1976

MINING PERMIT APPLICATION
FOR
MINING THE FLAMBEAU COPPER DEPOSIT
RUSK COUNTY, WISCONSIN

Prepared by
Flambeau Mining Corporation
Ladysmith, Wisconsin

September 1976

MINING PERMIT APPLICATION

Submitted by

FLAMBEAU MINING CORPORATION

Ladysmith, Wisconsin

September 14, 1976

TABLE OF CONTENTS

Page

Page

LIST OF FIGURES

LIST OF TABLES

LIST OF EXHIBITS

SECTION 1

BASELINE DATA

[redacted]

SECTION 1

1.1.0 NOTICE OF INTENT TO SUBMIT A MINING PERMIT APPLICATION FOR NEW OPERATION

Pursuant to the requirements of Section 6 of the Rusk County Zoning Ordinance, the following mining permit application for a new operation is submitted for County Board approval by Flambeau Mining Corporation (FMC).

1.1.1 DESCRIPTION OF PROPOSED PROJECT

FMC, a wholly owned subsidiary of Kennecott Copper Corporation (KCC), proposes to establish an open pit copper mine one mile southwest of Ladysmith in Rusk County, Wisconsin. The copper sulfide ore would be concentrated at the project site and transported out of Wisconsin for smelting.

1.1.2 LAYOUT OF PROPOSED FACILITIES

See Exhibit A

1.1.3 PLANT CONSTRUCTION SCHEDULE

Construction on this project cannot commence until notification by the WDNR, other state and local bodies, and the Corps of Engineers that the necessary mining plans and permits have been approved and the KCC Board of Directors authorizes the expenditure of funds. The process plant and facilities construction period is expected to last 18 to 24 months after the beginning of mine prestripping (see Exhibit B for construction sequence).

1.1.4 ESTIMATED PROJECT COST

The total estimated cost of this project is approximately $27 million.

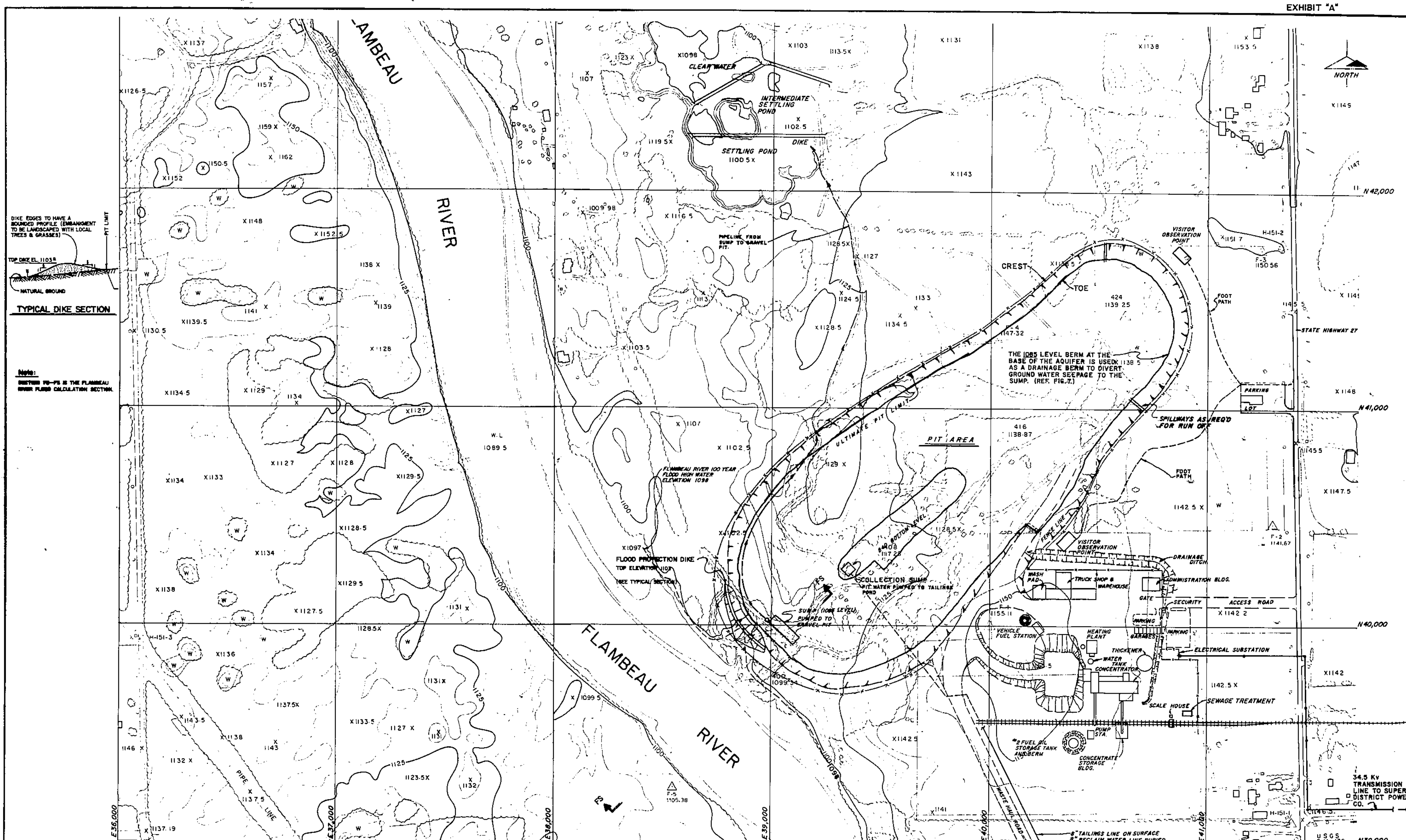
1.1.5 DESCRIPTION OF PROCESS

Ore from the mine would be upgraded in a concentrator plant located immediately adjacent to the mine. Because concentrate production from the mine would be much too small by itself to support a conventional smelter, the metal-bearing concentrates will be shipped by rail out of the state for smelting and refining. Processing of the mine ore entails crushing, grinding, flotation and dewatering. Briefly, the concentrating process is as follows (additional information is provided in Section 2):

1. Crushing: Ore from the mine is crushed to minus 3/4-inch size by a jaw crusher and a cone crusher working in series. This process will normally occur on one shift per day, seven days per week.

2. Grinding: The crushed ore is reduced to pulp by grinding in a rod mill and a ball mill working in series. This process will be operated three shifts per day, seven days per week.

EXHIBIT "A"



~ SEE SHEET 2 FOR CONTINUATION ~

GRAPHIC SCALE: 0 100 300 500 750

REFERENCE	DWG. No.	DESCRIPTION
	BCM 82-00-104	PLOT PLAN - SHEET NO. 2
	105	PLOT PLAN - SHEET NO. 3
	106	PLOT PLAN - SHEET NO. 4

NO.	DATE	REVISIONS	BY	CHK'D	ENG'R	CH.ENG
1	1-30-75	ADDED DIKE	KRD			
2	1-28-76	CHGE DWG NO FROM [illegible]	LLM			
3	6-29-76	GENERAL REVISION	KB			

	BY	DATE		BY	DATE
SECT. ENGR.			DESIGN	LLM	11.4.75
C. DES. ENGR.			DRAWN	HCB	MARCH, 1973
PROJ. ENG.			CHK'D.		
SAFETY ENGR.			DES. ENGR.	LLM	11.4.75
CHIEF ENGR.			SCALE:	AS SHOWN	

KENNECOTT COPPER CORPORATION
ENGINEERING CENTER
METAL MINING DIVISION
1515 MINERAL SQUARE
SALT LAKE CITY, UTAH

FLAMBEAU MINING CORP.

PLOT PLAN
OPEN PIT AREA
SHEET 1 OF 4

MICROFILM	EC-MMD JOB
	506

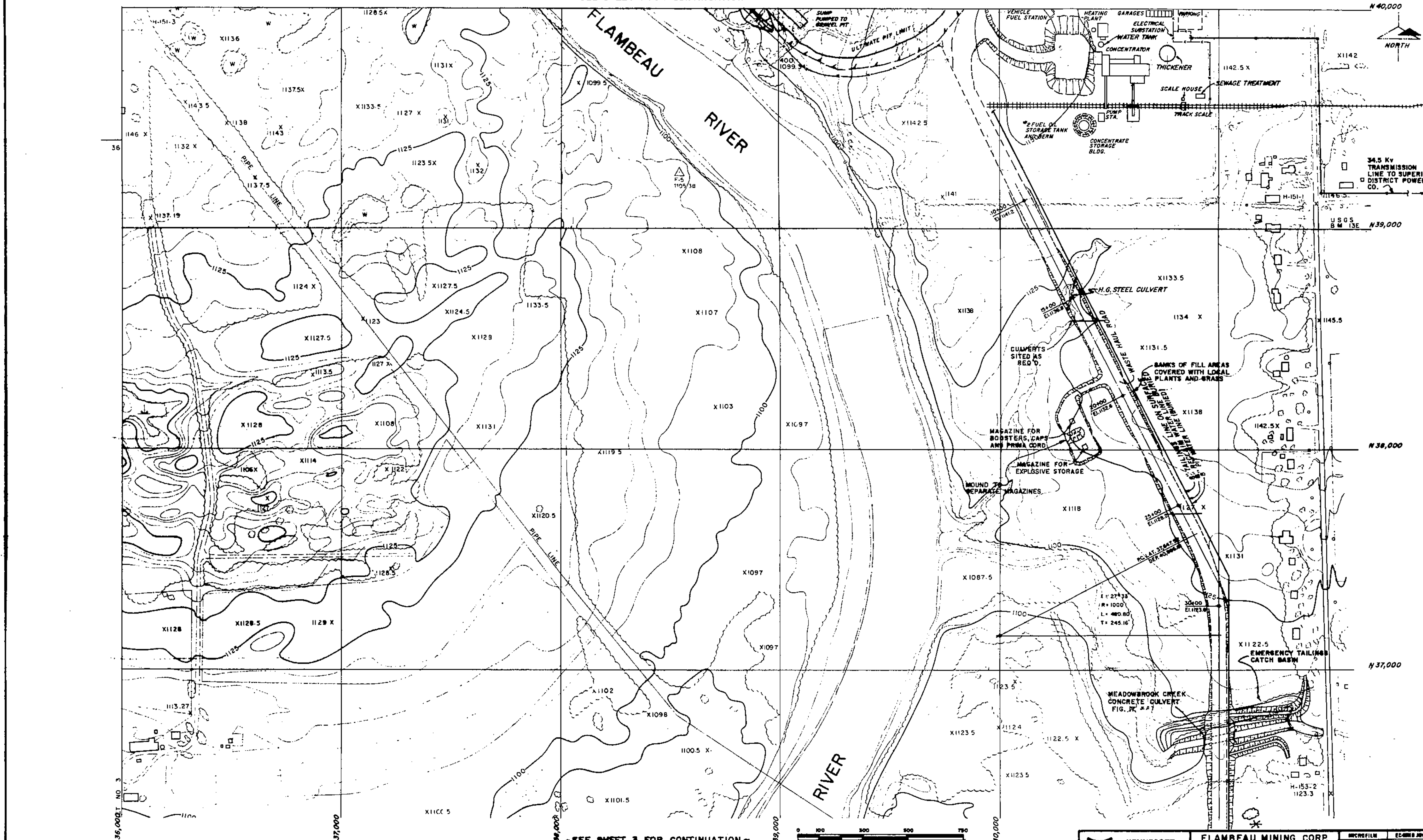
EC-MMD DRAWING	REV.
FM76-03-116	3

DIVISION DRAWING NO.

EC-MMD 18 REV. 3-1-72

EXHIBIT "A"

- SEE SHEET 1 FOR CONTINUATION -



- SEE SHEET 3 FOR CONTINUATION -

GRAPHIC SCALE: 0 100 300 500 750

REFERENCE Dwg. No.	DESCRIPTION
80K 82-00-103	PLOT PLAN - SHEET NO. 1
105	PLOT PLAN - SHEET NO. 3
106	PLOT PLAN SHEET NO. 4

NO.	DATE	REVISIONS	BY
1	[illegible]	[illegible]	LLM
2	6-30-[illegible]	General Revision	KB

	BY	DATE
DESIGN	LLM	11-4-75
DRAWN	NLB	MARCH, 1973
CHK'D.		
DES. ENGR.	LLM	11-4-75
SCALE:	AS SHOWN	

KENNECOTT COPPER CORPORATION
ENGINEERING CENTER
METAL MINING DIVISION
1515 MINERAL SQUARE
SALT LAKE CITY, UTAH

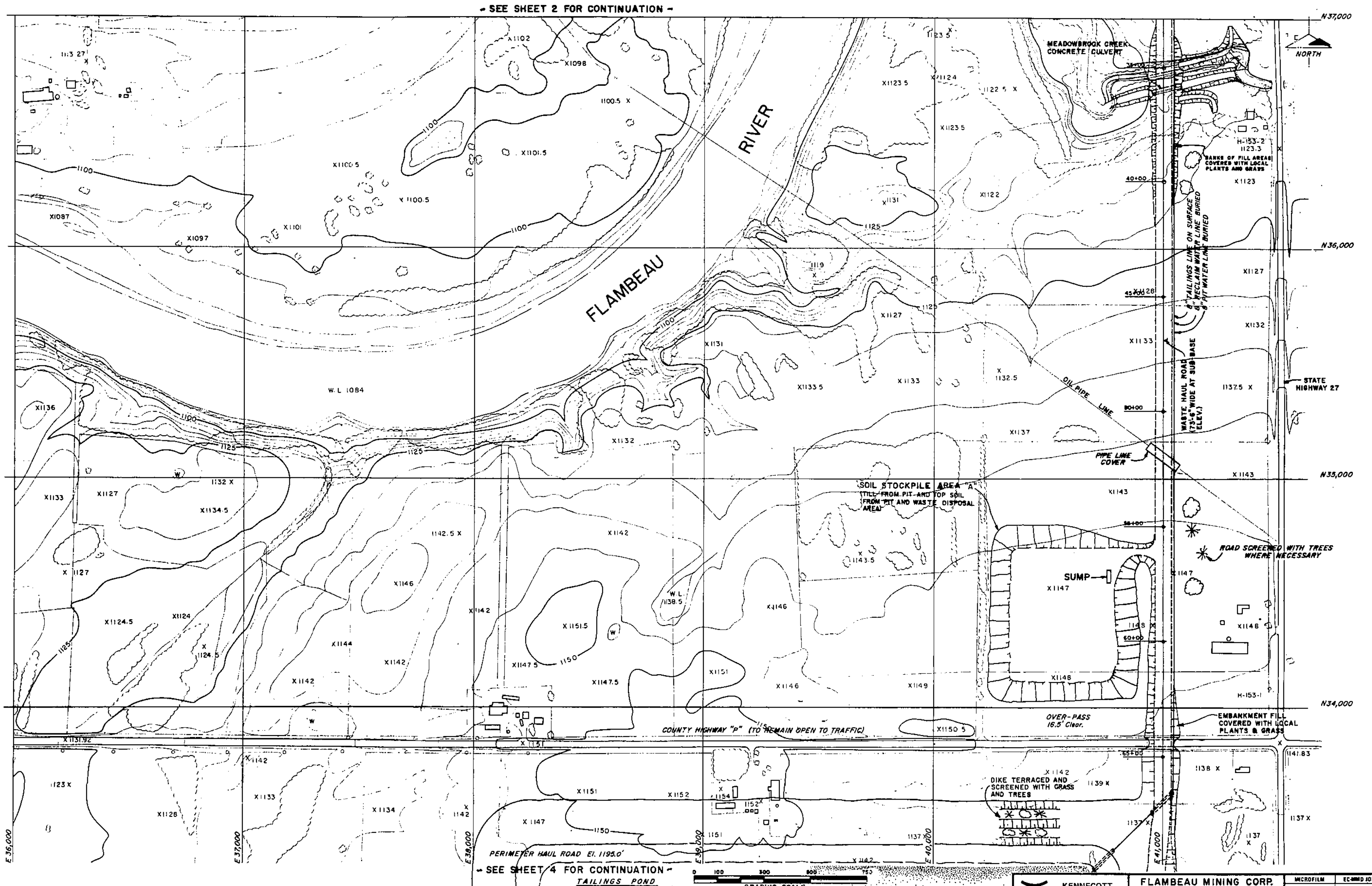
FLAMBEAU MINING CORP.

PLOT PLAN
PLANT SITE AND HAUL ROAD
SHEET 2 OF 4

MICROFILM: 506
EC-MMD DRAWING: FM76-03-117 REV. 2

EC-MMD 16 REV. 5-1-72

EXHIBIT "A"



REFERENCE Dwg. No.	DESCRIPTION
BCM 82-00-103	PLOT PLAN - SHEET NO. 1
104	PLOT PLAN - SHEET NO. 2
106	PLOT PLAN - SHEET NO. 4

NO.	DATE	REVISIONS	BY	CHK'D	ENG'R	CH.ENG
1	Oct 75	General Revision				
2	1.26.76	CHGE DWG NO FROM BCM82-00-105	LLM			
3	6-10-76	CHANGED STOCKPILE SIZE	KB			

	BY	DATE
DESIGN	LLM	11.4.75
DRAWN	NLB	MARCH, 1973
CHK'D.		
DES. ENGR.	LLM	11.5.75
SCALE:	AS SHOWN	

KENNECOTT COPPER CORPORATION
ENGINEERING CENTER
METAL MINING DIVISION
1515 MINERAL SQUARE
SALT LAKE CITY, UTAH

FLAMBEAU MINING CORP.

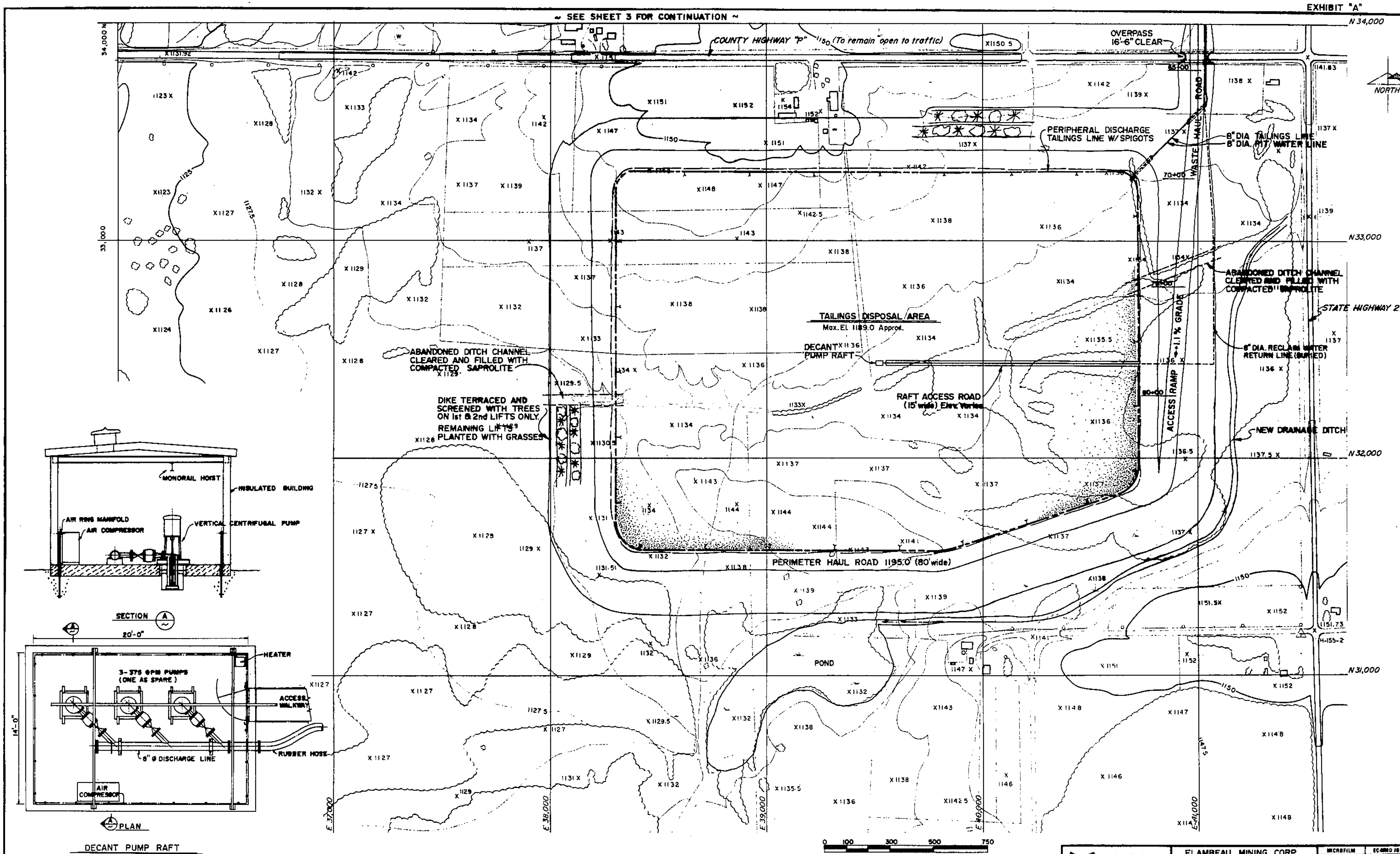
PLOT PLAN
HAUL ROAD AND STOCKPILE AREA
SHEET 3 OF 4

MICROFILM | EC-MMD JOB 506
EC-MMD DRAWING FM76-03-118 | REV. 3
DIVISION DRAWING NO.

EC-MMD 18 REV 5-1-72

EXHIBIT "A"

~ SEE SHEET 3 FOR CONTINUATION ~



DECANT PUMP RAFT

	Dwg. No.	DESCRIPTION
REFERENCE	BCM82-00-103	PLOT PLAN – SHEET NO. 1
	-104	– SHEET NO. 2
	-105	– SHEET NO. 3

NO.	DATE	REVISIONS	BY
1	Jan 75	Added Decant Tower Details	
2	Oct 75	General Revision	
3	Jan 76	Misc. Revisions	
4	1-26-76	CHGE. Dwg. No. From BCM82-00-106 Ua	
5	6-30-76	MISC. REVISIONS	KB

	BY	DATE
DESIGN	KRD	11.4.75
DRAWN	KRD	March 1973
CHK'D.		
DES. ENGR.	LM	11.5.75
SCALE:	AS SHOWN	

KENNECOTT COPPER CORPORATION
ENGINEERING CENTER
METAL MINING DIVISION
1515 MINERAL SQUARE
SALT LAKE CITY, UTAH

FLAMBEAU MINING CORP.

PLOT PLAN
WASTE CONTAINMENT AREA
SHEET 4 OF 4

MICROFILM / EC-MMD JOB: 506
EC-MMD DRAWING: FM76-03-119 REV. 5

EC-MMD 15 REV. 9-1-77

3. Flotation: By aeration and the addition of chemical reagents, the copper sulfide mineral grains are physically separated from the ore pulp in a froth. The copper sulfide-rich froth, containing roughly 25% copper and a minor amount of precious metals, is continually removed from the top of the flotation cells and, when dewatered, is termed "concentrate" - the end product of the FMC operation. The remaining impoverished pulp, or tailing, is pumped from the cells to a prepared site for disposal as a waste product. This process will be operated three shifts per day, seven days per week.

4. Dewatering: The concentrate is dewatered by settling in a thickener tank and finally by vacuum filtering. This excess water along with tailings water from the waste containment area will be recycled with concentrator process makeup water coming primarily from mine drainage and at times possibly from wells.

5. Drying: After dewatering, the concentrate will be further dried in a rotary kiln for final shipment. Dryer temperatures will be less than 1600°F so that sulfur dioxide will not be produced.

1.1.6 PROCESS EQUIPMENT

It is the policy of KCC to procure all plant equipment on a competitive bid basis. Procurement specifications for equipment are presently being generated for this purpose. Bids, however, cannot be obtained until the necessary mining plans and permits are secured and funds are authorized by the KCC Board of Directors. Therefore, at this time it is impossible to designate the manufacturer of the many pieces of equipment which will be required for process purposes.

1.1.7 ANTICIPATED PRODUCTION RATE

Ore:	1,000 tpd removed from open pit
Wasterock:	4,120 tpd removed from open pit
Copper concentrate produced:	160 tpd (average)
Tailings:	840 dry tpd
Composition:	50% to 70% quartz, mica and clays, and 30% to 50% iron sulfide (iron pyrite)
Copper recovery from ore:	86% to 89% depending on ore type and grade

1.1.8 OPERATING SCHEDULE

Open pit mine:	5 days/week, 8 hours/day (normally)
Concentrator: Crushing	7 days/week, 8 hours/day (normally)
Concentrator: Grinding, Flotation, Dewatering, Drying	7 days/week, 24 hours/day (normally)
Truck shop:	5 days/week, 8 hours/day (normally)
Administrative offices:	5 days/week, 8 hours/day (normally)

1.1.9 LEGAL DESCRIPTION OF FLAMBEAU MINING CORPORATION PROPERTY (Figure 1)

Government Lot Seven (7) of Section Three (3); mineral rights only in Government Lot Two (2) of Section Four (4); all of Section Nine (9) excepting the NE¼NE¼, excepting Government Lots One (1) and Two (2), and excepting surface rights only on a two (2) acre tract in the NE corner of NW¼NE¼; all of Section Ten (10) lying east of State Highway 27 excepting three (3) tracts of land described as:

1. NE¼NE¼

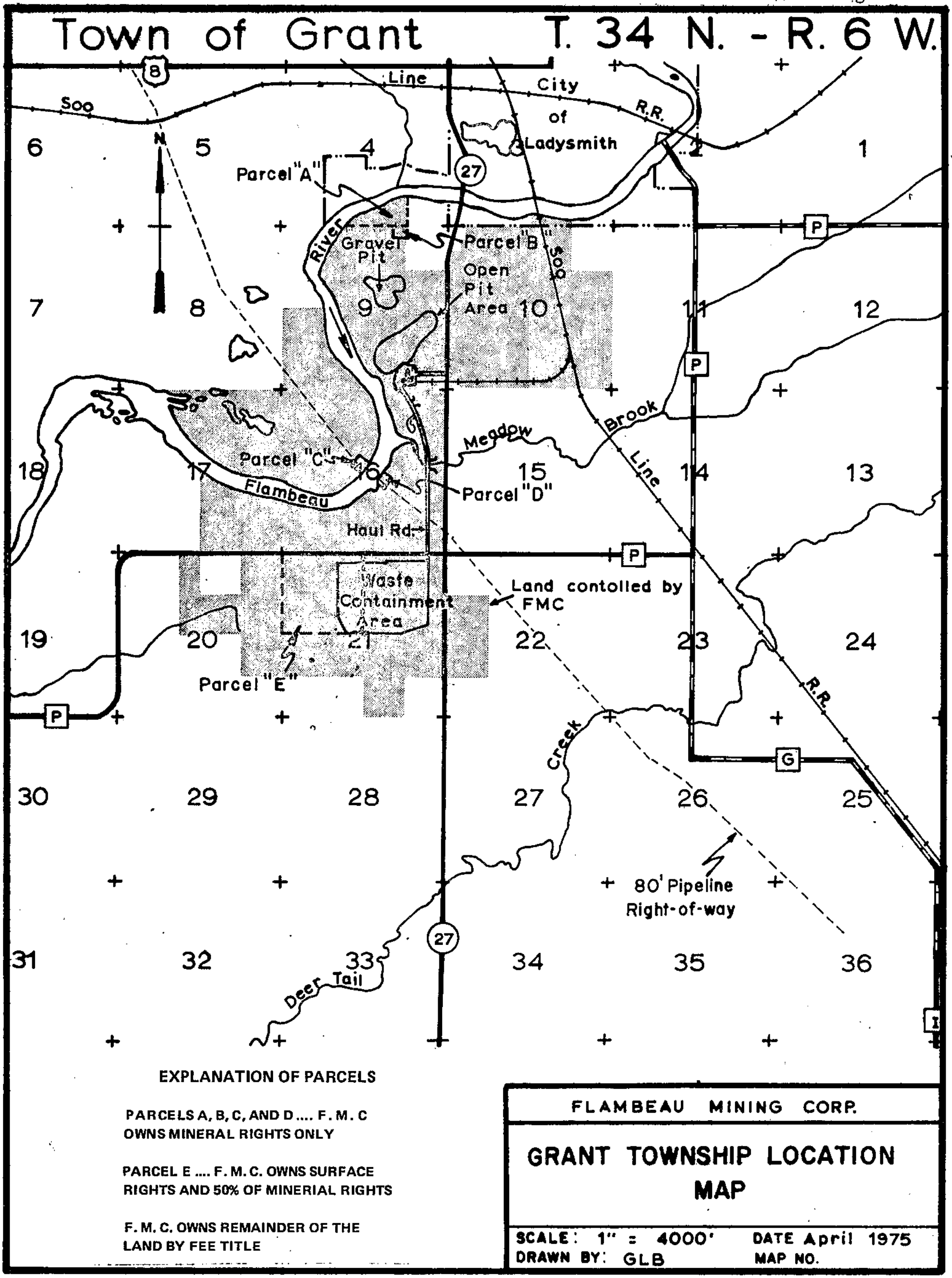
2. Commencing at the intersection of the South right-of-way line of Gokey Road with the East right-of-way line of State Highway 27, thence Southerly along said East right-of-way line, 175 feet, to the point of beginning of the land to be herein described; thence Southerly along the East line of highway 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; and

3. Commencing at the intersection of the South right-of-way line of Gokey 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 angles, 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;

all of Section Sixteen (16); the E½ and Government Lots Six (6) and Seven (7) of Section Seventeen (17); theE½E½NW¼, the NE¼SE¼, and the NE¼ excepting the NW¼NE¼ of Section Twenty (20); the N½, the N½S½, and the SW¼SE¼ of Section Twenty-one (21); and the SW¼NW¼ and the NW¼SW¼ of Section Twenty-two (22);

all in Township Thirty-four (34) North, Range Six (6) West, subject to State, County and Town rights-of-way, small tracts owned by Lakehead Pipe Line Company in Section Sixteen (16) and their easement in Sections Nine (9) and Sixteen (16), railroad right-of-way in Sections Three (3) and Ten (10), and reservation of 50% of the mineral rights by Cornell University in the NW¼ of Section Twenty-one (21).

Figure 1


Town of Grant
T. 34 N. - R. 6 W.
Soo Line R.R.
City of Ladysmith
Parcel "A"
Parcel "B"
Parcel "C"
Parcel "D"
Parcel "E"
Gravel Pit
Open Pit Area
River
Flambeau
Meadow Brook
Soo Line R.R.
Haul Rd.
Waste Containment Area
Land contolled by FMC
Creek
Deer Tail
80' Pipeline Right-of-way
EXPLANATION OF PARCELS
PARCELS A, B, C, AND D .... F. M. C OWNS MINERAL RIGHTS ONLY
PARCEL E .... F. M. C. OWNS SURFACE RIGHTS AND 50% OF MINERIAL RIGHTS
F. M. C. OWNS REMAINDER OF THE LAND BY FEE TITLE
FLAMBEAU MINING CORP.
GRANT TOWNSHIP LOCATION MAP
SCALE: 1" = 4000'
DATE April 1975
DRAWN BY: GLB
MAP NO.

1.2.0 SOILS

Soils (in the pedologic sense*) in the project area are predominantly silt loams derived from thin local loess overlying acidic sand and gravel outwash and stony sandy loam reddish-brown glacial till. These soils are productive of small grain and hay crops commonly planted on dairy farms of the area.

Natural drainage ranges from good over outwash where the water table is below four feet, to poor where the water table rises seasonally above the soil surface on both till and outwash plains. Some soils derived from outwash have a sandy loam surface texture, rather than silt loam. Also present are bodies of wet alluvial soils, mucks and peats.

1.2.1 PROJECT SITE - NORTHERN END

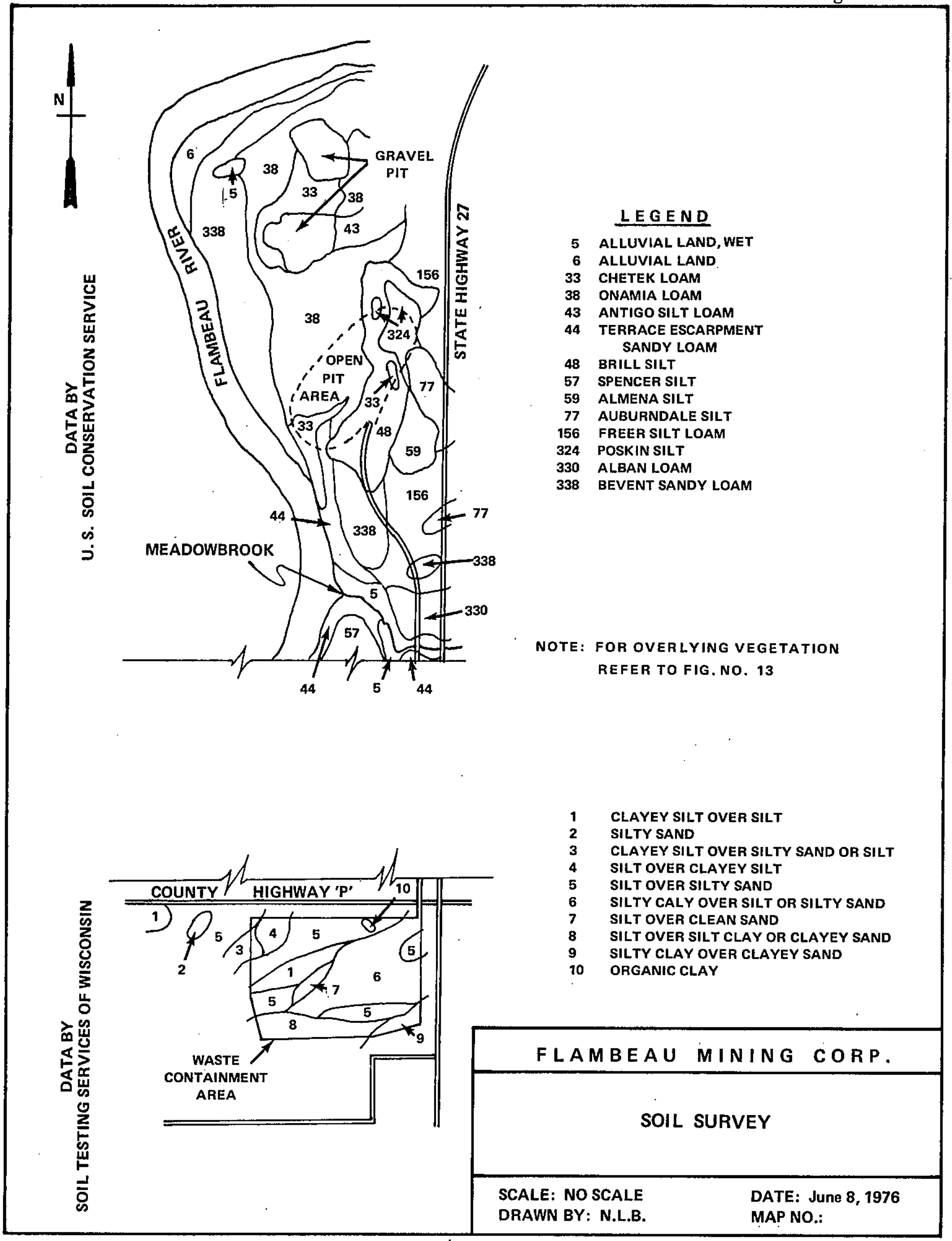
The U. S. Soil Conservation Service has mapped soils to a depth of five feet over the northern end of the project site (Figure 2). The Onamia (#38) soil is a well drained loamy soil over sand and gravel outwash. The Brill series (#48) is a moderately well drained silty soil underlain by sand and gravel at 20 to 40 inches. At the southwestern end of the proposed pit are Chetek (#33) series soils. These are loamy soils on a small set of stream terraces. The major soil series over the northeast end of the proposed pit is Poskin (#324). This soil type is a somewhat poorly drained silt over acidic sand and gravel.

Soils have been tested to a greater depth in the proposed plant area to determine their suitability for construction. These deeper soils consist of an upper layer of silty sand to eight or more inches below the surface and are underlain by cleaner gravelly fine to coarse-grained sands. Clay deposits were found beneath the sands approximately 20 to 35 feet below the surface. The clays are quite firm, with low water contents and unconfined strengths in excess of 4.5 tsf (tons per square foot). Below the clay is a dense silty and clayey sand or silty sand with varying amounts of gravel to either the sandstone or bedrock.

Soils along the proposed haul road route are primarily the Freer (#156) and Alban (#330) series. Although no particular problems would be expected with the Alban series, the Freer soils are poorly drained with a water table at less than three feet. This soil is highly susceptible to frost action.

*Soil in the pedologic or green plant productivity sense extends to the depth of four to five feet, the depth of rooting of common perennial plants. Elsewhere in section, use of the word soil with respect to material below a depth of five feet is in the geologic sense, i.e., of unconsolidated geologic material below the common rooting zone of perennial plants.

Figure 2



N
DATA BY
U. S. SOIL CONSERVATION SERVICE
GRAVEL
PIT
FLAMBEAU RIVER
STATE HIGHWAY 27
OPEN
PIT
AREA
MEADOWBROOK
6
5
38
33
38
43
338
156
38
324
77
33
33
48
59
156
44
77
338
338
5
330
57
44
5
44
LEGEND
5 ALLUVIAL LAND, WET
6 ALLUVIAL LAND
33 CHETEK LOAM
38 ONAMIA LOAM
43 ANTIGO SILT LOAM
44 TERRACE ESCARPMENT SANDY LOAM
48 BRILL SILT
57 SPENCER SILT
59 ALMENA SILT
77 AUBURNDALE SILT
156 FREER SILT LOAM
324 POSKIN SILT
330 ALBAN LOAM
338 BEVENT SANDY LOAM
NOTE: FOR OVERLYING VEGETATION REFER TO FIG. NO. 13
DATA BY
SOIL TESTING SERVICES OF WISCONSIN
COUNTY HIGHWAY 'P'
10
1
2
5
3
4
5
5
1
6
7
5
5
8
9
WASTE
CONTAINMENT
AREA
1 CLAYEY SILT OVER SILT
2 SILTY SAND
3 CLAYEY SILT OVER SILTY SAND OR SILT
4 SILT OVER CLAYEY SILT
5 SILT OVER SILTY SAND
6 SILTY CALY OVER SILT OR SILTY SAND
7 SILT OVER CLEAN SAND
8 SILT OVER SILT CLAY OR CLAYEY SAND
9 SILTY CLAY OVER CLAYEY SAND
10 ORGANIC CLAY
FLAMBEAU MINING CORP.
SOIL SURVEY
SCALE: NO SCALE
DRAWN BY: N.L.B.
DATE: June 8, 1976
MAP NO.:

In general, the soils in the waste containment area consist of two associations: Almena-Auburndale and Peat. Almena-Auburndale association occupies a broad, nearly level to gently undulating glacial till plain. The Almena soils are somewhat poorly drained silt loam found on low broad interstream ridges. Auburndale soils are poorly drained and found at the foot slopes of the Almena. These silt loams have a well developed but thin silt-rich cap. Because of the above average silt content and the topographical position of the Auburndale soil in broad depressional areas, perched water tables or surface water areas are commonly found.

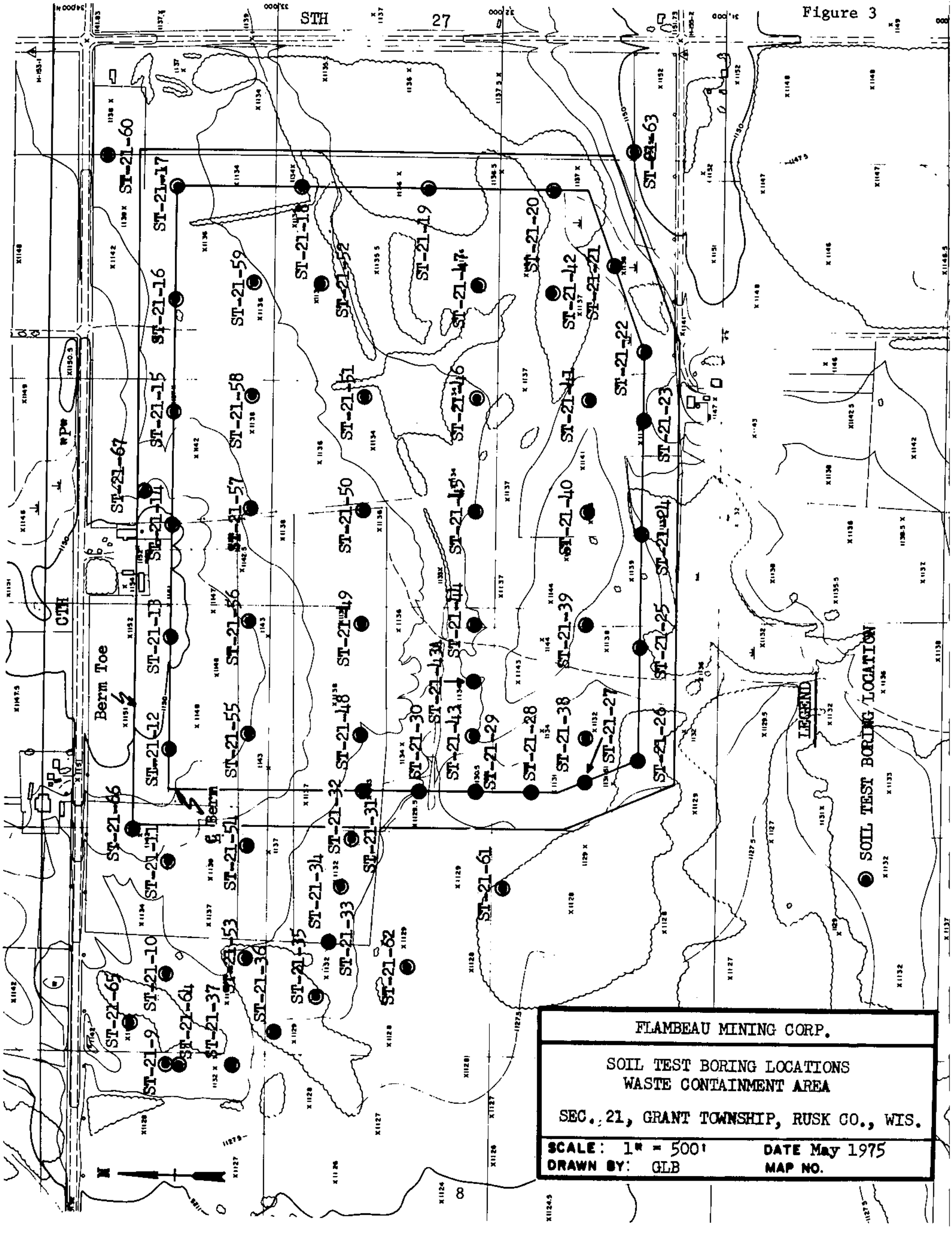
1.2.2 PROJECT SITE - WASTE CONTAINMENT AREA

Extensive soil testing has been conducted by Soil Testing Services of Wisconsin, Inc. of Green Bay in the proposed waste containment area (Figure 3). The borings generally revealed at least 3.5 to 4 feet of tight silts or clayey silts (Auburndale), however, two interior borings, ST21-44 and ST21-45, had 2.5 and 2 feet respectively.

The soil profile in this area is characterized by a mantle of a silt, clayey silt, or fine sandy silt that underlies the topsoil. The depth of this layer varied from about 3 to 4.5 feet, although there were several areas where the layer was slightly thicker to about 5 feet. This was at ST21-15 where an organic clay was found to 10 feet and in ST21-52 and ST21-59 where the very fine sandy silts or silts extended to depths of about 8 to 12 feet. A soils map showing a general distribution of the soils in the upper 6 feet is shown on Figure 2.

The silts were generally softer in the upper 2 feet as indicated by the higher water contents in excess of 20%. The samples from 2 to 4 feet were firmer as indicated by lower water contents and a higher dry density. In most of the borings, these finer grained soils were underlain by fine-to-medium or fine-to-coarse sands with varying amounts of silt and gravel. Generally the amount of silt as indicated on the grain-size analysis curves exceeded 20%. This deposit was considered a dense glacial till that extended to the end of the borings. In a few of the borings, the soil actually graded into a silty and sandy clay or clayey sand till, but was still in a dense condition. These soils extended to the end of the borings at either 15 or 30 feet. In general, the glacial till deposits were quite dense in nature. The exception to this was ST21-18 where silty very fine sands in a medium dense condition were found to the end of this boring at 17 feet. This condition extended to ST21-19, but access to this boring could not be gained and therefore it was advanced only to 10 feet by hand augers. However, the sandy silts were found underlying the silty and clayey sands in ST21-63 which was advanced by a truck-mounted drill rig.

Figure 3



STH 27
CTH
Berm Toe
Berm
LEGEND
SOIL TEST BORING LOCATION
FLAMBEAU MINING CORP.
SOIL TEST BORING LOCATIONS
WASTE CONTAINMENT AREA
SEC. 21, GRANT TOWNSHIP, RUSK CO., WIS.
SCALE: 1" = 500'
DATE May 1975
DRAWN BY: GLB
MAP NO.

Within these silty sand till deposits were found sands with considerably less silt (less than 10%) and therefore would greatly affect the permeability. Such a sand deposit was found in an occasional boring, but was continuously found starting at boring ST21-36, proceeding to the north to ST21-9, and then to the east to ST21-14. These sands consisted of a fine-to-medium sand with varying amounts of gravel and only traces of silt. This condition was confirmed in additional borings ST21-65 and ST21-66, but in ST21-67 a clean sand deposit was not encountered.

Zones of this cleaner sand were found at about the 4 to 9 or 12-foot level from ST21-44 to ST21-50 and on to ST21-58. However, borings adjacent to this zone did not encounter any of these cleaner sand deposits. This clean sand was also found at the 6 to 9-foot level at ST21-28 and ST21-29, and also at deeper depths in ST21-22. There appear to be isolated areas of this cleaner, more permeable sand deposit, but such sands were generally not found at the surface, and in all cases were overlain by a more impervious silt or clayey silt. In borings ST21-62 and ST21-61 and in the open swampy area to the southwest, the soil conditions were similar except for a 4-foot layer of peat over a clayey sand.

1.3.0 HYDROLOGY

1.3.1 SURFACE WATER

The project site includes an unimpeded 4.2-mile segment of the Flambeau River. The river drains a total area of approximately 1,993 square miles, and has a low gradient of about three feet per mile. There are nine dams and impoundments on the river, four of which are in Rusk County. The nearest dams are the Thornapple Dam (13-foot head) located about nine river miles southwest of the project site and the Peavey Paper Mill Dam (17-foot head) located approximately 3.8 miles above the site. The other dams on the Flambeau in Rusk County are the Dairyland REA Cooperative Dam (68-foot head) and the Big Falls Dam (50-foot head), both of which are located upstream from the project site.

Through the project site, the Flambeau River is a broad, meandering, entrenched stream with very little floodplain (Exhibit A). The average width of the river is 350 feet and the average gradient in this area is approximately two feet per mile. The course of the river at the project site has apparently changed very little in postglacial time. The disproportionately large meanders were probably formed while the Flambeau River was receiving large quantities of glacial meltwater.

River flow data are kept at a U. S. Geological Survey gaging station located 2.5 miles downstream from the Thornapple Dam. Average (mean) discharge at the station is 1,844 cubic feet per second (cfs). Normal or median discharge is 1,500 cfs. The recorded maximum discharge was 17,400 cfs on May 1, 1954, and the recorded minimum was 100 cfs in August of 1957. The discharge rate which is equaled or exceeded 95%

of the time has been established as 734 cfs at Ladysmith. River flows in the Ladysmith area are influenced by rainfall, snow melt and runoff, and the operations of several power plants, especially the Dairyland Dam.

Observations by the WDNR since 1969 indicate an average water level of the Flambeau River west of the ore deposit of 1,085 feet above mean sea level (msl), and a normal highwater mark of 1,086 msl. Prior to 1969, the average water level at this site was 1,094 msl, but removal of the Port Arthur Dam, six miles below the mine site, has lowered the average level by nine feet. Flood elevation and flows for a 100-year reoccurrence flood have been estimated from data provided by the Big Falls gage station. A 22,500 cfs 100-year flow has been predicted which would crest at an elevation of 1,098 msl, or 13 feet above the average water level (Figure 4). These flood elevation calculations were based on a velocity of 4.5 feet per second using the Conger method.

There are seven small streams which drain into the Flambeau River from the project site (Figure 5). Stream D (Meadowbrook Creek) and Stream G have continuous flows. Streams E, F and G have been channelized over parts of their lengths and generally exhibit sluggish or intermittent flows. Maximum discharge rates of these streams in 1973 were measured or estimated by company personnel.

Stream	Maximum Discharge - 1973 cfs
A	1.0
B	1.4
C	6.2
D (Meadowbrook Creek)	No measurement
E	3.1
F	1.1
G	3.1

Discharge rates for Streams A, B, C, F and G were measured using the V-notch weir technique. The discharge of Stream E was estimated from data on Stream G. The Meadowbrook Creek discharge rate was not measured in 1973; however, the 100-year reoccurrence flood discharge was estimated to be 1,800 cfs using the Conger technique.

There are two very small man-made ponds located northwest of the proposed pit. Other small wetland areas and ponds of much less than one acre are present in depressional areas throughout the project site.

Much of the eastern portion of Section 20 and the western part of Section 21 consists of wetlands. These wetlands extend into the west half of Section 20 beyond the project area. This area is drained by Stream G which flows some 2.6 miles to its mouth at the Flambeau River in the SE¼, Section 24, T34N, R7W. Water usually stands over this area to a depth of one foot or more. The area is underlain by a few inches to several feet of peat.

Figure 4

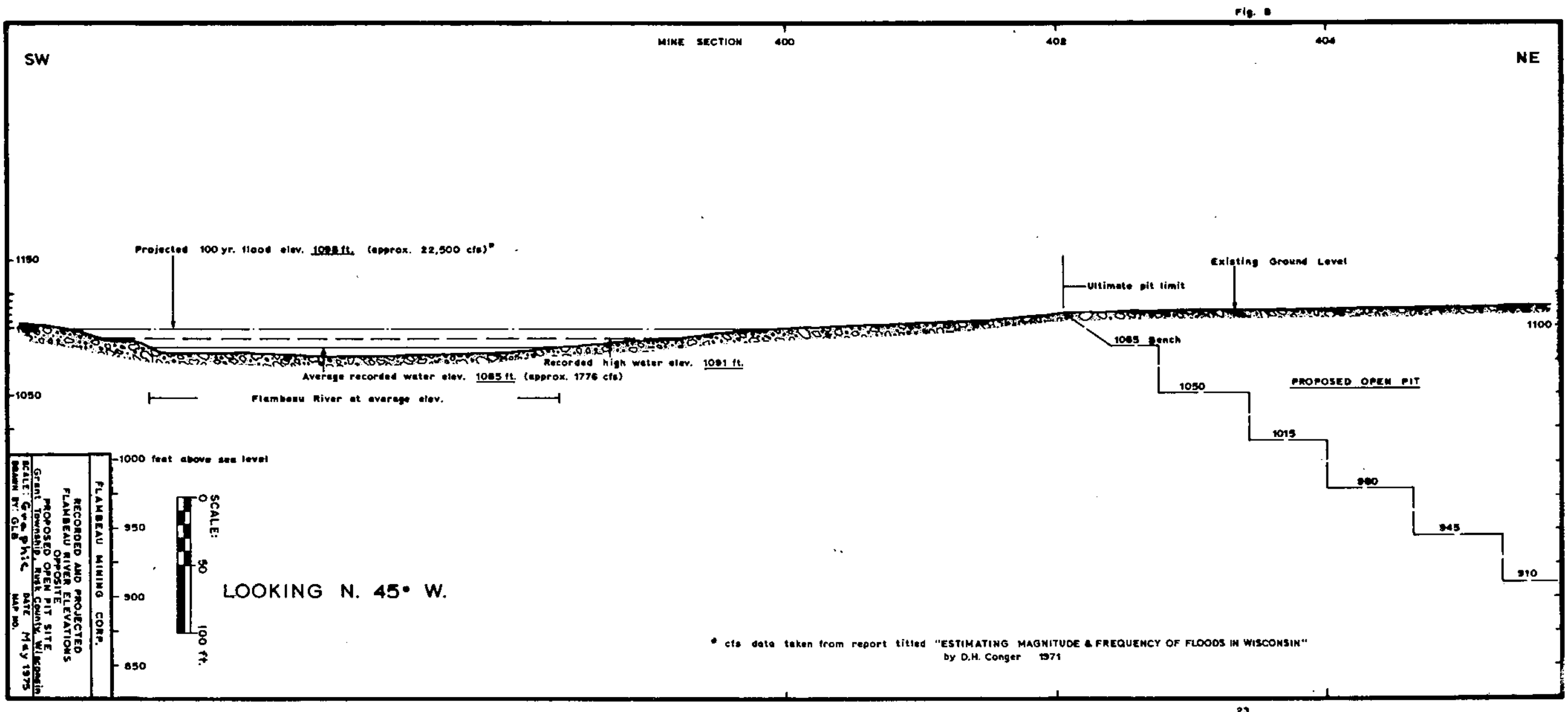
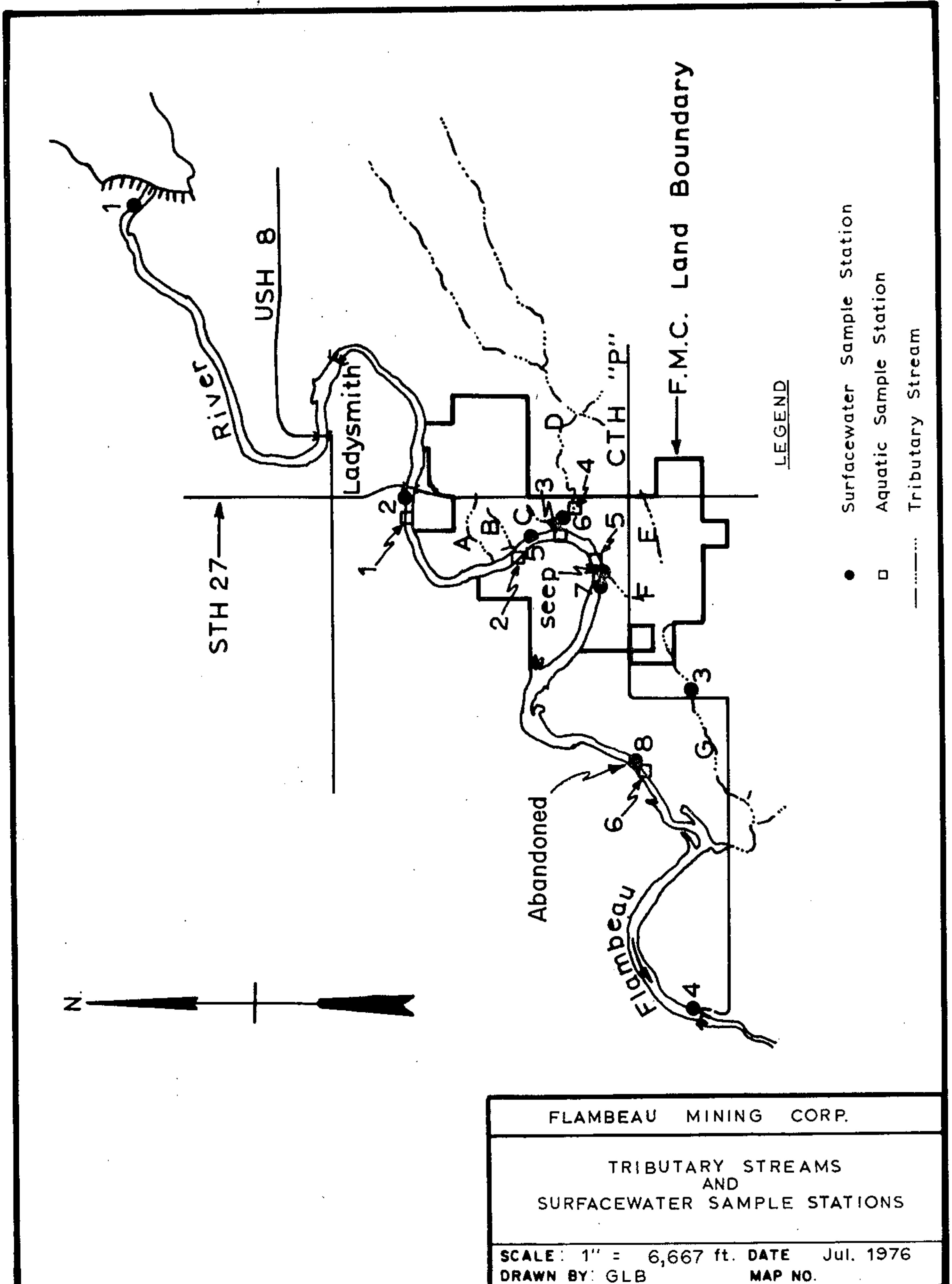


Fig. 8
MINE SECTION 400
402
404
SW
NE
1150
1100
1050
1000 feet above sea level
950
900
850
Projected 100 yr. flood elev. 1098 ft. (approx. 22,500 cfs)*
Existing Ground Level
Ultimate pit limit
1065 Bench
Recorded high water elev. 1091 ft.
Average recorded water elev. 1085 ft. (approx. 1776 cfs)
Flambeau River at average elev.
PROPOSED OPEN PIT
1050
1015
980
945
910
SCALE:
0 50 100 ft.
LOOKING N. 45° W.
* cfs data taken from report titled "ESTIMATING MAGNITUDE & FREQUENCY OF FLOODS IN WISCONSIN"
by D.H. Conger 1971
23
FLAMBEAU MINING CORP.
RECORDED AND PROJECTED
FLAMBEAU RIVER ELEVATIONS
OPPOSITE
PROPOSED OPEN PIT SITE
Grant Township, Rusk County, Wisconsin
SCALE: Graphic DATE May 1975
DRAWN BY: GLB MAP NO.

Figure 5



N
River
Flambeau
USH 8
Ladysmith
STH 27
CTH "P"
F.M.C. Land Boundary
Abandoned
seep
A
B
C
D
E
F
G
1
2
3
4
5
6
7
8
LEGEND
Surfacewater Sample Station
Aquatic Sample Station
Tributary Stream
FLAMBEAU MINING CORP.
TRIBUTARY STREAMS
AND
SURFACEWATER SAMPLE STATIONS
SCALE: 1" = 6,667 ft.
DATE Jul. 1976
DRAWN BY: GLB
MAP NO.

The principal uses of the Flambeau River are for power generation, disposal of treated sewage and paper mill effluent, recreation, wildlife habitat and livestock watering. In Rusk County the river is not used for domestic water supplies or commercial navigation.

The tributary streams which flow through the project site and the ponds and wetlands are used for agricultural purposes and by wildlife.

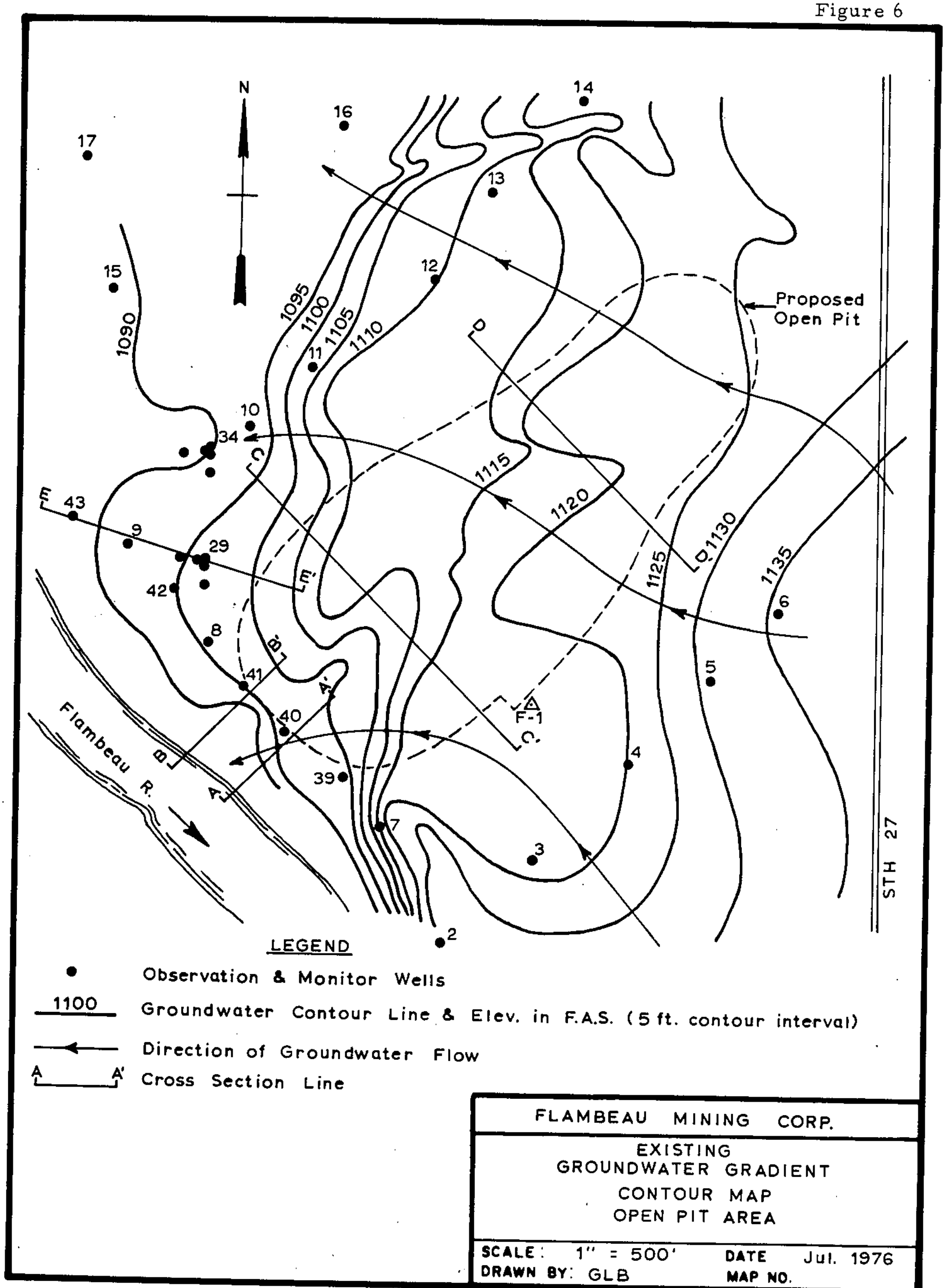
1.3.2 GROUNDWATER

At the project site, free groundwater is contained, with minor exceptions, in the unconsolidated glacial materials, in the Cambrian sandstone which lies above the Precambrian bedrock in the area of the orebody, and to a slight extent within the fractured Precambrian bedrock itself. The highly impermeable clay saprolite developed during ancient weathering of the Precambrian rocks serves as a barrier to downward movement of groundwater. As a result of this controlling factor, the slope of the present water table roughly parallels the nearly horizontal ancient bedrock surface. The thickness of the zone of saturation above this surface ranges from 18 to 80 feet. Perched water tables, or zones of differential permeability, of limited areal extent occur in isolated areas above shallow layers of impermeable glacial material. Movement of groundwater in the saturated zone above bedrock takes place through horizontally discontinuous but vertically interconnected aquifers. Seasonal fluctuations in the depth to the main water table are on the order of four to five feet.

Two basic types of glacial materials are present. The areas inside the large meanders of the Flambeau River are occupied by glacial outwash deposits consisting of moderately well sorted sands and gravels. Elsewhere, the project site is largely underlain by glacial till consisting of unsorted silt-rich materials. Aquifers are more abundant, extensive and better interconnected in the outwash deposits than in the till. Confined aquifers, perched groundwater tables, or zones of differential permeability, are more abundant in the areas underlain by till than in the outwash area.

To determine groundwater conditions in the proposed mine area, the company drilled 20 wells during June 1970 at the locations shown in Figure 6. Low-capacity and short-duration pumping tests were conducted in eight of these wells. A total of 16 field permeameter tests from wells drilled in July 1973 were also conducted at selected locations around the planned pit perimeter. Thirty-one of these wells are within the area shown in Figure 6. Additional information was obtained from nearby domestic wells, from the mineral exploration core holes, from soil test borings and from three shallow pits excavated to bedrock along the proposed southwest perimeter of the mine.

The average depth and configuration of the water table in the proposed mine area is shown on Figure 6. The water table, which reflects the hydraulic gradient, slopes approximately 1.5% to the northwest across the orebody, steepens to 6% in the NNE-trending transition zone between glacial till and glacial outwash deposits, then flattens to 2% in the

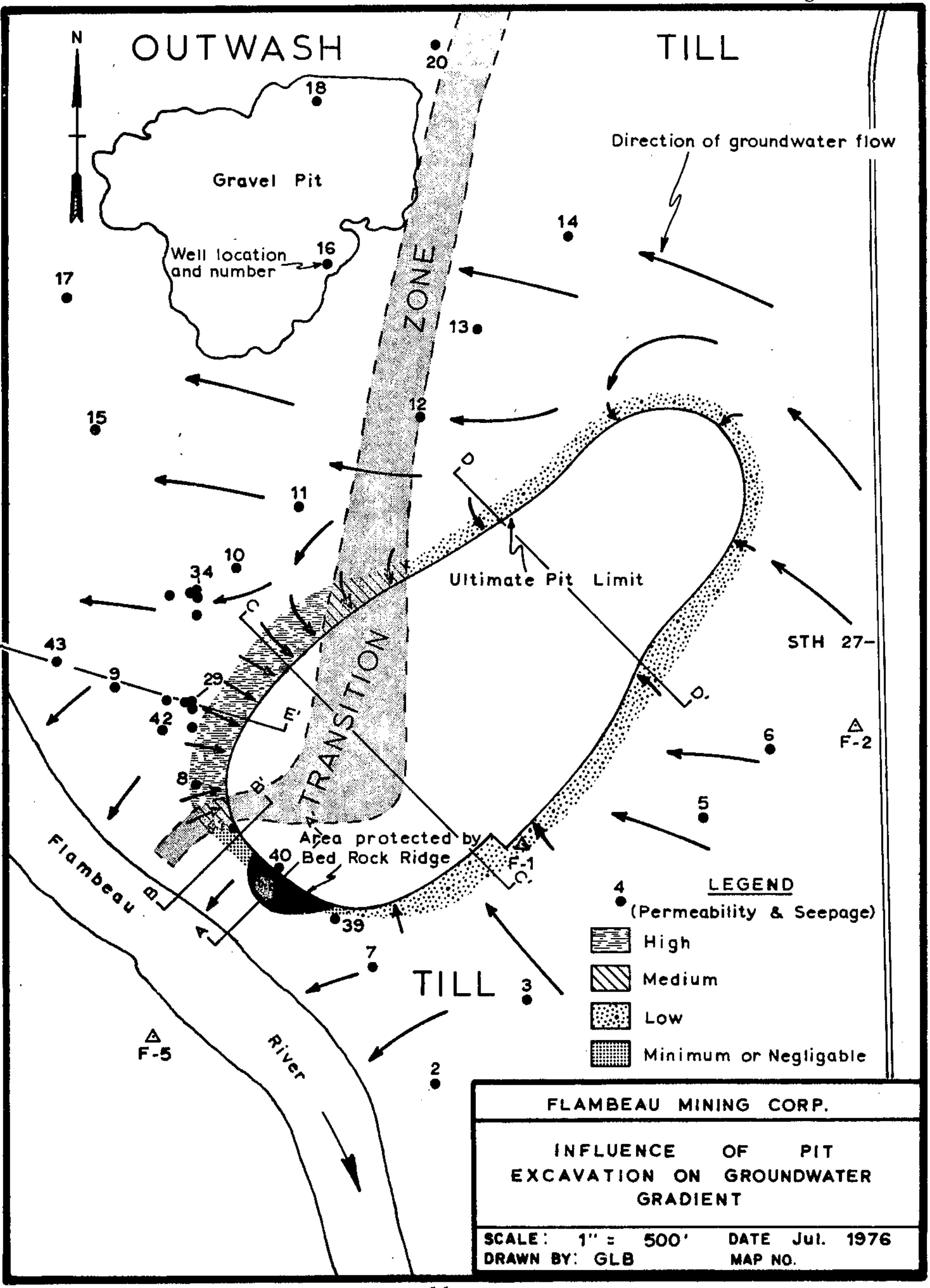

N
17
16
14
13
12
15
1090
1095
1100
1105
1110
11
10
34
Proposed
Open Pit
D
D'
C
C'
1115
1120
1125
1130
1135
E
E'
43
9
29
42
8
B'
B
A'
A
41
40
39
F-1
7
3
4
5
6
2
Flambeau R.
STH 27
LEGEND
Observation & Monitor Wells
1100
Groundwater Contour Line & Elev. in F.A.S. (5 ft. contour interval)
Direction of Groundwater Flow
A A'
Cross Section Line
FLAMBEAU MINING CORP.
EXISTING
GROUNDWATER GRADIENT
CONTOUR MAP
OPEN PIT AREA
SCALE: 1" = 500'
DATE Jul. 1976
DRAWN BY: GLB
MAP NO.

outwash material inside the large meander of the Flambeau River northwest of the orebody. The water table roughly parallels the slope of the Precambrian bedrock surface which appears to slope 2% to the northwest into the ancestral Flambeau valley, except along the southwest end of the proposed pit where the water table slopes to the southwest to the Flambeau River.

Fluctuations of the water table, measured in wells 6 and 12 (Figure 7) in the area underlain by till and wells 8 and 15 in outwash, indicate that water table levels are controlled by precipitation and runoff rather than by river levels.

The transition zone between glacial till and glacial outwash, as determined by drill hole data, soil test borings, and geomorphological studies, is from 250 to 400 feet wide and follows the line defined by test wells 20, 12 and 40, as shown in Figure 7. Hydrogeologic cross sections related to Figure 7 are presented in Figures 7A, B and C. Table 1 summarizes the field test data and aquifer characteristics for wells 8, 9, 29, 34, 39, 42 and 43, and for the 16 field permeater tests in the vicinity of the orebody. (The apparent low soil permeability at ST9-18 may be explained by a small sample quantity obtained for this test. The low permeability at ST9-22 may be due to silt and clay seams which were found in the sandstone.) The wells were located between the proposed pit and the Flambeau River in the outwash zone to test the area of greatest permeability, where aquifer yields were expected to be greatest. The highest permeability values were found in wells 8, 29 and 43. Well 43, located in outwash materials 300 feet from the river and 800 feet from the proposed pit, had the highest values. Drawdown tests performed on wells 29 and 34 (each surrounded by four monitor wells) supplied data that indicated very low values and yields for the outwash deposits. These data suggest that interaction of the Flambeau River with groundwater in the mine area is slight.

Groundwater conditions in the waste containment area were determined from data developed in eight monitor wells and sixty soil test holes as shown on Figure 8. Hydrogeologic cross sections of the area are presented in Figures 8A and 8B. The Precambrian bedrock surface slopes toward the northwest into the ancestral Flambeau valley in this area as it does in the area of the orebody. A layer of clay saprolite of variable thickness is also present at the bedrock surface. A thin remnant of Cambrian sandstone overlies bedrock west of the area. Glacial deposits overlying bedrock range in thickness from 55 to at least 124 feet and, except northwest of the area, consist of till overlain by a continuous mantle of silty materials ranging from 3.5 to 11.5 feet in thickness. Northwest of the area, topsoils are underlain by coarser grained sandy materials which were deposited along the edges of the large stagnant-ice mass which formerly occupied the present wetland area to the west. The wetlands occupy the site of a basin in the original ground moraine surface, which after the stagnant-ice mass melted, filled with lacustrine silts and a thick accumulation of peat.



OUTWASH
TILL
N
20
18
Gravel Pit
Direction of groundwater flow
14
Well location and number
16
17
ZONE
13
12
15
D
11
10
34
Ultimate Pit Limit
E
C
43
9
29
STH 27
E'
42
TRANSITION
D'
6
F-2
8
B'
5
Area protected by Bed Rock Ridge
40
F-1
Flambeau
B
C'
4
LEGEND
(Permeability & Seepage)
39
A
High
7
Medium
TILL
3
Low
F-5
River
Minimum or Negligable
2
FLAMBEAU MINING CORP.
INFLUENCE OF PIT EXCAVATION ON GROUNDWATER GRADIENT
SCALE: 1" = 500'
DATE Jul. 1976
DRAWN BY: GLB
MAP NO.

Figure 7a

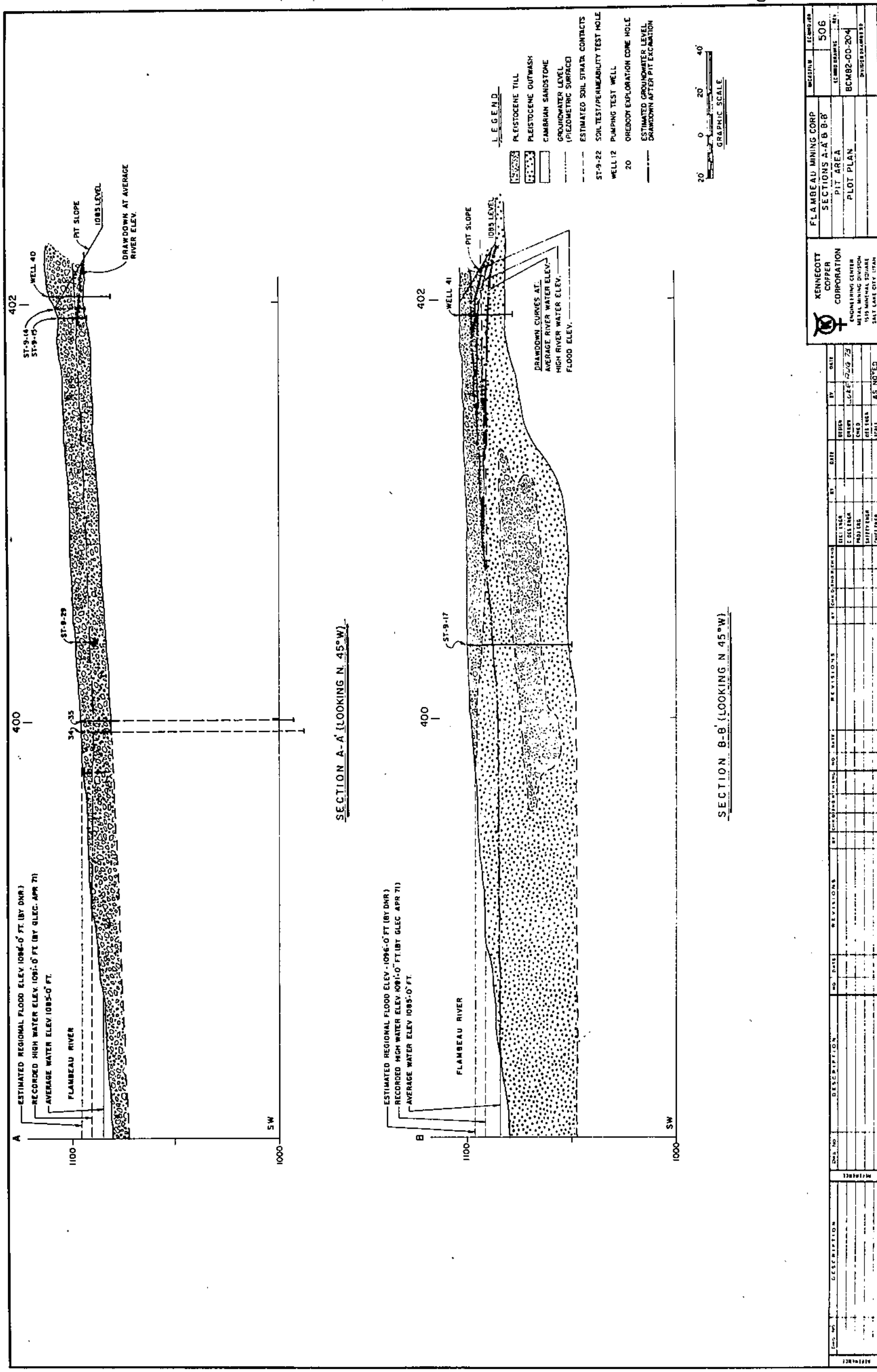
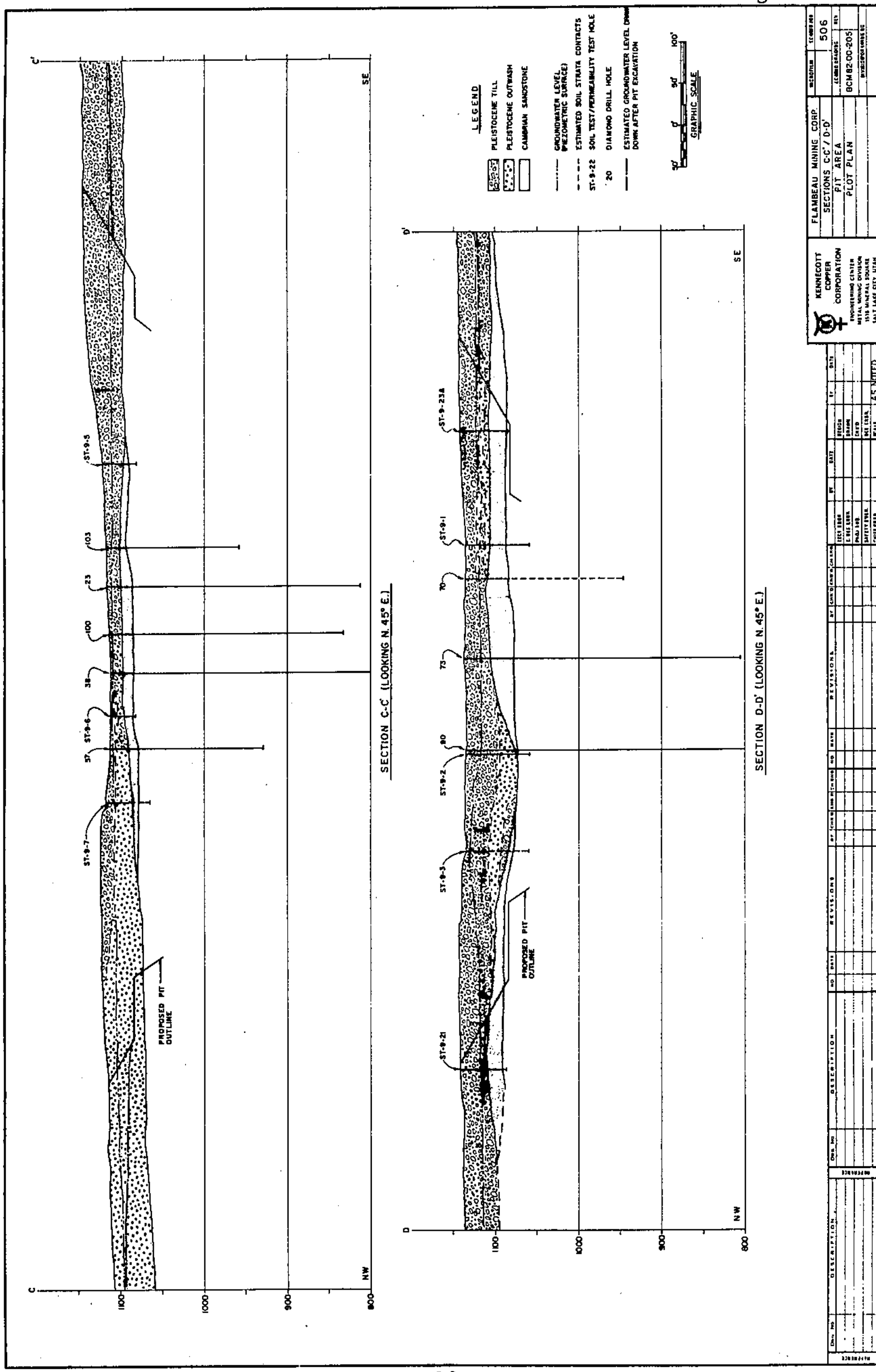

SECTION A-A' (LOOKING N. 45°W)
SECTION B-B' (LOOKING N 45°W)
ESTIMATED REGIONAL FLOOD ELEV 1096-0" FT (BY DNR)
RECORDED HIGH WATER ELEV 1091-0" FT (BY GLEC APR 71)
AVERAGE WATER ELEV 1085-0" FT.
FLAMBEAU RIVER
SW
1100
1000
400
402
34
35
ST-9-29
ST-9-14
ST-9-15
WELL 40
PIT SLOPE
1085 LEVEL
DRAWDOWN AT AVERAGE RIVER ELEV.
ST-9-17
WELL 41
DRAWDOWN CURVES AT:
AVERAGE RIVER WATER ELEV.
HIGH RIVER WATER ELEV.
FLOOD ELEV.
A
B
LEGEND
PLEISTOCENE TILL
PLEISTOCENE OUTWASH
CAMBRIAN SANDSTONE
GROUNDWATER LEVEL (PIEZOMETRIC SURFACE)
ESTIMATED SOIL STRATA CONTACTS
ST-9-22 SOIL TEST/PERMEABILITY TEST HOLE
WELL 12 PUMPING TEST WELL
20 OREBODY EXPLORATION CORE HOLE
ESTIMATED GROUNDWATER LEVEL DRAWDOWN AFTER PIT EXCAVATION
20' 0 20' 40'
GRAPHIC SCALE
KENNECOTT COPPER CORPORATION
ENGINEERING CENTER
METAL MINING DIVISION
1515 MINERAL SQUARE
SALT LAKE CITY UTAH
FLAMBEAU MINING CORP
SECTIONS A-A' & B-B'
PIT AREA
PLOT PLAN
MAY, 1974
506
BCM82-00-204
AS NOTED
REVISIONS
DESCRIPTION

Figure 7b



LEGEND
PLEISTOCENE TILL
PLEISTOCENE OUTWASH
CAMBRIAN SANDSTONE
GROUNDWATER LEVEL (PIEZOMETRIC SURFACE)
ESTIMATED SOIL STRATA CONTACTS
ST-9-22 SOIL TEST/PERMEABILITY TEST HOLE
20 DIAMOND DRILL HOLE
ESTIMATED GROUNDWATER LEVEL DRAWDOWN AFTER PIT EXCAVATION
GRAPHIC SCALE
50' 0 50' 100'
SECTION C-C' (LOOKING N.45° E.)
SECTION D-D' (LOOKING N.45° E.)
C
C'
D
D'
NW
SE
1100
1000
900
800
ST-9-5
103
23
100
38
ST-9-6
57
ST-9-7
ST-9-23A
ST-9-1
70
73
80
ST-9-2
ST-9-3
ST-9-21
PROPOSED PIT OUTLINE
FLAMBEAU MINING CORP.
SECTIONS C-C' / D-D'
PIT AREA
PLOT PLAN
506
BCM82-00-205
KENNECOTT COPPER CORPORATION
ENGINEERING CENTER
METAL MINING DIVISION
1515 MINERAL SQUARE
SALT LAKE CITY UTAH
MAY, 1974
AS NOTED

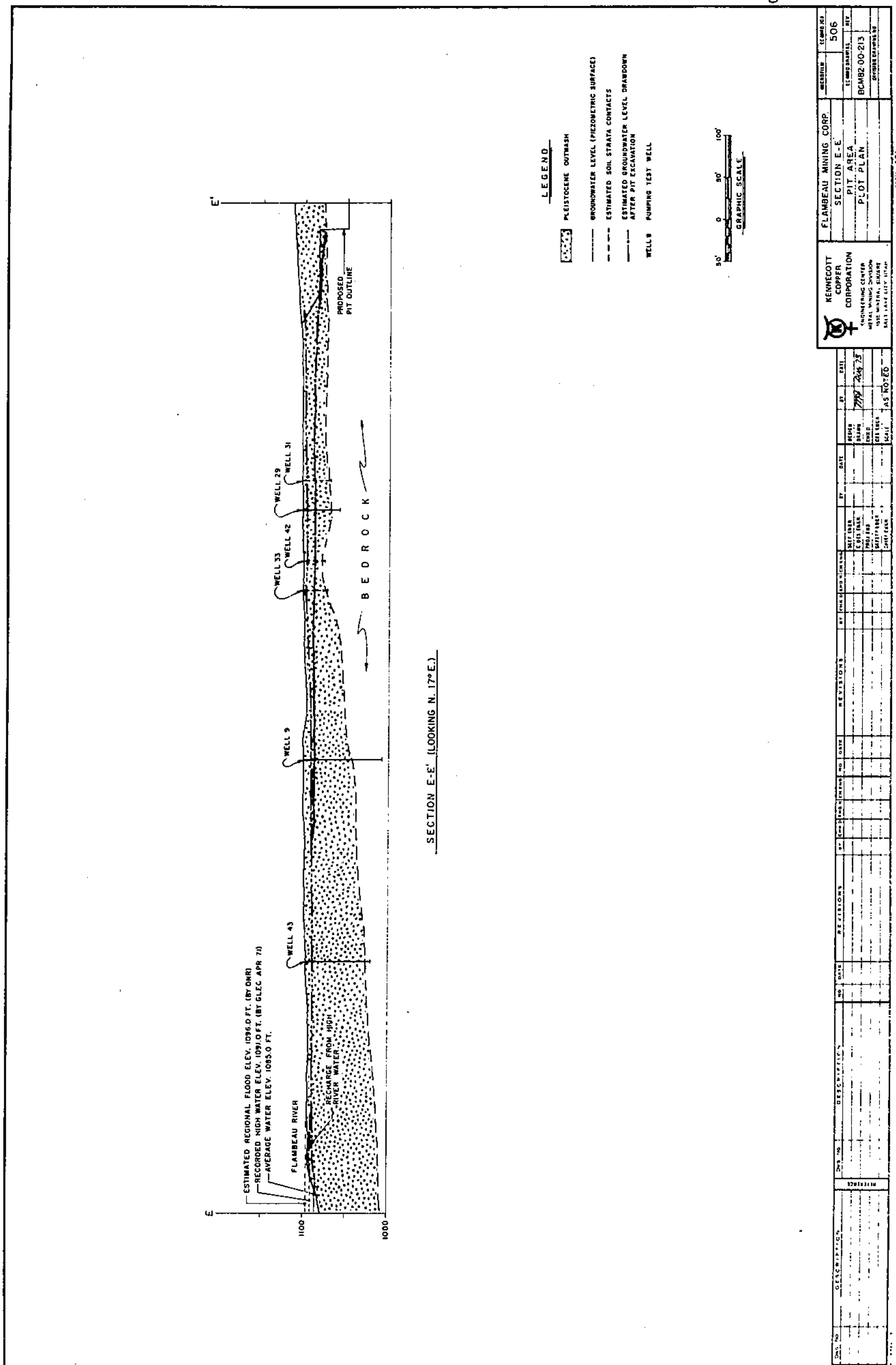

E
E'
ESTIMATED REGIONAL FLOOD ELEV. 1096.0 FT. (BY DNR)
RECORDED HIGH WATER ELEV. 1091.0 FT. (BY GLEC APR 71)
AVERAGE WATER ELEV. 1085.0 FT.
FLAMBEAU RIVER
1100
1000
RECHARGE FROM HIGH RIVER WATER
WELL 43
WELL 9
WELL 33
WELL 42
WELL 29
WELL 31
B E D R O C K
PROPOSED PIT OUTLINE
SECTION E-E' (LOOKING N. 17° E.)
LEGEND
PLEISTOCENE OUTWASH
GROUNDWATER LEVEL (PIEZOMETRIC SURFACE)
ESTIMATED SOIL STRATA CONTACTS
ESTIMATED GROUNDWATER LEVEL DRAWDOWN AFTER PIT EXCAVATION
WELL 9 PUMPING TEST WELL
50' 0 50' 100'
GRAPHIC SCALE
KENNECOTT COPPER CORPORATION
ENGINEERING CENTER
METAL MINING DIVISION
SALT LAKE CITY, UTAH
FLAMBEAU MINING CORP.
SECTION E-E'
PIT AREA
PLOT PLAN
506
BCM82-00-213
AS NOTED
MAY, 1974

TABLE 1

SUMMARY OF FIELD PERMEABILITY TESTS
ORE BODY AREA

Test No. (Figure 7)	Permeability Ft/Day	Permeability GPD/Ft^2	Material Tested
T.W. 8	7.15	53.48	Outwash (SW)
9	5.07	37.92	Outwash (SW)
29	7.06	52.80	Outwash (SW)
34	0.53	3.96	Outwash (SW) (?)
39	1.47	11.00	Till (SM)
42	3.51	26.25	Outwash (SW)
43	136.2	1018.8	Outwash (SW)
ST-9-17 A	3.96	29.4	Outwash (SW)
18	5.57×10^{-6}	4.17×10^{-5}	Till (SM)
19	5.66	42.34	Bedrock - Sandstone
19A	10.63	79.51	Outwash (SW)
20A	4.42×10^{-3}	3.31×10^{-2}	Bedrock - Sandstone
21	1.32	9.87	Bedrock - Sandstone
22	7.94×10^{-5}	5.94×10^{-4}	Bedrock - Sandstone
22A	2.66	19.90	Till (SM)
23	2.85	21.32	Bedrock - Sandstone
23A	4.25	31.79	Till (SM)
24	3.19	23.86	Bedrock - Sandstone
25	2.06	15.41	Till (SM)
26	1.46×10^{-2}	0.11	Till (SM)
27B	4.83×10^{-2}	0.36	Till (SM)
28B	1.13	8.45	Till (SM)
29	1.16×10^{-1}	0.87	Till (SM)

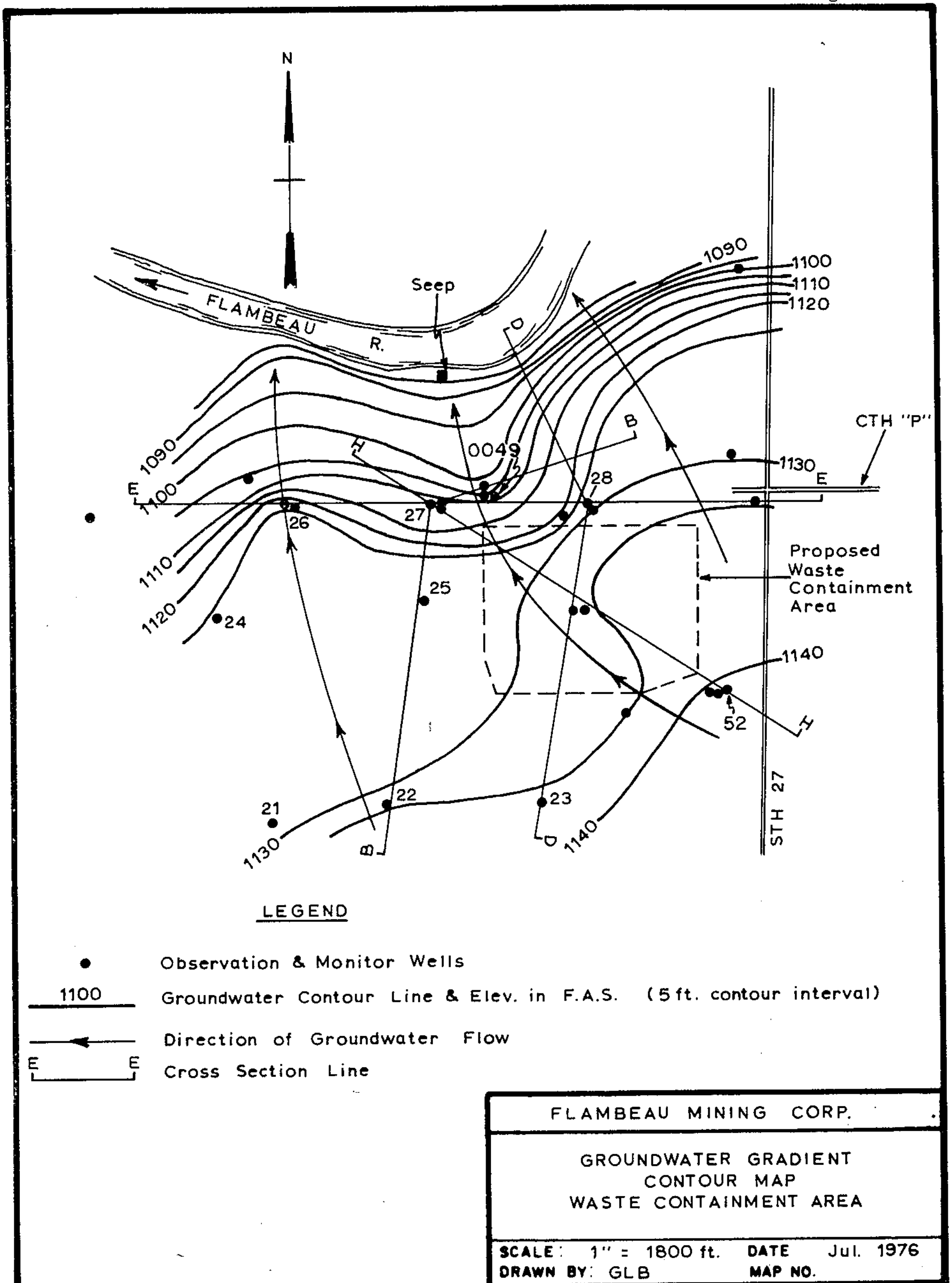
Permeabilities: By Lithology

Soils - SW	20 to 80 gpd/ft^2	50 Avg.
Soils - SM	0.1 to 20 gpd/ft^2	5 Avg.
Bedrock-Sandstone	10 to 50 gpd/ft^2	20 Avg.
Till Section		20 Avg.

By Pit Sector (in till - sandstone section)

West Side	50 gpd/ft^2 (approx. from ST-9-18 to 20)
Southwest Side	10 gpd/ft^2 (approx. from ST-9-26 to 18)
Remainder	20 gpd/ft^2

Figure 8



N
FLAMBEAU R.
Seep
1090
1100
1110
1120
1130
1140
CTH "P"
0049
B
D
E
H
21
22
23
24
25
26
27
28
52
Proposed Waste Containment Area
STH 27
LEGEND
Observation & Monitor Wells
1100 Groundwater Contour Line & Elev. in F.A.S. (5 ft. contour interval)
Direction of Groundwater Flow
E E Cross Section Line
FLAMBEAU MINING CORP.
GROUNDWATER GRADIENT
CONTOUR MAP
WASTE CONTAINMENT AREA
SCALE: 1" = 1800 ft.
DATE Jul. 1976
DRAWN BY: GLB
MAP NO.

Figure 8a

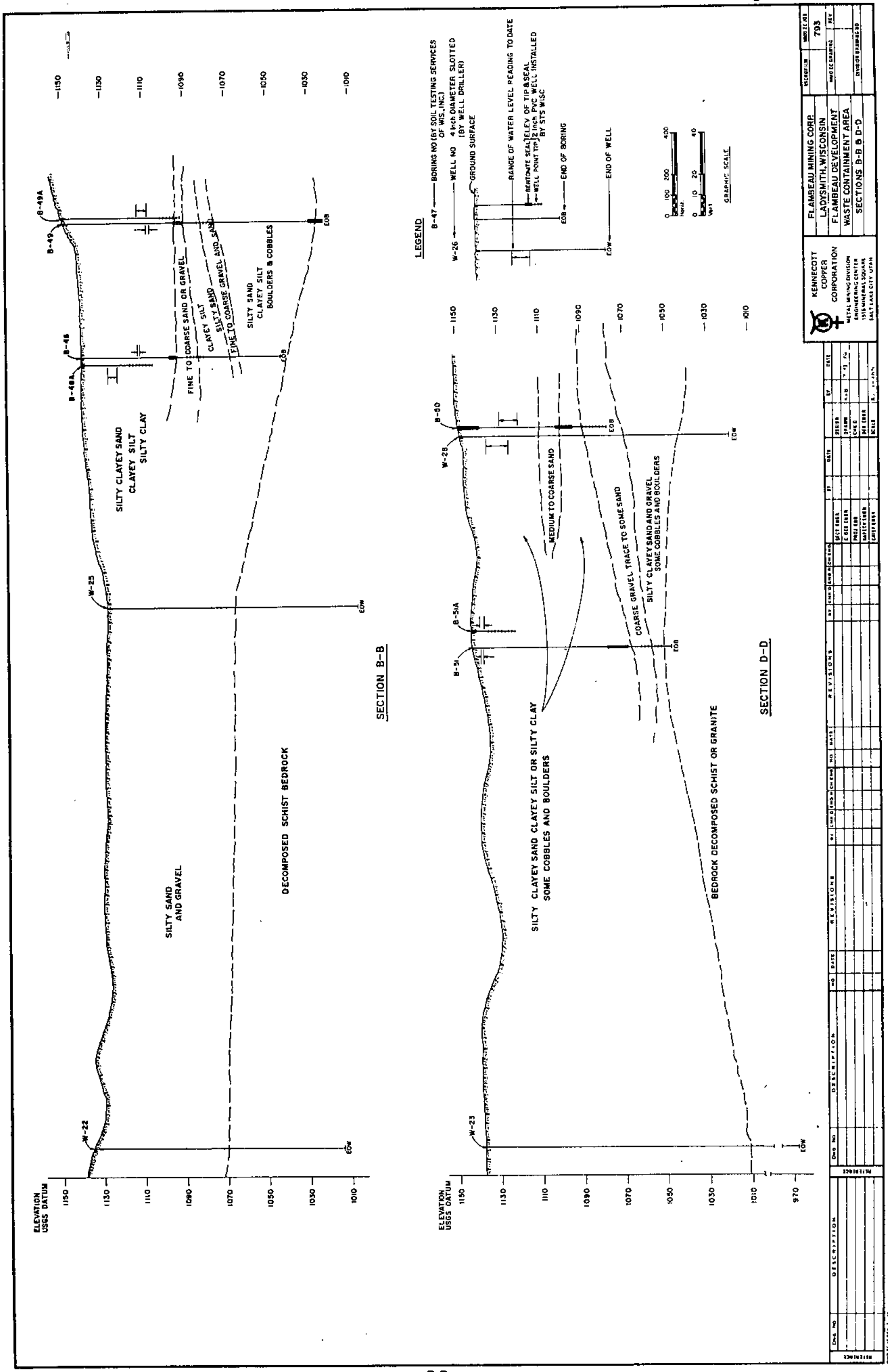
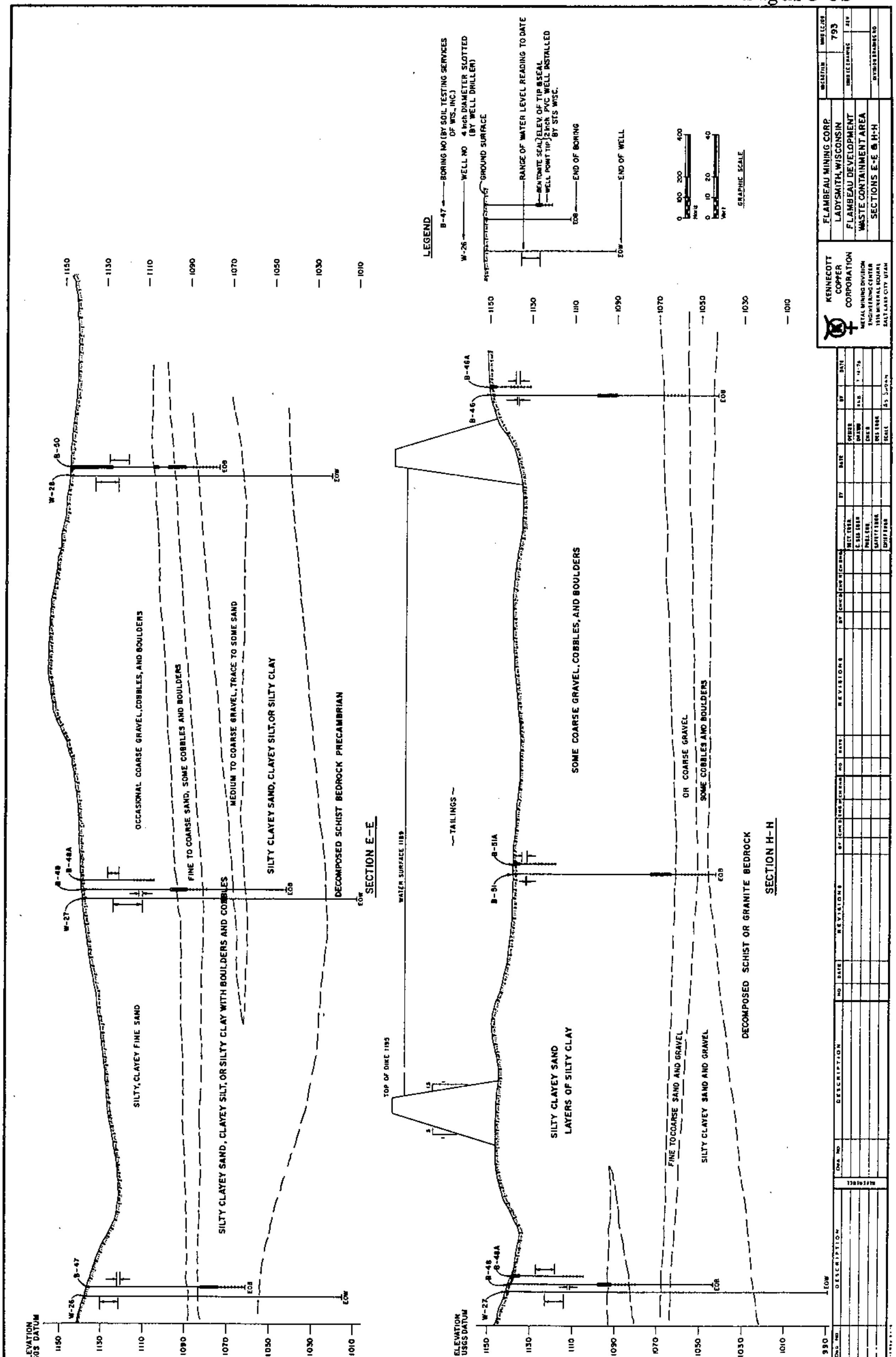

SECTION B-B
SECTION D-D
ELEVATION USGS DATUM
SILTY CLAYEY SAND
CLAYEY SILT
SILTY CLAY
FINE TO COARSE SAND OR GRAVEL
CLAYEY SILT
SILTY SAND
SILTY COARSE GRAVEL AND SAND
FINE TO COARSE GRAVEL AND SAND
SILTY SAND
CLAYEY SILT
BOULDERS & COBBLES
SILTY SAND AND GRAVEL
DECOMPOSED SCHIST BEDROCK
MEDIUM TO COARSE SAND
COARSE GRAVEL TRACE TO SOME SAND
SILTY CLAYEY SAND AND GRAVEL
SOME COBBLES AND BOULDERS
SILTY CLAYEY SAND CLAYEY SILT OR SILTY CLAY
SOME COBBLES AND BOULDERS
BEDROCK DECOMPOSED SCHIST OR GRANITE
LEGEND
BORING NO (BY SOIL TESTING SERVICES OF WIS., INC.)
WELL NO 4 inch DIAMETER SLOTTED (BY WELL DRILLER)
GROUND SURFACE
RANGE OF WATER LEVEL READING TO DATE
BENTONITE SEAL
WELL POINT TIP
ELEV OF TIP & SEAL
2 inch PVC WELL INSTALLED BY STS WISC
END OF BORING
END OF WELL
GRAPHIC SCALE
KENNECOTT COPPER CORPORATION
METAL MINING DIVISION
SALT LAKE CITY UTAH
FLAMBEAU MINING CORP.
LADYSMITH, WISCONSIN
FLAMBEAU DEVELOPMENT
WASTE CONTAINMENT AREA
SECTIONS B-B & D-D
793

Figure 8b


SECTION E-E
SECTION H-H
ELEVATION USGS DATUM
SILTY, CLAYEY FINE SAND
OCCASIONAL COARSE GRAVEL, COBBLES, AND BOULDERS
FINE TO COARSE SAND, SOME COBBLES AND BOULDERS
SILTY CLAYEY SAND, CLAYEY SILT, OR SILTY CLAY WITH BOULDERS AND COBBLES
MEDIUM TO COARSE GRAVEL, TRACE TO SOME SAND
SILTY CLAYEY SAND, CLAYEY SILT, OR SILTY CLAY
DECOMPOSED SCHIST BEDROCK PRECAMBRIAN
TOP OF DIKE 1195
WATER SURFACE 1189
~TAILINGS~
SILTY CLAYEY SAND
LAYERS OF SILTY CLAY
SOME COARSE GRAVEL, COBBLES, AND BOULDERS
FINE TO COARSE SAND AND GRAVEL
OR COARSE GRAVEL
SOME COBBLES AND BOULDERS
SILTY CLAYEY SAND AND GRAVEL
DECOMPOSED SCHIST OR GRANITE BEDROCK
LEGEND
BORING NO (BY SOIL TESTING SERVICES OF WIS., INC.)
WELL NO 4 inch DIAMETER SLOTTED (BY WELL DRILLER)
GROUND SURFACE
RANGE OF WATER LEVEL READING TO DATE
BENTONITE SEAL ELEV. OF TIP & SEAL
WELL POINT TIP 2 inch PVC WELL INSTALLED BY STS WISC.
END OF BORING
END OF WELL
GRAPHIC SCALE
KENNECOTT COPPER CORPORATION
FLAMBEAU MINING CORP.
LADYSMITH, WISCONSIN
FLAMBEAU DEVELOPMENT
WASTE CONTAINMENT AREA
SECTIONS E-E & H-H
793

Because of the presence of extensive layers of relatively permeable silty materials at shallow depths over most of the area, perched water tables or areas of differential permeability are common. The depth of the soil to the normal groundwater table varies from about 15 feet at the highest point along County Highway P to less than one foot in the lowland area just west of the proposed waste containment area. The existing groundwater flow pattern is to the north-northwest. Most of the flow is toward the Flambeau River and emerges as seeps and springs along the river bank. Some groundwater does flow into the wetlands west of the proposed waste containment area (Figure 8).

In general, soil permeabilities are low to very low and uniform under the waste containment area. Presently, most incident precipitation runs off this area into the adjacent wetlands because of the low capacity of the soils to transmit water. Table 2 lists the average permeabilities of the soils which underlie the area. Most of the soils tested had permeabilities near one ft/year (1×10^{-6} cm/sec), although some permeabilities were as low as 0.03 ft/year (2.8×10^{-8} cm/sec). The thickness of these relatively impermeable strata range from beneath the topsoil to more than 11 feet deep. Northwest of the proposed waste containment area the 3.5 feet of impermeable soil (Soil 4, one ft/yr) is underlain with a layer of more permeable sand (Soil 5, 1,000 ft/yr). All of the testing consistently showed that the permeability of the near-surface soils was quite low, and in fact the underlying soils also had quite low permeabilities. This is due to the high percentage of silt and the generally dense nature of the underlying till.

TABLE 2

PERMEABILITIES OF SELECTED BASE SOILS UNDER THE WASTE CONTAINMENT AREA

Sampling Station	Depth and Thickness of Soil Tested (ft)	Soil Type	Average Permeabilities (ft/yr)
21-27	6.0 - 7.0	Silt over silty sand	0.67
21-33	2.0 - 3.5	Clayey silt over silty sand	1.13
21-38	0.0 - 8.0	Silt over silty sand	1.74
21-53	2.0 - 5.0	Silt over silty sand	0.07
21-40	0.0 - 11.5	Silt over silty sand	0.93

Source: Soil Testing Services of Wisconsin, Inc. 1973

The major exception is a layer of the cleaner sands found beneath the north dike wall starting at boring ST21-11, and terminating eastward between ST21-14 and ST21-15. Similar sands were also encountered between borings ST21-28 and ST21-29 near the southwest corner of the proposed dike (Figure 3). Permeabilities in these areas are approximately 100 ft/yr. These cleaner, more permeable sandy subsoils are underlain by dense, less permeable silty sands which are located at a depth of 13 to 15 feet below the surface.

1.4.0 GEOLOGY

The Canadian Shield is an extensive region of Precambrian-age rock that forms the bedrock for a land area of about 1,800,000 square miles. Most of this area lies in Canada, but about 93,000 square miles lie in the northern parts of Minnesota, Wisconsin and Michigan (Figure 9). Major rock types of the Shield consist of gneisses, mixed volcanic suites and the so-called greenstone belts, and sediments including banded iron formations. Surrounding, intruding and replacing these rock types are igneous rocks of varying compositions. All of these rocks have been subjected to structural deformation (folding or faulting) during Precambrian time. However, they have been little disturbed since Cambrian time, and the Shield now forms one of the most geologically stable areas on the earth's crust. Present-day seismic activity in the region and in Rusk County is extremely low.

It is within the greenstone volcanic belts that a considerable portion of the massive sulfide deposits are found. The term greenstone is frequently used when no accurate rock determination is possible and includes rocks that have been so altered that they have assumed a distinctive green color because of the presence of the mineral chlorite. Greenstone belts consisting of volcanic and volcani-sedimentary rocks are found in northern Wisconsin and are generally covered by a thin mantle of Pleistocene glacial material or, farther to the south, by ever-increasing amounts of younger Paleozoic sediments.

One of many such covered greenstone belts lies south of Ladysmith in Rusk County. It is within this steeply dipping northeast-trending complex suite of volcanic rocks that the Flambeau deposit was identified in 1968. The volcanics are terminated west of the project site by a granite intrusion which is believed to be the southern extension of a large granite body underlying Ladysmith. There is no indication the sulfide mineralization extends beneath Ladysmith (Figure 10).

The Flambeau deposit is completely covered by Pleistocene glacial material. The glacial material varies in thickness from ten feet over the mineralization between the river and pit to 30 feet at the east end of the proposed pit. Rapid thickening of the glacial material to the northwest suggests the presence of an ancestral Flambeau valley now filled with at least 90 feet of gravel-rich outwash. These outwash deposits are currently being mined for gravel and are locally an important source of well water. East of the outwash is a SSW-trending transition zone. This zone, of variable width, composition and permeability, is a transition between the outwash material and the more silt-rich till deposits to the east (Figure 7). Glacial till, characterized by high silt content, variable composition and generally low permeabilities, overlies the southwest, south and east half of the open pit. Interbedded with and overlying the till is a silty sand probably derived from windblown material.

In late Precambrian time, intensive weathering and disintegration of the steeply tilted volcanic rocks formed a clay-rich layer, termed saprolite, at the Precambrian bedrock surface in the orebody area.

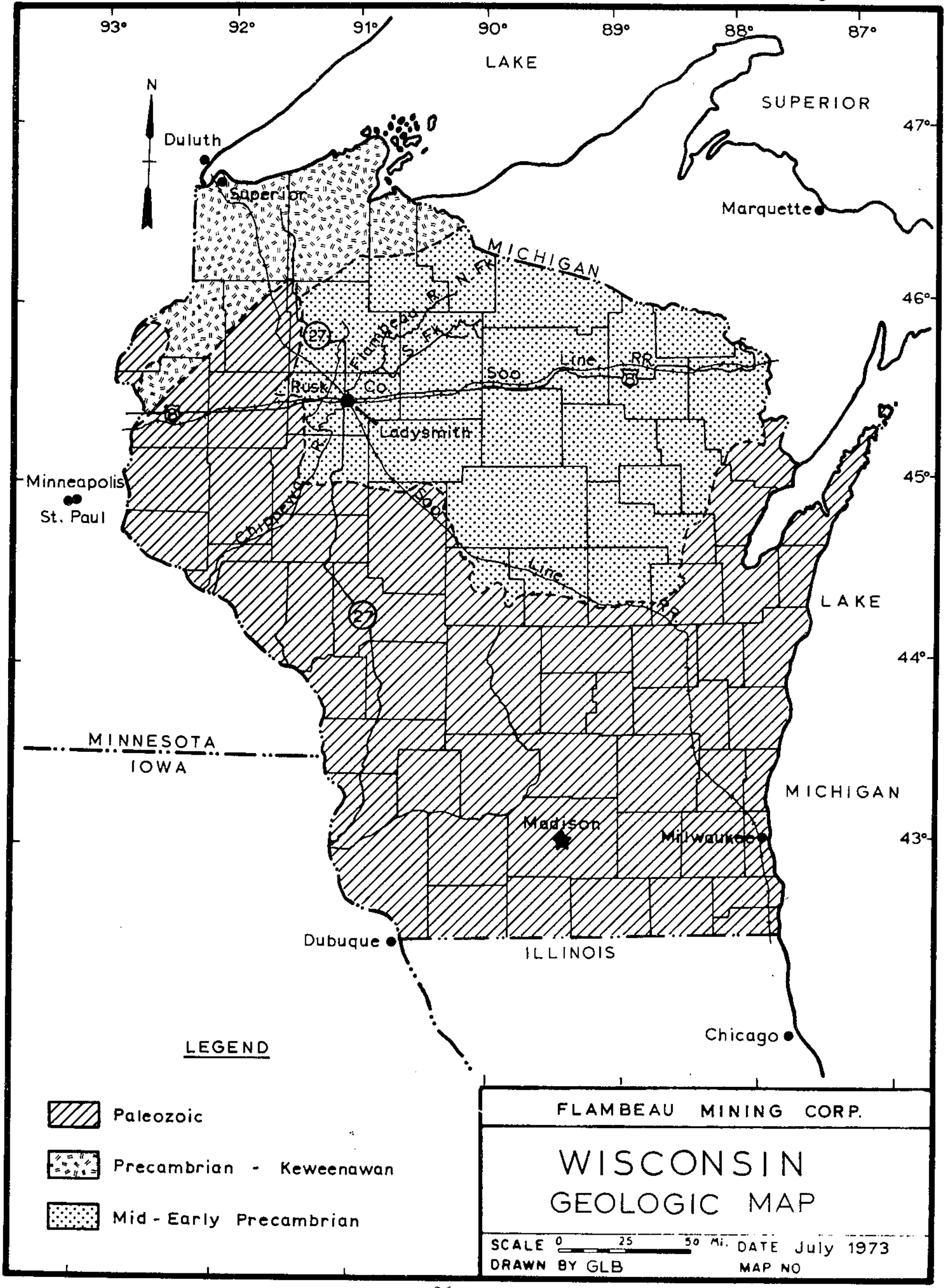
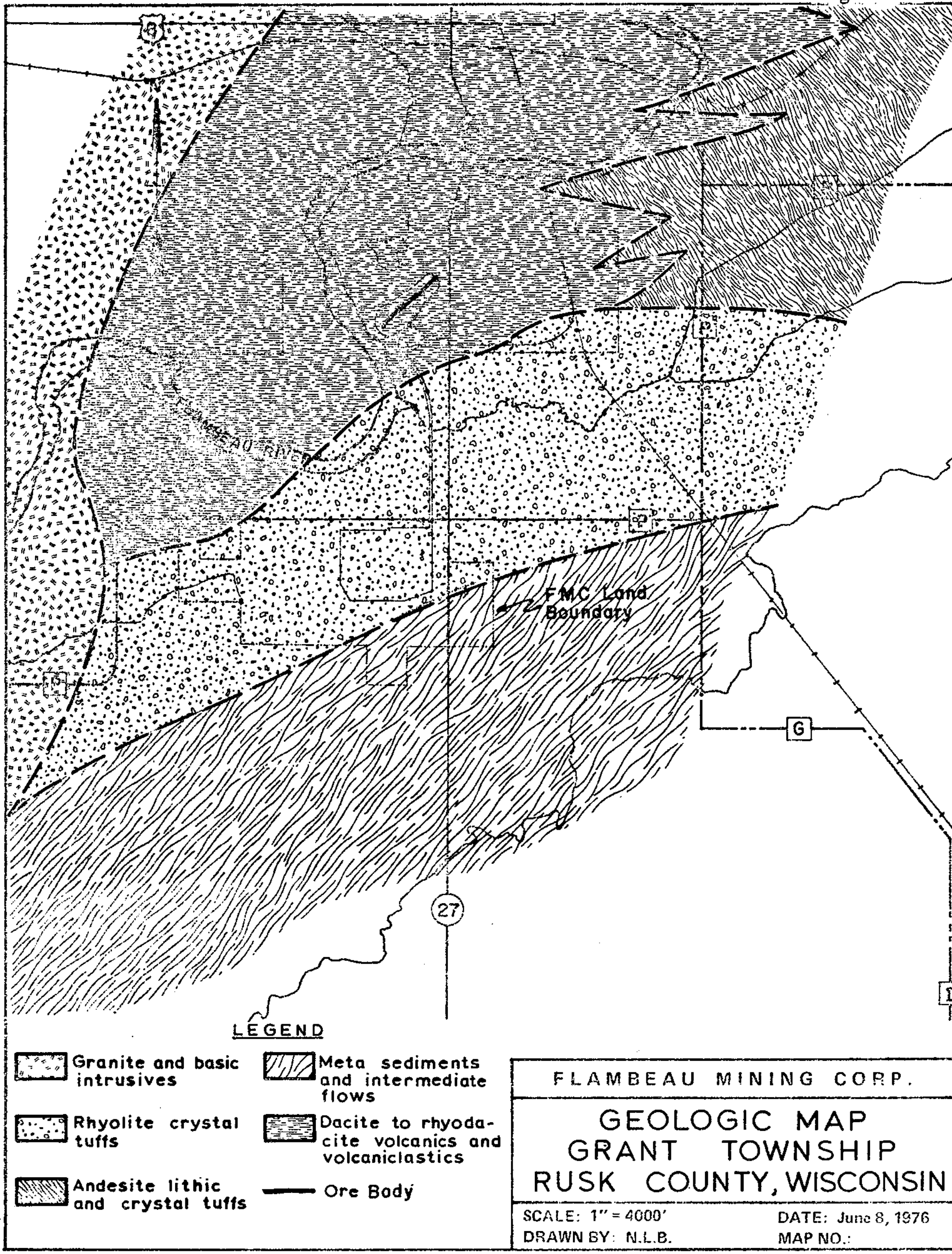

93°
92°
91°
90°
89°
88°
87°
47°
46°
45°
44°
43°
LAKE
SUPERIOR
N
Duluth
Superior
Marquette
MICHIGAN
Flambeau R.
N. Fk.
S. Fk.
27
Soo Line RR
Rusk Co.
Ladysmith
Minneapolis
St. Paul
Chippewa R.
LAKE
MICHIGAN
MINNESOTA
IOWA
Madison
Milwaukee
Dubuque
ILLINOIS
Chicago
LEGEND
Paleozoic
Precambrian - Keweenawan
Mid - Early Precambrian
FLAMBEAU MINING CORP.
WISCONSIN
GEOLOGIC MAP
SCALE 0 25 50 Mi.
DATE July 1973
DRAWN BY GLB
MAP NO

Figure 10


8
FLAMBEAU RIVER
FMC Land Boundary
27
G
LEGEND
Granite and basic intrusives
Rhyolite crystal tuffs
Andesite lithic and crystal tuffs
Meta sediments and intermediate flows
Dacite to rhyodacite volcanics and volcaniclastics
Ore Body
FLAMBEAU MINING CORP.
GEOLOGIC MAP
GRANT TOWNSHIP
RUSK COUNTY, WISCONSIN
SCALE: 1" = 4000'
DATE: June 8, 1976
DRAWN BY: N.L.B.
MAP NO.:

The saprolite layer is thickest adjacent to the orebody and beneath the Cambrian sandstone, and thins rapidly away from the mineralization under the glacial cover. Saprolite is particularly well developed in those rocks rich in plagioclase feldspar such as the actinolite schist. The presence of the saprolite layer limits groundwaters from reaching the Precambrian bedrock surface.

The Precambrian bedrock consists of a complex interfingering suite of volcanic and volcaniclastic rocks now metamorphosed and altered to schists and phyllites (Figure 11). These rocks were probably volcanic flows, ash beds, pumice deposits and volcanic-derived sediments of Middle Precambrian age. Within this complex volcanic pile is a distinctive rock type, a quartz-sericite schist, termed the ore horizon since it contains the copper orebody. The ore horizon pinches and swells along strike for 15,000 feet and varies in width from 25 to 200 feet. Only the one ore horizon containing a single known orebody 2,400 feet in length has been found on FMC land holdings in the Town of Grant (Figure 12). The upper enriched part of the orebody extends under but not across the Flambeau River.

The ore horizon, because it contains more quartz than the adjoining rocks, has resisted erosion to form a gentle broad northeast-trending ridge in the Precambrian bedrock surface. This bedrock ridge is of significance to the development and operation of the open pit mine, for it acts as a natural impermeable barrier between the river and the pit located some 300 feet to the east (Figure 7A). The buried ridge rises beneath the east bank of the river to reach a subsurface elevation of 1,095 feet under the west pit perimeter. This elevation is approximately ten feet higher than the average river level.

1.5.0 MINERAL DEPOSIT

The Flambeau orebody lies conformably within a quartz-sericite schist and is intimately associated with lenses of metachert. The orebody strikes north 45° east and dips approximately 70° to the northwest. Diamond drilling has outlined a tabular-shaped massive sulfide deposit 2,400 feet long, averaging 50 feet in width, and extending to 800 feet beneath the surface. Deeper drilling has not intersected economical mineralization. Massive sulfide mineralization, greater than 50% sulfide, grades at depth into semimassive sulfides which vary from 20% to 50% sulfide. An envelope of disseminated sulfides, predominantly pyrite with minor amounts of chalcopyrite, encloses the orebody and is found along strike within the ore horizon. The width of this pyrite halo averages 110 feet to the north of the orebody but only 55 feet to the south. Contacts between the massive-semimassive orebody and the enclosing rock vary from knife-edge sharp to gradational over 15 to 20 feet. Therefore any improvements in mining technology or higher copper prices would not have an appreciable effect in increasing ore reserves.

Pyrite is the predominant sulfide mineral. The chief copper mineral is chalcopyrite which is found scattered throughout the pyrite. In the upper or north wall of the orebody the sulfides are crudely banded;

Figure 11

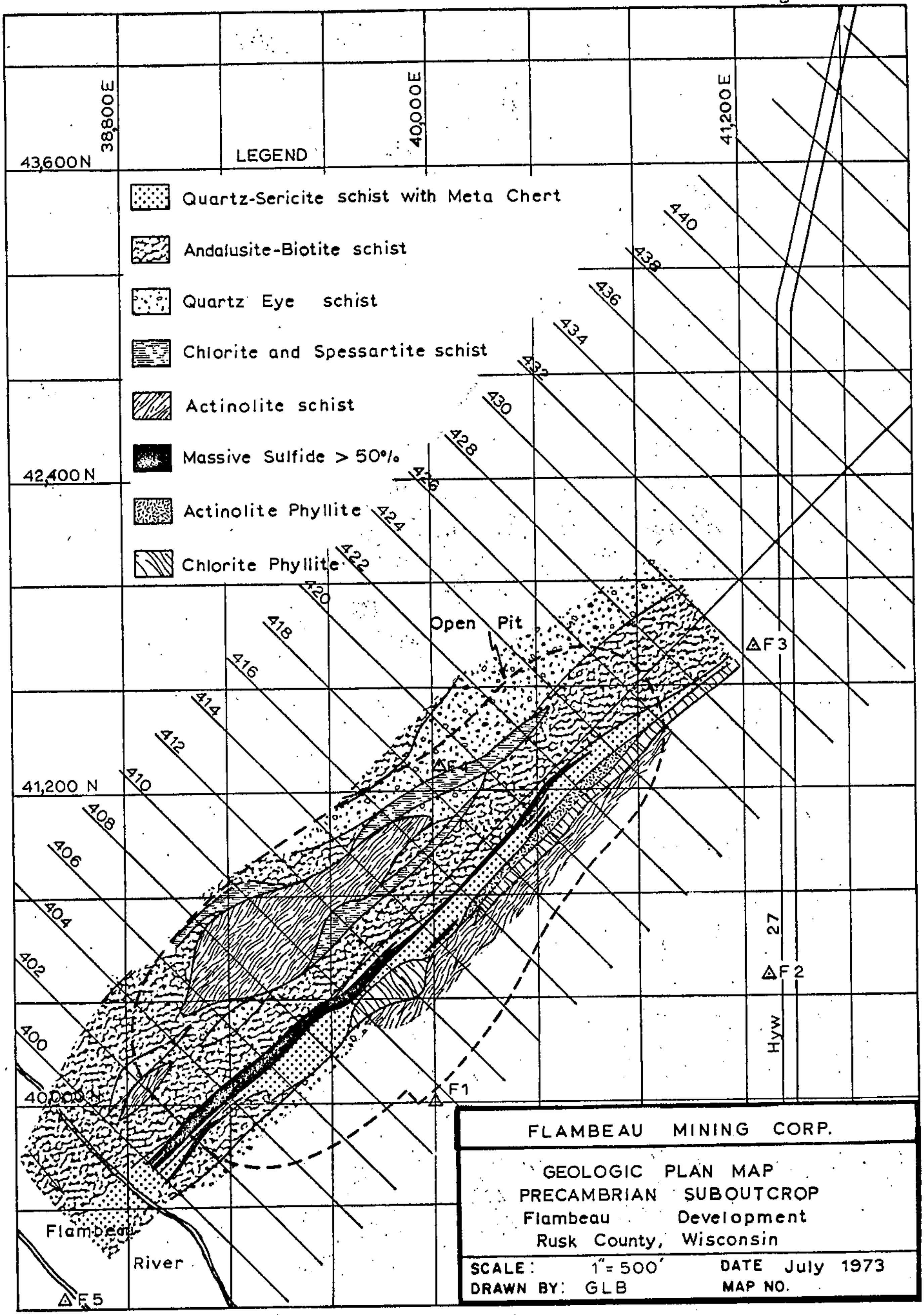
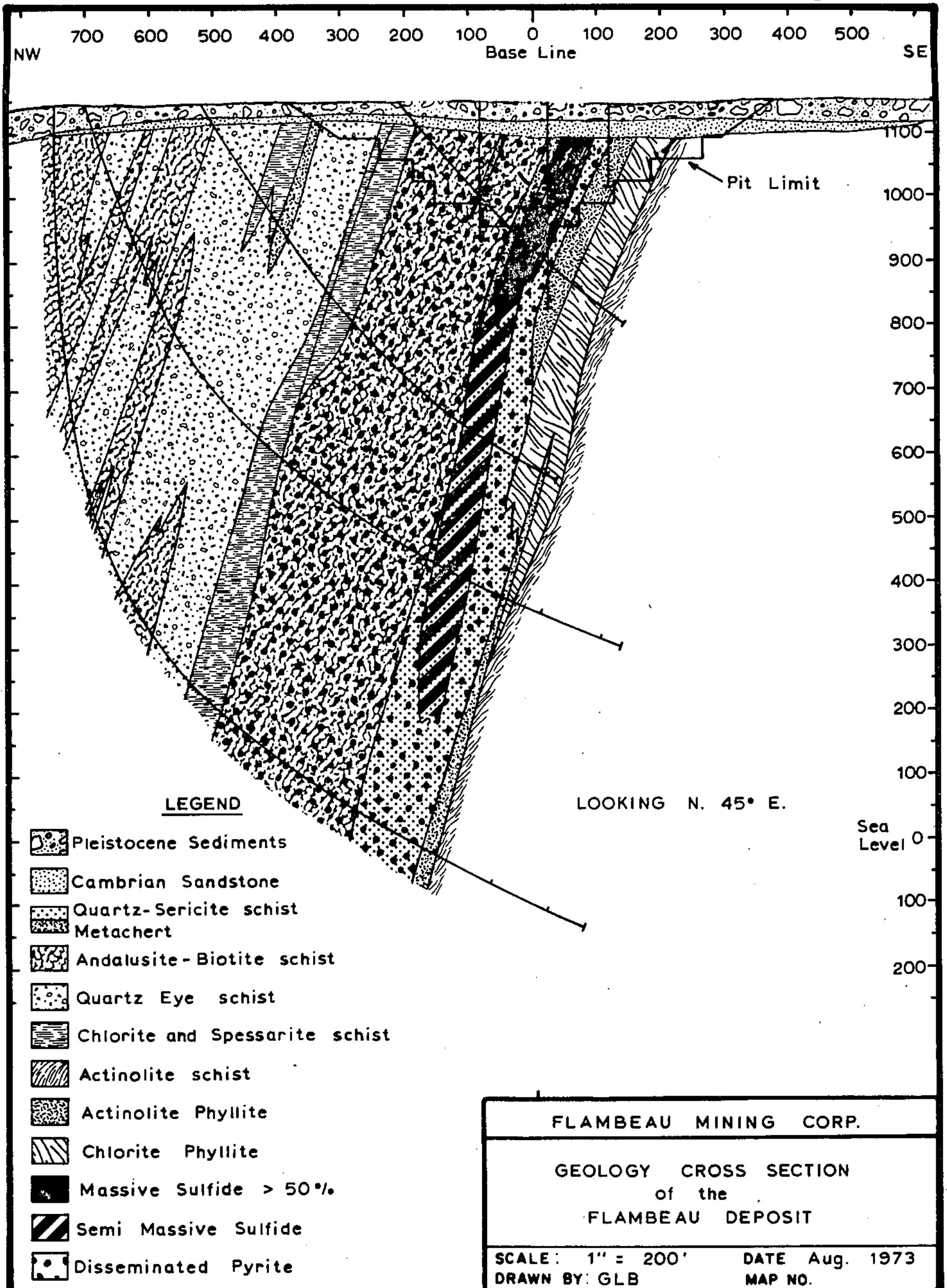

38800E
40,000E
41,200E
43,600N
42,400 N
41,200 N
40,000 N
LEGEND
Quartz-Sericite schist with Meta Chert
Andalusite-Biotite schist
Quartz Eye schist
Chlorite and Spessartite schist
Actinolite schist
Massive Sulfide > 50%
Actinolite Phyllite
Chlorite Phyllite
Open Pit
F1
F2
F3
F5
Hyw 27
Flambeau
River
400
402
404
406
408
410
412
414
416
418
420
422
424
426
428
430
432
434
436
438
440
FLAMBEAU MINING CORP.
GEOLOGIC PLAN MAP
PRECAMBRIAN SUBOUTCROP
Flambeau Development
Rusk County, Wisconsin
SCALE: 1" = 500'
DATE July 1973
DRAWN BY: GLB
MAP NO.

Figure 12



700 600 500 400 300 200 100 0 100 200 300 400 500
NW
Base Line
SE
1100
Pit Limit
1000
900
800
700
600
500
400
300
200
100
LEGEND
LOOKING N. 45° E.
Sea Level 0
100
200
Pleistocene Sediments
Cambrian Sandstone
Quartz-Sericite schist
Metachert
Andalusite-Biotite schist
Quartz Eye schist
Chlorite and Spessarite schist
Actinolite schist
Actinolite Phyllite
Chlorite Phyllite
Massive Sulfide > 50%
Semi Massive Sulfide
Disseminated Pyrite
FLAMBEAU MINING CORP.
GEOLOGY CROSS SECTION
of the
FLAMBEAU DEPOSIT
SCALE: 1" = 200'
DATE Aug. 1973
DRAWN BY: GLB
MAP NO.

however, the character of the mineralogy changes across the orebody as well as with depth. Sphalerite, a zinc sulfide, increases noticeably toward the lower contact of the orebody, imparting a well banded appearance to the orebody when mixed with pyrite and chalcopyrite. At depth, pyrite decreases, sphalerite is reduced to minor amounts, and the chalcopyrite grains coalesce to form irregular masses. The uppermost 50 to 150 feet of the orebody has been supergene enriched. Chalcocite is the predominant copper mineral in the upper portion of the enriched zone, whereas bornite predominates in the lower half. The disseminated pyrite halo has been enriched on either side of the massive sulfide vein. Zinc minerals are virtually absent in the enriched zone.

Copper with trace amounts of gold and silver would be produced from the Flambeau orebody. Although small amounts of zinc are found in the lower wall and in satellitic lenses beneath the vein, there is insufficient tonnage to warrant recovery under present economic conditions.

The ore has been tested for asbestos and no cummingtonite or other problem fibrous silicate minerals are present in the Flambeau ore. Their absence is important from a public health standpoint since asbestos fibers are suspected to cause lung cancer when inhaled in small quantities over an extended period of time.

1.6.0 BIOTIC CHARACTERISTICS

1.6.1 TERRESTRIAL AND AQUATIC PLANT COMMUNITIES

The basic plant communities of the Flambeau project site are shown on Figure 13. The Point-Quarter Method was used for the analysis of the woody species in the communities of the study area, whereas the list and abundance estimates of the herbaceous flora relied on the expertise of the botanical investigator.

The mixed deciduous-coniferous lowland forest occupies the most acreage of any plant community in the study area (Table 3). Of the 1,000 acres in the study area, the mixed deciduous-coniferous lowland forest comprises approximately 280 acres, or 28%. The forest is classified as lowland because of the relative closeness of the groundwater table to the surface of the forest floor. This forest community borders the marshes and swamps.

The predominant species are the trembling aspen (Populus tremuloides), red maple (Acre rubrum), the elms (Ulmus sp.), black ash (Fraxinus nigra) and white birch (Betula papyrifera). The forest has been disturbed in recent times. Some of the more mature trembling aspen south of the waste containment area were cut for pulp in 1972 by former owners. There is evidence from the old stumps in the forest that this area had suffered a fire many years ago. Local residents claim that the present pulp cutting is the third crop from this land. Burned sites are the most favorable to the trembling aspen (a prolific seeder) which makes up 47% of the trees in this lowland forest.

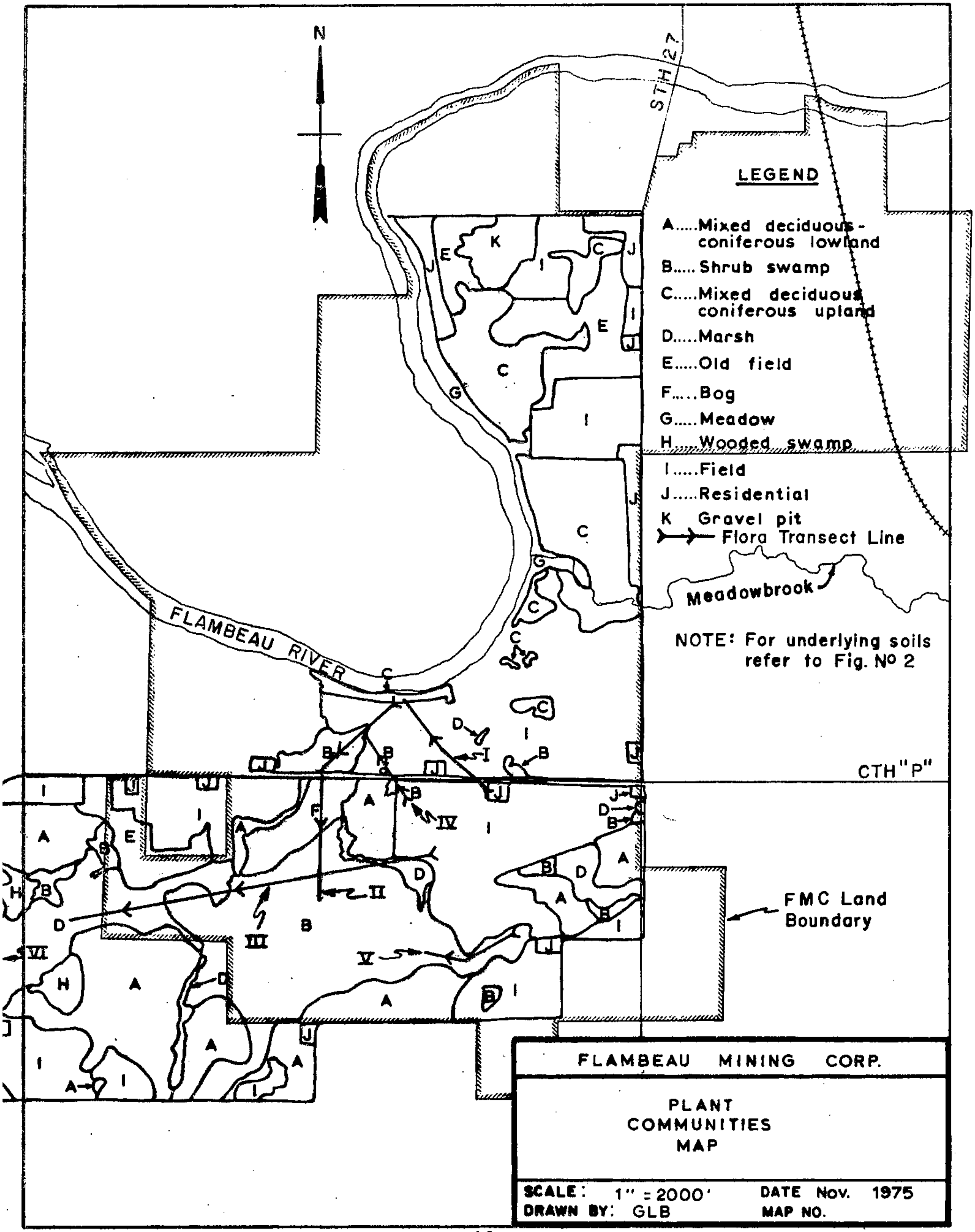

N
STH 27
LEGEND
A.....Mixed deciduous-coniferous lowland
B.....Shrub swamp
C.....Mixed deciduous coniferous upland
D.....Marsh
E.....Old field
F.....Bog
G.....Meadow
H.....Wooded swamp
I.....Field
J.....Residential
K Gravel pit
Flora Transect Line
Meadowbrook
NOTE: For underlying soils refer to Fig. No 2
FLAMBEAU RIVER
CTH "P"
FMC Land Boundary
FLAMBEAU MINING CORP.
PLANT COMMUNITIES MAP
SCALE: 1" = 2000'
DATE Nov. 1975
DRAWN BY: GLB
MAP NO.

TABLE 3

DESCRIPTION AND DISTRIBUTION OF PLANT COMMUNITIES

Map Symbol	Name	Major Species	Acreage	Percent of Total Area	Percent of Major Communities
A	Mixed deciduous-coniferous lowland	Aspen, red maple, ash, elm, white birch	282	16.6	28.2
B	Shrub swamp	Alder, willow, dogwood	262	15.4	26.2
C	Mixed deciduous-coniferous upland	White birch, red maple, aspen, sugar maple, black ash, basswood, elm, hemlock, bur oak, butternut	176	10.3	17.6
D	Sedge meadow	Sedges, cattails, grasses, rushes	111	6.5	11.1
E	Old field	Grasses	103	6.1	10.3
F	Bog	Sphagnum mat, ericads	28	1.6	2.8
G	River Basin Community	Grasses, sedges, willow, silver maple	23	1.3	2.3
H	Wooded swamp	Tamarack	15	.9	1.5
			1,000	58.7	100
	OTHER REGIONS WITHIN AREA (not studied)				
I	Field	Disturbed annually	618	36.3	
J	Residential	Disturbed continuously	60	3.5	
K	Gravel pit	Disturbed recently	23	1.3	
		Total	1,701	99.8	

If this lowland forest is allowed to remain undisturbed, natural vegetational succession will continue toward tolerant trees. The aspen and red maple will provide a very good canopy for the growth of shade-tolerant species such as sugar maple, ironwood and basswood. With the arrival of these species and their eventual dominance, this forest will succeed toward the mesic classification. During the period of time of the environmental impact report study (spring of 1973), the predominant groundlayer species that were examined were those species that were in flower. A floristic summary reveals that most of the species were found to be in the crowfoot buttercup, lily, violet, and dogwood families. Some of the species that indicate the high degree of soil moisture were jack-in-the-pulpit (Arisaema triphyllum), Trillium and swamp buttercup.

The shrub swamp occupies approximately 240 acres or 24% of the study area. This community has two locations; one is a border to a sedge marsh while the other is a major stand. The dominant vegetative species in the shrub swamp is the tag alder which is so dominant that only an occasional willow can be seen reaching a competitive height. Near the outer boundaries of this community, tamarack, aspen, red maple and black ash are frequently observed. Within the groundlayer the families with a high degree of representation are: balsam touch-me-not, crowfoot buttercup, rose, fern, dogwood, violet, arum, grass, sedge, mint and madder. Small openings where no tag alder grows are present in this alder swamp community. These "gap-phase" examples of microsuccession are dominated by cattail and narrow-leaved cattail. However, because there are also many small tag alder present near the borders of these spaces, it seems likely that in time the cattail will be replaced by tag alder. The shrub swamp soil is waterlogged, black and mucky. Often it is covered by a foot or more of water, and if kept in this condition the alder swamp has a high degree of stability. One factor that has helped to maintain the stability of a major part of this swamp is a beaver dam located about one-half mile west of the west dike of the proposed waste containment area. This damming may have preserved the tag alder as the climax vegetation.

The importance of this community is its value to wildlife. Due to the presence of the beaver pond, there is a potential brood area for ducks. Adjacent to the beaver pond, the shrub swamp community provides a feeding area for woodcock and a nesting and feeding area for ruffed grouse. During the winter months the alder swamp is populated by snowshoe hare.

The mixed deciduous-coniferous upland forest is the third largest plant community consisting of approximately 176 acres or 17.6% of the area that was studied. Transects through this forest habitat showed that it is more complex than the lowland deciduous-coniferous forest. In fact, it contains more species of trees than any other woody plant community and is the most advanced plant community on the basis of natural succession. The most numerous trees (in descending order) are: white birch, red maple, aspen, sugar maple, black ash, basswood, elm, hemlock, bur oak, butternut and balsam fir. This community is not very homogeneous. There are almost pure stands of various species of trees isolated within the general community. The few hemlock found in this community are isolated and quite large. Basswood exhibits the same phenomenon, only to a lesser degree.

This forest is classified as wet mesic. Left undisturbed, this forest will succeed to the mesic classification. The red maple, white birch and black ash will slowly be replaced by more shade-tolerant species such as sugar maple, hemlock and basswood. In this geographical area, these three species are the climax vegetation.

A complete list of the woody species in the upland mixed deciduous-coniferous forest is provided in Table 4. The most prevalent springtime herbaceous groundlayer families include the lily, crowfoot buttercup, fern and violet. A detailed list of ferns and fern allies is found in Table 5.

Of special interest is the number of dead trees in the mixed deciduous-coniferous upland forest in the area designated for the open pit mine. After analyzing a one-acre quadrat, it was discovered that 23% of the trees were dead (Table 6). Of the 362 trees with a minimum two-inch d.b.h. (diameter at breast height) counted, 277 were alive and 85 were dead. Several of the elms and ashes had dead branches but were counted as being alive since there was some green foliage. Of the 85 dead trees, 75 of them were bitternut hickory. The exact cause of death of these trees has only been hypothesized. One probable cause is the eight to twelve-foot lower groundwater table as a result of the removal of the Port Arthur Dam in 1969. Since the bitternut hickory is normally found on wet bottomlands, an eight to twelve-foot drop in the water table may have caused severe "die-back" in the trees. A U. S. Soil Conservation Service forester and their plant pathologist were contacted and their consensus is that the ash and hickory have definitely been affected by the lowering of the water table. These species can tolerate high water table levels, but probably cannot tolerate this much lowering of the water table. The Ladysmith WDNR forester has indicated this could be a cause, but also that these trees are on the edge of their range and often do not live to maturity. Bitternut hickory are often affected by a disease that forms numerous galls on their twigs. Since there are known diseases of bitternut hickory, and since this is the northernmost part of its range (where it probably is less hardy), the water table drawdown and "die-back" combination seems the most probable explanation.

The sedge meadow comprises about 111 acres or 11.1% of the study area. It is an open community where the soils are wet but without standing water during the growing season. During the spring runoff and after a heavy summer rain the soil may become covered with a few inches of water. The soil is a combination peat and muck. Sedges are the dominant vegetation although cattails appear toward wetter conditions. The outer boundaries of the sedge meadow are fringed with tag alder and willows. Just inside these shrubs red-osier dogwood and

TABLE 4

WOODY SPECIES WITHIN THE OPEN PIT AREA

FALL SURVEY

GYMNOSPERMAE

PINACEAE
- Pinus rosinosa - red pine
- Pinus strobus - white pine
- Larix larcicina - tamarack
- Abies balsamea - balsam fir
- Tsuga canadensis - hemlock

TAXACEAE
- Taxus canadensis - American yew

ANGIOSPERMAE

ACERACEAE
- Acer rubrum - red maple
- Acer saccharum - sugar maple
- Acer saccharinum - silver maple
- Acer spicatum - mountain maple

ANACARDIACEAE
- Rhus radicans - poison ivy
- Rhus typhina - staghorn sumac

AQUIFOLIACEAE
- Ilex verticillata - black alder
- Nemopanthus mucronata - mountain holly

BETULACEAE
- Corylus americana - American hazelnut
- Corylus cornuta - beaked hazelnut
- Ostrya virginiana - ironwood
- Carpinus caroliniana - bluebeech
- Betula lutea - yellow birch
- Betula papyrifera - white birch
- Alnus rugosa - alder

CAPRIFOLIACEAE
- Diervilla lonicera - bush honeysuckle
- Lonicera canadensis - American fly honeysuckle
- Lonicera tatarica - tartarian honeysuckle
- Sambucus canadensis - common elder
- Viburnum lentago - nannyberry

CORNACEAE
- Cornus alternifolia - pagoda dogwood
- Cornus racemosa - gray dogwood
- Cornus stolonifera - red-osier dogwood

ERICACEAE
- Gaultheria procumbens - wintergreen

FAGACEAE
- Quercus macrocarpa - bur oak
- Quercus rubra - red oak

JUGLANDACEAE
- Juglans cincerea - butternut
- Carya cordiformis - bitternut hickory

OLEACEAE
- Fraxinus nigra - black ash
- Fraxinus pennsylvanica - green ash

ROSACEAE
- Spirea alba - meadow sweet
- Crataegus sp. - thornapple
- Rubus allegheniensis - blackberry
- Rubus idaeus - red raspberry
- Rubus oxidentalis - black raspberry
- Prunus americana - American plum
- Prunus pennsylvanica - pin cherry
- Prunus serotina - wild black cherry
- Prunus virginiana - choke cherry

RUBIACEAE
- Mitchella repens - partridgeberry

RUTACEAE
- Xanthoxylum americanum - prickly ash

SALICACEAE
- Salix Bebbiana -
- Salix discolor - pussy willow
- Salix fragilis - crack willow
- Salix rigida -
- Populus grandidentata - large-toothed aspen
- Populus tremuloides - quaking aspen

SAXIFRAGACEAE
- Ribes cyanosbati -
- Ribes hirtellum - smooth gooseberry
- Ribes rotundifolium -

THYMELACEA
- Dirca palustris - leatherwood

TILIACEAE
- Tilia americana - basswood

ULMACEAE
- Ulmus americana - American elm
- Ulmus rubra - slippery elm
- Ulmus thomasii - cork elm

VITACEAE
- Parthenocissus quinquenfolia - Virginia creeper

TABLE 5

FERNS AND FERN ALLIES OF THE OPEN PIT AREA

POLYPODIACEAE
- *Pteridium aquilinum* - bracken fern
- *Adiantum pedatum* - maidenhair fern
- *Atherium Felix* - femina - lady fern
- *Dryopteris cristata* - crested fern
- *Dryopteris spinulosa* - florist fern
- *Dryopteris phegopteris* - long beech fern
- *Dryopteris disjuncta* - oak fern
- *Onoclea sensibilis* - sensitive fern
- *Pteretis pensylvanica* - ostrich fern

OSMUNDACEAE
- *Osmunda claytoniana* - interrupted fern
- *Osmunda cinnamomea* - cinnamon fern

OPHIOGLOSSACEAE
- *Botrychium virginianum* - rattlesnake fern

LYCOPODIACEAE
- *Lycopodium lucidulum* - shining clubmoss
- *Lycopodium obscurum* - groundpine (flatbranch)
- *Lycopodium annotinum* - bristly clubmoss
- *Lycopodium complanatum* - groundpipe

EQUISETACEAE
- *Equisetum hymelae* - tall scouring-rush

TABLE 6

SURVIVAL OF TREES IN A ONE-ACRE QUADRAT IN THE OPEN PIT AREA
(All trees over two inches d.b.h.)

Species	Alive	Dead
Basswood	1	-
Bitternut hickory	4	75
Black ash	130	4
Black cherry	1	-
Blue beech	3	-
Bur oak	12	-
Butternut	5	2
Elm	70	4
Ironwood	13	-
Red oak	3	-
Sugar maple	33	-
White birch	2	-
	277 (77%)	85 (23%)

Spirea alba are located, whereas most of the sedge meadow vegetation is composed of sedges of the genus Carex, grasses, mints (Scutellaria galericulata), the swamp milkweed (Asclepias incarnata), the cattails (Typha latifolia and Typha angustifolia), and Iris versicolor.

The old field community comprises approximately 103 acres or 10.3% of the study area. Parcels are classified as old field because they have not been disturbed (plowed) for two to three years and were allowed to revert to forest. If this process is allowed to continue, the old field will eventually succeed to a shrubland and then to a climax forest in several hundred years. The old field community within the study area already exhibits a range of succession from small trees to shrubs to grassland. The invading trees are trembling aspen, large-toothed aspen, red pine, white birch, red oak and bur oak. Some of the prevalent shrubs include staghorn sumac, pin cherry and chokecherry. The predominant families with representatives in the groundlayer vegetation are grass, composite, sedge, pink rose and pea. In one section of the old field community, near the eastern boundary of the pit site, a perched water table enables the soil to remain quite moist. The predominant shrubs here under these conditions are willows, whereas much of the groundlayer species is in reed canary grass and goldenrod.

The bog in this study area comprises 28 acres or 2.8% of the total area that has been studied. The term bog refers to a soil-vegetation complex in which a rather specialized group of herbs and low shrubs grow on a wet, acid soil composed of peat. This particular bog is quite old, has filled in any open water spaces and is being invaded by wet-lowland and wet-mesic species of trees. Tamarack, white birch, trembling aspen and white pine can be seen growing on the sphagnum mat. The pattern of natural succession would be for the bog to become a wooded (tamarack) swamp, then a lowland wet mesic forest, and finally a mesic forest exhibiting climax vegetation. If left undisturbed, this is the pattern that would undoubtedly be followed here; tamarack is already the most prevalent tree. The two most important families of plants growing on the mat are heath and the sedges.

The river basin community comprises approximately 23 acres or 2.3% of the total study area and was formed as a result of the removal of the Port Arthur Dam. The removal of the dam caused the level of the Flambeau River to drop eight to twelve feet along the project site. The drop in water level exposed a considerable amount of land that is now being invaded by terrestrial vegetation. The environmental conditions along the river basin range from semi-aquatic to xeric (dry soils). The semi-aquatic areas are where cool springs run down the bank to the river. There is very dense vegetation along these miniature streambanks. The xeric conditions exist in open areas where the river had deposited large amounts of sand and gravel.

Because of the wide range of conditions, there is also a wide variance in the invading plants. The most prevalent woody species is the willow. However, there has been considerable invasion by the silver maple, box elder and tag alder. Other woody species that are invading but are not numerous are red maple, cottonwood, balsam, fir and elm. The silver maple invasion is interesting because there are no known natural stands of it in the immediate area. Of the herbaceous plants the most predominant families are grass, sedge, composite, crowfoot buttercup and the rush.

The wooded swamp comprises approximately 15 acres or 1.5% of the total study area. The characteristic vegetation of the wooded swamp is the tamarack. Coupled with a sphagnum mat and a high number of ericads (heather) in the understory, the tamarack swamp is very closely related to the bog. Associating with the tamaracks are tag alder, white birch and an occasional white pine. The prevalent families of the ground-layer species are heath, dogwood, sedge, lily, orchid, primrose and crowfoot buttercup. This wooded swamp, if left undisturbed, would undoubtedly succeed to a lowland mixed coniferous-deciduous forest as has been described earlier. Black ash, red maple and aspen would slowly invade the fringes of the wooded swamp until they had completely crowded out the tamarack.

1.6.2 ANIMAL COMMUNITIES

FMC carried out a three-phase quantitative-qualitative vertebrate study which entailed: (1) a qualitative vertebrate survey in the fall of 1972; (2) a qualitative large mammal survey in the fall of 1972 through the spring of 1973; and (3) a quantitative small mammal survey conducted from April 14 through June 18, 1973. The quantitative survey was carried out to determine species populations and densities. Because of the low capture success, the results of that survey are not presented. However, the results of the qualitative survey indicate the species which are known to inhabit the project site.

A composite list of all mammal species identified on the project site is presented in Table 7. The bobcat is listed as having changing status in Wisconsin. Deer were found over most of the project site. Deer browsing in the Meadowbrook Creek area during winter came from east of State Highway 27. Otter, in addition to moving in the bog area, plied the river edge itself but did not venture up Meadowbrook Creek. Although fox were numerous in the early winter of 1972, reduced numbers were observed later probably due to trapping. Beaver may have also been lost through trapping. Mammals seen on the west bank of the Flambeau include white-tailed deer, otter, red fox, raccoon, striped skunk, muskrat, gray squirrel, red squirrel and chipmunk.

Many of the larger mammals, such as the otter, bobcat, fox, muskrat, mink, weasel, raccoon, skunk and beaver, are considered furbearers and are either hunted or trapped. There are specific hunting and trapping seasons on most of these species, and all species have been taken on the project site. WDNR estimates of the hunting and trapping harvest on the project site are presented in Table 8. The range of values reflect changing populations, changing hunting regulations, and the amount of hunting pressure.

TABLE 7

SPECIES LIST
ALL MAMMALS OBSERVED AND/OR TRAPPED
Interval 9-16-72 - 6-10-73

Family	Common Name	
Canidae	Red fox	Vulpes fulva
Castoridae	Beaver	Castor canadensis
Cervidae	White-tailed deer	Odocoileus virginianus
Cricetidae	Deer mouse	Peromyscus sp.
	Meadow vole	Microtus pennsylvanicus
	Muskrat	Ondatra zibethica
	Red-backed vole	Clethrionomys grapperi
	White-footed mouse	Peromyscus leucopus
Felidae	Bobcat	Lynx rufus
Leporidae	Snowshoe hare	Lepus americanus
Mustelidae	Badger	Taxidea taxus
	Mink	Mustela vison
	River otter	Lutra canadensis
	Striped skunk	Mephitis mephitis
	Weasel	Probably three species but Mustela erminea positive
Procyonidae	Raccoon	Procyon lotor
Sciuridae	Eastern chipmunk	Tamias striatus
	Least chipmunk	Eutamias minimus
	Franklin's ground squirrel	Citellus franklinii
	Thirteen-lined squirrel	Citellus tridecemlineatus
	Northern flying squirrel	Glaucomys sabrinus
	Southern flying squirrel	Glaucomys volans
	Eastern gray squirrel	Sciurus carolinensis
	Red squirrel	Tamisciurius hudsonicus
	Woodchuck	Marmota monax
Soricidae	Masked shrew	Sorex cinaerious
	Short-tailed shrew	Blarina brevicauda
Talpidae	Starnose mole	Condylura cristata
Zapodidae	Meadow jumping mouse	Zapus hudsonius
	Woodland jumping mouse	Napaeozapus insignis

TABLE 8

AVERAGE ANNUAL HUNTING AND TRAPPING HARVEST 1963 to 1973

Hunted Species	Range
Bear	1 - 2
Deer	10 - 20
Hare - snowshoe	10 - 30
Rabbit - cottontail	10 - 30
Squirrel	30 - 80
Trapped Species	
Beaver	10 - 15
Coyote	5 - 7
Fox (red preferred)	10 - 15
Mink	5 - 10
Muskrat	50 - 100
Otter	5 - 10
Raccoon	20 - 40
Skunk (unprotected)	20 - 50
Weasel (unprotected)	10 - 20

Among the small mammals, deer mice were the predominant species captured. Chipmunks and gray squirrels were also captured in large numbers.

Avian populations were studied quantitatively and qualitatively from March 3, 1973 to July 12, 1973 as a part of the impact study. The different species of birds present in this area were also noted as part of a vertebrate population study conducted in the months of October and November 1972. More data were accumulated from December 1972 through early March 1973. The areas under study are quite typical of north central Wisconsin. In the study areas are found a small pond, marshlands, creeks, old fields, meadows, plowed ground, wooded swamp, upland hardwoods, lowland hardwoods, brushy areas or thickets and roadsides.

The results of the spring 1973 study are presented in Table 9. A composite species list, including winter observation, is given in Table 10.

The bird populations in the various habitats were normal as compared to records of previous years compiled by the Wisconsin Society for Ornithology. One exception was the numbers of purple martins seen. For reasons unknown, the martin population of the Mississippi River Valley was only 15% of normal during the 1972 season. Since martins often return to the same nesting area where they are hatched, it was expected that the martin numbers would again be low in 1973. This proved to be true. Not all of the species that migrate through this area were seen, nor were all species seen identified. No owls were seen during the spring and summer period, although one species was seen during the fall and winter surveys. An immature bald eagle was

SPRING AND SUMMER BIRD SIGHTINGS 1973
(DCHC - EIS)

TABLE 9

Month	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7
Day	12	16	21	23	26	28	30	4	6	9	11	13	16	18	20	21	22	24	26	28	29	1	3	5	6	8	10	12	13	15	17	18	16	17	18	19	20	21	22	23	24	25	27	28	29	1	2	3	5	6	7	8	9	10	11	12
Grebe, Horned (Horned)																			1																																					
Grebe, P-b								1					1																																								1			
Heron, G-b									1																																															
Bittern, Am.																						1				2																														
Duck, Wood																							2									2																			2					
Duck, Am-Gold-eye		2	1	1				1			1		1																																											
Duck, Buf.-head	1	4		1	2	6		1	2			1	4	2																																										
Hawk, S-s																											1																													
Hawk, B-w																								1																																
Hawk, Marsh								1																																													2			
Hawk, Sparrow	1											1							1									1					1	1					1										1				2			
Rail, Sora																																1																								
Killdeer	1	1			1				2	1	2	2	1		2				1	1				1	1	1		1	2	3	2	1	1	1		1	2			1	2			1	3	4	2	3	4	1		2	3	1	3	4
Woodcock																1		2			1						1				1				2				1			2	2	1	1	3	1	1	2	1	2	2	2	1	2	1
Snipe, Wilson's																					1				1			2			4	1		3		1					3				1			1								
Plover, Upland															1																																									
Tern, Black																																																					2	10	4	7
Dove, Rock	Common →																																																							
Dove, Mourning											1			2			1	2	3			1	1	1	2	1	1	3	1	1	1	1	2			1	1	1	2	2	1	1				1	1	1	1	1	2			2	1	1
Cuckoo, B-b																																																		1				1		
Nighthawk																																																					1			
Swift, Chimney																				1			2						3		1												1					2								
Kingfisher, B.																				1																1															1					
Flicker, Y-s								1						2	1		1		1	1			1			1	1	2	1	1		1		1	1	1	2	1	1					1		1			1	2	1	1	1	1	1	1
Woodpecker, R-h																																					1														1					
Sapsucker, Y-b																		1		1					1							1								1													2	1		1
Woodpecker, Hairy					1						1						1					1				1					1									1											1					
Woodpecker, Downy	1			2			1					1				1			2				1	1			1						1			1			1				1			1				1			1			
Kingbird, East.																													1								1										1									
Flycatcher, Crest.																																																					1		1	
Phoebe, East.																					2																																			
Swallow, Tree														1	1			2	1	2	2	3	4	Common →																																
Swallow, Barn																						2	3	2	4	1	2	3	4	6	2	1	3	3	2	2	4	6	8	5	2	4	8	6	4	5	2	4	6	8	10	10	10	8	10	10
Swallow, Cliff																									1	1	2	1	3	4	1	2	3	4	6	2	4	3	1		4	6	8	2	4	6	10	8	12	15	10	25	20	15	10	10
Martin, Purple															1				2				1						4			1		2			1			4			1			2	2				2	6		4		1
Blue Jay			1			2	1			1	2	2		2	1	1	1			1		2			1				1			1					2	1				1			2				1				1	2		
Crow	1		2	1	2	3	1		2	4	5	1	1	2	2	4		1	2	6	2	1	2	3	2	2	2	3	4	1	2		4	2	4	2	2	2	1	4	3	1		4	5	3	4	2	3	2	5	3	2	4	5	2
Chickadee, Bl-c	1		2	1	1	1		2	1	1	2	1	1	2			1	1	2	1	2	2	2		1	1	3	2	3	3	1	3	1	2	1	1	1	2	1	1			1	2	1	1	2	1	1	1		2	1	2	1	1
Nuthatch, W-b	1		2	1			2			1	1	1	2	1		1	2	2				1	2	1	1	1	2	1	1			1			1	1			1	1	1	1	1	2	2	1	1				1	1			1	
Wren, House																												1						1					1		1							1			1		1	1	1	1
Wren, S-b Marsh																																1	2	1	3	4	4	5	6	5	Common →															
Catbird																													1	1			1	2	2	1	1			1	1	1	2	1	1	1			1	1		1	1	1	2	1
Brown Thrasher																1	2	1	1	1	1		1			1	1		1	2	1	2	2	1	1		1	1	1	2	1	2	3	1	1	1	1	2	2		1		1	1		1
Robin	Common →						Abundant →													Common →																																				
Veery																												1			1	2	1	2	3	1	2		1			3	1	1	2	3	3	2	3	3		1	2	3	2	2
Bluebird, East.	3	4	6	8	6	8	10	4	3	6	8	6	5	4	2				2	1	1	2		1	1	1	1									1	2		1	2	3	4	1		2	1	1						1	1		
Kinglet, G-c									1							1																																								
Waxwing, Cedar																																1			1						1												1	1		
Starling	Common →																																																							
Vireo, R-e																																	1	2	1		1	3	4	6	Common →															
Vireo, Warbling																																			1									1									1			
Warbler, Yellow																															2			3	2	3	4	Common →																		
Warbler, Y-th																														4	6	8	Common →																							
Warbler, C-s-sided																																	1	2		1	1	2	3	1	2	1	4	3	2	2	1	3	1	4	1	2	2	3	4	2
Oven-bird																										1					1					1											1					1				
Redstart																																																				1				
Sparrow, House	Common →																																																							
Bobolink																											1			2		1			1	2	6	8	10	Common →																
Meadowlark, East.				1	2		1	2	3	4	6	Common →																																												
Meadowlark, West.				1	2		3	4	5	Fairly Common →																																														
Blackbird, R-w	Abundant →																																																							
Oriole, Balt.																															1					2				2																
Blackbrid, Rusty	Common →																																																							
Blackbird, Brew.																						8	6	4	4	2	3	2	3	4	5	6	2	3	1	3	6	7	2	3	4		1	3	4	2		2	3	4		1	3	4	5	
Grackle	Common →																																																							
Cowbird												2	2	3	4	6	Common →																																							
Tanager, Scar.																											1				1																									
Grosbeak, R-b																																1		2			1					2				1	1	1	3	1		1	2	1		1
Bunting, Indigo																																				1				2			1					1				2				
Grosbeak, Eve.	8	10	12	9	10	6			5	8	10	5	6	4			8	2		1	4	6	10		4	3	2	1	6	2																										
Finch, Purple		2		1			2	3	4		2	1		2	4	6	3	1		4	2	1		3	2	6	5	1	2	4	1						1		2				3	1	2		1		2				1			
Goldfinch	Common →																																																							
Towhee																																1			2		1	1		1	2	1		1	1	2	1		1	1	1			1	1	
Sparrow, Sav.											1	2	1	1	1	2	4	5	6	2	3	5	6	Common →																																
Sparrow, Le Conte's																																																						2	1	1
Sparrow, Vesp.											1		2	3		5	1	2	4	2																																				
Junco, S-cl	Abundant →																					Common →																																		
Sparrow, Tree	Common →																																																							
Sparrow, Chip.													1		1	2	1		1			1	1	1	2	1	1	1	1	2		3	1	2	1		1	1	1		1	2	1	1	1	1	1			1	1		2	1	1	
Sparrow, Cl-c																																2	1	1		3	2	2	3	1		2	2			3	1	1	1			1	1		1	2
Sparrow, W-th																						1			2	1				1					1	2				1				1	1	1		1	1			1	1			
Sparrow, Fox	2	1	1		2		1		1	3	1	1	2		3	1																																								
Sparrow, Swamp																	1			1	1		1	2	3	1	2	2	1	1	3	4	2	1		1	2	3	1	2	2	4	1	2	5	1	2	1	5	2	1	2	1	5	2	1
Sparrow, Song	Common →																																																							

TABLE 10

COMPOSITE BIRD SITING LIST
(and where observed)

Name	Pit Area	Road Side
Grebe, Horned	x	
Grebe, P-b	x	
Heron, G-b		x
Bittern, Am.		x
Duck, Wood	x	x
Duck, Am-Gold-eye	x	
Duck, Buf.-head	x	
Hawk, S-s		x
Hawk, B-w		x
Hawk, Marsh		x
Hawk, Sparrow		x
Rail, Sora		x
Killdeer	x	x
Woodcock		x
Snipe, Wilson's		x
Plover, Upland		x
Tern, Black		x
Dove, Rock		x
Dove, Mourning	x	x
Cuckoo, B-b		x
Nighthawk		x
Swift, Chimney	x	x
Kingfisher, B.	x	x
Flicker, U-s	x	x
Woodpecker, R-h	x	x
Sapsucker, Y-b	x	x
Woodpecker, Hairy	x	x
Woodpecker, Downy	x	x
Kingbird, East.	x	x
Flycatcher, Crest.		x
Phoebe, East.		x
Swallow, Tree	x	x
Swallow, Barn		x
Swallow, Cliff		x
Martin, Purple		x
Blue Jay	x	x
Crow	x	x
Chickadee, Bl-c	x	x
Nuthatch, W-b	x	x
Wren, House		x
Wren, S-b Marsh	x	x
Catbird	x	x

Name	Pit Area	Road Side
Brown Trasher		x
Robin	x	x
Veery	x	x
Bluebird, East.	x	x
Kinglet, G-c	x	
Waxwing, Cedar		x
Starling	x	x
Vireo, R-e	x	x
Vireo, Warbling		x
Warbler, Yellow	x	x
Warbler, Y-th	x	x
Warbler, C-nut-sided	x	x
Oven-bird	x	x
Redstart		x
Sparrow, House		x
Bobolink	x	x
Meadowlark, East.	x	x
Meadowlark, West.	x	x
Blackbird, R-w	x	x
Oriole, Balt.		x
Blackbird, Rusty	x	x
Blackbird, Breu.		x
Grackle	x	x
Cowbird	x	x
Tanager, Scar.		x
Grosbeak, R-b		x
Bunting, Indigo		x
Grosbeak, Eve.		x
Finch, Purple		x
Goldfinch	x	x
Towhee	x	x
Sparrow, Sav.	x	x
Sparrow, Le Conte's		x
Sparrow, Vesp.	x	x
Junco, S-cl	x	x
Sparrow, Tree	x	x
Sparrow, Chip.	x	x
Sparrow, Cl-c		x
Sparrow, W-th	x	
Sparrow, Fox	x	x
Sparrow, Swamp	x	x
Sparrow, Song	x	x

sited in the vicinity of the proposed waste containment area by WDNR personnel during November 1974. Bald eagles are on the Wisconsin List of Endangered Species. The upland plover is listed as having changing status in Wisconsin.

Cursory spring 1973 qualitative survey of amphibians and reptiles on the mine site was conducted. The three transects made in the area of the proposed pit and the proposed waste containment area are shown on Figure 14. No record of where each species was seen was made. Although no populations estimates were made, the species listed in Table 11 were found in 100 hours of field work.

TABLE 11

REPTILE AND AMPHIBIAN SURVEY

Reptilia	
Common snapping turtle (Chelydra serpentian)	Uncommon
Painted turtle (Chrysemys picta)	Very common
Eastern garter snake (Thamnophis sirtalis)	Common
Amphibia	
Tiger salamander (Ambystoma tigrinium)	Common
Blue-spotted salamander (Ambystoma laterale)	Probably common
Red-backed salamander (Plethedon cinereus)	Fairly common
American toad (Bufo terrestris)	Very common
Spring peeper (Hyla crucifex)	Very common
Grey tree frog (Hyla versicolor)	Common
Pickeral frog (Rana palustris)	Uncommon
Mink frog (Rana septentrionalis)	Common

The number of insect species is greater than any other group of animals. Because insects occupy every level of ecosystems, they are important components of the fauna, serving to link many other species to the plant communities. Insects were collected and observed in representative habitats because most insects are bound to a particular habitat by food preferences or other requirements. Collections were made near or in small pond, marsh, grassland, pasture, old field, upland hardwood, small creek, wet banks, brush and roadside habitats. Collecting was done by sweep net, hand collecting and sightings. No effort was made to take large numbers of insects. A few specimens were keyed to species, e.g., giant water bug (Belastoma sp.), dobson's fly (Coradalus cornutus) (Linn) and an unusual Lygaeid. Collecting was done once a week from late March until July. A total of 20 hours of collecting was done. The list appearing in Table 12 includes individuals which were within the abilities of the consultant; the identification of order and species was not possible. No unusual insect families were collected, and insects seen were typical for the Ladysmith area. This observation is based on a number of past years spent in the field collecting, and comparisons with lists in publications.

Figure 14

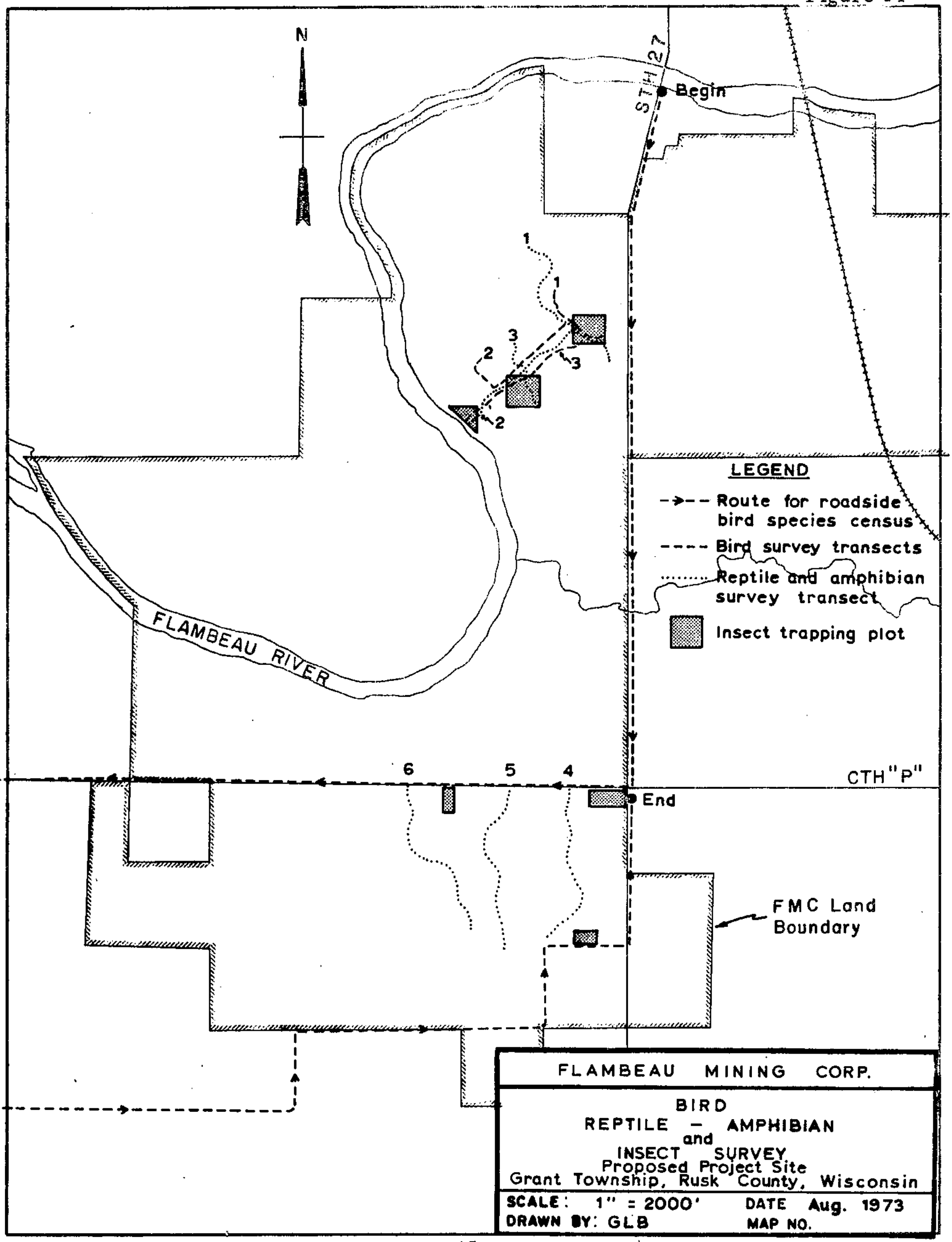

N
STH 27
Begin
1
1
2
3
3
2
LEGEND
Route for roadside bird species census
Bird survey transects
Reptile and amphibian survey transect
Insect trapping plot
FLAMBEAU RIVER
6
5
4
CTH"P"
End
FMC Land Boundary
FLAMBEAU MINING CORP.
BIRD
REPTILE – AMPHIBIAN
and
INSECT SURVEY
Proposed Project Site
Grant Township, Rusk County, Wisconsin
SCALE: 1" = 2000'
DATE Aug. 1973
DRAWN BY: GLB
MAP NO.

TABLE 12

REPRESENTATIVE ORDERS AND FAMILIES OF INSECTS
FOUND ON THE PROJECT SITE

Order Collembola
- Family Entomobryidae - springtails

Order Ephemeroptera
- Family Ephemeridae - mayflies

Order Odonata
- Family Aeshnidae - darners
- Family Libellulidae - skimmers
- Family Coenagrionidae - damselflies

Order Orthoptera
- Family Acrididae - short horned grasshoppers
- Family Tettigoniidae - long horned grasshoppers
- Family Gryllidae - crickets
- Family Blattidae - roaches

Order Plecoptera
- Family Perlidae - stoneflies

Order Thysanoptera
- Family Thripidae - common thrips

Order Hemiptera
- Family Corixidae - water boatmen
- Family Notonectidae - backswimmers
- Family Nepidae - water scorpions
- Family Gelastocoridae - toad bugs
- Family Balostomatidae - giant water bugs
- Family Gerridae - water striders
- Family Miridae - leaf bugs
- Family Phymatidae - ambush bugs
- Family Reduviidae - assassin bugs
- Family Tingididae - lace bugs
- Family Lygaeidae - lygaeid bugs
- Family Coreidae - leaf-footed bugs
- Family Corizidae - grass bugs
- Family Pentatomidae - stink bugs

Order Homoptera
- Family Cicadidae - cicadas
- Family Membracidae - treehoppers
- Family Cercopidae - spittlebugs
- Family Cicadellidae - leafhoppers
- Family Fulgoridae - planthoppers
- Family Aleyrodidae - white flies
- Family Aphididae - plant lice
- Family Coccidae - scales

Order Neuroptera
- Family Corydalidae - dobson flies
- Family Chrysopidae - lacewings

Order Coleoptera
- Family Cicindelidae - tiger beetles
- Family Carabidae - ground beetles
- Family Dytiscidae - predaceous diving beetles
- Family Gyrinidae - whirligig beetles
- Family Histeridae - hister beetles
- Family Hydrophilidae - water scavenger beetles
- Family Silphidae - carrion beetles
- Family Staphylinidae - rove beetles
- Family Cantharidae - soldier beetles
- Family Lampyridae - fireflies
- Family Dermestidae - skin beetles
- Family Cleridae - checkered beetles
- Family Elateridae - click beetles
- Family Buprestidae - mettalic wood borers
- Family Phalacridae - shining flower beetles
- Family Cocconellidae - ladybird beetles
- Family Meloidae - blister beetles
- Family Mordellidae - tumbling flower beetles
- Family Tenebrionidae - darkling beetles
- Family Scarabaeidae - scarabs
- Family Cerambycidae - long horned wood borers
- Family Chrysomelidae - leaf beetles
- Family Mylabridae - weevils
- Family Curculionidae - snout beetles
- Family Scolytidae - bark beetles

Order Mecoptera
- Family Panorpidae - scorpionflies

Order Trichoptera
- Family Limnephilidae - caddisflies

Order Lepidoptera
- Family Papilionidae - swallowtails
- Family Pieridae - whites and sulfurs
- Family Danaidae - milkweed butterflies
- Family Satyridae - wood nymphs
- Family Nymphalidae - four-footed butterflies
- Family Lycaenidae - blues, coppers and hair streaks
- Family Sphingidae - hawk moths
- Family Arctiidae - tiger moths
- Family Noctuidae - noctuid moths
- Family Liparidae - tussock moths
- Family Geometridae - measuring worms
- Family Gelechiidae - leaf miners and gall moths
- Family Gracilariidae - leaf miners

Order Diptera
- Family Tipulidae - crane flies
- Family Psychodidae - sand flies
- Family Chironomidae - midges
- Family Ceratopogonidae - punkies
- Family Simuliidae - buffalo gnats
- Family Culicidae - mosquitoes
- Family Cecidomyiidae - gall midges
- Family Tabanidae - horse and deer flies
- Family Bombyliidae - bee flies
- Family Asilidae - robber flies
- Family Empididae - dance flies
- Family Syrphidae - syrphid flies
- Family Tachinidae - tachinid flies
- Family Calliphoridae - blow flies
- Family Sarcophagidae - flesh flies
- Family Muscidae - house flies

Order Hymenoptera
- Family Tenthredinidae - sawflies
- Family Ichneumonidae - ichneumons
- Family Braconidae - braconids
- Family Cynipidae - gall wasps
- Family Chrysididae - cuckoo wasps
- Family Formicidae - ants
- Family Vespidae - wasps
- Family Apidae - bees

Biological sampling of the plankton, benthos and fish populations of the Flambeau River and Meadowbrook Creek has been carried out by the Dames and Moore consulting firm (Figure 5). The results of their study are summarized below.

Phytoplankton and zooplankton were collected from midway in the water column at the following locations on May 2, 1973:

Station Number	Location	Depth* (meters)
1	0.30 miles west of State Highway 27 bridge near the north bank, 1.60 miles upstream from proposed open pit	1.5
2	Near the west bank across from southwest edge of proposed open pit	1.3
3	Near east bank at mouth of Meadowbrook Creek, 0.45 miles downstream from station 2	0.8
4	0.50 miles east of the Flambeau in Meadowbrook Creek, immediately west of State Highway 27	0.5
5	0.95 miles downstream from station 2, on south bank near entrance of intermittent drainage ditch, approximately 0.30 miles north of proposed waste containment area	1.2
6	3.90 miles downstream from station 2 near southeast bank	1.5

*All depths were recorded in spring during a period of high flow.

Sixty-six species of phytoplankton were identified. Fifty species were diatoms. The diatoms not only dominated the species list, but also comprised over 50% of the cells in most of the samples. Species of the diatom genera Fragilaria, Melosira, Navicula and Nitzschia were common in all samples. None of the species commonly occurring in the samples is considered to be a pollution-tolerant or pollution-indicative organism.

Thirteen zooplankton taxa were identified including two copepods, two protozoans and seven rotifers. The rotifers were the dominant organisms in the samples taken.

Plankton quantities were relatively low at all locations. Plankton abundance and distribution were probably influenced by the weather conditions at the time of sampling. These included abnormally high water levels, low water temperature and low solar illumination.

Benthic organisms were collected at the six locations previously described (Figure 5) between April 26 and May 4, 1973. Approximately 80 different species were identified. The chironomids, trichopterans and ephemeropterans were represented by 27, 11 and 10 different species respectively. The chironomids dominated all the quantitative samples, comprising from 41.3% to 50.2% of the total benthos. Total density of organisms ranged from a low of 248 organisms/m^2 at station 6 to 800 organisms/m^2 at station 1.

Fish were sampled at ten locations in the Flambeau River using fyke nets and in Meadowbrook Creek with a 110-volt AC shocker. Fifteen species were collected. Seven species were taken in the fyke nets and ten species by electrofishing. Minnows dominated the catch from Meadowbrook Creek. Northern pike, which were not collected in the Dames and Moore survey, have been taken from Meadowbrook Creek during past WDNR surveys. No one species was predominant in the collections from the Flambeau River. The total number of fish collected in the Flambeau River was very low. This was probably due to a low survey gear efficiency. However, it appears that the fish populations in the river near the proposed mine site are somewhat limited by a lack of instream cover, and fluctuating water levels during spawning seasons.

An electrofishing survey of the Thornapple Flowage (impoundment on the Flambeau River below the mine site) was conducted by the WDNR in May of 1972. Eleven species were collected. Black bullheads were the most abundant species followed by walleyes. A list of the fish species which have been collected in the Flambeau River during the Dames and Moore and various WDNR surveys is given in Table 13.

The lake sturgeon is classified as a threatened species by the U. S. Fish and Wildlife Service. This classification applies to species which are not in immediate danger of extinction but whose numbers have been depleted or are decreasing at an alarming rate. The lake sturgeon population in Wisconsin is considered to be relatively stable.

1.7.0 MAN-MADE FEATURES

The transportation network through the project site consists basically of State Highway 27, County Highway P, and township roads (Figure 1). State Highway 27 running north-south intersects the proposed mining property for 1¼ miles and is tangent to it for an additional 1½ miles; County Highway P runs east-west intersecting the property for 1½ miles. There is approximately ¼ mile of city street tangent to the property on the north and township roads are tangent for approximately 1¼ miles. The principal motor vehicle traffic is along State Highway 27 which is an all-weather two-lane highway in good condition.

The Wisconsin Department of Transportation studied traffic flows in the area during 1973. The average daily traffic count on State Highway 27 between Ladysmith and County Highway P was 2,090. The traffic count on County Highway P was 150. FMC conducted traffic

TABLE 13

FISH OF THE FLAMBEAU RIVER BETWEEN LADYSMITH AND THE THORNAPPLE DAM

Family Common Name	Scientific Name
Acipenseridae	
Lake sturgeon	Acipenser fulvescens Rafinesque
Catostomidae	
White sucker	Catostomus commersoni (Lacepede)
Shorthead redhorse	Moxostoma macrolepidotum
Centrarchidae	
Black crappie	Pomoxis nigromaculatus (Lesueur)
Bluegill	Lepomis macrochirus Rafinesque
Pumpkinseed	Lepomis gibbosus (Linnaeus)
Rock bass	Ambloplites rupestris (Rafinesque)
Smallmouth bass	Micropterus dolomieui (Lacepede)
Cyprinidae	
Blacknose dace	Rhinichthys atratulus (Hermann)
Common shiner	Notropis cornutus (Mitchill)
Creek chub	Semotilus atromaculatus (Mitchill)
Emerald shiner	Notropis atherinoides Rafinesque
Hornyhead chub	Nocomis biguttatus (Kirtland)
Longnose dace	Rhinichthys cataractae (Valenciennes)
Northern red-belly dace	Phoxinus eos (Cope)
Redside dace	Clinostomus elongatus (Kirtland)
Esocidae	
Muskellunge	Esox masquinongy (Mitchill)
Northern pike	Esox lucius Linnaeus
Gadidae	
Burbot	Lota lota (Linnaeus)
Ictaluridae	
Black bullhead	Ictaluras melas (Rafinesque)
Channel catfish	Ictaluras punctatus (Rafinesque)
Percidae	
Johnny darter	Etheostoma nigrum Rafinesque
Walleye	Stizostedion vitreum vitreum (Mitchill)
Yellow perch	Perca flavescens (Mitchill)
Percopsidae	
Trout-perch	Percopsis omiscomaycus (Walbaum)

counts in April and June 1973. The results of this survey are presented in Table 14 and Figure 15. The densities are normal for these types of highways and, except for late afternoon, no significant overloading was recorded.

TABLE 14

TRAFFIC DENSITIES ON STATE HIGHWAY 27 AND COUNTY HIGHWAY P, GRANT TOWNSHIP, RUSK COUNTY

	State Highway 27	County Highway P
Highest hourly density/hour	306/4:00 PM	26/12:00 noon
Lowest hourly density/hour	2/4:00 AM	0/1:00-5:00 AM 9:00-11:00 PM
Average hourly density	105	7.33
Total vehicles in 96 hours	10,035	704

Tracks of the Soo Line Railroad run through the northeast corner of the project site (Figure 1). This is the principal rail connection between Chicago-Milwaukee and Superior-Duluth.

A 34-inch crude-oil pipeline, owned by Lakehead Pipe Line Company, Inc., crosses the project site diagonally in a northwesterly direction, buried approximately three feet below the surface (Figure 1). The 80-foot-wide pipeline right-of-way crosses the Flambeau River approximately 1,340 feet southwest of the mouth of Meadowbrook Creek, continues across the project site, and crosses under State Highway 27 north of its intersection with County Highway P.

Lake Superior District Power Company has a 33 KV line which follows the railway line; they also have numerous branch lines distributed about the project site as shown in Figure 16. Wisconsin Telephone Company line distribution is also shown.

Located on FMC's holdings are several farms, year-round household units and a township hall, each with its own well (Figure 17).

1.8.0 HISTORICAL AND ARCHAEOLOGICAL FEATURES

1.8.1 HISTORICAL FEATURES

The Wisconsin State Historical Society has not recorded any archaeological activity sites in the entire Town of Grant. There are no historic sites in Rusk County listed in the National Register of Historic Places. However, seven buildings within the county have been suggested to the society as candidates for the Register; none of these buildings are in Grant Township. Photographs of buildings which have been or are planned to be razed on the project site were forwarded to

FIGURE 15

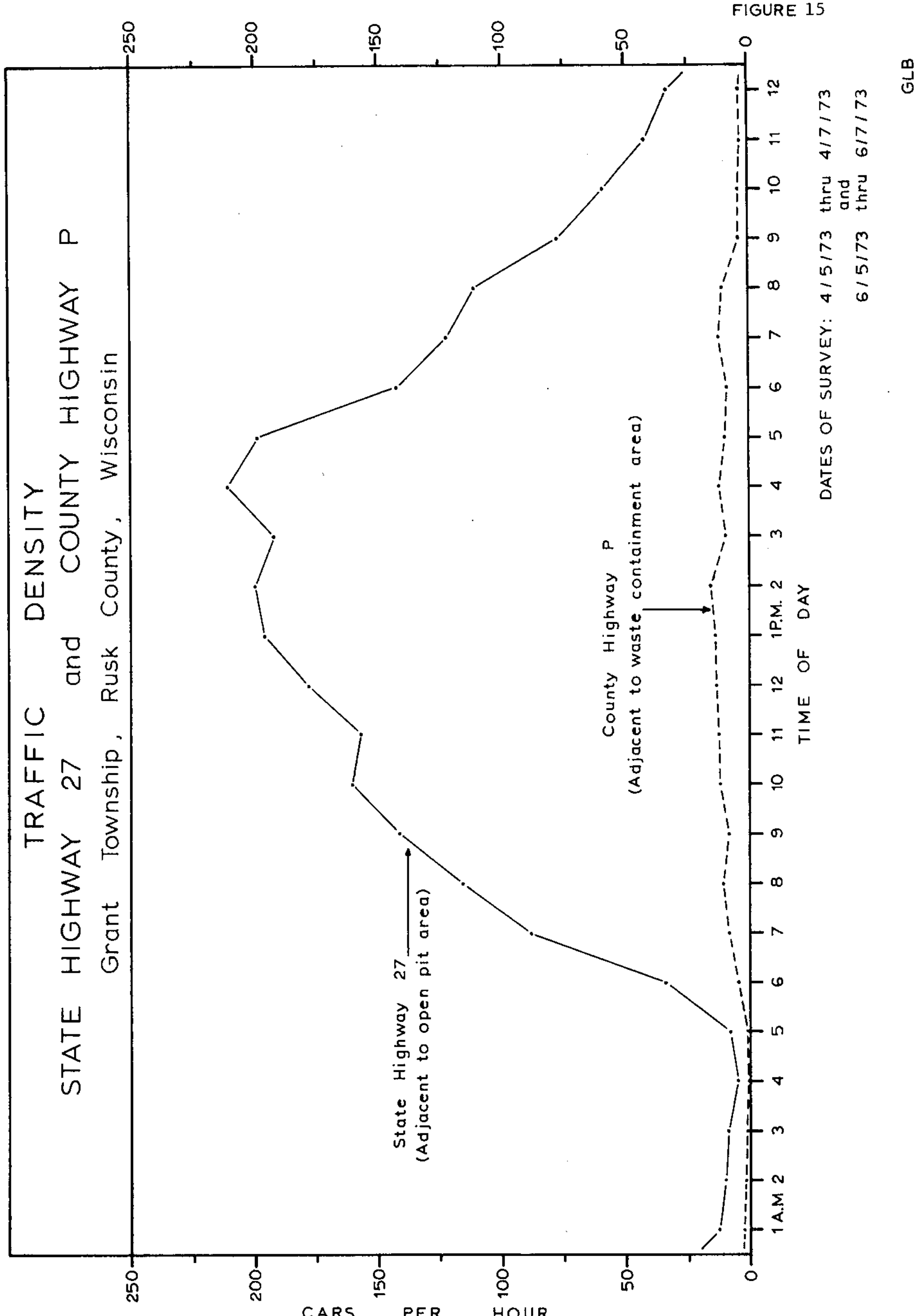
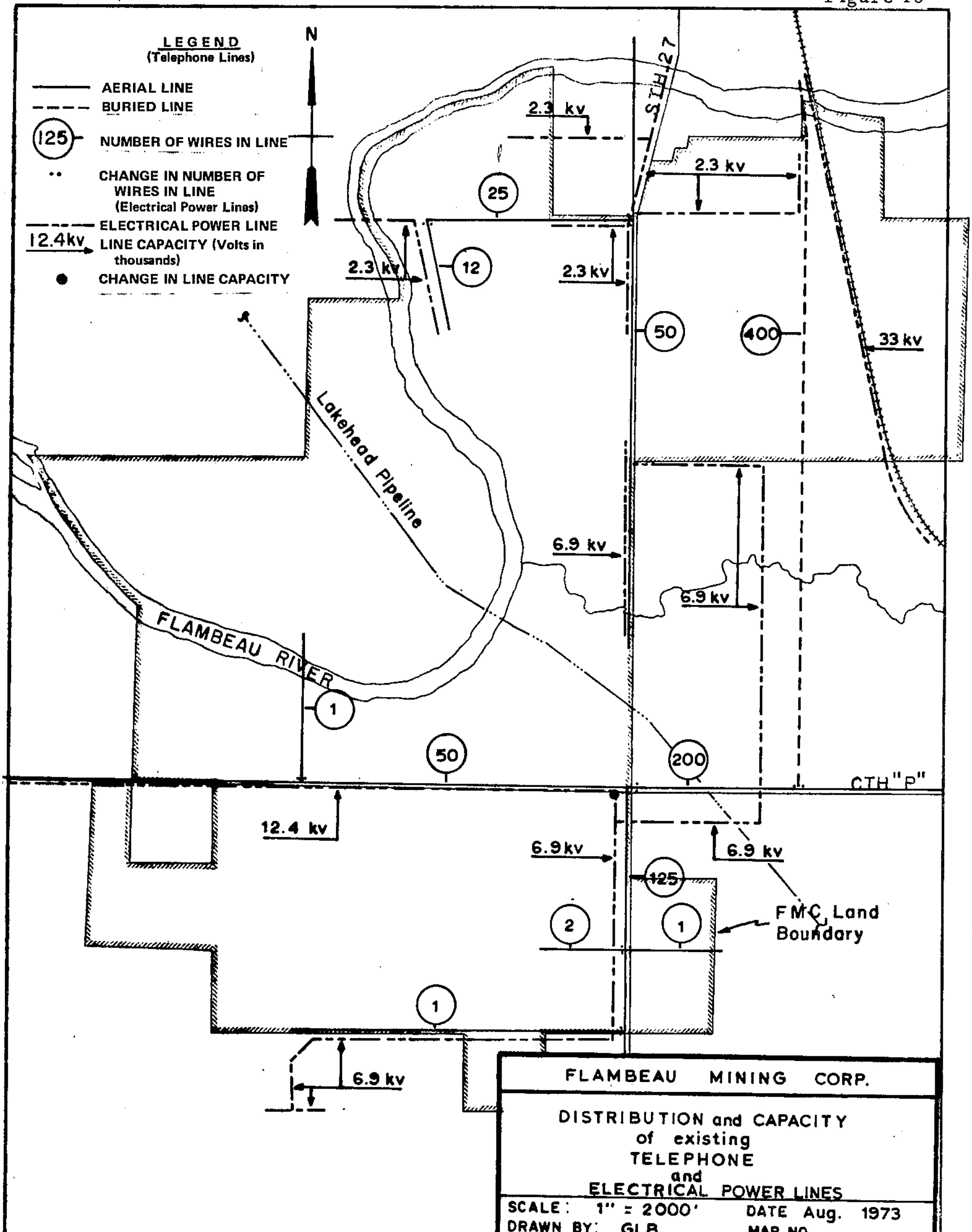
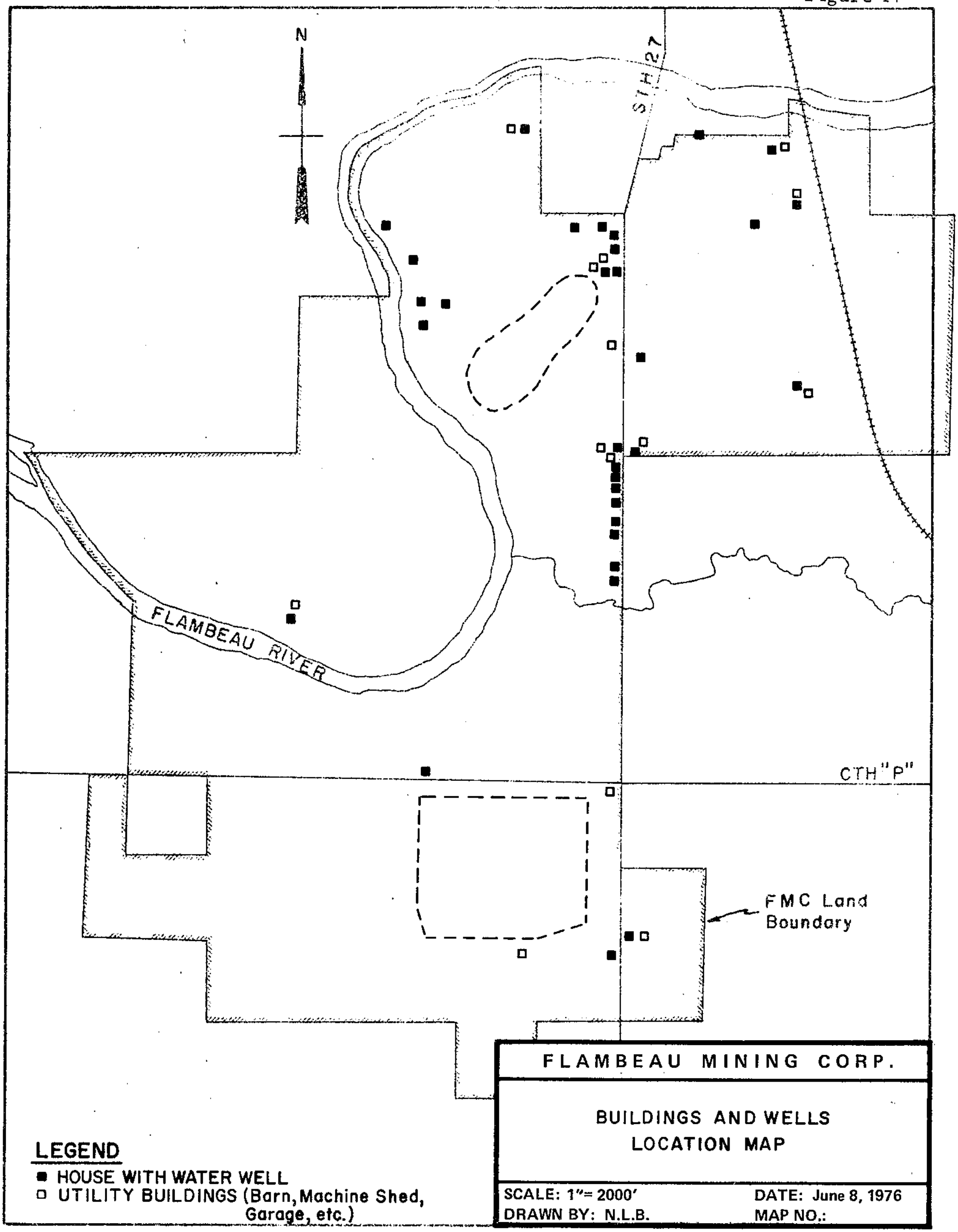

TRAFFIC DENSITY
STATE HIGHWAY 27 and COUNTY HIGHWAY P
Grant Township, Rusk County, Wisconsin
State Highway 27
(Adjacent to open pit area)
County Highway P
(Adjacent to waste containment area)
CARS PER HOUR
250
200
150
100
50
0
1A.M. 2
3
4
5
6
7
8
9
10
11
12
1P.M. 2
TIME OF DAY
DATES OF SURVEY: 4/5/73 thru 4/7/73
and
6/5/73 thru 6/7/73
GLB

Figure 16



LEGEND
(Telephone Lines)
AERIAL LINE
BURIED LINE
125 NUMBER OF WIRES IN LINE
CHANGE IN NUMBER OF WIRES IN LINE
(Electrical Power Lines)
ELECTRICAL POWER LINE
12.4kv LINE CAPACITY (Volts in thousands)
CHANGE IN LINE CAPACITY
N
STH 27
2.3 kv
25
2.3 kv
12
2.3 kv
2.3 kv
50
400
33 kv
Lakehead Pipeline
6.9 kv
6.9 kv
FLAMBEAU RIVER
1
50
200
CTH "P"
12.4 kv
6.9 kv
6.9 kv
125
2
1
FMC Land Boundary
1
6.9 kv
FLAMBEAU MINING CORP.
DISTRIBUTION and CAPACITY of existing TELEPHONE and ELECTRICAL POWER LINES
SCALE: 1" = 2000'
DATE Aug. 1973
DRAWN BY: GLB
MAP NO.

Figure 17


N
STH 27
FLAMBEAU RIVER
CTH "P"
FMC Land Boundary
FLAMBEAU MINING CORP.
BUILDINGS AND WELLS LOCATION MAP
SCALE: 1"= 2000'
DATE: June 8, 1976
DRAWN BY: N.L.B.
MAP NO.:
LEGEND
■ HOUSE WITH WATER WELL
□ UTILITY BUILDINGS (Barn, Machine Shed, Garage, etc.)

the State Historic Preservation Officer for his determination of their eligibility for inclusion in the National Register of Historic Places. The State Historical Society has indicated that no sites of historical significance would be affected by the project.

1.8.2 ARCHAEOLOGICAL FEATURES

FMC employed a qualified archaeologist, Dr. William McHugh then of the Department of Anthropology, University of Wisconsin, Milwaukee, to conduct a search for evidence of prehistoric sites on the project area. A study of aerial photographs, interviews with local residents and collectors, foot traverses, soil phosphate testing in selected areas, searches for disturbed plant habitat indicators, and test pits were used in a search for activity sites. Special attention was given to likely locales such as the bluffs along the Flambeau River and the areas along Meadowbrook Creek. One flake of chert was found along the eroded north shoreline of the Flambeau in Section 17 (Figure 1), but it did not show any evidence of either manufacture or utilization. Interviews with residents revealed two small, local collections reported to have come from lands within the project site, and one small collection from just west of the project site. These collections indicate some prehistoric aboriginal activity in the area.

Two specimens were obtained from the north end of the project site. Both are made of Hixton Silicified Sandstone which originates at an aboriginal quarry site near Hixton, Wisconsin, some 100 miles to the south. A side-notched projectile point indicates a Late Archaic time period (2,000 BC - 1,000 BC). A bifacially worked knife suggests the presence of an activity area in this locale, but sod covering the field precluded a surface survey.

Most of the onsite artifacts came from the northeast corner of FMC land holdings and west of the Soo Line around a now-filled ancient lake. This area is now grown up in sod which did not permit a close examination of the surface. The overwhelming majority of artifacts are projectile points which indirectly indicate that a substantial amount of prehistoric hunting activity occurred around the shores of this small lake. Projectile point typology indicates the presence of Late Archaic (2,000 BC - 1,000 BC), Early Woodland (1,000 BC - 500 BC), Middle Woodland (500 BC - AD 500), and Late Woodland (AD 500 - AD 1,400) activity around this small lake. Several of the small points are made of locally available quartzite but the others are made of chert foreign to the project site area.

Artifacts have also been recovered from the Flambeau shoreline one-half mile west of the project site. These include a large scraping plane, a lamellar flake and a stemmed point which are made of Hixton Silicified Sandstone. A Middle Woodland time period (500 BC - AD 500) is suggested by these artifacts.

A second more detailed archaeological survey was conducted by Joseph Tiffany from the University of Wisconsin, Eau Claire (Exhibit C). Plowed fields were examined, old fields were plowed on a regular spacing, and forested areas surveyed by test pits on a predetermined grid system. It was concluded from this survey that "...no further archaeological work is necessary in the areas to be disturbed." It was suggested "...to avoid the possibility of further intensive excavation, that the alternate railroad spur right-of-way be moved south or abandoned due to its seeming proximity to the Drum site." The south route has been selected for this reason and also because it provides the shortest distance between the mainline and the plant with minimum cut-and-fill (Figure 1).

The archaeological surveys of the Flambeau project area determined that prehistoric cultural activities have indeed left traces in the form of artifacts from the project area. Physical survey of selected parts of the area failed to locate any of the specific locales of prehistoric human activity.

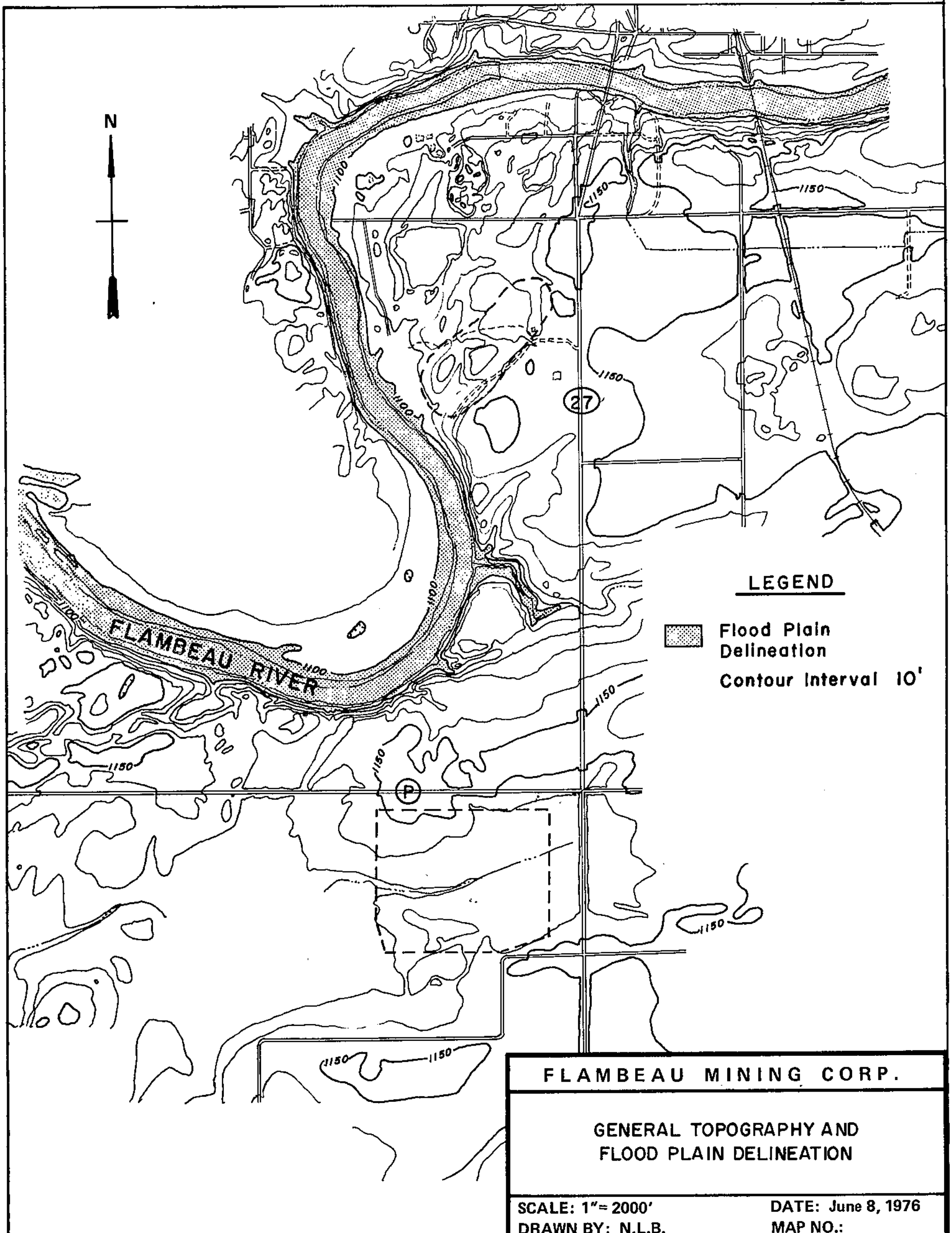
1.9.0 FLOODPLAIN DELINEATION

Flood elevations and flows for a 100-year reoccurrence flood have been estimated from data provided by the Big Falls gage station. From the data, a 22,500 cfs* 100-year flow has been predicted. Using this flow data in volume comparison to a cross section drawn along the proposed pit axis, it is evident that the river could rise to an elevation of 1,098 (Figure 4) or come within two feet of overlapping into the west end of the open pit. To prevent river flood waters from entering the pit, a small compacted earth fill dike is proposed as shown on Exhibit A.

The 100-year reoccurrence flood of 22,500 cfs is predicted by KCC's Metal Mining Division Engineering Center to crest at the 1,098 elevation. This flood elevation figure is in close agreement with data provided by the Department of Housing and Urban Development Flood Hazard Boundary Map H-OZ, November 1975, that shows a flood would raise the Flambeau River to an approximate elevation of 1,100 feet in the southwest corner of Ladysmith city limits located less than one mile upstream of the proposed open pit (Figure 18). The flood analysis was developed from Conger's method using a river velocity of 4.5 feet per second and the flow area measured from Figure 4. By balancing flow and velocity, it was determined that the maximum crest would reach to 1,098 feet. However, the crest would be lower than 1,098 if river velocity were greater than 4.5 feet per second during the 100-year flood. Velocities measured at Ladysmith in January 1975 averaged 4.62 feet per second during a low-flow period along a representative stretch of river downstream of the Ladysmith Dam.

*Conger, Duane H., Estimating Magnitude and Frequency of Floods in Wisconsin, U.S.G.S., Water Resource Division, Open File Report, Madison, Wisconsin, 1971.

Figure 18



N
FLAMBEAU RIVER
1100
1150
27
P
LEGEND
Flood Plain Delineation
Contour Interval 10'
FLAMBEAU MINING CORP.
GENERAL TOPOGRAPHY AND FLOOD PLAIN DELINEATION
SCALE: 1"= 2000'
DATE: June 8, 1976
DRAWN BY: N.L.B.
MAP NO.:

1.10.0 CHARACTERISTICS OF PROJECT SITE

1.10.1 CLIMATIC AND METEOROLOGICAL

The project site is located in a humid continental (cool summer phase) climatic belt which stretches from New England, through the Great Lakes states, into south central Canada. The winters are long, snowy and cold while the summers are relatively short with a few short periods that are hot and humid.

Weather observation data are available for Weyerhauser which is located 18 miles west of Ladysmith (U. S. Department of Commerce, 1961). Limited data are also available from the Ladysmith Ranger Station. A summary of temperature and precipitation data is presented in Table 15.

TABLE 15

TEMPERATURE AND PRECIPITATION

	Temperature (°F)				Precipitation (inches)		
	Monthly Mean		Extremes at Weyerhauser		Monthly Mean		Greatest Daily
	W*	L**	High	Low	W*	L**	W*
January	12.4	9.3	54	-41	0.77	2.18	1.06
February	15.5	14.1	58	-37	0.77	1.09	0.90
March	26.5	27.3	79	-26	1.31	1.95	1.08
April	42.6	43.4	87	4	2.48	2.36	3.20
May	54.8	53.9	107	21	3.62	3.46	3.10
June	63.7	64.1	98	30	4.92	5.71	2.66
July	68.5	67.7	109	39	3.90	4.49	3.70
August	66.5	65.4	102	34	4.14	3.17	4.06
September	57.5	57.2	99	21	3.42	4.12	2.70
October	46.8	47.8	86	6	2.22	3.35	2.53
November	30.6	31.3	77	-13	1.63	1.79	1.90
December	17.6	19.7	62	-30	0.92	2.06	1.44
Year	42.0	41.8	109	-41	30.10	35.73	

* W - Weyerhauser (U. S. Department of Commerce, 1961)
**L - Ladysmith (1965-1971 only) (Ladysmith Ranger Station)

The long-term monthly mean temperature at Weyerhauser varies from a low of 12.4°F in January to a summar high of 68.7° in July. The lowest temperature recorded at Ladysmith in recent years was -33° and the maximum was +94°. The minimum-maximum range recorded at Weyerhauser is -41° to +109°.

Wind data are not available for Weyerhauser. Data interpolation from Minneapolis and Wausau should approximate the long-term wind patterns. The prevailing winds are westerly from late fall through early spring and from southerly and westerly directions the remainder of the year. April and May are the windiest months, and July and August are the least windy. Wind direction and velocity at Ladysmith have been measured from April 1 to October 1 during recent years. Wind direction during those months is summarized in Figure 19. The highest monthly average wind velocity is 11 mph during May and the lowest average wind velocity is 7.9 mph during August.

1.10.2 SCENIC

No rare or particularly unusual landforms have been identified within the area controlled by FMC. The banks of the Flambeau River do have scenic value.

1.10.3 RECREATIONAL USE

There are increasing pressures on recreational resources in all of Wisconsin. Rusk County does not possess a well developed recreational base and much of the tourist trade bypasses the county for the lake areas to the northwest.

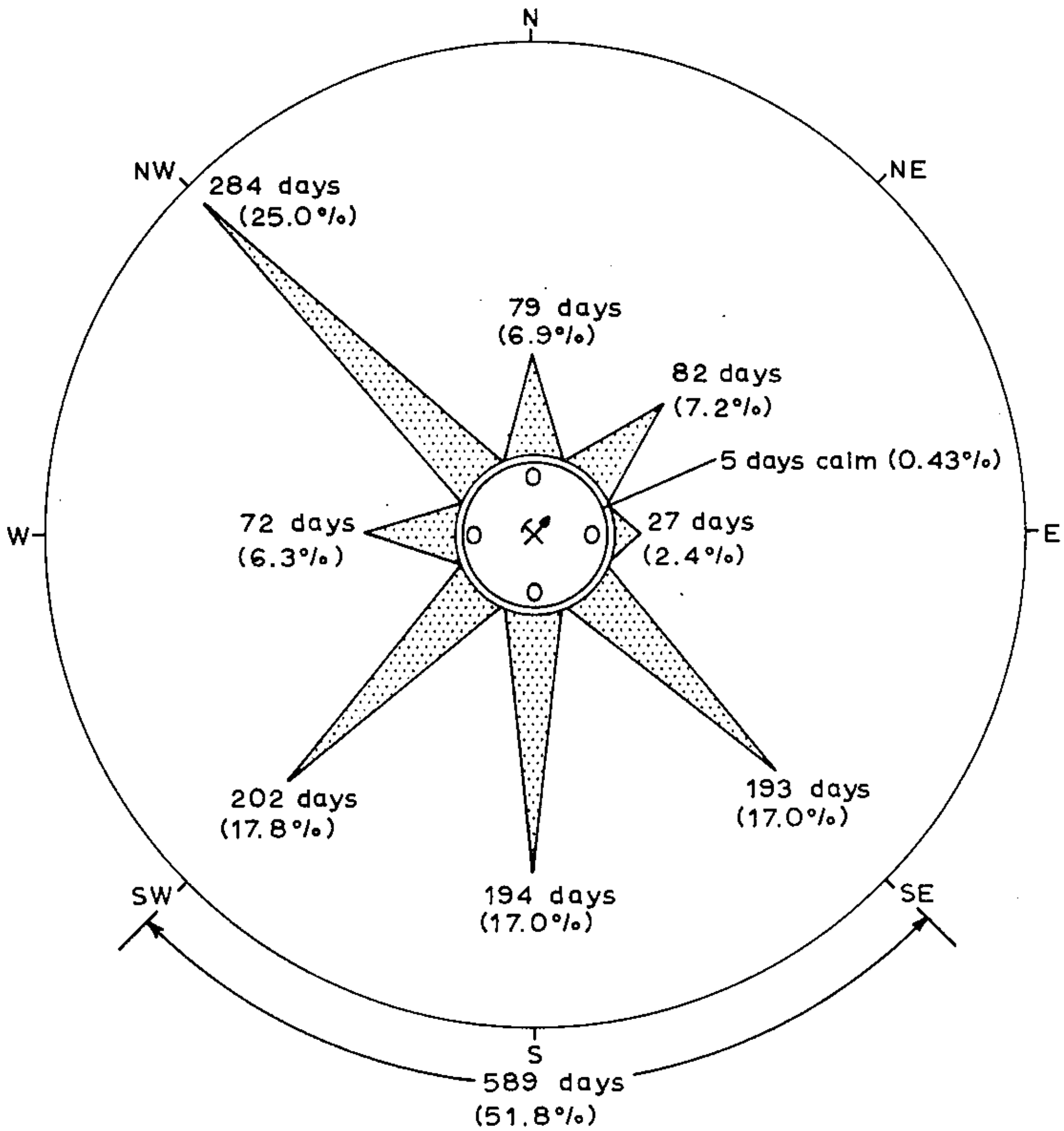
The nearest federal recreation land is that block of the Chequamegon National Forest in Taylor County. Brunet Island State Park in Chippewa County 23 miles south of the project site is the closest state park. The Flambeau River which flows through the project site is designated as part of the Chippewa River Water Trail. The southern end of the Flambeau River State Forest is located in the northeast corner of Rusk County less than 20 road miles from Ladysmith. There are five state wildlife areas in Rusk County with a total of 2,297 acres. The 1,044-acre Silvernail Wildlife Area is located north of Ladysmith. The WDNR maintains a public access site at the former Port Arthur Dam.

The county and some local municipalities provide lands for outdoor recreation. About 85,000 acres of the locally administered land is county forest land. Land entered under the Forest Crop Law is also open to public hunting and fishing. This amounts to over 20,000 acres.

Approximately eight river miles north of the proposed mine site is the Dairyland Reservoir, formed by a hydroelectric dam built in 1951 which encompasses 2,000 acres. Approximately 17 road miles south of the site is a large hydroelectric dam built in 1948 which has created the Holcombe Flowage with 112 miles of shoreline extending up the Jump and Chippewa Rivers. These areas are developing with many year-round "summer" homes and some resort facilities. The Thornapple Flowage just south of the project site is not heavily used for recreation.

The number of lodging rooms available in Rusk County in 1973 for tourists was 250 with a statewide total of 75,750. The largest of these facilities are classified as small motels with less than 30 rooms. The number of available rooms was 0.33% of the total in the state, which is essentially equal to the population percentage, indicating that the economy of the area is not greatly influenced by tourism.

Figure 19



NOTES:

Data collected at Ladysmith Ranger Station

1138 days recorded*

*Records were kept for the months April thru October only

FLAMBEAU MINING CORP.

WIND DIRECTION
1965-1971

SCALE	NONE	DATE	Jun. 1976
DRAWN BY	GLB	MAP NO.	

There is little recreational use associated specifically with the area of the project site, except that which occurs on the river course through the property, i.e., canoeing and fishing. In the uplands there is some hunting, trapping and berrypicking.

1.10.4 HISTORICAL AND ARCHAEOLOGICAL FEATURES

Historical and archaeological features have been described in Sections 1.8.1 and 1.8.2 on pages 50, 54 and 55.

1.10.5 AIR QUALITY

Rusk County is located in the Northwest Wisconsin - Duluth Minnesota Interstate Air Quality Control Region. There has been no long-term air quality monitoring in Rusk County.

Air quality in Ladysmith can be assumed to be similar or better than that of Eau Claire (population 44,619) for which air quality data exists. A summary of air quality data and the National Ambient Air Quality Standards is presented in Table 16. From these data it appears that ambient air quality near the mine site would comply with current standards. FMC is installing four air monitoring stations (see Section 3).

1.10.6 NOISE

Three surveys of background noise levels were taken at 27 sites (Table 17). These 27 sites were chosen to obtain and document the necessary background levels which exist at the present time. They completely circumscribe the operating property and are in populated areas that might be affected by extraneous noise introduced by FMC. These average noise levels indicated generally elevated noise levels when the Ladysmith Sand and Gravel processing plant was in operation and are listed on both the dBA and dBC scales. However, there were no noise levels during the three surveys that exceeded the presently accepted standard of 90 dBA.

1.10.7 WATER QUALITY AND QUANTITY

1.10.7.1 SURFACE WATER

A generalized description of the Flambeau River system flow rates, wetlands distribution and local water uses may be found in Section 1.3.1 on pages 9 through 13 and on Figures 4 and 5.

The Flambeau River is required to meet the water quality standards for recreation, and fish and aquatic life of Chapter NR102 of the Wisconsin Administrative Code. There are seven major discharge points in the Flambeau River basin, all of which are above the mine site.

TABLE 16

AIR QUALITY AT EAU CLAIRE AND NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Averaging Time	Primary Standard**3	Secondary Standard**4	Eau Claire ($\mu g/m^3$) 1974	Eau Claire ($\mu g/m^3$) 1973
Particulate matter	Annual (Geometric Mean)	75 µg	60 µg[1]	25.66	25.38
	24 hour	260 µg*	150 µg*	82.40	61.70
Sulfur Oxides (SO_x) (measured at SO_2)	Annual (Arithmetic Mean)	80 µg (0.03 ppm)	--------	8.19	4.28
	24 hour	365 µg (0.14 ppm)*	--------	76.30	34.90
	3 hour	---------	1,300 µg (0.05 ppm)*	-----	-----
Carbon Monoxide (CO)	8 hour	10 mg (9 ppm)*	Same as primary	-----	-----
	1 hour	40 mg (35 ppm)*	Same as primary	-----	-----
Hydrocarbons (HC) (nonmethane measured as CH_4)	3 hour (6 to 9 a.m.)	160 µg (0.24 ppm)*2	Same as primary	-----	-----
Nitrogen Dioxide (NO_2)	Annual (Arithmetic Mean)	100 µg (0.05 ppm)	Same as primary	25.20	-----
Photochemical Oxidants (O_x) (measured as O_3)	1 hour	160 µg (0.08 ppm)*	Same as primary	44.80	-----

**Concentration in weight per cubic meter (corrected to 25° C and 760 mm of Hg)

*Concentration not to be exceeded more than once per year

1As a guide to be used in assessing implementation plans in achieving the 24-hour STD.

2As a guide in devising implementation plans to achieve oxidant standards

3Primary standards are designed to protect public health

4Secondary standards are designed to protect public welfare

Source: Air Quality Data Summary
Wisconsin Department of Natural Resources
1973, 1974

TABLE 17
BACKGROUND COMMUNITY NOISE DATA

Reading No.	Location	1. dBC	2. dBC	3. dBC	1. dBA	2. dBA
1	Rest Home Parking Lot	68.3	72.7	73.0	51.3	55.3
2	Southeast Corner of Hospital Bldg.	72.7	82.3	74.0	56.0	60.7
2A	West end of Hospital Bldg.	69.5	76.3	71.3	48.5	54.3
3	Northeast of College Bldg.	73.3	71.0	68.0	48.7	48.7
4	South of College Bldg.	72.0	82.0	72.3	51.3	62.0
4A	North of College Bldg.	60.0	78.7	72.7	40.0	45.7
4B	West of College Bldg.		76.7	74.0		50.0
5	Northwest of College Dormitory	73.3	79.0	73.3	52.3	59.0
5A	STH 27 - South end of Bridge	63.5	71.3	70.3	46.5	54.7
5B	North of local Sand & Gravel Co.'s Ready Mix Plant		87.7	72.3		69.7
5C	East of local Sand & Gravel Co. crusher - Behind Tree Screen		64.3	66.0		61.3
6	Northeast of Gravel Screen	74.7	86.7	76.7	59.0	77.3
7	East of Gravel Screen	72.7	85.7	78.0	56.3	80.7
8	East of Gravel Crusher	73.3	90.7	87.0	52.7	83.3
9	South of Gravel Crusher	69.0	83.3	82.7	46.7	72.3
10	West of Gravel Crusher	66.0	91.3	91.7	46.7	88.0
10A	STH 27 - Northeast of Proposed Pit	69.0	72.3	62.6	46.0	54.7
11	North end of former Rusk Co. Gravel Pit	70.0	77.3	70.0	46.7	50.3
12	South end of former Rusk Co. Gravel Pit	65.3	68.7	58.7	47.3	44.0
13	STH 27 - North end of Proposed Pit	73.0	75.7	64.0	52.0	52.3
14	STH 27 - Plant Access Road	76.0	71.7	73.3	53.0	45.7
15	Haul Road - 1000 feet South of Proposed Pit	54.0	51.7	50.3	41.7	40.0
16	Haul Road - 3000 feet South of Proposed Pit	57.7	47.3	52.0	44.0	40.0
16A	STH 27 - East of Haul Road	69.0	69.7	66.7	53.0	49.7
17	CTH "P" - East Side of Haul Road Crossing	75.0	72.7	70.0	53.0	48.0
18	CTH "P" - West Side of Haul Road Crossing	75.0	72.7	72.7	52.3	45.0
19	CTH "P" NW Corner of Proposed Waste Containment Area	67.0	55.3	58.7	47.3	40.0
20	South Side of Proposed Waste Containment Area	69.0	64.7	62.3	47.0	41.7
21	STH 27 - East Side of Proposed Waste Containment Area	66.3	57.7	54.3	47.3	43.3
22	Town Road and Soo Line R.R. Tracks N.E. of Proposed Pit (Without Train)	68.7	66.0	62.0	44.0	46.7
22A	Town Road and Soo Line R.R. Tracks N.E. of Proposed Pit (With Train)	84.0			55.0	
23	STH 27 East of Proposed Haul Road			60.3		
24	STH 27 East of Proposed Pit			59.0		
25	West Bank of Flambeau River Across from local Sand & Gravel Co.			48.0		
26	West Bank of Flambeau River Across from West end of Proposed Pit			51.7		
27	STH 27 at Hospital (without traffic)			62.0		
28	STH 27 at Hospital (with traffic)			99.0		

(See Footnotes: 1., 2., 3., 1., 2. for the columns above)

FOOTNOTES:
1. All readings taken without local Sand and Gravel Co.'s Crusher Running and without tree leaves. Reading Dates: April 4, 1973 and April 5, 1973
2. All readings taken with local Sand and Gravel Co.'s Crusher running and without tree leaves. Reading Dates: May 10, 1973 and May 11, 1973.
3. All readings taken with local Sand and Gravel Co.'s Crusher running and with tree leaves. Reading Dates: June 21, 1973 and June 22, 1973.

NOTE: Wind screen was not used on meter and wind speeds varied from 8 mph to 17 mph.
NOTE: dBC and dBA readings listed under columns 1, 2 and 3 are an average of three (3) readings taken at separate times.
NOTE: dBA is a weighted measurement which closely reflects the human ear's perception of sound. dBC is a measurement of peak levels of noise.

Table 18 summarizes these major effluent sources. The effluent sources which most directly affect the surface water quality at the mine site are the City of Ladysmith sewage treatment plant and the Peavey Paper Mill discharge.

The WDNR did water quality sampling of the Flambeau River near the project site in 1969. The results of that year's survey are presented in Table 19.

FMC has conducted more detailed water quality analysis along the Flambeau River since April 1970 and continues to the present. The sampling stations are shown on Figure 5. The results of the survey from 1970 to June 1973 are presented in Table 20.

The survey results show that, generally, state water quality standards are satisfied. However, there are significant concentrations of iron, manganese, nitrate and phosphates.

Hardness: The water is considered to be soft or moderately soft. Total hardness ($CaCO_3$) averages less than 50 mg/l, total alkalinity (biocarbonates) less than 40 mg/l and the pH is within a neutral range and meets state standards.

Dissolved Oxygen: The dissolved oxygen (DO) content varied mainly with seasonal changes of temperature and remained above the 5 mg/l minimum standard with the exception of the Ladysmith sewage effluent.

Solids: More than half of the total solids (total residue) in the river were volatile or probably organic in nature. Increases in total, suspended and volatile solids immediately downstream from the Ladysmith sewage outfall as well as increases in soluble phosphorus, chlorides, BOD and fecal coliform counts document that organic effluents are being introduced from the sewage treatment plant.

Phosphorus: Soluble phosphorus may be a limiting factor for plant growth during certain periods of the year. The required range of available phosphorus for growth of most algal species is 0.01 to 0.05 mg/l. Soluble phosphorus concentrations in the Flambeau average 0.04 mg/l with a minimum concentration of 0.006 mg/l.

Available Nitrogen: Although the technique used for nitrate analysis is regarded as inaccurate, the estimated nitrate concentrations appear quite normal for stream waters of this type. However, the ammonia values are excessively high. In oxygenated systems, ammonia is converted to nitrites or nitrates and a concentration of more than 0.1 mg/l is indicative of organic pollution. In the Flambeau system, the excessive ammonia levels present may reflect the decay of organic matter in the oxygen-poor waters of wetlands tributary to the river. Deposits of peat and other materials are abundant in backwater areas of the Flambeau River and the man-induced water level changes in this

TABLE 18

MAJOR DISCHARGE IN THE FLAMBEAU RIVER BASIN

Source	Type of Waste	Treatment	Average Daily Discharge Gal./Day	BOD5 (lbs.)	T.S.S.* (lbs.)	Date
City of Ladysmith	Sewage	Secondary	541,000	125	103	4/75
Peavey Paper Mills	Paper	Fiber Recovery	1,612,000	1,765	1,905	3/75
City of Park Falls	Sewage	Secondary	614,000	133	---	4/75 10/69
Flambeau Paper Company	Sulfite Pulp and Paper	Fiber Recovery, Evaporation & Disposal	6,650,000	17,051	10,808	3/75
Mercer S.D. #1	Sewage	Secondary	38,000	14	---	10/69
Village of Butternut	Sewage	Lagoon	190,000	30	33	10/69 4/75
City of Phillips	Sewage	Secondary	281,700	79	95	4/75

*Total Suspended Solids

Source: Upper Chippewa River Pollution Investigation Survey - DNR - 1970; Unpublished Self Monitoring Reports, 1975

TABLE 19

DNR WATER QUALITY SURVEY - 1969

Location	Date	BOD mg/l	Temp. °C	pH	DO mg/l	MFFCC Per 100 ml
Dairyland Dam	6/24/69	1.2	18	7.3	7.5	< 5
	8/12/69	<1.0	24	7.3	5.6	< 5
	9/10/69	3.0	21	7.4	6.1	< 5
State Hwy "8" Bridge	1/29/69	<1.0	0	6.8	8.3	5
	6/25/69	1.5	18	7.2	7.2	35
	8/12/69	1.2	24	7.2	5.1	20
Peavey Dam	1/29/69	<1.0	0	6.8	8.4	< 5
	6/25/69	1.8	18	7.3	7.2	240
	8/12/69	1.5	24	7.1	5.1	20
	8/19/69	2.5	23	6.9	5.8	---
Peavey Paper Mills	1/29/69	75.0	9	8.1	9.5	<10,000
	6/26/69	43.0	26	7.7	7.7	< 5
	8/19/69	165.0	28	7.4	6.6	<10
County Hwy "G" Bridge	1/29/69	1.2	0	6.8	9.3	< 5
	6/26/69	2.5	19	6.7	7.9	20
	8/19/69	2.0	22	7.2	5.2	30
	10/22/69	2.0	13	7.4	4.5	5
Ladysmith Sewerage Outfall	1/29/69	33.0	7	7.4	6.9	480,000
	6/26/69	31.0	20	7.2	4.3	320,000
	8/19/69	21.0	22	7.3	3.6	89,000
	10/21,22/69	25.0	--	7.5	---	---
State Hwy "27" Bridge	1/29/69	2.4	0	6.8	10.3	900
	6/26/69	<1.0	19	7.2	7.7	220
	8/19/69	2.0	23	7.3	6.2	270
	10/22/69	1.0	12	7.1	10.4	5
Port Arthur Dam	1/29/69	1.5	0	6.8	9.3	160
Thornapple Dam	6/26/69	<1.0	18	7.2	7.4	470
	8/19/69	1.5	24	7.3	7.2	5

TABLE 20

SURFACE WATER QUALITY SURVEY
FLAMBEAU MINING CORPORATION

	Stations 1	2	4	5
Temperature [°C]*	11.0 0.0-26.0	10.9 0.0-26.0	11.0 0.0-26.0	11.9 0.0-26.0
Dissolved Oxygen*	8.8 6.3-13.4	9.5 6.9-14.0	9.1 6.7-14.6	9.6 6.6-14.1
pH [Standard Units]*	6.7 6.5-7.0	6.7 6.5-7.2	6.7 6.5-7.1	6.8 6.5-7.2
pH [Standard Units - Lab]	7.2 6.6-8.2	6.9 6.6-8.0	7.2 6.8-8.6	7.2 6.6-7.7
Carbonates ($CaCO_3$)	0	0	0	0
Bicarbonates ($CaCO_3$)	37.1 5-60	34.9 15-76	37.8 13-79.1	35.5 14-56
Total Hardness ($CaCO_3$)	45.7 11.5-77.0	47.6 8.7-90.0	49.4 7.7-87.0	48.3 9.6-83.0
Total Solids	116 45-254	138 60-306	119.3 50-245	106.7 15-200
Total Volatile Solids	49.2 3-90	68.1 3-206	63.4 4-137	56.8 8-139
Suspended Solids	6.0 1-20	16.3 1-176	5.4 1-11	5.9 1-10
Suspended Volatile Solids	3.2 0.5-10	12.5 0.8-174	2.8 0.5-6	2.8 1-4
Color [Standard Units]	76.6 20-140	77.1 50-120	79.3 25-200	77.8 50-150
Ammonia Nitrogen (N)	<0.01-1.20	<0.01-0.80	<0.01-0.50	<0.01-0.88
Nitrate Nitrogen (N)	<0.01-1.00	<0.01-0.85	<0.01-0.80	<0.01-1.00
Organic Nitrogen (N)	<0.01-7.20	<0.01-3.90	<0.01-3.80	<0.01-2.00
Total Phosphorus (P)	<0.02-0.50	<0.02-0.42	<0.02-0.80	<0.02-0.26
Soluble Phosphorus (P)	<0.006-0.16	<0.006-0.16	<0.006-0.12	<0.006-0.12
Chlorides	7.3 2.0-50.0	8.8 2.3-60.0	7.8 1.9-50.0	8.0 2.2-50.0
Sulfates	7.0 0.8-15.0	6.5 0.7-11.0	6.2 0.6-11.0	5.7 0.6-11.0
Surfactants	<0.01-0.07	<0.01-0.06	<0.01-0.07	<0.01-0.10
BOD (5-day)	1.8 0.7-4.1	4.1 0.8-43.0	1.9 0.2-4.0	2.1 0.2-4.0

TABLE 20 (cont'd)

Iron	<0.04-2	<0.04-6	<0.04-6	<0.04-6
Manganese	<0.025-0.8	<0.025-0.4	<0.025-0.2	<0.025-0.1
Zinc	<0.01-4.80	<0.01-0.45	<0.01-3.90	<0.01-2.40
Copper	<0.01-0.40	<0.01-0.40	<0.01-0.80	<0.01-0.05
Arsenic	<0.01-0.05	<0.01-0.05	<0.01-0.05	<0.01-0.05
Phenol [ug/l]	<1-18	1.9 0.16-8	1.5 0.16-2	<1-6
Odor [Threshold No.]	1.3 1-4	1.5 1-8	1.2 1-4	1.6 1-8
Hexane Extraction	5.2 0.2-14	4.5 0.2-10	3.7 0.3-13	5.2 0-10
Fecal Coliform Count [no./100 ml]	22 0-127	1.387 41-10,000	245 0-890	420 1-2,100

*These parameters were measured in the field.

Note: The upper values in the table are an average and the lower values are the range. No mean values are presented for parameters which had concentrations below the detection levels of the tests.

Note: All values are in mg/l unless otherwise indicated.

stretch of the river cause large fluctuations which periodically flush water out of these areas of anaerobic decomposition and ammonia production. Total available nitrogen is not a limiting factor for plant growth in the river.

Heavy Metals: Reported levels of heavy metals varied considerably in the company testing.

Arsenic: Concentrations of arsenic greater than 0.05 mg/l constitute a hazard in the marine environment. Levels less than 0.01 mg/l present minimal risk of deleterious effects (EPA, 1972). The concentrations reported in the water quality study were quite consistent and appear to be normal for this environment. Arsenic does not appear to be detrimental in its present concentrations.

Iron and Manganese: Average levels of these metals were not found to be unusual for this drainage basin, but the excessive variation between samples is noteworthy. Concentrations in excess of 0.3 mg/l constitute a hazard to marine life and are aesthetically displeasing to humans due to the effects on the taste of the water if it is consumed. At times iron concentrations exceed recommended standards. Levels below 0.05 mg/l present minimal risk of deleterious effects to marine life (EPA, 1972).

Zinc and Copper: Values of up to 4.8 ppm zinc and 0.40 ppm copper were reported. Such concentrations could have retarded diatoms and other algal species growth. At an average hardness concentration of the Flambeau and 22° Centigrade, 4.29 mg/l of zinc would reduce the growth of a diatom population by 50%; however, at 30° Centigrade, only 1.32 mg/l produces the same effect. Therefore, the zinc concentrations of 4.8 and 3.9 mg/l reported from stations 1 and 4 respectively, during July 1970, probably had an adverse effect. Lower values of 1.2 and 2.4 mg/l zinc were recorded during June 1970. Copper in excess of 0.15 mg/l produces a noticeable effect on Scenedesmus (algal species). Copper sulfate concentrations as low as 0.05 mg/l have been found to be harmful to certain algal species. Toxic effects may have been present during April and May 1970 when concentrations exceeded the indicated harmful values.

Fecal Coliforms: Coliform counts vary considerably in both surveys. Downstream of the Ladysmith sewage outfall, fecal coliform counts alone regularly exceed the 200/100 ml total coliform standard established for recreational use. This could constitute a public health hazard for swimming (Wisconsin Administrative Code NR102).

The water quality of Stream G (see Figure 5) is much lower than the Flambeau River itself. Dissolved oxygen concentrations met state standards only twice during the survey. Total solids averaged 260 mg/l higher than at the highest station on the Flambeau. Suspended solids averaged 91 mg/l higher, total iron averaged 2.74 mg/l higher, soluble phosphates averaged 0.26 mg/l higher, total volatile solids averaged 72 mg/l higher, chlorides averaged 1.8 mg/l higher, color averaged 80 s.u. higher, hexane extraction averaged slightly higher, nitrates averaged higher by 0.26 mg/l, and odor averaged slightly higher than the Flambeau River. This tributary is a very small stream flowing through a swampy area. At times during the warmest months, the company had difficulty in taking samples because of the extremely low stream flow. The decaying vegetation in the area no doubt contributed much to these results. Besides stagnation, no conclusion other than the different nature of the drainage area is drawn from the relatively poor water quality shown by the survey.

The excessive variation of several water quality parameters plus man-caused water level changes in the Flambeau result in a mixed water quality. Poorest water quality exists immediately downstream from Ladysmith, as a result of the combined effluents from the municipal sewage treatment plant, the paper mill, and the water level fluctuations. Fecal coliform counts and dissolved oxygen were the only parameters that might frequently fail to meet state water quality standards. Copper and zinc concentrations may be harmful to plant and invertebrate populations during certain times of the year. Iron concentrations may also be harmful to aquatic life.

Lowered water levels, due to the removal of the Port Arthur Dam, coupled with spring runoff and man-caused surges resulting from power generation above the mine site, combine to physically disrupt the river ecosystem. Periodic flushing of stagnant waters from shoreline areas could be one cause of the high levels of ammonia and heavy metals that appear in the river waters both above and below the project site. However, although specific river flow rates were not taken during sampling of the Flambeau River, there is no correlation between high iron concentrations and high river flows, the season of the year, or sampling point location on the river. Heavy metals associated with scattered areas of mineralization in the greenstone belts that are contacted by groundwaters could also be drawn into the river when the water levels are lowered. It is quite clear that the ecological condition of the river at present is unstable.

1.10.7.2 GROUNDWATER

A description of groundwater conditions, aquifer types, soils, observation wells and well testing has been described in Section 1.3.2, pages 13 through 24, and illustrated on Figures 6 through 8B.

FMC has sampled groundwater quality at the proposed mine area and at the proposed waste containment area. The results of this survey at the mine site are presented in Table 21. In all wells iron and manganese levels exceeded the respective recommended standards of 0.3 mg/l and 0.05 mg/l established by the U. S. Public Health Service (USPHS) and by Chapter NR111, Wisconsin Administrative Code, as the recommended acceptable levels for potable water supplies (for aesthetic reasons). Copper, zinc and lead were also present in excess of normal background levels. Test wells 40 and 41 were found to average more than 1.0 ppm of copper which exceeds state and

ANALYSES OF GROUNDWATER WELLS, MINE SITE, FLAMBEAU DEVELOPMENT PROJECT,
LADYSMITH, WISCONSIN

ANALYSIS[6]	TEST WELL NUMBERS						
	6[1]	14[1]	17[3]	18[4]	29[2]	40[5]	41[5]
pH (Standard Units)	7.1 6.9-7.2	6.2 5.8-6.7	6.7 6.5-6.9	6.7 6.3-6.9	6.4 6.0-6.6	6.2 6.1-6.4	6.2 5.9-6.3
pH (S.U. - Laboratory)	7.2 6.9-7.6	6.5 6.0-7.6	7.1 6.6-7.6	6.6 6.3-7.0	6.6 6.1-7.2	6.8 6.1-7.6	6.4 6.1-6.7
Total Hardness ($CaCo_3$)	191 170-206	43 28-72	99 92-110	90 80-112	54 40-92	63 44-104	76 62-88
Total Solids	250 170-330	110 20-320	165 15-550	124 80-176	105 60-195	101 10-143	146 65-250
Nitrate Nitrogen (N)	0.6 0.2-2.3	0.2 0.1-0.5	0.3 0.3-1.2	1.4 0.8-1.8	0.5 0.3-0.8	0.7 0.4-1.0	0.4 0.1-0.8
Sulphates	<1-11	4.2 0.1-10	3.8 2-5	3.5 0.2-12	4.4 0.1-9.0	16.2 8-32	16.5 11.32
Aluminum ug/l	<1-<6	<1-<6	<6	<1-<6	<1-<6	<0.5-<6	<0.5-<6
Arsenic	<.01-<.05	<.01-<.05	<.05	<.01-<.05	<.01-<.05	<0.01	<0.01
Barium	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Boron	<.02-.06	<.02-.04	<.02	<.02-.02	<.02-.03	.14 .02-.24	.13 .06-.24
Cadmium	<.001-<.02	<.001-<.02	<.01-<.02	<.001-<.02	<.001-<.02	<.001-<.02	<.001-<.02
Chromium	<.02	<.02	<.02	<.02	<.02	<.02-0.2	<.02-.15
Copper	<.025-<.05	<.025-<.05	<.025-<.05	<.025-<.05	<.025-<.05	1.01 .025- 2.35	1.17 .025-4.35
Fluoride	<.02-.14	<.02-<.08	<.02	<.02-<.08	<.02-<.08	0.09 .02-.14	0.10 .02-.14
Iron	8.4 1.1-12	5.5 1.1-13	<.025-8	1.3 1.5-3.5	11.6 7.4-18.5	33.3 31-100	21.1 10-48
Lead	<.001-<.1	<.001-<.1	<.001-<.05	<.001-<.05	<.001-<.1	.250 .001-1.000	0.100 .001-.400
Magnesium	17.8 15.3-42	4.4 1.2-14	6.6 4.5-10	9.8 6-17	8.7 .3-42	9 7-16	9 6-10
Manganese	<.025- .51	<.025-0.7	<.025- .18	<.02- .06	<.025- .5	<.03- .63	0.99 .78-1.29
Mercury ug/l	<1	<1	<1	<1	<1	<1	<1
Molybdenum	<.001-<.4	<.001-<.4	<.001-<.4	<.001-<.4	<.001-<.4	<.001	<.001
Nickel	<.01-<.05	<.01-<.05	<.01-<.05	<.01-<.05	<.01-<.05	<.01-.18	<.01-.15
Selenium	<.01-<.3	<.01-<.3	<.01-<.3	<.01-<.3	<.01-<.3	<.01	<.01
Silver	<.01-<1	<.01-<1	<.01-<1	<.01-<1	<.01-<1	<.01	<.01
Zinc	.86 .17-1.32	<.025- .06	<.005-<.01	<.025- .06	<.005-2.3	.14 .07-.23	0.20 .09-.51

[1]Sampling commenced July 1971 [2]Sampling commenced September 1971 [3]Sampled July 1971 to December 1971
[4]Sampling commenced January 1972 [5]Sampling commenced December 1972 [6]All values are in mg/l unless indicated otherwise
[7]The lower values are the range. The upper values are the mean. In some cases; mean values are not applicable since some true values were below the detection limits of the applicable tests.

federal drinking water standards. The same wells also had high lead levels which exceeded the drinking water standard based on health considerations of 0.05 mg/l. Fecal coliform were found in all wells, but these test results are considered invalid because of the well construction (Figure 7).

The presence of high levels of zinc, copper and lead in several wells indicates interaction with the orebody, as does the pattern of pH recorded for the test wells. Wells 6, 40, 41, 29 and 17, sited at points across the strike of the orebody and progressively down the hydraulic gradient, had average pHs of 7.1, 6.2, 6.2, 6.4 and 6.7 respectively. The trend established by these data indicates interaction of groundwater with the orebody as the waters move down slope across the body and then recovery by dilution and soil attenuation to near neutrality in the sands and gravels to the northwest (Figure 20). Since there is also some groundwater movement to the southwest along the strike of the orebody, it is likely that this groundwater containing high concentrations of heavy metals is not diluted prior to entering the Flambeau River.

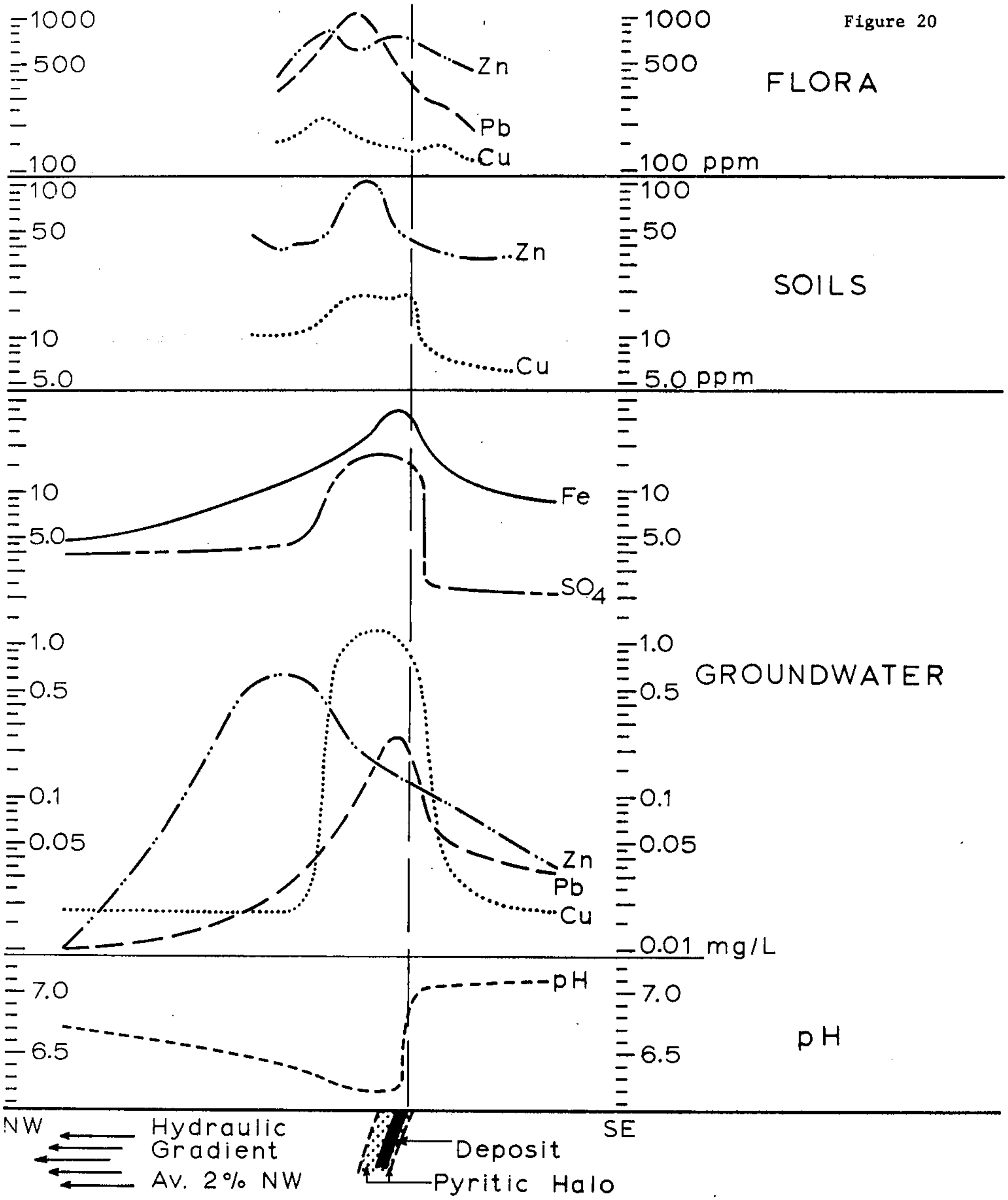
Groundwater conditions in the waste containment area have been described under Section 1.3.2 of this report on pages 15, 21, 22, 23 and 24 and illustrated on Figures 8 through 8B.

Groundwater quality in the waste containment area is somewhat different than at the mine area. In all wells sampled, iron and manganese levels exceeded the USPHS and WDNR aesthetic standards for potable water. Color and odor also exceeded the USPHS and WDNR aesthetic standards for drinking water in the very limited testing for these parameters. Total hardness is a potentially objectionable quality in all of the wells. Individual samples from wells 21 and 27 (Figure 8) showed dissolved solids concentrations above the USPHS recommended upper limit of 500 mg/l. The base metal content of all wells sampled was relatively low and is believed to approximate local background levels. The best water quality of the area was observed in well 26, located in an area underlain by permeable sand-sized materials. All wells sampled in the waste containment area possessed coliform bacteria at some test period. Although the levels were lower than those of the mine area, the test results are thought to be unreliable because of well construction. The results of the company's water quality analysis from all wells in the waste containment area are summarized in Table 22.

1.10.8 VEGETATION

FMC has undertaken the monitoring of vegetation downgradient from the proposed waste containment area to determine the background levels of heavy metal concentrations. Copper, lead and zinc have been monitored to date. Plants that have deep root systems and those that require a rather moist environment were sampled. Average metal concentrations along each of the five transects and one plot studied are reported in Table 23 and are shown on Figure 13.

Figure 20



IDEALIZED CROSS SECTION
RELATIONSHIPS BETWEEN FLAMBEAU DEPOSIT
and its
ENVIRONMENT

TABLE 22

GROUNDWATER QUALITY WASTE CONTAINMENT AREA

Analysis	#21	#24	#26	#27
Aluminum, ug/l Al	<6	<6	<6	<6
Arsenic, mg/l As	<0.05	<0.05	<0.05	<0.05
Barium, mg/l Ba	<0.2	<0.2	<0.2	<0.2
Boron, mg/l B	<0.02	<0.02	<0.02	<0.02
Cadmium, mg/l Cd	<0.025	<0.025	<0.025	<0.025
Chromium, mg/l Cr	<0.02	<0.02	<0.02	<0.02
Fluoride, mg/l F	<0.02-0.30	<0.02-0.30	<0.02-0.14	<0.02-0.08
Lead, mg/l Pb	<0.1	<0.1	<0.1	<0.1
	23.0	21.1	17.3	24.3
Magnesium, mg/l Mg	1.5-45.7	2.7-41	1.2-35	1.5-43
Mercury, ug/l Hg	<1	<1	<1	<1
Molybdenum, mg/l Mo	<0.4	<0.4	<0.4	<0.4
Nickel, mg/l Ni	<0.05	<0.05	<0.05	<0.05
Selenium, mg/l Se	<0.3	<0.3	<0.3	<0.3
Silicon, mg/l Si	<1-35	<1-38	<1-40	<1-29
Silver, mg/l Ag	<0.04	<0.04	<0.04	<0.04
Zinc, mg/l Zn	<0.005-23	<0.005-2.7	<0.005-2.0	<0.005-36
5-day BOD, mg/l	0.2-6.6	0.3-7.3	0.1-6.6	0.1-7.2
pH	6.6-9.5	6.6-7.5	6.6-7.8	6.7-7.8
COD, mg/l	<4-9	<4-19	<4-16	<4-13
Sulfate, mg/l SO_4	0.1-14	0.1-19	0.1-16	0.1-36
Total Dissolved	435	299	223	313
Solids, mg/l	55-1334	255-340	65-333	193-700
Total Hardness, mg/l $CaCO_3$	187-240	235-272	75-224	200-276
Calcium, mg/l Ca	23-96.7	34-68.7	11-48	30-59.2
Chlorides, mg/l Cl	1-7	3.5-11	3-11	2-10
Copper, mg/l Cu	<0.05	<0.05	<0.05	<0.05
Iron, mg/l Fe	2.3-64	0.1-24	<0.025-9	<0.025-37
Manganese mg/l Mn	<0.05-2.4	<0.05-1.1	<0.05-0.6	<0.05-0.8
Nitrates, mg/l as N	0.2-1	0.05-1.1	<0.01-0.8	0.05-1.4
Phosphorus, mg/l P	0.145-0.80	0.182-2.04	<0.02-0.33	0.055-0.656

NOTE: Color and odor are not presented due to the limited number of samples taken.

NOTE: Coliform values are not reported due to inaccuracies introduced by well construction.

TABLE 23

AVERAGE METAL CONCENTRATIONS IN VEGETATION
DOWNGRADIENT OF THE WASTE CONTAINMENT AREA

Plant Species	Transect Number I			II			III			IV			V			VI		
	Cu	Pb	Zn	Cu	Pb	Zn	Cu	Pb	Zn	Cu	Pb	Zn	Cu	Pb	Zn	Cu	Pb	Zn
Canada thistle	110	42	300							70	47	306						
Dandelion	134	63	515															
Cattail				47	47	249	52	48	266				48	37	273	72	36	244
Alder				249	95	1083	132	114	1010	279	47	749	153	92	870	196	105	1139
Red-osier dogwood				42	68	231	46	52	282	41	60	182	35	60	182	85	67	356

Note: All concentrations in parts per million

1.10.9 INVERTEBRATES AND FISH

Invertebrates were collected from eight stations on the Flambeau River during July 1975 for the purpose of determining existing concentrations of heavy metals in the vicinity of the copper deposit. These stations were at the same locations as used for surface water sampling (Figure 5). Stations 1, 3 and 4 were located between the pit site and the State Highway 27 bridge. Stations 2, 5, 6, 7 and 8 were located downstream from the pit site. Table 24 gives the species which were collected at the various sites and subsequently analyzed by flame atomic absorption spectrophotometry. The metal concentrations found in the samples are shown in Table 25. In general, these values do not show any relationship to the point of collection above or below the orebody.

An analysis of heavy metal concentrations in seven fish specimens from the Flambeau River was conducted for inclusion in our environmental impact report. The results of this analysis are presented in Table 26. Fish Nos. 1 through 5 were collected immediately below the Peavey Paper Mill dam (3.8 miles upstream from the mine site) and fish Nos. 6 and 7 were taken 3.9 miles downstream from the site.

1.10.10 PHYSICAL AND CHEMICAL

The presence of the massive sulfide orebody is the principal unique physical feature of the project site.

A unique physical-chemical-biological feature involving soils, groundwaters and biota exists concerning heavy metals. Conjecture on the effects of heavy metal accumulation in the flora and fauna of the site appears later in this section. Evidence for migration of metals from the orebody upwards comes from several sources. Test wells 40 and 41 which are between the proposed pit and the Flambeau River show excessive levels of soluble copper (up to 2.35 and 4.34 mg/l copper respectively) (Table 21). Soluble lead in wells 40 (Figure 7) and 41

TABLE 24

BIOLOGICAL IDENTIFICATION OF FLAMBEAU RIVER SAMPLE COMPONENTS PREPARED FOR METAL ANALYSIS

Field Sample No.	Laboratory Sample No.	Species
1	1-1	Crayfish, *Orconectes virilis*,
	1-2	Fingernail clams, *Sphaerium*
2	2-1	Crayfish, *Orconectes virilis*, dry homogenate
3	3-1	Crayfish, *Orconectes virilis*
4	4-1	Snails, *Campeloma*
		Crayfish, *Orconectes virilis*
5	5-1	Crayfish, *Orconectes virilis*, dry homogenate
6	6-1	Fingernail clams, *Sphaerium*
	6-2	Clam, *Fusconaia flava*
	6-3	Clam, *Fusconaia flava*
7	7-1	Clam, *Lampsilis siliquoidea*
	7-2	Clam, *Lampsilis siliquoidea*
	7-3	Clam, *Ligumia recta*
	7-4	Clam, *Ligumia recta*
8	8-1	Snails, *Campeloma*
	8-2	Crayfish, *Orconectes virilis*

TABLE 25

ANALYSIS OF METALS IN INVERTEBRATES

Laboratory Sample No.	Cu	Zn	Mn	Pb	Ni	Co	Cd
1-1	78	158	2,210	6	16	73	1
1-2	4.1	15	220	<0.3	3	< 0.3	< 0.1
2-1	110	170	522	3	7	2.7	0.5
3-1	86	151	690	10	15	26	2
4-1	30	83	420	<0.4	< 0.7	< 0.4	< 0.2
5-1	72	123	589	2	30	2	0.4
6-1	3.7	15	430	<1	< 2	< 1	< 0.4
6-2	7.4	8.8	900	30	13	19	3.0
6-3	30	374	11,700	6.5	2.5	6.8	2.2
7-1	11	10.5	650	47	24	24	5.1
7-2*	4.4	3.5	680	<0.4	1.4	< 0.4	< 0.2
7-3	11	13	1,470	49	20	24	4.9
7-4*	2.5	41	1,570	6	3	2.4	1.2
8-1	17	110	760	6.3	4.6	10	1.3
8-2	90	115	784	1	42	2.1	0.2

1. Collections made July 14-22, 1975 in the Flambeau River downstream from Ladysmith.

2. Values shown are ppm (umg of metal per gram of dry sample), except for samples marked with an asterisk (*) which are ug of metal per gram of wet flesh.

TABLE 26

MINERAL CONCENTRATIONS IN FISH SAMPLES FROM THE FLAMBEAU RIVER

SAMPLE IDENTIFICATION & SPECIES	TOTAL LENGTH (cm)	WEIGHT (grams)	SAMPLE TYPE	DRY/WET RATIO	ARSENIC (ppm) WET	ARSENIC (ppm) DRY	COPPER (ppm) WET	COPPER (ppm) DRY	CHROMIUM (ppm) WET	CHROMIUM (ppm) DRY	MERCURY (ppm) WET	MERCURY (ppm) DRY	MANGANESE (ppm) WET	MANGANESE (ppm) DRY	LEAD (ppm) WET	LEAD (ppm) DRY	ZINC (ppm) WET	ZINC (ppm) DRY
Fish #1 Walleye	37.3	446	Muscle	0.204	<0.01	<0.03	0.34	1.68	0.12	0.60	1.29	6.32	0.24	1.20	0.61	2.99	4.10	20.13
			Liver								>1.00	>3.27						
Fish #2 Walleye	34.7	336	Muscle	0.206	0.02	0.08	0.68	2.72	0.17	0.68	0.74	3.69	0.34	1.35	0.98	3.88	6.06	24.08
			Liver								0.23	0.75						
Fish #3 Walleye	33.1	340	Muscle	0.218	0.01	0.05	6.37	29.2	0.29	1.34	0.52	2.39	0.32	1.46	1.06	4.87	8.81	40.44
			Liver	0.305	<0.26	<0,84	1.72	5,62	1.72	5.62	0.42	1.37	3.43	11.2	6.44	21.1	16.31	53.44
Fish #4 Walleye	28.7	181	Muscle	0.209	0.02	0.08	0.54	2.59	0.49	2.33	1.09	5.22	0.54	2.59	1.63	7.78	5.97	28.53
			Liver								0.49	1.60						
Fish #5 Rock Bass	20.0	164	Muscle	0.212	0.02	0.10	0.43	2.04	0.14	0.68	0.80	3.77	0.72	3.40	2.88	13.6	7.80	36.73
			Liver								0.52	1.70						
Fish #6 Redhorse	57.3	2.58(Kg)	Muscle	0.221	0.02	0.10	0.35	1.58	0.35	1.58	0.73	3.30	0.79	3.55	0.65	2.96	3.76	16.99
			Liver	0.307	<0.07	<0.24	2.41	7.87	1.93	6.30	0.27	0.88	6.75	22.0	7.23	23.6	29.68	97.64
Fish #7 Redhorse	55.5	2.44(kg)	Muscle	0.217	<0.01	<0.03	0.43	2.00	0.29	1.34	0.74	3.41	0.68	3.12	0.60	2.79	3.24	14.93
			Liver	0.249	<0.07	<0.28	3.24	13.02	1.39	5.58	0.30	0.98	6.50	26.0	1.74	6.98	19.02	76.28

averaged 0.25 and 1 ppm respectively. These metal levels exceed USPHS recommendations for well water and are roughly two orders of magnitude greater than normal.

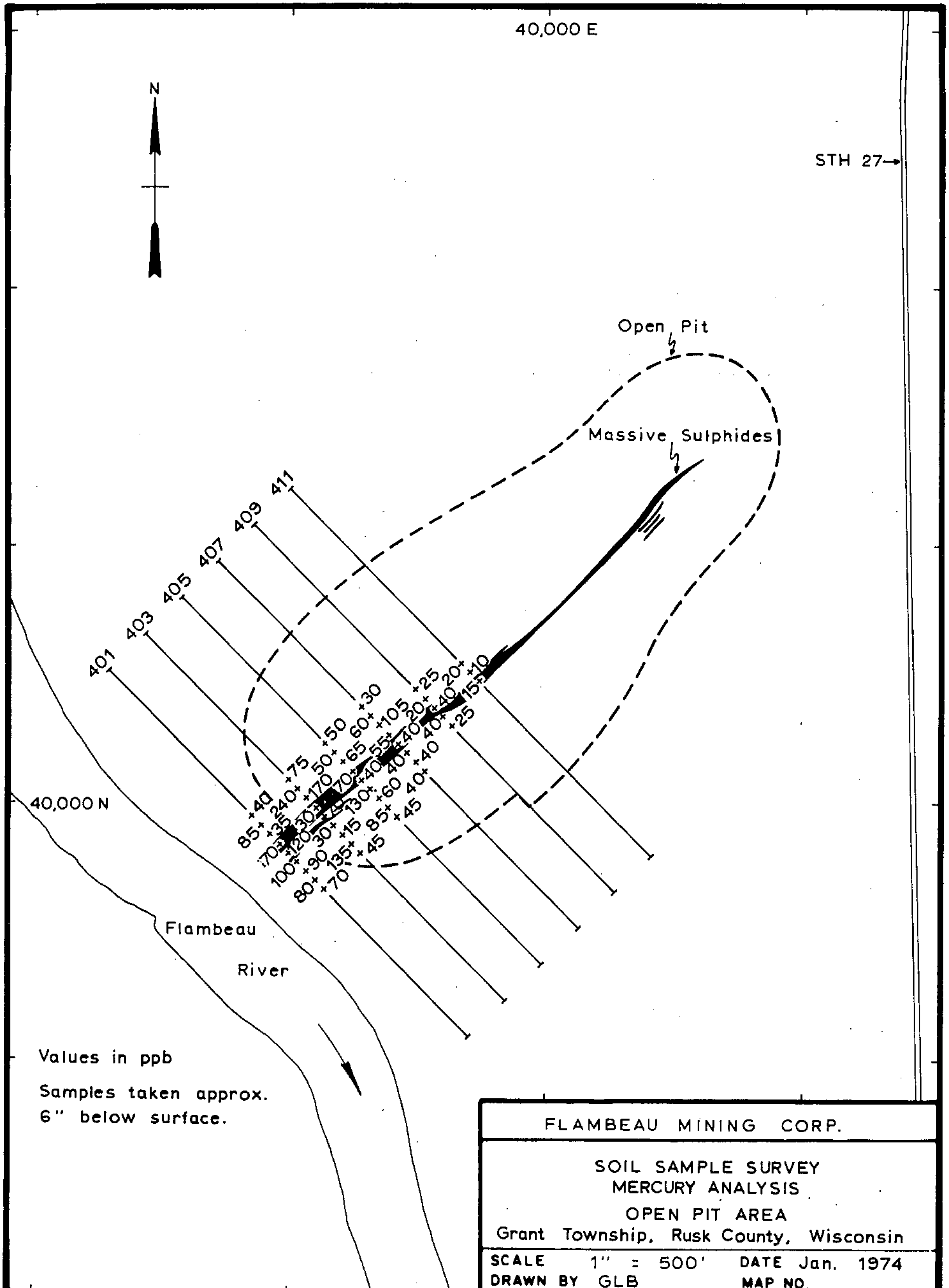
Groundwater flow data indicate a flow pattern from the southeast to the northwest across the orebody, above the saprolite cap and bedrock, toward the Flambeau River. Interaction of groundwater with the orebody releases metal, sulfate and hydrogen ions to the groundwater. Average groundwater pH drops from 7.1 upgradient (southeast) of the orebody to 6.2 at wells 40 and 41 and recovers to 6.7 about 800 feet downgradient (northwest) from the orebody. Copper, zinc, lead, iron and sulfates all rise significantly in groundwater over and downgradient of the orebody.

FMC studies on levels of copper, zinc, lead and mercury in soils of the mine site are highly suggestive that significant interactions of the orebody with the biotic components of the ecosystem are occurring through the soils. Elevated mercury levels reaching a maximum of 240 ppb in the humus layers of the soil appear over and downgradient of the orebody. Mercury levels are especially high near the southwest end of the orebody where the depth of cover thins to 17 feet (Figure 21). The presence of so much of a highly toxic metal in the humified layers of the soils is very suggestive of involvement with the biota as concentrators or movers of this metal.

The levels of lead found in humus layers above the orebody (Figure 22) are quite comparable to those found near highways where there is deposition of particulate lead compounds from automobile exhaust. At the Flambeau site the background level is about 10 ppm, with zones enriched in lead up to 35 ppm found above and to the northwest of the orebody. Similar to mercury, the lead anomalies are concentrated near the Flambeau River and down the hydraulic gradient from the orebody. Little variation was found in deeper soil layers where metal levels were uniformly lower. A significant interaction of the soils with vehicular traffic is unlikely for the Flambeau open pit area.

Copper levels in the soils do not appear to be anomalous (Figure 23). Zinc levels are elevated in some areas, especially near the center of the orebody where sphalerite (ZnS) is found in greater amounts than in the rest of the orebody. Zinc levels (Figure 24) of up to 195 ppm at the open pit area are about 3.4 times background for non-mineralized soils, although the average of all Flambeau samples is only slightly above the average for Upper Mississippi District non-mineralized soils (Table 27).

Figure 21


40,000 E
N
STH 27
Open Pit
Massive Sulphides
401
403
405
407
409
411
40,000 N
Flambeau
River
Values in ppb
Samples taken approx.
6" below surface.
FLAMBEAU MINING CORP.
SOIL SAMPLE SURVEY
MERCURY ANALYSIS
OPEN PIT AREA
Grant Township, Rusk County, Wisconsin
SCALE 1" = 500'
DATE Jan. 1974
DRAWN BY GLB
MAP NO.

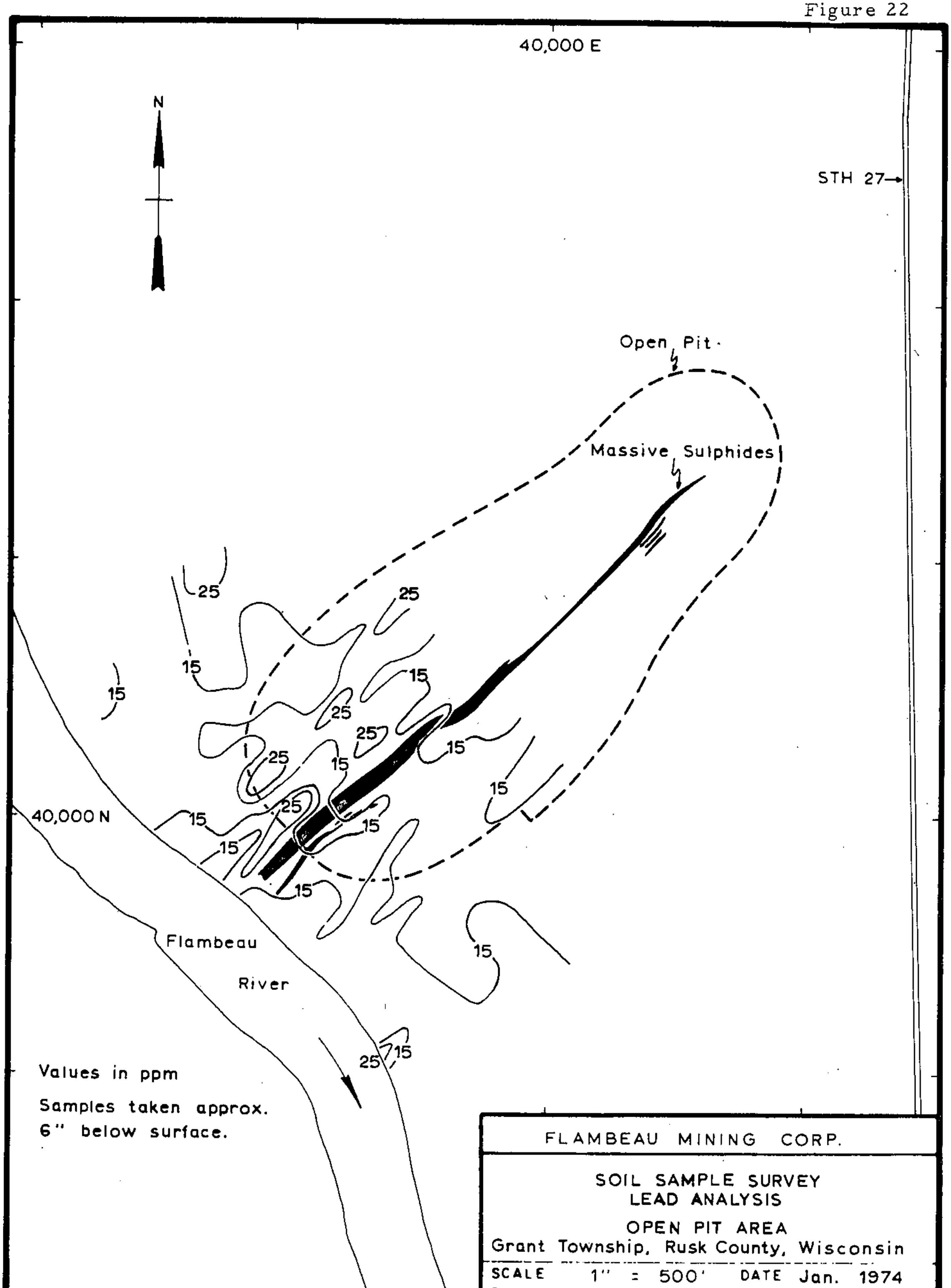
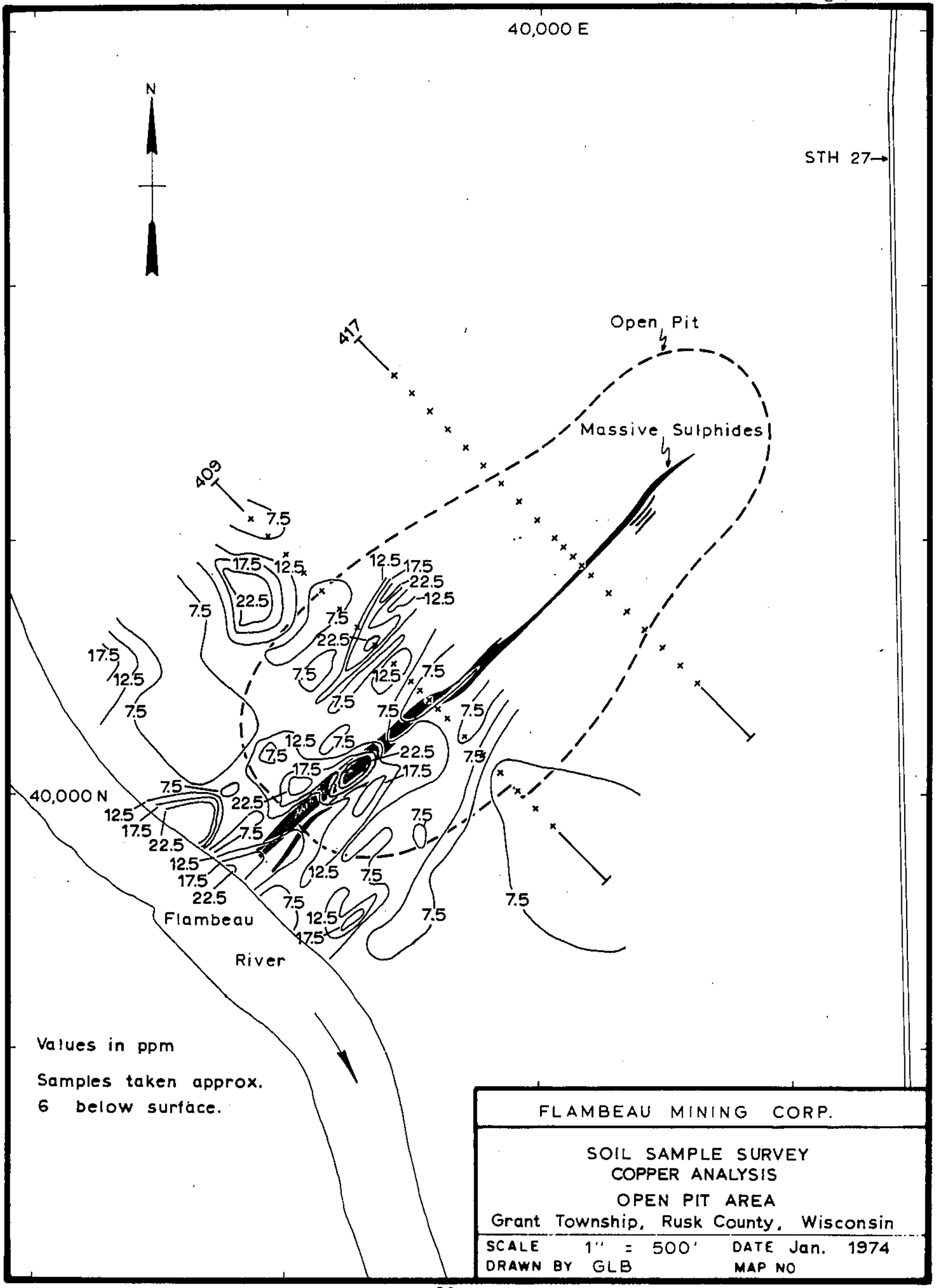

40,000 E
N
STH 27
Open Pit
Massive Sulphides
25
15
40,000 N
Flambeau
River
Values in ppm
Samples taken approx.
6" below surface.
FLAMBEAU MINING CORP.
SOIL SAMPLE SURVEY
LEAD ANALYSIS
OPEN PIT AREA
Grant Township, Rusk County, Wisconsin
SCALE 1" = 500'
DATE Jan. 1974
DRAWN BY GLB
MAP NO

Figure 23


40,000 E
N
STH 27
Open Pit
Massive Sulphides
417
409
40,000 N
Flambeau
River
Values in ppm
Samples taken approx.
6 below surface.
FLAMBEAU MINING CORP.
SOIL SAMPLE SURVEY
COPPER ANALYSIS
OPEN PIT AREA
Grant Township, Rusk County, Wisconsin
SCALE 1" = 500'
DATE Jan. 1974
DRAWN BY GLB
MAP NO

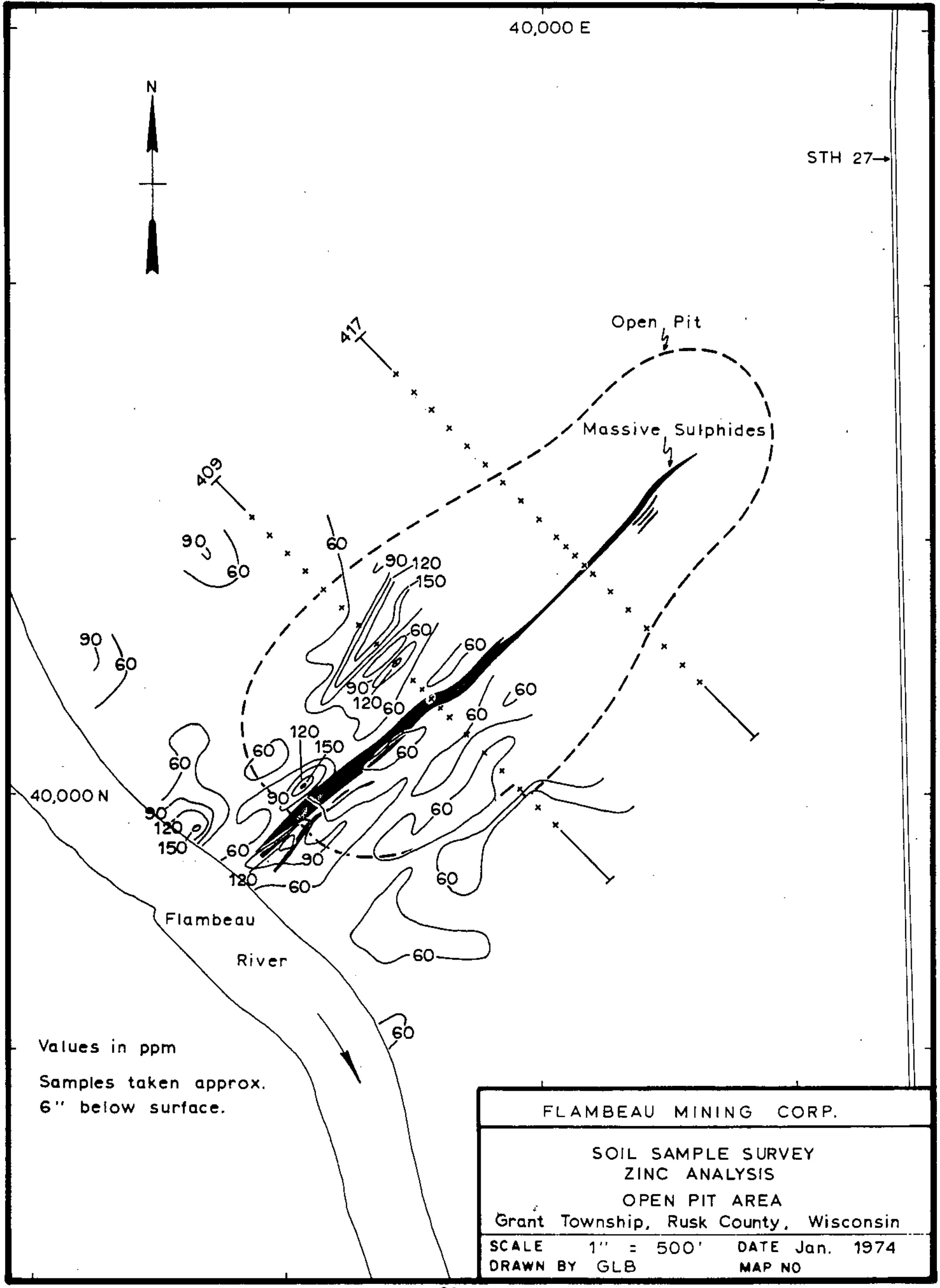

40,000 E
N
STH 27
Open Pit
Massive Sulphides
417
409
40,000 N
Flambeau
River
90
60
120
150
Values in ppm
Samples taken approx.
6" below surface.
FLAMBEAU MINING CORP.
SOIL SAMPLE SURVEY
ZINC ANALYSIS
OPEN PIT AREA
Grant Township, Rusk County, Wisconsin
SCALE 1" = 500'
DATE Jan. 1974
DRAWN BY GLB
MAP NO

TABLE 27

AVERAGE SOIL LEVELS OF HEAVY METALS IN THE UPPER MISSISSIPPI DISTRICT SOILS COMPARED TO THE FLAMBEAU OPEN PIT AREA

Approx. Soil Horizon	In Upper Mississippi District: Mineralized Zones ppm Lead	Zinc	Non-Mineralized Zones ppm Lead	Zinc	On Flambeau Open Pit Area: Lead as ppm	Zinc as ppm	Mercury as ppb	Copper as ppm
A	124	1007	18	58	15	50	61.4	16.2
B	67	114	13	48	16	60.6		
C	117	1019	13	49	11.5	43.5	42.5	11.8

Analysis of the vegetation over the orebody and up and down the hydraulic gradient was performed by selecting a mixed sample of second-year twigs and leaves from a variety of trees characteristic of the vegetation along mine section lines 401, 409 and 411 (Table 28). For location of section lines, refer to Figure 21. The trees across the open pit area vary a good deal with respect to size and species composition. For example, hemlock was not found in section line 411, but was the dominant species in section 401, while a few individuals of this species appeared in line 409. Although the data collected in this ecosystem survey suffers from a lack of species consistency, the levels reported probably represent a truer picture of the community involvement with heavy metals than an examination of any single tree species could.

TABLE 28

SUMMARY OF HEAVY METALS
Residue Data on the Flambeau Open Pit Area
(All data is on a ppm ash weight basis)

Sample Line	Metal	Up Hydraulic Gradient	Down Hydraulic Gradient	Percent Increase Downgradient*	Absolute Percent Increase**
Number sampled		5	10		
	Copper	62	104.8	69	69
411	Zinc	254.2	581.5	129	129
	Lead	114	560.9	392	392
Number sampled		8	22		
	Copper	103.4	167.2	62	170
409	Zinc	500.9	638.9	28	151
	Lead	102.8	525.7	411	361
Number sampled		8	32		
	Copper	91.8	157.4	71	154
401	Zinc	266	526.6	98	107
	Lead	208.3	781.8	275	586

*These percentages are the change within the sample line.

**These percentages are the change between the trees in upgradient 411 (which should have the least interaction with the orebody) with the trees downgradient in the respective sample line.

The most striking anomalies show up with lead. However, in the case of each metal, the downgradient trees always had a higher level of metals than did upgradient trees (Figure 25 and Table 29). The Flambeau open pit area trees ranged from 56 to 484 ppm copper, 87 to 2,130 ppm zinc, and 39 to 3,949 ppm lead.

TABLE 29

SOIL SAMPLE SURVEY
COPPER AND ZINC ANALYSIS

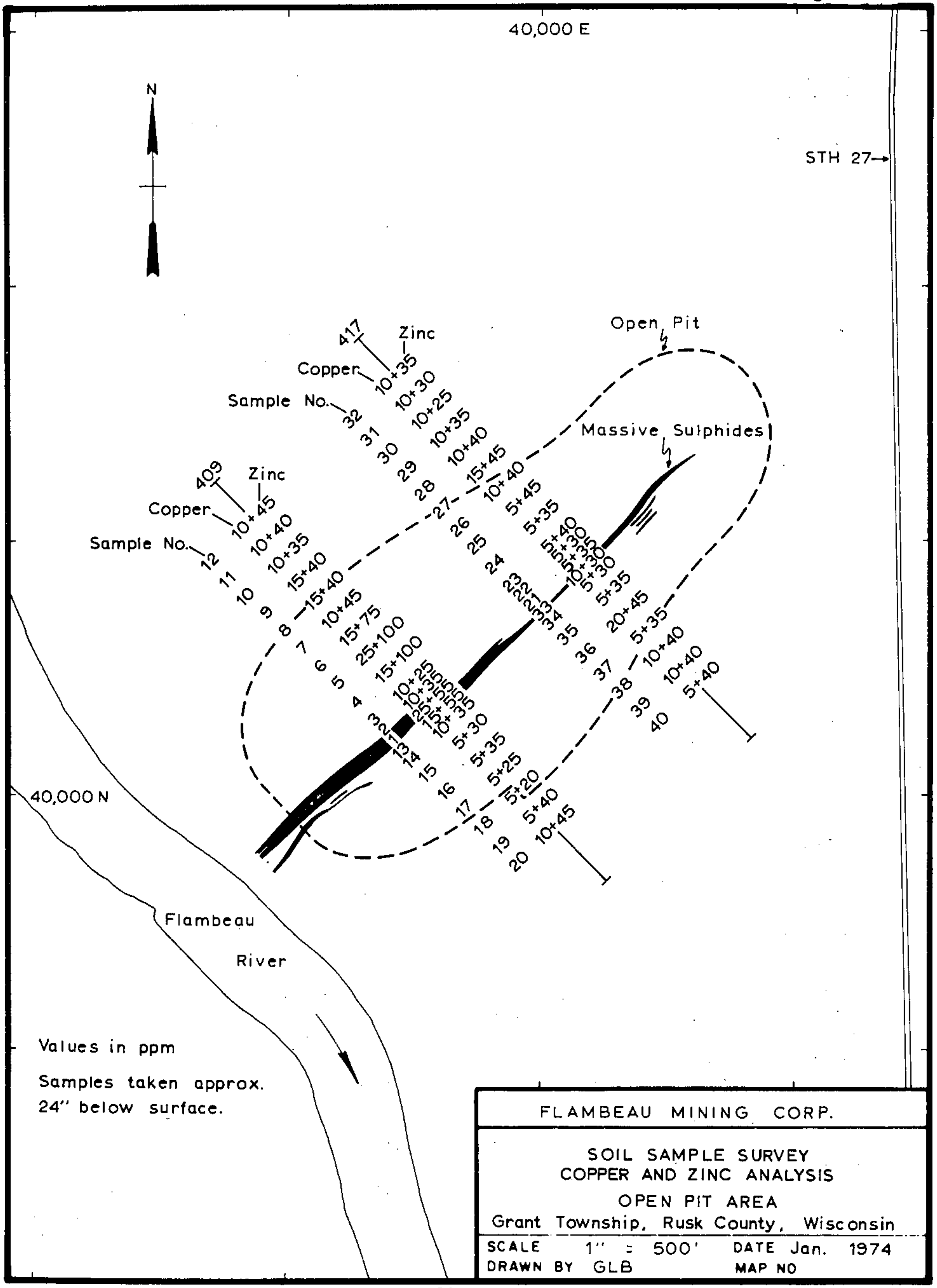
Section 409			Section 417			Proposed Project Site		
Sample No.	ppm Cu	ppm Zn	Sample No.	ppm Cu	ppm Zn	Sample No.	ppm Cu	ppm Zn
1	25	55	21	5	35	55	50	45
2	10	35	22	5	30	56	10	35
3	10	25	23	5	40	57	10	45
4	15	100	24	5	35	58	10	40
5	25	100	25	5	45	59	10	60
6	15	75	26	10	40	60	10	35
7	10	45	27	15	45			
8	15	40	28	10	40			
9	15	40	29	10	35			
10	10	35	30	10	25			
11	10	40	31	10	30			
12	10	45	32	10	35			
13	15	55	33	10	30			
14	10	35	34	5	30			
15	5	30	35	5	35			
16	5	35	36	20	45			
17	5	25	37	5	35			
18	5	20	38	10	40			
19	5	40	39	10	40			
20	10	45	40	5	40			

Note: Samples were taken approximately 24 inches below surface.

Five of 32 downgradient trees on the 402 section exceeded 2,000 ppm. The larger hemlock were the most heavily lead contaminated. Because of the ashing technique used for these data, no information was obtained on the levels of mercury in the Flambeau vegetation.

Both lead and mercury are known to be very toxic to vertebrates - mercury as an acute toxin especially when joined to certain organic compounds such as methyl mercury, and lead as a chronic poison that is especially damaging to certain enzyme systems and bone metabolism. An explanation for the anomalously low populations of insects, birds and mammals in the proposed pit area is suggested since the organic input of lead and probably mercury into the humus layers from leaf and needle fall must be significant within the open pit site. The presence of so much lead and mercury in these ecosystems is curious in that the assays of drill cores from the site show relatively little

Figure 25


40,000 E
N
STH 27
Open Pit
Massive Sulphides
Zinc
Copper
Sample No.
40,000 N
Flambeau
River
Values in ppm
Samples taken approx. 24" below surface.
FLAMBEAU MINING CORP.
SOIL SAMPLE SURVEY
COPPER AND ZINC ANALYSIS
OPEN PIT AREA
Grant Township, Rusk County, Wisconsin
SCALE 1" = 500'
DATE Jan. 1974
DRAWN BY GLB
MAP NO

lead and mercury. However, mercury is volatile and is known to "leak" from similar ore deposits, and lead salts are among the most mobile metal compounds known in the environment. Whether the low animal populations are due to direct poisoning or lack of food organisms for the predaceous species is not known.

It seems likely that the high natural levels of zinc, copper and possibly mercury in the waters and biota of the Flambeau River are due in part to soils derived from weathering of Precambrian greenstone belts of northern Wisconsin which contain above average amounts of these and other minerals.

1.11.0 NAMES AND ADDRESSES - 312-ACRE PROJECT SITE

Flambeau Mining Corporation P. O. Box 194 Ladysmith, Wisconsin 54848	Principal owner
State of Wisconsin	State Highway 27 right-of-way
County of Rusk	County Highway P right-of-way
Soo Line Railroad Company Soo Line Building Box 530 Minneapolis, Minnesota 55440	Railroad right-of-way in Section 10, T34N, R6W
Lakehead Pipe Line Company, Inc. 3025 Tower Avenue Superior, Wisconsin 54880	Pipeline easement in Section 16, T34N, R6W
Town of Grant	North-south town road right-of-way in Section 10, T34N, R6W
Cornell University Ithaca, New York 14853	One-half undivided mineral rights in the NW¼ of Section 21, T34N, R6W

1.12.0 LEGAL DESCRIPTION

All land owned, leased or with option to purchase or lease is described on page 3.

1.13.0 APPROVALS, LICENSES, PERMITS AND ORDINANCES

Wisconsin Department of Natural Resources

Following is a list of permit applications that have been submitted to the WDNR:

Date Submitted	
2-20-76	Chapter 30.12 - Structures and Deposits in Navigable Waterways: A permit for the box culvert to serve as the haul road crossing of Meadowbrook Creek in Section 16, T34N, R6W. The WDNR on 3-29-76 reported this permit not required but 30.19(1)(c) was.
2-20-76	Chapter 30.19 - Enlargement and Protection of Waterways: A permit to create an artificial lake (open pit mine) within 500 feet of the ordinary highwater mark of an existing navigable stream (Flambeau River).
2-20-76	Chapter 30.195 - Changing of Stream Courses: A permit to divert Meadowbrook Creek after construction of a box culvert.
4-27-76	Chapter 31.12 - Map, Profile and Plans: Plan approval for an earthen dike (dam) which would be constructed along the southwest corner of the open pit to protect it from floodwaters.
2-20-76	Chapter 107.05(2) - Water May be Conducted Across Land: A permit to divert water from the Flambeau River for industrial makeup water at the beginning of mining.
5-27-76	Chapter 30.19(1)(c) - Grading Permit on Bank of Navigable Waters: Grade an area in excess of 10,000 square feet adjacent to Meadowbrook Creek. Received WDNR notice to publish 6-9-76.
	Chapter 30.18 - Fill Pit Lake. WDNR requested this be deferred until completion of mining.
	Chapter 144.025(e) - Department of Natural Resources - Water Resources: A permit to construct one or more wells which singly or in aggregate would have an installed pump capacity of 70 gallons per minute (100,000 gallons per day) or more. This submission will be deferred closer to startup to better determine requirements.
	Chapter 144.04 - Approval of Plans: Plan approval for industrial and sanitary wastewater treatment facilities. Preliminary plan approval received from WDNR 6-2-76.

Chapter 144.39 - Notice Required for Construction: A notice of intent to establish an air contaminant source.

4-14-76 Chapter 147 - Pollution Discharge Elimination: A permit to discharge effluent to ground and/or surface waters.

Other Permits and Approvals

Wisconsin Department of Industry, Labor and Human Relations
Regulations concerning occupational health and safety.

Wisconsin Department of Transportation
At-grade railroad crossing of a state highway.
Access road onto a state highway.

Wisconsin Department of Health and Social Services
Approval of plans for the sewage disposal system.

Wisconsin Public Service Commission
Approval to build a railroad spur (Soo Line Railroad, applicant).

Rusk County
Mining permit.
Zoning permit to establish a mining operation in an Industrial District.
Plan approval for sewage disposal system.
Plan approval to construct an overpass over County Highway P.

Town of Grant
Conditional use permit.

Lakehead Pipe Line Company, Inc.
Letter of agreement to construct haul road over their pipeline.

U. S. Army Corps of Engineers
Section 404 permit for depositing fill material in a wetland and an environmental impact statement.

1.14.0 APPLICANT'S QUALIFICATION

KCC is an integrated producer of metals, minerals and metal products, principally copper and copper products and coal. It is the largest domestic producer of copper, the largest domestic producer of coal, and an important source of molybdenum, gold, silver, lead, zinc, titanium slag, high purity iron and iron powders. KCC is required by an order of the Federal Trade Commission to divest itself of its interest in Peabody Coal Company.

In 1975 KCC had a net income of $21.7 million from $1,526.5 million sales and other revenue. Current assets amount to $2,223,697,141. In 1975 the average number of employees was 31,500. For additional information, refer to KCC Form 10-K, available upon request.

1.15.0 PROSPECTING AND MINING PERMITS

FMC does not hold and has not requested any prospecting and mining permits in the State of Wisconsin or on properties adjoining the boundaries of the State of Wisconsin.

SECTION 2

OPERATION PLANS

[redacted]

SECTION 2

2.1.0 CONSTRUCTION PHASE

The construction period is expected to last 18 to 24 months after the beginning of the mine prestripping. During this period, disturbed soils will have maximum exposure to erosional processes. Thus, rapid stabilization of disturbed areas and prompt construction of runoff-collection systems are an integral part of our initial planning to achieve minimum pollution. This construction and especially the waste containment dikes will be supervised and controlled by a team of project engineers, one or more of whom will be Registered Wisconsin Professional Engineers (Exhibit B).

2.1.1 SITE PREPARATION

The first action during the construction phase requires the removal of trees, stumps and brush from the project site. Tree removal will be kept at a minimum, leaving as many natural wooded screens around the impacted areas as possible. The largest tree-removal job will be approximately 30 acres over the west end of the open pit site. Trees between the pit perimeter and the east bank of the Flambeau River will remain as a natural barrier. Additional trees have been planted in this area to supplement and enhance existing vegetation. FMC plans to leave trees in and around the eastern pit perimeter as a temporary screen during construction and early life of the open pit (Figure 26).

Other areas requiring selective tree removal are the rail spurline and waste haul road corridors, the powder magazines, and the southeast corner of the waste containment site. Removal of trees from these areas would involve a total of approximately 42 acres. However, tree stumps will not be removed in the waste containment area so as to preserve the natural density and continuity of the upper layers of silts and clays (Figure 27).

Some of the timber will be chipped, stockpiled and used to stabilize soil banks during construction. The balance will be sold as marketable timber and firewood, or otherwise disposed of in accordance with state provisions.

Once the sites have been cleared of trees, the following simultaneous actions will be implemented: construct (1) a mine site access road, flood-control dike and start prestripping, (2) the Meadowbrook Creek culvert, (3) a reinforced soil bridge over County Highway P, and (4) a sleeve for the Lakehead pipeline.

2.1.2 MINE ACCESS ROAD

A temporary mine access road will be constructed from the abandoned Rusk County gravel pit south to the proposed pit. This road will be used to bring in equipment necessary to commence prestripping, construction of the silt-collection and flood-control systems, and plant

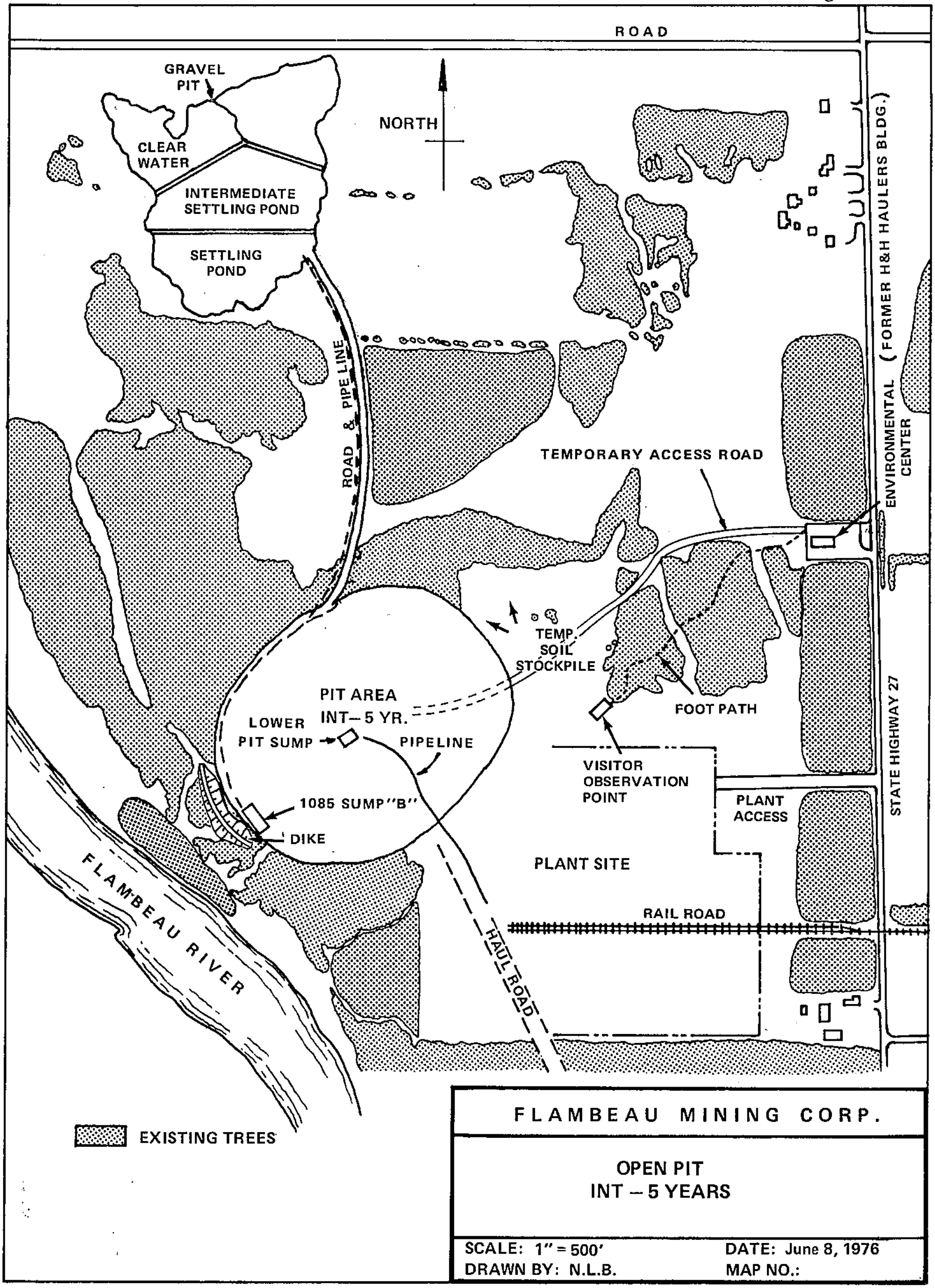
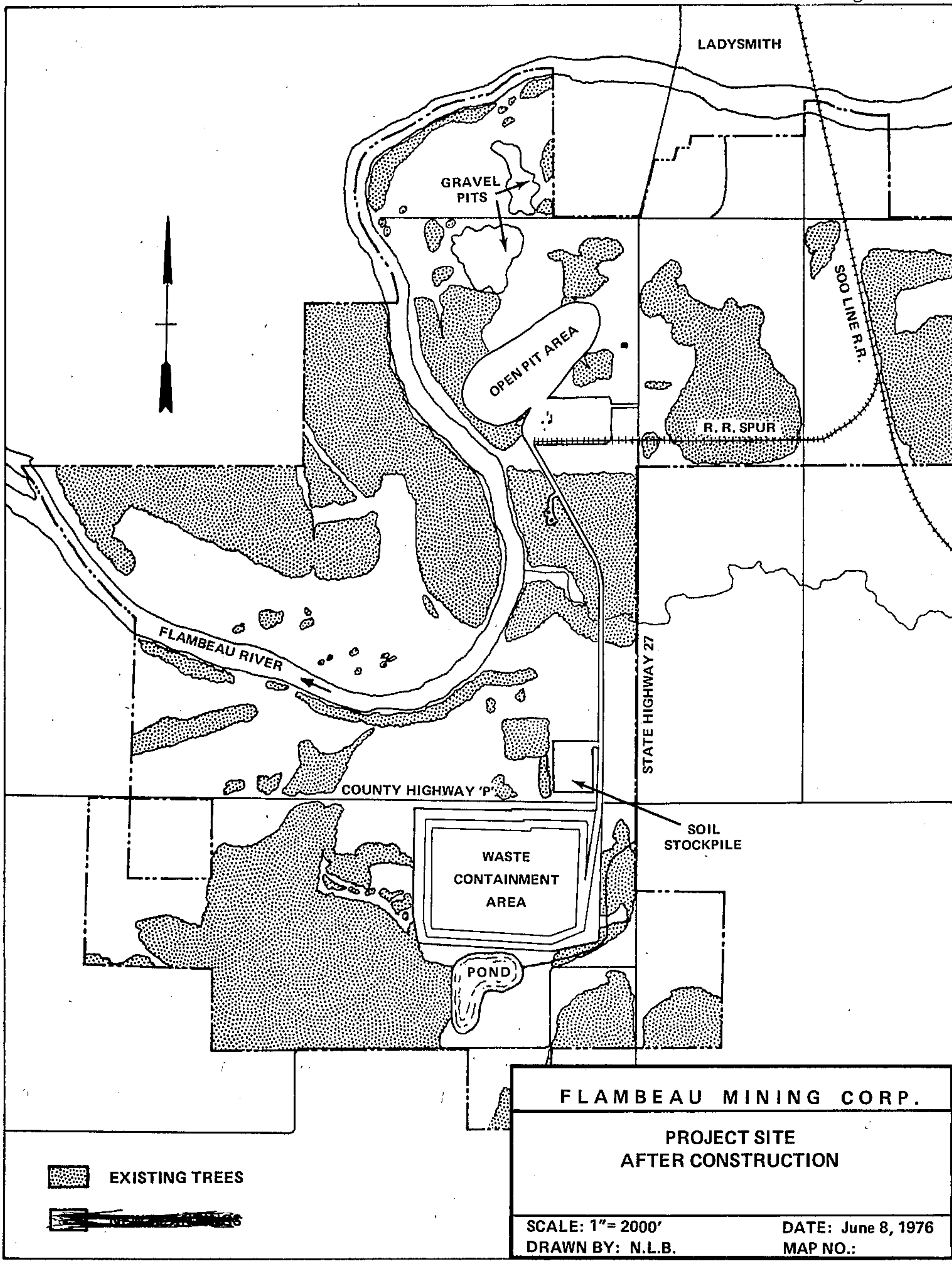

ROAD
GRAVEL PIT
CLEAR WATER
INTERMEDIATE SETTLING POND
SETTLING POND
NORTH
ROAD & PIPE LINE
(FORMER H&H HAULERS BLDG.)
ENVIRONMENTAL CENTER
TEMPORARY ACCESS ROAD
TEMP. SOIL STOCKPILE
PIT AREA
INT– 5 YR.
LOWER PIT SUMP
PIPELINE
FOOT PATH
VISITOR OBSERVATION POINT
1085 SUMP "B"
DIKE
PLANT ACCESS
PLANT SITE
STATE HIGHWAY 27
RAIL ROAD
FLAMBEAU RIVER
HAUL ROAD
EXISTING TREES
FLAMBEAU MINING CORP.
OPEN PIT
INT – 5 YEARS
SCALE: 1" = 500'
DRAWN BY: N.L.B.
DATE: June 8, 1976
MAP NO.:

Figure 27


LADYSMITH
GRAVEL PITS
SOO LINE R.R.
OPEN PIT AREA
R. R. SPUR
FLAMBEAU RIVER
STATE HIGHWAY 27
COUNTY HIGHWAY 'P'
SOIL STOCKPILE
WASTE CONTAINMENT AREA
POND
EXISTING TREES
FLAMBEAU MINING CORP.
PROJECT SITE
AFTER CONSTRUCTION
SCALE: 1"= 2000'
DATE: June 8, 1976
DRAWN BY: N.L.B.
MAP NO.:

site preparation. The existing gravelled road in the proposed pit area would be improved to allow for servicing of construction equipment at the former H & H Haulers building. Gravel for road construction and improvements will be taken from the abandoned Rusk County gravel pit which FMC purchased in 1970. Vegetation will be established on the shoulders of all roads in the mine area which fall outside of the final pit perimeter.

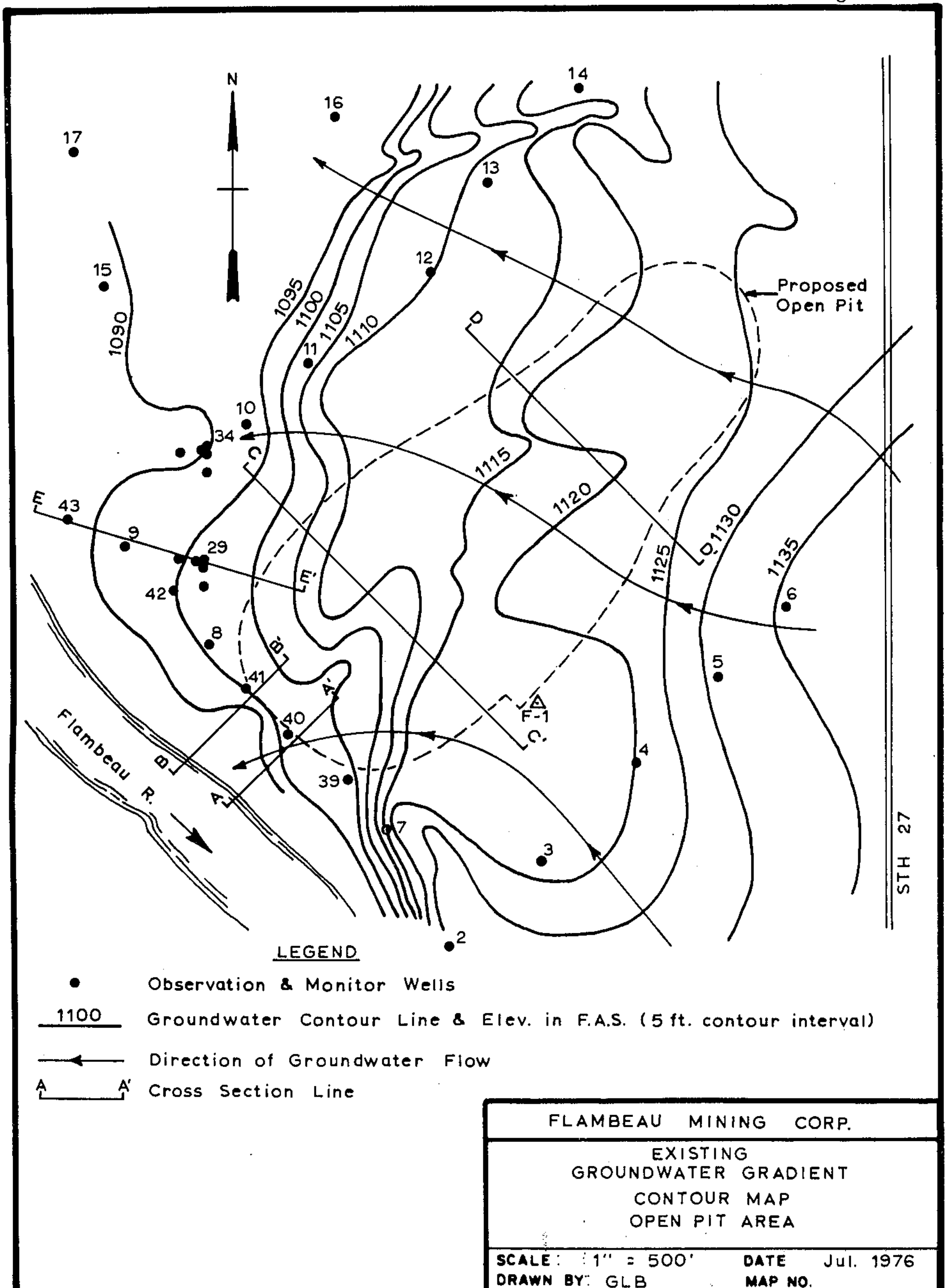
2.1.3 SETTLING PONDS AND GROUNDWATER CONTROL

Short-term activity will continue in the gravel pit until a series of settling ponds has been constructed and a pipeline laid along the access road between the proposed open pit and the gravel pit (Exhibit D).

A system of collection ditches and sumps will be constructed to collect groundwater inflow and precipitation into the excavation (Figure 26). An upper permanent collection sump will be constructed at the west end of the pit on the 1,085-foot bench (Sump B). During prestripping, silt-rich waters would be collected by this system and pumped north to settling ponds in the abandoned gravel pit nearby and allowed to decant and seep into the groundwater. The quality of the groundwater discharge during prestripping will be affected due to siltation and long-term reaction with the buried orebody. Once the area is dewatered and a cone of depression is established, groundwater discharge quality should improve and discharge rates should decrease. To predict groundwater flow conditions after pit excavation, the company used a finite element computer flow model (Figures 28 and 29). Groundwater flow into the pit as calculated from the model could yield up to 1,620 gpm. Allowance was made in this calculation for inflow resulting from reversal of the existing hydraulic gradient on the northwest, or present downgradient, side of the pit. The bedrock ridge described under Geology (Section 1) in this permit application would prevent the intrusion of river waters through the groundwater system into the pit from the southwest end of the pit. From permeabilities measured in the test wells, it is estimated that the glacial outwash materials present in the northwest sector of the pit perimeter would transmit an average of 50 gallons per square foot per day (0.0347 gpm). Thus, the highest amount of groundwater flow and intrusion of river water through the glacial outwash materials in the 1,000-foot segment of pit wall subject to such intrusion is estimated to be 347 gpm. The 1,620 gpm inflow is expected to be the maximum short-term groundwater discharge into the excavation.

When in operation, the mine geologist would, as part of his regular duties, map the subsurface geology to determine the permeabilities of the pit walls. This work, coupled with water well monitoring, would provide an accurate determination of the groundwater flow conditions.

Figure 28


N
17
16
14
13
12
15
11
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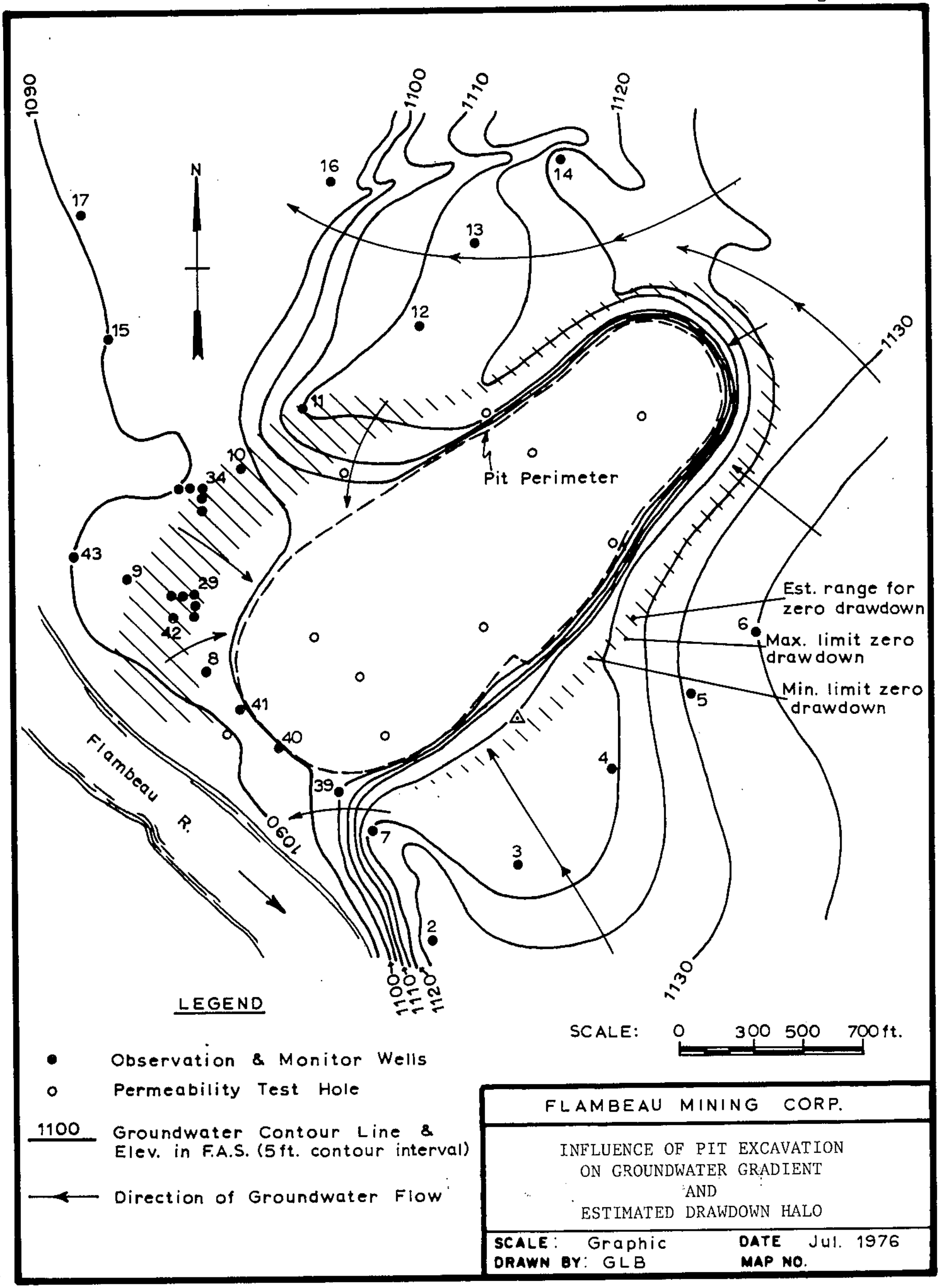
34
43
9
29
42
8
41
40
39
7
3
2
4
5
6
F-1
1090
1095
1100
1105
1110
1115
1120
1125
1130
1135
Proposed Open Pit
Flambeau R.
STH 27
A
A'
B
B'
C
C'
D
D'
E
E'
LEGEND
Observation & Monitor Wells
1100 Groundwater Contour Line & Elev. in F.A.S. (5 ft. contour interval)
Direction of Groundwater Flow
Cross Section Line
FLAMBEAU MINING CORP.
EXISTING GROUNDWATER GRADIENT CONTOUR MAP OPEN PIT AREA
SCALE: 1" = 500'
DATE Jul. 1976
DRAWN BY: GLB
MAP NO.

Figure 29


1090
1100
1110
1120
1130
N
16
17
13
14
12
15
11
10
34
Pit Perimeter
43
9
29
42
8
41
40
39
7
3
4
2
5
6
Est. range for zero drawdown
Max. limit zero drawdown
Min. limit zero drawdown
Flambeau R.
LEGEND
Observation & Monitor Wells
Permeability Test Hole
1100 Groundwater Contour Line & Elev. in F.A.S. (5 ft. contour interval)
Direction of Groundwater Flow
SCALE: 0 300 500 700 ft.
FLAMBEAU MINING CORP.
INFLUENCE OF PIT EXCAVATION
ON GROUNDWATER GRADIENT
AND
ESTIMATED DRAWDOWN HALO
SCALE: Graphic
DATE Jul. 1976
DRAWN BY: GLB
MAP NO.

The 1,050-foot elevation bench will be excavated toward the completion of the prestripping phase. This bench will contain the lower collection sump which will collect all water that could possibly be contaminated. All water from this sump will be diverted south to the waste containment area, depending upon makeup water requirements.

Although the hydrological studies suggest that the glacial materials surrounding the mine pit could yield up to 1,620 gpm, based on their permeabilities and the existing groundwater conditions, the long-term yield of such a volume of groundwater is considered unlikely for several reasons (Figure 28). First, experience with other mine pits has shown a rapid initial inflow into a pit during excavation followed by great reduction in flows of up to 80% to 90% of the initial flow. Secondly, in this case, 82% of the water-bearing upper pit perimeter wall could consist of till within which aquifer continuity is very poor. Finally, if the till and outwash in the cone of depression would be dewatered, incident precipitation and regional groundwater flow recharge would have to come through adjacent soils, most of which have low to very low transmissivities. Thus, the effects of evapotranspiration plus the above factors indicate a very slow infiltration through the soils into the mine pit. The company's long-term estimate of groundwater flow into the pit after flows have stabilized is 320 gpm, which is 20% of the calculated theoretical figure.

The water from the lower sump (1,050 level), which will collect possibly contaminated waters due to reaction of precipitation and Precambrian inflow water with sulfide mineralization, will be diverted to the waste containment reservoir. This lower water-collection system will descend as the excavation is deepened to its projected maximum depth of 285 feet beneath the surface. It is estimated that approximately 223 gpm will have to be diverted to meet industrial makeup water requirements. All of this makeup water will probably be obtained first from the lower and then from the upper mine collection systems. Should it be found that an outside source of water is required, a supply would be obtained from high-capacity wells constructed northwest of the gravel pit.

Upon establishment of the mine access road, sufficient topsoil and subsoils will be removed from the proposed open pit to expose silty sands required to construct a flood-control dike. The topsoils and subsoils will be temporarily stockpiled separately on the east end of the proposed pit. Any siltation runoff from these short-term stockpiles would enter the prestrip mine area where it would be collected and disposed of properly.

2.1.4 FLOOD-CONTROL DIKE

A flood-control dike will be constructed at the southwest end of the open pit (Permit 31.12) (Exhibit A). The dike will be constructed of silty sand materials in 12-inch lifts and compacted according to design specifications. Upon completion, the 5-foot-high dike will be covered with subsoils and planted with grasses and trees to screen the area from view from the river. An undisturbed vegetated strip 300 feet wide will be left between the prestripped and dike areas during construction to catch and filter any silt-laden runoff waters. This dike will serve two purposes during the prestripping phase of the mine. First it will prevent flooding of the mine construction site by the Flambeau River in the event of an upstream 100-year storm. Secondly, it will prevent silt-rich runoff waters, generated as the prestrip area is enlarged, from entering and contaminating the river. At the east toe of the flood-control dike will be constructed a temporary water-collection sump. Runoff waters from the disturbed mine construction site and the temporary soil stockpile will be collected and piped into the prepared gravel-pit settling ponds (Figure 26).

2.1.5 PRESTRIPPING

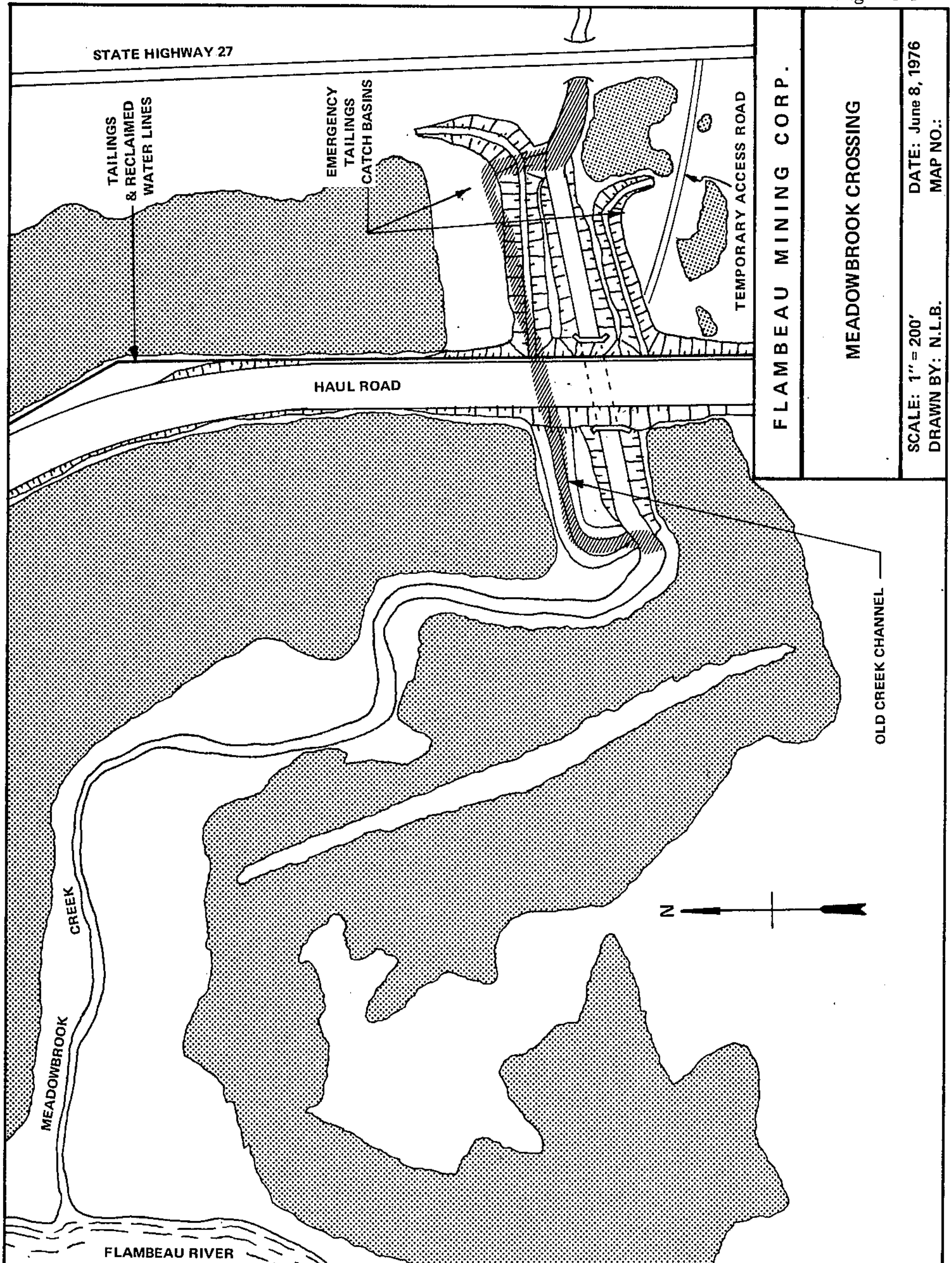
With the flood-control dike and water-collection sump in place, topsoils and subsoils can be removed from the remainder of the area to be prestripped, and stockpiled on the east end of the proposed pit (Figure 26). This prestripping phase has a two-fold objective of providing materials for construction of the haul road, process plant site and waste dikes, and exposing a three-to-four-months' supply of ore for the process plant. Initial prestripping of the topsoil is designed to expose an area known to be underlain by silty sands and gravel materials. The silty sands will be used for materials of construction for the flood-control dike, fill around the Meadowbrook culvert and reinforced soil bridge, and construction of the waste containment dikes. The gravelly sands and sandy gravels will be used for road construction and process plant site preparation.

During initial prestripping, a chain-link-type fence will be erected to enclose the process plant site, making it a secured area (Exhibit A). Completion of the fence will block the temporary mine road to the former H & H Haulers buildings. That part of the temporary mine road lying outside of the fence would be removed, leaving a gravelled area adjacent to State Highway 27 for visitor parking. The temporary road right-of-way would be graded to conform with surrounding land contours, mulched, seeded with appropriate grasses and legumes, and planted with trees. By the time the fence is complete, a permanent access road will be constructed south into the process plant site.

2.1.6 MEADOWBROOK CROSSING

Construction of the Meadowbrook culvert (Figure 30) will require the establishment of a temporary access road using materials from either the gravel pit or mine site. A new channel will be excavated but not connected to Meadowbrook Creek until completion of the box culvert (Permits 30.195 and 30.19(1)(c)). Water pumped out of the excavation will be piped to adjacent settling ponds constructed in the waste haul road right-of-way before discharge into the creek. Upon completion

Figure 30


STATE HIGHWAY 27
TAILINGS & RECLAIMED WATER LINES
EMERGENCY TAILINGS CATCH BASINS
TEMPORARY ACCESS ROAD
HAUL ROAD
OLD CREEK CHANNEL
N
MEADOWBROOK CREEK
FLAMBEAU RIVER
FLAMBEAU MINING CORP.
MEADOWBROOK CROSSING
SCALE: 1" = 200'
DRAWN BY: N.L.B.
DATE: June 8, 1976
MAP NO.:

of construction, the ponds will either be removed or buried under the waste haul road fill. If the pond sediment is to be removed for maintaining foundation integrity of the haul road, it will be trucked into the waste containment area. Changing the course of Meadowbrook Creek will increase the stream velocity from 4.5 to 5.2 feet per second. In order to prevent erosion, FMC will place riprap on the streambed of the new channel, and the banks will be vegetated. The temporary gravel road will remain until completion of the tailings catchment basins, then would be graded to conform with surrounding land contours, mulched and seeded with appropriate grasses and legumes.

2.1.7 HIGHWAY BRIDGE

The third action requiring prompt attention will be the construction of a soil reinforced bridge 500 feet west of State Highway 27. This bridge will carry the waste haul road over County Highway P. Construction of this bridge will not alter County Highway P and is not expected to disturb normal traffic flow. If for unseen reasons a temporary traffic diversion is required, traffic could be rerouted one-half mile to the south on an existing township gravel road (Exhibit A).

2.1.8 LAKEHEAD PIPELINE

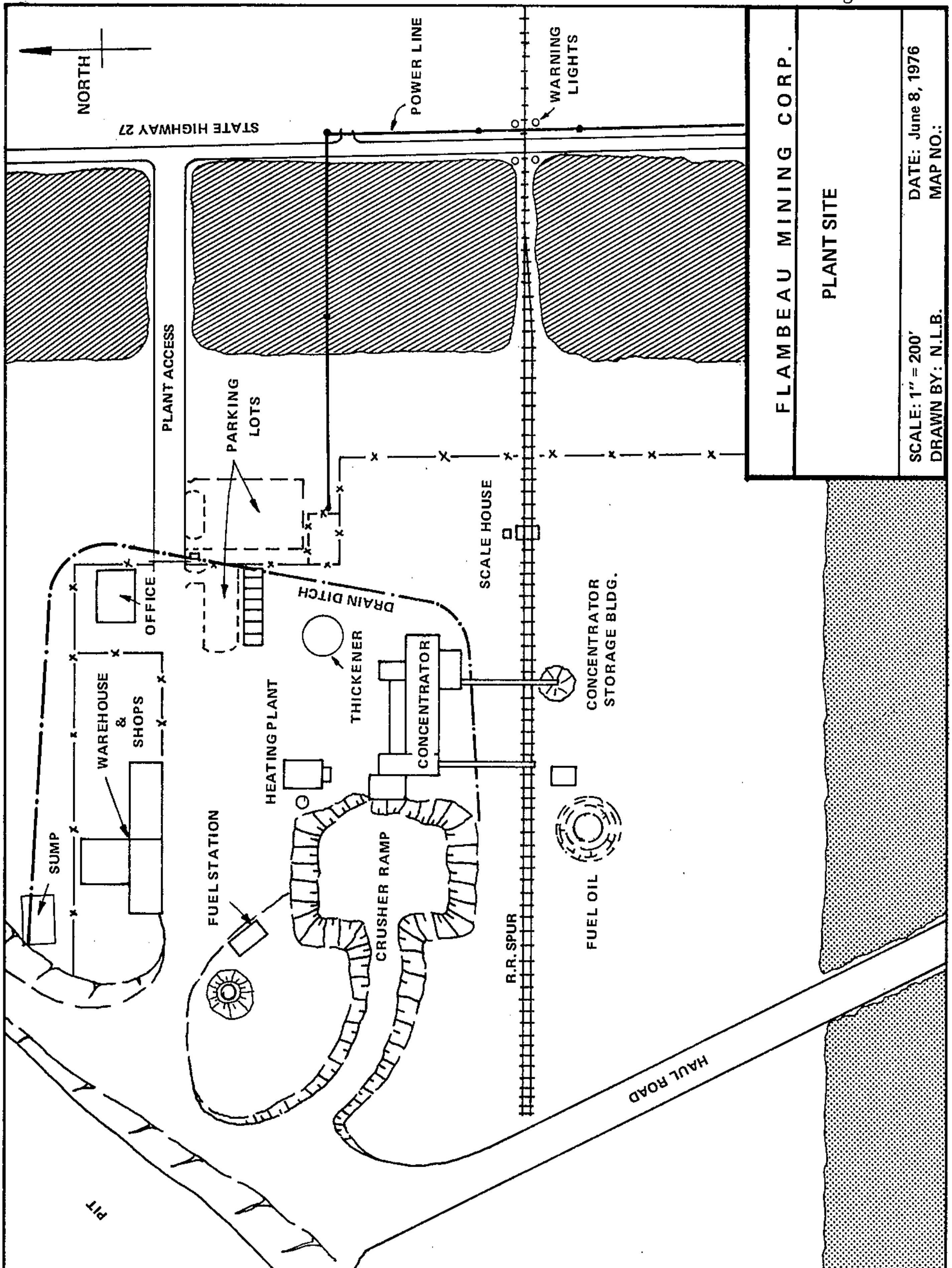
Finally, a reinforcement needs to be placed around the Lakehead crude-oil pipeline where it passes under the waste haul road. It is planned to sleeve the pipeline in accordance with standard practice to prevent additional pressure or movement of the pipeline by haul road use. This construction would be done under the supervision of the Lakehead Pipe Line Company, Inc., using their own men and materials (Exhibit A).

Near completion of the above actions would initiate the next set of actions: (1) prepare the process plant site for construction, (2) construct the spurline, (3) construct the waste haul road, and (4) prepare the waste containment area.

2.1.9 PROCESS PLANT SITE

The preparation of the process plant site will require the removal of topsoil and subsoils to a depth of approximately 12 to 18 inches (Figure 31). These materials will be temporarily stockpiled onsite to form a low dike and runoff-collection ditch downgradient to the east. Trapped waters will be collected in a settling pond located in the north corner of the process plant site and pumped to the 1085 sump (B) for eventual disposal into the gravel pit. An undisturbed area will be maintained parallel to State Highway 27 and the banks of the intermittent stream. This area is already planted with various deciduous and coniferous trees. No vegetation will be disturbed along the Flambeau River bank west of the process site. This undisturbed area has been planted with mixed trees and protected by a barbed wire fence. All runoff waters will be directed away from the river and intermittent stream, located in the southeast corner of the site, to the sump described above.

Figure 31


FLAMBEAU MINING CORP.
PLANT SITE
SCALE: 1" = 200'
DRAWN BY: N.L.B.
DATE: June 8, 1976
MAP NO:
NORTH
STATE HIGHWAY 27
POWER LINE
WARNING LIGHTS
PLANT ACCESS
PARKING LOTS
SCALE HOUSE
OFFICE
DRAIN DITCH
THICKENER
CONCENTRATOR
CONCENTRATOR STORAGE BLDG.
WAREHOUSE & SHOPS
HEATING PLANT
SUMP
FUEL STATION
CRUSHER RAMP
R.R. SPUR
FUEL OIL
HAUL ROAD
PIT

Varying amounts and kinds of materials will be trucked on the site from the mine prestripping via the all-weather gravelled waste haul road. These prestripped materials will be used for site preparation and compacted according to specifications for construction of various elements of the process plant and ancillary buildings. During this phase of site construction, an access road would be built from State Highway 27 to the plant. This road would be temporarily gravelled and contoured for drainage. The road shoulders and edges would be stabilized and vegetated to prevent soil erosion.

Construction of the process plant buildings will be an ongoing process throughout the 18 to 24-month period (Exhibit B). After the shell of the primary crusher section located on the west end of the concentrator building is in place, a ramp will be constructed up to the lip of the jaw crusher dump pocket. The ramp will be approximately 30 feet high with 3:1 slopes and will be constructed of silty sands taken from the pit excavation. When in place, the slopes will be graded, mulched and planted with legumes and grass. The top of the ramp will embrace a rectangular area of approximately 0.6 acre and will be used to stockpile ore to feed the primary crusher during the weekend. A water-collection system will be installed to collect runoff water from the ore stockpile pad and the shop area. This water will be diverted to the lower pit collection sump (1,050 level).

2.1.9.1 PROCESS PLANT ANCILLARY FACILITIES

An onsite sewage treatment plant would be constructed to handle approximately 3,000 gpd of human sewage (Exhibit A). At the end of each work shift for a period of about 15 minutes, it is estimated that about 100 gpm of wastewater would be generated. Sufficient surge tank storage capacity would be provided ahead of the sewage treatment plant to allow for the design treatment rate of 3,000 gpd. Design of the sewage treatment facility is in accordance with local and state codes.

The present design plan includes three bulk storage tanks for petroleum products. Storage facilities for No. 2 oil for heating and diesel equipment use would be two API steel storage tanks with a total of 230,000-gallon capacity. These tanks would be located above ground in the concentrator area where they may be serviced by rail or truck tankers. A 2,000-gallon-capacity underground non-metallic tank would be provided for gasoline storage.

All tanks would be designed and installed according to standard industrial and insurance-carrier codes for bulk storage of petroleum products, including EPA regulations of December 11, 1973 as amended relating to protection of navigable waterways. The surface tanks would be appropriately bermed with all process equipment (pumps, valves, meters, etc.) located inside the berms.

Wastewater from the truck and equipment-washing facility and runoff from the process plant site will be collected in a sump located down-gradient to the north of the buildings. This soiled water will be pumped into the waste containment area via the lower pit sump pipeline. Periodically this and other sumps will require cleaning, with the sediment trucked to the waste containment area.

Upon completion of construction of the process plant site, the soils from the onsite soil stockpile will be returned where needed and any surplus soils will be taken to the permanent soil stockpile north of the waste containment area. Finally the site would be landscaped, and specific areas including the plant access road paved.

2.1.10 RAILROAD SPUR

A railroad spur approximately 6,100 feet long will be constructed from the Soo mainline west into the plant site (Figure 32). Route selection was made for the shortest distance between the mainline and the plant with minimum cut-and-fill. Where cut-and-fill is necessary, the banks will be graded, mulched and seeded with grasses and legumes. Culverts will be installed to prevent ponding on the upgradient side of the spurline. Special care will be taken when crossing State Highway 27 at right angles to minimize traffic disruption. Appropriate highway safety signals will be erected at the crossing in accordance with the rules of the Wisconsin Division of Highways and the Wisconsin Public Service Commission. Completion of the spurline must be coordinated with delivery of large equipment for the process plant.

2.1.11 WASTE HAUL ROAD

A heavy-duty, all-weather waste haul road will be constructed from the pit perimeter 7,000 feet south to the waste containment area (Exhibit A). The road will be designed to carry a 90-ton gross load with minimum maintenance and no paved surface (Exhibit E). All topsoils will first be removed from the right-of-way and temporarily stockpiled onsite to the south of the process plant area or routed to the permanent soil stockpile north of the waste containment area. Because the subgrade soils are susceptible to severe frost action, and several areas have a high groundwater table, cuts will be minimized with most of the roadway built on frost-resistant fill. Segregated soils from the mine prestripping will be utilized to build up a compacted roadway to a thickness of 54 inches. Culverts will be placed to prevent ponding on the uphill side of the road.

2.1.12 POWDER MAGAZINE

Speedy installation of the waste haul road is important to transfer prestripped materials to the permanent soil stockpile and waste containment areas. Once these two disposal areas are in operation, attention can be directed to ancillary road construction projects. For example, a service road is required for the magazine site located between the waste haul road and the Flambeau River (Figure 33). Again, minimum surface would be disturbed during construction of this 1.2-acre site. Because of the small area involved, minimum

Figure 32

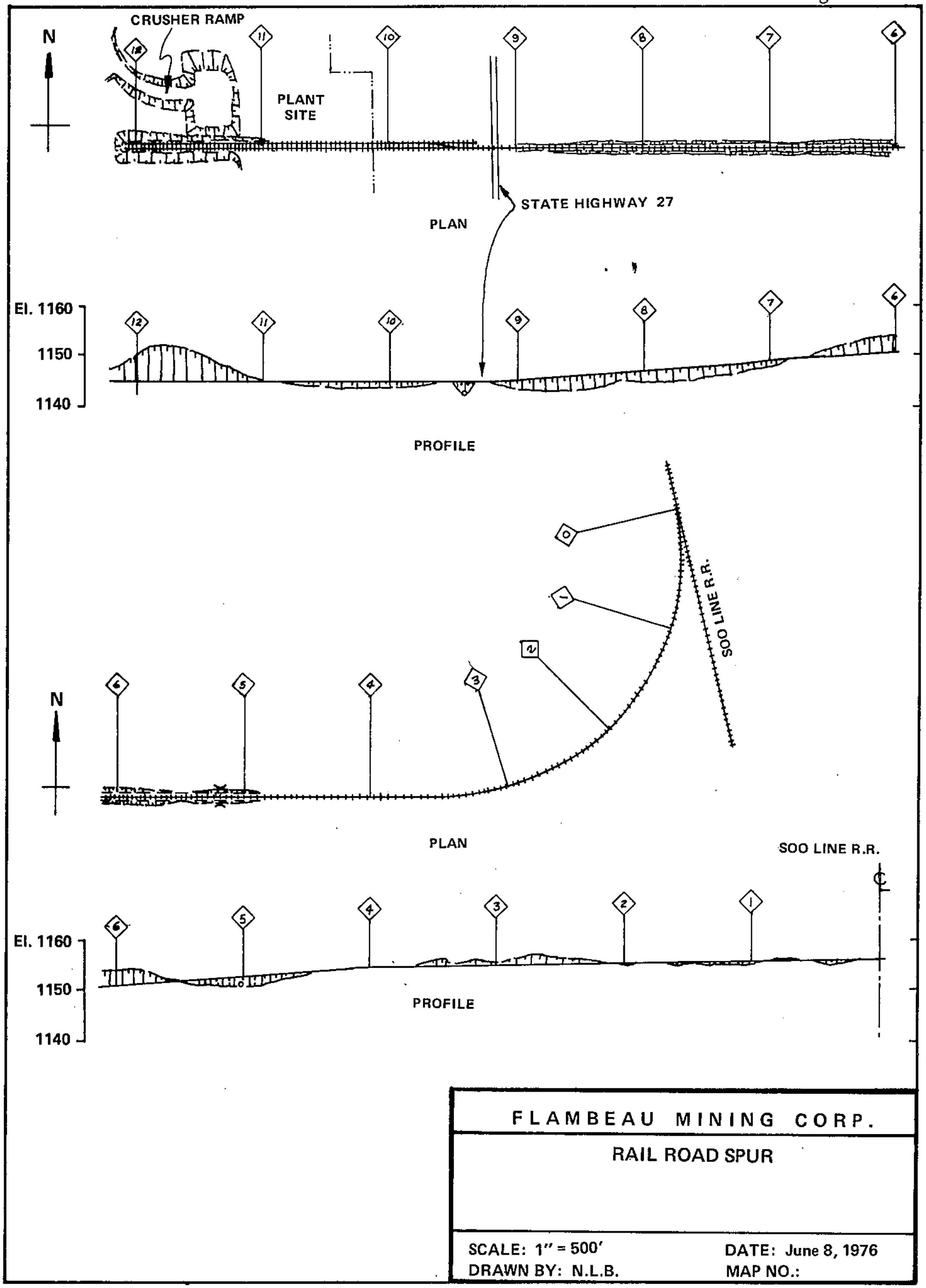
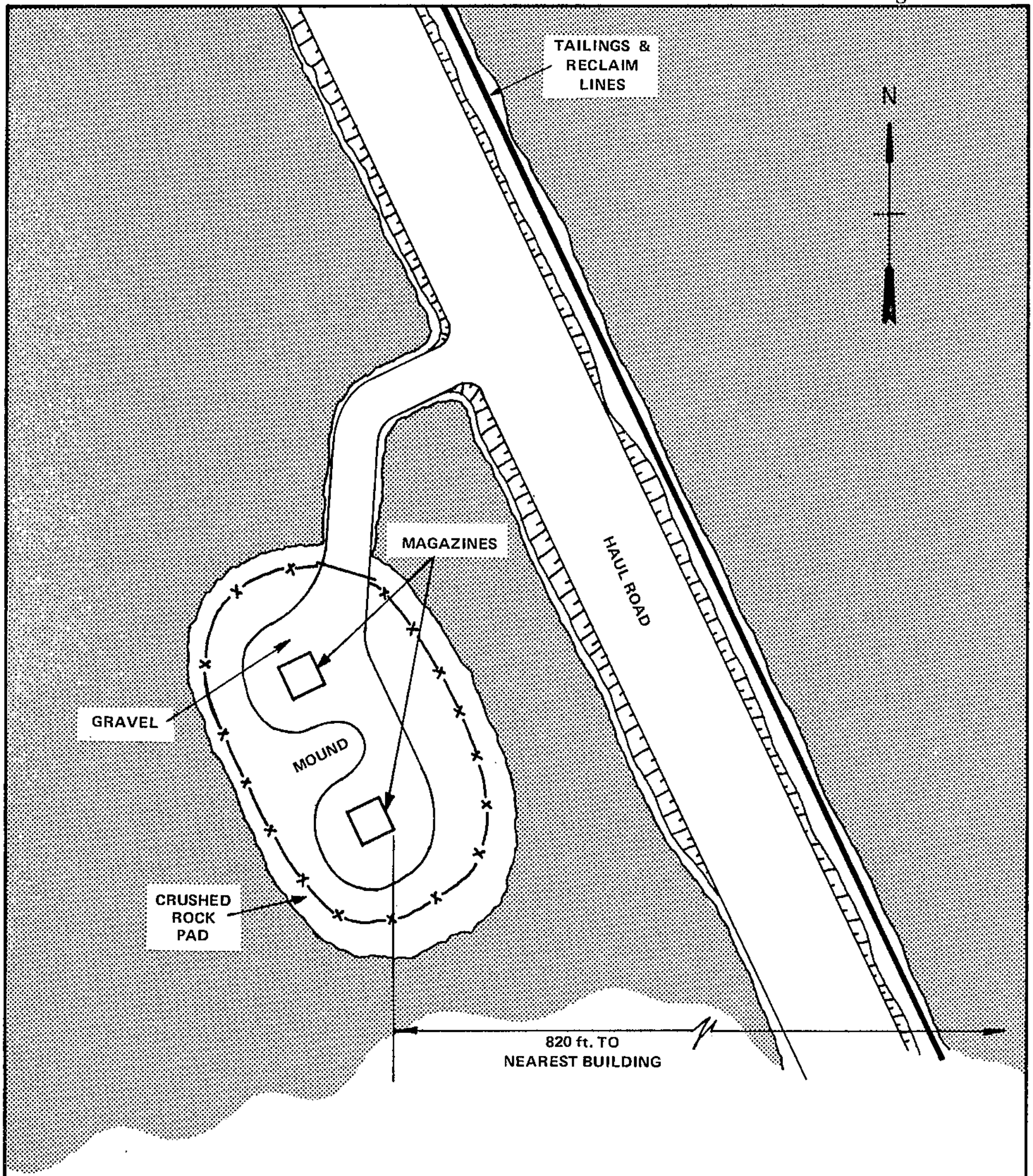

CRUSHER RAMP
N
PLANT
SITE
STATE HIGHWAY 27
PLAN
El. 1160
1150
1140
PROFILE
SOO LINE R.R.
N
PLAN
SOO LINE R.R.
El. 1160
1150
1140
PROFILE
FLAMBEAU MINING CORP.
RAIL ROAD SPUR
SCALE: 1" = 500'
DRAWN BY: N.L.B.
DATE: June 8, 1976
MAP NO.:

Figure 33



FLAMBEAU MINING CORP.

POWDER MAGAZINES

SCALE: No Scale
DRAWN BY: N.L.B.
DATE: June 8, 1976
MAP NO.:

surface runoff is expected. Once the magazines are constructed, they will be protected by dikes made out of non-vegetative materials because of fire safety requirements. However, the dikes will be covered by gravel or similar material to prevent soil erosion.

2.1.13 TAILINGS PIPELINE AND EMERGENCY TAILINGS CATCHMENT BASINS

The 8-inch tailings pipeline will be laid into a ditch parallel to the waste haul road (Exhibits A and E). The pipeline and tailings disposal area will be inspected on a daily basis. An automatic alarm will be built into the system to alert the operator to any pipeline failure. This will allow an orderly shutdown of the plant facility for pipeline repair. The shutdown would be accomplished in about 30 minutes upon discovery of the failure.

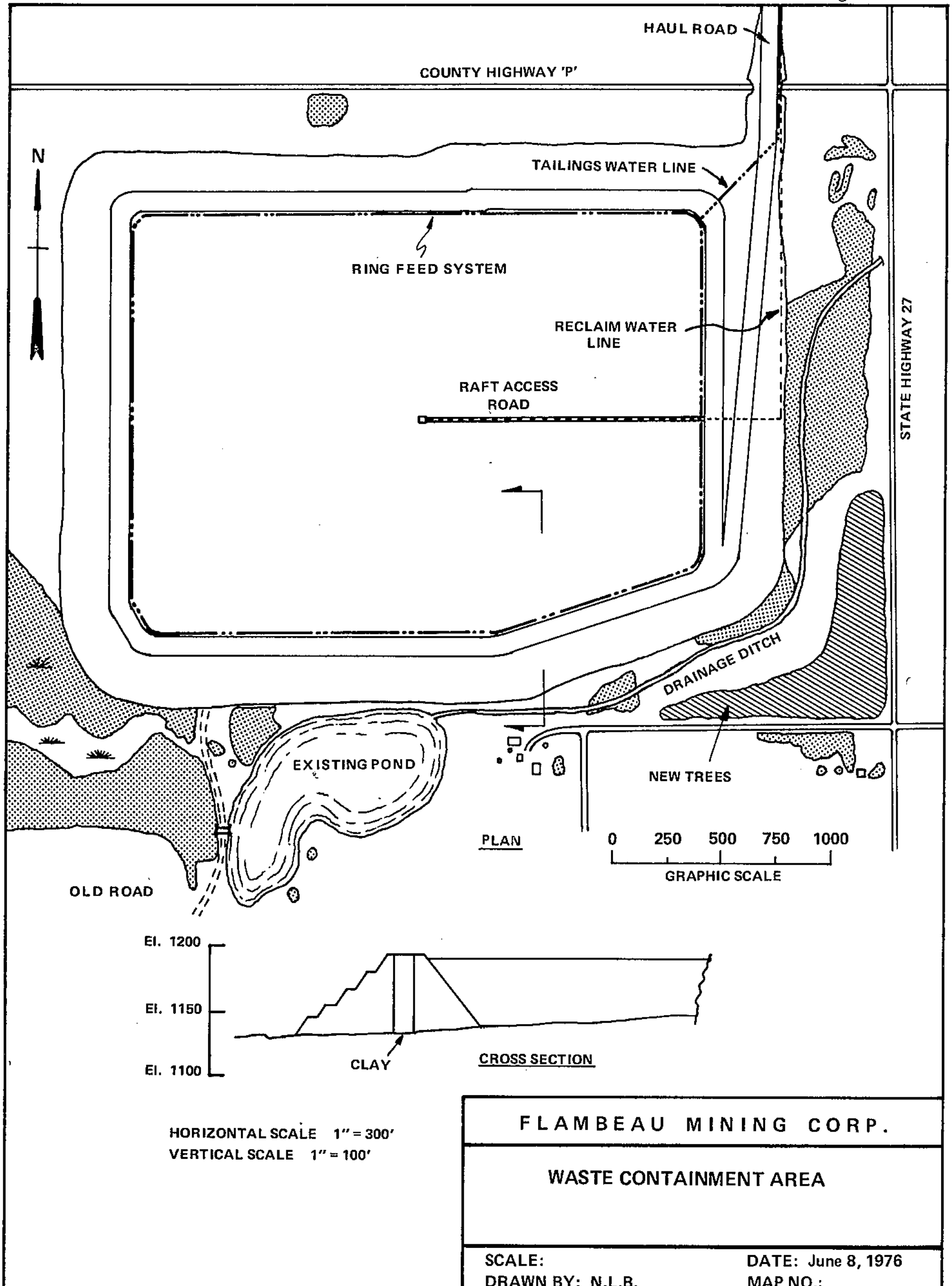
Emergency tailings catchment basins designed to hold 700,000 gallons or the equivalent of 20 hours of tailings flow will be constructed on either side of Meadowbrook Creek and on the north side of the intermittent stream. They will be constructed on the east or uphill side of the waste haul road (Figure 30). Escaped tailings from a pipeline failure would be captured in these basins and pumped back into the pipeline through a one-way valve system upon resumption of operations. The basin would then be cleaned of remaining tailings and the basin foundation recompacted. Removed sediments would be trucked into the waste containment area. Since the basins will be constructed on impermeable soils which will be mechanically compacted, the basins will from time to time fill with water. Therefore, to maintain the basins for their intended use to catch escaped tailings under emergency situations, the basins will be dewatered with the water pumped into the lower pit sump pipeline.

At Meadowbrook the north catchment pond dike will be placed into the abandoned stream channel. As soon as the waste haul and ancillary roads and catchment ponds are in place, correct mulching and seed application will be promptly employed to eliminate siltation. Upon stabilization of these soil banks and dikes, the temporary access road into Meadowbrook Creek will be removed and the entire disturbed area graded, mulched, seeded and planted with trees.

2.1.14 DIVERSION DITCH

Early in the construction phase as the waste haul road is being constructed south of the pit perimeter, a drainage ditch will be excavated at the waste containment area (Figure 34). This ditch will direct surface runoff south around the east and south sides of the waste dikes to enter the wetlands to the west. Thus, the water inventory of this important ecosystem would not be affected. Construction of the ditch will expose soils which will be graded to a 15° slope and seeded with grasses. The ditch will have a gradient less than 3% so that water velocities will not be sufficient to undercut the banks. However, aquatic vegetation will be planted

Figure 34


HAUL ROAD
COUNTY HIGHWAY 'P'
N
TAILINGS WATER LINE
RING FEED SYSTEM
RECLAIM WATER LINE
RAFT ACCESS ROAD
STATE HIGHWAY 27
DRAINAGE DITCH
EXISTING POND
NEW TREES
PLAN
0
250
500
750
1000
GRAPHIC SCALE
OLD ROAD
El. 1200
El. 1150
El. 1100
CLAY
CROSS SECTION
HORIZONTAL SCALE 1" = 300'
VERTICAL SCALE 1" = 100'
FLAMBEAU MINING CORP.
WASTE CONTAINMENT AREA
SCALE:
DRAWN BY: N.L.B.
DATE: June 8, 1976
MAP NO.:

along the banks of the ditch to prevent any erosional tendencies during heavy spring runoff or under storm conditions. Once the ditch bed has stabilized, the influent water will be clear and suitable for use by waterfowl and other wildlife. The ditch will discharge into an existing pond created by an old road transversing the wetlands. This old road will be maintained to provide access for inspection of the waste containment dikes.

The completion of the ditch system will be coordinated with the construction and progress of the haul road into the waste area. At this point of the construction phase, saprolite clay will be exposed in the mine site and available for fill in the existing drainage ditch which bisects the waste area. Surface water would therefore be diverted into the new drainage system and the abandoned ditch cleaned of debris and vegetation, and filled with saprolite. At the same time, peat and topsoils under the waste dike in excess of six inches can be removed and trucked north into the permanent soil stockpile site (Exhibit A).

2.1.15 SOIL STOCKPILE

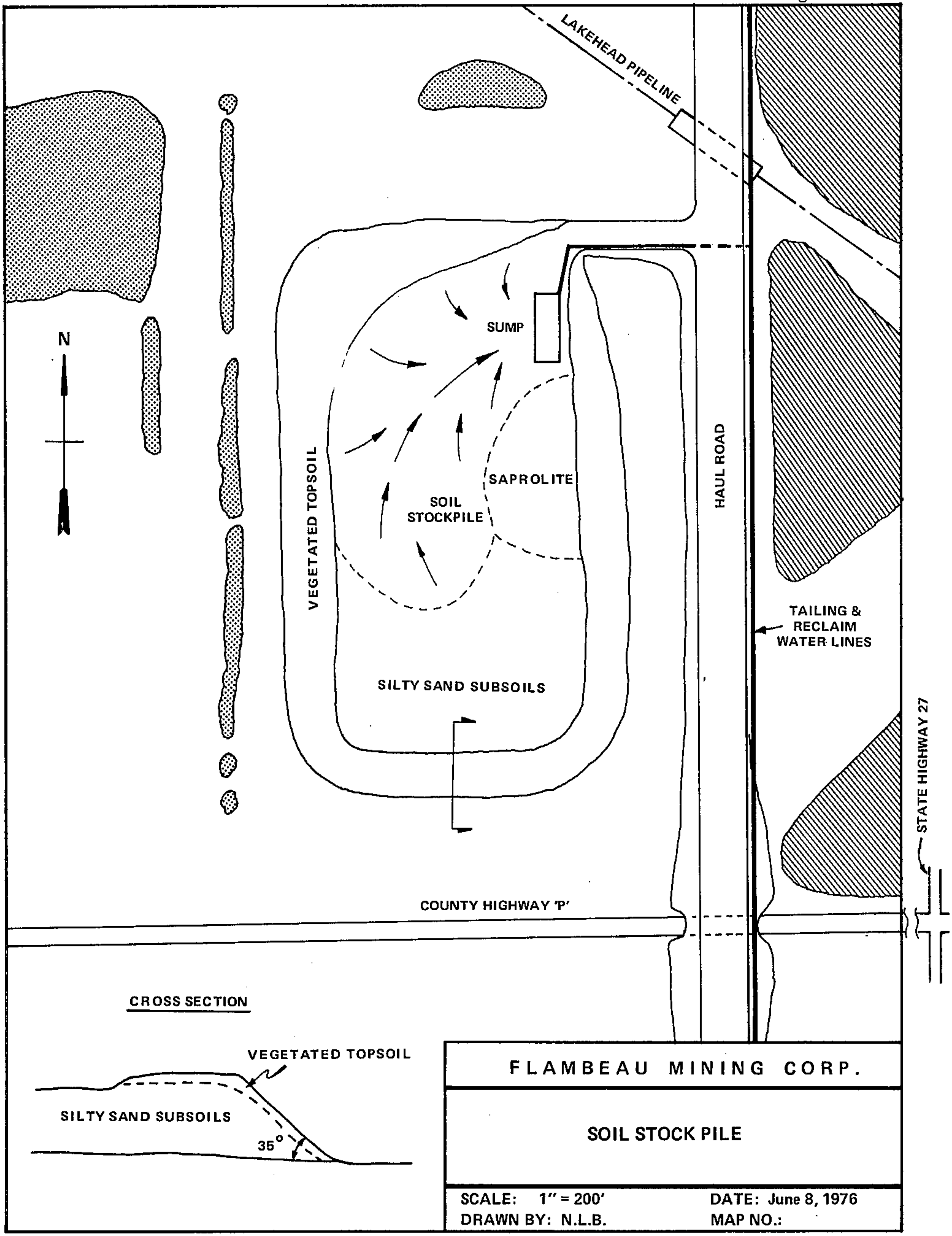
Particular attention has been paid to the construction and operation of the permanent soil stockpile site (Figure 35). A "C"-shaped area open to the north would be constructed, placing the topsoils on the outer perimeter. Within the site would be placed in segregated piles the silty sands and saprolite from the mine prestripping.
Once the innermost materials are placed in the stockpile to a predetermined height, the topsoils would be graded on the outside walls of the pile and vegetated. These stabilized dike walls would remain in place until near the end of the life of the operation. Materials added to or taken from the stockpile would be accomplished from within these dikes. Muddied waters would be collected in temporary collection ponds until the tailings pipeline is completed. At that time excess stockpile waters could be pumped into the waste area via the 8-inch lower pit sump pipeline.

2.1.16 WASTE CONTAINMENT AREA

The waste area is now ready for construction of dikes, incorporating waste materials excavated from the mine prestripping. As mentioned in Section 2.1.0, the construction of the waste containment dikes will be supervised by a Wisconsin Registered Professional Engineer. It will be his duty to direct a quality control program to assure that construction methods meet design specifications. Furthermore he will direct onsite tests to determine size of materials, density, compaction, etc. on a regular schedule with these tests results forwarded to the appropriate state agencies.

The requirements of a stable and impermeable dike necessitate construction with selected materials placed as shown in Exhibit F (also see Section 1). To reduce seepage through identified areas

Figure 35


LAKEHEAD PIPELINE
N
SUMP
SAPROLITE
SOIL
STOCKPILE
VEGETATED TOPSOIL
HAUL ROAD
TAILING &
RECLAIM
WATER LINES
SILTY SAND SUBSOILS
STATE HIGHWAY 27
COUNTY HIGHWAY 'P'
CROSS SECTION
VEGETATED TOPSOIL
SILTY SAND SUBSOILS
35°
FLAMBEAU MINING CORP.
SOIL STOCK PILE
SCALE: 1" = 200'
DATE: June 8, 1976
DRAWN BY: N.L.B.
MAP NO.:

of the dike foundation underlain by more permeable glacial materials, a cutoff trench will be excavated varying in depth from 13 to 18 feet and approximately 10 feet wide beneath the dike core in the area shown in Exhibit F. The materials excavated from these trenches will be placed within the waste area. The trenches will be backfilled with saprolite and compacted to at least 95% of the maximum dry density as determined by the Standard Proctor Test. Although FMC does not expect much seepage water into the cutoff trenches, nevertheless temporary settling ponds will be constructed out of prestripped materials to contain any excess seepage or storm water inflows. Upon completion of the cutoff trenches, the settling ponds can be either removed or more likely buried at a later time by tailings.

There will be sufficient prestrip material to construct all the first lift of the dike to an elevation of 1142.5 feet at 90% compaction. Construction of the dike will begin at one of the 1142 contours crossing the north perimeter of the waste area. Typically two parallel lifts will be formed within the 363-foot-wide dike perimeter with a central trench left temporarily open. All dike materials will be deposited in narrow lifts and compacted with appropriate construction equipment. As the parallel lifts are put in place, the trench would be dewatered if necessary with water pumped into settling ponds already constructed for the cutoff trenches or within the waste site once the dikes prevent escape. The open trench would then be filled with compacted saprolite to form a 40-foot-wide core. Compaction of the saprolite core will be carried to at least 95% of the maximum dry density of the material.

Over the life of the operation the waste containment dike walls will have to be raised continuously (Exhibit F). The stabilization of the dike as each successive lift is added will consist of revegetation of disturbed areas on slopes graded to 35°. Soils stockpiled north of the waste containment area will be used to dress the outside of the dikes. To ensure optimum germination and plant growth, the soils will be tested and treated with conditioners. Various seed mixtures have been tested on slopes constructed of similar materials in the abandoned gravel pit. These tests indicate that emerald crown vetch is a tenacious and excellent revegetator of slopes up to 40° and will persist even on north-facing slopes. However, crown vetch is less useful for wildlife than another onsite-tested plant - birdsfoot trefoil. The trefoil is less tolerant on north-facing or shaded slopes and therefore will be used in sunny locations. During stabilization of the dike slopes, a mixture of mulch, fertilizer and seed will be hydraulically introduced on the outer walls. An undisturbed grassy strip will be left around the outside toe of the dike to filter any silty runoff water before it enters the surrounding wetlands.

As the dikes extend upward, scattered plantings of shrubs to improve wildlife habitat and aesthetics of the dikes will be attempted. Plantings of aesthetically desirable species will be largely concentrated on the north and east sides, with shrubs more suitable for wildlife planted on the south and west sides next to the wetlands.

To keep the tailings wet so that dust formation would be minimized and to provide additional protection for the dikes, a ring feed system will be installed around the dike perimeter. The slurry will be deposited into the waste containment area via spigots spaced roughly 50 feet apart. With this method, the coarser fraction of the tailings settles rapidly and creates a slope from the dike to the center of the reservoir. Thus, there would be shallow water against the dike with deeper water toward the center. During freezing weather the slurry will have to be delivered through a single pipe because a ring feed system will freeze (Figure 34).

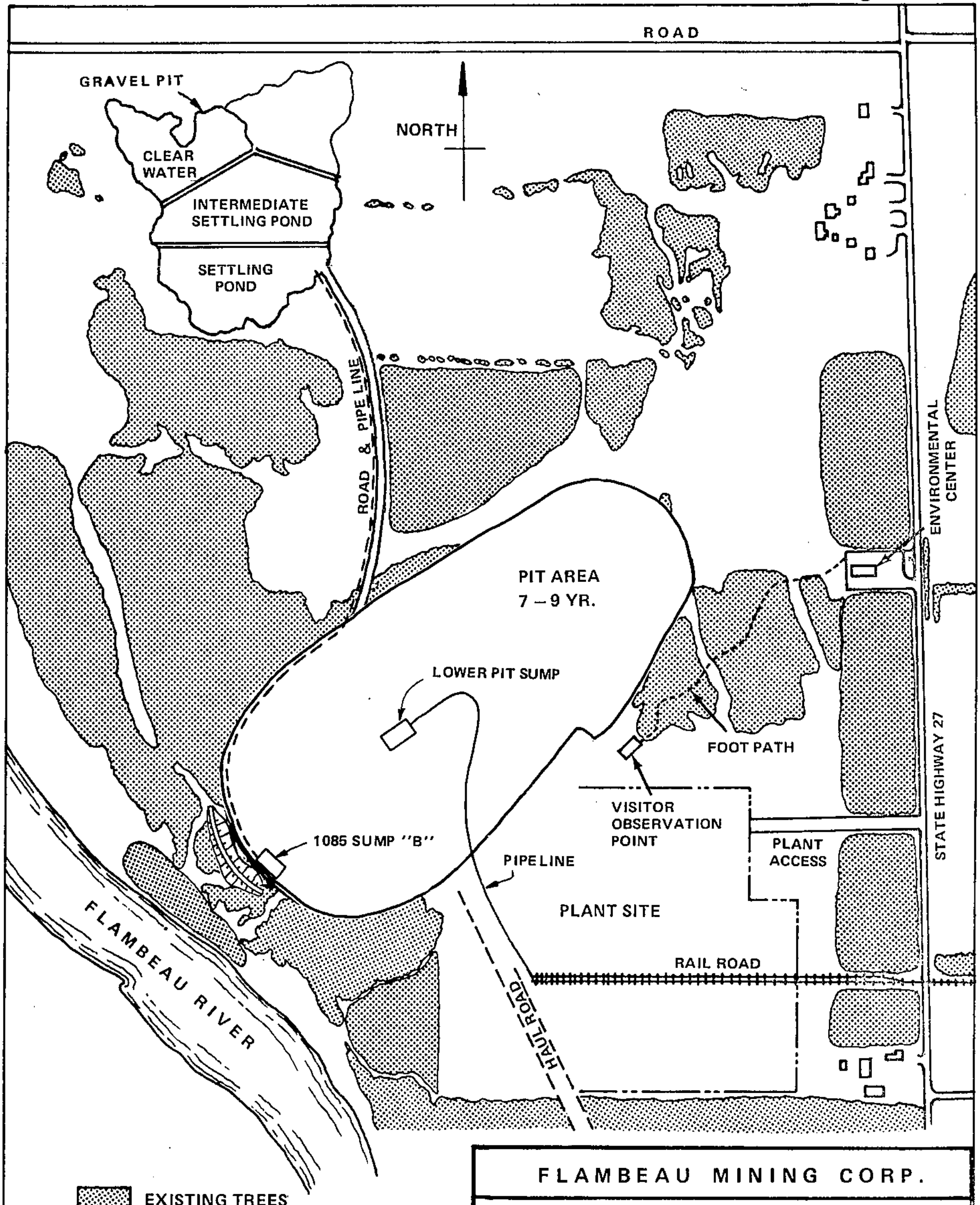
2.1.17 INITIAL PROCESS WATER REQUIREMENTS

Before actual mining and processing of the copper ore can take place, approximately 135 million gallons of water will be required. This water will be contained in the process plant circuit with the bulk stored in the waste containment reservoir. Much of this water will come from the various water-collection systems scattered throughout the project site and described above. However, some water will probably be required from the Flambeau River via a temporary diversion pipeline. No permanent water-collection system or pipeline will be erected to disturb the beauty of the Flambeau River banks. Indeed it will not be possible to see the mine operation when canoeing down the river, this being one of the objectives in designing the rehabilitation plan.

2.2.0 METHOD OF MINING

The orebody would be mined by open pit methods over an 11-year period (Figures 26, 36 and 37). At the end of this time, the surface intercept of the open pit would embrace an elliptical-shaped area of 55 acres, some 2,400 feet long and averaging 1,000 feet across. Three types of material will be excavated from the expanding open pit. Copper ore will be trucked to the process plant for beneficiation. In order to mine one ton of ore, a little more than four tons of wasterock and unconsolidated glacial materials must be removed. These two waste products will be trucked to the waste area or soil stockpile site for dike construction and rehabilitation. The material balance schedule for the project is shown in Exhibit G.

The planned open pit mining method is conventional for a small operation of this type. Technical details, e.g., bench height, berm width, hole size, spacing, explosives charge, could change in practice as additional information on the nature of the rock is developed. An overall slope angle of 35° will be maintained until progressive rock mechanics studies indicate a change. Bench height will be 35 feet. To break the required tonnage of ore and waste on a five-day mining, seven-day milling work basis, forty 6-3/4-inch blast holes per week will be required. These will be drilled by a mobile rotary blast hole drill. The cuttings from the hole being drilled are flushed out by compressed air and water applied to the bit through a hollow drill stem.

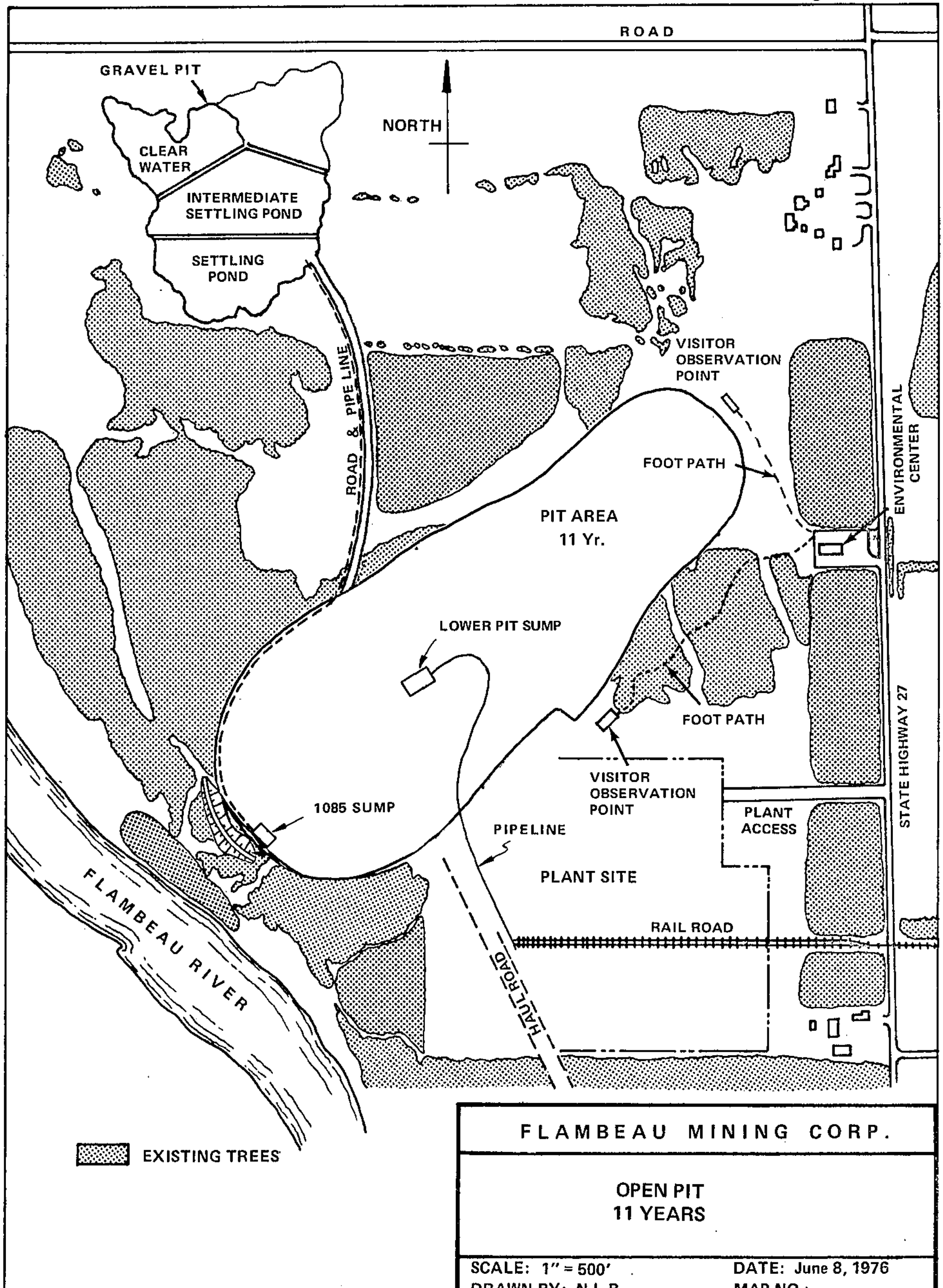


FLAMBEAU MINING CORP.

OPEN PIT
7 – 9 YEARS

SCALE: 1" = 500'
DATE: June 8, 1976
DRAWN BY: N.L.B.
MAP NO.:

Figure 37


ROAD
GRAVEL PIT
NORTH
CLEAR WATER
INTERMEDIATE SETTLING POND
SETTLING POND
ROAD & PIPE LINE
VISITOR OBSERVATION POINT
ENVIRONMENTAL CENTER
FOOT PATH
PIT AREA 11 Yr.
LOWER PIT SUMP
FOOT PATH
VISITOR OBSERVATION POINT
1085 SUMP
PIPELINE
PLANT ACCESS
STATE HIGHWAY 27
PLANT SITE
RAIL ROAD
FLAMBEAU RIVER
HAUL ROAD
EXISTING TREES
FLAMBEAU MINING CORP.
OPEN PIT
11 YEARS
SCALE: 1" = 500'
DATE: June 8, 1976
DRAWN BY: N.L.B.
MAP NO.:

Ammonium nitrate for blasting will be loaded into a bulk transport truck of 1½-ton capacity, which is provided with a unit for adding and mixing the required amount of fuel oil immediately prior to pumping the mixture into the hole. In the event of a wet hole, a plastic bag liner will be used to contain the ammonium nitrate-fuel oil explosive or a moisture-proof explosive will be used. Each hole will be loaded with roughly 300 pounds of explosives which will fill up one-half of the hole. The rest of the hole will be filled with fine rock arising from the drilling operation. To minimize the noise impact, ground vibration and air impact, millisecond delays will be used such that the holes are exploded in sequence. The amount of explosive used is estimated as six tons per five-day week, and in summer months blasting will normally take place once per week. In the winter, under freezing conditions, more frequent small blasts will be used to avoid the extended storage of material liable to freeze.

The wasterock will be loaded into 50-ton haulage trucks for transport to the waste containment area where it is either used for building the dikes or, in the case of material containing pyrite, placed inside the dikes. Subsoils will be placed in the soil stockpile. The ore will also be loaded into 50-ton haulage trucks for delivery to the primary jaw crusher. During dry periods, the haulage roads will be sprinkled by a water truck to suppress dust.

The noise produced by a moving 50-ton truck is estimated as between 77 and 88 dBA. The Society of Automobile Engineers (SAE) has established a standard procedure, SAE.J88, for testing the noise level of trucks. Using this procedure, the Caterpillar Tractor Company has established the noise levels of its type 773 50-ton off-highway truck equipped with Caterpillar's 600 hp engine as follows (page 120):

Stationary test	Distance (in front of truck)	50 feet
	Noise level	87.5 dBA
Moving test	In second range, direct drive at 1,900 rpm	Left side 86.5 dBA

The feasibility of extending the life of the mine by converting to an underground operation at the end of the open pit life would be reevaluated after several years of pit operation. Should the open pit bottom at 285 feet below the surface, as presently anticipated, access to the underground orebody would be by means of a two-compartment, production shaft sunk to a depth of 830 feet in the footwall of the orebody. This shaft would ultimately be equipped with a combined man-cage and haulage skip in one compartment and a ladderway, utilities, and a counter-weight in the other. Shaft stations would be cut at about 200-foot intervals below the pit bottom, and cross cuts would be developed from these to the ore. A main station with pumping and orehandling facilities would be constructed on the 400-foot level which would serve as the main haulage level for the mine. Stoping would commence on the 400-foot level (Figure 37).

To bring the underground mine to the production stage, the following items would also be required:

1. A vertical ventilation shaft which would be equipped as an escapeway. This shaft would be about 50 square feet in cross section and would intersect a level connected to the ventilation raises. A 50,000 cfm fan would be installed.

2. Ventilation and service raises in ore between levels at the extremities of the orebody. These would serve as upcast airways and would be equipped with pipes to handle the fill to be emplaced in the worked-out stopes.

3. An ore pass and parallel service raise in ore between the levels at the end of the production shaft cross cuts.

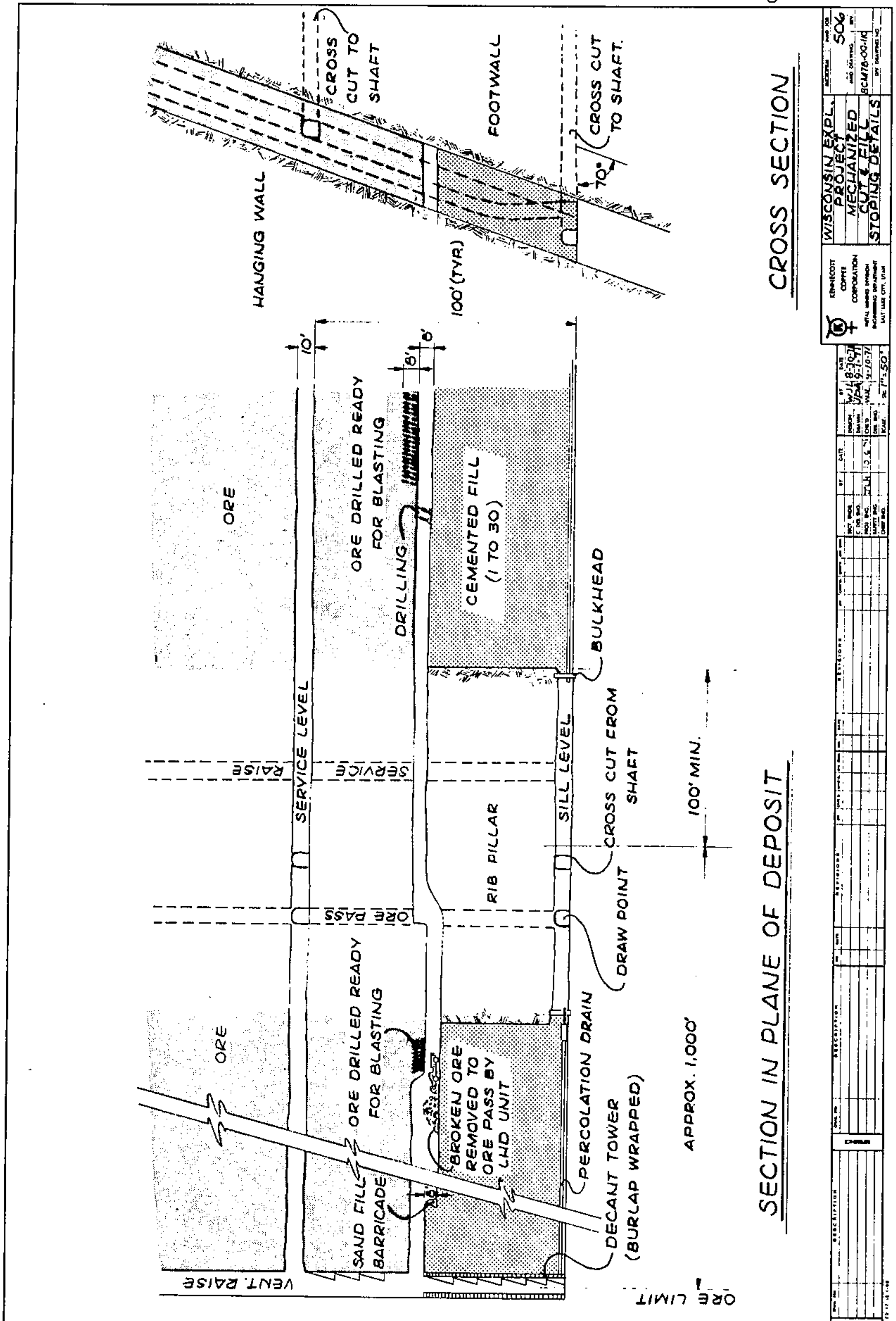
4. Installation of slusher trenches on the 400-foot level and loading pockets with spillage-handling arrangements below the level.

5. The erection of a gravel-washing plant to produce backfill.

Because of the need for minimizing surface subsidence and the incompetence of the hangingwall, cut-and-fill will be used as the stoping method (Figure 38). The orebody is continuous on strike and has a comparatively short strike length of ± 1,200 feet on either side of the shaft system. Accordingly it would be possible to consider the whole orebody below the pit as one stope, with one ore pass and one service raise cut in a low-grade pillar at the end of the shaft cross cuts for access.

The coarse fraction from the tailings contains up to 50% pyrite and would be unsuitable for fill. Therefore, gravel for the fill would come from the former Rusk County gravel pit located near the mine. This material would be crushed or screened to 1/2-inch and mixed with cement to provide a 1 to 30 ratio. The discard from the screening plant, amounting to 740,000 tons, will be pumped to the waste containment area. As mining progresses, the cement-rich fill would be pumped from the surface into the mined-out stopes at 70% solids to prevent subsidence of the surrounding ground. Water draining from the fill would be pumped to the surface and into the lower pit sump pipeline. Surface diamond drill holes have indicated that the underground mine would have comparatively minor water problems. Water from the fill operation would amount to roughly 30 gpm. Provisions would be made for a 200 gpm continuous pumping system and a 100 gpm standby system.

The underground work schedule would be three shifts per day, five days per week, with a mine production rate of 1,400 tons per day. The total number of employees on the property, including surface and staff, is estimated to be 143. The underground mining operation would prolong the overall life of the venture about eleven years.


HANGING WALL
CROSS CUT TO SHAFT
FOOTWALL
CROSS CUT TO SHAFT
70°
100' (TYP.)
CROSS SECTION
10'
8'
6'
ORE
ORE DRILLED READY FOR BLASTING
DRILLING
CEMENTED FILL (1 TO 30)
BULKHEAD
SERVICE LEVEL
RAISE
SERVICE
SILL LEVEL
CROSS CUT FROM SHAFT
100' MIN.
RIB PILLAR
ORE PASS
DRAW POINT
ORE
ORE DRILLED READY FOR BLASTING
BROKEN ORE REMOVED TO ORE PASS BY LHD UNIT
PERCOLATION DRAIN
APPROX. 1,000'
SAND FILL BARRICADE
DECANT TOWER (BURLAP WRAPPED)
VENT. RAISE
ORE LIMIT
SECTION IN PLANE OF DEPOSIT
KENNECOTT COPPER CORPORATION
WISCONSIN EXPL. PROJECT
MECHANIZED CUT & FILL STOPING DETAILS

2.3.0 CONCENTRATOR

Ore from the mine would be upgraded in a concentrator plant located immediately adjacent to the mine. Because concentrate production from the mine would be much too small by itself to support a conventional smelter, or such other reduction methods as hydrometallurgy and pyrometallurgy, the metal-bearing concentrate will be shipped by rail out of the state for smelting and refining.

The flow of material in the concentrator is shown in Figure 39. In the case of the open pit operation, ore will be delivered to the concentrator by 50-ton rear-dump trucks during day shift on five days per week. In the case of underground mining, ore will be brought by truck or conveyor from the headframe ore pocket to the concentrator.

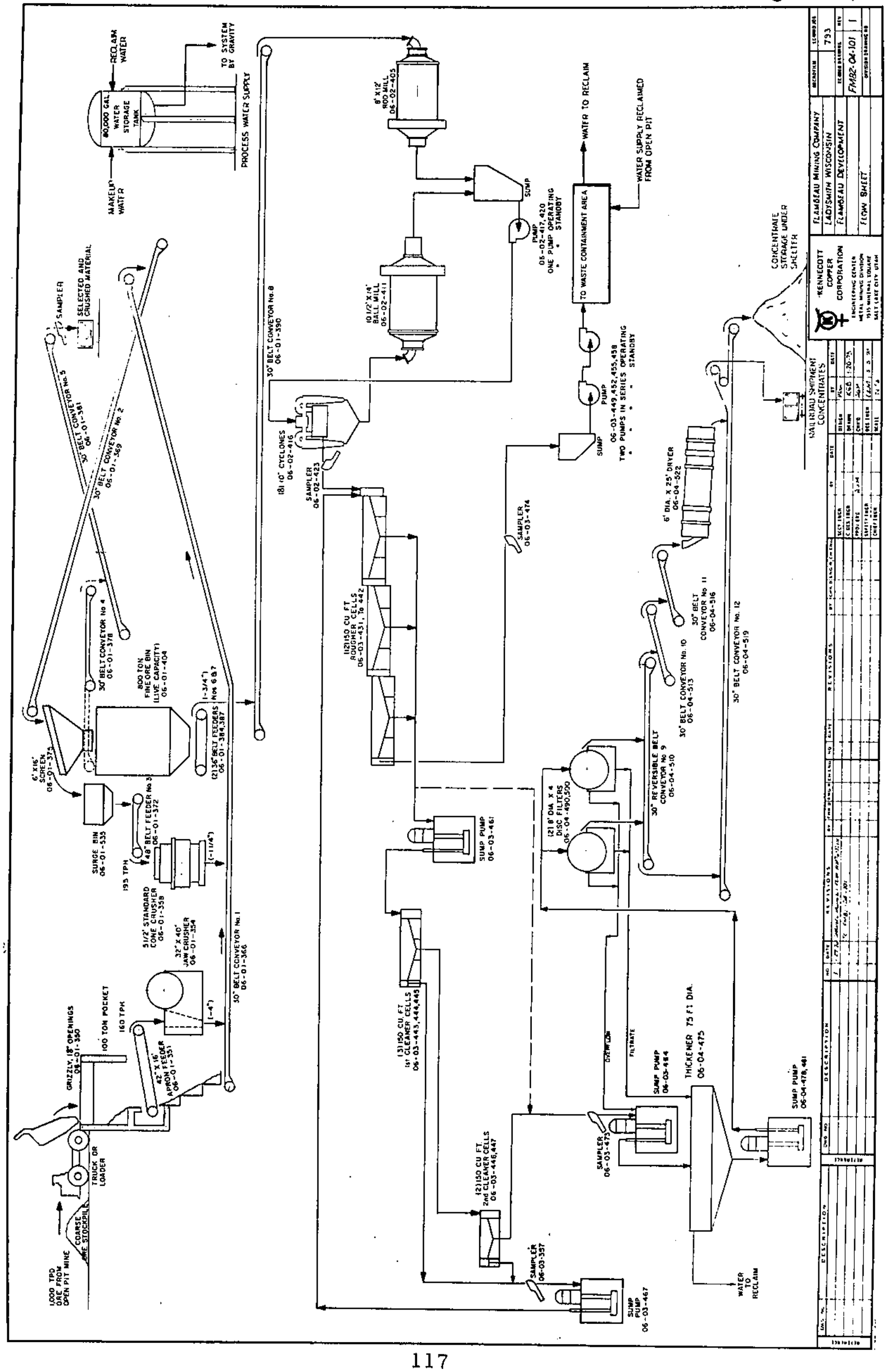
A ground stockpile will be established adjacent to the concentrator so that the crusher can be fed by a front-end loader over the weekend when the mine is not operating. The ore will be dumped into a 100-ton live capacity pocket from which it will be drawn by an apron feeder and delivered to a jaw crusher (see page 100, Section 2.1.9).

The crusher product will drop onto a belt conveyor which discharges to a vibrating screen with a 3/4-inch slotted lower deck. Screen undersize will drop into the fine ore bin. Screen oversizé will be fed to a cone crusher set at 1/2-inch which discharges to the same conveyor as the jaw crusher product. The 3/4-inch product will be stored in an 800-ton live capacity fine ore bin which is located inside the concentrator building to minimize problems with frozen ore in winter.

Fine ore will be drawn from the bin by two variable-speed slot belt feeders and fed to an eight-foot diameter by twelve-foot rod mill. The process of crushing through to feeding the fine ore to the rod mill is dry and consequently dust-forming. Dust is removed by means of hoods under suction and designed according to KCC's Industrial Hygiene Standards. Two separate dust-collecting systems will be installed - the one operates on the crushing system through to the fine bin and will function only when the crusher system is in operation - normally one shift per day. The other system operates on a feed from the fine ore bin to the rod mill - three shifts per day, seven days per week.

Based on a yearly average production rate, 492 gpm of industrial water is added to the fine ore feed to the rod mill. Roughly 419 gpm or 85% of this amount is recycled water. The coarsely ground ore slurry from the rod mill is discharged to a sump from which it is pumped to a bank of cyclone classifiers. The finely ground slurry fraction from the classifier overflow goes to the flotation circuit. The coarsely ground slurry fraction from the classifier underflow is fed to a ball mill for further grinding. The ball mill discharge is recirculated to the sump serving the cyclones. To the rod mill and the ball mill feed, a total of 5,000 pounds per day of slaked lime is added to give an alkaline (pH 11) pulp in the flotation circuit.

Figure 39


1000 TPD ORE FROM OPEN PIT MINE
COARSE ORE STOCKPILE
TRUCK OR LOADER
GRIZZLY, 18" OPENINGS 06-01-350
100 TON POCKET
160 TPH
42" X 16' APRON FEEDER 06-01-351
32" X 40" JAW CRUSHER 06-01-354
30" BELT CONVEYOR No. 1 06-01-366
5 1/2' STANDARD CONE CRUSHER 06-01-358
195 TPH
48" BELT FEEDER No. 3 06-01-372
SURGE BIN 06-01-535
6' X 16' SCREEN 06-01-373
30" BELT CONVEYOR No. 4 06-01-378
800 TON FINE ORE BIN (LIVE CAPACITY) 06-01-404
(2) 36" BELT FEEDERS Nos 6 & 7 06-01-384,387
30" BELT CONVEYOR No. 2 06-01-369
30" BELT CONVEYOR No. 5 06-01-381
SAMPLER
SELECTED AND CRUSHED MATERIAL
MAKEUP WATER
80,000 GAL. WATER STORAGE TANK
RECLAIM WATER
TO SYSTEM BY GRAVITY
PROCESS WATER SUPPLY
30" BELT CONVEYOR No. 8 06-01-390
8' X 12' ROD MILL 06-02-405
(1) 10 1/2' X 14' BALL MILL 06-02-411
SUMP
PUMP 06-02-417,420 ONE PUMP OPERATING STANDBY
(8) 10" CYCLONES 06-02-416
SAMPLER 06-02-423
(12) 150 CU FT ROUGHER CELLS 06-03-431, TO 442
TO WASTE CONTAINMENT AREA
WATER TO RECLAIM
WATER SUPPLY RECLAIMED FROM OPEN PIT
PUMP 06-03-449,452,455,458 TWO PUMPS IN SERIES OPERATING STANDBY
SUMP
SAMPLER 06-03-474
SUMP PUMP 06-03-461
(3) 150 CU FT 1st CLEANER CELLS 06-03-443,444,445
(2) 150 CU FT 2nd CLEANER CELLS 06-03-446,447
SAMPLER 06-03-357
SUMP PUMP 06-03-467
SAMPLER 06-03-473
SUMP PUMP 06-03-464
OVERFLOW
FILTRATE
THICKENER 75 FT DIA. 06-04-475
SUMP PUMP 06-04-478,481
WATER TO RECLAIM
(2) 8' DIA X 4 DISC FILTERS 06-04-490,500
30" REVERSIBLE BELT CONVEYOR No. 9 06-04-510
30" BELT CONVEYOR No. 10 06-04-513
30" BELT CONVEYOR No. 11 06-04-516
6' DIA. X 25' DRYER 06-04-522
30" BELT CONVEYOR No. 12 06-04-519
RAILROAD SHIPMENT CONCENTRATES
CONCENTRATE STORAGE UNDER SHELTER
KENNECOTT COPPER CORPORATION
ENGINEERING CENTER METAL MINING DIVISION SALT LAKE CITY UTAH
FLAMBEAU MINING COMPANY
LADYSMITH WISCONSIN
FLAMBEAU DEVELOPMENT
FLOW SHEET
793
FMB2-04-101

The slaked lime will be delivered by covered trucks and stored as a dry product in a 50-ton enclosed bin from which it will be delivered as required by an enclosed conveyor system to a flaking circuit. The flaking circuit will be located inside the concentrator building.

All other flotation reagents will be received and stored in 55-gallon drums inside the concentrator building. Reagents will be mixed as required in agitated mix tanks. The resulting mixture will be pumped to holding tanks of approximately two-days capacity located on the mill floor.

The ore slurry at 28% solids will be delivered to a bank of mechanical rougher flotation cells. At this point approximately 150 pounds per day of promoter (typically Aerofloat 238) and 120 pounds per day of a frother (typically 25% cresylic acid, 75% MIBC) will be added. By aeration and the addition of these chemical reagents, the copper sulfide mineral grains are physically separated from the ore pulp in a froth. The copper sulfide-rich froth, called rougher concentrate, is continually removed from the top of the flotation cells. The impoverished pulp from the rougher cells is the plant tailings and will be pumped to the waste containment area. The rougher concentrate will be cleaned in a bank of cleaner cells and recleaner cells to produce the final mill concentrates and a cleaner tailings which will be returned to the head of the rougher flotation cells for recycling.

Provision has been made in the design of the flotation section of the concentrator for addition of a zinc-recovery circuit. As the orebody is mined, the zinc content increases as the mining depth increases. When the zinc content becomes significant, an economic analysis will be made and if viable a zinc-recovery circuit will be added.

The final copper concentrate, containing minor amounts of gold and silver, will be piped to a thickener and then pumped to two vacuum filters set on a mezzanine floor for dewatering. Filter cake will drop through the floor onto a belt conveyor feeding a rotary kiln dryer. The dryer product will be conveyed either directly to railroad cars or to a covered concentrate stockpile. Provision will also be made for bypassing the dryer and feeding the filter cake directly to the railroad cars on storage.

The dryer will be equipped with its separate dust-collection system which will operate whenever the dryer is in operation. This is expected to be three shifts per day, seven days per week. The dryer product will normally contain 9% water and, to prevent any losses as the surface of the concentrate storage pile dries out, the pile will be completely enclosed in a building.

The noise level from the concentrator and, in particular, close to the crushing section (which normally operates on day shift only, five days per week) is estimated to be below legal limits. This is based on noise levels at other KCC operations. For example, the noise level three feet away from the open door of the Bonneville, Utah concentrator, which can crush and grind 35,000 tpd of run-of-mine ore from the Bingham Pit, is only 74.0 dBA and 85.0 dBC with the crusher section running, compared with 62.5 dBA and 72.0 dBC with the crusher idle. (The dBA scale most resembles the response of the human ear; the dBC records impact peaks with no levelling effect.) The noise level from a 1,000 tpd crushing section with the crushers firmly tied to a massive concrete pedestal will be negligible in Ladysmith or at the college.

The tailings slurry will contain the following concentrations of typical reagents used in the concentrator:

Reagent	Parts per Million (ppm)
Promoter - Aerofloat 238	0.45
Frother - cresylic acid	14.00
Frother - methyl amyl alcohol (MIBC)	16.00

The toxicity of the promoter and the methyl amyl alcohol frother in the strengths above is minor. Concentrations of 100 to 200 ppm over periods of three to five days would be required to kill fish such as trout and salmon. Furthermore, the promoter biodegrades and the concentration is reduced to 0.1 ppm after fifteen days. The methyl amyl alcohol frother biodegrades to a concentration of 0.5 ppm in sixteen days. The cresylic acid frother in the above concentration is toxic to fish life. Cresylic acid, however, in the presence of organisms found in tailings solutions, completely breaks down into harmless constituents in less than eight days - much less than its retention time. The high alkalinity of the solution inhibits the oxidation of pyrite. Computer studies based on the measured permeabilities of the soils in the floor of the waste containment area and the constituents of the dikes show that it would take much more time for any leakage to traverse from the inside to the outside of the waste containment area than is required for reagent degradation.

During its 11-year life, the open pit mining operation would generate a total of 2,617,000 tons of tailings (dry weight) at an average rate of 840 tons per day. A possible subsequent underground operation would produce 2,886,000 tons at an average rate of 860 tons per day. The tailings would be composed of finely ground minerals in the following approximate proportions:

50% to 70%	Quartz, mica and clays
30% to 50%	Iron sulfide (pyrite)

The tailings, in the form of a slurry, would be pumped from the plant through a 7,000-foot, eight-inch diameter pipeline to a waste containment area located south of the mine. Excess water from the waste containment area would be recycled through the concentrator plant. The tailings would be contained behind dikes constructed of waste materials from the mine, having average dimensions as follows:

Height	56 feet
Width at top	80 feet
Width at base	363 feet

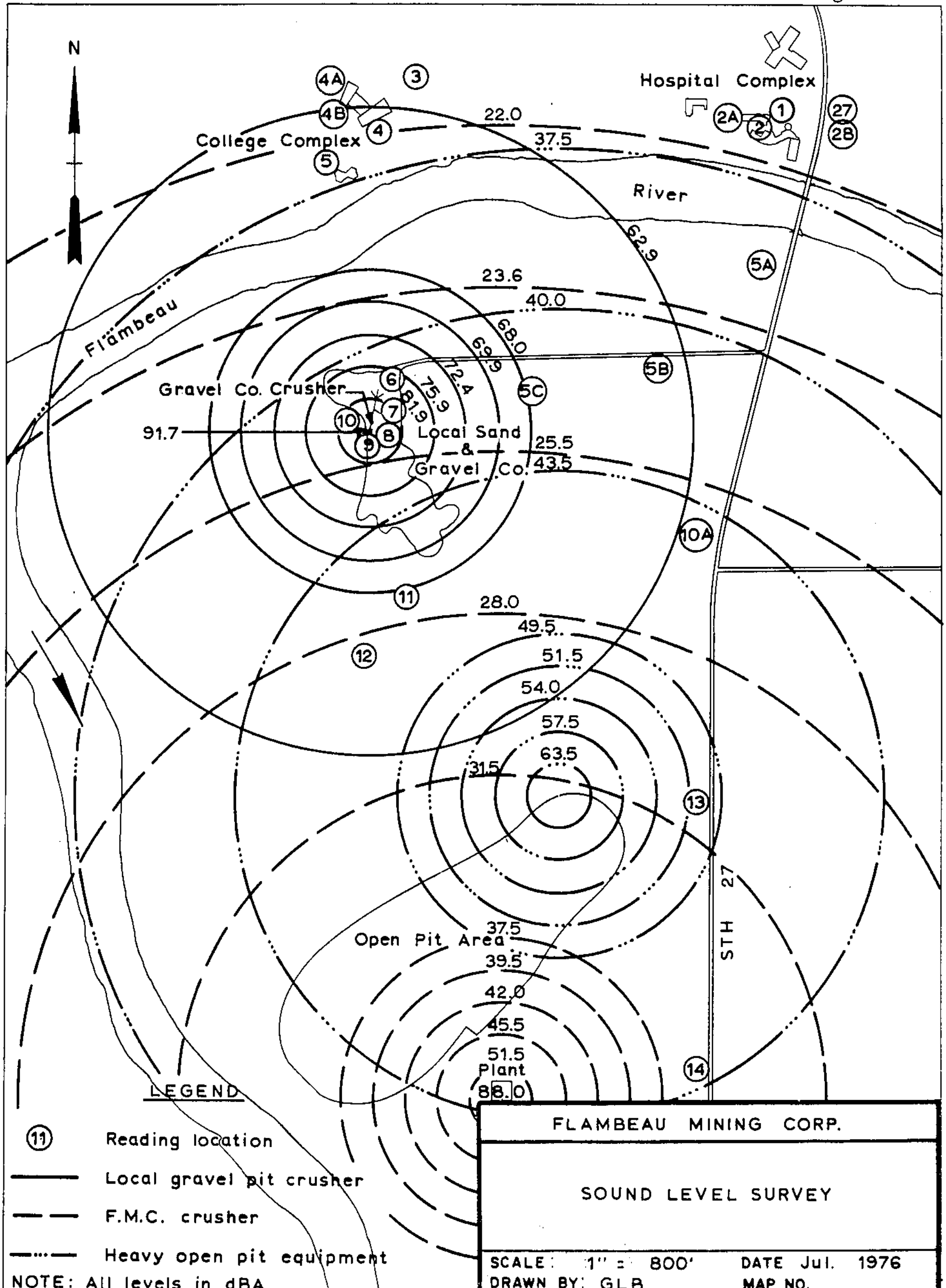
The volume inside the enclosure is sufficient to contain the tailings from both an open pit and an underground operation, plus silt from the underground backfill plant.

A clean pyrite concentrate can be produced by further flotation of the tailings. The sale of pyrite for sulfuric acid production or other uses has been pursued since 1971 without success. The abundance of basic sulfur in the United States excludes pyrite as a source for sulfuric acid. Also, the creation of sulfuric acid from pyrite requires a burning process which is pretty much prohibited by the EPA. The storage of the product pyrite until such time as a market might develop would create a serious and possibly dangerous situation; nevertheless KCC is still pursuing a pyrite market.

2.4.0 NOISE

The environmental noise impact of the FMC operation on the community of Ladysmith, specifically the hospital, nursing home and college, was obtained by utilizing data from a typical KCC crushing operation with a production rate of 35,000 tpd (page 118). The calculations for the noise levels to be expected in the community were based upon a flat terrain void of vegetative growth and buildings (free field). The levels which are expected at the college, nursing home and hospital, assuming the only source of noise to be the FMC mining operation, would be 22.0 dBA. This level is well below the present normal background levels of approximately 54 dBA, which means the FMC operation would have no contribution to community noise levels. The adjacent sand and gravel operation is the primary source of noise contribution to the community at the present time and will still be the major contributor when FMC is operating.

Existing trees, high terrain and buildings would tend to reduce the levels of high frequency noise (above 500 Hz) in the community but would have very little, if any, attenuation for the low frequency energy. The levels will increase slightly during infrequent blasting. This noise is of short duration (impact noise). The present background levels are shown in Section 1. The levels to be expected based on worst-case crusher data of 88.0 dBA measured at three feet from the open door and at different distances outward from the operation are shown on Figure 40. Also shown by overlay are the levels from the FMC heavy equipment, assuming the trucks produce continuous noise, which is not the case, and a sound pressure level of 100 dBA three feet from the equipment power plant. A third overlay shows the level to be expected in the community based on a sound pressure level of 91.7 dBA taken at 65 feet from the presently operating sand and gravel crusher.


N
Hospital Complex
College Complex
River
Flambeau
Gravel Co. Crusher
91.7
Local Sand & Gravel Co.
Open Pit Area
Plant
88.0
STH 27
22.0
37.5
62.9
23.6
40.0
68.0
69.9
72.4
75.9
81.9
25.5
43.5
28.0
49.5
51.5
54.0
57.5
63.5
31.5
37.5
39.5
42.0
45.5
51.5
4A
3
4B
4
5
2A
2
1
27
2B
5A
5B
5C
6
7
10
8
9
10A
11
12
13
14
LEGEND
11 Reading location
Local gravel pit crusher
F.M.C. crusher
Heavy open pit equipment
NOTE: All levels in dBA
FLAMBEAU MINING CORP.
SOUND LEVEL SURVEY
SCALE: 1" = 800'
DATE Jul. 1976
DRAWN BY: GLB
MAP NO.

All machinery such as the 50-ton trucks used to haul wasterock to the waste containment area will be equipped to meet applicable sound standards. For example, the sound level generated by these trucks will vary from 77 to 88.5 dBA at 50 feet away which is less than the proposed EPA standard of 90 dBA for operation of heavy trucks on public roads, effective October 1, 1974 (page 113).

The sound intensity level, as additional trucks are added, is logrithmic.

$$dB = 10 \log I/I_o$$

where I_o is the original intensity, and I is the cumulative intensity of the additional trucks.

For example, if one truck produces 80 dB, cumulatively, five trucks would be 400 dB. The problem would set up as

$$dB = 10 \log 400/80 = 7 \text{ dB additional intensity}$$

Thus, five trucks would produce a dB reading of 87 dB.

During the course of a normal shift operation, the five trucks would be spread over the length of the project site and only at shift startup and shutdown would they be grouped. At this time the trucks would be empty with their engines operating at a very low sound level.

SECTION 3

ENVIRONMENTAL IMPACTS

[redacted]

SECTION 3

3.1.0 INTRODUCTION

The primary environmental impacts of the proposed action are identified and described in this section. Secondary and cumulative impacts are identified and described only where a sound basis exists for the prediction of such impacts. Much of the section is devoted to presentation of the bases upon which identification and determination of the magnitudes of the impacts were made. Impacts have been quantified to the degree practicable but many, including those relating to water quality which are probably those of greatest importance, cannot be quantified in advance. In such cases, realistic ranges and the most likely expected values are given.

3.2.0 IMPACT ON SOILS

Large quantities of soils will be moved, manipulated, stored and reused during the life of the proposed operation (Table 30 and Exhibit G). Erosion and deposition will be controlled through adherence to several policies:

1. All soils moved to the stockpile will be seeded in the stockpile to stabilize the accumulation. The major soil stockpile (Figure 35) will be given further protection by a tree screen.

2. All soils exposed on any significant slope will be mulched, fertilized and seeded as soon as possible to prevent water and aeolian erosion.

3. In especially sensitive areas such as the haul road crossing of Meadowbrook Creek, after emplacement and compaction of fill and soils, matting, seeding or sodding of the roadside will be carried out. Temporary runoff catchment basins will also be used during construction to control siltation of such areas.

4. All seeding and revegetation work will use the best available information on seed mixtures, mulching and fertilization.

5. Topsoils will be segregated from subsoils and vegetated.

Ongoing tests have indicated that the subsoils can support the growth of seed mixtures if there is use of recommended fertilization. Most of the soils to be moved and reused will be acidic in nature (5.5-7.0).

Much soil will be removed before emplacement of buildings, construction of the haul road and construction of the waste containment area. Approximately 130 acres of topsoils will be permanently covered under the waste containment area. Presently these soils support mostly cropland, pasture, old field, lesser amounts of mixed forests and wetlands.

TABLE 30

WASTE MATERIALS PRODUCTION AND DISPOSAL - PRE-PRODUCTION PERIOD

	Cubic Yards Produced	Cubic Yards Used in Construction	Net Cubic Yards to Storage Areas (Exhibit A)
Topsoil (1-3' thick)			
Pit area	22,000	--	22,000
Dike foundation area	131,000	--	131,000
Plant area		All reused at site	--
Subtotal - Storage Area A	153,000	--	153,000
Till			
Open pit material	485,000		
Haulage roads		160,000	
Outer dike surface		143,000	
Subtotal	485,000	303,000	182,000
Waste rock			
Common open pit material	200,000		
Dike wall		200,000	--
Subtotal	200,000	200,000	--
Saprolite open pit material	394,000		
Dike core		114,344	
Trench lining		22,000	
Ditch lining		1,000	
Subtotal - Storage Area B	394,000	137,344	256,656
Underground development rock	--	--	--
Subtotal	--	--	--
Total waste rock	594,000	337,344	256,656
TOTALS	1,232,000	640,344	591,656

It is currently planned to construct onsite treatment facilities for sewage wastes. Excess water effluent accumulation will be disposed of through woodland irrigation in order to provide a use for these wastes. The impact of these enriched waters on the receiving soils should be similar to simple irrigation and fertilization. Increase in the productivity of in situ plant communities is expected.

The quantities of soils lost owing to erosion are difficult to predict. The majority of soils to be manipulated are dense silty sands and clays, highly impermeable and water retentive after saturation. What losses do occur will probably be largely of silt and clay fines. Rapid revegetation will be essential to minimize these losses.

3.3.0 IMPACT ON HYDROLOGY

3.3.1 GENERAL

A collection ditch will be installed inside the pit perimeter at the top of the clay saprolite layer, approximately at the 1,085-foot elevation. This ditch will collect groundwater inflow and meteoric waters falling on the adjacent surface and the uppermost pit slopes to prevent their contact with sulfide-bearing bedrock. The collected water will be used for industrial purposes. Any excess will be pumped to the gravel pit for settling and return by percolation to the groundwater system. Waters escaping from the upper collection system, and those entering directly as precipitation below the 1,085 level, will be collected in the pit bottom and pumped to the waste containment area for storage and subsequent industrial use. If necessary, additional water supply to meet industrial needs will be obtained from wells located in the vicinity of the gravel pit.

In order to predict water supply and disposal conditions during the various stages of mine development and process operations, a water balance study was made. Water flow rates during construction, initial production, yearly average operation, summer and winter operations, and shutdown were developed using both the calculated theoretical and the expected rates of groundwater flow into the pit. Flow rates for the former are shown on Figures 41 through 45 and are explained below. Flow rates for the latter are shown on Figures 46 through 51.

3.3.1.1 DURING CONSTRUCTION

During the construction phase (Figure 26), sufficient prestripping will be done to expose a three months' supply of ore. Groundwater inflow to the pit from the glacial tills and the sandstone, estimated to average 1,620 gpm, will be collected in the 1,085-level ditch and gravitated to the 1,085 sump. Precipitation above the 1,085 level, estimated to average a net 96 gpm after evaporation, will be collected in the same ditch. Thus the 1,085 sump will receive an average of 1,716 gpm. Of this, 50 gpm will be

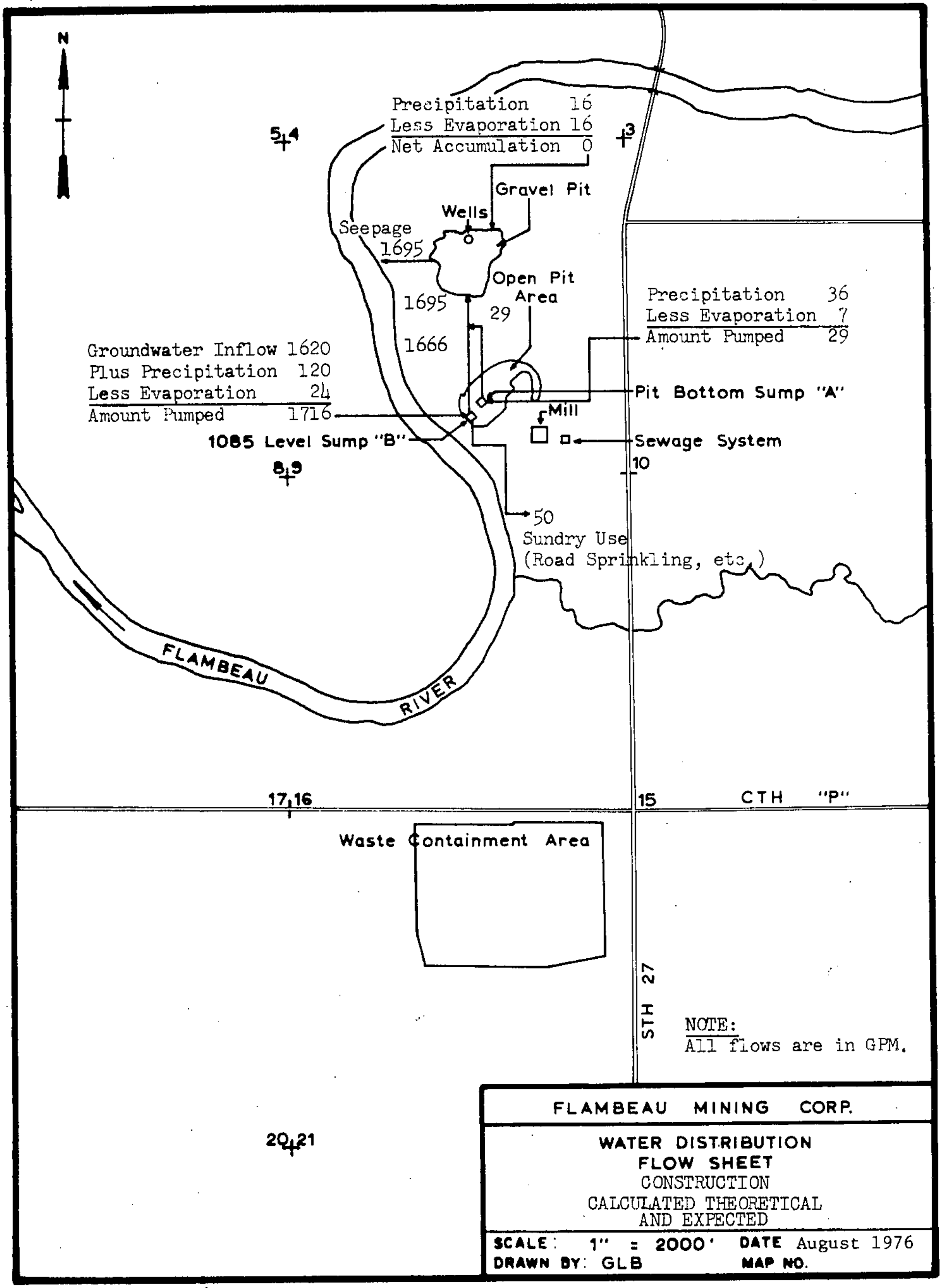

N
Precipitation 16
Less Evaporation 16
Net Accumulation 0
Gravel Pit
Wells
Seepage
1695
Open Pit
Area
1695
29
1666
Precipitation 36
Less Evaporation 7
Amount Pumped 29
Groundwater Inflow 1620
Plus Precipitation 120
Less Evaporation 24
Amount Pumped 1716
Pit Bottom Sump "A"
Mill
1085 Level Sump "B"
Sewage System
5,4
3
8,9
10
50
Sundry Use
(Road Sprinkling, etc.)
FLAMBEAU RIVER
17,16
15
CTH "P"
Waste Containment Area
STH 27
NOTE:
All flows are in GPM.
20,21
FLAMBEAU MINING CORP.
WATER DISTRIBUTION
FLOW SHEET
CONSTRUCTION
CALCULATED THEORETICAL
AND EXPECTED
SCALE: 1" = 2000'
DATE August 1976
DRAWN BY: GLB
MAP NO.

Figure 42

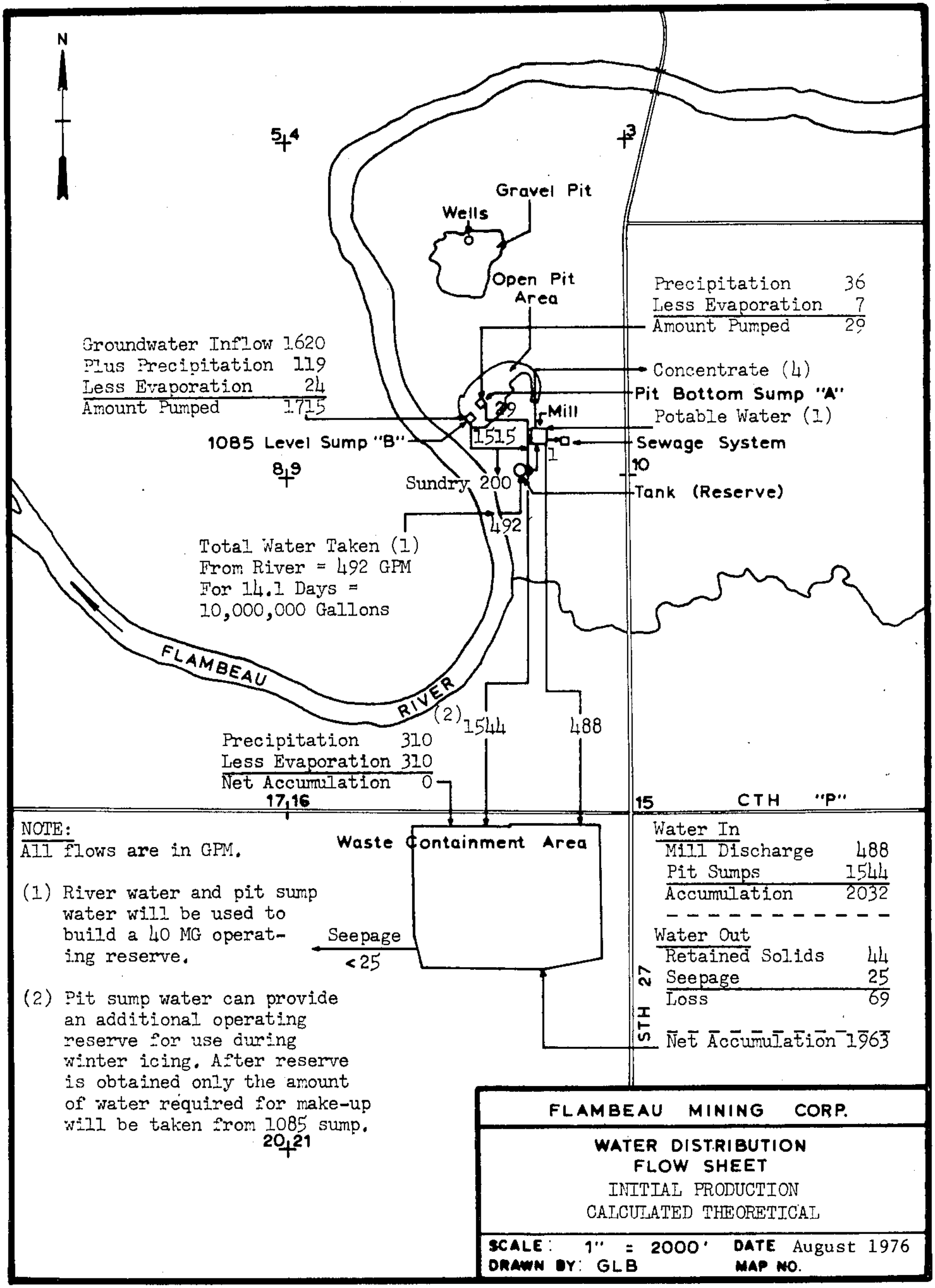

N
5,4
3
Gravel Pit
Wells
Open Pit Area
Precipitation 36
Less Evaporation 7
Amount Pumped 29
Groundwater Inflow 1620
Plus Precipitation 119
Less Evaporation 24
Amount Pumped 1715
Concentrate (4)
Pit Bottom Sump "A"
29
Mill
Potable Water (1)
1515
1085 Level Sump "B"
Sewage System
1
8,9
10
Sundry 200
Tank (Reserve)
492
Total Water Taken (1)
From River = 492 GPM
For 14.1 Days =
10,000,000 Gallons
FLAMBEAU RIVER
(2) 1544
488
Precipitation 310
Less Evaporation 310
Net Accumulation 0
17,16
15
CTH "P"
NOTE:
All flows are in GPM.
(1) River water and pit sump water will be used to build a 40 MG operating reserve.
(2) Pit sump water can provide an additional operating reserve for use during winter icing. After reserve is obtained only the amount of water required for make-up will be taken from 1085 sump.
20,21
Waste Containment Area
Seepage
<25
Water In
Mill Discharge 488
Pit Sumps 1544
Accumulation 2032
Water Out
Retained Solids 44
Seepage 25
Loss 69
Net Accumulation 1963
STH 27
FLAMBEAU MINING CORP.
WATER DISTRIBUTION
FLOW SHEET
INITIAL PRODUCTION
CALCULATED THEORETICAL
SCALE: 1" = 2000'
DATE August 1976
DRAWN BY: GLB
MAP NO.

Figure 43

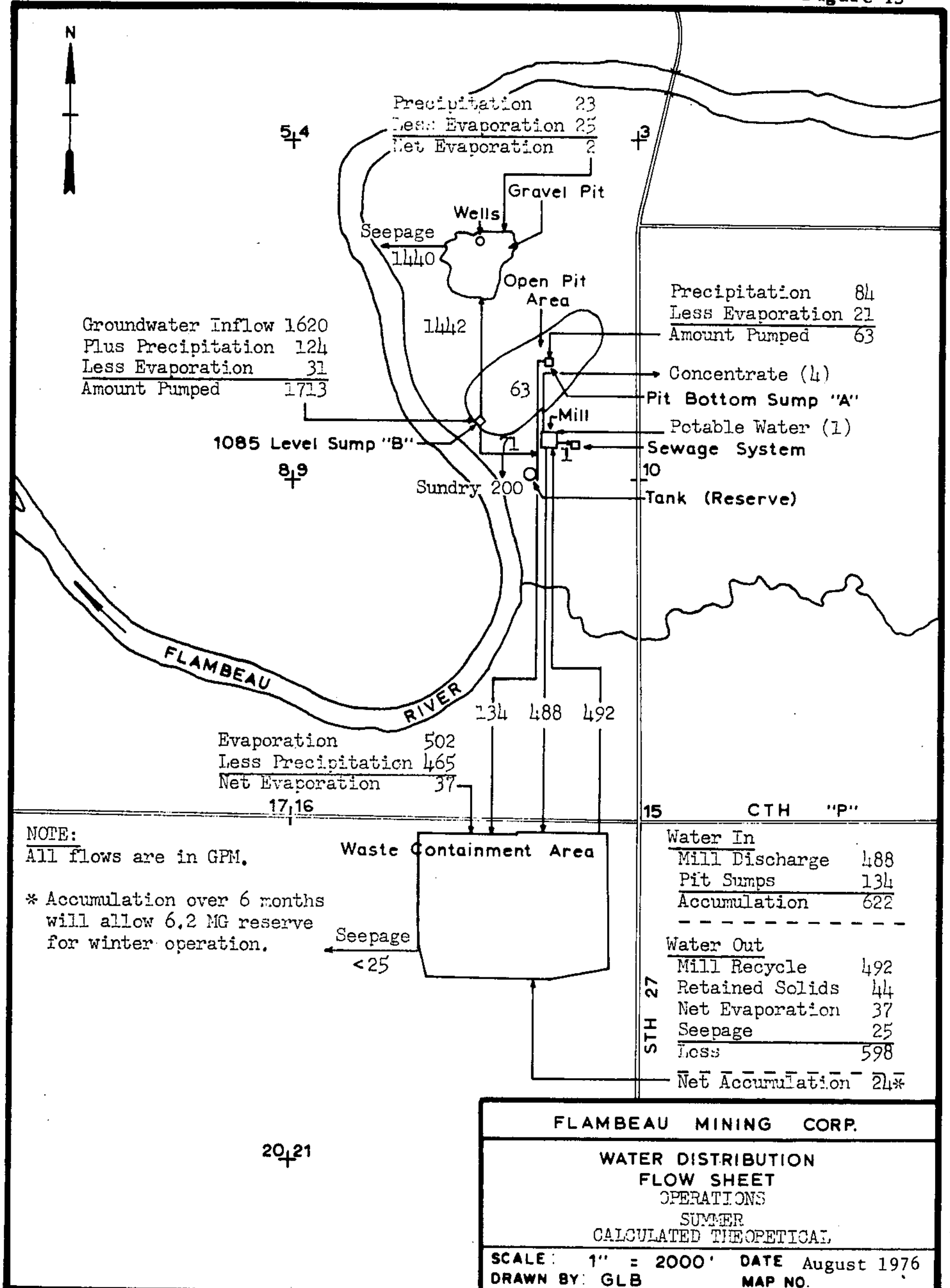
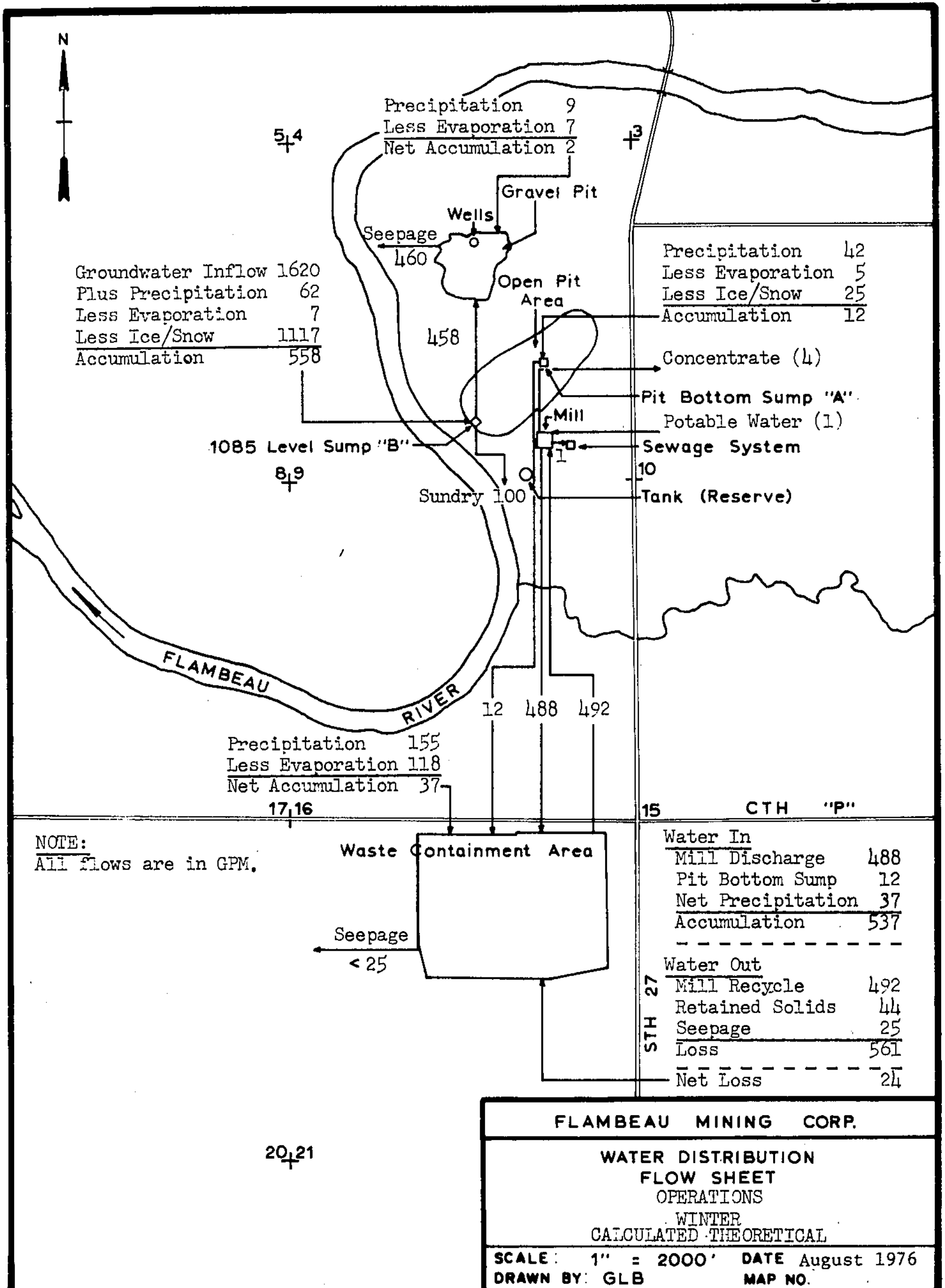
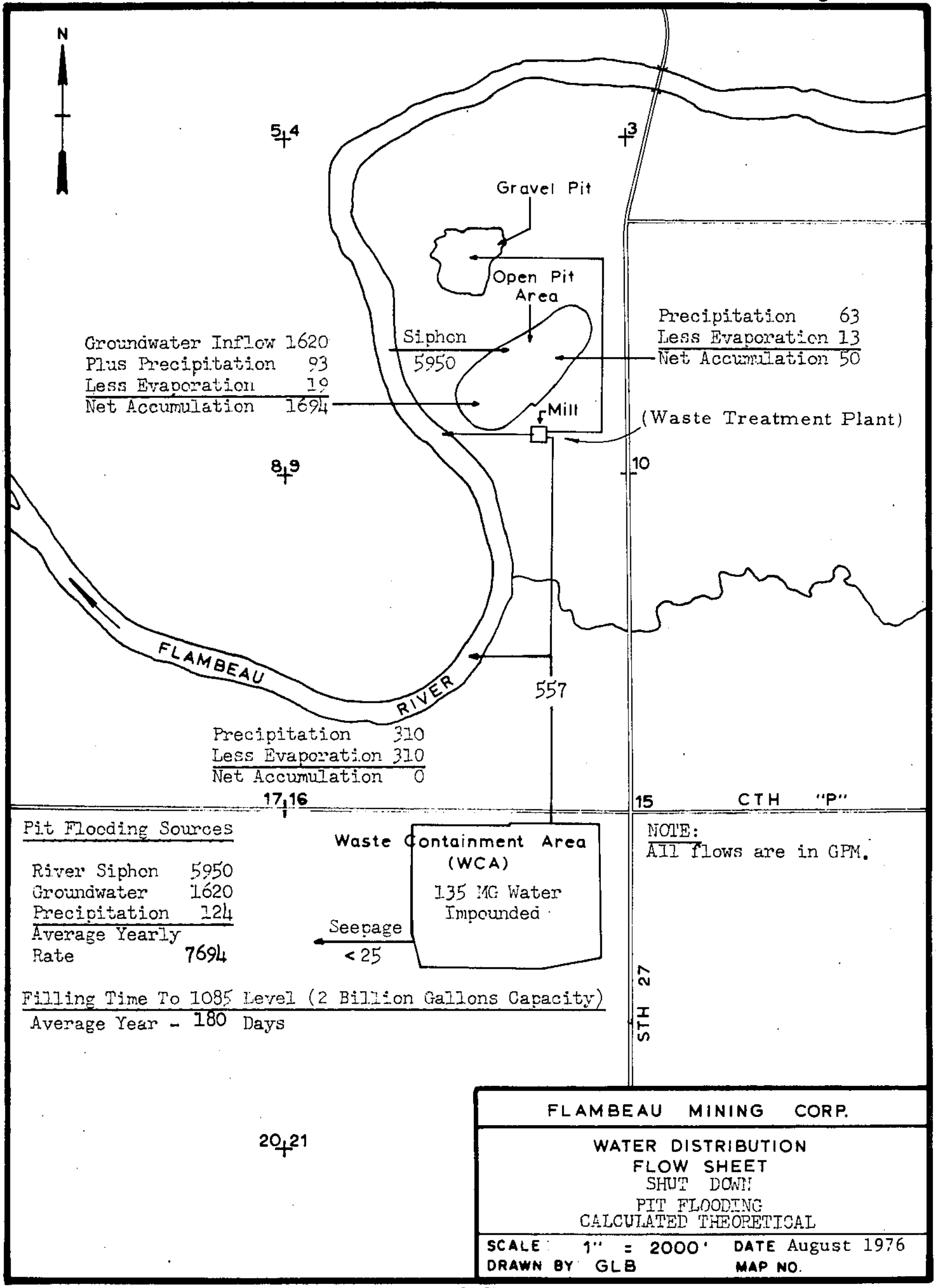

N
Precipitation 23
Less Evaporation 25
Net Evaporation 2
5,4
3
Gravel Pit
Wells
Seepage
1440
Open Pit Area
1442
Precipitation 84
Less Evaporation 21
Amount Pumped 63
Groundwater Inflow 1620
Plus Precipitation 124
Less Evaporation 31
Amount Pumped 1713
63
Concentrate (4)
Pit Bottom Sump "A"
Mill
Potable Water (1)
1085 Level Sump "B"
71
1
Sewage System
8,9
10
Sundry 200
Tank (Reserve)
FLAMBEAU RIVER
134
488
492
Evaporation 502
Less Precipitation 465
Net Evaporation 37
17,16
15
CTH "P"
NOTE:
All flows are in GPM.
* Accumulation over 6 months will allow 6.2 MG reserve for winter operation.
Waste Containment Area
Seepage
<25
Water In
Mill Discharge 488
Pit Sumps 134
Accumulation 622
Water Out
Mill Recycle 492
Retained Solids 44
Net Evaporation 37
Seepage 25
Loss 598
Net Accumulation 24*
STH 27
20,21
FLAMBEAU MINING CORP.
WATER DISTRIBUTION
FLOW SHEET
OPERATIONS
SUMMER
CALCULATED THEORETICAL
SCALE: 1" = 2000'
DATE August 1976
DRAWN BY: GLB
MAP NO.

Figure 44



N
Precipitation 9
Less Evaporation 7
Net Accumulation 2
5 4
3
Gravel Pit
Wells
Seepage
460
Open Pit
Area
Groundwater Inflow 1620
Plus Precipitation 62
Less Evaporation 7
Less Ice/Snow 1117
Accumulation 558
458
Precipitation 42
Less Evaporation 5
Less Ice/Snow 25
Accumulation 12
Concentrate (4)
Pit Bottom Sump "A"
Mill
Potable Water (1)
1085 Level Sump "B"
Sewage System
1
8 9
10
Sundry 100
Tank (Reserve)
FLAMBEAU
RIVER
12
488
492
Precipitation 155
Less Evaporation 118
Net Accumulation 37
17 16
15
CTH "P"
NOTE:
All flows are in GPM.
Waste Containment Area
Seepage
< 25
Water In
Mill Discharge 488
Pit Bottom Sump 12
Net Precipitation 37
Accumulation 537
Water Out
Mill Recycle 492
Retained Solids 44
Seepage 25
Loss 561
Net Loss 24
STH 27
20 21
FLAMBEAU MINING CORP.
WATER DISTRIBUTION
FLOW SHEET
OPERATIONS
WINTER
CALCULATED THEORETICAL
SCALE: 1" = 2000'
DATE August 1976
DRAWN BY: GLB
MAP NO.

Figure 45



N
Gravel Pit
Open Pit Area
Siphon 5950
Groundwater Inflow 1620
Plus Precipitation 93
Less Evaporation 19
Net Accumulation 1694
Precipitation 63
Less Evaporation 13
Net Accumulation 50
Mill
(Waste Treatment Plant)
FLAMBEAU RIVER
557
Precipitation 310
Less Evaporation 310
Net Accumulation 0
CTH "P"
STH 27
Pit Flooding Sources
River Siphon 5950
Groundwater 1620
Precipitation 124
Average Yearly Rate 7694
Waste Containment Area (WCA)
135 MG Water Impounded
Seepage < 25
NOTE: All flows are in GPM.
Filling Time To 1085 Level (2 Billion Gallons Capacity)
Average Year - 180 Days
FLAMBEAU MINING CORP.
WATER DISTRIBUTION FLOW SHEET
SHUT DOWN
PIT FLOODING
CALCULATED THEORETICAL
SCALE 1" = 2000'
DATE August 1976
DRAWN BY GLB
MAP NO.

Figure 46

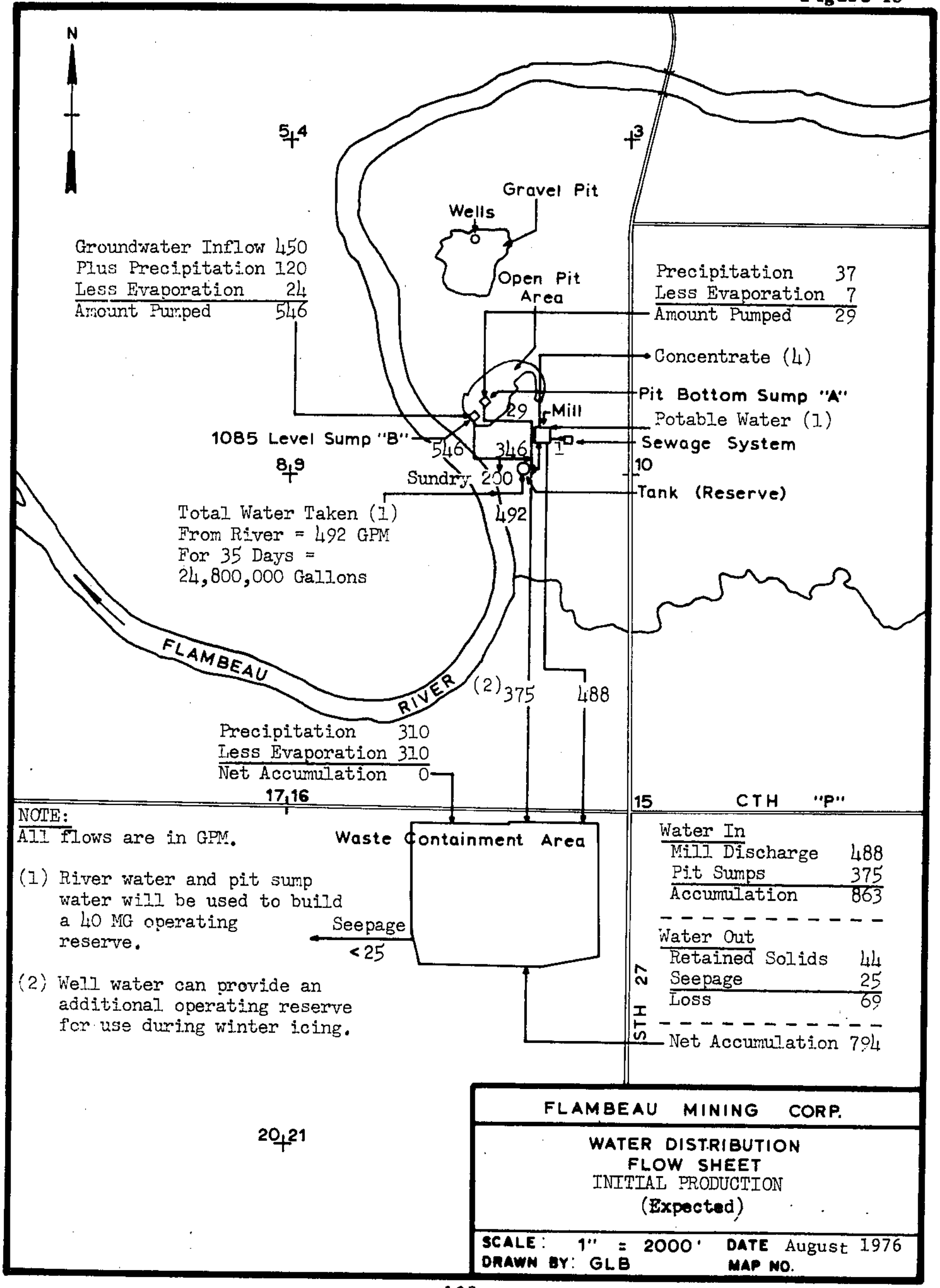

N
5,4
3
Gravel Pit
Wells
Open Pit Area
Groundwater Inflow 450
Plus Precipitation 120
Less Evaporation 24
Amount Pumped 546
Precipitation 37
Less Evaporation 7
Amount Pumped 29
Concentrate (4)
Pit Bottom Sump "A"
29
Mill
Potable Water (1)
1085 Level Sump "B"
546
346
1
Sewage System
8,9
10
Sundry 200
Tank (Reserve)
492
Total Water Taken (1)
From River = 492 GPM
For 35 Days =
24,800,000 Gallons
FLAMBEAU RIVER
(2) 375
488
Precipitation 310
Less Evaporation 310
Net Accumulation 0
17,16
15
CTH "P"
NOTE:
All flows are in GPM.
(1) River water and pit sump water will be used to build a 40 MG operating reserve.
(2) Well water can provide an additional operating reserve for use during winter icing.
Waste Containment Area
Seepage
<25
Water In
Mill Discharge 488
Pit Sumps 375
Accumulation 863
Water Out
Retained Solids 44
Seepage 25
Loss 69
Net Accumulation 794
STH 27
20,21
FLAMBEAU MINING CORP.
WATER DISTRIBUTION
FLOW SHEET
INITIAL PRODUCTION
(Expected)
SCALE: 1" = 2000'
DATE August 1976
DRAWN BY: GLB
MAP NO.

Figure 47

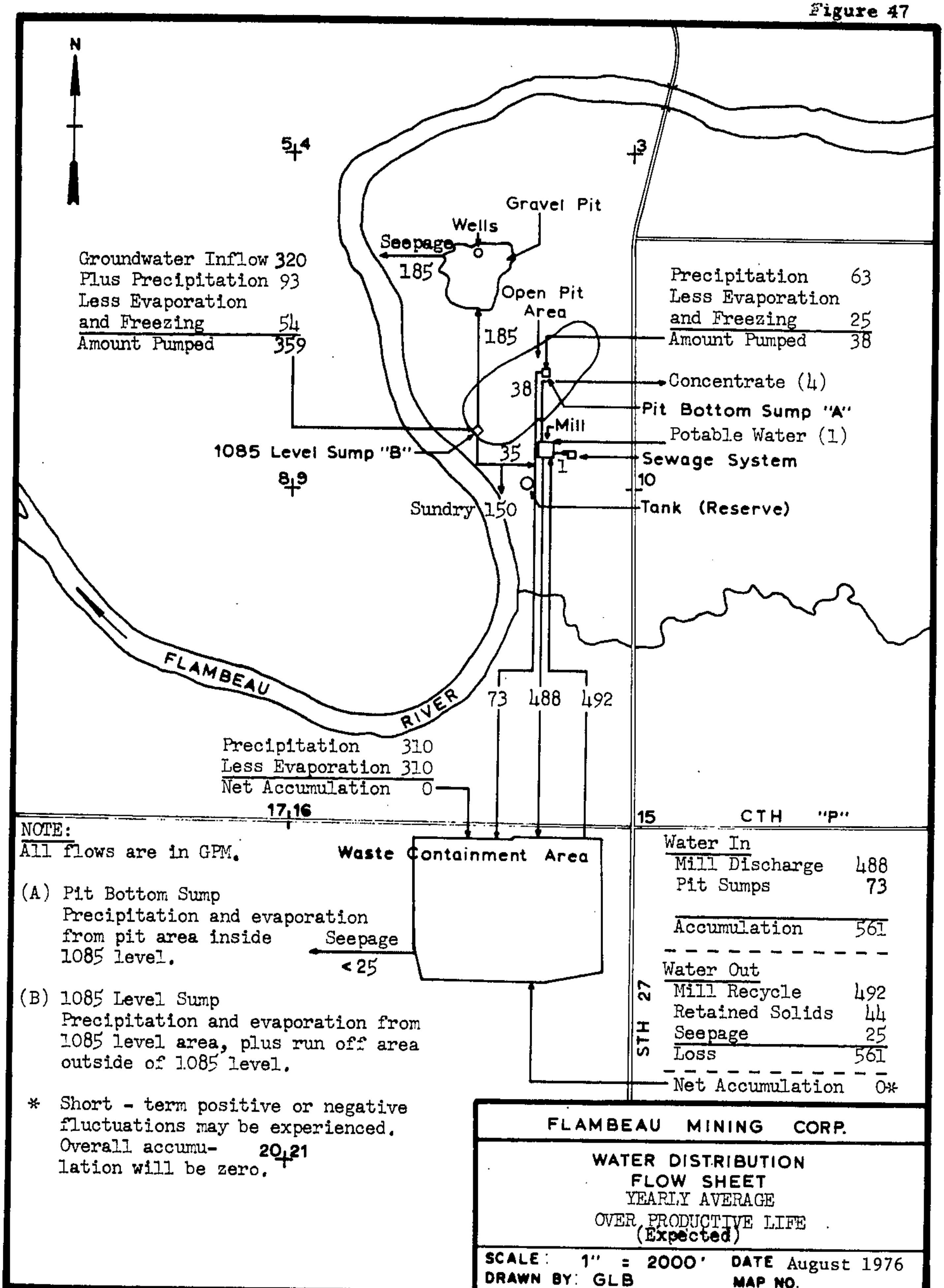
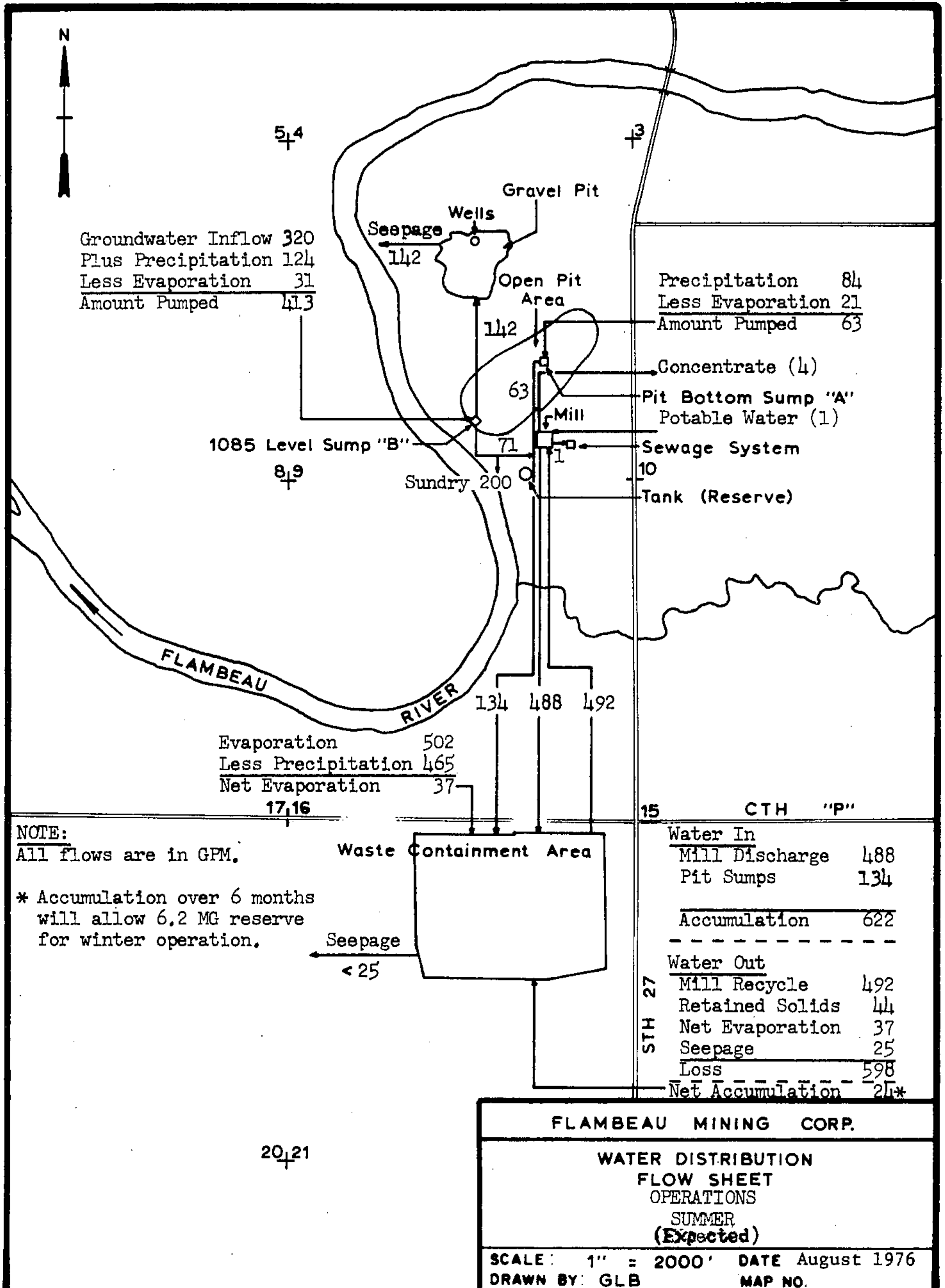

N
5,4
3
Gravel Pit
Wells
Seepage
185
Open Pit Area
185
Groundwater Inflow 320
Plus Precipitation 93
Less Evaporation and Freezing 54
Amount Pumped 359
Precipitation 63
Less Evaporation and Freezing 25
Amount Pumped 38
Concentrate (4)
38
Pit Bottom Sump "A"
Mill
Potable Water (1)
1085 Level Sump "B"
35
1
Sewage System
8,9
10
Sundry 150
Tank (Reserve)
FLAMBEAU RIVER
73
488
492
Precipitation 310
Less Evaporation 310
Net Accumulation 0
17,16
15
CTH "P"
NOTE:
All flows are in GPM.
Waste Containment Area
(A) Pit Bottom Sump
Precipitation and evaporation from pit area inside 1085 level.
Seepage
< 25
(B) 1085 Level Sump
Precipitation and evaporation from 1085 level area, plus run off area outside of 1085 level.
* Short - term positive or negative fluctuations may be experienced. Overall accumulation will be zero.
20,21
Water In
Mill Discharge 488
Pit Sumps 73
Accumulation 561
Water Out
Mill Recycle 492
Retained Solids 44
Seepage 25
Loss 561
Net Accumulation 0*
STH 27
FLAMBEAU MINING CORP.
WATER DISTRIBUTION
FLOW SHEET
YEARLY AVERAGE
OVER PRODUCTIVE LIFE
(Expected)
SCALE: 1" = 2000'
DATE August 1976
DRAWN BY: GLB
MAP NO.

Figure 48



N
5 4
3
Gravel Pit
Wells
Seepage
142
Groundwater Inflow 320
Plus Precipitation 124
Less Evaporation 31
Amount Pumped 413
Open Pit Area
Precipitation 84
Less Evaporation 21
Amount Pumped 63
142
Concentrate (4)
63
Pit Bottom Sump "A"
Mill
Potable Water (1)
1085 Level Sump "B"
71
Sewage System
1
8 9
10
Sundry 200
Tank (Reserve)
FLAMBEAU RIVER
134
488
492
Evaporation 502
Less Precipitation 465
Net Evaporation 37
17 16
15
CTH "P"
NOTE:
All flows are in GPM.
* Accumulation over 6 months will allow 6.2 MG reserve for winter operation.
Waste Containment Area
Seepage
< 25
Water In
Mill Discharge 488
Pit Sumps 134
Accumulation 622
Water Out
Mill Recycle 492
Retained Solids 44
Net Evaporation 37
Seepage 25
Loss 598
Net Accumulation 24*
STH 27
20 21
FLAMBEAU MINING CORP.
WATER DISTRIBUTION FLOW SHEET
OPERATIONS
SUMMER
(Expected)
SCALE: 1" = 2000'
DATE August 1976
DRAWN BY: GLB
MAP NO.

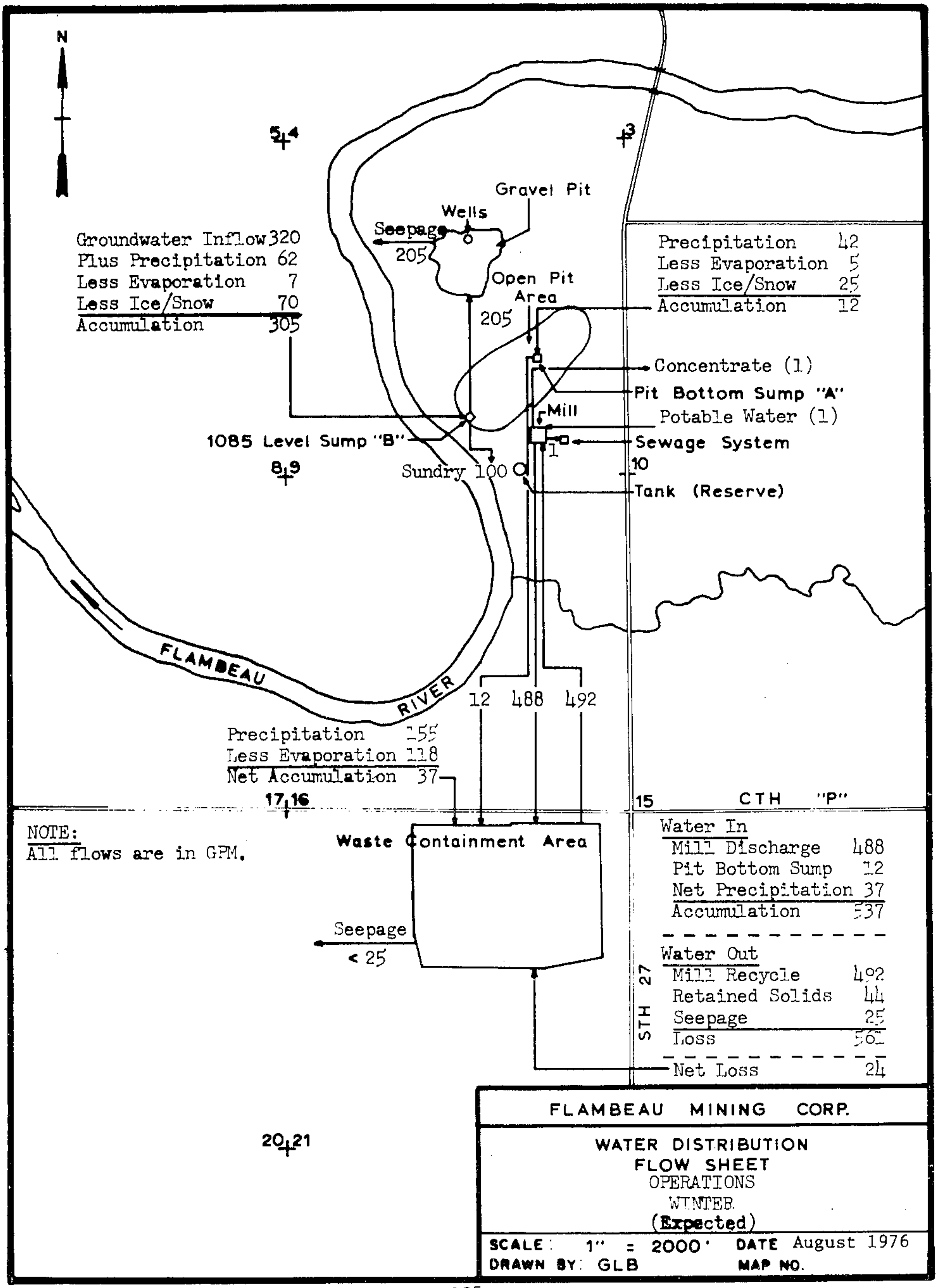

N
Gravel Pit
Wells
Seepage
205
Groundwater Inflow 320
Plus Precipitation 62
Less Evaporation 7
Less Ice/Snow 70
Accumulation 305
Open Pit Area
205
Precipitation 42
Less Evaporation 5
Less Ice/Snow 25
Accumulation 12
Concentrate (1)
Pit Bottom Sump "A"
Mill
Potable Water (1)
1085 Level Sump "B"
Sewage System
1
Sundry 100
Tank (Reserve)
10
FLAMBEAU RIVER
12
488
492
Precipitation 155
Less Evaporation 118
Net Accumulation 37
15
CTH "P"
NOTE:
All flows are in GPM.
Waste Containment Area
Water In
Mill Discharge 488
Pit Bottom Sump 12
Net Precipitation 37
Accumulation 537
Seepage
< 25
Water Out
Mill Recycle 492
Retained Solids 44
Seepage 25
Loss 561
Net Loss 24
STH 27
FLAMBEAU MINING CORP.
WATER DISTRIBUTION FLOW SHEET
OPERATIONS
WINTER
(Expected)
SCALE: 1" = 2000'
DATE August 1976
DRAWN BY: GLB
MAP NO.

Figure 50

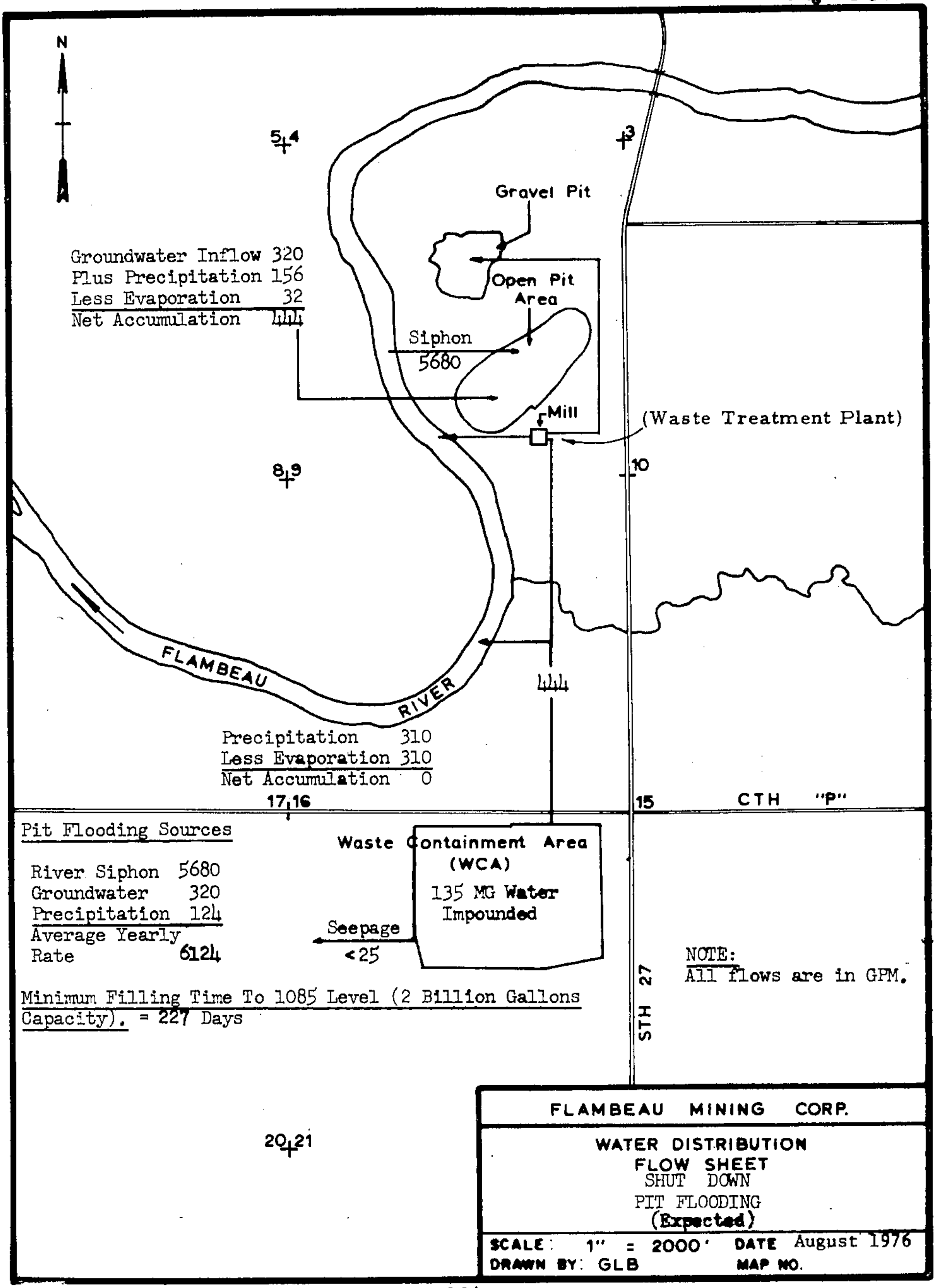
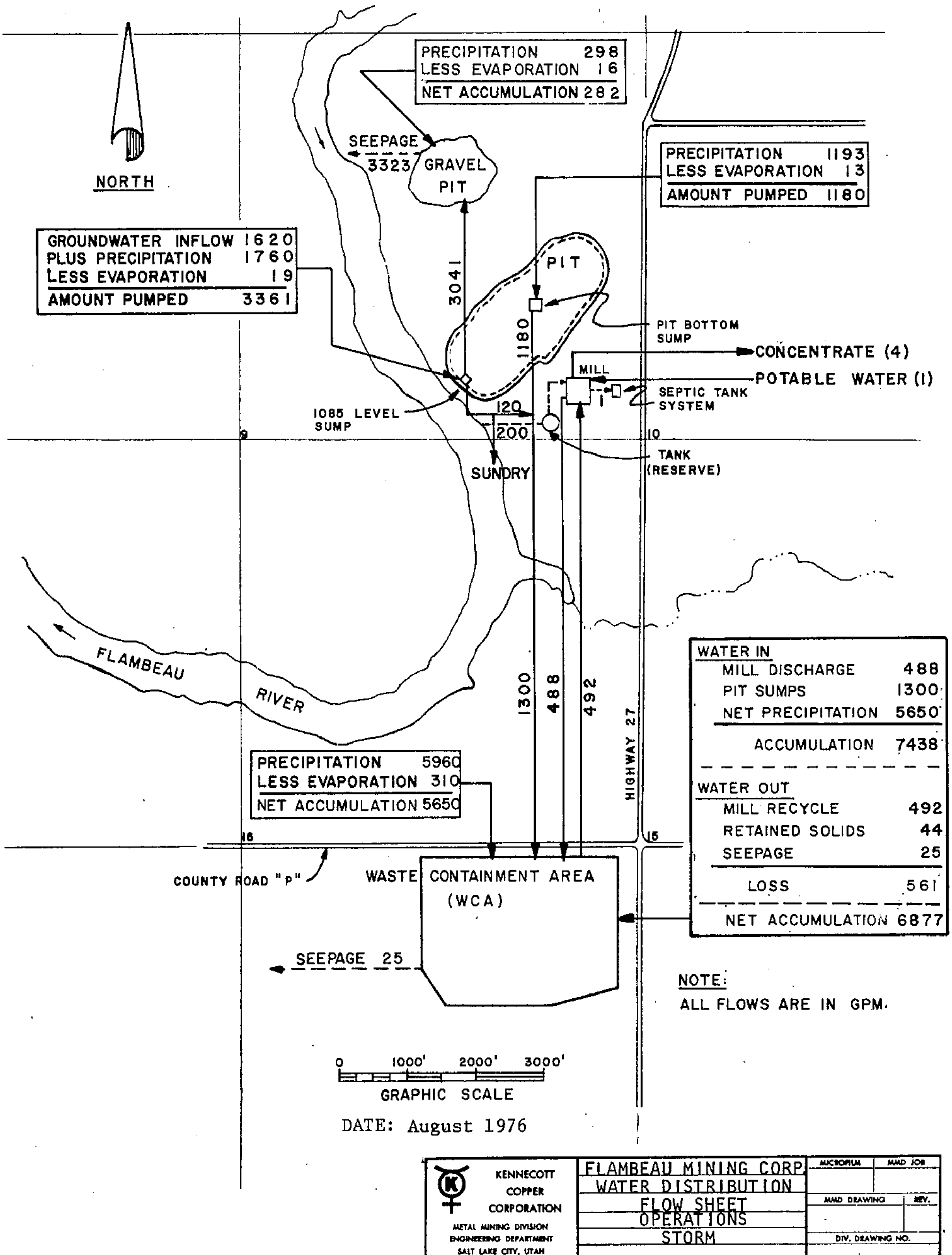

N
Gravel Pit
Open Pit Area
Groundwater Inflow 320
Plus Precipitation 156
Less Evaporation 32
Net Accumulation 444
Siphon 5680
Mill
(Waste Treatment Plant)
FLAMBEAU RIVER
444
Precipitation 310
Less Evaporation 310
Net Accumulation 0
CTH "P"
STH 27
Pit Flooding Sources
River Siphon 5680
Groundwater 320
Precipitation 124
Average Yearly Rate 6124
Waste Containment Area (WCA)
135 MG Water Impounded
Seepage <25
NOTE: All flows are in GPM.
Minimum Filling Time To 1085 Level (2 Billion Gallons Capacity). = 227 Days
FLAMBEAU MINING CORP.
WATER DISTRIBUTION FLOW SHEET
SHUT DOWN
PIT FLOODING
(Expected)
SCALE: 1" = 2000'
DATE August 1976
DRAWN BY: GLB
MAP NO.

Figure 51



NORTH
PRECIPITATION 298
LESS EVAPORATION 16
NET ACCUMULATION 282
SEEPAGE
3323
GRAVEL PIT
PRECIPITATION 1193
LESS EVAPORATION 13
AMOUNT PUMPED 1180
GROUNDWATER INFLOW 1620
PLUS PRECIPITATION 1760
LESS EVAPORATION 19
AMOUNT PUMPED 3361
3041
PIT
1180
PIT BOTTOM SUMP
CONCENTRATE (4)
MILL
POTABLE WATER (1)
SEPTIC TANK SYSTEM
1085 LEVEL SUMP
120
200
SUNDRY
TANK (RESERVE)
9
10
FLAMBEAU RIVER
1300
488
492
HIGHWAY 27
WATER IN
MILL DISCHARGE 488
PIT SUMPS 1300
NET PRECIPITATION 5650
ACCUMULATION 7438
WATER OUT
MILL RECYCLE 492
RETAINED SOLIDS 44
SEEPAGE 25
LOSS 561
NET ACCUMULATION 6877
PRECIPITATION 5960
LESS EVAPORATION 310
NET ACCUMULATION 5650
16
15
COUNTY ROAD "P"
WASTE CONTAINMENT AREA (WCA)
SEEPAGE 25
NOTE:
ALL FLOWS ARE IN GPM.
0 1000' 2000' 3000'
GRAPHIC SCALE
DATE: August 1976
KENNECOTT COPPER CORPORATION
METAL MINING DIVISION
ENGINEERING DEPARTMENT
SALT LAKE CITY, UTAH
FLAMBEAU MINING CORP.
WATER DISTRIBUTION
FLOW SHEET
OPERATIONS
STORM
MICROFILM
MMD JOB
MMD DRAWING
REV.
DIV. DRAWING NO.

diverted for sundry uses such as road sprinkling and the remaining 1,666 gpm pumped to the gravel pit for disposal. Precipitation below the 1,085 level, estimated to average 29 gpm after evaporation, will be collected in the lower sump at the center of the new pit and pumped to the gravel pit also. The gravel pit will thus receive for a short while an average of 1,695 gpm from the mine in the final stage of the construction period. As soon as the waste containment dike is in place and water can be stored, all waters from the open pit will be diverted into this area.

3.3.1.2 INITIAL PRODUCTION

Process water required for operation of the concentrator will be taken from the Flambeau River at the rate of 492 gpm until, together with 1,544 gpm pumped to the waste containment area from the pit, a total reserve of 40 million gallons has been accumulated in the waste containment area. This is estimated to take 14 days, during which time a total of 10 million gallons will have been taken from the river. No water will be disposed of in the gravel pit during this period (see Exhibit D).

The pit sumps together will continue to receive 1,744 gpm, as during the construction phase. Of this, 200 gpm will be diverted for sundry uses and the remaining 1,544 gpm will be pumped to the waste containment area. An additional 488 gpm will be pumped from the mill (4 gpm of the 492 gpm entering the mill from the river is retained as moisture in the copper concentrates shipped out), making a total flow of 2,032 gpm into the waste containment area. Of this total, an estimated 44 gpm will remain entrained in the tailings, and an estimated maximum of 25 gpm will escape by seepage through the dikes and the floor of the pond. It is assumed that evaporation from the pond will equal precipitation. Thus, available water will accumulate in the waste containment area at the rate of 1,963 gpm.

3.3.1.3 OPERATIONS - YEARLY AVERAGE

An essentially closed system will be maintained and the average yearly net accumulation of available water in the waste containment area will be zero as shown on Figure 47. Except for potable water, no outside source of water will be required if groundwater inflow to the pit exceeds 146 gpm. Water collected in the 1,085 sump in excess of that required for industrial use will be disposed of in the gravel pit. If the calculated theoretical groundwater inflow of 1,620 gpm is realized, the excess to be disposed of would be 950 gpm.

3.3.1.4 OPERATIONS - SUMMER

To secure an increased operating reserve for the winter months, flows will be adjusted during the six summer months to allow 6.2 million gallons to accumulate in the waste containment area at an average rate of 24 gpm as shown on Figure 43. Excess water from the 1,085 sump to be disposed of in the gravel pit will average 1,442 gpm.

3.3.1.5 OPERATIONS - WINTER

During the six winter months, the 6.2 million gallon reserve accumulated in the waste containment area during the summer will be depleted at an average rate of 24 gpm as shown in Figure 44. Excess water from the 1,085 sump to be disposed of in the gravel pit will average 458 gpm. Should it be found in practice that pond icing in winter interferes with decant recovery, it may be necessary to increase the accumulated reserve in the waste containment area by diverting additional flow from the 1,085 sump to the waste containment area. However, a decant bubbler system should prevent icing problems.

3.3.1.6 SHUTDOWN

Upon the cessation of mining, the open pit will be flooded with water from the Flambeau River, and the normal inflows of groundwater and incident precipitation. Approximately 2 billion gallons of water will be required to fill the pit to the 1,092 level. Approximately 1.4 billion gallons of this will be obtained by siphoning from the river at a rate of 5,950 gpm. At this rate of siphoning from the river, it will take 180 days to fill the pit if water from the other sources is obtained at the rates shown on Figure 45.

3.3.2 SURFACE WATER - QUANTITY

3.3.2.1 FLAMBEAU RIVER

The planned mining operation will cause no detectable changes in the flow and water levels of the Flambeau River. The planned withdrawal of 10 million gallons of river water during a 14-day period at the beginning of operations will take place at a rate of 492 gpm, which is 1.1 cubic feet per second (cfs). This is insignificant when compared with the average river discharge of 1,844 cfs at the U.S.G.S. gauging station below the Thornapple power plant. The withdrawal of 1.4 billion gallons of river water during a 180-day period to fill the pit upon the cessation of mining will take place at a rate of 5,950 gpm, which is 13.3 cfs. This is 0.7% of the average river discharge at the Thornapple plant, and 1.8% of the 734 cfs calculated as the 95% river flow at Ladysmith.

3.3.2.2 TRIBUTARIES TO THE FLAMBEAU RIVER

The water courses of small tributary streams to the Flambeau will be disturbed as little as possible in order to preserve the natural qualities of the area, and to prevent the development of erosional problems. Surface flow through intermittent tributary stream A (Figure 5) will not be affected by the open pit as it originates in and discharges from a minute watershed to the northwest of the pit. Where necessary facilities such as the pipeline to the settlement basins in the gravel pit intersect this drainage, care will be taken to install crossings that will not obstruct or contaminate any natural flow. Intermittent tributary stream B will be largely eliminated since its watershed is mostly within the perimeter of the planned open pit. Seepage intercepted in the upper collection system inside the pit perimeter will be used to irrigate riparian vegetation during periods of insufficient rainfall.

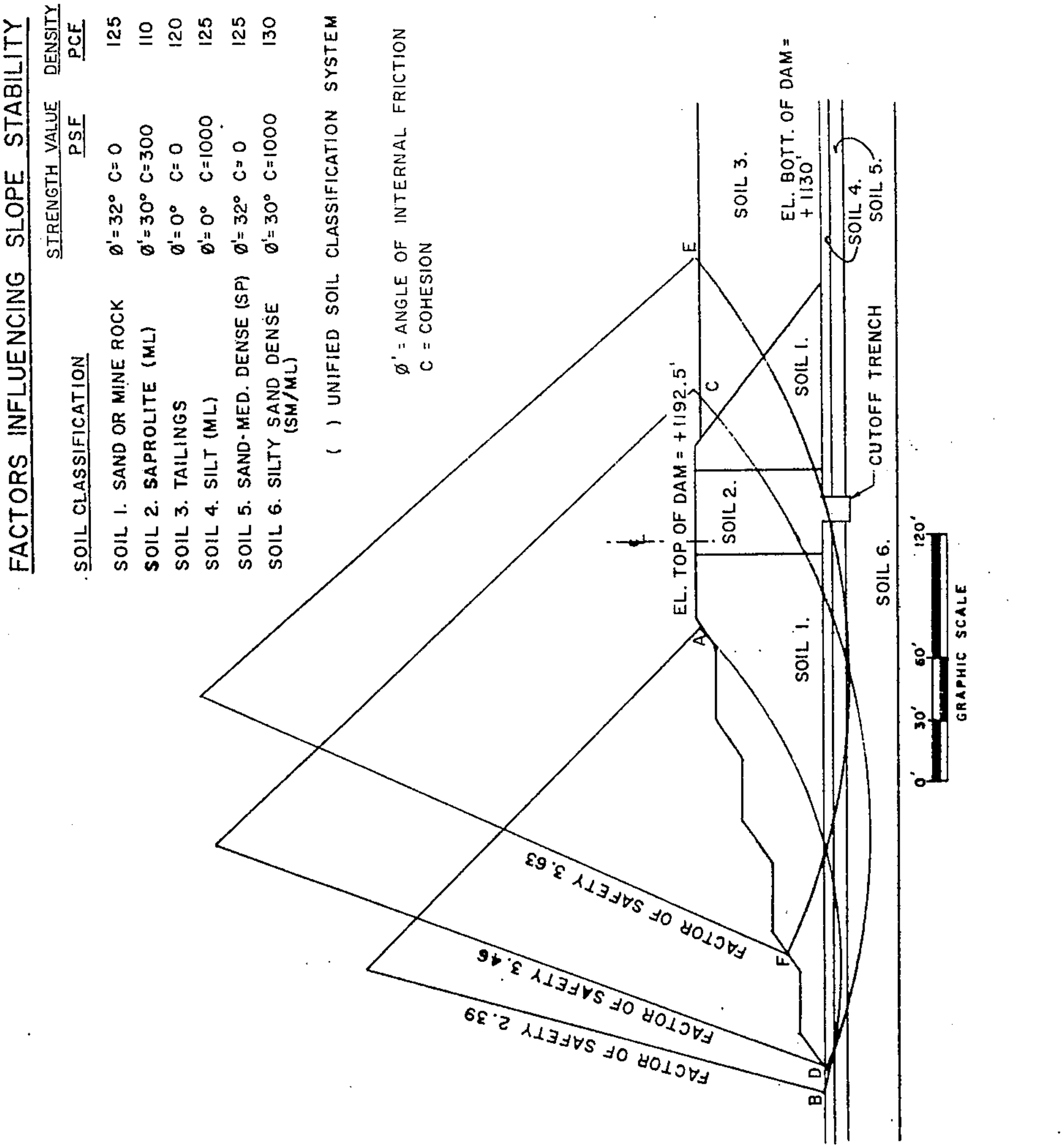
No alteration of the flow in tributary streams C and D will be created, except briefly during construction of the haul road as culverts are installed. The haul road is designed to channel runoff into the present established drainage courses and thus eliminate possible ponding problems and the creation of new channelways.

Tributary stream E which crosses the proposed waste containment area will be diverted around the southeast section of the dike as shown in Figure 34. Basically, the rerouting will substitute a channelized portion of this stream for a part that was channelized by previous owners. It has been determined by the WDNR to be non-navigable. The rerouting of this stream will not influence water levels in the adjacent wetlands as all of the wetland basins in Sections 20 and 21 are interconnected. Flows in streams F and G will not be influenced by the waste containment facility, although the existence of the facility will remove about 160 acres from the stream G watershed.

The controlling criterion established for design of the waste containment facility was that there be minimal escape of the impounded waters. Escape by breaching or overtopping of the dike is highly improbable. The calculated factors of safety shown in Figure 52 indicate that the stability of the dike structure will be more than adequate. The dike construction schedule provides for maintaining at least ten feet of freeboard at all times above the pond surface. This amount of freeboard is more than adequate when it is considered that a four-inch rainfall (the recorded maximum) would only add 5.4 inches to the pond, including waters collected in the open pit and directed to the pond.

Except for its possible effect on water quality, above-ground seepage from the waste containment facility is expected to be insignificant. Computer simulations of seepage loss through and beneath the dike, under a 50-foot fluid mass head and with no allowance made for reductions in permeability due to the accumulation of slimes and chemical precipitates, indicate that 0.57 gallons per day per linear foot of dike will escape to the surface outside the toe of the dike after a period of approximately 19 years. Thus, the maximum total above-ground seepage around the full 11,650-foot perimeter of the waste containment area is estimated to be 5 gpm after the 19-year flow propagation time.

After the cessation of mining, the revegetated upper surface of the waste containment area will be sloped southward at a grade of 0.5% toward a concrete spillway designed to take a 100-year flood.



KENNECOTT COPPER CORPORATION METAL MINING DIVISION ENGINEERING DEPARTMENT SALT LAKE CITY, UTAH	FLAMBEAU MINING CORP. STABLITY ANALYSIS PROPOSED WASTE CONTAINMENT AREA	MICROFILM / MMD JOB 506 MMD DRAWING BCM82-00-116 / REV. DIV DRAWING NO

MAY, 1974

3.3.3 GROUNDWATER - QUANTITY

3.3.3.1 MINE AREA

Excavation of the proposed open pit will have a pronounced local effect on the groundwater gradient and flowpaths adjacent to the pit. The present northwesterly flow of groundwaters across the mine area would be intercepted by the pit. Normal recharge of aquifers in the glacial outwash deposits immediately northwest of the pit would be altered, and the glacial tills to the southwest, south and southeast of the pit would be partly dewatered.

To predict groundwater flow conditions after pit excavation, a finite element computer flow model was used. A typical model setup is illustrated in Exhibit H. Figures 7A through 7C show cross sections A-A' through E-E', located as shown on Figure 7, which illustrates the effect of pit excavation on the flow gradients. Groundwater flow into the pit as calculated from the model would be 1,620 gpm. Allowance was made in this calculation for inflow resulting from reversal of the existing hydraulic gradient on the northwest, or present downgradient, side of the pit. The bedrock ridge described in Geology (Section 1) of this permit application will prevent the intrusion of river waters through the groundwater system into the pit from the south end of the pit near well 39 northwestward to a point near well 41. At this point, the bedrock surface dips below the 1,085-foot elevation of the average river level and slopes gradually down to a low elevation of 1,075 feet near well ST9-20, some 1,100 feet northeast of the river. From permeabilities measured in the test wells, it is estimated that the glacial outwash materials present in the southwest sector of the pit perimeter will transmit an average of 50 gallons per square foot per day (0.0347 gpm). Thus, the highest amount of groundwater flow and intrusion of river water through the glacial outwash materials as shown in Figure 7 in the 1,000-foot segment of pit wall subject to such intrusion is estimated to be 347 gpm.

Figure 29 indicates the expected maximum and minimum extent of the cone of groundwater depression around the pit. Aquifer recharge outside the cone of depression northwest of the pit is expected to continue at the present rates. The low and very irregular permeability characteristics of the glacial tills and the heterogeneity of the till-outwash contact zone northwest of the pit would result in a decidedly asymmetric cone of depression. The lateral extent of the drawdown cone would be mostly controlled by the permeability characteristics of the glacial deposits and is estimated to vary from a minimum of 50 feet at the southwest end of the pit to a maximum of 500 feet in the heterogeneous soils northwest of the pit.

Although the hydrological studies suggest that the glacial materials surrounding the mine pit could yield up to 1,620 gpm, based on their permeabilities and the existing groundwater conditions, the long-term yield of such a volume of groundwater is considered unlikely for several reasons. First, experience with other mine pits has shown a rapid initial inflow into a pit during excavation followed by great reduction in flows up to 80% to 90% of the initial flow. Secondly, in this case 82% of the water-bearing upper pit perimeter wall will consist of till within which aquifer continuity is very poor. Finally, once the till and outwash in the cone of depression is dewatered, incident precipitation and regional groundwater flow recharge must come through adjacent soils, most of which have low to very low transmissivities. Thus the effects of evapotranspiration plus the above factors indicate a very slow infiltration through the soils into the mine pit. A more realistic long-term estimate of groundwater flow into the pit after flows have stabilized is 320 gpm which is 20% of the calculated theoretical figure.

Many of the trees within the drawdown cone northwest of the pit are species that prefer moist soils, e.g., black ash and hemlock. Soil moisture levels and tree survival will be monitored during the operation because these trees will be of considerable value to FMC in the post-mining development of the pit into a recreational lake. Some irrigation of these trees may be needed during the life of the operation.

Because all property within the cone of groundwater drawdown around the pit will be owned by FMC, no private water wells will be affected. The locations of existing nearby wells relative to the proposed mining operation and FMC property boundaries are shown on Figure 17. Excavation of the pit will, however, intercept the water supply to the two seeps located northwest of the pit with the result that flow from these seeps will be drastically reduced or will cease entirely. Preservation of the water-dependent vegetation at these sites will be maintained through irrigation as required.

Groundwater flow across the orebody toward the Flambeau should be almost entirely eliminated by excavation of the pit. Because there are significant, probably detrimental, quantities of dissolved copper, zinc and lead in the present waters which have percolated over the orebody, the removal of this source of natural contamination to the Flambeau River should be a positive effect.

Some problems of slumping and maintenance of the pit slope configuration are expected during the early years of mining due to intrusion of groundwaters through transected aquifers.

3.3.3.2 WASTE CONTAINMENT AREA

The diversion of stream E to the south, around the southeast corner of the waste containment facility, will have no effect on groundwater supply outside the facility. The rerouted flow of stream E when added to the area surrounding the southeast corner of the facility will be taken up by the adjacent wetlands into which the stream presently discharges.

Creation of the waste containment area and the imposition of the resulting fluid mass head on the underlying area will produce an insignificant increment of recharge to the groundwaters in the waste containment area. Permeabilities and expected vertical travel times through the soils underlying the area are given in Table 31. The abandoned channel of stream E will be excavated and filled with compacted clay saprolite to ensure that the floor of the future pond is sealed. Other portions of the area underlain by relatively permeable soils will be sealed by keying the clay core of the dike down into deeper impervious soil layers. This will be done around the west, northwest and north central portions of the dike.

The rate of seepage through the entire dike, around its full perimeter, is estimated to be approximately 6 gpm under a 50-foot fluid mass head. Only 1 gpm of this flow will remain in the groundwater system, however, as approximately 5 gpm of that total flow will escape to the surface outside the toe of the dike. The rate of seepage through the 125-acre floor of the waste containment area is estimated to be 19 gpm under a fluid mass head of 50 feet - which would not be reached until the final year of underground mining. No allowance was made in the estimate for the sealing effect which will be produced by the accumulation of slimes and precipitates within the tailings. Thus, the increment of recharge to the groundwater system resulting from the creation of the waste containment area would be 20 gpm at maximum. Seepage would continue at a reduced rate indefinitely after the cessation of the operation.

Flow velocities in the soil materials beneath the waste containment area, and through the clay-cored dike, will be very slow and the retention time of the tailings waters in the ground will be considerable. The flow propagation time through the most permeable soil beneath the dike from a point inside the dike core to a point beneath the toe of the dike is estimated to be 19 years under a 50-foot fluid mass head.

A series of monitor wells to detect seepage have been installed on the downgradient side of the facility and additional wells will be installed and monitored throughout and after the life of the mining operation.

3.3.4 SURFACE WATER - QUALITY

3.3.4.1 FLAMBEAU RIVER

No impact on Flambeau River water quality is expected. The Flambeau is already so physically manipulated by man that it is difficult to see any consistent baselines which may be used to assess impacts. Biological productivity is abnormally low to begin with in all sections of this aquatic ecological community. A lowering of productivity would be the most likely ill effect of mine drainage leakage into the river. Because discharges of mine wastes to the

TABLE 31

PERMEABILITIES AND EXPECTED TRAVEL TIME OF TAILINGS WATER THROUGH SELECTED BASE SOILS UNDER THE WASTE CONTAINMENT AREA

Boring Number	Sample Tested	Depth & Thickness of Sample Tested	Soil Type(1)	Averaged cm/sec.	Permeabilities feet/day(2)	Porosity(3)	Thickness of Soil Layer to Dissipate Head(4)	Time in days required for water(5) to pass through soil stratum(6) at various heads in days. 1'	6'	10'	25'	50'
ST-21-27	4	6' to 7'	SM	6.5×10^{-7}	1.842×10^{-3}	0.23	0 to 7'	6100	1017	610	244	122
ST-21-33	2	2' to 3.5'	ML	1.1×10^{-6}	3.11×10^{-3}	0.33	0 to 3.8'	1550	258	155	62	31
ST-21-38	1	0 to 2'	OL									
	2	2' to 4'	SM-ML									
	3	4' to 6'	SM	1.7×10^{-6}	4.81×10^{-3}	0.28	0 to 8'	3750	625	375	150	75
	4	6' to 8'	SM									
ST-21-53	2	2' to 4'	ML	6.6×10^{-8}	1.87×10^{-4}	0.28	0 to 4'	2400	400	240	96	48
ST-21-40(7)	1	0 to 2'	ML									
	2	2' to 4'	ML	9.1×10^{-7}	2.57×10^{-3}	0.26	0 to 11.5'	13,350	2,225	1,335	534	267
	5	10' to 11.5'	SM									

Notes:

1. As per Unified Soil Classification System
2. Where number of strata were tested, the arithmetic average was calculated. Please see STS Report 4970, dated 12-12-72, Part I, Figure 8.
3. Total porosity
4. Calculations of travel time based on assumption that all of head is dissipated through this thickness. Thus, the calculations may be conservative.
5. Calculations of travel time based on following forumulas:
   a. $v \text{ seepage} = v_s \; \frac{\text{discharge velocity}}{\text{porosity}} = \frac{v \text{ discharge}}{n} = \frac{v_d}{n}$
   b. $v_d = ki$
   c. $v_s = \frac{ki}{n}$
   d. $t = \text{time} = \text{thickness}/\, v_s$
   (Reference: Seepage, Drainage & Flow Nets, Cedergren, Harry R. (John Wiley & Sons, 1967)
6. The analysis assumes that there will be no self-sealing in the waste containment area from slimes. (However, experience with existing tailings ponds suggest that slimes accumulation will act to seal the pond bottom so that leakage will be minimized.
7. This soil would not be flooded until more than 6 feet of tailings and water have accumulated in the waste containment area.

Source: Soil Testing Services of Wisconsin
January 15, 1976

river will not occur, no ill effects are expected. Water monitoring at the mine site and waste containment area will give adequate warning of unexpected leakage from these facilities to enable FMC to correct any problem that may arise.

One interesting possibility relating to the removal of the orebody through mining and the attendant control of groundwater interactions with the metal deposit could be a reduction of heavy metals discharge to the Flambeau River through groundwater flows. Data on existing water quality both for groundwater and the Flambeau itself suggest that the migration of copper, zinc, lead, sulfate and hydrogen ions now occurs from the orebody to the river. Extraction of the orebody should remove this probable source of natural river contamination.

3.3.4.2 TRIBUTARIES TO THE FLAMBEAU RIVER

Impacts on water quality in intermittent tributary stream A will be limited to a minor amount of siltation for a short time during the construction period while a pipeline crossing is installed. Intermittent tributary stream B will be largely eliminated since its watershed is mostly within the perimeter of the planned open pit. The remaining course of this stream between the pit perimeter and the river will not be disturbed. It will drain no waters from within the pit as these will be directed into the 1,085 sump.

Impacts on water quality in tributary streams C and D will also be limited to minor amounts of siltation during the construction of the waste haul road while culverts are installed. During the installation of the culverts, stream D will be diverted and temporary dams constructed to provide settling ponds for control of siltation. Upon the completion of construction, the dams will be removed.

Any unplanned leakage from the tailings or water reclaim pipelines would not enter streams C and D, or other surface waters. The pipelines will be laid along the east shoulder of the haul road, away from the river. The lines will be elevated on a slight arc over the crossings of streams C and D, and catchment basins will be provided on either side of both streams to contain any leakage from the pipelines.

Minor amounts of siltation will occur during the construction period while stream E is rechanneled around the southeast section of the waste containment area. A temporary settling pond will be constructed to control this siltation. Some siltation will occur periodically throughout the life of the open pit operation as the waste containment dikes are constructed. This will be controlled by vegetation of the lower, already completed portions of the dikes. Any siltation escaping will quickly settle out in the sluggish waters of the adjacent wetland.

As already stated, the maximum total above-ground seepage around the full 11,650-foot perimeter of the waste containment area is estimated to be less than 5 gpm. This possible seepage would enter the tag alder swamp located immediately down-drainage from the waste containment area which is underlain by an anaerobic layer of peat up to seven feet thick and is permanently saturated with water. The presence of *Vaccinium sp.* vegetation indicates a slightly acidic condition; surface water samples characteristically have a pH in the range of 5.5 to 6.

Any leakage from the waste containment dikes that appears on the surface must percolate through the waterlogged peat for a horizontal distance of approximately 1.6 miles before reaching a tributary of the Flambeau River. Samples of the peat were taken from sites that would be 300 to 500 feet from the outer toe of the waste containment dike and which would therefore come in contact with any surface discharge from the waste containment area. Experimental studies conducted by KCC showed that these peats were able to effectively adsorb heavy metal ions. The peats also showed a capacity to substantially neutralize sulfuric acid (pH of 2.3) in 24 hours. Tests were also run on the adsorptive capacity of the peat for alcohol, cresols and dithiophosphate with similar results; there being substantial removal of all species within 30 days. These tests suggest that the peats of the surrounding wetlands should act as an effective barrier to water pollution by any leakage from the waste containment area. However, peat does have a finite adsorptive capacity which indicates that in time there would be a flow of metal ions farther away from the dike wall and into the peat.

3.3.4.3 PIT LAKE

Limnological conditions within the pit lake is discussed in Section 4. Because a number of interacting factors are involved, the prediction of water quality within the lake is extremely difficult. The upper and lower waters can be expected to have different water qualities and will probably function ecologically as two separate and distinct systems. The monimolimnion is expected to develop anaerobic or reducing conditions, whereas aerobic conditions will prevail in the mixolimnion. The mixolimnion waters are expected to be moderately soft and markedly oligotrophic, or low in nutrients. It is expected that concentrations of toxic metals in mixolimnion waters can be maintained at acceptable levels by use of lime to effect pH control. Thus, it is concluded that the upper waters of the pit lake should afford excellent opportunities for recreational activities such as swimming and boating. Without extensive management, however, these waters would be quite unproductive biologically and probably would not support a significant fishery. These waters might also be acceptable as cooling water for industrial use or as a heat pump.

3.3.5 GROUNDWATER - QUALITY

3.3.5.1 MINE AREA

Groundwater quality in the mine site area should be largely unaffected by the open pit. Existing high levels of iron, manganese and hardness present in the groundwaters of the area are dependent upon soil characteristics which will not change. The coliform bacteria content of groundwater in the area may decrease from present levels during the operation of the mine as some surrounding residences and cattle-feeding operations are eliminated. Removal of the orebody through mining should eventually improve groundwater quality with respect to copper, zinc, lead, sulfate and pH as there is some evidence that the present groundwaters are interacting with the orebody.

The mixolimnion waters of the post-mining pit lake will interact with the surrounding groundwater. As the quality of the lake water is expected to be comparable to that of the groundwater, groundwater quality should be largely unaffected except for a possible increase in hardness due to the use of lime to control pH.

3.3.5.2 WASTE CONTAINMENT AREA

Seepage from the waste containment area into the groundwater would come from under the dike at a rate of 1 gpm and through the bottom of the waste containment area at a rate of 19 gpm. These estimated seepage rates through the dike would occur after 19 years due to the relative impermeability of the compacted dike construction, clay core design and low permeability natural base soils. It is expected that seepage would occur sooner through the bottom of the waste area but would still have to travel beneath the dike, taking 9.4 years. These seepage rates are predicted without considering the effect of slime sealing or loss of permeability due to consolidation of the base soils from the weight of the waste containment area materials. The effect of these two factors could minimize the flow of seepage.

Initially the tailings would be very alkaline due to the addition of lime in the concentrator circuit. However, this condition could be reversed by oxidation of the pyrite in the top layers of the tailings if they are not covered by water. The chemistry in the tailings basin would probably be as follows:

1. $2FeS_2 + 7\ O_2 + 2H_2O = 2Fe^{++} + 4SO_4^{=} + 4H^+$

2. $4Fe^{++} + O_2 + 4H^+ = 4Fe^{+++} + 2\ H_2O$

3. $Fe^{+++} + 3H_2O = Fe(OH)_3 + 3H^+$

4. $FeS_2 + 14Fe^{+++} + 8H_2O = 15Fe^{++} + 2SO_4^{=} + 16H^+$

The oxidation of the sulfide of the pyrite to sulfate (1) releases dissolved ferrous iron and hydrogen ions (acidity) into the water. Subsequently, the dissolved ferrous iron undergoes oxygenation to ferric iron (2) which then hydrolyzes to form insoluble ferric hydroxide (3), and generates more acidity. Ferric iron can also be reduced by pyrite itself, as in (4), where sulfide is again oxidized and acidity is released along with additional ferrous iron which may re-enter the reaction cycle via equation (2). Therefore, once the process has been started by the oxidation of pyrite, little additional oxygen is required to sustain the acid-generating reactions. The dissolution of 1 mole of iron pyrite leads ultimately to the release of 4 equivalents of acidity.

Some of the acidity could be neutralized by reaction with other minerals in the wasterock such as kaolinite:

$$\underset{\text{kaolinite}}{Al_2\,Si_2\,O_5\,(OH_4)} + 6H^+ + 3SO_4^= = Al_2\,(SO_4)_3 + \underset{\text{amorphous silicia}}{2SiO_2} + 5H_2O$$

and residual lime:

$$\underset{\text{lime}}{CaCO_3} + 2H^+ + SO_4^= = CaSO_4 + CO_2\uparrow + H_2O$$

The resulting solution which would escape from the waste containment facility would be a mixture of ferrous and magnesium sulfates and calcium sulfates, limited by the solubility of gypsum, with some free sulfuric acid and aluminum sulfate.

The initial rate of acid generation within the waste containment facility would be primarily controlled by the diffusion of oxygen into the tailings. Due to weather fluctuations the oxygen flux would vary widely and would be expected to range from 2.0×10^{-11} to 1.0×10^{-8} g O_2 / cm^2/sec. during the spring, summer and fall seasons if the tailings surface were left untreated. This oxygen flux range corresponds to an acid generation rate of from 0.1 to 64 lb of sulfuric acid/acre/day. The most likely average oxygen flux of 1×10^{-10} g/cm^2sec. corresponds to an acid generation rate of 0.75 lb/acre/day, or a total of approximately 100 lb per day.

FMC proposes designs to prevent acid generation but plans to treat acid seepage, should it occur, through surface intercepter ditches and a neutralizer-conditioner plant.

The rate of acid generation would be reduced by treatment of the upper surface of the tailings upon the cessation of mining. The presence of lime-based chemicals (pH 10-11) directly within the uppermost tailings layer from tailing slurry would passivate the pyrite mineral surfaces and would also neutralize acid formed in the aerobic zone. The installation of a sealant, such as bentonite clay and low permeability soil on top of the tailings surface, would reduce the oxygen flux and thereby inhibit initial oxidation of the pyrite. The total effectiveness of such a measure cannot be quantified at this time. Experimental studies of the actual tailings materials in situ would be required to develop the quantitative information needed to establish an effective set of treatment procedures.

3.4.0 IMPACT ON MINERAL RESOURCES (GEOLOGICAL)

A direct and irreversible impact of the mining operation would be depletion of the known mineral resources contained within the project area.

All economically recoverable copper would be extracted from the orebody. Yet-to-be-determined characteristics of the deposit itself, such as rock strengths and the nature of ore to waste contacts in detail, which will become known as mining progresses, plus future technology and economics, will determine the ultimate extraction. Self-interest will virtually assure maximum extraction of copper from the deposit by FMC. Because the halo mineralization bordering the orebody is so low in grade and limited in quantity, the possibility is vanishingly small that future advances in technology and economics would ever permit later extraction of this material. In short, the known usable copper resources of the project area would be totally exhausted by the mining operation.

Other commodities of potential worth contained in the ore deposit are gold, silver, zinc and the mineral pyrite. Again, self-interest will assure optimal extraction and recovery of these commodities by FMC. At least 60% of the gold and silver contained in the ore will be recovered in the processing of the copper. The feasibility of adding a flotation circuit in the mill to produce zinc-bearing sphalerite concentrate will be evaluated before mining reaches this deeper mineralization which contains potentially recoverable amounts of zinc. The pyrite-bearing tailings to be produced as an unavoidable by-product from the milling of the copper ore constitute a potential sulfur and iron resource which would not otherwise be available. Although a market for this material is being sought, none is known at this time.

Well sorted gravel of sufficient quality to be considered a mineral resource is present only in the glacial outwash deposits located west and north of the orebody. Only a small amount of this material will be removed in the excavation of the open pit. If underground mining of the lower portion of the orebody is undertaken, approximately 1.2 million cubic yards of gravel would be used as backfill in the stopes. This material would be obtained from the former Rusk County gravel pit located 2,000 feet north of the mine. As Rusk County contains ample gravel reserves, the extraction of this amount of usable gravel is of little consequence.

3.5.0 IMPACT ON LANDFORMS (GEOMORPHOLOGY)

There would be four impacts on the intrinsic landscape: two excavated pits, a low flat-topped hill and a road bed.

The open pit as proposed will occupy 55 acres and will be approximately 285 feet deep at its deepest point. This major geomorphological impact will exist during the final months of operating the open pit or for eleven more years should it be decided to continue with underground mining beneath the open pit. At the cessation of mining the open pit will be allowed to fill with water and the walls above the water level contoured to slope approximately 15^{o} toward the lakeshore. Thus, the final impact on the landscape will be an artificial lake covering approximately 50 acres set within a 10 to 50-foot deep basin.

The waste containment area would present a flat-topped, grassy hill occupying 156 acres. Depending upon contingencies related to the sale of pyrite tailings and the economic advisability of underground mining at the end of the open pit mining, the waste containment hill could be 30 to 60 feet high with a top surface of approximately 130 acres.

The remains of the haul road bed will persist as a low, ridge-like hill in some areas. Cuts, embankments and the right-of-way through wooded areas will be visible to the critical observer. The most significant geomorphological feature on the project site, the steep river banks located on the outside meander banks of the Flambeau, will not be physically disturbed by the mining operations.

Should it prove economically feasible to extend the mining operation a second eleven years via underground mining, there would be additional excavation within the now-abandoned Rusk County gravel pit and possible expansion of this pit by as much as 30 acres. The rehabilitated gravel pit would form a gently sloped basin some 20 feet deep.

3.6.0 IMPACT ON BIOTIC CHARACTERISTICS

3.6.1 FLORA

Table 32 shows an estimation of the acreage of changed land use due to the construction of the proposed mine. Of the total 2,750 acres acquired for the mine, it is estimated that only 312 acres will experience a change in land use. The major impacts will occur in reduction of producing agricultural fields and reduction of the mixed deciduous-coniferous upland forest.

Elsewhere on FMC land holdings, cropland will be kept in production throughout the life of the mine. FMC sees this land as a valuable natural resource that requires good long-term management.

TABLE 32

CHANGED LAND USE DUE TO MINE CONSTRUCTION

Project Site Components	Existing							After Rehabilitation							
	Upland Forest	Crop-Land	Old Field	Shrub Swamp	Low-land Forest	Gravel Mining	Total	Upland Forest	Crop-land	Old Field	Shrub Swamp	Low-land Forest	Gravel Mining	Lake	Total
Open pit	41		14				55	5						50	55
Gravel pit						40	40			40					40
Soil stockpile		30					30		30						30
Haul road	7	8					15	7	8						15
Rail spur			3		10		13					13			13
Plant site		3					3	3							3
Waste containment area		100		20	36		156			156					156
Subtotal	48	141	17	20	46	40		15	38	196	0	13	0	50	
Total							312								312

In order to lessen the impact of the total mine development and to improve control of a variety of processes, trees and tree screens have been planted on much of the project site. These plantings will be protected in order to lessen the impact of erosion at the time of construction and during the mine operation. Wherever possible, trees and shrubs that are present as seedlings in areas that will be excavated or covered will be used as transplanting stock (Figure 27).

The large tag alder swamp in the vicinity of the waste containment area will not be affected so long as the water levels in this area are maintained at their present level. The rerouting of the drainage ditch which crosses State Highway 27 around the south side of the waste containment area will maintain these water levels. Continuous monitoring will be done to ensure that these habitats are preserved in their present state.

Vegetation along the route of the waste haul road will be protected against dust by the use of a sprinkling truck to suppress dust on the road. Erosion along the road will be controlled by the application of matting, sod or mulch-seed mixtures to the banks and ditches.

3.6.2 FAUNA

The disruption of 312 acres as the mining operation proceeds means the possible displacement or loss of perhaps 1,000 to 3,000 or more mouse-sized mammals. This could create a difficult situation for predators which rely on these animals for food, especially during the first year or two. It is reasonable to assume that the presence of such mammals as weasel, mink and fox within the project site will be reduced in number correspondingly.

Disturbance of areas of climax forest will most likely cause the flying squirrel to move. Chipmunks will lose some desirable habitat, which could result in a reduction in their number by 30 or more. Red squirrels likewise will lose desirable habitat and could be reduced in number by 20 or more. Both species will either increase in density in undisturbed habitat within the project site or will move from the site. There is little chance they will actually die or be killed. If they increase in density, their predators will remain; if they move, part of the predator food is lost. It cannot be determined at this stage what indirect developments might have adverse or beneficial impacts on their species. Since gray squirrels are a hunted species, their reduction might, if more numbers were involved, have economic and aesthetic significance. However, their numbers are already small, and the probable reduction of 10 due to the road construction cannot be considered significant. The squirrels could migrate to favorable habitat on the Flambeau River's west bank, slightly north of the pit.

Two important considerations should be kept in mind in relation to the larger mammals. The first is that reduction of their habitat will mean that some number of these must migrate to other localities. Economic and aesthetic impacts, while slight, are present. The mining operation is not likely to destroy these animals, but will cause them to move. The ground squirrels, woodchucks and badger probably can move to suitable land if their present habitat is destroyed. Movement of fox, deer, weasel and squirrel will be somewhat restricted because of the barrier created by the pit. These animals are not likely to alter their movement to the northeast end of the pit area; instead, any movement is likely to occur between the pit and the Flambeau River.

There will be two other barriers created because of the mining operation: the waste containment area and the haul road. The waste containment area will probably cause all larger mammals to move along the Flambeau River; routes south or west through the waste containment area will be closed. The haul road will be only partially restrictive as animals will tend to move across it, although some road kill will occur. There are no specific animal corridors in the area under study, but as mentioned above, after pit construction the area between the pit and the Flambeau River will likely develop into a significant corridor for a good deal of animal movement. There will be some bottleneck in this corridor, created by the proposed magazine site and the road leading to these magazines. The activity and sound of the mining operation may restrict animal use during daytime.

Since the mining operations will affect a small area and since it will not affect any species that is rare or unusual or any significant portion of the terrain that is used exclusively for nesting of any species, the impact of the mining operations on birds will not be significant. Probably the special needs of any resident species displaced can be met by the surrounding terrain and accepted by the species. Visits into the surrounding area show more of the same types of habitats as exist on the mine site, and these are lightly populated. The pit operations will disturb those species that prefer meadows and scattered hardwoods. There should be relatively few bird species disturbed, most of which are migrants; these have ample room to disperse to adjacent compatible areas.

Any of the forms of reptiles and amphibians found will have little trouble finding suitable habitat if displaced, for much of Rusk County is good amphibian habitat. Whether these species will move out of the disturbed area or be killed is not known. Certainly amphibian larval forms would perish if their aquatic habitat is lost. However, amphibians are prolific breeders and the loss of even large numbers of eggs or tadpoles will have little effect on these populations, since the disturbed portion of the mine holdings comprises such a small area (20 acres) of the moist land habitats within the project site. Predicting the effect of the waste containment area presents some difficulty. The possible leaching of soluble salts from the area and variations of the pH could have a profound effect on the permeable-skinned amphibians. Mobile impervious-skinned reptiles will, no doubt, move if disturbed or if deprived of their foods and there is favorable habitat nearby for them to occupy. Of the various animal groups surveyed, the reptiles and amphibians are probably the most vulnerable to any changes that might result from some phases of the mining operations. Management of the waste containment area to prevent leakage of heavy metals should ameliorate or prevent altogether direct effects on amphibians.

The mining operations will have some impact on the insect population, but this would be more of a shift in insect species rather than any profound impact on the insects. In the pit area the plant eaters will certainly be displaced and then replaced by the more rapacious forms such as the Asilids and Cincindellids, for example. A shift of species from one area to another should be expected. If ponds (perched water tables) were drained, aquatic forms would have to move or die. However, hydrological data suggest that most of these perched water tables and ponds will remain intact. In any case, good insect habitat is not far away. Vertebrates that live in the area and consume insects should experience little inconvenience.

There are no rare and endangered populations of animals from any taxonomic category which might be pushed into extinction by the operation of this project. The only rare and endangered species which might be attracted to the project site with some frequency is the bald eagle, which has been occasionally sighted by FMC and WDNR personnel. It is possible that eagles may be attracted to some of the large timber which will be left along the Flambeau River.

3.6.3 AQUATIC ENVIRONMENT

Faced with the existing river conditions plus the engineering design for the project which is to recycle and contain or treat any waters used or encountered in the mining operations, it is most difficult to see either a significant impact on Flambeau water quality or how this could be assessed if an impact did occur. The Flambeau is already so physically manipulated by man that it is difficult to see any consistent baseline which may be used for comparison. Biological productivity is abnormally low to begin with in all sections of the ecological communities. A lowering of productivity would be the most likely ill effect of mine effluents. Because drainage of mine wastes to the river during operations will not occur, no ill effects are expected.

3.7.0 IMPACT ON MAN-MADE FACILITIES

Other than making a direct connection to the existing telephone lines which are known to be of sufficient capacity to accommodate these needs, there will be minor impact on this utility (Figure 16).

Central station electric power will be provided by means of a line run from the existing 33 KV trunk line which follows the railroad right-of-way. This line will be run along existing road-utility rights-of-way, then directly across the concentrator site where a small substation will be installed near the concentrator buildings. Feeder lines will be run from this station to the various mine facilities. At the waste containment area and near the old gravel pit there are existing 12.6 KV and 2.3 KV lines which are adequate for FMC operation needs.

In general, any new construction will follow existing rights-of-way, and maximum use of existing lines will be made in order to lessen both environmental impacts and investment. The total power draw is expected to be 1.5 megawatts during regular operation and a maximum startup draw of 2.0 megawatts. The monthly electric power consumption is projected to be 1,064,000 kilowatt hours. Such levels can be provided without stress on the capacities of existing generating and distribution facilities.

A potable water supply for the FMC operation will be obtained from a six to eight-inch well to be drilled in the vicinity of the process plant.

An adequate sewage disposal system will be constructed to handle a peak load of 100 gpm for a short period of time (15 minutes) at the end of each shift. Plant site soil characteristics will determine the design and location of the sanitary system. Design of any disposal system to be constructed in the plant area will be in accordance with local and state codes. After the system is installed, the site will be revegetated.

The existing 34-inch Lakehead Pipe Line Company, Inc. line will be crossed by the FMC haul road approximately 1,320 feet north of County Highway P. As construction proceeds, liaison with pipeline company officials will be maintained to assure that adequate protection is made of this facility. The impact on this facility is expected to be nil.

In general, each existing right-of-way has been protected by the plans for this project. Maximum use will be made of existing rights-of-way. The haul road between the mine and the waste containment area, two access roads into the property, and the railroad spurline are the only human-used corridors to be added by the proposed action.

3.8.0 IMPACT ON LAND USE

The impact on the 2,750-acre site should in total perspective be a positive one. For the first time since the area was interrupted by logging there will be one owner and an overall land use plan. FMC has worked closely with local officials in determining the overall land use plan for the site. During the life of the mine, FMC's intended use of the 2,750 acres is as shown below:

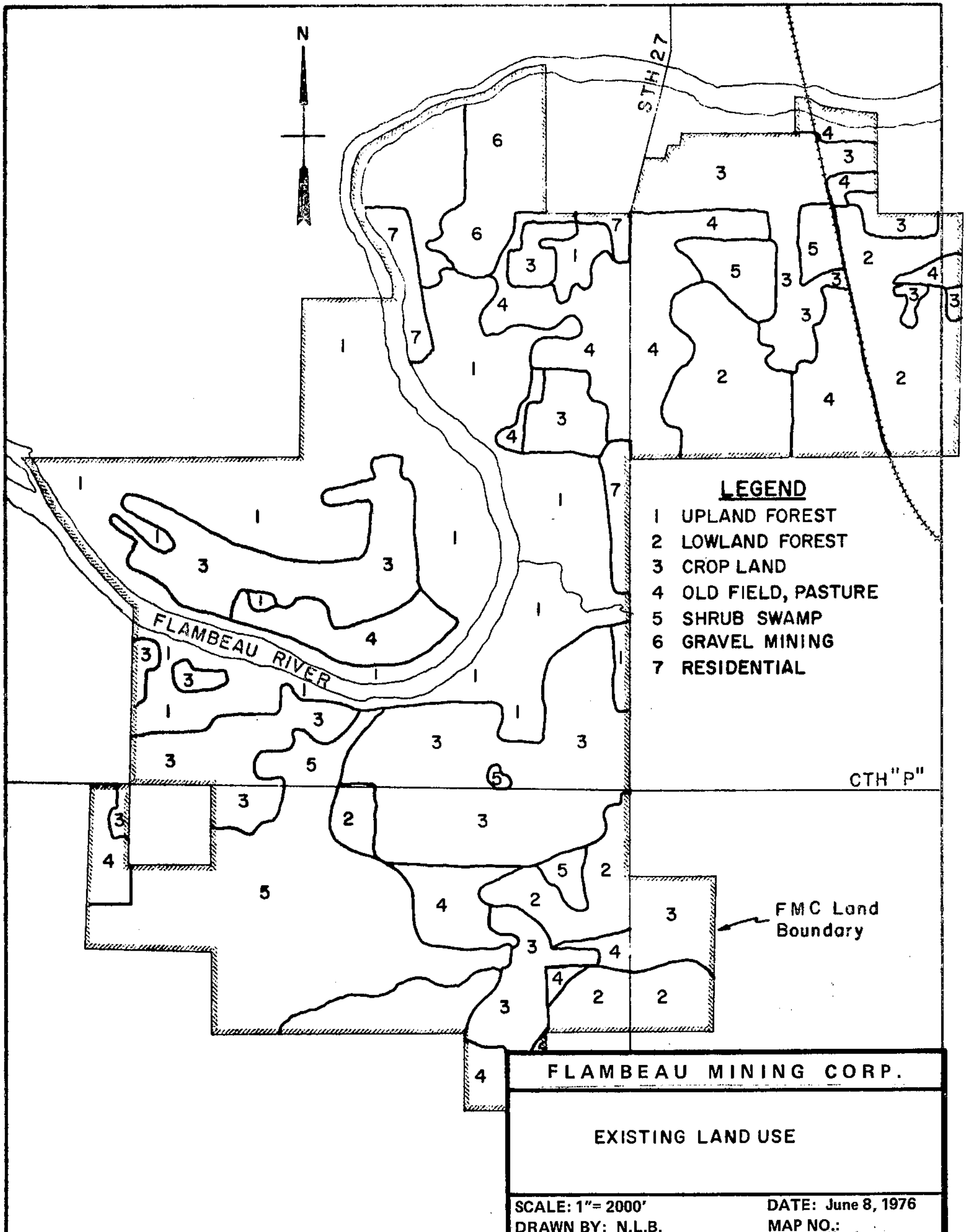
	Acres
Mining	
Open pit copper mine	55
Gravel from Rusk County pit	10
Gravel from new pit (contingent)	30
Plant	3
Haulage facilities	
Haul road and pipeline	15
Rail siding	13
Waste containment area including dikes	156
Soil stockpile	30
Total	312

This 312 acres is approximately 11% of the total area. The remaining 2,438 acres, acquired for visual and noise-screening purposes, is to be continued in its present use as advisable, and managed on a multiple use basis (Figures 53 and 54). Impact on land change usage is shown on Table 33.

3.9.0 IMPACT ON HISTORICAL AND ARCHAEOLOGICAL FEATURES

No historic buildings or candidates for the Register of National Historic Places are present on the 2,750-acre site.

Two archaeological surveys have been conducted on the 312-acres to be impacted; results were negative. However, because some Indian artifacts were found near the junction of our proposed northern spur-line with the Soo main track, this area has been abandoned in favor of the alternate southern route.


N
STH 27
FLAMBEAU RIVER
CTH"P"
FMC Land Boundary
LEGEND
1 UPLAND FOREST
2 LOWLAND FOREST
3 CROP LAND
4 OLD FIELD, PASTURE
5 SHRUB SWAMP
6 GRAVEL MINING
7 RESIDENTIAL
FLAMBEAU MINING CORP.
EXISTING LAND USE
SCALE: 1"= 2000'
DATE: June 8, 1976
DRAWN BY: N.L.B.
MAP NO.:

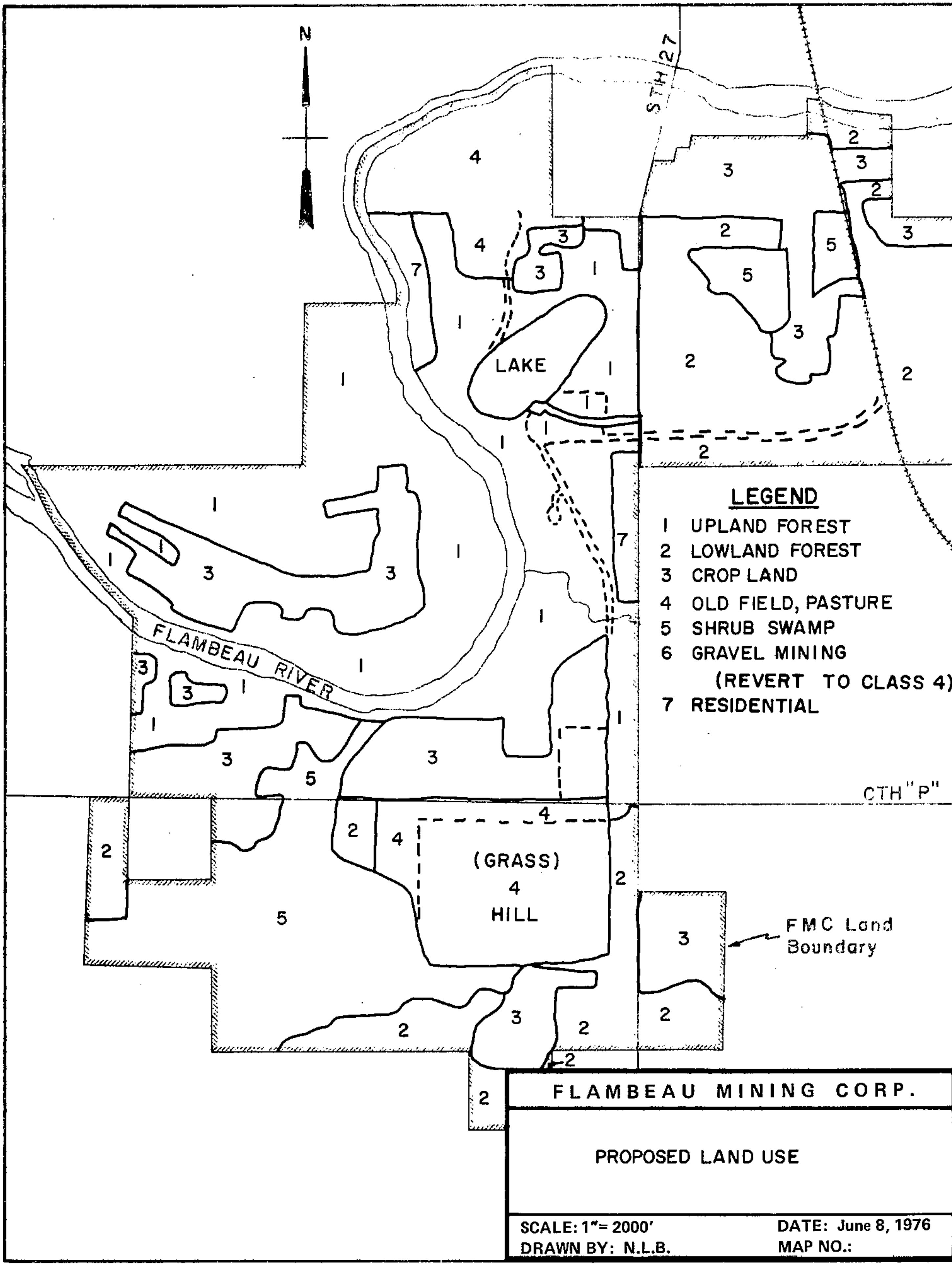

N
STH 27
LAKE
FLAMBEAU RIVER
(GRASS)
4
HILL
CTH "P"
FMC Land Boundary
LEGEND
1 UPLAND FOREST
2 LOWLAND FOREST
3 CROP LAND
4 OLD FIELD, PASTURE
5 SHRUB SWAMP
6 GRAVEL MINING
(REVERT TO CLASS 4)
7 RESIDENTIAL
FLAMBEAU MINING CORP.
PROPOSED LAND USE
SCALE: 1"= 2000'
DATE: June 8, 1976
DRAWN BY: N.L.B.
MAP NO.:

TABLE 33

APPROXIMATE ACREAGES IN LAND USE CATEGORIES

	Existing 1976	During Operations	Proposed Rehabilitation	Percent Change Over Mine Life
Upland forest	710	679	884	+ 24
Cropland	690	560	590	- 14
Old field-pasture	470	429	326	- 31
Shrub swamp	380	360	360	- 6
Lowland forest	375	320	480	+ 28
Gravel mining	65	30	0	-100
Residential	60	60	60	0
Lake	0	0	50	+100
Totals	2,750	2,438	2,750	

Waste containment area	156
Open pit	55
Gravel pit	40
Soil stockpile	30
Haul road	15
Rail spur	13
Plant site	3
Total	312
Total	2,750

SECTION 4

RECLAMATION PLAN

[redacted]

4.1.0 RECLAMATION PLAN

Mine rehabilitation is a continuous process that commences during exploration and continues after the mine has closed down.

The plans and procedures presented here are based on the current assessment of the activities to be conducted at the project site. Incorporated in the plan are presently known methods of sound and careful land management. Over the life of the mine there could be modifications and changes to these plans mutually agreed to by FMC and the WDNR. Any revised plan could result from increased knowledge, better ways to identify and prevent environmental pollution, new or modified compliance requirements, and changes in environmental quality standards. However, the basic operating procedures will remain over the project life of the mine as described under 144.85(3)(b) Wisconsin Statutes.

The mining activity will physically disturb a core area of 312 acres. The remaining 2,438 acres will be used as visual screens and as a buffer zone around the operation. Following is a description of reclamation plans for the 312-acre core area.

The cost of the rehabilitation plan to be discussed below, exclusive of the exploration phase, has been estimated at $3,719,955. These costs as detailed in Exhibit I were developed using current contractor costs.

4.2.0 EXPLORATION AND EVALUATION PHASE

Rehabilitation work to date has consisted of diamond-drill-site revegetation, the only areas disturbed so far. FMC mapped and inventoried tree communities before selecting tree species to complement existing tree stands as well as to meet the needs of areas chosen for reforestation.

Three critical areas were identified: west along State Highway 27, the east bank of the Flambeau River, and north of the open pit between the mine and Ladysmith (Figure 55). Since 1969 over 20,000 trees and shrubs (Table 34) have been planted in the three critical areas, based on advice from local WDNR foresters and corporate consultants. The tree-planting objectives were the establishment of visual screens along the road and river corridors and site beautification. Visual screening required a short-term quick-growing tree such as red pine and indigenous poplar and white birch which have naturally invaded some areas. For longer-term site beautification at the end of the operation, slower-growing trees such as hemlock and maple have been planted. Trees have been and will be taken from within the open pit perimeter and transplanted to new permanent locations. Care has been taken to leave open meadow and wetlands in order not to tree saturate reforested areas or establish monocultures.

Figure 55

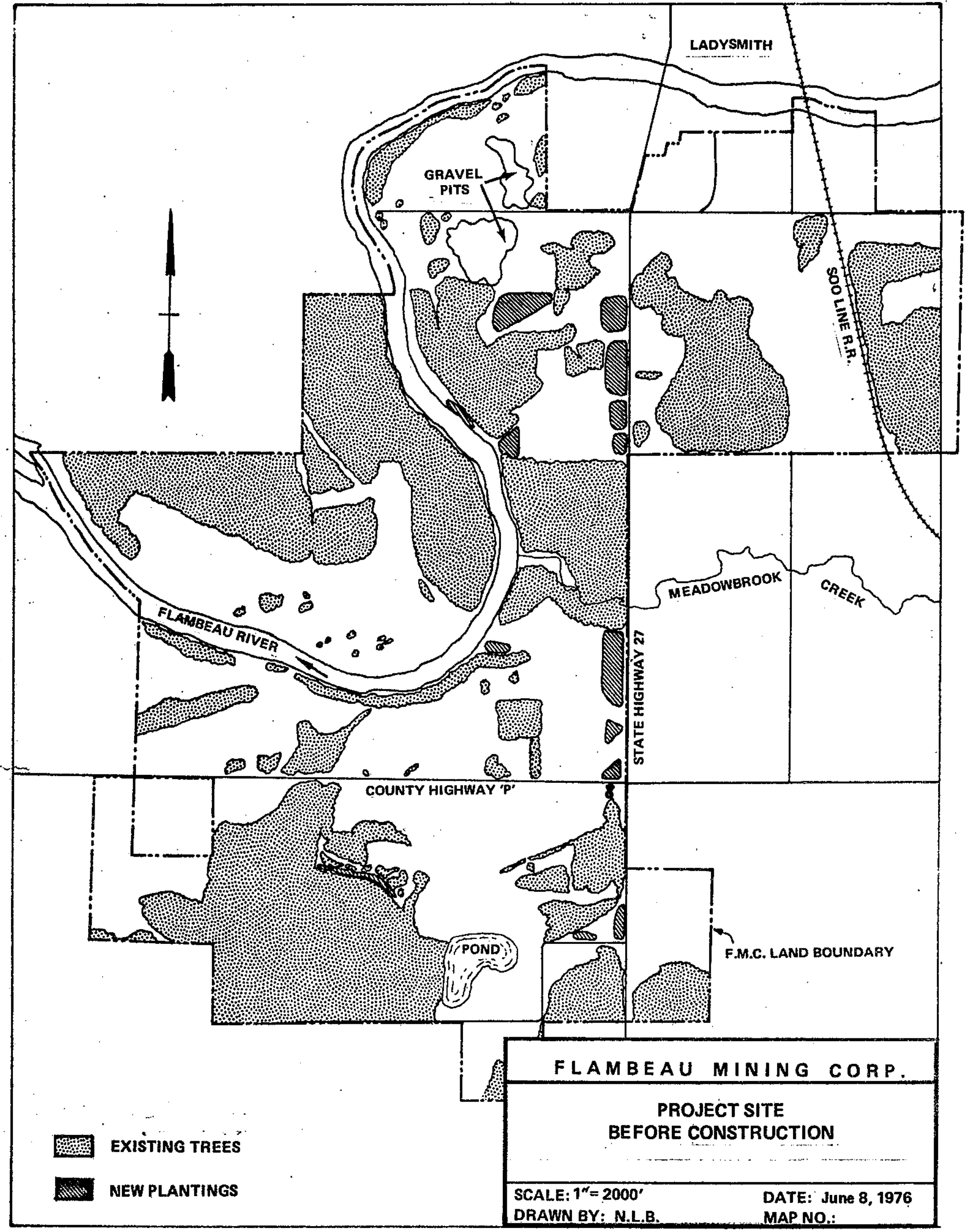

LADYSMITH
GRAVEL PITS
SOO LINE R.R.
MEADOWBROOK
CREEK
FLAMBEAU RIVER
STATE HIGHWAY 27
COUNTY HIGHWAY 'P'
POND
F.M.C. LAND BOUNDARY
FLAMBEAU MINING CORP.
PROJECT SITE
BEFORE CONSTRUCTION
SCALE: 1"= 2000'
DATE: June 8, 1976
DRAWN BY: N.L.B.
MAP NO.:
EXISTING TREES
NEW PLANTINGS

TABLE 34

PLANTINGS ON FMC LAND

Tree species planted on FMC land

Red pine
White spruce
Black spruce
White cedar
Hard maple
Amur maple
White pine
White birch
Balsam
Hemlock
Cottonwood
Green ash

Shrub species planted on FMC land

Silky dogwood
Washington hawthorne
Red amur honeysuckle
Silver buffalo berry
Late lilac
European black alder
European wayfarer
Thornapple
Gray dogwood
Wild american plum

Seed types planted on FMC land

Mackinaw birdsfoot trefoil
Emerald crown vetch
Perennial pea
Wagner flat pea

Continuation and maintenance of corporate tree resources will be an ongoing program with protection of some tree communities for aesthetic considerations. Other less critical tree areas will be harvested as they mature. In addition, the site is being used by the U. S. Soil Conservation Service to test experimental tree and shrub species under controlled conditions.

4.3.0 MINING PHASE

Surface disturbance during the mining phase will be largely restricted to the open pit site. Otherwise land disturbance throughout the project site will be minimal and contained within the 312 acres which will have already been stabilized during construction. Therefore the chief rehabilitation function throughout the operating life of the mine will be to maintain and strengthen slope stabilization measures that have already been established.

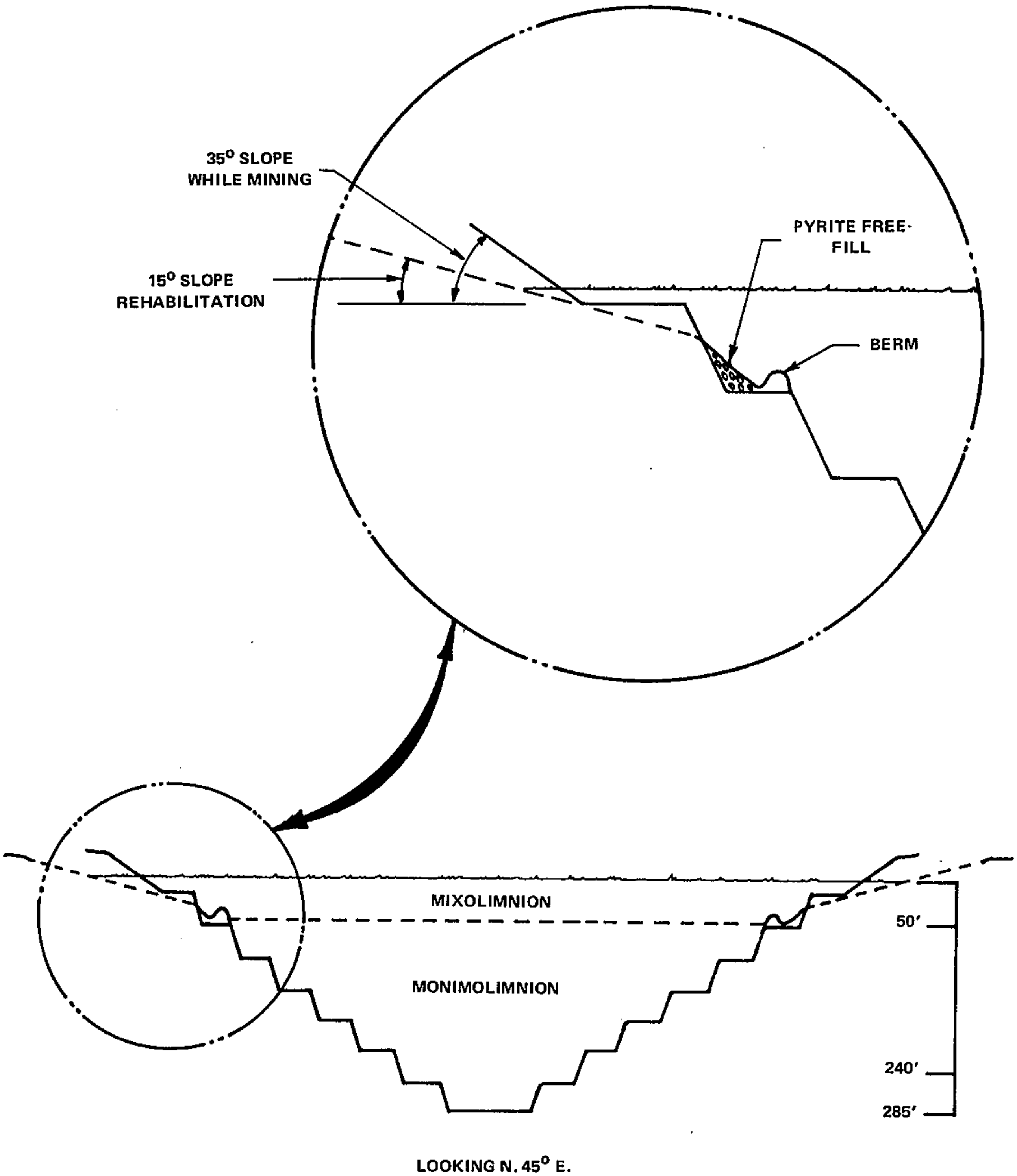
The pit perimeter will first be reached during the first few years of production at the west end. As the pit expands, the final perimeter will be reached progressively to the east until the east perimeter is achieved toward the end of the operation. Once the perimeter is established, the glacial materials will be graded to a 15° slope, mulched, fertilized and seeded with legumes and grasses (Figure 56). Thus, stabilization of the upper pit rim will be an ongoing program throughout the operation. At the toe of the graded perimeter bank will be dug a permanent groundwater-collection ditch to divert inflow waters to the 1085-foot level sump positioned at the west end of the pit. The haul road ditches will be terraced with riprap materials to reduce runoff-water velocity.

As the excavation moves to the east, the remaining trees within the security fence will have to be felled, probably during the third to fifth year of the operation. However, by the time these trees are removed, induced and natural reforestation between the pit and State Highway 27 will provide an effective replacement screen. Assuming that the mine commences production in 1979, the trees planted along the highway will be ten years old and will vary in height from 10 to 20 feet, depending on the tree species and soil conditions.

4.4.0 FINAL PROJECT SITE REHABILITATION

It is difficult to formulate a comprehensive site rehabilitation plan and recommend ultimate land use and ownership for a time 13 to 24 years into the future. FMC's rehabilitation policy has been to emphasize multiple land use and design flexibility in formulation of various rehabilitation components (Figure 57). The purpose is to provide future corporate management with a multiple choice to best suit land use requirements when mining operations cease. The final rehabilitation plans outlined below are only the best ideas or suggestions based on our current knowledge of the site and present land use guidelines. Undoubtedly our planning could be modified and

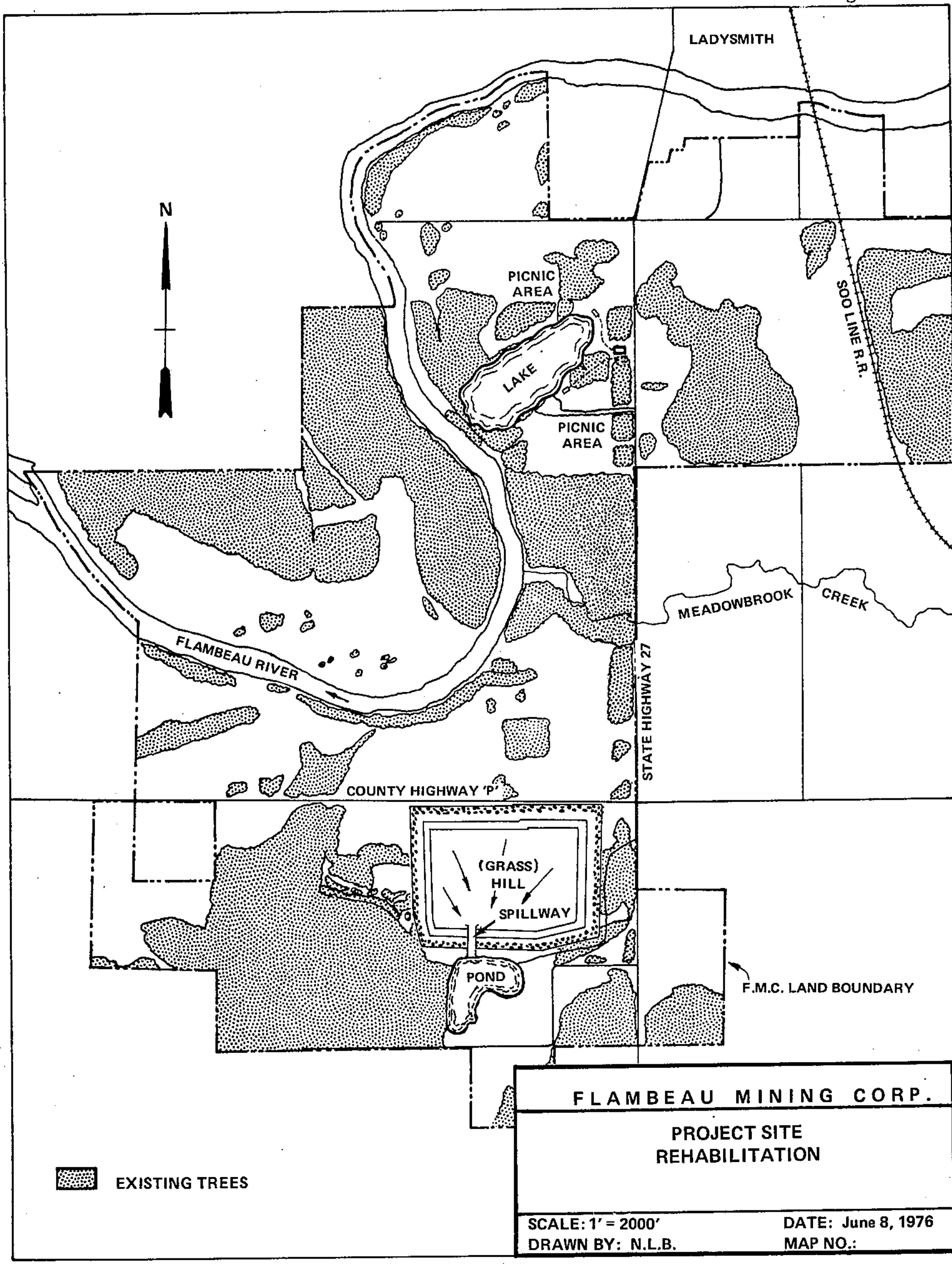
Figure 56



FLAMBEAU MINING CORP.

PIT LAKE
CROSS SECTION
SCHEMATIC

SCALE: NO SCALE
DRAWN BY: N.L.B.
DATE: June 8, 1976
MAP NO.:


LADYSMITH
N
PICNIC AREA
LAKE
PICNIC AREA
SOO LINE R.R.
MEADOWBROOK CREEK
FLAMBEAU RIVER
STATE HIGHWAY 27
COUNTY HIGHWAY 'P'
(GRASS) HILL
SPILLWAY
POND
F.M.C. LAND BOUNDARY
EXISTING TREES
FLAMBEAU MINING CORP.
PROJECT SITE REHABILITATION
SCALE: 1' = 2000'
DATE: June 8, 1976
DRAWN BY: N.L.B.
MAP NO.:

our final rehabilitation plan adjusted to better meet the needs at that time. If the open pit can be followed by an economic underground operation, these rehabilitation plans would be used after 22 years of operation; otherwise they would be used after 11 years.

In the following section on reclamation, usage of the word revegetation refers to plant selection to provide optimum coverage as determined by past and ongoing tests of seed types, mulches and fertilizers.

4.4.1 OPEN PIT MINE

Rehabilitation of the pit into a lake would probably commence during the last few years of open pit mining at the same time that the east perimeter is being established (Figures 56 and 58). Wasterock which is relatively free of sulfides (less than 1%) would be used to cover any sulfide-rich rocks in the upper portion of the excavation. This sulfide-free wasterock will be obtained from stripping of the northeast portion of the orebody and will be spread over the weakly mineralized upper portions of the pit instead of being hauled to the waste containment area. If underground mining proved to be economically feasible, the pit dewatering would continue until all mining ceased, then the pit would be allowed to fill with water.

The open pit would be filled with water to an approximate elevation of 1,092 feet above sea level to form an ellipsoidal-shaped lake of approximately 55 acres having a maximum depth of approximately 240 feet (Figure 58).

It is the intent of FMC to create a lake having acceptable water quality. There are two possible methods of filling the pit lake. Table 35 presents data on the two alternatives.

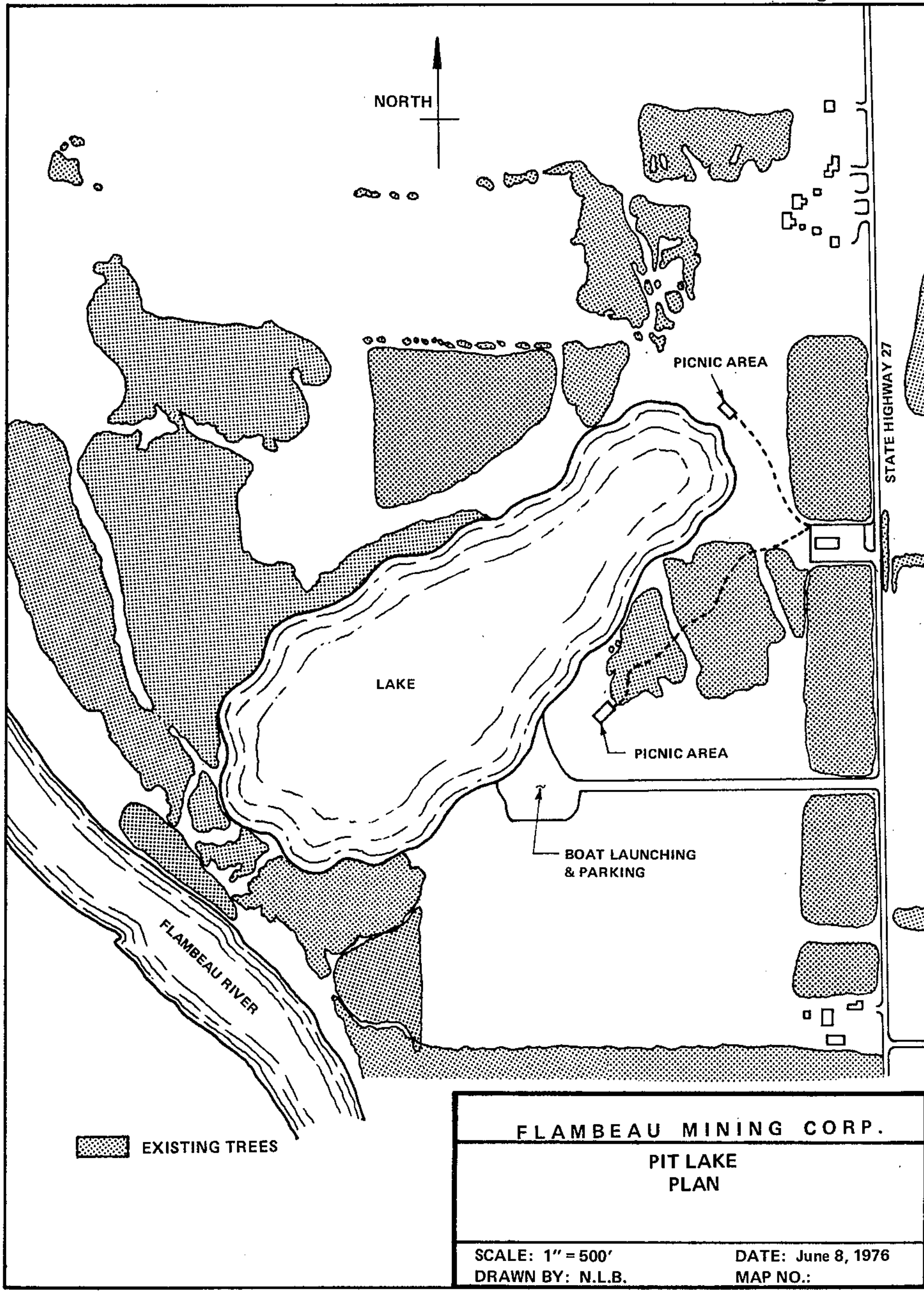
TABLE 35

WATER VOLUMES AND FILLING TIME - PIT LAKE ALTERNATIVES

Alternative	Source of Water	Estimated* Rate (gpm)	Filling Time (Days)	Volume (Billion Gallons)
1	Groundwater	1,620	857	2.00
2	Groundwater	1,620	183	0.43
	River water	5,950	183	1.57

*Estimated rates are based on theoretical values calculated by FMC.

Alternative 1 involves slowly filling the pit by the natural infiltration of groundwater. The rate of infiltration initially could be as high as 1,620 gpm or as low as 320 gpm and would slowly diminish until the water level in the pit reaches equilibrium near the natural


NORTH
PICNIC AREA
STATE HIGHWAY 27
LAKE
PICNIC AREA
BOAT LAUNCHING
& PARKING
FLAMBEAU RIVER
EXISTING TREES
FLAMBEAU MINING CORP.
PIT LAKE
PLAN
SCALE: 1" = 500'
DATE: June 8, 1976
DRAWN BY: N.L.B.
MAP NO.:

groundwater level. It is estimated that it would take between 2¼ and 8 years to fill the pit lake using this method. This alternative would require no positive action by the company, and in the absence of any other alternative method of filling the pit, this method would naturally occur.

Alternative 2 would speed up the process of filling the pit by using water pumped from the Flambeau River as the primary source of water with groundwater also contributing a percentage of the water needed. The time needed to fill the pit would depend on the rate of water withdrawn from the Flambeau River, but would probably be less than one year. For example, at a pumped rate of 5,950 gpm, the pit could be filled in less than seven months. This alternative would require a 30.18 Permit to divert river water, and is FMC's preferred method.

The pit walls below the lake surface would have an overall slope of about 35°, consisting of 35-foot near-vertical steps and horizontal benches. The two upper benches would be approximately 35 feet wide; the lower benches would be somewhat narrower. The 1,085 level bench would be about 7 feet below the lake surface. The shoreline would be gently contoured so that a safe littoral zone would be created (Figure 56). The next lower bench, at the 1,050 level, would be approximately 42 feet below the lake surface, near the predicted base of the mixolimnion (top waters). To control water chemistry and wind-driven downward water currents, a berm approximately 6 feet high would be constructed of rock on the edge of the 1,050 level bench.

Above the lake surface, the pit walls would rise from 10 to 50 feet at an approximate slope of 15° to the original ground surface. Stabilization of these slopes with vegetation, such as crown vetch and trefoil, would have been in progress before cessation of mining. Tree plantings to provide a wind screen around the circumference of the proposed pit have already been begun and would be completed prior to the commencement of mining. Tree species which can survive the expected lowering of the water table around the pit, and others known to be capable of tolerating modest root-wetting such as would probably occur after the pit is flooded, would be employed.

Prevailing winds in the Ladysmith area are from the west, southwest and northwest (Figure 19). Available records indicate that the average wind velocity in the windiest month (May) is 11 mph, and that the lowest monthly average wind velocity is 7.9 mph (August). The highest percentage of winds would blow across the short axis of the pit lake from the northwest or southeast, or obliquely from the south, north, east or west, and thus would reduce the wind piling effect on the lake. Winds from the southwest and northeast would sweep along the long axis of the lake for 25% of the time. This perspective of the lake would be protected by 50 feet of the pit wall above the water level on the northeast and by the mature tree canopy 50 to 60 feet high between the pit and the river on the southwest.

The presence of the 1,085 level bench some seven feet below the water surface, and the 1,050 level bench and berm some 42 feet below the surface would have a combined energy-absorbing surface equal to approximately 172% of the entire lake surface. Therefore, wave action and wind piling would be diminished at or above the 42-foot depth, effectively promoting stability of any stratification phenomena in the lake. The downward thrust of water masses beyond the 1,050 level bench in a lakeward direction would force upon the next bench, and the mass would be restricted to a narrower horizontal space. The total effect of the stepped pit walls would be to retard downward movements forcing shoreward, and to redirect water masses upward toward the center of the lake.

Because the groundwater flow in the area of the pit is westerly toward the Flambeau River, the water in the pit lake would flow out through the unconsolidated glacial material toward the river. Therefore, the water near the top of the pit lake would be slowly replaced by groundwater from east of the pit.

Regardless of the method of filling the pit, the lake would eventually become meromictic (non-mixing). The water quality of the mixolimnion (top waters) would be similar to that of the groundwater except possibly for elevated concentrations of sulfate, total dissolved solids, and various metals. The mixolimnion should be highly aerobic so that high concentrations of sulfide should not occur. The water temperature would vary with seasonal changes in air temperature but would be higher than those of the monimolimnion (bottom waters) except in winter.

Either method of filling of the pit would result in a pit lake which would be aesthetically acceptable. In both cases, the color of the pit lake waters would be acceptable and would not have an odor. It is unlikely that nuisance algae blooms, which would be aesthetically unpleasant, would develop since the lake would contain enough dissolved copper under all circumstances to inhibit algae growth.

The water quality of the pit lake would be of sufficient quality to allow for such activities as swimming, boating, sailing, fishing and water skiing under either method of filling the lake. However, the small size of the lake as well as its shape present only very limited opportunities for these water-related activities; also the nutrient deficiency of the lake would limit warm-water fishing. In fact, the upper waters in the lake would be of much higher quality than that of the adjacent Flambeau River except for the amounts of nutrients available. An investigation, with assistance from the WDNR, would be conducted on the best type or types of fish that could be planted in the lake.

Although the water quality of the mixolimnion pit lake would be high enough for such agricultural purposes as irrigation and stock watering, other sources of such water in the area are much more readily available.

The water quality of the monimolimnion (bottom waters) can be expected to be quite different from that of the mixolimnion. The monimolimnion would be anaerobic so sulfide minerals which would be leached out of the walls of the pit lake would not be oxidized to sulfate but would remain as sulfide. The water would have a low pH so a large percentage of the sulfide would be in the form of hydrogen sulfide. Most metal sulfides (including copper sulfide) are very insoluble, so the monimolimnion should be low in dissolved metals.

It is expected that the sulfide concentration of the monimolimnion would be sufficiently high so that copper sulfide (and other metal sulfides) would precipitate out at the interface between the monimolimnion and the mixolimnion. Thus, the monimolimnion should act to scavenge copper and other metals from the upper water should they occur, keeping their concentrations below what would otherwise be expected. The temperature of the bottom water would be cold and would not change appreciably throughout the year. Due to the low pH and high sulfide concentration, the water would be highly corrosive and would have an objectionable taste and odor.

An attractive feature of the site is that an industry developing on the site would find an inexpensive and readily available source of cooling water and/or process water. The pit lake would, in some respects, be ideal as a cooling pond for a user of large volumes of cooling water such as a steam-electric power plant. The 55-acre lake would be large enough to provide the cooling needs of a power plant in the range of 50-100 megawatts (MW). If spray cooling modules were added to the pit lake to increase the cooling capacity of the lake, a much larger plant (in the range of 500-1,000 MW or more) could possibly be built on the site.

Although the water of the monimolimnion would be of poor quality and would have to be treated for most process water uses, it might in many instances be acceptable as cooling water without pretreatment. The upper waters would be of high enough quality so that it could be used as process water or cooling water in most industries without pretreatment. Another possibility is to use the meromictic lake as a heat pump which would provide air conditioning in summer and heat in winter. Power for the system could be obtained from a wind-driven generator or other power source.

In summary, although the water quality of the mixolimnion of the pit lake would be of acceptable quality for most water uses, the location, size and shape of the lake make it rather unattractive in comparison with other water resources in the nearby area. The bottom waters would be of poor quality and would need substantial pretreatment before they would be acceptable for most consumptive water uses. The large volume of water available might make the site attractive for industrial development, especially one which needs a large volume of cooling water.

The creation of a pit lake would require a Chapter 30.19 Permit since it would be located within 500 feet of a navigable water, the Flambeau River. Title to the bed of the lake would be retained by FMC. The waters of the lake would become navigable waters of the state. Under Alternative 1, no additional permits would be required. Under Alternative 2, a Chapter 30.18 permit would be required to divert water from the Flambeau River to fill the lake.

4.4.2 UNDERGROUND MINE

The underground mine would require all of the facilities constructed for the open pit mine with the exception of the pit itself.

Upon conclusion of mining, usable equipment would be salvaged from underground; the headframes, hoist and compressor buildings and other ancillary facilities would be dismantled and removed.

The construction of the concrete-lined shafts would include provisions for eventual sealing. A two-foot-thick cap, reinforced with rebar, would be placed on each shaft about three feet below the existing ground surface with the remaining hole filled with subsoils.

The site would then be cleared of any debris and the area graded, disced and revegetated (Figure 58).

4.4.3 PROCESS PLANT

Rehabilitation of the process plant site will be minimal during its operational life and will be restricted to good housekeeping techniques to prevent accidents that could result in damage or degradation of stabilized areas. Proper handling and disposal of all generated products will assist in maintaining a high level of environmental protection around the process plant and throughout the project site.

When mining ceases, some or all of the process plant site buildings might be of use to another industry wishing to establish in northern Wisconsin. Therefore, efforts will be made to find a purchaser and keep the buildings in use so that they can continue to contribute to the economic well being of the area. If a third party does purchase the buildings, the rail spur may remain to service the site. In the event that no purchaser can be found, the buildings will be dismantled and salvaged or removed and reused elsewhere. All foundations would be removed and placed into the bottom of the open pit. The site would then be cleared of any debris and contaminated soils for disposal into the waste containment area. Finally, the process plant area would be graded, disced and revegetated (Figure 58).

4.4.4 RAILROAD SPUR

The spurline tracks and ties will be torn up and sold on the scrap market or otherwise disposed of legally. The spurline traverses woodlands so the right-of-way will be disced, seeded with legumes and grasses, and planted with trees (Figure 57).

4.4.5 POWDER MAGAZINES

The powder magazines will be dismantled and removed. The area and its access road will be graded, disced and planted with trees (Figure 57).

4.4.6 WASTE HAUL ROAD

The waste haul road will be rehabilitated, conforming to land usage on either side of the right-of-way. The three emergency catchment basins will be filled, using roadbed material, and planted with legumes and trees. The Meadowbrook Creek crossing will remain so as to provide direct access to adjacent cultivated fields. The crossing surface would be revegetated. The culvert located in the intermittent stream would be removed, and the area would be graded and revegetated (Figure 57).

4.4.7 GRAVEL PITS

There are two gravel pits located to the north of the orebody, occupying a total of 65 acres (Figure 59). One is the former Rusk County gravel pit which has been idle since purchased by FMC in 1970. The other is being used by the Ladysmith Concrete Company, Inc. and will remain active through 1982.

Upon conclusion of activity by Ladysmith Concrete Company, Inc., the edge of the gravel pit will be sloped to 35° and the entire area planted to local vegetation. Rehabilitation will commence at the former Rusk County gravel pit at the start of prestripping. The steep edges will be sloped to 35° and all areas not in use will be planted to local vegetation. At the conclusion of mining, the remaining portion will be disced and planted. In the case of an underground operation, required fill would be obtained from the gravel pits, thus requiring the area to be rehabilitated a second time.

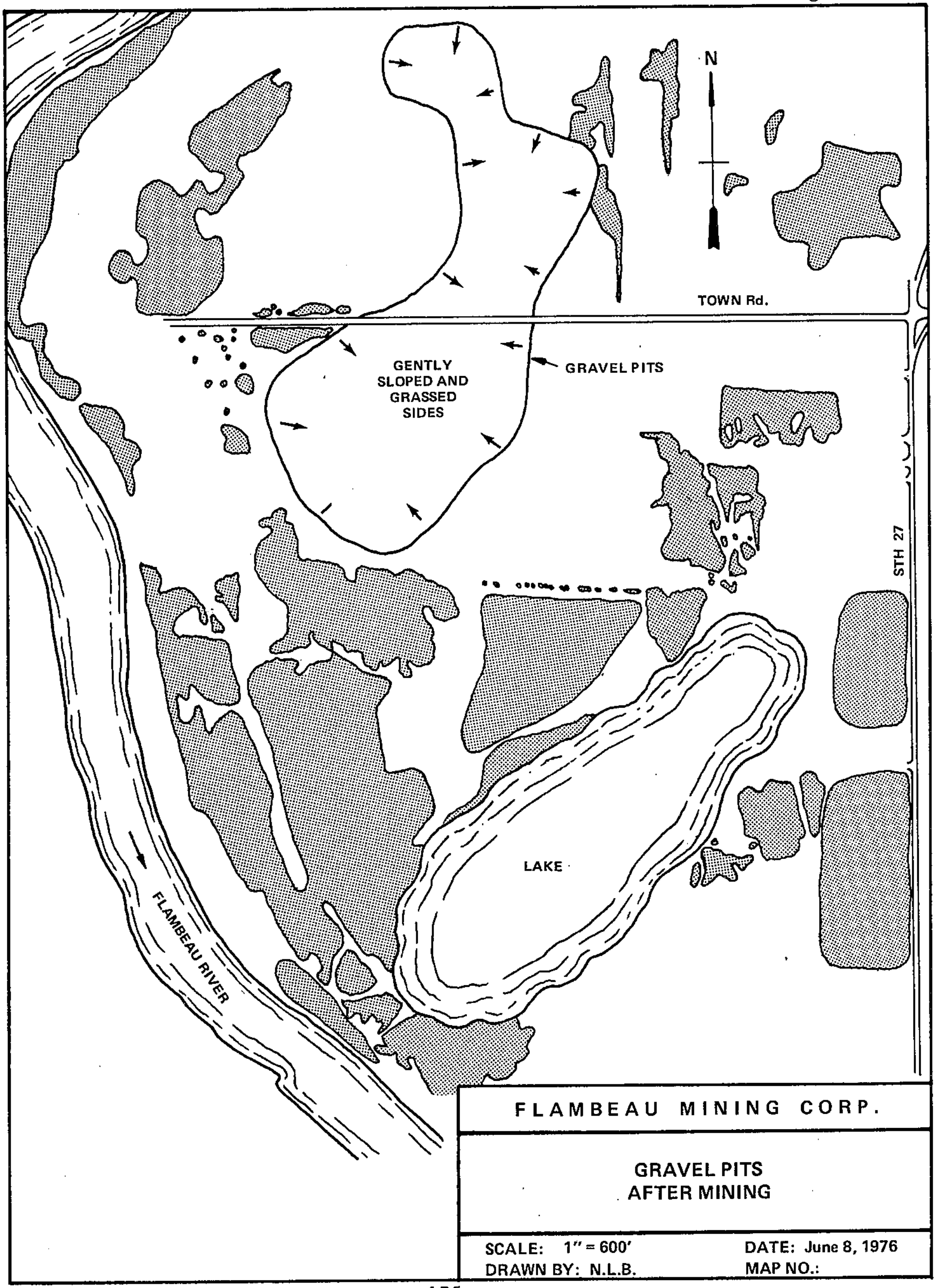
4.4.8 HIGHWAY BRIDGE

The reinforced soil bridge will remain in place until all the soils and waste haul roadbed materials are placed on top of the waste containment area. The soil stockpile and waste haul road area south of Meadowbrook Creek will be graded, disced and returned to agricultural use. The bridge will then be dismantled with all soils used to cover the waste containment area (Figure 57). Bridge debris will be disposed of legally, probably to a local scrap dealer.

4.4.9 WASTE CONTAINMENT AREA

It is presently estimated that the waste containment area would contain approximately 135 million gallons of water at the conclusion of mining. During the final years of operation when the water balance figures are better defined, every effort will be made to minimize intake water so that final water accumulation in the waste containment area would be at a minimum figure.

Figure 59


N
TOWN Rd.
GENTLY
SLOPED AND
GRASSED
SIDES
GRAVEL PITS
STH 27
LAKE
FLAMBEAU RIVER
FLAMBEAU MINING CORP.
GRAVEL PITS
AFTER MINING
SCALE: 1" = 600'
DATE: June 8, 1976
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MAP NO.:

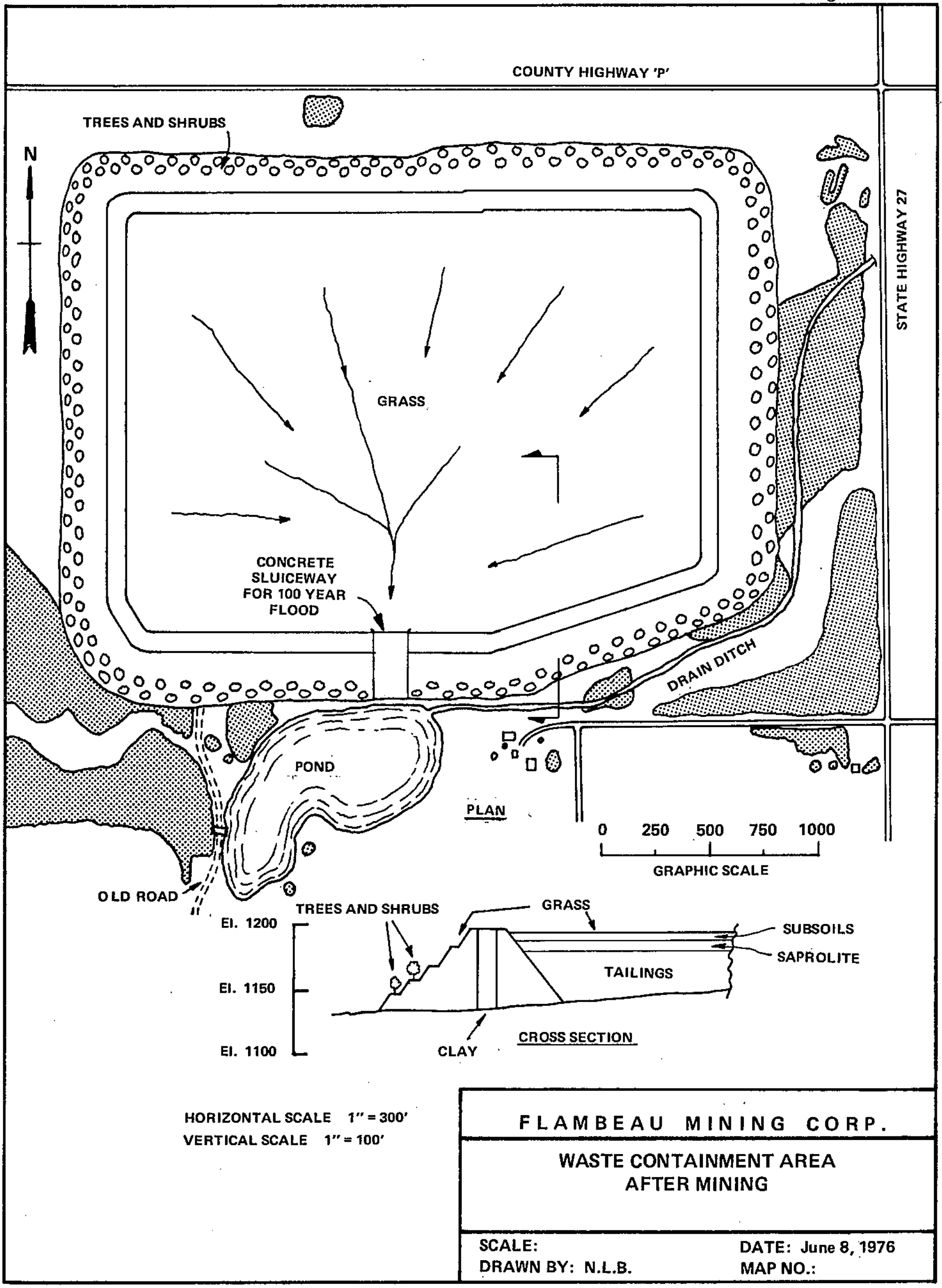
The water remaining in the waste containment area would be analyzed to determine its quality and if found acceptable would be discharged directly to the Flambeau River which would require a WPDES permit. Should water quality analysis of the final water stored in the waste containment area dictate additional treatment, the water would be returned to the concentrator via the existing reclaim water return line for treatment within the concentrator plant before discharge to the Flambeau River and/or the gravel pit.

Toward the end of the life of the operation, the ring feed system would direct the deposition of tailings in such a manner as to create a gently sloping surface from the west, north and east toward the center and the south thereby creating a low spot in the waste containment area near the south dike wall (Figure 60).

After the site is dewatered, the tailings will be covered by highly impervious 12-inch cap such as saprolite clay to minimize precipitation from entering the buried tailings. Once this layer is in place, the freeboard will be bulldozed from the outside into the center of the area, maintaining the slope described above. Additional cover material will be provided from clearing the soil stockpile site and from the waste haul road. The area upon construction completion would be planted to local vegetation. The shape of the replanted waste containment area would be that of a large (about 130 acres) very shallow bowl sloping at .5% or less toward the center and to the south. To drain this basin, a channel would be cut through the center of the south dike at an elevation and width capable of passing waters of the 100-year flood. The channel would be concrete lined with a concrete spillway through the dike and down the southwest wall. This permanent drain system will eliminate or minimize the movement of water through the tailings after the mine is shut down. Once vegetation is established on top of the waste containment area, the possibility of surface erosion, even under unusual conditions such as a 100-year flood, would be slight. Even if runoff would occur, the established vegetation, some of which would be more than ten years old, would minimize gully erosion.

The design and operation of the waste containment area is such to ensure long-term protection of the environment. A major consideration in this design was to eliminate or minimize water recharge into this area. The diversion ditch discussed in Section 2 would divert surface water around the area, the artificial impermeable cap would minimize precipitation from entering, and the naturally occurring highly impervious bottom soil materials would restrict seepage to groundwater, thus minimizing surface and groundwater recharge into the waste containment area.

Should no water quality deterioration be recorded during the life of the project, it would seem reasonable to assume that the waste site will continue to remain safe after mining ceases. However, to ensure that no long-term degradation does occur, FMC will continue water


COUNTY HIGHWAY 'P'
TREES AND SHRUBS
N
STATE HIGHWAY 27
GRASS
CONCRETE SLUICEWAY FOR 100 YEAR FLOOD
DRAIN DITCH
POND
PLAN
0 250 500 750 1000
GRAPHIC SCALE
OLD ROAD
El. 1200
El. 1150
El. 1100
TREES AND SHRUBS
GRASS
SUBSOILS
SAPROLITE
TAILINGS
CLAY
CROSS SECTION
HORIZONTAL SCALE 1" = 300'
VERTICAL SCALE 1" = 100'
FLAMBEAU MINING CORP.
WASTE CONTAINMENT AREA AFTER MINING
SCALE:
DRAWN BY: N.L.B.
DATE: June 8, 1976
MAP NO.:

monitoring and reporting of these results to the state. Monitoring is discussed in detail in Section 5, but briefly a series of in-dike, outside-core monitor wells would be installed. If adverse water quality conditions are identified and are attributable to mine waste storage, FMC would as a short-term solution either extract the contaminated water by pumping or by a dike-toe collection ditch. This water then would be either treated and discharged or be pumped back into the waste containment area. During this period an extensive study would be conducted with the objective of determining the best long-term solution.

Possible corrective activities could consist of one or a combination of the following, depending upon the size and nature of the seep:

1. Excavation and rebuilding of that section of dike that contains seepage channels.

2. Construction of a water-collection system and treatment plant. Such plants are in operation at several locations in Canada to treat acidic seeps from waste piles which did not include any of the safeguards incorporated in our design as described above. Nor was site selection given much consideration to prevent seepage. However, water treatment technology is being rapidly improved and generally consists of a series of conditioner tanks, cyclones, neutralization, and sludge-collection ponds.

Mines that have started operations in the last five to six years have used prestripping material to construct a dike to contain the mill tailings. The tailings are then deposited within the dike exactly as FMC proposes. These dikes are constructed of unsegregated material without too much regard for site selection. This is in contrast to FMC's proposal which carefully and thoroughly selected the site and then engineered the dike construction with the objective of eliminating all seepage. These other recent operations will be watched to determine if any problems arise from their tailings impoundments and if so, what corrective measures are being taken. FMC is the only operation, to our knowledge, which has so far undertaken these safeguards.

4.4.10 EDUCATIONAL-RECREATIONAL BENEFITS

KCC has for many years conducted tours around its operating mines out west for summer tourists and interested groups. This has provided an excellent opportunity for people from all walks of life to see first hand development of our natural resources and to ask questions of KCC's staff who act as guides.

The construction and operation of Wisconsin's first copper mine by FMC will undoubtedly create much local and statewide interest. The project site is readily available to tourist traffic since the open pit will be only 400 feet west of State Highway 27. To accommodate visitor traffic, the gravelled area surrounding the former H & H Haulers building will be converted into a car park (Figure 26). The building will be remodeled into an interpretative center to display the discovery, geology, mining, monitoring and rehabilitation aspects of the site. This display will be equally divided between operational and environmental concerns. Such an interpretative center would hopefully be the result of a cooperative effort by FMC and personnel from local and regional land-related agencies and schools. This center will be designed to demonstrate that mining and other land uses such as farming and recreation are compatible within the context of a small but well designed site.

Leading from the interpretative center will be a winding trail through a young growth of aspen and birch to a visitors' lookout or observation point. The observation point will be built toward the close of the construction phase and after completion of the security fence. To take advantage of viewing the early stages of open pit mining, the observation point will be located on the south central side of the final pit perimeter. A second observation point will be constructed after trees are removed over the east end of the orebody within the fenced area. Information explaining the mining process will be available at each observation point. In addition, the access trails to each viewing area will be designed to make people aware of the surrounding flora and the type and age of trees planted by the company.

The project site has in the past been used by local residents for hunting, fishing, canoeing and cross-country skiing. Hunting, because of the risk of accidents to people and property, will be restricted to the southwest corner of lands controlled by FMC or west across the Flambeau River. Cross-country skiing has been enjoyed west of the river for several years on abandoned logging trails. These trails have been maintained and improved by FMC staff for use by the public. This ski area is of unique geologic and environmental interest in that it contains diversified animal and plant populations in an area characterized by glacial eskers and kettle lakes. Fishing and canoeing on the Flambeau River will continue uninterrupted since the mining operation should not affect the quality or aesthetics of the river.

Therefore, it is FMC's intention to develop local recreation more along the lines of "wilderness" use such as canoeing and cross-country skiing which are quiet sports requiring a low capital investment. The west end of the ski area is an ideal location for a primative canoe camping site on an esker overlooking the Flambeau River. At the present there are no canoe camping sites between Josie Creek ten miles upstream and the first known site downriver before the confluence with the Chippewa River, a distance of 16 miles. Any canoe site would be a low upkeep area consisting of a small cleared area with a grate and hand-operated pump for drinking water. At the conclusion of mining, the north slope of the waste containment area could be used for toboggan runs.

Considerable valuable data has been compiled during the past four years on the ecosystem of a small part of northern Wisconsin and made part of FMC's environmental impact statement. As the mine site continues to be monitored and studied during the construction and operational phases, the company plans to share this information with public and private interest groups. There are real educational benefits to be gained through the development of this deposit, for FMC fully realizes that the way it conducts mining in the Town of Grant could set precedent in our industry for years to come.

4.5.0 PROPOSED FINAL LAND USE PLAN

The land holdings of FMC comprise a total of 2,750 acres, of which 312 acres will be required for the project site. The remaining 2,438 acres will be managed in the following manner.

Reference has been made throughout this report for the need to protect the environment along with consideration of optimum land management and use, land being our most basic resource.

Open pit mining is an undeniably traumatic treatment of land wherever it occurs. Therefore, stewardship for the lands that surround a mine becomes doubly important from an ethical viewpoint. Recognizing that open pit mining will traumatize some of the FMC lands, care of the remainder becomes an obligation of the highest order. Care for land resources involves several elements of strategy which include at least the following:

1. Evaluation of each parcel to determine its best use. This evaluation includes recognition of the needs of the company, agriculture, forestry, aesthetics, wildlife and the general public.

2. Development of the alternatives available for each land parcel.

3. Choice of what is the best use given all of the applicable considerations.

4. The writing of a management plan for each parcel in the context of the entire metal mining operation.

The vegetation and land management plans which follow were developed in this fashion. Advice was sought from a variety of sources (U. S. Soil Conservation Service, Wisconsin Department of Natural Resources), limited research on various biotic elements was conducted, and the multiple use criterion for the property was adopted as the central element of the land management schemes to be developed. It is believed that these plans represent the best use and modus operandi to attain these uses that can be developed at this time.

4.5.1 VEGETATION MANAGEMENT PLAN

The development of the vegetation management plan which was covered in preceding sections has proceeded from several premises, and includes the needs of the company, the concept of multiple use, and the general concept of control of erosion and wind as rapidly and as thoroughly as possible. As with any long-term ecological plan, it is foreseen that the plan could be modified as the mine develops. All modifications will be consistent with the general plan of taking into account the various climatic conditions and processes which are important in this region and which could cause difficulty if they were not considered. Continuation of farming, improvement of wildlife habitat, provision of recreational areas for human activities and other needs will be considered as well. Careful assessment of the impacts and trade-offs will be made for these decisions following this philosophy.

4.5.2 LAND MANAGEMENT PLAN

The development of the land management plan (2,438 acres) took into consideration the following:

1. Economic returns possible from the wise management of all the developed company lands, e.g., cropland.

2. The multiple use of lands for continuous tree yield and wildlife values.

3. The varied needs of environmental education, recreation and aesthetics.

Three time perspectives are considered:

1. A short term, assuming an 11-year mine life.

2. A medium term, assuming a 22-year mine life.

3. A projection of the long term, after the year 2000 when the mine will be completely rehabilitated and these lands turned to a new purpose. Of course it is difficult to see that far ahead and guess at the content and structure of mores, aesthetic values and economic needs of that yet-to-be-developed society.

Figure 53 delineates the basic kinds of habitats located on company lands acquired for visual screening, to provide access to the rail siding on the east side of the property and to control the development across the river from the main mine site. These lands cover approximately 2,750 acres and have the following uses today: a major portion, 1,085 acres, is in lowland and upland forests; 470 acres are in fallow or old field land use; 690 acres are in cropland; 380 acres are in shrub swamp lands; about 65 acres are in gravel mining; and 60 acres are in residential use. The areas shown on this map would be continued in their present land use for the most part as detailed in Table 33. Figure 54 delineates the proposed land use.

4.5.2.1 UPLAND FOREST

Before modern man settled northern Wisconsin, Rusk County was predominantly forest due to a combination of geography, climatic conditions, and poor rocky soils. Therefore, a part of our overall land use plan will be to allow less productive farmland (old fields) to revert to either upland or lowland forest.

Large stands of upland mixed deciduous-coniferous forest exist and will be monitored and maintained by using the best forestry advice and techniques available. It is estimated that approximately 200 acres of saw log timber is now available onsite and will be harvested. However, no timber cutting will be permitted within 100 feet of the Flambeau River, along State Highway 27 or around the open pit perimeter. These areas hold too much value as aesthetic resources or as protectors of the proposed meromictic lake.

4.5.2.2 CROPLANDS

According to the most recent U. S. Department of Agriculture - Agricultural Stabilization and Conservation Service (U.S.D.A - A.S.C.S.) records, FMC purchased 822 acres of cropland in Grant Township. However, since these statistics were compiled in the early 1970's, many former landowners allowed some of their poorer lands to revert to forest. The more productive land, amounting to 690 acres, is being kept in cropland by FMC and leased to local farmers. After a study of agricultural trends within Rusk County and northern Wisconsin in general, FMC decided not to continue dairy farming which has been on a steady decline since the Second World War. Instead, FMC foresees a need for raising food grains and hay as a land use more in keeping with projected agricultural trends. Thus, less productive fields will be allowed to revert to forest, whereas productive cropland will be continued in use, but that use will be switched from dairying to raising of food grains and cattle feed.

Cropland will be leased throughout the mine life. Farming practices will be rigorously monitored and tenants will be required to consult with local agricultural officials to ensure that best use is made of the land. Because livestock raising will be minimized on company land, soil erosion along the Flambeau River and Meadowbrook Creek will be considerably reduced. At the same time, immature trees will have a chance to survive and grow to reduce bank erosion and improve onsite aesthetics. Also, by not having cows, water contamination through additives of nitrogen, phosphorous, bacteria and B.O.D. will be reduced.

Farming will continue onsite after the mining operation. Only 100 acres of cropland will be lost due to development of the mine

(Table 33 and Figure 54). This represents a 14% decrease of on-site cropland which is not an unreasonable loss when compared to the tonnage of copper metal produced.

4.5.2.3 OLD FIELDS - PASTURE

The greatest percentage loss of existing land use will be the natural succession of old field and pasture to forest. Over the life of the mine, 144 acres will be allowed to revegetate naturally or be planted with trees. This poor quality land, which requires large quantities of chemical fertilizers and energy to produce below average crop yields, will be returned to producing timber and providing game habitat.

4.5.2.4 SHRUB SWAMP

Approximately 380 acres of shrub swamp are present on the property especially on the east side of State Highway 27 and to the south and west of the tailings disposal area. It is anticipated that these areas will not be capable of supporting any kind of an intensive forestry management and therefore these areas will be left as they are to serve as wildlife production and bedding areas for the foreseeable future.

4.5.2.5 LOWLAND FORESTS

At scattered locations around the mining property there exist areas which are capable of supporting either a lowland mixed deciduous-coniferous forest or a rapid rotation pulp production. It is anticipated that plantings will be made of red pine and white birch to augment natural popple, in order to provide a pulp crop approximately 25 to 30 years after planting. It is anticipated that if planting can be done in the same year that the mining operation begins, a pulp crop can be obtained from these areas during the last phases of the mining operation or while the mine pit is being rehabilitated as a lake 22 to 25 years after the beginning of the mining operation. After this pulp crop is cut (possibly clear cut) an effort will be made to encourage either aspen regrowth by the latest available techniques or the area will be planted to a variety of woody species capable of surviving in this area in the long term. No provision will be made to drain these areas so that the areas could be converted into agriculture or other land uses for such would involve major changes in the ecology of the area.

4.5.2.6 RESIDENTIAL AREAS

The residential properties will be continued in this land use. The acreage involved is so small that individual plans will not be drawn for each one.

In summary then, 2,438 acres in total of the mine property's 2,750 acres will be maintained for the most part in the land use that presently exists upon them. These properties will be managed for the economic return that is possible on them and would be rehabilitated as detailed above at the end of the mine life. It is expected that these properties will provide a small economic return to the company and may provide enough return to pay a significant portion of the taxes assessed against the property throughout the mine life. The best currently available management technology will be used in these areas to assure that the properties retain as pleasing an aesthetic image as possible during the time that these properties are managed for yields of agricultural or woodland products. It is expected that with good housekeeping care in implementing these plans, an improved quality of the landscape may actually be possible; this while improving the economic output of these lands over what they presently have been. The ecological advantage of having the entire 2,750 acres managed by a single landowner should become apparent.

SECTION 5

MONITORING PLANS

[redacted]

5.1.0 WATER MONITORING - SURFACE

After discovery of the Flambeau deposit, the corporation set up in 1970 an extensive surface water monitoring program to collect baseline data on the Flambeau River and its tributaries that flow across the project site. A total of eight monitor stations were established and sampled on a monthly basis for one full year. At the end of the first year, the frequency was reduced to quarterly and then in the third year it was further reduced to a semiannual schedule which now represents the present sampling program. Station 8 had to be abandoned because of difficulty in obtaining permission from the landowner to enter his land; consequently station 8 has now been moved upstream to the site of the former Port Arthur Dam (Figure 61). Station 9 will be established as a new station west of the gravel pit at the request of the WDNR. Station 10 will monitor discharge into the gravel pit.

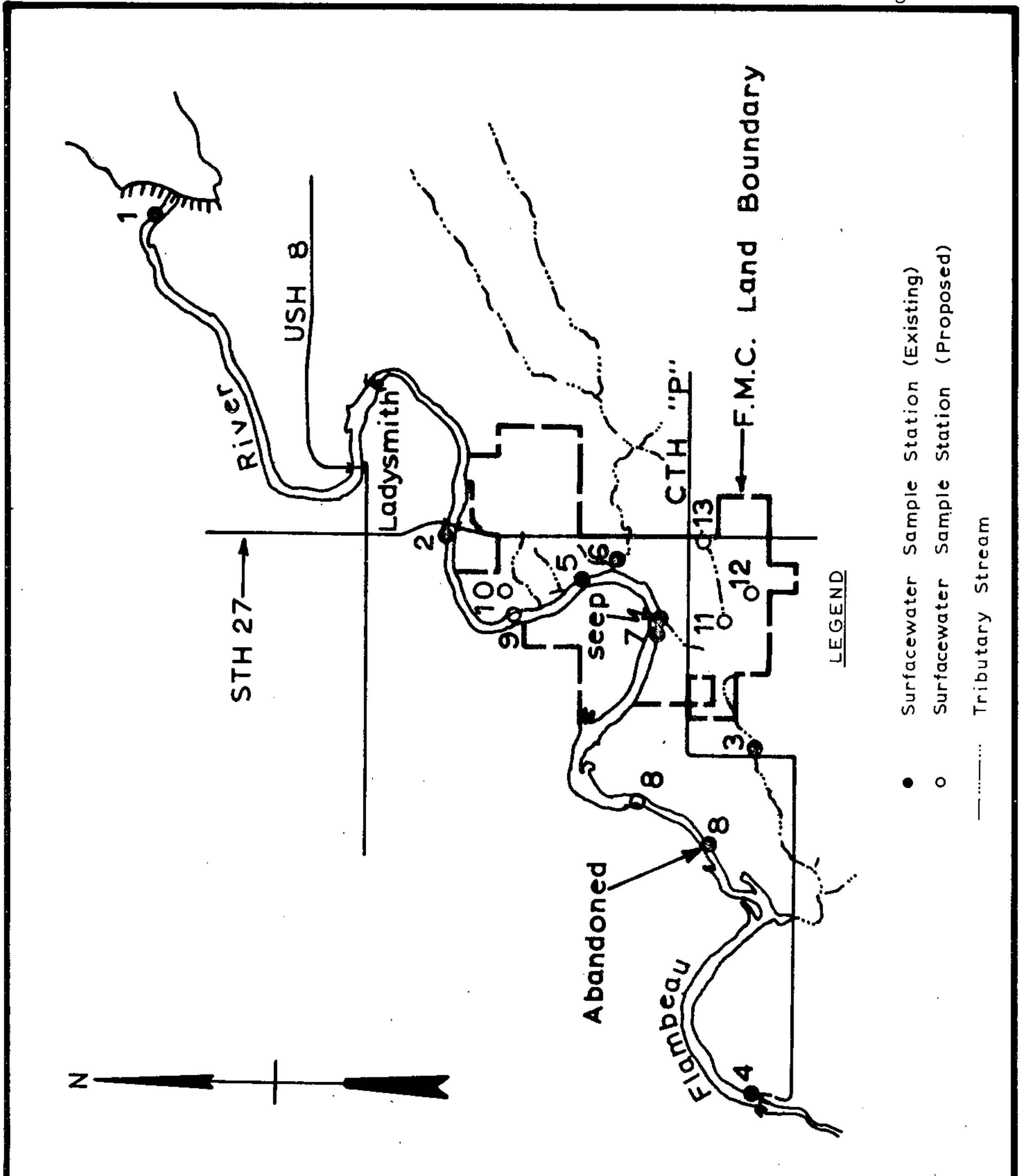
Sample frequency at some of the monitor stations will be increased once construction is underway. Table 36 lists the purpose, location and water system to be sampled after the start of construction.

The quarterly or semiannual frequency schedule will be maintained throughout construction, operation and post operation. Sample frequency would be adjusted particularly if key chemical parameters such as pH or sulfate show anomalous changes. River and creek flow data will be taken each time that surface water quality samples are collected.

Additional proposed surface water stations will be located nearer to the operation. It is the intent of these stations listed in Table 37 and illustrated on Figures 61 and 62 to determine water quality changes before discharge or seepage into the Flambeau River and its tributaries. Sample stations 14 and 15 are not illustrated but would be taken from a boat at the approximate geographic center of the proposed pit lake.

Stations 11 through 13 will be utilized to sample surface water in the unlikely event that a seep occurs at the toe of the waste dike. The toe of the dike will be visually inspected on a regular basis to determine that the dike is functioning as designed. Should a seep be detected, its quality and quantity would be determined, and if adverse water quality is indicated, then the procedure as outlined in Section 4, page 178, would be implemented.

Baseline water quality data will be collected monthly for one year from stations 11 through 13 before commencement of construction. There might be a disruption in sample frequency during construction but these points would return to a quarterly schedule once the first lift of the dike and diversion ditch are in place. Sample frequency after obtaining baseline data and before construction could be reduced to a quarterly and semiannual basis depending upon the mine development schedule.



FLAMBEAU MINING CORP.

EXISTING AND PROPOSED
SURFACEWATER SAMPLE STATIONS
LOCATION MAP

SCALE 1" = 6,667 ft. DATE Jul. 1976
DRAWN BY GLB MAP NO.

Figure 62

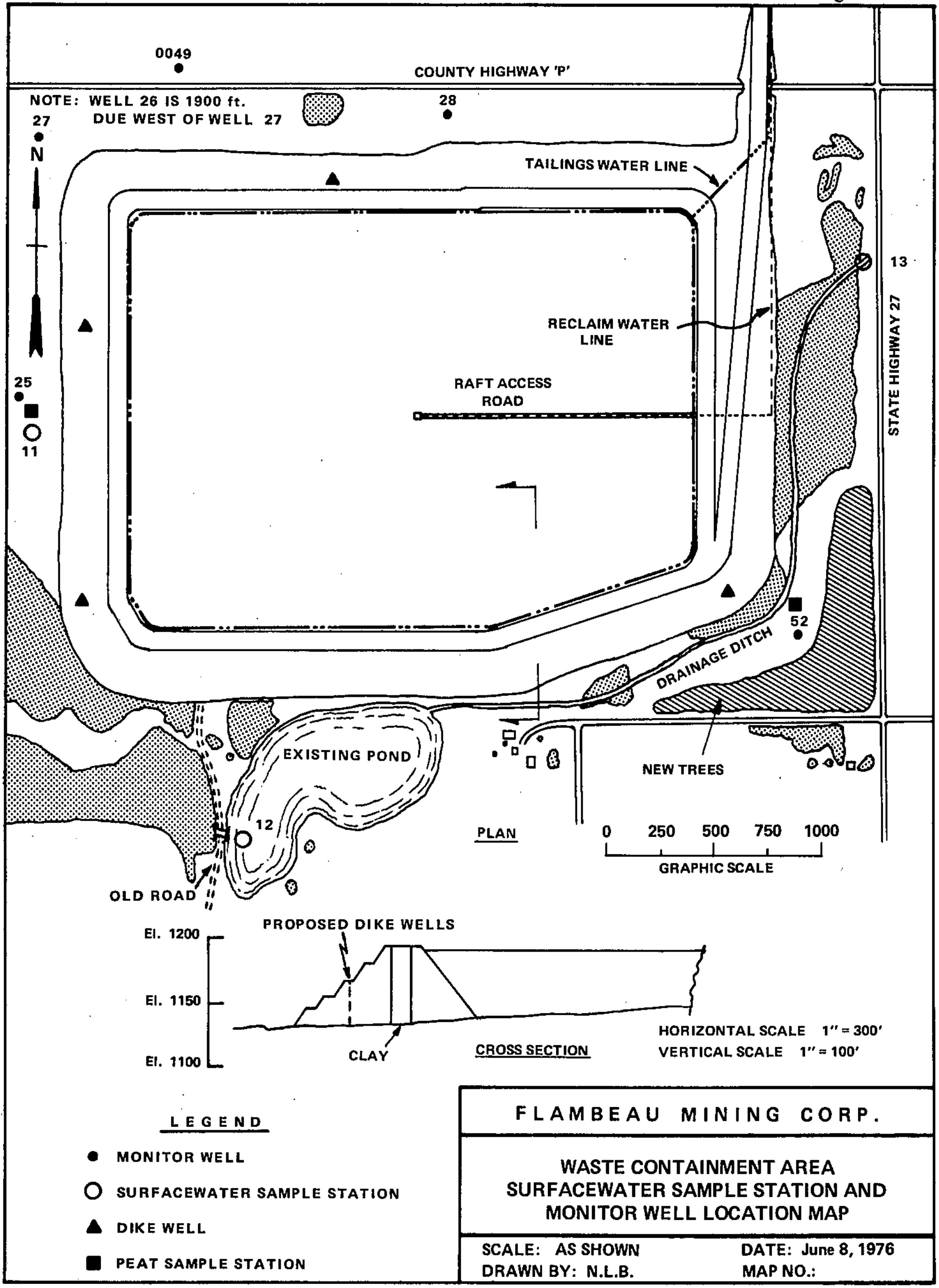

0049
COUNTY HIGHWAY 'P'
NOTE: WELL 26 IS 1900 ft. DUE WEST OF WELL 27
27
28
N
TAILINGS WATER LINE
13
RECLAIM WATER LINE
STATE HIGHWAY 27
25
11
RAFT ACCESS ROAD
52
DRAINAGE DITCH
EXISTING POND
NEW TREES
12
PLAN
0 250 500 750 1000
GRAPHIC SCALE
OLD ROAD
PROPOSED DIKE WELLS
El. 1200
El. 1150
El. 1100
CLAY
CROSS SECTION
HORIZONTAL SCALE 1" = 300'
VERTICAL SCALE 1" = 100'
LEGEND
MONITOR WELL
SURFACEWATER SAMPLE STATION
DIKE WELL
PEAT SAMPLE STATION
FLAMBEAU MINING CORP.
WASTE CONTAINMENT AREA SURFACEWATER SAMPLE STATION AND MONITOR WELL LOCATION MAP
SCALE: AS SHOWN
DATE: June 8, 1976
DRAWN BY: N.L.B.
MAP NO.:

TABLE 36

SURFACE WATER SAMPLE STATIONS, FLAMBEAU RIVER AND TRIBUTARIES

Station No.	Location	Purpose	Water System
1	Dairyland Dam No. I Tainter Gate section	Water data entering Grant Township and upstream of Ladysmith	Center of Flameau River on upstream side of dam
2	State Highway 27 20' downstream of bridge's north pier	Water data entering project site and downstream of Ladysmith	Flambeau River north bank
3	Tributary G East side of County P culvert	Water data downstream of waste site	Center of tributary stream
4	Thornapple Dam Center of west flume in trash rack building	Water data existing Grant Township	Flambeau River west bank above dam
5	Open Pit 600' downstream of intersection of open pit long axis with east bank of Flambeau River	Water data adjacent to open pit	Flambeau River east bank
6	Meadowbrook Creek 400' upstream of confluence with Flambeau River	Water data below haul road crossing	Centerline of creek
7	Seep Area Intersection of intermittent stream and south bank of Flambeau River	Water data north of waste site and existing project site	Flambeau River south bank
8	Port Arthur Public access area	Water data downstream of the waste containment site	Flambeau River west bank
9	Gravel Pit Upstream of intersection of open pit long axis with east bank of Flambeau River	Water data adjacent to gravel pit	Flambeau River east bank

For sample frequency, please refer to Table 38.

TABLE 37

PROPOSED ADDITIONAL SURFACE WATER SAMPLE STATIONS, FLAMBEAU PROJECT SITE

Station No.	Location	Purpose	Water System
10*	Point discharge into gravel pit	Quality of discharge from open pit into gravel pit settling ponds	8" discharge pipe
11	West center toe of waste containment area dike	Quality of wetland water	2' square hand-dug pond, 2' deep
12	Point discharge of water diversion ditch around east and south sides of waste containment area	Quality of diversion discharge in wetland	Centerline of intermittent stream
13	East of waste containment dike at west exit of State Highway 27 culvert	Water quality entering project site at waste containment area	Centerline of intermittent stream
14	Meromictic lake	Mixolimnion	Upper lake waters
15	Meromictic lake	Monimolimnion	Lower lake waters

*Sample frequency to be determined during WPDES hearings.

For sample frequency of stations 11 through 15, please refer to Table 38.

TABLE 38
CHEMICAL PARAMETERS AND WATER SAMPLE FREQUENCY, FLAMBEAU PROJECT

Parameters	Surface Sample Stations															Groundwater Sample Stations												Seep Area	Four Wells in WCA Dike Wall
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	6	14	17	19	25	26	27	28	29	40	52	0049		
Alkalinity M. O. mg/l as $CaCO_3$			X								X	X	X	X															
Antimony mg/l as Sb	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Arsenic mg/l as As	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Beryllium mg/l as Be	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Cadmium mg/l as Cd	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Calcium mg/l as Ca	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Coliform MPN/100 ml	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Copper mg/l as Cu	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Dissolved oxygen mg/l as O_2 (F)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X														
Extractables (oil and grease) mg/l	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Iron mg/l as Fe	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Lead mg/l as Pb	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Manganese mg/l as Mn	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Mercury mg/l as Hg	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Nickel mg/l as Ni	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Nitrate-Nitrite mg/l as N	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Nitrogen total Kjeldahl mg/l as N			X								X	X	X	X															
pH (L) (F)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Phenols mg/l			X								X	X	X	X						X	X	X	X			X	X	X	
Phosphorous (total) mg/l as P			X								X	X	X	X						X	X	X	X			X	X	X	
Selenium mg/l as Se	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Sulfate mg/l as SO_4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Temperature °C (F)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Thallium mg/l as Th	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Total dissolved solids mg/l	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Total suspended solids mg/l	X	X	X	X	X	X	X	X	X	X	X	X	X	X															
Zinc mg/l as Zn	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Annual frequency - pre-construction	2	2	2	2	2	2	12*	2	12*	-	12*	12*	12*	-	-	2	2	12*	12*	12*	2	2	12*	2	2	12*	12*	12*	-
Annual frequency - construction, operation, post operation	2	2	4	2	4	4	4	2	4	12**	4	4	4	12	12	4	4	4	4	4	4	4	4	4	(AB)	4	4	4	12

(L) Laboratory
(F) Field analysis
(AB) Abandoned, replaced by well 8

* Take these pre-construction and construction samples for one full year, then reduce to quarterly, and then semiannually.
** Monthly during periods of discharge

At the cessation of mining the open pit would be flooded and a lake formed. Two water samples would be taken on a monthly basis until stratification has been documented. At that time the sample frequency would be reduced. One sample, No. 14, would be taken within 50 feet of the surface to sample the water quality of the upper layer (mixolimnion), whereas No. 15 would be taken below 50 feet to check the quality of the lower layer (monimolimnion). Temperature and water conductivity readings would be taken at five-foot intervals down to 100 feet below the lake surface until stratification.

Also at the cessation of mining the water remaining in the waste containment area would be analyzed to determine its quality (see Section 4, page 174). During discharge water would be monitored continuously for pH value and conductivity.

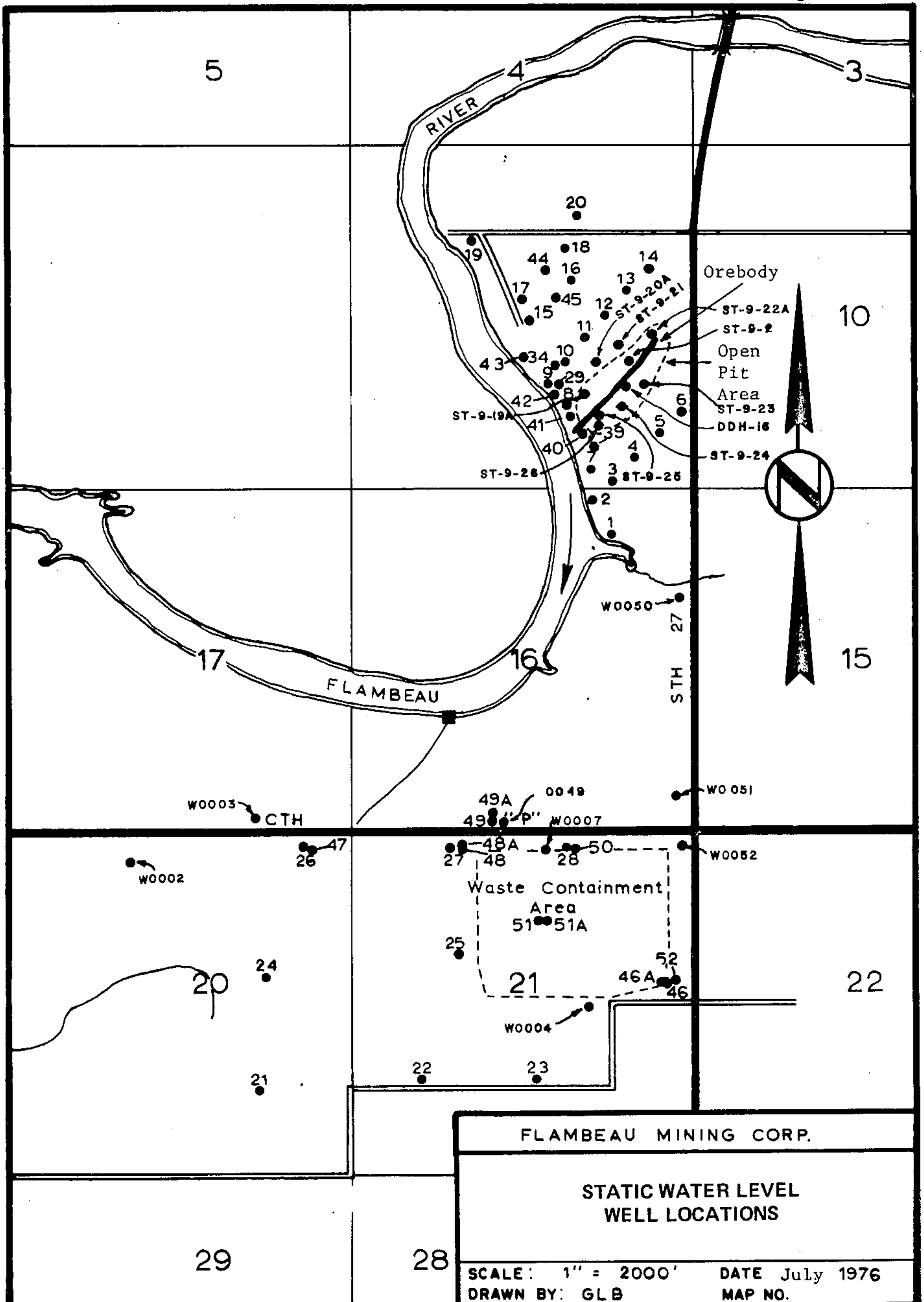
5.2.0 WATER MONITORING - GROUNDWATER

Baseline groundwater data has been collected since 1971 on the same general sample frequency described for surface water. On the project site monitor wells have been drilled or converted from potable use to check (1) static water levels (Figure 63) and/or (2) water quality. All wells have been used to measure static levels continually since 1970. A total of six wells have been used to collect baseline water quality data. These wells, illustrated on Figures 62 and 64, are 6, 14, 26, 27, 29 and 40. These wells will be supplemented by wells 17, 19, 25, 28, 52 and 0049, also shown on the same figures. Static level readings and water quality data will be collected during construction, mine operation, and for a currently undetermined period of time after cessation of mining.

5.2.1 GROUNDWATER - MINE

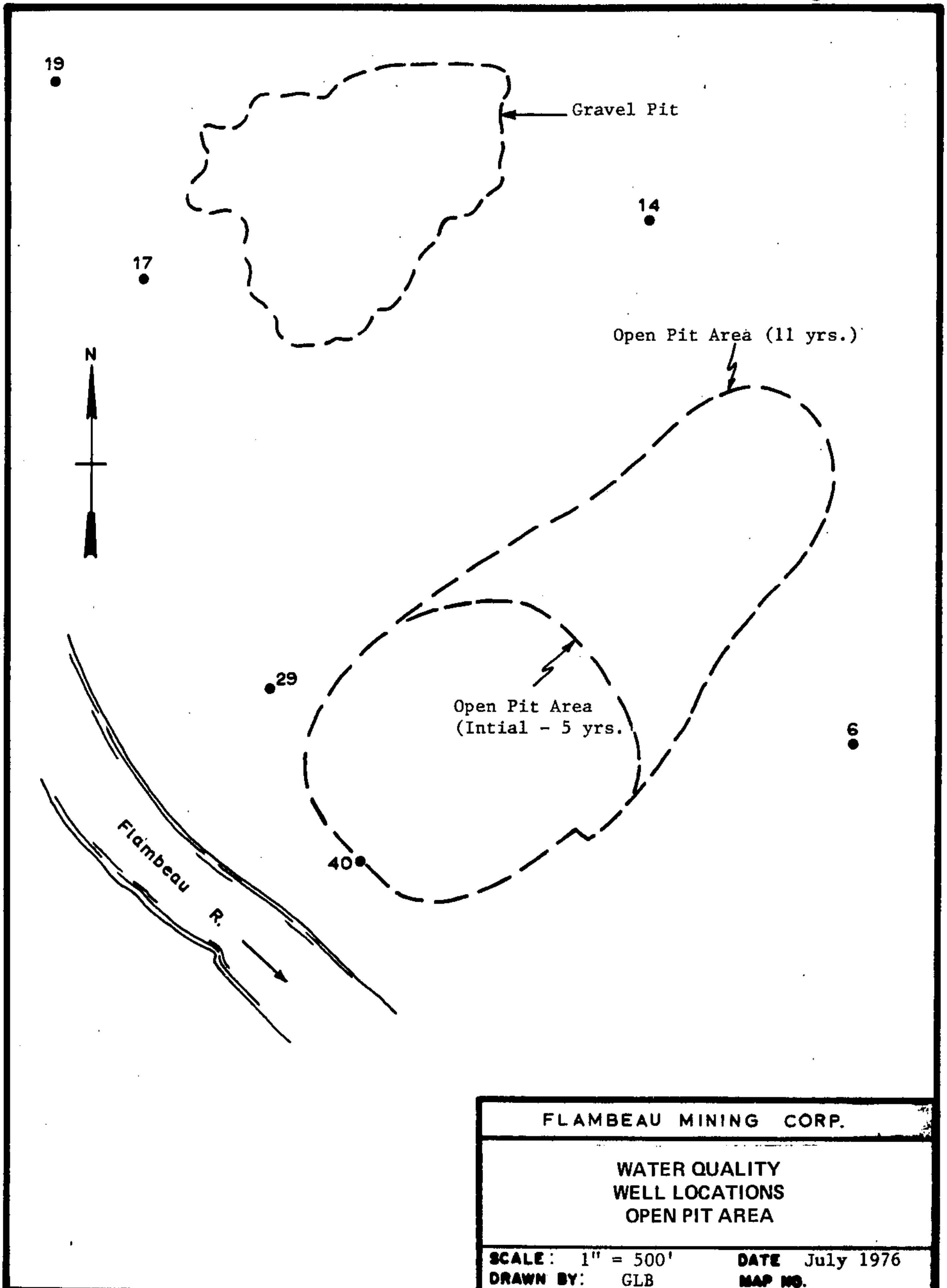
Around the open pit site, key wells will be monitored during operation on a monthly basis. Static water level readings will be taken the last week of each month. Since most local aquifers occur within silt-rich glacial materials on top of bedrock (ledge rock), the groundwater monitoring program will determine the extent of aquifer drawdown resulting from pit excavation. During the first three to five years of pit operation, three sets of wells will be available to supply drawdown data. Circumscribing the ultimate pit perimeter are two-inch-diameter soil test holes which will be monitored before many are lost into the expanding pit. Permanent observation wells located approximately 1,000 feet on either side of the open pit long axis will supply readings throughout the operation. Finally, potable wells at company-owned houses along the north property boundary and more distant monitor wells will be observed as a final check.

The quality of groundwater entering the open pit from the southeast or up hydraulic gradient will be sampled by well 6 on a quarterly basis (Figure 64). Downgradient groundwater will be monitored by wells 14, 17, 19, 29 and 40 on a similar frequency. It would be



5
4
3
RIVER
20
19
18
44
16
14
13
17
45
12
15
11
ST-9-20A
ST-9-21
Orebody
ST-9-22A
ST-9-2
10
43
34
10
9
29
Open
Pit
Area
8
42
6
ST-9-23
ST-9-19A
41
5
DDH-16
35
40
4
ST-9-24
ST-9-26
3
ST-9-25
2
1
W0050
STH 27
17
16
15
FLAMBEAU
W0003
CTH
49A
0049
49
"P"
W0007
W0 051
47
26
48A
50
W0052
W0002
27
48
28
Waste Containment
Area
51
51A
25
52
24
20
21
46A
46
22
W0004
22
23
21
FLAMBEAU MINING CORP.
STATIC WATER LEVEL
WELL LOCATIONS
29
28
SCALE: 1" = 2000'
DATE July 1976
DRAWN BY: GLB
MAP NO.

Figure 64


19
Gravel Pit
14
17
N
Open Pit Area (11 yrs.)
29
Open Pit Area
(Intial - 5 yrs.)
6
Flambeau
R.
40
FLAMBEAU MINING CORP.
WATER QUALITY
WELL LOCATIONS
OPEN PIT AREA
SCALE: 1" = 500'
DATE July 1976
DRAWN BY: GLB
MAP NO.

impractical to sample on a more frequent schedule because (1) groundwater entering the drawdown cone will flow toward the excavation during mining, (2) travel time through the silt-rich glacial materials from the edge of the cone of depression to the monitor wells is slow, being measured in years, and (3) there is no contact between the perched aquifers and the underlying mineralized Precambrian-aged rock because of the virtually impervious saprolite (clay) layer (see Section 1, page 13). Water seeping into the upper pit collection system will be sampled on a monthly basis as it is discharged into the gravel pit settling ponds. Also between the ponds and company-owned houses located on the Flambeau River wells 17 and 19 will be monitored on a quarterly basis.

Any adverse trends detected during discharge to the gravel pit or by monitor wells would result in program re-evaluation and appropriate corrective action. Monitoring of groundwater in and around the lake will continue until the WDNR is satisfied that our reclamation plan is in compliance with state statutes.

5.2.2 GROUNDWATER - WASTE CONTAINMENT AREA

Static groundwater levels around the waste containment area have been recorded since 1971 on a basis similar to the pit area groundwater program. Water levels will continue to be taken on a monthly basis during the last week of each month from wells during waste containment area construction, mine operations and after mine closure (Figure 63).

The quality of groundwater entering the waste containment area from the southeast or up hydraulic gradient will be sampled by well 52. Downgradient groundwater will be monitored by wells 25, 26, 27, 28, and 0049, all on a quarterly basis. Because of the highly impermeable soils in this area, it has been calculated (Table 31) that it will take discharge water considerable time to exit the waste containment area. For this reason, it is impractical to monitor these wells (or drill new wells) at the toe (outside edge) of the dike and sample on a monthly basis during construction. It would however be more logical to install four wells through the dike to the natural soils beneath the waste dike on the outside of the clay core. These points would be monitored on a monthly basis to ascertain whether seepage is present at the base of the dike. Should water be detected, it will be tested monthly for pH and sulfate content. Sulfate generation from pyrite in waste material has been described in Section 3, page 148. An increase in heavy metal ion content can be anticipated provided the pH is sufficiently lowered. Provided sulfate and pH levels remain within the range of baseline data listed on Table 21, then the waste containment system is operating as designed. Nevertheless, a full suite of chemical parameters will be taken once a year as listed on Table 38 from the wells within the waste dike. The purpose of each groundwater monitor well is listed on Table 39.

Care was also taken in the final waste containment site selection to choose an area that contains no private wells down the groundwater gradient.

TABLE 39

GROUNDWATER SAMPLE STATIONS

	Monitor Well	Purpose
Mine Site	6	Upgradient water quality of the open pit
	14	Water quality between the open pit and privately owned homes
	17	Downgradient water quality of gravel pit settling ponds
	19	As 17. Both wells (17, 19) are located between gravel pit and two company-owned houses.
	29	Downgradient water quality of open pit. Chief purpose will be to monitor water after the pit is flooded.
	40	Water quality over the buried mineral vein. Well will be abandoned during pit construction.
Waste Containment Area	25	Downgradient water quality west of waste area and beneath wetlands
	26	Downgradient water quality, northwest toe of waste dike
	27	Downgradient water quality, north center toe of waste dike
	28	Downgradient water quality, northeast toe of waste dike
	52	Upgradient water quality southeast of waste area
	0049	Downgradient water quality north of waste area where flow lines appear to concentrate
	Seep Area	Downgradient water quality as it enters the Flambeau River (seep is approximately 50 feet south of normal highwater mark of the Flambeau River)
	Four dike wells	To detect water and quality thereof within the waste dike

5.3.0 CHEMICAL PARAMETERS AND WATER SAMPLE FREQUENCY SUMMARY

Chemical parameters to be measured are based upon current and projected state and federal requirements. As stated in the above section, sulfate and to a lesser extent pH are the key chemical parameters to be monitored. FMC has designed the proposed mine operation to prevent sulfate generation with concomitant elevation of heavy metal ions into surface and groundwater so as to meet government standards.

The analytical program will be periodically reviewed as the project progresses or as necessitated by government requirements. All surface and groundwater quality results will be submitted to the WDNR upon receipt of verified test results. Surface water samples are taken and will continue to be taken on the second Wednesday of the month under normal operating conditions; groundwater samples are taken the next day.

FMC will continue to water monitor after cessation of mining until the project site has been inspected to determine that reclamation is in accordance with the mining and reclamation plan and that FMC has complied fully with Wisconsin Statute 144.90.

Table 38 shows a complete list of the surface water and groundwater quality monitor stations, sample frequencies, and chemical parameters to be measured. Five of the chemical parameters will be determined for a 12-month period to document background levels around a known massive sulfide deposit before construction begins. Once this general interest data has been gathered for the scientists, FMC will reduce these parameter determinations to an annual frequency. Samples will be taken in October. The chemical parameters are antimony, beryllium, nickel, selenium and thallium.

5.4.0 AIR

During the public hearing held March 4, 1976 in Ladysmith for the Flambeau Mine Environmental Impact Statement, concern was raised regarding lack of baseline air quality and effects of mining on ambient air. Because of the small scale of the proposed mine, design considerations to minimize dust generation, and no instate smelting by FMC, we saw little reason to undertake air monitoring. However, in light of public concern, an air monitoring program will be installed to collect baseline data. The program will be evaluated at the end of three years.

Four high-volume 24-hour continuous air samplers will be installed according to WDNR specifications. In accordance with EPA guidelines, air samples will be collected every sixth day. Mass particulate levels will be determined inhouse on all filters. Selected samples will be analyzed for particulate size distribution, and all samples will be retained throughout the life of the operation.

Gases will not be analyzed since gas generation is insignificant. FMC has checked with powder company officials and found that the following gases and approximate amounts would be generated by 300 pounds (amount in one hole) of explosives (94% ammonium nitrate, 6% diesel fuel) during a normal blast. It is estimated that about six tons of explosives contained within forty holes will be used each week.

Water as steam	2,894 cubic feet
Nitrogen	1,150 cubic feet
Carbon dioxide	450 cubic feet
Hydrogen	32 cubic feet
Carbon monoxide	17 cubic feet

Only during incomplete combustion, which rarely occurs due to improved blasting techniques, would gases such as nitrogen oxides be generated. There are no known methods of collecting such minor amounts of blast-generated gases.

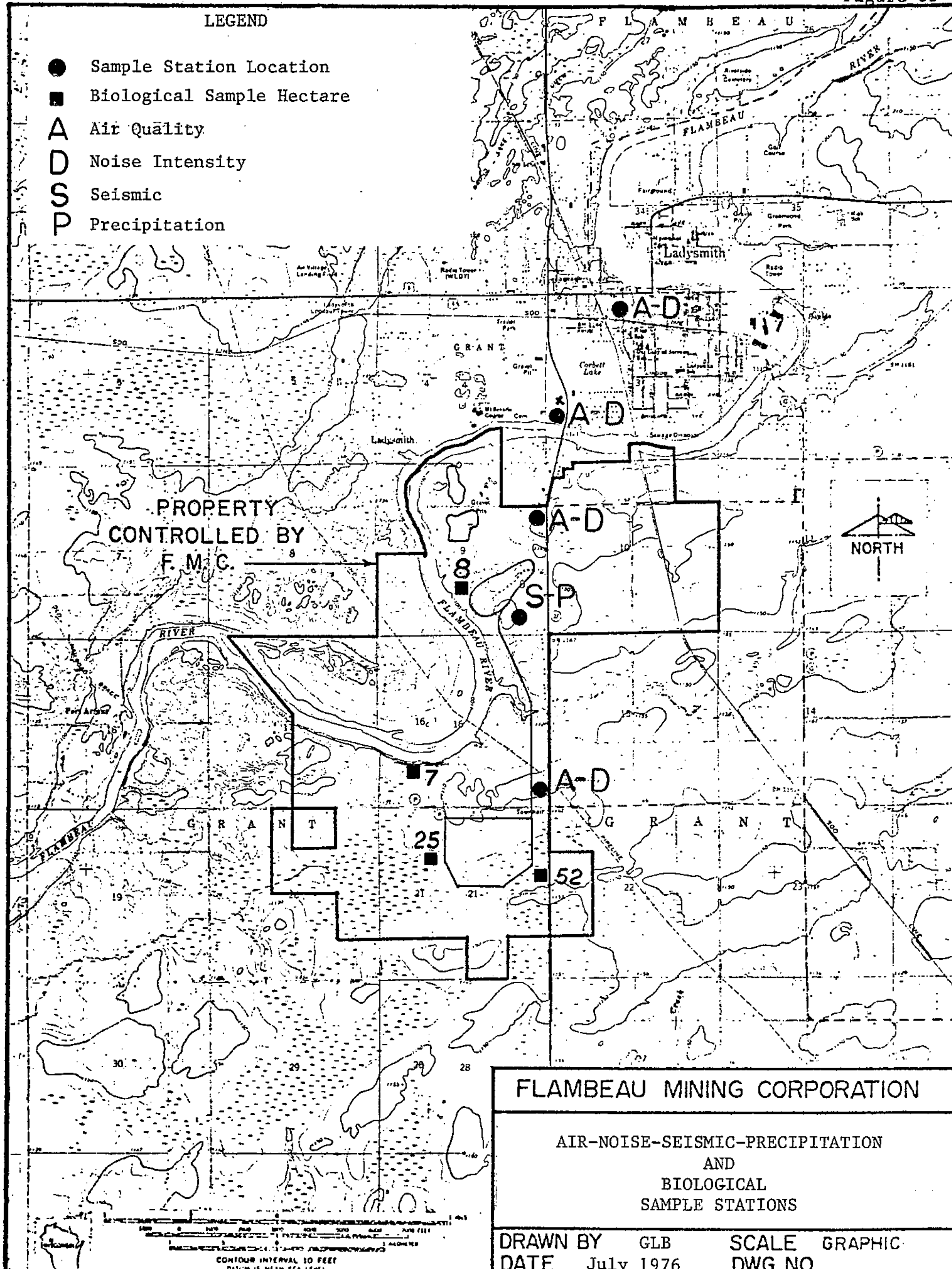
Calculations show that 2.3 pounds of SO_2 per hour would be generated by concentrate drying and 6.4 pounds of SO_2 per hour would be generated from use of oil to fuel the dryer and to heat the process plant buildings. These small releases of gas are in line with other Rusk County heating plants such as the hospital, high school and college. No other sources of SO_2 will result from the process.

Two air samplers will be established on FMC property (Figure 65). One will be located at the northeast corner of the waste containment site and the other northeast of the open pit. Both samplers are located down the prevalent wind direction of active areas (Figure 19). Similarly, two additional samplers will be placed in the City of Ladysmith. The old hospital and City Hall roofs have been selected as prime locations for background ambient air quality measurement.

Additional sampling of sensitive work areas such as loading of broken rock into trucks, crushing of ore within the process plant, etc. will be conducted on a routine basis. Dust suppressant and collection methods are more completely described in our Notice of Intent to Establish an Air Contaminant Source which has been submitted to the WDNR.

5.5.0 NOISE AND SHOCK

The project site and surrounding company land is being and will continue to be managed to minimize sound transmission. Maturing forested areas existing on the project site will be maintained around the ultimate pit perimeter to aid in this objective. It is not expected that noise will be a source of problems. EPA regulations on ambient noise levels will be met with periodic sound level readings recorded throughout all areas of the operation to ensure compliance.


LEGEND
Sample Station Location
Biological Sample Hectare
A Air Quality
D Noise Intensity
S Seismic
P Precipitation
PROPERTY CONTROLLED BY F.M.C.
A-D
S-P
8
7
25
52
FLAMBEAU RIVER
Ladysmith
GRANT
NORTH
CONTOUR INTERVAL 10 FEET
FLAMBEAU MINING CORPORATION
AIR-NOISE-SEISMIC-PRECIPITATION
AND
BIOLOGICAL
SAMPLE STATIONS
DRAWN BY GLB
SCALE GRAPHIC
DATE July 1976
DWG. NO.

The U. S. Bureau of Mines and others in the blasting industry have conducted an extensive investigation on the problem of seismic effects of quarry blasting. Their conclusions are that blasting damage can occur from either air blasts or ground vibration, or a combination of both. They have also recommended procedures which will minimize or eliminate these problems.

The FMC operation will utilize the latest of these blasting techniques which will include a qualified blasting supervisor to design and detonate all blasts. At the start of operations, a series of blasting tests will be conducted to determine the particle velocity propagation law for this open pit operation.

The U. S. Bureau of Mines and others involved in blasting have published articles on damage criteria based on the particle velocity of ground motion in the vicinity of structures. These vibration levels are:

0-2 in/sec	Safe
2-4 in/sec	Caution
4- in/sec	Damage

It is expected that the particle velocity of ground motion for the FMC operation will be much less than 2 in/sec at the closest dwelling.

Open pit blasting noise has not been a problem at any of KCC's operating mines. Most probably this condition results from the nature of copper mineralized material. Unlike the flinty and extremely hard homogeneous taconite that requires heavy blasting to achieve fragmentation, copper ores are relatively soft and generally intensively fractured in place. Standard practice in the non-ferrous industry involves light blasting that literally only shakes the material by lifting it a few feet and setting it down in place. Very little throw or displacement is ever encountered.

Ground vibration control is a function of (1) distance and (2) charge size per delay interval. The second is controllable and is accounted for in the blasting design. The first is not controllable but due to the distance (1,490 feet) to the closest dwelling, this should not be a factor. In addition, transmission of ground vibration is less likely to occur than air vibration. Geologic investigations in the open pit area show that rock units strike in a northeast direction. Thus, if ground vibration were to be transmitted any appreciable distance, it would be along the length of the rock units. For this reason, FMC purchased land east across State Highway 27 to control land along strike of the deposit. Additional land was purchased to the northeast of the open pit which, because it supports a healthy mature stand of hardwood forest, will further reduce transmission of noise from the pit-process plant toward the hospital.

Air blast control is a function of atmospheric conditions and blasting technique. Temperature variations in the atmosphere are the most important of the atmospheric conditions to be considered in determining the timing of the blast. Other conditions which will be considered before detonation are cloud cover and wind velocity and direction.

The blasting technique will include blast-hole stemming to confine the expanding gas pressures and the use of covered detonating fuse or electric caps which detonate the charge. Again, the distance to the closest dwelling is great enough that the impact will be minimal.

In conclusion, noise will be monitored on a regular basis throughout all areas of the operation. Air blast and ground vibrations will also be monitored onsite until the optimum blasting procedure is established.

5.6.0 BIOLOGICAL SAMPLING

The Flambeau River ecosystem is a priority item for monitoring. Previous studies (as reported in the WDNR Environmental Impact Statement, February 1976) have established pre-existing levels of metals in the fish and benthos of the river which are relatively high. FMC proposes to monitor game fish species annually and fingernail clams semiannually for the heavy metals listed in Tables 25 and 26. The rationale for these two selections is:

1. Game fish, particularly the walleyed pike, are the only likely pathway of metals from the river to the human diet. The Flambeau River is known to be considerably contaminated with mercury, copper and zinc as background. It is important that FMC and others maintain a vigilent study of the levels of these metals in the Flambeau's game fish. Twenty fish will be sampled annually at WDNR direction.

2. Fingernail clams are especially effective bioconcentrators of bivalent cations (e.g., calcium, strontium, zinc). Since a number of these heavy metals are of concern to this project, the clams will act as an early indicator to potential changes in the ecosystem. These will be sampled semiannually at surface water stations 5, 6, 7 and 9 on the Flambeau River (Figure 61).

Water enters the Flambeau River from runoff plus groundwater discharge. Surface and groundwater monitoring will show whether the mine makes any significant pollutant inputs through these routes. However, much more sensitive indicators of mining impact are present on the site other than gross water concentrations of metals. These include living bioconcentrators and geoconcentrators of mineral soils and organic peats. In the first instance, living organisms collect metals via concentration, while the non-living support soils and peats act as effective cation adsorbers or exchangers. Environmental Impact Statement studies have established the background levels of metals in certain tree species, peats and soils.

FMC proposes to focus these studies on four one-hectare areas co-sited with surface and groundwater monitor sites (Figure 61) as previously indicated. Hectare numbers correspond to the numbers of wells enclosed within the study area.

1. From the riparian vegetation hectare 8 near the mine site, samples of leaves and twigs, whole seedlings of hemlock, white birch and sugar maple, and humified soils will be taken annually. The effects of lowering groundwater between the open pit and the Flambeau River on existing trees will also be monitored in hectare 8. All soil cores will be retained onsite throughout the life of the operation.

2. From the two waste containment area hectares (25 and 52), samples of leaves and twigs from tag alder and red osier plus cores of peats will be taken annually.

3. From the hectare established at the seeps near surface sample station 7 (the seeps to be monitored as a groundwater station), tap-rooted composites (e.g., thistle), alfalfa and other forage plants will be sampled plus humified soils will be taken semiannually.

4. A peat sampling station will be monitored up and down the groundwater gradient of the waste containment area in the same watershed in order to obtain adequate background and control data. The upgradient station will be west of the culvert which carries the intermittent stream beneath State Highway 27 into Section 21 (Figure 62). The downgradient sample will be collected in hectare 25 (Figure 61).

Onsite studies of dominant plants have documented that the species mentioned above have concentrated metals near the orebody. Also, soils are known to contain elevated metal values above the orebody in the humified layers. KCC research laboratories have documented that the peats downgradient of the waste containment area are effective adsorbers of heavy metals. FMC believes that while analysis of the water samples may demonstrate (1) major leakage from the waste containment area or (2) improvement in the lowering of metals flux at the mine site as the ore is removed from that biological system, the biological-soils-peat components of these systems are far more likely to demonstrate bioconcentration or exchange of the very low levels of contamination that are possible from minimal seepage. Thus, this type of ecosystem monitoring should provide a far more sensitive and accurate gauge of the impact of metal releases from this project than the traditional water sampling will provide.

5.7.0 PERSONS LEGALLY AND OPERATIONALLY RESPONSIBLE FOR LONG-TERM MAINTENANCE

Persons legally and operationally responsible for the long-term maintenance of the Flambeau project are as follows:

Edwarde R. May
Acting Project Manager
Flambeau Mining Corporation
P. O. Box 194
Ladysmith, Wisconsin 54848

Robert W. Shilling
New Mines Development Manager
Kennecott Copper Corporation
Metal Mining Division
Kennecott Building
Salt Lake City, Utah 84111

These names will remain in effect until a general manager is appointed for the Flambeau project.

5.8.0 MEASURES FOR NOTIFYING THE PUBLIC

If at any time during the course of the construction, operation or post-operation phases of the project the company detects a potentially hazardous condition, FMC will immediately contact:

The WDNR regional office at Spooner, Wisconsin

The Rusk County Board Chairman or his appointed designee