			TOTAL CHROMIUM mg/l			COBALT mg/l			COPPER mg/l			C.O.D. mg/l		
	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK
10/14/87	<0.05	<0.05	<0.05	<0.005	<0.005	<0.005	<0.05	<0.05	<0.05	(b)	(b)	(b)	20	15	<5
11/04/87	<0.05	<0.05	<0.05	<0.005	<0.005	<0.005	<0.05	<0.05	<0.05	<0.005	<0.005	<0.005	35	35	5
12/02/87	<0.05	<0.05	<0.05	<0.005	<0.005	<0.005	<0.05	<0.05	<0.05	<0.005	<0.005	<0.005	35	35	10
1/06/88	<0.05	(a)		<0.005	(a)		<0.05	(a)	<0.05	<0.005	(a)		40	(a)	5
2/03/88	<0.05	<0.05	<0.05	<0.005	<0.005	<0.005	<0.05	<0.05	<0.05	0.030	0.011	0.008	30	20	5
3/01/88	<0.05	<0.05	<0.05	<0.005	<0.005	<0.005	<0.05	<0.05	<0.05	(b)	(b)	(b)	10	10	<5
4/08/88	<0.05	<0.05	<0.05	<0.005	<0.005	<0.005				0.009	0.013	0.007			
5/05/88	<0.05	<0.05	<0.05	<0.005	<0.005	<0.005				<0.010	<0.010	<0.010			
6/02/88	<0.05	<0.05	<0.05	<0.005	<0.005	<0.005				<0.010	<0.010	<0.010			
7/07/88	<0.05	<0.05	<0.05	<0.005	<0.005	<0.005				<0.010	<0.010	<0.010			
8/09/88	<0.05	<0.05	<0.05	<0.005	<0.005	<0.005				(b)	(b)	(b)			
9/08/88	<0.05	<0.05	<0.05	<0.005	<0.005	<0.005				<0.010	<0.010	<0.010			
AVERAGE	0.00	0.00	0.00	0.000	0.000	0.000	0.00	0.00	0.00	<0.005	<0.005	<0.005	28	23	<5
MINIMUM	<0.05	<0.05	<0.05	<0.005	<0.005	<0.005	<0.05	<0.05	<0.05	<0.005	<0.005	<0.005	10	10	<5
MAXIMUM	<0.05	<0.05	<0.05	<0.005	<0.005	<0.005	<0.05	<0.05	<0.05	0.030	0.013	0.008	40	35	10

TABLE NO. 5-1 (Cont.)

SAMPLING DATE	FLUORIDE mg/l			TOTAL HARDNESS mg/l			IRON mg/l			LEAD mg/l			MAGNESIUM mg/l		
	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK
10/14/87	0.2	0.1	<0.1	37	37	<2	0.20	0.16	<0.10	<0.005	<0.005	<0.005	4.1	4.3	0.07
11/04/87	0.1	0.1	<0.1	58	58	<2	0.39	0.33	<0.10	<0.005	<0.005	<0.005	4.3	4.0	<0.05
12/02/87	0.1	0.1	<0.1	49	49	<2	0.41	0.42	<0.10	<0.005	<0.005	<0.005	3.8	3.7	<0.05
1/06/88	0.2	(a)	<0.1	50	(a)	<2	0.45	(a)		<0.005	(a)	<0.005	4.2	(a)	
2/03/88	0.2	0.2	<0.1	60	60	<2	0.47	0.47	<0.10	<0.005	<0.005	<0.005	4.1	4.1	<0.05
3/01/88	0.2	0.2	<0.1	60	60	<2	0.51	0.54	<0.10	<0.005	<0.005	<0.005	4.1	4.2	<0.05
4/08/88	0.2	0.2	<0.1	40	40	<2				<0.005	<0.005	<0.005	2.9	3.1	<0.05
5/05/88	0.1	<0.1	<0.1	43	41	<2				<0.005	<0.005	<0.005	3.6	3.5	0.071
6/02/88	0.2	0.2	<0.1	40	42	<2				<0.005	<0.005	<0.005	4.0	4.4	0.14
7/07/88	<0.1	<0.1	<0.1	60	64	<2				<0.005	<0.005	<0.005	4.4	4.1	0.07
8/09/88	<0.1	0.2	<0.1	55	59	<2				<0.005	<0.005	<0.005	4.5	3.8	0.07
9/08/88	0.2	0.2	<0.1	71	63	4				<0.005	<0.005	<0.005	3.3	2.7	<0.05
AVERAGE	0.1	0.1	0.0	52	52	<2	0.40	0.38	0.00	0.000	0.000	0.000	3.9	3.8	<0.05
MINIMUM	<0.1	<0.1	<0.1	37	37	<2	0.20	0.16	<0.10	<0.005	<0.005	<0.005	2.9	2.7	<0.05
MAXIMUM	0.2	0.2	<0.1	71	64	4	0.51	0.54	<0.10	<0.005	<0.005	<0.005	4.5	4.4	0.14

TABLE NO. 5-1 (Cont.)

SAMPLING DATE	MANGANESE mg/l			MERCURY mg/l			MOLYBDENUM mg/l			NICKEL mg/l			AMMONIA NITROGEN mg/l		
	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK
10/14/87	0.05	<0.05	<0.05	<0.0005	<0.0005	<0.0005	0.067	<0.029	<0.029	<0.007	<0.007	<0.007	<0.10	<0.10	<0.10
11/04/87	0.08	<0.05	<0.05	<0.0005	<0.0005	<0.0005	0.042	<0.029	<0.029	<0.007	<0.007	<0.007	0.3	0.1	<0.1
12/02/87	(b)	(b)	(b)	<0.0005	<0.0005	<0.0005	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
1/06/88	<0.05	(a)	<0.05	<0.0005	(a)		<0.029	(a)		<0.007	(a)		2.2	(a)	<0.1
2/03/88	<0.05	<0.05	<0.05	<0.0005	<0.0005	<0.0005	<0.029	<0.029	<0.029	0.010	<0.007	<0.007	0.4	0.4	<0.1
3/01/88	<0.05	0.055	<0.05	<0.0005	<0.0005	<0.0005	<0.029	<0.029	<0.029	<0.007	<0.007	<0.007	0.3	0.2	<0.1
4/08/88				<0.0005	<0.0005	<0.0005				<0.007	<0.007	<0.007	0.2	0.2	<0.1
5/05/88				<0.0005	<0.0005	<0.0005				<0.030	<0.030		<0.1	<0.1	<0.1
6/02/88				<0.0005	<0.0005	<0.0005				<0.030	<0.030	<0.030	0.2	0.1	<0.1
7/07/88				<0.0005	<0.0005	<0.0005				<0.030	<0.030	<0.030	0.17	0.17	0.11
8/09/88				<0.0005	<0.0005	<0.0005				<0.030	<0.030	<0.030	0.12	<0.1	<0.1
9/08/88				<0.0005	<0.0005	<0.0005				<0.030	<0.030	<0.030	0.25	0.27	0.14
AVERAGE	<0.05	<0.05	0.00	0.0000	0.0000	0.0000	<0.029	0.000	0.000	<0.007	0.000	0.000	0.4	0.15	<0.1
MINIMUM	<0.05	<0.05	<0.05	<0.0005	<0.0005	<0.0005	<0.029	<0.029	<0.029	<0.007	<0.007	<0.007	<0.10	<0.1	<0.1
MAXIMUM	0.08	0.055	<0.05	<0.0005	<0.0005	<0.0005	0.067	<0.029	<0.029	<0.010	<0.030	<0.030	2.2	0.40	0.14

TABLE NO. 5-1 (Cont.)

SAMPLING DATE	NITRATE/NITRITE NITROGEN mg/l			TOTAL KJELDAHL NITROGEN mg/l			DISSOLVED OXYGEN mg/l (field)			pH s.u. (field)			SELENIUM mg/l		
	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK
10/14/87	0.07	0.06	<0.05	2	1	<1	10.5	10.5		6.26	6.23		<0.005	<0.005	<0.005
11/04/87	(b)	(b)	(b)	<1	<1	<1	10.4	10.3		6.29	6.20	6.60	<0.005	<0.005	<0.005
12/02/87	0.11	0.10	<0.05	2	1	1				6.38	6.38		<0.005	<0.005	<0.005
1/06/88	0.12	(a)	0.06	2	(a)	<1				6.73	(a)		<0.005	(a)	<0.005
2/03/88	0.21	0.18	<0.05	2	2	2	11.2	11.0		6.59	6.33		<0.005	<0.005	<0.005
3/01/88	0.16	0.16	<0.05	<1	<1	<1	10.2	10.0		6.45	6.62		<0.005	<0.005	<0.005
4/08/88	0.35	0.34	<0.07	<1	<1	<1	11.8	11.9		7.04	7.06		<0.005	<0.005	<0.005
5/05/88	0.17	0.18	<0.05	<1	<1	<1	10.6	9.5		7.10	7.07		<0.005	<0.005	<0.005
6/02/88	0.14	0.10	<0.05	<1	<1	<1	9.0	9.05		6.98	7.14		<0.005	<0.005	<0.005
7/07/88	<0.05	<0.05	<0.05	<1	<1	<1	6.5	6.0		7.09	7.01		<0.005	<0.005	<0.005
8/09/88	(b)	(b)	(b)	2	2	<1	7.3	7.9		6.95	7.16		<0.005	<0.005	<0.005
9/08/88	<0.05	<0.05	<0.05	<1	<1	<1	11.7	11.7		7.98	7.92		<0.005	<0.005	<0.005
AVERAGE	0.13	0.12	<0.05	<1	<1	<1	9.9	9.8		6.82	6.83	6.60	0.000	0.000	0.000
MINIMUM	<0.05	<0.05	<0.05	<1	<1	<1	6.5	6.0		6.26	6.20	6.60	<0.005	<0.005	<0.005
MAXIMUM	0.35	0.34	0.06	2	2	2	11.8	11.9		7.98	7.92	6.60	<0.005	<0.005	<0.005

TABLE NO. 5-1 (Cont.)

SAMPLING DATE	SILVER mg/l			SODIUM mg/l			TOTAL DISSOLVED SOLIDS mg/l			TOTAL ORGANIC CARBON mg/l			TOTAL SUSPENDED SOLIDS mg/l		
	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK
10/14/87	<0.005	<0.005	<0.005	6.0	6.3	<0.5	83	95	<1	15	8.3	<0.1	1	5	1
11/04/87	<0.005	<0.005	<0.005	6.2	5.1	<0.5	99	110	4	8.98	13.9	<0.1	7	<5	<5
12/02/87	(b)	(b)	(b)	6.0	6.2	0.55	86	84	<1	18.1	23.1	<0.10	7	<5	<5
1/06/88	<0.0004	(a)	<0.0004	6.6	(a)	<0.5	130	(a)		13.89	(a)		<5	(a)	
2/03/88	<0.0004	<0.0004	<0.0004	7.8	7.9	<0.5	100	100	<5	10.0	0.26	<0.1	<5	11	<5
3/01/88	<0.0004	<0.0004	<0.0004	8.1	8.4	<0.5	100	120	<20	8.99	7.81	<0.10	<5	<5	<5
4/08/88	<0.0004	<0.0004	<0.0004				36	21	<20	(b)	(b)	(b)	<10	<10	<10
5/05/88	<0.0004	<0.0004	<0.0004				120	120	33	11.1	12.3	0.84	<10	<10	<10
6/02/88	<0.0004	<0.0004	<0.0004				140	120	<20	12.4	11.4	0.62	<10	<10	<10
7/07/88	<0.0004	<0.0004	<0.0004				130	140	36	10.4	10.6	0.54	12	<10	<10
8/09/88	<0.0004	<0.0004	<0.0004				79	89	<20	11.2	10.7	0.5	13	15	<10
9/08/88	<0.0004	<0.0004	<0.0004				93	83	<20	11.3	10.5	0.37	<10	<10	<10
AVERAGE	0.0000	0.0000	0.0000	6.8	6.8	<0.5	100	98	7	11.9	10.9	0.29	3	3	<1
MINIMUM	<0.0004	<0.0004	<0.0004	6.0	5.1	<0.5	36	21	<1	8.98	0.26	<0.1	1	<5	1
MAXIMUM	<0.005	<0.005	<0.005	8.1	8.4	0.55	140	140	36	18.1	23.1	0.84	13	15	1

TABLE NO. 5-1 (Cont.)

SAMPLING DATE	SPECIFIC CONDUCTIVITY Micro mhos/cm (field)			SULFATE mg/l			SULFUR mg/l			TEMPERATURE Degrees Celcius (field)			THALLIUM mg/l		
	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK
10/14/87	139	138		11	11	<5	(b)	(b)	(b)	10	10		<0.005	<0.005	<0.005
11/04/87	131	122		8	9	<5	<7	<7	<7	8	8		<0.005	<0.005	<0.005
12/02/87	118	130		10	11	<5	<7	<7	<7	3	3		<0.005	<0.005	<0.005
1/06/88	160	(a)		12	(a)	<5	<7	(a)		1	1		<0.005	(a)	<0.005
2/03/88	169	177		14	14	<5	<11	<11	<11	1	1		<0.005	<0.005	<0.005
3/01/88	169	171		10	9	<5	<7	<7	<7	1	1		<0.005	<0.005	<0.005
4/08/88	126	115		<5	<5	<5	<7	<7	<7	2	2				
5/05/88	109	101		8	7	<5	3.1	3.3	<1.7	11.0	12.0				
6/02/88	120	121		7	6	<5	4.2	2.9	<1.7	18.0	18.5				
7/07/88	152	150		15	15	<5	3.2	3.0	<1.7	22.5	24.5				
8/09/88	179	153		13	13	<5	4.0	4.0	<1.7	23.5	23.5				
9/08/88	152	150		11	11	<5	3.7	3.8	<1.7	20.5	20.5	20.5			
AVERAGE	144	139		10	10	0	1.7	1.7	0.0	10.1	10.4	20.5	0.000	0.000	0.000
MINIMUM	109	101		<5	<5	<5	3.1	2.9	<1.7	1.0	1.0	20.5	<0.005	<0.005	<0.005
MAXIMUM	179	177		15	15	<5	4.2	4.0	<11	23.5	24.5	20.5	<0.005	<0.005	<0.005

TABLE NO. 5-1 (Cont.)

SAMPLING DATE	TIN mg/l			TITANIUM mg/l			URANIUM mg/l			ZINC mg/l		
	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK	UP STREAM	DOWN STREAM	FIELD BLANK
10/14/87	<0.067	<0.067	<0.067	<0.004	<0.004	<0.004	<0.001	<0.001	<0.001	<0.05	<0.05	<0.05
11/04/87	<0.067	<0.067	<0.067	<0.004	<0.004	<0.004	<0.001	<0.001	<0.001	<0.05	<0.05	<0.05
12/02/87	<0.067	<0.067	<0.067	0.004	<0.004	<0.004	0.011	0.009	0.003	<0.05	<0.05	<0.05
1/06/88	0.093	(a)		<0.004	(a)		<0.001	(a)		<0.05	(a)	<0.05
2/03/88	<0.067	<0.067	<0.067	<0.004	<0.004	<0.004	(b)	(b)	(b)	<0.05	<0.05	<0.05
3/01/88	(b)	(b)	(b)	<0.004	<0.004	<0.004	0.002	0.002	<0.001	0.05	0.068	<0.05
4/08/88										<0.05	<0.05	<0.05
5/05/88										<0.05	<0.05	<0.05
6/02/88										<0.05	<0.05	<0.05
7/07/88										<0.05	<0.05	<0.05
8/09/88										<0.05	<0.05	<0.05
9/08/88										<0.05	<0.05	<0.05
AVERAGE	<0.067	0.000	0.000	<0.004	0.000	0.000	0.003	0.003	<0.001	<0.05	<0.05	0.00
MINIMUM	<0.067	<0.067	<0.067	<0.004	<0.004	<0.004	<0.001	<0.001	<0.001	<0.05	<0.05	<0.05
MAXIMUM	0.093	<0.067	<0.067	0.004	<0.004	<0.004	0.011	0.009	0.003	0.05	0.068	<0.05

(a)-Data Point Deleted From Data Set - Sample Non-Representative
(b)-Data Point Deleted From Data Set - Contamination in Field Blank

6.0 DESCRIPTION OF PROPOSED WASTEWATER TREATMENT FACILITIES

6.1 Introduction

As discussed in Section 4.0, seven water source categories have have been identified as being associated with the Flambeau Project. Three of these categories, as listed below, have been identified as needing some degree of treatment prior to discharge.

- Category No. 4 - Contact Pit Water
- Category No. 5 - Contact Runoff
- Category No. 6 - Leachate From the Type II Storage Pile

Throughout the remainder of this report, the combined flow from these three categories will be referenced to as Stream One.

Water from one category, Category No. 3 - Type I Runoff and Non-Contact Pit Water, will be diverted to planned settling ponds. This category will be referred to as Stream Two throughout the remainder of this report.

The following discussion addresses Streams One and Two on an individual basis.

6.2 Stream One

Stream One is expected to consist of wastewater from three principal sources: mine seepage and precipitation; Type II storage pad drainage; and runoff from ore haulage roads, crushing and loadout areas, and shop facilities. Water from these sources will be pumped to a wastewater treatment facility to be located south of the crusher and Type II storage pile (Figure No. 3). The treatment plant is designed to process this water for acid neutralization and metal removal in a two stage chemical/physical treatment process consisting of lime treatment and sulfide precipitation followed by multi-media filtration. The discussion that follows addresses anticipated flow rates to the wastewater treatment plant; the results of a bench test study to assess the effectiveness of the proposed treatment process; and a detailed description of the treatment process, solids handling, and treated water discharge.

6.2.1. Projected Flow Rates

Table No. 6-1 contains projections of the flow of water to the wastewater treatment plant under three conditions: 1) annual average flow; 2) average flow during the typically rainy months of the year (April through October) and 3) average flow during the month of typical maximum precipitation (June). Flow rates are shown for each area or site feature contributing water to the wastewater treatment plant. Included in the table is the projection of the inflow of groundwater into the open pit for two conditions as determined in the Kennecott Model report. The first condition represents the maximum pit inflow rate, while the second represents the predicted highest year average annual inflow. The values shown are those determined to be at the high end (high recharge and permeability) of the sensitivity analysis completed as part of the modeling work. These high end values were used for wastewater treatment plant sizing. The table shows that flows are projected to range from 296 gpm on an annual basis to 570 gpm during the maximum month.

During or shortly after storm events the generation of wastewater will occur at rates higher than the average discussed above. Since a uniform flow of wastewater to the treatment plant is desirable for optimum plant performance, provisions have been made in the design of the wastewater treatment plant for temporary water storage in a lined surge pond and in a lined

TABLE NO. 6-1

Projected Wastewater Treatment Plant Flow Rates

	Average Flow in GPM		
	Annual	Wet Season[1]	Max. Month[2]
Precipitation and Runoff			
Open pit	50	73	101
Type II storage pile	47	69	95
Plant/crusher	19	28	37
Ore haul road	5	7	9
Subtotal	121	177	242
Maximum Pit Inflow[3]	328	328	328
Average Pit Inflow[4]	175	175	175
Total WWTP Flow Rates			
With Maximum Pit Inflow	449	505	570[5]
With Average Pit Inflow	296	352	417

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[1] April through October

[2] June

[3] Maximum inflow of groundwater into the pit that would require treatment at the wastewater treatment plant (WWTP). Taken from Figure 14 of the "Groundwater Model for the Kennecott Flambeau Project" by Prickett, et al., July 1989. Value represents flow at approximately day 1460 after excavation commences for high recharge and permeability conditions. Flow occurring at day 30 was not used since dewatering of overburden will not result in removed water being sent to the WWTP. Value represents peak flow which will occur for only a short time during the year of record.

[4] Average annual inflow of groundwater into the pit that requires treatment at the WWTP. Taken from Figure 9 of the "Groundwater Model for the Kennecott Flambeau Project" by Prickett, et al., July 1989. Value represents highest average annual inflow (year 5) based on high recharge and permeability conditions.

[5] Assumes peak inflow occurs during maximum month.

runoff catchment pond. The capacity of these two ponds is 1,771,500 and 643,000 gallons respectively. In addition, the mine pit will be used for emergency water storage in the event of a major storm. Each pond will have overflow piping to return water to the mine if the pond becomes full. The storage system has the capacity to store water for sufficient time to do major maintenance work on the wastewater treatment plant, should it be necessary.

Given the average flows in Table No. 6-1, the above method of providing surge capacity, Flambeau's desire to provide sufficient capacity at the plant to minimize disruption of mining due to storm events, the design capacity for the wastewater treatment plant has been set at 800 gpm. Figure No. 5 is a flow sheet showing the origin of the wastewaters that make up Stream One and how the water will be directed to the wastewater treatment plant.

6.2.2 <u>Bench Test Studies</u>

In early 1988 Flambeau requested that the WDNR develop proposed effluent limits for the project based on baseline data collected for the Flambeau River in late 1987. This information, based on proposed rules, was provided to Flambeau in a memorandum dated April 7, 1988. Although it was recognized that these were estimated effluent limits, a treatment process was selected which was felt capable of treating the projected wastewater such that the limits as estimated in the April 7th letter could be met. This process consisted of lime treatment for acid neutralization and metals removal followed by sulfide precipitation and multi-media filtration.

After the treatment process was selected, a bench test program was developed to verify that the selected system could meet the estimated effluent limits. A detailed report regarding the bench test study is contained in Appendix A. The results of the study are summarized in Table No. 6-2.

Since the completion of the bench test study, revised proposed effluent limits were provided by WDNR in the September 1989 Draft Environmental Impact Statement. A comparison of the bench test results to the revised limits is presented in Table No. 6-3.

The bench test, using worst case test conditions, showed that the lime treatment process did an efficient job of removing metals in the wastewater and with the exception of copper, it would produce an effluent that would meet the estimated limits (Table No. 6-3). The sulfide precipitation process was shown to be capable of lowering the copper concentration in the lime treatment effluent to levels below the estimated limits.

The wastewater used for the bench study was generated from high sulfur waste rock obtained during drilling at the Flambeau site. The measured components of this wastewater are contained in Table No. 6-2. The bench study showed that the ability of the treatment process to meet the estimated effluent limits was not a function of the strength of the influent stream.

TABLE NO. 6-2

Projected Treatment Plant Performance
(Based on Bench Scale Testing)

Parameter	Influent Water[1] (mg/l)	Lime Treatment Effluent (mg/l)	Sulfide Precipitation Effluent (mg/l)	Estimated Effluent Limits[2] (mg/l)
Arsenic	0.09-0.2	<0.003	<0.003	0.720
Cadmium	0.094-1.46	0.0007-0.0012	<0.0003	0.0034
Chromium, Trivalent	0.003-0.014	<0.002	<0.002	1.903
Chromium, T	0.003-0.014	<0.002	<0.002	0.032
Copper	94-910	0.20-0.35	<0.010	0.0177
Lead	0.047-0.280	<0.002	<0.002	0.0641
Mercury	<0.0005-0.00073	<0.0005	<0.0005	0.0048
Nickel	0.082-1.9	<0.03	<0.03	1.524
Selenium	0.006-0.016	0.004-0.007	0.003	0.260
Silver	0.0024-0.017	<0.0004-0.0005	<0.0004	0.0011
Zinc	24-240	0.07-0.12	<0.03	0.125

[1] Based on high sulfur waste rock samples. Actual loading is anticipated to be lower.

[2] Based on WDNR letter from Dave Olig, dated April 7, 1988. Calculations in the letter were based on proposed rules and preliminary data.

NOTE: Influent water and lime treatment results represent the range of test results obtained during the bench test program. Sulfide precipitation data represents the results from the final tests conducted as part of the bench test.

TABLE NO. 6-3

September 1989 Projected Effluent Limits Compared to Bench Test Results[1]

Parameter	Lime Treatment Effluent	Sulfide Precipitation Effluent	Preliminary Effluent Limits[2] Monthly Average	Weekly Average	Daily Maximum
Aluminum	No Data	No Data	---	0.822	1.5
Arsenic	<0.003	<0.003	---	---	0.728
Beryllium	No Data	No Data	0.103	---	---
Cadmium	0.0007-0.0012	<0.0003	0.05	0.0071	0.0949
Chromium, Total	<0.002	<0.002	---	0.981	5.36
Chromium (+6)	<0.002	<0.002	---	---	0.0284
Copper	0.2-0.35	<0.01	0.15	---	0.0501
Lead	<0.002	<0.002	0.3	0.136	0.591
Mercury	<0.0005	<0.0005	0.00034	---	0.002
Nickel	<0.03	<0.03	---	1.17	3.12
Selenium	0.004-0.007	0.003	---	---	0.116
Silver	<0.0004-0.0005	<0.0004	---	---	0.0066
Thallium	No Data	No Data	---	---	1.41
Zinc	0.07-0.12	<0.03	0.75	---	0.299

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[1] All values in mg/l (parts per million)
[2] Values taken from Table 3-2, page 50, Draft Environmental Impact Statement

6.2.3 Treatment Process Description

Following is a detailed description of the treatment process proposed for Stream One. Figure No. 6 contains a flow sheet for the process.

6.2.3.1. Lime Treatment

Lime treatment is commonly used for acid neutralization and metal precipitation. Most operating metallic mines are currently operating a similar system on mine wastewaters which are acidic and which contain metals. Acid in the wastewater is neutralized to produce a sparingly soluble salt as illustrated below:

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

Eq. 1b $Ca^{+2} + SO_4^{-2} \text{ --> } CaSO_4$

With lime treatment, metals are precipitated with varying effectiveness as hydroxides and calcium salts, depending upon the pH of the system. Generally, a pH in the range of 9 to 10 provides an optimum range for effective metal precipitation. Higher pH often results in dissolution of some metal hydroxides as complexes and decreases effectiveness. Regardless of pH, the bench studies have shown that lime treatment alone may not provide a sufficient level of metals removal to meet the estimated effluent limits for copper. It will provide an effective step to remove the majority of dissolved metals and improve the effectiveness of the polishing treatments which follow. Typical metal precipitation reactions which occur with lime treatment are:

Eq 2a $\mathrm{Fe^{+3} + Ca(OH)_2 \dashrightarrow FeO(OH) + Ca^{+2} + H^+}$

Eq 2b $\mathrm{Cu^{+2} + Ca(OH)_2 \dashrightarrow Cu(OH)_2 + Ca^{+2}}$

Eq 2c $\mathrm{Zn^{+2} + Ca(OH)_2 \dashrightarrow Zn(OH)_2 + Ca^{+2}}$

Eq 2d $\mathrm{Pb^{+2} + Ca(OH)_2 \dashrightarrow Pb(OH)_2 + Ca^{+2}}$

Eq 2e $\mathrm{2AsO_4^{-3} + 3Ca(OH)_2 \dashrightarrow Ca_3(AsO_4)_2 + 6OH^-}$

Eq 2f $\mathrm{Cd^{+2} + Ca(OH)_2 \dashrightarrow Cd(OH)_2 + Ca^{+2}}$

The proposed lime treatment system will consist of a lime storage and slaking facility to produce a 15 percent lime slurry, a rapid-mix tank for lime treatment of the wastewater, a flocculation system, a thickener for the sedimentation and removal of precipitated solids.

Design criteria for the lime system includes the following:

- The level of treatment required.

- Feed water flows up to 800 gpm.

- Neutralization will be accomplished with 15 percent milk of lime. Milk of lime will be produced by slaking lime stored in a 46-ton silo (250-MAA-01) in a two-ton per hour lime slaker (250-NLS-01). Milk of lime will be stored in a 16,000-gallon agitated storage tank (250-MDA-05).

- Lime usage, consistent with Eq. 1a and 1b and 2a through 2f, of up to 12 tpd. Metal hydroxide/gypsum solids will be produced at up to 33.5 dry tons per day at a maximum influent feed rate of 800 GPM.

- Ten-minute detention time for lime mixing with wastewater based on total flow including recirculated streams. The detention time was selected to use the lime efficiently because of its low solubility. The 10-minute detention time will be accomplished, along with neutralization in a 10,000-gallon neutralizing and mixing tank (250-MDA-04).

- A 60-foot diameter x 10-foot sidewall clarifier (250-NCL-01) which will provide an overflow rate of less than 0.30 gpm/ft^2 and will produce 25 percent settled solids. The clarifier will be equipped with a flocculant mixing system which will enhance the formation of settleable solids. The clarifier will not be covered. The tank walls will be insulated to prevent convection currents from disturbing the solids settling process. The solids will contain precipitated metal hydroxides and calcium salts along with suspended solids present in the influent. Settling and clarification will be aided by the addition of a polyacrylimide flocculant. Concentrated flocculant will be received and stored in a 4,000-gallon storage tank (250-MDA-07) and diluted to 100 - 1000 ppm with water in an in-line mixer (250-NAI-01). The diluted polyacrylimide flocculant will then be stored in a 500-gallon dilute flocculant tank (250-MDA-06) and added to the clarifier feed mixing system to achieve a final concentration of approximately one ppm.

- The settled solids will be recirculated so that the solids recycle factor is 17 or greater. The high recirculating load promotes increased precipitated particle size, which aids settling.

- The thickened precipitate will be bled off from the recirculation loop, and fed to an 8,000-gallon underflow storage tank (250-MDA-017). The precipitate will then be pumped to a truck for transport to the Type II storage pile. Characteristics of the precipitate generated from the bench test studies are contained in Appendix A. It should be noted when reviewing this data, that these solids were generated using wastewater representing worst case conditions.

6.2.3.2 Sulfide Precipitation

Sulfide precipitation has been incorporated into the wastewater treatment system process design to promote the removal of copper and zinc from the lime treatment effluent. In the event that lime treatment alone achieves discharge limits, the sulfide treatment process will not be operated. Typical metal precipitation reactions of the sulfide precipitation process are:

Eq 3a. $Cu^{+2} + Na_2S \text{ ---> } CuS + 2Na^+$

Eq 3b. $Zn^{+2} + Na_2S \text{ ---> } ZnS + 2Na^+$

Eq 3c. $Fe^{+2} + Na_2S \text{ ---> } FeS + 2Na^+$

Eq 3d. $2Fe^{+3} + 3Na_2S \text{ ---> } 2FeS + 6Na^+ + S^o$

Eq 3e. $H_20 + 1/2\ 0_2 + Na_2S \text{ ---> } S^o + 2NaOH$

The very low solubility of the metal sulfides is the key to the effectiveness of the method. Precipitation of residual metals requires that the pH be slightly acid (5 to 6) for best results. This will require re-acidification of the lime precipitation effluent.

The sulfide precipitation system consists of two agitated tanks in series, each providing approximately five minutes detention time (reaction times are fast and the reagents are readily soluble), a sulfuric acid dilution and addition system, a sodium sulfide dilution and addition system, and a sulfide precipitate filter station consisting of three multi-media filters.

Design criteria for the sulfide precipitation system include the following:

- The clarifier will produce a maximum of 810 gpm overflow which will be treated with sodium sulfide in two 4,000-gallon mixing tanks (250-MDA-012 and 250-MDA-013). The tanks will provide a minimum combined detention time of about ten minutes.

- Sulfide treatment will require a pH of 5-6. To achieve this pH, clarifier effluent will be acidified with sulfuric acid at a strength of one to ten percent. Concentrated sulfuric acid will be stored in a 1,200-gallon tank (250-MDA-08) at 93 to 98 percent and diluted to a one to ten percent solution in a 500-gallon dilute acid tank (250-MDA-09). A variable flow metering pump will provide up to 50 ppm acid to the 4,000-gallon mixing tanks. The acid storage and dilution system will be enclosed by containment curbs.

- Sodium sulfide will be mixed in a 300-gallon tank (250-MDA-010) at a strength of one to ten percent, or as required. This solution will then be added to a 500-gallon feed tank (250-MDA-011) for addition at up to 50 ppm into the 4,000-gallon mixing tanks. The sodium sulfide mixing and storage system will also be curbed.

- Generation of hydrogen sulfide in the mixing tanks could occur only under major system failures and only in air concentrations of less than 5 ppm. The mixing tanks will be covered and vented as a precaution against this unlikely event. Stationary hydrogen sulfide monitors will be installed in the area to alert operators if the gas is present so the cause can be corrected.

- Flocculant from the flocculant system will be added to the sulfide mixing tanks as required.

- The mixing tanks will feed a 7,500-gallon multi-media filter feed tank (250-MDA-014) which will provide a surge capability ahead of the three seven-foot diameter by five-foot multi-media filters (250-NFL-01, 250-NFL-02, 250-NFL-03). The filters will be designed at 10 gpm/ft^2 (an industry standard) with two filters in operation and one in backwash. The suspended solids loading to the filters will be designed for a maximum of 50 ppm with a 1 ppm effluent.

- Filter backwash will be collected in a 6,000-gallon backwash storage tank (250-MDA-02) which will act as a surge tank so that the backwash can be bled to the clarifier at 10 gpm.

6.2.3.3 <u>Effluent Discharge</u>

Effluent from the filters will report to a 10,000-gallon pH neutralization tank (250-MDA-01) where milk of lime will be added to adjust the pH to a level between 6 and 8. Effluent from the pH neutralization tank will pass through a continuous flow monitoring system which will be linked to a flow proportional sampler. This system will provide the capabilities of 24 hour flow proportional sampling. From this monitoring system, the effluent will flow through an enclosed pipe for direct discharge into the Flambeau River (Figure No. 3). In the unlikely event of an upset in the treatment process, the effluent will be diverted to a recycle pump and will be pumped to either the mine surge pond or the runoff catchment pond and held for re-treatment.

6.3 Stream Two

Stream Two consists of runoff from the Type I stockpile and non contact pit water. Water from these sources will either flow by gravity or be pumped to settling ponds. The primary purpose of the ponds will be to remove sediment. The ponds can also be used to provide treatment on an as-needed basis. Based on the purpose for the ponds and an analysis of the influent water quality, the ponds can be constructed on native soil without a liner. The ponds themselves are an integral part of the Type I storage pile as the majority of the water passing through them will originate as runoff from the pile.

Figure No. 7 is a flow sheet showing the origin of the water that will be delivered to the settling ponds. Figure No. 8 illustrates the hydraulic profile of the settling pond system. The location of the ponds is shown on Figure No. 3.

The discussion that follows provides information relating to settling pond design, operation, and effluent discharge. A discussion of average and peak flow rates into the ponds was presented in Section 4.3.

6.3.1 Settling Pond Design

Runoff from the Type I stockpile and water from the pit during Phase I and Phase II stripping will be directed to two settling ponds aligned in series. Each pond will have a 1.4-acre surface area and be 17.5 feet deep. Of this depth, 12.5 feet will be provided for live storage, with three feet for sediment storage and two feet for freeboard. The ponds will be located to the southwest of the Type I stockpile (see Figure No. 3). Given their dimensions, the ponds will have a live storage capacity of approximately 6,927,000 gallons.

The site drainage system will be designed for the 25 year storm event, which is equal to 4.6 inches of precipitation. Making a conservative assumption (i.e., not taking evaporation and infiltration into the Type I stockpile into account) the entire 4.6 inches of rainfall will need to be stored. Using the 40-acre area of the Type I stockpile, the volume of water that would have to be stored from the 25 year storm would equal 4,996,000 gallons. Comparing this figure to the volume available indicates that the ponds have more than sufficient capacity to store the water that would be generated from the 25-year storm.

Based on total stockpile area, the volume of runoff expected from a 25-year, 24 hour duration storm (4.6 inches) totals 4,996,000 gallons which will take only 72 percent of the pond storage capacity leaving a 1.39 factor of safety. This is a very conservative design because no inflow reduction has been incorporated for infiltration into the stockpile soils. The pond is sized so that even if full, a detention time of approximately 34 hours can be expected from the 25-year event average inflow of 7.6 CFS.

During Phase I and II stripping operations, water from the open pit will also be delivered to the settling ponds. The ponds will have sufficient capacity to store over 1,900,000 gallons of water from this source even if they contain all the runoff from a 25 year storm. Since the pit itself can act as a retention basin, hydraulic calculations regarding settling pond storage capacity versus open pit generated water are not necessary. If settling pond capacity is being approached during a major storm, pumping from the open pit would cease. The possibility of the above scenario happening is very remote, since the duration of pumping from the pit to the ponds is short and the probability of a 25-year storm occurring during that time period is small.

Under normal conditions, the ponds are designed to operate as settling ponds. The first pond in the series will act to remove larger suspended materials and provide initial settling of colloids if and when they are present. The second pond will allow final settling to occur. Water will normally be allowed to flow from the first to second pond via an overflow spillway (Figure No. 9). The clear water from the second pond will flow via effluent structures into the Flambeau River.

It is estimated that the Type I stockpile will produce 100 tons per acre per year of sediment, which is equal to approximately 2,700 cubic yards. Sediment storage capacity within the ponds is equal to approximately 3,300 cubic yards. Therefore, it will be necessary to remove sediment from the ponds on an annual basis. Sediment removed from the pond will be returned to the Type I stockpile.

The ponds can also operate as a retention pond to hold water for batch treatment, should treatment be necessary. Each pond will also have a bottom outlet structure. The bottom discharge will consist of a 16-inch diameter corrugated metal pipe with manually operated gates on the outlet structures that can be opened to allow stored water to be removed. This system will also be used under normal operating conditions to maintain storage capacity in the ponds. The potential need for treatment may result from the production of colloidal materials.

Waste characterization work for the overburden and saprolite materials indicated that colloids suspension may result when water comes into contact with the two materials once they have been disturbed. It should be noted that waste characterization studies have also shown that it is probable that the greatest quantities of colloids will result from the initial wetting of overburden and saprolite and that as these materials age on the Type I stockpile, less and less colloids will occur in the runoff water. The suspension would consist largely of colloidal sized particles primarily of iron and aluminum oxyhydroxides. Associated with these colloids could be small quantities of copper, lead and zinc. As established by analytical testing, the bulk of the metals present are in suspension and not in the dissolved state.

Based on mining industry experience at other locations, an addition of polymer has been demonstrated to be an effective method for the removal of such colloids. To select a polymer that could be used, if necessary, and assess its performance, a bench test study was conducted. The bench test study showed that a polymer is available to successfully aid in removing colloids, if present, from the influent water. Chemical analyses showed that pH adjustment may be required at times to assist in metal removal. A detailed discussion of the study is contained in a report in Appendix A.

The present operational plan for the addition of either lime and/or polymer will rely on manually feeding these solutions. The basins will need to be operated as retention ponds if the addition of settling aids is required. If colloids present a continuous problem, Flambeau will take the necessary steps to provide a more automated chemical feed system.

Finally, additional analytical tests were undertaken to determine any potential impacts from these ponds on groundwater quality. During the bench test studies analytical tests were performed to determine the amount of dissolved metals that were in the worst case wastewater used for the test. The dissolved metals as referred to above are defined as those which can pass through a 0.45 micron filter. Table No. 6-4 compares the results of these tests to the primary and secondary drinking water standards. The results of the comparison show that the settling ponds can be constructed on native soil without a liner system.

This conclusion is supported by the fact that the dissolved metals concentration in the influent water for projected worst case conditions are lower than primary drinking water standards. Therefore, exfiltration from the settling ponds should not exceed primary standards.

In the case of secondary standards, the apparent concentration of iron in the worst case influent is above the standard. The waste characterization studies completed for the project have shown that iron, though, is easily sorbed by the soils at the project site. Thus it is anticipated that this should not be a problem.

In addition, there is also significant evidence that the majority of the iron in the 0.45 micron filtrate reported as being "dissolved" is actually in the colloidal state. This hypothesis is supported by two observations. The first is that the 0.45 micron filtrate had 55 mg/l of suspended solids as determined through the use of a glass fiber filter with an estimated porosity of 0.2 microns. The second is that the

TABLE NO. 6-4

Comparison of Dissolved Metals Content In Stream Two Influent to Primary and Secondary Drinking Water Standards

Parameter	Concentrations (mg/l) Influent Water[1]	 Drinking Water Standard
Arsenic	0.006	0.05
Cadmium	<0.01	0.01
Chromium (Total)	0.018	0.05
Copper	0.17	1.0[2]
Iron	7.5	0.3[2]
Lead	0.041	0.05
Mercury	<0.0005	0.002
Selenium	<0.003	0.01
Silver	<0.0004	0.05
Zinc	0.090	5.0[2]

[1] Represents a worst case scenario since the influent water was prepared from the initial wetting of till and saprolite.

[2] Secondary Standards.

supernatant from the polymer addition tests contained 0.3 mg/l of iron, which is the solubility constant for ferric. Iron in the ferric state is expected from an oxygenerated water such as Stream Two. These two facts when compared to the reported dissolved iron concentration of 7.5 mg/l leads to the conclusion that 7.2 mg/l of the reported dissolved iron is actually in suspension with a particle size ranging from 0.2 to 0.45 microns. It is expected that this iron would be removed from suspension as water filters through the base of the ponds and therefore effluent iron concentrations would not be greater than the secondary drinking water standard.

6.3.2 Settling Pond Operation and Maintenance

The setting ponds are designed to accept run-off water from the Type I stockpile via an inlet structure that collects water from the perimeter ditch inside the berm around the Type I stockpile. The inlet structure will be a concrete box, approximately six feet wide by six feet long by three feet deep with a weir opening on the east side to receive flow from the perimeter ditch. The west side of the box will enclose two (2) 30 inch CMP inlet pipes with manual flap gates. By opening the gates, water can be directed to either or both of the settling ponds. Should flocculant or lime be required to aid in settling out sediments, it will be manually introduced at the inlet structure by plant operating personnel. The amount added will be determined based on observed sediment loadings, flow as measured by the weir and laboratory analyses.

During Phase I and Phase II preproduction stripping of the mine, non-contact water will be pumped from the pit via a temporary pipeline and discharged into the drainage swale at the base of the stockpile for diversion to the settling ponds. The pipeline will discharge onto a riprapped area to prevent erosion of the drainage swale.

Each pond will have a vertical outlet structure comprised of a circular pipe with flap gate outlets on approximately four feet - zero inch vertical spacing. The vertical outlet structures will be connected to a common 16 inch CMP drain pipe that will discharge to a drainage ditch leading to the Flambeau River. These structures will be used to drain the settling ponds between storms and after sediments have settled out. Each pond will be drained from the top down so as to minimize the release of any sediments in the effluent going to the Flambeau River. In the event of prolonged periods of precipitation and run-off, each pond has a spillway overflow. The first pond can overflow to the second, and the second to the drainage ditch leading to the Flambeau River.

The spillway structures will be constructed of concrete with flared inlet aprons and flat discharge flumes. The flumes spillway will have low side walls to contain the overflow and direct it to the bottom of the berm slopes. Energy dissipation riprap will be placed at the bottom of each flume to prevent erosion. The spillway outlet elevations will be two (2) feet below the top of the berm.

Sediments can be periodically removed from the ponds by a front-end loader after an individual pond has been drained and allowed to dry out. During the cleaning period, routine run-off will be handled by the pond not being cleaned. Any removed sediments will be placed on the Type I stockpile. If required, this work would be scheduled during historical periods of low precipitation.

Normal operation of the settling ponds will proceed as follows:

1. Water will enter the first of the settling ponds. Solids will settle while clear water overflows into the second settling pond.
2. Water will further settle in the second settling pond until discharged via the bottom discharge corrugated metal pipe.
3. In the event of prolonged periods of precipitation, discharge via the spillway on the second pond may occur.

When settling of colloids is required, the operator will take the following steps:

1. Water will be allowed to settle to meet effluent limits. If testing shows polymer and lime addition is required, it will be manually added.
2. Water will be allowed to overflow into the second pond. The clear water will be discharged via the bottom discharge corrugated metal pipe. Water quality will be checked to assure effective flocculation of the colloidal material.
3. In the event of prolonged periods of precipitation, discharge via the spillway on the second pond may occur.

6.3.3 **Water Discharge**

Water will be normally discharged from the settling ponds via a 16-inch CMP discharge pipe (Figure No. 3). The effluent from the settling ponds, conveyed by the 16 inch CMP or the spillway structure, will pass through a continuous battery powered flow monitoring system. Grab samples will be collected to represent the discharge from the settling ponds. The effluent will flow via open flow channel structures to the Flambeau River or to Wetland No. 1.

6.4 Operations Staffing

Discussed below are the staffing needs and management and operations responsibilities for the wastewater treatment plant and settling ponds.

6.4.1 Staffing Needs

An estimate of staffing needs for the Flambeau Project wastewater treatment facility was completed with the use of the publication "Estimating Staffing for Municipal Wastewater Treatment Facilities, (M01)."

The operations staffing of an industrial wastewater treatment facility can vary from that of a municipal treatment plant. Areas such as maintenance, clerical, supervisory, and yardwork can be handled by other departments within an industry's organization. Therefore, it is necessary to make adjustments reflecting industrial operations when using the above document. The following summary discusses each aspect of the staffing requirements for the proposed wastewater treatment facilities as adjusted for an industrial environment.

The staffing requirement as calculated from M01 is as follows:

Area of Responsibility	Hours/Year	Personnel Nos.
Operations	1,789	1.0
Maintenance	856	0.5
Supervisory	515	0.3
Clerical	61	<0.1
Laboratory	695	0.4
Yardwork	300	0.2
Total	4,216	2.4

6.4.2 Duties and Responsibilities

6.4.2.1 Operations

The operation of the proposed chemical/physical treatment processes will involve the following duties:

- Monitor wastewater treatment plant and settling pond functions and detect and interpret changes and variations in the plant and ponds or in wastewater characteristics.

- After interpreting these changes, make the necessary alterations to control the treatment processes.

- Coordinate and assist in the completion of routine maintenance or repairs.

- Monitor the completion of the basic laboratory analyses.

- Set up operational programs and maintenance schedules for efficient and continued operation of the facilities and provide long range planning and day-to-day operational decisions.

- Complete and maintain operational records including WPDES monitoring reports.

The person responsible for the operation of the wastewater treatment system will be a certified wastewater treatment plant operator. The operation of the treatment facility will likely require one full-time operator.

6.4.2.2 Maintenance

The mining facility will have a maintenance department. The wastewater treatment plant operator will draw from this pool of people to complete both routine and non scheduled maintenance. The M01 calculations indicate the need for one part time maintenance person. Needed maintenance will be performed by maintenance personnel serving the entire project's needs.

6.4.2.3 Supervisory

Supervisory duties will be handled within the mine organizational structure. The supervision of the wastewater treatment plant will be handled by the mine manager.

6.4.2.4 Clerical

All clerical duties associated with the wastewater treatment facilities will be assumed by the clerical staff within the mine organization.

6.4.2.5 Laboratory

Laboratory duties will be handled by a certified or registered laboratory as defined under Wisconsin Administrative Code NR 149.

6.4.2.6 Yardwork

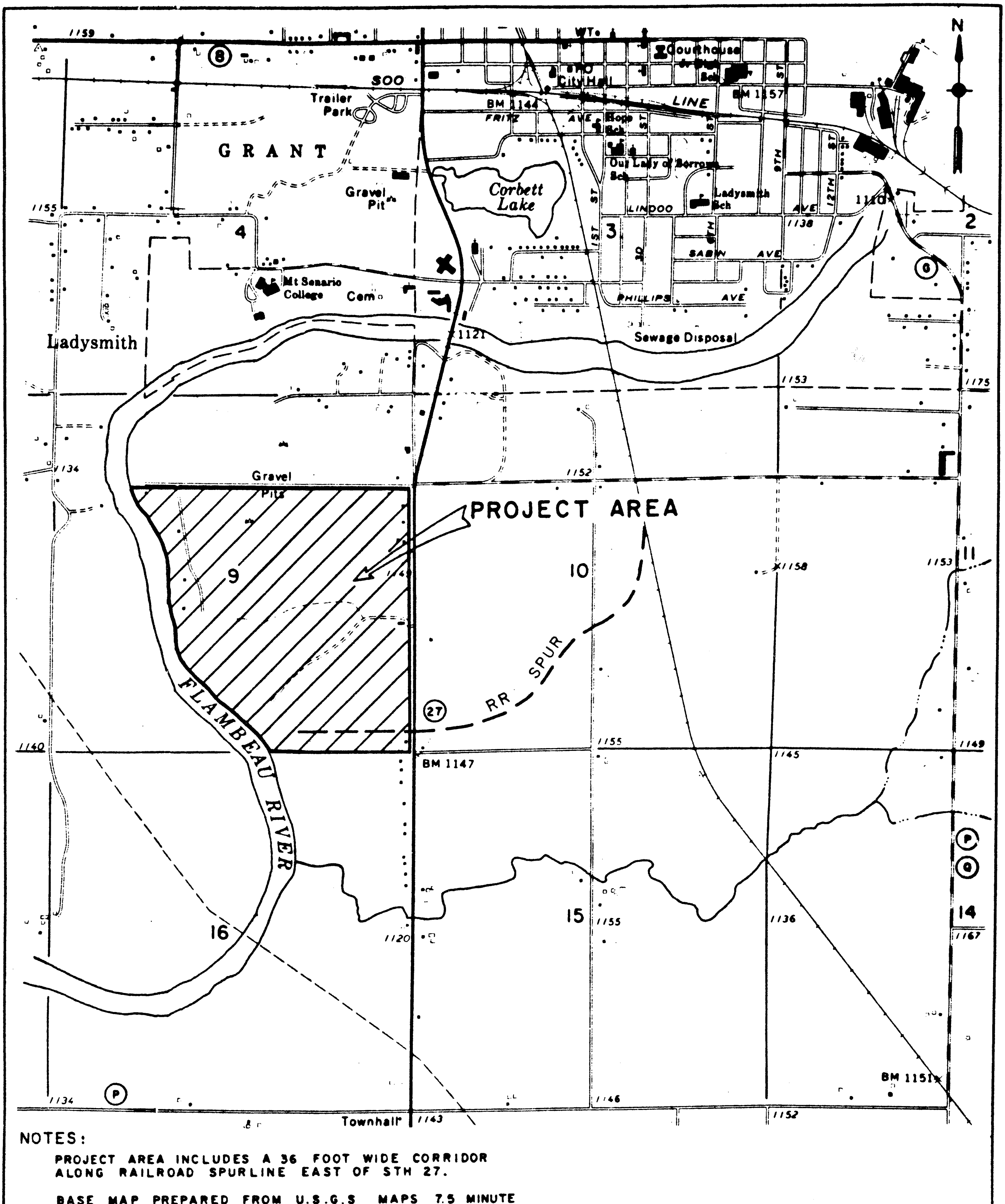
The mining facility will have a generalized staff from which they will draw to do yardwork.

7.0 SUMMARY AND CONCLUSIONS

There will be two wastewater streams from the Flambeau Project. Stream One will consist of water requiring treatment at the proposed wastewater treatment plant. The selected treatment process for Stream One will consist of lime treatment and sulfide precipitation followed by multi-media filtration. Stream Two will consist primarily of detention and settling. At times there may be treatment required for the removal of colloids prior to discharge which will be handled by the manual addition of polymer and lime to the settling ponds.

The bench studies completed as part of this Preliminary Engineering Report show that the estimated effluent limits can be met by the wastewater treatment processes selected for the Flambeau Project.

Figures for Final Engineering Report



NOTES:

PROJECT AREA INCLUDES A 36 FOOT WIDE CORRIDOR ALONG RAILROAD SPURLINE EAST OF STH 27.

BASE MAP PREPARED FROM U.S.G.S MAPS 7.5 MINUTE SERIES, LADYSMITH AND THORNAPPLE WI. QUADRANGLES

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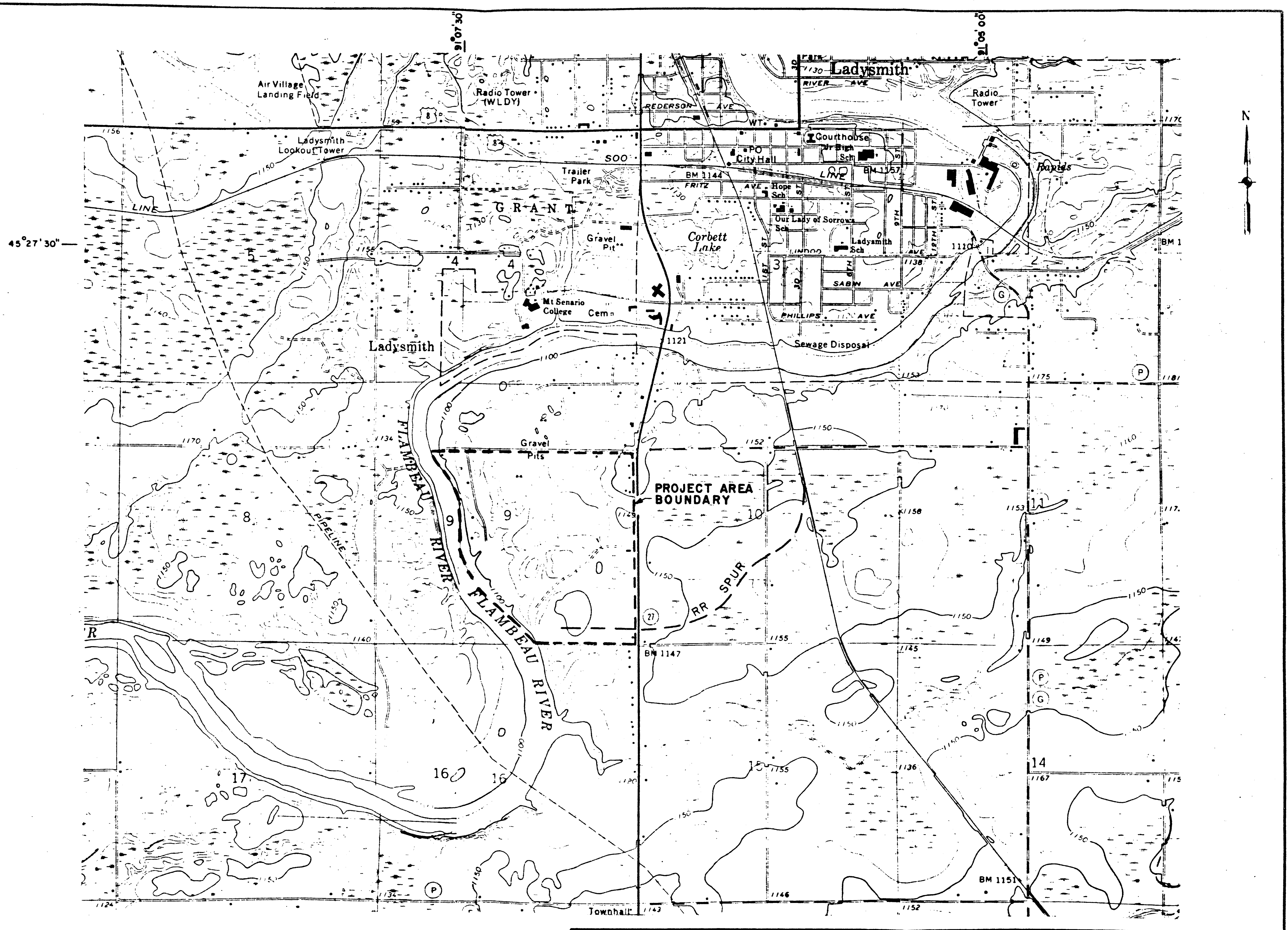
GEOSCIENCES & ENVIRONMENTAL MANAGEMENT DIVISION
GREEN BAY, WISCONSIN

KENNECOTT MINERALS COMPANY
FLAMBEAU PROJECT
LADYSMITH, WISCONSIN

NOTES	APPROVAL		DATE
	DESIGNED BY		
	DRAWN BY	SJL	2/89
	CHECKED BY	GWS	3/89
	APPROVED BY		
	CAD No.	SCALE 1" = 2000'	

FIGURE NO. 1
PROJECT AREA LOCATION

Job No	Dwg No	REV



NOTE: BASE MAP PREPARED FROM U.S.G.S. MAPS 7.5 MINUTE SERIES, LADYSMITH AND THORNAPPLE WISCONSIN QUADRANGLES

REFERENCES DWG. NO.	DESCRIPTION	REFERENCES DWG. NO.	DESCRIPTION	NO	DATE	REVISIONS	BY	CHK'D	ENG'R	ENG'R MGR.	NO.	DATE	REVISIONS	BY	CHK'D	ENG'R	ENG'R MGR.

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GEOSCIENCES & ENVIRONMENTAL MANAGEMENT DIVISION
GREEN BAY, WISCONSIN

	BY	DATE
PROJ. ENG'R		
MGR. PROCESS ENG'R		
ENG'R MGR.		

	BY	DATE
DESIGN		
DRAWN	S.J.L.	2/89
CHK'D	G.W.S.	3/89
DES. ENG'R		
SECT ENG'R		

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KENNECOTT
MINERALS
COMPANY
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SALT LAKE CITY, UTAH
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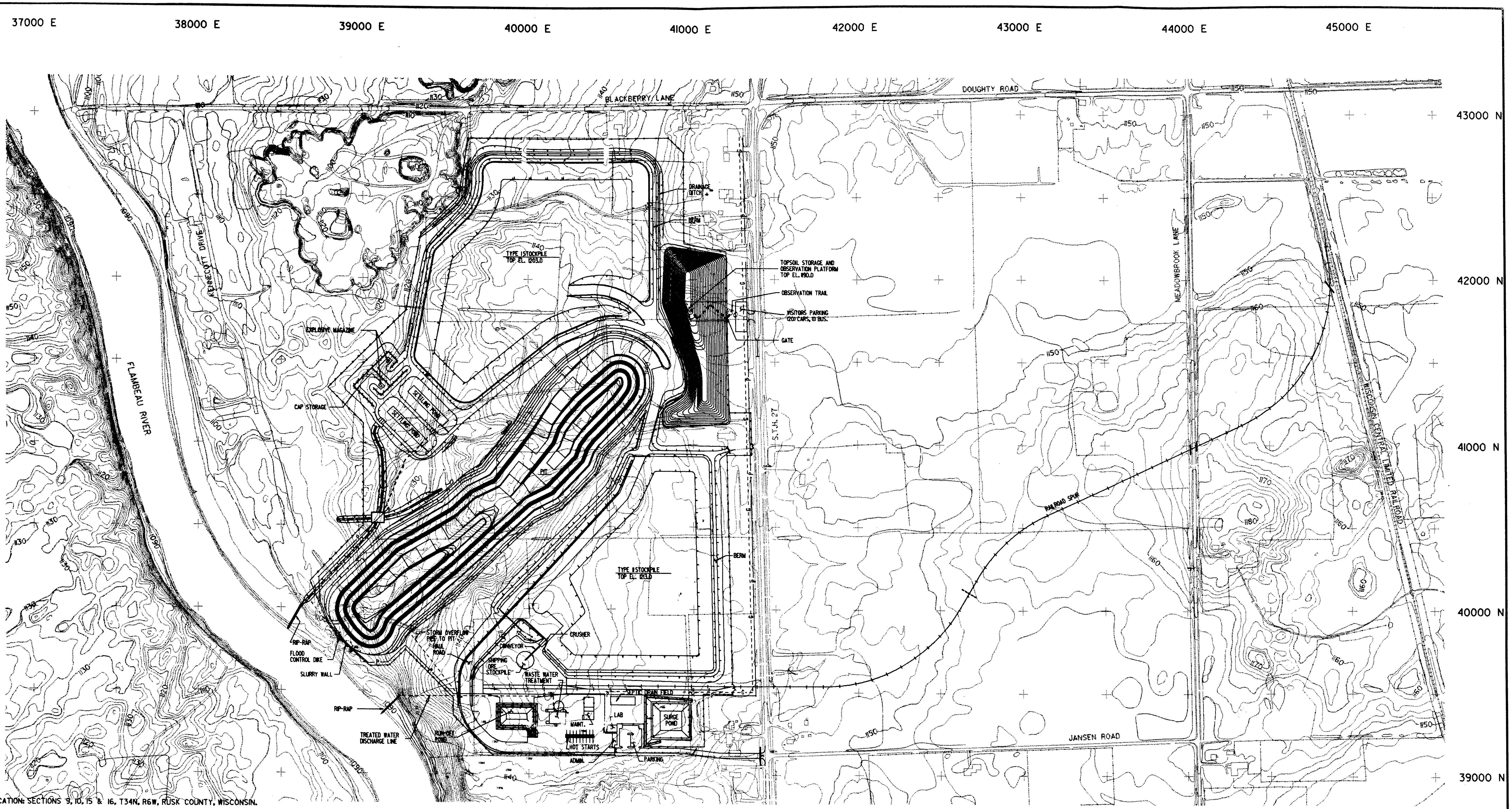
FIGURE NO. 2
TOPOGRAPHIC MAP

MICROFILM
JOB
DRAWING NO.
REV.
DIVISION DRAWING NO.
SCALE 1" = 2000'



NOTES:

1. SITE LOCATION: SECTIONS 9, 10, 15 & 16, T34N, R6W, RUSK COUNTY, WISCONSIN.
2. TOPOGRAPHIC BASE MAP PREPARED FROM AERIAL SURVEY BY SURDEX CORPORATION, CHESTERFIELD, MISSOURI. DATE OF PHOTOGRAPHY - APRIL 24, 1970. ROADS, TREES AND BUILDINGS WERE UPDATED AS PER AERIAL PHOTOGRAPH TAKEN BY MARKHURD CORPORATON, MINNEAPOLIS, MINNESOTA. DATE OF PHOTOGRAPHY - SEPTEMBER 14, 1987.
3. ELEVATIONS BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS TWO FEET.
4. HORIZONTAL DATUM BASED ON PROJECT SITE GRID SYSTEM. SITE GRID COORDINATES CORRELATION TO STATE PLANE COORDINATES DERIVED AS FOLLOWS:

SITE GRID COORDINATES CONTROL MONUMENT F-1	STATE PLANE COORDINATES
40000 N =	587, 357. 8087 N
40000 E =	1, 713, 516. 1229 E

THE ANGULAR ROTATION FROM STATE PLANE BEARINGS TO SITE GRID BEARINGS IS 359°-13′-23″ RIGHT WITH CONTROL POINT F-1 AS THE BASE POINT.

5. MINE FACILITIES DESIGN BY FORD, BACON & DAVIS, INCORPORATED, SALT LAKE CITY, UTAH AND PINCOCK, ALLEN & HOLT, INCORPORATED, LAKEWOOD, COLORADO.

LEGEND

·····1100·····	EXISTING CONTOUR
═══	EXISTING PAVED ROADWAY
-----	EXISTING TRAIL/GRAVEL SURFACE
⬭	TREES AND/OR BRUSH
··+··+··	FENCE
⊕ F-1	CONTROL MONUMENT

REFERENCES DWG. NO.	DESCRIPTION

REFERENCES DWG. NO.	DESCRIPTION

NO.	DATE	REVISIONS	BY	CHK'D	ENG'R	ENG'R MGR.

NO.	DATE	REVISIONS	BY	CHK'D	ENG'R	ENG'R MGR.
	12/89	UPDATED SITE PLAN	M.J.O.	J.W.S.		

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GEOSCIENCES & ENVIRONMENTAL MANAGEMENT DIVISION
GREEN BAY, WISCONSIN

	BY	DATE
PROJ. ENG'R		
MGR. PROCESS ENG'R		-
ENG'R MGR.		

	BY	DATE
DESIGN		
DRAWN	M.J.O.	12/89
CHK'D	J.W.S.	12/89
DES. ENG'R		
SECT ENG'R		

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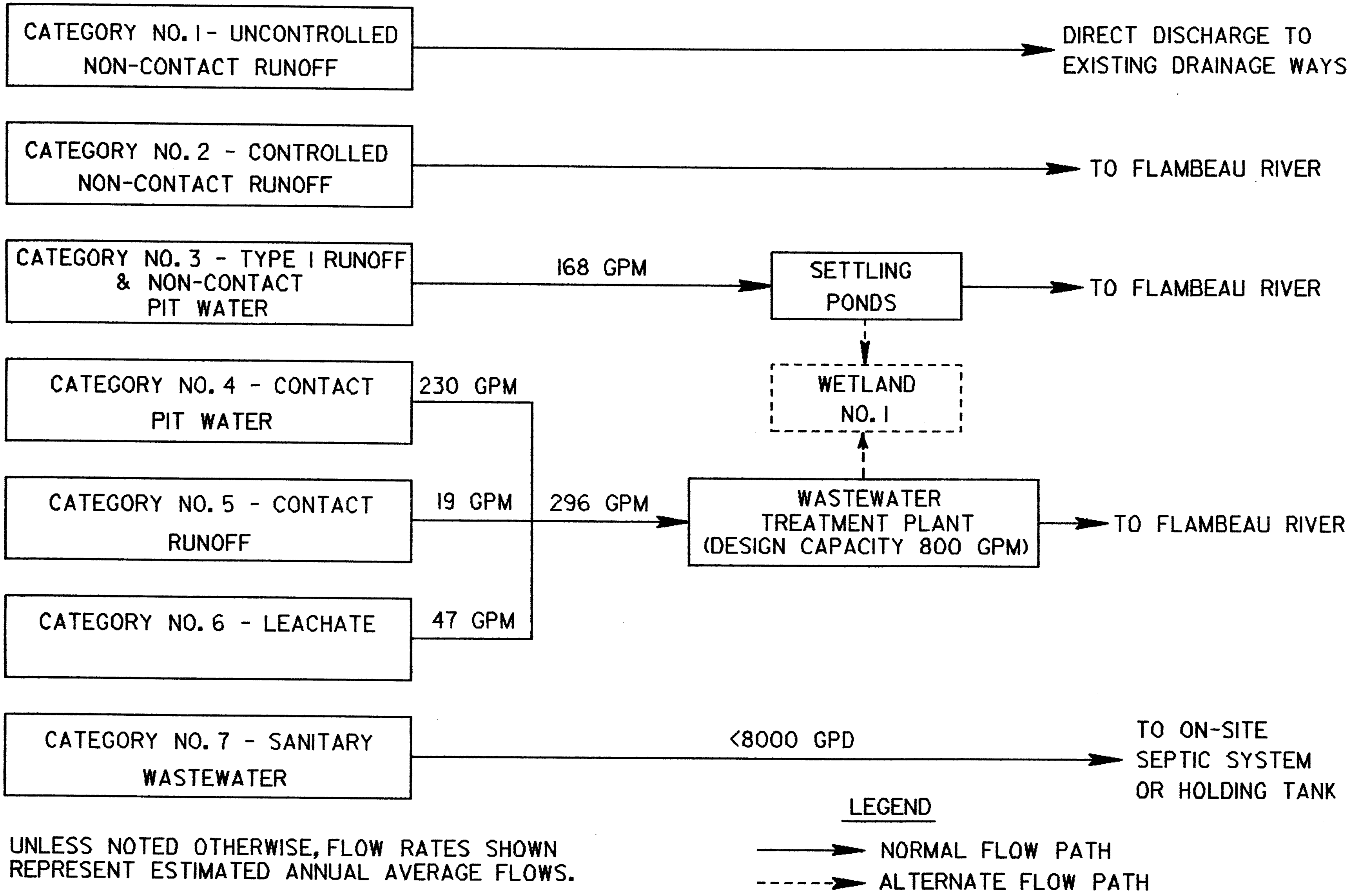
FIGURE NO. 3
SITE PLOT PLAN

MICROFILM	JOB
DRAWING NO.	REV.
DIVISION DRAWING NO.	
SCALE	SEE BAR SCALE



NOTE: UNLESS NOTED OTHERWISE, FLOW RATES SHOWN REPRESENT ESTIMATED ANNUAL AVERAGE FLOWS.

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GEOSCIENCES & ENVIRONMENTAL MANAGEMENT DIVISION
GREEN BAY, WISCONSIN

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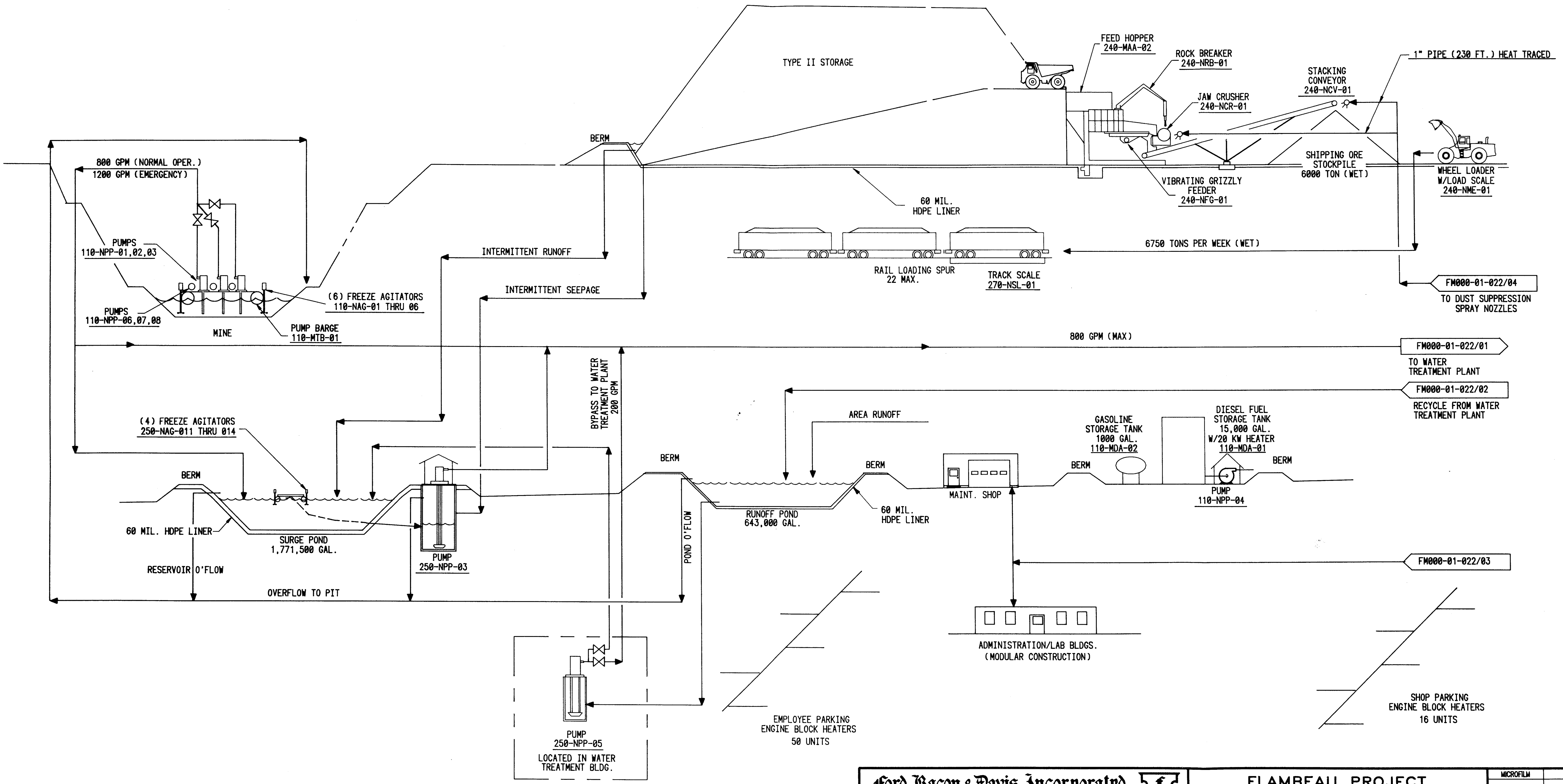
No	REVISIONS	NOTES
△	CAT. NO. 3, 4, 5, 6 GPM	BY JWS 11-25-89
△		
△		
△		
△		

APPROVAL		DATE
DESIGNED BY		
DRAWN BY	MJO	2/89
CHECKED BY	GWS	3/89
APPROVED BY		
CAD No.	SCALE NTS	

FIGURE NO. 4
WATER & WASTEWATER GENERATION, TREATMENT, AND DISCHARGE

Job No
Dwg No
REV

①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭	⑮	⑯	⑰	⑱	⑲	⑳	㉑	㉒	㉓	㉔	㉕	㉖	㉗	㉘	㉙	㉚	㉛	㉜	㉝	㉞	㉟



Ford, Bacon & Davis, Incorporated
ENGINEERS-CONSTRUCTORS
SALT LAKE CITY, UTAH
F B & D 1894

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SALT LAKE CITY, UTAH
84112

FIGURE NO. 5
FLOW SHEET
MINE FACILITY

MICROFILM	JOB
	M6033R
DRAWING NO.	REV.
FM000-01-021	1
DIVISION DRAWING NO.	
OWNER OPERATED	
SCALE	NONE

	BY	DATE
PROJ. ENG'R	JLC	11/4/88
MGR PROCESS ENG'R		
ENG'R MGR		

	BY	DATE
DESIGN	DK	9/20/88
DRAWN	TEQ	10/21/88
CHK'D	HJV	11/3/88
DES. ENG'R	JLC	2/1/89
SECT ENG'R		

NO	DATE	REVISIONS	BY	CHK'D	ENG'R	ENG'R MGR
1	3/9/89	GENERAL REVISION	PSH			

BY	DATE	REVISIONS	BY	CHK'D	ENG'R	ENG'R MGR

REFERENCES

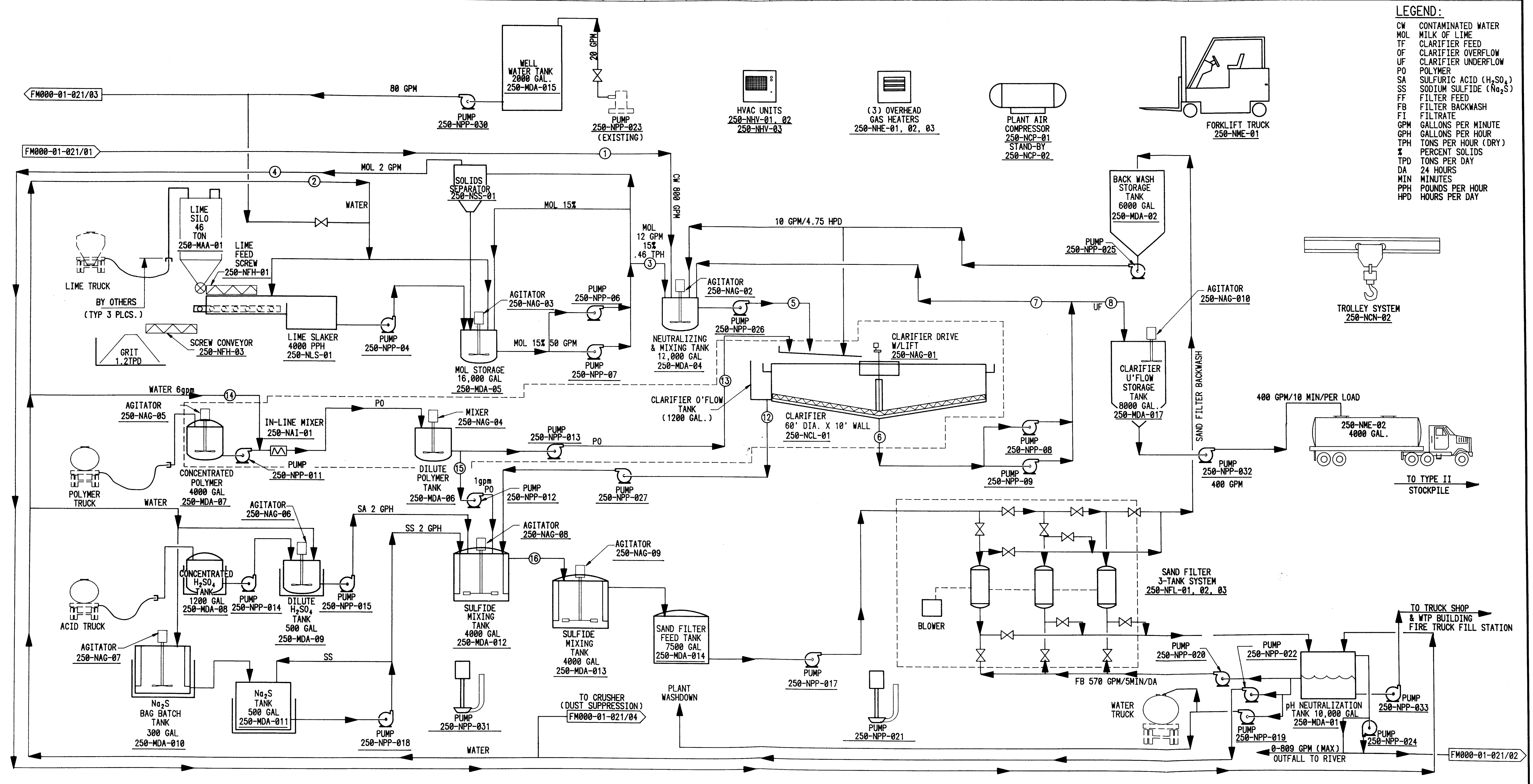
DWG. NO	DESCRIPTION

REFERENCES

DWG. NO	DESCRIPTION

MK697C

PROCESS PORT	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭	⑮	⑯	⑰	⑱	⑲	⑳	㉑	㉒	㉓	㉔	㉕	㉖	㉗	㉘	㉙
GPM	800	58.7	12	2	1197	396.3	375	21.3				795.7	5	6	1	796.7													
#/MIN (SOLID)	6.7	0	15.3	0	991.5	991.5	938.3	53.2				0	0	0	0	0													
SG (SLURRY)	1.00	1.00	1.09	1.01	1.06	1.2	1.2	1.2				0	1.0	1.0	1.0	1.0													
ph	3.5	7.0	12	12	8.5	8.5	8.5	8.5				8.5	7.0	7.0	7.0	6.0													
% SUSPENDED SOLIDS	0.1	0	15	0	8.1	25	25	25				0	0	0	0	0													



LEGEND:

CW	CONTAMINATED WATER
MOL	MILK OF LIME
TF	CLARIFIER FEED
OF	CLARIFIER OVERFLOW
UF	CLARIFIER UNDERFLOW
PO	POLYMER
SA	SULFURIC ACID (H_2SO_4)
SS	SODIUM SULFIDE (Na_2S)
FF	FILTER FEED
FB	FILTER BACKWASH
FI	FILTRATE
GPM	GALLONS PER MINUTE
GPH	GALLONS PER HOUR
TPH	TONS PER HOUR (DRY)
%	PERCENT SOLIDS
TPD	TONS PER DAY
DA	24 HOURS
MIN	MINUTES
PPH	POUNDS PER HOUR
HPD	HOURS PER DAY

REFERENCES DWG. NO	DESCRIPTION

REFERENCES DWG. NO	DESCRIPTION	BY	DATE	REVISIONS	BY	CHK'D	ENG'R	ENG'R MGR

NO	DATE	REVISIONS	BY	CHK'D	ENG'R	ENG'R MGR
0	2/1	ISSUED FOR CLIENT REVIEW	TEQ	LRH	JLC	DK
1	2/9	MISC. REVISIONS	TEQ	LRH	JLC	DK

Ford, Bacon & Davis, Incorporated
ENGINEERS-CONSTRUCTORS
SALT LAKE CITY, UTAH

	BY	DATE
PROJ. ENG'R	JLC	11-4-88
MGR PROCESS ENG'R		
ENG'R MGR		

	BY	DATE
DESIGN	TB	4-22-88
DRAWN	WCB	4-27-88
CHK'D	HJV	11-4-88
DES. ENG'R		
SECT ENG'R		

FLAMBEAU PROJECT

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MINERALS
COMPANY

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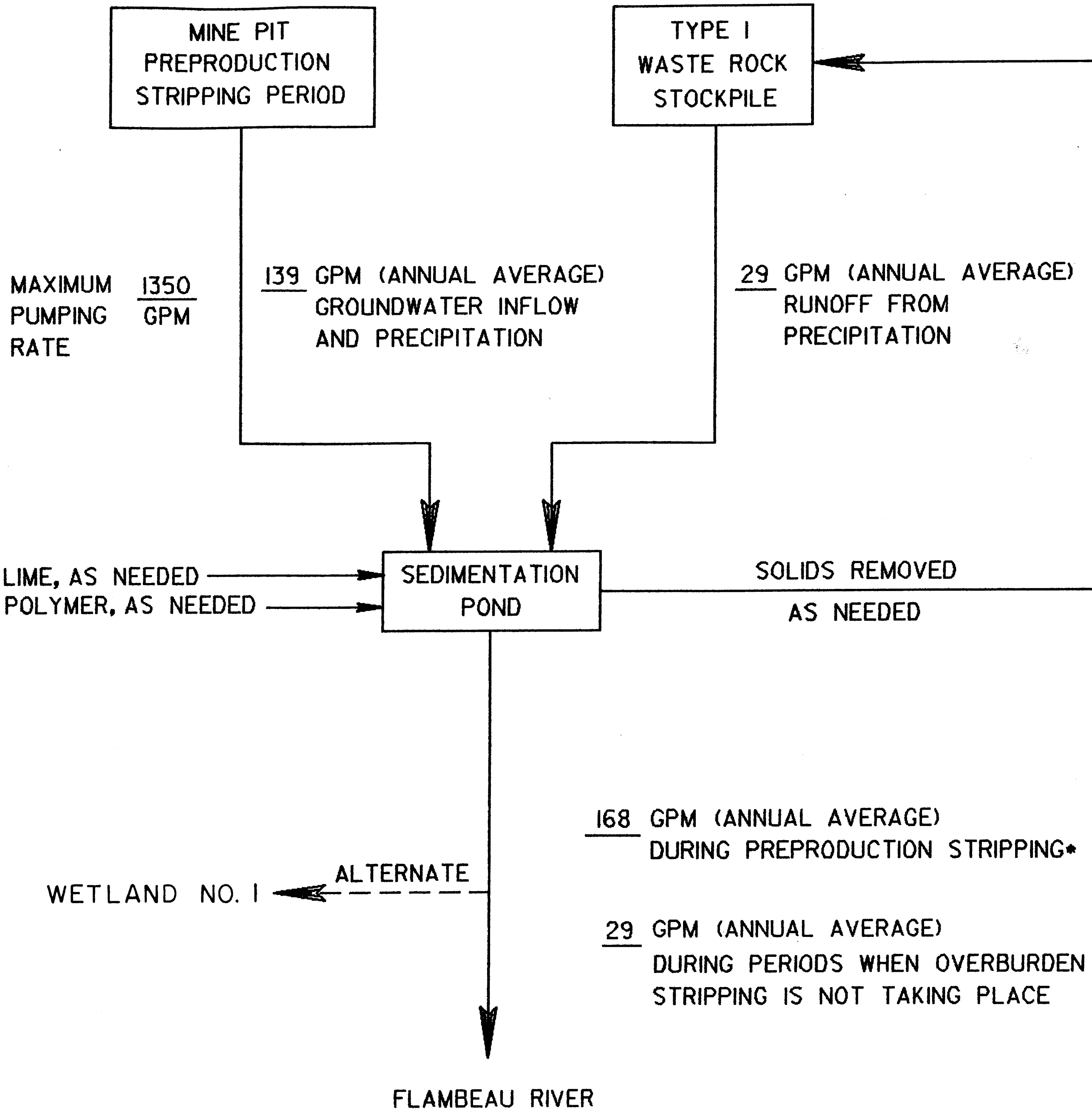
SALT LAKE CITY, UTAH
84112

FIGURE NO. 6
WASTEWATER
TREATMENT PLANT
FLOW SHEET

MICROFILM	
JOB	M6033R
DRAWING NO.	FM0001-01-022
REV.	1
DIVISION DRAWING NO.	OWNER OPERATED
SCALE	NONE

MJ492D



* DURING STRIPPING IN PHASE II ANNUAL AVERAGE FLOW WILL BE SLIGHTLY LESS

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	DRAWN BY	MJO	2/89
	CHECKED BY	GWS	3/89
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	CAD No.	SCALE	

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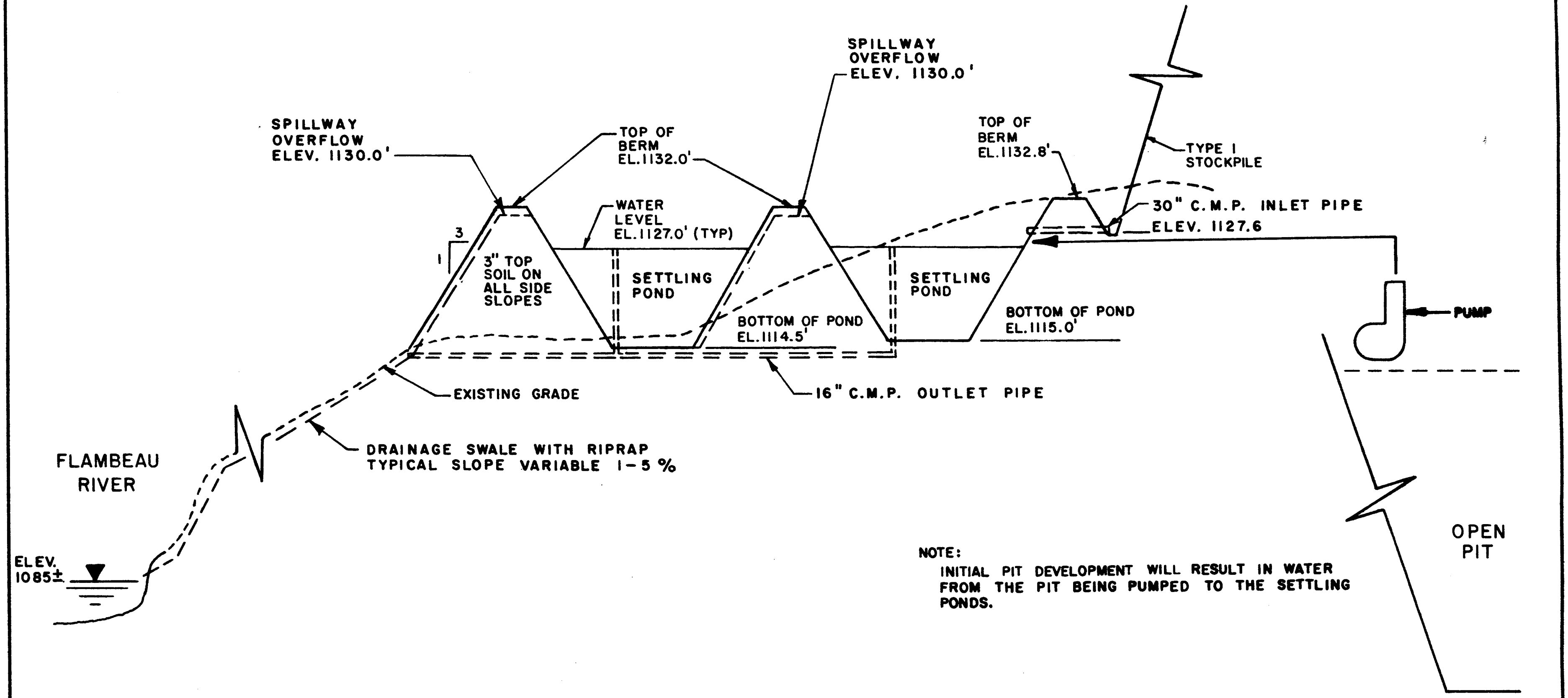
FIGURE NO. 7
SEDIMENTATION POND
LINE DIAGRAM

Job No	Dwg No	REV



NOTE:
INITIAL PIT DEVELOPMENT WILL RESULT IN WATER FROM THE PIT BEING PUMPED TO THE SETTLING PONDS.

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FIGURE NO. 8
SETTLING POND
HYDRAULIC PROFILE

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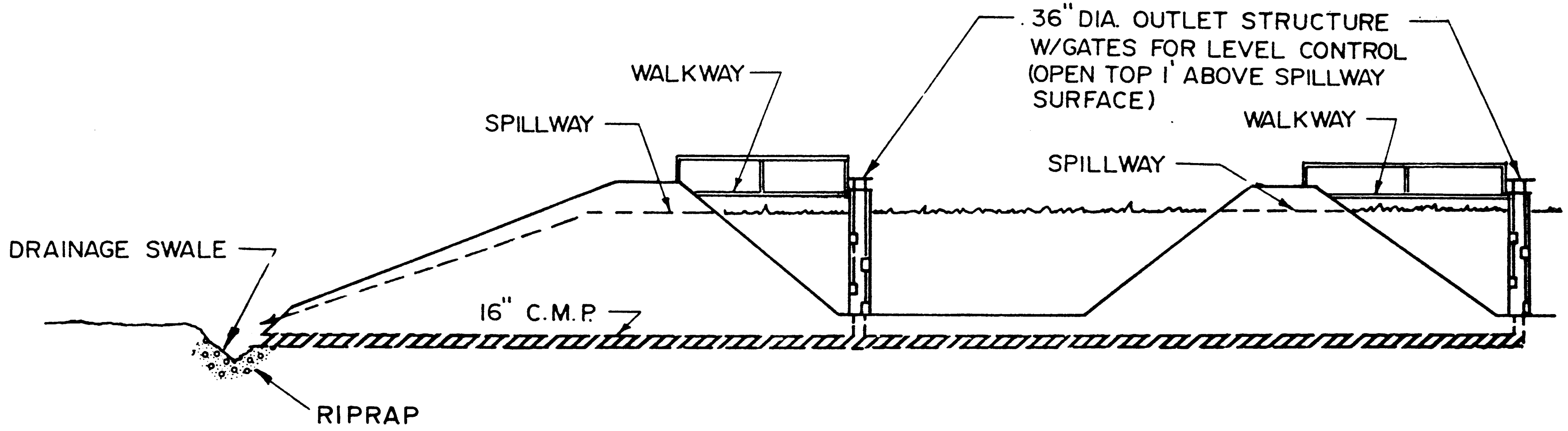

NOTE: A FLOW MONITORING AND SAMPLING STATION WILL BE PROVIDED AT THE DISCHARGE FROM THE SETTLING POND.

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FIGURE NO. 9
SETTLING PONDS
CROSS SECTION

No	REVISIONS	NOTES	APPROVAL		DATE
1	ADD NOTE	BY GJB 11-25-89	DESIGNED BY		
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			CHECKED BY	GWS	3/89
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			CAD No.	SCALE	

Job No
Dwg No
REV

APPENDIX A

Bench Test Study Report

WASTEWATER TREATMENT TECHNICAL PROCESS PERFORMANCE PROCEDURES BENCH SCALE EVALUATION REPORT FOR THE KENNECOTT FLAMBEAU PROJECT

Prepared for:

KENNECOTT MINERALS COMPANY

Prepared by:

FOTH & VAN DYKE and Associates Inc.
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MARCH 1989

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414/497-2500

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1.0 INTRODUCTION

Kennecott Minerals Company (Kennecott) intends to develop a copper mine near Ladysmith, Wisconsin. This project has been named the Flambeau Project. Engineering efforts associated with the development of the mine plan for the project have identified two wastewater streams that will be discharged to the Flambeau River or an adjacent wetland. Stream One will consist of water requiring treatment at the planned wastewater treatment plant. Stream Two will consist of water that will be settled prior to discharge. At times treatment for the removal of colloids may be performed for Stream Two. Given the projected characteristics of the influent waters based on detailed waste characterization work and the estimated effluent limits, a process design has been selected for each of the two streams.

The Wisconsin Department of Natural Resources (WDNR), as a part of the WPDES permitting process for wastewater discharges, and as a part of the approval process for the construction of wastewater treatment facilities, requires that pilot or bench tests be undertaken to verify the adequacy of proposed treatment technologies. Two such tests were performed for the Flambeau project. The first test evaluated the performance of the treatment technology selected for Stream One. The second test evaluated the selected technology for Stream Two. This report provides a summary of the test procedures and their results.

The procedures presented in this document are designed to demonstrate the adequacy and efficiency of the proposed treatment technologies. They are not intended to represent research to evaluate alternate technologies.

Because this is a proposed project, there is no actual wastewater available for bench scale testing. The wastewater that was used was generated artificially in the laboratory. This results in a down-scaled pilot study which is referred to as a bench test. The purpose of the bench test demonstration is to verify the levels of wastewater treatment which are attainable from the proposed treatment technologies.

All of the analytical procedures used in the two evaluations are in conformance with NR 219 of the Wisconsin Administrative Code. The analyses were completed by Foth & Van Dyke's laboratory and the Oneida Environmental Technology Center (ORTEK) laboratory which are certified by the WDNR under NR 149 of the Wisconsin Administrative Code.

Following is a discussion of each of the two bench test studies performed for the Flambeau Project.

2.0 BENCH TEST STUDY STREAM ONE

The technology proposed for the treatment of Stream One has been selected by Ford, Bacon & Davis, Inc., Salt Lake City, Utah. It includes lime precipitation, gravity settling, pH adjustments to within 5.0 to 6.0 s.u., sulfide precipitation, multi-media filtration, and pH neutralization. Treatment will be accomplished in a wastewater treatment plant to be constructed on site.

2.1 Bench Test Study Procedures

The bench test study for Stream One simulated each step of the proposed treatment process, sequencing the various technologies in the order in which they are planned to occur.

The tests were carried out in one-liter beakers using 900-ml samples for each segment of testing. The samples were analyzed after each level of treatment to determine the individual treatment capabilities of each process. When the optimum chemical treatment level was determined for the first level of treatment -- in this case lime precipitation -- the next level of treatment, pH adjustment and sulfide precipitation, were evaluated. This sequencing of optimization, followed by the next step in the train of treatment technologies, was followed through the entire bench test. Thus, each level of treatment was built upon the optimum performance of the previous treatment technology.

On February 22, 1988, a work plan for the Waste Steam One bench test study was forwarded to the WDNR for review. On March 18, 1988, a revised work plan was submitted. On April 7, 1988, WDNR approved the planned procedures with modifications. As part of the review process, WDNR agreed that the proposed bench scale test would be subject to modification based on the results obtained during any step in the test.

The following discussion contains a description of each of the five steps completed as part of the bench test study. Any major modifications to the test procedures approved by the WDNR were discussed with the WDNR prior to their implementation.

The first step in the test consisted of the generation of wastewater to be used in the study. Steps II through IV involved testing of the lime precipitation, sulfide precipitation and multi-media filtration processes. Step V addressed granulated activated carbon treatment. Granular activated carbon treatment was originally included in the treatment train as a polishing step to remove mercury from the wastewater stream. Waste characterization studies and the preparation of wastewater for the bench test study have shown that mercury is typically not present in waste rock leachates. Therefore, the granular activated carbon treatment process was eliminated from the treatment process.

2.1.1 Step I - Wastewater Generation

Since mining activities have not commenced, the wastewater for this evaluation was prepared following leaching procedures used in the waste characterization evaluations described in the previously submitted Scope of Study. This procedure was approved by the WDNR in a December 2, 1987, letter.

The rock material used for the leaching procedure was taken from a composite of Type II waste rock samples known as WW-1. The samples, having an average total sulfur content of approximately 34 percent, were obtained from diamond drill core samples taken from the proposed mine site. The WW-1 composite was selected for the bench study since it was anticipated that its constituents would represent the spectrum of elements present in the Type II waste rock. The composite sample was also felt to yield wastewater in concentrations that would represent the approximate highest loading rate on the wastewater treatment system.

Since lime precipitation is a very effective treatment process for the initial removal of concentrated contaminants, the primary concern in the bench test study was the ultimate removal of low concentration contaminants. Therefore, since the test wastewater had contaminant concentrations which exceeded the limits potentially imposed by the WDNR, wastewater samples which represented all expected wastewater contaminant levels were not needed for the test.

A detailed description of the leaching process used to generate the wastewater for the test is described below.

A. The waste rock core chip composite (WW-1) was leached in a 7-1/2 gallon cylindrical high-density polyethylene tank. The chips were supported above the base of the tank by a circular plate made from sheet acrylic, in which drain holes had been drilled. The plate was mounted on legs made of cast acrylic rod. In order to limit the loss of any fine grained material which might result from the leaching process, the top of the acrylic plate was covered with a mat of heavy metal-free borosilicate glass wool. The column was charged with the WW-1 composite waste rock. The rock had been broken into a maximum particle size of one to two inches in diameter.

B. The waste rock was leached with a synthetic solution approximating the pH of rainwater (5.3 s.u.). Laboratory grade deionized water was used for the leaching solution. Nitric acid was added to lower the pH.

C. The columns were saturated for one day and allowed to drain for two days. The leachate was collected during the first day of the draining cycle. The second day of the draining cycle allowed the rocks to undergo a drying period. This cycle was repeated with the same column of waste rock as many times as necessary to generate the amount of wastewater needed. This cycling was designed to represent a natural wetting and drying cycle from precipitation.

2.1.2 Step II - Lime Treatment

The first stage of the treatment process included the addition of lime to the wastewater. This process allows for the hydroxide precipitation of the heavy metals in the wastewater. The optimum pH at which the highest removal efficiencies can be obtained was determined. Wastewater samples were subjected to various dosage rates of lime to achieve incremental pH levels. After the samples were allowed to settle, the supernatants were analyzed and removal efficiencies calculated.

A detailed description of this process follows:

A. A series of five, one-liter beaker sample containers were set up. Each beaker was filled with 900 mls of wastewater, making sure the wastewater was well mixed prior to being split so that each sample was equal in physical and chemical characteristics.

B. Each of the five samples was continuously stirred while a five percent lime solution was added to adjust and maintain the pH in four of the samples. The fifth sample was used as a control.

The five percent lime solution was prepared using high calcium hydrated lime obtained from Western Lime and Cement Co. A five percent lime solution was substituted for the 20 percent solution referenced in the original procedures to make it easier to keep the lime in suspension. Two sets of tests were run in order to generate enough sample for analytical purposes. The amount of lime required to adjust the pH was recorded and is listed below.

TEST NO. 1

Sample No.	pH	Mls. of Five Percent Lime Solution Required
1	Control	No Lime Addition
2	8.0	40.5
3	9.0	41.2
4	10.0	41.7
5	11.0	47.0

TEST NO. 2

Sample No.	pH	Mls. of Five Percent Lime Solution Required
1	Control	No Lime Addition
2	8.0	40.3
3	9.0	41.4
4	10.0	42.6
5	11.0	46.7

C. After each sample was mixed for approximately ten minutes, the samples were allowed to settle for three hours. This mixing and settling time represents the current design loading rates for the planned full scale wastewater treatment system. It should be noted that it was not necessary to evaluate polymers as part of this test since the lime floc settled readily.

After the three-hour settling time, the supernatants from Test Nos. 1 and 2 were decanted and combined into a composite sample for each pH level. The results of laboratory analyses on the supernatants, from the lime treatment process are included in Table No. 2-A1. Laboratory data sheets are contained in Attachment No. 1.

D. The results from the laboratory data were evaluated to determine which chemical feed rate had resulted in the optimum removal efficiency. The results of the lime treatment process were also graphed to demonstrate the treatment efficiencies.

Figure No. 2-A1 is a plot of lime feed rates against pH change. Figure Nos. 2-A2 and 2-A3 are plots of contaminant concentrations for selected parameters against the various pH levels. It was evident from reviewing the figures that different metals had different removal efficiencies at the various pH levels. Metals not graphed were reported at below minimum detection levels.

The results from the laboratory data were evaluated and it was determined that a pH level of 9.0 s.u. provides optimum removal efficiency. The calculated removal efficiencies at pH 9.0 are as follows:

TABLE NO. 2-A1

Bench Study Laboratory Data
Lime Treatment

Composite Samples From Test Nos. 1 and 2

Parameters, units	Control Raw Wastewater	pH 8.0	pH 9.0	pH 10.0	pH 11.0
Arsenic, ug/l	200	<3	<3	3	5
Cadmium, ug/l	1,460	12	2.8	1.7	0.5
Chromium, T. ug/l	7	--	--	--	--
Copper, ug/l	910,000	740	350	770	570
Cr-3, ug/l	---	<2	<2	<2	<2
Cr-6, ug/l	No Data	<2	<2	<2	<2
Lead, ug/l	47	<2	<2	<2	<2
Mercury, ug/l	<0.5	<0.5	<0.5	<0.5	<0.5
Nickel, ug/l	1,900	<30	<30	<30	<30
pH, std. units	3.1	5.0	5.9	7.1	8.8
Selenium, ug/l	16	7	7	6	8
Silver/ug/l	2.4	<0.4	0.5	<0.4	<0.4
T. Sus. Solids, mg/l	30	10	20	40	40
Zinc, ug/l	240,000	340	120	200	210

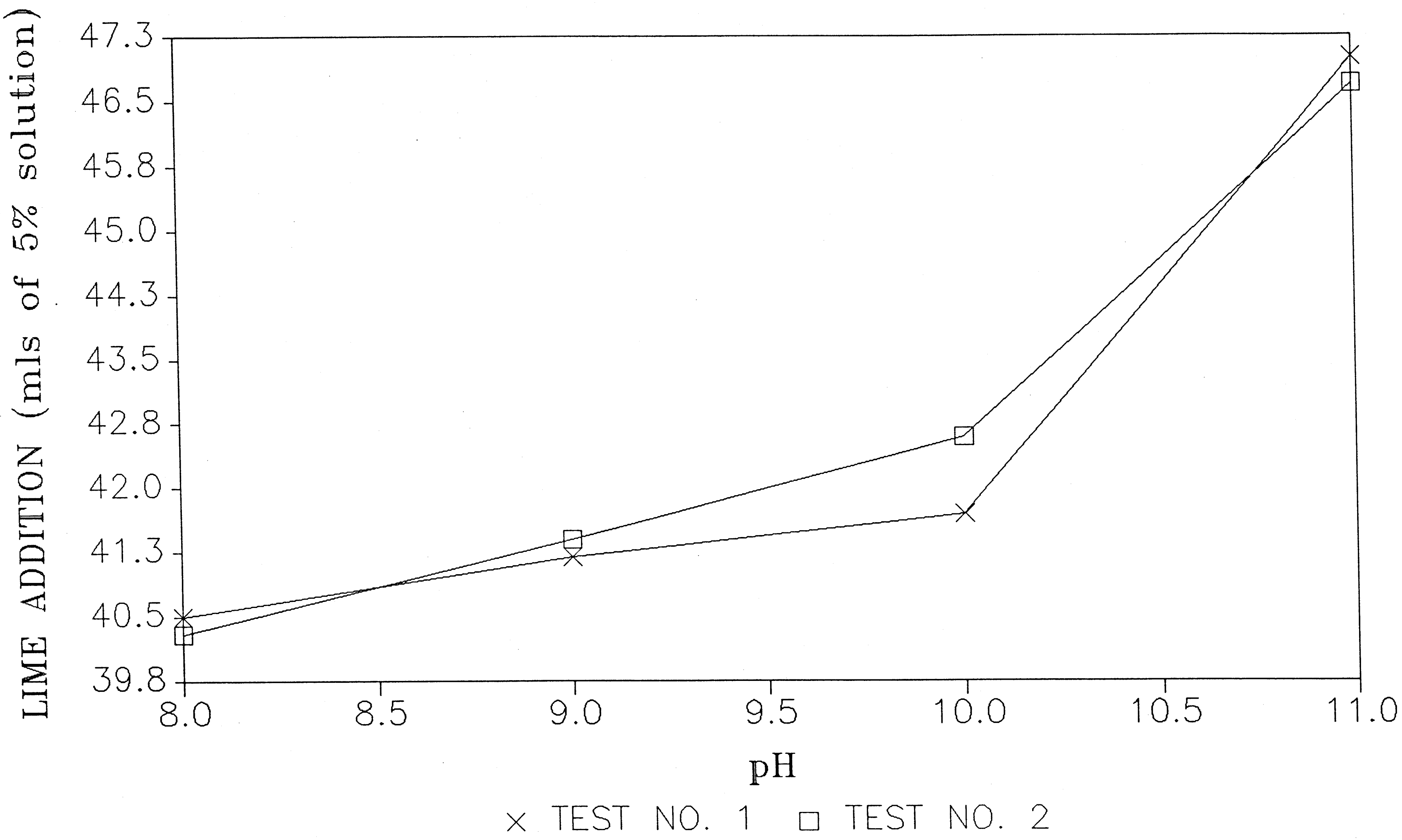

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FIGURE NO. 2-A1
LIME TREATMENT PROCESS
pH ADJUSTMENT

Job No	Dwg No	REV

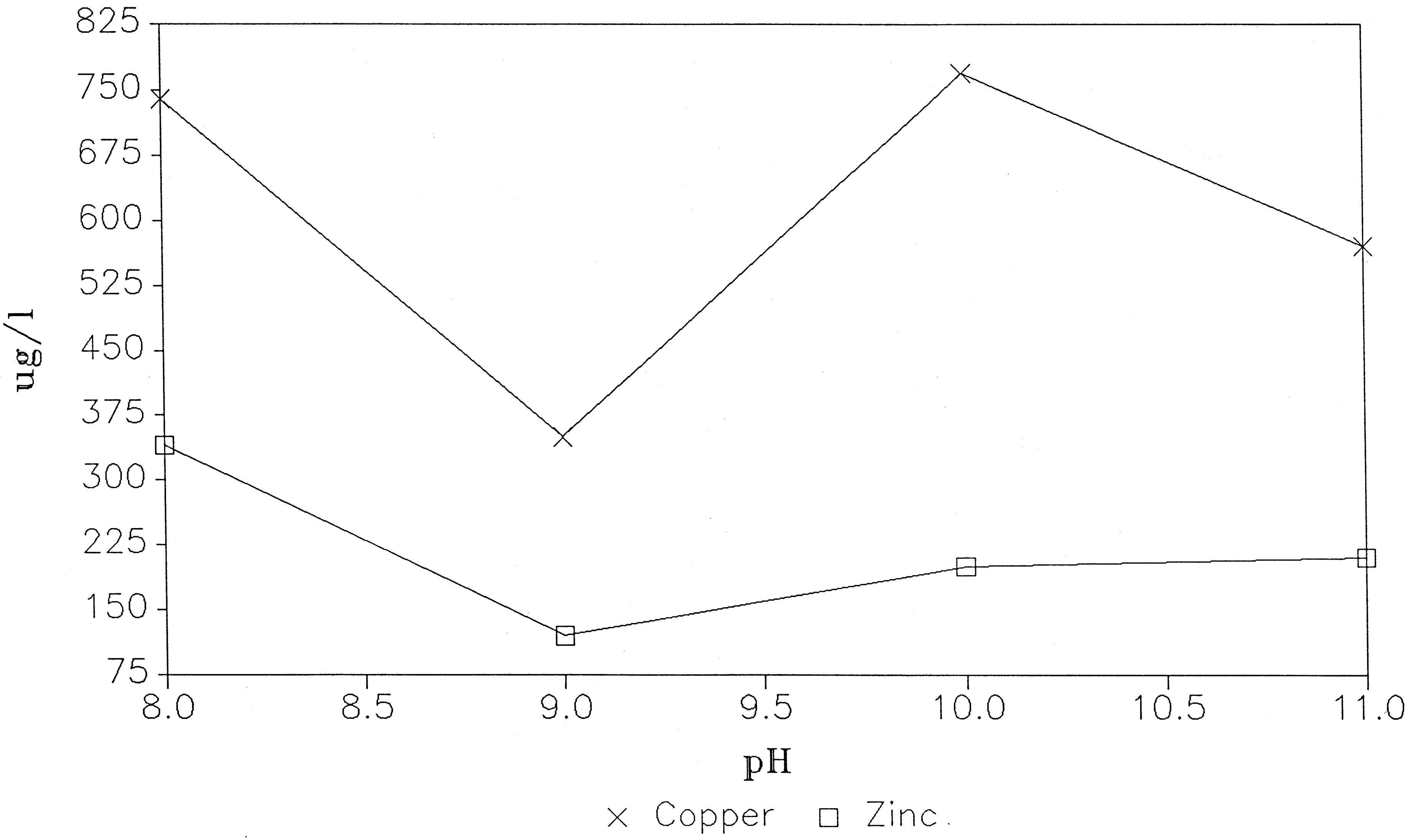

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FIGURE NO. 2 - A2

LIME TREATMENT PROCESS
COPPER AND ZINC

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Job No
Dwg No
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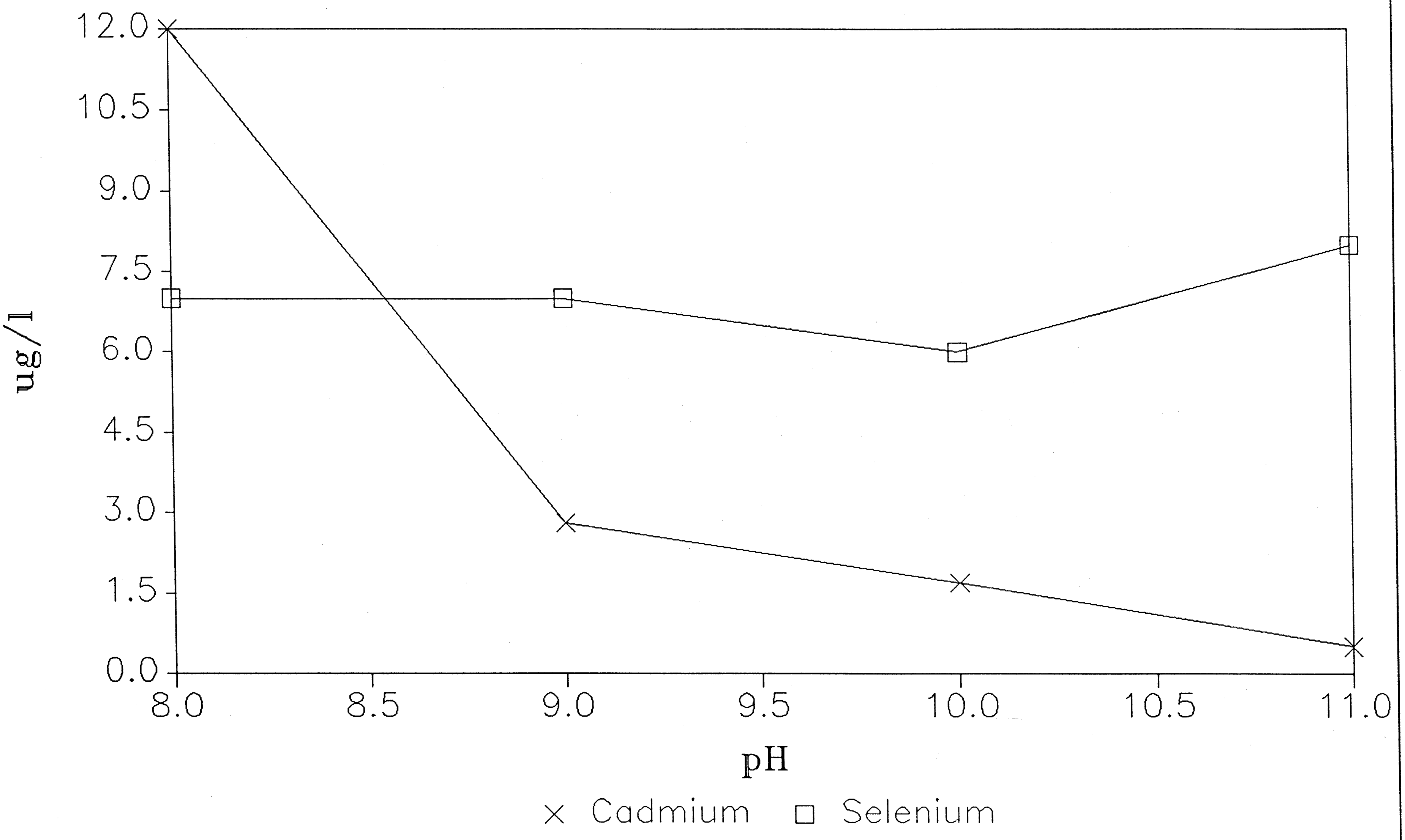

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FIGURE NO. 2 - A3
LIME TREATMENT PROCESS
CADMIUM AND SELENIUM

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Job No
Dwg No
REV

Parameter	% Efficiency
Arsenic	>98.5
Copper	99.9
Mercury	BMDL*
Selenium	56.3
Silver	79.2
Total Suspended Solids	33.3
Cadmium	99.8
Lead	>95.7
Nickel	>98.4
Zinc	99.9
Chromium^{+3}	BMDL*
Chromium^{+6}	BMDL*
Total Chromium	BMDL*

*Values below minimum detection limits.

2.1.3 Step III - Sulfide Precipitation Process

The sulfide precipitation process that has been proposed is the soluble sulfide, Na_2S process. In this process, the sulfide ion complexes with metal ions and precipitates out of solution.

The treatment process is enhanced by adjusting the pH to a level of 5.0 to 6.0 s.u. with sulfuric acid prior to the sodium sulfide being added. A detailed description of the procedures used to evaluate sulfide precipitation follows:

A. To prepare for the test an 18.5-liter sample of wastewater was treated with 225 mls of a ten percent lime solution to reach the optimum pH level of 9.0 s.u. as determined in Step II. Following the ten-minute mixing time, the sample was allowed to settle for three hours. Approximately 13.3

liters of supernatant was then decanted from the sample, leaving 5.4 liters of sludge.

B. A stock solution of sodium sulfide was prepared by dissolving ten grams of reagent grade sodium sulfide ($Na_2S \cdot 9H_2O$) in 700 mls of laboratory grade deionized water and then diluting to 1,000 mls. This allowed the addition of one milliliter of sulfide solution to the wastewater with an equivalent weight of ten milligrams of sodium sulfide.

C. Using the supernatant from Step III A., eight one-liter beaker sample containers were set up. Each beaker was filled with 900 mls of supernatant, making sure the supernatant was well mixed prior to being split, and that each sample was equal in physical and chemical characteristics.

D. During mixing of each sample, sulfuric acid was added to adjust the pH to a level of 6.0 s.u. Approximately 1.0 ml of 0.1 N H_2SO_4 was required to reduce the pH of a 900-ml sample from 7.45 to 6.0 s.u.

E. After the pH had been adjusted, sulfide solution was added at incremental quantities and each sample thoroughly mixed. A control blank was set up in which no sulfuric acid or sulfide solution was added. The range of quantities for sulfide addition were determined as follows:

Dosage Rates: 50 mg/l = 5 mls stock solution/1,000 ml sample
100 mg/l = 10 mls stock solution/1,000 ml sample
200 mg/l = 20 mls stock solution/1,000 ml sample
400 mg/l = 40 mls stock solution/1,000 ml sample
800 mg/l = 80 mls stock solution/1,000 ml sample

F. After mixing for approximately 15 minutes, the samples were filtered through a Whatman 934-AH glass fiber filter. This mixing time is approximately equal to the design criteria for the planned full scale treatment facility. The filtering step allowed for the evaluation of the sulfide process efficiency in precipitating metal ions without having to go through an extensive multi-media filtration process for each test run. Step IV evaluated the multi-media filtration process for removal of solids.

G. After the samples had been passed through the filter, they were analyzed. The laboratory analyses results from the sulfide precipitation process are included in Table No. 2-A2. Raw laboratory data is contained in Attachment No. 1.

H. The results from the laboratory data were evaluated to determine which chemical feed rate resulted in the optimum removal efficiency. This was accomplished using a graph (Figure No. 2-A4) which plots copper and zinc concentrations in the treated wastewater against the various sulfide dosage rates. A review of the graph showed that a sulfide dosage rate of 400 mg/l (40 mls of stock solution) provided the optimum removal efficiency. Copper and zinc were the only constituents plotted since the remaining parameters were reported at levels below minimum detection limits.

2.1.4 Step IV - Multi-Media Filtration

Multi-media filtration is used to remove the solids generated from the sulfide precipitation process. The proposed filter for the full scale treatment facility will consist of a multi-media bed system.

TABLE NO. 2-A2

Bench Study Laboratory Data
Sulfide Precipitation

	Raw Wastewater[1]	Step II Sprntnt.[2]	Step III Blank	Step III 5 ml Na2S	Step III 10 ml Na2S	Step III 20 ml Na2S	Step III 40 ml Na2S	Step III 80 ml Na2S
Arsenic, ug/l	90	<3	<3	<3	<3	<3	<3	<3
Copper, ug/l	650,000	240	200	81	53	15	<10	130
Mercury, ug/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Selenium, ug/l	<150	<150	<150	<150	<150	<150	<150	<150
Silver/ug/l	4.7	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Cadmium, ug/l	780	0.7	0.7	<0.3	<0.3	<0.3	<0.3	0.8
Lead, ug/l	51	<2	<2	<2	<2	<2	<2	<2
Nickel, ug/l	830	<30	<30	<30	<30	<30	<30	<30
Zinc, ug/l	170,000	71	83	72	40	35	77	85
Cr-3, ug/l	3*	<2	<2	<2	<2	<2	<2	<2
Cr-6, ug/l	3*	<2	<2	<2	<2	<2	<2	<2
pH, std units	3.7	4.5	4.8	5.2	6.3	10.4	10.9	9.6

*Reported as total chromium

[1] Before lime treatment

[2] After lime treatment

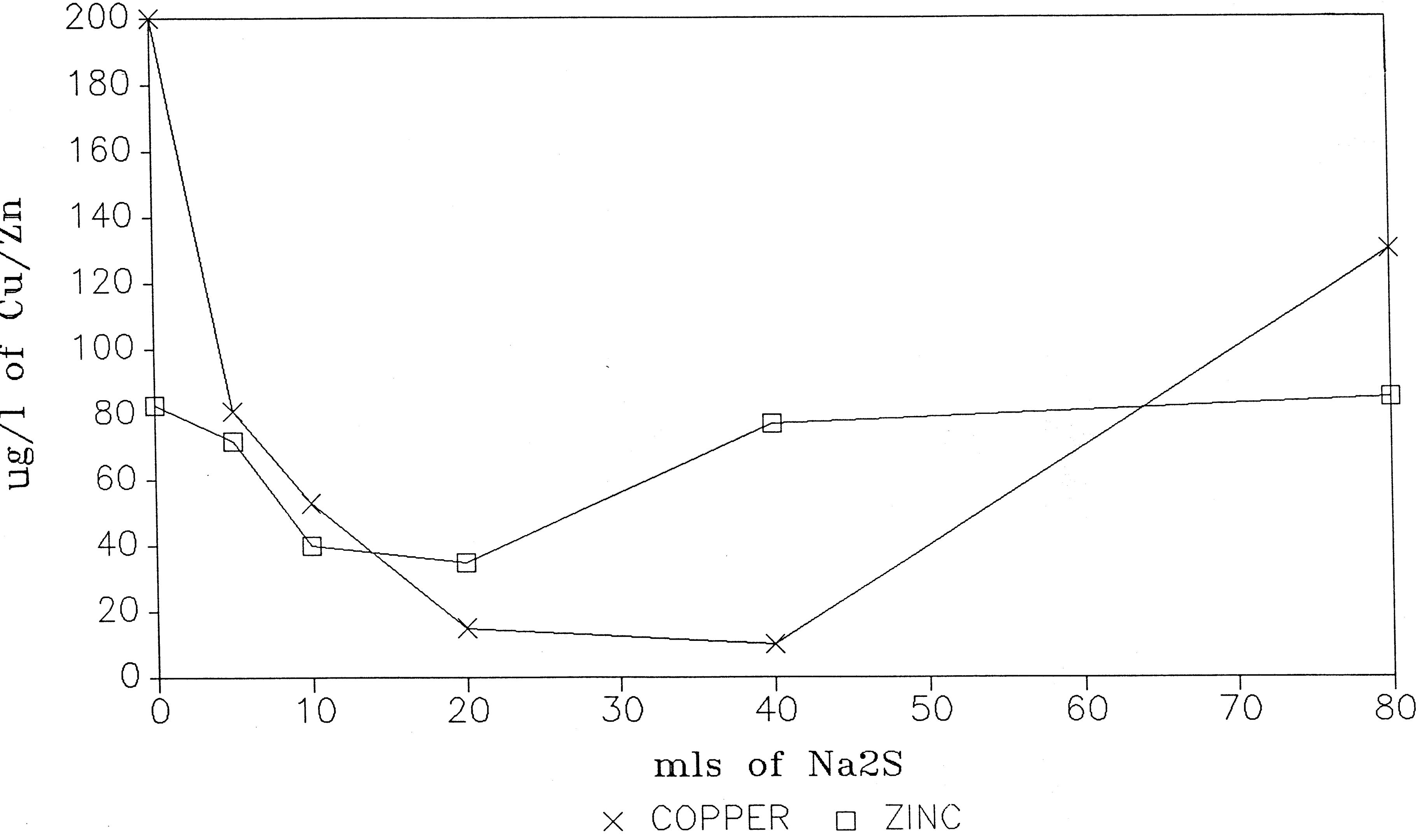

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FIGURE NO. 2-A4
SULFIDE TREATMENT PROCESS
COPPER AND ZINC

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Job No
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The multi-media bed system combines anthracite with two gradations of garnet. A diagram of this process is shown in Figure No. 2-A5. Although a laboratory scale system was used for the test, the depths of the media and the sequencing of the media reflect the actual design criteria for the planned full scale system.

As compared to the filter specified in the work plan, the diameter of the laboratory scale multi-media filter was reduced in size from six inches to four inches, and the head space was increased from four inches to 36 inches.

The anthracite and garnet samples were obtained from Garnet Abrasives and Water Filtration. The pea gravel was obtained locally, and was washed prior to placement in the filter. A detailed description of the filtration process follows:

A. The filter was prepared for the test by first running 20 liters of laboratory grade deionized water through the column prior to the introduction of the prepared wastewater. A sample of the deionized water was collected at the end of this purging cycle and analyzed for the same parameters as listed in Item IV D (Table No. 2-A3). Raw Laboratory data is contained in Attachment No. 1.

B. A 32-liter sample of raw wastewater was treated with 108 ml of a ten-percent lime solution to reach the optimum pH level of 9.0 s.u. as determined in Step II. The initial pH of the sample was 3.4 s.u. Following the ten-minute mixing time, the sample was allowed to settle for three hours. Approximately 29 liters of supernatant was then decanted from the sample, leaving three liters of sludge. Approximately one liter of the supernatant was used for analytical testing. One tenth milliliter of concentrated H_2SO_4 was added to 27.6 liters of lime treatment supernatant

TABLE NO. 2-A3

Bench Study Laboratory Data
Multi-Media Filtration and Granular Activated Carbon

	Raw Wastewater	Lime Treatment Supernatant	Lime Treatment Sludge	Multi-Media Filtration D.I. Water[1]	Multi-Media Filtration Effluent	G.A.C. D.I. Water	G.A.C. Effluent	G.A.C. pH7 Effluent
Parameters, units								
Arsenic, ug/l	100	<3	950	<3	<3	<3	<3	<3
Copper, ug/l	94,000	200	980,000	43	<10	<10	<10	<10
Mercury, ug/l	0.73	<0.5	8.9	<0.5	<0.5	<0.5	<0.5	<0.5
Selenium, ug/l	6	4	<30*	<3	3	<3	<3	<3
Silver, ug/l	17	<0.4	220	<0.4	<0.4	<0.4	<0.4	<0.4
pH, s.u.	3.8	6.5	5.1	5.3	5.3	5.4	4.6	4.8
T. Sus. Solids, mg/l	190	<10	---	<10	<10	<10	<10	13
Cadmium, ug/l	94	1.2	990	<0.3	<0.3	<0.3	<0.3	<0.3
Lead, ug/l	280	<2	2200	<2	<2	<2	<2	<2
Nickel, ug/l	82	<30	780	<30	<30	<30	<30	<30
Zinc, ug/l	24,000	100	270,000	<30	<30	<30	<30	<30
T. Cr, ug/l	14	<2	44	<2	<2	3	6	6
T. Solids, %	--	--	0.6	--	--	--	--	--

*High detection limit due to sample matrix problem.

[1] Multi-media filtration follows sulfide precipitation.

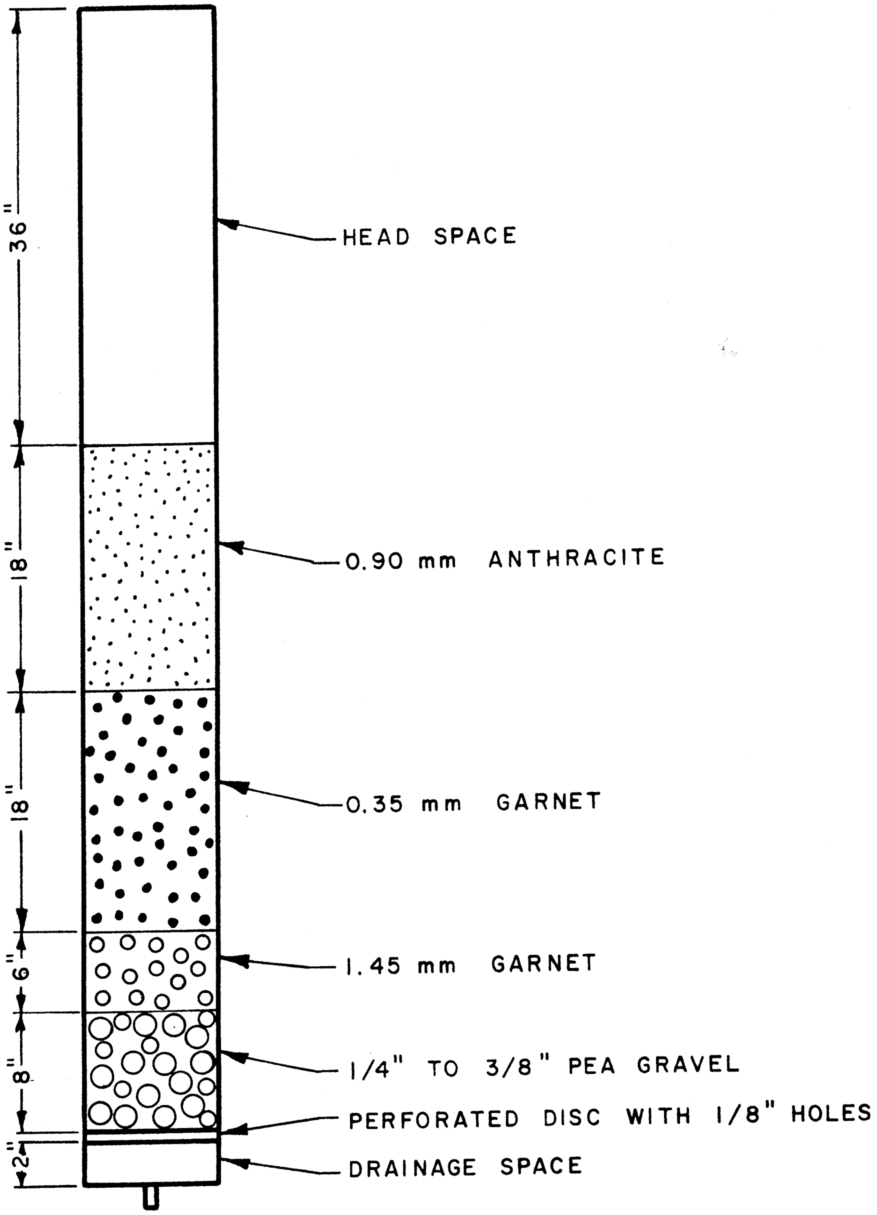

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FIGURE NO. 2-A5
4" DIAMETER
LABORATORY SCALE SAND FILTER

Job No
Dwg No
REV

to reduce the pH from 7.6 to 6.0 s.u. The sample was then treated with 1,100 ml of stock sodium sulfide solution to reach the optimum 400 mg/l level as determined in Step III. Following the required 15-minute sulfide contact mixing period, the sample was introduced to the filter.

C. The wastewater prepared in the previous paragraph was filtered through the laboratory scale filter. The first seven liters of filtrate were discarded, leaving approximately twice that amount left in the filter column. The next 12 liters were collected for analysis and for use in Step V.

D. The 12 liters of wastewater collected in the previous step were mixed. Two liters of this mixed sample were analyzed. The results of this analysis are shown in Table No. 2-A3. Raw Laboratory results are contained in Attachment No. 1. The remaining ten liters of wastewater were used in the granular activated carbon (GAC) performance demonstration.

E. An analysis of the solids from Step IV. B was completed. The results of the test are shown in Table No. 2-A3. Raw laboratory data is contained in Attachment No. 1

2.1.5 Step V - Granular Activated Carbon Treatment

The granular activated carbon (GAC) treatment process is designed to be a polishing step following the lime, sulfide, and multi-media filtration treatment technologies. GAC complexes with metal ions through various forms of physical and chemical adsorption and absorption. The wastewater is passed through a column of GAC. The full scale column is designed to allow a contact time of at least 3.5 minutes with the carbon. The bench test simulates this on a reduced scale, but with a contact time of 3.5 minutes.

The carbon that was used for this treatment process is Nuchar WV-B (10 x 25 granular wood-base activated carbon). The original carbon was intended to be Nuchar Aqua A. Westvaco no longer manufactures Aqua A. A detailed description of the test procedure is as follows:

A. The GAC filter as shown in Figure No. 2-A6, was prepared by running 20 liters of laboratory grade deionized water through the column prior to the introduction of the prepared wastewater. A sample of the deionized water was collected at the end of this purging cycle and analyzed for the same parameters as listed in Step V. C.

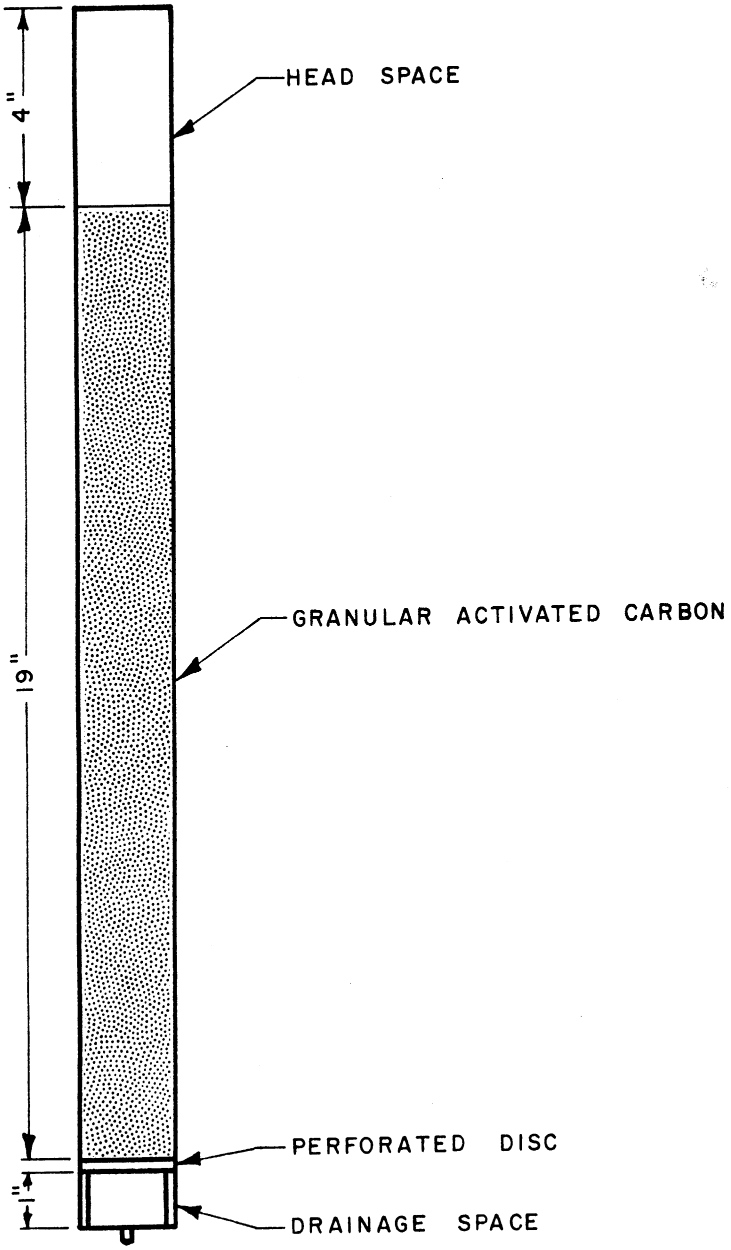
B. The ten liters of wastewater generated through Step IV. C were passed through the carbon filter. While the sample was filtering, three 1,000-ml samples were collected and composited. The samples were collected at the following times:

   1. After two liters of wastewater were passed through the filter.

   2. After five liters of wastewater were passed through the filter.

   3. After eight liters of wastewater were passed through the filter.

C. Once the sample had been composited and well mixed, it was split into two equal parts. One sample remained unchanged, and the other sample had the pH adjusted to 7.0 s.u. with the same lime solution used in the first step of this process. Approximately 0.1 ml of a ten percent lime solution was required to increase the pH of the 1,500 ml GAC effluent sample from 4.4 to 7.0 s.u. Both of the samples were analyzed.



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GREEN BAY, WISCONSIN

NOTES	APPROVAL		DATE
	DESIGNED BY		
	DRAWN BY	S.J.L.	3/89
	CHECKED BY		
	APPROVED BY		
	CAD No.	SCALE	

KENNECOTT MINERALS COMPANY
FLAMBEAU PROJECT
LADYSMITH, WISCONSIN

FIGURE NO. 2-A6
2" DIAMETER LABORATORY SCALE
GRANULAR ACTIVATED CARBON FILTER

Job No	Dwg No	REV

The laboratory analysis results from the granular activated carbon treatment process are contained in Table No. 2-A3. Raw laboratory data is contained in Attachment No. 1.

2.1.6 Summary and Conclusions

Table No. 2-A4 contains a summary of the results of the bench test studies for Stream One. The results are also compared to the estimated effluent limits for the Flambeau River as estimated by the WDNR. The lime treatment effluent data represents the range of analytical results obtained through the bench test program at the optimum pH of 9.0 s.u. The results show that lime treatment will produce an effluent that will meet the desired effluent quality for all parameters with the exception of copper, and zinc. The study also showed that the efficiency of lime treatment in terms of the treated effluent concentrations is not a function of the concentration of the parameters in the influent water. This conclusion is reached by comparing the raw wastewater and lime treatment analytical results on Table Nos. 2-A1, A2, and A3. The comparison shows significant variability in the concentrations of metals in the raw water, while little variability is seen in the lime treatment effluent.

The sulfide treatment effluent data in Table No. 2-A4 represents the results obtained from the multi-media filtration process (Step IV). For this test, optimum lime treatment (pH 9.0 s.u.) and optimum sulfide addition (400 mg/l) were used with the resulting effluent passed through a multi-media filter. The results of the test show that the selected treatment process will produce an effluent that meets estimated effluent limits for the project. The efficiency of the sulfide treatment process also shows that granular activated carbon treatment is not required to meet estimated effluent limits.

TABLE NO. 2-A4

Summary of Bench Test Results
Stream One

Parameter	Influent Water[1] (mg/l)	Lime Treatment Effluent (mg/l)	Sulfide Precipitation Effluent (mg/l)	Carbon Absorption Effluent (mg/l)	Estimated Effluent Limits[2] (mg/l)
Arsenic	0.09-0.2	<0.003	<0.003	<0.003	0.720
Cadmium	0.094-1.46	0.0007-0.0012	<0.0003	<0.0003	0.0034
Chromium, Trivalent	0.003-0.014	<0.002	<0.002	See F.N. 3	1.903
Chromium, T	0.003-0.014	<0.002	<0.002	0.006[4]	0.032
Copper	94-910	0.20-0.35	<0.010	<0.010	0.0177
Lead	0.047-0.280	<0.002	<0.002	<0.002	0.064
Mercury	<0.0005-0.00073	<0.0005	<0.0005	<0.0005	0.0048
Nickel	0.082-1.9	<0.03	<0.03	<0.03	1.524
Selenium	0.006-0.016	0.004-0.007	0.003	<0.003	0.260
Silver	0.0024-0.017	<0.0004-0.0005	<0.0004	<0.0004	0.0011
Zinc	24-240	0.07-0.12	<0.03	<0.03	0.125

[1] Based on high sulfur waste rock samples. Actual loading is anticipated to be lower.

[2] Based on WDNR letter from Dave Olig, dated April 7, 1988. Calculations in the letter were based on proposed rules and preliminary data.

[3] Trivalent Chromium was not run because total chromium was found to be influenced by the carbon.

[4] Levels of 0.003 to 0.006 mg/l of total chromium were coming from the granular activated carbon as background levels.

NOTE: Influent water and lime treatment results represent the range of test results obtained during the bench test program. Sulfide precipitation and carbon absorption data represent the results from the final tests conducted as part of the bench test.

3.0 BENCH TEST STUDY FOR STREAM TWO

Mining activities associated with the Flambeau Project involve the stockpiling of Type I materials consisting of till, saprolite, sandstone, and Type I waste rock. Waste characterization studies have indicated that colloids may result when water comes into contact with the till and saprolite. The suspension consists primarily of colloids of iron and aluminum oxyhydroxides. Small amounts of copper, lead and zinc may be associated with the colloids. It should be noted that waste characterization studies have also shown that it is probable that the greatest quantities of colloids will result from the initial wetting of overburden and saprolite and that as these materials age on the Type stockpile, less and less colloids will occur in the runoff water. When the colloids are present in runoff water it will be necessary to remove them prior to discharging the water to the receiving body. Polymers have been shown to be effective in flocculating and settling colloidal particles. This bench test has been designed to determine which polymer will be acceptable for this purpose and to then determine the settling rates for the suspended material.

3.1 Bench Test Study Procedures

The bench test program was conducted in five phases. The first phase consisted of the generation of runoff water to be used in the tests. The second and third phases consisted of polymer selection and feed rate optimization for till runoff. The fourth phase consisted of feed rate optimization for combined till/saprolite runoff. The last phase consisted of pH adjustment to assist in metals removal. A discussion of each phase of the testing follows.

3.1.1 Phase I Stormwater Runoff Generation

Stormwater runoff for use in the bench test study was generated from composited till samples and from a saprolite composite. The method of generation is discussed below.

Till Stormwater Runoff

a. A total of 24,192.4 grams of moist till samples (7,080.0 grams of the east till composite, 9,510.3 grams of the West till composite, and 7,602.1 grams of the Central till composite) were composited, divided in two and placed in five-gallon leaching tanks.

b. Each composite was leached with 6-1/2 liters of DI water for eight hours for three consecutive leachings.

c. The generated leachates were composited for use in the bench test study.

Saprolite Stormwater Runoff

a. A total of 7,254.4 grams of moist Type I saprolite composite was placed in a five-gallon leaching tank.

b. The sample was leached with 4-1/2 liters of DI water for eight hours for three consecutive leachings.

c. The generated leachates were collected for use in the bench test study.

Sandstone was not used in preparing the stormwater runoff samples for the bench test studies since this material does not produce colloids when it comes in contact with water. As shown through the waste characterization work, the sandstone may though, leach small amounts of chromium. By the nature of the sandstone, the chromium present is expected to be in a trivalent state as opposed to a hexavalent state.

To confirm this, a sample of sandstone was agitated and leached with simulated rainwater for a period of 24-hours in order to maximize the chromium released. The leachate was analyzed to determine the quantity of both trivalent and hexavalent chromium using ion chromatographic techniques.

The results were as follows:

Total Chromium	8.2 ug/l
Hexavalent Chromium	<2 ug/l

Trivalent chromium, calculated as the difference between total and hexavalent chromium, is between 6.2 and 8.2 ug/l. The analytical procedures and results for the chromium analysis are included in the waste characterization study for the Flambeau Project. The waste characterization study can be found in Section 3.5.6 of the project Environmental Impact Report.

The estimated effluent limits for trivalent chromium are 1,903 ug/l. The estimated effluent limits for hexavalent chromium are 32 ug/l. A comparison of the sandstone leaching studies to the estimated effluent limits indicate that chromium release from the sandstone will not exceed estimated effluent limits.

3.1.2 Phase II - Polymer Selection and Initial Optimization

This phase of the study involved selecting polymers and determining which of those selected performed most favorably. This step also involved analytical work to assess the performance of the initial polymer screening process. A description of the steps in the Phase II work follows.

Step I - Polymer Selection

A series of polymers were prepared in conformance with manufacturers' specifications. Fresh polymer working solutions were used for this bench test. Polymers used in this test included:

Manufacturer: Wisconsin Entek, Inc.
3225 Kingsley Way
Madison, WI 53713

Polymer: CE-809
CE-815
CE-835
CE-865

Manufacturer: SecoDyne Inc.
P. O. Box 9
Amherst, WI 54406

Polymer: 430
1430
611
688
1630
450
1450
630
788
1650

Manufacturer: Calgon Corporation
8053 Bloomington Freeway
Minneapolis, MN 55420

Polymer: H-100
R25
R300
WT2439
WT2479
233
Ca-25
R200
WT2219
WT2459
WT3100
253

Step II - Preliminary Polymer Screening

A series of 100-ml till stormwater runoff samples were used for the evaluation of the polymers. Each sample was dosed at the rate of approximately 20 mg/l of polymer. This dosage rate was used, even though it is much higher than the final expected rate, to determine which polymer(s) reacted favorably with the colloidal material and to effectively settle them. The success of this step was measured by visual observation and recorded.

Step III - Secondary Polymer Screening

The polymers that reacted favorably with the colloidal material were evaluated in this step. These polymers were: CE-835, 611, 630, 1650, WT 2439.

A series of four 100-ml samples were taken from the till runoff generated in Phase I and dosed with polymer at the following levels:

Sample A - 0.0 mg/l polymer
Sample B - 4.0 mg/l polymer
Sample C - 8.0 mg/l polymer
Sample D - 10.0 mg/l polymer

The samples were mixed for approximately ten minutes. After the mixing period, the samples were allowed to settle. The settling rate for each sample was observed and recorded.

Step IV - Polymer Optimization

Polymer WT 2439 generated the optimum settling characteristics in Step III and was further evaluated as follows. The results of Step III testing indicated that the optimum polymer dosage rate was between 4.0 and 8.0 mg/l polymer. Therefore, the following dosage rates were evaluated using the procedures outlined in Step III.

Sample A - 5.0 mg/l polymer
Sample B - 6.0 mg/l polymer
Sample C - 7.0 mg/l polymer

In order to confirm the polymer dosage rate, a larger (500 ml) sample of till runoff water was treated with the polymer. The results of this test indicated that a dosage rate of 11 mg/l of polymer was required to totally clear the sample as determined by visual inspection. Following this test the supernatant was decanted. Both the supernatant and solids were analyzed for selected parameters. The results of these tests are contained in Table No. 3-A1. Raw laboratory data are included in Attachment No. 2.

Step V - Observations - Test I

The Phase II study resulted in the selection of a polymer that would flocculate and settle colloids in the sample. The test did not result in the determination of what the treatment end point should be. To do this, the dosage rate needs to be keyed to the threshold of the most restrictive chemical parameter, i.e., if copper will drive the wastewater discharge permit, then the polymer dosage rate must reduce copper below the effluent limit. The polymer, though, must not mutually exclude other less restrictive parameters. The analytical results indicated that with the exception of copper the initial polymer test resulted in an effluent that meets estimated effluent limits. Therefore, additional testing would be required to further optimize the polymer addition process and to address copper removal.

It should be noted that when working with polymers, there is virtually no settling time. A polymer either works or it does not. When the correct dosage is achieved, solids settle within minutes with no appreciable gain in solids reduction over extended settling time periods.

3.1.3 Phase III - Further Dosage Rate Optimization

In the Phase II tests a series of polymers were tested to determine if one would be superior in flocculating and settling solids found in till runoff samples. It was found that Calgon WT 2439 was acceptable and therefore should be used for further testing. Phase III testing required the generation of a second batch of till runoff using Phase I procedures.

TABLE NO. 3-A1

Bench Study Laboratory Data
Polymer[1] Tests On Till Runoff
Series 1

Parameter	Till Runoff (RAW)	Polymer Supernate	Polymer Solids[2]
Arsenic, ug/l	11	<3	12
Cadmium, ug/l	<3	<3	<2.0
T. Chromium, ug/l	40	3	36
Copper, ug/l	120	31	170
Lead, ug/l	10	<2	19
Mercury ug/l	<0.50	<0.50	<0.17
Nickel, ug/l	<30	<30	22
Selenium, ug/l	<3	<3	0.62
Silver, ug/l	<0.4	<0.4	<10
Zinc, ug/l	68	18	58
Total Dissolved Solids, mg/l	220	26	--
Total Suspended Solids, mg/l	16	70	--
Total Solids	---	--	0.5%
Iron, mg/l	21	1.4	22[3]
pH, s.u.	7.0	6.9	--

NOTE: Since the analysis for total chromium in the supernatant results in concentrations less than the estimated effluent limit for hexavalent chromium, the hexavalent chromium analysis was not required.

[1] Calgon WT 2439
[2] ug/g unless otherwise noted.
[3] mg/g

The till runoff generation process used the same till material used in Phase II. This resulted in a somewhat lower concentration of colloidal material, but the sample still had adequate colloids for a polymer optimization test.

A stock polymer solution using Calgon WT 2439 was made up of 0.5 g of polymer per 500 ml of water. A dilute polymer solution was made by adding 50 ml of stock polymer solution to 450 ml of water, a 1:10 dilution. The first polymer test was designed to verify results of the Phase II test. The following conditions applied:

Run 1 -

Sample volume: 100 ml till leachate
Polymer added: 0.4 and 0.8 ml stock polymer solution
Mixing: Continuous 30 sec.

Results -

Polymer Dose/100 ml sample	Comments
0.4 ml	Supernatant cloudy
0.8 ml	Supernatant clear

Because it was difficult to pipet 0.2 ml volumes of polymer, the next set of tests added polymer from the 1:10 diluted polymer solution. The second test had the following conditions:

Run 2 -

Sample volume: 100 ml till leachate
Polymer added: 4.0, 5.0, 6.0, 7.0 ml dilute polymer solution
Mixing: Continuous 30 sec.

Results -

Polymer Dose/100 ml Sample	Comments
4.0 ml	Supernatant cloudy
5.0 ml	Supernatant clear
6.0 ml	Supernatant clear
7.0 ml	Supernatant clear

A third set of tests were run using 100 ml samples. The polymer dosage rates chosen were between 4 and 5 ml. All other conditions remained the same.

Run 3 -

Polymer dose/100 ml Sample	Comments
4.5 ml	Supernatant slightly cloudy
4.8 ml	Supernatant cloudy but clearing

Since no clear supernatant could be obtained by reducing polymer dosages below 5.0 ml (dilute) per 100 ml sample, further testing used that dose rate on a larger sample size. It was found that the polymer was less effective when used on larger sample volumes, therefore another set of tests at higher dosage rates were set up as follows:

Run 4 -

Sample volume:	500 ml
Polymer added:	25.0, 27.5, 29.0 and 30.0 ml dilute polymer solution
Mixing:	continuous 2 min.

Results -

Polymer Dose/500 ml	Comments
25.0 ml	Supernatant cloudy-noticeably suspended
27.5 ml	Supernatant cloudy-suspended fines
29.0 ml	Supernatant cloudy-clearing
30.0 ml	Supernatant near clear

As predicted, the dosage rate that was optimum for a 100-ml sample would not suffice for a 500-ml sample. There are at least two explanations for this occurrence. First, it is normal for larger volumes to react differently during chemical addition than small samples. Second, if polymer emulsions are diluted, the polymer coils will open and are less effective. Therefore, using the 1:10 dilute polymer may very well require a higher dosage.

A further test was conducted to obtain sufficient samples for laboratory analysis. Here polymer was added to a two-liter sample at a dosage rate of 60 ml/liter (dilute polymer solution). Samples were well mixed and allowed to settle for three hours. About 1,500 ml of supernatant was decanted from the top for metals and solids analysis. Settled floc was withdrawn for a similar analysis. The results are included in Table No. 3-A2. Raw laboratory data is included in Attachment No. 2. The analytical results in Table No. 3-A2 are similar to those obtained from Phase II testing.

3.1.4 Phase IV - Till and Saprolite Runoff Polymer

In Phases II and III removal of colloids from till runoff was evaluated. After the till is removed during pre-production stripping and mining activities have commenced, Type I saprolite will be placed on the Type I stockpile. Runoff generated from the stockpile will then originate from both till and saprolite. Therefore, a third test was conducted to determine if colloidal material generated from both saprolite and till could be removed from the combined runoff.

Calgon WT 2439, which proved effective in the till studies, was used for this test. A concentrated stock solution of polymer was made by mixing 0.5g of polymer in 500 ml of water. A dilute solution was then made by diluting this stock at a 1:10 ratio. Saprolite runoff was tested under the following conditions:

TABLE NO. 3-A2

Bench Study Laboratory Data
Polymer[1] Tests on Till Runoff - Series 2

Parameter	Till Runoff (Raw)	Polymer Supernate	Polymer Solids[2]
Arsenic, ug/l	7	< 3	16
Cadmium, ug/l	<10	<10	< 1.9
T. Chromium, ug/l	24	4	36
Copper, ug/l	87	25	190
Lead, ug/l	6	2	19
Mercury, ug/l	< 0.50	< 0.50	< 0.35
Nickel, ug/l	<30	<30	23
Selenium, ug/l	< 3	< 3	0.58
Silver, ug/l	< 0.4	< 0.4	< 10
Zinc, ug/l	45	18	72
Total Dissolved Solids, mg/l	350	90	-
Total Suspended Solids, mg/l	145	35	-
Total Solids	-	-	0.69%
Iron, mg/l	13	2.3	23[3]
Hardness, mg/l	48	20	-
pH, s.u.	7.1	7.0	-

NOTE: Since the analysis for total chromium in the supernatant results in concentrations less than the estimated effluent limit for hexavalent chromium, the hexavalent chromium analysis was not required.

[1] Calgon WT 2439
[2] ug/g unless otherwise noted.
[3] mg/g

Run 1 -

Sample volume: 100 ml
Polymer added: 0.4, 0.8, and 1.2 ml stock polymer solution
Mixing: Continuous 30 sec.

Results -

Polymer Dose/100 ml	Comment
0.4 ml	Supernatant cloudy
0.8 ml	Supernatant clear
1.2 ml	Supernatant clear with light suspended

Results indicate an optimum polymer dosage rate around 0.8 ml per 100-ml sample. A second set of tests was then run with the following conditions:

Run 2 -

Sample volume: 100 ml
Polymer added: 5.0, 6.0, 7.0, 8.0, 9.0, and 10.0 ml dilute polymer solution
Mixing: Continuous 30 sec.

Results -

Polymer Dose/100 ml	Comment
5.0 ml	Supernatant cloudy
6.0 ml	Supernatant cloudy
7.0 ml	Supernatant cloudy
8.0 ml	Supernatant clear, but tinted
9.0 ml	Supernatant clear, with slight tint
10.0 ml	Supernatant clear, no tint

As was the case with till runoff, an excess of polymer was required to obtain the same settleability results. The result is a 20 percent increase in polymer dosage over stock polymer usage. However, an optimum dosage rate was established as a baseline. This rate is one pound of polymer for 9,000 gallons of wastewater.

To more readily reflect conditions in the field, final tests were conducted using till runoff and saprolite runoff in a 1:1 mix.

From previous tests it was found that the Phase II tests on till runoff required more polymer for flocculation and settling than the till runoff for the Phase III testing. Also, the till/saprolite runoff polymer dosage rates were between the two till runoff samples. The till runoff supplied for this test was the remaining portion of the raw sample from the Phase II tests and was expected to be somewhat stronger than saprolite runoff. Therefore, it was expected that it would require at least 10 ml of dilute polymer or 1.0 ml of stock polymer per a 100 ml till/saprolite mix. The test samples were set up accordingly. The following conditions applied.

Run 3 -

Sample type:	Till/saprolite runoff mix - 1:1
Sample volume:	100 ml
Polymer added:	0.8, 1.0, 1.2, 1.4, 1.6, and 1.8 ml stock polymer
Mixing:	Continuous 30 sec.

Results -

Polymer Dose/100 ml	Comment
0.8 ml	Supernatant cloudy
1.0 ml	Supernatant tinted with suspendeds
1.2 ml	Supernatant tinted with some suspendeds
1.4 ml	Supernatant clear
1.6 ml	Supernatant clear with some suspendeds
1.8 ml	Supernatant tinted with suspendeds

Results from the test indicate a 1.4 ml dose of stock polymer per 100-ml sample would provide the clearest supernatant. This dosage rate was then tested on a larger scale. A volume of 28 ml stock polymer was added to a two-liter sample and mixed. The sample was allowed to settle for two hours in a two-liter graduated cylinder. After settling, 1,500 ml of supernatant was drawn off for analysis. Settled solids was likewise saved for analysis.

The results of the analyses are included in Table No. 3-A3. Raw laboratory data is contained in Attachment No. 2.

A review of the data in Table No. 3-A3 indicates that the combined runoff from the till and saprolite had some characteristics different than the till runoff. For instance, the combined runoff had a pH of 5.5 s.u. vs. approximately 7.0 for the till alone. Copper, zinc, lead and silver were higher in the combined raw runoff than in the till raw runoff. Removal efficiencies as a function of the concentration of selected parameters following polymer treatment was virtually the same for the combined runoff when compared to the till alone.

3.1.5 Phase V pH Adjustment

From the previous tests, it was learned that polymer WT 2439 could sufficiently reduce colloidal solids in the wastewater. This holds true for both the till and the till/saprolite runoff mix. However, the results of the tests indicated two areas that required further attention. First, the pH of the combined till/saprolite sample was low, and second, concentrations of copper were above the estimated effluent limit.

The end point for the Phase II through IV tests was reached when the supernatant was clear as defined by visual observation. At that point, a settling period was allowed and the supernatant was decanted. It was not possible through visual observation to determine if additional polymer was needed to further reduce quantities of metals that may be above discharge standards. When the analytical test results were known, it was determined that additional polymer was needed.

TABLE NO. 3-A3

Bench Study Laboratory Data
Polymer[1] Tests on Till/Saprolite Runoff

Parameter	Till/Saprolite Runoff (Raw)	Polymer Supernate	Polymer Solids[2]
Arsenic, ug/l	10	< 3	16
Cadmium, ug/l	<10	<10	< 1.8
T. Chromium, ug/l	32	2	33
Copper, ug/l	400	31	530
Lead, ug/l	100	2	86
Mercury, ug/l	< 0.50	< 0.50	< 0.17
Nickel, ug/l	<30	<30	21
Selenium, ug/l	< 3	< 3	0.54
Silver, ug/l	1.1	< 0.4	<10
Zinc, ug/l	150	19	170
Total Suspended Solids, mg/l	370	<10	-
Total Solids	-	-	0.33%
Iron, mg/l	15	0.3	22[3]
Hardness, mg/l	40	16	-
pH	5.5	5.5	-

NOTE: Since the analysis for total chromium in the supernatant results in concentrations less than the estimated effluent limit for hexavalent chromium, the hexavalent chromium analysis was not required.

[1] Calgon WT 2439

[2] ug/g unless otherwise noted.

[3] mg/g

The objective of the Phase V was to reduce the copper concentration in the supernatant to meet the estimated effluent limit. It was felt that this could be accomplished by increasing the polymer dosage rate and/or by using pH adjustment to encourage copper to drop out of solution. The test was completed in four steps.

Step I - Chemical Preparation

As in the Phase II, III, and IV tests, a fresh stock polymer (WT 2439) solution was prepared (0.5 g polymer per 500-ml DI water). A sample of high calcium hydrated lime was obtained from Western Lime and Cement Co. A one percent solution of lime was prepared to be used for pH adjustment. The sample to be used was the same till/saprolite used for the Phase IV tests.

Step II - Sample pH Adjustment

Three 200-ml samples of the till/saprolite runoff from the previous test were prepared for testing. Samples were to have a pH of 7, 8, and 9 s.u. respectively. An initial pH reading of the samples was 6.9 s.u. The rise in pH from 5.5 s.u. to 6.9 s.u. may have been the result of the aeration of the sample and the length of holding time between test procedures. Since the sample had little buffering capacity, no lime was added to the first sample and it was considered to be equivalent to pH 7. Since there was no buffering capacity in the till/saprolite runoff sample, very little lime was required to raise the pH to 8.0 and to 9.0 s.u. This condition should be anticipated for future field application.

Step III - Polymer Addition

Stock polymer solution was added to three samples from Step II above. One minute of continuous stirring was required to thoroughly mix the polymer into the sample. Polymer was added until no visible solids remained in the supernatant. Samples 1 and 2 appeared to be clear after 1.9 mls of polymer were added. Clear conditions did not result until 2.4 mls were added to sample 3. An additional 0.5 ml of polymer was then added to both samples 1 and 2 to bring the total polymer added to all samples to the same amount so that the polymer was not the variable in the tests. The following conditions applied:

Sample Type	Sample Volume	pH	Polymer Used	Comments
1. Till/ Saprolite Mix	200 ml	6.9	2.4 ml	Clear, no floating solids
2. Till/ Saprolite Mix	200 ml	8.0	2.4 ml	Clear, some floating solids
3. Till/ Saprolite Mix	200 ml	9.0	2.4 ml	Clear, more floating solids

Step IV - Observations

Analytical tests for copper were performed on the supernatant for each of the three samples. The results of the test (Attachment No. 2) showed copper to be less than 10 ug/l for each sample. These results indicate that provided the runoff has a pH range of 6.9 to 9.0 s.u., and that additional polymer is added beyond the end point as defined by visual observation, estimated effluent limits can be met.

3.1.6 Summary and Conclusions

From Phase II through V testing, it was determined that a cationic polymer, specifically Calgon WT 2439, could successfully reduce colloidal material in runoff to acceptable concentrations. In addition, concentrations of metals can be reduced to below the estimated effluent limits (Table No. 3-A4).

With the exception of one set of samples, all samples received and tested had a near neutral pH. For full-scale operation, lime should only be used to maintain pH between 6.0 and 9.0 s.u.

TABLE NO. 3-A4

Projected Settling Pond Performance (Based on Bench Scale Testing)

Parameter	Concentration (mg/L)			
	Influent Water[1]	Polymer Supernatant	Polymer & pH Adjust.	Estimated Effluent Limits[3]
Arsenic	0.010	<0.003		0.720
Cadmium	<0.010	<0.010		0.0034
Chromium (Total)[2]	0.032	0.002		0.032
Copper	0.400	0.031	<0.010	0.0177
Hardness	40	16		--
Iron	15	0.300		--
Lead	0.100	0.002		0.0641
Mercury	<0.0005	<0.0005		0.0048
Nickel	<0.030	<0.030		1.524
Selenium	<0.003	<0.003		0.260
Silver	0.0011	<0.0004		0.0011
Zinc	0.150	0.019		0.125
pH	5.5	5.5	6.9-9	--
Total Suspended Solids	370	<10		--

[1] Represents a worst case scenario, since the influent water was prepared from the initial wetting of till and saprolite.

[2] Hexavalent chrome was not run since the value for a total chrome was less than 0.01 mg/l for the polymer supernatant.

[3] Based on WDNR letter from Dave Olig, dated April 7, 1988. Calculations in the letter were based on proposed rules and preliminary data.

Polymer WT 2439 is purchased as a powder. As a powder, this polymer has a good shelf life. Any emulsion made up from this powder should be made as concentrated as can be practically used during treatment. Over-dilution of polymer will cause deterioration of the polymer structure.

The bench test used wastewater which represents a worst case situation. Because of this, actual feed rates will have to be set through field observations.

ATTACHMENT NO. 1

Waste Stream One Bench Test Study Laboratory Data

FOTH AND VAN DYKE
Engineers/Architects
2737 S. Ridge Road
P.O. Box 19012
Green Bay, Wisc. 54307-9012

LABORATORY ANALYSIS RESULTS

W.D.N.R. LAB CERT. NO. 405051240

Client	Kennecott	Sampled By	DJL
Address		Scope I.D.	87K10
		Billing Line No.	
		Liaison	D. Turriff
Name of Rep.		Supply Order No.	
Telephone No.	(000) 000-0000	Result Sheet No.	37719.00

Sample I.D.	WW-1 Control	WW-1 pH 8.0	WW-1 pH 9.0	WW-1 pH 10.0	WW-1 pH 11.0
Date Collected	4/5/88	4/5/88	4/5/88	4/5/88	4/5/88
Date Received	4/5/88	4/5/88	4/5/88	4/5/88	4/5/88
Parameters, units	Results				
Arsenic, ug/l	200	< 3	< 3	3	5
Copper, ug/l	910,000	740	350	770	570
Mercury, ug/l	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Selenium, ug/l	16	7	7	6	8
Silver, ug/l	2.4	< 0.4	0.5	< 0.4	< 0.4
pH, std. units	3.1	5.0	5.9	7.1	8.8
T. Sus. Solids, mg/l	30	10	20	40	40
Cadmium, ug/l	1460	12	2.8	1.7	0.5
Lead, ug/l	47	< 2	< 2	< 2	< 2
Nickel, ug/l	1900	< 30	< 30	< 30	< 30
Zinc, ug/l	240,000	340	120	200	210
Cr+3, ug/l	---	< 2 **	< 2 **	< 2 **	< 2 **
Cr+6, ug/l	*	< 2	< 2	< 2	< 2
T. Chromium, ug/l	7 **				

comments: * No data due to interference.
** Low spike recovery.
Selenium analysis - Sample matrix problem, low spike recovery.

Signed: David Turriff Date: May 3, 1988

FOTH AND VAN DYKE
Engineers/Architects
2737 S. Ridge Road
P.O. Box 19012
Green Bay, Wisc. 54307-9012

LABORATORY ANALYSIS RESULTS

W.D.N.R. LAB CERT. NO. 405051240

Client Kennecott
Address

Name of Rep.
Telephone No. (000) 000-0000

Sampled By D. Loritz
Scope I.D. 87K10
Billing Line No.
Liaison D. Turriff
Supply Order No.
Result Sheet No. 38460.01

Sample I.D.	Raw Waste Water	Step II Sprntnt.	Step III Blank	Step III 5 ml Na2S	Step III 10 ml Na2S
Date Collected	8/18/88	8/19/88	8/23/88	8/23/88	8/23/88
Date Received	8/23/88	8/23/88	8/23/88	8/23/88	8/23/88
Parameters, units	Results				
Arsenic, ug/l	90	< 3	< 3	< 3	< 3
Copper, ug/l	650,000	240	200	81	53
Mercury, ug/l	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Selenium, ug/l	< 150	< 150	< 150	< 150	< 150
Silver, ug/l	4.7	< 0.4	< 0.4	< 0.4	< 0.4
Cadmium, ug/l	780	0.7	0.7	< 0.3	< 0.3
Lead, ug/l	51	< 2	< 2	< 2	< 2
Nickel, ug/l	830	< 30	< 30	< 30	< 30
Zinc, ug/l	170,000	71	83	72	40
Cr +3, ug/l	3 *	< 2	< 2	< 2	< 2
Cr +6, ug/l	3 *	< 2	< 2	< 2	< 2
pH, std units	3.7	4.5	4.8	5.2	6.3

comments: * Reported as Total Chromium.

Signed: David Turriff Date: October 18, 198

FOTH AND VAN DYKE
Engineers/Architects
2737 S. Ridge Road
P.O. Box 19012
Green Bay, Wisc. 54307-9012

LABORATORY ANALYSIS RESULTS

W.D.N.R. LAB CERT. NO. 405051240

Client	Kennecott	Sampled By	D. Loritz
Address		Scope I.D.	87K10
		Billing Line No.	
		Liaison	D. Turriff
Name of Rep.		Supply Order No.	
Telephone No.	(000) 000-0000	Result Sheet No.	38460.02

Sample I.D.	Step III 20 ml Na2S	Step III 40 ml Na2S	Step III 80 ml Na2S
Date Collected	8/23/88	8/23/88	8/23/88
Date Received	8/23/88	8/23/88	8/23/88
Parameters, units		Results	
Arsenic, ug/l	< 3	< 3	< 3
Copper, ug/l	15	< 10	130
Mercury, ug/l	< 0.5	< 0.5	< 0.5
Selenium, ug/l	< 150	< 150	< 150
Silver, ug/l	< 0.4	< 0.4	< 0.4
Cadmium, ug/l	< 0.3	< 0.3	0.8
Lead, ug/l	< 2	< 2	< 2
Nickel, ug/l	< 30	< 30	< 30
Zinc, ug/l	35	77	85
Cr +3, ug/l	< 2	< 2	< 2
Cr +6, ug/l	< 2	< 2	< 2
pH, std units	10.4	10.9	9.6

comments:

Signed: David Turiff Date: October 18, 19

Oneida Research & Technology Center
2496 West Mason Street
P. O. Box 12435
Green Bay, WI 54307-2435
Phone No.: (414)498-2222

LABORATORY ANALYSIS RESULTS

W.D.N.R. LAB CERT. NO. 405099530

Client Kennecott
Address

Name of Rep.
Telephone No. (000) 000-0000

Sampled By DJL
P.O. #
Job # 87K10
Report to: D. Turriff
Invoice # 1114
Result Sheet No. 38738.01

Sample I.D.	Raw Wastewater	Lime Trtmt Sprntnt.	Lime Trtmt Sludge	Sand Filt. D.I. Water	San. Filt. Effluent
Date Collected	10/16-18	10/19/88	10/19/88	10/14/88	10/20/88
Date Received	10/20/88	10/20/88	10/20/88	10/20/88	10/20/88
Parameters, units			Results		
Arsenic, ug/l	100	< 3	950	< 3	< 3
Copper, ug/l	94,000	200	980,000	43	< 10
Mercury, ug/l	0.73	< 0.5	8.9	< 0.5	< 0.5
Selenium, ug/l	6	4	< 30 *	< 3	3
Silver, ug/l	17	< 0.4	220	< 0.4	< 0.4
pH, s.u.	3.8	6.5	5.1	5.3	5.3
T. Sus. Solids, mg/l	190	< 10	--	< 10	< 10
Cadmium, ug/l	94	1.2	990	< 0.3	< 0.3
Lead, ug/l	280	< 2	2200	< 2	< 2
Nickel, ug/l	82	< 30	780	< 30	< 30
Zinc, ug/l	24,000	100	270,000	< 30	< 30
T. Cr, ug/l	14	< 2	44	< 2	< 2
T. Solids, %			0.6		

comments: * High detection limit due to sample matrix problem.

Signed: David Turriff Date: November 23, 198

Oneida Research & Technology Center
2496 West Mason Street
P. O. Box 12435
Green Bay, WI 54307-2435
Phone No.: (414)498-2222

LABORATORY ANALYSIS RESULTS

W.D.N.R. LAB CERT. NO. 405099530

Client Kennecott
Address

Name of Rep.
Telephone No. (000) 000-0000

Sampled By DJL
P.O. #
Job # 87K10
Report to: D. Turriff
Invoice # 1114
Result Sheet No. 38738.02

Sample I.D.	G.A.C. DI Water	G.A.C. Effluent	G.A.C.pH 7 Effluent
Date Collected	10/26/88	10/26/88	10/26/88
Date Received	10/27/88	10/27/88	10/27/88
Parameters, units	Results		
Arsenic, ug/l	< 3	< 3	< 3
Copper, ug/l	< 10	< 10	< 10
Mercury, ug/l	< 0.5	< 0.5	< 0.5
Selenium, ug/l	< 3	< 3	< 3
Silver, ug/l	< 0.4	< 0.4	< 0.4
pH, s.u.	5.4	4.6	4.8
T. Sus. Solids, mg/l	< 10	< 10	13
Cadmium, ug/l	< 0.3	< 0.3	< 0.3
Lead, ug/l	< 2	< 2	< 2
Nickel, ug/l	< 30	< 30	< 30
Zinc, ug/l	< 30	< 30	< 30
T. Cr, ug/l	3	6	6

comments:

Signed: David Turriff Date: November 23, 19

ATTACHMENT NO. 2

Waste Stream Two Bench Test Study Laboratory Data

ORTEK
Oneida Environmental Technology Center
2496 West Mason Street
P. O. Box 12435
Green Bay, WI 54307-2435
Telephone: (414) 498-2222

LABORATORY ANALYSIS RESULTS

W.D.N.R. LAB CERT. NO. 405099530

Client Kennecott
Address

Name of Rep.
Telephone No. (000) 000-0000

Sampled By Bill West
P.O. #
Job # 87K10
Report to: Bill West
Invoice # 1423
Result Sheet No. 39015.01

Sample I.D.	Till Leachate 1	Supernate Polymer
Date Collected	12/21/88	12/21/88
Date Received	12/21/88	12/21/88
Parameters, units	Results	
Arsenic, ug/l	11	< 3
Mercury, ug/l	< 0.50	< 0.50
Silver, ug/l	< 0.4	< 0.4
Cadmium, ug/l	< 3	< 3
Nickel, ug/l	< 30	< 30
T. Chromium, ug/l	40	3
Copper, ug/l	120	31
Selenium, ug/l	< 3	< 3
Lead, ug/l	10	< 2
Zinc, ug/l	68	18
TDS, mg/l	220	26
TSS, mg/l	16	70
pH, std. units	7.0	6.9
Iron, ug/l	21,000	1400

Comments:

Signed: David Turiff Date: February 1, 1

ORTEK
Oneida Environmental Technology Center
2496 West Mason Street
P. O. Box 12435
Green Bay, WI 54307-2435
Telephone: (414) 498-2222

LABORATORY ANALYSIS RESULTS

W.D.N.R. LAB CERT. NO. 405099530

Client Kennecott
Address

Name of Rep.
Telephone No. (000) 000-0000

Sampled By Bill West
P.O. #
Job # 87K10
Report to: Bill West
Invoice # 1423
Result Sheet No. 39015.02

Sample I.D. Sludge Polymer
Date Collected 12/21/88
Date Received 12/21/88

Parameters, units	Results
Arsenic, ug/g	12
Mercury, ug/g	< 0.17
Silver, ug/g	< 10
Cadmium, ug/g	< 2.0
Nickel, ug/g	22
Total Chromium, ug/g	36
Copper, ug/g	170
Selenium, ug/g	0.62
Lead, ug/g	19
Zinc, ug/g	58
Total Solids, %	0.50
Iron, ug/g	22,000

Comments:

Signed: David Turiff Date: January 26, 19

ORTEK
Oneida Environmental Technology Center
2496 West Mason Street
P. O. Box 12435
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Telephone: (414) 498-2222

LABORATORY ANALYSIS RESULTS

W.D.N.R. LAB CERT. NO. 405099530

Client Kennecott
Address

Name of Rep.
Telephone No. (000) 000-0000

Sampled By DJD
P.O. #
Job # 87K10
Report to: B. West
Invoice # 1419
Result Sheet No. 39043.01

Sample I.D.	Ken-Till Raw	Ken-Till Super
Date Collected	12/28/88	12/28/88
Date Received	12/28/88	12/28/88
Parameters, units	Results	
Arsenic, ug/l	7	< 3
Mercury, ug/l	< 0.50	< 0.50
Silver, ug/l	< 0.4	< 0.4
Cadmium, ug/l	< 10	< 10
Nickel, ug/l	< 30	< 30
Total Chrome, ug/l	24	4
Iron, ug/l	13,000	2300
Copper, ug/l	87	25
Selenium, ug/l	< 3	< 3
Lead, ug/l	6	2
Zinc, ug/l	45	18
Hardness, mg/l	48	20
TSS, mg/l	145	35

Comments:

Signed: David Turiff Date: January 26, 19

ORTEK
Oneida Environmental Technology Center
2496 West Mason Street
P. O. Box 12435
Green Bay, WI 54307-2435
Telephone: (414) 498-2222

LABORATORY ANALYSIS RESULTS

W.D.N.R. LAB CERT. NO. 405099530

Client Kennecott
Address

Name of Rep.
Telephone No. (000) 000-0000

Sampled By DJD
P.O. #
Job # 87K10
Report to: B. West
Invoice # 1419
Result Sheet No. 39043.02

Sample I.D.	Ken-Till Raw	Ken-Till Super
Date Collected	12/28/88	12/28/88
Date Received	12/28/88	12/28/88
Parameters, units	Results	
TDS, mg/l	350	90
pH, Std. Units	7.1	7.0

Comments:

Signed: David Turriff Date: February 1, 198

ORTEK
Oneida Environmental Technology Center
2496 West Mason Street
P. O. Box 12435
Green Bay, WI 54307-2435
Telephone: (414) 498-2222

LABORATORY ANALYSIS RESULTS

W.D.N.R. LAB CERT. NO. 405099530

Client Kennecott
Address

Name of Rep.
Telephone No. (000) 000-0000

Sampled By DJD
P.O. #
Job # 87K10
Report to: Bill West
Invoice # 1419
Result Sheet No. 39043.03

Sample I.D. Ken-Till Sludge
Date Collected 12/28/88
Date Received 12/28/88

Parameters, units	Results
Arsenic, ug/g	16
Mercury, ug/g	< 0.35
Silver, ug/g	< 10
Cadmium, ug/g	< 1.9
Nickel, ug/g	23
Total Chromium, ug/g	36
Iron, ug/g	23,000
Copper, ug/g	190
Selenium, ug/g	0.58
Lead, ug/g	19
Zinc, ug/g	72
Total Solids, %	0.69

Comments:

Signed: David Turiff Date: January 26, 19

ORTEK
Oneida Environmental Technology Center
2496 West Mason Street
P. O. Box 12435
Green Bay, WI 54307-2435
Telephone: (414) 498-2222

LABORATORY ANALYSIS RESULTS

W.D.N.R. LAB CERT. NO. 405099530

Client Kennecott
Address

Name of Rep.
Telephone No. (000) 000-0000

Sampled By Bill West
P.O. #
Job # 87K10
Report to: B. West
Invoice # 1440
Result Sheet No. 39055.01

Sample I.D.	Sap/Till Dissolved	Sap/Till	Sap/Till Super
Date Collected	01/03/89	01/03/89	01/03/89
Date Received	01/03/89	01/03/89	01/03/89
Parameters, units	Results		
Arsenic, ug/l	6	10	< 3
Mercury, ug/l	< 0.50	< 0.50	< 0.50
Silver, ug/l	0.4	1.1	< 0.4
Cadmium, ug/l	< 10	< 10	< 10
Nickel, ug/l	< 30	< 30	< 30
Total Chromium, ug/l	18	32	2
Iron, ug/l	7500	15,000	300
Copper, ug/l	170	400	31
Selenium, ug/l	< 3	< 3	< 3
Lead, ug/l	41	100	2
Zinc, ug/l	90	150	19
TSS, mg/l	55	370	< 10
Hardness	4	40	16

Comments:

Signed: David Turiff Date: February 1, 198

ORTEK
Oneida Environmental Technology Center
2496 West Mason Street
P. O. Box 12435
Green Bay, WI 54307-2435
Telephone: (414) 498-2222

LABORATORY ANALYSIS RESULTS

W.D.N.R. LAB CERT. NO. 405099530

Client	Kennecott	Sampled By	Bill West
Address		P.O. #	
		Job # 87K10	
		Report to: B. West	
		Invoice #	1440
Name of Rep.		Result Sheet No.	39055.02
Telephone No.	(000) 000-0000		

Sample I.D.	Sap/Till Dissolved	Sap/Till	Sap/Till Super
Date Collected	01/03/89	01/03/89	01/03/89
Date Received	01/03/89	01/03/89	01/03/89
Parameters, units		Results	
pH, Std. Units	5.5	5.5	5.5

Comments: *If total Chrome is greater than 0.05 mg/l, run Hexchrome.

Signed: David Tarriff Date: February 1, 1989

ORTEK
Oneida Environmental Technology Center
2496 West Mason Street
P. O. Box 12435
Green Bay, WI 54307-2435
Telephone: (414) 498-2222

LABORATORY ANALYSIS RESULTS

W.D.N.R. LAB CERT. NO. 405099530

Client	Kennecott	Sampled By	Bill West
Address		P.O. #	
		Job # 87K10	
		Report to: B. West	
Name of Rep.		Invoice #	1440
Telephone No.	(000) 000-0000	Result Sheet No.	39055.03

Sample I.D.	Sap/Till Sludge
Date Collected	01/03/89
Date Received	01/03/89

Parameters, units	Results
Arsenic, ug/g	16
Mercury, ug/g	< 0.17
Silver, ug/g	< 10
Cadmium, ug/g	< 1.8
Nickel, ug/g	21
Total Chromium, ug/g	33
Iron, ug/g	22,000
Copper, ug/g	530
Selenium, ug/g	0.54
Lead, ug/g	86
Zinc, ug/g	170
Total Solids, %	0.33

Comments:

Signed: David Turriff Date: February 1, 1

ORTEK
Oneida Environmental Technology Center
2496 West Mason Street
P. O. Box 12435
Green Bay, WI 54307-2435
Telephone: (414) 498-2222

LABORATORY ANALYSIS RESULTS

W.D.N.R. LAB CERT. NO. 405099530

Client FOTH & VAN DYKE
Address (Kennecott)

Name of Rep.
Telephone No. (000) 000-0000

Sampled By B. West
P.O. #
Job # 87K10
Report to: B. West
Invoice # 1468
Result Sheet No. 39187.00

Sample I.D.	Sap/Till ph7	Sap/Till ph8	Sap/Till ph9
Date Collected	01/31/89	01/31/89	01/31/89
Date Received	01/31/89	01/31/89	01/31/89
Parameters, units	Results		
Copper, ug/l	< 10	< 10	< 10

Comments:

Signed: David Tussiff Date: February 1, 198

APPENDIX B

Flambeau Property Legal Descriptions

EXHIBIT A

The real estate premises are described as follows:

The South one-half of the South one-half of the Northeast Quarter of the Northeast Quarter, the Northwest Quarter of the Northeast Quarter, except beginning at the Northeast (NE) corner of said Northwest Quarter of the Northeast Quarter, thence West along the South line of the existing road Four Hundred Ten (410') feet, thence South Two Hundred Twelve and 5/10 (212.5') feet, thence East Four Hundred Ten (410') feet, thence North Two Hundred Twelve and 5/10 (212.5') feet to the point of beginning, the Southeast Quarter of the Northeast Quarter, the Northeast Quarter of the Southeast Quarter, the Southeast Quarter of the Southeast Quarter, Government Lots Three (3), Four (4), Five (5), Six (6), Seven (7), and Eight (8), Section Nine (9), Township Thirty-four (34) North, Range Six (6) West.

That part of the Northwest Quarter of the Northeast Quarter lying East of the Railroad, Section Ten (10), Township Thirty-four (34) North, Range Six (6) West, except that part of Lot One (1) of Certified Survey Map, Page 284; That part of Government Lot Seven (7), Section Three (3), Township Thirty-four (34), Range Six (6) West lying West of Railroad, that Part of the Northwest Quarter of the Northeast Quarter of Section Ten (10), Township Thirty-four (34) North, Range Six (6) West lying West of Railroad; that Part of the Southwest Quarter of the Northeast Quarter lying East of Railroad, that Part of the Southwest Quarter of the Northeast Quarter lying West of Railroad, the Southeast Quarter of the Northeast Quarter, the NOrtheast Quarter of the Northwest Quarter, that Part of the Northwest Quarter of the Northwest Quarter lying East of State Highway 27, excepting parcels described as follows:

A parcel in the Northwest Quarter of the Northwest Quarter commencing at the Northeast corner, thence 200 feet West, thence 66 feet South, thence 200 feet East, thence 66 feet North to the point of beginning; and

Commencing at the intersection of the South right-of-way line of a Town Road with the East right-of-way line of State Highway 27; thence Southerly along said East right-of-way line 175 feet, thence Easterly at right angle, 150 feet, thence Northerly at right angles and parallel to said East right-of-way line, 215 feet to the South line of Town Road, thence Westerly along town road 156 feet, to the point of beginning; and

Commencing at the intersection of the South right-of-way line of a Town Road with the East right-of-way line of State Highway 27, thence Southerly along said East right-of-way line, 175 feet, to the point of beginning of the land to be herein described; thence Southerly along the East lihe of Highway 208.7 feet, thence Easterly at right angles, 208.7 feet, thence Northerly at right angles and parallel to said East right-of-way line, 208.7 feet; thence Westerly at right angles, 208.7 feet to the point of beginning.

The Southwest Quarter of the Northwest Quarter, the Southeast Quarter of the Northwest Quarter, the Northeast Quarter of the Southwest Quarter, the Northwest Quarter of the Southwest Quarter, the Southwest Quarter of the Southwest Quarter, the Southeast Quarter of the Southwest Quarter, the Northeast Quarter of the Southeast Quarter, the Northwest Quarter of the Southeast Quarter lying East of Railroad, the Northwest Quarter of the Southeast Quarter lying West of Railroad, the Southwest Quarter of the Southeast Quarter lying East of Railroad, the Southwest Quarter of the Southeast Quarter lying West of Railroad, the Southeast Quarter of the Southeast Quarter of Section Ten (10), Township Thirty-four (34) North, Range Six (6) West.

Government Lots One (1), Two (2) except a parcel of land lying within Government Lot Two (2), Section Sixteen (16), Township Thirty-four (34) North, Range Six (6) West described as follows: Commencing at the Northwest corner of said Section Sixteen (16), said corner being the center line of North and South Town Road and intersection of East and West fence, thence North 89°0'E along the North line of Section Sixteen (16) a distance of 594.4 feet; thence South 37°30'E a distance of 2860.9 feet; thence South 56°15'E a distance of 341.1 feet to the point of beginning; thence South 33°45'W a distance of 50.0 feet, thence South 56°15'E a distance of 197.0 feet to an intersection with the Northwesterly edge of the Flambeau River; thence North 37°11'E a distance of 50.09 feet; thence North 27°17'E a distance of 150.96 feet, thence North 56°15'W a distance of 183.0 feet; thence South 33°45'W a distance of 150.0 feet to the point of beginning, Three (3), Four (4), Five (5), Six (6) except a parcel of land lying within Government Lot Six (6), Section Sixteen (16), Township Thirty-four (34) North, Range Six (6) West, said parcel being more particularly described as follows: Commencing at the southeast corner of said Section Sixteen (16), said corner being the intersection of the corner line of State Highway 27 and the center line of County Road T, thence north no (0) degrees, three (03) minutes west along the center line of State Highway 27 a distance of eight hundred forty and one-tenths (840.0) feet; thence north fifty-three (53) degrees fifty-one (51) minutes west a distance of eighteen hundred fifty-four and two-tenths (1854.2) feet; thence north fifty-six (56) degrees, fifteen (15) minutes west a distance of six hundred forty-seven and no-tenths (647.0) feet to the point of beginning; thence south thrity-three (33) degrees forty-five (45) minutes west a distance of fifty and no-tenths (50.0) feet; thence north fifty-six (56) degrees, fifteen (15) minutes west a distance of one hundred ninety eight and two-tenths (198.2) feet to an intersection with the southeasterly edge of the Flambeau River; thence north thirty-one (31) degrees, forty-one (41) minutes east a distance of fifty and three one-hundredths (50.03) feet; thence north thirty (30) degrees forty (40) minutes east a distance of one hundred fifty and twenty-two one-hundredths (150.22) feet, thence south fifty-six (56) degrees, fifteen (15) minutes east a distance of two hundred eight and 08/100 (208.08) feet, thence south thirty-three (33) degrees, forty-five (45) minutes west a distance of one hundred fifty and no-tenths (150.0) feet to the point of beginning, Seven (7), and Eight (8); the Northwest Quarter of the Northwest Quarter, the Northeast Quarter of the Southeast Quarter, the Southwest Quarter of the Southeast Quarter, the Southeast Quarter of the Southeast Quarter of Section Sixteen (16), Township Thirty-four (34) North, Range Six (6) West.

Government Lots Three (3), Four (4), Five (5), Six (6), and Seven (7), the Northeast Quarter of the Northeast Quarter, the Northwest Quarter of the Northeast Quarter, ^ of Section Seventeen (17), Township Thirty-four (34) North, Range Six (6) West.

The Northeast Quarter of the Northeast Quarter, the Southwest Quarter of the Northeast Quarter, the Southeast Quarter of the Northeast Quarter, the East one-half of the East one-half of the Northwest Quarter, the Northeast Quarter of the Southeast Quarter of Section Twenty (20), Township Thirty-four (34) North, Range Six (6) West.

the Southwest Quarter of the Southeast Quarter, The Northeast Quarter of the Northeast Quarter, the Northwest Quarter of the Northeast Quarter, the Southwest Quarter of the Northeast Quarter, the Southeast Quarter of the Northeast Quarter, the Northeast Quarter of the Northwest Quarter, the Northwest Quarte of the Northwest Quarter, the Southwest Quarter of the Northwest Quarter, the Southeast Quarter of the Northwest Quarter, the Northeast Quarter of the Southwest Quarter, the Northwest Quarter of the Southwest Quarter, the Northeast Quarter of the Southeast Quarter, the Northwest Quarter of the Southeast Quarter, the Southwest Quarter of the Southeast Quarter of Section Twenty-one (21), Township Thirty-four (34) North, Range Six (6) West.

The Southwest Quarter of the Northwest Quarter, and the Northwest Quarter of the Southwest Quarter of Section Twenty-two (22), Township Thirty-four (34) North, Range Six (6) West.

Located in the City of Ladysmith, and Township of Grant, Rusk County, State of Wisconsin.