Manual

Updated Resident Project Representative Manual

Flambeau Project Pit Backfill, Type II Material

Scope ID: 97F003

Flambeau Mining Company
Ladysmith, Wisconsin

April 1997

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engineers · architects · scientists

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Updated Resident Project Representative Manual

97F003

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April 1997

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Flambeau Project
Pit Backfill, Type II Material

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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 preparation and 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, backfilling work performed during the fall of 1996, and laboratory analysis of amended backfill material performed during the winter of 1996-97. 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-ft compacted lifts. Neutralizing material will be added in the form of crushed limestone to the stockpiled Type II material prior to excavation and placement in the pit as fill. 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 addition of the specified amount of limestone to the backfill material as determined by tests performed on the stockpiled Type II material prior to relocation to the pit.

- The dozer placement of the backfill material to a lift thickness of approximately 3 ft, with an upper limit of 3 ft, 4 in.

- The completion of a minimum of two passes (complete area coverage) of compaction upon the lift area.

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-ft lifts required to fill the entire pit at the deepest point of excavation. Type II material will be placed at the bottom of the pit. Temporary sumps may be located in the east portion of the pit until backfilling allows for drainage to occur to the south and west. Backfilled lifts in the pit will be sloped to allow drainage of precipitation across the top of the fill to the collection sump(s). Some grade control 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-ft 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.

Backfill lift construction will be accomplished in designated distinct fill areas within each pit section rather than installing complete lifts across the entire base of each section at any point in time. Backfill volumes will be monitored by designating the distinct area to receive backfill, establishing horizontal and vertical survey control for the area, placement and compaction of fill including collection 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.

Prior to relocation into the pit as backfill, the stockpiled Type II material will be sampled and tested as outlined in this manual to determine the required limestone amendment rate for stored acidity. The samples will be taken on a maximum 60-ft grid. The amendment rate for stored acidity will be added to the rate required to neutralize future acidity which could potentially be generated prior to resaturation with groundwater to establish the actual amendment rate to be applied in the field.

3 Acceptance Criteria and Required Data Collection and Documentation

3.1 Limestone Application Rate Determination

Prior to placement into the pit as fill, stockpiled Type II material will be sampled and tested for paste pH and conductivity to determine the appropriate rate of limestone application. This sampling and testing program is described below.

3.1.1 Stockpile Sampling

3.1.1.1 Sampling on Stockpile Surface

At least 2 days prior to excavation, a 60-ft grid pattern will be established over the area of Type II material to be excavated. Adjacent to the sideslopes, the first grid location on top of the stockpile will be established at a distance of approximately 20 ft from the outer edge of the stockpile. A test pit will be excavated by backhoe at each grid point to a depth equal to the relocation lift (approximately 15 ft). A bulk sample will be obtained by scraping the sidewall of the pit with the backhoe bucket from bottom to top. The bulk sample will be placed on the ground surface next to the pit. The bulk sample will be split by visual quartering and a subsample of <¼-in size fraction will be obtained from each quarter of the bulk sample. Approximately 2 lb (1 kg) of <¼-in material for each subsample will be collected.

3.1.1.2 Sampling on Type II Stockpile Sideslope

Sideslope samples will be taken over the length of the slope that corresponds to the vertical lift height (15 ft) at a spacing of 30 ft. At each sample location, three bulk samples will be obtained by scraping the sideslope with a backhoe bucket along the appropriate length of sideslope at depths of 1 ft, 3 ft, and 6 ft. Each bulk sample will be placed in separate piles and visually quartered. A representative subsample of <¼-in size fraction will be obtained from each quartered bulk sample. Approximately 2 lbs (1 kg) will be obtained for each subsample. A single composite sample for each bulk sample is to be prepared by blending equal weights from each of the four subsamples.

3.1.2 Testing Procedures

3.1.2.1 Surface Samples

Paste parameters, namely pH and conductivity, will be performed on each subsample (quarter bulk sample for 15 ft deep pits or the composite samples from the sidewalls). The protocol for these tests are found in Appendix A. All sample locations that exhibit class C characteristics will be tested for alkali demand. The alkali demand test will be performed on a composite of the subsamples collected at the location where class C material was identified. For the balance of the sample locations, alkali demand tests on one of every ten sample locations will be performed. The protocol for this test is also found in Appendix A.

3.1.2.2 Sideslope Samples

Paste parameters (pH and conductivity) will be performed on each of the composite samples from each of the three bulk samples. All samples that exhibit class C characteristics will be tested for alkali demand. The alkali demand test will be performed on the composite sample of the subsamples obtained at each C class depth. For the balance of the sample locations, alkali demand tests on one of every ten sample locations will be performed.

3.1.3 Limestone Application Rate Determination

The rate of limestone application will be determined by following the three steps outlined below.

Step 1 Using the paste parameter test results from the collected samples, classify the test pit locations or sideslope samples as either A, B, or C material as determined below and as shown in Figure 3-1.

- The Material is to be classified as A if paste pH is >5.0 s.u. and paste conductivity is <2200 μS/cm.

- The Material is to be classified as B if the paste pH is ≤5.0 s.u. and paste conductivity is <2200 μS/cm, or if the paste pH is >5.0 s.u. and the conductivity is ≥2200 μS/cm.

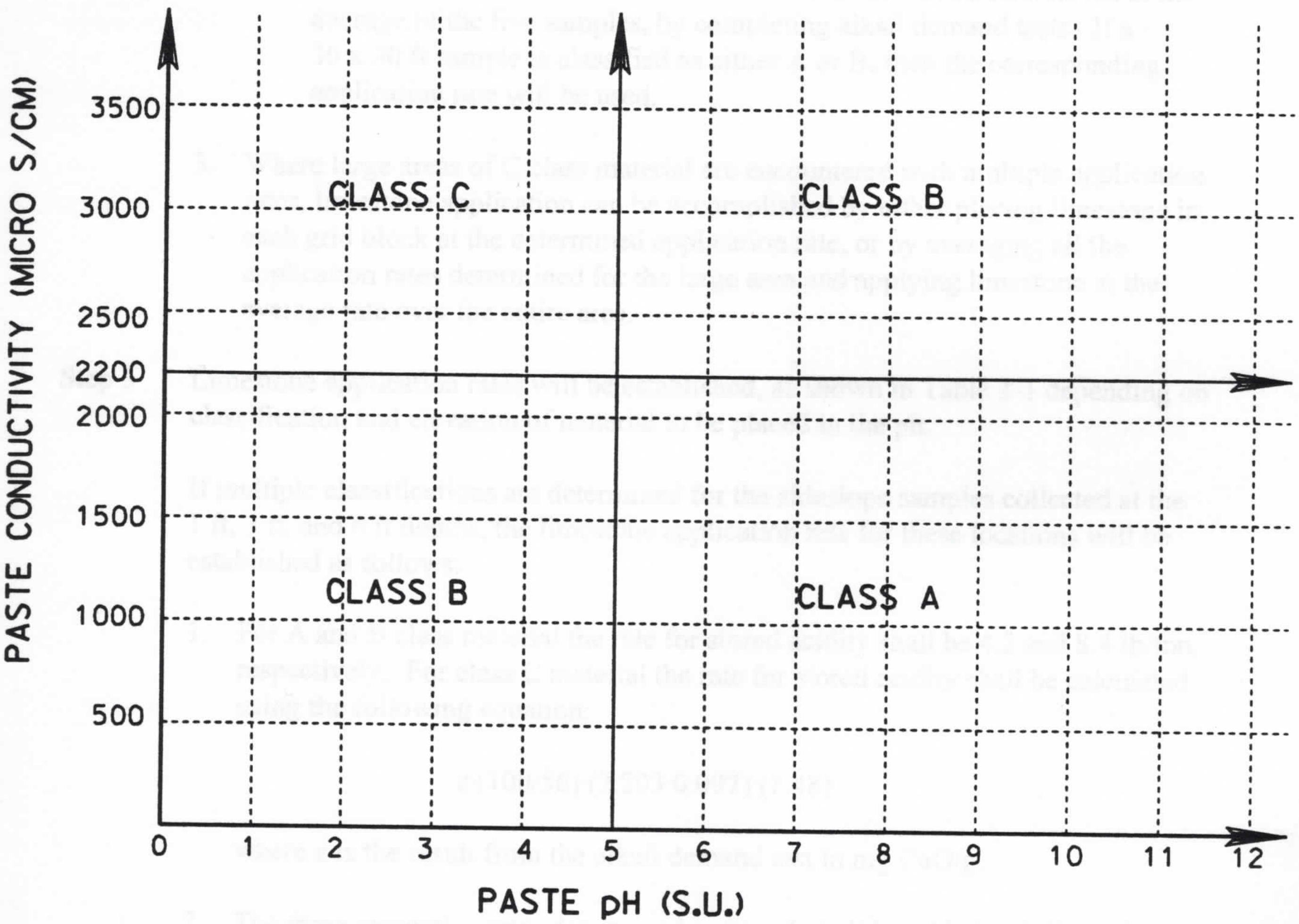
- The Material is to be classified as C if the pH is ≤5.0 s.u. and the conductivity is ≥2200 μS/cm.

All samples identified as C class material are to be immediately submitted for alkali demand testing.

Step 2 The material classes will then be plotted on a plan of the lift that is to be relocated, and the areas of similar classes identified. These areas will be delineated by establishing boundaries at the midpoints between sample locations.

It is anticipated that conditions of isolated single samples of a different material class within a larger area of a singular class, or that large areas of class C materials with multiple application rates may be encountered. The following interpretation will be applied to these areas.

1. Where isolated B class material is encountered (on the 60 x 60 ft sampling grid) within primarily A class material, the area for limestone application at the B class rate will be delineated at the midpoint with all immediately adjacent A class sample locations.



FLAMBEAU MINING COMPANY

FIGURE 3-1

TYPE II STOCKPILE MATERIAL CLASSIFICATION

Scale:	AS SHOWN	Date:	MARCH, 1997
Prepared By:	Foth & Van Dyke	By:	JOW

C:\cadwork\6f01f5.dgn

2. Where isolated C class material is encountered (on the 60 x 60 ft sampling grid) within predominantly A class or B class material, the following will be undertaken:

   - Samples will be obtained at a grid of 30 x 30 ft centered around the sample location where the C class material was encountered. This will provide four additional samples around the location of the anomaly, and will enable a better definition of the area. The alkali demand will be established at the average of the five samples, by completing alkali demand tests. If a 30 x 30 ft sample is classified as either A or B, then the corresponding application rate will be used.

3. Where large areas of C class material are encountered with multiple application rates, limestone application can be accomplished by either placing limestone in each grid block at the determined application rate, or by averaging all the application rates determined for the large area and applying limestone at the average rate over the entire area.

Step 3 Limestone application rates will be established, as shown in Table 3-1 depending on classification and elevation of material to be placed in the pit.

If multiple classifications are determined for the sideslope samples collected at the 1 ft, 3 ft, and 6 ft depths, the limestone application rate for these locations will be established as follows:

1. For A and B class material the rate for stored acidity shall be 4.2 and 8.4 lb/ton, respectively. For class C material the rate for stored acidity shall be calculated using the following equation:

$$z \cdot (100/56) \cdot (2.203 \cdot 0.097) \cdot (1.48)$$

where z is the result from the alkali demand test in mg CaO/g.

2. The three respective rates determined in Step 1 shall be added and divided by 3 to determine the average rate.

3. The average rate determined in Step 2 shall be added to the appropriate future oxidation rate (Table 3-1) based on the elevation of material placement in the pit to establish the total limestone application rate for the respective sampling location.

Table 3-1

Limestone Application Rate Determination[1,2]

Classification	Pit Placement Elevation (a.s.l.)	Limestone Application Rate (lb/ton)		
		Contained Acidity	Future Oxidation	Total
A	at or above 1065	4.2	5.4	9.6
A	at or above 1055 and below 1065	4.2	3.7	7.9
A	at or above 1045 and below 1055	4.2	1.8	6.0
A	below 1045	4.2	1.0	5.2
B	at or above 1065	8.4	5.4	13.8
B	at or above 1055 and below 1065	8.4	3.7	12.1
B	at or above 1045 and below 1055	8.4	1.8	10.2
B	below 1045	8.4	1.0	9.4
C	at or above 1065			z[3]•(100/56)•(2.203•0.907)•(1.48)+5.4
C	at or above 1055 and below 1065			z[3]•(100/56)•(2.203•0.907)•(1.48)+3.7
C	at or above 1045 and below 1055			z[3]•(100/56)•(2.203•0.907)•(1.48)+1.8
C	below 1045			z[3]•(100/56)•(2.203•0.907)•(1.48)+1.0

[1]The limestone application rates shown in this table were calculated assuming the limestone will have a moisture content of 5% and a theoretical alkali availability of 95%.
[2]See Step 3 in Section 3.1.3 for description of method to determine limestone application rate for sideslope samples where multiple material classifications are encountered at a given location.
[3]Result of alkali demand test (mgCaO/g).

3.2 Limestone Application

3.2.1 Application Method and Documentation

The following procedures will be used for limestone application.

3.2.1.1 Type II Stockpile Material

The rate of limestone application will be determined pursuant to Section 3.1 of this manual. The amount of limestone to be added is to be calculated using the horizontal extent of the stockpile area to be excavated, the vertical height of the excavation, and a Type II material stockpile density of 160 lb/cu ft. The thickness of limestone to be spread across the stockpiled material application area will be determined using 90 lb/cu ft for the density of loose limestone.

Following surface grading of the application area, the limestone will be delivered by either an over the road dump truck containing the appropriate amount of pre-weighed crushed limestone, or by a preweighed (by on-site scale) paddle scraper or dump truck from an on-site stockpile. The limestone will be delivered in known weighed amounts to each classified area (A, B or C) and evenly spread across the area. The limestone will be spread by a grader to a uniform thickness across the application area. Once the limestone is in place, excavation of the treated material will occur by backhoe and/or front end loader. Excavated material will be deposited into haul trucks for transport to the backfill area in the pit.

Initial mixing of the limestone will occur as the stockpiled Type II material is excavated and placed in the haul trucks. Material will be excavated in a continued vertical face to optimize commingling of limestone and Type II material. Additional mixing will take place as the Type II material is placed in the pit when it is spread by the dozer.

To document the limestone application during the backfilling process, the stockpile area to receive limestone will be classified as A, B, or C as described in Section 3.1 on the 60 x 60 ft grid used during sampling as described in Section 3.1. The results of the paste parameter testing, grid classification, pit placement elevations, and limestone application rate determinations will be documented on the test pit classification and limestone application worksheets in Appendix B. The limestone delivered to the designated areas will be weighed prior to delivery and spread over each classified area. The application area, classification, and quantity of limestone applied to the stockpile application area will be documented on the limestone application observation form (LAO) in Appendix B. As a qualitative check, the average thickness of limestone across the application area will be observed to verify adequate, uniform spreading has occurred. Physical and chemical characteristics of the crushed limestone explained in Section 3.2.2, in addition to application details, will be recorded on the LAO.

3.2.1.2 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.

3.2.1.3 Wind Event Application

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

3.2.1.4 Traffic on Limestoned Areas

Traffic on limestoned areas will be minimized. In areas where traffic is required to occur over limestoned areas, the traffic areas will be delineated with lath or other such means. The traffic area will be covered with a layer of treated Type II material sufficient to provide a roadbed for haul truck traffic to travel upon.

3.2.1.5 Moisture Content Corrections

Variations in limestone moisture contents, due to local weather or transport, will be monitored by collecting a representative moisture sample, from the stockpiled limestone, prior to release. If moisture contents above 5% are encountered, a correction based on weight will be made to compensate for the increased weight of excess water in the limestone.

3.2.2 Limestone Material Testing

Crushed limestone will be delivered from an off-site source directly to the stockpile application area prior to placement. The resident project representative shall initially collect one sample for every 100 tons of crushed limestone delivered to the site. The sampling rate will either be increased or decreased depending on the variability of the results. 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 Equivalency (CCE)	pile run
Neutralizing Index	pile run

The summary of the results of the testing will be filed with the daily construction observation report (DCOR), in Appendix B, 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. The limestone specification is as follows:

Mechanical Analysis		Chemical Analysis
Sieve No.	% Passing	
8	96	Calcium Carbonate Equivalent = 95% or higher
100	36-100	

The limestone application rates presented in Table 3-1 are calculated based on a theoretical alkali availability within the limestone of 95%. If the limestone actually used has a theoretical alkali availability less than 95%, an adjustment to the application rates presented in Table 3-1 will be required. The theoretical limestone alkali availability will be measured initially and at the rate of one test per each 2,000 tons of limestone used. The protocol for the alkali availability test is contained in Appendix A.

3.3 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.

3.4 Lift Material Thickness

3.4.1 Lift Material Installation

Pit backfilling will consist of the placement of stockpiled, limestone amended, 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-ft lift, with an upper limit of 3 ft, 4 in. The lift thickness will be marked on lath or by other such means. The lath will be placed on a 150-ft grid in the area to be filled. The lath will be painted with a line located approximately 3-ft above the existing grade. The approximate 3-ft elevation will be established to allow overland flow drainage to be maintained. The fill material will be placed to the mark and then appropriately compacted.

3.4.1.1 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 and/or during wet events during backfilling 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 or to recent rainfall events. Once lift placement has reached approximately 12 vertical ft 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.

3.4.1.2 Oversize Material

Pieces of waste rock which are larger than 36 in. in all three dimensions shall be segregated from the general pit backfill and broken until one dimension of the rock is approximately 24 in 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.

3.4.2 Elevation Documentation

Record survey elevations shall be taken on a maximum 150 x 150 ft 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 ft. 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.

3.5 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 equivalent compactor.

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 B. A description of the backfill material type including color and an estimate of the amount of fines 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 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 released by the resident project representative will not be allowed to receive overlying Type II material.

3.6 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.

3.6.1 Photographs

Photographs shall be taken of major construction elements. A representative 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 B.

3.6.2 Pit Sidewall Observation

As the pit is backfilled, the pit sidewall shall be observed. General sidewall rock types, mineralization, fractures, faults, weep holes, 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.

3.7 Weep Hole Abandonment

Weep hole abandonment is to be accomplished ahead of the backfilling process. The resident project representative shall note on the DCOR that abandonment has taken place prior to backfilling reaching respective weep hole locations.

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. It should be noted that Flambeau may modify the test program by additions, deletions, or revisions based on the utility of the data being collected.

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:

II B 1010 E 1000N 500E

- 1000N 500E — Sample grid location (mine grid inside pit; local grid outside pit).
- E — East or West portion of pit.
- 1010 — Top of lift elevation for backfill samples.
- B — Material source identifier.
- II — Material type identifier.

4.2 Sampling Frequency and Testing

4.2.1 Pit Backfill Material (From Pit or Stockpile)

A minimum of one sample of any new (other than already tested) Type II waste rock that will be used in pit backfilling will be collected. The samples should be obtained from the stockpile at a location chosen to represent the new 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)

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)

4.2.2.1 General Sampling and Testing

One sample of in-place backfilled material shall be collected from every 5,000 cu yd for the first 30,000 cu yd, then one sample per every 30,000 cu yd 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)
- Specific Gravity (ASTM D 854)

In addition to the above, one sample will be collected for every 150,000 cu yd for the purpose of completing a hydraulic conductivity (ASTM D 2434) test.

4.2.2.2 In-Place (Pit) Testing

4.2.2.2.1 Alkalinity/Acidity Testing

Sampling of the backfilled material will be performed for each approximate 60,000 tons of Type II material placed into the pit to document the condition of the amended material. Four test pits, evenly distributed over the material, will be excavated to 3 ft in depth (i.e., equal to the placement lift height) by backhoe or similar means. A representative sample of approximately 2 lb (1 kg) in size of the <¼-in material should be obtained from each of the test pits. Paste parameters will be determined on a subsample from each representative sample. The remaining portions of each representative sample will be mixed in equal proportions (by weight) to provide a single composite sample. Testing requirements are discussed below.

Below the 1045 ft Elevation

Paste parameters will also be determined on each single composite sample. Short-term equilibration tests for simple equilibrium pH determinations (leach extraction test, Appendix C) will also be conducted on each composite sample consisting of shake flask extractions completed at a solids-to-liquid ratio of 1:1. While these are not rapid tests, they will be useful in documenting the performance of the alkali amendment program. On an approximate once per week basis, filtered supernatant will be analyzed for selected additional parameters.

Above the 1045 ft Elevation

Testing on the material above the 1045 ft elevation will be as described for that below this elevation, but will also include an assessment of the excess limestone that is available to neutralize future acidity. An acid consumption test, as described in Appendix C, will be used to assess the excess alkali available for acid neutralization after the contained acidity has been neutralized. This testing will be undertaken on each of the composited backfill samples taken from above the 1045 ft elevation.

For QA/QC on the acid consumption test, one in every ten samples will be submitted to an external laboratory for a similar assessment.

4.2.2.2.2 Confirmation Column Testing

In addition to the test described in the previous section, eight to ten samples of the in-place amended Type II material will be collected at random over the backfilling period for column testing. Sixty-pound bulk samples will be collected. Testing will be performed on the <¼-in size fraction using the anoxic column test procedures described in Appendix C.

4.3 Density Testing

4.3.1 Field Test for Density of Material in the Stockpile

Three to five density tests using the nuclear density meter will be performed on each lift of material to be removed from the Type II stockpile. The density data will be used to document that the use of the 160 lb/cu ft density value for stockpiled material is conservative. Test data will be recorded on the Density Tests of Stockpiled Material form located in Appendix B.

4.3.2 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 B.

4.3.3 Quality Assurance Checks for Nuclear Density Testing

Once at the start of the backfilling procedure, then at a frequency of once every 30,000 cu yd, sand cone density tests (ASTM D 1556) shall be performed at the same location and at the same time as a nuclear density test is performed. The sand cone test data will be compared to the nuclear density test data to verify that the nuclear density meter is measuring density-moisture relationships consistent with the relationship established during the 1996 field compaction tests. Sand cone density field and laboratory data should be recorded on the Density Tests of Compacted Fill form contained in Appendix B.

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 cu yd.

4.3.4 Laboratory Compaction Control Report - Fill Material

When different material types are placed in the pit, 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.

4.3.5 Field Density Locations

Density tests will be located across a given lift to provide a frequency of tests at one density test per 10,000 cu yd of in-place fill. In addition to being recorded on the Density Test of Compacted Fill form in Appendix B, locations of density tests will be noted on the lift figures attached to the daily reports.

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.

5 Daily Construction Observation Report

A construction observation report (Appendix B) 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

Paste Parameter (pH and Conductivity) Test Protocol
Alkali Demand Test Protocol
Alkali Availability Test Protocol

Paste Parameter (pH and Conductivity) Test Protocol

Equipment

1. Portable pH and conductivity meters
2. 2x Glass/plastic beakers (150 to 250 ml)
3. ¼ inch hand sieve
4. Measuring cup or scoop (approximately 60 to 65 ml)
5. Distilled water
6. Spatula

Method

1. A sample of approximately 2-3 kg is taken with a small shovel, discarding the obvious oversize (>75 mm) material.

2. The sample is sieved through a ¼-in screen to produce approximately 2 kg of <¼-in material. From the undersize material, a sample of 65 ml, using a scoop that can be scraped level to remove excess sample, is obtained. The remainder of the sample is to be archived as needed.

3. The sample is placed in a 150 to 200 ml beaker, and the scoop is rinsed and the residue is added to the beaker, using exactly 100 ml of water.

4. The prepared sample is mixed thoroughly using a spatula.

5. The pH and conductivity of the supernatant is measured immediately with calibrated field equipment. **IMPORTANT: Do not contact the solids with the glass pH probe - it is fragile and may scratch.** Ensure that the readings have stabilized before recording the values.

Alkali Demand Test Protocol

Equipment and Reagents

1. 1.0 liter Erlenmeyer flasks or roll bottles
2. Distilled water
3. Hydrated lime ($Ca(OH)_2$)
4. Sulfuric Acid (1M)
5. pH and conductivity meters
6. Rotary shaker or rollers

Method

1. Prepare a 200 g/l hydrated lime slurry. The suspension is maintained by continuous mixing. A 10 ml sample of the hydrated lime slurry should be titrated with sulfuric acid at a known molarity to determine the reactivity (R) of the lime slurry as mols $Ca(OH)_2$ per liter. The reactivity should be determined for each fresh batch of lime slurry that is prepared.

2. In triplicate, place 500 g of the <¼-in sample in a 1.0 l Erlenmeyer flask or roll bottle. The 500 g sample shall be prepared by taking a representative 125 g sample from each subsample at the location to be tested.

3. Add 500 ml distilled water to each sub-sample, and lightly agitate for 1 hour.

4. Allow solids to settle for a few minutes and measure solute pH and conductivity.

5. Calculate the ratio of the conductivity to pH for each of the three samples, and from Figure B-1 or B-2 obtain the volumes of lime slurry to be added to each sample using the highest ratio from the three samples.

6. Add the indicated volumes of lime slurry to the respective vessels.

7. Gently agitate the samples for a period of approximately 24 hours and record the final pH and conductivity.

Interpretation

The alkali demand for the sample is determined from the lime addition rate that yields a final pH nearest 7.0, but greater than 6.5. The alkali demand is back-calculated on the basis of the reactivity of the lime slurry and the weight of the sample as follows:

Alkali demand as lime (mg/kg) = $R*V*74/m$

where:
- R = reactivity in mols $Ca(OH)_2$/liter
- V = ml lime slurry added
- m = weight of sample in grams

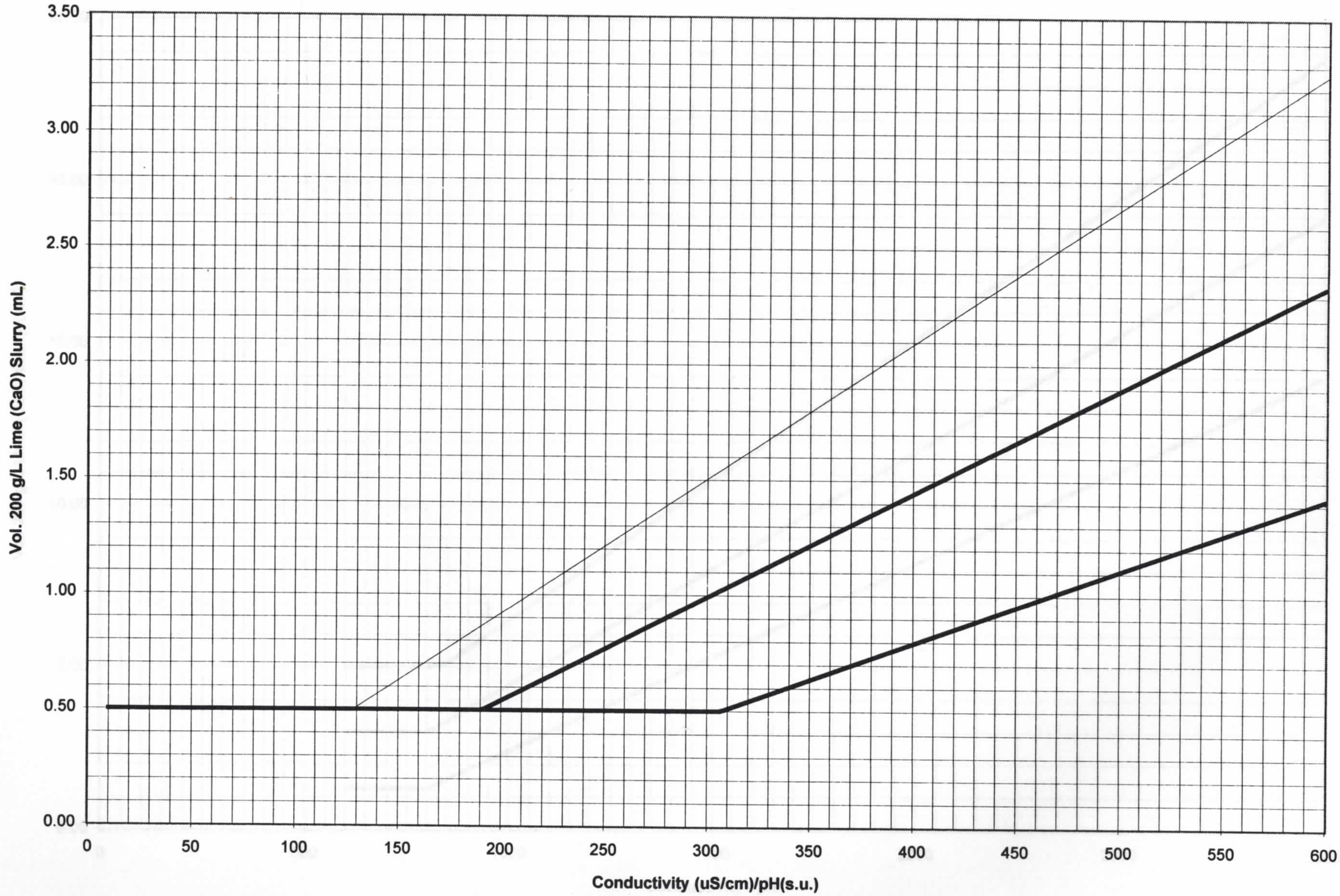
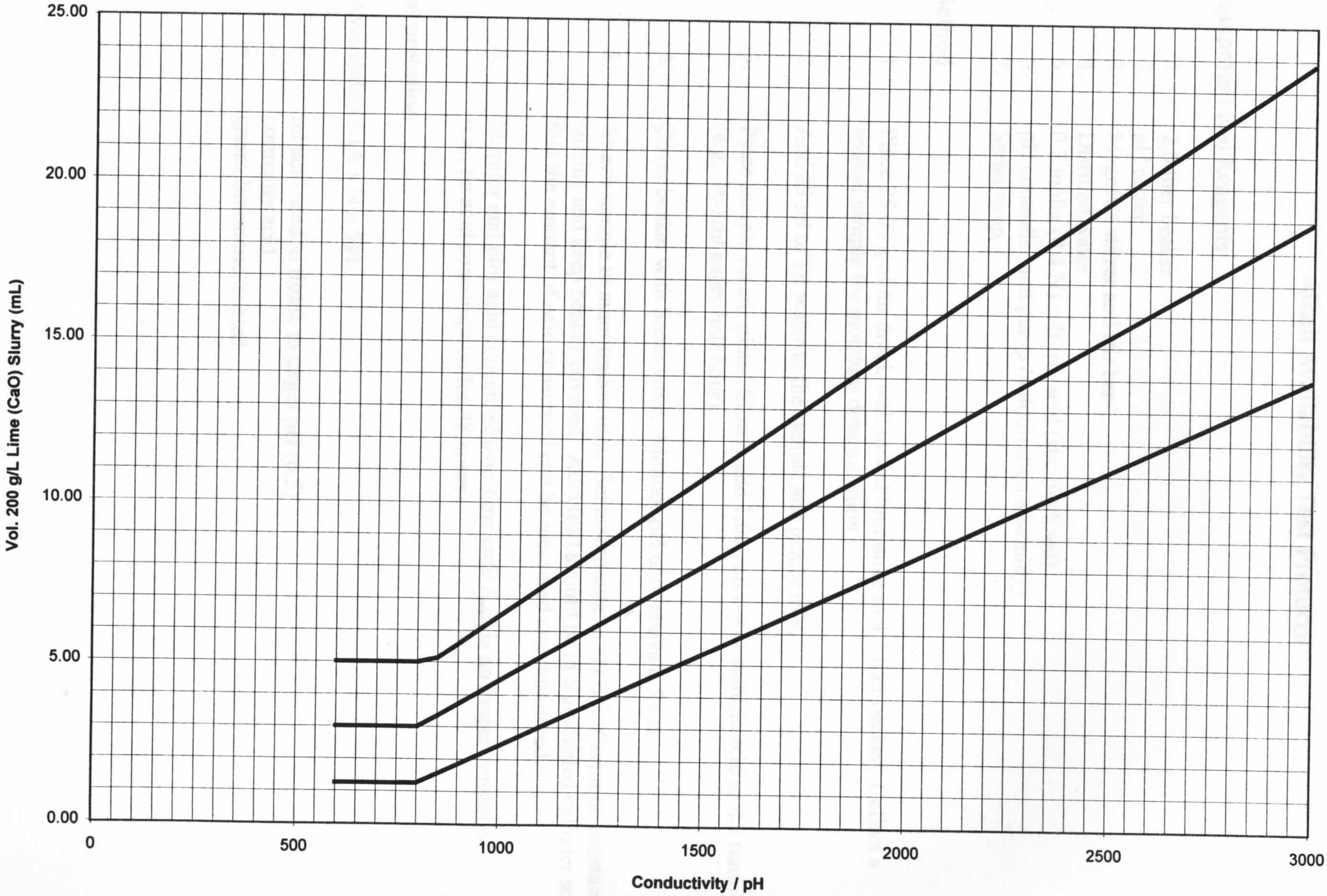

3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Vol. 200 g/L Lime (CaO) Slurry (mL)
0
50
100
150
200
250
300
350
400
450
500
550
600
Conductivity (uS/cm)/pH(s.u.)

FIGURE B-1



JTC\97F003\ALKALI_A.XLS

FIGURE B-2

Alkali Availability Test Protocol

Equipment and Reagents

1. 2.0 liter beaker
2. pH meter
3. Magnetic stirrer and stir bar
4. Distilled water
5. 0.2 molar (0.4 N) sulfuric acid (standardized)
6. pH controller and pump (autotitration assembly)
7. Saran wrap

Method

1. Place 25.00 g of air dried, well mixed limestone in a 2 liter beaker. Collect a second sample for moisture determination.

2. Add 25 ml of DI water to the sample and gently mix.

3. Place sample on stir plate. Slowly add 1,000 ml 0.4 N sulfuric acid to the sample (e.g., 100 ml every half hour).

4. Cover beaker with Saran wrap. Monitor pH until above 6.5 s.u.

5. Attach sample to autotitration unit. Set autotitrator to pH 6.5. Continue constant stirring and keep beaker covered. Acid feed should be in a graduated cylinder so that the amount of acid consumed can be measured and monitored.

6. Monitor and plot acid consumed over time until acid is no longer consumed (i.e., no acid consumption for 48 hours).

Interpretation

% Availability = (A x N x 5)/L

A	=	ml acid used to titrate to target pH (6.5)
N	=	normality acid
L	=	grams limestone titrated

Appendix B

Test Pit Classification Worksheet
Class C Limestone Application Worksheet
Limestone Application Observation Form
Daily Construction Observation Report
Photo Log
Density Tests of Stockpiled Material Form
Density Tests of Compacted Fill Form

Appendix C

Leach Extraction Test Protocol
Modified Acid Consumption Test Protocol
Anoxic Saturated Column Test Procedure

Leach Extraction Test Protocol

Equipment

1. 1 liter Erlenmeyer flasks or roll bottles
2. distilled water
3. pH, redox and conductivity meters
4. rotary shaker or rollers as appropriate
5. filtration equipment and 0.45μm filter membranes

Method

1. Cone and quarter the <¼-in material from the composite sample. Weigh out accurately three individual 500 gram samples from three of the four quarters, respectively, and place in individual 1 liter extraction vessels.

2. Add 500 ml distilled water to each extraction vessel.

3. Gently agitate the sample as determined by the monitoring requirements. For simple equilibrium pH determination only, the extraction period should vary between 24 and 72 hours. To obtain dissolved constituent concentrations, allow an equilibration period of 120 to 168 hours.

4. Allow solids to settle (0.5 to 1 hour) and measure solute pH, conductivity and redox potential.

5. Decant clear supernatant, filter through a 0.45 μm medium, and preserve as required for analysis.

List of Analytes

1. For simple pH determinations: field pH, field redox, & field conductivity.

2. For extended parameter testing: field pH, field redox, field conductivity, alkalinity/acidity
   Anions: SO_4^{2-}
   Cations: Cd, Ca, Cu, Fe(T), Mn, Mg, Zn

Modified Acid Consumption Test Protocol

Equipment and Reagents

1. 2.0 liter Erlenmeyer flask
2. pH meter
3. Burette
4. Spatula or magnetic stirrer
5. Distilled water
6. 0.001 molar (0.002 N) sulfuric acid
7. 0.01 molar (0.01 N) sodium hydroxide (NaOH)
8. 250 ml glass beaker

Method

1. The residue from the anoxic leach test is air dried, blended and quartered using a sample splitter to yield a dry weight sample of about 10 grams. The exact weight of the sample is obtained. The moisture content of the sample is determined on a second quarter of the sample.

2. Place the sample in a 2 liter Erlenmeyer flask, and add exactly 1000 ml of the 0.001 molar sulfuric acid. Record the total weight of the sample and the flask. Place the sample on a rotary shaker and allow to react for a period of 24 hours.

3. After 24 hours contact time, replace evaporative losses by readjusting the total weight of the flask and sample to that recorded in Step 2. The final pH is obtained and recorded.

4. Allow the solids to settle, and decant the clear solution. If necessary, filter the solution. Obtain an exact aliquot of 100 ml of the clear solution, and place in the 250 ml beaker. Agitate the sample using a magnetic stirrer. Titrate the solution with the 0.01 N NaOH to a stable endpoint pH of 8.3. Record the amount of titrant added as a function of the pH.

Interpretation

The residual neutralization potential (NP) for the sample is calculated as follows:

$NP = (50{,}000*N_A-100*V*N_B)/w$

where NP = the residual neutralization potential in mg CaCO3 eq. / g
N_A = normality of the sulfuric acid
N_B = normality of the sodium hydroxide
V = volume sodium hydroxide required to titrate the 100 ml sample to a pH=8.3
w = dry weight of the sample in grams

Anoxic Saturated Column Test Protocol

Equipment

1. Column: ID = 4 inches
   Height = 16 inches
   sealable top and baseplate within and outlets as shown in Figure C-1.
2. Argon gas
3. Feed water reservoir
4. pH, redox and conductivity meters
5. Tubing and valves as required

Method

1. *Column set-up*:

   a. The sample of <¼-inch material is blended to prevent particle size segregation. Where an amendment is required, approximately 16 lb (7.5 kg) of the amended and blended material is prepared. The column is prepared by placing a bottom screen (fine nylon mesh) on the baseplate of the column, as shown in Figure B-2. The weight of the column is obtained, and the sample is loaded to fill the column level with the top. The sample is then lightly compacted to result in minimal settling during the saturation process. The bulk density of the sample should be checked by calculation prior to sealing the column. The another nylon mesh screen is placed on top of the sample, and the column is sealed.

   b. Set up an Erlenmeyer (250 to 500 ml) flask or similar with a stopper that has 4 holes bored through it as follows to serve as (a) argon inlet, (b) argon outlet with water trap as before, (c) column discharge in and (d) leachate return to column. The lines for the leachate in, leachate out and argon in should be submerged below the leachate surface. The argon vent should be above the leachate surface.

   c. Provide the column feed line and column discharge lines with shut-off valves or clamps as near to the Erlenmeyer flask as possible.

2. *Start-up:*

   a. Place approximately 200 ml of distilled de-aerated water in the Erlenmeyer flask.

   b. Place stopper firmly in place.

   c. Sparge with argon for a few minutes until air has been displaced. Ensure water trap is in place.

   d. Seal off column feed and discharge lines in appropriate locations and cut in preparation for connections. Take care to maintain anoxic conditions.

   e. Connect feed and discharge lines to the Erlenmeyer flask.

f. Terminate argon sparging.

g. Start peristaltic pump to displace approximately 1 liter every eight hours - running continuously.

3. *Every Third Day pH and Conductivity Measurements:*

   a. Stop peristaltic pump.

   b. Seal off feed leachate lines.

   c. Activate argon sparging.

   d. Lift off stopper and obtain pH and conductivity measurements, taking care to minimize exposure to atmospheric conditions.

   e. Once measurements are complete, replace stopper.

   f. Continue argon sparging for a few minutes so that all air has been displaced.

   g. Terminate argon sparging.

   h. Open leachate recycle lines and activate pump.

4. *Leachate Sampling and Analysis:*

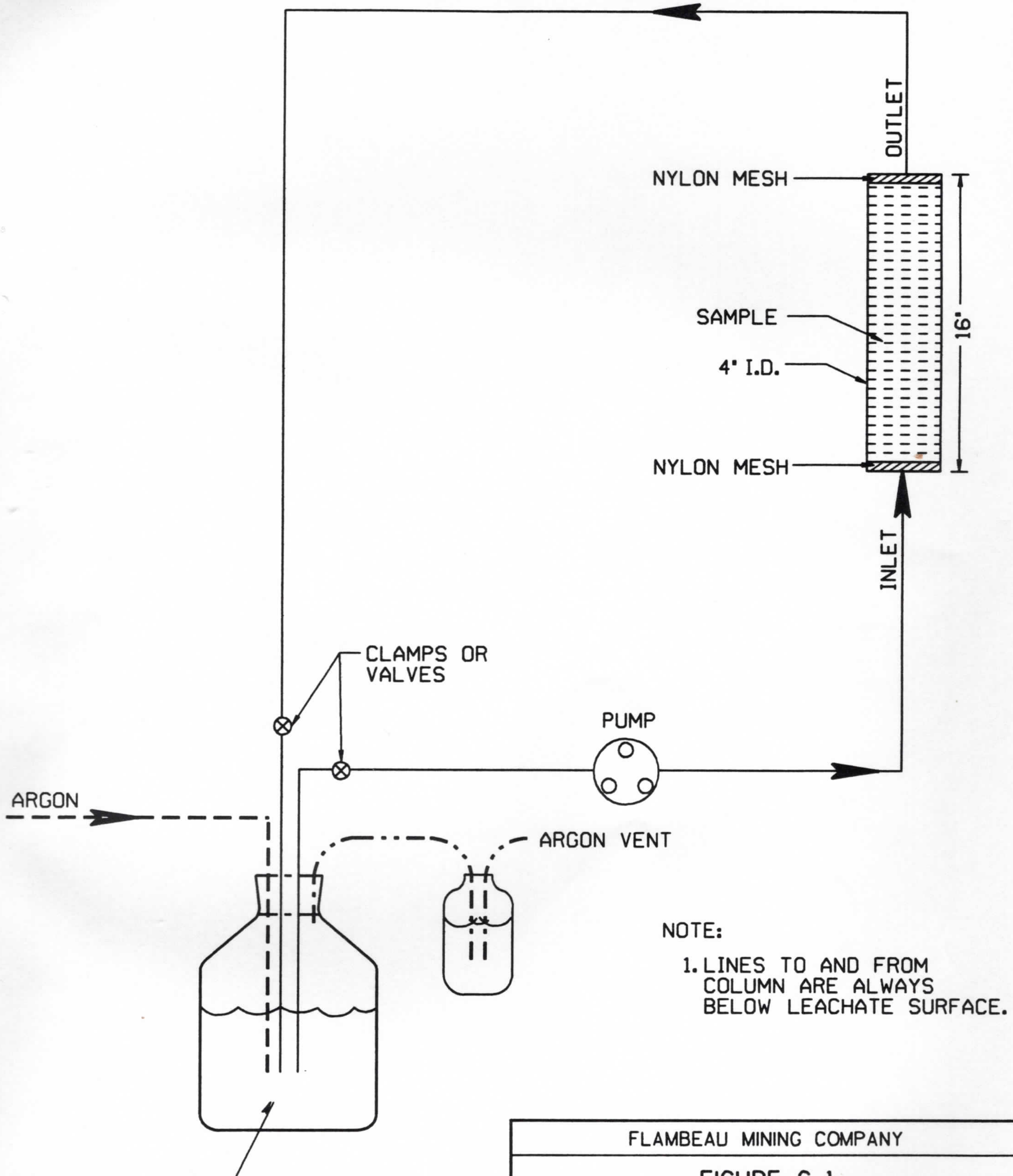
   The pH and conductivity measurements taken every three days are monitored until no significant change in either parameter is detected for consecutive measurements, with a minimum of three measurements taken.

   After the pore water has equilibrated for the appropriate period of time, the outlet tube is removed from the water trap and placed in the leachate receptacle. To maintain anoxic conditions, the head space of the vessel is continuously flushed with argon gas. The pore water is then slowly displaced from the column with de-aerated (by vacuum) distilled water that is being sparged with argon to remove dissolved oxygen. The pore water should be displaced at a continuous rate of about 4 ml/min or less (i.e over a 4 hour or greater period), to minimize the effects of channel flow. The column is again sealed as before. The redox potential, pH and conductivity of the displaced pore water is to be obtained while maintaining anoxic conditions. The solute is then split, filtered and preserved as appropriate for dissolved constituent analysis.

Step 3 is repeated until no significant change in the pH and conductivity is observed. Step 4 is then repeated for a minimum of two solute samples. At this stage the test results will be assessed with respect to equilibrium pH and conductivity to determine the need for continuing the test.

List of Analytes

field pH, field redox, field conductivity, field alkalinity/acidity
Anions: SO_4^{2-}
Cations: Cd, Ca, Cu, Fe(T), Mn, Mg, and Zn



NOTE:

1. LINES TO AND FROM COLUMN ARE ALWAYS BELOW LEACHATE SURFACE.

FLAMBEAU MINING COMPANY			
FIGURE C-1 TYPICAL ANOXIC COLUMN TEST SET-UP			
Scale: NOT TO SCALE		Date: MARCH, 1997	
Prepared By: Foth & Van Dyke			By: JOW

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