FM 12

Report

Fall 1996 Backfilling Plan for Stockpiled Type II Material

Scope ID: 96F013

Flambeau Mining Company
Ladysmith, Wisconsin

October 1996

ROUTING & REQUEST

Please...
- ☐ Read
- ☐ Handle
- ☐ Approve

And...
- ☐ Forward
- ☐ Return
- ☐ Keep or Toss
- ☐ Review with Me

To:

From:

Date:

Foth & Van Dyke

engineers · architects · scientists

Foth & Van Dyke
engineers · architects · scientists

October 8, 1996

Mr. Lawrence J. Lynch
Mine Reclamation Section
Bureau of Waste Management
Wisconsin Department of Natural Resources
101 South Webster Street, GEF II
Madison, WI 53707

Dear Mr. Lynch:

Re: Flambeau Mining Company - Fall 1996 Backfilling Plan for Stockpiled Type II Material

On behalf of Flambeau Mining Company (Flambeau), Foth & Van Dyke is submitting three copies of the enclosed report titled *Fall 1996 Backfilling Plan for Stockpiled Type II Material.* The report provides detailed information regarding procedures to be used by Flambeau in the fall of 1996 to begin pit backfilling using material from the Type II stockpile. Included with this information are details regarding the limestone addition rate to be used this fall, and procedures for limestone addition.

Flambeau's plan is to commence backfilling using stored Type II material in mid-October and to continue work until the weather conditions preclude further backfilling (estimated to be late November 1996). During this period, Flambeau expects to backfill between 100,000 to 150,000 tons or more of stored Type II material. Limited backfilling with stored Type II material this fall will provide valuable information that will be used by Flambeau over the winter to finalize preparations for the major backfilling event planned for 1997.

If you have any comments or questions regarding this submittal, please contact us at (414) 197-2500.

Sincerely,

Foth & Van Dyke

James B. Hutchison, P.E.
Project Engineer

Jerry W. Sevick, P.E.
Vice President

JBH1:JWS:mld2

MLD2\96F013\GBAPP\38439\10000

In early September 1996, following Wisconsin Department of Natural Resources approval, Flambeau Mining Company (Flambeau) began the process of backfilling its mined out open pit by relocating freshly mined Type II material from the west end to the east end of its open pit. Flambeau is now finalizing preparations for the next phase of the backfilling process, which is scheduled to begin in mid-October 1996 and continue until weather conditions preclude achieving desired compaction, which typically occurs in late November. This document describes Flambeau's plans for backfilling stockpiled Type II material during the fall of 1996.

The fall of 1996 backfilling plan involves the relocation of between 100,000 and 150,000 tons of stockpiled Type II material to the mined out open pit. The backfill material will be placed in approximate 3-ft lifts and compacted. Backfilling of Type II material, both fresh and stored, includes the application of alkali, in the form of limestone, to the backfilled material. Testing has been completed to determine the rate of limestone application required to neutralize stored acidity and control metals release from stockpiled Type II material. Oxygen transport modeling has been completed to determine the limestone application rate required to control acidity generated as a result of further oxidation during the backfilling and groundwater recovery periods. As a result of this testing and the modeling, it was determined that a limestone addition rate of 17.2 lb per ton of stockpiled Type II material placed would be appropriate for fall of 1996 backfilling.

This limestone addition rate represents a conservative calculation methodology which is weighted heavily on surface or near surface samples and the <¼-in size fraction. Tests have shown that these sample segments contain more stored oxidation products than Type II materials located at depth in the stockpile.

As part of this testing work, a series of confirmation tests were completed to establish that limestone would perform as expected. In addition, data from the testing was used to model the estimated long-term pore water quality in the backfilled open pit after groundwater recovery. The results obtained from the confirmation testing and the geochemical model compared very well. Finally, the 1996 predicted pore water quality was compared to predictions included in the project's 1989 Mine Permit Application. This comparison, shown below, shows that the two predictions are consistent.

Predicted Pore Water Quality (mg/L)

Parameter	1989 Prediction[1]	1996 Prediction
Copper	0.014	<0.01
Iron	0.32	<1.5
Manganese	0.52	<1.7
Sulfate	1,360	<1,000

[1]From *Mine Permit Application*, Foth & Van Dyke, Revised December 1989.

Data obtained from the fall of 1996 backfilling activities, and additional testing to be completed during the fall and winter of 1996/97, will provide information to optimize procedures for backfilling the major portion of the stockpiled Type II material in 1997.

Fall 1996 Backfilling Plan for Stockpiled Type II Material
Flambeau Project

Contents

Tables

Page

Figures

Appendices

1 Introduction

As part of its approved 1989 Mine Permit Application (MPA), Flambeau Mining Company (Flambeau) detailed its plan to backfill stored waste rock and overburden into the mined out Flambeau open pit as part of the Flambeau Project's overall reclamation plan. The pit backfilling process actually commenced in early September 1996 following Wisconsin Department of Natural Resources (WDNR) approval. This backfilling involves the relocation of mined Type II fresh waste rock generated in the west end of the pit to the east end of the pit. As part of the process, alkali in the form of limestone is added to the relocated material, which is placed in approximate 3-ft lifts and compacted.

The next phase of the backfilling process is to involve the relocation, in the fall of 1996, of between 100,000 to 150,000 tons or more of Type II material from the Type II stockpile to the east end of the pit. It is desirable to complete the backfilling of this material to assist in the optimization of the procedures to be used in 1997 when approximately 4,500,000 tons of Type II material will be backfilled.

To prepare for backfilling of stockpiled Type II material in the fall of 1996, Flambeau has completed oxygen modeling and field and laboratory testing to specify the form of alkali to be added to the backfilled Type II material and to establish the proper dosage rate. The purpose of this report is to document Flambeau's plan for backfilling stockpiled Type II material in the fall of 1996.

Section 2 of this report provides background information regarding the planned fall of 1996 backfilling work. Section 3 contains a detailed discussion of the plan. Section 4 describes testing work completed to date. Interpretation of the collected data is presented in Section 5. To support 1997 backfilling, Flambeau will collect additional data. An overview of the planned data collection process is described in Section 6.

In addition to Flambeau itself, numerous other parties were involved in the planning and development of the backfilling program described in this report. Foth & Van Dyke was primarily responsible for planning the work, coordination of activities, development of material handling methods, and report development. Steffen, Robertson, and Kirsten, Inc., of Vancouver, British Columbia, provided input into the development of material handling methods and the selection of the alkali material to be used for neutralization; oxygen modeling work; developing procedures for carbonate availability, sequential extraction and confirmation testing; the majority of the data interpretation; and the development of the framework for additional data collection. Thresher & Son, Inc., was primarily responsible for the development of the field sample collection program; the completion of paste pH and lime neutralization testing and data interpretation regarding these tests. Paste pH testing was performed by Thresher & Son, Inc., and Flambeau personnel in Flambeau's on-site laboratory. Carbonate availability testing, the sequential extractions, and confirmation extractions were completed by Thresher & Son, Inc., at Foth & Van Dyke's Green Bay offices. Analytical laboratory work was performed by Northern Lake Service, Inc., Crandon, Wisconsin.

2 Background

2.1 Approved Backfilling Process

Section 5.0 of the project's approved MPA provides a detailed discussion of the planned open-pit backfilling process. Briefly, backfilling is to be conducted through the replacement of material excavated from the pit. Type II material is to be backfilled first. Type I waste rock is to be backfilled on top of Type II material, followed by saprolite, sandstone, and till, in that order. Backfilled material, with the exception of saprolite, is to be placed in approximate 3-ft lifts and compacted. Saprolite is to be placed in approximate 1-ft lifts and compacted. In addition to the sequence of material placement, alkali in the form of a lime slurry was specified in the MPA to be added to Type II material in sufficient quantity to raise the pH of the water in the backfilled Type II material to approximately 6.5 su. As discussed in the August 1996 ***Resident Project Representative Manual*** (RPRM) and in this report, with the exception of the substitution of limestone for hydrated lime as the alkali addition, Flambeau's current backfilling concept is substantially the same as that which was approved in the 1989 MPA.

2.2 Backfill Planning

Flambeau began making preparations for the commencement of the backfilling of Type II material in February 1996. The preparation work, consisting of the following activities, was undertaken with the intent of completing backfilling in accordance with the approaches and concepts contained in the approved MPA.

- Verifying material balances and evaluating final reclamation plans.
- Completing Type II compaction and permeability testing.
- Evaluating pH and acidity characteristics of the material in the Type II stockpile.
- Verifying the neutralizing agent and finalizing the application method.
- Establishing final excavation and loading methods at the Type II stockpile.
- Establishing final backfilling methods and equipment needs.

Throughout the planning process, Flambeau has maintained contact with the WDNR and has submitted the results of its work in the form of reports or other communications. For instance, separate reports have been prepared and submitted relating to Type II material compaction and permeability testing. Limestone application methods, backfilling methods and equipment, and excavation and loading methods at the Type II stockpile were all specified in the RPRM which was previously submitted to WDNR. The evaluation of the pH characteristics of the material in the Type II stockpile is presented in this report. Preliminary work which has been completed regarding the backfill material balance and final reclamation plans has been discussed with WDNR. Additional work in this area is planned and will be forwarded to the agency when completed. Overall, Flambeau has completed a substantial amount of work in support of its Type II backfilling plans.

2.3 Type II Material

The backfilling of Type II material involves the handling of both fresh waste rock not removed from the pit and waste rock stored in the Type II material stockpile. Since early September 1996, the majority of mined fresh Type II waste rock has not been removed from the pit. This material has been generated in the west end of the pit where mining will continue until late first quarter 1997. Upon excavation, the Type II waste rock is hauled to the east end of the pit, where mining has ceased, and is deposited, spread, and compacted in-place. The majority of the additional fresh Type II waste rock that will continue to be generated until mining ceases will be backfilled in this manner. Small amounts of fresh waste rock may on occasion be hauled to the Type II material stockpile. The total amount of fresh waste rock to be backfilled directly is estimated to range from 70,000 to 100,000 tons.

Over the life of the mine, approximately 4,500,000 tons of Type II material has been stored on the Type II stockpile. During backfilling, all of this material will be relocated from the Type II stockpile to the lower portions of the mined out open pit.

2.4 Limestone Application Rate

As part of the backfilling of Type II material, alkali in the form of limestone will be added to both the fresh and stored material to control pH and subsequent metals release. In the case of fresh waste rock, the limestone need is defined by the pyrite oxidation that will take place during the backfilling period and the period before resaturation due to groundwater recovery. For the stored Type II material, limestone needs are defined by the stored acidity generated while the material was exposed on the stockpile, and the acidity that will be generated during backfilling and before resaturation.

As outlined in this report, Flambeau has used the following two methods to determine the applicable limestone addition rates for Type II backfilling.

- The first involves the completion of oxygen transport modeling to define the amount of oxidation that will take place at depth during backfilling and prior to reflooding.
- The second method involves determining the distribution of pH and stored acidity in the stockpiled material, establishing a limestone addition rate based on this data, and verifying that the addition rate will result in the control of pH conditions and metals release in the backfilled pit.

For the fresh waste rock backfilling that started in early September 1996, Flambeau opted to use a conservative limestone addition rate of 4 lb per ton. As described in more detail in Section 3.2 below, using the results from the oxygen modeling work, Flambeau proposes to amend the limestone addition rate for future fresh waste rock backfilling to 1.1 lb per ton. For the stored Type II material, the limestone application rate required to account for oxidation during the backfilling and the groundwater recovery periods would range from 1.1 to 3.9 lb per ton from the bottom to the top of the backfilled Type II material, respectively.

Based on the work completed to date, Flambeau expects that the overall limestone addition rate for stored acidity for all Type II material would average approximately 16.1 lb per ton. As discussed in Section 4.2 of this report, the limestone demand for the stored acidity in the Type II stockpile is expected to vary, so that the use of a variable limestone application rate is under consideration. The low end of the variable range is expected to apply to material that has been on the stockpile the least amount of time or which is located at depth within the stockpile. Material located at the extreme outer edges has been near the surface for a long period of time and is expected to require the most limestone. It is Flambeau's intent to collect additional information in the fall and winter of 1996 to develop a plan that will consist of the application of varied limestone quantities as dictated by the needs of the Type II material as it is excavated. The process of additional data collection and analysis will allow Flambeau to optimize the limestone application rate for the major backfilling work to be done in 1997. As discussed in Section 6 of this report, Flambeau intends to prepare a work plan for this data collection phase and provide it to WDNR.

In the fall of 1996, Flambeau plans to backfill 100,000 to 150,000 tons or more of stored Type II material. There is currently approximately 4,500,000 plus tons in the Type II stockpile. As also described later in this report, sufficient information has been collected to establish a conservative fixed limestone application rate for the planned fall of 1996 backfilling. Flambeau feels it is very important to complete a minor amount of backfilling of stored Type II material in 1996 as part of the process of preparing for the major backfilling work to be done in 1997. Backfilling a minor amount of stored material in 1996 will allow Flambeau to optimize:

- Limestone application methods;
- Excavation and hauling methods;
- Spreading and compaction methods; and
- Methods to provide quality control during backfilling.

In addition, the fall of 1996 work will allow Flambeau to clearly define 1997 manpower needs and to provide data on in-place densities which is needed to complete the assessment of the overall site material balance. The data collected in the fall of 1996 will be used over the winter to optimize plans for 1997 when the major site backfilling activities will occur.

3 Fall of 1996 Stockpiled Type II Material Backfill Plan

In the fall of 1996, Flambeau plans to excavate, transport, and backfill in the east end of its open pit 100,000 to 150,000 tons or more of the stockpiled Type II material. Material movement and backfilling is estimated to occur during the period from mid-October until weather conditions preclude achieving desired compaction, which typically occurs in late November in the Ladysmith area. The approximate location of the stockpiled material to be moved is shown in Figure 3-1.

3.1 Material Handling Methods

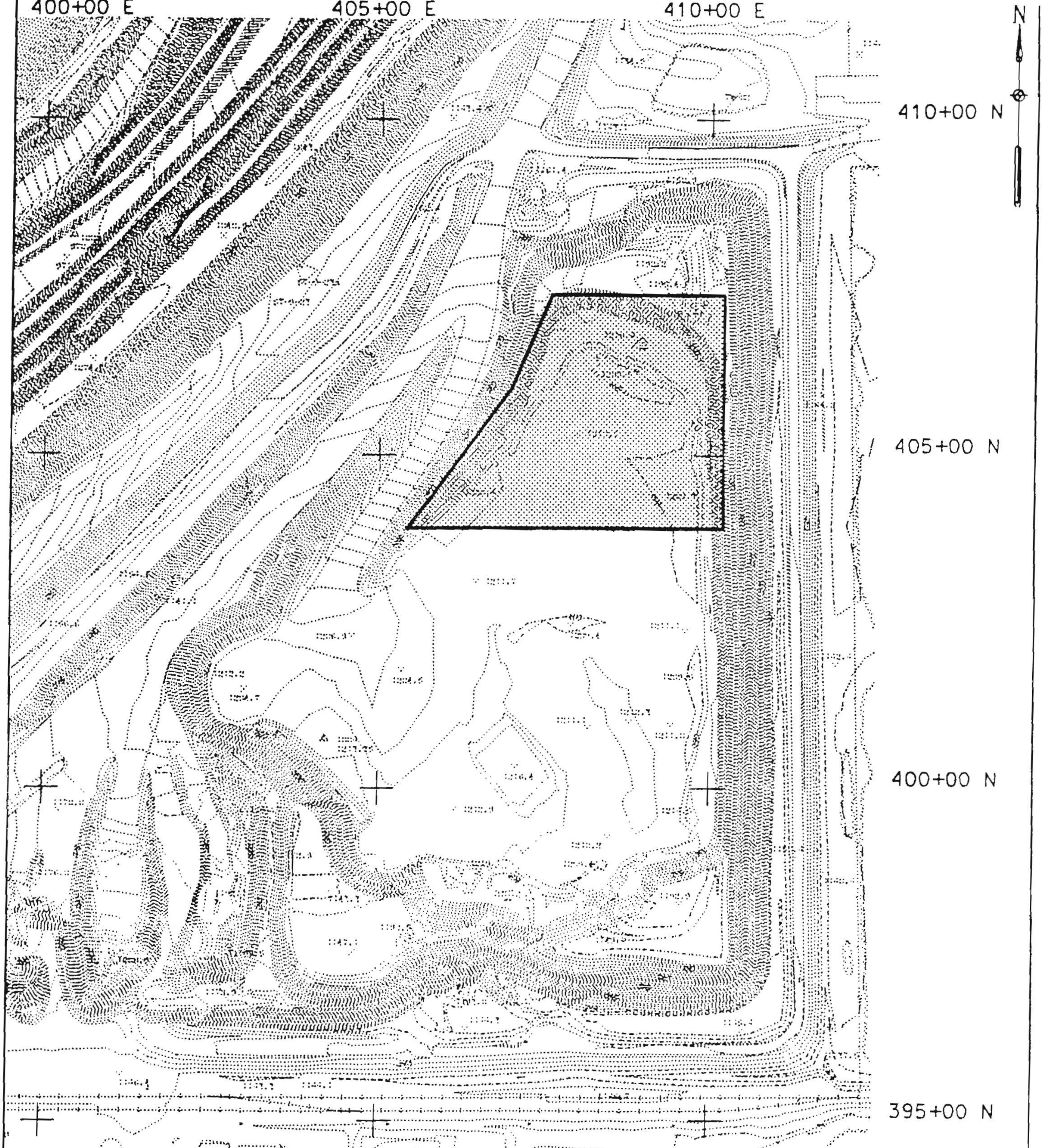
Material handling methods will be the same as those outlined in Section 3 of the August 1996 RPRM, with the exception of the limestone application rate. Briefly, Type II material will be excavated by a backhoe or front end loader in a 15-ft lift across the approximate area shown in Figure 3-1. Unit volumes within the area outlined in Figure 4-1 will be established on a regular basis for excavation purposes. Prior to excavation, the limestone quantity calculated to meet the limestone demand will be evenly spread over the unit area. The excavated material will be transported via the site haul road to the east end of the open pit using on-site haul equipment and unloaded in the area designated to receive backfill. The material will be spread evenly across the area in an approximate 3-ft lift, with an upper limit of 3-ft, 4-in. Compaction will be initially accomplished by a dozer during material spreading, then by either a fully loaded 50-ton haul truck, a Bomag BW213D-2(2A) sheepsfoot vibratory compactor, a Caterpillar 815 static compactor, or equivalent. Data as outlined in the RPRM will be collected by the resident project representative for each lift to verify that project acceptance criteria have been achieved. It is not anticipated that clarifier underflow solids will be encountered in the area designated in Figure 3-1. If such materials are encountered, they will be relocated to another area of the stockpile for backfilling in 1997.

3.2 Limestone Application Rate

The characteristics of the limestone to be applied during the backfilling of stored Type II material is specified in Section 3.1.2 of the RPRM. The planned limestone application rate will consist of two components. The first is the amount of limestone needed to neutralize oxidation products that are currently stored in the stockpiled Type II material. Based on the results of the test work completed to date, a conservative limestone addition rate of 16.1 lb per ton for this component has been established for the fall of 1996 backfilling of stored material. This topic is discussed at length in Section 5 of this report. The 1997 rate, which will be developed after completion of the additional data collection work described in Section 6 of this report, is expected to vary based on the variability of the stored oxidation products in the Type II material stockpile.

The second component of limestone addition has been defined by the recently completed oxygen transport modeling for the backfilled pit. This work is outlined in the October 1996 report titled *Oxygen Transport and Related Alkalinity Requirements - Flambeau Mine Pit Backfill*, which is provided in Appendix A. The objective of the oxygen transport modeling was to estimate the oxidation rates and alkalinity requirements associated with the backfilling and groundwater recovery periods. The major conclusions of this work are:

- The restriction of oxygen transport will limit the rate of acid generation, and hence the requirement for alkalinity addition, in the backfilled pit.



FLAMBEAU MINING COMPANY		
FIGURE 3-1 PLANNED 1996 TYPE II MATERIAL EXCAVATION FOR BACKFILLING		
Scale: 1" = 200'	Date: SEPTEMBER, 1996	
Prepared By: Foth & Van Dyke		By: GAM

C:\cadwork\5f28f2.dgn

95F028

- The planned till cover will further restrict the access of oxygen to the underlying waste rock, and may result in substantial decreases in the required alkalinity addition.

- Oxygen transport calculations indicate that a maximum of approximately 3.5 lb per ton of available alkalinity will be required to neutralize oxidation products generated during backfilling and reflooding. During reflooding, oxygen transport will be limited to the upper 30 to 60 ft of reactive waste rock. The maximum alkalinity addition will be required only in the upper few feet of this layer.

- During the groundwater recovery period, oxygen will not reach the more deeply buried waste rock, and lesser amounts of alkalinity will be required in lower levels of the pit backfill. A minimum application rate of approximately 1 lb per ton of available alkalinity should be adequate to neutralize oxidation products that will form during backfilling and reflooding of the lowermost waste rock.

In order to establish the limestone application rate using the results from the oxygen transport modeling work, two adjustment factors need to be applied. The first relates to the carbonate availability of the limestone to be used. The second involves the moisture content of the limestone. In Section 3.1.2 of the RPRM, a carbonate availability of 95% has been specified for the limestone. The moisture content of the limestone to be used has been shown to range from 4 to 6%. Using a minimum calcium carbonate availability of 95% and average moisture of 5%, the final limestone addition rate based on the oxygen modeling work is 1.1 to 3.9 lb per ton, depending on the depth within the pit that Type II material is placed.

Figure 4.1 of the oxygen modeling report clearly shows that the alkali availability requirement due to oxidation during backfilling and prior to groundwater recovery drops below 1 lb per ton at depths below 50 ft from the ground surface. Given that backfilling in the fall of 1996 will be substantially below the 50-ft threshold, Flambeau proposes to use an amended rate of 1.1 lb per ton. Rates to be used for 1997 application will be established at a later date.

The overall limestone addition rate for the fall 1996 stockpiled Type II material can be calculated as shown in Table 3-1.

Table 3-1

Limestone Addition Rate

Component	Limestone Addition Rate[1]
Stored Acidity	16.1 lb per ton
Acidity Generated During Backfilling and Prior to Groundwater Recovery	1.1 lb per ton
Total	17.2 lb per ton

[1]Corrected for carbonate availability and moisture content.

In keeping with the results of the oxygen transport modeling work, Flambeau proposes to amend the limestone addition rate for fresh waste rock to 1.1 lb per ton.

3.3 Resident Project Representative Manual

As noted, with the exception of the limestone addition rate, the August 1996 RPRM contains all the information needed to support the successful backfilling of stored Type II material in the fall of 1996. To assist in the implementation of this work, the RPRM has been updated (Appendix B) to reflect the limestone application rates to be used for stored Type II material and the amended rate for fresh Type II waste rock. The updates to the manual are highlighted to assist the reader.

In addition to the updates relating to limestone addition rates, Section 3.1.1.1 of the manual has been updated to reflect a minor field change made in September 1996, with WDNR input, pertaining to limestone application during backfilling of fresh waste rock. Also, an updated version of the limestone application observation report is in use at the site, an example of which is included in the updated RPRM contained in Appendix B.

4 Stockpiled Type II Material Testing

Flambeau has conducted an investigation of the stockpiled Type II material which has consisted of: 1) testing material samples collected during the completion of three borings within the central part of the Type II stockpile; 2) performing a preliminary screening of Type II material for its stored acidity and using this test to determine the alkali addition required to neutralize the stored acidity within the material during backfilling; 3) performing a preliminary screening of surficial Type II materials for other stored oxidation products; 4) determining the effect of the neutralization of stored acidity upon the potential release of other stored oxidation products; 5) performing sequential extractions of stored oxidation products; 6) the determination of the alkali availability of the limestone materials selected for neutralization of acidity; and 7) a confirmation test of Type II material to determine that the method of alkali addition will lead to an acceptable pore water quality within the backfilled Type II material. Each component of the investigation was dependent on the information and conclusions drawn from the previous components. A description of each component follows. The interpretation of the results from the testing is presented in Section 5.

4.1 Borings

4.1.1 Objective

The objective of this test was to determine the pH and moisture content of Type II materials from within the Type II stockpile.

4.1.2 Methods

Three borings 50 to 60 ft deep were completed within the central portion of the Type II stockpile in the first quarter of 1996. Type II material samples were recovered on 5-ft intervals using reverse air techniques. The individual intervals were composited and analyzed for pH (1:1 with DI water) and their field moisture contents.

4.1.3 Results

The results of the analyses performed on the collected material are presented in Table 4-1 and show that the pH in the central portion of the stockpile is near neutral. The near neutral pH values measured in the samples mirror the pH values measured in the basal drainage from the stockpile (see Figure 1 of Appendix C).

4.2 Paste pH and Lime Neutralization Tests

4.2.1 Objective

The first objective of this test was to determine the paste pH and the second objective was to determine the stored acidity of the fine (<¼-in) fraction of the stockpiled Type II material.

Table 4-1

Analyses of Material Samples Recovered During the Flambeau Type II Stockpile Boring Program

Sample No.	Sample Interval (ft)	Material pH (su)	Field Moisture (%)
8-1	0-5	5.19	5.26
8-2	5-10	5.53	4.61
8-3	10-15	5.25	4.90
8-4	15-20	5.29	3.55
8-5	20-25	5.05	3.04
8-6	25-30	5.35	2.42
8-7	30-35	5.69	4.51
8-8	35-40	5.76	3.40
8-9	40-45	5.91	4.91
8-10	45-50	5.34	4.56
8-11	50-55(±)	5.50	5.14
9-1	0-5	5.18	3.80
9-2	5-10	7.06	6.40
9-3	10-15	6.28	3.62
9-4	15-20	6.44	4.69
9-5	20-25	6.74	5.98
9-6	25-30	5.77	5.65
9-7	30-35	5.58	4.71
9-8	35-40	5.67	4.09
9-9	40-45	5.24	3.28
9-10	45-50	7.46	6.98
9-11	50-55	7.38	6.33
9-12	55-60(±)	7.33	5.32
10-1	0-5	6.66	7.72
10-2	5-10	6.72	6.01
10-3	10-15	6.46	5.09

Table 4-1 *(Continued)*

Sample No.	Sample Interval (ft)	Material pH (su)	Field Moisture (%)
10-4	15-20	5.82	5.09
10-5	20-25	5.21	4.54
10-6	25-30	5.23	5.56
10-7	30-35	5.51	4.06
10-8	35-40	9.58	4.22
10-9	40-45	7.03	6.08
10-10	45-50	5.68	5.11
10-11	50-55	7.56	8.92
10-12	55-60(±)	6.87	6.65
Averages		6.12	5.04

4.2.2 Methods

In June and July 1996, samples of Type II materials were collected at 17 sites from the surface of the stockpile at locations shown on Figure 4-1. Additional samples were collected at depths of about 3 and 10 ft using a backhoe. The samples are identified by location and depth as follows: the first number in the sample identification is the sample location. The second number, separated from the first by a dash, is the sample depth. For those cases where no second number is listed, only one sample was collected at the surface.

The samples were sieved in the field to separate the <¼-in fraction from the total sample for laboratory analysis. As shown in Section 4.3, the <¼-in fraction is more reactive and contains more stored oxidation products than the coarser portion of the materials. Paste pH tests were conducted on all of the <¼-in fraction samples to determine the extractable stored acidity. The paste pH tests were conducted on moist material samples that were equilibrated with deionized water, site groundwater (from monitoring well MW-1005P) and site groundwater containing variable quantities of hydrated lime.

Equilibration with the lime suspensions was used to determine the acidity of the materials. Lime suspensions were used rather than solid limestone because lime suspensions were expected to react with the Type II materials very rapidly thus providing information sooner than limestone. pH measurements were conducted approximately every 2 hr for a period of 24 hr to determine the kinetics of pH and acidity reactions with the equilibrating waters for approximately two-thirds of the samples.

4.2.3 Results

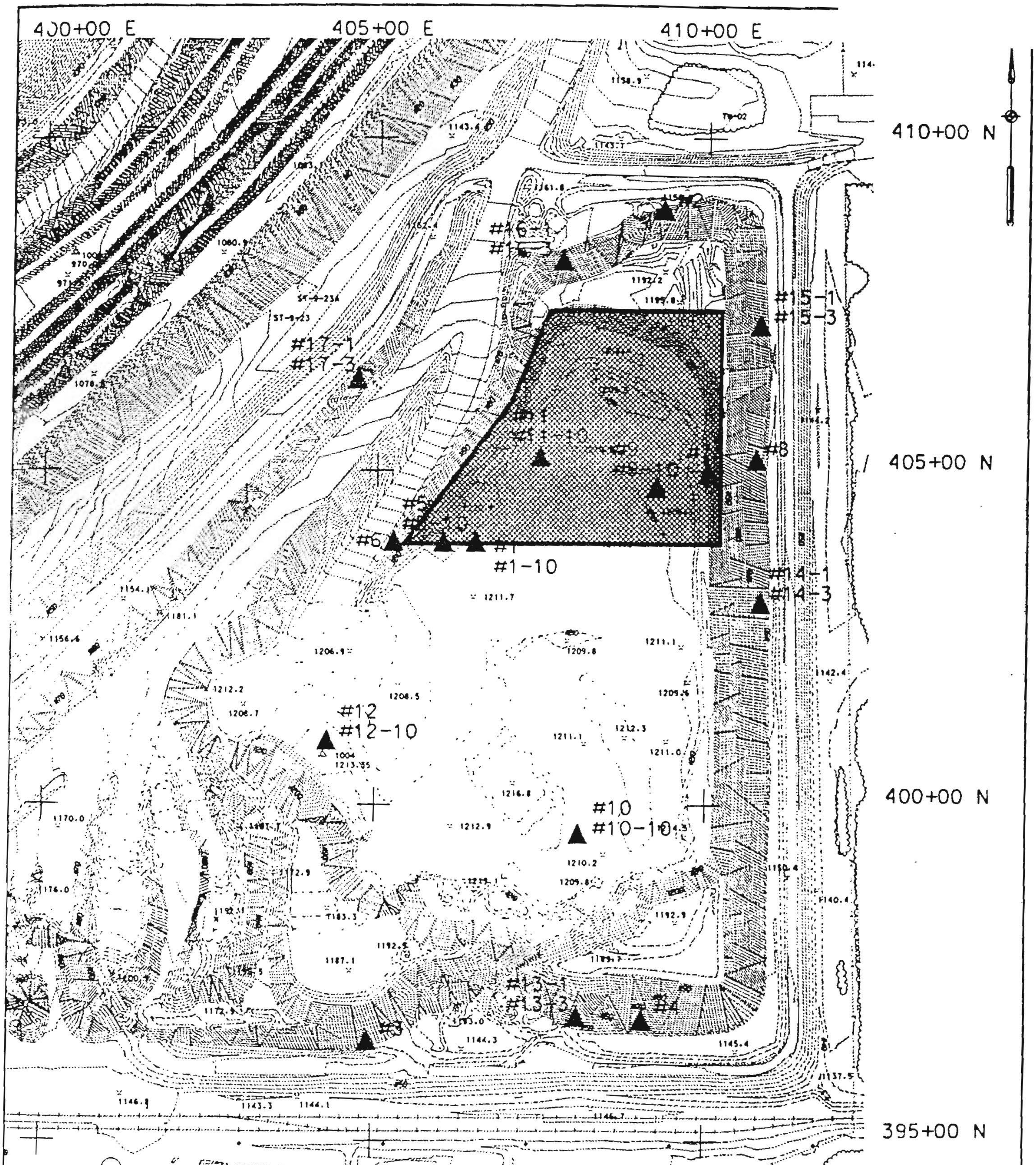
The results of the paste pH kinetic tests showed that the stored acidity reacts completely with the equilibrating water within the first 1 to 2 hr of testing. Therefore testing of these materials for their paste pH value can be conducted rapidly rather than over a long equilibration period. Paste pH determinations were conducted on the remaining samples using a 1 to 2-hr equilibration period.

The relevant portion of the lime neutralization test results for each sample graphically relating paste pH values to lime addition are shown in Figures 2 through 31 of Appendix C. The quantity of lime required to raise the pH of the <¼-in fraction to a value of 6.5 su was determined using these graphs and is presented in Table 4-2. The average lime addition to raise the interstitial pore water pH to a value of 6.5 su in the tested samples was calculated to be 9.8 lbs per ton of material. It is noteworthy that deeper samples consistently required a lower lime addition rate.

4.3 Evaluation of Immediately Extractable Oxidation Products

4.3.1 Objectives

The objective of this test was to quantify the immediately extractable oxidation products stored in Type II material samples with a wide range of paste pH values. A secondary objective was to compare the immediately extractable oxidation products stored in different size fractions.



FLAMBEAU MINING COMPANY

FIGURE 4-1

TYPE II STOCKPILE SAMPLE LOCATIONS AND PROPOSED 1996 EXCAVATION AREA

Scale: 1" = 200'	Date: SEPTEMBER, 1996	
Prepared By:	Foth & Van Dyke	By: GAM

C:\cadwork\5f28f3.dgn

95F028

Table 4-2

Calculated Quantities of Lime Required to Raise the pH of the Flambeau Stockpiled Type II Material (<¼-in Size Fraction) to a Value of 6.5 (su)[1]

Sample No.	Unamended Paste pH[2]	Calc. Lime Addition (mg/g of Moist Material)	Calc. Lime Addition (#/T of Moist Material)
1	5.5	1.1	2.2
1-10	7.2	0	0
2	4.5	1.9	3.8
3	1.8	14	28
4	3.4	6.4	13
5	4.6	2.7	5.4
5-10	5.0	0.95	1.9
6	3.7	6.8	14
7	4.2	5.9	12
8	0.5	13	26
9	4.7	3.0	6.0
9-10	4.7	1.9	3.8
10	4.2	6.8	14
10-10	6.8	0	0
11	4.7	4.1	8.2
11-10	5.1	0.67	1.3
12	4.2	6.9	14
12-10	5.9	0[3]	0[3]
13-1	2.0	7.3	15
13-3	3.8	3.4	6.8
14-1	4.5	3.9	7.8
14-3	4.1	4.1	8.2
15-1	1.4	15	30
15-3	1.8	16	32
16-1	4.8	3.2	6.4
16-3	4.9	2.1	4.2

Table 4-2 *(Continued)*

Sample No.	Unamended Paste pH[2]	Calc. Lime Addition (mg/g of Moist Material)	Calc. Lime Addition (#/T of Moist Material)
17-1	4.7	5.2	10
17-3	4.5	3.8	7.6
6 plus 1-10 mixture	5.3	1.7	3.4
Average		4.8	9.8

[1]Based upon the results of the paste pH tests.
[2]Using deionized water.
[3]The regression analysis of the lime addition for sample 12-10 shows that no lime addition is required. A hand plotted fit of the data suggests that as little as 0.25 mg/g (0.5 #/T) might be required to raise the pH of the interstitial water to a value of 6.5 (su).

4.3.2 Methods

Stored oxidation products were extracted from Type II materials at a 1:1 solid to liquid ratio, using site groundwater, and approximately 2,500 g of the <¼-in fraction of six samples (1, 1-10, 5, 5-10, 6, and 7) collected as part of the program described in Section 4.2 above. The samples were selected to provide a wide range in paste pH and calculated alkali demand.

The relative proportions (Table 4-3) of three size gradations, <¼-in, ¼-in to 3-in and >3-in, were estimated for ten samples from five locations (13, 14, 15, 16, and 17) identified in Section 4.2 above. Samples of the <¼-in and the ¼-in to 3-in fractions were collected from three of the locations (13-1, 15-1, and 17-3) in order to determine the relationship between size gradation and extractable stored oxidation products. These three samples were chosen for analysis based upon the wide range of their paste pH values. The <¼-in fraction was extracted at a 1:1 solid to liquid ratio, using approximately 2,500 g of material with site groundwater similar to the above mentioned extractions. The ¼-in to 3-in fraction was extracted under saturated conditions using site groundwater.

4.3.3 Results

The calculated quantities of oxidation products extracted from samples 13-1, 15-1, and 17-3 where both size fractions were reacted are summarized in Tables 4-4, 4-5, and 4-6. The calculated quantities of oxidation products extracted from samples 1, 1-10, 5, 5-10, 6, and 7 where the <¼-in size fraction was reacted are summarized in Table 1 of Appendix C. The calculated quantities of oxidation products extracted from additional samples (13-3, 14-1, 14-3, 15-3, 16-1, 16-3, and 17-1) where the ¼-in to 3-in size fraction was reacted are shown in Table 2 of Appendix C. The laboratory results of the analyses of both the <¼-in fraction and the ¼-in to 3-in fraction extractions are also included in Appendix C.

A comparison of the calculated extractable oxidation products from the <¼-in and the ¼-in to 3-in fractions of the three samples are presented in Tables 4-4 through 4-6. As seen in the tables, the quantity of extractable oxidation products from the <¼-in fraction is generally much greater than the quantity extracted from the ¼-in to 3-in fraction. Therefore the use of the easily tested <¼-in fraction to determine extractable oxidation products will result in a conservative overestimate of the extractable oxidation products from the entire stockpiled Type II material.

Table 4-3

Estimated Size Gradation of Flambeau Type II Stockpiled Material

Sample No.	Location	>3-in Fraction (%)	¼-in to 3-in Fraction (%)	<¼-in Fraction (%)
13-1	South Slope	40	42	18
13-3	South Slope	25	45	30
14-1	East Slope (S)	33	40	27
14-3	East Slope (S)	60	24	16
15-1	East Slope (N)	25	53	22
15-3	East Slope (N)	20	48	32
16-1	North Slope	25	45	30
16-3	North Slope	25	45	30
17-1	West Slope	35	42	23
17-3	West Slope	40	30	30

35 40 25%

Table 4-4

Comparison of Calculated Immediately Extractable Oxidation Products from Two Size Fractions of Flambeau Stockpiled Type II Material Single Extractions with Site Groundwater

Sample No. 13-1

Parameter	Unamended Extraction (mg/kg), <¼-in Fraction	Unamended Extraction (mg/kg), ¼-in to 3-in fraction
Paste pH (su)	2.03	NA
Extraction pH (su)	2.43	2.24
Lab pH (su)	2.5/2.4	2.6
Conductivity (μS/cm)	3,600	6,190
Alkalinity (pH >6.5)	NA/NA	NA
Calcium	280	77
Magnesium	60	NA
Potassium	<2.0	NA
Sodium	14	NA
Acidity (pH <6.5)	2,800/3,400	1,700
Iron	320	240
Sulfate	2,100	600
Aluminum	23	NA
Antimony	0.0026	NA
Arsenic	0.070	0.034
Cadmium	0.10	0.074
Chromium	0.028	NA
Cobalt	4.6	NA
Copper	1,200	19
Manganese	17	12
Mercury	0.00020	NA
Nickel	2.1	NA
Selenium	0.027	NA
Thallium	0.64	NA
Zinc	23	16
$NO_3 + NO_2$	0.43	NA
Solid to Liquid Ratio	1:1	3.5:1

NA = not analyzed

Table 4-5

Comparison of Calculated Immediately Extractable Oxidation Products from Two Size Fractions of Flambeau Stockpiled Type II Material Single Extractions with Site Groundwater

Sample No. 15-1

Parameter	Unamended Extraction (mg/kg), <¼-in fraction	Unamended Extraction (mg/kg), ¼-in to 3-in fraction
Paste pH (su)	1.53	NA
Extraction pH (su)	2.05	2.00
Lab pH (su)	2.4/2.4	2.2
Conductivity (μS/cm)	5,300	8,500
Alkalinity (pH >6.5)	NA/NA	NA
Calcium	140	51
Magnesium	53	NA
Potassium	5.2	NA
Sodium	7.0	NA
Acidity (pH <6.5)	7,000/8,200	>2,900
Iron	2,000	1,100
Sulfate	5,600	1,500
Aluminum	56	NA
Antimony	<0.0015	NA
Arsenic	0.98	0.32
Cadmium	0.22	0.044
Chromium	0.12	NA
Cobalt	2.0	NA
Copper	450	16
Manganese	5.8	2.7
Mercury	0.00020	NA
Nickel	0.95	NA
Selenium	0.15	NA
Thallium	4.4	NA
Zinc	6.8	2.9
$NO_3 + NO_2$	0.35	NA
Solid to Liquid Ratio	1:1	4.1:1

NA = not analyzed

Table 4-6

Comparison of Calculated Immediately Extractable Oxidation Products from Two Size Fractions of Stockpiled Flambeau Type II Material Single Extractions with Site Groundwater

Sample No. 17-3

Parameter	Unamended Extraction (mg/kg), <¼-in fraction	Unamended Extraction (mg/kg), ¼-in to 3-in fraction
Paste pH (su)	4.55	NA
Extraction pH (su)	4.56	3.78
Lab pH (su)	4.8/4.8	3.5
Conductivity (μS/cm)	2,400	3,000
Alkalinity (pH >6.5)	NA/NA	NA
Calcium	390	98
Magnesium	74	NA
Potassium	7.2	NA
Sodium	14	NA
Acidity (pH <6.5)	1,100/1,200	980
Iron	0.099	4.5
Sulfate	860	520
Aluminum	0.15	NA
Antimony	<0.0015	NA
Arsenic	<0.0012	0.0034
Cadmium	0.38	0.33
Chromium	<0.0067	NA
Cobalt	2.2	NA
Copper	640	50
Manganese	11	5.9
Mercury	<0.000095	NA
Nickel	1.2	NA
Selenium	0.027	NA
Thallium	0.10	NA
Zinc	97	56
$NO_3 + NO_2$	0.39	NA
Solid to Liquid Ratio	1:1	2.9:1

NA = not analyzed

4.4 Alkali Amended Extraction Test

4.4.1 Objective

The objective of this test was to determine the quantity of oxidation products that would be immediately extractable from the stockpiled Type II materials after addition of sufficient alkalinity to raise the pH to circumneutral levels. These values could then be compared to the quantities of oxidation products extracted from corresponding unamended samples. A secondary objective was to assess the pore water quality as a function of pH.

4.4.2 Method

Samples of <¼-in material from three samples (13-1, 15-1, and 17-3) with widely differing paste pH values were extracted at a 1:1 solid to liquid ratio, using approximately 2,500 g of material with site groundwater and with site groundwater amended with hydrated lime calculated to raise the pH of the interstitial water to several circumneutral values.

4.4.3 Results

The calculated quantity of extracted substances are included in Tables 3 through 5 of Appendix C. The laboratory results of the extraction analyses are also included in Appendix C. The relationship between extraction pH and the quantity of copper, manganese, iron, and sulfate for each sample are shown in Figures 32 through 47 of Appendix C. As seen in these figures, the overall lowest quantities of all of the substances extracted is generally between pH values of 6.5 to 7.0 su, the pH of the site groundwater. A comparison to the data in Section 4.3 clearly indicates that the addition of alkali material to the backfill will neutralize the stored acidity and control the leachability of the stored oxidation products. The effect on pore water quality is also illustrated in Figures 32 through 47 of Appendix C. At the 1:1 extraction ratio, mg/kg are equivalent to mg/L.

4.5 Sequential Extractions

4.5.1 Objective

The objective of the sequential extraction testing was to provide an indication of the stored acidity and soluble constituent content of the stockpiled Type II material. The cumulative acidity released in the sequential extraction test provides an indication of the stored acidity that is not released during a single extraction procedure.

4.5.2 Methods

A shake flask extraction was completed at a solid to liquid ratio of 1:1, using a 500 g sample of the <¼-in rock in deionized water. On three occasions, at intervals of about 24 hr, approximately 50% of the leachate was removed for analysis. The removed leachate was replaced with deionized water after the first two samples were taken.

4.5.3 Results

Sequential extraction tests were completed on samples 1, 4 and 15-3. Detailed results are provided in Tables 1 to 6 of Appendix D. The first of each set of two tables per sample provides the test parameters and field test results. The second table provides the analytical results for the solutes. Laboratory data sheets are located after the tables.

In general, the results show a decrease in electrical conductivity, i.e., total dissolved salt content with each extraction, which is consistent with the decrease in sulfate concentrations for samples 4 and 15-3. Concentrations in the solutes produced from sample 1 were, however, significantly lower than the other two and remained approximately constant over the three solute exchanges. The results clearly indicate that while a significant proportion of the stored oxidation products are removed during a single extraction, the results of a single extraction will not provide an accurate estimate of the total stored acidity of a sample.

Table 4-7 summarizes the total acidity released during the sequential extraction tests, compared to the alkali demand obtained from the lime neutralization tests. The relatively high constituent concentrations observed in the final solute analyses indicates that some acidity remained in the samples at the termination of the test. This is confirmed when the lime consumption, as determined above in Section 4.2, is compared with the total acidity extracted for each sample during the sequential extraction tests.

Table 4-7

Comparison Lime Neutralization and Sequential Extraction Test Results

Sample	Unamended Paste pH	Lime Neutralization (mg/g)	Lime Demand Based on Cumulative Acidity from Sequential Extraction Tests (mg/g)
1	5.5	1.1	0.4
4	3.5	6.4	3.5
15-3A	1.8	16.0	6.4

The results indicate that in each case only approximately half of the total acidity was extracted at completion of the sequential extractions. The lime neutralization test described in Section 4.2 above is therefore a better indicator of the total stored acidity contained in the sample than either a single or multiple extraction.

4.6 Limestone Carbonate Availability

4.6.1 Objective

The objective of the limestone carbonate availability test was to measure the fraction of the limestone that will react with sulfuric acid. This measurement represents the theoretical availability of the limestone to provide alkalinity.

4.6.2 Methods

A 25.0 g sample of limestone was tested at the size distribution that will be used in the field. The sample was titrated with 0.387 N sulfuric acid in a stirred beaker to an acidic endpoint. The acid was added incrementally, and the equilibrated pH was recorded as a function of the volume acid added.

4.6.3 Results

The results of this test are provided in Table 7 of Appendix D, and the titration curve is illustrated in Figure 1 of Appendix D. The availability of the limestone was calculated on the basis of the molar equivalent ratio of the acid added to the theoretical calcite content of limestone sample.

The results show that, to an endpoint pH of 7.0, approximately 95% of the limestone had reacted. At an endpoint of about 6.5, the availability increased to about 97%.

4.7 Limestone Neutralization Confirmation Testing

4.7.1 Objectives

The first objective of the limestone neutralization tests was to confirm that the alkali addition rates, calculated on the basis of the lime neutralization tests and the theoretical availability, are sufficient to neutralize the pore water and stored acidity contained in the Type II material. The second objective was to demonstrate that ultimate pore water quality will be similar to that predicted by equilibrium modelling. The third objective of the test was to assess the stability of the secondary mineral phases formed by limestone neutralization under reducing conditions.

4.7.2 Methods

Confirmation tests were completed on the <¼-in fraction of two of the samples collected from the Type II stockpile as part of work described under Section 4.2 above. The two collected samples represent the highest (sample 15-3) and average (sample 16-1), in terms of alkali demand, as well as different pH conditions (1.8 and 4.8, respectively).

Limestone was added to the samples at rates that were calculated based on the lime neutralization tests discussed in Section 4.2. The theoretical demand was corrected for the 95% availability of limestone (to pH 7) and an excess was applied. For the less acidic sample (sample 16-1), an excess of about 30% was applied to ensure that neutral pH conditions would be attained. For the acidic sample (sample 15-3) it was thought that "blinding" (armouring) of the limestone through the formation of insoluble mineral phases was possible. In order that the possible effects of blinding could be distinguished, the limestone addition was restricted to 5% above the theoretical requirement.

Representative subsamples of 500 g each were split from the bulk samples from each of the locations identified, and blended with the estimated limestone dosage. To sample 15-3, 11.5 g of limestone were added, and 2.9 g were added to sample 16-1. These represent limestone addition rates of 46 lb per ton (23 mg/g) and 11.6 lb per ton (5.8 mg/g), respectively. The limestone amended samples were placed in separate contact vessels to which 4.0 L of distilled water were added. The headspace of each vessel was flushed with argon gas to displace oxygen and the vessels were sealed from the atmosphere. The vessels were gently agitated. Solute samples from this set of tests, designated as test "A", were extracted after 2, 7, 22, 51, 72, 102, and 449 hr of contact and analyzed.

In a duplicate set of tests (designated as test "B"), the equilibration reactions were allowed to proceed to 102 hr of contact time, after which a reducing agent, sodium thiosulfate ($Na_2S_2O_3$) was added at a rate of about 5.7 g/L (0.036 M). Solute samples were extracted before the addition of the reducing agent, and then after 123, 144 and at 449 hr of contact time had elapsed.

4.7.3 Results

Complete results are shown in Tables 8 through 15 of Appendix D. Laboratory data sheets are also contained in Appendix D. The results are summarized below.

4.7.3.1 Sample 15-3

Solute pH values in test "A" increased to about 5.0 after a contact time of 22 hr, and were buffered to about 7.5 after a contact time of 449 hr, as shown in Table 4-8. This confirms that the limestone addition rate estimate based on a 5% excess is sufficient to neutralize the stored acidity and buffer the solute to a pH typical of a carbonate buffered system. The neutral pH indicates that blinding of the limestone does not appear to be a significant factor.

Equilibration reaction rates are slow in comparison to lime neutralization. It is evident that at the 102 hr contact time, fully equilibrated conditions had not been achieved. For example, pH continued to increase to 7.5 during the contact time of 449 hr.

With the exception of manganese, the dissolved constituent concentrations decreased with increased contact time. Further decreases are expected as the solution continues to equilibrate. Modeling of the 102-hr solute concentrations using the geochemical model MINTEQA2 (Allison et al., 1991) indicated supersaturation of secondary copper minerals and goethite. The same modeling indicated near equilibrium conditions for the secondary manganese mineral rhodochrosite.

The duplicate test (test "B") had a lower pH after a contact time of 102 hr than the first (test "A") test, indicating slightly lower equilibration reaction rates. The difference may be a result of sample variability, i.e., the second subsample may have had a slightly higher acidity content. Consequently, dissolved metal concentrations were higher than those observed for the "A" test.

Table 4-8

Summary of Confirmation Test Results
<¼-in Fraction

Sample	Time (h)	Lab pH	Field Redox mV	SO_4 (mg/L)	Cu (mg/L)	Fe (mg/L)	Mn (mg/L)	Zn (mg/L)
15-3 "A"	2	3.9	282	290	130	18	1.4	3.2
	22	4.9	170	350	120	0.2	1.5	3.0
	102	6.8	157	720	2.3	0.16	1.7	1.4
	449	7.5	42	na	na	na	na	na
15-3 "B"	102	5.8	180	650	120	0.22	1.5	10
$Na_2S_2O_3$ added	123	8.4	4	1800	140	<0.17	1.0	0.72
	144	7.7	1	2300	170	0.62	0.82	0.74
	449	7.9	33	na	na	na	na	na
16-1 "A"	2	6.4	177	72	28	<0.079	1.5	0.43
	23	7.1	111	92	44	<0.079	1.5	0.27
	102	7.3	100	110	0.086	<0.079	1.0	0.8
	449	8.1	15	na	na	na	na	na
16-1 "B"	102	7.1	97	120	0.59	<0.079	1.5	1.6
$Na_2S_2O_3$ added	123	9.0	-8	1400	26	<0.17	0.014	<0.12
	144	8.8	-37	1100	48	0.21	0.013	0.21
	449	8.13	23	na	na	na	na	na

Note: na = analytical tests in progress
nd = below detection limit

Once the reducing agent was added, the redox decreased by about 100 mV. A rapid net production of alkalinity caused an increase in the pH. The increased sulfate concentrations are attributable to the use of thiosulfate as a reducing agent. The following reaction series explains the increase in pH:

First, ferric iron is reduced to ferrous iron by thiosulfate as follows:

$$4Fe^{3+} + 4e^{-} \text{ ---> } 4\,Fe^{2+} \qquad 1$$
$$\underline{S_2O_3^{2-} + 6OH^{-}} \quad \underline{\text{---> } 2SO_3^{2-} + 3H_2O + 4e^{-}} \qquad 2$$
$$4Fe^{3+} + S_2O_3^{2-} + 6OH^{-} \text{ ---> } 4\,Fe^{2+} + 2SO_3^{2-} + 3H_2O \qquad 3$$

(Potentials for half Reactions 1 and 2 are +0.77 mV and +0.58 mV respectively).

While the overall reaction (3) consumes 6 mols of OH^-, the subsequent dissolution of ferric hydroxide yields 12 mols of OH^- as follows:

$$4Fe(OH)_3 \text{ ---> } 4Fe^{3+} + 12\,OH^{-} \qquad 4$$

The most important result of the test is that dissolved iron concentrations remained relatively low under reducing conditions. Based on phase diagrams presented in Garrels and Christ (1965), siderite ($FeCO_3$) is probably the controlling phase. Manganese is also readily precipitated from solution. Phase diagrams presented in Garrels and Christ (1965) suggest that rhodochrosite ($MnCO_3$) may have been precipitated as a result of the change in redox potential.

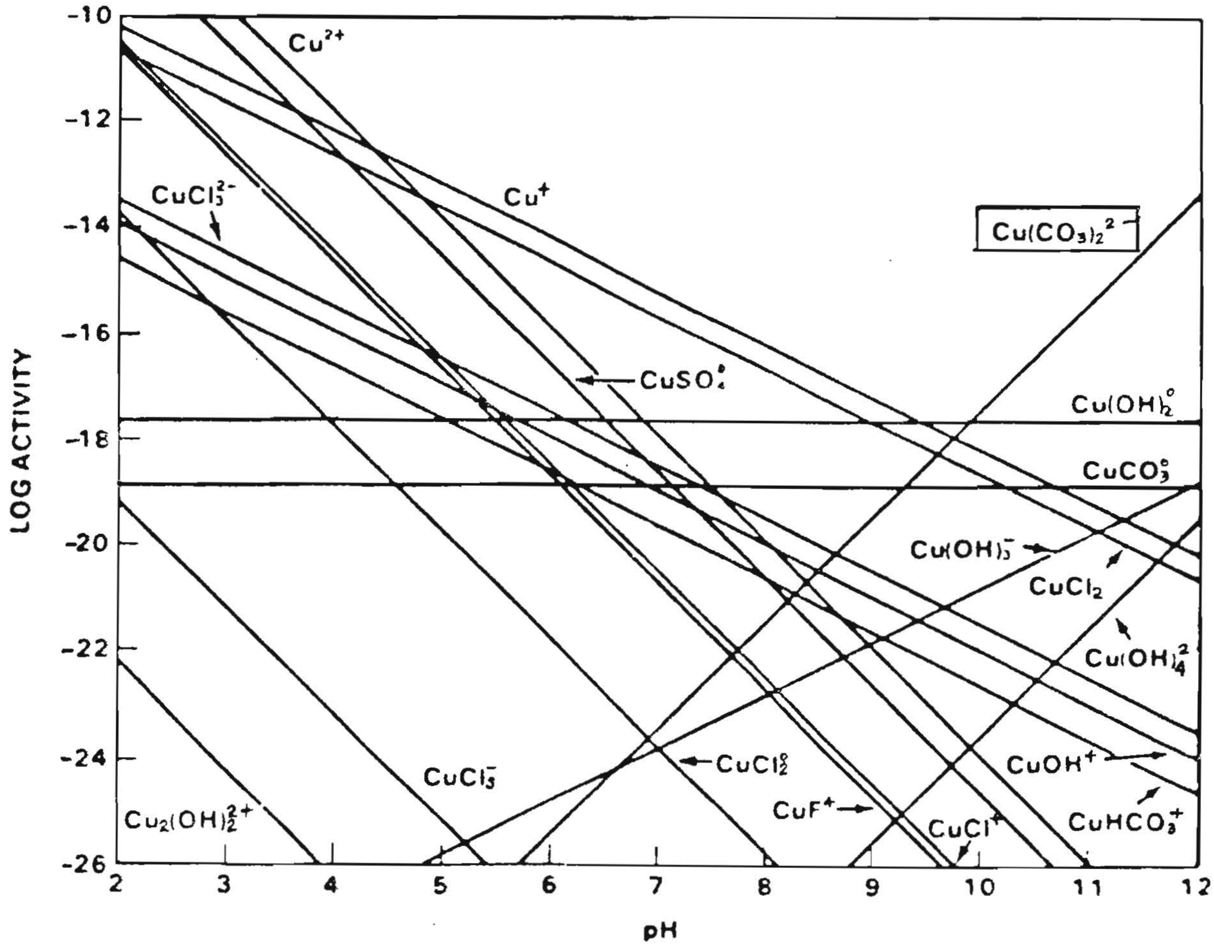
The addition of the reducing agent somewhat complicated the interpretation of the test by increasing the pH while decreasing the redox potential. Some of the consequent changes in pore water quality can be clearly attributed to the change in pH. For example, the dissolution of copper is a result of the formation of a stable $Cu(CO_3)_2^{2-}$ (aq) complex, which is only stable at high pH, as shown in the activity diagram for copper provided in Figure 4-2. However, the reducing test clearly demonstrates the value of a carbonate based alkalinity such as limestone in controlling the soluble concentrations of iron and manganese.

4.7.3.2 Sample 16-1

Referring to Table 4-8, the leachate pH rapidly increased to more than 6.0, and then continued to increase slowly to about 8.1 after 449 hr of equilibration. After 102 hr of contact, dissolved metal concentrations had decreased to low levels. Some obvious differences with respect to leachate composition were observed for the duplicate tests at 102 hr contact time, most likely a result of variability in the stored oxidation products in the respective subsamples. However, both samples were neutralized, and both samples had similar dissolved constituent concentrations.

Leachate concentrations for Test A are presented in Table 4-8 and the benefit of the limestone addition is clear. Manganese and zinc remain at relatively elevated concentrations after the limestone amendment. It should however be noted that the rate of precipitation of the corresponding carbonate minerals is slow, therefore the ultimate concentration of these parameters would be expected to decrease with time.

As in the test for sample 15-3, the addition of the reducing agent generated excess alkalinity and caused a significant, and rapid, increase in pH. Consequently, copper was complexed as $Cu(CO_3)_2^{2-}$ and re-dissolved. However, monitoring at 449 hr indicates that the solute pH is being



NOTES: pE + pH = 7

ACTIVITIES: $SO_4^{2-} = CL^- = 10^{-3}$ ATM.

$F^- = 10^{-4}$ ATM.

CO_2 (gas) = $10^{-3.52}$ ATM.

SOURCE: CHEMICAL ATTENUATION RATES, COEFFICIENTS, AND CONSTANTS IN LEACHATE MIGRATION. EPRI, FEBRUARY 1984

FLAMBEAU MINING COMPANY			
FIGURE 4-2 RELATIVE STABILITY OF SOLID AND AQUEOUS COPPER SPECIES			
Scale:	NONE	Date:	OCTOBER, 1996
Prepared By:	Foth & Van Dyke	By:	KMP

C:\cadwork\5f28f4.dgn

95F028

buffered to a lower pH of about 8.1. While the analytical results at 449 hr contact time were not available, the solubility of copper was assessed with the MINTEQA2 model, using the concentrations from the 144 hr sample as input, and specifying the pH from the 449 hr sample. The modeling results suggest that copper should be reprecipitated resulting in a final solution concentration of about 0.085 mg/L.

4.7.3.3 Conclusions

The limestone additions in the confirmation tests were sufficient to buffer the solute pH to a near neutral pH. Estimating the limestone requirement on the basis of the paste pH test with an excess of 5% limestone (used for the highest alkali case sample) proved to be sufficient to neutralize acidity and control pore water quality, even under reducing conditions.

Laboratory results from the tests under reducing conditions indicate that iron will not be mobilized under long term saturated conditions. It appears that even when iron is reduced to the ferrous form it dissolves and is reprecipitated as siderite. Manganese concentrations decreased rapidly, and appears to have been precipitated as rhodochrosite. Copper concentrations are expected to be maintained at low values. Cadmium, selenium, mercury and lead were not observed at significant concentrations and are not expected to be of concern.

5 Data Interpretation

5.1 Benefits of Carbonate Neutralization

The two main advantages of carbonate (limestone ($CaCO_3$)) neutralization over lime neutralization are:

- The low solubility of the limestone ensures that it is consumed "on demand" and is not dissolved and transported away from the reaction sites.

- Limestone buffers the pore water to a neutral to slightly alkaline pH, even if an excess is added. In contrast, lime overdosing can lead to very high pH values, which may dissolve some metals, such as copper, as a result of complexing reactions that take place.

It is also necessary to consider the long term conditions that will develop in the backfill. After reflooding, it is anticipated that relatively reducing conditions will develop within the Type II backfill. The reducing conditions may have adverse effects on the stability of some of the secondary mineral phases that have formed during the neutralization process. For example, under reducing conditions, the reduction of ferric iron to ferrous iron may result in the dissolution of precipitated amorphous iron oxy-hydroxides. Ferrous iron does not precipitate as a hydroxide at a near neutral pH, and relatively high concentrations may result. However, the presence of excess carbonate from limestone would result in the precipitation of siderite ($FeCO_3$), thus controlling the dissolved iron concentration in the pore water. Other metals that are expected to be controlled through the formation of stable carbonate phases include manganese, zinc and copper.

To confirm the effectiveness of limestone additions, the testing described in Section 4.7 was undertaken. The significance of the results, with respect to application rates is discussed below in Sections 5.2 and 5.3, and, with respect to predicted pore water quality, in Section 5.4.

5.2 Overall Limestone Application Rate

5.2.1 Theoretical Carbonate Availability and Blinding

The results from the confirmation testing show that the limestone addition rates can effectively be estimated from the paste pH test procedure. The theoretical availability of the limestone was found to be in excess of 95%. Factoring this in and allowing an excess of about 5% proved to be sufficient to buffer the pore water of even the worst case sample. Carbonate blinding did not appear to be a significant factor.

5.2.2 Field Variability

Limestone application rates have been calculated for all the samples taken at the 17 locations shown on Figure 4-1 on the basis of the paste pH results, and are presented in Table 5-1. These rates have been corrected for the 95% carbonate availability, limestone moisture content at 5%, and adjusted to provide 10% excess carbonate as discussed in the following paragraphs.

Table 5-1

Final Calculated Limestone Addition Rates

Sample	Unamended Paste pH[1]	Calculated Limestone Rates[2]	
		(mg/g of moist material)	(lb/ton of moist material)
1	5.5	1.8	3.6
1-10	7.2	0.0	0.0
2	4.5	3.1	6.2
3	1.8	23.0	46.0
4	3.4	10.5	21.0
5	4.6	4.4	8.9
5-10	5.0	1.6	3.1
6	3.7	11.2	22.3
7	4.2	9.7	19.4
8	0.5	21.4	42.7
9	4.7	4.9	9.9
9-10	4.7	3.1	6.2
10	4.2	11.2	22.3
10-10	6.8	0.0	0.0
11	4.7	6.7	13.5
11-10	5.1	1.1	2.2
12	4.2	11.3	22.7
12-10	5.9	0.0	0.0
13-1	2.0	12.0	24.0
13-3	3.8	5.6	11.2
14-1	4.5	6.4	12.8
14-3	4.1	6.7	13.5
15-1	1.4	24.6	49.3
15-3	1.8	26.3	52.6
16-1	4.8	5.3	10.5
16-3	4.9	3.5	6.9
17-1	4.7	8.5	17.1
17-3	4.5	6.2	12.5
Average		8.0	16.1

[1]Using deionized water.
[2]Adjusted for carbonate availability at 95%, limestone moisture content at 5%, and to provide 10% excess carbonate.

It is clear from the table that there is a good correlation between the paste pH and the limestone requirement. It should be noted that the limestone requirement varies considerably amongst the samples. This variability appears to be spatially related. For example, the samples collected from a depth of 10 ft invariably require a lower addition rate than the corresponding surface sample. Furthermore, samples collected from the lower sections of the sideslopes of the Type II stockpile (i.e., locations which have experienced the longest exposure period) tend to be more oxidized and require a higher limestone dosage. Samples 3, 8, 15, 4, and 13 all originate from the lower sections of the sideslopes and all have a high alkali demand. The samples collected from the top surface of the pile (i.e., most recently placed) all tend to have lower alkali demands.

These variations in the alkali demand should be considered when the overall alkali application rate is determined. A single application rate, such as the overall average, may be insufficient where the worst case material is encountered, and will be excessive where material with a lower alkali demand is encountered. On the other hand, a worst case approach will be excessively expensive, as the maximum alkali demand is approximately 3 to 4 times the average, based on the currently available data which is dominated by surface samples. At depth, where material has not been exposed to oxidizing conditions for extended periods, the discrepancy will be even greater.

Several factors will decrease the importance of variability. First, the material will be mixed in the excavation and placement process. Second, placing material in lifts will result in vertical mixing. Third, during the reflooding, reactants from one portion of the backfill will be transported to other portions.

To account for the possibility of field variability within the limited amount of material to be backfilled in 1996, the limestone requirement has been adjusted, as shown in Table 5-1, to include a 10% carbonate excess. As discussed in Section 6 below, the possibility of varying the application rate to respond to variability in alkali requirement will be considered in future investigations.

5.3 Fall 1996 Limestone Application Rate

Testing of the stockpiled Type II material indicated that the paste pH test is a reliable method for determining the limestone addition rate. The sampling that has been undertaken has shown, however, that there is considerable variability in the calculated alkali addition rate throughout the stockpile.

The Type II material planned for relocation this fall is shown in plan on Figure 4-1, which also shows the sample locations. Material will be excavated to a depth of fifteen feet below the current surface of the stockpile. The material that will be relocated is from recent mining and therefore has not been exposed to oxidation for an extended period. Therefore, with respect to the state of oxidation of the material, it is expected that the material will be relatively homogeneous and should have a below average alkali demand.

Three sample locations are directly within this area, namely 7, 9 and 11. The surface samples showed an average limestone demand (inclusive of 95% availability, adjustment for limestone moisture content and 10% excess) of about 14.3 lb per ton (7.1 mg/g). The highest alkali demand was observed for sample 7 at 19.4 lb per ton (9.7 mg/g). Two samples (9-10 and 11-10) taken at a depth of 10 ft on average only required 4.2 lb per ton (2.2 mg/g). Other locations in close proximity, probably representing similar material as contained in the relocation unit, include samples 1 and 5, both of which exhibit a lower alkali demand. Deep samples collected at sites 1 and 5 exhibit a lower alkali demand than their surficial counterparts.

Based on the test results from the area to be relocated in 1996, the average alkali demand is expected to be lower than the overall average for the stockpile. Given the limited number of samples from this area, Flambeau proposes to conservatively apply the overall average of 16.1 lb per ton (8.0 mg/g) of limestone, which is the average calculated from all samples taken to date. This is about 13% higher than the average for the area. Furthermore, indications are that at depth in the stockpile a lower alkali addition rate will be required. Since excavation will be by backhoe from the surface of the pile, material at depth will be mixed continuously with that at surface. This blending will result in a "smoothing" of the material characteristics, and will preclude placement of high alkali demand material in seclusion.

A limestone addition rate of 16.1 lb per ton (8.0 mg/kg) is therefore considered to be sufficient to neutralize the pore water and stored acidity contained in the rock planned for relocation during the fall of 1996. To this must be added 1.1 lb per ton of limestone to neutralize acidity generated from future oxidation prior to resaturation due to groundwater recovery. Therefore, a field limestone application rate of 17.2 lb per ton is proposed for the 1996 backfill. This rate will neutralize the stored oxidation products and the oxidation that may occur during backfilling and before reflooding.

5.4 Estimated Long Term Pore Water Quality

In the long term, pore water quality is expected to be controlled by equilibria with secondary minerals. As discussed in Section 4.7.3, equilibrium conditions had not fully been reached in the testing to date. However it is believed that the results obtained for sample 16-1 are likely the closest to equilibrium conditions, and therefore should represent the long term pore water quality.

Geochemical equilibrium modeling using MINTEQA2 (Allison et al., 1991) was undertaken to estimate equilibrated pore water constituent concentrations. To complete the modeling, leachate from sample 15-1, representing the worst case pore water, was used as input. Calcite was entered as a finite solid phase at the estimated dosage rate. Saturation indices were calculated for the mineral phases in the MINTEQA2 data base. Equilibrium conditions were then allowed to establish, by selecting and allowing only those mineral phases to precipitate that had positive saturation indices and were considered most likely to be formed. In Table 5-2 the water quality observed for sample 16-1 test "A" at a contact time of 102 hr is compared with predicted pore water quality. Only the major elements are listed, together with the anticipated controlling mineral phase(s). As the table shows, the predictions from the equilibrium model are similar to that observed for sample 16-1.

The observed copper concentration compares well with that predicted by the equilibrium modeling. The modeling results suggest a solubility of <1.5 mg/L for iron in the event that siderite is the controlling secondary mineral phase. However, the observed concentrations were consistently below the predicted value, even for reducing conditions.

Table 5-2

Observed and Estimated Long Term Pore Water Quality

Parameter	Observed	Estimated	Controlling
pH	7.3	7.5	
Cu	0.086	<0.01	malachite or tenorite
Fe	<0.079	<1.5	siderite ($FeCO_3$)
Mn	1.0	<1.7	rhodochrosite ($MnCO_3$)
Zn	0.80	<1.5	$ZnCO_3 \cdot H_2O$
SO_4^{2-}	na	~1000	gypsum

Notes: all units in mg/L except for pH (su)
nd = below detection limit
na = not applicable

A manganese concentration of less than 1.7 mg/L is predicted for equilibrium with rhodochrosite. This compares with the steady concentrations observed for both samples prior to the addition of a reducing agent. At the more reducing conditions, the results suggest a decrease in the manganese concentration.

On the basis of using a low magnesium limestone, the sulfate concentration is expected to be about 1,000 mg/L, controlled by equilibrium with gypsum.

Table 5-3 shows a comparison of pore water quality as predicted in the 1989 MPA to that predicted in 1996 for the elements of major concern. A review of the table shows that the two predictions compare well.

Table 5-3

Predicted Pore Water Quality (mg/L)

Parameter	1989 Prediction[1]	1996 Prediction
Copper	0.014	<0.01
Iron	0.32	<1.5
Manganese	0.52	<1.7
Sulfate	1,360	≈1,000

[1]From *Mine Permit Application*, Foth & Van Dyke, Revised December 1989.

6 Additional Data Collection

The results from the testing completed to date, and as presented in this report, provide an understanding of the geochemical and physical needs to support the backfilling of the stockpiled Type II material planned for relocation during the fall of 1996. This is because the planned relocation represents a relatively uniform block of material, which will not vary greatly in its alkali demand. It is therefore reasonable and cost effective to use a single amendment rate.

However, when the Type II stockpile is considered in its entirety, it is clear that there is significant variability in the waste rock characteristics. The alkali demand varies considerably, and a single average limestone amendment rate is not reasonable or cost effective. Flambeau therefore plans to complete additional investigations to establish a method to apply a variable limestone addition rate. The primary objectives of the proposed investigations are listed below. A work plan addressing the investigations will be prepared and submitted to the WDNR for review.

6.1 Short Range Variability and Amendment Rates

As shown by the current test results there is considerable variation spatially within the stockpile with respect to the state of oxidation, and the alkali demand. This variability is depth and exposure related, and determines the alkali amendment rate. It is desirable to determine the range of the variability and its impact on the amendment rate. Both field and laboratory investigations will be completed to acquire the necessary information.

6.2 Pore Water Quality

To provide additional confirmation of the predicted pore water quality, longer term (2 to 3 wk) laboratory investigations will be completed under anoxic conditions for a variety of Type II materials at the calculated limestone addition rates.

6.3 Clarifier Underflow Solids Stability

Thickener or clarifier underflow (CUF) solids have been generated using primarily lime neutralization under oxidizing conditions. The primary products from this process therefore are metal oxy-hydroxides and gypsum. The effect of the metal oxy-hydroxides under the long term anoxic conditions will be addressed in the planned laboratory program.

6.4 Field Control of Alkali Application Rates

Because of the variability in the alkali demand observed for the samples tested to date, the potential for controlling the rate of limestone amendment to suite material characteristics will be investigated. First, the reliability for using rapid field tests to predict the limestone addition rate will be assessed. Second, field operating requirements, such as number of samples and sampling requirements will be addressed. Both laboratory and field testing will be undertaken.

6.5 Type I Waste Rock

Recent seepage quality from the Type I waste rock stockpile has shown elevated dissolved copper concentrations in isolated sections of the stockpile. Laboratory testing will be undertaken to assess the need, if any, to amend the Type I waste rock to control constituents in the pore water in the long term.

7 References

Allison et al., 1991. *MINTEQA2 Version 3.11.* U.S. Environmental Protection Agency, Center for Exposure Assessment Modeling, Athens, Ga.

Garrels, R.M. and C.L. Christ, 1965. *Solutions, Minerals and Equilibria.* Freeman, Cooper and Company, San Francisco.

Hem, J., 1989. *Study and Interpretation of the Chemical Characteristics of Natural Water.* Third Edition, U.S. Geological Survey Water Supply Paper 2254.

Rai D., and J.M. Zachara, 1984. *Chemical Attenuation Rates, Coefficients, and Constants in Leachate Migration Volume 1: A Critical Review.* Environmental Physics and Chemistry Program, Energy Analysis and Environment Division, EA-3356, Vol. 1.

Appendix A

Oxygen Transport and Related Alkalinity Requirements - Flambeau Mine Pit Backfill

F107108

OXYGEN TRANSPORT AND ALKALINITY ADDITION
FLAMBEAU MINE PIT BACKFILL

Prepared for:

FOTH & VAN DYKE
2737 S. Ridge Road
P.O. Box 19012
Green Bay WI
54307-9012

Prepared by:

STEFFEN ROBERTSON AND KIRSTEN (CANADA) INC.
Suite 800, 580 Hornby Street
Vancouver, B.C.   V6C 3B6
Tel: (604) 681-4196 • Fax: (604) 687-5532

OCTOBER, 1996

F107108

OXYGEN TRANSPORT AND ALKALINITY ADDITION
FLAMBEAU MINE PIT BACKFILL

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

F107108

OXYGEN TRANSPORT AND RELATED ALKALINITY REQUIREMENTS FLAMBEAU MINE PIT BACKFILL

1.0 INTRODUCTION

As part of its approved mine plan, Flambeau Mining Company (FMC) will relocate waste rock at the Flambeau Mine into a former open pit. After groundwater levels in the area recover from the current drawdown, the backfilled waste rock will be below the water table. Oxidation of the sulfide minerals contained in the waste rock would then be inhibited by the slow transport of oxygen through the groundwater.

The waste rock has already been on surface for up to five years. During that time, the oxidation of sulfide minerals has led to an accumulation of acidity. To prevent that acidity being released to the groundwater, FMC is proposing to add crushed limestone to the waste rock. A program of laboratory tests to measure the currently stored acidity, and to estimate the associated alkalinity requirement, is underway.

However, further oxidation of sulfide minerals may result during the period of waste rock backfilling, which is expected to take place over 1996 and 1997, and during the period of groundwater recovery, which may take up to fourteen years. To prevent the accumulation and discharge of acidity during the backfilling and groundwater recovery periods, FMC is proposing to mix additional crushed limestone with the backfilled waste rock.

The objective of the work reported herein was to estimate the oxidation rates and alklainity requirements associated with the backfilling and groundwater recovery periods.

SRK's scope of work was defined in a proposal dated July 5, 1996 (Daryl Hockley to Mr. Jerry Sevick), and a subsequent authorisation to proceed dated July 15, 1996 (Jerry W. Sevick to Mr. Daryl Hockley). The work consisted of:

- Mathematical modelling of oxygen transport and reaction in the waste rock during the backfilling and groundwater recovery periods; and,
- On the basis of the oxygen modelling, estimation of the alkalinity requirement to neutralize oxidation products that may form between the time the backfill is placed and the time that it is fully submerged by the groundwater.

Section 2 below lists the information that was made available to SRK. Section 3 presents the oxygen modeling. Section 4 converts results of the oxygen modeling to estimated alkalinity requirements. Conclusions and recommendations are summarised in Section 5.

2.0 AVAILABLE INFORMATION

The following documents were available to SRK:

1. Seep monitoring data from the Type I stockpile, from Kennecott Minerals, dated March 13, 1996.

2. Table showing specific gravity and moisture absorption properties of Type II waste rock, and plots of grain size distributions.

3. Report entitled "Prediction of Groundwater Quality Downgradient of the Reclaimed Pit for the Kennecott Flambeau Project", (Foth & Van Dyke, July 1989).

4. Section 3.5.6 "Waste Characterization" from the 1989 Environmental Impact Report, with figures and appendices.

5. A plan of the open pit from the 1989 permit.

6. A plan of the open pit as finally excavated, hand drawn in 1996.

7. A schematic cross section showing the proposed stratigraphy of the material to be backfilled, dated February 1996.

8. A hand drawn long section through the pit, dated 7-9-96.

9. A plot of water table elevation versus time from Prickett (1996), showing the water table reaching the top of the Type II waste rock eleven years after the backfilling is completed, and the top of the Type I waste rock after an additional three years. (Annotation by Foth and Van Dyke states that earlier predictions indicated the groundwater table would recover more rapidly and the waste rock would be underwater within three years).

3.0 OXYGEN TRANSPORT MODELING

In sulfidic waste rock, oxygen reacts with the sulfide minerals to form acidity and sulfate, and release metals. Although the reactions can be supported temporarily by other oxidizing substances, such as ferric iron, limitations to the oxygen supply effectively control the overall rate and extent of sulfide oxidation. An understanding of the limitations to oxygen supply can therefore allow the theoretical potential for contaminant release to be estimated, and a conservative estimate of the required alkalinity addition to be derived.

Section 3.1 below reviews the mechanisms by which oxygen can be transported into waste rock. Section 3.2 describes a mathematical model of the transport and reaction processes that will control the supply of oxygen to waste rock in the Flambeau pit during backfilling and groundwater recovery. Section 3.3 presents estimates of oxygen concentrations in the backfilled waste rock, as predicted by the transport model. In Section 3.4, the predicted oxygen concentrations are used to derive estimates of oxidation rates and neutralization requirements.

3.1 Oxygen Transport Mechanisms

Transport of oxygen through waste rock occurs by several mechanisms, including advection and diffusion in infiltration and groundwater, convection in air due to thermal or barometric gradients, and diffusion through air filled porosity.

The advection and diffusion of oxygen in water have been discussed by Pantelis and Ritchie (1991), and Colin (1986). In waste rock above the water table, with moderate precipitation and infiltration rates, the rates of oxygen transport in water are typically less than the lowest estimates of oxygen transport by air phase diffusion, i.e. through nearly saturated soil covers.

Below the water table, oxygen transport is only through groundwater. Low flow rates, the limited solubility of oxygen, and the consumption of oxygen by sulfides and organic matter in the surrounding soil and rock limit the importance of groundwater as an oxygen source.

Barometric pumping has been investigated by Massmann and Farrier (1992), who considered transport in soils. They concluded that barometric pumping can be the dominant transport mechanism when most of the soil surface is sealed, and transport is restricted to discrete openings. When the soil surface is not sealed, the effect of barometric pumping is less important, and is additive to diffusive transport. At most, it may roughly double the transport associated with diffusion alone.

Thermal convection is the subject of several papers reviewed by Ritchie (1994). The review includes examples where thermal convection is clearly the dominant air transport mechanism. However, the requirements for thermal convection include a permeable rock, localised heat sources due to locally rapid oxidation, and a convection path to and from the "hot spot". The application of covers to the surface of rock piles has been shown to stop thermal convection (Gelinas et al, 1994, Harries & Ritchie 1981). In the Flambeau project, compaction of the rock will reduce its permeability, the spreading of the rock will distribute any "hot spots" over a wide area, and the low permeability of the pit walls will act as a break in any convection paths. Therefore, it can be concluded that thermal convection is unlikely to be an important transport mechanism in the backfilled pit.

Diffusion through the unsaturated pore space within the backfilled rock and the till cover is therefore likely to be the dominant transport mechanism. Although recent research has indicated that multi-component diffusion (Cussler 1984) and Knudsen flow (Massman and Farrier 1994) can have secondary effects, the process of oxygen diffusion in porous media is still most commonly described by Fick's Law, with the diffusion coefficient replaced by an effective diffusion coefficient that accounts for the tortuosity and partial saturation of the pores. Fick's Law will be used herein, with a range of effective diffusion coefficients to indicate the limited effect of secondary processes.

3.2 Description of the Oxygen Diffusion Model

3.2.1 Model Equations

Oxygen transport by Fickian diffusion in a porous media can be described by the mass transport equation:

$$\frac{dC}{dt} = D\frac{\partial^2 C}{\partial x^2} - r * C$$

where: **C** is the oxygen concentration in the gas phase at a point (mol m^{-3}); **t** is time (s); **D** is the effective diffusion coefficient (m^2s^{-1}); **x** is a distance vector (m); and **r** is a first order rate constant (s^{-1}). **D** is a function of both the porosity, tortuosity and water content of the media as well as the temperature, pressure and chemical composition of the air phase. In general, variability in the porous media properties have a far greater impact on **D** than variability in the air phase properties.

The use of a first order rate constant to relate the oxygen concentration to the oxygen consumption rate implies two assumptions. The first is that the oxidation rate is directly proportional to the local concentration of oxygen. There are conceptual models of sulphide oxidation reactions, and empirical data, that suggest alternative formulations of the rate term. The first order assumption is used here because it leads to higher estimates of the depth of oxygen penetration. The second assumption is that the rate of oxidation is constant at a given oxygen concentration. In fact other variables, such as pH and the presence of the bacteria *T. ferrooxidans*, can also influence the rate of sulfide oxidation. However, explicit consideration of these other factors would lead to a great increase in the complexity of the oxygen transport model and require input data with a level of detail that is difficult (or impossible) to verify at field scale. Therefore, the approach herein is to use a range of rate constants to cover the range of possibilities that might be observed in the backfilled waste rock.

3.2.2 Solution Method

Numerical Solution

A finite difference code was developed to solve the above diffusion equation in two dimensions. The code has the advantage of allowing scenarios with variable model parameters (**D**,**r**) and complex geometries to be simulated. The code was written in a Visual Basic module within a Microsoft Excel 5.0 workbook. Input is taken from, and output is written to, Excel worksheets. Solution of the set of finite difference equations is by the Alternating Difference Implicit (ADI) method.

Analytical Solution

A one-dimensional analytical solution was obtained to provide an exact solution for simple geometries, and to allow the numerical code to be checked. For one-dimensional oxygen diffusion through homogenous waste rock with a soil cover, the boundary conditions are given by:

$$C(x=0) = C_0$$
$$C(\infty) = 0$$

where $x=0$ is at the surface.

Assuming that no oxygen consumption occurs in the cover layer, and the system has reached steady state, the solution is given by:

For $0 < x < L$:

$$C(x) = \frac{C_1 - C_o}{L} x + C_o$$

For $L < x < \infty$:

$$C(x) = C_1 e^{\sqrt{\frac{r}{D_2}}(x-L)}$$

Where L is the non-reactive cover thickness (m), C_o is the concentration of oxygen in the atmosphere (8.89 mol m^{-3}), C_1 is the concentration of oxygen at the cover / waste rock interface, and D_2 is the effective diffusion coefficient for waste rock.

The flux through the cover and into the waste rock is given by:

$$q = \frac{D_1 C_o \sqrt{rD_2}}{D_1 + L\sqrt{D_2 r}}$$

Where q is the mass flux of oxygen into the waste rock (mol m^{-2} s^{-1}); and D_1 is the effective diffusion coefficient for the cover.

The concentration at the cover / waste rock interface can be determined from:

$$C_1 = \frac{-qL}{D} + C_o$$

3.2.3 Input Parameters

Geometry and stratigraphy for the oxygen transport calculations were obtained from the documents listed in Section 2.

Values of the diffusion coefficients were obtained from literature sources:

- For waste rock, Ritchie (1994) reported a range of diffusion coefficients of 2.25×10^{-6} to 6.85×10^{-6} m^2s^{-1}, measured in situ at a number of mine sites.

- For a compacted till cover SENES (1995) reported a range of diffusion coefficients of 5.64×10^{-6} to 1.66×10^{-8} m^2s^{-1}.

As discussed below, most of the model runs were carried out using both the upper and lower end of the reported ranges.

Diffusion coefficients for the saprolite and sandstone layers were assumed to be the same as for the Type I and Type II waste rock.

Field measurements of oxygen consumption rates in waste rock were summarised by Ritchie (1994) and range from $3x10^{-8}$ to $8.8x10^{-8}$ kg O_2 $m^{-3}{}_{rock}$ s^{-1} (Ritchie, 1994). Assuming a waste rock porosity of 0.2 and atmospheric oxygen concentration of 8.9 mol m^{-3}, the corresponding first order rate constants range from $1.6x10^{-6}$ to $3.6x10^{-8}$ s^{-1} respectively. Figure 3.1 shows the rate constants derived from Ritchie's (1994) compilation, and the range of rate constants assumed for this study. The assumed upper rate constant of $1.3x10^{-6}$ s^{-1} is slightly lower than the maximum reported by Ritchie (1994), but it should be noted that the maximum cited by Ritchie was measured in a rapidly oxidising, acidic waste rock in a tropical environment. The assumed lower rate constant of $8.9x10^{-8}$ s^{-1} was selected to provide slightly greater oxidation (hence more conservative estimates) than the lower values cited by Ritchie (1994). Unpublished data collected by SRK in waste rock with a sulfide content similar to the Flambeau waste rock indicated reaction rate constants of about 10^{-7} s^{-1}, closer to the lowest value assumed herein.

Oxygen consumption was assumed not to occur in the saprolite and sandstone layers. Sulfides, if present in the saprolite, would cause some oxidation to occur, resulting in partial consumption of the oxygen before it could reach the Type I and Type II rock. The assumption of no oxidation allows a more conservative (i.e. higher) estimate of oxygen penetration into the Type I and Type II waste rock.

3.3 Diffusion Model Results

3.3.1 Two Dimensional Simulations

Initial two-dimensional simulations were carried out using the geometry of the schematic cross-section (item 8 in Section 2). The results showed that oxygen diffusion occurs evenly across the lateral extent of the pit and can thus be adequately represented by a one-dimensional model. Further predictive simulations were carried out using a one dimensional column of rock taken through the centre of the schematic section. The depth of each layer was assumed to be as shown in Figure 3.2.

3.3.3 Sensitivity Runs

In addition to the depth of each layer, the one dimensional oxygen diffusion model required two input parameters, oxygen diffusion coefficient *D* and the oxygen consumption rate constant *r*. Sensitivity runs were conducted to investigate the range of oxygen profiles obtained from different combinations of *D* and *r*, and to verify the numerical results by comparison to the analytical solution.

Four simulations were completed:

- low D and low r (run sens1b);
- low D and high r (run sens1a);
- high D and low r (run sens1c); and
- high D and high r (run sens1d).

In all cases the profiles reached steady state within the first two years. The parameters used in each simulation are summarised in Table 3.1.

The oxygen concentration profiles for these runs are shown in Figure 3.3. Summary results are also listed in Table 3.1. The results show that a combination of high *D* and high *r* result in the greatest oxygen flux into the column, and hence the greatest overall oxygen consumption. (In a steady state condition, the flux of oxygen into the column must equal the consumption of oxygen within the column.) However, in all cases, the flux into the column varied within less than a factor of four.

The last columns of Table 3.1 show the depth of oxygen penetration. Because of the first order assumption, oxygen concentrations approach zero asymptotically, hence there is some oxygen at any depth. The depth of penetration was therefore arbitrarily measured as the depth at which the total oxygen consumption was equal to 1x10-7 mol $m^{-3}{}_{air}$ s^{-1}. At this low oxygen consumption rate, the generation of acidity is negligible (approximately 0.01 kg $CaCO_3$/tonne). Table 3.1 show combinations of high *D* and low *r* combination result in the deepest penetration of oxygen into the backfill column. However, the difference between the deepest and shallowest penetration is only a factor of two. In all cases, the deeper portions of the backfill are predicted to exhibit low oxygen concentrations and very low oxidation rates.

As the results of the sensitivity analyses show, the predicted oxygen flux into the column and the predicted depth of oxygen penetration are relatively insensitive to variations in the values of *D* and *r* assigned to the waste rock. Despite varying input *D* values by a factor of three, and input *r* values by a factor of 15, the predicted values vary by only a factor of four. These results provide some comfort that second order processes, which may influence *D* or *r* values, would not strongly influence the predicted oxygen profiles.

3.3.4 Predictive Runs

Two sets of predictive model runs were completed. The first set simulated oxygen transported during the backfilling. The second set simulated oxygen transport after the backfilling is completed, i.e. during re-flooding.

3.3.4.1 During Backfilling

Four steady state predictive runs were completed using a one layer waste rock system exposed to the atmosphere to simulate pit oxidation during waste rock deposition. The runs covered the range of input *D* and *r* values:

- low D and low r (run pred3b);
- low D and high r (run pred3a);
- high D and low r (run pred3c); and,
- high D and high r (run pred3d).

The input parameters and summary results are listed in Table 3.2. Complete results from each run are provided in Appendix A.

3.3.4.2 During Re-Flooding

After the backfilling is complete, a till cover will be placed over the waste rock. It is well established in the literature that till covers can be an effective barrier to oxygen penetration (e.g. Colin 1986, Nicholson et al., 1989). All of the cited references agree that the water content of the till is important to the control of oxygen penetration. To cover a range of possibilities for the proposed cover of the Flambeau pit, both a "wet" and a "dry" cover (low and high oxygen penetration) were simulated.

Type I waste rock was assumed to be unreactive. In a project in Ronneburg, Germany, it was found that oxidation in upper layers of rock can limit the migration of oxygen to underlying, more acid generating material (SRK 1993, 1996a, 1996b). Neglecting the potential for oxygen consumption in the Type I rock is therefore expected to lead to conservatively high estimates of oxygen transport to the Type II rock.

In the Type II rock, both high and low *r* values were simulated. All runs used the lower D value for the waste rock, because it is expected to be compacted by both the dynamic loading from the the truck traffic and the static load of the overlying backfill.

A total of four runs resulted:

- "Dry" cover, low r in Type II waste rock (run pred1c);
- "Dry" cover, high r in Type II waste rock (run pred1d);
- "Wet" cover, low r in Type II waste rock (run pred2c); and,
- "Wet" cover, high r in Type II waste rock (run pred2d).

As with the sensitivity analyses, the runs reached steady state within two years. The input parameters and outputs are summarised in Table 3.3. Complete outputs for each run are included in Appendix B.

3.4 Predicted Oxidation and Alkalinity Consumption Rates

The results of the oxygen transport modeling allow estimation of the rate of oxidation at different depths in the backfilled pit, and the rate of alkalinity consumption required to neutralize the resulting oxidation products .

The consumption of oxygen at any point in the simulated columns of backfill can be calculated directly from the oxygen concentration profile and the reaction rate constant, i.e.

$$O_2 \text{ consumption (moles } O_2 \text{ m}^{-3}{}_{rock} \text{ s}^{-1})$$
$$= r\,(\text{s}^{-1})\; O_2 \text{ concentration (moles m}^{-3}{}_{air}) * Ø\,(\text{m}^3{}_{air}\text{ m}^{-3}{}_{rock})$$

where Ø is the air-filled porosity. For each of the predictive runs, the O_2 consumption rate at each point in the profile is given in the complete outputs (Appendices A and B).

The oxygen consumption rate can then be converted to an alkalinity consumption rate according to the overall reaction:

$$FeS_2 + 15/4\ O_2 + 3/2\ H_2O + 2Mg_fCa_{(1-f)}CO_3$$
$$= 2f\ MgSO_4 + 2(1\text{-}f)CaSO_4 + 2CO_2 + Fe(OH)_3$$

The reaction stoichiometry indicates that, for every 15/4 moles of O_2 consumed in the oxidation of pyrite, two moles of alkalinity will be required to neutralise the acidity. The alkaline mineral in the above can include any combination of calcium and magnesium. For simplicity, the output tables express the alkalinity consumption in terms of neutralisation potential (NP), which has units of kg $CaCO_3$/tonne.

Figures 3.4 and 3.5 show the NP consumption rates at various depths in the column for each of the predictive runs. The NP consumption rate (kg $CaCO_3$ tonne^{-1} yr^{-1}) can be thought of as a measure of the NP required to consume the acidity generated in each year that the rock remains above the water table.

Figure 3.4 shows the NP consumption rates at any one time during the backfilling. As discussed in the following section, the profiles will slide upwards as the pit is filled.

Figure 3.5 clearly shows that NP consumption rates during re-flooding will be much greater in the upper levels of the backfill. Also noteworthy is the benefit of a better till cover in reducing the NP consumption rates. As was also shown by the sensitivity analysis, NP consumption rates at depth are much lower and are insensitive to the assumed reaction rate constant. The implication is that estimated alkalinity requirements for the waste rock placed in the lower levels of the pit are independent of model assumptions.

4.0 ALKALINITY REQUIREMENTS

4.1 Alkalinity Requirement for the Backfilling Period

In the preceding section, Figure 3.4 shows a profile of NP consumption at various depths in the pit during backfilling, as predicted by the oxygen transport model. However, the figure shows the profile at one point in time during the backfilling. In fact, because the surface of the waste rock moves upward as the backfilling continues, the profile shown in Figure 3.4 will also move upward. The following simple calculations allow the profile to be translated to an average rate alkalinity requirement.

- Under the conservative assumption that it will take two years to fill the 65 m deep pit, the profile shown in Figure 3.3 will move upward at an average rate of 32.5 m/year.

- Assuming that the depth of oxygen penetration during backfilling is approximately 10 m (see Figure 3.4), each point in the backfill will be exposed to oxidation for approximately 10/32.5 years, or about four months.

- Using a conservative estimate of 0.5 kg $CaCO_3$ $tonne^{-1}$ $year^{-1}$ as the average NP consumption rate, the total NP consumption during the backfilling at any point in the column will be approximately 0.15 kg $CaCO_3$/tonne.

The predicted alkalinity requirement to neutralise acidity generated during the backfilling is about 0.15 kg $CaCO_3$/tonne, or about 0.4 lbs/ton.

The actual limestone addition rate will be subject to the constraints on chemical availability. The above alkalinity requirement is expressed as "effective" neutralisation potential, *i.e.* it would need to be increased to account for the relative availability of the limestone.

4.2 Alkalinity Requirement for the Groundwater Recovery Period

Figure 3.5 shows the rate of NP consumption at various depths in the backfilled pit during groundwater recovery, as predicted by the oxygen transport model. All of the curves in the figure show a peak NP consumption at the top of the reactive waste rock, and an exponential decrease below. An imaginary curve drawn through the highest estimated NP consumption rate at each depth would represent a conservative estimate of the overall NP requirement. The imaginary curve would roughly form a right triangles, with:

- a peak NP consumption rate of 0.13 kg $CaCO_3$ $tonne^{-1}$ $year^{-1}$ at the top of the Type II waste rock; and,
- a base NP consumption rate of 0.013 kg $CaCO_3$ $tonne^{-1}$ $year^{-1}$ at approximately 15 m below the surface.

The overall NP requirement to neutralise acidity generated during re-flooding can be estimated at each of the above points by multiplying the NP consumption rate by the time for re-flooding. Under the slowest re-flooding scenario (item 10 in Section 2), it will take eleven years from the completion of the backfilling to the saturation of the top of the Type II waste rock.

The resulting estimated alkalinity requirements for the groundwater recovery period are shown in Figure 4.1.

Figure 4.1 also shows the estimated alkalinity requirement for the backfilling period, and the estimated total alkalinity requirement for the backfilling and groundwater recovery periods. The maximum alkalinity required to neutralise acidity generated during the backfilling and groundwater recovery periods is 3.5 lbs/ton. (As discussed in Section 1, the alkalinity required to neutralize current acidity is not considered herein.) It is noteworthy that the estimated alkalinity requirement is not constant with depth. In fact, the figure shows that alkalinity additions should be concentrated in the upper level of the Type II waste rock. At greater depths, the alkalinity is only required to neutralize oxidation products from the relatively short backfilling period.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The following summarises the major conclusions of this work:

- The restriction of oxygen transport will limit the rate of acid generation, and hence the requirement for alkalinity addition, in the backfilled pit.
- The planned till cover will further restrict the access of oxygen to the underlying waste rock, and may result in substantial decreases in the required alkalinity addition.
- Oxygen transport calculations indicate that a maximum of approximately 3.5 lbs/ton of available alkalinity (see Figure 4.1) will be required to neutralise oxidation products generated during backfilling and re-flooding. During re-flooding, oxygen transport be limited to the upper 10-20 m of reactive waste rock. The maximum alkalinity addition will be required only in the uppermost layers.
- During the groundwater recovery period, oxygen will not reach the more deeply buried waste rock, and lesser amounts of alkalinity will be required in lower levels of the pit backfill. A minimum application rate of approximately 1 lb./ton of available alkalinity should be adequate to neutralise oxidation products that will form during backfilling and re-flooding of the lowermost waste rock.

This report, **F107108, Oxygen Transport and Alkalinity Addition - Flambeau Mine Pit Backfill**, has been prepared by,

STEFFEN ROBERTSON AND KIRSTEN (CANADA) INC.

Daryl Hockley, P.Eng.
Project Manager

R-124/lg

6.0 REFERENCES

Prickett, Thomas A. & Associates and Engineering Technologies Associates, Inc., 1996 Flambeau Mine Groundwater Model.

Pantelis, G. and Ritchie, A.I.M., 1991a. Macroscopie Transport Mechanisms as a Rate-Limiting Factor in Dump Leaching of Pyritic Ores. Appl. Math. Modelling 15, 136-143.

Collin M. , 1987. Mathmatical Modelling of Water and Oxygen Transport in Layered Soil Covers for Depsoits of Pyritic Mine Tailings (Ph.D. Thesis). Royal Institue of Technology Department of Chemical Engineering S-100 44, 1-189.

Massmann J. and Farrier, D.F., 1992. Effects of Atmospheric Pressures on Gas Transport in the Vadose Zone. Water Resources Research, Vol. 28, No. 3, 777-791.

Gelinas, P. et al, 1994. Monitoring and Modeling of Acid Mine Drianage from Waste Rocks Dumps, La Mine Doyon Case Study.

Harries, J.R. and Richie A.I.M., 1981. The Use of Temperature Profiles to Estimate the Pyritic Oxidation Rate in a Waste Rock Dump from an Open-Cut Mine. Water Air Soil Pollution, 405-423.

Ritchie, A.I.M., 1994. Sulfide Oxidation Mechanisms - Controls and Rates of Oxygen Transport. In "The Environmental Geochemistry of Sulfide Mine Wastes", D.A. Blowes & J.L Jambor, Eds., CANMET, 1994.

Cussler E.L., 1984. Diffusion: Mass Transfer in Fluid Systems. Cambridge University Press.

Nicholson R.V. et al, 1989. Reduction of Acid Generation in Mine Tailings Through the Use of Moisture-Retaining Cover Layers as Oxygen Barriers. Canadian Geotechical Journal No. 26, 1-8 (1989).

Steffen, Robertson and Kirsten (Canada) Inc., 1996a. Final Report - Investigation of Methods for In Situ Remediation of Nordhalde and Innenkippe, Report W104203 for Wismut GmbH.

Steffen, Robertson and Kirsten (Canada) Inc., 1996b. Geochemical Modelling of Halde Beerwalde and Halde Drosen, Report W104207 for Wismut GmbH.

TABLES

TABLE 3.1
Summary of Sensitivity Runs, Input Parameters and Results

Run	Description	D_{till}	D_{waste}	r_{waste1}	r_{waste2}	O_2 Flux	O_2 Penetration Depth (pit)		O_2 Penetration Depth (waste rock)	
		(m^2s^{-1})	(m^2s^{-1})	(s^{-1})	(s^{-1})	(mol $m^{-2}s^{-1}$)	(m)	(ft)	(m)	(ft)
Sens1b	low D, low r	2.00E-06	2.00E-06	0.0	8.90E-08	1.17E-06	15.2	50	8.5	28
Sens1a	low D, high r	2.00E-06	2.00E-06	0.0	1.30E-06	1.53E-06	13.7	45	7.0	23
Sens1c	high D, low r	6.00E-06	6.00E-06	0.0	8.90E-08	2.86E-06	21.3	70	14.6	48
Sens1d	high D, high r	6.00E-06	6.00E-06	0.0	1.30E-06	4.25E-06	18.3	60	11.6	38

TABLE 3.2
Input Parameters and Model Outputs for Simulations of Backfilling Period

Run	Description	D_{waste}	r_{waste2}	O_2 Flux	O_2 Penetration Depth (waste rock)	
		($m^2 s^{-1}$)	(s^{-1})	(mol $m^{-2} s^{-1}$)	(m)	(ft)
Pred3b	low D, low r	2.00E-06	8.90E-08	3.71E-06	9.8	32.2
Pred3a	low D, high r	2.00E-06	1.30E-06	1.26E-05	5.6	18.4
Pred3c	high D, low r	6.00E-06	8.90E-08	6.48E-06	16.8	55.2
Pred3d	high D, high r	6.00E-06	1.30E-06	2.37E-05	9.8	32.2

TABLE 3.3
Input Parameters and Model Outputs for Simulation of Re-Flooding Period

Run	Description	D_{till} (m^2s^{-1})	D_{waste} (m^2s^{-1})	r_{waste1} (s^{-1})	r_{waste2} (s^{-1})	O_2 Flux $(mol\ m^{-2}s^{-1})$	O_2 Penetration Depth (pit)		O_2 Penetration Depth (waste rock)	
							(m)	(ft)	(m)	(ft)
Pred1c	dry cover, low r	2.00E-06	2.00E-06	0.0	8.90E-08	1.17E-06	15.3	50	8.5	28.0
Pred1d	dry cover, high r	2.00E-06	2.00E-06	0.0	1.30E-06	1.53E-06	13.7	45	7.0	23.0
Pred2c	wet cover, low r	5.00E-07	2.00E-06	0.0	8.90E-08	8.25E-07	13.7	45	7.0	23.0
Pred2d	wet cover, high r	5.00E-07	2.00E-06	0.0	1.30E-06	9.85E-07	13.7	45	7.0	23.0

FIGURES

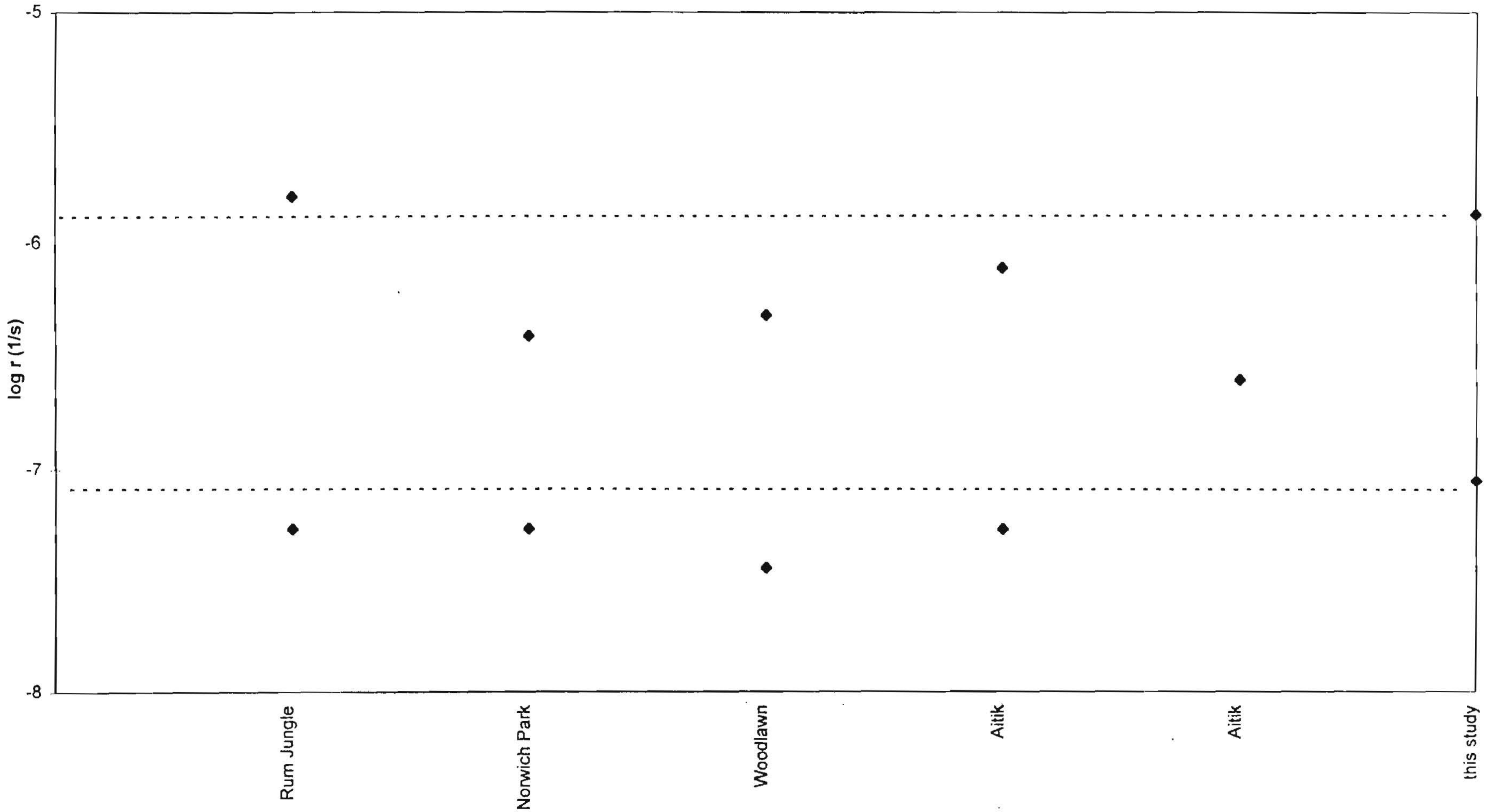


Figure 3.1. Reaction rate constants

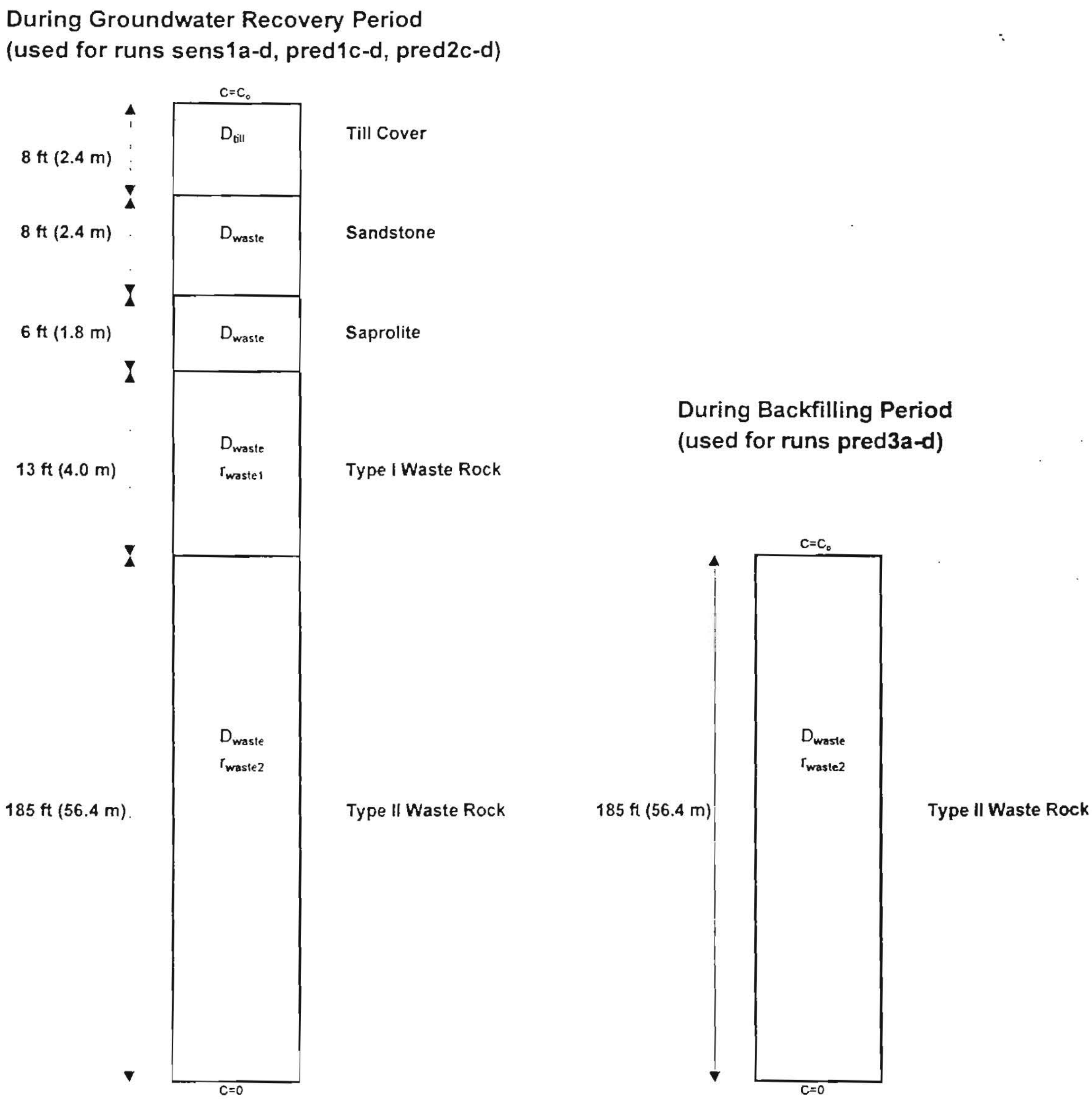


Figure 3.2 - Schematic of dimensions used for oxygen diffusion modeling

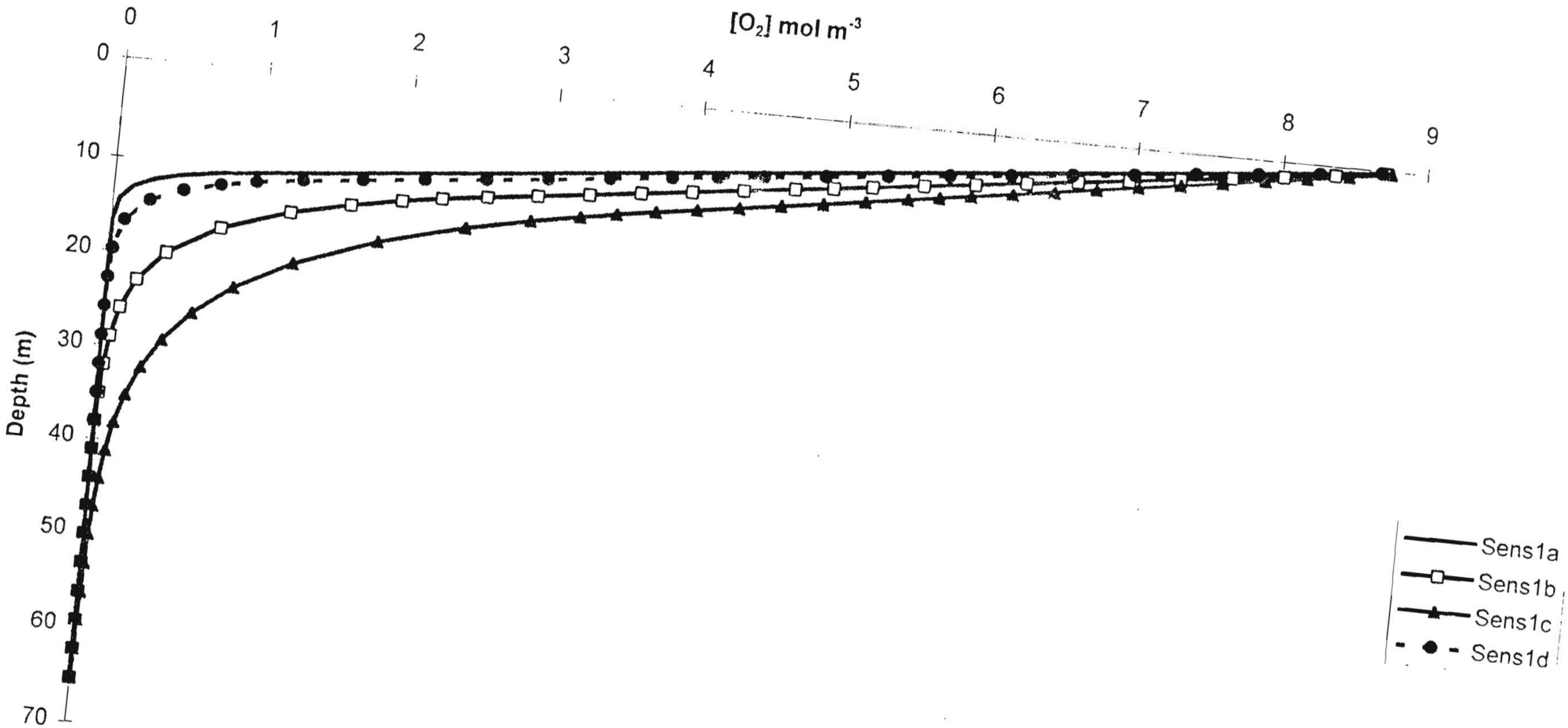


Figure 3.3 Oxygen concentration profiles from sensitivity analyses

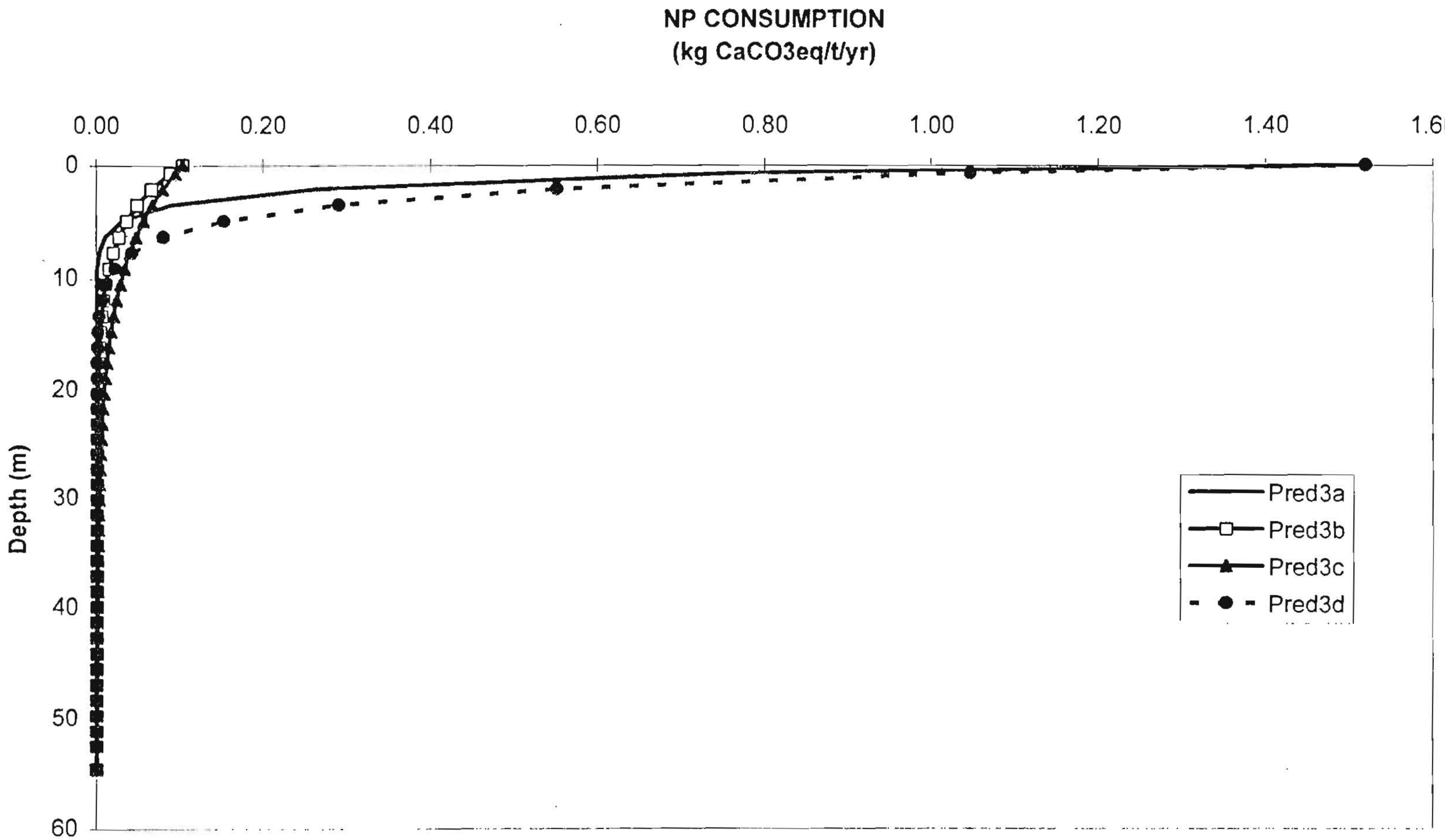


Figure 3.4 NP consumption profiles for backfilling period

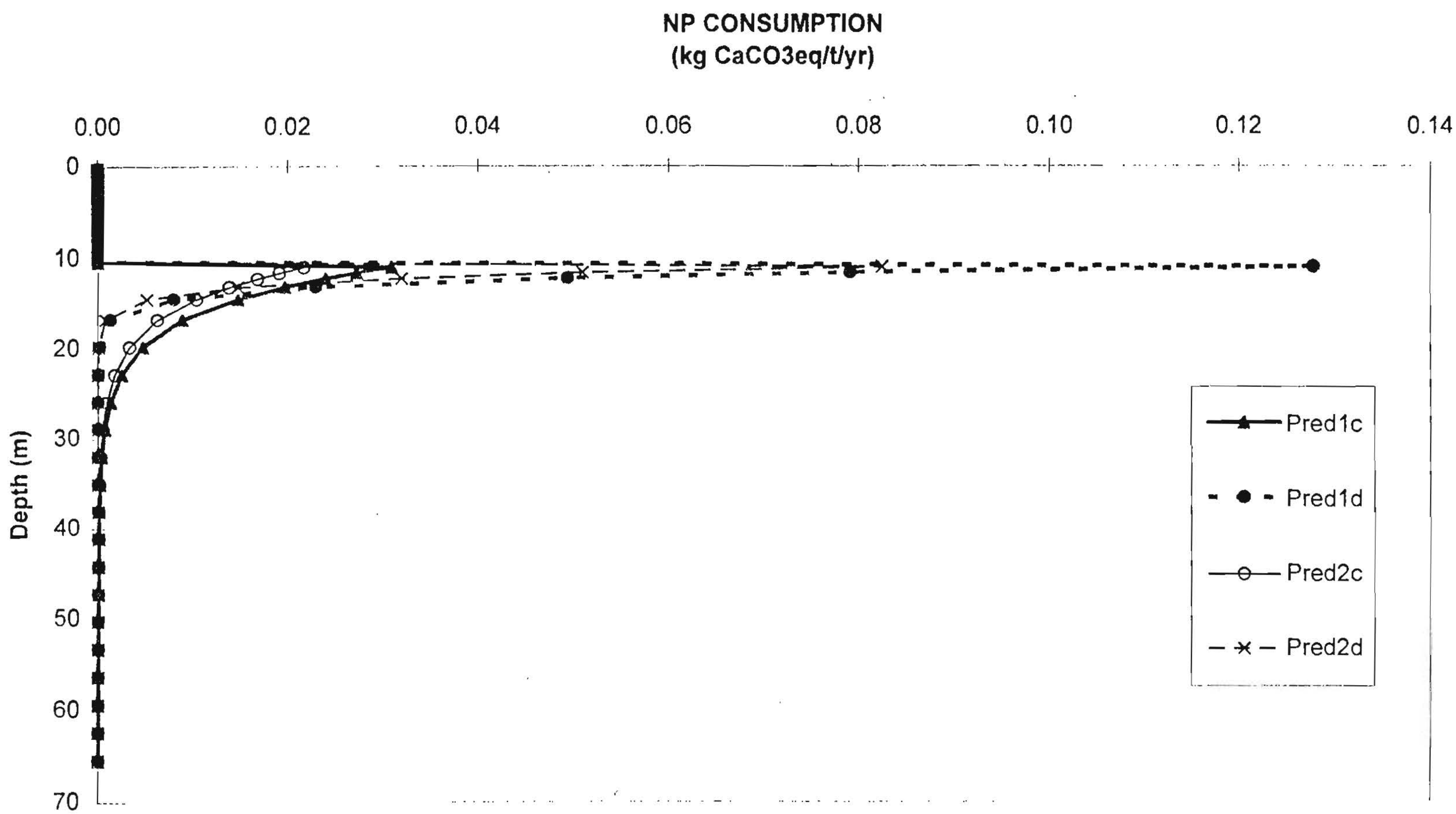
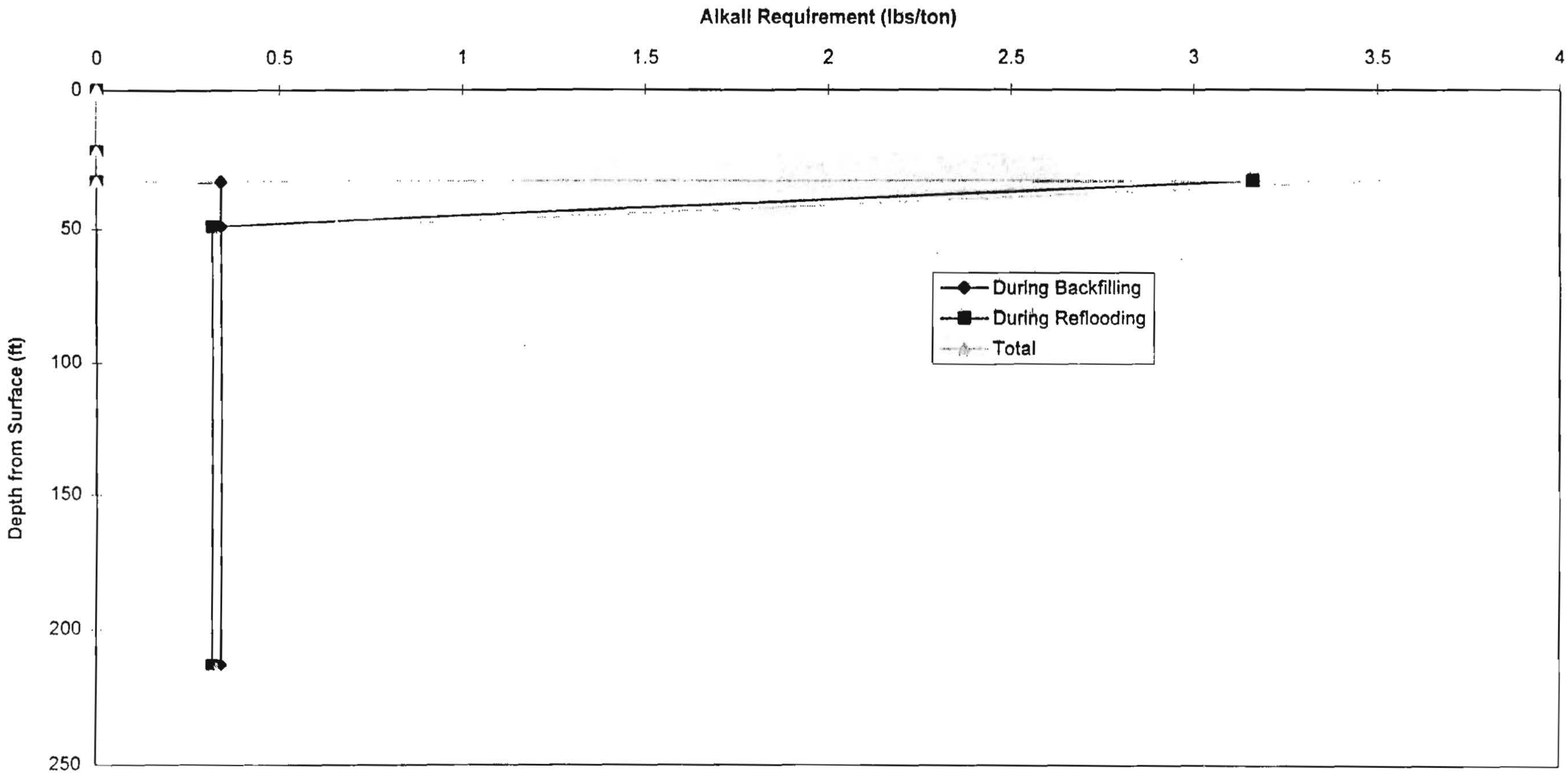


Figure 3.5 NP consumption profiles for groundwater recovery period



33

Figure 4.1 Alkalinity requirement vs. depth in backfilled waste rock

APPENDIX A

MODEL OUTPUTS

COUPLED O_2/CO_2/Mg/SO_4/Ca MODEL

MODEL DETAILS

Filename	sens1a.xls
Date	7/26/96
Description:	Flambeau Mining Co.
	Case 1 (backfilled pit - final design) - Sensitivity Run
	D_{till} (m^2s^{-1}) 2.00E-06
	D_{waste} (m^2s^{-1}) 2.00E-06
	r_{waste1} (s^{-1}) 0.00E+00
	r_{waste2} (s^{-1}) 1.30E-06

INPUT PARAMETERS

Finite Difference Parameters	
nodes x	1
nodes y	40
time periods	1
init delt (s)	0.01
[O2] at surface (mol/m³)	8.9
[CO2] at surface (mol/m³))	0.0141
Model Options	
CO2 OPTION	0
FES2 OPTION	0
O2 OPTION	1
Geochemical Options	
Precipitation (m/s)	1.10E-09 (62 mm / year)
Infiltration Coefficient	1.00
Kgypsum	-
Infiltration (m/s)	1.10E-09 = recharge * infiltration coefficient
Fraction Flow Paths (G)	0.10
Diffusion Parameters	
Dw (m2/s)	2.20E-09
Da (m2/s)	1.80E-05
τ	0.273
α	3.28
H	33.9

OUTPUT TIMES

time (s)	time (y)	Output col
3.5E+08	11	1
0.0E+00		6
0.0E+00		11
0.0E+00		16
0.0E+00		21
0.0E+00		26
0.0E+00		31

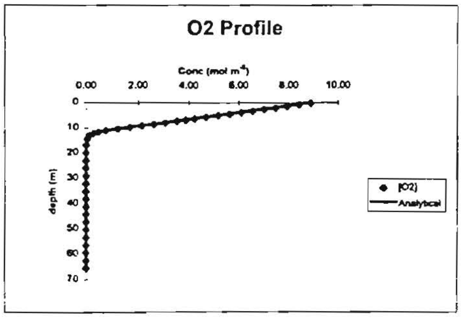
FES2 OPTION
0 - No FES2 DEPLETION
1 - ALLOW FES2 DEPLETION

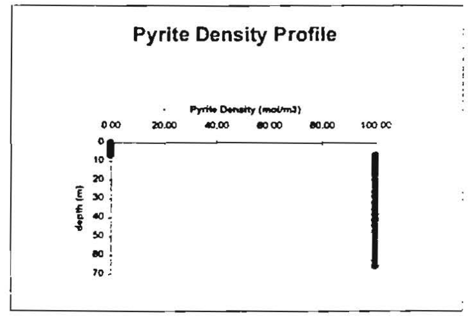
CO2 OPTION:
0 - No CO2 Coupling
1 - CO2 Coupling

O2 OPTION
0 - HALF ORDER REACTION
1 - FIRST ORDER REACTION
2 - MIXED FIRST ORDER / HALF ORDER

MODEL INPUTS										
Material	DEPTH (m)	Cell Sizes (m)	r (s-1)	Porosity (%)	Saturation (%)	F	SulfDens (mol/m³)	Diff Coeff (m2/s)	$[O_2]$ (mol/m³)	$[CO_2]$ (mol/m³)
Till	0.305	0.6096	0	17%	0%	-	0	2.00E-06	8.89	1.41E-02
Till	0.914	0.6096	0	17%	0%	-	0	2.00E-06	0.00	0.00E+00
Till	1.524	0.6096	0	17%	0%	-	0	2.00E-06	0.00	0.00E+00
Till	2.134	0.6096	0	17%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	2.743	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	3.353	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	3.962	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	4.572	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	5.182	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	5.791	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	6.401	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	6.858	0.3048	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	7.315	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	7.925	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	8.534	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	9.144	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	9.754	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	10.363	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	10.973	0.6096	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	11.582	0.6096	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	12.192	0.6096	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	13.106	1.2192	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	14.478	1.524	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	16.764	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	19.812	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	22.860	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	25.908	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	28.956	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	32.004	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	35.052	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	38.100	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	41.148	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	44.196	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	47.244	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	50.292	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	53.340	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	56.388	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	59.436	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	62.484	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	65.532	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00

RESULTS FOR YEAR: 11





Flux in (mol/m²s)	1.53E-06
O_2 cons. (mol/m²s)	1.40E-06
Dpen (m)	13.716

t=11													
DEPTH (m)	CONC O2 (mol/m³)	O2 Cons (mol/m³s)	CO2 Prod (mol/m³s)	CONC CO2 (mol/m³)	mols O2 cons per m3 rock	NP consmptn kg CaCO3eq/t/yr	SO4 (mol/L)	Ca (mol/L)	Mg (mg/L)	SO4 (mg/L)	Ca (mg/L)	Sulf dens mol/m³
0.305	8.890	0.00E+00	0.00E+00	0.0141	0.00E+00	0.00E+00						0.00
0.914	8.425	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
1.524	7.959	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
2.134	7.494	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
2.743	7.029	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
3.353	6.563	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
3.962	6.098	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
4.572	5.633	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
5.182	5.168	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
5.791	4.702	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
6.401	4.237	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
6.858	3.888	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
7.315	3.539	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
7.925	3.074	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
8.534	2.608	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
9.144	2.143	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
9.754	1.678	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
10.363	1.212	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
10.973	0.747	9.71E-07	-5.18E-07	0.0000	1.46E-07	1.28E-01						100.00
11.582	0.462	6.01E-07	-3.20E-07	0.0000	9.01E-08	7.90E-02						100.00
12.192	0.289	3.76E-07	-2.00E-07	0.0000	5.64E-08	4.94E-02						100.00
13.106	0.134	1.74E-07	-9.28E-08	0.0000	2.61E-08	2.29E-02						100.00
14.478	0.047	6.08E-08	-3.24E-08	0.0000	9.12E-09	8.00E-03						100.00
16.764	0.008	9.84E-09	-5.25E-09	0.0000	1.48E-09	1.29E-03						100.00
19.812	0.001	1.24E-09	-6.63E-10	0.0000	1.86E-10	1.63E-04						100.00
22.860	0.000	1.57E-10	-8.38E-11	0.0000	2.36E-11	2.07E-05						100.00
25.908	0.000	1.99E-11	-1.06E-11	0.0000	2.98E-12	2.61E-06						100.00
28.956	0.000	2.51E-12	-1.34E-12	0.0000	3.76E-13	3.30E-07						100.00
32.004	0.000	3.17E-13	-1.69E-13	0.0000	4.76E-14	4.17E-08						100.00
35.052	0.000	4.01E-14	-2.14E-14	0.0000	6.01E-15	5.27E-09						100.00
38.100	0.000	5.07E-15	-2.70E-15	0.0000	7.60E-16	6.66E-10						100.00
41.148	0.000	6.41E-16	-3.42E-16	0.0000	9.62E-17	8.43E-11						100.00
44.196	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
47.244	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
50.292	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
53.340	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
56.388	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
59.436	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
62.484	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
65.532	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00

COUPLED O_2/CO_2/Mg/SO_4/Ca MODEL

MODEL DETAILS

Filename	sens1b.xls	
Date	7/26/96	
Description:	Flambeau Mining Co.	
	Case 1 (backfilled pit - final design) - Sensitivity Run	
	D_{till} (m^2s^{-1})	2.00E-06
	D_{waste} (m^2s^{-1})	2.00E-06
	r_{waste1} (s^{-1})	0.00E+00
	r_{waste2} (s^{-1})	8.90E-08

INPUT PARAMETERS

Finite Difference Parameters		
nodes x	1	
nodes y	40	
time periods	1	
init delt (s)	0.01	
[O2] at surface (mol/m³)	8.9	
[CO2] at surface (mol/m³))	0.0141	
Model Options		
CO2 OPTION	0	
FES2 OPTION	0	
O2 OPTION	1	
Geochemical Options		
Precipiation (m/s)	1.10E-09	(62 mm / year)
Infiltration Coefficient	1.00	
Kgypsum	-	
Infiltration (m/s)	1.10E-09	= recharge * infiltration coefficient
Fraction Flow Paths (G)	0.10	
Diffusion Parameters		
Dw (m2/s)	2.20E-09	
Da (m2/s)	1.80E-05	
τ	0.273	
α	3.28	
H	33.9	

OUTPUT TIMES

time (s)	time (y)	Output col
3.5E+08	11	1
0.0E+00		6
0.0E+00		11
0.0E+00		16
0.0E+00		21
0.0E+00		26
0.0E+00		31

FES2 OPTION
0 - No FES2 DEPLETION
1 - ALLOW FES2 DEPLETION

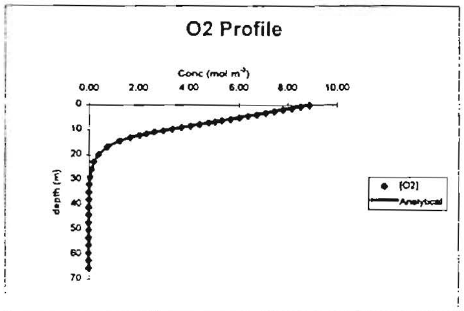
CO2 OPTION:
0 - No CO2 Coupling
1 - CO2 Coupling

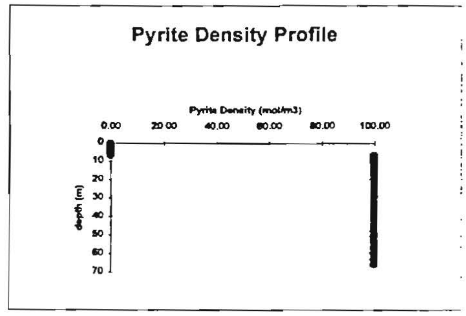
O2 OPTION
0 - HALF ORDER REACTION
1 - FIRST ORDER REACTION
2 - MIXED FIRST ORDER / HALF ORDER

MODEL INPUTS

Material	DEPTH (m)	Cell Sizes (m)	r (s-1)	Porosity (%)	Saturation (%)	F	SulfDens (mol/m³)	Diff Coeff (m2/s)	[O_2]$_{init}$ (mol/m³)	[CO_2]$_{init}$ (mol/m³)
Till	0.305	0.6096	0	17%	0%	-	0	2.00E-06	8.89	1.41E-02
Till	0.914	0.6096	0	17%	0%	-	0	2.00E-06	0.00	0.00E+00
Till	1.524	0.6096	0	17%	0%	-	0	2.00E-06	0.00	0.00E+00
Till	2.134	0.6096	0	17%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	2.743	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	3.353	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	3.962	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	4.572	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	5.182	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	5.791	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	6.401	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	6.858	0.3048	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	7.315	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	7.925	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	8.534	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	9.144	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	9.754	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	10.363	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	10.973	0.6096	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	11.582	0.6096	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	12.192	0.6096	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	13.106	1.2192	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	14.478	1.524	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	16.764	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	19.812	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	22.860	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	25.908	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	28.956	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	32.004	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	35.052	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	38.100	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	41.148	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	44.196	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	47.244	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	50.292	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	53.340	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	56.388	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	59.436	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	62.484	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	65.532	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00

RESULTS FOR YEAR: 11





Flux In (mol/m²s)	1.17E-06
O_2 cons. (mol/m²s)	7.33E-07
Dpen (m)	15.24

t=11												
DEPTH (m)	CONC O2 (mol/m³)	O2 Cons (mol/m³s)	CO2 Prod (mol/m³s)	CONC CO2 (mol/m³)	mols O2 cons per m3 rock	NP consmptn kg CaCO3eq/t/yr	SO4 (mol/L)	Ca (mol/L)	Mg (mg/L)	SO4 (mg/L)	Ca (mg/L)	Sulf dens mol/m³
0.305	8.890	0.00E+00	0.00E+00	0.0141	0.00E+00	0.00E+00						0.00
0.914	8.532	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
1.524	8.175	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
2.134	7.817	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
2.743	7.460	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
3.353	7.102	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
3.962	6.745	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
4.572	6.387	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
5.182	6.030	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
5.791	5.672	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
6.401	5.315	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
6.858	5.047	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
7.315	4.779	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
7.925	4.421	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
8.534	4.064	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
9.144	3.706	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
9.754	3.349	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
10.363	2.991	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
10.973	2.633	2.34E-07	-1.25E-07	0.0000	3.52E-08	3.08E-02						100.00
11.582	2.320	2.06E-07	-1.10E-07	0.0000	3.10E-08	2.71E-02						100.00
12.192	2.044	1.82E-07	-9.70E-08	0.0000	2.73E-08	2.39E-02						100.00
13.106	1.681	1.50E-07	-7.98E-08	0.0000	2.24E-08	1.97E-02						100.00
14.476	1.262	1.12E-07	-5.99E-08	0.0000	1.69E-08	1.48E-02						100.00
16.764	0.760	6.76E-08	-3.61E-08	0.0000	1.01E-08	8.89E-03						100.00
19.812	0.404	3.59E-08	-1.92E-08	0.0000	5.39E-09	4.72E-03						100.00
22.860	0.214	1.91E-08	-1.02E-08	0.0000	2.86E-09	2.51E-03						100.00
25.908	0.114	1.01E-08	-5.41E-09	0.0000	1.52E-09	1.33E-03						100.00
28.956	0.061	5.39E-09	-2.87E-09	0.0000	8.08E-10	7.09E-04						100.00
32.004	0.032	2.86E-09	-1.53E-09	0.0000	4.29E-10	3.76E-04						100.00
35.052	0.017	1.52E-09	-8.11E-10	0.0000	2.28E-10	2.00E-04						100.00
38.100	0.009	8.08E-10	-4.31E-10	0.0000	1.21E-10	1.06E-04						100.00
41.148	0.005	4.29E-10	-2.29E-10	0.0000	6.44E-11	5.65E-05						100.00
44.196	0.003	2.28E-10	-1.22E-10	0.0000	3.42E-11	3.00E-05						100.00
47.244	0.001	1.21E-10	-6.47E-11	0.0000	1.82E-11	1.59E-05						100.00
50.292	0.001	6.45E-11	-3.44E-11	0.0000	9.67E-12	8.48E-06						100.00
53.340	0.000	3.43E-11	-1.83E-11	0.0000	5.15E-12	4.52E-06						100.00
56.388	0.000	1.84E-11	-9.81E-12	0.0000	2.76E-12	2.42E-06						100.00
59.436	0.000	1.01E-11	-5.37E-12	0.0000	1.51E-12	1.32E-06						100.00
62.484	0.000	5.90E-12	-3.15E-12	0.0000	8.85E-13	7.76E-07						100.00
65.532	0.000	4.18E-12	-2.23E-12	0.0000	6.26E-13	5.49E-07						100.00

COUPLED $O_2/CO_2/Mg/SO_4/Ca$ MODEL

MODEL DETAILS

Filename	sens1c.xls
Date	7/26/96
Description:	Flambeau Mining Co.
	Case 1 (backfilled pit - final design) - Sensitivity Run
	D_{till} (m^2s^{-1}) 6.00E-06
	D_{waste} (m^2s^{-1}) 6.00E-06
	r_{waste1} (s^{-1}) 0.00E+00
	r_{waste2} (s^{-1}) 8.90E-08

INPUT PARAMETERS

Finite Difference Parameters

nodes x	1
nodes y	40
time periods	1
init delt (s)	0.01
[O2] at surface (mol/m³)	8.9
[CO2] at surface (mol/m³))	0.0141

Model Options

CO2 OPTION	0
FES2 OPTION	0
O2 OPTION	1

Geochemical Options

Precipiation (m/s)	1.10E-09	(62 mm / year)
Infiltration Coefficient	1.00	
Kgypsum	-	
Infiltration (m/s)	1.10E-09	= recharge * infiltration coefficient
Fraction Flow Paths (G)	0.10	

Diffusion Parameters

Dw (m2/s)	2.20E-09
Da (m2/s)	1.80E-05
τ	0.273
α	3.28
H	33.9

OUTPUT TIMES

time (s)	time (y)	Output col
3.5E+08	11	1
0.0E+00		6
0.0E+00		11
0.0E+00		16
0.0E+00		21
0.0E+00		26
0.0E+00		31

FES2 OPTION
0 - No FES2 DEPLETION
1 - ALLOW FES2 DEPLETION

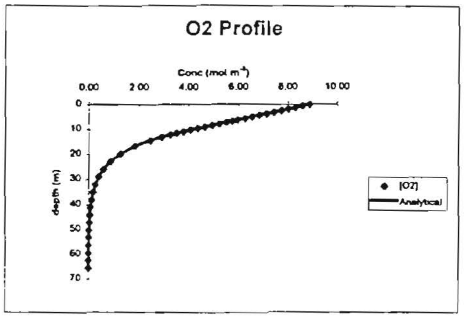
CO2 OPTION:
0 - No CO2 Coupling
1 - CO2 Coupling

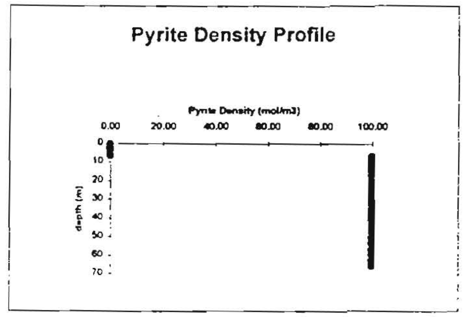
O2 OPTION
0 - HALF ORDER REACTION
1 - FIRST ORDER REACTION
2 - MIXED FIRST ORDER / HALF ORDER

MODEL INPUTS

Material	DEPTH (m)	Cell Sizes (m)	r (s-1)	Porosity (%)	Saturation (%)	F	SulfDens (mol/m³)	Diff Coeff (m2/s)	$[O_2]_{init}$ (mol/m³)	$[CO_2]_{init}$ (mol/m³)
Till	0.305	0.6096	0	17%	0%	-	0	6.00E-06	8.89	1.41E-02
Till	0.914	0.6096	0	17%	0%	-	0	6.00E-06	0.00	0.00E+00
Till	1.524	0.6096	0	17%	0%	-	0	6.00E-06	0.00	0.00E+00
Till	2.134	0.6096	0	17%	0%	-	0	6.00E-06	0.00	0.00E+00
Sandstone	2.743	0.6096	0	16%	0%	-	0	6.00E-06	0.00	0.00E+00
Sandstone	3.353	0.6096	0	16%	0%	-	0	6.00E-06	0.00	0.00E+00
Sandstone	3.962	0.6096	0	16%	0%	-	0	6.00E-06	0.00	0.00E+00
Sandstone	4.572	0.6096	0	16%	0%	-	0	6.00E-06	0.00	0.00E+00
Saprolite	5.182	0.6096	0	22%	0%	-	0	6.00E-06	0.00	0.00E+00
Saprolite	5.791	0.6096	0	22%	0%	-	0	6.00E-06	0.00	0.00E+00
Saprolite	6.401	0.6096	0	22%	0%	-	0	6.00E-06	0.00	0.00E+00
Type I - Waste Rock	6.858	0.3048	0.00E+00	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type I - Waste Rock	7.315	0.6096	0.00E+00	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type I - Waste Rock	7.925	0.6096	0.00E+00	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type I - Waste Rock	8.534	0.6096	0.00E+00	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type I - Waste Rock	9.144	0.6096	0.00E+00	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type I - Waste Rock	9.754	0.6096	0.00E+00	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type I - Waste Rock	10.363	0.6096	0.00E+00	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	10.973	0.6096	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	11.582	0.6096	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	12.192	0.6096	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	13.106	1.2192	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	14.478	1.524	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	16.764	3.048	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	19.812	3.048	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	22.860	3.048	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	25.908	3.048	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	28.956	3.048	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	32.004	3.048	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	35.052	3.048	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	38.100	3.048	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	41.148	3.048	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	44.196	3.048	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	47.244	3.048	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	50.292	3.048	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	53.340	3.048	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	56.388	3.048	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	59.436	3.048	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	62.484	3.048	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	65.532	3.048	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00

RESULTS FOR YEAR: 11





Flux in (mol/m²s)	2.86E-06
O_2 cons. (mol/m³s)	2.08E-06
Dpen (m)	21.336

t=11													
DEPTH (m)	CONC O2 (mol/m³)	O2 Cons (mol/m³s)	CO2 Prod (mol/m³s)	CONC CO2 (mol/m³)	mols O2 cons per m3 rock	NP consmptn kg CaCO3eq/t/yr	SO4 (mol/L)	Ca (mol/L)	Mg (mg/L)	SO4 (mg/L)	Ca (mg/L)	Sulf dens mol/m³
0.305	8.890	0.00E+00	0.00E+00	0.0141	0.00E+00	0.00E+00						0.00
0.914	8.599	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
1.524	8.308	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
2.134	8.017	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
2.743	7.726	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
3.353	7.436	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
3.962	7.145	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
4.572	6.854	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
5.182	6.563	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
5.791	6.272	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
6.401	5.981	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
6.858	5.763	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
7.315	5.545	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
7.925	5.254	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
8.534	4.963	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
9.144	4.672	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
9.754	4.381	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
10.363	4.090	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
10.973	3.800	3.38E-07	-1.80E-07	0.0000	5.07E-08	4.45E-02						100.00
11.582	3.530	3.14E-07	-1.68E-07	0.0000	4.71E-08	4.13E-02						100.00
12.192	3.279	2.92E-07	-1.56E-07	0.0000	4.38E-08	3.84E-02						100.00
13.106	2.931	2.61E-07	-1.39E-07	0.0000	3.91E-08	3.43E-02						100.00
14.478	2.480	2.21E-07	-1.18E-07	0.0000	3.31E-08	2.90E-02						100.00
16.764	1.858	1.65E-07	-8.82E-08	0.0000	2.48E-08	2.17E-02						100.00
19.812	1.285	1.14E-07	-6.10E-08	0.0000	1.71E-08	1.50E-02						100.00
22.860	0.888	7.90E-08	-4.22E-08	0.0000	1.19E-08	1.04E-02						100.00
25.908	0.614	5.46E-08	-2.91E-08	0.0000	8.20E-09	7.19E-03						100.00
28.956	0.425	3.78E-08	-2.01E-08	0.0000	5.67E-09	4.97E-03						100.00
32.004	0.294	2.61E-08	-1.39E-08	0.0000	3.92E-09	3.43E-03						100.00
35.052	0.203	1.81E-08	-9.63E-09	0.0000	2.71E-09	2.38E-03						100.00
38.100	0.140	1.25E-08	-6.66E-09	0.0000	1.87E-09	1.64E-03						100.00
41.148	0.097	8.65E-09	-4.61E-09	0.0000	1.30E-09	1.14E-03						100.00
44.196	0.067	5.99E-09	-3.19E-09	0.0000	8.98E-10	7.88E-04						100.00
47.244	0.047	4.16E-09	-2.22E-09	0.0000	6.24E-10	5.47E-04						100.00
50.292	0.033	2.90E-09	-1.55E-09	0.0000	4.35E-10	3.81E-04						100.00
53.340	0.023	2.04E-09	-1.09E-09	0.0000	3.06E-10	2.69E-04						100.00
56.388	0.016	1.47E-09	-7.82E-10	0.0000	2.20E-10	1.93E-04						100.00
59.436	0.012	1.09E-09	-5.82E-10	0.0000	1.64E-10	1.43E-04						100.00
62.484	0.010	8.67E-10	-4.62E-10	0.0000	1.30E-10	1.14E-04						100.00
65.532	0.009	7.62E-10	-4.06E-10	0.0000	1.14E-10	1.00E-04						100.00

COUPLED $O_2/CO_2/Mg/SO_4/Ca$ MODEL

MODEL DETAILS

Filename	sens1d.xls
Date	7/26/96
Description:	Flambeau Mining Co.
	Case 1 (backfilled pit - final design) - Sensitivity Run

D_{till} (m^2s^{-1})	6.00E-06
D_{waste} (m^2s^{-1})	6.00E-06
r_{waste1} (s^{-1})	0.00E+00
r_{waste2} (s^{-1})	1.30E-06

INPUT PARAMETERS

Finite Difference Parameters

nodes x	1	
nodes y	40	
time periods	1	
init delt (s)	0.01	
[O2] at surface (mol/m³)	8.9	
[CO2] at surface (mol/m³))	0.0141	
Model Options		
CO2 OPTION	0	
FES2 OPTION	0	
O2 OPTION	1	
Geochemical Options		
Precipitation (m/s)	1.10E-09	(62 mm / year)
Infiltration Coefficient	1.00	
Kgypsum	-	
Infiltration (m/s)	1.10E-09	= recharge * infiltration coefficient
Fraction Flow Paths (G)	0.10	
Diffusion Parameters		
Dw (m2/s)	2.20E-09	
Da (m2/s)	1.80E-05	
τ	0.273	
α	3.28	
H	33.9	

OUTPUT TIMES

time (s)	time (y)	Output col
3.5E+08	11	1
0.0E+00		6
0.0E+00		11
0.0E+00		16
0.0E+00		21
0.0E+00		26
0.0E+00		31

FES2 OPTION
0 - No FES2 DEPLETION
1 - ALLOW FES2 DEPLETION

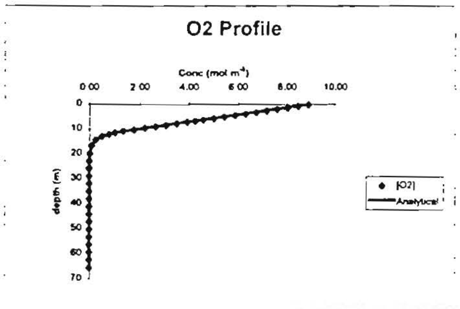
CO2 OPTION:
0 - No CO2 Coupling
1 - CO2 Coupling

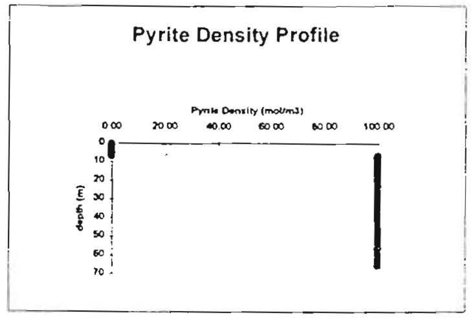
O2 OPTION
0 - HALF ORDER REACTION
1 - FIRST ORDER REACTION
2 - MIXED FIRST ORDER / HALF ORDER

MODEL INPUTS

Material	DEPTH (m)	Cell Sizes (m)	r (s-1)	Porosity (%)	Saturation (%)	F	SulfDens (mol/m³)	Diff Coeff (m2/s)	$[O_2]_{\infty}$ (mol/m³)	$[CO_2]_{\infty}$ (mol/m³)
Till	0.305	0.6096	0	17%	0%	-	0	6.00E-06	8.89	1.41E-02
Till	0.914	0.6096	0	17%	0%	-	0	6.00E-06	0.00	0.00E+00
Till	1.524	0.6096	0	17%	0%	-	0	6.00E-06	0.00	0.00E+00
Till	2.134	0.6096	0	17%	0%	-	0	6.00E-06	0.00	0.00E+00
Sandstone	2.743	0.6096	0	16%	0%	-	0	6.00E-06	0.00	0.00E+00
Sandstone	3.353	0.6096	0	16%	0%	-	0	6.00E-06	0.00	0.00E+00
Sandstone	3.962	0.6096	0	16%	0%	-	0	6.00E-06	0.00	0.00E+00
Sandstone	4.572	0.6096	0	16%	0%	-	0	6.00E-06	0.00	0.00E+00
Saprolite	5.182	0.6096	0	22%	0%	-	0	6.00E-06	0.00	0.00E+00
Saprolite	5.791	0.6096	0	22%	0%	-	0	6.00E-06	0.00	0.00E+00
Saprolite	6.401	0.6096	0	22%	0%	-	0	6.00E-06	0.00	0.00E+00
Type I - Waste Rock	6.858	0.3048	0.00E+00	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type I - Waste Rock	7.315	0.6096	0.00E+00	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type I - Waste Rock	7.925	0.6096	0.00E+00	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type I - Waste Rock	8.534	0.6096	0.00E+00	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type I - Waste Rock	9.144	0.6096	0.00E+00	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type I - Waste Rock	9.754	0.6096	0.00E+00	15%	0%	-	100	6 00E-06	0.00	0.00E+00
Type I - Waste Rock	10.363	0.6096	0.00E+00	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	10.973	0.6096	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	11.582	0.8096	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	12.192	0 6096	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	13.106	1.2192	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	14.478	1.524	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	16.764	3.048	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	19.812	3.048	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	22.860	3.048	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	25.908	3.048	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	28.956	3.048	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	32.004	3.048	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	35.052	3.048	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	38.100	3.048	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	41.148	3.048	1.30E-06	15%	0%	-	100	6 00E-06	0.00	0.00E+00
Type II - Waste Rock	44.196	3.048	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	47.244	3.048	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	50.292	3.048	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	53.340	3.048	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	56.388	3.048	1.30E-06	15%	0%	-	100	6 00E-06	0.00	0.00E+00
Type II - Waste Rock	59.436	3.048	1.30E-06	15%	0%	-	100	6 00E-06	0.00	0.00E+00
Type II - Waste Rock	62 484	3.048	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	65.532	3.048	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00

RESULTS FOR YEAR: 11





Flux in (mol/m²s)	4.25E-06
O_2 cons. (mol/m³s)	4.12E-06
Dpen (m)	18.288

t=11													
DEPTH (m)	CONC O2 (mol/m³)	O2 Cons (mol/m³s)	CO2 Prod (mol/m³s)	CONC CO2 (mol/m³)	mols O2 cons per m3 rock	NP consmptn kg CaCO3eq/t/yr	SO4 (mol/L)	Ca (mol/L)	Mg (mg/L)	SO4 (mg/L)	Ca (mg/L)	Sulf dens mol/m³
0.305	8.890	0.00E+00	0.00E+00	0.0141	0.00E+00	0.00E+00						0.00
0.914	8.458	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
1.524	8.026	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
2.134	7.595	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
2.743	7.163	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
3.353	6.731	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
3.962	6.299	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
4.572	5.868	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
5.182	5.436	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
5.791	5.004	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
6.401	4.572	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
6.858	4.249	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
7.315	3.925	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
7.925	3.493	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
8.534	3.061	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
9.144	2.630	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
9.754	2.198	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
10.363	1.766	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
10.973	1.334	1.73E-06	-9.25E-07	0.0000	2.60E-07	2.28E-01						100.00
11.582	1.010	1.31E-06	-7.00E-07	0.0000	1.97E-07	1.73E-01						100.00
12.192	0.767	9.97E-07	-5.32E-07	0.0000	1.50E-07	1.31E-01						100.00
13.106	0.495	6.44E-07	-3.43E-07	0.0000	9.65E-08	8.46E-02						100.00
14.478	0.267	3.47E-07	-1.85E-07	0.0000	5.20E-08	4.56E-02						100.00
16.764	0.087	1.13E-07	-6.04E-08	0.0000	1.70E-08	1.49E-02						100.00
19.812	0.023	3.02E-08	-1.61E-08	0.0000	4.54E-09	3.98E-03						100.00
22.860	0.006	8.07E-09	-4.31E-09	0.0000	1.21E-09	1.06E-03						100.00
25.908	0.002	2.16E-09	-1.15E-09	0.0000	3.23E-10	2.83E-04						100.00
28.956	0.000	5.75E-10	-3.07E-10	0.0000	8.63E-11	7.57E-05						100.00
32.004	0.000	1.54E-10	-8.19E-11	0.0000	2.30E-11	2.02E-05						100.00
35.052	0.000	4.10E-11	-2.19E-11	0.0000	6.15E-12	5.39E-06						100.00
38.100	0.000	1.09E-11	-5.84E-12	0.0000	1.64E-12	1.44E-06						100.00
41.148	0.000	2.92E-12	-1.56E-12	0.0000	4.38E-13	3.84E-07						100.00
44.196	0.000	7.80E-13	-4.16E-13	0.0000	1.17E-13	1.03E-07						100.00
47.244	0.000	2.08E-13	-1.11E-13	0.0000	3.12E-14	2.74E-08						100.00
50.292	0.000	5.56E-14	-2.97E-14	0.0000	8.34E-15	7.31E-09						100.00
53.340	0.000	1.48E-14	-7.92E-15	0.0000	2.23E-15	1.95E-09						100.00
56.388	0.000	3.96E-15	-2.11E-15	0.0000	5.94E-16	5.21E-10						100.00
59.436	0.000	1.06E-15	-5.65E-16	0.0000	1.59E-16	1.39E-10						100.00
62.484	0.000	2.89E-16	-1.54E-16	0.0000	4.33E-17	3.80E-11						100.00
65.532	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00

COUPLED O_2/CO_2/Mg/SO_4/Ca MODEL

MODEL DETAILS

Filename	PRED1c.XLS
Date	7/26/96
Description:	Flambeau Mining Co.
	Case 1 (backfilled pit - final design) - Predictive Run
D_{till} (m^2s^{-1})	2.00E-06
D_{waste} (m^2s^{-1})	2.00E-06
r_{waste1} (s^{-1})	0.00E+00
r_{waste2} (s^{-1})	8.90E-08

INPUT PARAMETERS

Finite Difference Parameters

nodes x	1
nodes y	40
time periods	1
init delt (s)	0.01
[O2] at surface (mol/m³)	8.9
[CO2] at surface (mol/m³))	0.0141

Model Options

CO2 OPTION	0
FES2 OPTION	0
O2 OPTION	1

Geochemical Options

Precipiation (m/s)	1.10E-09	(62 mm / year)
Infiltration Coefficient	1.00	
Kgypsum	-	
Infiltration (m/s)	1.10E-09	= recharge * infiltration coefficient
Fraction Flow Paths (G)	0.10	

Diffusion Parameters

Dw (m2/s)	2.20E-09
Da (m2/s)	1.80E-05
τ	0.273
α	3.28
H	33.9

OUTPUT TIMES

time (s)	time (y)	Output col
3.5E+08	11	1
0.0E+00		6
0.0E+00		11
0.0E+00		16
0.0E+00		21
0.0E+00		26
0.0E+00		31

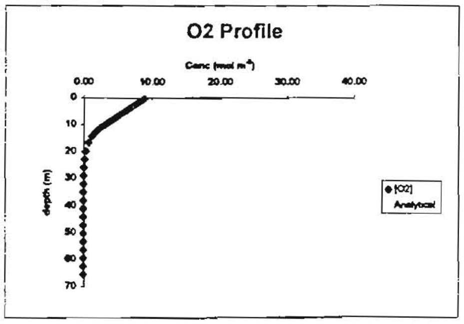
FES2 OPTION
0 - No FES2 DEPLETION
1 - ALLOW FES2 DEPLETION

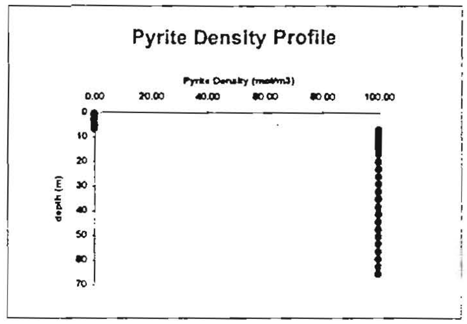
CO2 OPTION:
0 - No CO2 Coupling
1 - CO2 Coupling

O2 OPTION
0 - HALF ORDER REACTION
1 - FIRST ORDER REACTION
2 - MIXED FIRST ORDER / HALF ORDER

MODEL INPUTS										
Material	DEPTH (m)	Cell Sizes (m)	r (s-1)	Porosity (%)	Saturation (%)	F	SulfDens (mol/m³)	Diff Coeff (m2/s)	[O_2] (mol/m³)	[CO_2] (mol/m³)
Till	0.305	0.6096	0	17%	0%	-	0	2.00E-06	8.89	1.41E-02
Till	0.914	0.6096	0	17%	0%	-	0	2.00E-06	0.00	0.00E+00
Till	1.524	0.6096	0	17%	0%	-	0	2.00E-06	0.00	0.00E+00
Till	2.134	0.6096	0	17%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	2.743	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	3.353	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	3.962	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	4.572	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	5.182	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	5.791	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	6.401	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	6.858	0.3048	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	7.315	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	7.925	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	8.534	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	9.144	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	9.754	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	10.363	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	10.973	0.6096	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	11.582	0.6096	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	12.192	0.6096	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	13.106	1.2192	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	14.478	1.524	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	16.764	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	19.812	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	22.860	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	25.908	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	28.956	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	32.004	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	35.052	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	38.100	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	41.148	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	44.196	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	47.244	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	50.292	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	53.340	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	56.388	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	59.436	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	62.484	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	65.532	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00

RESULTS FOR YEAR: 11





Flux in (mol/m²s)	1.17E-06
O_2 cons. (mol/m³s)	1.17E-06
Dpen (m)	15.24

t=11												
DEPTH (m)	CONC O2 (mol/m³)	O2 Cons (mol/m³s)	CO2 Prod (mol/m³s)	CONC CO2 (mol/m³)	mols O2 cons per m3 rock	NP consmptn kg CaCO3eq/t/yr	SO4 (mol/L)	Ca (mol/L)	Mg (mg/L)	SO4 (mg/L)	Ca (mg/L)	Sulf dens mol/m³
0.305	8.890	0.00E+00	0.00E+00	0.0141	0.00E+00	0.00E+00						0.00
0.914	8.532	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
1.524	8.175	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
2.134	7.817	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
2.743	7.460	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
3.353	7.102	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
3.962	6.745	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
4.572	6.387	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
5.182	6.030	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
5.791	5.672	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
6.401	5.315	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
6.858	5.047	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
7.315	4.779	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
7.925	4.421	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
8.534	4.064	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
9.144	3.706	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
9.754	3.349	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
10.363	2.991	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
10.973	2.633	2.34E-07	-1.25E-07	0.0000	3.52E-08	3.08E-02						100.00
11.582	2.320	2.06E-07	-1.10E-07	0.0000	3.10E-08	2.71E-02						100.00
12.192	2.044	1.82E-07	-9.70E-08	0.0000	2.73E-08	2.39E-02						100.00
13.106	1.681	1.50E-07	-7.98E-08	0.0000	2.24E-08	1.97E-02						100.00
14.478	1.262	1.12E-07	-5.99E-08	0.0000	1.69E-08	1.48E-02						100.00
16.764	0.760	6.76E-08	-3.61E-08	0.0000	1.01E-08	8.89E-03						100.00
19.812	0.404	3.59E-08	-1.92E-08	0.0000	5.39E-09	4.72E-03						100.00
22.860	0.214	1.91E-08	-1.02E-08	0.0000	2.86E-09	2.51E-03						100.00
25.908	0.114	1.01E-08	-5.41E-09	0.0000	1.52E-09	1.33E-03						100.00
28.956	0.061	5.39E-09	-2.87E-09	0.0000	8.08E-10	7.09E-04						100.00
32.004	0.032	2.86E-09	-1.53E-09	0.0000	4.29E-10	3.76E-04						100.00
35.052	0.017	1.52E-09	-8.11E-10	0.0000	2.28E-10	2.00E-04						100.00
38.100	0.009	8.08E-10	-4.31E-10	0.0000	1.21E-10	1.06E-04						100.00
41.148	0.005	4.29E-10	-2.29E-10	0.0000	6.44E-11	5.65E-05						100.00
44.196	0.003	2.28E-10	-1.22E-10	0.0000	3.42E-11	3.00E-05						100.00
47.244	0.001	1.21E-10	-6.47E-11	0.0000	1.82E-11	1.59E-05						100.00
50.292	0.001	6.45E-11	-3.44E-11	0.0000	9.67E-12	8.48E-06						100.00
53.340	0.000	3.43E-11	-1.83E-11	0.0000	5.15E-12	4.52E-06						100.00
56.388	0.000	1.84E-11	-9.81E-12	0.0000	2.76E-12	2.42E-06						100.00
59.436	0.000	1.01E-11	-5.37E-12	0.0000	1.51E-12	1.32E-06						100.00
62.484	0.000	5.90E-12	-3.15E-12	0.0000	8.85E-13	7.76E-07						100.00
65.532	0.000	4.18E-12	-2.23E-12	0.0000	6.26E-13	5.49E-07						100.00

COUPLED $O_2/CO_2/Mg/SO_4/Ca$ MODEL

MODEL DETAILS

Filename	PRED1d.XLS
Date	7/26/96
Description:	Flambeau Mining Co.
	Case 1 (backfilled pit - final design) - Predictive Run
	D_{till} (m^2s^{-1}) 2.00E-06
	D_{waste} (m^2s^{-1}) 2.00E-06
	r_{waste1} (s^{-1}) 0.00E+00
	r_{waste2} (s^{-1}) 1.30E-06

INPUT PARAMETERS

Finite Difference Parameters	
nodes x	1
nodes y	40
time periods	1
init delt (s)	0.01
[O2] at surface (mol/m^3)	8.9
[CO2] at surface (mol/m^3))	0.0141
Model Options	
CO2 OPTION	0
FES2 OPTION	0
O2 OPTION	1
Geochemical Options	
Precipiation (m/s)	1.10E-09 (62 mm / year)
Infiltration Coefficient	1.00
Kgypsum	-
Infiltration (m/s)	1.10E-09 = recharge * infiltration coefficient
Fraction Flow Paths (G)	0.10
Diffusion Parameters	
Dw (m2/s)	2.20E-09
Da (m2/s)	1.80E-05
τ	0.273
α	3.28
H	33.9

OUTPUT TIMES

time (s)	time (y)	Output col
3.5E+08	11	1
0.0E+00		6
0.0E+00		11
0.0E+00		16
0.0E+00		21
0.0E+00		26
0.0E+00		31

FES2 OPTION
0 - No FES2 DEPLETION
1 - ALLOW FES2 DEPLETION

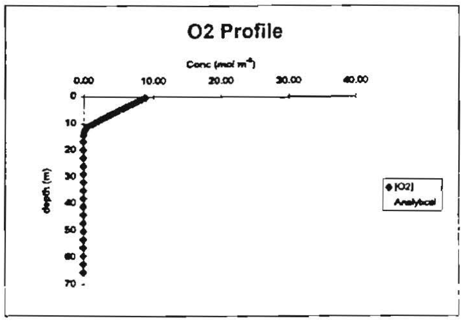
CO2 OPTION:
0 - No CO2 Coupling
1 - CO2 Coupling

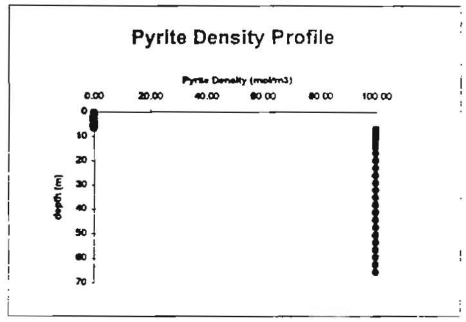
O2 OPTION
0 - HALF ORDER REACTION
1 - FIRST ORDER REACTION
2 - MIXED FIRST ORDER / HALF ORDER

MODEL INPUTS

Material	DEPTH (m)	Cell Sizes (m)	r (s-1)	Porosity (%)	Saturation (%)	F	SulfDens (mol/m^3)	Diff Coeff (m2/s)	$[O_{2,init}]$ (mol/m^3)	$[CO_{2,init}]$ (mol/m^3)
Till	0.305	0.6096	0	17%	0%	-	0	2.00E-06	8.89	1.41E-02
Till	0.914	0.6096	0	17%	0%	-	0	2.00E-06	0.00	0.00E+00
Till	1.524	0.6096	0	17%	0%	-	0	2.00E-06	0.00	0.00E+00
Till	2.134	0.6096	0	17%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	2.743	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	3.353	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	3.962	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	4.572	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	5.182	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	5.791	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	6.401	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	6.858	0.3048	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	7.315	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	7.925	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	8.534	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	9.144	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	9.754	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	10.363	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	10.973	0.6096	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	11.582	0.6096	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	12.192	0.6096	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	13.106	1.2192	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	14.478	1.524	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	16.764	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	19.812	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	22.860	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	25.908	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	28.956	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	32.004	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	35.052	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	38.100	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	41.148	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	44.196	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	47.244	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	50.292	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	53.340	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	56.388	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	59.436	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	62.484	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	65.532	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00

RESULTS FOR YEAR: 11





Flux in (mol/m²s)	1.53E-06
O_2 cons. (mol/m²s)	1.53E-06
Dpen (m)	13.716

t=11													
DEPTH (m)	CONC O2 (mol/m³)	O2 Cons (mol/m³s)	CO2 Prod (mol/m³s)	CONC CO2 (mol/m³)	mols O2 cons per m3 rock	NP consmptn kg CaCO3eq/t/yr	SO4 (mol/L)	Ca (mol/L)	Mg (mg/L)	SO4 (mg/L)	Ca (mg/L)	Sulf dens mol/m³
0.305	8.890	0.00E+00	0.00E+00	0.0141	0.00E+00	0.00E+00						0.00
0.914	8.425	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
1.524	7.959	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
2.134	7.494	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
2.743	7.029	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
3.353	6.563	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
3.962	6.098	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
4.572	5.633	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
5.182	5.168	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
5.791	4.702	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
6.401	4.237	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
6.858	3.888	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
7.315	3.539	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
7.925	3.074	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
8.534	2.608	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
9.144	2.143	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
9.754	1.678	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
10.363	1.212	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
10.973	0.747	9.71E-07	-5.18E-07	0.0000	1.46E-07	1.28E-01						100.00
11.582	0.462	6.01E-07	-3.20E-07	0.0000	9.01E-08	7.90E-02						100.00
12.192	0.289	3.76E-07	-2.00E-07	0.0000	5.64E-08	4.94E-02						100.00
13.106	0.134	1.74E-07	-9.28E-08	0.0000	2.61E-08	2.29E-02						100.00
14.478	0.047	6.08E-08	-3.24E-08	0.0000	9.12E-09	8.00E-03						100.00
16.764	0.008	9.84E-09	-5.25E-09	0.0000	1.48E-09	1.29E-03						100.00
19.812	0.001	1.24E-09	-6.63E-10	0.0000	1.86E-10	1.63E-04						100.00
22.860	0.000	1.57E-10	-8.38E-11	0.0000	2.36E-11	2.07E-05						100.00
25.908	0.000	1.99E-11	-1.06E-11	0.0000	2.98E-12	2.61E-06						100.00
28.956	0.000	2.51E-12	-1.34E-12	0.0000	3.76E-13	3.30E-07						100.00
32.004	0.000	3.17E-13	-1.69E-13	0.0000	4.76E-14	4.17E-08						100.00
35.052	0.000	4.01E-14	-2.14E-14	0.0000	6.01E-15	5.27E-09						100.00
38.100	0.000	5.07E-15	-2.70E-15	0.0000	7.60E-16	6.66E-10						100.00
41.148	0.000	6.41E-16	-3.42E-16	0.0000	9.62E-17	8.43E-11						100.00
44.196	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
47.244	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
50.292	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
53.340	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
56.388	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
59.436	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
62.484	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
65.532	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00

COUPLED O_2/CO_2/Mg/SO_4/Ca MODEL

MODEL DETAILS

Filename	PRED2c.XLS
Date	7/26/96
Description:	Flambeau Mining Co.
	Case 1 (backfilled pit - final design) - Predictive Run
	D_{till} (m^2s^{-1}) 5.00E-07
	D_{waste} (m^2s^{-1}) 2.00E-06
	r_{waste1} (s^{-1}) 0.00E+00
	r_{waste2} (s^{-1}) 8.90E-08

INPUT PARAMETERS

Finite Difference Parameters

nodes x	1
nodes y	40
time periods	1
init delt (s)	0.01
[O2] at surface (mol/m³)	8.9
[CO2] at surface (mol/m³))	0.0141

Model Options

CO2 OPTION	0
FES2 OPTION	0
O2 OPTION	1

Geochemical Options

Precipiation (m/s)	1.10E-09	(62 mm / year)
Infiltration Coefficient	1.00	
Kgypsum	-	
Infiltration (m/s)	1.10E-09	= recharge * infiltration coefficient
Fraction Flow Paths (G)	0.10	

Diffusion Parameters

Dw (m2/s)	2.20E-09
Da (m2/s)	1.80E-05
τ	0.273
α	3.28
H	33.9

OUTPUT TIMES

time (s)	time (y)	Output col
3.5E+08	11	1
0.0E+00		6
0.0E+00		11
0.0E+00		16
0.0E+00		21
0.0E+00		26
0.0E+00		31

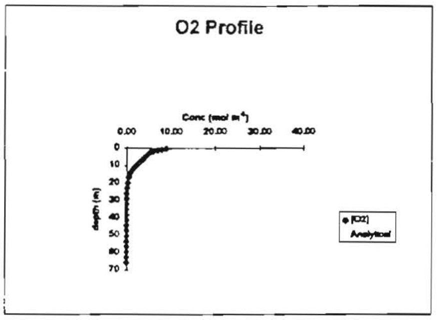
FES2 OPTION
0 - No FES2 DEPLETION
1 - ALLOW FES2 DEPLETION

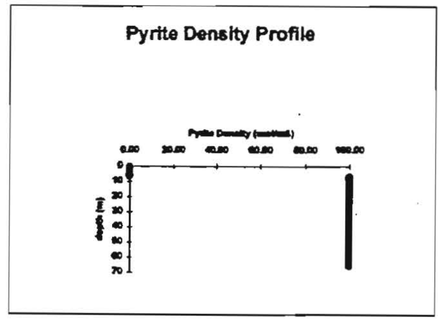
CO2 OPTION:
0 - No CO2 Coupling
1 - CO2 Coupling

O2 OPTION
0 - HALF ORDER REACTION
1 - FIRST ORDER REACTION
2 - MIXED FIRST ORDER / HALF ORDER

MODEL INPUTS										
Material	DEPTH (m)	Cell Sizes (m)	r (s-1)	Porosity (%)	Saturation (%)	F	SulfDens (mol/m³)	Diff Coeff (m2/s)	[O_2]$_{init}$ (mol/m³)	[CO_2]$_{init}$ (mol/m³)
Till	0.305	0.6096	0	17%	0%	-	0	5.00E-07	8.89	1.41E-02
Till	0.914	0.6096	0	17%	0%	-	0	5.00E-07	0.00	0.00E+00
Till	1.524	0.6096	0	17%	0%	-	0	5.00E-07	0.00	0.00E+00
Till	2.134	0.6096	0	17%	0%	-	0	5.00E-07	0.00	0.00E+00
Sandstone	2.743	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	3.353	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	3.962	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	4.572	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	5.182	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	5.791	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	6.401	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	6.858	0.3048	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	7.315	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	7.925	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	8.534	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	9.144	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	9.754	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	10.363	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	10.973	0.6096	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	11.582	0.6096	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	12.192	0.6096	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	13.106	1.2192	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	14.478	1.524	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	16.764	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	19.812	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	22.860	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	25.908	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	28.956	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	32.004	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	35.052	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	38.100	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	41.148	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	44.196	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	47.244	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	50.292	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	53.340	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	56.388	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	59.436	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	62.484	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	65.532	3.048	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00

RESULTS FOR YEAR: 11





Flux in (mol/m²s)	8.25E-07
O_2 cons. (mol/m³s)	8.25E-07
Dpen (m)	13.716

t=11												
DEPTH (m)	CONC O2 (mol/m³)	O2 Cons (mol/m³s)	CO2 Prod (mol/m³s)	CONC CO2 (mol/m³)	ols O2 con per m3 rock	P consmpt CaCO3eq/t	SO4 (mol/L)	Ca (mol/L)	Mg (mg/L)	SO4 (mg/L)	Ca (mg/L)	Sulf dens mol/m³
0.305	8.890	0.00E+00	0.00E+00	0.0141	0.00E+00	0.00E+00						0.00
0.914	7.885	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
1.524	6.879	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
2.134	5.874	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
2.743	5.245	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
3.353	4.994	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
3.962	4.742	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
4.572	4.491	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
5.182	4.240	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
5.791	3.988	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
6.401	3.737	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
6.858	3.548	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
7.315	3.360	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
7.925	3.108	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
8.534	2.857	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
9.144	2.606	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
9.754	2.354	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
10.363	2.103	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
10.973	1.852	1.65E-07	-8.79E-08	0.0000	2.47E-08	2.17E-02						100.00
11.582	1.631	1.45E-07	-7.74E-08	0.0000	2.18E-08	1.91E-02						100.00
12.192	1.437	1.28E-07	-6.82E-08	0.0000	1.92E-08	1.68E-02						100.00
13.106	1.182	1.05E-07	-5.61E-08	0.0000	1.58E-08	1.38E-02						100.00
14.478	0.887	7.90E-08	-4.21E-08	0.0000	1.18E-08	1.04E-02						100.00
16.764	0.534	4.75E-08	-2.54E-08	0.0000	7.13E-09	6.25E-03						100.00
19.812	0.284	2.53E-08	-1.35E-08	0.0000	3.79E-09	3.32E-03						100.00
22.860	0.151	1.34E-08	-7.16E-09	0.0000	2.01E-09	1.76E-03						100.00
25.908	0.080	7.13E-09	-3.80E-09	0.0000	1.07E-09	9.38E-04						100.00
28.956	0.043	3.79E-09	-2.02E-09	0.0000	5.68E-10	4.98E-04						100.00
32.004	0.023	2.01E-09	-1.07E-09	0.0000	3.02E-10	2.65E-04						100.00
35.052	0.012	1.07E-09	-5.70E-10	0.0000	1.60E-10	1.41E-04						100.00
38.100	0.006	5.68E-10	-3.03E-10	0.0000	8.52E-11	7.47E-05						100.00
41.148	0.003	3.02E-10	-1.61E-10	0.0000	4.53E-11	3.97E-05						100.00
44.196	0.002	1.60E-10	-8.56E-11	0.0000	2.41E-11	2.11E-05						100.00
47.244	0.001	8.53E-11	-4.55E-11	0.0000	1.28E-11	1.12E-05						100.00
50.292	0.001	4.53E-11	-2.42E-11	0.0000	6.80E-12	5.96E-06						100.00
53.340	0.000	2.41E-11	-1.29E-11	0.0000	3.62E-12	3.17E-06						100.00
56.388	0.000	1.29E-11	-6.90E-12	0.0000	1.94E-12	1.70E-06						100.00
59.436	0.000	7.08E-12	-3.78E-12	0.0000	1.06E-12	9.31E-07						100.00
62.484	0.000	4.15E-12	-2.21E-12	0.0000	6.23E-13	5.46E-07						100.00
65.532	0.000	2.94E-12	-1.57E-12	0.0000	4.40E-13	3.86E-07						100.00

COUPLED O_2/CO_2/Mg/SO_4/Ca MODEL

MODEL DETAILS

Filename: PRED2d.XLS
Date: 7/26/96
Description: Flambeau Mining Co.
Case 1 (backfilled pit - final design) - Predictive Run

D_{till} (m^2s^{-1}) 5.00E-07
D_{waste} (m^2s^{-1}) 2.00E-06
r_{waste1} (s^{-1}) 0.00E+00
r_{waste2} (s^{-1}) 1.30E-06

INPUT PARAMETERS

Finite Difference Parameters

nodes x	1
nodes y	40
time periods	1
init delt (s)	0.01
[O2] at surface (mol/m³)	8.9
[CO2] at surface (mol/m³))	0.0141

Model Options

CO2 OPTION	0
FES2 OPTION	0
O2 OPTION	1

Geochemical Options

Precipiation (m/s)	1.10E-09	(62 mm / year)
Infiltration Coefficient	1.00	
Kgypsum	-	
Infiltration (m/s)	1.10E-09	= recharge * infiltration coefficient
Fraction Flow Paths (G)	0.10	

Diffusion Parameters

Dw (m2/s)	2.20E-09
Da (m2/s)	1.80E-05
τ	0.273
α	3.28
H	33.9

OUTPUT TIMES

time (s)	time (y)	Output col
3.5E+08	11	1
0.0E+00		6
0.0E+00		11
0.0E+00		16
0.0E+00		21
0.0E+00		26
0.0E+00		31

FES2 OPTION
0 - No FES2 DEPLETION
1 - ALLOW FES2 DEPLETION

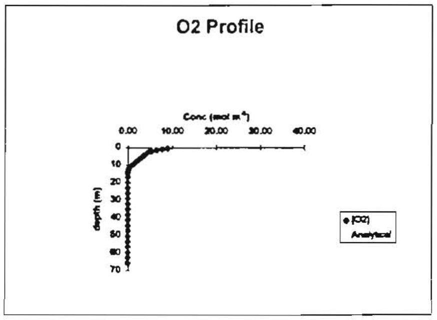
CO2 OPTION:
0 - No CO2 Coupling
1 - CO2 Coupling

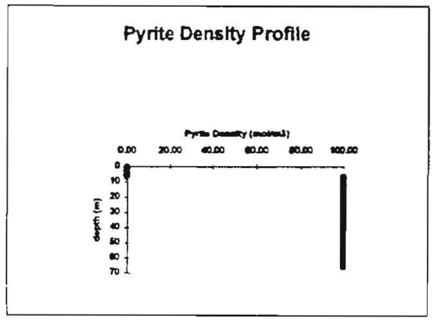
O2 OPTION
0 - HALF ORDER REACTION
1 - FIRST ORDER REACTION
2 - MIXED FIRST ORDER / HALF ORDER

MODEL INPUTS

Material	DEPTH (m)	Cell Sizes (m)	r (s-1)	Porosity (%)	Saturation (%)	F	SulfDens (mol/m³)	Diff Coeff (m2/s)	$[O_2]$ (mol/m³)	$[CO_2]$ (mol/m³)
Till	0.305	0.6096	0	17%	0%	-	0	5.00E-07	8.89	1.41E-02
Till	0.914	0.6096	0	17%	0%	-	0	5.00E-07	0.00	0.00E+00
Till	1.524	0.6096	0	17%	0%	-	0	5.00E-07	0.00	0.00E+00
Till	2.134	0.6096	0	17%	0%	-	0	5.00E-07	0.00	0.00E+00
Sandstone	2.743	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	3.353	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	3.962	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Sandstone	4.572	0.6096	0	16%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	5.182	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	5.791	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Saprolite	6.401	0.6096	0	22%	0%	-	0	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	6.858	0.3048	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	7.315	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	7.925	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	8.534	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	9.144	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	9.754	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type I - Waste Rock	10.363	0.6096	0.00E+00	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	10.973	0.6096	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	11.582	0.6096	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	12.192	0.6096	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	13.106	1.2192	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	14.478	1.524	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	16.764	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	19.812	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	22.860	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	25.908	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	28.956	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	32.004	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	35.052	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	38.100	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	41.148	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	44.196	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	47.244	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	50.292	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	53.340	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	56.388	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	59.436	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	62.484	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	65.532	3.048	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00

RESULTS FOR YEAR: 11





Flux in (mol/m²s)	9.85E-07
O_2 cons. (mol/m²s)	9.85E-07
Dpen (m)	13.716

t=11												
DEPTH (m)	CONC O2 (mol/m³)	O2 Cons (mol/m³s)	CO2 Prod (mol/m³s)	CONC CO2 (mol/m³)	ols O2 con per m3 rock	P consmpt CaCO3eq/t	SO4 (mol/L)	Ca (mol/L)	Mg (mg/L)	SO4 (mg/L)	Ca (mg/L)	Sulf dens mol/m³
0.305	8.890	0.00E+00	0.00E+00	0.0141	0.00E+00	0.00E+00						0.00
0.914	7.689	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
1.524	6.488	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
2.134	5.287	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
2.743	4.536	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
3.353	4.236	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
3.962	3.935	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
4.572	3.635	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
5.182	3.335	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
5.791	3.035	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
6.401	2.734	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						0.00
6.858	2.509	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
7.315	2.264	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
7.925	1.984	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
8.534	1.683	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
9.144	1.383	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
9.754	1.083	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
10.363	0.782	0.00E+00	0.00E+00	0.0000	0.00E+00	0.00E+00						100.00
10.973	0.482	6.27E-07	-3.34E-07	0.0000	9.40E-08	8.24E-02						100.00
11.582	0.298	3.88E-07	-2.07E-07	0.0000	5.82E-08	5.10E-02						100.00
12.192	0.187	2.42E-07	-1.29E-07	0.0000	3.64E-08	3.19E-02						100.00
13.106	0.086	1.12E-07	-5.99E-08	0.0000	1.69E-08	1.48E-02						100.00
14.478	0.030	3.93E-08	-2.09E-08	0.0000	5.89E-09	5.16E-03						100.00
16.764	0.005	6.35E-09	-3.39E-09	0.0000	9.52E-10	8.35E-04						100.00
19.812	0.001	8.02E-10	-4.28E-10	0.0000	1.20E-10	1.05E-04						100.00
22.860	0.000	1.01E-10	-5.41E-11	0.0000	1.52E-11	1.33E-05						100.00
25.908	0.000	1.28E-11	-6.83E-12	0.0000	1.92E-12	1.68E-06						100.00
28.956	0.000	1.62E-12	-8.64E-13	0.0000	2.43E-13	2.13E-07						100.00
32.004	0.000	2.05E-13	-1.09E-13	0.0000	3.07E-14	2.69E-08						100.00
35.052	0.000	2.59E-14	-1.38E-14	0.0000	3.88E-15	3.40E-09						100.00
38.100	0.000	3.27E-15	-1.74E-15	0.0000	4.90E-16	4.30E-10						100.00
41.148	0.000	4.15E-16	-2.21E-16	0.0000	6.22E-17	5.45E-11						100.00
44.196	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
47.244	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
50.292	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
53.340	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
56.388	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
59.436	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
62.484	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
65.532	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00

COUPLED O_2/CO_2/Mg/SO_4/Ca MODEL

MODEL DETAILS

Filename	PRED3a.xls
Date	7/26/96
Description:	Flambeau Mining Co.
	Case 2 (backfilled pit - Type II Waste Rock only)
	D_{wr} (m^2s^{-1}) -
	D_{waste} (m^2s^{-1}) 2.00E-06
	r_{waste1} (s^{-1}) -
	r_{waste2} (s^{-1}) 1.30E-06

INPUT PARAMETERS

Finite Difference Parameters

nodes x	1
nodes y	40
time periods	1
init delt (s)	0.01
[O2] at surface (mol/m³)	8.9
[CO2] at surface (mol/m³))	0.0141

Model Options

CO2 OPTION	0
FES2 OPTION	0
O2 OPTION	1

Geochemical Options

Precipitation (m/s)	1.10E-09	(62 mm / year)
Infiltration Coefficient	1.00	
Kgypsum	-	
Infiltration (m/s)	1.10E-09	= recharge * infiltration coefficient
Fraction Flow Paths (G)	0.10	

Diffusion Parameters

Dw (m2/s)	2.20E-09
Da (m2/s)	1.80E-05
τ	0.273
α	3.28
H	33.9

OUTPUT TIMES

time (s)	time (y)	Output col
3.5E+08	11	1
0.0E+00		6
0.0E+00		11
0.0E+00		16
0.0E+00		21
0.0E+00		26
0.0E+00		31

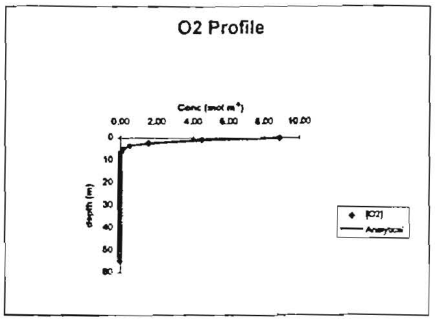
FES2 OPTION
0 - No FES2 DEPLETION
1 - ALLOW FES2 DEPLETION

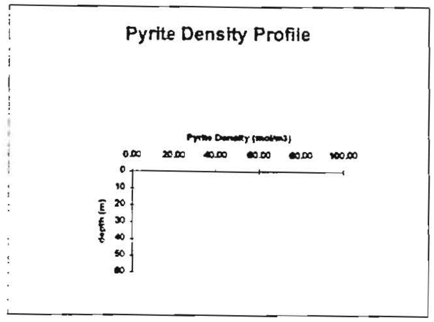
CO2 OPTION:
0 - No CO2 Coupling
1 - CO2 Coupling

O2 OPTION
0 - HALF ORDER REACTION
1 - FIRST ORDER REACTION
2 - MIXED FIRST ORDER / HALF ORDER

MODEL INPUTS										
Material	DEPTH (m)	Cell Sizes (m)	r (s-1)	Porosity (%)	Saturation (%)	F	SulfDens (mol/m³)	Diff Coeff (m2/s)	[O_2]$_{init}$ (mol/m³)	[CO_2]$_{init}$ (mol/m³)
Type II - Waste Rock	0.005	0.01	1.30E-06	15%	0%	-	100	2.00E-06	8.89	1.41E-02
Type II - Waste Rock	0.710	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	2.110	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	3.510	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	4.910	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	6.310	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	7.710	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	9.110	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	10.510	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	11.910	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	13.310	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	14.710	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	16.110	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	17.510	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	18.910	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	20.310	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	21.710	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	23.110	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	24.510	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	25.910	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	27.310	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	28.710	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	30.110	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	31.510	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	32.910	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	34.310	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	35.710	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	37.110	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	38.510	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	39.910	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	41.310	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	42.710	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	44.110	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	45.510	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	46.910	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	48.310	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	49.710	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	51.110	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	52.510	1.4	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	54.610	2.8	1.30E-06	15%	0%	-	100	2.00E-06	0.00	0.00E+00

RESULTS FOR YEAR: 11





Flux in (mol/m²s)	1.24E-05
O_2 cons. (mol/m²s)	1.26E-05
Dpen (m)	5.61

t=11												
DEPTH (m)	CONC O2 (mol/m³)	O2 Cons (mol/m³s)	CO2 Prod (mol/m³s)	CONC CO2 (mol/m³)	ols O2 con per m3 rock	P consmpt CaCO3eq/t	SO4 (mol/L)	Ca (mol/L)	Mg (mg/L)	SO4 (mg/L)	Ca (mg/L)	Sulf dens mol/m³
0.005	8.890	1.16E-05	-6.16E-06	0.0141	1.73E-06	1.52E+00						100.00
0.710	4.505	5.86E-06	-3.12E-06	0.0000	8.78E-07	7.70E-01						100.00
2.110	1.536	2.00E-06	-1.06E-06	0.0000	2.99E-07	2.63E-01						100.00
3.510	0.524	6.81E-07	-3.63E-07	0.0000	1.02E-07	8.95E-02						100.00
4.910	0.179	2.32E-07	-1.24E-07	0.0000	3.48E-08	3.05E-02						100.00
6.310	0.061	7.91E-08	-4.22E-08	0.0000	1.19E-08	1.04E-02						100.00
7.710	0.021	2.70E-08	-1.44E-08	0.0000	4.05E-09	3.55E-03						100.00
9.110	0.007	9.20E-09	-4.91E-09	0.0000	1.38E-09	1.21E-03						100.00
10.510	0.002	3.14E-09	-1.67E-09	0.0000	4.70E-10	4.12E-04						100.00
11.910	0.001	1.07E-09	-5.70E-10	0.0000	1.60E-10	1.41E-04						100.00
13.310	0.000	3.65E-10	-1.94E-10	0.0000	5.47E-11	4.79E-05						100.00
14.710	0.000	1.24E-10	-6.63E-11	0.0000	1.86E-11	1.63E-05						100.00
16.110	0.000	4.24E-11	-2.26E-11	0.0000	6.36E-12	5.57E-06						100.00
17.510	0.000	1.44E-11	-7.70E-12	0.0000	2.17E-12	1.90E-06						100.00
18.910	0.000	4.93E-12	-2.63E-12	0.0000	7.39E-13	6.48E-07						100.00
20.310	0.000	1.68E-12	-8.96E-13	0.0000	2.52E-13	2.21E-07						100.00
21.710	0.000	5.73E-13	-3.05E-13	0.0000	8.59E-14	7.53E-08						100.00
23.110	0.000	1.95E-13	-1.04E-13	0.0000	2.93E-14	2.57E-08						100.00
24.510	0.000	6.66E-14	-3.55E-14	0.0000	9.98E-15	8.75E-09						100.00
25.910	0.000	2.27E-14	-1.21E-14	0.0000	3.40E-15	2.98E-09						100.00
27.310	0.000	7.74E-15	-4.13E-15	0.0000	1.16E-15	1.02E-09						100.00
28.710	0.000	2.64E-15	-1.41E-15	0.0000	3.96E-16	3.47E-10						100.00
30.110	0.000	9.00E-16	-4.60E-16	0.0000	1.35E-16	1.18E-10						100.00
31.510	0.000	3.08E-16	-1.64E-16	0.0000	4.63E-17	4.06E-11						100.00
32.910	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
34.310	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
35.710	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
37.110	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
38.510	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
39.910	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
41.310	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
42.710	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
44.110	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
45.510	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
46.910	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
48.310	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
49.710	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
51.110	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
52.510	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00
54.610	0.000	1.30E-16	-6.93E-17	0.0000	1.95E-17	1.71E-11						100.00

COUPLED O_2/CO_2/Mg/SO_4/Ca MODEL

MODEL DETAILS

Filename	PRED3b.xls
Date	7/26/96
Description:	Flambeau Mining Co.
	Case 2 (backfilled pit - Type II Waste Rock only)
	D_{ss} (m^2s^{-1}) -
	D_{waste} (m^2s^{-1}) 2.00E-06
	r_{waste1} (s^{-1}) -
	r_{waste2} (s^{-1}) 8.90E-08

INPUT PARAMETERS

Finite Difference Parameters

nodes x	1
nodes y	40
time periods	1
init delt (s)	0.01
[O2] at surface (mol/m³)	8.9
[CO2] at surface (mol/m³))	0.0141

Model Options

CO2 OPTION	0
FES2 OPTION	0
O2 OPTION	1

Geochemical Options

Precipiation (m/s)	1.10E-09	(62 mm / year)
Infiltration Coefficient	1.00	
Kgypsum	-	
Infiltration (m/s)	1.10E-09	= recharge * infiltration coefficient
Fraction Flow Paths (G)	0.10	

Diffusion Parameters

Dw (m2/s)	2.20E-09
Da (m2/s)	1.80E-05
τ	0.273
α	3.28
H	33.9

OUTPUT TIMES

time (s)	time (y)	Output col
3.5E+08	11	1
0.0E+00		6
0.0E+00		11
0.0E+00		16
0.0E+00		21
0.0E+00		26
0.0E+00		31

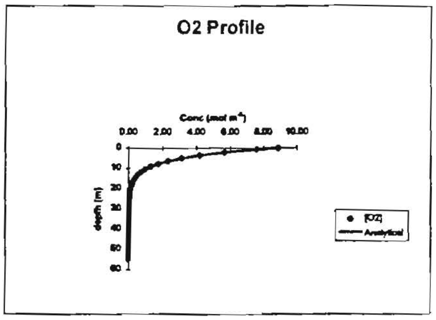
FES2 OPTION
0 - No FES2 DEPLETION
1 - ALLOW FES2 DEPLETION

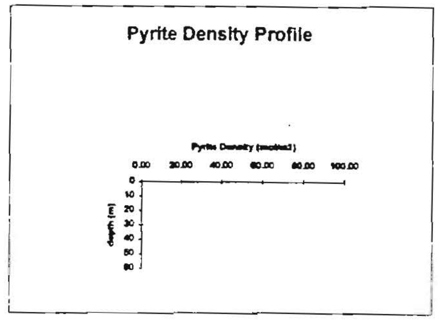
CO2 OPTION:
0 - No CO2 Coupling
1 - CO2 Coupling

O2 OPTION
0 - HALF ORDER REACTION
1 - FIRST ORDER REACTION
2 - MIXED FIRST ORDER / HALF ORDER

MODEL INPUTS										
Material	DEPTH (m)	Cell Sizes (m)	r (s-1)	Porosity (%)	Saturation (%)	F	SulfDens (mol/m³)	Diff Coeff (m2/s)	[$O_{2,init}$ (mol/m³)	[$CO_{2,init}$ (mol/m³)
Type II - Waste Rock	0.005	0.01	8.90E-08	15%	0%	-	100	2.00E-06	8.89	1.41E-02
Type II - Waste Rock	0.710	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	2.110	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	3.510	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	4.910	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	6.310	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	7.710	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	9.110	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	10.510	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	11.910	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	13.310	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	14.710	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	16.110	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	17.510	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	18.910	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	20.310	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	21.710	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	23.110	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	24.510	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	25.910	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	27.310	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	28.710	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	30.110	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	31.510	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	32.910	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	34.310	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	35.710	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	37.110	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	38.510	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	39.910	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	41.310	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	42.710	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	44.110	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	45.510	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	46.910	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	48.310	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	49.710	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	51.110	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	52.510	1.4	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00
Type II - Waste Rock	54.610	2.8	8.90E-08	15%	0%	-	100	2.00E-06	0.00	0.00E+00

RESULTS FOR YEAR: 11





Flux in (mol/m²s)	3.71E-06
O_2 cons. (mol/m²s)	3.71E-06
Dpen (m)	9.81

t=11													
DEPTH (m)	CONC O2 (mol/m³)	O2 Cons (mol/m³s)	CO2 Prod (mol/m³s)	CONC CO2 (mol/m³)	ols O2 con per m3 rock	P consmpt CaCO3eq/t	SO4 (mol/L)	Ca (mol/L)	Mg (mg/L)	SO4 (mg/L)	Ca (mg/L)	Sulf dens mol/m³
0.005	8.690	7.91E-07	-4.22E-07	0.0141	1.19E-07	1.04E-01						100.00
0.710	7.583	6.75E-07	-3.60E-07	0.0000	1.01E-07	8.87E-02						100.00
2.110	5.650	5.03E-07	-2.68E-07	0.0000	7.54E-08	6.61E-02						100.00
3.510	4.210	3.75E-07	-2.00E-07	0.0000	5.62E-08	4.93E-02						100.00
4.910	3.137	2.79E-07	-1.49E-07	0.0000	4.19E-08	3.67E-02						100.00
6.310	2.337	2.08E-07	-1.11E-07	0.0000	3.12E-08	2.73E-02						100.00
7.710	1.741	1.55E-07	-8.27E-08	0.0000	2.32E-08	2.04E-02						100.00
9.110	1.297	1.15E-07	-6.16E-08	0.0000	1.73E-08	1.52E-02						100.00
10.510	0.967	8.60E-08	-4.59E-08	0.0000	1.29E-08	1.13E-02						100.00
11.910	0.720	6.41E-08	-3.42E-08	0.0000	9.62E-09	8.43E-03						100.00
13.310	0.537	4.78E-08	-2.55E-08	0.0000	7.16E-09	6.28E-03						100.00
14.710	0.400	3.56E-08	-1.90E-08	0.0000	5.34E-09	4.68E-03						100.00
16.110	0.298	2.65E-08	-1.41E-08	0.0000	3.96E-09	3.49E-03						100.00
17.510	0.222	1.98E-08	-1.05E-08	0.0000	2.96E-09	2.60E-03						100.00
18.910	0.165	1.47E-08	-7.85E-09	0.0000	2.21E-09	1.94E-03						100.00
20.310	0.123	1.10E-08	-5.85E-09	0.0000	1.64E-09	1.44E-03						100.00
21.710	0.092	8.17E-09	-4.36E-09	0.0000	1.23E-09	1.07E-03						100.00
23.110	0.068	6.09E-09	-3.25E-09	0.0000	9.13E-10	8.01E-04						100.00
24.510	0.051	4.54E-09	-2.42E-09	0.0000	6.80E-10	5.96E-04						100.00
25.910	0.038	3.38E-09	-1.80E-09	0.0000	5.07E-10	4.44E-04						100.00
27.310	0.028	2.52E-09	-1.34E-09	0.0000	3.78E-10	3.31E-04						100.00
28.710	0.021	1.88E-09	-1.00E-09	0.0000	2.81E-10	2.47E-04						100.00
30.110	0.016	1.40E-09	-7.46E-10	0.0000	2.10E-10	1.84E-04						100.00
31.510	0.012	1.04E-09	-5.56E-10	0.0000	1.56E-10	1.37E-04						100.00
32.910	0.009	7.76E-10	-4.14E-10	0.0000	1.16E-10	1.02E-04						100.00
34.310	0.006	5.78E-10	-3.08E-10	0.0000	8.67E-11	7.60E-05						100.00
35.710	0.005	4.31E-10	-2.30E-10	0.0000	6.46E-11	5.67E-05						100.00
37.110	0.004	3.21E-10	-1.71E-10	0.0000	4.82E-11	4.22E-05						100.00
38.510	0.003	2.39E-10	-1.28E-10	0.0000	3.59E-11	3.15E-05						100.00
39.910	0.002	1.78E-10	-9.52E-11	0.0000	2.68E-11	2.35E-05						100.00
41.310	0.001	1.33E-10	-7.10E-11	0.0000	2.00E-11	1.75E-05						100.00
42.710	0.001	9.93E-11	-5.30E-11	0.0000	1.49E-11	1.31E-05						100.00
44.110	0.001	7.42E-11	-3.96E-11	0.0000	1.11E-11	9.76E-06						100.00
45.510	0.001	5.56E-11	-2.97E-11	0.0000	8.34E-12	7.31E-06						100.00
46.910	0.000	4.19E-11	-2.23E-11	0.0000	6.28E-12	5.50E-06						100.00
48.310	0.000	3.18E-11	-1.69E-11	0.0000	4.76E-12	4.18E-06						100.00
49.710	0.000	2.44E-11	-1.30E-11	0.0000	3.66E-12	3.21E-06						100.00
51.110	0.000	1.92E-11	-1.02E-11	0.0000	2.88E-12	2.53E-06						100.00
52.510	0.000	1.57E-11	-8.36E-12	0.0000	2.35E-12	2.06E-06						100.00
54.610	0.000	1.24E-11	-6.62E-12	0.0000	1.86E-12	1.63E-06						100.00

COUPLED O_2/CO_2/Mg/SO_4/Ca MODEL

MODEL DETAILS

Filename	PRED3c.xls	
Date	7/26/96	
Description:	Flambeau Mining Co.	
	Case 2 (backfilled pit - Type II Waste Rock only)	
	D_{ss} (m^2s^{-1})	-
	D_{waste} (m^2s^{-1})	6.00E-06
	r_{waste1} (s^{-1})	-
	r_{waste2} (s^{-1})	8.90E-08

INPUT PARAMETERS

Finite Difference Parameters

nodes x	1
nodes y	40
time periods	1
init delt (s)	0.01
[O2] at surface (mol/m³)	8.9
[CO2] at surface (mol/m³))	0.0141

Model Options

CO2 OPTION	0
FES2 OPTION	0
O2 OPTION	1

Geochemical Options

Precipiation (m/s)	1.10E-09	(62 mm / year)
Infiltration Coefficient	1.00	
Kgypsum	-	
Infiltration (m/s)	1.10E-09	= recharge * infiltration coefficient
Fraction Flow Paths (G)	0.10	

Diffusion Parameters

Dw (m2/s)	2.20E-09
Da (m2/s)	1.80E-05
τ	0.273
α	3.28
H	33.9

OUTPUT TIMES

time (s)	time (y)	Output col
3.5E+08	11	1
0.0E+00		6
0.0E+00		11
0.0E+00		16
0.0E+00		21
0.0E+00		26
0.0E+00		31

FES2 OPTION
0 - No FES2 DEPLETION
1 - ALLOW FES2 DEPLETION

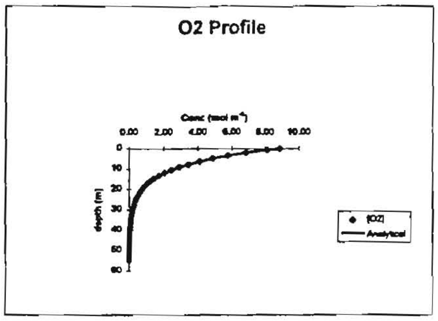
CO2 OPTION:
0 - No CO2 Coupling
1 - CO2 Coupling

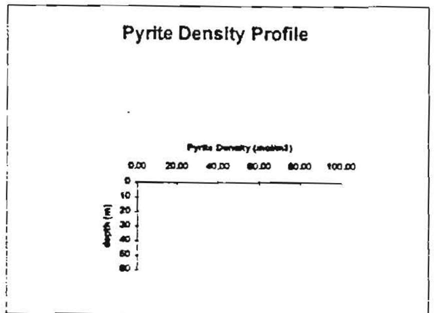
O2 OPTION
0 - HALF ORDER REACTION
1 - FIRST ORDER REACTION
2 - MIXED FIRST ORDER / HALF ORDER

MODEL INPUTS

Material	DEPTH (m)	Cell Sizes (m)	r (s-1)	Porosity (%)	Saturation (%)	F	SulfDens (mol/m³)	Diff Coeff (m2/s)	[O2 init (mol/m³)	[CO2 init (mol/m³)
Type II - Waste Rock	0.005	0.01	8.90E-08	15%	0%	-	100	6.00E-06	8.89	1.41E-02
Type II - Waste Rock	0.710	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	2.110	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	3.510	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	4.910	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	6.310	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	7.710	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	9.110	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	10.510	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	11.910	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	13.310	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	14.710	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	16.110	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	17.510	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	18.910	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	20.310	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	21.710	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	23.110	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	24.510	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	25.910	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	27.310	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	28.710	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	30.110	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	31.510	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	32.910	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	34.310	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	35.710	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	37.110	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	38.510	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	39.910	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	41.310	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	42.710	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	44.110	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	45.510	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	46.910	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	48.310	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	49.710	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	51.110	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	52.510	1.4	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	54.610	2.8	8.90E-08	15%	0%	-	100	6.00E-06	0.00	0.00E+00

RESULTS FOR YEAR: 11





Flux in (mol/m²s)	6.47E-06
O_2 cons. (mol/m²s)	6.48E-06
Dpen (m)	16.81

						t=11						
DEPTH (m)	CONC O2 (mol/m³)	O2 Cons (mol/m³s)	CO2 Prod (mol/m³s)	CONC CO2 (mol/m³)	ols O2 con per m3 rock	P consmpt CaCO3eq/t	SO4 (mol/L)	Ca (mol/L)	Mg (mg/L)	SO4 (mg/L)	Ca (mg/L)	Sulf dens mol/m³
0.005	8.890	7.91E-07	-4.22E-07	0.0141	1.19E-07	1.04E-01						100.00
0.710	8.130	7.24E-07	-3.86E-07	0.0000	1.09E-07	9.51E-02						100.00
2.110	6.857	6.10E-07	-3.25E-07	0.0000	9.15E-08	8.02E-02						100.00
3.510	5.783	5.15E-07	-2.75E-07	0.0000	7.72E-08	6.77E-02						100.00
4.910	4.878	4.34E-07	-2.32E-07	0.0000	6.51E-08	5.71E-02						100.00
6.310	4.114	3.66E-07	-1.95E-07	0.0000	5.49E-08	4.81E-02						100.00
7.710	3.470	3.09E-07	-1.65E-07	0.0000	4.63E-08	4.06E-02						100.00
9.110	2.926	2.60E-07	-1.39E-07	0.0000	3.91E-08	3.42E-02						100.00
10.510	2.468	2.20E-07	-1.17E-07	0.0000	3.29E-08	2.89E-02						100.00
11.910	2.082	1.85E-07	-9.88E-08	0.0000	2.78E-08	2.44E-02						100.00
13.310	1.756	1.56E-07	-8.33E-08	0.0000	2.34E-08	2.05E-02						100.00
14.710	1.481	1.32E-07	-7.03E-08	0.0000	1.98E-08	1.73E-02						100.00
16.110	1.249	1.11E-07	-5.93E-08	0.0000	1.67E-08	1.46E-02						100.00
17.510	1.053	9.37E-08	-5.00E-08	0.0000	1.41E-08	1.23E-02						100.00
18.910	0.888	7.91E-08	-4.22E-08	0.0000	1.19E-08	1.04E-02						100.00
20.310	0.749	6.67E-08	-3.56E-08	0.0000	1.00E-08	8.77E-03						100.00
21.710	0.632	5.63E-08	-3.00E-08	0.0000	8.44E-09	7.40E-03						100.00
23.110	0.533	4.74E-08	-2.53E-08	0.0000	7.12E-09	6.24E-03						100.00
24.510	0.450	4.00E-08	-2.13E-08	0.0000	6.00E-09	5.26E-03						100.00
25.910	0.379	3.38E-08	-1.80E-08	0.0000	5.06E-09	4.44E-03						100.00
27.310	0.320	2.85E-08	-1.52E-08	0.0000	4.27E-09	3.75E-03						100.00
28.710	0.270	2.40E-08	-1.28E-08	0.0000	3.60E-09	3.16E-03						100.00
30.110	0.228	2.03E-08	-1.08E-08	0.0000	3.04E-09	2.67E-03						100.00
31.510	0.192	1.71E-08	-9.13E-09	0.0000	2.57E-09	2.25E-03						100.00
32.910	0.162	1.45E-08	-7.71E-09	0.0000	2.17E-09	1.90E-03						100.00
34.310	0.137	1.22E-08	-6.51E-09	0.0000	1.83E-09	1.61E-03						100.00
35.710	0.116	1.03E-08	-5.50E-09	0.0000	1.55E-09	1.36E-03						100.00
37.110	0.098	8.73E-09	-4.65E-09	0.0000	1.31E-09	1.15E-03						100.00
38.510	0.083	7.39E-09	-3.94E-09	0.0000	1.11E-09	9.72E-04						100.00
39.910	0.070	6.27E-09	-3.34E-09	0.0000	9.40E-10	8.24E-04						100.00
41.310	0.060	5.33E-09	-2.84E-09	0.0000	7.99E-10	7.01E-04						100.00
42.710	0.051	4.55E-09	-2.42E-09	0.0000	6.82E-10	5.98E-04						100.00
44.110	0.044	3.89E-09	-2.08E-09	0.0000	5.84E-10	5.12E-04						100.00
45.510	0.038	3.35E-09	-1.79E-09	0.0000	5.03E-10	4.41E-04						100.00
46.910	0.033	2.91E-09	-1.55E-09	0.0000	4.37E-10	3.83E-04						100.00
48.310	0.029	2.56E-09	-1.36E-09	0.0000	3.83E-10	3.36E-04						100.00
49.710	0.026	2.27E-09	-1.21E-09	0.0000	3.41E-10	2.99E-04						100.00
51.110	0.023	2.06E-09	-1.10E-09	0.0000	3.08E-10	2.70E-04						100.00
52.510	0.021	1.90E-09	-1.01E-09	0.0000	2.85E-10	2.50E-04						100.00
54.610	0.020	1.75E-09	-9.32E-10	0.0000	2.62E-10	2.30E-04						100.00

COUPLED O_2/CO_2/Mg/SO_4/Ca MODEL

MODEL DETAILS

Filename	PRED3d.xls
Date	7/26/96
Description:	Flambeau Mining Co.
	Case 2 (backfilled pit - Type II Waste Rock only)
D_{til} (m^2s^{-1})	-
D_{waste} (m^2s^{-1})	6.00E-06
r_{waste1} (s^{-1})	-
r_{waste2} (s^{-1})	1.30E-06

INPUT PARAMETERS

Finite Difference Parameters

nodes x	1
nodes y	40
time periods	1
init delt (s)	0.01
[O2] at surface (mol/m³)	8.9
[CO2] at surface (mol/m³))	0.0141

Model Options

CO2 OPTION	0
FES2 OPTION	0
O2 OPTION	1

Geochemical Options

Precipiation (m/s)	1.10E-09	(62 mm / year)
Infiltration Coefficient	1.00	
Kgypsum	-	
Infiltration (m/s)	1.10E-09	= recharge * infiltration coefficient
Fraction Flow Paths (G)	0.10	

Diffusion Parameters

Dw (m2/s)	2.20E-09
Da (m2/s)	1.80E-05
τ	0.273
α	3.28
H	33.9

OUTPUT TIMES

time (s)	time (y)	Output col
3.5E+08	11	1
0.0E+00		6
0.0E+00		11
0.0E+00		16
0.0E+00		21
0.0E+00		26
0.0E+00		31

FES2 OPTION

0 - No FES2 DEPLETION
1 - ALLOW FES2 DEPLETION

CO2 OPTION:

0 - No CO2 Coupling
1 - CO2 Coupling

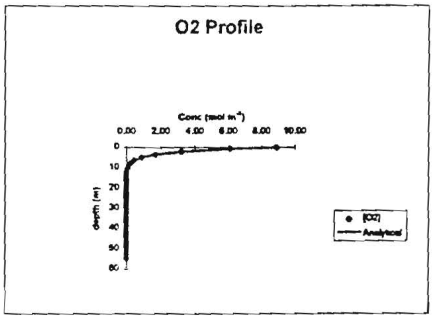
O2 OPTION

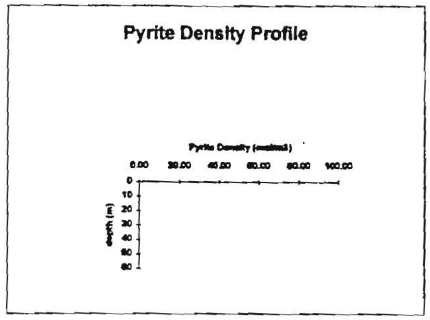
0 - HALF ORDER REACTION
1 - FIRST ORDER REACTION
2 - MIXED FIRST ORDER / HALF ORDER

MODEL INPUTS

Material	DEPTH (m)	Cell Sizes (m)	r (s-1)	Porosity (%)	Saturation (%)	F	SulfDens (mol/m³)	Diff Coeff (m2/s)	[O_2]ini (mol/m³)	[CO_2]ini (mol/m³)
Type II - Waste Rock	0.005	0.01	1.30E-06	15%	0%	-	100	6.00E-06	8.89	1.41E-02
Type II - Waste Rock	0.710	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	2.110	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	3.510	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	4.910	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	6.310	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	7.710	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	9.110	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	10.510	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	11.910	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	13.310	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	14.710	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	16.110	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	17.510	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	18.910	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	20.310	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	21.710	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	23.110	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	24.510	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	25.910	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	27.310	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	28.710	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	30.110	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	31.510	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	32.910	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	34.310	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	35.710	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	37.110	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	38.510	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	39.910	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	41.310	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	42.710	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	44.110	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	45.510	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	46.910	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	48.310	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	49.710	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	51.110	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	52.510	1.4	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00
Type II - Waste Rock	54.610	2.8	1.30E-06	15%	0%	-	100	6.00E-06	0.00	0.00E+00

RESULTS FOR YEAR: 11





Flux in (mol/m²s)	2.36E-05
O_2 cons. (mol/m³s)	2.37E-05
Dpen (m)	9.81

t=11												
DEPTH (m)	CONC O2 (mol/m³)	O2 Cons (mol/m³s)	CO2 Prod (mol/m³s)	CONC CO2 (mol/m³)	ols O2 con per m3 rock	P consmpt CaCO3eq/t	SO4 (mol/L)	Ca (mol/L)	Mg (mg/L)	SO4 (mg/L)	Ca (mg/L)	Sulf dens mol/m³
0.005	8.890	1.16E-05	-6.16E-06	0.0141	1.73E-06	1.52E+00						100.00
0.710	6.122	7.96E-06	-4.24E-06	0.0000	1.19E-06	1.05E+00						100.00
2.110	3.226	4.19E-06	-2.24E-06	0.0000	6.29E-07	5.51E-01						100.00
3.510	1.700	2.21E-06	-1.18E-06	0.0000	3.32E-07	2.91E-01						100.00
4.910	0.896	1.16E-06	-6.21E-07	0.0000	1.75E-07	1.53E-01						100.00
6.310	0.472	6.14E-07	-3.27E-07	0.0000	9.20E-08	8.07E-02						100.00
7.710	0.249	3.23E-07	-1.72E-07	0.0000	4.85E-08	4.25E-02						100.00
9.110	0.131	1.70E-07	-9.09E-08	0.0000	2.56E-08	2.24E-02						100.00
10.510	0.069	8.98E-08	-4.79E-08	0.0000	1.35E-08	1.18E-02						100.00
11.910	0.036	4.73E-08	-2.52E-08	0.0000	7.10E-09	6.22E-03						100.00
13.310	0.019	2.49E-08	-1.33E-08	0.0000	3.74E-09	3.28E-03						100.00
14.710	0.010	1.31E-08	-7.01E-09	0.0000	1.97E-09	1.73E-03						100.00
16.110	0.005	6.92E-09	-3.69E-09	0.0000	1.04E-09	9.10E-04						100.00
17.510	0.003	3.65E-09	-1.95E-09	0.0000	5.47E-10	4.80E-04						100.00
18.910	0.001	1.92E-09	-1.03E-09	0.0000	2.88E-10	2.53E-04						100.00
20.310	0.001	1.01E-09	-5.40E-10	0.0000	1.52E-10	1.33E-04						100.00
21.710	0.000	5.34E-10	-2.85E-10	0.0000	8.01E-11	7.02E-05						100.00
23.110	0.000	2.81E-10	-1.50E-10	0.0000	4.22E-11	3.70E-05						100.00
24.510	0.000	1.48E-10	-7.91E-11	0.0000	2.22E-11	1.95E-05						100.00
25.910	0.000	7.81E-11	-4.17E-11	0.0000	1.17E-11	1.03E-05						100.00
27.310	0.000	4.12E-11	-2.20E-11	0.0000	6.17E-12	5.41E-06						100.00
28.710	0.000	2.17E-11	-1.16E-11	0.0000	3.25E-12	2.85E-06						100.00
30.110	0.000	1.14E-11	-6.10E-12	0.0000	1.71E-12	1.50E-06						100.00
31.510	0.000	6.02E-12	-3.21E-12	0.0000	9.03E-13	7.92E-07						100.00
32.910	0.000	3.17E-12	-1.69E-12	0.0000	4.76E-13	4.17E-07						100.00
34.310	0.000	1.67E-12	-8.92E-13	0.0000	2.51E-13	2.20E-07						100.00
35.710	0.000	8.81E-13	-4.70E-13	0.0000	1.32E-13	1.16E-07						100.00
37.110	0.000	4.64E-13	-2.48E-13	0.0000	6.97E-14	6.11E-08						100.00
38.510	0.000	2.45E-13	-1.30E-13	0.0000	3.67E-14	3.22E-08						100.00
39.910	0.000	1.29E-13	-6.88E-14	0.0000	1.93E-14	1.70E-08						100.00
41.310	0.000	6.79E-14	-3.62E-14	0.0000	1.02E-14	8.93E-09						100.00
42.710	0.000	3.58E-14	-1.91E-14	0.0000	5.37E-15	4.71E-09						100.00
44.110	0.000	1.89E-14	-1.01E-14	0.0000	2.83E-15	2.48E-09						100.00
45.510	0.000	9.94E-15	-5.30E-15	0.0000	1.49E-15	1.31E-09						100.00
46.910	0.000	5.24E-15	-2.80E-15	0.0000	7.86E-16	6.89E-10						100.00
48.310	0.000	2.77E-15	-1.47E-15	0.0000	4.15E-16	3.64E-10						100.00
49.710	0.000	1.46E-15	-7.80E-16	0.0000	2.20E-16	1.92E-10						100.00
51.110	0.000	7.83E-16	-4.18E-16	0.0000	1.17E-16	1.03E-10						100.00
52.510	0.000	4.36E-16	-2.32E-16	0.0000	6.53E-17	5.73E-11						100.00
54.610	0.000	1.92E-16	-1.02E-16	0.0000	2.87E-17	2.52E-11						100.00

Appendix B

Resident Project Representative Manual
Updated October 1996

WISCONSIN
James Brian
HUTCHISON
E-22484
Green Bay,
Wis.
PROFESSIONAL ENGINEER
10/8/96

Resident Project Representative Manual
Ladysmith, Wisconsin

Scope ID: 96F013

Prepared for
Flambeau Mining Company

Prepared by
Foth & Van Dyke and Associates Inc.

Updated October 1996

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

Resident Project Representative Manual
Flambeau Project
Pit Backfill, Type II Material

Contents

Contents *(continued)*

Page

Tables

Appendices

1 Introduction

This Resident Project Representative Manual has been prepared as a working document in order to provide guidance to the resident project representative during the placement of backfill into the pit at the Flambeau Mine Project (Flambeau) at Ladysmith, Wisconsin. This document has been prepared according to requirements of the Flambeau Mine permit and based on information gathered during the operation phase of the mine and a field compaction test program performed on Type II material in June 1996. Should field experience gained during pit backfilling result in the need to modify certain aspects of the methods and procedures described within this document, those portions of this document will be modified. Recommendations for changes will be developed by the resident project representative and approved by both the Flambeau and Foth & Van Dyke project managers prior to implementation. Proposed changes to acceptance criteria will be submitted to the WDNR for review.

The goal of the project is to provide a pit backfill that is both environmentally and structurally sound. To achieve this goal and to meet the requirements set forth in the mine permit, the pit backfill will be placed in approximate 3-foot compacted lifts. Neutralizing material will be added in the form of limestone to the Type II material placed in each lift. In order to achieve the project goal, the resident project representative will collect necessary data for each backfill lift and compare the data to acceptance criteria established for the project. Once the data for the lift is found to meet the acceptance criteria, the resident project representative will release that backfill for additional fill placement. The resident project representative is also responsible for the collection of the additional data discussed in Section 4 of this manual.

1.1 Acceptance Criteria

The criteria for backfilling acceptance consist of the following:

- The dozer placement of the backfill material to a lift thickness of approximately 3 feet, with an upper limit of 3 feet, 4 inches.
- The completion of a minimum of two complete area coverage passes with compaction equipment upon the lift area.
- The addition of a minimum of 1.1 pounds of limestone to each ton of fresh waste rock backfill material.
- The addition of a minimum of 17.2 pounds of limestone to each ton of backfill material from the Type II stockpile during the fall of 1996 backfilling work.

1.2 Manual Organization

An overview of the backfilling process is described in Section 2 of this manual. The data to be collected, methodology and documentation of information required for lift acceptance is addressed in Section 3. Additional data to be collected is discussed in Section 4. The anticipated contents of the daily construction observation report for the backfilling project is outlined in Section 5 of this manual.

2 Overview of Backfilling Process

There will be approximately seventy 3-foot lifts required to fill the entire pit. Type II material will make up the majority of lifts placed. Backfilling will begin in the east portion of the pit while mining is still taking place in the west portion of the pit. Temporary sumps will be located in the east portion of the pit until backfilling allows for drainage to occur to the south and west. Once mining is complete, backfilling of the west portion of the pit will commence. Backfilled lifts in the east portion of the pit will slope to the south and to the west at approximately 1½% or greater grades to allow drainage of precipitation across the top of the fill to collection sumps (or sump). Some grade control grading may be required between lift installations. Similar drainage characteristics will be used during lift placement in the west portion of the pit. Water collected in the sumps will be pumped to the project's surge pond for treatment at the site's treatment plant.

In order to provide more accurate control of information gathered during backfilling, the total pit area has been divided into an east pit section and a west pit section. Field maps will be prepared by the resident project representative for both the east and west pit sections to document the installation of each lift within each section. Each lift will be identified by an elevation based on the elevation of the lift at mine station 42,300E, 20,000N in the east section, and 40,250E, 20,200N in the west section. These are the locations of the lowest benches in each pit section. Each lift within each section will be depicted on a field generated figure in plan view with the 150-foot survey control grid pattern established across the pit area. Locations of soil samples, tests and measurements performed on the backfill as required in Sections 3 and 4 of this manual will be shown on the figures for each lift. Copies of appropriate lift figures will be attached to the daily reports described later in this manual.

To facilitate continued mining in the west half of the pit during initial backfilling and to facilitate efficient material handling during backfilling in general, lift construction will be accomplished by designating distinct fill areas within each pit section rather than installing complete lifts across the entire base of each section at any point in time. Backfilling will be accomplished by designating the distinct area to receive backfill, establishing horizontal and vertical survey control for the area, placement and compaction of fill followed by collections of vertical elevation information. The resident project representative will be required to designate areas for filling and to establish the elevations required in these areas to meet the acceptance criteria and to match elevations with previously filled areas and for areas to be filled in the future.

3 Acceptance Criteria and Required Data Collection and Documentation

3.1 Limestone Application

3.1.1 Application Method and Documentation

The description of lime addition in the Mine Permit Application called for application of lime on top of the compacted 3-foot lifts. Limestone, in lieu of lime, will be applied at a rate of 1.1 pounds per ton of fresh waste rock backfill material and at the rate of 17.2 pounds per ton of backfill material from the Type II stockpile during the fall of 1996 backfilling work. In order to increase the contact of the limestone with the Type II backfilled material, the following procedures will be used for limestone application.

3.1.1.1 In-Pit Backfill Material

Initial backfilling of the pit will be accomplished using in-pit Type II waste rock (fresh waste rock) excavated from the west section of the pit and immediately deposited as backfill in the east section of the pit without being stored in the Type II stockpile. Limestone will be added to this material at its point of origin, after blasting, but prior to excavation as described below.

The rate of limestone application will be 1.1 pounds per ton of fresh waste rock. The amount of limestone to be added is to be calculated using the horizontal extent of the shot area, a conservative vertical height of 10.5 feet, and a preshot density of 170 pounds per cubic foot. This computes to approximately 0.9 pound of limestone per square foot of shot material. Assuming 90 pounds per cubic foot for the density of loose limestone, this translates to 0.13 inches thick of limestone to be spread across the shot material.

The primary method of limestone application which will be used in areas where the top of the shot material is accessible by limestone application equipment is as follows. During mining, Type II waste rock to be backfilled directly will be shot in lifts of 10 feet. Prior to excavation and transport to the east end of the pit, the shot Type II material will be rough graded by a dozer and/or grader to allow travel by a site dump truck which will be used to place limestone on the shot material. The dump truck has a 10-foot bed mounted with a dump body hopper. The dump body hopper has a capacity of approximately 6 tons of limestone. Following grading of the shot area, the dump truck will deposit the calculated amount of limestone on the shot material. If needed, the limestone will be spread by a grader to relatively uniform thickness across the shot material. Once the limestone is in place, excavation of the shot material and limestone will occur by backhoe and/or front end loader. Excavated material will be deposited into haul trucks for transport to the backfill area.

Initial mixing of the limestone will occur as the shot Type II material is excavated and placed in the haul trucks. To minimize segregation of limestone from the lower portions of the shot area, excavation will occur along a continuous 10-foot vertical face. Additional mixing will take place as the Type II material is dumped in the east end of the pit and when it is spread by the dozer.

A second method of limestone application to shot material will be used for those areas where the shot material is located next to the pit wall in narrow widths and where ore and waste rock are interfingered, both of which makes limestone application difficult. This method entails initially excavating and placing the shot material in the 3-foot backfill lift and then placing the prescribed amount of limestone evenly over the lift. The limestone will then be worked into the backfilled lift with a dozer or grader mounted scarifying tooth (teeth). Following scarification, the material will be regraded and compacted.

To document the actual limestone application during the backfilling process for either method of limestone application, the area of the shot material will be determined either by measuring or by surveying to establish the square foot area to receive limestone. The limestone to be added to the shot material will be weighed in the dump truck prior to delivery and spreading over the shot material. The area of shot material and quantity of limestone applied to the shot area will be documented on the Limestone Application Observation (LAO) form in Appendix A. As a check, the average depth of limestone across the area will be observed to verify adequate, even spreading has occurred. This observation will also be noted on the LAO.

3.1.1.2 Type II Stockpile Material

The same basic process used for limestone application in the pit will be used for limestone addition on top of the Type II stockpile. The stockpiled Type II material will be excavated in approximate 15-foot thick lifts, placed into haul trucks and delivered to the pit for backfilling.

Limestone will be added to material to be excavated by the same dump truck described in Section 3.1.1.1. The dump truck will place the limestone in the area designated to be excavated. The limestone will either be placed in piles which will be evenly spread across the area. Excavation of the Type II material and limestone will be performed with a backhoe and/or front end loader on an open 15-foot deep excavation.

The limestone will be added at a rate of 17.2 pounds per ton of Type II backfill material during the fall of 1996 backfilling work. The amount of limestone to be added to the Type II stockpile material will be determined by surveying and staking the area to be excavated. The limestone addition rate will be calculated using the same procedure as described in Section 3.1.1.1 except a 15-foot lift and density of 160 pounds per cubic foot will be used. This computes to 20.6 pounds of limestone per square foot of excavation (or a layer of approximately 2.75 inches thick). The area to receive limestone will be determined by survey and noted on the LAO. The actual amount of limestone added to each area will be weighed in the dump truck and documented on the LAO. As a check, the average depth of limestone across the area will be observed to verify adequate, even spreading has occurred. This observation will also be noted on the LAO.

3.1.1.3 Precipitation Event Reparations

If precipitation occurs after limestone application and prior to excavation, the resident project representative shall observe the limestoned area. If the limestoned area has been affected by the precipitation event, the resident project representative will direct appropriate action to repair the area. Such action could involve regrading or additional limestone placement.

3.1.1.4 Wind Event Application

Limestone added within the pit and on the Type II stockpile may encounter some wind events during the backfill process. If wind becomes problematic, the limestone will be wetted immediately upon spreading by the grader across the area to be excavated.

3.1.1.5 Traffic on Limestoned Areas

Traffic on limestoned areas will be minimized. In areas where traffic is required to occur over limestoned areas on a consistent basis, the traffic areas will be delineated with lath or other such means. The limestone will be furrowed in the traffic lanes such that the traffic may straddle the furrow. The furrowed limestone will be lightly wetted to minimize dusting.

3.1.2 Limestone Material Testing

Crushed limestone will be delivered from an off-site source to a holding area prior to placement. The resident project representative shall collect one sample for every 100 tons of crushed limestone delivered to the site. The crushed limestone shall be tested for the following:

Test	Sample Type
Sieve analysis to the #200 sieve (ASTM C 136)	pile run
Calcium Carbonate	pile run
Neutralizing Index	pile run

The results of the testing will be filed with the daily construction observation report (DCOR), in Appendix A, when the material was applied. If the chemical and/or mechanical results indicate that the limestone specifications shown below are not being met, then either the quantity of limestone added to the backfill will be adjusted to achieve an equivalent neutralizing capability or new sources of limestone will be used.

- Limestone specifications:

Mechanical Analysis		Chemical Analysis
Sieve No.	% Passing	
8	80-100	Calcium Carbonate Equivalent = 95% or higher
100	40-100	

3.2 Limestone Application Release

At the completion of limestone application on an area of material to be excavated and then placed as pit backfill, the LAO calculations will be checked by a second party on the resident project representative's team. Upon documentation of correct calculations, the area to be excavated as pit backfill shall be deemed "released", and ready to be used as limestone amended backfill.

3.3 Lift Material Thickness

3.3.1 Lift Material Installation

Initial pit backfilling will consist of the placement of both freshly-excavated, as well as, stockpiled Type II material. Type II material to be backfilled will be deposited in the active backfill area by haul equipment. A dozer will spread the material evenly across the area in an approximate 3-foot lift, with an upper limit of 3 feet, 4 inches. The lift thickness will be marked on lath or by other such means. The lath will be placed on a 150-foot grid in the area to be filled. The lath will be painted with a line located approximately 3-feet above the existing grade. The approximate 3-foot elevation will be established to allow the 1½% or greater slope for drainage purposes to be maintained. The fill material will be placed to the mark and then appropriately compacted.

During the initial phase of the backfilling process in the east section of the pit, the haul vehicles will be depositing material from east to west. The haul vehicles will back to the point where the material is to be deposited, and then drive forward dropping their load. The narrow pit bottom will restrict the haul vehicles from turning around until an approximate elevation of 980 feet to 990 feet is reached. Upon reaching the elevation when the vehicles can safely turn around, they will drive forward into the pit, end dump material, and drive forward to exit.

3.3.1.1 High Moisture Material

It will be necessary to place some backfill material in the initial lifts at the base of the pit in wet conditions even though standing water within the pit will be removed by dewatering methods prior to backfill placement. This is due to inflow that occurs in the pit. Once lift placement has reached approximately 12 vertical feet above the existing bottom grade, material which is observed to severely pump over large areas beneath the compaction equipment due to excess moisture shall be scarified and recompacted until the severe pumping is no longer observed. Materials anticipated to be prone to pumping shall be placed in areas of low truck traffic.

3.3.1.2 Oversize Material

Pieces of waste rock which are larger than 36 inches in all three dimensions shall be segregated from the general pit backfill and broken until one dimension of the rock is approximately 24 inches or less. These broken pieces will be placed at the base of a backfill lift such that the maximum dimension is in the approximate horizontal position. Continued placement of loose fill over these pieces can then be accomplished.

3.3.2 Elevation Documentation

Record survey elevations shall be taken on a maximum 150-foot by 150-foot grid by the site surveyors. The grid system shall be the same system used to stake loose lift thickness control points. Documentation of elevations shall be performed on the grid to document the following grades:

- Base grade of the pit and sidewalls (or final outline of the pit)
- Final grade of Type II fill

Elevation measurements will be made to the nearest 0.1 feet. The field book used for collecting the elevation information shall be kept on file by the resident project representative. The elevations at each point will be placed on the lift figure developed for each specific lift area.

3.4 Compaction

Compaction of the pit backfill will be initially accomplished by a dozer during material spreading into each lift, then by a fully loaded 50 ton haul truck, or either a Bomag BW213D-2(2A) sheepsfoot vibratory compactor or a Caterpillar 815 static compactor or equivalent.

A description of the compaction equipment used, number of passes, general direction of equipment travel, starting time and ending time, and weather conditions will be noted in the DCOR found in Appendix A. A description of the backfill material type including color and an estimate of the amount of P200 material in the backfill material will also be documented in the

DCOR. A person shall be designated as the pass observer and shall document the movement and coverages of the dozer and compaction equipment. Once a lift has received two passes of compaction, it will be deemed compacted. Portions of lifts may be final released by the resident project representative which will allow continued haulage while other backfilled areas may require additional compaction prior to release. A lift area not final released by the resident project representative will not be allowed to receive overlying Type II material.

3.5 Other Information

In order to satisfy permit requirements and as stated in Section 5.7.2.6 of the Mine Permit Application, the following activities will also be performed.

3.5.1 Photographs

Photographs shall be taken of major construction elements. A sufficient number of photographs shall be taken to document the construction of each construction item. Each photograph shall be a 35 mm color photograph and shall be recorded on the Photo Log contained in Appendix A.

3.5.2 Pit Sidewall Observation

As the pit is backfilled, the pit sidewall shall be observed. General sidewall rock types, mineralization, fractures, faults, and areas of significant groundwater inflow will be noted and checked with the mine maps developed during mining. All pertinent areas shall be noted on the mine maps.

4 Additional Data Collection

In addition to the acceptance criteria information and permit required data described in Section 3 of this manual, the following additional voluntary data will be collected by Flambeau. The voluntary information will be archived for possible future reference related to the Flambeau Project and refinement of backfilling techniques and documentation procedures.

4.1 Material Testing

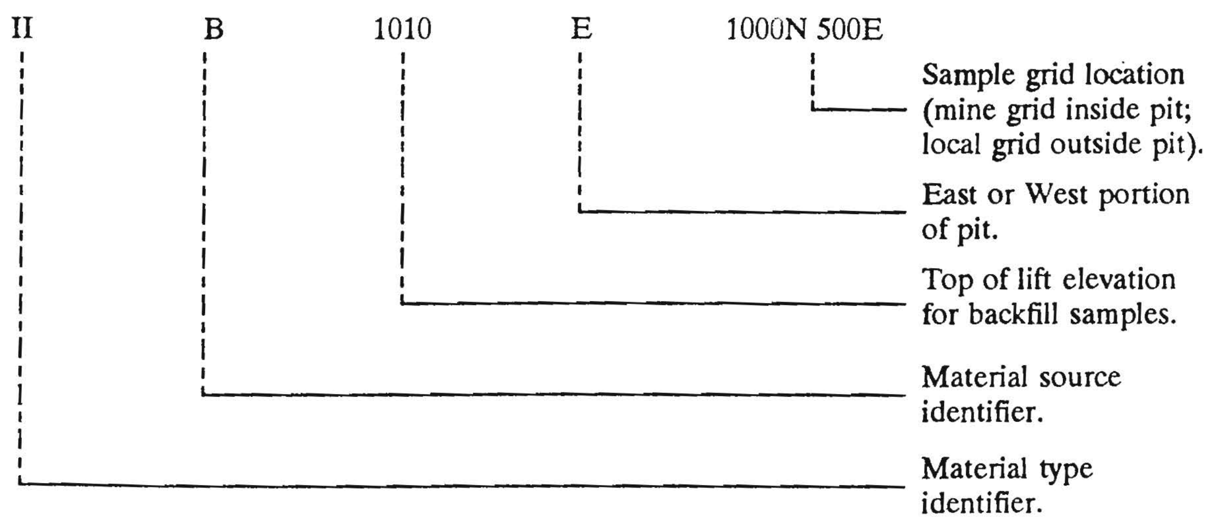
A sampling and testing program to gather grain size data, moisture contents, moisture density relationships, hydraulic conductivities, and specific gravity data will be completed as described below. The following designation procedures will be used to identify samples and tests performed during backfilling.

4.1.1 Sample and Test Designations

Material Type	Material Type Identifier
Type II Material	II
Limestone	LS

Material Source	Material Source Identifier
Stockpile	S
Backfill Within Pit	B

Example:



4.2 Sampling Frequency and Testing

4.2.1 Pit Backfill Material (From Pit or Stockpile)

Prior to commencement of backfilling, a minimum of one sample of any new Type II waste rock that will be used in pit backfilling will be collected. The samples should be obtained from the pit and the existing stockpile at a location chosen to represent the material to be used in the backfilling work. The following analyses shall be performed on the collected samples of each new material to predetermine the characteristics of the material prior to placement:

- Sieve analysis to the #200 sieve (ASTM C 136)
- Moisture content (ASTM D 2216)
- Moisture-density relationship (ASTM D 1557)
- Specific gravity (ASTM D 854)
- Atterberg limits (ASTM D 4318)

If, during the continuation of backfilling, changes in material characteristics are noted, additional samples shall be collected and the same series of tests performed.

4.2.2 Pit Backfill Material (In-Place)

One sample of in-place backfilled material shall be collected from every 5,000 cubic yards for the first 30,000 cubic yards, then one sample per every 30,000 cubic yards thereafter unless the test data indicate alternate frequencies are justified. Each sample shall be collected at locations where field density tests have been performed and shall be analyzed for the following:

- Sieve analysis to the #200 sieve (ASTM C 136)
- Moisture content (ASTM D 2216)
- Moisture density relationship (ASTM D 1557)
- Hydraulic conductivity (ASTM D 2434)
- Specific Gravity (ASTM D 854)
- Atterberg limits (ASTM D 4318)

4.3 Density Testing

4.3.1 Field Test for Density of In-Place Material

Field tests provide a means of comparing the densities of field-compacted soils with the densities obtained in the laboratory. As outlined in Section 4.2.1, at least one Proctor moisture-density relationship shall be developed for each different soil type used to backfill the pit. The Proctor moisture-density relationship will take into account the presence of large stone sizes by following ASTM 4718.

Nuclear density meters shall be used for determining in-place densities and moisture contents. Field density test results/data shall be recorded on the Density Tests of Compacted Fill form contained in Appendix A.

4.3.2 Quality Assurance Checks for Nuclear Density Testing

Once at the start of the backfilling procedure, then at a frequency of once every 30,000 cubic yards, sand cone density tests (ASTM D 1556) shall be performed to verify that the nuclear density meter is measuring density-moisture relationships accurately. A method of calibration will be developed similar to that used in the Field Compaction Test Report regarding this project. Sand cone density field and laboratory data should be recorded on the Density Tests of Compacted Fill form contained in Appendix A.

Density meter moisture content shall be checked/calibrated by moisture content determination in the field using either a microwave method (ASTM D 4643) or other rapid moisture determination methods such as by using a stove. The frequency of this test shall be once every 30,000 cubic yards.

4.3.3 Laboratory Compaction Control Report - Fill Material

Fill material will be tested in the laboratory for maximum dry density and optimum moisture content. The values will be listed in a table as shown in the example in Table 4-1 and will be employed for historical reference and to provide data for backfilling technique revisions. The maximum dry densities to be used during backfilling will be listed on the Density Test of Compacted Fill form for each density test performed.

Table 4-1

Modified Proctor Results Summary[1]

Sample Number	Soil Description	Maximum Dry Density (pcf)	Optimum Moisture Content (pcf)
II-B-900E-20,000N 42,000E	Type II old	134.8	8

[1]Example sample number, soil description, maximum dry density, and optimum moisture content shown.

4.3.4 Field Density Locations

Density tests will be located across a given lift to provide a frequency of tests at one density test per 2,000 cubic yards of in-place fill. This translates to approximately 2.4 tests per acre per lift. In addition to being recorded on the Density Test of Compacted Fill form in Appendix A, locations of density tests will be noted on the lift figures attached to the daily reports.

5 Daily Construction Observation Report

A construction observation report (Appendix A) is to be prepared by the resident project representative for each day of activity. The following information is to be contained in or attached to the report.

- Date.
- Type of observation.
- Summary of hours worked per day.
- Summary of weather conditions.
- Summary of quantity of material placed per day.
- Description of backfill material, including color and approximate P200 quantity.
- Summary of limestone placed per day.
- Summary of any meetings held and attendees.
- Equipment and personnel on the project.
- Summary of construction activities and locations; note activities on Lift Figures.
- Description of limestone (off-site materials) received and stored on site.
- Description of backfill conveyance and compaction procedures used:
  - Compaction method;
  - Number of passes;
  - Direction of compaction equipment;
  - Starting and ending time of compaction.
- Test locations, procedures, results and test data sheets.
- Calibration and recalibration of test equipment.
- Summary of samples collected.
- Survey data.
- Personnel involved in observation and sampling activities.
- Summary of photos taken for documentation.
- Description of delays in construction activities.

- Detailed description of problems or non-conforming construction and resolution/ alternatives for each situation.

- Approximate quantities completed each day including the pounds of limestone added to Type II material used as backfill and the number of loads of pit backfill placed.

- Description of areas of Type II material released for use as limestone amended backfill.

- Description of areas released for additional backfill placement.

- Signature of the resident project representative.

Appendix A

Daily Construction Observation Report
Limestone Application Observation Form
Density Tests of Compacted Fill Form
Photo Log

Foth & Van Dyke
engineers · architects · scientists

Client: ______________________ Scope ID: __________
Project: ______________________ Page: __________
Prepared By: ______________________ Date: __________

DAILY CONSTRUCTION OBSERVATION REPORT

Location ______________________

Safety Inspection/Comments ______________________

WEATHER	Temp (° F)		Sky Cond.	Precip. (in.)			Site Conditions (describe)	
	Low	High	Clear Pt. Cldy Cloudy	None	Rain	Snow	Dry	Muddy

Contractors on site *(include no. of personnel per contractor)*

Other personnel on site — *Purpose*

Work observation report, comments: ______________________

For additional comments, include additional sheets

White: Files Yellow: Owner Pink: Field

FORM CEC030-A (8/96)

Flambeau Mining Co. - 96F013
Limestone Application Observation

Foth & Van Dyke
engineers · architects · scientists

Date	Application Area Location	Application Area Coordinates	Application Area Elevations (ft msl)	Application Total Area (sq ft)	Average Height (ft)	Required Limestone (lbs)

Actual Limestone Added (lbs)	Calcium Carbonate Equivalency (% CCE)	Application Rate (lbs/ton)	Targeted Application Thickness (in.)	Comments

additional comments, calculations, etc. ______________________________

Assumes density of limestone is 80 lbs pcf.

DENSITY TESTS OF COMPACTED FILL

Contractor: ____________________

Compaction Equipment: ____________________

____

Weather: ____________________

Method of Test:

☐ Nuclear Meter *(ASTM: D2922)*

☐ Sand Cone *(ASTM: D1556)*

Area/Location Tested: ____________________

____

____

Report Number: ____________________

Test No.	Test Location (Coordinates)		Depth of Probe	Elevation	Proctor Used	Wet Density (pcf)	Moisture Content (%)	Dry Density (pcf)	Percent Compaction	Remarks
	N	E								
	N	E								
	N	E								
	N	E								
	N	E								
	N	E								
	N	E								
	N	E								
19	N	E								
	N	E								
	N	E								
	N	E								
	N	E								
	N	E								

Proctor No.	Soil Classification	Max. Dry Density (pcf)	Moisture Content (%)	Compaction Spec. (%)

General Note:
Density test results are valid only at the locations and elevations tested.

Nuclear Meter Used: ____________________

Model: __________ Serial No.: __________

Standard Counts: ____________________

Density: __________ Moisture: __________

Foth & Van Dyke
engineers · architects · scientists

Client: ____________________ Scope I.D.: __________

Project: ____________________ Page: __________

Prepared by: ____________________ Date: __________

Checked by: ____________________ Date: __________

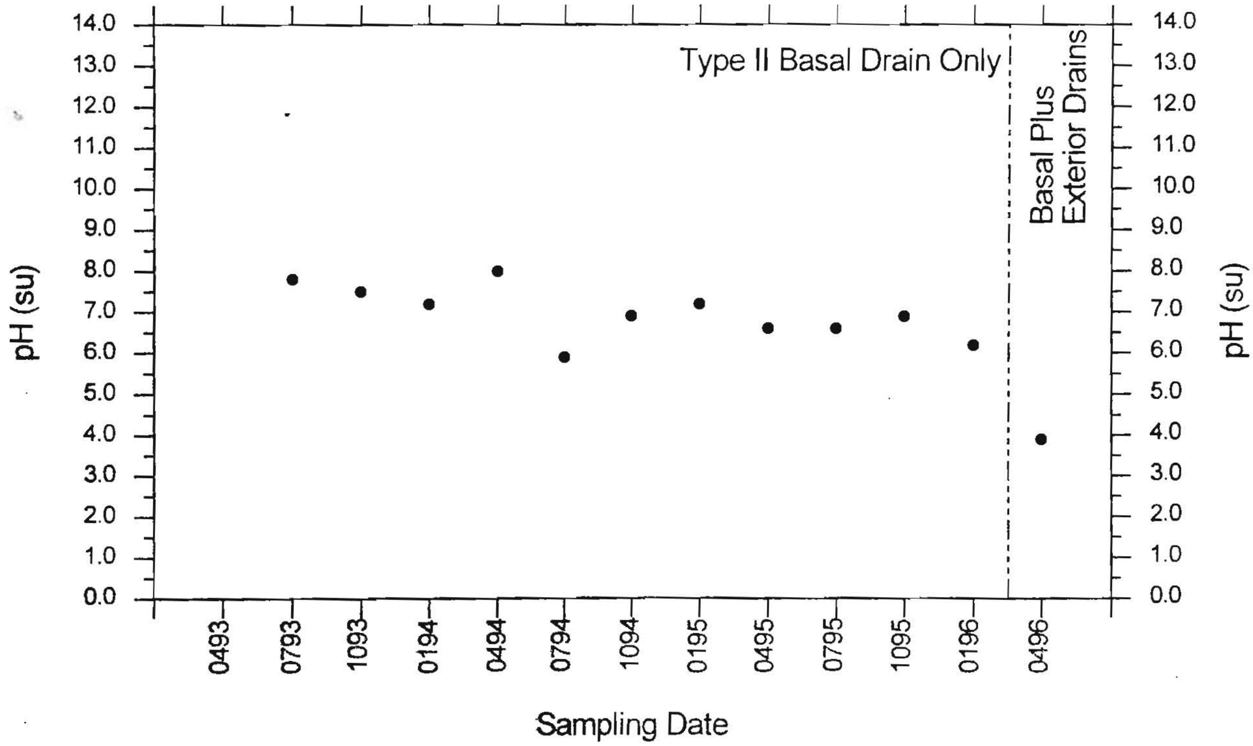
PHOTO LOG

Roll Number	Photo Number	Date Taken	Description

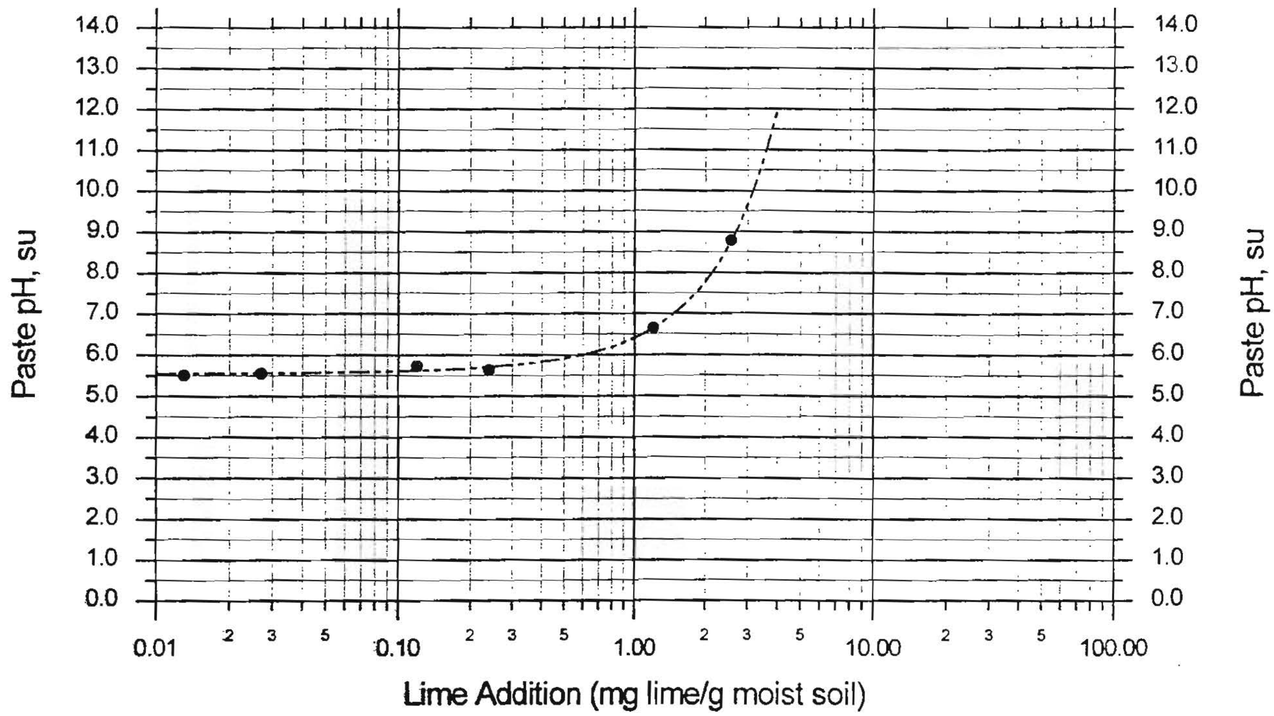
Appendix C

Laboratory and Analytical Data for the Initial Screening Tests

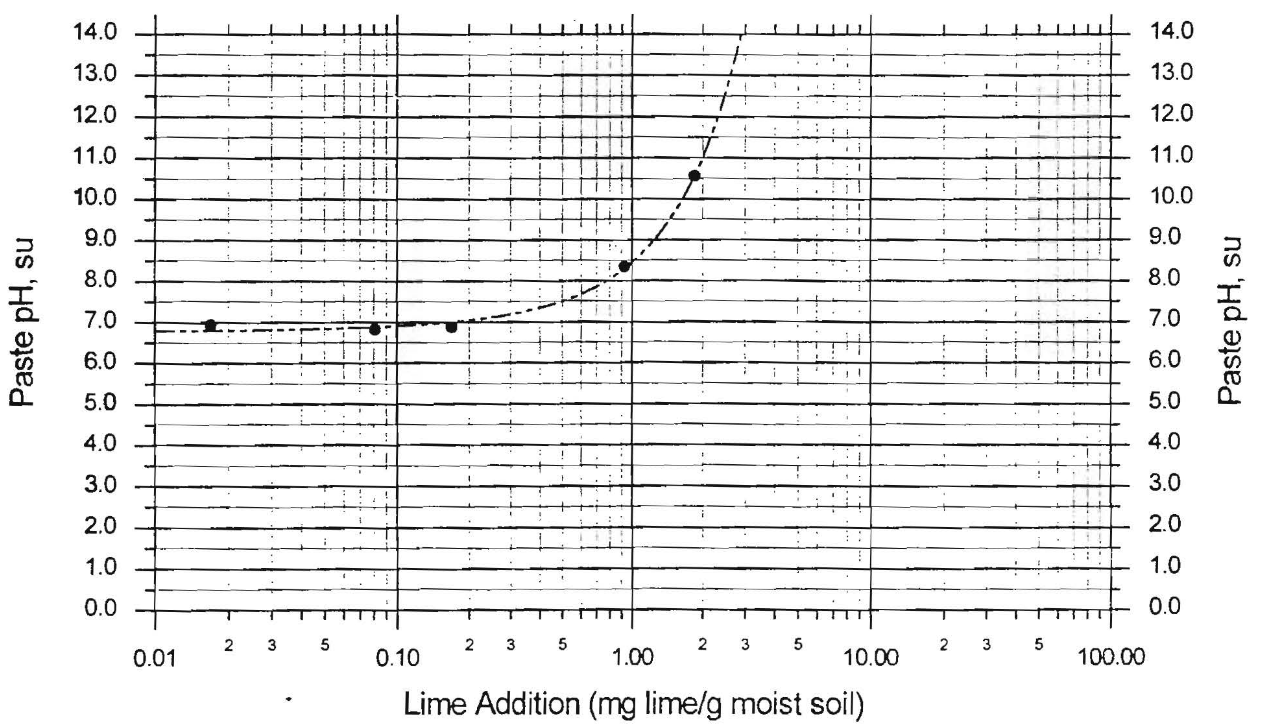
- Appendix C Figure 1. Quarterly Values in the Flambeau Type II Stockpile Leachate
- Appendix C Figures 2-29. Relationship of Paste pH to Quantity of Lime Added
- Appendix C Table 1. Calculated Immediately Extractable Oxidation Products from Flambeau Stockpiled Type II Material (<¼-in Size Fraction) Single Extractions (1:1) with Site Groundwater
- Laboratory Data Sheets for Extraction Data from <¼-in Size Fraction Material Single Extractions
- Appendix C Table 2. Calculated Immediately Extractable Oxidation Products from Stockpiled Flambeau Type II Material (¼-in - 3-in Size Fraction) Single Extractions with Site Groundwater
- Laboratory Data Sheets for Extraction Data from ¼-in - 3-in Size Fraction Material Single Extractions
- Appendix C Tables 3-5. Calculated Immediately Extractable Oxidation Products from Stockpiled Flambeau Type II Material (<¼-in Size Fraction) Single Extractions (1:1) with Alkali Amendment and Site Groundwater
- Laboratory Data Sheets for Extraction Data from Alkali Amended <¼-in Size Fraction Material Single Extractions
- Appendix C Figures 30-41. Relationship of Extraction pH to Quantity of Selected Parameters Extracted During <¼-in Size Fraction Single Extractions



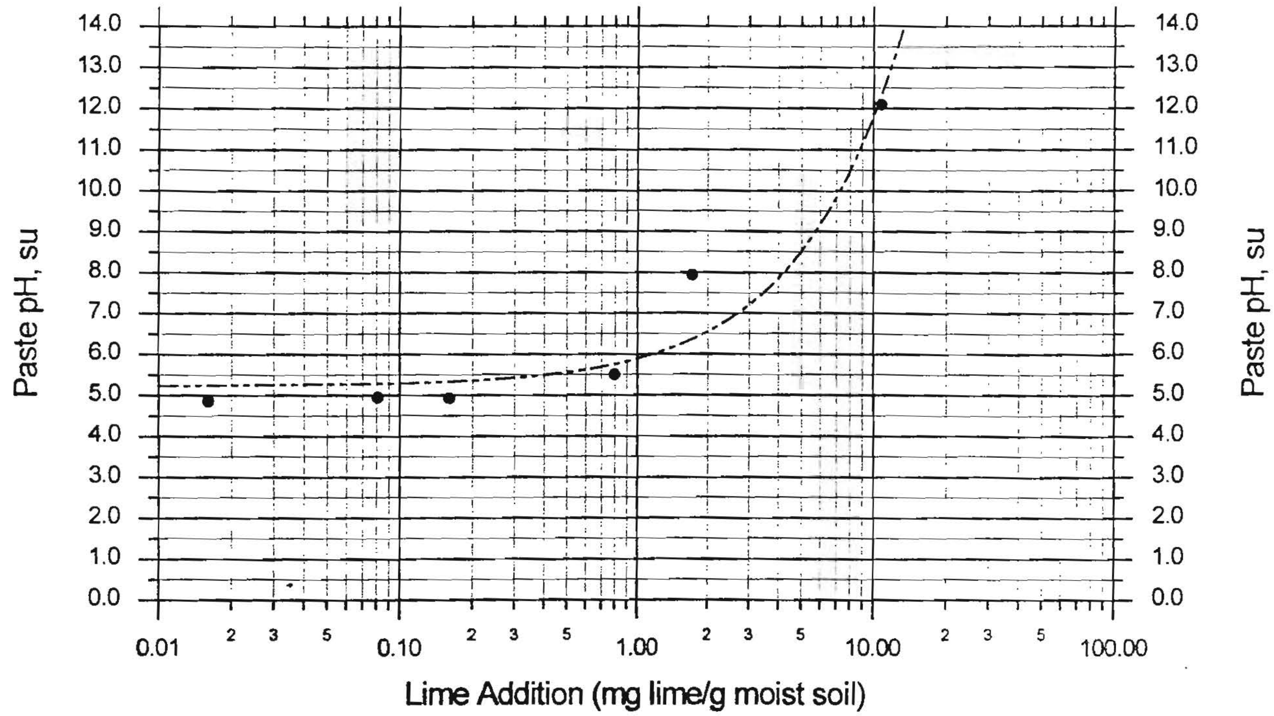
Appendix C Figure 1. Quarterly pH Values in the Flambeau Type II Stockpile Leachate.



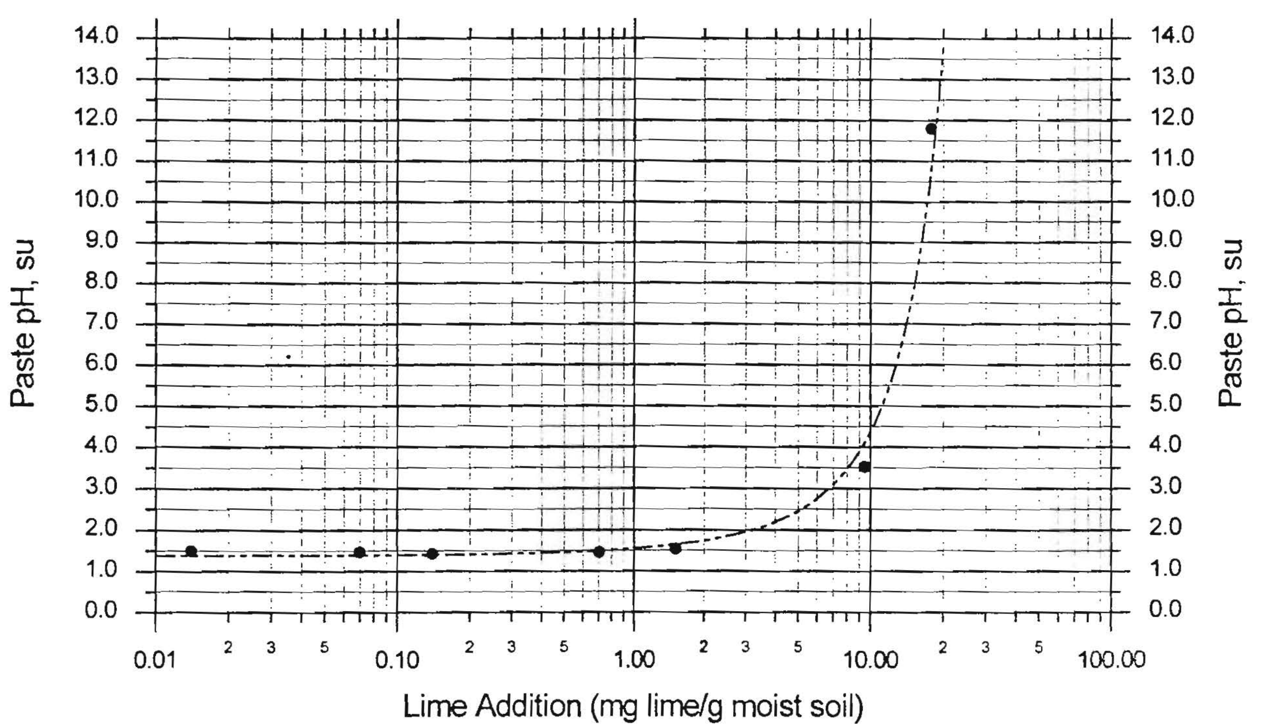
Appendix C Figure 2. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 1.



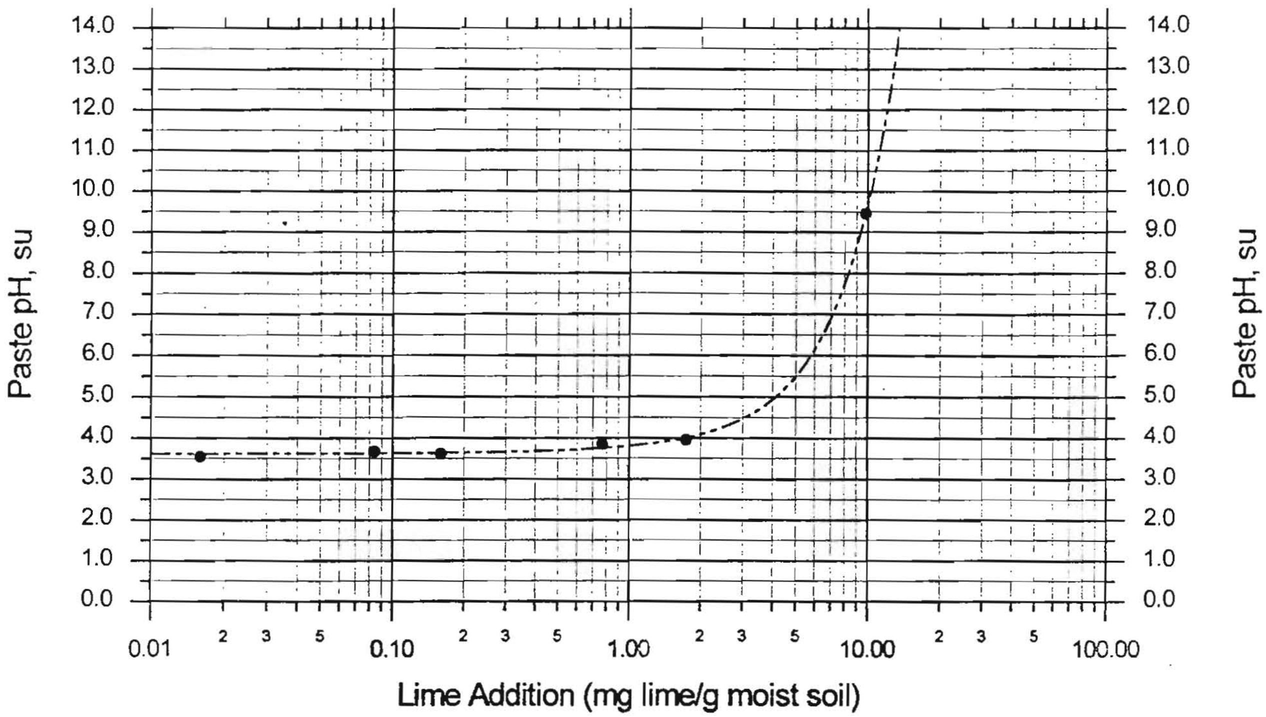
Appendix C Figure 3. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 1-10.



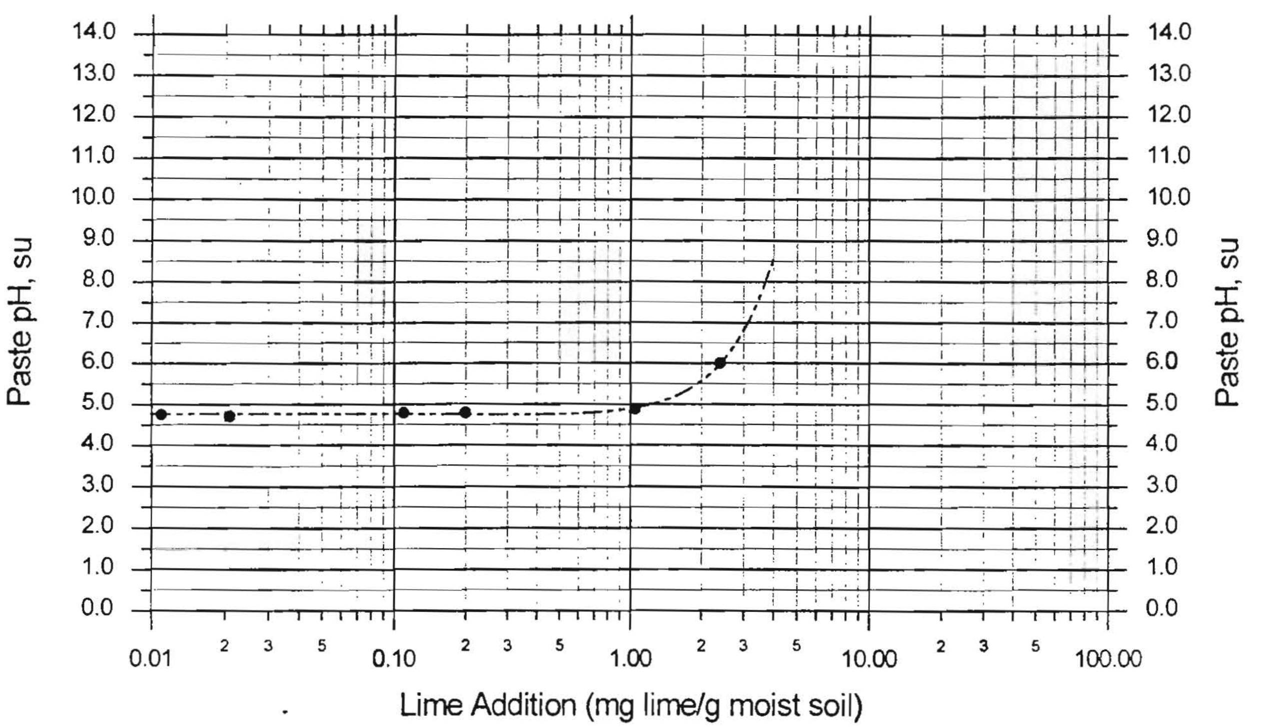
Appendix C Figure 4. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 2.



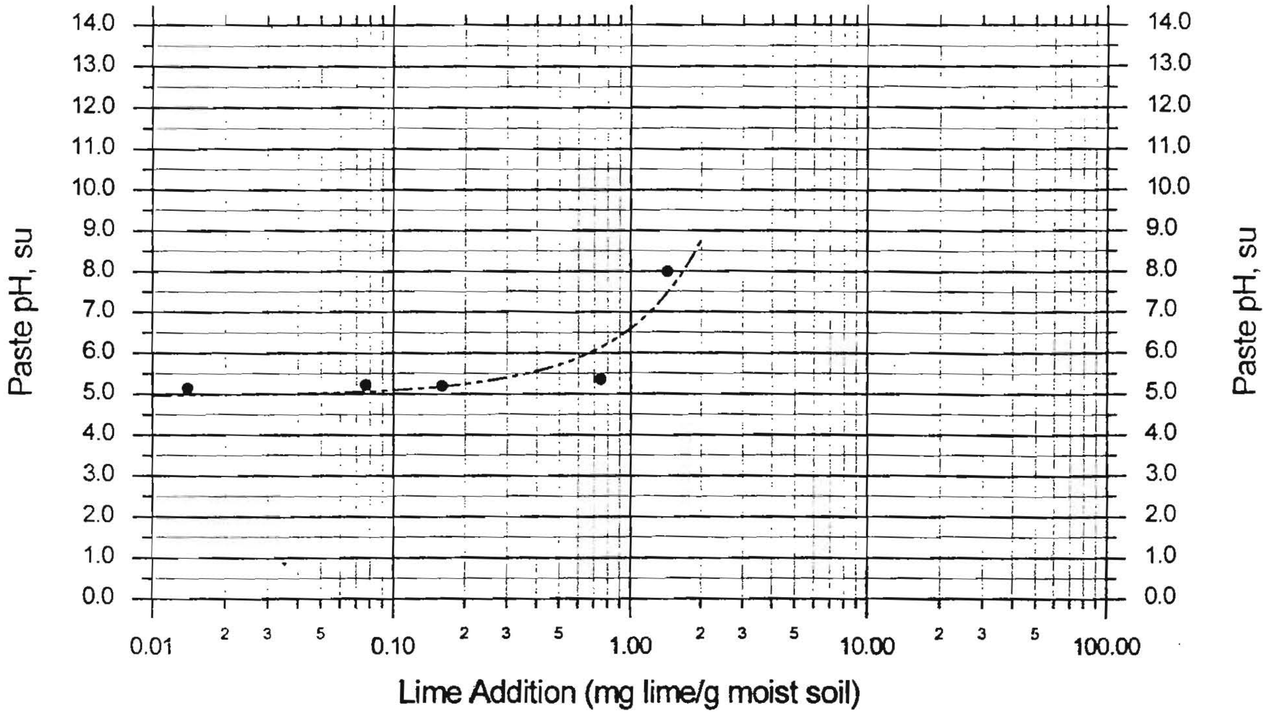
Appendix C Figure 5. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 3.



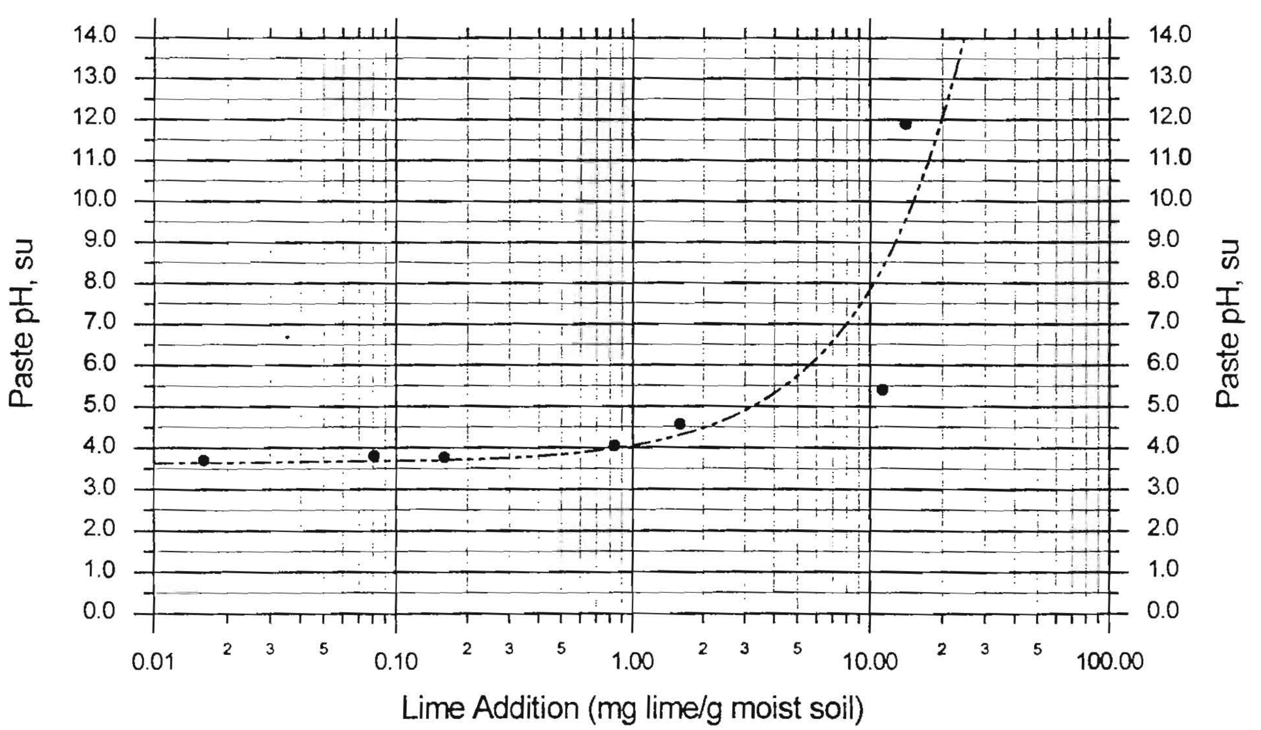
Appendix C Figure 6. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 4.



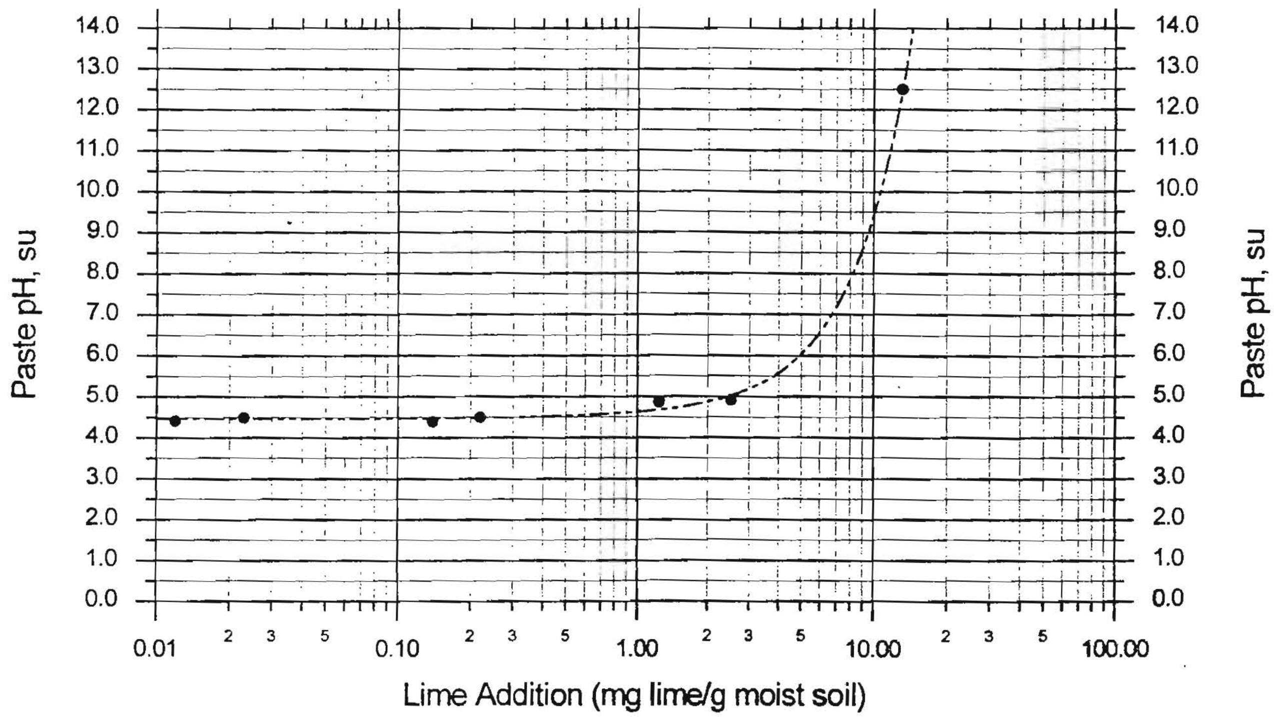
Appendix C Figure 7. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 5.



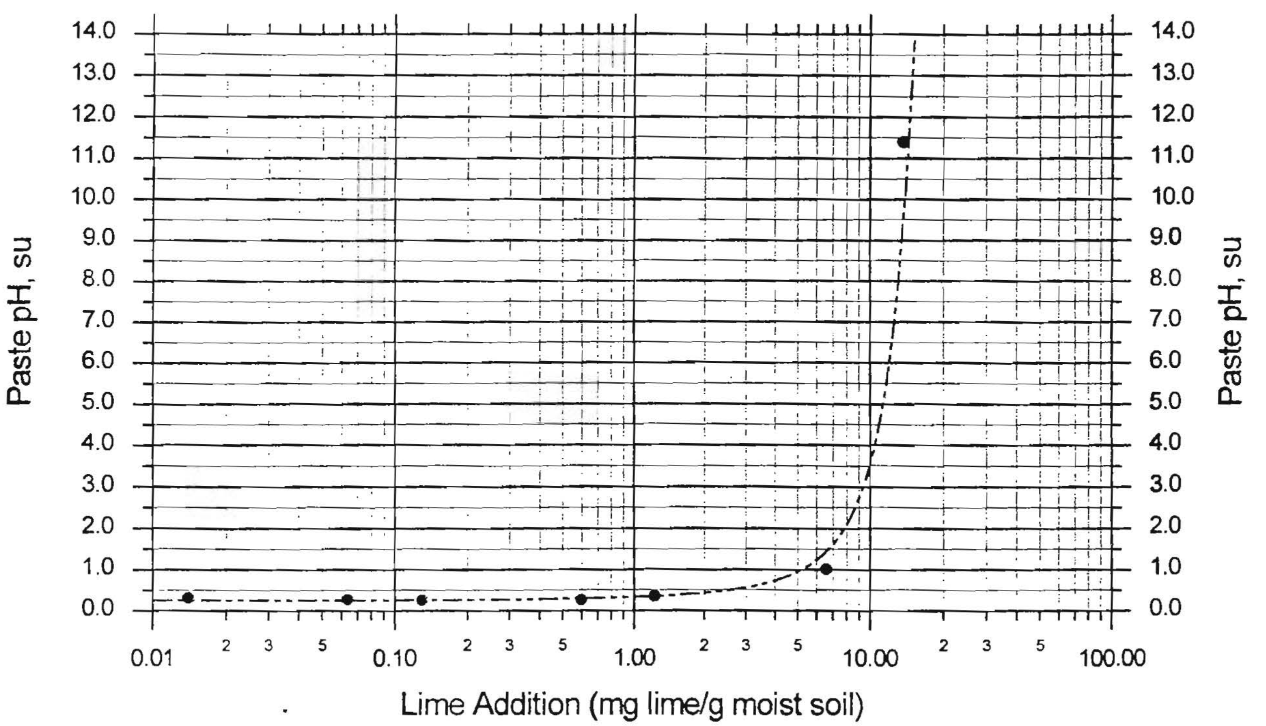
Appendix C Figure 8. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 5-10.



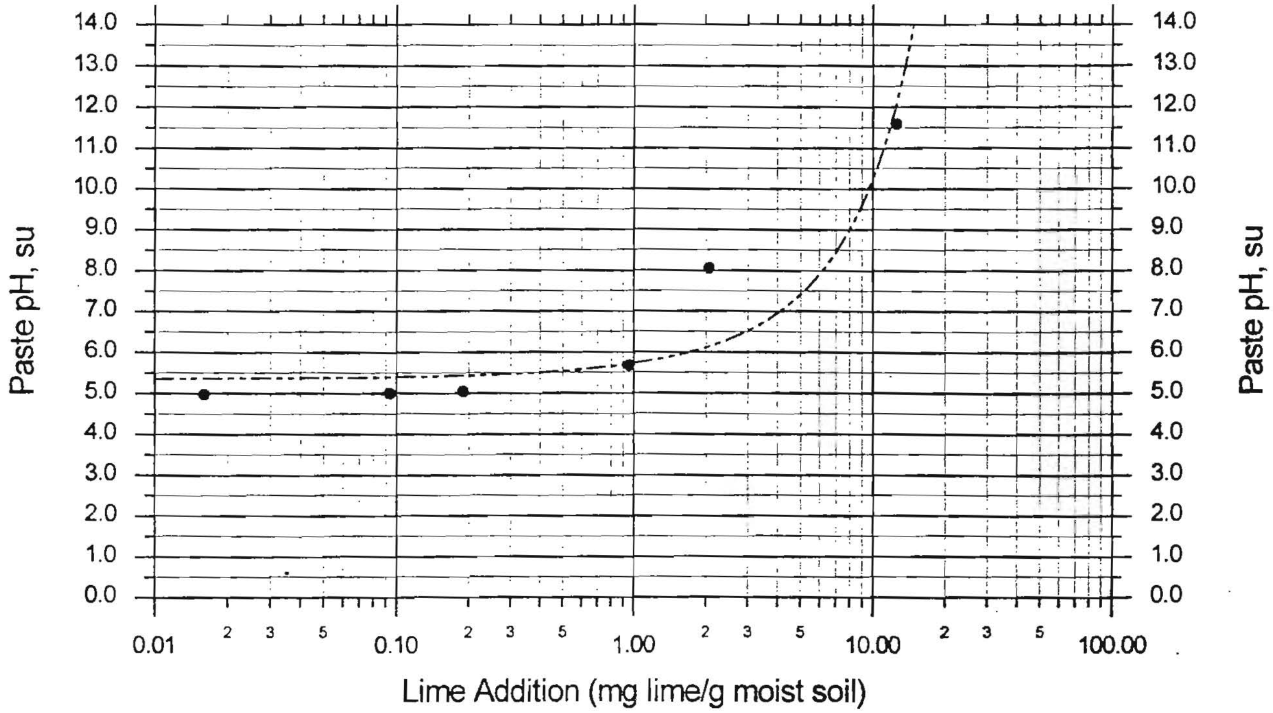
Appendix C Figure 9. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 6.



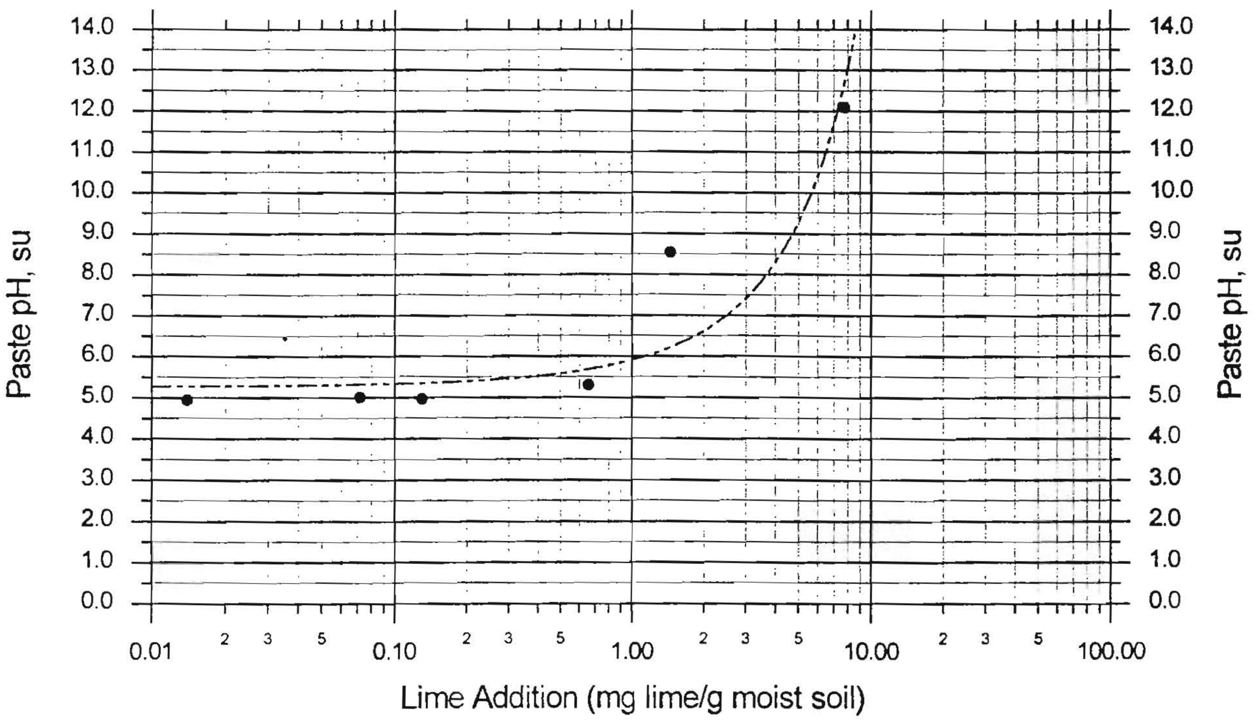
Appendix C Figure 10. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 7.



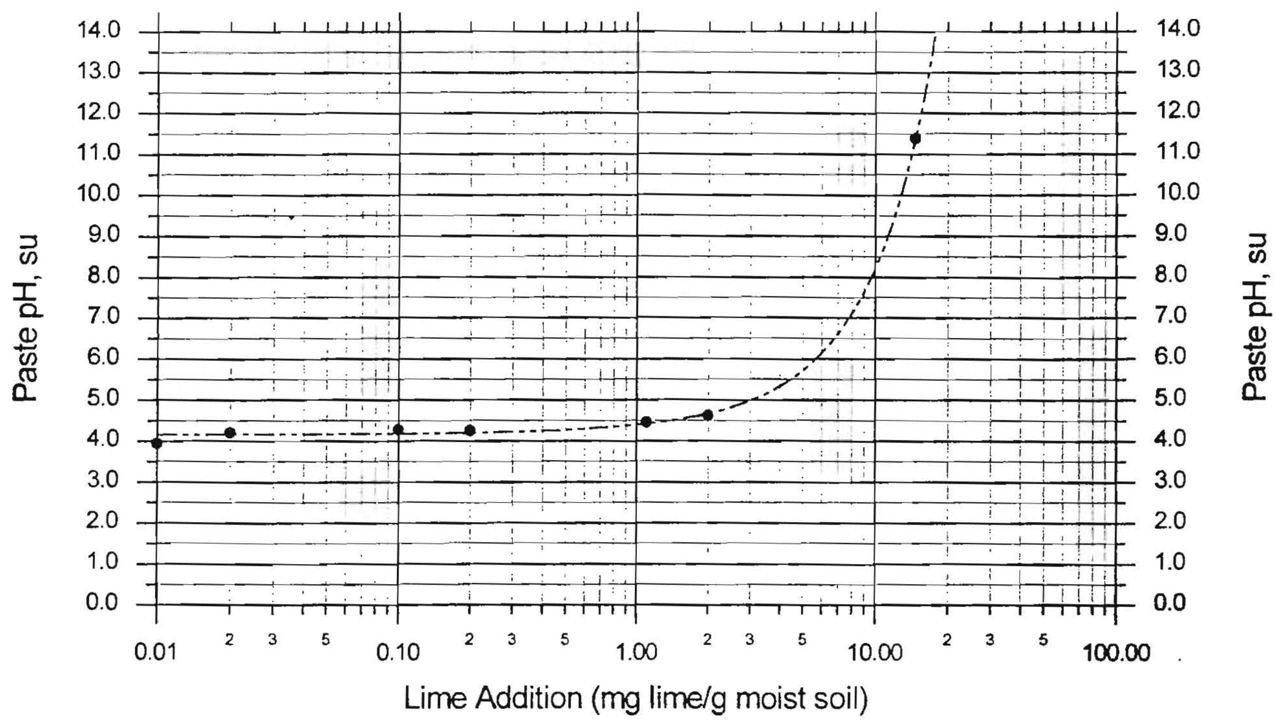
Appendix C Figure 11. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 8.



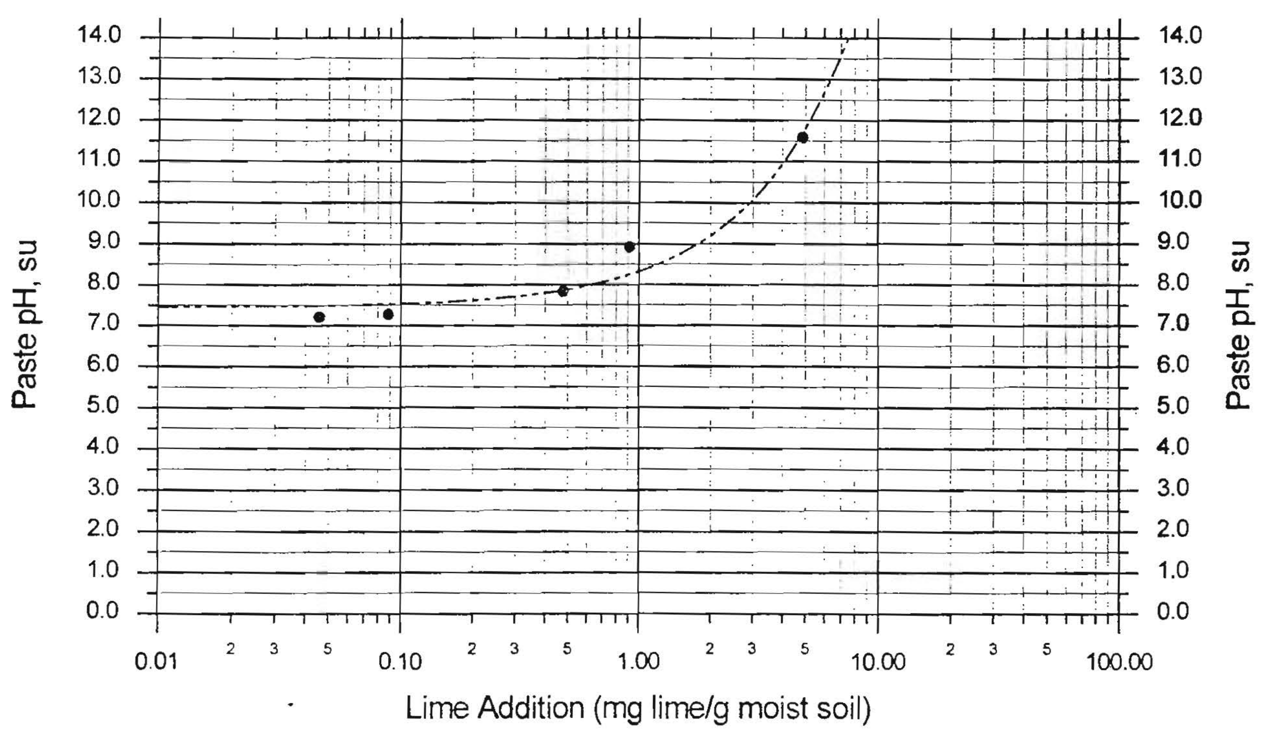
Appendix C Figure 12. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 9.



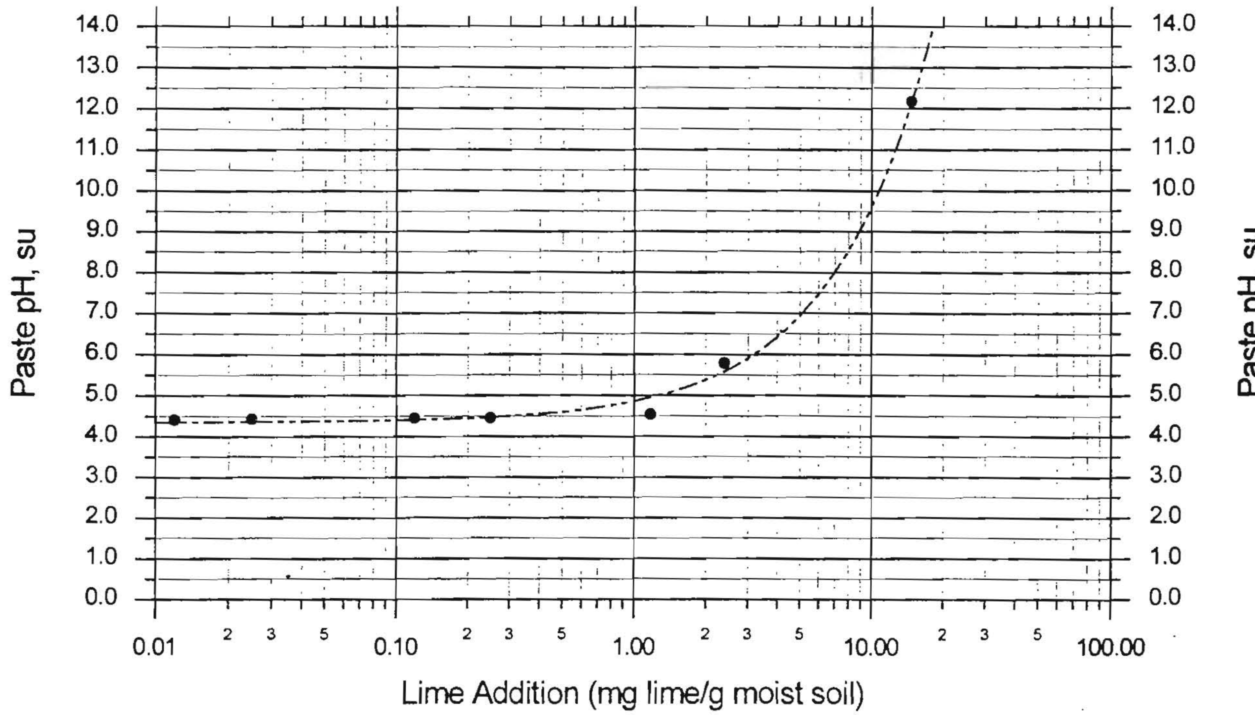
Appendix C Figure 13. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 9-10.



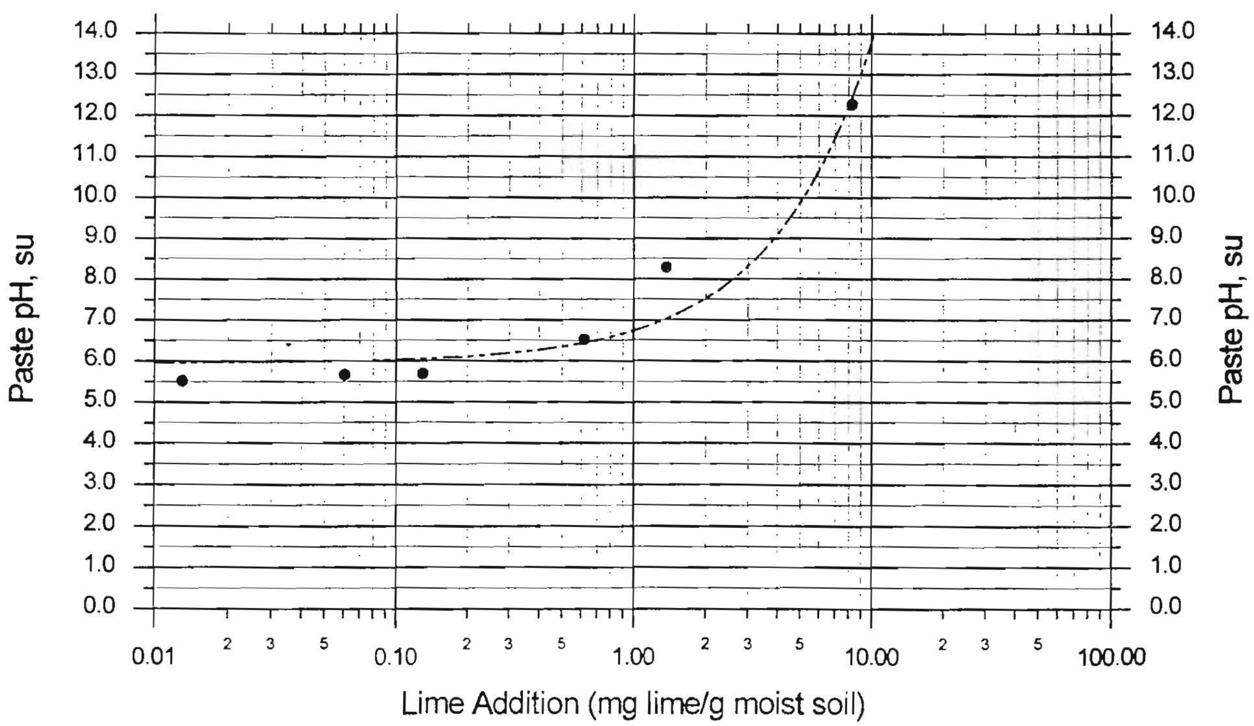
Appendix C Figure 14. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 10.



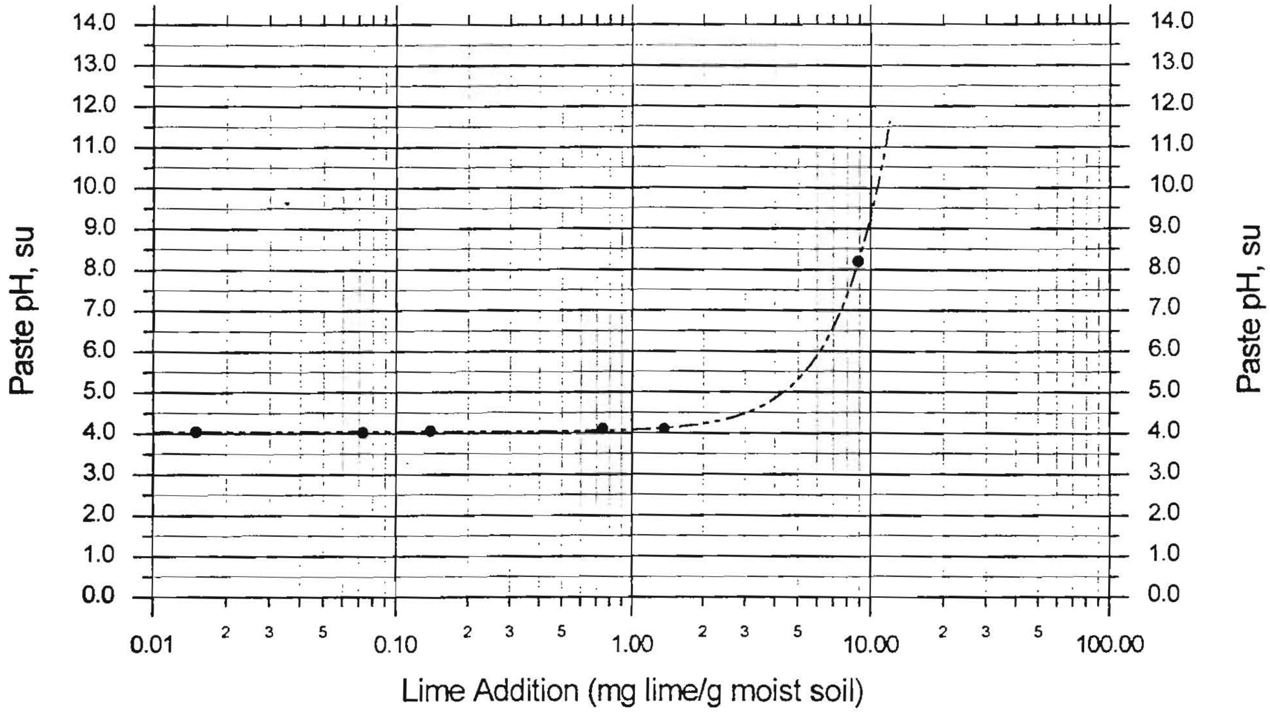
Appendix C Figure 15. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 10-10.



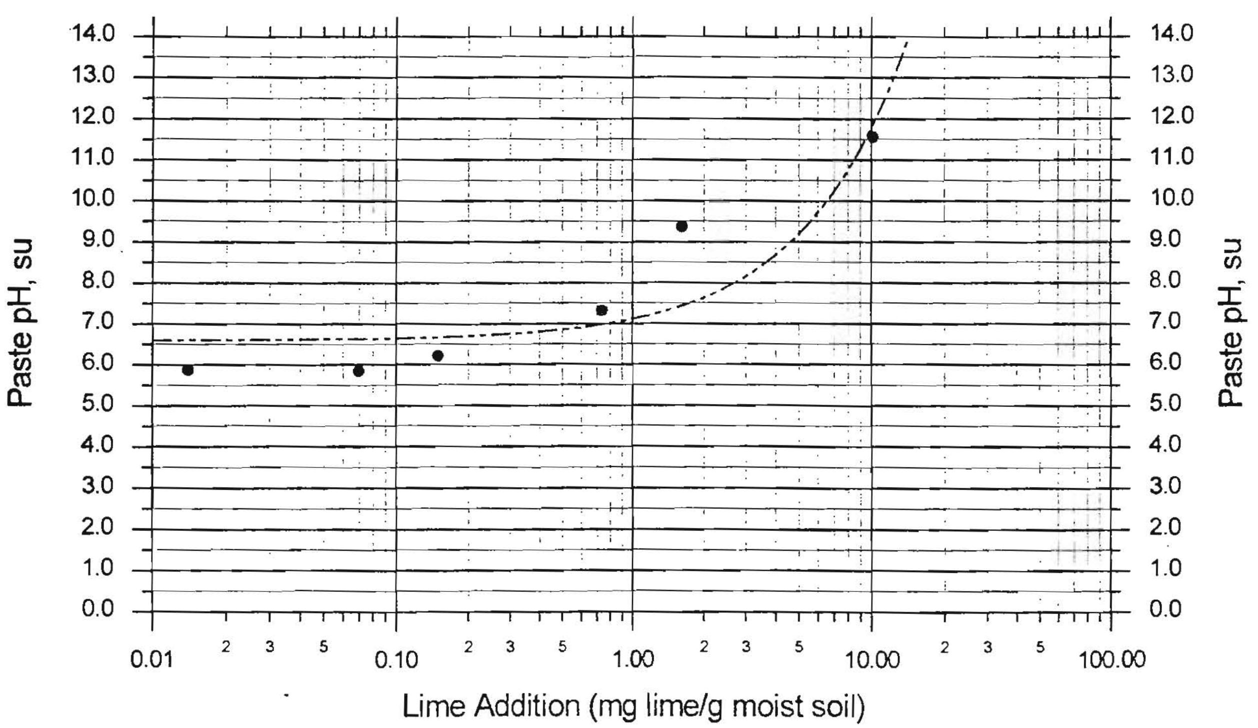
Appendix C Figure 16. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 11.



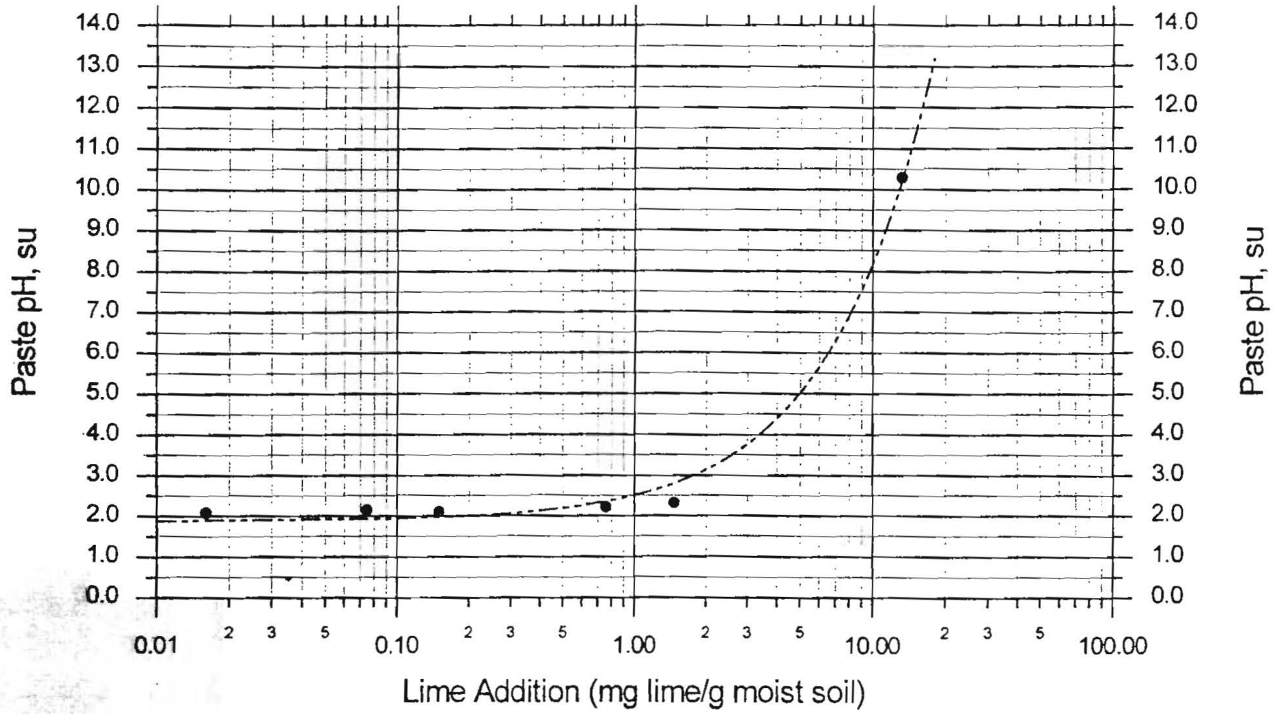
Appendix C Figure 17. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 11-10.



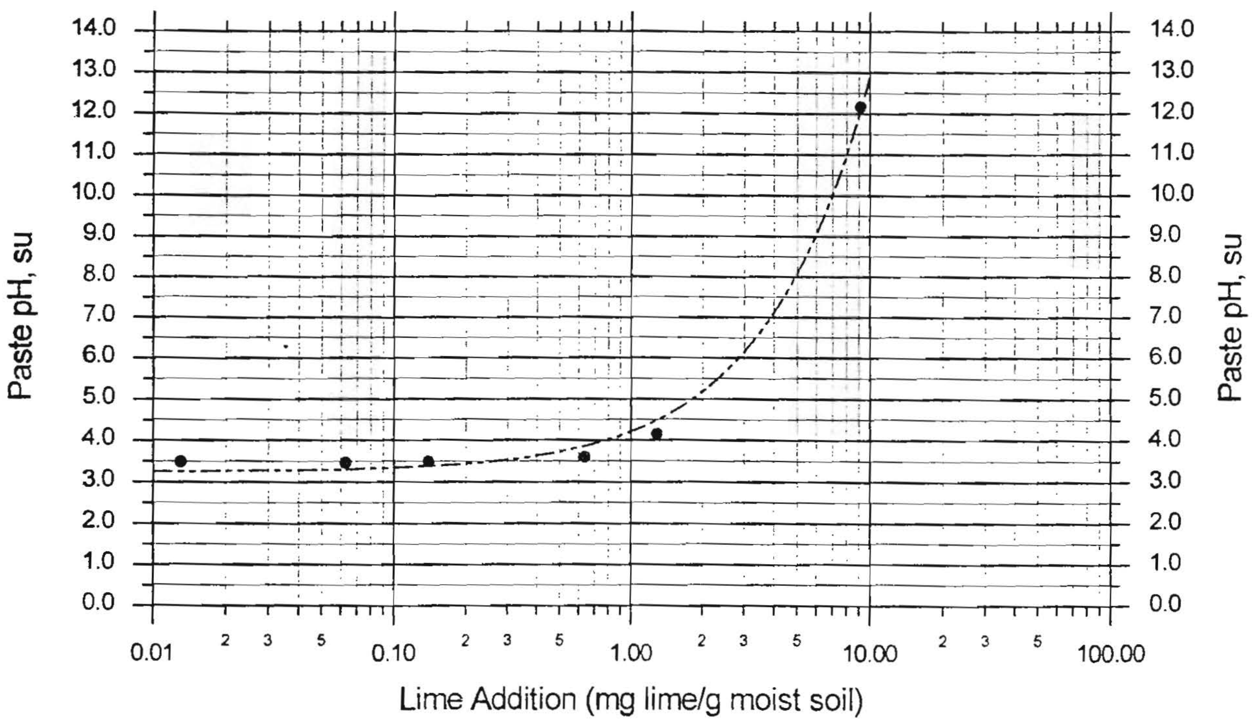
Appendix C Figure 18. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 12.



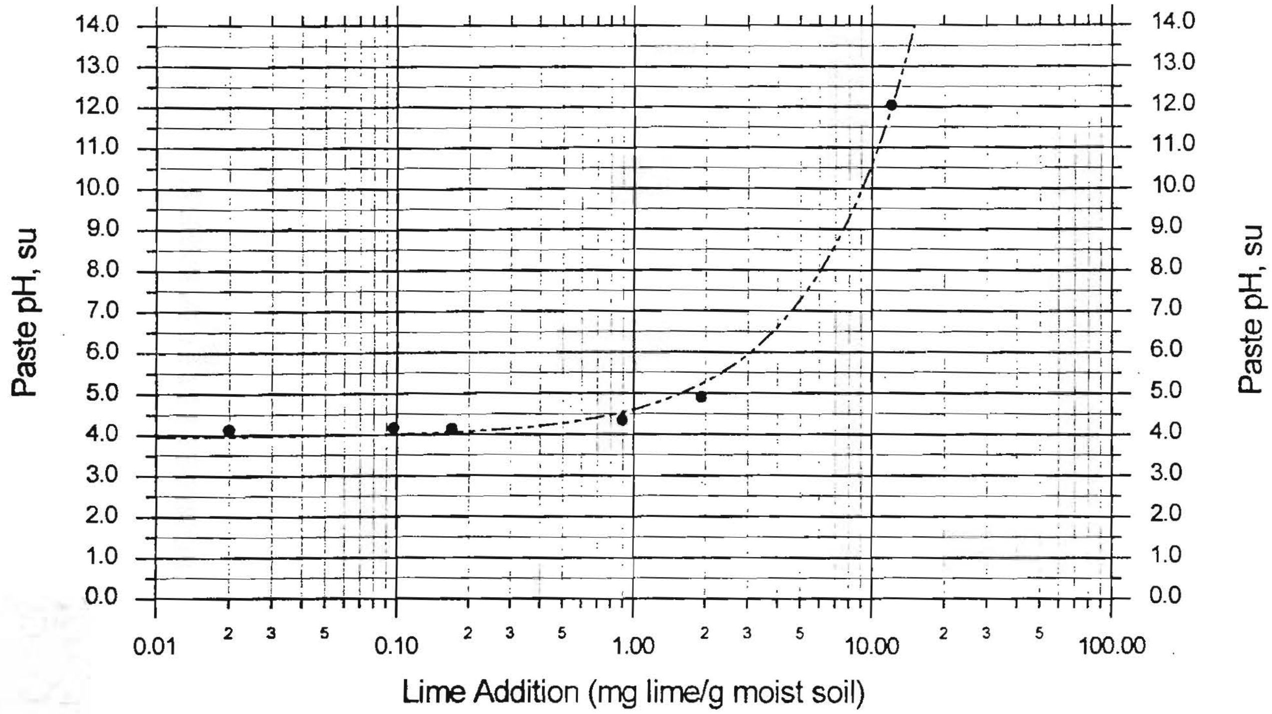
Appendix C Figure 19. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 12-10.



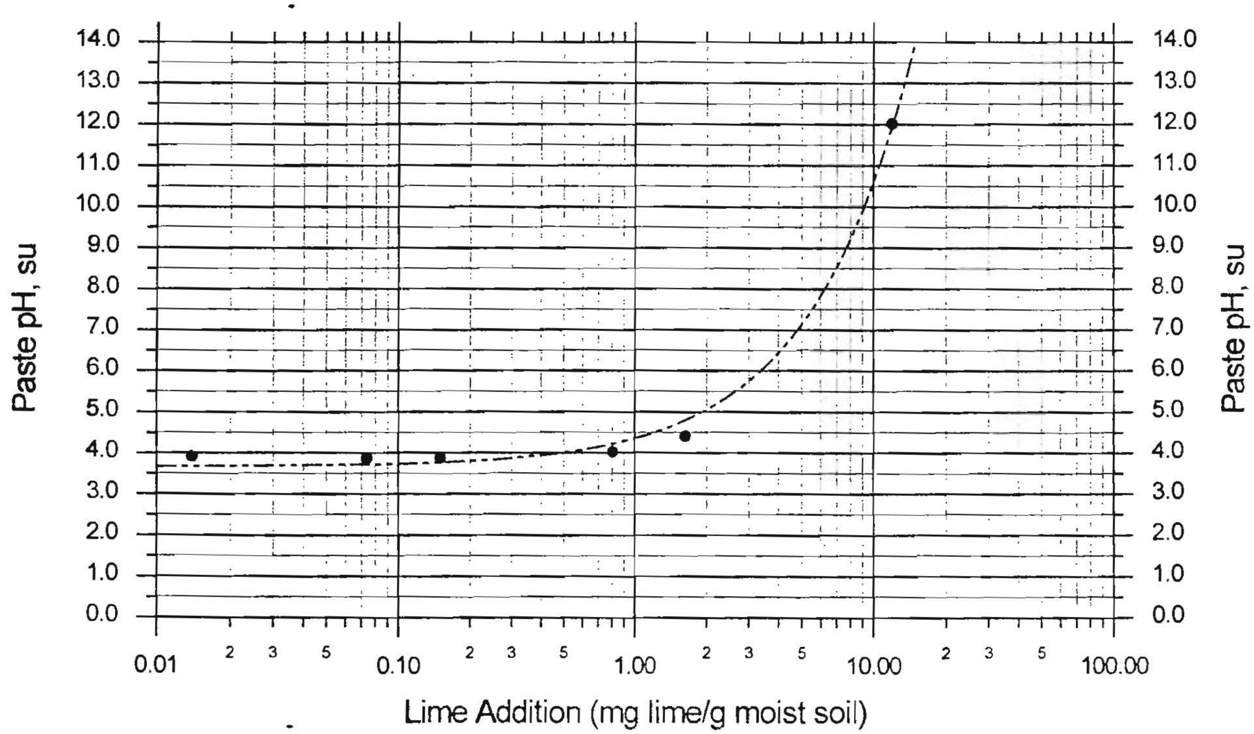
Appendix C Figure 20. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 13-1



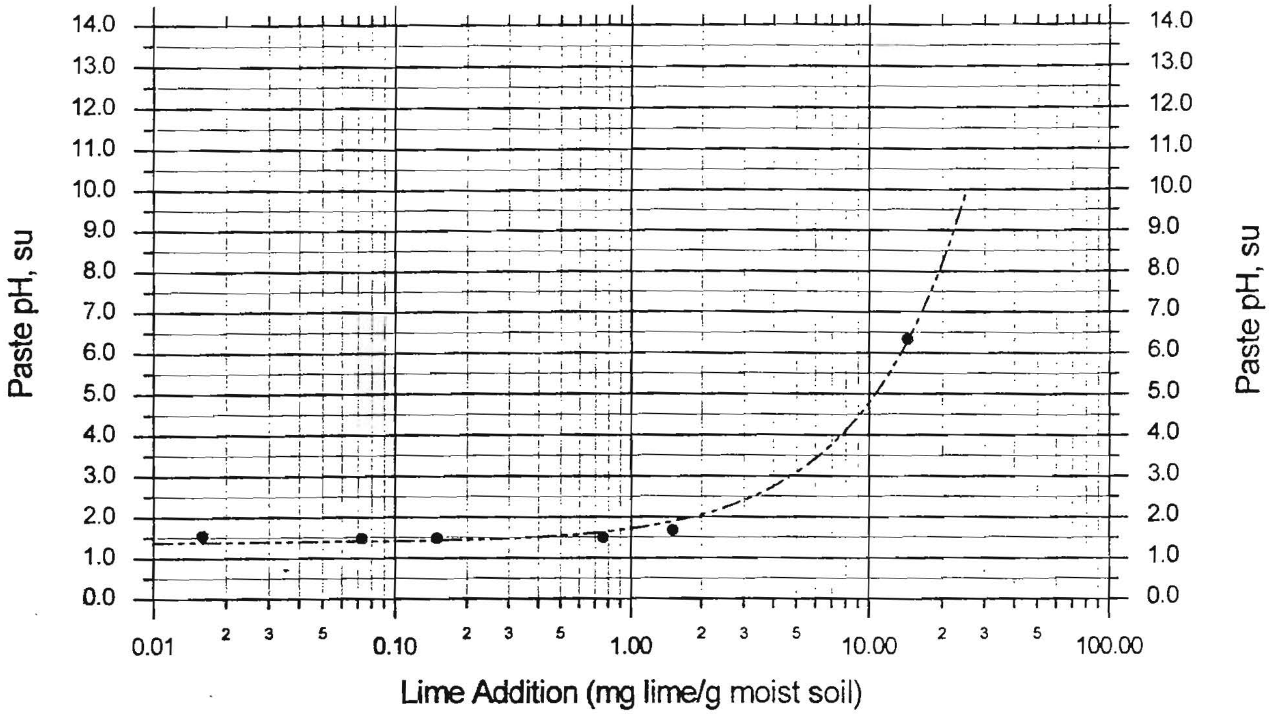
Appendix C Figure 21. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 13-3



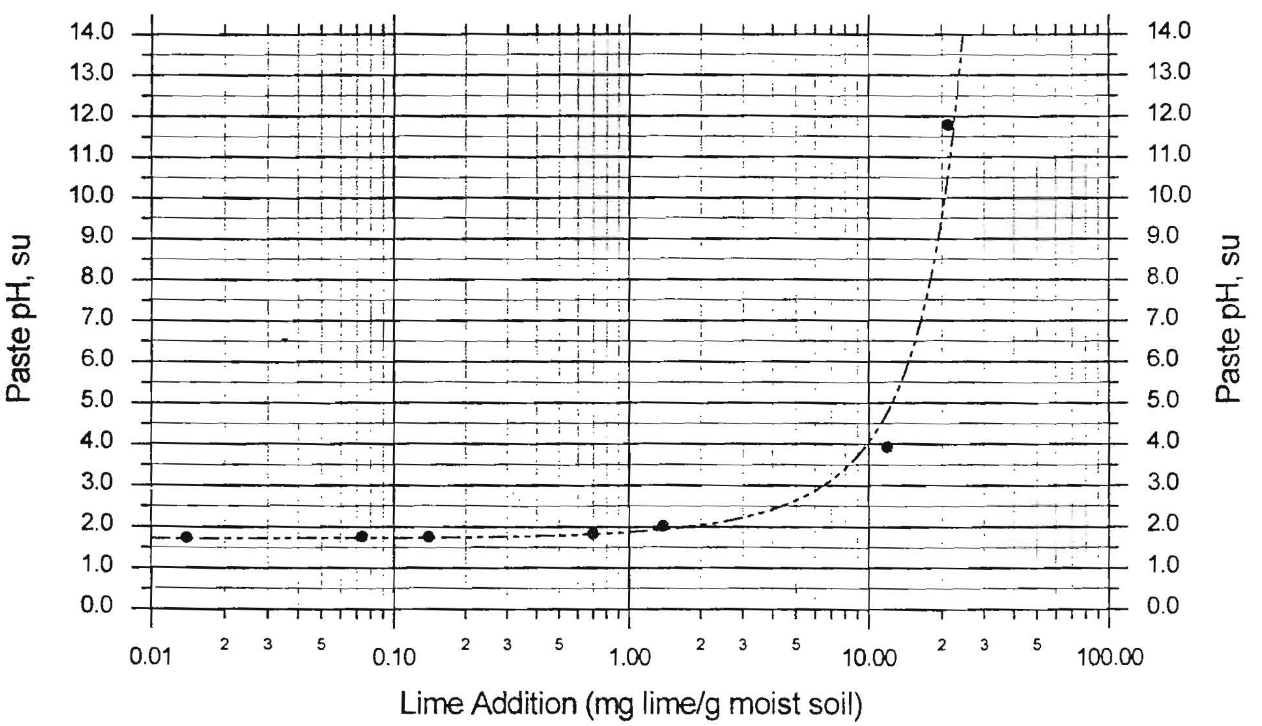
Appendix C Figure 22. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 14-1



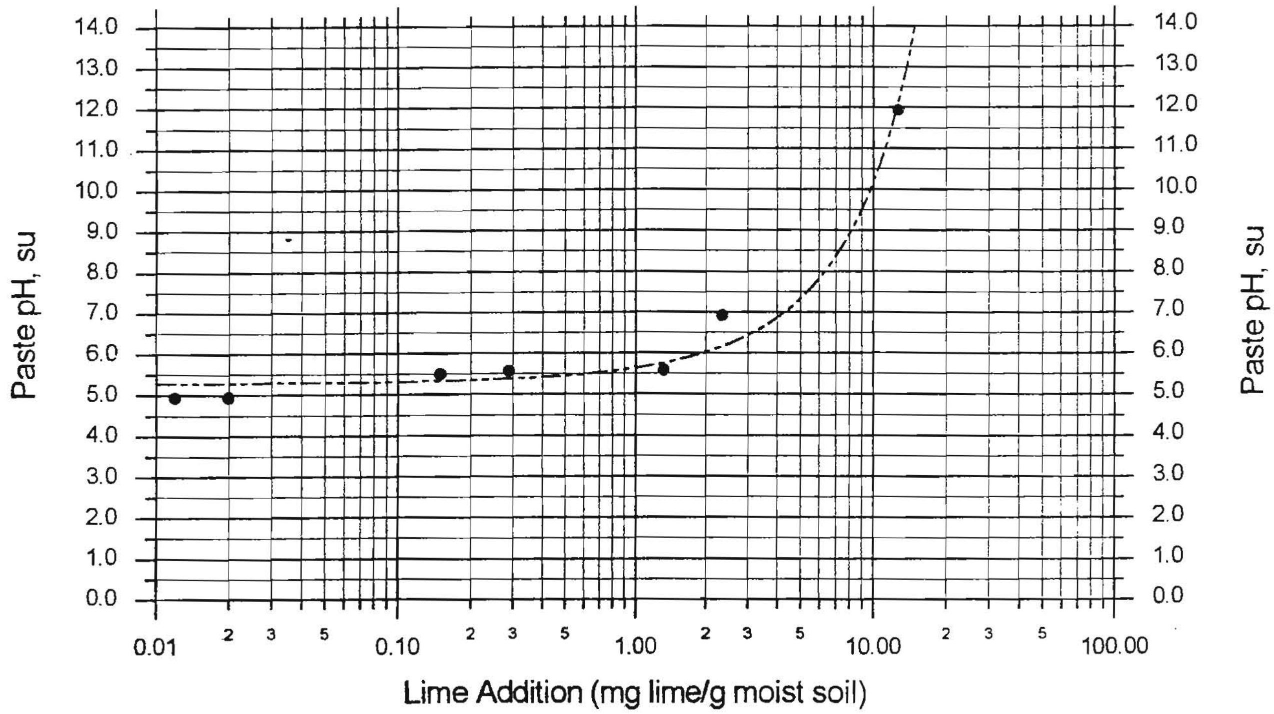
Appendix C Figure 23. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 14-3



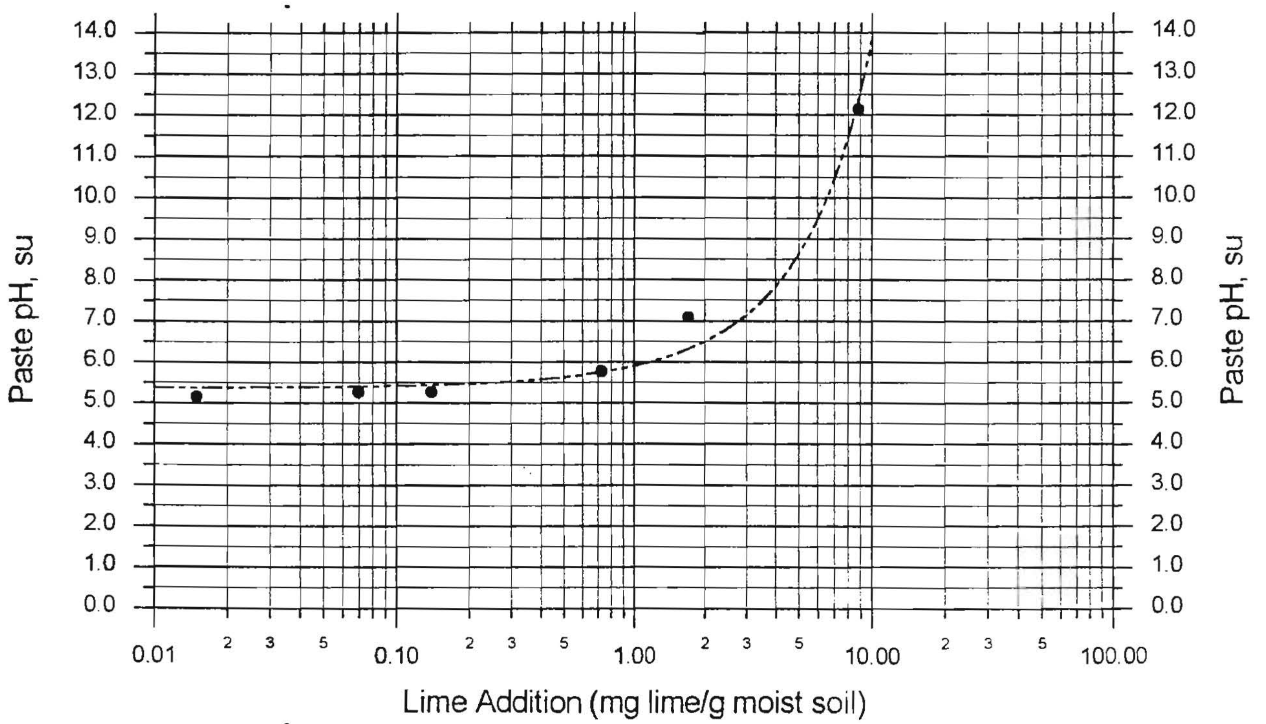
Appendix C Figure 24. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 15-1



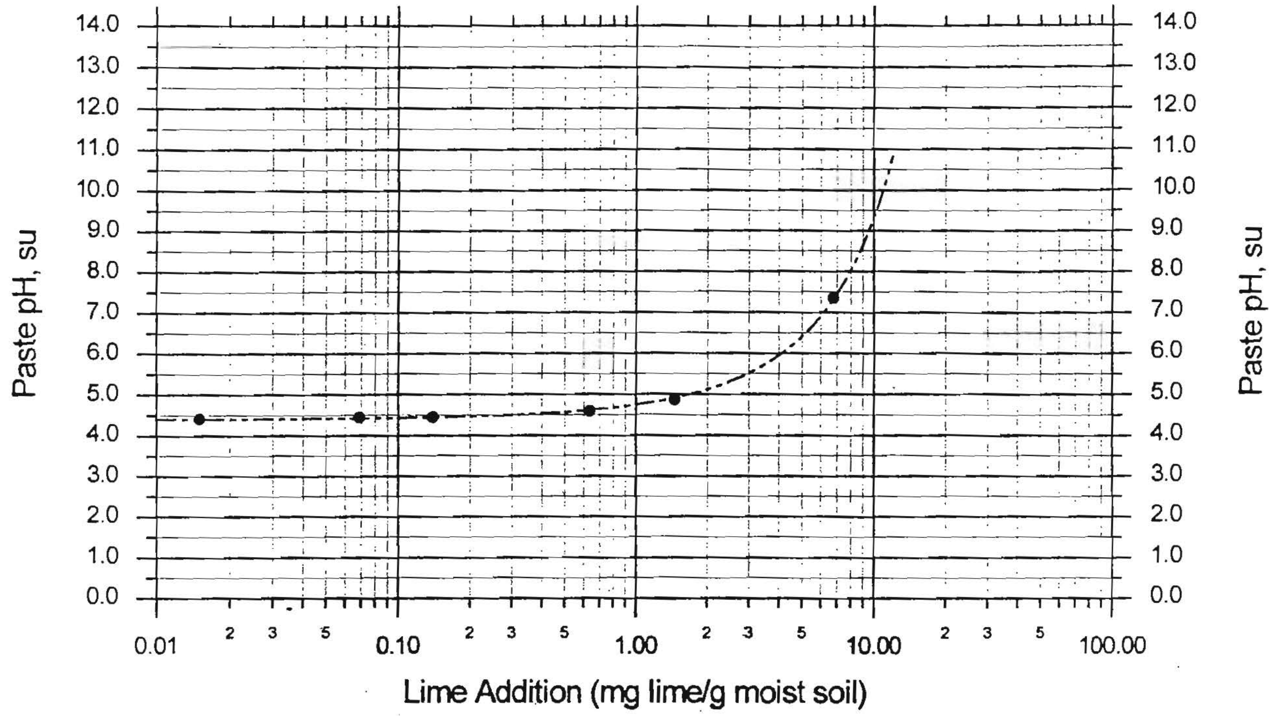
Appendix C Figure 25. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 15-3



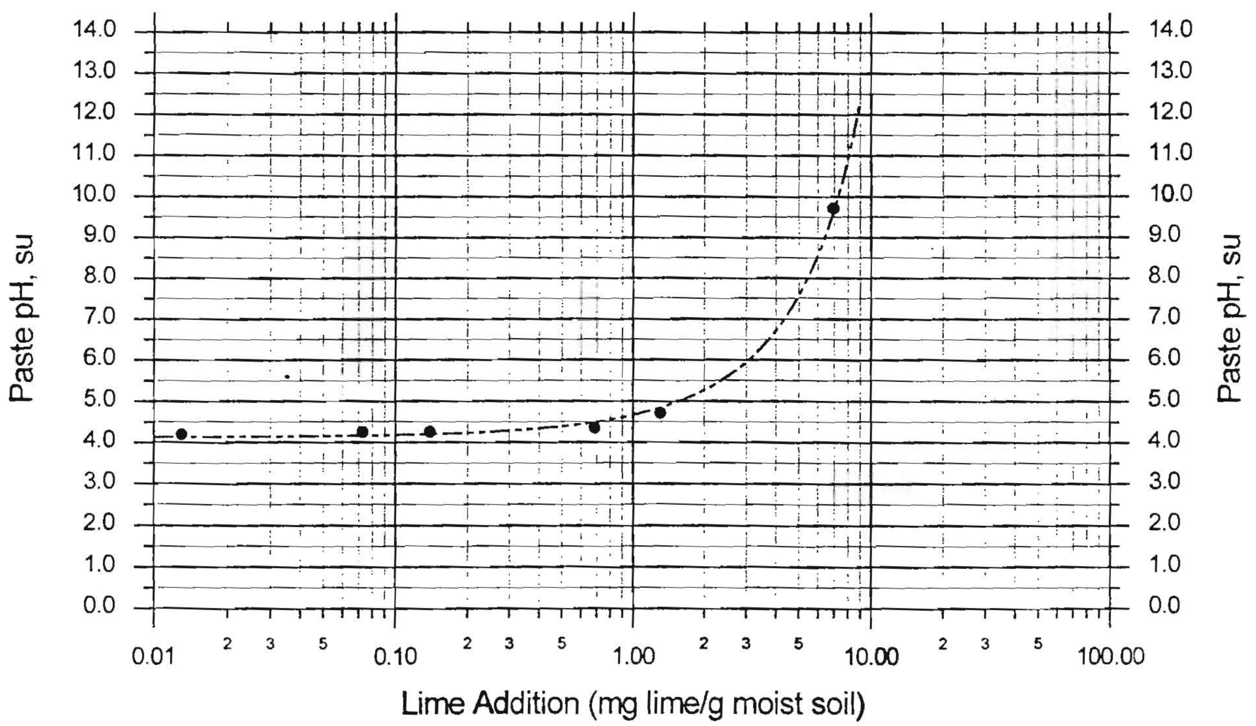
Appendix C Figure 26. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 16-1



Appendix C Figure 27. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 16-3



Appendix C Figure 28. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 17-1



Appendix C Figure 29. Relationship of Paste pH to Quantity of Lime Added to the <1/4" Size Fraction of Sample 17-3

Appendix C Table 1. Calculated Immediately Extractable Oxidation Products from Flambeau Stockpiled Type II Material (<¼" Size Fraction) Single Extractions (1:1) with Site Groundwater

Parameter	Sample No. 1 Unamended Extraction (mg/kg)	Sample No. 1-10 Unamended Extraction (mg/kg)	Sample No. 5 Unamended Extraction (mg/kg)
Paste pH (su)	5.59	6.92	4.51
Lab pH (su)	6.8	7.0	5.6
Conductivity (μS/cm)	1,900	440	2,000
Alkalinity (pH >6.5)	100	190	NA
Calcium	320	67	300
Magnesium	110	21	120
Potassium	60	8.8	35
Sodium	31	12	28
Acidity (pH <6.5)	NA	NA	500
Iron	<0.0010	0.0033	<0.0050
Sulfate	970	110	1,300
Aluminum	<0.0034	<0.0034	0.031
Antimony	0.0039	<0.0021	<0.010
Arsenic	0.0027	<0.0016	<0.0080
Cadmium	0.027	0.00025	0.082
Chromium	0.0029	<0.00026	0.0070
Cobalt	3.0	0.0051	3.3
Copper	1.6	0.31	160
Manganese	17	0.67	42
Mercury	<0.000044	<0.00044	<0.000095
Nickel	0.94	0.027	1.6
Selenium	0.39	0.020	0.47
Thallium	<0.0028	<0.0028	<0.014
Zinc	3.2	<0.012	56
$NO_3 + NO_2$	9.7	0.090	4.0

NA = not analyzed

Appendix C Table 1 (cont). Calculated Immediately Extractable Oxidation Products from Flambeau Stockpiled Type II Material (<¼" Size Fraction) Single Extractions (1:1) with Site Groundwater

Parameter	Sample No. 5-10 Unamended Extraction (mg/kg)	Sample No. 6 Unamended Extraction (mg/kg)	Sample No. 7 Unamended Extraction (mg/kg)
Paste pH (su)	5.15	3.81	4.42
Lab pH (su)	6.1	5.0	5.2
Conductivity (μS/cm)	830	3,100	2,100
Alkalinity (pH >6.5)	NA	NA	NA
Calcium	100	250	220
Magnesium	36	190	76
Potassium	<2.0	<2.0	17
Sodium	13	24	19
Acidity (pH <6.5)	79	2,200	750
Iron	<0.0050	<0.020	1.0
Sulfate	360	2,600	1,100
Aluminum	<0.017	1.2	1.8
Antimony	<0.010	<0.042	<0.042
Arsenic	<0.0080	<0.032	<0.032
Cadmium	0.016	0.11	0.073
Chromium	<0.0013	0.0070	<0.0052
Cobalt	0.99	4.1	3.2
Copper	16	1,000	430
Manganese	4.0	59	4.1
Mercury	<0.000095	<0.000095	<0.000095
Nickel	0.49	2.4	1.7
Selenium	0.034	0.065	0.040
Thallium	<0.014	<0.056	<0.056
Zinc	6.8	22	15
$NO_3 + NO_2$	1.0	1.7	30

NA = not analyzed

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

 NLS PROJECT# 28298

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: MW1005P **NLS#: 110289**
Ref. Line 1 of COC 19715 Description: MW1005P
Collected: 07/10/96 Received: 07/12/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	260	mg/L	3.0	11	EPA 310.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was within the holding time to the method endpoint.					
Aluminum, dis. as Al by ICP	0.027	mg/L	0.0034	0.012	SW846 6010	07/15/96
Antimony, dis. as Sb by ICP	ND	ug/L	2.1	7.5	SW846 6010	07/15/96
Arsenic, dis. as As by ICP	ND	ug/L	1.6	5.7	SW846 6010	07/15/96
Cadmium, dis. as Cd by ICP	ND	ug/L	0.12	0.38	SW846 6010	07/15/96
Calcium, dis. as Ca by ICP	49	mg/L	0.30	0.30	SW846 6010	07/15/96
Chromium, dis. as Cr by ICP	0.42	ug/L	0.26	0.93	SW846 6010	07/15/96
Cobalt, dis. as Co by ICP	0.81	ug/L	0.43	1.5	SW846 6010	07/15/96
Conductivity, lab	420	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu by ICP	1.0	ug/L	0.54	1.9	SW846 6010	07/15/96
Iron, dis. as Fe by ICP	0.86	mg/L	0.0010	0.0035	SW846 6010	07/15/96
Magnesium, dis. as Mg by ICP	20	mg/L	0.30	0.30	SW846 6010	07/15/96
Manganese, dis. as Mn by ICP	90	ug/L	0.18	0.61	SW846 6010	07/15/96
Mercury, dis. as Hg	ND	ug/L	0.095	0.34	SW846 7470A	07/19/96
Nickel, dis. as Ni by ICP	1.5	ug/L	0.44	1.6	SW846 6010	07/15/96
Nitrogen, NO2 + NO3 as N (filtered)	ND	mg/L	0.023	0.083	EPA 353.2	07/17/96
pH, lab	6.8	s.u.	1.0		SW846 9045	07/12/96
Potassium, dis. as K	8.7	mg/L	0.20	0.66	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	ND	ug/L	1.8	6.5	SW846 7740	07/22/96
Sodium, dis. as Na by ICP	11	mg/L	0.0033	0.011	SW846 6010	07/15/96
Sulfate, as SO4 (filtered)	3.9	mg/L	2.5	2.5	SW846 9036	07/18/96
Thallium, dis. as Tl by ICP	ND	ug/L	2.8	10	SW846 6010	07/15/96
Zinc, dis. as Zn by ICP	ND	ug/L	12	12	SW846 6010	07/15/96

18

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: #1 **NLS#: 110290**
Ref. Line 2 of COC 19715 Description: #1
Collected: 07/11/96 Received: 07/12/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	100	mg/L	1.5	5.3	EPA 310.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was within the holding time to the method endpoint.					
Aluminum, dis. as Al by ICP	ND	mg/L	0.0034	0.012	SW846 6010	07/15/96
Antimony, dis. as Sb by ICP	3.9	ug/L	2.1	7.5	SW846 6010	07/15/96
Arsenic, dis. as As by ICP	2.7	ug/L	1.6	5.7	SW846 6010	07/15/96
Cadmium, dis. as Cd by ICP	27	ug/L	0.12	0.38	SW846 6010	07/15/96
Calcium, dis. as Ca by ICP	320	mg/L	0.30	0.30	SW846 6010	07/15/96
Chromium, dis. as Cr by ICP	2.9	ug/L	0.26	0.93	SW846 6010	07/15/96
Cobalt, dis. as Co by ICP	3000	ug/L	0.43	1.5	SW846 6010	07/15/96
Conductivity, lab	1900	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu by ICP	1600	ug/L	0.54	1.9	SW846 6010	07/15/96
Iron, dis. as Fe by ICP	ND	mg/L	0.0010	0.0035	SW846 6010	07/15/96
Magnesium, dis. as Mg by ICP	110	mg/L	0.30	0.30	SW846 6010	07/15/96
Manganese, dis. as Mn by ICP	17000	ug/L	0.18	0.61	SW846 6010	07/15/96
Mercury, dis. as Hg	ND	ug/L	0.095	0.34	SW846 7470A	07/19/96
Nickel, dis. as Ni by ICP	940	ug/L	0.44	1.6	SW846 6010	07/15/96
Nitrogen, NO2 + NO3 as N (filtered)	9.7	mg/L	0.23	0.83	EPA 353.2	07/17/96
pH, lab	6.8	s.u.	1.0		SW846 9045	07/12/96
Potassium, dis. as K	60	mg/L	2.0	6.6	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	390	ug/L	37	130	SW846 7740	07/22/96
Sodium, dis. as Na by ICP	31	mg/L	0.0033	0.011	SW846 6010	07/15/96
Sulfate, as SO4 (filtered)	970	mg/L	250	250	SW846 9036	07/18/96
Thallium, dis. as Tl by ICP	ND	ug/L	2.8	10	SW846 6010	07/15/96
Zinc, dis. as Zn by ICP	3200	ug/L	12	12	SW846 6010	07/15/96

19

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: #1-10 **NLS#: 110291**
Ref. Line 3 of COC 19715 Description: #1-10
Collected: 07/11/96 Received: 07/12/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	190	mg/L	1.5	5.3	EPA 310.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was within the holding time to the method endpoint.					
Aluminum, dis. as Al by ICP	ND	mg/L	0.0034	0.012	SW846 6010	07/15/96
Antimony, dis. as Sb by ICP	ND	ug/L	2.1	7.5	SW846 6010	07/15/96
Arsenic, dis. as As by ICP	ND	ug/L	1.6	5.7	SW846 6010	07/15/96
Cadmium, dis. as Cd by ICP	0.25	ug/L	0.12	0.38	SW846 6010	07/15/96
Calcium, dis. as Ca by ICP	67	mg/L	0.30	0.30	SW846 6010	07/15/96
Chromium, dis. as Cr by ICP	ND	ug/L	0.26	0.93	SW846 6010	07/15/96
Cobalt, dis. as Co by ICP	5.1	ug/L	0.43	1.5	SW846 6010	07/15/96
Conductivity, lab	440	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu by ICP	310	ug/L	0.54	1.9	SW846 6010	07/15/96
Iron, dis. as Fe by ICP	0.0033	mg/L	0.0010	0.0035	SW846 6010	07/15/96
Magnesium, dis. as Mg by ICP	21	mg/L	0.30	0.30	SW846 6010	07/15/96
Manganese, dis. as Mn by ICP	670	ug/L	0.18	0.61	SW846 6010	07/15/96
Mercury, dis. as Hg	ND	ug/L	0.095	0.34	SW846 7470A	07/19/96
Nickel, dis. as Ni by ICP	27	ug/L	0.44	1.6	SW846 6010	07/15/96
Nitrogen, NO2 + NO3 as N (filtered)	0.090	mg/L	0.023	0.083	EPA 353.2	07/17/96
pH, lab	7.0	s.u.	1.0		SW846 9045	07/12/96
Potassium, dis. as K	8.8	mg/L	2.0	6.6	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	20	ug/L	1.8	6.5	SW846 7740	07/22/96
Sodium, dis. as Na by ICP	12	mg/L	0.0033	0.011	SW846 6010	07/15/96
Sulfate, as SO4 (filtered)	110	mg/L	25	25	SW846 9036	07/18/96
Thallium, dis. as Tl by ICP	ND	ug/L	2.8	10	SW846 6010	07/15/96
Zinc, dis. as Zn by ICP	ND	ug/L	12	12	SW846 6010	07/15/96

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: #5 **NLS#: 110292**
Ref. Line 4 of COC 19715 Description: #5
Collected: 07/11/96 Received: 07/12/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Acidity, tot. as CaCO3	500	mg/L	2.0		EPA 305.1	08/05/96
Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was within the holding time to the method endpoint.						
Aluminum, dis. as Al by ICP	0.031	mg/L	0.017	0.060	SW846 6010	07/15/96
Antimony, dis. as Sb by ICP	ND	ug/L	10	38	SW846 6010	07/15/96
Arsenic, dis. as As by ICP	ND	ug/L	8.0	28	SW846 6010	07/15/96
Cadmium, dis. as Cd by ICP	82	ug/L	0.60	1.9	SW846 6010	07/15/96
Calcium, dis. as Ca by ICP	300	mg/L	1.5	1.5	SW846 6010	07/15/96
Chromium, dis. as Cr by ICP	7.0	ug/L	1.3	4.6	SW846 6010	07/15/96
Cobalt, dis. as Co by ICP	3300	ug/L	2.2	7.5	SW846 6010	07/15/96
Conductivity, lab	2000	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu by ICP	160000	ug/L	54	190	SW846 6010	07/16/96
Iron, dis. as Fe by ICP	ND	mg/L	0.0050	0.018	SW846 6010	07/15/96
Magnesium, dis. as Mg by ICP	120	mg/L	1.5	1.5	SW846 6010	07/15/96
Manganese, dis. as Mn by ICP	42000	ug/L	0.90	3.0	SW846 6010	07/15/96
Mercury, dis. as Hg	ND	ug/L	0.095	0.34	SW846 7470A	07/19/96
Nickel, dis. as Ni by ICP	1600	ug/L	2.2	8.0	SW846 6010	07/15/96
Nitrogen, NO2 + NO3 as N (filtered)	4.0	mg/L	0.23	0.83	EPA 353.2	07/17/96
pH, lab	5.6	s.u.	1.0		SW846 9045	07/12/96
Potassium, dis. as K	35	mg/L	2.0	6.6	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	470	ug/L	37	130	SW846 7740	07/22/96
Sodium, dis. as Na by ICP	28	mg/L	0.016	0.055	SW846 6010	07/15/96
Sulfate, as SO4 (filtered)	1300	mg/L	250	250	SW846 9036	07/18/96
Thallium, dis. as Tl by ICP	ND	ug/L	14	50	SW846 6010	07/15/96
Zinc, dis. as Zn by ICP	56000	ug/L	60	60	SW846 6010	07/15/96

21

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: #5-10 **NLS#: 110293**
Ref. Line 5 of COC 19715 Description: #5-10
Collected: 07/11/96 Received: 07/12/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Acidity, tot. as CaCO3	79	mg/L	2.0		EPA 305.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was within the holding time to the method endpoint.					
Aluminum, dis. as Al by ICP	ND	mg/L	0.017	0.060	SW846 6010	07/15/96
Antimony, dis. as Sb by ICP	ND	ug/L	10	38	SW846 6010	07/15/96
Arsenic, dis. as As by ICP	ND	ug/L	8.0	28	SW846 6010	07/15/96
Cadmium, dis. as Cd by ICP	16	ug/L	0.60	1.9	SW846 6010	07/15/96
Calcium, dis. as Ca by ICP	100	mg/L	1.5	1.5	SW846 6010	07/15/96
Chromium, dis. as Cr by ICP	ND	ug/L	1.3	4.6	SW846 6010	07/15/96
Cobalt, dis. as Co by ICP	990	ug/L	2.2	7.5	SW846 6010	07/15/96
Conductivity, lab	830	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu by ICP	16000	ug/L	2.7	9.5	SW846 6010	07/15/96
Iron, dis. as Fe by ICP	ND	mg/L	0.0050	0.018	SW846 6010	07/15/96
Magnesium, dis. as Mg by ICP	36	mg/L	1.5	1.5	SW846 6010	07/15/96
Manganese, dis. as Mn by ICP	4000	ug/L	0.90	3.0	SW846 6010	07/15/96
Mercury, dis. as Hg	ND	ug/L	0.095	0.34	SW846 7470A	07/19/96
Nickel, dis. as Ni by ICP	490	ug/L	2.2	8.0	SW846 6010	07/15/96
Nitrogen, NO2 + NO3 as N (filtered)	1.0	mg/L	0.023	0.083	EPA 353.2	07/17/96
pH, lab	6.1	s.u.	1.0		SW846 9045	07/12/96
Potassium, dis. as K	ND	mg/L	2.0	6.6	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	34	ug/L	1.8	6.5	SW846 7740	07/22/96
Sodium, dis. as Na by ICP	13	mg/L	0.016	0.055	SW846 6010	07/15/96
Sulfate, as SO4 (filtered)	360	mg/L	120	120	SW846 9036	07/18/96
Thallium, dis. as Tl by ICP	ND	ug/L	14	50	SW846 6010	07/15/96
Zinc, dis. as Zn by ICP	6800	ug/L	60	60	SW846 6010	07/15/96

22

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

PAGE: 6 NLS PROJECT# 28298

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: #6 **NLS#: 110294**
Ref. Line 6 of COC 19715 Description: #6
Collected: 07/11/96 Received: 07/12/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Acidity, tot. as CaCO3	2200	mg/L	2.0		EPA 305.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was within the holding time to the method endpoint.					
Aluminum, dis. as Al by ICP	1.2	mg/L	0.068	0.24	SW846 6010	07/15/96
Antimony, dis. as Sb by ICP	ND	ug/L	42	150	SW846 6010	07/15/96
Arsenic, dis. as As by ICP	ND	ug/L	32	110	SW846 6010	07/15/96
Cadmium, dis. as Cd by ICP	110	ug/L	2.4	7.6	SW846 6010	07/15/96
Calcium, dis. as Ca by ICP	250	mg/L	6.0	6.0	SW846 6010	07/15/96
Chromium, dis. as Cr by ICP	7.0	ug/L	5.2	19	SW846 6010	07/15/96
Cobalt, dis. as Co by ICP	4100	ug/L	8.6	30	SW846 6010	07/15/96
Conductivity, lab	3100	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu by ICP	1000000	ug/L	110	380	SW846 6010	07/16/96
Iron, dis. as Fe by ICP	ND	mg/L	0.020	0.070	SW846 6010	07/15/96
Magnesium, dis. as Mg by ICP	190	mg/L	6.0	6.0	SW846 6010	07/15/96
Manganese, dis. as Mn by ICP	59000	ug/L	3.6	12	SW846 6010	07/15/96
Mercury, dis. as Hg	ND	ug/L	0.095	0.34	SW846 7470A	07/19/96
Nickel, dis. as Ni by ICP	2400	ug/L	8.8	32	SW846 6010	07/15/96
Nitrogen, NO2 + NO3 as N (filtered)	1.7	mg/L	0.023	0.083	EPA 353.2	07/17/96
pH, lab	5.0	s.u.	1.0		SW846 9045	07/12/96
Potassium, dis. as K	ND	mg/L	2.0	6.6	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	65	ug/L	3.7	13	SW846 7740	07/22/96
Sodium, dis. as Na by ICP	24	mg/L	0.066	0.22	SW846 6010	07/15/96
Sulfate, as SO4 (filtered)	2600	mg/L	250	250	SW846 9036	07/18/96
Thallium, dis. as Tl by ICP	ND	ug/L	56	200	SW846 6010	07/15/96
Zinc, dis. as Zn by ICP	22000	ug/L	240	240	SW846 6010	07/15/96

23

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: #7 **NLS#: 110295**
Ref. Line 7 of COC 19715 Description: #7
Collected: 07/11/96 Received: 07/12/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Acidity, tot. as CaCO3	750	mg/L	2.0		EPA 305.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was within the holding time to the method endpoint.					
Aluminum, dis. as Al by ICP	1.8	mg/L	0.068	0.24	SW846 6010	07/15/96
Antimony, dis. as Sb by ICP	ND	ug/L	42	150	SW846 6010	07/15/96
Arsenic, dis. as As by ICP	ND	ug/L	32	110	SW846 6010	07/15/96
Cadmium, dis. as Cd by ICP	73	ug/L	2.4	7.6	SW846 6010	07/15/96
Calcium, dis. as Ca by ICP	220	mg/L	6.0	6.0	SW846 6010	07/15/96
Chromium, dis. as Cr by ICP	ND	ug/L	5.2	19	SW846 6010	07/15/96
Cobalt, dis. as Co by ICP	3200	ug/L	8.6	30	SW846 6010	07/15/96
Conductivity, lab	2100	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu by ICP	430000	ug/L	54	190	SW846 6010	07/16/96
Iron, dis. as Fe by ICP	1.0	mg/L	0.020	0.070	SW846 6010	07/15/96
Magnesium, dis. as Mg by ICP	76	mg/L	6.0	6.0	SW846 6010	07/15/96
Manganese, dis. as Mn by ICP	4100	ug/L	3.6	12	SW846 6010	07/15/96
Mercury, dis. as Hg	ND	ug/L	0.095	0.34	SW846 7470A	07/19/96
Nickel, dis. as Ni by ICP	1700	ug/L	8.8	32	SW846 6010	07/15/96
Nitrogen, NO2 + NO3 as N (filtered)	30	mg/L	1.2	4.2	EPA 353.2	07/17/96
pH, lab	5.2	s.u.	1.0		SW846 9045	07/12/96
Potassium, dis. as K	17	mg/L	2.0	6.6	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	40	ug/L	1.8	6.5	SW846 7740	07/22/96
Sodium, dis. as Na by ICP	19	mg/L	0.066	0.22	SW846 6010	07/15/96
Sulfate, as SO4 (filtered)	1100	mg/L	250	250	SW846 9036	07/18/96
Thallium, dis. as Tl by ICP	ND	ug/L	56	200	SW846 6010	07/15/96
Zinc, dis. as Zn by ICP	15000	ug/L	240	240	SW846 6010	07/15/96

24

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS LAB CERT NO [illegible]

ANALYTICAL REPORT

 NLS PROJECT# 28298

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: Solution E **NLS#: 110296**
Ref. Line 8 of COC 19715 Description: Solution E
Collected: 07/12/96 Received: 07/12/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (unfiltered)	290	mg/L	15	53	EPA 310.1	07/19/96
Conductivity, lab	260	umho@25C	1.0		EPA 120.1	08/05/96

Sample ID: Soil, 0709GC-Limestone **NLS#: 110297**
Ref. Line 9 of COC 19715 Description: Soil, 0709GC-Lime
Collected: 07/09/96 Received: 07/12/96 Reported: 08/14/96

25

Parameter	Result	Units	MDL	LOQ	Method	Date
Arsenic, tot. as As by furnace	3.2	mg/Kg DWB	1.5	5.1	SW846 7060	07/29/96
Cadmium, tot. as Cd	ND	mg/Kg DWB	0.16	0.56	SW846 6010	07/30/96
Calcium, tot. as Ca	170000	mg/Kg DWB	1300	1300	SW846 6010	07/24/96
Calcium carbonate equivalence	82	% as CaCO3	0.10		ASTM C602	07/18/96
Iron, tot. as Fe	4500	mg/Kg DWB	0.73	2.5	SW846 6010	07/29/96
Magnesium, tot. as Mg	96000	mg/Kg DWB	1300	1300	SW846 6010	07/24/96
Manganese, tot. as Mn	750	mg/Kg DWB	0.56	1.9	SW846 6010	07/24/96
Solids, total on solids	92.9	%	0.10		EPA 160.3	07/16/96
Sulfur, total as S on solids	ND	mg/Kg DWB	14		LECO	08/05/96
Metals digestion - total (soil/sludge) ICP	yes				SW846 3050	07/23/96
Metals digestion - total (soil/sludge) furnace	yes				SW846 3050	07/23/96

Please note that analytical results greater than the MDL but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

MDL = Method Detection Limit LOQ = Limit of Quantitation ND = Not Detected Date = Date Analysis Performed
DWB = Dry Weight Basis NA = Not Applicable %DWB = (mg/kg DWB)/10000

Steven R. Cuyer
Reviewed by:

Authorized by:
R. T. Krueger
Laboratory Manager

Appendix C Table 2. Calculated Immediately Extractable Oxidation Products from the Stockpiled Flambeau Type II Material (¼" - 3" Size Fraction) Single Extractions with Site Groundwater

Parameter	Sample 13-3 (mg/kg)	Sample 14-1 (mg/kg)	Sample 14-3 (mg/kg)	Sample 15-3 (mg/kg)
Extraction pH (su)	4.62	3.57	3.72	2.21
Lab pH (su)	3.4	4.2	3.5	2.4
Conductivity (μS/cm)	2,470	2,420	2,400	6,420
Alkalinity (pH >6.5)	NA	NA	NA	NA
Calcium	72	86	84	40
Acidity (pH <6.5)	560	270	490	2,300
Iron	8.1	1.2	4.3	370
Sulfate	370	270	350	1,200
Arsenic	0.0029	0.00086	0.0019	0.20
Cadmium	0.044	0.016	<0.011	0.015
Copper	127	37	48	128
Manganese	11	2.2	2.0	2.8
Zinc	11	3.2	3.2	4.7

NA = not analyzed, copper values provided by Flambeau

Appendix C Table 2 (cont). Calculated Immediately Extractable Oxidation Products from the Stockpiled Flambeau Type II Material (¼" - 3" Size Fraction) Single Extractions with Site Groundwater

Parameter	Sample 16-1 (mg/kg)	Sample 16-3 (mg/kg)	Sample 17-1 (mg/kg)
Extraction pH (su)	5.45	4.65	4.80
Lab pH (su)	3.9	4.7	4.3
Conductivity (μS/cm)	963	1,100	2,600
Alkalinity (pH >6.5)	NA	NA	NA
Calcium	44	44	90
Acidity (pH <6.5)	54	320	520
Iron	1.5	0.28	0.64
Sulfate	160	150	430
Arsenic	0.00073	0.00065	0.0016
Cadmium	<0.012	<0.011	0.15
Copper	1.3	2.6	60
Manganese	2.5	2.2	5.8
Zinc	0.67	0.82	43

NA = not analyzed, copper values provided by Flambeau

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: 13-1B-1 NLS#: 112700
Ref. Line 1 of COC 3607 Description: 13-1B-1
Collected: 08/01/96 Received: 08/16/96 Reported: 09/03/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	6000	mg/L	2.0		EPA 305.1	09/03/96
	Additional Comments: The method calls for an end point pH of 3.7 or 8.3 s.u. The actual end point used was 6.5 s.u., per client request. Sample was received beyond the method holding time.					
Arsenic, dis. as As by furnace	120	ug/L	4.8	17	SW846 7060	08/22/96
Cadmium, dis. as Cd	0.26	mg/L	0.039	0.14	SW846 6010	08/29/96
Calcium, dis. as Ca	270	mg/L	3.0	3.0	SW846 6010	08/30/96
Iron, dis. as Fe	840	mg/L	0.079	0.26	SW846 6010	08/30/96
Manganese, dis. as Mn	42	mg/L	0.0086	0.031	SW846 6010	08/29/96
pH, lab	2.6	s.u.	1.0		SW846 9045	08/16/96
Sulfate, as SO4 (filtered)	2100	mg/L	250	250	SW846 9036	08/28/96
Zinc, dis. as Zn	56	mg/L	0.12	0.12	SW846 6010	08/29/96

Sample ID: 13-3B-1 NLS#: 112701
Ref. Line 2 of COC 3607 Description: 13-3B-1
Collected: 08/01/96 Received: 08/16/96 Reported: 09/03/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	1800	mg/L	2.0		EPA 305.1	09/03/96
	Additional Comments: The method calls for an end point pH of 3.7 or 8.3 s.u. The actual end point used was 6.5 s.u., per client request. Sample was received beyond the method holding time.					
Arsenic, dis. as As by furnace	9.3	ug/L	1.2	4.3	SW846 7060	08/22/96
Cadmium, dis. as Cd	0.14	mg/L	0.039	0.14	SW846 6010	08/29/96
Calcium, dis. as Ca	230	mg/L	3.0	3.0	SW846 6010	08/30/96
Iron, dis. as Fe	26	mg/L	0.079	0.26	SW846 6010	08/30/96
Manganese, dis. as Mn	34	mg/L	0.0086	0.031	SW846 6010	08/29/96
pH, lab	3.4	s.u.	1.0		SW846 9045	08/16/96
Sulfate, as SO4 (filtered)	1200	mg/L	250	250	SW846 9036	08/28/96
Zinc, dis. as Zn	36	mg/L	0.12	0.12	SW846 6010	08/29/96

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: 14-1B-1 **NLS#: 112702**
Ref. Line 3 of COC 3607 Description: 14-1B-1
Collected: 08/01/96 Received: 08/16/96 Reported: 09/03/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	1100	mg/L	2.0		EPA 305.1	09/03/96
	Additional Comments: The method calls for an end point pH of 3.7 or 8.3 s.u. The actual end point used was 6.5 s.u., per client request. Sample was received beyond the method holding time.					
Arsenic, dis. as As by furnace	3.5	ug/L	1.2	4.3	SW846 7060	08/22/96
Cadmium, dis. as Cd	0.066	mg/L	0.039	0.14	SW846 6010	08/29/96
Calcium, dis. as Ca	350	mg/L	3.0	3.0	SW846 6010	08/30/96
Iron, dis. as Fe	5.0	mg/L	0.079	0.26	SW846 6010	08/30/96
Manganese, dis. as Mn	9.0	mg/L	0.0086	0.031	SW846 6010	08/29/96
pH, lab	4.2	s.u.	1.0		SW846 9045	08/16/96
Sulfate, as SO4 (filtered)	1100	mg/L	250	250	SW846 9036	08/28/96
Zinc, dis. as Zn	13	mg/L	0.12	0.12	SW846 6010	08/29/96

29

Sample ID: 14-3B-1 **NLS#: 112703**
Ref. Line 4 of COC 3607 Description: 14-3B-1
Collected: 08/01/96 Received: 08/16/96 Reported: 09/03/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	1700	mg/L	2.0		EPA 305.1	09/03/96
	Additional Comments: The method calls for an end point pH of 3.7 or 8.3 s.u. The actual end point used was 6.5 s.u., per client request. Sample was received beyond the method holding time.					
Arsenic, dis. as As by furnace	6.7	ug/L	1.2	4.3	SW846 7060	08/22/96
Cadmium, dis. as Cd	ND	mg/L	0.039	0.14	SW846 6010	08/29/96
Calcium, dis. as Ca	290	mg/L	3.0	3.0	SW846 6010	08/30/96
Iron, dis. as Fe	15	mg/L	0.079	0.26	SW846 6010	08/30/96
Manganese, dis. as Mn	6.8	mg/L	0.0086	0.031	SW846 6010	08/29/96
pH, lab	3.5	s.u.	1.0		SW846 9045	08/16/96
Sulfate, as SO4 (filtered)	1200	mg/L	250	250	SW846 9036	08/28/96
Zinc, dis. as Zn	11	mg/L	0.12	0.12	SW846 6010	08/29/96

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

    NLS PROJECT# 28974

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: 15-1B-1   NLS#: 112704
Ref. Line 5 of COC 3607   Description: 15-1B-1
Collected: 08/01/96   Received: 08/16/96   Reported: 09/03/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	>12000 mg/L		2.0		EPA 305.1	09/03/96
	Additional Comments: The method calls for an end point pH of 3.7 or 8.3 s.u. The actual end point targeted was 6.5 s.u., per client request. The attainable endpoint was only 3.7 due to excess precipitate formation. Sample was received beyond the method holding time.					
Arsenic, dis. as As by furnace	1300	ug/L	120	430	SW846 7060	08/22/96
Cadmium, dis. as Cd	0.18	mg/L	0.036	0.13	SW846 6010	08/29/96
Calcium, dis. as Ca	210	mg/L	3.0	3.0	SW846 6010	08/30/96
Iron, dis. as Fe	4400	mg/L	1.7	5.7	SW846 6010	08/30/96
Manganese, dis. as Mn	11	mg/L	0.013	0.044	SW846 6010	08/29/96
pH, lab	2.2	s.u.	1.0		SW846 9045	08/16/96
Sulfate, as SO4 (filtered)	6300	mg/L	2500	2500	SW846 9036	08/28/96
Zinc, dis. as Zn	12	mg/L	0.12	0.12	SW846 6010	08/29/96
Metals digestion - dissolved ICP	yes				SW846 3005	08/20/96

30

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

 NLS PROJECT# 28974

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: 15-3B-1 NLS#: 112705
Ref. Line 6 of COC 3607 Description: 15-3B-1
Collected: 08/01/96 Received: 08/16/96 Reported: 09/03/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	10000	mg/L	2.0		EPA 305.1	09/03/96
	Additional Comments: The method calls for an end point pH of 3.7 or 8.3 s.u. The actual end point used was 6.5 s.u., per client request. Sample was received beyond the method holding time.					
Arsenic, dis. as As by furnace	840	ug/L	60	220	SW846 7060	08/22/96
Cadmium, dis. as Cd	0.064	mg/L	0.039	0.14	SW846 6010	08/29/96
Calcium, dis. as Ca	170	mg/L	3.0	3.0	SW846 6010	08/30/96
Iron, dis. as Fe	1600	mg/L	0.079	0.26	SW846 6010	08/30/96
Manganese, dis. as Mn	12	mg/L	0.0086	0.031	SW846 6010	08/29/96
pH, lab	2.4	s.u.	1.0		SW846 9045	08/16/96
Sulfate, as SO4 (filtered)	5100	mg/L	2500	2500	SW846 9036	08/28/96
Zinc, dis. as Zn	20	mg/L	0.12	0.12	SW846 6010	08/29/96

Sample ID: 16-1B-1 NLS#: 112706
Ref. Line 7 of COC 3607 Description: 16-1B-1
Collected: 08/05/96 Received: 08/16/96 Reported: 09/03/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	170	mg/L	2.0		EPA 305.1	09/03/96
	Additional Comments: The method calls for an end point pH of 3.7 or 8.3 s.u. The actual end point used was 6.5 s.u., per client request. Sample was received beyond the method holding time.					
Arsenic, dis. as As by furnace	2.3	ug/L	1.2	4.3	SW846 7060	08/22/96
Cadmium, dis. as Cd	ND	mg/L	0.039	0.14	SW846 6010	08/29/96
Calcium, dis. as Ca	140	mg/L	3.0	3.0	SW846 6010	08/30/96
Iron, dis. as Fe	4.8	mg/L	0.079	0.26	SW846 6010	08/30/96
Manganese, dis. as Mn	7.8	mg/L	0.0086	0.031	SW846 6010	08/29/96
pH, lab	3.9	s.u.	1.0		SW846 9045	08/16/96
Sulfate, as SO4 (filtered)	510	mg/L	250	250	SW846 9036	08/28/96
Zinc, dis. as Zn	2.1	mg/L	0.12	0.12	SW846 6010	08/29/96

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

 NLS PROJECT# 28974

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: 16-3B-1 NLS#: 112707
Ref. Line 8 of COC 3607 Description: 16-3B-1
Collected: 08/05/96 Received: 08/16/96 Reported: 09/03/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	1100	mg/L	2.0		EPA 305.1	09/03/96
Additional Comments: The method calls for an end point pH of 3.7 or 8.3 s.u. The actual end point used was 6.5 s.u., per client request. Sample was received beyond the method holding time.						
Arsenic, dis. as As by furnace	2.2	ug/L	1.2	4.3	SW846 7060	08/22/96
Cadmium, dis. as Cd	ND	mg/L	0.039	0.14	SW846 6010	08/29/96
Calcium, dis. as Ca	150	mg/L	3.0	3.0	SW846 6010	08/30/96
Iron, dis. as Fe	0.95	mg/L	0.079	0.26	SW846 6010	08/30/96
Manganese, dis. as Mn	7.6	mg/L	0.0086	0.031	SW846 6010	08/29/96
pH, lab	4.7	s.u.	1.0		SW846 9045	08/16/96
Sulfate, as SO4 (filtered)	520	mg/L	250	250	SW846 9036	08/28/96
Zinc, dis. as Zn	2.8	mg/L	0.12	0.12	SW846 6010	08/29/96

Sample ID: 17-1B-1 NLS#: 112708
Ref. Line 9 of COC 3607 Description: 17-1B-1
Collected: 08/05/96 Received: 08/16/96 Reported: 09/03/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	1800	mg/L	2.0		EPA 305.1	09/03/96
Additional Comments: The method calls for an end point pH of 3.7 or 8.3 s.u. The actual end point used was 6.5 s.u., per client request. Sample was received beyond the method holding time.						
Arsenic, dis. as As by furnace	5.6	ug/L	1.2	4.3	SW846 7060	08/22/96
Cadmium, dis. as Cd	0.51	mg/L	0.039	0.14	SW846 6010	08/29/96
Calcium, dis. as Ca	310	mg/L	3.0	3.0	SW846 6010	08/30/96
Iron, dis. as Fe	2.2	mg/L	0.079	0.26	SW846 6010	08/30/96
Manganese, dis. as Mn	20	mg/L	0.0086	0.031	SW846 6010	08/29/96
pH, lab	4.3	s.u.	1.0		SW846 9045	08/16/96
Sulfate, as SO4 (filtered)	1500	mg/L	250	250	SW846 9036	08/28/96
Zinc, dis. as Zn	150	mg/L	1.2	1.2	SW846 6010	08/29/96

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: 17-3B-1 NLS#: 112709
Ref. Line 10 of COC 3607 Description: 17-3B-1
Collected: 08/05/96 Received: 08/16/96 Reported: 09/03/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	2800	mg/L	2.0		EPA 305.1	09/03/96

Additional Comments: The method calls for an end point pH of 3.7 or 8.3 s.u. The actual end point used was 6.5 s.u., per client request. Sample was received beyond the method holding time.

Parameter	Result	Units	LOD	LOQ	Method	Date
Arsenic, dis. as As by furnace	9.6	ug/L	1.2	4.3	SW846 7060	08/22/96
Cadmium, dis. as Cd	0.95	mg/L	0.039	0.14	SW846 6010	08/29/96
Calcium, dis. as Ca	280	mg/L	3.0	3.0	SW846 6010	08/30/96
Iron, dis. as Fe	13	mg/L	0.079	0.26	SW846 6010	08/30/96
Manganese, dis. as Mn	17	mg/L	0.0086	0.031	SW846 6010	08/29/96
pH, lab	3.5	s.u.	1.0		SW846 9045	08/16/96
Sulfate, as SO4 (filtered)	1500	mg/L	250	250	SW846 9036	08/28/96
Zinc, dis. as Zn	160	mg/L	1.2	1.2	SW846 6010	08/29/96

Sample ID: 18-1B-1 NLS#: 112710
Ref. Line 11 of COC 3607 Description: 18-1B-1
Collected: 08/05/96 Received: 08/16/96 Reported: 09/03/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	70	mg/L	2.0		EPA 305.1	09/03/96

Additional Comments: The method calls for an end point pH of 3.7 or 8.3 s.u. The actual end point used was 6.5 s.u., per client request. Sample was received beyond the method holding time.

Parameter	Result	Units	LOD	LOQ	Method	Date
Arsenic, dis. as As by furnace	2.0	ug/L	1.2	4.3	SW846 7060	08/22/96
Cadmium, dis. as Cd	0.95	mg/L	0.039	0.14	SW846 6010	08/29/96
Calcium, dis. as Ca	100	mg/L	3.0	3.0	SW846 6010	08/30/96
Iron, dis. as Fe	10	mg/L	0.079	0.26	SW846 6010	08/30/96
Manganese, dis. as Mn	1.8	mg/L	0.0086	0.031	SW846 6010	08/29/96
pH, lab	5.4	s.u.	1.0		SW846 9045	08/16/96
Sulfate, as SO4 (filtered)	230	mg/L	25	25	SW846 9036	08/28/96
Zinc, dis. as Zn	2.2	mg/L	0.12	0.12	SW846 6010	08/29/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection
DWB = Dry Weight Basis
LOQ = Limit of Quantitation
NA = Not Applicable
ND = Not Detected
%DWB = (mg/kg DWB)/10000
Date = Date Analysis Performed

Steven R. Cuypi
Reviewed by:

Authorized by:
R. T. Krueger
Laboratory Manager

Appendix C Table 3. Calculated Immediately Extractable Oxidation Products from Stockpiled Flambeau Type II Material Single Extractions (1:1) with Alkali Amendment and Site Groundwater

Sample No. 13-1A, <¼" fraction

Parameter	Unamended Extraction (mg/kg)	Extraction at pH ≈ 5.5 (mg/kg)	Extraction at pH ≈ 6.5 (mg/kg)	Extraction at pH ≈ 7.5 (mg/kg)
Paste pH (su)	2.03	NA	NA	NA
Extraction pH (su)	2.43	5.76	6.72	7.11
Lab pH (su)	2.5	5.5	6.8	6.9
Conductivity (μS/cm)	3,600	1,900	2,500	2,000
Alkalinity (pH >6.5)	NA	20	140	98
Calcium	280	710	840	910
Magnesium	60	60	57	60
Potassium	<2.0	<2.0	2.9	<200
Sodium	14	16	14	12
Acidity (pH <6.5)	3,400	NA	NA	NA
Iron	320	<0.0050	<0.0050	0.28
Sulfate	2,100	950	880	1,600
Aluminum	23	<0.017	<0.017	<0.017
Antimony	0.0026	<0.0015	<0.0015	<0.0015
Arsenic	0.070	<0.0080	<0.0080	<0.0080
Cadmium	0.10	0.065	0.013	0.0054
Chromium	0.028	0.0022	0.0018	0.0013
Cobalt	4.6	3.9	1.9	0.90
Copper	1,200	52	1.7	0.72
Manganese	17	14	9.9	7.1
Mercury	0.00020	0.00020	0.0032	0.0055
Nickel	2.1	1.7	0.54	0.21
Selenium	0.027	0.033	0.042	0.038
Thallium	0.64	<0.014	<0.014	<0.014
Zinc	23	12	1.5	0.37
$NO_3 + NO_2$	0.43	0.72	0.83	0.73

NA = not analyzed

Appendix C Table 4. Calculated Immediate Extractable Oxidation Products from Stockpiled Flambeau Type II Material Single Extractions (1:1) with Alkali Amendment and Site Groundwater

Sample No. 15-1A, <¼" fraction

Parameter	Unamended Extraction (mg/kg)	Extraction at pH ≃ 5.5 (mg/kg)	Extraction at pH ≃ 6.5 (mg/kg)	Extraction at pH ≃ 7.5 (mg/kg)
Paste pH (su)	1.53	NA	NA	NA
Extraction pH (su)	2.05	6.30	6.94	7.41
Lab pH (su)	2.4	5.9	6.6	6.7
Conductivity (μS/cm)	5,300	2,300	2,300	2,200
Alkalinity (pH >6.5)	NA	140	140	60
Calcium	140	630	620	600
Magnesium	53	93	86	74
Potassium	5.2	2.6	3.8	4.7
Sodium	7.0	14	14	14
Acidity (pH <6.5)	8,200	NA	NA	NA
Iron	2,000	0.045	1.0	<0.0010
Sulfate	5,600	740	850	1,400
Aluminum	56	<0.017	0.038	<0.0034
Antimony	<0.0015	<0.0015	<0.0015	<0.0015
Arsenic	0.98	<0.0080	<0.0080	<0.0016
Cadmium	0.22	0.0014	<0.00060	<0.00012
Chromium	0.12	<0.0013	<0.0013	<0.00026
Cobalt	2.0	0.59	0.075	0.0096
Copper	450	0.45	0.29	0.030
Manganese	5.8	5.4	1.6	0.32
Mercury	0.00020	<0.000095	<0.000095	<0.000095
Nickel	0.95	0.14	0.022	0.0036
Selenium	0.15	0.033	0.024	0.026
Thallium	4.4	<0.014	<0.014	<0.014
Zinc	6.8	0.260	<0.060	<0.060
$NO_3 + NO_2$	0.35	0.79	0.85	0.94

NA = not analyzed

Appendix C Table 5. Calculated Immediately Extractable Oxidation Products from Stockpiled Flambeau Type II Material Single Extractions (1:1) with Alkali Amendment and Site Groundwater

Sample No. 17-3A, <¼" fraction

Parameter	Unamended Extraction (mg/kg)	Extraction at pH ≈ 5.5 (mg/kg)	Extraction at pH ≈ 6.5 (mg/kg)	Extraction at pH ≈ 7.5 (mg/kg)
Paste pH (su)	4.55	NA	NA	NA
Extraction pH (su)	4.56	4.86	6.40	6.82
Lab pH (su)	4.8	5.2	6.4	6.9
Conductivity (μS/cm)	2,400	2,500	1,800	1,600
Alkalinity (pH >6.5)	NA	NA	95	100
Calcium	390	520	680	650
Magnesium	74	78	66	65
Potassium	7.2	7.8	6.5	6.7
Sodium	14	14	16	16
Acidity (pH <6.5)	1,200	970	NA	NA
Iron	0.099	0.019	<0.0050	<0.0050
Sulfate	860	1,300	510	880
Aluminum	0.15	0.11	<0.017	<0.017
Antimony	<0.0015	<0.0015	<0.0074	<0.0074
Arsenic	<0.0012	<0.0012	<0.0080	<0.0080
Cadmium	0.38	0.44	0.15	0.052
Chromium	<0.0067	<0.0067	<0.0013	<0.0013
Cobalt	2.2	2.3	1.5	0.90
Copper	640	400	2.5	1.7
Manganese	11	11	8.6	6.6
Mercury	<0.000095	<0.000095	<0.000095	<0.000095
Nickel	1.2	1.2	0.68	0.33
Selenium	0.027	0.027	0.028	0.034
Thallium	0.10	<0.080	<0.014	<0.014
Zinc	97	110	24	5.7
$NO_3 + NO_2$	0.39	0.61	0.71	0.73

NA = not analyzed

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

 NLS PROJECT# 28459

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: 0720C-13-1A-U **NLS#: 110837**
Ref. Line 1 of COC 18213 Description: 0720C-13-1A-U
Collected: 07/20/96 Received: 07/23/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Acidity, tot. as CaCO3	3400	mg/L	2.0		EPA 305.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was within the holding time to the method endpoint.					
Aluminum, dis. as Al	23	mg/L	0.0073	0.023	SW846 6010	07/31/96
Antimony, dis. as Sb by furnace	2.6	ug/L	1.5	5.1	SW846 7041	07/26/96
Arsenic, dis. as As by furnace	70	ug/L	6.0	22	SW846 7060	07/29/96
Cadmium, dis. as Cd	0.10	mg/L	0.0039	0.014	SW846 6010	07/30/96
Calcium, dis. as Ca	280	mg/L	3.0	3.0	SW846 6010	08/02/96
Chromium, dis. as Cr	0.028	mg/L	0.0067	0.024	SW846 6010	07/30/96
Cobalt, dis. as Co	4.6	mg/L	0.0044	0.016	SW846 6010	08/06/96
Conductivity, lab	3600	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu	1200	mg/L	0.32	1.0	SW846 6010	07/30/96
Iron, dis. as Fe	320	mg/L	0.079	0.26	SW846 6010	08/02/96
Magnesium, dis. as Mg	60	mg/L	3.0	3.0	SW846 6010	08/02/96
Manganese, dis. as Mn	17	mg/L	0.0086	0.031	SW846 6010	07/30/96
Mercury, dis. as Hg	0.20	ug/L	0.095	0.34	SW846 7470A	07/26/96
Nickel, dis. as Ni	2.1	mg/L	0.017	0.061	SW846 6010	07/30/96
Nitrogen, NO2 + NO3 as N (filtered)	0.43	mg/L	0.23	0.83	EPA 353.2	08/07/96
pH, lab	2.5	s.u.	1.0		SW846 9045	07/23/96
Potassium, dis. as K	ND	mg/L	2.0	6.6	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	27	ug/L	9.2	32	SW846 7740	07/31/96
Sodium, dis. as Na	14	mg/L	0.069	0.23	SW846 6010	08/14/96
Sulfate, as SO4 (filtered)	2100	mg/L	250	250	SW846 9036	08/06/96
Thallium, dis. as Tl	0.64	mg/L	0.080	0.28	SW846 6010	08/05/96
Zinc, dis. as Zn	23	mg/L	0.12	0.12	SW846 6010	07/30/96

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: 0720C-13-1A-5.5 **NLS#: 110838**
Ref. Line 2 of COC 18213 Description: 0720C-13-1A-5.5
Collected: 07/20/96 Received: 07/23/96 Reported: 08/14/96

38

Parameter	Result	Units	MDL	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	20	mg/L	1.5	5.3	EPA 310.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was analyzed within the holding time to the method endpoint.					
Aluminum, dis. as Al by ICP	ND	mg/L	0.017	0.060	SW846 6010	07/24/96
Antimony, dis. as Sb by furnace	ND	ug/L	1.5	5.1	SW846 7041	07/26/96
Arsenic, dis. as As by ICP	ND	ug/L	8.0	28	SW846 6010	07/24/96
Cadmium, dis. as Cd by ICP	65	ug/L	0.60	1.9	SW846 6010	07/24/96
Calcium, dis. as Ca by ICP	710	mg/L	1.5	1.5	SW846 6010	07/24/96
Chromium, dis. as Cr by ICP	2.2	ug/L	1.3	4.6	SW846 6010	07/24/96
Cobalt, dis. as Co by ICP	3900	ug/L	2.2	7.5	SW846 6010	07/24/96
Conductivity, lab	1900	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu by ICP	52000	ug/L	2.7	9.5	SW846 6010	07/24/96
Iron, dis. as Fe by ICP	ND	mg/L	0.0050	0.018	SW846 6010	07/24/96
Magnesium, dis. as Mg by ICP	60	mg/L	1.5	1.5	SW846 6010	07/24/96
Manganese, dis. as Mn by ICP	14000	ug/L	0.90	3.0	SW846 6010	07/24/96
Mercury, dis. as Hg	0.20	ug/L	0.095	0.34	SW846 7470A	07/26/96
Nickel, dis. as Ni by ICP	1700	ug/L	2.2	8.0	SW846 6010	07/24/96
Nitrogen, NO2 + NO3 as N (filtered)	0.72	mg/L	0.23	0.83	EPA 353.2	08/07/96
pH, lab	5.5	s.u.	1.0		SW846 9045	07/23/96
Potassium, dis. as K	ND	mg/L	2.0	6.6	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	33	ug/L	9.2	32	SW846 7740	07/31/96
Sodium, dis. as Na by ICP	16	mg/L	0.016	0.055	SW846 6010	07/24/96
Sulfate, as SO4 (filtered)	950	mg/L	250	250	SW846 9036	08/06/96
Thallium, dis. as Tl by ICP	ND	ug/L	14	50	SW846 6010	07/24/96
Zinc, dis. as Zn by ICP	12000	ug/L	60	60	SW846 6010	07/24/96

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: 0720C-13-1A-6.5 NLS#: 110839
Ref. Line 3 of COC 18213 Description: 0720C-13-1A-6.5
Collected: 07/20/96 Received: 07/23/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	140	mg/L	1.5	5.3	EPA 310.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was analyzed within the holding time to the method endpoint.					
Aluminum, dis. as Al by ICP	ND	mg/L	0.017	0.060	SW846 6010	07/24/96
Antimony, dis. as Sb by furnace	ND	ug/L	1.5	5.1	SW846 7041	07/26/96
Arsenic, dis. as As by ICP	ND	ug/L	8.0	28	SW846 6010	07/24/96
Cadmium, dis. as Cd by ICP	13	ug/L	0.60	1.9	SW846 6010	07/24/96
Calcium, dis. as Ca by ICP	840	mg/L	1.5	1.5	SW846 6010	07/24/96
Chromium, dis. as Cr by ICP	1.8	ug/L	1.3	4.6	SW846 6010	07/24/96
Cobalt, dis. as Co by ICP	1900	ug/L	2.2	7.5	SW846 6010	07/24/96
Conductivity, lab	2500	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu by ICP	1700	ug/L	2.7	9.5	SW846 6010	07/24/96
Iron, dis. as Fe by ICP	ND	mg/L	0.0050	0.018	SW846 6010	07/24/96
Magnesium, dis. as Mg by ICP	57	mg/L	1.5	1.5	SW846 6010	07/24/96
Manganese, dis. as Mn by ICP	9900	ug/L	0.90	3.0	SW846 6010	07/24/96
Mercury, dis. as Hg	3.2	ug/L	0.095	0.34	SW846 7470A	07/26/96
Nickel, dis. as Ni by ICP	540	ug/L	2.2	8.0	SW846 6010	07/24/96
Nitrogen, NO2 + NO3 as N (filtered)	0.83	mg/L	0.23	0.83	EPA 353.2	08/07/96
pH, lab	6.8	s.u.	1.0		SW846 9045	07/23/96
Potassium, dis. as K	2.9	mg/L	2.0	6.6	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	42	ug/L	9.2	32	SW846 7740	07/31/96
Sodium, dis. as Na by ICP	14	mg/L	0.016	0.055	SW846 6010	07/24/96
Sulfate, as SO4 (filtered)	880	mg/L	250	250	SW846 9036	08/06/96
Thallium, dis. as Tl by ICP	ND	ug/L	14	50	SW846 6010	07/24/96
Zinc, dis. as Zn by ICP	1500	ug/L	60	60	SW846 6010	07/24/96

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: 0720C-13-1A-7.5 **NLS#: 110840**
Ref. Line 4 of COC 18213 Description: 0720C-13-1A-7.5
Collected: 07/20/96 Received: 07/23/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	98	mg/L	1.5	5.3	EPA 310.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was analyzed within the holding time to the method endpoint.					
Aluminum, dis. as Al by ICP	ND	mg/L	0.017	0.060	SW846 6010	07/24/96
Antimony, dis. as Sb by furnace	ND	ug/L	1.5	5.1	SW846 7041	07/26/96
Arsenic, dis. as As by ICP	ND	ug/L	8.0	28	SW846 6010	07/24/96
Cadmium, dis. as Cd by ICP	5.4	ug/L	0.60	1.9	SW846 6010	07/24/96
Calcium, dis. as Ca by ICP	910	mg/L	1.5	1.5	SW846 6010	07/24/96
Chromium, dis. as Cr by ICP	1.3	ug/L	1.3	4.6	SW846 6010	07/24/96
40 Cobalt, dis. as Co by ICP	900	ug/L	2.2	7.5	SW846 6010	07/24/96
Conductivity, lab	2000	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu by ICP	720	ug/L	2.7	9.5	SW846 6010	07/24/96
Iron, dis. as Fe by ICP	0.28	mg/L	0.0050	0.018	SW846 6010	07/24/96
Magnesium, dis. as Mg by ICP	60	mg/L	1.5	1.5	SW846 6010	07/24/96
Manganese, dis. as Mn by ICP	7100	ug/L	0.90	3.0	SW846 6010	07/24/96
Mercury, dis. as Hg	5.5	ug/L	0.19	0.68	SW846 7470A	08/02/96
Nickel, dis. as Ni by ICP	210	ug/L	2.2	8.0	SW846 6010	07/24/96
Nitrogen, NO2 + NO3 as N (filtered)	0.73	mg/L	0.23	0.83	EPA 353.2	08/07/96
pH, lab	6.9	s.u.	1.0		SW846 9045	07/23/96
Potassium, dis. as K	ND	mg/L	200	670	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	38	ug/L	9.2	32	SW846 7740	07/31/96
Sodium, dis. as Na by ICP	12	mg/L	0.016	0.055	SW846 6010	07/24/96
Sulfate, as SO4 (filtered)	1600	mg/L	250	250	SW846 9036	08/06/96
Thallium, dis. as Tl by ICP	ND	ug/L	14	50	SW846 6010	07/24/96
Zinc, dis. as Zn by ICP	370	ug/L	60	60	SW846 6010	07/24/96

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: 0720C-15-1A-U NLS#: 110841
Ref. Line 5 of COC 18213 Description: 0720C-15-1A-U
Collected: 07/20/96 Received: 07/23/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Acidity, tot. as CaCO3	8200	mg/L	2.0		EPA 305.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was within the holding time to the method endpoint.					
Aluminum, dis. as Al	56	mg/L	0.034	0.12	SW846 6010	07/31/96
Antimony, dis. as Sb by furnace	ND	ug/L	1.5	4.6	SW846 7041	07/26/96
Arsenic, dis. as As by furnace	980	ug/L	28	96	SW846 7060	07/29/96
Cadmium, dis. as Cd	0.22	mg/L	0.0036	0.013	SW846 6010	07/30/96
Calcium, dis. as Ca	140	mg/L	3.0	3.0	SW846 6010	08/02/96
Chromium, dis. as Cr	0.12	mg/L	0.0093	0.037	SW846 6010	07/30/96
Cobalt, dis. as Co	2.0	mg/L	0.0090	0.032	SW846 6010	08/06/96
Conductivity, lab	5300	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu	450	mg/L	0.22	0.79	SW846 6010	07/30/96
Iron, dis. as Fe	2000	mg/L	1.7	5.7	SW846 6010	08/02/96
Magnesium, dis. as Mg	53	mg/L	3.0	3.0	SW846 6010	08/02/96
Manganese, dis. as Mn	5.8	mg/L	0.0013	0.0044	SW846 6010	07/30/96
Mercury, dis. as Hg	0.20	ug/L	0.095	0.34	SW846 7470A	07/26/96
Nickel, dis. as Ni	0.95	mg/L	0.013	0.047	SW846 6010	07/30/96
Nitrogen, NO2 + NO3 as N (filtered)	0.35	mg/L	0.23	0.83	EPA 353.2	08/07/96
pH, lab	2.4	s.u.	1.0		SW846 9045	07/23/96
Potassium, dis. as K	5.2	mg/L	3.6	12	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	150	ug/L	7.5	25	SW846 7740	07/31/96
Sodium, dis. as Na	7.0	mg/L	0.40	1.4	SW846 6010	08/14/96
Sulfate, as SO4 (filtered)	5600	mg/L	250	250	SW846 9036	08/06/96
Thallium, dis. as Tl	4.4	mg/L	0.058	0.21	SW846 6010	08/05/96
Zinc, dis. as Zn	6.8	mg/L	0.012	0.012	SW846 6010	07/30/96
Metals digestion - dissolved ICP	yes				SW846 3050	07/26/96
Metals digestion - dissolved Furnace	yes				SW846 3050	07/26/96

41

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: 0720C-15-1A-5.5 NLS#: 110842
Ref. Line 6 of COC 18213 Description: 0720C-15-1A-5.5
Collected: 07/20/96 Received: 07/23/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	140	mg/L	1.5	5.3	EPA 310.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was analyzed within the holding time to the method endpoint.					
Aluminum, dis. as Al by ICP	ND	mg/L	0.017	0.060	SW846 6010	07/24/96
Antimony, dis. as Sb by furnace	ND	ug/L	1.5	5.1	SW846 7041	07/26/96
Arsenic, dis. as As by ICP	ND	ug/L	8.0	28	SW846 6010	07/24/96
Cadmium, dis. as Cd by ICP	1.4	ug/L	0.60	1.9	SW846 6010	07/24/96
Calcium, dis. as Ca by ICP	630	mg/L	1.5	1.5	SW846 6010	07/24/96
Chromium, dis. as Cr by ICP	ND	ug/L	1.3	4.6	SW846 6010	07/24/96
Cobalt, dis. as Co by ICP	590	ug/L	2.2	7.5	SW846 6010	07/24/96
Conductivity, lab	2300	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu by ICP	450	ug/L	2.7	9.5	SW846 6010	07/24/96
Iron, dis. as Fe by ICP	0.045	mg/L	0.0050	0.018	SW846 6010	07/24/96
Magnesium, dis. as Mg by ICP	93	mg/L	1.5	1.5	SW846 6010	07/24/96
Manganese, dis. as Mn by ICP	5400	ug/L	0.90	3.0	SW846 6010	07/24/96
Mercury, dis. as Hg	ND	ug/L	0.095	0.34	SW846 7470A	07/26/96
Nickel, dis. as Ni by ICP	140	ug/L	2.2	8.0	SW846 6010	07/24/96
Nitrogen, NO2 + NO3 as N (filtered)	0.79	mg/L	0.23	0.83	EPA 353.2	08/07/96
pH, lab	5.9	s.u.	1.0		SW846 9045	07/23/96
Potassium, dis. as K	2.6	mg/L	2.0	6.6	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	33	ug/L	9.2	32	SW846 7740	07/31/96
Sodium, dis. as Na by ICP	14	mg/L	0.016	0.055	SW846 6010	07/24/96
Sulfate, as SO4 (filtered)	740	mg/L	250	250	SW846 9036	08/06/96
Thallium, dis. as Tl by ICP	ND	ug/L	14	50	SW846 6010	07/24/96
Zinc, dis. as Zn by ICP	260	ug/L	60	60	SW846 6010	07/24/96

42

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: 0720C-15-1A-6.5 NLS#: 110843
Ref. Line 7 of COC 18213 Description: 0720C-15-1A-6.5
Collected: 07/20/96 Received: 07/23/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	140	mg/L	1.5	5.3	EPA 310.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was analyzed within the holding time to the method endpoint.					
Aluminum, dis. as Al by ICP	0.038	mg/L	0.017	0.060	SW846 6010	07/24/96
Antimony, dis. as Sb by furnace	ND	ug/L	1.5	5.1	SW846 7041	07/26/96
Arsenic, dis. as As by ICP	ND	ug/L	8.0	28	SW846 6010	07/24/96
Cadmium, dis. as Cd by ICP	ND	ug/L	0.60	1.9	SW846 6010	07/24/96
Calcium, dis. as Ca by ICP	620	mg/L	1.5	1.5	SW846 6010	07/24/96
Chromium, dis. as Cr by ICP	ND	ug/L	1.3	4.6	SW846 6010	07/24/96
Cobalt, dis. as Co by ICP	75	ug/L	2.2	7.5	SW846 6010	07/24/96
Conductivity, lab	2300	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu by ICP	290	ug/L	2.7	9.5	SW846 6010	07/24/96
Iron, dis. as Fe by ICP	1.0	mg/L	0.0050	0.018	SW846 6010	07/24/96
Magnesium, dis. as Mg by ICP	86	mg/L	1.5	1.5	SW846 6010	07/24/96
Manganese, dis. as Mn by ICP	1600	ug/L	0.90	3.0	SW846 6010	07/24/96
Mercury, dis. as Hg	ND	ug/L	0.095	0.34	SW846 7470A	07/26/96
Nickel, dis. as Ni by ICP	22	ug/L	2.2	8.0	SW846 6010	07/24/96
Nitrogen, NO2 + NO3 as N (filtered)	0.85	mg/L	0.23	0.83	EPA 353.2	08/07/96
pH, lab	6.6	s.u.	1.0		SW846 9045	07/23/96
Potassium, dis. as K	3.8	mg/L	2.0	6.6	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	24	ug/L	9.2	32	SW846 7740	07/31/96
Sodium, dis. as Na by ICP	14	mg/L	0.016	0.055	SW846 6010	07/24/96
Sulfate, as SO4 (filtered)	850	mg/L	250	250	SW846 9036	08/06/96
Thallium, dis. as Tl by ICP	ND	ug/L	14	50	SW846 6010	07/24/96
Zinc, dis. as Zn by ICP	ND	ug/L	60	60	SW846 6010	07/24/96

43

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: 0720C-15-1A-7.5 NLS#: 110844
Ref. Line 8 of COC 18213 Description: 0720C-15-1A-7.5
Collected: 07/20/96 Received: 07/23/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	60	mg/L	1.5	5.3	EPA 310.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was analyzed within the holding time to the method endpoint.					
Aluminum, dis. as Al by ICP	ND	mg/L	0.0034	0.012	SW846 6010	07/24/96
Antimony, dis. as Sb by furnace	ND	ug/L	1.5	5.1	SW846 7041	07/26/96
Arsenic, dis. as As by ICP	ND	ug/L	1.6	5.7	SW846 6010	07/24/96
Cadmium, dis. as Cd by ICP	ND	ug/L	0.12	0.38	SW846 6010	07/24/96
Calcium, dis. as Ca by ICP	600	mg/L	0.30	0.30	SW846 6010	07/24/96
Chromium, dis. as Cr by ICP	ND	ug/L	0.26	0.93	SW846 6010	07/24/96
Cobalt, dis. as Co by ICP	9.6	ug/L	2.2	7.5	SW846 6010	07/24/96
Conductivity, lab	2200	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu by ICP	30	ug/L	0.54	1.9	SW846 6010	07/24/96
Iron, dis. as Fe by ICP	ND	mg/L	0.0010	0.0035	SW846 6010	07/24/96
Magnesium, dis. as Mg by ICP	74	mg/L	0.30	0.30	SW846 6010	07/24/96
Manganese, dis. as Mn by ICP	320	ug/L	0.18	0.61	SW846 6010	07/24/96
Mercury, dis. as Hg	ND	ug/L	0.095	0.34	SW846 7470A	07/26/96
Nickel, dis. as Ni by ICP	3.6	ug/L	0.44	1.6	SW846 6010	07/24/96
Nitrogen, NO2 + NO3 as N (filtered)	0.94	mg/L	0.23	0.83	EPA 353.2	08/07/96
pH, lab	6.7	s.u.	1.0		SW846 9045	07/23/96
Potassium, dis. as K	4.7	mg/L	2.0	6.6	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	26	ug/L	9.2	32	SW846 7740	07/31/96
Sodium, dis. as Na by ICP	14	mg/L	0.016	0.055	SW846 6010	07/24/96
Sulfate, as SO4 (filtered)	1400	mg/L	250	250	SW846 9036	08/06/96
Thallium, dis. as Tl by ICP	ND	ug/L	14	50	SW846 6010	07/24/96
Zinc, dis. as Zn by ICP	ND	ug/L	60	60	SW846 6010	07/24/96

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: 0720C-17-3A-U **NLS#: 110845**
Ref. Line 9 of COC 18213 Description: 0720C-17-3A-U
Collected: 07/20/96 Received: 07/23/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Acidity, tot. as CaCO3	1200	mg/L	2.0		EPA 305.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was within the holding time to the method endpoint.					
Aluminum, dis. as Al	0.15	mg/L	0.0073	0.023	SW846 6010	07/31/96
Antimony, dis. as Sb by furnace	ND	ug/L	1.5	5.1	SW846 7041	07/26/96
Arsenic, dis. as As by furnace	ND	ug/L	1.2	4.3	SW846 7060	07/29/96
Cadmium, dis. as Cd	0.38	mg/L	0.0039	0.014	SW846 6010	07/30/96
Calcium, dis. as Ca	390	mg/L	3.0	3.0	SW846 6010	08/02/96
Chromium, dis. as Cr	ND	mg/L	0.0067	0.024	SW846 6010	07/30/96
Cobalt, dis. as Co	2.2	mg/L	0.0044	0.016	SW846 6010	08/06/96
Conductivity, lab	2400	umho@25C	1.0	-	EPA 120.1	08/05/96
Copper, dis. as Cu	640	mg/L	0.32	1.0	SW846 6010	07/30/96
Iron, dis. as Fe	0.099	mg/L	0.0079	0.026	SW846 6010	08/02/96
Magnesium, dis. as Mg	74	mg/L	0.30	0.30	SW846 6010	08/02/96
Manganese, dis. as Mn	11	mg/L	0.00086	0.0031	SW846 6010	07/30/96
Mercury, dis. as Hg	ND	ug/L	0.095	0.34	SW846 7470A	07/26/96
Nickel, dis. as Ni	1.2	mg/L	0.017	0.061	SW846 6010	07/30/96
Nitrogen, NO2 + NO3 as N (filtered)	0.39	mg/L	0.23	0.83	EPA 353.2	08/07/96
pH, lab	4.8	s.u.	1.0		SW846 9045	07/23/96
Potassium, dis. as K	7.2	mg/L	2.0	6.6	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	27	ug/L	9.2	32	SW846 7740	07/31/96
Sodium, dis. as Na	14	mg/L	0.069	0.23	SW846 6010	08/14/96
Sulfate, as SO4 (filtered)	860	mg/L	250	250	SW846 9036	08/06/96
Thallium, dis. as Tl	0.10	mg/L	0.080	0.28	SW846 6010	08/05/96
Zinc, dis. as Zn	97	mg/L	0.12	0.12	SW846 6010	07/30/96

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

 NLS PROJECT# 28459

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: 0720C-17-3A-5.5 **NLS#: 110846**
Ref. Line 10 of COC 18213 Description: 0720C-17-3A-5.5
Collected: 07/20/96 Received: 07/23/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Acidity, tot. as CaCO3	970	mg/L	2.0		EPA 305.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was within the holding time to the method endpoint.					
Aluminum, dis. as Al	0.11	mg/L	0.0073	0.023	SW846 6010	07/31/96
Antimony, dis. as Sb by furnace	ND	ug/L	1.5	5.1	SW846 7041	07/26/96
Arsenic, dis. as As by furnace	ND	ug/L	1.2	4.3	SW846 7060	07/29/96
Cadmium, dis. as Cd	0.44	mg/L	0.0039	0.014	SW846 6010	07/30/96
Calcium, dis. as Ca	520	mg/L	3.0	3.0	SW846 6010	08/02/96
Chromium, dis. as Cr	ND	mg/L	0.0067	0.024	SW846 6010	07/30/96
Cobalt, dis. as Co	2.3	mg/L	0.0044	0.016	SW846 6010	08/06/96
Conductivity, lab	2500	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu	400	mg/L	0.32	1.0	SW846 6010	07/30/96
Iron, dis. as Fe	0.019	mg/L	0.0079	0.026	SW846 6010	08/02/96
Magnesium, dis. as Mg	78	mg/L	0.30	0.30	SW846 6010	08/02/96
Manganese, dis. as Mn	11	mg/L	0.00086	0.0031	SW846 6010	07/30/96
Mercury, dis. as Hg	ND	ug/L	0.095	0.34	SW846 7470A	07/26/96
Nickel, dis. as Ni	1.2	mg/L	0.017	0.061	SW846 6010	07/30/96
Nitrogen, NO2 + NO3 as N (filtered)	0.61	mg/L	0.23	0.83	EPA 353.2	08/07/96
pH, lab	5.2	s.u.	1.0		SW846 9045	07/23/96
Potassium, dis. as K	7.8	mg/L	2.0	6.6	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	27	ug/L	9.2	32	SW846 7740	07/31/96
Sodium, dis. as Na	14	mg/L	0.069	0.23	SW846 6010	08/14/96
Sulfate, as SO4 (filtered)	1300	mg/L	250	250	SW846 9036	08/06/96
Thallium, dis. as Tl	ND	mg/L	0.080	0.28	SW846 6010	08/05/96
Zinc, dis. as Zn	110	mg/L	0.12	0.12	SW846 6010	07/30/96

46

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

Sample ID: 0720C-17-3A-6.5 **NLS#: 110847**
Ref. Line 11 of COC 18213 Description: 0720C-17-3A-6.5
Collected: 07/20/96 Received: 07/23/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	95	mg/L	1.5	5.3	EPA 310.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was analyzed within the holding time to the method endpoint.					
Aluminum, dis. as Al by ICP	ND	mg/L	0.017	0.060	SW846 6010	07/24/96
Antimony, dis. as Sb by furnace	ND	ug/L	7.4	26	SW846 7041	07/31/96
Arsenic, dis. as As by ICP	ND	ug/L	8.0	28	SW846 6010	07/24/96
Cadmium, dis. as Cd by ICP	150	ug/L	0.60	1.9	SW846 6010	07/24/96
Calcium, dis. as Ca by ICP	680	mg/L	1.5	1.5	SW846 6010	07/24/96
Chromium, dis. as Cr by ICP	ND	ug/L	1.3	4.6	SW846 6010	07/24/96
Cobalt, dis. as Co by ICP	1500	ug/L	2.2	7.5	SW846 6010	07/24/96
Conductivity, lab	1800	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu by ICP	2500	ug/L	2.7	9.5	SW846 6010	07/24/96
Iron, dis. as Fe by ICP	ND	mg/L	0.0050	0.018	SW846 6010	07/24/96
Magnesium, dis. as Mg by ICP	66	mg/L	1.5	1.5	SW846 6010	07/24/96
Manganese, dis. as Mn by ICP	8600	ug/L	0.90	3.0	SW846 6010	07/24/96
Mercury, dis. as Hg	ND	ug/L	0.095	0.34	SW846 7470A	07/26/96
Nickel, dis. as Ni by ICP	680	ug/L	2.2	8.0	SW846 6010	07/24/96
Nitrogen, NO2 + NO3 as N (filtered)	0.71	mg/L	0.23	0.83	EPA 353.2	08/07/96
pH, lab	6.4	s.u.	1.0		SW846 9045	07/23/96
Potassium, dis. as K	6.5	mg/L	2.0	6.6	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	28	ug/L	9.2	32	SW846 7740	07/31/96
Sodium, dis. as Na by ICP	16	mg/L	0.016	0.055	SW846 6010	07/24/96
Sulfate, as SO4 (filtered)	510	mg/L	250	250	SW846 9036	08/06/96
Thallium, dis. as Tl by ICP	ND	ug/L	14	50	SW846 6010	07/24/96
Zinc, dis. as Zn by ICP	24000	ug/L	60	60	SW846 6010	07/24/96

47

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

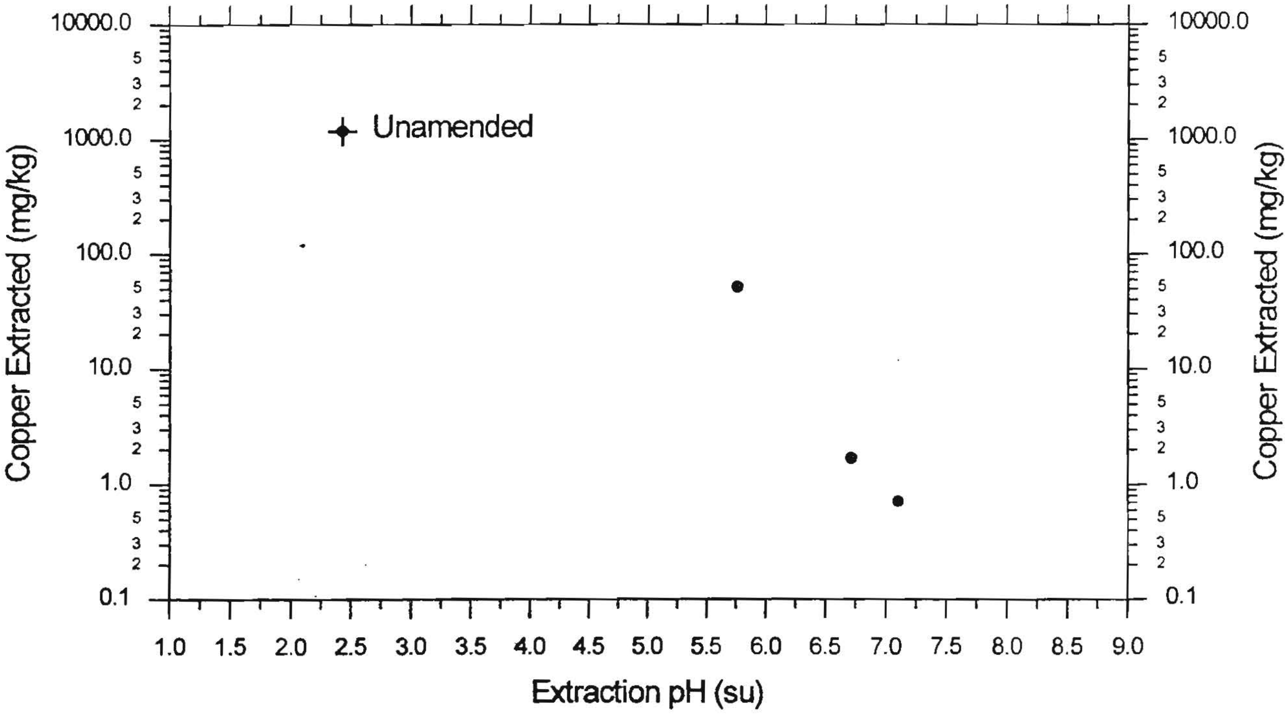
ANALYTICAL REPORT

Client: Flambeau Mining Company
Attn: Richard Dachel
N4100 Highway 27
Ladysmith, WI 54848

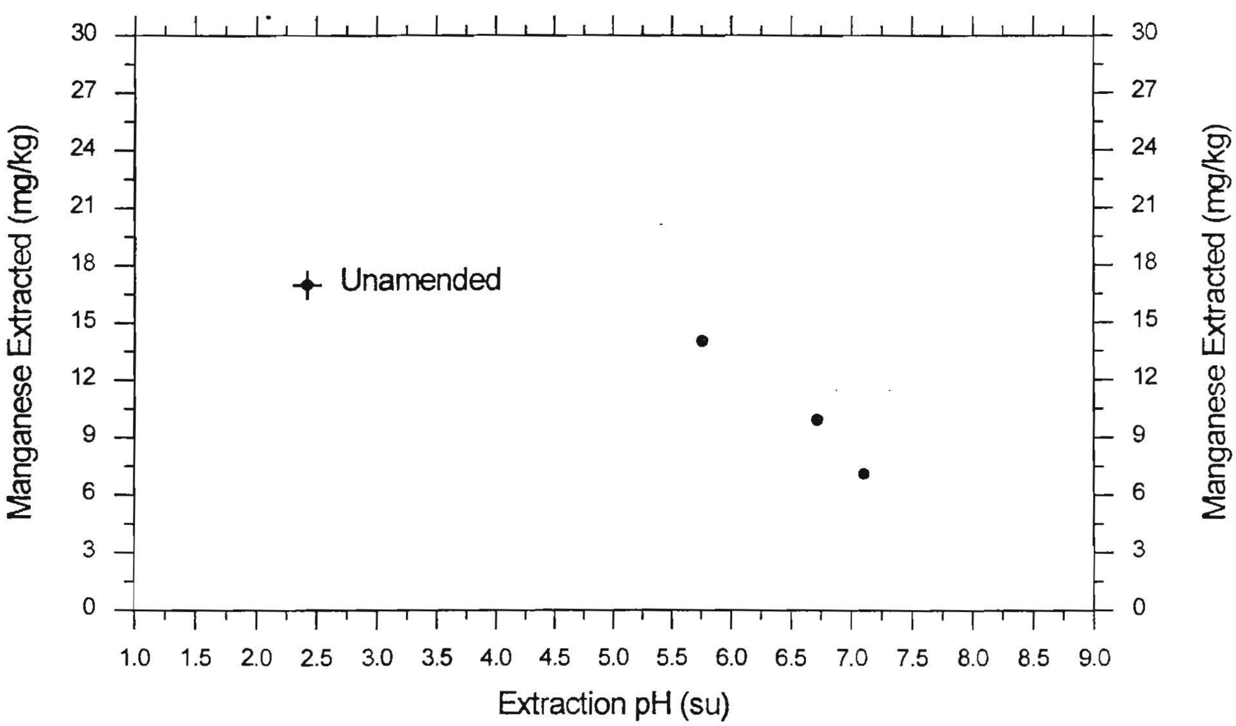
Sample ID: 0720C-17-3A-7.5 NLS#: 110848
Ref. Line 12 of COC 18213 Description: 0720C-17-3A-7.5
Collected: 07/20/96 Received: 07/23/96 Reported: 08/14/96

Parameter	Result	Units	MDL	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	100	mg/L	1.5	5.3	EPA 310.1	08/05/96
	Additional Comments: Sample was reanalyzed past the holding time to an endpoint of 6.5. The initial analysis was analyzed within the holding time to the method endpoint.					
Aluminum, dis. as Al by ICP	ND	mg/L	0.017	0.060	SW846 6010	07/24/96
Antimony, dis. as Sb by furnace	ND	ug/L	7.4	26	SW846 7041	07/31/96
Arsenic, dis. as As by ICP	ND	ug/L	8.0	28	SW846 6010	07/24/96
Cadmium, dis. as Cd by ICP	52	ug/L	0.60	1.9	SW846 6010	07/24/96
Calcium, dis. as Ca by ICP	650	mg/L	1.5	1.5	SW846 6010	07/24/96
Chromium, dis. as Cr by ICP	ND	ug/L	1.3	4.6	SW846 6010	07/24/96
Cobalt, dis. as Co by ICP	900	ug/L	2.2	7.5	SW846 6010	07/24/96
Conductivity, lab	1600	umho@25C	1.0		EPA 120.1	08/05/96
Copper, dis. as Cu by ICP	1700	ug/L	2.7	9.5	SW846 6010	07/24/96
Iron, dis. as Fe by ICP	ND	mg/L	0.0050	0.018	SW846 6010	07/24/96
Magnesium, dis. as Mg by ICP	65	mg/L	1.5	1.5	SW846 6010	07/24/96
Manganese, dis. as Mn by ICP	6600	ug/L	0.90	3.0	SW846 6010	07/24/96
Mercury, dis. as Hg	ND	ug/L	0.095	0.34	SW846 7470A	07/26/96
Nickel, dis. as Ni by ICP	330	ug/L	2.2	8.0	SW846 6010	07/24/96
Nitrogen, NO2 + NO3 as N (filtered)	0.73	mg/L	0.23	0.83	EPA 353.2	08/07/96
pH, lab	6.9	s.u.	1.0		SW846 9045	07/23/96
Potassium, dis. as K	6.7	mg/L	2.0	6.6	SW846 6010	08/08/96
Selenium, dis. as Se by furnace	34	ug/L	9.2	32	SW846 7740	07/31/96
Sodium, dis. as Na by ICP	16	mg/L	0.016	0.055	SW846 6010	07/24/96
Sulfate, as SO4 (filtered)	880	mg/L	250	250	SW846 9036	08/06/96
Thallium, dis. as Tl by ICP	ND	ug/L	14	50	SW846 6010	07/24/96
Zinc, dis. as Zn by ICP	5700	ug/L	60	60	SW846 6010	07/24/96

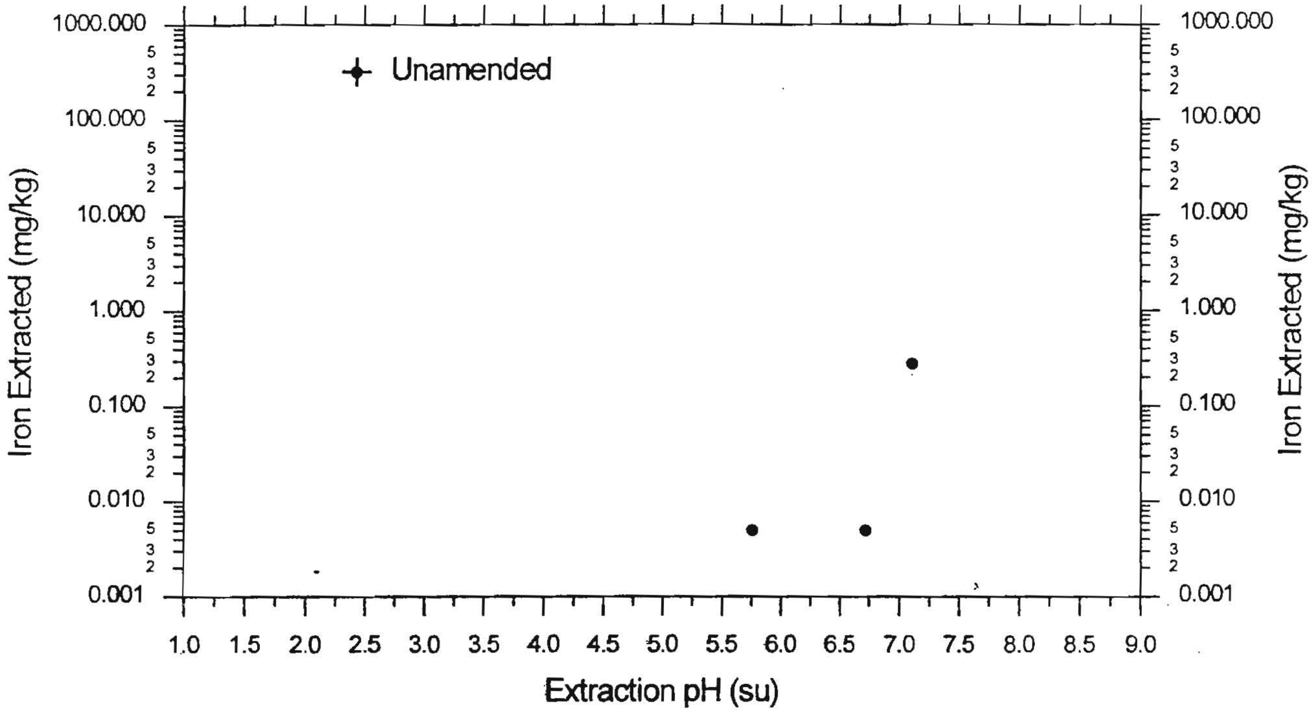
48



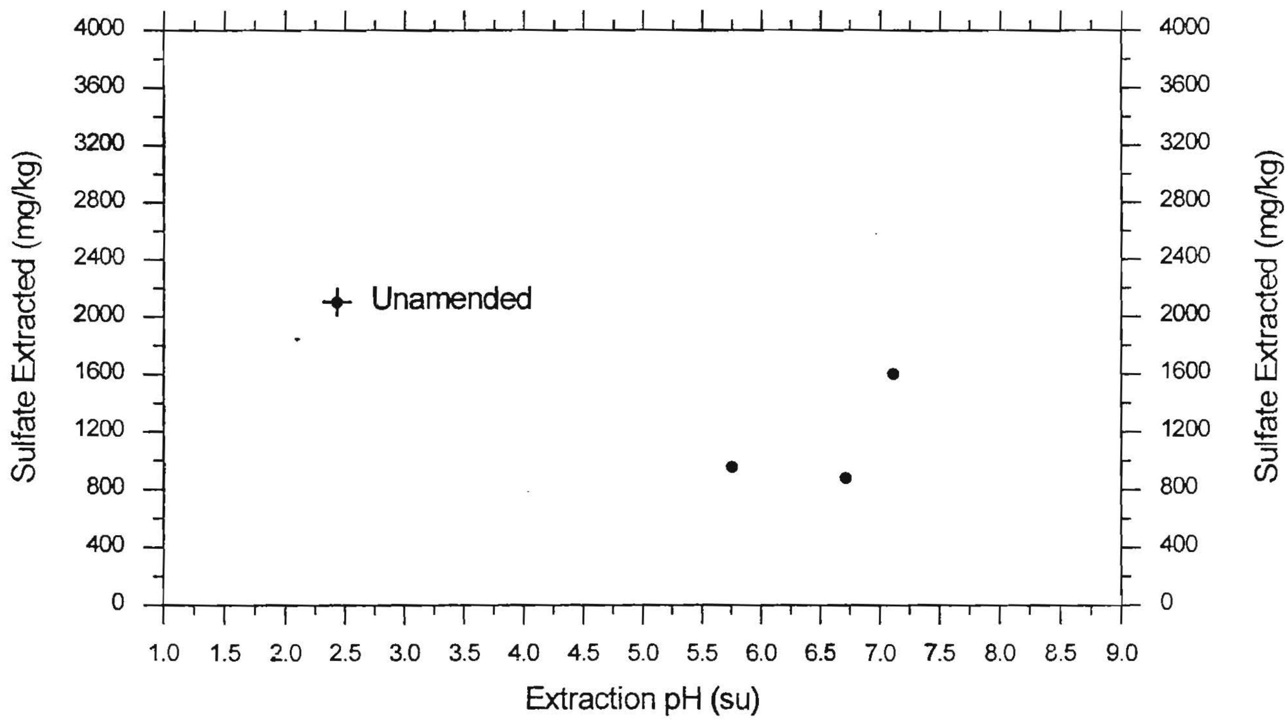
Appendix C Figure 30. Relationship of Extraction pH to Quantity of Copper Extracted from the <1/4" Size Fraction of Sample 13-1



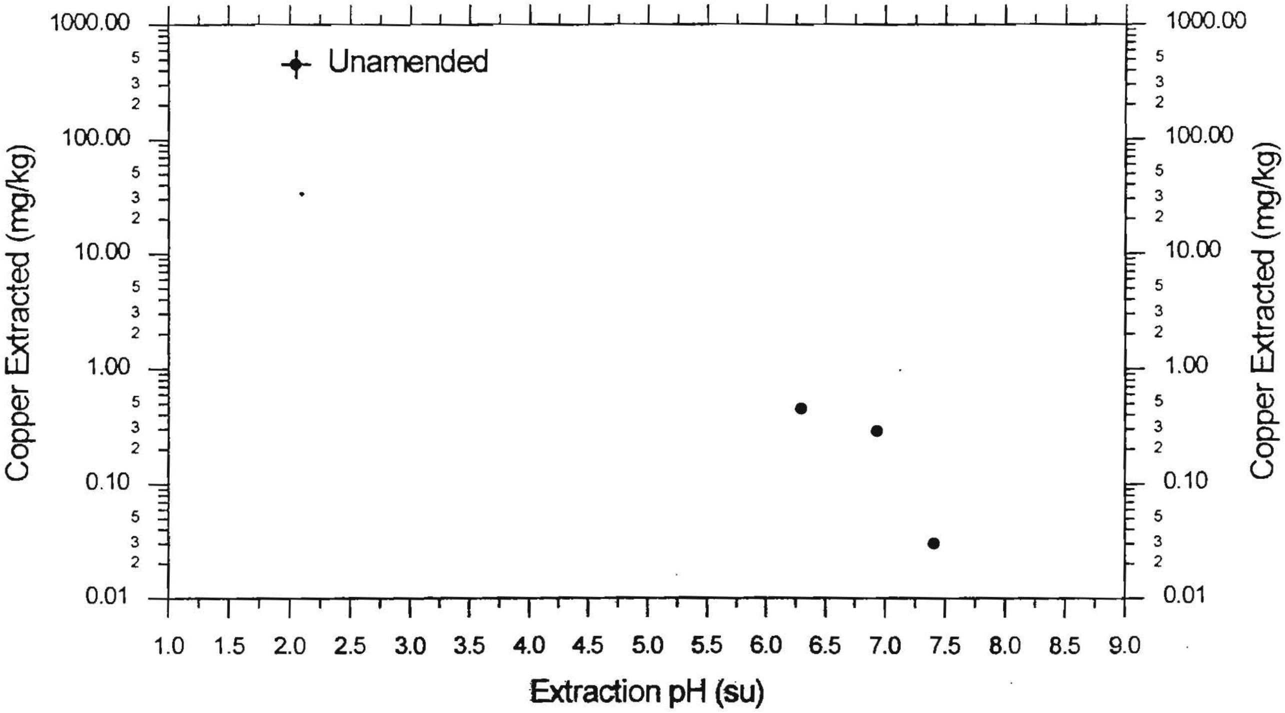
Appendix C Figure 31. Relationship of Extraction pH to Quantity of Managnese Extracted from the <1/4" Size Fraction of Sample 13-1



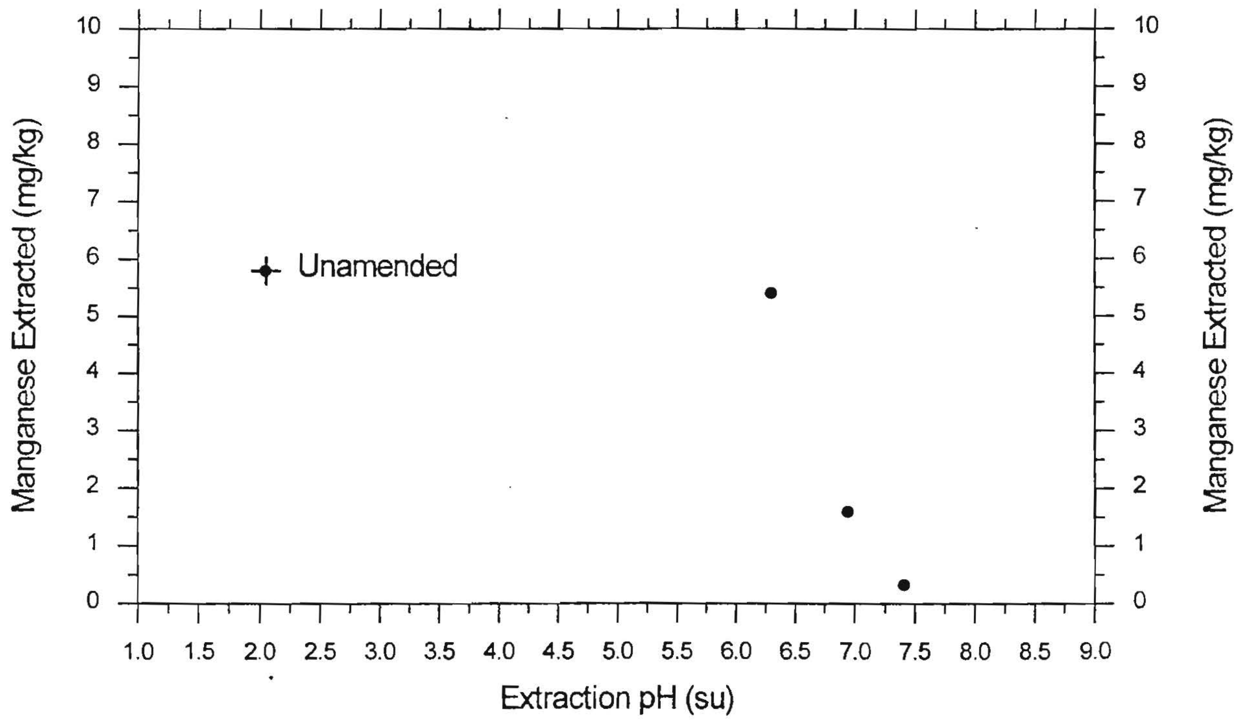
Appendix C Figure 32. Relationship of Extraction pH to Quantity of Iron Extracted from the <1/4" Size Fraction of Sample 13-1



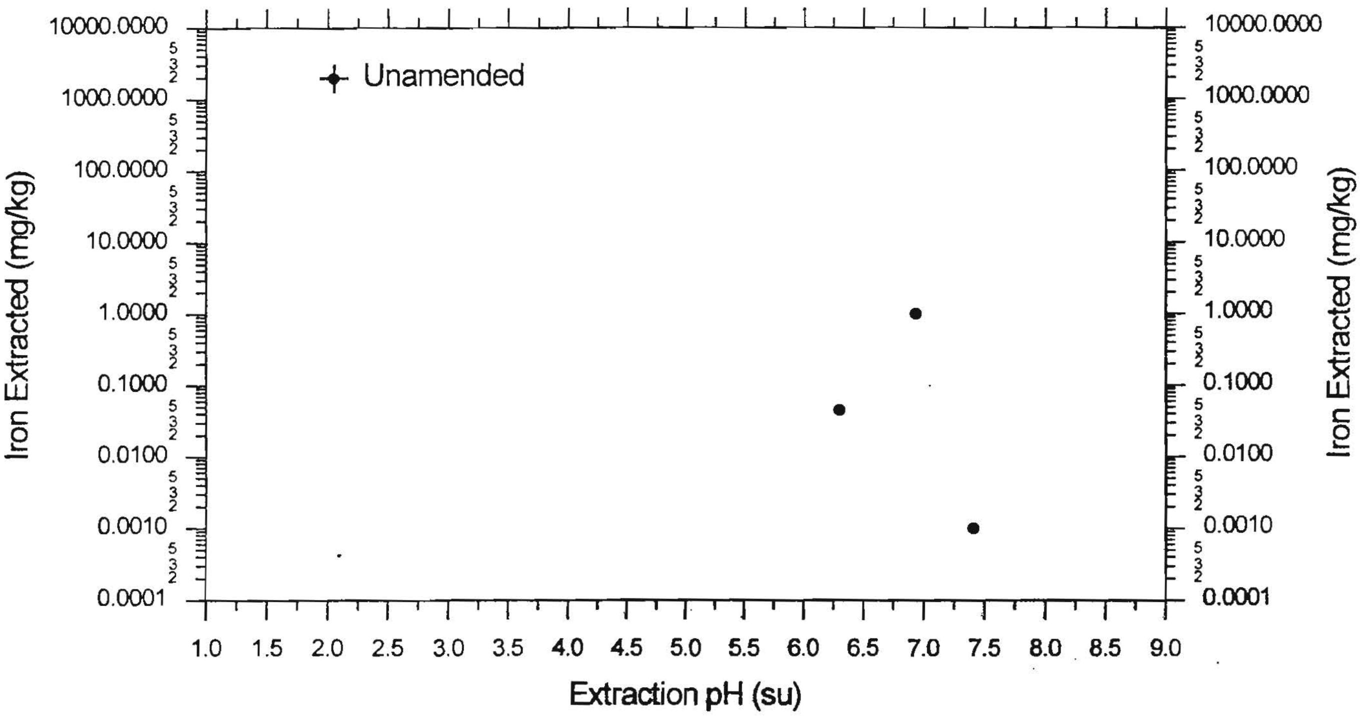
Appendix C Figure 33. Relationship of Extraction pH to Quantity of Sulfate Extracted from the <1/4" Size Fraction of Sample 13-1



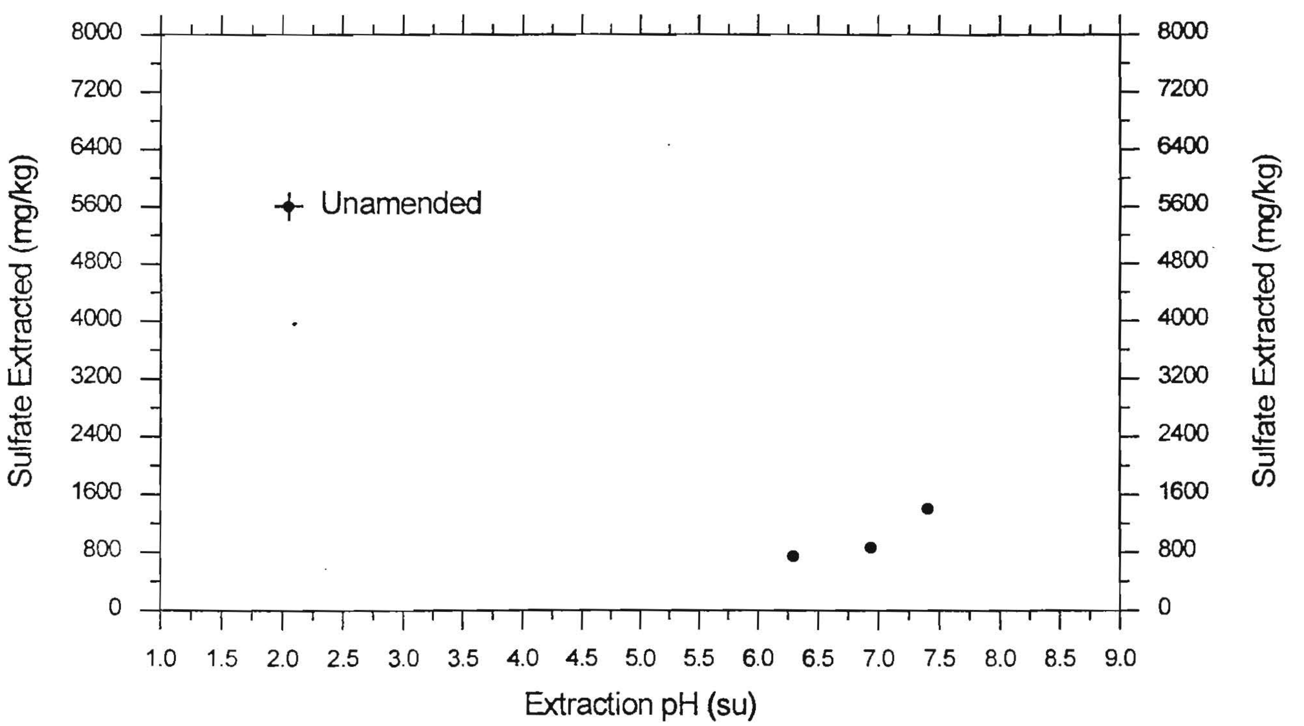
Appendix C Figure 34. Relationship of Extraction pH to Quantity of Copper Extracted from the <1/4" Size Fraction of Sample 15-1



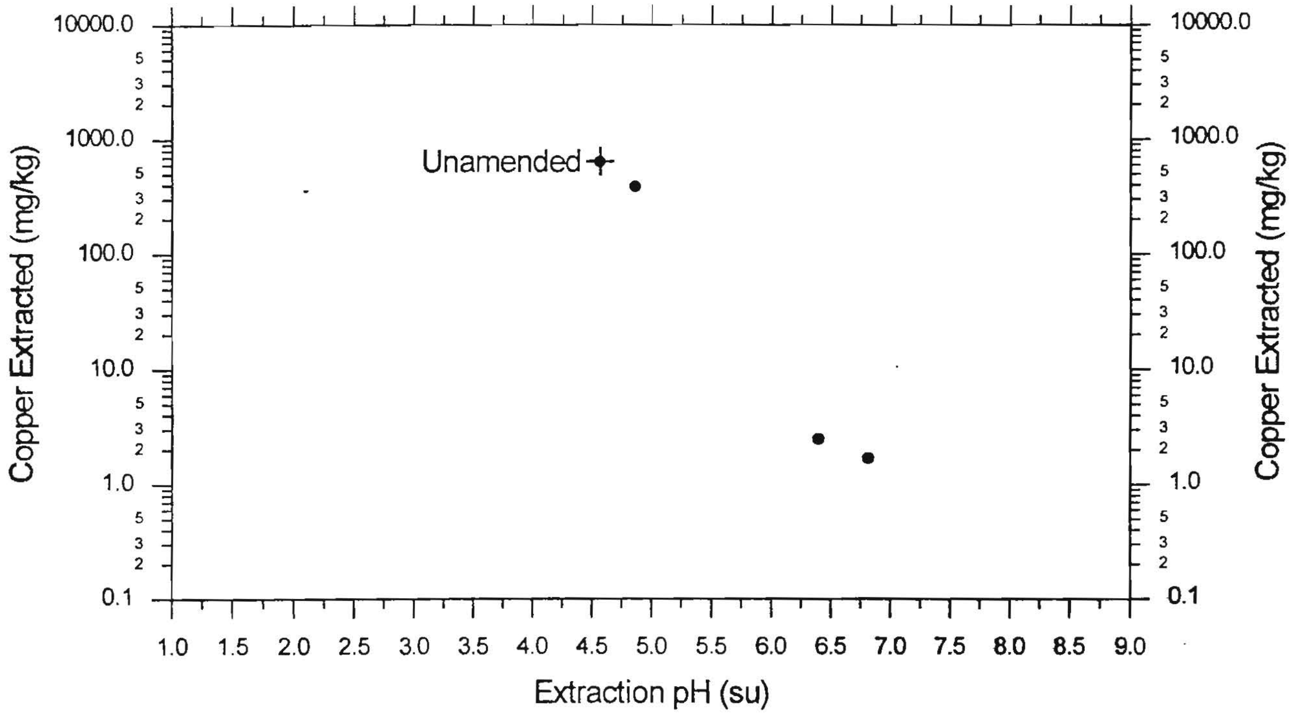
Appendix C Figure 35. Relationship of Extraction pH to Quantity of Managnese Extracted from the <1/4" Size Fraction of Sample 15-1



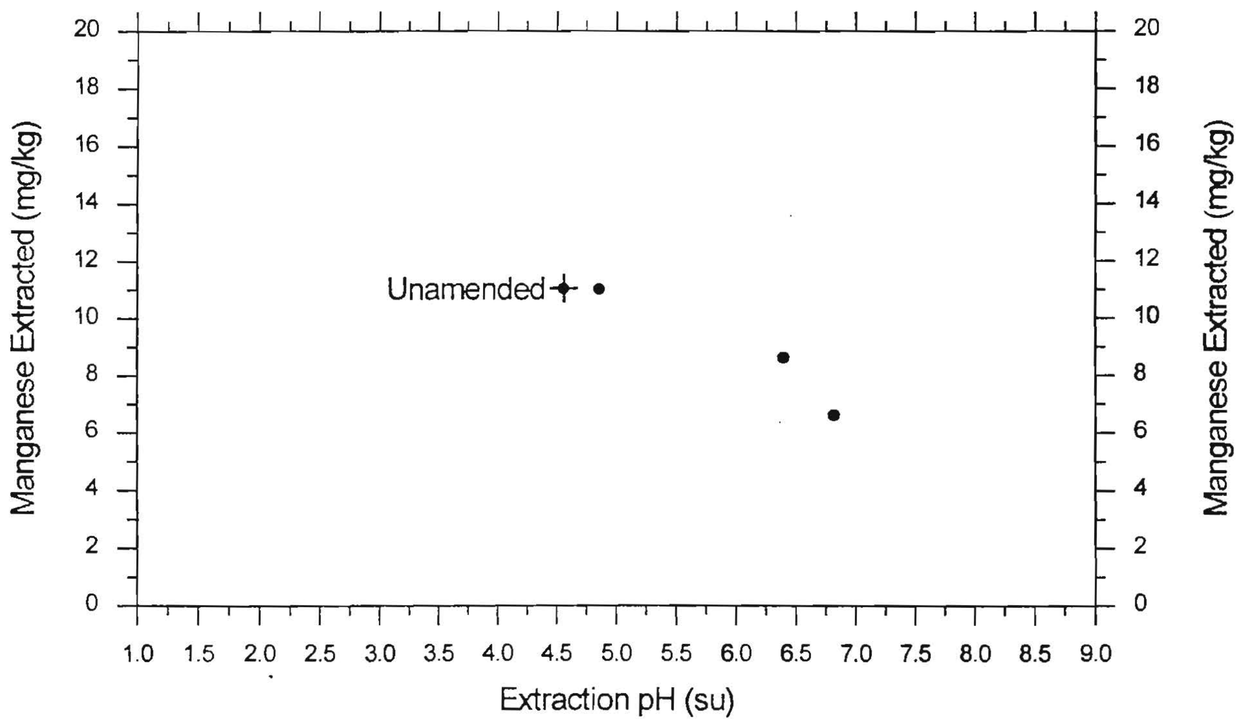
Appendix C Figure 36. Relationship of Extraction pH to Quantity of Iron Extracted from the <1/4" Size Fraction of Sample 15-1



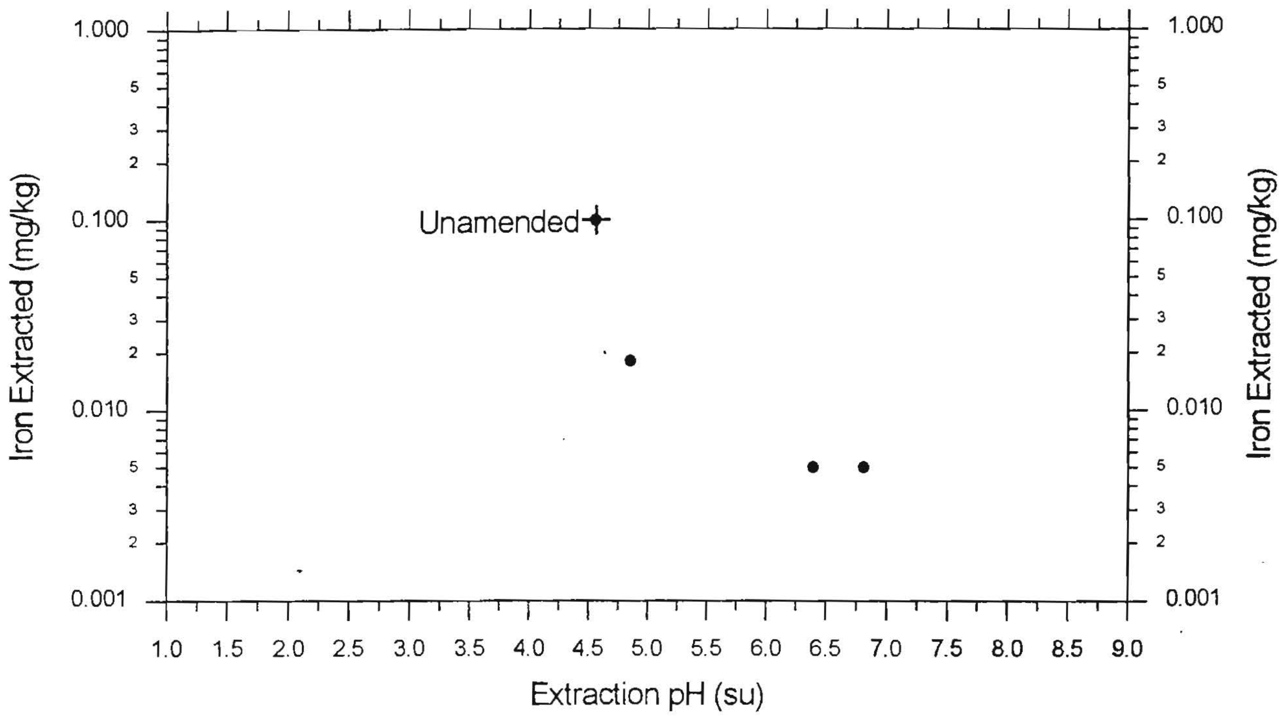
Appendix C Figure 37. Relationship of Extraction pH to Quantity of Sulfate Extracted from the <1/4" Size Fraction of Sample 15-1



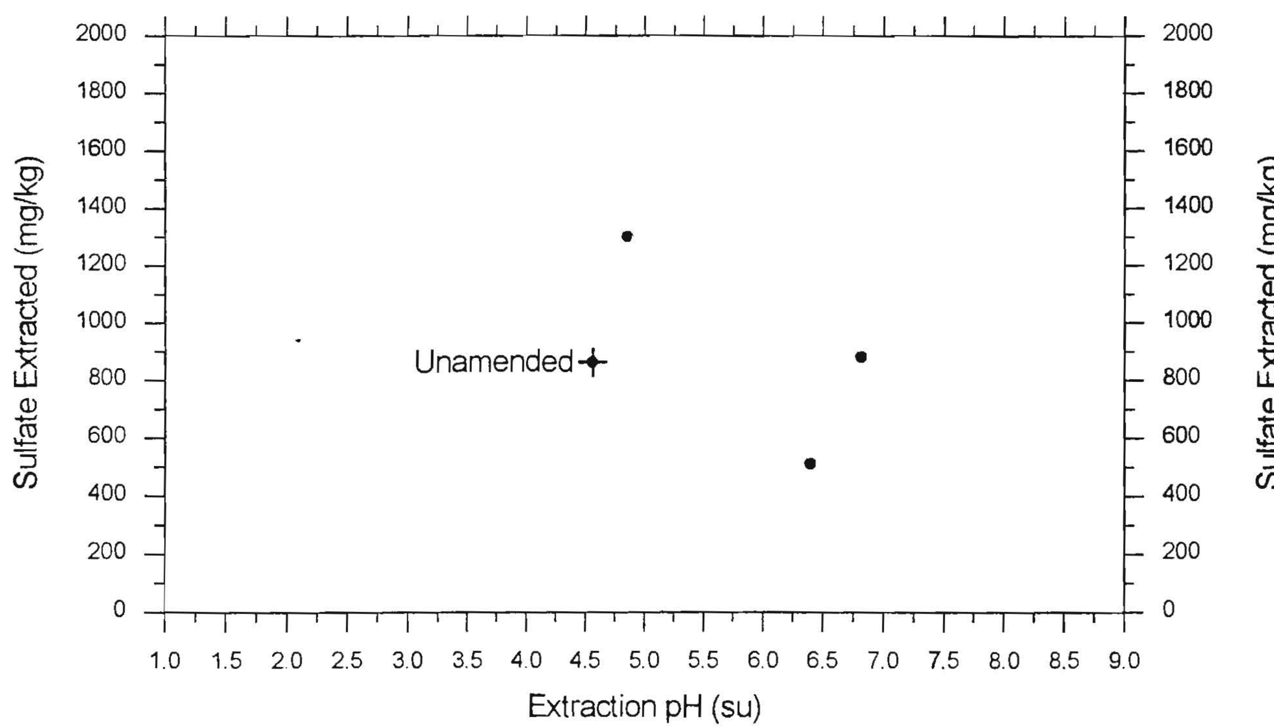
Appendix C Figure 38. Relationship of Extraction pH to Quantity of Copper Extracted from the <1/4" Size Fraction of Sample 17-3



Appendix C Figure 39. Relationship of Extraction pH to Quantity of Managnese Extracted from the <1/4" Size Fraction of Sample 17-3



Appendix C Figure 40. Relationship of Extraction pH to Quantity of Iron Extracted from the <1/4" Size Fraction of Sample 17-3



Appendix C Figure 41. Relationship of Extraction pH to Quantity of Sulfate Extracted from the <1/4" Size Fraction of Sample 17-3

Appendix D

Laboratory and Analytical Data for the Final Screening Tests

- Appendix D Tables 1-6. Field and Summary Analytical Data for the Sequential Extraction Test
- Laboratory Data Sheets for the Sequential Extraction Tests
- Appendix D Table 7. Flambeau Limestone Alkali Availability Test Data
- Appendix D Figure 1. Presentation of a Portion of the Flambeau Alkali Availability Test Data
- Appendix D Tables 8-15. Field and Summary Analytical Data for the Confirmation Test
- Laboratory Data Sheets for the Confirmation Test

Appendix D Table 1. Flambeau Stockpiled Type II Material Sequential Extraction Test Data

Sample No. 1 (Sample wt. = 500.01 g <¼" fraction waste rock)

Extractions Conducted Under Slightly Oxidizing Conditions

Sample	Run Time (hrs)	Leachate Extracted (mL)	DI Water Added (mL)	pH (su)	Conductivity (µS/cm @ 25°C)	T (°C)	Eh (mv)
Start	0	0	500	--	--	--	--
1	26½	310	310	5.28	2,360	23.3	--
2	50½	280	280	5.13	2,200	23.0	--
3	70½	270	0	4.88	1,138	22.7	--

Appendix D Table 2. Flambeau Stockpiled Type II Material Sequential Extraction Test

Analytical Data Summary

Sample No. 1 (Sample wt. = 500.01 g <¼" fraction waste rock)

Extractions Conducted Under Slightly Oxidizing Conditions

Parameter	Sample 1	Sample 2	Sample 3
Lab pH	4.9	5.0	5.0
Calcium	370	290	120
Magnesium	110	91	37
Acidity	190	490	190
Iron	<0.079	0.12	0.41
Sulfate	450	580	600
Cadmium	0.060	0.073	0.032
Copper	81	100	65
Lead	0.093	0.019	0.0078
Manganese	22	21	8.6
Mercury	<0.000067	<0.000067	<0.000067
Selenium	0.25	0.23	0.090
Zinc	12	11	5.2

All units are mg/L except pH which are in su.

Appendix D Table 3. Flambeau Stockpile Type II Material Sequential Extraction Test Data

Sample No. 4 (Sample wt. = 499.99 g <¼" fraction waste rock)

Extractions Conducted Under Slightly Oxidizing Conditions

Sample	Run Time (hrs)	Leachate Extracted (mL)	DI Water Added (mL)	pH (su)	Conductivity (μS/cm @ 25°C)	T (°C)	Eh (mv)
Start	0	0	500	--	--	--	--
1	26¾	370	370	4.31	4,680	23.2	--
2	50 1/6	340	340	4.56	2,270	22.7	--
3	70¾	340	0	4.72	896	22.5	--

Appendix D Table 4. Flambeau Stockpiled Type II Material Sequential Extraction Test

Analytical Data Summary

Sample No. 4 (Sample wt. = 499.99 g <¼" fraction waste rock)

Extractions Conducted Under Slightly Oxidizing Conditions

Parameter	Sample 1	Sample 2	Sample 3
Lab pH	4.3	4.6	4.8
Calcium	400	210	59
Magnesium	97	35	<3.0
Acidity	4,400	1,800	390
Iron	<8.0	<0.079	<0.010
Sulfate	3,900	1,100	310
Cadmium	0.98	0.36	0.10
Copper	1,700	540	170
Lead	0.021	0.0082	<0.015
Manganese	16	4.8	1.6
Mercury	<0.000067	<0.000067	<0.000067
Selenium	0.031	<0.0092	<0.0092
Zinc	98	29	9.0

All units are mg/L except pH which are in su.

Appendix D Table 5. Flambeau Stockpiled Type II Material Sequential Extraction Test Data

Sample No. 15-3 (Sample wt. = 500.07 g <¼" fraction waste rock)

Extractions Conducted Under Slightly Oxidizing Conditions

Sample	Run Time (hrs)	Leachate Extracted (mL)	DI Water Added (mL)	pH (su)	Conductivity (μS/cm @ 25°C)	T (°C)	Eh (mv)
Start	0	0	500	--	--	--	--
1	27	340	340	2.29	6,980	23.1	--
2	50¾	280	280	2.44	4,800	22.9	--
3	71	250	0	2.54	3,000	22.6	--

Appendix D Table 6. Flambeau Stockpiled Type II Material Sequential Extraction Test

Analytical Data Summary

Sample No. 15-3 (Sample wt. = 500.07 g <¼" fraction waste rock)

Extractions Conducted Under Slightly Oxidizing Conditions

Parameter	Sample 1	Sample 2	Sample 3
Lab pH	2.4	2.5	2.6
Calcium	140	96	36
Magnesium	59	34	12
Acidity	>8,000[a]	>4,300[a]	>1,600[a]
Iron	1,800	950	280
Sulfate	7,300	3,200	550
Cadmium	0.23	0.090	<0.0012
Copper	1,200	730	270
Lead	0.010	0.0041	<0.015
Manganese	7.7	4.6	1.8
Mercury	<0.000067	<0.000067	<0.000067
Selenium	0.13	0.057	0.019
Zinc	18	10	3.1

All units are mg/L except pH which are in su.

[a] = acidity values titrated to a pH = 3.7.
Due to the accumulation of a precipitate it was
not possible to titrate to the desired endpoint of pH = 6.5.

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue • Crandon, WI 54520
Tel: (715) 478-2777 • Fax: (715) 478-3060

September 27, 1996

Russell Janeshek
Foth & Van Dyke
2737 S. Ridge Road
Green Bay, WI 54307

Re: Flambeau Mining Company, Scope 96F013, NLS Project 29376

Dear Mr. Janeshek:

Enclosed is the final analytical report for the first batch of samples, received on September 9, 1996. The results were submitted to you via FAX transmissions as they became available and then a final hardcopy hand delivered on September 24. The attached copy is a revision of the September 24 version, correcting the sample identifications of the first 6 samples.

The assignment of an alkalinity or acidity test to each sample was done at Northern Lake Service (NLS) using a pH of 6.5 as the decision point. For a pH of less than or equal to 6.5, the acidity test was assigned to the sample. For a pH of greater than 6.5, the alkalinity test was assigned to the sample. The titration was performed to a pH of 6.5 with the exception of samples FMC-15Sx1, -2 and -3. The actual possible endpoint was 3.7 because of an excessive amount of precipitate which formed during the titration.

A dissolved digestion was performed prior to the ICP and GFAA metals analysis for samples FMC-15Sx1 and -2. The turbidity and discoloration of the samples indicated the need for the preparation step.

The sample volume available for the testing at NLS was limited. For some tests, quality control (QC) samples could not be generated using the actual sample matrix. QC samples were generated using a control matrix.

Some parameters have limits of detection (LOD) higher than those initially thought possible. The LODs are raised to reflect dilution steps required to bring target analyte levels within the instrument calibration range and/or to reduce the effect of matrix interferences.

If you have any questions or require additional information, please feel free to contact me at (715) 478-2777.

Sincerely,

Steven R. Crupi

Steven R. Crupi
Client Services Manager

Enclosures

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

 NLS PROJECT# 29376

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-1S x 1 NLS#: 114322
Ref. Line 1 of COC 21866 Description: FMC-1S x 1
Collected: 09/07/96 Received: 09/09/96 Reported: 09/26/96 Revised

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	190	mg/L	2.0		EPA 305.1	09/13/96
Additional Comments: The method calls for an endpoint pH of 3.7 or 8.3 s.u. The actual endpoint used was 6.5 s.u., per client request.						
Cadmium, dis. as Cd	0.060	mg/L	0.039	0.14	SW846 6010	09/20/96
Calcium, dis. as Ca	370	mg/L	3.0	3.0	SW846 6010	09/13/96
Copper, dis. as Cu	81	mg/L	0.032	0.10	SW846 6010	09/12/96
Iron, dis. as Fe	ND	mg/L	0.079	0.26	SW846 6010	09/13/96
Lead, dis. as Pb by furnace AAS	93	ug/L	1.9	6.4	SW846 7421	09/12/96
Magnesium, dis. as Mg	110	mg/L	3.0	3.0	SW846 6010	09/13/96
Manganese, dis. as Mn	22	mg/L	0.0086	0.031	SW846 6010	09/12/96
Mercury, dis. as Hg	ND	ug/L	0.067	0.24	SW846 7470A	09/13/96
pH, lab	4.9	s.u.	1.0		SW846 9045	09/10/96
Selenium, dis. as Se by furnace	250	ug/L	9.2	32	SW846 7740	09/12/96
Sulfate, as SO4 (filtered)	450	mg/L	250	250	SW846 9036	09/10/96
Zinc, dis. as Zn	12	mg/L	0.12	0.12	SW846 6010	09/12/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection
DWB = Dry Weight Basis
LOQ = Limit of Quantitation
NA = Not Applicable
ND = Not Detected
%DWB = (mg/kg DWB)/10000
Date = Date Analysis Performed

Steven R. Cuzzi
Reviewed by:

Authorized by:
R. T. Krueger
Laboratory Manager

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-1S x 2 NLS#: 114323
Ref. Line 2 of COC 21866 Description: FMC-1Sx 2
Collected: 09/08/96 Received: 09/09/96 Reported: 09/26/96 Revised

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	490	mg/L	2.0		EPA 305.1	09/13/96
Cadmium, dis. as Cd by ICP	73	ug/L	0.60	1.9	SW846 6010	09/11/96
Calcium, dis. as Ca by ICP	290	mg/L	1.5	1.5	SW846 6010	09/11/96
Copper, dis. as Cu by ICP	100000	ug/L	11	38	SW846 6010	09/11/96
Iron, dis. as Fe by ICP	0.12	mg/L	0.0050	0.018	SW846 6010	09/11/96
Lead, dis. as Pb by ICP	19	ug/L	7.3	26	SW846 6010	09/11/96
Magnesium, dis. as Mg by ICP	91	mg/L	1.5	1.5	SW846 6010	09/11/96
Manganese, dis. as Mn by ICP	21000	ug/L	0.90	3.0	SW846 6010	09/11/96
Mercury, dis. as Hg	ND	ug/L	0.067	0.24	SW846 7470A	09/13/96
pH, lab	5.0	s.u.	1.0		SW846 9045	09/10/96
Selenium, dis. as Se by furnace	230	ug/L	9.2	32	SW846 7740	09/12/96
Sulfate, as SO4 (filtered)	580	mg/L	250	250	SW846 9036	09/10/96
Zinc, dis. as Zn by ICP	11000	ug/L	60	60	SW846 6010	09/11/96

Additional Comments: The method calls for an endpoint pH of 3.7 or 8.3 s.u. The actual endpoint used was 6.5 s.u., per client request. (Acidity)

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection LOQ = Limit of Quantitation ND = Not Detected Date = Date Analysis Performed
DWB = Dry Weight Basis NA = Not Applicable %DWB = (mg/kg DWB)/10000

Reviewed by: Steven R. Cupi

Authorized by:
R. T. Krueger
Laboratory Manager

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

 NLS PROJECT# 29376

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-1S x 3 NLS#: 114324
Ref. Line 3 of COC 21866 Description: FMC-1S x 3
Collected: 09/09/96 Received: 09/09/96 Reported: 09/26/96 Revised

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	190	mg/L	2.0		EPA 305.1	09/13/96
	Additional Comments: The method calls for an endpoint pH of 3.7 or 8.3 s.u. The actual endpoint used was 6.5 s.u., per client request.					
Cadmium, dis. as Cd by ICP	32	ug/L	0.60	1.9	SW846 6010	09/11/96
Calcium, dis. as Ca by ICP	120	mg/L	1.5	1.5	SW846 6010	09/11/96
Copper, dis. as Cu by ICP	65000	ug/L	11	38	SW846 6010	09/11/96
Iron, dis. as Fe by ICP	0.41	mg/L	0.0050	0.018	SW846 6010	09/11/96
Lead, dis. as Pb by ICP	7.8	ug/L	7.3	26	SW846 6010	09/11/96
Magnesium, dis. as Mg by ICP	37	mg/L	1.5	1.5	SW846 6010	09/11/96
Manganese, dis. as Mn by ICP	8600	ug/L	0.90	3.0	SW846 6010	09/11/96
Mercury, dis. as Hg	ND	ug/L	0.067	0.24	SW846 7470A	09/13/96
pH, lab	5.0	s.u.	1.0		SW846 9045	09/10/96
Selenium, dis. as Se by furnace	90	ug/L	9.2	32	SW846 7740	09/12/96
Sulfate, as SO4 (filtered)	600	mg/L	250	250	SW846 9036	09/10/96
Zinc, dis. as Zn by ICP	5200	ug/L	60	60	SW846 6010	09/11/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection
DWB = Dry Weight Basis
LOQ = Limit of Quantitation
NA = Not Applicable
ND = Not Detected
%DWB = (mg/kg DWB)/10000
Date = Date Analysis Performed

Reviewed by: Steven R. Creger

Authorized by:
R. T. Krueger
Laboratory Manager

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-4S x 1 NLS#: 114325
Ref. Line 4 of COC 21866 Description: FMC-4S x 1
Collected: 09/07/96 Received: 09/09/96 Reported: 09/26/96 Revised

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	4400	mg/L	2.0		EPA 305.1	09/13/96
	Additional Comments: The method calls for an endpoint pH of 3.7 or 8.3 s.u. The actual endpoint used was 6.5 s.u., per client request.					
Cadmium, dis. as Cd	0.98	mg/L	0.039	0.14	SW846 6010	09/20/96
Calcium, dis. as Ca	400	mg/L	3.0	3.0	SW846 6010	09/13/96
Copper, dis. as Cu	1700	mg/L	0.32	1.0	SW846 6010	09/12/96
Iron, dis. as Fe	ND	mg/L	8.0	26	SW846 6010	09/13/96
Lead, dis. as Pb by furnace AAS	21	ug/L	0.37	1.3	SW846 7421	09/12/96
Magnesium, dis. as Mg	97	mg/L	3.0	3.0	SW846 6010	09/13/96
Manganese, dis. as Mn	16	mg/L	0.086	0.31	SW846 6010	09/12/96
Mercury, dis. as Hg	ND	ug/L	0.067	0.24	SW846 7470A	09/13/96
pH, lab	4.3	s.u.	1.0		SW846 9045	09/10/96
Selenium, dis. as Se by furnace	31	ug/L	9.2	32	SW846 7740	09/12/96
Sulfate, as SO4 (filtered)	3900	mg/L	2500	2500	SW846 9036	09/10/96
Zinc, dis. as Zn	98	mg/L	1.2	1.2	SW846 6010	09/12/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection LOQ = Limit of Quantitation ND = Not Detected Date = Date Analysis Performed
DWB = Dry Weight Basis NA = Not Applicable %DWB = (mg/kg DWB)/10000

Steven R. Cuyer
Reviewed by:

Authorized by:
R. T. Krueger
Laboratory Manager

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-4S x 2 NLS#: 114326
Ref. Line 5 of COC 21866 Description: FMC-4S x 2
Collected: 09/07/96 Received: 09/09/96 Reported: 09/26/96 Revised

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	1800	mg/L	2.0		EPA 305.1	09/13/96
	Additional Comments: The method calls for an endpoint pH of 3.7 or 8.3 s.u. The actual endpoint used was 6.5 s.u., per client request.					
Cadmium, dis. as Cd	0.36	mg/L	0.039	0.14	SW846 6010	09/20/96
Calcium, dis. as Ca	210	mg/L	3.0	3.0	SW846 6010	09/13/96
Copper, dis. as Cu	540	mg/L	0.32	1.0	SW846 6010	09/12/96
Iron, dis. as Fe	ND	mg/L	0.079	0.26	SW846 6010	09/13/96
Lead, dis. as Pb by furnace AAS	8.2	ug/L	0.37	1.3	SW846 7421	09/12/96
Magnesium, dis. as Mg	35	mg/L	3.0	3.0	SW846 6010	09/13/96
Manganese, dis. as Mn	4.8	mg/L	0.086	0.31	SW846 6010	09/12/96
Mercury, dis. as Hg	ND	ug/L	0.067	0.24	SW846 7470A	09/13/96
pH, lab	4.6	s.u.	1.0		SW846 9045	09/10/96
Selenium, dis. as Se by furnace	ND	ug/L	9.2	32	SW846 7740	09/12/96
Sulfate, as SO4 (filtered)	1100	mg/L	250	250	SW846 9036	09/10/96
Zinc, dis. as Zn	29	mg/L	1.2	1.2	SW846 6010	09/12/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection
LOQ = Limit of Quantitation
ND = Not Detected
Date = Date Analysis Performed
DWB = Dry Weight Basis
NA = Not Applicable
%DWB = (mg/kg DWB)/10000

Steven R. Cuyn
Reviewed by:

Authorized by:
R. T. Krueger
Laboratory Manager

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-4S x 3 **NLS#: 114327**
Ref. Line 6 of COC 21866 Description: FMC-4S x 3
Collected: 09/09/96 Received: 09/09/96 Reported: 09/26/96 Revised

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	390	mg/L	2.0		EPA 305.1	09/13/96
	Additional Comments: The method calls for an endpoint pH of 3.7 or 8.3 s.u. The actual endpoint used was 6.5 s.u., per client request.					
Cadmium, dis. as Cd by ICP	100	ug/L	1.2	3.8	SW846 6010	09/11/96
Calcium, dis. as Ca by ICP	59	mg/L	3.0	3.0	SW846 6010	09/11/96
Copper, dis. as Cu by ICP	170000	ug/L	54	190	SW846 6010	09/11/96
Iron, dis. as Fe by ICP	ND	mg/L	0.010	0.035	SW846 6010	09/11/96
Lead, dis. as Pb by ICP	ND	ug/L	15	52	SW846 6010	09/11/96
Magnesium, dis. as Mg by ICP	ND	mg/L	3.0	3.0	SW846 6010	09/11/96
Manganese, dis. as Mn by ICP	1600	ug/L	1.8	6.1	SW846 6010	09/11/96
Mercury, dis. as Hg	ND	ug/L	0.067	0.24	SW846 7470A	09/13/96
pH, lab	4.8	s.u.	1.0		SW846 9045	09/10/96
Selenium, dis. as Se by furnace	ND	ug/L	9.2	32	SW846 7740	09/12/96
Sulfate, as SO4 (filtered)	310	mg/L	250	250	SW846 9036	09/10/96
Zinc, dis. as Zn by ICP	9000	ug/L	120	120	SW846 6010	09/11/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection
LOQ = Limit of Quantitation
ND = Not Detected
Date = Date Analysis Performed
DWB = Dry Weight Basis
NA = Not Applicable
%DWB = (mg/kg DWB)/10000

Steven R. Crager
Reviewed by:

Authorized by:
R. T. Krueger
Laboratory Manager

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

 NLS PROJECT# 29376

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-15S x 1 **NLS#: 114328**
Ref. Line 7 of COC 21866 Description: FMC-15S x 1
Collected: 09/07/96 Received: 09/09/96 Reported: 09/26/96 Revised

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	>8000 mg/L		2.0		EPA 305.1	09/13/96
	Additional Comments: The method calls for an endpoint pH of 3.7 or 8.3 s.u. The attainable endpoint was 3.7 s.u. due to excessive precipitate formation.					
Cadmium, dis. as Cd	0.23	mg/L	0.036	0.13	SW846 6010	09/20/96
Calcium, dis. as Ca	140	mg/L	3.0	3.0	SW846 6010	09/13/96
Copper, dis. as Cu	1200	mg/L	0.22	0.79	SW846 6010	09/12/96
Iron, dis. as Fe	1800	mg/L	0.17	0.57	SW846 6010	09/13/96
Lead, dis. as Pb by furnace AAS	10	ug/L	0.78	2.6	SW846 7421	09/12/96
Magnesium, dis. as Mg	59	mg/L	3.0	3.0	SW846 6010	09/13/96
Manganese, dis. as Mn	7.7	mg/L	0.13	0.44	SW846 6010	09/12/96
Mercury, dis. as Hg	ND	ug/L	0.067	0.24	SW846 7470A	09/13/96
pH, lab	2.4	s.u.	1.0		SW846 9045	09/10/96
Selenium, dis. as Se by furnace	130	ug/L	7.5	25	SW846 7740	09/12/96
Sulfate, as SO4 (filtered)	7300	mg/L	2500	2500	SW846 9036	09/10/96
Zinc, dis. as Zn	18	mg/L	1.2	1.2	SW846 6010	09/12/96
Metals digestion - dissolved ICP	yes				SW846 3005	09/11/96
Metals digestion - dissolved Furnace	yes				SW846 3005	09/11/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection LOQ = Limit of Quantitation ND = Not Detected Date = Date Analysis Performed
DWB = Dry Weight Basis NA = Not Applicable %DWB = (mg/kg DWB)/10000

Steven R. Cupi
Reviewed by:

Authorized by:
R. T. Krueger
Laboratory Manager

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-15S x 2 **NLS#: 114329**
Ref. Line 8 of COC 21866 Description: FMC-15S x 2
Collected: 09/08/96 Received: 09/09/96 Reported: 09/26/96 Revised

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	>4300 mg/L		2.0		EPA 305.1	09/13/96
	Additional Comments: The method calls for an endpoint pH of 3.7 or 8.3 s.u. The attainable endpoint was 3.7 s.u. due to excessive precipitate formation.					
Cadmium, dis. as Cd	0.090	mg/L	0.036	0.13	SW846 6010	09/20/96
Calcium, dis. as Ca	96	mg/L	3.0	3.0	SW846 6010	09/13/96
Copper, dis. as Cu	730	mg/L	0.22	0.79	SW846 6010	09/12/96
Iron, dis. as Fe	950	mg/L	0.17	0.57	SW846 6010	09/13/96
Lead, dis. as Pb by furnace AAS	4.1	ug/L	0.78	2.6	SW846 7421	09/12/96
Magnesium, dis. as Mg	34	mg/L	3.0	3.0	SW846 6010	09/13/96
Manganese, dis. as Mn	4.6	mg/L	0.13	0.44	SW846 6010	09/12/96
Mercury, dis. as Hg	ND	ug/L	0.067	0.24	SW846 7470A	09/13/96
pH, lab	2.5	s.u.	1.0		SW846 9045	09/10/96
Selenium, dis. as Se by furnace	57	ug/L	7.5	25	SW846 7740	09/12/96
Sulfate, as SO4 (filtered)	3200	mg/L	250	250	SW846 9036	09/10/96
Zinc, dis. as Zn	10	mg/L	1.2	1.2	SW846 6010	09/12/96
Metals digestion - dissolved ICP	yes				SW846 3005	09/11/96
Metals digestion - dissolved Furnace	yes				SW846 3005	09/11/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection
DWB = Dry Weight Basis
LOQ = Limit of Quantitation
NA = Not Applicable
ND = Not Detected
%DWB = (mg/kg DWB)/10000
Date = Date Analysis Performed

Steven R. Cergei
Reviewed by:

Authorized by:
R. T. Krueger
Laboratory Manager

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-15S x 3 NLS#: 114330
Ref. Line 9 of COC 21866 Description: FMC-15S x 3
Collected: 09/09/96 Received: 09/09/96 Reported: 09/26/96 Revised

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	>1600 mg/L		2.0		EPA 305.1	09/13/96
	Additional Comments: The method calls for an endpoint pH of 3.7 or 8.3 s.u. The attainable endpoint was 3.7 s.u. due to excessive precipitate formation.					
Cadmium, dis. as Cd by ICP	ND	ug/L	1.2	3.8	SW846 6010	09/11/96
Calcium, dis. as Ca by ICP	36	mg/L	3.0	3.0	SW846 6010	09/11/96
Copper, dis. as Cu by ICP	270000	ug/L	54	190	SW846 6010	09/11/96
Iron, dis. as Fe by ICP	280	mg/L	0.010	0.035	SW846 6010	09/11/96
Lead, dis. as Pb by ICP	ND	ug/L	15	52	SW846 6010	09/11/96
Magnesium, dis. as Mg by ICP	12	mg/L	3.0	3.0	SW846 6010	09/11/96
Manganese, dis. as Mn by ICP	1800	ug/L	1.8	6.1	SW846 6010	09/11/96
Mercury, dis. as Hg	ND	ug/L	0.067	0.24	SW846 7470A	09/13/96
pH, lab	2.6	s.u.	1.0		SW846 9045	09/10/96
Selenium, dis. as Se by furnace	19	ug/L	9.2	32	SW846 7740	09/12/96
Sulfate, as SO4 (filtered)	550	mg/L	250	250	SW846 9036	09/10/96
Zinc, dis. as Zn by ICP	3100	ug/L	120	120	SW846 6010	09/11/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection
LOQ = Limit of Quantitation
ND = Not Detected
Date = Date Analysis Performed
DWB = Dry Weight Basis
NA = Not Applicable
%DWB = (mg/kg DWB)/10000

Steven R. Cuypi
Reviewed by:

Authorized by:
R. T. Krueger
Laboratory Manager

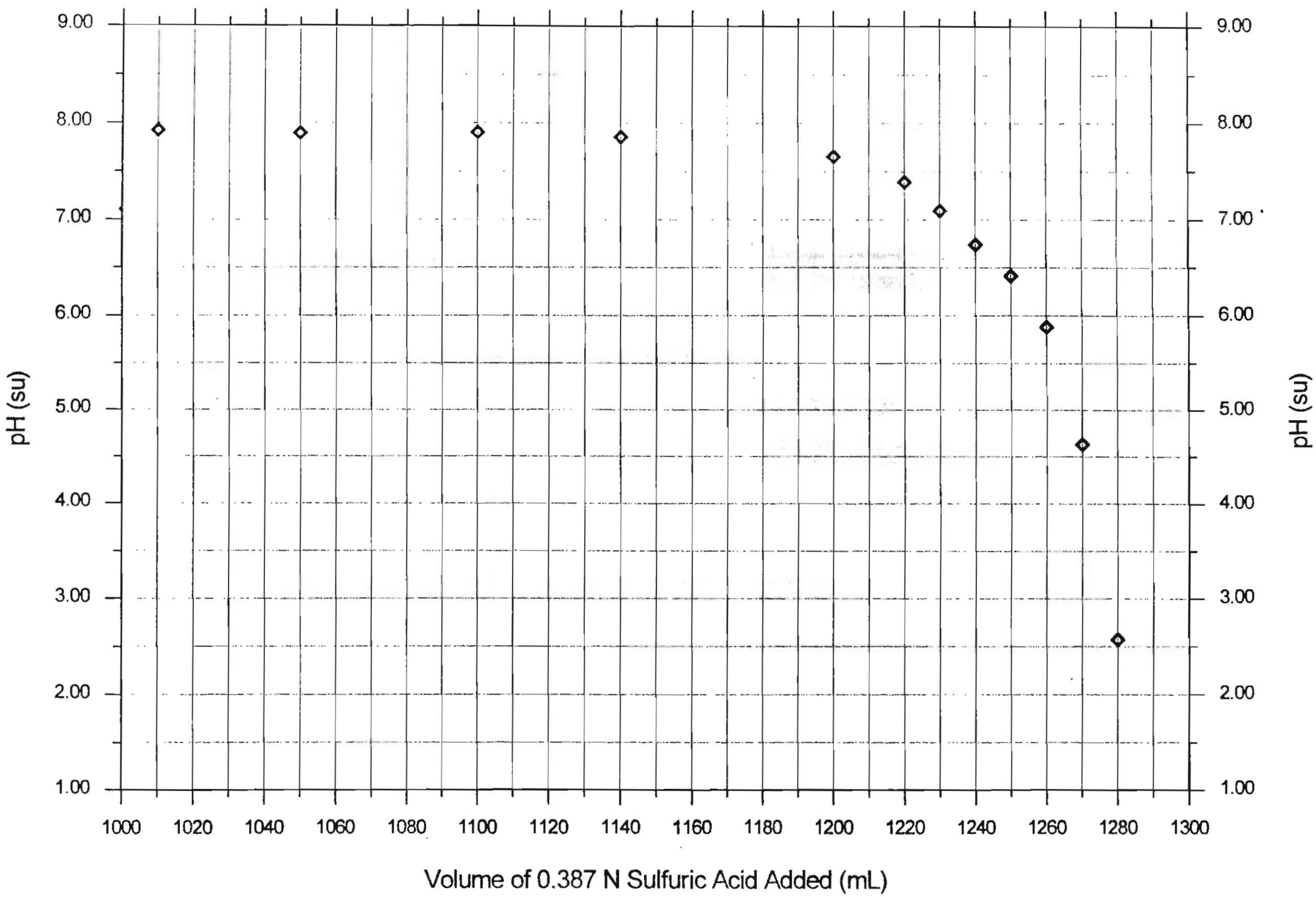
Appendix D Table 7. Flambeau Limestone Alkali Availablity Test

Great Lakes Limestone, 40-100 (Sample wt. = 25.00 g)

0.387 N Sulfuric Acid Added (mL)	pH (su)
330	7.86
370	7.81
410	7.80
450	7.81
490	7.85
530	7.89
570	7.90
610	7.88
650	7.85
690	7.89
730	7.90
770	7.88
810	7.98
850	7.97

0.387 N Sulfuric Acid Added (mL)	pH (su)
890	7.99
950	7.90
1010	7.92
1050	7.89
1100	7.90
1140	7.85
1200	7.65
1220	7.39
1230	7.09
1240	6.74
1250	6.41
1260	5.88
1270	4.63
1280	2.57

Standardization of acid performed in triplicate.



Appendix D Figure 1. Presentation of a Portion of the Flambeau Alkali Availability Test Data for Great Lakes Limestone 40-100.

Appendix D Table 8. Flambeau Stockpiled Type II Material Confirmation Test Data

Sample No. 15-3 Test A (Sample wt. = 500.02 g <¼" fraction waste rock + 11.56 g limestone)

Extractions Conducted Under Anoxic Conditions, Maintained by Sparging with Argon Gas

Sample	Run Time (hrs)	Leachate Extracted (mL)	DI Water Added (mL)	pH (su)	Conductivity (μS/cm @ 25°C)	T (°C)	Eh (mv)
Start	0	0	4,000	--	--	--	--
1	2	234	0	2.71	1,580	19.6	+282
2	7	250	0	3.23	1,640	19.8	+277
3	22	248	0	4.14	1,680	20.2	+170
4	51	256	0	5.94	1,930	20.8	+136
5	72	244	0	6.22	2,010	19.9	+61
6	102	273	0	6.80	2,060	20.8	+157
7	449	384	0	7.51	2,180	20.9	+41.6

Appendix D Table 9. Flambeau Stockpiled Type II Material Confirmation Test

Analytical Data Summary

Sample No. 15-3 Test A (Sample wt. = 500.02 g <¼" fraction waste rock + 11.56 g limestone)

Extractions Conducted Under Anoxic Conditions, Maintained by Sparging with Argon Gas

Parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	
Lab pH	3.9	4.1	4.9	5.7	6.3	6.8	
Alkalinity	--	--	--	--	--	19	
Calcium	170	190	270	440	520	540	
Magnesium	12	13	10	7.2	12	13	
Acidity	350	500	590	340	78	--	
Iron	18	5.7	0.20	0.19	0.13	0.16	
Sulfate	290	500	350	780	880	720	
Cadmium	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	
Copper	130	150	120	52	19	2.3	
Lead	0.0098	0.0025	0.0023	<0.0019	<0.0019	0.11	
Manganese	1.4	1.5	1.5	1.4	1.6	1.7	
Mercury	<0.00027	<0.00027	<0.00027	<0.00027	<0.00027	<0.00027	
Selenium	0.17	0.12	0.046	<0.0092	<0.0092	<0.0092	
Zinc	3.2	3.4	3.0	2.4	2.3	1.4	

Appendix D Table 10. Flambeau Stockpiled Type II Material Confirmation Test Data

Sample No. 15-3 Test B (Sample wt. = 500.03 g <¼" fraction waste rock + 11.00 g limestone)

Extractions Conducted Under Anoxic Conditions, Maintained by Sparging with Argon Gas

Sample	Run Time (hrs)	Leachate Extracted (mL)	DI Water Added (mL)	pH (su)	Conductivity (µS/cm @ 25°C)	T (°C)	Eh (mv)
Start	0	0	4,000	--	--	--	--
1[a]	102	239	0	5.64	1,320	20.8	+180
2	123	236	0	7.18	7,910	20.9	+3.5
3	144	259	0	7.40	8,270	22.3	+1.3
4	449	405	0	7.85	8,410	20.4	+33.6

[a] Following extraction no. 1, 22.70 g of $Na_2S_2O_3$ were added to the tank, thereby creating anoxic reducing conditions in the tank which were maintained for the remainder of the test.

Appendix D Table 11. Flambeau Stockpiled Type II Material Confirmation Test

Analytical Data Summary

Sample No. 15-3 Test B (Sample wt. = 500.03 g <¼" fraction waste rock + 11.00 g limestone)

Extractions Initially Conducted Under Anoxic Conditions, Maintained by Sparging with Argon Gas, Followed by Anoxic Reducing Conditions

Parameter	Sample 1	Sample 2	Sample 3				
Lab pH	5.8	8.4	7.7				
Alkalinity	--	74	60				
Calcium	440	440	450				
Magnesium	11	6.4	11				
Acidity	280	--	--				
Iron	0.22	<0.17	0.62				
Sulfate	650	1,800	2,300				
Cadmium	<0.039	<0.036	<0.036				
Copper	120	140	170				
Lead	1.2	<0.0039	<0.0039				
Manganese	1.5	1.0	0.82				
Mercury	0.00052	--	--				
Selenium	<0.0092	<0.075	<0.075				
Zinc	10	0.72	0.74				

Appendix D Table 12. Flambeau Stockpiled Type II Material Confirmation Test Data

Sample No. 16-1 Test A (Sample wt. = 499.99 g <¼" fraction waste rock + 2.90 g limestone)

Extractions Conducted Under Anoxic Conditions, Maintained by Sparging with Argon Gas

Sample	Run Time (hrs)	Leachate Extracted (mL)	DI Water Added (mL)	pH (su)	Conductivity (μS/cm @ 25°O)	T (°C)	Eh (mv)
Start	0	0	4,000	--	--	--	--
1	2	266	0	6.58	280	19.6	+177
2	7	254	0	6.20	287	19.8	+196
3	22	241	0	6.66	332	20.1	+111
4	51	279	0	7.47	371	20.8	+114
5	72	248	0	7.74	404	19.8	+33
6	102	274	0	7.82	414	20.5	+100
7	449	387	0	8.13	435	20.4	+15.2

Appendix D Table 13. Flambeau Stockpiled Type II Material Confirmation Test

Analytical Data Summary

Sample No. 16-1 Test A (Sample wt. = 500.03 g <¼" fraction waste rock + 2.90 g limestone)

Extractions Conducted Under Anoxic Conditions, Maintained by Sparging with Argon Gas

Parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	
Lab pH	6.4	6.5	7.1	7.0	7.2	7.3	
Alkalinity	--	--	11	26	28	32	
Calcium	24	30	51	64	69	69	
Magnesium	5.4	4.8	4.8	<3.0	<3.0	3.1	
Acidity	36	34	--	--	--	--	
Iron	<0.079	<0.079	<0.079	<0.079	<0.079	<0.079	
Sulfate	72	75	92	92	95	110	
Cadmium	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	
Copper	28	23	44	0.45	0.32	0.086	
Lead	0.0018	0.00064	<0.00037	<0.0019	<0.0019	0.021	
Manganese	1.5	1.5	1.5	1.7	1.3	1.0	
Mercury	<0.00027	<0.00027	<0.00027	<0.00027	<0.00027	<0.00027	
Selenium	<0.0092	<0.0092	<0.0092	<0.0092	<0.0092	<0.0092	
Zinc	0.43	0.41	0.27	<0.12	<0.12	0.80	

Appendix D Table 14. Flambeau Stockpiled Type II Materials Confirmation Test Data

Sample No. 16-1 Test B (Sample wt. = 500.03 g <¼" fraction waste rock + 2.90 g limestone)

Extractions Conducted Under Anoxic Conditions, Maintained by Sparging with Argon Gas

Sample	Run Time (hrs)	Leachate Extracted (mL)	DI Water Added (mL)	pH (su)	Conductivity (μS/cm @ 25°C)	T (°C)	Eh (mv)
Start	0	0	4,000	--	--	--	--
1[a]	102	240	0	7.47	418	20.5	+97
2	123	264	0	9.13	7,070	20.8	-7.6
3	144	264	0	9.08	7,420	22.3	-36.9
4	449	407	0	8.13	7,640	20.4	+23.1

[a] Following extraction no. 1, 22.70 g of $Na_2S_2O_3$ were added to the tank, thereby creating anoxic reducing conditions in the tank which were maintained for the remainder of the test.

Appendix D Table 15. Flambeau Stockpiled Type II Material Confirmation Test

Analytical Data Summary

Sample No. 16-1 Test B (Sample wt. = 499.99 g <¼" fraction waste rock + 2.90 g limestone)

Extractions Initially Conducted Under Anoxic Conditions, Maintained by Sparging with Argon Gas, Followed by Anoxic Reducing Conditions

Parameter	Sample 1	Sample 2	Sample 3				
Lab pH	7.1	9.0	8.8				
Alkalinity	46	56	44				
Calcium	73	35	55				
Magnesium	<3.0	<3.0	3.6				
Acidity	--	--	--				
Iron	<0.079	<0.17	0.21				
Sulfate	120	1,400	1,100				
Cadmium	<0.039	<0.036	<0.036				
Copper	0.59	26	48				
Lead	0.047	<0.0039	<0.0039				
Manganese	1.5	0.014	0.013				
Mercury	<0.00027	--	--				
Selenium	<0.0092	--	--				
Zinc	1.6	<0.12	0.21				

NORTHERN LAKE SERVICE, INC.

Analytical Laboratory and Environmental Services

400 North Lake Avenue • Crandon, WI 54520
Tel: (715) 478-2777 • Fax: (715) 478-3060

October 7, 1996

Russell Janeshek
Foth & Van Dyke
2737 S. Ridge Road
Green Bay, WI 54307

Re: Flambeau Mining Company, Scope 96F013, NLS Projects 29675 and 29683

Dear Mr. Janeshek:

Enclosed are the final analytical reports for the samples received on September 20 and 23, 1996. The results were submitted to you via FAX transmissions as they became available.

The assignment of an alkalinity or acidity test to each sample was done at Northern Lake Service (NLS) using a pH of 6.5 as the decision point. For a pH of less than or equal to 6.5, the acidity test was assigned to the sample. For a pH of greater than 6.5, the alkalinity test was assigned to the sample. The intention was to titrate to 6.5 for the alkalinity and acidity tests. The titration was performed to a pH of 6.5 for the acidity test, but titration for the alkalinity tests was conducted as per the method (i.e., to a range of 4.3 - 4.7, with a goal of 4.5). The net effect may be a slight high bias on the alkalinity results. The term "slight" is used because the movement of the pH from near neutral (i.e., pH of 6.5) to the method pH (i.e., 4.5) is usually quick. It usually takes a small amount of acid for this change to occur. Given sufficient sample volume, the test could be redone to a pH of 6.5. However, the amount of time which has elapsed from sample collection could be a significant variable considering the relatively low numbers reported for alkalinity.

The sample volume available for the testing at NLS was limited. For some tests, quality control (QC) samples could not be generated using the actual sample matrix. QC samples were generated using a control matrix. The limited volume available for the metals analysis of four samples necessitated shortening the list of metals. Mercury analysis was deleted from the requested list of metals as discussed in the September 24, 1996, meeting at Foth & Van Dyke. The affected samples are -

FMC-15SXB-123	FMC-15SXB-144
FMC-16SXB-123	FMC-16SXB-144

Some parameters have limits of detection (LOD) higher than those listed in the quote. The LODs are raised to reflect dilution steps required to bring target analyte levels within the instrument calibration range and/or to reduce the effect of matrix interferences.

Four samples required an acid digestion prior to metals analysis. The samples were turbid and colored. A dissolved digestion was performed for these samples. The affected samples are-

FMC-15SXB-123	FMC-15SXB-144
FMC-16SXB-123	FMC-16SXB-144

If you have any questions or require additional information, please feel free to contact me at (715) 478-2777.

Sincerely,

Steven R. Crupi

Steven R. Crupi
Client Services Manager

Enclosures

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-15SxA-51 NLS#: 115815
Ref. Line 1 of COC 22175 Description: FMC-15SxA-51
Collected: 09/16/96 Received: 09/20/96 Reported: 10/07/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	340	mg/L	2.0		EPA 305.1	09/23/96
Additional Comments: Method requires an end point pH of 3.7 or 8.3 s.u. Client reqeusted an end point pH of 6.5 s.u.						
Cadmium, dis. as Cd	ND	mg/L	0.039	0.14	SW846 6010	09/27/96
Calcium, dis. as Ca	440	mg/L	3.0	3.0	SW846 6010	09/27/96
Chloride, as Cl (filtered)	3.2	mg/L	0.36	1.3	SW846 9251	09/24/96
Copper, dis. as Cu	52	mg/L	0.032	0.10	SW846 6010	09/27/96
Iron, dis. as Fe	0.19	mg/L	0.079	0.26	SW846 6010	09/27/96
30 Lead, dis. as Pb by furnace AAS	ND	ug/L	1.9	6.4	SW846 7421	09/27/96
Magnesium, dis. as Mg	7.2	mg/L	3.0	3.0	SW846 6010	09/27/96
Manganese, dis. as Mn	1.4	mg/L	0.0086	0.031	SW846 6010	09/27/96
Mercury, dis. as Hg	ND	ug/L	0.27	0.95	SW846 7470A	09/27/96
pH, lab	5.7	s.u.	1.0		SW846 9045	09/20/96
Selenium, dis. as Se by furnace	ND	ug/L	9.2	32	SW846 7740	09/25/96
Sulfate, as SO4 (filtered)	780	mg/L	250	250	SW846 9036	09/25/96
Zinc, dis. as Zn	2.4	mg/L	0.12	0.12	SW846 6010	09/27/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection
DWB = Dry Weight Basis
LOQ = Limit of Quantitation
NA = Not Applicable
ND = Not Detected
%DWB = (mg/kg DWB)/10000
Date = Date Analysis Performed

Reviewed by: [signature]

Authorized by:
R. T. Krueger
Laboratory Manager

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715) 478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-16SXA-51 NLS#: 115816
Ref. Line 2 of COC 22175 Description: FMC-16SXA-51
Collected: 09/16/96 Received: 09/20/96 Reported: 10/07/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	26	mg/L	3.0	11	EPA 310.1	09/25/96
Cadmium, dis. as Cd	ND	mg/L	0.039	0.14	SW846 6010	09/27/96
Calcium, dis. as Ca	64	mg/L	3.0	3.0	SW846 6010	09/27/96
Chloride, as Cl (filtered)	33	mg/L	0.36	1.3	SW846 9251	09/24/96
Copper, dis. as Cu	0.45	mg/L	0.032	0.10	SW846 6010	09/27/96
Iron, dis. as Fe	ND	mg/L	0.079	0.26	SW846 6010	09/27/96
Lead, dis. as Pb by furnace AAS	ND	ug/L	1.9	6.4	SW846 7421	09/27/96
Magnesium, dis. as Mg	ND	mg/L	3.0	3.0	SW846 6010	09/27/96
Manganese, dis. as Mn	1.7	mg/L	0.0086	0.031	SW846 6010	09/27/96
Mercury, dis. as Hg	ND	ug/L	0.27	0.95	SW846 7470A	09/27/96
pH, lab	7.0	s.u.	1.0		SW846 9045	09/20/96
Selenium, dis. as Se by furnace	ND	ug/L	9.2	32	SW846 7740	09/25/96
Sulfate, as SO4 (filtered)	92	mg/L	25	25	SW846 9036	09/25/96
Zinc, dis. as Zn	ND	mg/L	0.12	0.12	SW846 6010	09/27/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection
DWB = Dry Weight Basis
LOQ = Limit of Quantitation
NA = Not Applicable
ND = Not Detected
%DWB = (mg/kg DWB)/10000
Date = Date Analysis Performed

Thomas R Piede (signature)
Reviewed by:

Authorized by:
R. T. Krueger
Laboratory Manager

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-15SXA-72 NLS#: 115817
Ref. Line 3 of COC 22175 Description: FMC-15SXA-72
Collected: 09/17/96 Received: 09/20/96 Reported: 10/07/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	78	mg/L	2.0		EPA 305.1	09/23/96
	Additional Comments: Method requires an end point pH of 3.7 or 8.3 s.u. Client reqeusted an end point pH of 6.5 s.u.					
Cadmium, dis. as Cd	ND	mg/L	0.039	0.14	SW846 6010	09/27/96
Calcium, dis. as Ca	520	mg/L	3.0	3.0	SW846 6010	09/27/96
Chloride, as Cl (filtered)	3.0	mg/L	0.36	1.3	SW846 9251	09/24/96
Copper, dis. as Cu	19	mg/L	0.032	0.10	SW846 6010	09/27/96
Iron, dis. as Fe	0.13	mg/L	0.079	0.26	SW846 6010	09/27/96
Lead, dis. as Pb by furnace AAS	ND	ug/L	1.9	6.4	SW846 7421	09/27/96
Magnesium, dis. as Mg	12	mg/L	3.0	3.0	SW846 6010	09/27/96
Manganese, dis. as Mn	1.6	mg/L	0.0086	0.031	SW846 6010	09/27/96
Mercury, dis. as Hg	ND	ug/L	0.27	0.95	SW846 7470A	09/27/96
pH, lab	6.3	s.u.	1.0		SW846 9045	09/20/96
Selenium, dis. as Se by furnace	ND	ug/L	9.2	32	SW846 7740	09/25/96
Sulfate, as SO4 (filtered)	880	mg/L	250	250	SW846 9036	09/25/96
Zinc, dis. as Zn	2.3	mg/L	0.12	0.12	SW846 6010	09/27/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection
DWB = Dry Weight Basis
LOQ = Limit of Quantitation
NA = Not Applicable
ND = Not Detected
%DWB = (mg/kg DWB)/10000
Date = Date Analysis Performed

Thomas R Pirilo

Reviewed by:

Authorized by:

R. T. Krueger
Laboratory Manager

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

 NLS PROJECT# 29675

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-16SXA-72 NLS#: 115818
Ref. Line 4 of COC 22175 Description: FMC-16SXA-72
Collected: 09/17/96 Received: 09/20/96 Reported: 10/07/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	28	mg/L	3.0	11	EPA 310.1	09/25/96
Cadmium, dis. as Cd	ND	mg/L	0.039	0.14	SW846 6010	09/27/96
Calcium, dis. as Ca	69	mg/L	3.0	3.0	SW846 6010	09/27/96
Chloride, as Cl (filtered)	0.96	mg/L	0.36	1.3	SW846 9251	09/24/96
Copper, dis. as Cu	0.32	mg/L	0.032	0.10	SW846 6010	09/27/96
Iron, dis. as Fe	ND	mg/L	0.079	0.26	SW846 6010	09/27/96
Lead, dis. as Pb by furnace AAS	ND	ug/L	1.9	6.4	SW846 7421	09/27/96
Magnesium, dis. as Mg	ND	mg/L	3.0	3.0	SW846 6010	09/27/96
3 Manganese, dis. as Mn	1.3	mg/L	0.0086	0.031	SW846 6010	09/27/96
3 Mercury, dis. as Hg	ND	ug/L	0.27	0.95	SW846 7470A	09/27/96
pH, lab	7.2	s.u.	1.0		SW846 9045	09/20/96
Selenium, dis. as Se by furnace	ND	ug/L	9.2	32	SW846 7740	09/25/96
Sulfate, as SO4 (filtered)	95	mg/L	25	25	SW846 9036	09/25/96
Zinc, dis. as Zn	ND	mg/L	0.12	0.12	SW846 6010	09/27/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection
DWB = Dry Weight Basis
LOQ = Limit of Quantitation
NA = Not Applicable
ND = Not Detected
%DWB = (mg/kg DWB)/10000
Date = Date Analysis Performed

Thomas R Priebe
Reviewed by:

Authorized by:
R. T. Krueger
Laboratory Manager

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

 NLS PROJECT# 29675

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-15SXA-102 NLS#: 115819
Ref. Line 5 of COC 22175 Description: FMC-15SXA-102
Collected: 09/18/96 Received: 09/20/96 Reported: 10/07/96

34

Parameter	Result	Units	LOD	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	19	mg/L	3.0	11	EPA 310.1	09/25/96
Cadmium, dis. as Cd	ND	mg/L	0.039	0.14	SW846 6010	09/27/96
Calcium, dis. as Ca	540	mg/L	3.0	3.0	SW846 6010	09/27/96
Chloride, as Cl (filtered)	2.4	mg/L	0.36	1.3	SW846 9251	09/24/96
Copper, dis. as Cu	2.3	mg/L	0.032	0.10	SW846 6010	09/27/96
Iron, dis. as Fe	0.16	mg/L	0.079	0.26	SW846 6010	09/27/96
Lead, dis. as Pb by furnace AAS	110	ug/L	1.9	6.4	SW846 7421	09/27/96
Magnesium, dis. as Mg	13	mg/L	3.0	3.0	SW846 6010	09/27/96
Manganese, dis. as Mn	1.7	mg/L	0.0086	0.031	SW846 6010	09/27/96
Mercury, dis. as Hg	ND	ug/L	0.27	0.95	SW846 7470A	09/27/96
pH, lab	6.8	s.u.	1.0		SW846 9045	09/20/96
Selenium, dis. as Se by furnace	ND	ug/L	9.2	32	SW846 7740	09/25/96
Sulfate, as SO4 (filtered)	720	mg/L	250	250	SW846 9036	09/25/96
Zinc, dis. as Zn	1.4	mg/L	0.12	0.12	SW846 6010	09/27/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection
LOQ = Limit of Quantitation
ND = Not Detected
Date = Date Analysis Performed
DWB = Dry Weight Basis
NA = Not Applicable
%DWB = (mg/kg DWB)/10000

Thomas R Priebe
Reviewed by:

Authorized by:
R. T. Krueger
Laboratory Manager

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-16SXA-102 NLS#: 115820
Ref. Line 6 of COC 22175 Description: FMC-16SXA-102
Collected: 09/18/96 Received: 09/20/96 Reported: 10/07/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	32	mg/L	3.0	11	EPA 310.1	09/25/96
Cadmium, dis. as Cd	ND	mg/L	0.039	0.14	SW846 6010	09/27/96
Calcium, dis. as Ca	69	mg/L	3.0	3.0	SW846 6010	09/27/96
Chloride, as Cl (filtered)	ND	mg/L	0.36	1.3	SW846 9251	09/24/96
Copper, dis. as Cu	0.086	mg/L	0.032	0.10	SW846 6010	09/27/96
Iron, dis. as Fe	ND	mg/L	0.079	0.26	SW846 6010	09/27/96
Lead, dis. as Pb by furnace AAS	21	ug/L	1.9	6.4	SW846 7421	09/27/96
Magnesium, dis. as Mg	3.1	mg/L	3.0	3.0	SW846 6010	09/27/96
Manganese, dis. as Mn	1.0	mg/L	0.0086	0.031	SW846 6010	09/27/96
35 Mercury, dis. as Hg	ND	ug/L	0.27	0.95	SW846 7470A	09/27/96
pH, lab	7.3	s.u.	1.0		SW846 9045	09/20/96
Selenium, dis. as Se by furnace	ND	ug/L	9.2	32	SW846 7740	09/25/96
Sulfate, as SO4 (filtered)	110	mg/L	25	25	SW846 9036	09/25/96
Zinc, dis. as Zn	0.80	mg/L	0.12	0.12	SW846 6010	09/27/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection
DWB = Dry Weight Basis
LOQ = Limit of Quantitation
NA = Not Applicable
ND = Not Detected
%DWB = (mg/kg DWB)/10000
Date = Date Analysis Performed

Thomas R Priels
Reviewed by:

Authorized by:
R. T. Krueger
Laboratory Manager

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-15SXB-102 NLS#: 115821
Ref. Line 7 of COC 22175 Description: FMC-15SXB-102
Collected: 09/18/96 Received: 09/20/96 Reported: 10/07/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Acidity, tot. as CaCO3	280	mg/L	2.0		EPA 305.1	09/23/96
Additional Comments: Method requires an end point pH of 3.7 or 8.3 s.u. Client reqeusted an end point pH of 6.5 s.u.						
Cadmium, dis. as Cd	ND	mg/L	0.039	0.14	SW846 6010	09/27/96
Calcium, dis. as Ca	440	mg/L	3.0	3.0	SW846 6010	09/27/96
Chloride, as Cl (filtered)	2.5	mg/L	0.36	1.3	SW846 9251	09/24/96
Copper, dis. as Cu	120	mg/L	0.032	0.10	SW846 6010	09/27/96
Iron, dis. as Fe	0.22	mg/L	0.079	0.26	SW846 6010	09/27/96
Lead, dis. as Pb by furnace AAS	1200	ug/L	30	100	SW846 7421	09/30/96
Magnesium, dis. as Mg	11	mg/L	3.0	3.0	SW846 6010	09/27/96
Manganese, dis. as Mn	1.5	mg/L	0.0086	0.031	SW846 6010	09/27/96
Mercury, dis. as Hg	0.52	ug/L	0.27	0.95	SW846 7470A	09/27/96
pH, lab	5.8	s.u.	1.0		SW846 9045	09/20/96
Selenium, dis. as Se by furnace	ND	ug/L	9.2	32	SW846 7740	09/25/96
Sulfate, as SO4 (filtered)	650	mg/L	250	250	SW846 9036	09/25/96
Zinc, dis. as Zn	10	mg/L	0.12	0.12	SW846 6010	09/27/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection LOQ = Limit of Quantitation ND = Not Detected Date = Date Analysis Performed
DWB = Dry Weight Basis NA = Not Applicable %DWB = (mg/kg DWB)/10000

Thomas R Piule

Reviewed by:

Authorized by:
R. T. Krueger
Laboratory Manager

36

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

 NLS PROJECT# 29675

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-16SXB-102 NLS#: 115822
Ref. Line 8 of COC 22175 Description: FMC-16SXB-102
Collected: 09/18/96 Received: 09/20/96 Reported: 10/07/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	46	mg/L	3.0	11	EPA 310.1	09/25/96
Cadmium, dis. as Cd	ND	mg/L	0.039	0.14	SW846 6010	09/27/96
Calcium, dis. as Ca	73	mg/L	3.0	3.0	SW846 6010	09/27/96
Chloride, as Cl (filtered)	ND	mg/L	0.36	1.3	SW846 9251	09/24/96
Copper, dis. as Cu	0.59	mg/L	0.032	0.10	SW846 6010	09/27/96
Iron, dis. as Fe	ND	mg/L	0.079	0.26	SW846 6010	09/27/96
Lead, dis. as Pb by furnace AAS	47	ug/L	1.9	6.4	SW846 7421	09/27/96
Magnesium, dis. as Mg	ND	mg/L	3.0	3.0	SW846 6010	09/27/96
Manganese, dis. as Mn	1.5	mg/L	0.0086	0.031	SW846 6010	09/27/96
Mercury, dis. as Hg	ND	ug/L	0.27	0.95	SW846 7470A	09/27/96
pH, lab	7.1	s.u.	1.0		SW846 9045	09/20/96
Selenium, dis. as Se by furnace	ND	ug/L	9.2	32	SW846 7740	09/25/96
Sulfate, as SO4 (filtered)	120	mg/L	25	25	SW846 9036	09/25/96
Zinc, dis. as Zn	1.6	mg/L	0.12	0.12	SW846 6010	09/27/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection
LOQ = Limit of Quantitation
ND = Not Detected
Date = Date Analysis Performed
DWB = Dry Weight Basis
NA = Not Applicable
%DWB = (mg/kg DWB)/10000

Thomas R Piede

Reviewed by:

Authorized by:

R. T. Krueger
Laboratory Manager

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-15SXB-123   NLS#: 115823
Ref. Line 9 of COC 22175   Description: FMC-15SXB-123
Collected: 09/19/96   Received: 09/20/96   Reported: 10/07/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	74	mg/L	3.0	11	EPA 310.1	09/25/96
Cadmium, dis. as Cd	ND	mg/L	0.036	0.13	SW846 6010	09/27/96
Calcium, dis. as Ca	440	mg/L	3.0	3.0	SW846 6010	09/27/96
Chloride, as Cl (filtered)	2700	mg/L	180	650	SW846 9251	09/24/96
Copper, dis. as Cu	140	mg/L	0.022	0.079	SW846 6010	09/27/96
Iron, dis. as Fe	ND	mg/L	0.17	0.57	SW846 6010	09/27/96
Lead, dis. as Pb by furnace AAS	ND	ug/L	3.9	13	SW846 7421	09/27/96
Magnesium, dis. as Mg	6.4	mg/L	3.0	3.0	SW846 6010	09/27/96
Manganese, dis. as Mn	1.0	mg/L	0.013	0.044	SW846 6010	09/27/96
pH, lab	8.4	s.u.	1.0		SW846 9045	09/20/96
Selenium, dis. as Se by furnace	ND	ug/L	75	250	SW846 7740	10/06/96
Sulfate, as SO4 (filtered)	1800	mg/L	250	250	SW846 9036	09/25/96
Zinc, dis. as Zn	0.72	mg/L	0.12	0.12	SW846 6010	09/27/96
Metals digestion - dissolved ICP	yes				SW846 3005	09/25/96
Metals digestion - dissolved Furnace	yes				SW846 3005	09/25/96

38

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection   LOQ = Limit of Quantitation   ND = Not Detected   Date = Date Analysis Performed
DWB = Dry Weight Basis   NA = Not Applicable   %DWB = (mg/kg DWB)/10000

Thomas R Priele
Reviewed by:

Authorized by:
R. T. Krueger
Laboratory Manager

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-16SXB-123 NLS#: 115824
Ref. Line 10 of COC 22175 Description: FMC-16SXB-123
Collected: 09/19/96 Received: 09/20/96 Reported: 10/07/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	56	mg/L	3.0	11	EPA 310.1	09/25/96
Cadmium, dis. as Cd	ND	mg/L	0.036	0.13	SW846 6010	09/27/96
Calcium, dis. as Ca	35	mg/L	3.0	3.0	SW846 6010	09/27/96
Chloride, as Cl (filtered)	3000	mg/L	180	650	SW846 9251	09/24/96
Copper, dis. as Cu	26	mg/L	0.022	0.079	SW846 6010	09/27/96
Iron, dis. as Fe	ND	mg/L	0.17	0.57	SW846 6010	09/27/96
Lead, dis. as Pb by furnace AAS	ND	ug/L	3.9	13	SW846 7421	09/27/96
Magnesium, dis. as Mg	ND	mg/L	3.0	3.0	SW846 6010	09/27/96
Manganese, dis. as Mn	0.014	mg/L	0.013	0.044	SW846 6010	09/27/96
pH, lab	9.0	s.u.	1.0		SW846 9045	09/20/96
Selenium, dis. as Se by furnace	ND	ug/L	75	250	SW846 7740	10/06/96
Sulfate, as SO4 (filtered)	1400	mg/L	250	250	SW846 9036	09/25/96
Zinc, dis. as Zn	ND	mg/L	0.12	0.12	SW846 6010	09/27/96
Metals digestion - dissolved ICP	yes				SW846 3005	09/25/96
Metals digestion - dissolved Furnace	yes				SW846 3005	09/25/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection
LOQ = Limit of Quantitation
ND = Not Detected
Date = Date Analysis Performed
DWB = Dry Weight Basis
NA = Not Applicable
%DWB = (mg/kg DWB)/10000

Reviewed by:

Authorized by:
R. T. Krueger
Laboratory Manager

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

 NLS PROJECT# 29683

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-15SXB-144 NLS#: 115861
Ref. Line 1 of COC 22176 Description: FMC-15SXB-144
Collected: 09/20/96 Received: 09/23/96 Reported: 10/07/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	44	mg/L	3.0	11	EPA 310.1	09/25/96
Cadmium, dis. as Cd	ND	mg/L	0.036	0.13	SW846 6010	09/27/96
Calcium, dis. as Ca	55	mg/L	3.0	3.0	SW846 6010	09/27/96
Chloride, as Cl (filtered)	3000	mg/L	36	130	SW846 9251	10/01/96
Copper, dis. as Cu	48	mg/L	0.022	0.079	SW846 6010	09/27/96
Iron, dis. as Fe	0.21	mg/L	0.17	0.57	SW846 6010	09/27/96
Lead, dis. as Pb by furnace AAS	ND	ug/L	3.9	13	SW846 7421	09/27/96
Magnesium, dis. as Mg	3.6	mg/L	3.0	3.0	SW846 6010	09/27/96
Manganese, dis. as Mn	0.013	mg/L	0.013	0.044	SW846 6010	09/27/96
pH, lab	8.8	s.u.	1.0		SW846 9045	09/24/96
Selenium, dis. as Se by furnace	ND	ug/L	75	250	SW846 7740	10/06/96
Sulfate, as SO4 (filtered)	1100	mg/L	250	250	SW846 9036	09/25/96
Zinc, dis. as Zn	0.21	mg/L	0.12	0.12	SW846 6010	09/27/96
Metals digestion - dissolved ICP	yes				SW846 3005	09/25/96
Metals digestion - dissolved Furnace	yes				SW846 3005	09/25/96

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Tel:(715)478-2777 Fax:(715)478-3060

WIS. LAB CERT. NO. 721026460

ANALYTICAL REPORT

Client: Foth & Van Dyke Associates
Attn: Russ Janeshek
2737 S. Ridge Road
PO Box 19012
Green Bay, WI 54307

Project Description: Flambeau Mining
Project Title: 96F013

Sample ID: FMC-16SXB-144 NLS#: 115862
Ref. Line 2 of COC 22176 Description: FMC-16SXB-144
Collected: 09/20/96 Received: 09/23/96 Reported: 10/07/96

Parameter	Result	Units	LOD	LOQ	Method	Date
Alkalinity, tot. as CaCO3 (filtered)	60	mg/L	3.0	11	EPA 310.1	09/25/96
Cadmium, dis. as Cd	ND	mg/L	0.036	0.13	SW846 6010	09/27/96
Calcium, dis. as Ca	450	mg/L	3.0	3.0	SW846 6010	09/27/96
Chloride, as Cl (filtered)	2600	mg/L	36	130	SW846 9251	10/01/96
Copper, dis. as Cu	170	mg/L	0.022	0.079	SW846 6010	09/27/96
Iron, dis. as Fe	0.62	mg/L	0.17	0.57	SW846 6010	09/27/96
Lead, dis. as Pb by furnace AAS	ND	ug/L	3.9	13	SW846 7421	09/27/96
Magnesium, dis. as Mg	11	mg/L	3.0	3.0	SW846 6010	09/27/96
Manganese, dis. as Mn	0.82	mg/L	0.013	0.044	SW846 6010	09/27/96
pH, lab	7.7	s.u.	1.0		SW846 9045	09/24/96
Selenium, dis. as Se by furnace	ND	ug/L	75	250	SW846 7740	10/06/96
Sulfate, as SO4 (filtered)	2300	mg/L	250	250	SW846 9036	09/25/96
Zinc, dis. as Zn	0.74	mg/L	0.12	0.12	SW846 6010	09/27/96
Metals digestion - dissolved ICP	yes				SW846 3005	09/25/96
Metals digestion - dissolved Furnace	yes				SW846 3005	09/25/96

Please note that analytical results greater than the LOD but less than the LOQ are within a region of "Less-Certain Quantitation". Results greater than the LOQ are considered to be in the region of "Certain Quantitation".

LOD = Limit of Detection LOQ = Limit of Quantitation ND = Not Detected Date = Date Analysis Performed
DWB = Dry Weight Basis NA = Not Applicable %DWB = (mg/kg DWB)/10000

Reviewed by: Thomas R Priebe

Authorized by:
R. T. Krueger
Laboratory Manager