PREDICTION OF ACID ROCK DRAINAGE

RED MOUNTAIN PROJECT

by

SCOTT FROSTAD

B.Sc., University of Western Ontario, 1984

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTERS OF APPLIED SCIENCE

in

THE FACULTY OF GRADUATE STUDIES

(Department of Mining and Mineral Process Engineering)

We accept this thesis as conforming

to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

April, 1999

© Scott Frostad, 1999

In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the head of my department or by his or her representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of MMPE

The University of British Columbia
Vancouver, Canada

Date April 22ND /99

DE-6 (2/88)

ABSTRACT

Mine waste planning and management is essential to minimize the environmental impacts resulting from the deposition of mine and milling wastes, particularly with respect to acid rock drainage (ARD). Kinetic tests such as humidity cells are widely used in an attempt to predict the rates of acid generation and neutralization, water quality and time to onset of acidity. Results from a kinetic prediction program to assist in the development of a waste management plan for the Red Mountain project in North-western British Columbia have been used to evaluate the effects of testing under a variety of controlled conditions and to make long term predictions. Results of laboratory tests conducted on samples with masses of 1 to 50 kg were compared to large scale (20-tonne) test results conducted at the mine site.

Non-aerated cells provided rates of weathering that were similar to the standard humidity cells. The advantages of the non-aerated test protocol over the standard humidity cell include:

- improved repeatability of results,
- less expensive apparatus,
- easier to operate, and
- require less time to obtain rates of weathering.

Increasing the volume of leach water did not influence the sulfate release rate, yet it increased the rate of neutralization potential (NP) depletion. The results indicate that water addition to kinetic tests must be sufficient to remove weathering products but must not be excessive that may artificially inflate NP depletion.

The cumulative amount of Mg and Ca released at the point of acidity was greater for column

tests than for humidity cells, which was attributed to the test protocol. Therefore, predicting time to acidity from estimates of NP depletion are questionable. Based on the testwork, time to acidity seems to relate better to measurements of cumulative sulfate release (acid production).

Laboratory oxidation rates, corrected for surface area and temperature, could not be scaled up to predict the field results. Therefore extensive laboratory kinetic test programs that attempt to account for variations in waste pile rock types are considered unwarranted until the models used to scale-up laboratory data are validated.

The large scale field tests produced results that were difficult to interpret and inconsistent when compared to the laboratory tests. In addition, field tests are prohibitively expensive and time consuming. Therefore, before conducting field tests, careful consideration of the expected results and test protocols is required.

ACKNOWLEDGMENTS

I would like to thank my advisors, Dr. R. W. Lawrence and Dr. B. Klein, and my committee members, Mr. W.W. White III and Dr. G. Poling for their informative discussions and valuable critique.

Financial support from the mining industry was considerable and I would like to thank Lac Minerals Ltd. (Mr. D. Cawood, Mr. G. MacVeigh), American Barrick (Mr. J. McDonough) and Royal Oak (Mr. R. Allan, Mr. L. Connell). Financing was also supplied by a Natural Science and Engineering Research Council (NSERC) Grant.

I gratefully acknowledge the help provided by Dr. Mory Ghomshi and Harold Bent who both contributed important ideas. I would like to thank Frank Armitage, Janet Wong of Rescan Environmental Services, and staff of Lac Minerals and Royal Oak for contributing time towards the field portion of this thesis. I would also like to thank Ragnar Udd and Mohammad Dadmanesh for their contributions towards the laboratory testwork.

The support of Frank Schmidiger, Pius Lo, Larry Wong and Sally Finora, staff of the Department of Mining and Mineral Process Engineering, was tremendous. Discussions with fellow students, namely Paul Dagenais, Elizabeth Sherlock and Valerie Bertrand, helped make getting organized a little easier.

I would like to thank Mike Sieb for the considerable time he spent assisting with the final edits.

Finally, I want to acknowledge my wife, Katie Langdon, who gave me endless encouragement and provided me with valuable time by attending to our newborn son, Ethan.

TABLE OF CONTENTS

ABSTRACT ii
ACKNOWLEDGMENTS iv
TABLE OF CONTENTS v
LIST OF TABLES viii
LIST OF FIGURES ix
DEDICATION xii

1.0 INTRODUCTION 1

1.1 OBJECTIVES 4

2.0 REVIEW OF ACID ROCK DRAINAGE 5

2.1 ACID GENERATION 5
2.2 TESTS FOR PREDICTING ACID ROCK DRAINAGE 9
2.2.1 Static Tests 9
2.2.2 Kinetic Tests 11
2.3 COMPARISON OF LARGE SCALE/FIELD AND LABORATORY DATA 14
2.4 PREDICTION 17

3.0 RED MOUNTAIN DEPOSIT 21

3.1 LOCATION AND PHYSIOGRAPHY 21
3.2 GEOLOGY 21
3.3 CLIMATE 24

4.0 EXPERIMENTAL METHODS AND PROCEDURES 25

4.1 WASTE ROCK CHARACTERIZATION 25
4.1.1 Sample Selection 25
4.1.2 Crushing, Screening and Splitting 27
4.1.3 Specific Gravity Determination 28
4.1.4 Grain Size Distribution 28
4.1.5 Void Ratio 31
4.1.6 Specific Surface Area 33
4.1.7 Mass and Total Surface Area Estimates of Field Cell Samples 35
4.1.8 Mineralogy 35
4.1.9 Acid-Base Accounting 37

4.2 KINETIC TEST TYPE AND OPERATION 39
4.2.1 Standard Cells 40
4.2.2 Tall Cells 43
4.2.3 Shaken Cells 43
4.2.4 Non-aerated Cell 45
4.2.5 Simulated Precipitation Cells 45
4.2.6 50-kg Cells 46
4.2.7 NP Columns 48
4.2.8 20-tonne (Field) Cells 50
4.3 LEACHATE ANALYTICAL PROCEDURES 53
4.4 DATA MANIPULATION 55

5.0 RESULTS AND DISCUSSION 59

5.1 STANDARD, TALL AND SHAKEN CELLS 59
5.1.1 Results 59
5.1.2 Discussion 68
5.1.2.1 Tall vs. Standard Cells 70
5.1.2.2 Trickle-leach vs. Shaken Cells 71
5.2 NON-AERATED CELL 73
5.2.1 Results 73
5.2.2 Discussion 74
5.3 SIMULATED PRECIPITATION CELLS 74
5.3.1 Results 74
5.3.2 Discussion 78
5.4 50-KG CELLS 81
5.4.1 Results 81
5.4.2 Discussion 87
5.5 NP COLUMNS 89
5.5.1 Results 89
5.5.2 Discussion 93
5.6 20-TONNE (FIELD) CELLS 94
5.6.1 Results 94
5.6.1.1 Water Storage and Discharge 97
5.6.1.2 Estimate of Sulfate Production Rates 98
5.6.1.1 Predicted Time to Acidity for Field Cells 102
5.6.2 Discussion 103

6.0 CONCLUSIONS AND RECOMMENDATIONS 107

7.0 REFERENCES 112

Appendix 1 Specific Surface Area Calculations 120

Appendix 2 Sample Analyses 126

Appendix 3 Modified ABA Procedure 132

Appendix 4 Graphic Comparisons - Standard, Non-aerated, Tall, and Shaken Cells 134

Appendix 5 Graphic Comparisons - NP Columns to Standard, Tall, and Shaken Cells 151

Appendix 6 Graphic Comparisons - 20-tonne (Field) Cells 157

Appendix 7 Tabulated Results - Standard Cells 165

Appendix 8 Tabulated Results - Tall Cells 182

Appendix 9 Tabulated Results - Shaken Cells 193

Appendix 10 Tabulated Results - Non-Aerated Cell 204

Appendix 11 Tabulated Results - Simulated Precipitation Cells 207

Appendix 12 Tabulated Results - 50-kg Cells 220

Appendix 13 Tabulated Results - NP Columns 225

Appendix 14 Daily Averages of Water Flow, pH, and Conductivity – 20-tonne (Field) Cells 236

Appendix 15 Daily Averages of External Air Temperatures and Internal Temperatures – 20-tonne (Field) Cells 241

Appendix 16 Water Chemistry - 20-tonne (Field) Cells 246

LIST OF TABLES

Table 1 Maximum, minimum and mean measurements of S.G. for samples HC-1 and HC-2 28

Table 2 Maximum, minimum and mean measurements of pore volume, and void ratios for the field cell samples 33

Table 3 Estimates of specific surface area 34

Table 4 Estimates of mass and total surface area for field cell samples 35

Table 5 Acid base accounting (ABA) results 38

Table 6 Summary of kinetic test program 40

Table 7 Summary of standard, tall and shaken cell results for feldspar porphyry samples 61

Table 8 Summary of standard, tall and shaken cell results for sedimentary samples 67

Table 9 Cumulative sulfate release at five weeks for samples HC-1 and HC-2 86

Table 10 % sulfide and % NP depleted at the point of acidity for NP columns 91

Table 11 Sulfate production rates from laboratory (average of standard cell rates) corrected for field temperatures and from field for samples HC-1 and HC-2 102

Table 12 Kinetic test results and predictions of time to acidity 106

LIST OF FIGURES

Figure 1: Location map of Red Mountain deposit, Northwestern British Columbia 22

Figure 2: Location map of the five waste rock samples 26

Figure 3: Homogenizing 20-tonne (field) cell material for splitting prior to sieve analysis 30

Figure 4: Sieve analysis of 20-tonne (field) cell material 30

Figure 5: Grain size distribution curves for two samples chosen for testing at various scales, HC-1 (porphyry intrusive) and HC-2 (sediment) 32

Figure 6: Grain size distribution curves for all five samples crushed to 100% passing $^1/_4$ inch 32

Figure 7: Standard humidity cells - frontal view 41

Figure 8: Standard and tall cells - side view 41

Figure 9: Tall cells - frontal view 44

Figure 10: 50-kg cells (photograph) 47

Figure 11: NP columns (photograph) 49

Figure 12: 20-tonne (field) cells (photograph) 51

Figure 13: Floor of 20-tonne (field) cell showing drainage control 51

Figure 14: Water pipe manifold, water collection vessel, and tipping bucket for 20-tonne (field) cells 52

Figure 15: pH and conductivity probes attached to water collection vessel lid 52

Figure 16: Sulfate production over time from standard, tall and shaken cells containing sample ABA-3 (feldspar porphyry with 5% pyrite) 62

Figure 17: Sulfate production over time from standard, non-aerated, tall and shaken cells containing sample HC-1 (feldspar porphyry with 5% pyrite, 3% pyrrhotite) 63

Figure 18: Sulfate production over time from standard, tall and shaken cells containing sample ABA-2 (feldspar porphyry with 7% pyrrhotite) 64

Figure 19: Sulfate production rates, carbonate molar ratios and average gravimetric water content from standard, non-aerated, tall and shaken cells containing feldspar porphyry samples ABA-3, HC-1 and ABA-2 65

Figure 20: Sulfate release over time from simulated precipitation cells containing sample HC-1 76

Figure 21: Carbonate molar ratio over time from simulated precipitation cells containing sample HC-1 77

Figure 22: pH, conductivity, sulfate production, carbonate molar ratio and recovered leachate volume over time from 50-kg cell containing feldspar porphyry sample HC-1 83

Figure 23: pH, conductivity, sulfate production, carbonate molar ratio and recovered leachate volume over time from 50-kg cell containing sedimentary sample HC-2 84

Figure 24: NP columns showing oxidation fronts of the samples HC-1, HC-2, ABA-1, ABA-2, ABA-3 from left to right 90

Figure 25: % sulfide depleted, % NP depleted and time to acidity from humidity cells and NP columns for sedimentary samples HC-2 and ABA-1 92

Figure 26: pH, conductivity, carbonate molar ratio and outflow from June 13 to September 19, 1996 for the two 20 tonne (field) cells containing samples HC-1 and HC-2 95

Figure 27: Weekly water inflow, outflow and degree of saturation from August 7 to October 31, 1995 and from June 13 to September 19, 1996 for the 20-tonne (field) cells 99

Figure 28: Void ratio versus % saturation at field capacity moisture contents (after Dawson and Morgenstern, 1995) with point locations of the 20-tonne (field) cell samples HC-1 and HC-2 100

Figure 29: Sulfate versus conductivity for 1995 and 1996 water samples collected from 20-tonne (field) cells containing samples HC-1 and HC-2 100

DEDICATION

This thesis is dedicated to the memory of Mr. David Cawood, Red Mountain project manager for Lac Minerals Ltd. It was due to the initial support of Mr. Cawood that this thesis became possible. Dave was an inspiration and joy to those of us who worked with him. He is missed.

1.0 INTRODUCTION

Acid rock drainage (ARD) is an immense environmental liability to the mining industry. ARD results when sulfide minerals (principally pyrite) within mine wastes are oxidized upon exposure to air and water. It typically has a high concentration of dissolved metals and therefore the potential to impact local aquatic life adversely and creates a hazard to public health. The magnitude of the problem in Canada is reflected by the mass estimate of acid-generating wastes being over 2.5 billion tonnes (Feasby and Jones, 1994). The long-term maintenance costs of these materials to ensure protection of the environment is estimated to be between $2 and $5 billion (Geocon, 1995).

The primary reason for such a buildup of potentially harmful wastes is due to ARD being a time dependent process that may not occur until years or decades after the mine waste is produced. This acid generating process has been shown through research and field observations to be very difficult to stop once started (Feasby et al., 1997). For this reason, the preferable method of controlling ARD is to prevent it from occurring. Disposing of waste rock underwater before sulfide minerals begin to oxidize is regarded as the best ARD prevention technology and, as a consequence, all new mines in Canada are required to use engineered flooded impoundments where possible (Feasby et al., 1997).

Tests have been developed that attempt to accurately determine the acid producing potential of mine wastes. The simplest of these is the acid base accounting (ABA) static test and its modifications (Sobek et al., 1978, Lawrence and Wang, 1997) that quantifies the acid-producing and acid-neutralizing minerals contained in a sample of waste. In British Columbia, a rock is presently judged as having no ARD concern if its neutralizing capability is four times its acid

potential (Price et al., 1997). This safety factor may appear extreme but it exemplifies the low level of confidence placed on ARD prediction techniques. This static test has poor predictive qualities because kinetic processes control the ARD phenomenon. For better predictions, therefore, the reaction rates of the minerals involved must be considered. Even if an ABA test shows a sample as having more neutralizing potential than acid potential, ARD can occur if the rate of acid generation is faster than the rate at which it is neutralized.

Kinetic tests are conducted for samples deemed as having an uncertain potential to produce ARD or to determine metal leaching characteristics. The tests can provide a measure of the relative rates of acid generation and neutralization. A standard kinetic test is the humidity cell that subjects a sample to artificial weathering. Monitoring the quality of leachate provides mineral reaction rates that are then used to predict (1) waste pile drainage chemistry, (2) if ARD will occur, and if so (3) when ARD will occur.

Confidence in the ARD predictions is critical to enable mining wastes to be handled in a cost efficient and environmentally acceptable manner. Decisions must be made as to which portion of the waste may be deposited safely and which portion will need to be subjected to oxidation control such as being stored in an expensive engineered impoundment. For some mine waste management plans, predictions of how long a rock pile can be exposed to site conditions before being disposed of underwater may be critical. Unless regulators have confidence in the ARD predictions, they must include a high factor of safety to ensure that land and watercourses are protected. Unfortunately, results can differ for similar samples due to the various kinetic test methodologies used at different laboratories. Predicting the long term behaviour of a waste pile exposed to site-specific conditions requires scaling up of the test results using numerous site-

specific parameters that must be measured and/or estimated.

An effective kinetic test methodology returns repeatable and precise results that can be interpreted with consistency. Obtaining repeatable results from a kinetic test requires a firm control of the operating conditions, while precision generally improves with test duration. A solid interpretation of the test results needs a thorough knowledge of the processes that occur as a result of the imposed conditions and sample mineralogy. Scaling up the results of kinetic testwork to make predictions of the long term weathering reactions of a waste dump requires the differences between a laboratory kinetic test and an actual waste dump to be considered.

The study reported in this thesis involved an extensive kinetic prediction program using samples from the Red Mountain mine development in British Columbia to make long term predictions of waste rock weathering and to evaluate the effects of testing under a variety of controlled conditions. Tests were conducted on samples weighing 1 to 3 kg and under different protocols to evaluate the dependence of the data and the resulting interpretations on the procedures. Kinetic testing was conducted on samples of different sizes using 50 kg samples in the laboratory and 20 tonne samples at the mine site to allow calculation of rate coefficients for scale-up. To assist in scaling up laboratory rates to actual field conditions, the influence of simulated precipitation events of various frequencies, duration and intensity were examined. Tests to determine the effective neutralization potential were also carried out with the purpose of refining predictions of when a waste pile will become an acid generator.

1.1 Objectives

The objectives of this research were to:

- Develop specific kinetic test protocols that can be used for ARD prediction evaluations for other mine developments in Canada and elsewhere.
- Carry out kinetic weathering tests on mine waste rock under various conditions and at different scales within the laboratory and the field to provide more confidence in scaling up laboratory data to predict the weathering characteristics of a waste dump.
- Provide the future mine operators of the proposed Red Mountain Mine in British Columbia with more precise prediction data to assist in permit application and to provide more cost effective and confident development of the waste management plan for environmental protection.

2.0 REVIEW OF ACID ROCK DRAINAGE

2.1 Acid Generation

Mine wastes typically contain a high proportion of sulfide minerals. These minerals are formed at high temperatures and pressure within the earth and become unstable when exposed at the earth's surface. The sulfides are oxidized by a series of chemical and biological reactions with oxygen and ferric iron (Fe^{3+}) being the most important oxidants. The reaction for pyrite oxidation by dissolved oxygen proceeds as follows (Stumm and Morgan, 1981; Ehrlich, 1981):

$$\mathbf{FeS_2 + H_2O + 7/2\ O_2 \rightarrow Fe^{2+} + 2SO_4^{2-} + 2H^+} \qquad \mathbf{(1)}$$

Although reaction (1) occurs abiotically, catalysis of the oxidation by sulfide oxidizing bacteria can accelerate the reaction rate by several orders of magnitude (Stumm and Morgan, 1981; Kleinmann et al., 1981; McKibben and Barnes, 1986; Nicholson et al., 1988). This biotic increase of the oxidation rate has been shown to primarily occur when the pH is below 4 (Arkesteyn, 1980).

A second reaction associated with the formation of ARD is the oxidation of ferrous iron to the ferric form (Stumm and Morgan, 1981; Ehrlich, 1981) :

$$\mathbf{Fe^{2+} + 1/4\ O_2 + H^+ \rightarrow Fe^{3+} + 1/2H_2O} \qquad \mathbf{(2)}$$

The oxidation of pyrite by ferric iron is expressed as (Stumm and Morgan, 1981):

$$FeS_2 + 14Fe^{3+} + 8H_2O \rightarrow 15Fe^{2+} + 2SO_4^{2-} + 16H^+ \quad (3)$$

Studies by Moses et al. (1987) and Moses and Herman (1991) found ferric iron to be the preferred oxidant of pyrite (reaction 3) in the neutral pH range, and that the major role of oxygen is to oxidize ferrous iron (reaction 2), despite the low solubility of ferric iron in the higher range of pH. At low pH ranges, Moses et al. (1987) reported ferric iron oxidation rates at least 2 orders of magnitude higher than oxidation by dissolved oxygen. The production of ferrous iron by the reactions (1) and (3) provides further substrate for bacterial oxidation and thereby creates more ferric iron for further sulfide oxidation.

Ferric iron may also undergo hydrolysis and precipitate as ferric hydroxide which generates three moles of acidity for each mole of iron. When the pH is above 4, the common reaction is:

$$Fe^{3+} + 3H_2O \rightarrow Fe(OH)_3 + 3H^+ \quad (4)$$

Other ferric iron minerals can precipitate, such as goethite (α - FeOOH), or schwertmannite ($Fe_8O_8(OH)_6SO_4$) (Bigham et al., 1990), releasing varying amounts of H^+. The orange-brown staining of iron oxides can usually be observed visually.

Pyrrhotite ($Fe_{(1-x)}S_2$) is another common iron sulfide mineral and is abundant within the Red Mountain waste rock. The reaction for pyrrhotite oxidation by dissolved oxygen can be written as:

$$Fe_{(1-x)}S + (2 - x/2)O_2 + xH_20 \rightarrow (1-x)Fe^{2+} + SO_4^{2-} + 2xH^+ \quad (5)$$

and the oxidation of pyrrhotite by ferric iron as:

$$Fe_{(1-x)}S + (8 - 2x)Fe^{3+} + 4H_20 \rightarrow (9-3x)Fe^{2+} + SO_4^{2-} + 8H^+ \quad (6)$$

As with pyrite, the oxidation of pyrrhotite by ferric iron is faster than oxidation by oxygen (Janzen et al., 1997).

Pyrrhotite has been shown to oxidize at a faster rate than pyrite (Flann and Lucaszewski, 1970; Kakovsky and Kosikov, 1975; Nicholson and Scharer, 1994; Janzen et al., 1997). A recent study by Janzen et al. (1997) found that the specific surface area of pyrrhotite is as much as ten times higher than pyrite. They found fractures along cleavage planes and surface roughness to cause the specific surface area of pyrrhotite to be 6 to 40 times greater than the theoretical specific surface area as calculated from a spherical geometry. Their results also demonstrated that as the particle size of pyrrhotite decreases, the rate of oxidation (corrected for measured surface area) increases. Crushing of pyrrhotite crystals was considered to increase the defect density, and thus the surface area available for oxidation. Furthermore, different size reduction methods produced various specific surface areas reflecting different breakage mechanisms imposed on the pyrrhotite sample used.

Other explanations for the higher oxidation rate of pyrrhotite than pyrite include the non-oxidative dissolution of pyrrhotite, which appears to be a significant contributor of ferrous iron release in weathering (Janzen et al., 1997). The ferrous iron would be available for oxidation to ferric iron (reaction 2) thereby promoting pyrrhotite oxidation (reaction 6). No reason was given by Janzen et al. (1997) as to why the non-oxidative dissolution rates differed for the twelve samples they evaluated. It has also been suggested that the deficiency of iron in the crystal

structure of pyrrhotite may create a lower stability of the crystal lattice than that of pyrite (Vaughan and Craig, 1978). It should be noted that pyrrhotite generates less acid per mole than pyrite due to its lower content of iron. However, with oxidation rates that are 20 to 100 times faster, pyrrhotite can produce greater quantities of acid in a given period of time.

Neutralization of acidity is primarily from calcium carbonate and magnesium carbonate minerals when present in the waste rocks (Kleinmann et al, 1981; Lapakko, 1994a). Examples of these minerals include calcite ($CaCO_3$), magnesite ($MgCO_3$) and dolomite ($CaMg(CO_3)_2$). The reactions for calcite and magnesite when the pH is above approximately 6.3 are:

$$\mathbf{CaCO_3 + H^+ \rightarrow HCO_3^- + Ca^{2+}} \quad \textbf{(7)}$$

$$\mathbf{MgCO_3 + H^+ \rightarrow HCO_3^- + Mg^{2+}} \quad \textbf{(8)}$$

and when the pH is below approximately 6.3:

$$\mathbf{CaCO_3 + 2H^+ \rightarrow H_2CO_3 + Ca^{2+}} \quad \textbf{(9)}$$

$$\mathbf{MgCO_3 + H^+ \rightarrow H_2CO_3 + Mg^{2+}} \quad \textbf{(10)}$$

Calcite is the most important neutralizing mineral as it has been shown to be the most reactive carbonate, dissolving at a faster rate than magnesite and dolomite (Rauch and White, 1977; Busenberg and Plummer, 1986). The dissolution rate of carbonate minerals is primarily determined by pH with the rate of dissolution increasing with a decrease in pH. Other important rate determining factors include the partial pressure of carbon dioxide and equilibrium

conditions. If the dissolution of carbonates is occurring in water that is in contact with a gas phase, then carbon dioxide is able to enter the water to maintain equilibrium. The solubility of carbonates within water that is in contact with a gas phase is greater than carbonates within water that does not have gas exchange (Stumm and Morgan, 1981).

Silicate minerals may also provide a source of neutralization (Busenberg and Clemency, 1976; Sherlock et al., 1995; Kwong and Ferguson, 1997) but they are far less effective neutralizers than carbonates due to their slow dissolution rates. The effectiveness of silicate minerals as neutralizers of acidity is optimized by:

- a slow rate of acid production,
- a high percentage of the mineralogy is comprised of silicate minerals, and
- the exposed surface area of the silicate minerals is large (Morin and Hutt, 1994).

A recent study by Kwong and Ferguson (1997) demonstrated that mafic silicates like biotite, pyroxene, chlorite, epidote and amphibole are more efficient acid-neutralizing minerals than feldspar, but they are typically less abundant.

2.2 Tests for Predicting Acid Rock Drainage

The tests for predicting ARD are referred to as either static or kinetic.

2.2.1 Static Tests

A static test is an initial test used to determine the acid producing potential and neutralization

potential of a sample. Acid Base Accounting (ABA) is a static test used to determine the acid potential (AP) and the neutralizing potential (NP) of a sample and the difference between the two values provides an indication of the net neutralizing potential (Net NP) which can be negative or positive. The acid potential (AP) of a sample is the theoretical quantity of acid that would be produced if the total sulfur content or, in some test procedures, the sulfide-sulfur content were converted to sulfuric acid. The determination of total sulfur and sulfur species are simple procedures with repeatable results. The neutralization potential (NP) is a more difficult parameter to measure due to the variety and reactivity of the minerals involved.

The NP determination test of Sobek et al. (1978), used widely in the mining industry, involves boiling a finely ground sample in an excess of hydrochloric acid then back-titrating the residual acid with sodium hydroxide to pH 7.0. This procedure has been shown by Lawrence and Wang (1996) to overestimate NP in some cases because the highly acidic conditions of the test allows slow-reacting silicate minerals, which would not contribute alkalinity under field conditions, to contribute to the apparent NP. Lawrence (1990) developed the Modified Acid Base Accounting Procedure to address this problem of overestimation. The sample digestion stage of the procedure, more recently modified by Lawrence and Wang (1996), is performed at ambient temperatures for a longer time period than the Sobek procedure. In addition, the amount of acid added is controlled so that the pH at the end of the digestion stage remains within a specific range (2.0 to 2.5). Another means of determining NP is by measuring the inorganic carbon content of a sample, thus obtaining a measure of the quantity of carbonate minerals. However, this test has the potential to overestimate NP by including iron and manganese carbonates that provide no net neutralization of acid (Norecol, 1991; Lapakko, 1994a; Li, 1997).

A recent study by White et al. (1998) examined the effects of protocol variables and sample mineralogy on static test NP. Static tests showed that NP variability for a given sample was strongly influenced by differences in sample particle size, amount of acid addition, and back-titration endpoint, influenced in one test by digestion duration, and virtually unaffected by acid type and temperature of digestion. It was also shown that the extent to which the protocol variables influenced the NP values was a function of sample mineralogy.

2.2.2 Kinetic Tests

Kinetic tests, in which a sample is subjected to periodic leaching cycles to simulate weathering, are carried out to determine the acid generation and metal leaching characteristics of the sample. Such tests are carried out to confirm the acid generating potential of a sample as predicted in static testing and/or to predict water quality of resultant drainage. A kinetic test subjects a sample to weathering to provide predictions of relative rates of sulfide oxidation and neutralizing mineral dissolution and water quality. These rates can be used to determine if a sample will produce acidic drainage more accurately then an ABA test. The rates may also be used to predict when a waste pile will begin producing acidic drainage. This estimation could be critical for mining operations where waste rock is exposed to field conditions before control measures, such as underwater disposal, can be applied.

An accelerated-weathering humidity cell apparatus and procedure was developed by Caruccio (1968). The humidity cell has since been modified and the protocol changed by researchers, industry and government. Typically, the test involves placing a crushed sample into a vessel, subjecting it to cycles of dry and humidified air, followed by weekly rinses and collection of weathering products. The resultant rinse water volume and chemistry is then related to the rock

weight or surface area to determine rates of sulfate production (sulfide oxidation), neutralization and metal release. A cell procedure, as modified by Lawrence (1990), still uses the 7-day cycle of 3 days of dry air followed by 3 days of humid air but the air is no longer supplied to the upper surface of the sample. Instead, air enters the bottom of a cylindrical cell, passes through a sample (typically 1 kg and crushed to minus 6 mm (-¼ inch)), and exits through the top. Leaching of the weathering products is conducted on the seventh day with distilled, deionized water and involves trickling water through the sample or flooding the sample then draining.

Obtaining repeatable results from laboratory kinetic tests can be difficult due to fluctuations in the operating conditions. The parameters that may vary during a test are airflow, air humidity, temperature and the percentage of water removed during aeration. Humidity cell tests conducted by the U.S. Bureau of Mines (USBM) showed that the precision of humidity cell test data improves with a consistent airflow (Pool and Balderrama, 1994). They also found that the percent of pore water removed and amount of leachate recovered can affect the rate of acid production. The USBM made several improvements to the design of Lawrence (1990) to ensure more consistent airflow and humidity to the cells and incorporated these into a U.S. ASTM standard (White and Sorini, 1997). One addition is the use of vessels of water through which air exiting the cells must bubble. The bubbling water allows for visual determination of the airflow rate through individual cells which may then be adjusted by screw clamps or valves. Another improvement is the use of a desiccant column to ensure dry air during the dry-air cycle.

Column weathering tests and soxhlet reactors are other examples of laboratory kinetic tests. Bradham and Caruccio (1990) carried out a comparative study of these two procedures against the standard humidity cell test. The column tests, much larger than the humidity cells, were also

leached on a weekly basis but not supplied with pumped air. The soxhlet reactor method requires a pulverized sample to be kept in a drying oven at 105° C and is leached on a weekly basis in a soxhlet extractor for two hours. The samples (tailings) retained a high volume of water in the column tests due to the fine particle fraction used. This environment of constant saturation was found to favour the dissolution of carbonates and inhibit pyrite oxidation. The humidity cell tests accelerated the rate of pyrite oxidation relative to carbonate dissolution while the soxhlet extractors accelerated the dissolution of calcium carbonate relative to pyrite oxidation. Whether a specific sample would release acidic or alkaline leachate was concluded to be dependent upon the balance of the acidic water and alkaline water produced. The amount of acidic and alkaline water produced was, in turn, considered to be a function of the amount of acid and alkaline producing materials, and of the rates of both reactions. The reaction rates were found dependent upon the leaching method used.

Large scale laboratory and field kinetic tests have been performed by a variety of researchers in an attempt to relate small scale results to actual field processes. A large scale laboratory kinetic test is the SRK modified humidity cell (Brodie et al., 1991). It is constructed with 30-cm diameter PVC pipe and holds 50 to 65 kg of material with a particle size of 100% finer than 10 cm. The weekly water is applied with a trickle leach over 5 days with 50% added on the last day to simulate a rainfall flush. Limited volumes of water are used to approximate field estimated rates and conducted specifically so that not all the oxidation product is removed. Brodie et al. (1991) contend that the standard humidity cell flush, intended to completely remove all oxidation products, significantly alters the chemical environment of the test specimen.

Field scale cells were constructed by Rescan (1992) at the Kutcho Creek mine site near Dease

Lake, BC. Three wooden cribs, having slatted walls lined with geotextile, were each filled with 20 tonnes of waste rock. The crib floors were sloped and lined with high-density polyethylene to direct water into collection buckets. Pile temperatures and site rainfall were recorded with a datalogger and the collected water was periodically sampled. The total infiltration of these pads was roughly, on a mass basis, a factor of 100 less than the flushing rate used in the laboratory humidity cell tests.

An ongoing study involving five field test piles, ranging from 820 to 1300 tonnes, was initiated by the Minnesota Department of Natural Resources (MNDNR), Division of Minerals in 1978 (Eger and Lapakko, 1981, 1985; Lapakko, 1994b). The piles were constructed on a liner sloped towards a perforated plastic pipe fitted with a cumulative flow meter and a flow-weighted composite sampler. For each pump discharge, a fixed volume of sample was placed into a compositing container and analyzed weekly through 1990 and biweekly afterwards. It was determined that the volume of rinse water per unit mass of rock was roughly three orders of magnitude lower than the laboratory experiments.

2.3 Comparison of Large Scale/Field and Laboratory Data

To address the difficulty of scaling up laboratory results, the SRK modified humidity cells and the two field tests previously described were complimented with standard humidity cell testwork. The SRK cell, when charged with a sample having a high ARD potential (Net NP of -499), showed a change in pH from 7.4 to 3.6 during the initial twelve weeks of testing, while the standard humidity cell changed from pH 7.3 to 6.0 during the same period of testing (Brodie et al., 1991). Lapakko (1994b) noted that of the five waste piles studied, the two piles with the highest sulfur content had lower pH drainage in the field (by 1 to 1.5 units) than returned from

the laboratory. Rescan (1992) considered one of their Kutcho field tests (blended sample with a till cap) to be more reactive then expected having a pH drop to between 3 and 4 during the second year. The laboratory humidity cell having the same blended sample maintained a neutral pH but was only conducted for a 20 week period. The following explanations were offered:

- the low flushing rate of large scale tests creates a high production of acid water due to a large quantity of unflushed acid products, enough to overwhelm the neutralization potential (Rescan, 1992; Lapakko, 1994b), and
- a high flushing rate in a humidity cell creates a high production of alkaline water since the minus ¼" material used has a high exposure of neutralizing minerals (Brodie et al., 1991).

These explanations, that leach volume influences the balance of acid and alkaline water production and thus the drainage quality, are supported by the previously discussed findings of Bradham and Caruccio (1990).

The proportion of exposed (available) sulfides, on a surface area basis, may be higher within waste rock dumps than laboratory samples. Studies by Lapakko (1994b) and Price and Kwong (1997) have shown an increase of sulfide content with decreasing particle size. Price and Kwong (1997) considered the differences in sulfide content between particle size fractions to result from variation in the strength, cohesion and distribution of the primary minerals in the primary rock. They suggest that if rock particles were preferentially breaking along sulfidic seams as the particle size of a sample is reduced, then fine sulfide particles would accumulate. Lapakko (1994b) suggested that an elevated sulfide content within the fine fraction might produce different results for a sample within the field than would be measured within the laboratory. He contends that since the fine fraction of the field rock is responsible for most of the specific surface area, there would be a higher proportion of sulfide minerals exposed in the field than in

the laboratory when compared on a surface area basis.

The surface area of exposed sulfide minerals has been reported to be directly proportional to the oxidation rate (Sato, 1960a, 1960b; Nelson, 1978; Lapakko, 1980). A study that successfully used unit-surface-area to correlate laboratory humidity cell sulfate production rates with those obtained from an exposed minewall was carried out by Morin and Hutt (1995). The field procedure involved isolating a specific area of minewall with silicon caulking then periodically rinsing these areas and analyzing the water. They reported a sulfate production rate within 4% of the average laboratory sulfate rate obtained from humidity cells and columns.

The influence of variable precipitation events on leachate chemistry has been noted in field tests (Rescan, 1992; Bethune and Lockington, 1997) and in the laboratory (Day et al., 1997; Soregaroli and Lawrence, 1998). Chemical trends of drainage from the Rescan (1992) field scale cells were reported as being most affected by the rate of flushing from precipitation events. They concluded that the amount of sulfate released was proportional to water flow and the quantity of precipitated sulfate minerals that were easily soluble.

These findings are supported by Bethune and Lockington (1997) who contend that drainage chemistry from their four 80 tonne waste rock test piles in Brisbane, Australia was dependent upon the frequency, intensity and duration of storm events. They measured low pH values of field drainage when long periods between storm events were followed by high rainfall volume.

Results of reduced flushing frequency in the laboratory by Day et al. (1997) indicated that as the time between flushing increases, the average sulfate release rate decreases. Day et al. (1997) considered this to be caused by blinding of reaction products and/or chemical saturation of pore

water. Rinse water was applied at various frequencies, as well as different volumes, during a humidity cell test program by Soregaroli and Lawrence (1998). They concluded that standard humidity cells do not account for site specific, physical and geochemical controls such as wetting and mineral solubility, and may therefore significantly over-estimate waste pile release rates.

2.4 Prediction

Prediction of the time before a waste pile produces ARD (lag time) is typically done by using static ABA tests combined with kinetic humidity cell tests. By knowing the total NP of a sample and determining the rate of NP depletion from humidity cell tests, the lag time may be estimated. Predicting the lag time from NP depletion rates requires the assumption that ARD is produced once the available neutralizing minerals are depleted and sulfide minerals are continuing to oxidize. However, as discussed in Section 2.2, a measurement of NP is dependent upon the static test procedure used and the NP depletion rate upon the kinetic test procedure used. Another consideration is that the total NP is not available for neutralizing acidity since a portion of the neutralizing minerals is encapsulated within rock particles.

Predicting the lag time is routinely done by using various methods that can provide a range of values. One method is to consider a percentage of the NP as being unavailable. Rescan (1992) considered 50% of the NP determined by a static test as being unavailable at the Kutcho Creek project. Ferguson and Morin (1991) estimated an average unavailable NP of 73% from an ARD database. Another method is to use a specific amount of NP as being unavailable such as the 10-15 kg $CaCO_3$/tonne recently advocated by Morin and Hutt (1997). For the Red Mountain site, Morin and Hutt (1996) used humidity cell testwork to obtain a site-specific amount of 8 kg $CaCO_3$/tonne NP as being unavailable. Predictions based on these methods are difficult to use

with confidence because the factor of safety is difficult to discern. This point is exemplified by the kinetic field test program of Lapakko (1994b) finding that only 0.5% to 8% of ABA NP was depleted when drainage pH dropped below 6.0.

What needs to be considered in a lag time prediction method is how the site-specific conditions will affect the balance of acid and alkaline water production. This point can be demonstrated by the humidity cell test program of Day et al. (1997) that used samples having low sulfur and an NP ratio greater than 2. These samples returned low sulfate release rates and the rate of NP release was considered to be controlled by simple dissolution of carbonate minerals rather than acid production. A lag time prediction based on the carbonate dissolution rate, as controlled by the leaching conditions of the humidity cell test, would be in error if acid generation controlled the rate of carbonate dissolution in the field.

Li (1997) has recognized the importance of considering relative rates of acid and alkaline water production on lag time prediction. Li conducted humidity cell tests on materials that contained a high proportion of sulfides and slow-reacting neutralizing minerals. He found that the onset of acidity occurred before the depletion of NP as determined by static tests. Li contends the leachate became acidic because the rate of neutralization was slower than the rate of acid generation. He considers that available NP must be determined by conducting a humidity cell test past the onset of ARD or roughly estimated by applying mineral reactivity factors to mineralogical compositions.

Scaling up laboratory humidity cell reaction rates to the field must account for differences in temperature. Arrhenius suggested, in 1889, that temperature could be linked to reaction rates with an *activation energy* as described by:

$$k = A \exp [-E_a / RT] \quad (11)$$

where k is the reaction rate constant, A is the Arrhenius factor (units of k), E_a is the activation energy (J • mol^{-1}), R is the gas constant, 8.31 J • $mol^{-1}K^{-1}$, and T is the temperature (K). Humidity cell reaction rates may be related to the field by using temperature measurements from the site and the activation energy values for pyrite and pyrrhotite, provided by tables for specific pH ranges.

Understanding the hydrology of a waste pile is important since it directly influences air movement and temperature (Nicholson et al., 1989; Ritchie, 1994) and the long-term prediction of contaminant loading to the environment (López et al., 1997). A recent study by Newman et al. (1997) has shown that in unsaturated, layered systems such as waste rock piles, water may flow preferentially through the fine-grained material rather than the coarse-grained material. This is supported by observations of highly oxidized, fine-grained material surrounded by fresh waste rock by Robertson and Barton-Bridges (1990) who interpreted this as evidence of preferential oxidation within fine-grained layers. Since the fine particles contain most of the reactive surface area, preferential flow through the fines would facilitate efficient flushing of the weathering products. A thorough flushing of the fine material would explain the results of a recent study by Garvie et al. (1997) in which oxygen and temperature profiles of a 40 year old waste dump in Tasmania were measured. They found that the overall oxidation rate of the dump, as determined by oxygen and temperature measurements from nine probe holes, to be consistent with the sulfate load in the drainage. It was concluded that water infiltrating the dump must be interacting with all the oxidation sites and not with only a fraction of the total volume.

An accurate prediction of how a waste pile and its water quality will evolve with time requires some degree of modeling. An example is the long-term decrease in oxidation rate for a sulfide particle which is typically handled with a "shrinking core" model (Wen, 1968; Levenspiel, 1972; Lin et al., 1997). The rate of sulfide oxidation is considered to decrease as the reacted portion of the sulfide particle forms a barrier between a fresh surface and reactants (Jaynes et al., 1984; Davis and Ritchie, 1986). This model can also be used to account for a sulfide surface barrier created by a buildup of precipitated secondary minerals. The long-term influences of mineral precipitation and dissolution on waste pile water chemistry are typically accounted for using aqueous equilibrium models (Allison et al., 1990; see Jambor and Blowes, 1994). It is suggested by Morin et al. (1995) that a waste pile can accumulate weathering products as precipitated secondary minerals and that the dissolution rate of these minerals control waste dump sulfate and metal release rates.

A critical review of models applicable to ARD (Perkins et al., 1997) was recently completed for the Canadian MEND program. It was concluded that the geochemical models, such as the equilibrium approach, are useful for understanding the geochemical processes involved and comparing different decommissioning scenarios. They recommended that long-term predictions of water chemistry from waste piles be made using empirical/engineering models that are based on laboratory and field tests.

3.0 RED MOUNTAIN DEPOSIT

3.1 Location and Physiography

The Red Mountain gold-silver deposit is located 18 kilometers east of the port town of Stewart, British Columbia (Figure 1). It is bounded by the Cambria Icefield to the east and Bromley Glacier and its tributaries to the west. The area is characterized by steep terrain ranging from 550 m at the bottom of the Bitter Creek access road to 2129 m at the Red Mountain peak. Access is by helicopter from Stewart.

3.2 Geology

Red Mountain is underlain by Middle to Upper Triassic and Early Jurassic sedimentary and volcanic rocks (Anderson, 1993; Greig et al., 1994). Rhys et al. (1995) described the geology of the Red Mountain deposit in detail.

The sedimentary rocks are dark grey to black, commonly carbonaceous, massive to thinly bedded mudstone and siltstone. When proximal to intrusions they are tan to pale green in colour from carbon leaching and sericite alteration. These stratigraphic packages are seen to range from 1 to 200 metres in thickness.

Early Jurassic plutons, sills, and dykes have intruded the sedimentary-volcanic package. The largest intrusion, the Goldslide hornblende-feldspar porphyry, lies below the mountain peak. The orebody is proximal to the Goldslide intrusion, dips approximately 60° to the southwest, and occurs within both feldspar porphyry intrusive and sediments. The feldspar porphyry is fine to medium grained and contains 25 to 50%, 1 to 3 mm feldspar phenocrysts. The original

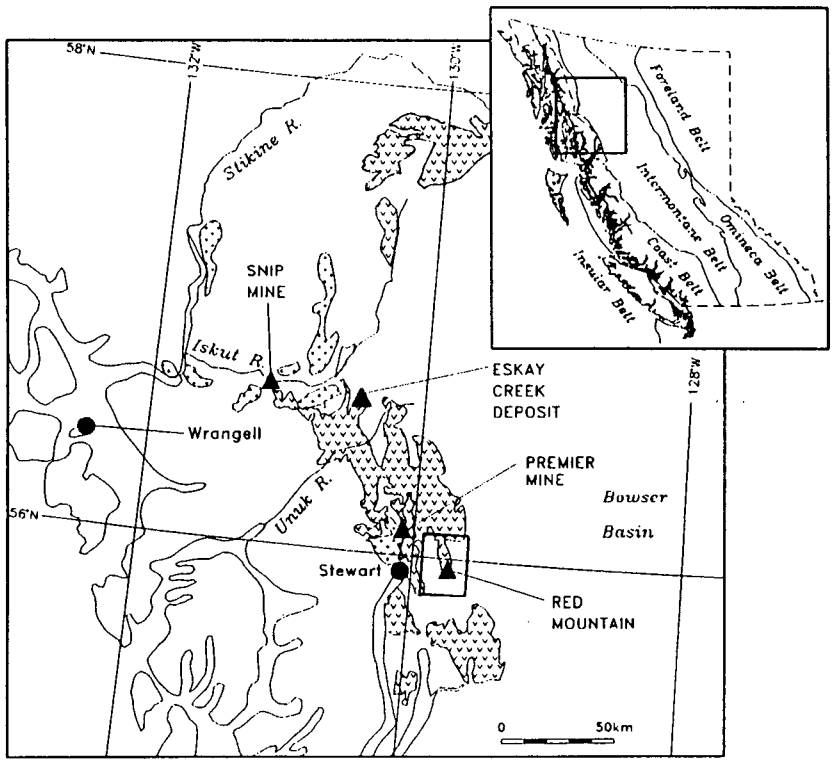


Figure 1: Location map of Red Mountain deposit, Northwestern British Columbia.

hornblende phenocrysts in these rocks have been almost completely altered to chlorite and muscovite.

Distinct zones of alteration were recognized at Red Mountain and are subparallel to the upper contact of the Goldslide porphyry (Thompson, 1994d; Rhys et al., 1997). Pyrite-dominant alteration occurs in the footwall rocks of the orebody and varies in thickness from 70 to 200 metres. This alteration zone is characterized by > 2% disseminated and veinlet pyrite within a cream to pale grey, sericite + quartz ± K-feldspar ± calcite-altered matrix. The pyrite ± quartz ± calcite ± sericite ± chlorite veins are 1 to 15 mm wide and locally up to 60 cm.

The gold and silver is hosted by zones of pyrite veins, veinlets, breccia veins and pervasively disseminated pyrite. The pyrite veins commonly have dark green chlorite envelopes, contain up to 15% quartz with minor amounts of chlorite, calcite and muscovite, and are typically 0.5 to 3.0 cm in width but up to 1 metre wide. This mineralization is typically hosted by pale grey, strongly sericite-altered feldspar porphyry or, less commonly, by tan to pale green, sericite altered mudstone and siltstone. A common feature of the gold and silver zones is an aureole of disseminated and vein sphalerite ± pyrrhotite that is developed in both the footwall and hanging-wall rocks and varies in thickness from 2 to 50 metres.

Pyrrhotite-dominant alteration occurs in the hanging-wall and is typically 100 to 200 metres thick. The pyrrhotite mineralization is > 0.5% and occurs as fine to medium grained disseminations and fracture fill. Mineralogy of this pervasive alteration, grey to brown grey in colour, is K-feldspar + chlorite + titanite + pyrrhotite ± pyrite ± carbonates ± albite. The veins of pyrrhotite ± pyrite ± chalcopyrite ± chlorite ± calcite ± quartz ± sphalerite ± galena veins are 0.3 to 2 cm in width and locally > 15 cm.

3.3 Climate

A high altitude and close proximity to the Pacific Ocean directly influences the Red Mountain climate. Significant precipitation falls in all months, with the Stewart Airport recording a mean annual precipitation of 1880 mm for the years 1974 to 1992. The average annual snowfall at the Airport is 7 meters. Stewart, at sea level, only receives one third of its precipitation by snow whereas the Red Mountain camp can receive snow at any time.

Precipitation at the project site (altitude 1,500 metres) was found to be similar to that received at the Stewart Airport (Rescan, 1994). A precipitation gauge, which utilizes antifreeze and a pressure transducer for measurement over all four seasons, was operated near the Red Mountain camp beginning in August 1993. A tipping bucket rain gauge was added to the weather station in April 1994 to measure summer rainfall. The air temperature at this station from July 1993 to June 1994 averaged 0°C compared to 5.6 °C in Stewart over the same time period. The mean annual air temperature at Stewart is 5.9 °C.

4.0 EXPERIMENTAL METHODS AND PROCEDURES

4.1 Waste Rock Characterization

4.1.1 Sample Selection

According to the preliminary mine development plans for the Red Mountain project, the waste rock pile will contain 60 to 70% feldspar porphyritic intrusive and 30 to 40% bedded tuffaceous sediment. These proportions were considered when sampling was conducted for testwork. Five samples were selected: three of feldspar porphyry and two of sedimentary rock. Since the orebody will most likely be mined from the footwall side, the same side as the exploration drift development, all but one of the selected samples was footwall rock. Figure 2 shows the location of the five waste rock samples.

Two of the samples, HC-1 and HC-2, were obtained from underground slashes and were used to fill the large-scale field humidity cells. HC-1 is feldspar porphyry intrusive material while HC-2 is sedimentary with minor feldspar porphyry dyke material. The slashes were hand sampled and then shipped to the University of British Columbia for further preparation, analysis and testing. The feldspar porphyry and sediment samples weighed 230 kg and 110 kg, respectively. Both of these samples had approximately 10% minus 2 inch material.

The other three samples, ABA-1, 2 and 3, were compiled from Lac Mineral's ABA sample stockpile. Lac Minerals collected samples for ABA analysis from each round blasted during development of the exploration drift. The ABA-1 sample is sediment material and samples ABA-2 and 3 are feldspar porphyry intrusive material. These samples were crushed to 80% minus 2 inch then quartered on site using a Gilson splitter. One quarter of each sample was sent

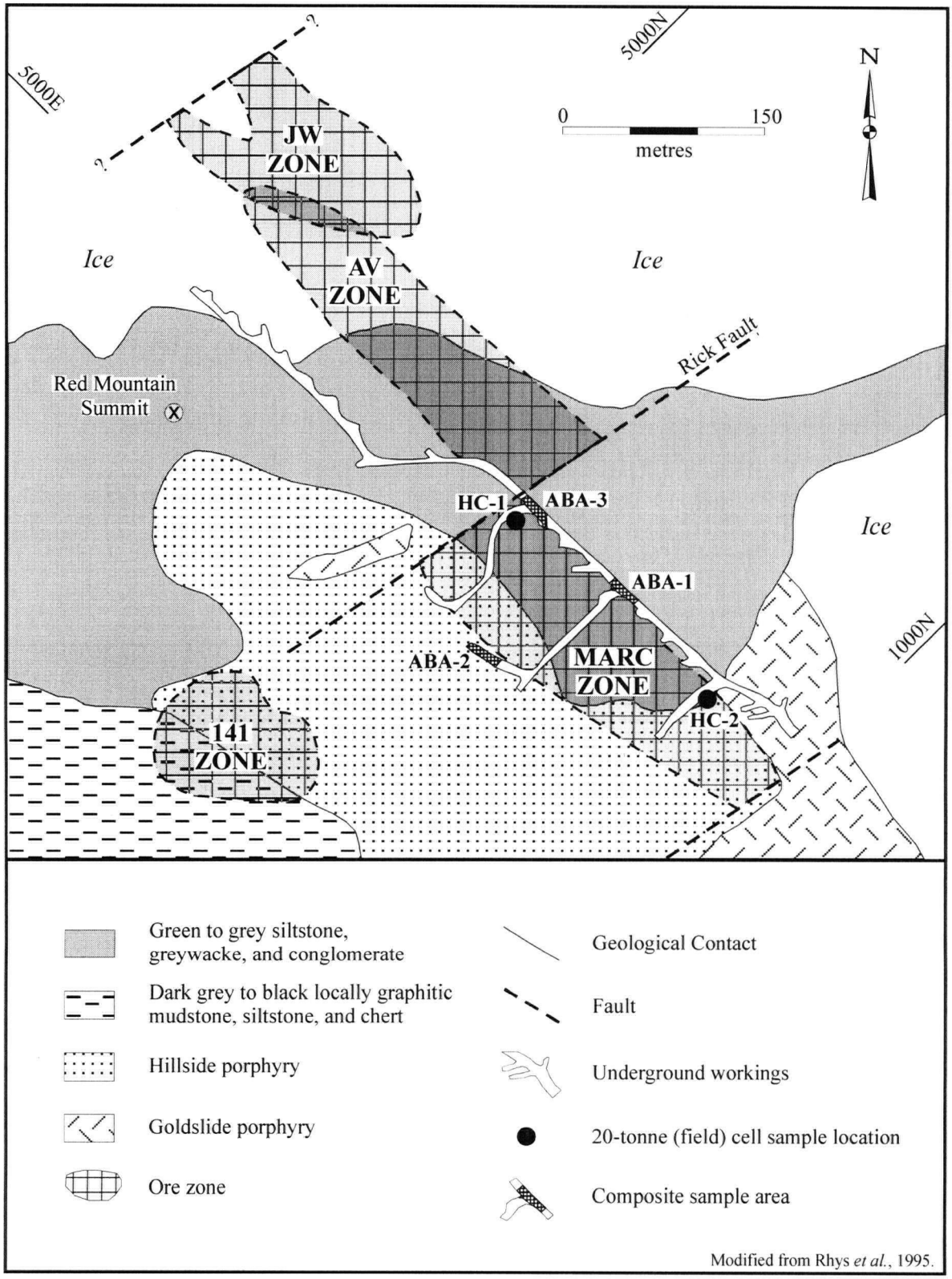


Figure 2: Location map of the five waste rock samples.

to Eco-Tech Laboratories in Kamloops, BC for ABA analysis and the remainder was stockpiled. From these stockpiled samples, three 77 to 91 kg composite samples were created, each representing approximately 25 metres of drift length.

4.1.2 Crushing, Screening and Splitting

All the laboratory samples were initially passed through a 1.5 inch screen and the oversize material then fed to a laboratory jaw crusher with a discharge opening of 1.5 inches. Since the crusher feed opening (gape) was 3 inches, a sledgehammer was first required for initial size reduction of the two slash samples, HC-1 and HC-2.

The samples were quartered to permit storage of splits prior to further size reduction. The quartering of the samples was conducted by first agitating each sample for 3 minutes within a 3-screen vibrating sieve shaker. The -1.5 +1 inch size material was placed on a concrete floor and the outer edges of the pile shoveled to the top while working around the pile about 20 times. This ensured thorough mixing before the pile was quartered. The -1 +½ inch material was quartered with a Gilson Splitter whereas the -½ +¼ inch and -¼ inch fractions were split with a Jones Riffle. All splits were then weighed and bagged.

Splits from each of the five samples were then selected and crushed to minus ¼ inch to create 1, 3 and 5 kg samples for the humidity cell and column tests. Multiple splits of this material were obtained using a Jones Riffle. If the mass of a split was over the desired mass by less than 10%, the excess was arbitrarily removed with a scoop. If two samples were combined to create a single sample, the mass ratios were used to determine the amount of reduction required for each sample.

The two 50-kg tests were charged with -1.5 inch material. The samples used for these tests, HC-1 and HC-2, had the required masses of each size fraction calculated. This was done by determining the mass percent of the four size fractions, -1.5 +1 inch, -1 +½ inch, -½ +¼ inch and -¼ inch, for each sample after being crushed to minus 1.5 inches. These proportions were then used to create the 50 kg samples using the splits from each size fraction.

4.1.3 Specific Gravity Determination

The S.G.s were determined so that sample masses could be estimated from their volume. The procedure involved adding 15 mL of water to a 25 mL graduated cylinder, weighing, adding sufficient -¼ inch sample to bring the water line to 25 mL, and then re-weighing. The results are presented in Table 1. The average S.G.s for the feldspar porphyry (HC-1) and sediment (HC-2) were calculated to be 2.71 and 2.72, respectively.

Table 1: Maximum, minimum and mean measurements of S.G. for samples HC-1 and HC-2.

	S.G.			
Sample	N	max.	min	mean
HC-1	6	2.65	2.74	2.71
HC-2	6	2.66	2.76	2.72

4.1.4 Grain Size Distribution

The grain size distributions of all five samples were determined. This included the various sized HC-1 and HC-2 samples to facilitate the scaling up of results from the typical 1-kg tests (minus ¼ inch) to the 50-kg tests (minus 1.5 inch) to the field cell tests. Sieve analyses were performed on two 1-kilogram splits of the minus ¼ inch fraction of each sample using the British Standard

sieve series 410-62. The screens from 4 mesh to 35 mesh were combined as one set of screens. These sieves were then placed on a vibrating sieve shaker for 3 minutes. The remaining sieves, from 48 to 400 mesh, were stacked and the fines agitated for 5 minutes on the shaker. The mass of each size fraction was recorded and the weight percent passing each sieve size determined.

The minus 1.5 inch material of samples HC-1 and HC-2 was previously divided into four size fractions with the mass percent of each fraction determined (Section 4.1.2). The minus ¼ inch size fraction was assigned the grain size distribution as determined for the HC-1 and HC-2 samples.

A sieve analysis was conducted on large portions of the two slash samples that were set aside in 1994. Two scoop buckets of each sample (approx. 5-7 tonnes) were placed onto a bermed palate measuring 8 feet square and lined with 40 mil polyethylene plastic. During the summer of 1996, over a period of 3 days, Royal Oak employees disassembled and screened these piles. All oversized fragments, those not passing the 3 inch screen, had their individual length, width and height measurements recorded. The remaining material was passed through a 2-inch and 1-inch screen with their respective masses determined from a hanging weight scale. The minus 1-inch material was placed at the centre of the palate and the outer edges shoveled to the top while working around the pile about 20 times (Figure 3). The pile was then quartered and a split was passed through ¾, ½, ⅓, and ¼ inch screens and each fraction was weighed (Figure 4).

An estimate of the mass of the oversize fragments was obtained from the fragment measurements. The 3 dimensions of each oversize fragment were multiplied together to estimate the fragment volume, then the volumes summed to obtain the total oversize volume.

Figure 3: Homogenizing 20-tonne (field) cell material for splitting prior to sieve analysis.

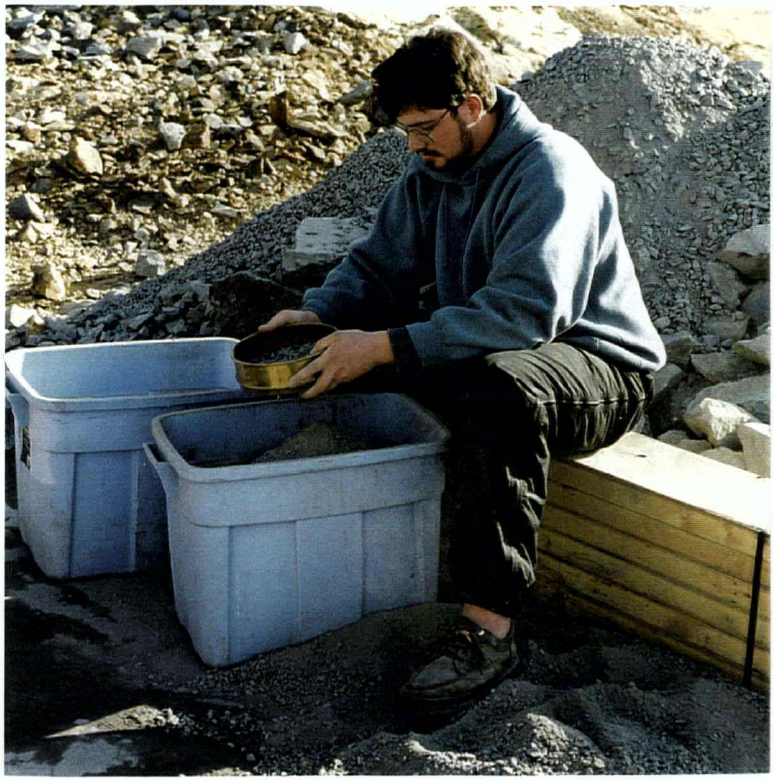


Figure 4: Sieve analysis of 20-tonne (field) cell material.

The total oversize mass was calculated using the equation:

$$M_s = V_s * S.G. \quad (14)$$

where M_s is the mass of the solids and Vs is the volume of the solids. The minus ¼ inch fraction was assigned a grain size distribution equal to the laboratory measurements. The particle mass finer than 2 mm for the HC-1 and HC-2 samples is estimated at 3.3% and 3.1%, respectively. These estimates compare favourably with measurements made for the Kitsault Mine, B.C. where 3% of the waste pile mass was determined to be finer than 2 mm (McLaren, 1986).

The grain size distribution curves for the HC-1 and HC-2 samples of various crush size are shown in Figure 5. The grain size distribution curves for all five samples crushed to 100% passing ¼ inch are plotted on a semilogarithmic graph in Figure 6.

4.1.5 Void Ratio

The void ratio is an index of the pore volume of a sample (volume of sample not occupied by solid particles) relative to the volume of solids. Void ratio *e* is defined as:

$$e = V_f / V_s = V_f / (V_t - V_f) \quad (15)$$

where V_f is the volume of pores, V_s is the volume of solids and V_t is the total volume of the representative sample.

Void ratio measurements of the two underground slash samples were conducted to facilitate mass estimates and allow for calculations of the degree of saturation. The method of determining the

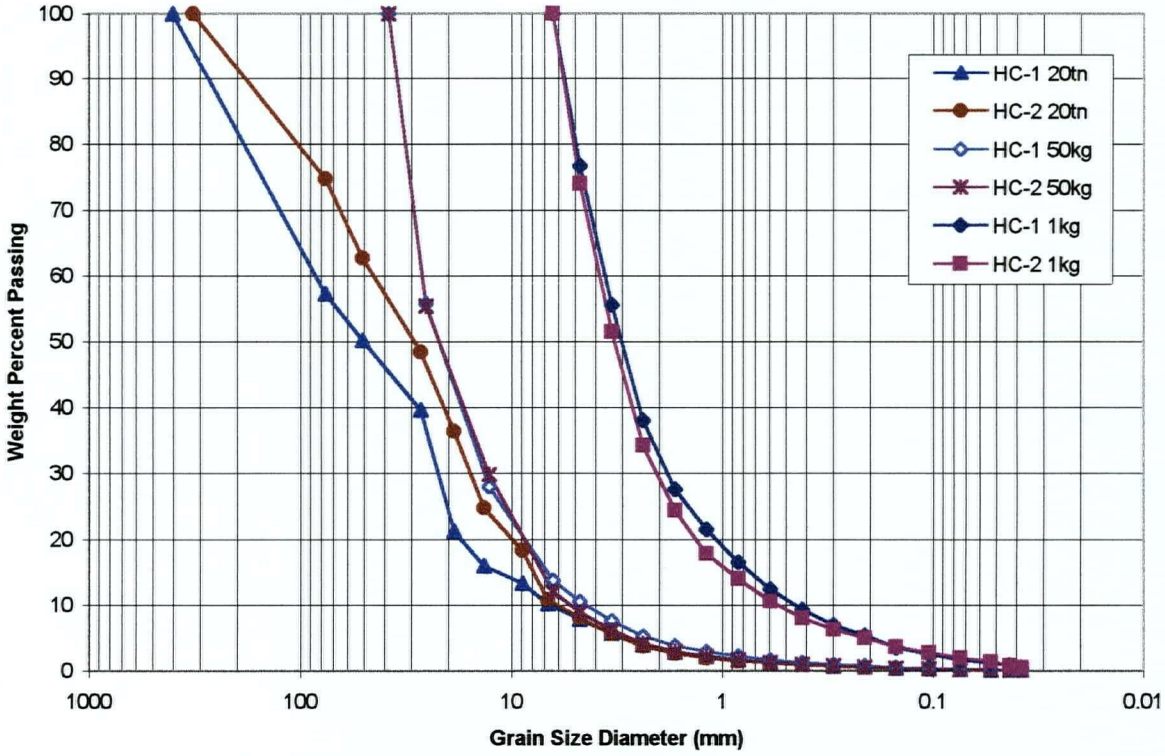


Figure 5: Grain size distribution curves for two samples chosen for testing at various scales, HC-1 (porphyry intrusive) and HC-2 (sediment).

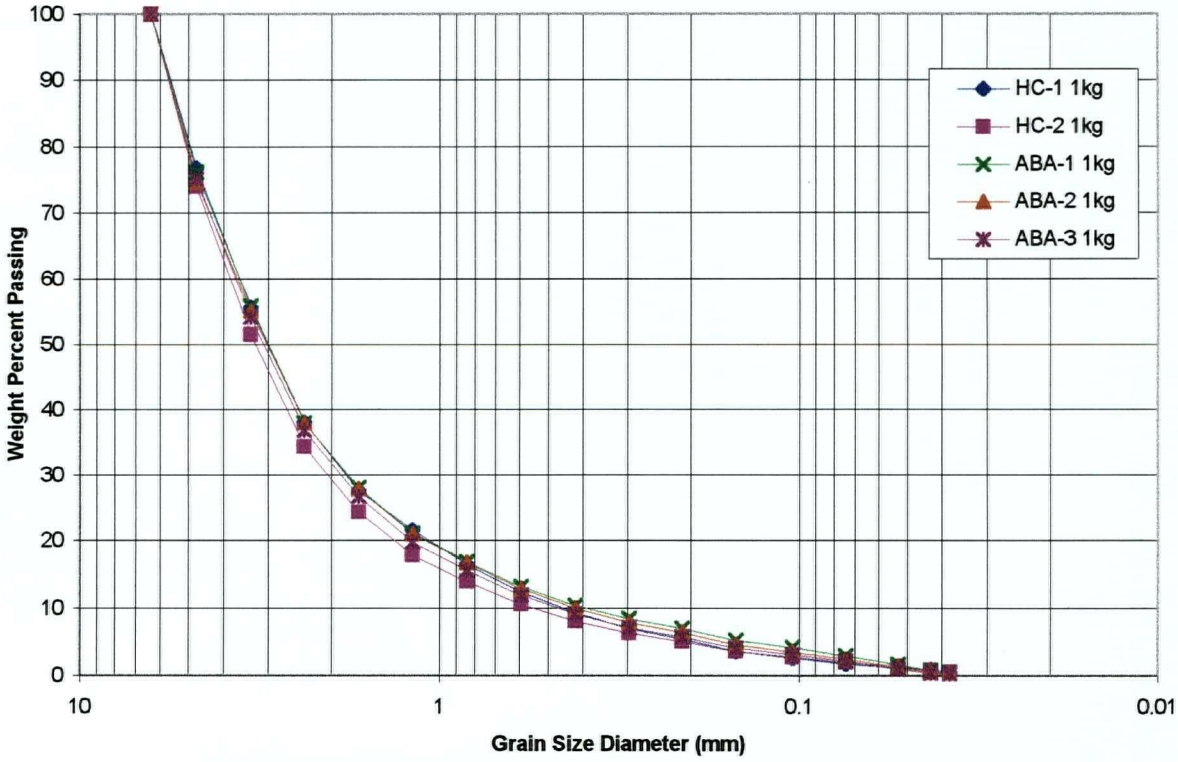


Figure 6: Grain size distribution curves for all five samples crushed to 100% passing $^{1}/_{4}$ inch.

void ratios involved measuring the rate of water flow from an underground pipe, conducted by measuring the time required to fill a 200-litre barrel. A scoop bucket, having steel plates welded over the drainage holes, was then driven under the overhead pipe. By measuring the time required to fill the bucket with water, the volume of the scoop bucket was estimated. The bucket was then filled with rock from the slash sample, driven back under the water pipe, and the time for it to top up with water was recorded. The scoop volume is the sample volume, V_t, and the volume of water required to fill the sample air voids is the pore volume, V_f. This procedure was conducted five times for each sample and the results were averaged. The time taken to fill the 200-litre barrel was measured repeatedly throughout the test to determine fluctuations in the water flow rate. The results of these tests are presented in Table 2. The average void ratio of the HC-1 feldspar porphyry slash sample of 0.74 was significantly higher than that for the HC-2 sediment sample of 0.53.

Table 2: Maximum, minimum and mean measurements of pore volume, and void ratios for the field cell samples.

Sample (u/g slash)	Particle size (inches)	V_t (m^3)	V_f (m^3)				e
			N	max.	min	mean	
HC-1	- 15.7	1.36	5	0.66	0.51	0.58	0.74
HC-2	- 12.6	1.36	5	0.52	0.43	0.47	0.53

4.1.6 Specific Surface Area

Specific surface areas for the samples were determined using a calculation based on the sizes and shapes of the particles. As discussed by Hillel (1982), the specific surface area of a sphere or cube can be expressed as:

$$a_m = 6 / \rho d \quad (16)$$

where a_m is the total surface area per unit mass, ρ is density and d is the particle diameter. The approximate specific surface area of granular material, per unit mass of particles, is calculated from knowledge of the particle size distribution by the summation equation:

$$a_m = (6 / \rho d) \sum (c_i / d_i) \quad (17)$$

where c_i is the mass fraction of particles of average diameter d_i. For this study, the average particle diameter of each size fraction was assigned the size fraction's mid range diameter.

The specific surface areas calculated for the five samples are listed in Table 3. The detailed specific surface area calculations from the sieve analysis results are found in Appendix 1.

Table 3: Estimates of specific surface area.

		Sieve size with 100% passing		Mass of sample screened	Specific surface area
Sample	Test size	(inches)	(mm)	(kg)	(m^2/kg)
HC-1	1 kg	0.25	6.4	1.0	2.92
	50 kg	1.50	38.1	50	0.50
	20 tonne	15.7	400	7,100	0.35
HC-2	1 kg	0.25	6.4	1.0	2.60
	50 kg	1.50	38.1	50.0	0.44
	20 tonne	12.6	320	5,200	0.38
ABA-1	1 kg	0.25	6.4	1.0	3.58
ABA-2	1 kg	0.25	6.4	1.0	3.14
ABA-3	1 kg	0.25	6.4	1.0	2.83

4.1.7 Mass and Total Surface Area Estimates of Field Cell Samples

The total volume of each field cell sample (solids + pores) was estimated by multiplying the cell dimensions together and adding a volume estimate of rock exposed above the cell. The total volume of solids was then estimated from the void ratios using $V_s = V_t / (1 + e)$. The sample mass M_s was then calculated from the V_s and the measured S.G. With the masses estimated, the total surface areas of these samples were determined using their specific surface areas. The results are found in Table 4.

Table 4: Estimates of mass and total surface area for field cell samples.

Sample	V_t (m^3)	V_s (m^3)	M_s (tonnes)	Total surface area (m^2)
HC-1 20 tonne	11.1	6.39	17.4	6080
HC-2 20 tonne	11.1	7.26	19.8	7500

4.1.8 Mineralogy

The mineralogy of the five samples was assessed through hand samples and petrographic analysis. For each sample, 10 to 12 hand samples were selected and described with an emphasis on alteration style, and sulfide percentages and mode of occurrence. During the exploration phase of the Red Mountain deposit, numerous samples (131) were examined petrographically (Barnett, 1991; Ford, 1993; Vancouver Petrographics, 1994; Thompson, 1994a, 1994b, and 1994c). Petrographic descriptions were chosen from these reports as being representative of the five samples selected for testing based on rock type, alteration and location.

The feldspar porphyry samples HC-1, ABA-2 and ABA-3, varied in sulfide types and percentages but were relatively similar in degree and style of alteration. Sample HC-1 contained

approximately 4-5% pyrite (3-4% as disseminations, remainder as fine fracture fill), 2-3% disseminated pyrrhotite (<1% as fine fracture fill) and 0.5% wispy sphalerite. Of the feldspar porphyry composite samples, ABA-2 was pyrrhotite-rich (5-7% as disseminations) while the other, ABA-3, was pyrite-rich (4-5% as disseminations).

In hand specimen, the feldspar porphyry samples show 40-50% white phenocrysts (<2mm, generally <1mm) within a pale green-grey, aphanitic groundmass. In thin section, the feldspar phenocrysts are replaced by K-feldspar and minor chlorite. The former mafic phenocrysts (hornblende?) are replaced by K-feldspar + chlorite + sericite + carbonate + titanite $\pm$ clinozoisite $\pm$ apatite. The matrix consists of fine-grained quartz, K-feldspar, chlorite and sericite. Irregular veinlets and microfractures of quartz, chlorite and carbonate are common. Estimated mineral percentages for the feldspar porphyry samples are: 30-35% K-feldspar, 15-20% quartz, 10-15% chlorite, 5-10% sericite, 5-10% albitic feldspar, 5-10% actinolite, 5-7% sulfides, 3-5% titanite, 1-3% carbonate/calcite, 1% clinozoisite and trace amounts of apatite.

The sediment samples HC-2 and ABA-1, varied in type of sulfide mineralization but, as with the feldspar porphyry samples, were relatively similar in the degree and style of alteration. Sample HC-2 contained an estimated 2-3% disseminated pyrrhotite, 1-2% disseminated pyrite and 1-2% wispy sphalerite. The sediment sample ABA-1 was visually estimated as containing 5-7% disseminated pyrrhotite.

In hand sample, the sediment samples were pale green to light grey, medium to fine grained and locally banded. In thin section, the sediment consists of K-feldspar grains that are variably replaced by sericite, carbonate minerals and clinozoisite. Chlorite, pyrrhotite and carbonate form irregular clusters that may represent pseudomorphed hornblende (?) crystals. Estimated mineral

percentages for the two sediment samples are: 35-40% K-feldspar, 20-25% sericite, 15-20% quartz, 5-7% sulfides, 3-5% chlorite, 3-5% clinozoisite, 1-3% carbonate and 1-2% titanite + TiO_x.

4.1.9 Acid-Base Accounting

Acid-Base Accounting (ABA) determines the balance between the acid producing minerals of a sample and the minerals that can neutralize acidity. The acid potential (AP) of the samples used were determined from sulfide and sulfate assays conducted by Chemex Laboratories, Vancouver, B.C. A sulfide-sulfur content of each sample was obtained by subtracting the sulfate-sulfur content from the total sulfur. The AP is calculated by multiplying the sulfide-sulfur content of the sample by 31.25 to convert to units of kg of calcium carbonate equivalent per tonne of material. Sample assays performed by Chemex Labs, North Vancouver, are found in Appendix 2.

The neutralization potential (NP) was determined using a method based on the Modified ABA procedure as outlined by Lawrence (1990). The test allows for a gradual addition of acid to the pulverized sample solution and is carried out at room temperature over a 24-hour period. This is a modification of the Sobek et al. (1978) NP determination that is conducted under highly acidic conditions and which has the potential to overestimate the NP of the sample (Lawrence and Wang, 1996). The NP values of each of the five samples were determined three times and the results were averaged. The details of the Modified ABA test procedure used to determine the NP is found in Appendix 3.

The carbonate NP method was also used to determine NP values for each sample. This method

assumes that all the inorganic carbon present occurs within carbonate minerals capable of neutralizing acid. All five samples were assumed free of organic-C. This was considered a safe assumption for the sediment samples due to their high degree of alteration. The total carbon value was obtained using a Coulimetrics Model 5030 Carbonate Carbon apparatus linked to a Coulimetrics Model 5010 CO_2 Coulometer.

The carbonate NP was calculated from the carbon content as follows:

$$\text{Carbonate NP (kg } CaCO_3/t) = \frac{\text{mg C in sample}}{\text{weight in sample (g)}} * \frac{\text{molecular weight of } CaCO_3}{\text{atomic weight of C}}$$

The reported paste pH values are averages of underground samples that represent the same portion of drift as the five samples used. These samples, taken for ABA analysis while advancing the exploration drift, were processed by Eco-Tech Laboratories, Kamloops, B.C. The values of paste pH and the results of the ABA tests are listed in Table 5.

Table 5: Acid base accounting (ABA) results

Sample	Paste pH	AP (kg $CaCO_3$/tonne)	NP (kg $CaCO_3$/tonne)	CO_3 NP (kg $CaCO_3$/tonne)	Net NP (kg $CaCO_3$/tonne)	NPR
HC-1	8.35	182	44.6	27	-137	0.25
HC-2	8.35	123	11.9	9.4	-112	0.10
ABA-1	8.06	140	36.3	32	-104	0.26
ABA-2	8.22	148	33.1	28	-115	0.22
ABA-3	8.01	97	25.0	12	-72	0.26

Comparing the Carbonate NP values to the Modified NP values indicates that neutralizing minerals besides the carbonates are present and that they provide a substantial amount of NP for the feldspar porphyry samples HC-1 and ABA-3. Based on the mineralogical examinations, non-carbonate minerals that could be providing a source of NP in the feldspar porphyry samples are

chlorite and actinolite (Kwong and Ferguson, 1997) and to a lesser degree silicate minerals such as sericite and albitic feldspar (Busenberg and Clemency, 1976). Since the samples were not examined for the presence of Fe and Mn carbonates that do not contribute to NP, the Carbonate NP values and, to a lesser extent, Modified NP values may be overestimated (Price, 1997; White et al., 1998).

All samples returned negative NPR values indicating that all samples would be expected to produce acidic drainage at some point in time. The lowest NPR was obtained for the HC-2 sample indicating that it has the greatest potential to generate acidic drainage.

4.2 Kinetic Test Type and Operation

Thirty-four kinetic tests were performed, with two of these being conducted in large-scale field cells. The laboratory tests included twenty-five cylindrical bench-top humidity cells, five leach columns and two 50-kg cells. Construction of laboratory cells, columns and field cell components, as well as operation of the laboratory tests, took place within the Department of Mining and Mineral Process Engineering.

A summary of the kinetic testwork conducted is listed in Table 6.

Table 6: Summary of kinetic test program.

Kinetic test type	Particle size	Start Date	Finish Date	No. of tests	No. of tests by sample				
					HC-1	HC-2	ABA-1	ABA-2	ABA-3
Standard	- 6.4 mm	Jan 96	Dec 96	8	1	1	2	2	2
Tall	- 6.4 mm	Jan 96	Dec 96	5	1	1	1	1	1
Shaken	- 6.4 mm	Jan 96	Dec 96	5	1	1	1	1	1
Non-aerated	- 6.4 mm	Feb 96	Dec 96	1	1				
Simulated precipitation	- 6.4 mm	Feb 96	Dec 96	6	6				
50-kg	- 38.1 mm	Jan 96	Dec 96	2	1	1			
NP column	- 6.4 mm	Dec 95	Dec 96	5	1	1	1	1	1
20-tonne	- 400 mm	Oct 94	Sept 96	2	1	1			
			Totals	34	13	6	5	5	5

4.2.1 Standard Cells

The standard cells (Figure 7) were made of clear, Plexiglas pipe measuring 10 cm in diameter. They were made 20 cm in height and held 1-kg charges of minus ¼ inch material. Inside the cells was a perforated acrylic plate to support the sample above the air feed. These plates were covered with 3 layers of fine mesh screen before the samples were loaded. Each cell had three hose nipples (Figure 8):

- one hose nipple located on the side wall 1 cm from the cell bottom allowed dry/wet air to be supplied to the cells via,
- a second nipple located on the centre of the cell lid permitted air to exit and rinse water was applied through, and
- a third nipple located on the centre of the cell bottom allowed water to drain through.

The 1-kg charges were rolled within sealed plastic bags prior to being placed in the cells to ensure thorough mixing.

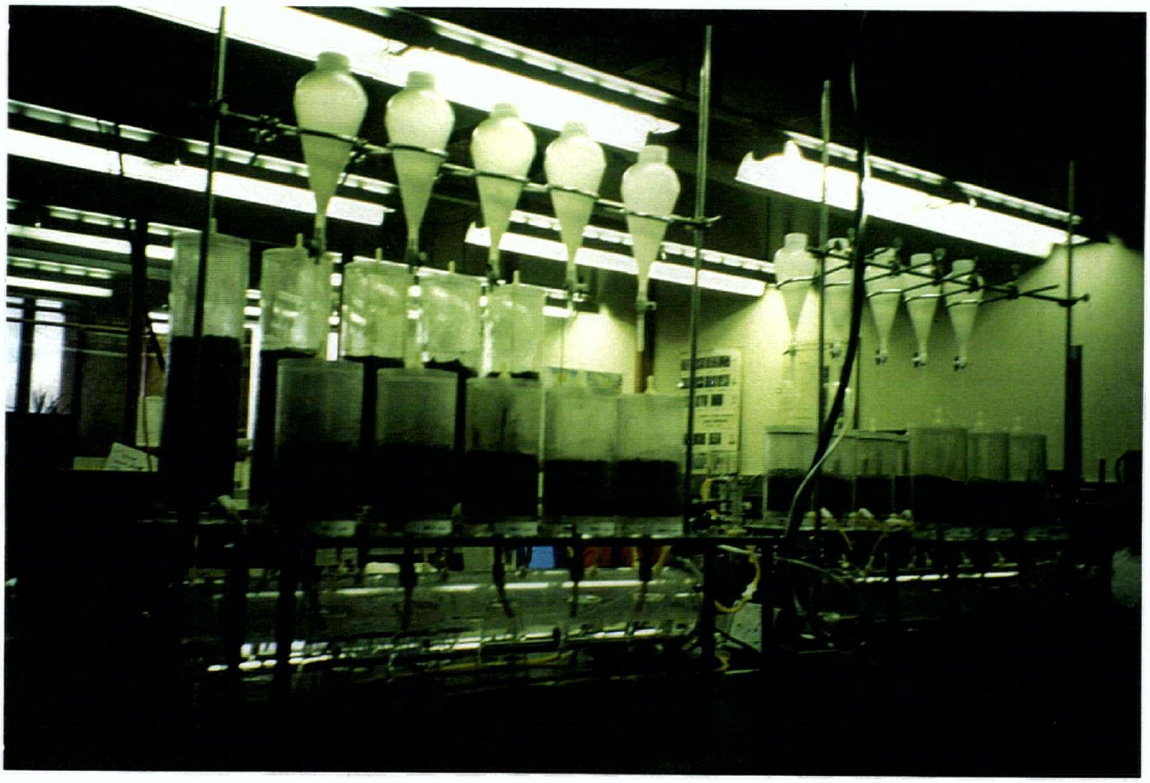


Figure 7: Standard humidity cells - frontal view.

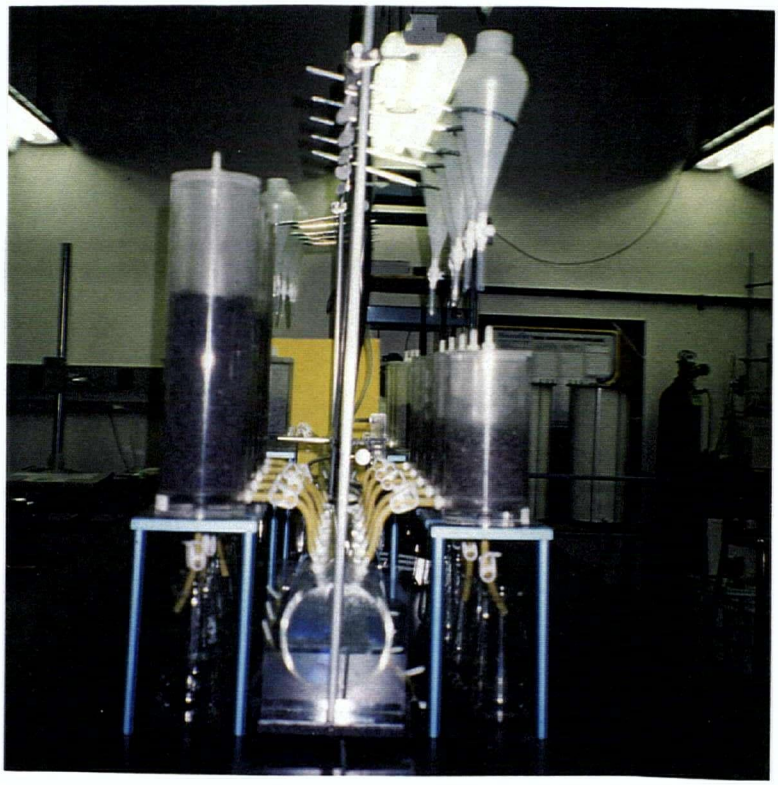


Figure 8: Standard and tall cells - side view.

The initial two leaches of these cells were carried out by completely flooding the sample with distilled de-ionized water, soaking for an hour, draining, flooding again, and then soaking for a day before draining. This procedure was conducted to remove any weathering products that had accumulated prior to the start of the tests.

A weekly cycle consisted of passing dry air through the cell for three days, then moist air from a humidifier for three days, followed by a distilled de-ionized water leach during the seventh day. The airflow through each cell was maintained at approximately 0.5 litres per minute. During the humid air cycles, water in the humidifiers was maintained at a temperature between 28 and 30°C.

A 500-mL standard volume of water was dripped into each cell using a separatory flask and was applied over a period of approximately one hour. The volume of the leachate collected after one day was determined by a mass measurement using a digital readout balance. Individual cell weights were measured three times a week; at the end of the dry air period, the end of the wet air period and at the end of the leachate day.

Difficulties were encountered in maintaining similar operating conditions, primarily with respect to keeping the airflow through each cell equal and uniform. Similar operating conditions were deemed necessary for the repeatability of results. Two airflow regulators were used to control the air supply to the four benches of humidity cells. During the dry cycle, two air hoses ran from each airflow regulator. Each air hose supplied air to one bench supporting six humidity cells. The humidity cells were attached to the air hoses by T-connectors. It was found that the cells connected closest to the airflow regulators dried faster than the cells connected to the end of the air hose. To remedy this, the air inlet hose to each cell was fitted with a screw clamp to allow adjustment of individual cell airflow.

A further refinement involved the addition of "bubblers" to each cell, as recommended by White and Sorini (1993). The bubblers were glued to the cell lids and consisted of 100 mL glass vessels half-filled with water and fitted with a rubber stopper holding two glass tubes. Air then flowed from the top of the humidity cell into a hose connected one of the glass tubes. This glass tube extended to the vessel bottom and allowed the air to bubble through water before exiting via a short glass tube that allowed for airflow measurement. The bubbling water allowed for a visual assessment of the airflow rate. O-ring seals were installed to the lids of each humidity cell to prevent leaks and to ensure good control of airflow.

4.2.2 Tall Cells

The tall cells (Figure 9) were 40 cm in height, 10 cm in diameter and held 3-kg charges of minus ¼ inch material. Since the diameter was the same as the standard cell, the flowpath length for rinse water and supplied air was three times greater for the tall cells than the standard cells.

The operating methodology used was similar to that for the standard cells, as previously outlined, which included the use of "bubblers" for better air control. For each tall cell, three 1-kg charges were rolled individually within sealed plastic bags and placed within the cells. The 500 mL volume of water dripped into each tall cell resulted in a lower water to solid ratio than the standard cells due to the greater sample mass used.

4.2.3 Shaken Cells

Five shaken cells were setup with a similar design as the standard cells but the leach procedure was different. These cells were flooded with 500 mL of distilled de-ionized water for an hour. The cell was then physically lifted and gently moved in a circular motion along a horizontal

Figure 9: Tall cells - frontal view.

plane to cause swirling of the rinse water. The swirling motion was done for approximately 30 seconds before draining to promote the removal of all the weathering products. The fines that drained from the cell were returned at the start of the next leach cycle.

Two initial leaches were conducted within a 24-hour period by flooding the cells. The flooding procedure was done to remove weathering products accumulated prior to the test. The shaken cells were operated in a similar manner to that used for the standard and tall cells with respect to the rate of airflow, humid air temperatures, and the weekly cycle of dry/moist air. "Bubblers" were added to the shaken cells at the same time as the standard and tall cells.

4.2.4 Non-aerated Cell

One non-aerated cell was set-up and differed from the standard cell in that it was not subjected to weekly cycles of dry and wet air. The cell was trickle-leached weekly with 500-mL of distilled de-ionized water. It was of similar size and design as the standard cells and held a 1-kg charge of sample HC-1 crushed to minus ¼ inch.

Like the standard cells, this cell was flooded twice within the first 24 hours of operation to remove weathering products that had accumulated prior to the test. Weighing of the cell was done three times per week on a similar schedule to that for the standard cells.

4.2.5 Simulated Precipitation Cells

Six simulated precipitation cells were operated with variations of leach duration, volume and frequency. These cells were of similar design as the standard cell and were each filled with a 1-kg charge of sample HC-1 crushed to minus ¼ inch.

For the first 29 cycles of operation, they were operated in the same manner as the standard cells with dry/wet air cycles and 500 mL trickle leaches. After 29 cycles (200 days), air was no longer supplied to the cells, and the simulated precipitation procedures began after 31 cycles. Two cells received 50-mL of distilled water per leach, two received 100-mL per leach and the remaining two received 500-mL per leach. One of the 500-mL leach cells was used as a control by maintaining a weekly trickle leach while the leach frequency varied for the other five cells. Water was initially applied at a frequency of once every 3 to 4 days for a total of 3 weeks. The leach frequency was decreased to once a week for 4 weeks then once every two weeks for a month. Water was applied to a 50-mL and 100-mL leach cell over a 1-hour period, while the other two 50-mL and 100-mL leach cells received water over a 24-hour period. The two 500-mL cells retained a 1-hour leach period. Separatory flasks were used to provide the 1-hour trickle leaches, while a peristaltic pump was used to control the slow application rates during the 24-hour trickle leaches.

4.2.6 50-kg Cells

The two 50-kg cells (Figure 10) were made with 30-cm diameter PVC pipe. They were 75 cm in height, had an airtight polyethylene bottom and a sealed Plexiglas lid. They were similar in design to the standard humidity cells in that the sample was elevated above the air supply by means of a perforated polyethylene plate. The airflow exiting the cells was maintained at approximately 0.5 L/min. For the moist air cycle, air was routed through a plastic bucket containing water maintained at a temperature of 28-30^{o}C using an aquarium heater. A specially designed cart allowed for easy moving of the cells and provided room underneath for leachate collection vessels. The cells were trickle leached with 500 mL of water supplied from a

Figure 10: 50-kg cells.

peristaltic pump supplying six hoses placed in a radial pattern in the lid to ensure a slow and even distribution of the rinse water.

These two cells contained samples HC-1 and HC-2 that were crushed to minus 1.5 inches. The material was thoroughly mixed with a shovel on a concrete floor, manually split then shoveled into clean plastic sacks of plastic material. Prior to dumping the material into the cell, each sack was tied-off and rolled length-wise on the floor to promote a random grain size distribution.

The initial leach was conducted by filling the two cells with distilled water, then allowing them to rest for two days before draining. Dry and wet air cycles, 3 days each, were applied to the cells for 31 cycles (221 days). 500-mL trickle leaches were conducted weekly over a 1-hour period. After 31 cycles, the cells were no longer aerated.

4.2.7 NP Columns

The objective of the leach column testwork was to determine the available NP of the five samples. The experiment was designed to accelerate the process of NP depletion by supplying the columns with a continuous feed of acidified rinse water.

The NP columns (Figure 11) measured 5 cm in diameter and 180 cm in length. They were loaded with 5 kg of minus ¼ inch material. Trickle leaches of the columns were conducted with the use of a peristaltic pump. Two months after startup, the columns were fitted with hoses to accommodate the hookup of a compressed nitrogen gas cylinder.

Trickle leaching with acidic water (pH of 3) was maintained continuously for 360 days. Approximately 3.6 litres of water, acidified by adding 0.55 g/L H_2SO_4, was pumped through each

Figure 11: NP columns.

column weekly. The column leachate was collected every week for the initial 14 weeks then every two weeks. Nitrogen was routinely blown through the columns to purge the closed system of oxygen. This was done to minimize the amount of acidity produced by sulfide oxidization.

4.2.8 20-tonne (Field) Cells

Two wooden cribs (Figure 12), measuring 2.5 by 2.5 metres at the base and 1.5 metres in height, were constructed near the Red Mountain exploration portal during October 1994. The cribs were based on designs by Rescan Environmental Services Ltd. (1990) for the Kutcho Creek Property near Dease Lake, British Columbia and held approximately 20 tons of waste rock each. The walls of these cribs were slatted and lined with geotextile to permit limited oxygen entry as would exist in an actual waste rock pile. Rock was blasted and removed from within the exploration adit to obtain fresh samples of the feldspar porphyry (HC-1) and sediment (HC-2) material used to fill these field cells.

The floor of each crib, lined with 40-mil high-density polyethylene, was sloped inwards and towards the front. Infiltrating water was collected from each crib by two PVC pipes that lay along the floor centre (Figure 13) and two short PVC pipes at the front of the crib. The four pipes were joined by a manifold that directed water into a 7.5 litre vessel made from PVC piping (Figure 14). The vessel lid was tight fitting and had water entry and overflow hoses, attached pH and conductivity probes, and a dividing plate (Figure 15). The plate ensured that the water entering the vessel flowed to the bottom, and thus contacted the probes before exiting. Overflowing water entered a tipping bucket that allowed for measurement of outflow water volume and rate of flow. Temperature probes were buried within each pile, a temperature / humidity probe was installed on the top of the intrusive crib and a precipitation tipping bucket

Figure 12: 20-tonne (field) cells.

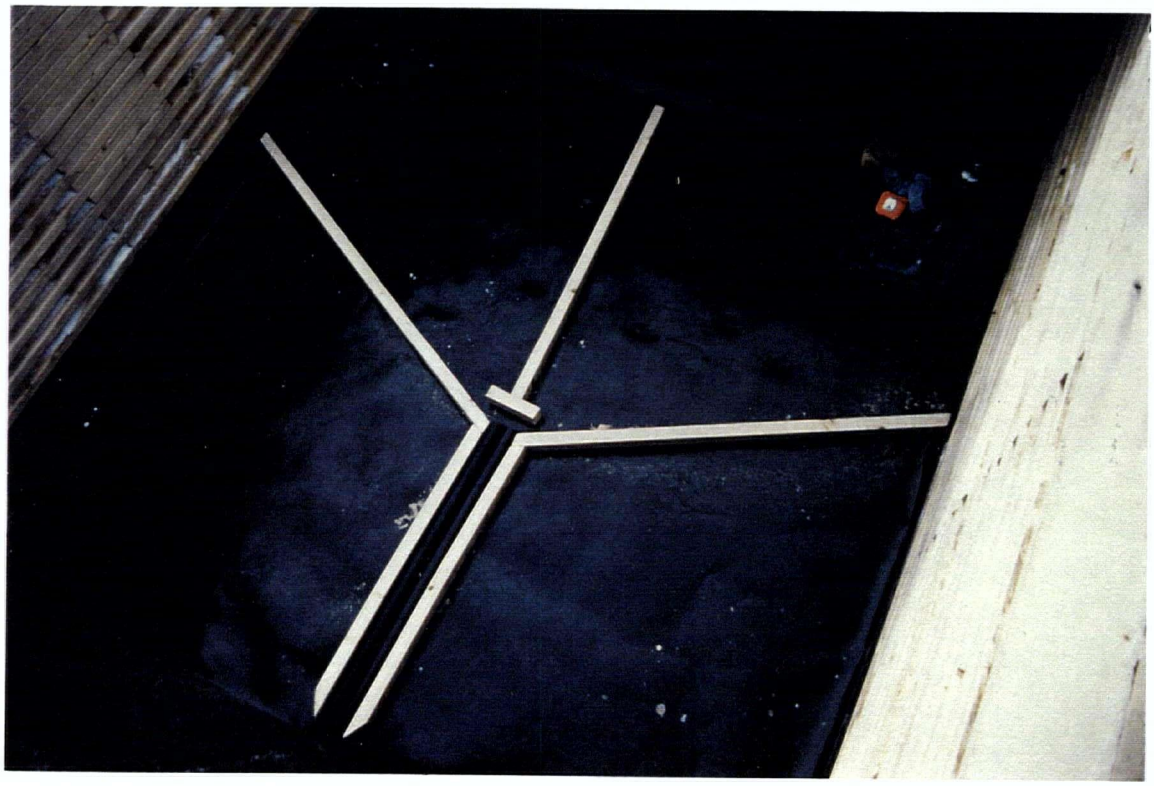


Figure 13: Floor of 20-tonne (field) cell showing drainage control.

Figure 14: Water pipe manifold, water collection vessel, and tipping bucket for 20-tonne (field) cells.

Figure 15: pH and conductivity probes attached to water collection vessel lid.

gauge placed on top of the crib containing the sedimentary rock sample. Readings from all these instruments were recorded by a Campbell Scientific CR10 datalogger powered by a solar panel.

The datalogger was programmed to take readings from each probe every 5 seconds. The water probe readings were averaged every 10 minutes and the internal crib temperature and external air temperature averaged every hour and the averaged values were stored in the datalogger. The total number of tips recorded by each tipping bucket in a ten-minute period was also recorded. When access was possible, the datalogger was downloaded to a portable computer or the data storage module was exchanged with a new one. One water sample was taken from each crib in October 1995 and seven more samples were taken during the summer of 1996. These samples were forwarded to Chemex Laboratories in Vancouver for the analysis of the standard parameters and total metals.

The data collected during the summer of 1995 is not complete due to difficulties. The incomplete data resulted from either poor weather conditions or lack of personnel on site during the period in which property ownership was changing. Complete water data were obtained in 1996; it was recorded from the time when the internal crib temperatures rose above $0^{o}C$ on June 10^{th}, to the freeze-up of the water collection containers on September 20^{th}.

4.3 Leachate Analytical Procedures

The pH and conductivity of leachates were recorded on a weekly basis. The alkalinity and sulfate concentrations were typically recorded every two weeks. The Ca, Mg, K and Na concentrations were also measured on a bi-weekly basis by atomic absorption spectrophotometry.

Alkalinity for samples with a pH greater than 4.5 were measured using the method outlined by the Standard Methods for the Examination of Water and Wastewater (1989). Typically, 50 mL of leachate was stirred using a magnetic stirrer while titrating with 0.02 N HCl to a pH 4.5 endpoint. The normality and volume of HCl used was recorded for calculating alkalinity using:

$$\text{Alkalinity (mg } CaCO_3/L) = \frac{50{,}000 \text{ N} * \text{V}}{V_S}$$

where: N = normality of HCl

V = volume (mL) of HCl required to reach pH 4.5

V_S = sample volume (mL)

Sulfate concentrations were determined by a turbidimetric method, based on the procedure outlined by the Standard Methods for the Examination of Water and Wastewater (1989). Reagents were prepared as follows:

1. An acetate buffering solution was prepared by dissolving 30 g of magnesium chloride ($MgCl_3 \cdot 6H_2O$), 5 g of sodium acetate ($CH_3COONa \cdot 3H_2O$), 1 g of potassium nitrate (KNO_3) and 20 mL of acetic acid (99% CH_3COOH) in 500 mL of distilled water and making up to 1000 mL.
2. A stock sulfate solution (1000 mg/L) was prepared by dissolving 1.253 g $MnSO_4$ (anhydrous) in distilled water and diluting to 1 litre. The stock solution was then used to prepare working sulfate standard solutions of 10, 20, 30 and 40 mg/L.

The procedure used for this study to determine sulfate concentrations was as follows:

1. The leachate was diluted with distilled water to a final volume of 100 mL to adjust the

estimated sulfate concentration to between 20 and 40 ppm. If the sulfate reading was outside of the 20 to 40 ppm range, the test would be repeated using an appropriate dilution.

2. 20 mL of the acetate buffer solution was added to the 100 mL aliquot, stirred briefly and one level spoonful of barium chloride was stirred into the solution for exactly one minute using a magnetic stirrer.
3. The sample was transferred to a 1 cm spectrophotometer cell that was then placed in a Perkin-Elmer Lambda 8 UV/VIS Spectrophotometer set at a wavelength of 420 nm.
4. After five minutes, the sample absorbence was recorded with respect to a distilled water reference solution.
5. A set of standards and distilled water blanks were run through the procedure.

Solutions prepared for sulfate readings were run in batches of four in the spectrophotometer using a continuously running stopwatch. The calculations were conducted with the aid of a Microsoft Excel spreadsheet. A calibration curve of absorbence against sulfate (ppm) was drawn each week using the readings obtained from the standard solutions. The sample readings were then entered into the resultant equation and multiplied by the dilution factor.

4.4 Data Manipulation

Initially an Excel file was setup for each of the 32 experiments but updating this number of files on a weekly basis was found to be too time consuming. An Excel template was then created to permit all of the data collected over a week to be input. The format of the Excel template was similar to the format in which the weekly cell data was recorded. The template calculated:

- leachate volume by subtracting the flask mass from the total leachate plus flask mass,
- gravimetric water content,

- sulfate concentration, and
- alkalinity.

One record was generated for each cell; this represented the leachate quality and operating conditions for the cell for that particular week.

Each week, the 32 newly created records were appended to a single Microsoft Access database table. The database table allowed sorting by cell number and then by date. These data were linked to an Excel spreadsheet where the remaining calculations were done. Since analyses were not done every cycle, missing data was calculated through interpolation of the preceding and subsequent measured values. The primary calculations performed were as follows:

Cumulative SO_4 Flux (mg/kg)

$$= \text{cumulative total of: } \frac{SO_4 \text{ concentration per cycle (mg/L)} * \text{leachate volume (L)}}{\text{sample weight (kg)}}$$

Remaining Sulfide-S (% of original)

$$= \text{Initial Sulfide-S (\%)} - \frac{((\text{Cumulative Sulfate Flux (mg/kg)} * \text{atomic weight of S} / \text{molecular weight of } SO_4) / 10000) * 100\%}{\text{Initial Sulfide-S (\%)}}$$

Sulfate Production Rate (mg/kg/wk)

$$= \frac{\text{Cumulative } SO_4 \text{ Flux from one cycle (mg/kg)} - \text{Cumulative } SO_4 \text{ Flux from earlier cycle (mg/kg)}}{\text{time difference between cycles (days)} * (1 \text{ wk}/ 7 \text{ days})}$$

Sulfate Production Rate by Surface Area ($mg/m^2/wk$)

$$= \frac{\text{Sulfate Production Rate (mg/kg/wk)}}{\text{Specific Surface Area } (m^2/kg)}$$

Carbonate Molar Ratio

$$= \frac{((\text{Ca (mg/L)}/\text{ atomic weight of Ca}) + (\text{Mg (mg/L)} / \text{ atomic weight of Mg}))}{SO_4 \text{ (mg/L)} / \text{ molecular weight of } SO_4}$$

Cumulative NP Depletion

= cumulative total of :

$$\frac{\text{Carbonate Molar Ratio per cycle} * SO_4 \text{ concentration (mg/L)} * \text{leachate volume (L)} * (\text{molecular weight of } CaCO_3 / \text{ molecular weight of } SO_4)}{\text{sample weight (kg)}}.$$

NP Depleted (%)

$$= \frac{(\text{Initial NP} - \text{Cumulative NP}) * 100}{\text{Initial NP}}$$

NP Depletion Rate (mg $CaCO_3$/kg/wk)

$$= \frac{\text{Carbonate Molar Ratio} * \text{Sulfate Production Rate} * \text{molecular weight of } CaCO_3}{\text{molecular weight of } SO_4}$$

$$= \frac{((\text{Ca (mg/L)}/40.08) + (\text{Mg (mg/L)}/24.31))}{\cancel{SO_4 \text{ (mg/L)}} / \cancel{96.06}} * \frac{\cancel{SO_4 \text{ (mg/L)}} * \text{leachate volume (L)}}{\text{sample weight (kg)}} * \frac{100.09}{\cancel{96.06}}$$

$$= \frac{((\text{Ca (mg/L)}/40.08) + (\text{Mg (mg/L)}/24.31)) * \text{volume of leachate out (L)}}{\text{sample weight (kg)}} * 100.09$$

- Note that the calculation of NP Depletion Rate does not require a sulfate concentration.

Cumulative Metal Flux (mg/kg)

$$= \text{cumulative total of: } \frac{\text{metal concentration per cycle (mg/L) * leachate volume (L)}}{\text{sample weight (kg)}}$$

Metal Extraction Rate (mg/kg/wk)

$$= \frac{\text{Cumulative Metal Flux from cycle (mg/kg) - Cumulative Metal Flux from earlier cycle (mg/kg)}}{\text{time difference between cycles (days) * (1 wk / 7 days)}}$$

Gravimetric Water Content

$$= \frac{\text{mass of sample moisture}}{\text{mass of sample}}$$

$$= \frac{\text{total mass - mass of apparatus - mass of sample}}{\text{mass of sample}}$$

Arrhenius Equation: effect of temperature on reaction rate constants

$$\ln (k_2 / k_1) = (E_a / R) * ((1 / T_1) - (1 / T_2))$$

where T_2 and T_1 are two temperatures (K), k_2 and k_1 are the rate constants at these temperatures, E_a is the activation energy ($J \bullet mol^{-1}$) and R is the gas constant, 8.31 $J \bullet mol^{-1}K^{-1}$.

5.0 RESULTS AND DISCUSSION

5.1 Standard, Tall and Shaken Cells

5.1.1 Results

Results from the standard, tall and shaken cells are graphically compared in Appendix 4 and tabulated in Appendixes 8 to 10. For each sample, Appendix 4 has nine stacked graphs with each graph representing a different parameter and having profiles of the three cell types, four in the case of sample HC-1. The plotted parameters include pH, conductivity, alkalinity, sulfate, average gravimetric water content, carbonate molar ratio, sulfur depletion (%), sulfate production rate and calcium depletion rate. Alkalinity is a measure of the acid neutralizing capacity. The gravimetric water content (moisture retention) is the average of the two measurements taken during the week. This was considered appropriate after examination of the data revealed considerably lower cell moisture following the dry cycle then a minor moisture change after the wet cycle. The molar ratio of calcium and magnesium to sulfate indicates the amount of excess alkalinity in the leachate and thus the effectiveness of the neutralizing minerals. The rates for all graphs at any time are the average for the previous 5 cycles (see Section 4.4). Results from the non-aerated cell (sample HC-1) are included in the comparative graphs but are reviewed separately in Section 5.2. The final pH, rates and carbonate molar ratios for the humidity cells, discussed below and presented in Table 12, are averages of the last five available cycles.

Visual observations of the shaken cells during the course of the experiment revealed that particle segregation was occurring. The accumulation of fine material within the cell bottom was pronounced during the initial 1 to 2 months of testing. Another visual observation was that only the bottom portion the tall cells was drying during the 3 day portion of the dry air cycle.

In general, the patterns of leachate conductivity for all the cells closely matched the patterns of sulfate production for the respective cells. The conductivity of the tall cell leachate was typically 2 to 3 times greater than the standard and shaken cells due to its lower water to solid ratio.

All the feldspar porphyry samples produced neutral leachate throughout almost 50 weeks of kinetic testing. A summary of standard, tall and shaken cell results for the three feldspar porphyry samples are presented in Table 7. Stacked profiles of the weekly sulfate production rate for the feldspar porphyry samples are shown in Figures 16 to 18. The profiles for each sample have a horizontal line representing the average sulfate production rate from the last five available cycles of the standard cells. This line has been included to assist in comparing the standard cells to the tall, shaken and non-aerated cells. To simplify the comparison between cell types, only comments on the sulfate production rates are provided in Table 7. Limiting specific comments to sulfate production is considered appropriate since the patterns of calcium release are very similar to those of sulfate production for these cells (Appendix 4).

A general observation is that all three feldspar porphyry samples exhibit increasing rates of sulfate production from day 100 to day 350. Another general observation is that the carbonate molar ratios (Appendix 4) fluctuated above 1.0 for the initial 200 days before beginning to stabilize at values less than 1.0 (with the exception of the shaken cell containing sample ABA-2).

The histograms of sulfate production rate, molar ratio and gravimetric moisture content (Figure 19) show the three feldspar porphyry samples in order of increasing pyrrhotite content from left to right. The standard and tall cells have increasing sulfate production rates with an increase of contained pyrrhotite. The shaken cells returned the highest sulfate production rates for the pyrite-

Table 7: Summary of standard, tall and shaken cell results for feldspar porphyry samples.

Sample	Pyrite (%)	Pyrrh. (%)	Cell Type	SO_4 prod'n (mg/kg/wk)	NP depl'n (mg/kg/wk)	Carb. molar ratio	Comments on SO_4 production rate
ABA-3	5	-	standard-1	53.2	53.9	0.97	• not stable when test terminated at 343 days.
			standard-2	44.5	45.4	0.97	• relatively stable after approximately 200 days.
			tall	48.1	42.3	0.84	• relatively stable after approximately 200 days.
			shaken	57.8	42.8	0.87	• decreased until day 103 (26 mg/kg/wk), then slowly increased until test terminated at 328 days. • test not conducted long enough to determine whether sulfate rate stable.
HC-1	5	3	standard	58.3	58.0	0.95	• relatively stable after approximately 200 days.
			tall	49.9	42.3	0.81	• relatively stable after approximately 75 days.
			shaken	68.5	70.2	0.98	• decreased until day 103, slowly increased until day 207, relatively stable until day 250 (@ 55 mg/kg/wk), then increased to higher rate. • test not conducted long enough to determine whether sulfate rate stabilized (345 days).
ABA-2	-	7	standard-1	84.1	73.9	0.84	• broad fluctuations throughout test period. • not stable when test terminated at 343 days.
			standard-2	68.1	60.0	0.85	• relatively stable when test terminated at 328 days.
			tall	57.9	53.1	0.88	• relatively stable after approximately 250 days.
			shaken	34.9	41.7	1.15	• decreased until day 145 (17 mg/kg/wk), increased until day 207, then stabilized after approximately 250 days.

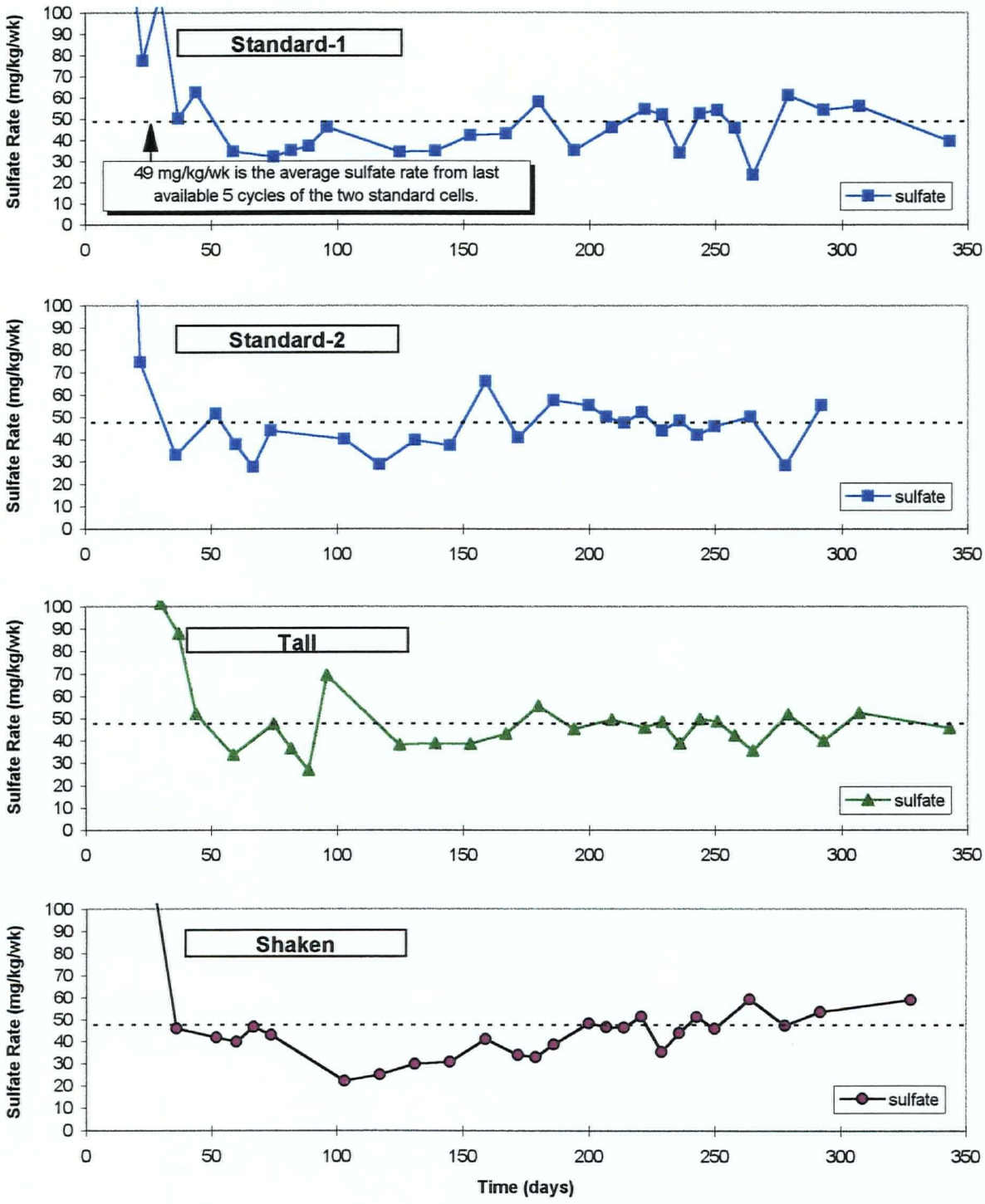


Figure 16: Sulfate production over time from standard, tall and shaken cells containing sample ABA-3 (feldspar porphyry with 5% pyrite).

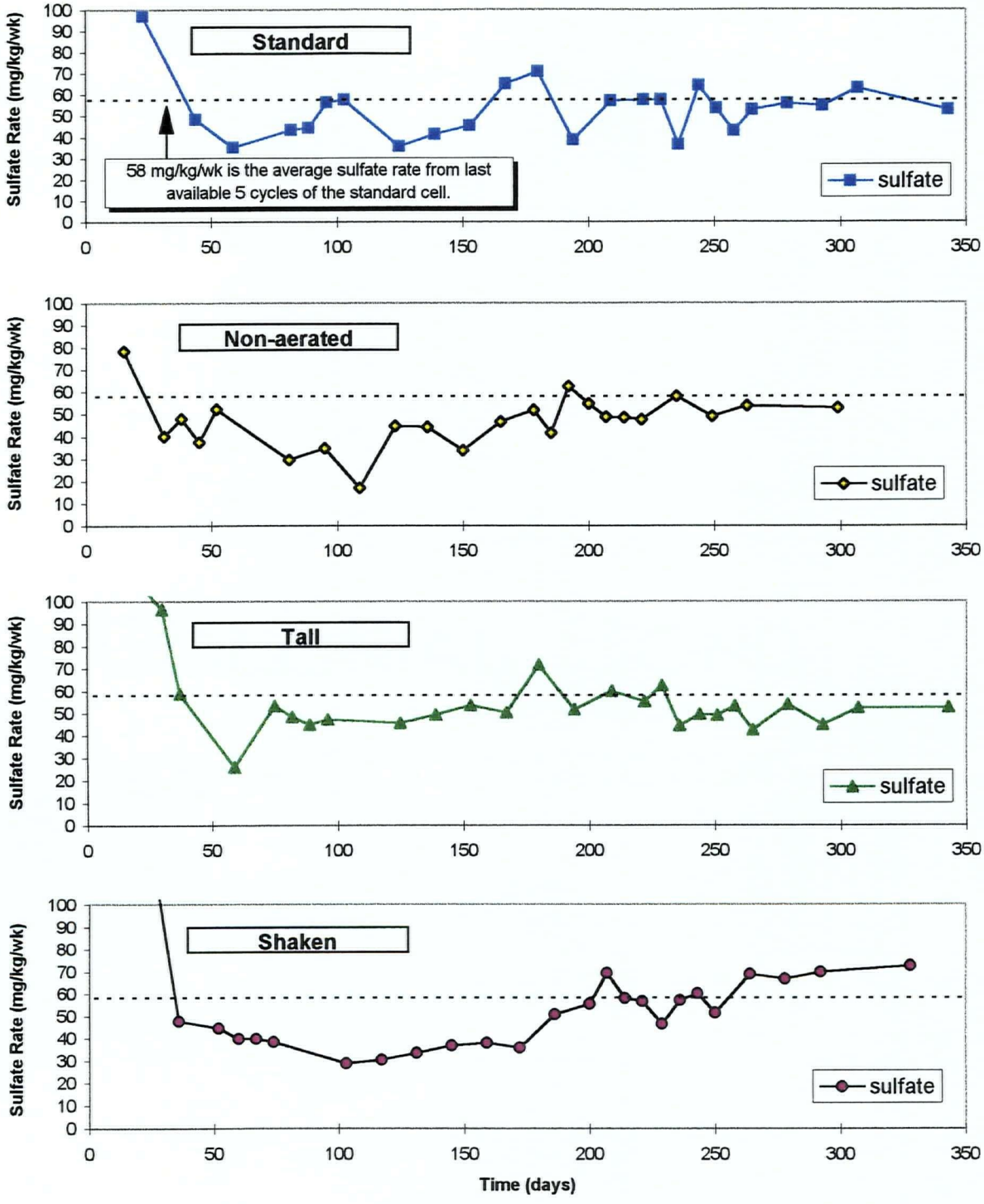


Figure 17: Sulfate production over time from standard, non-aerated, tall and shaken cells containing sample HC-1 (feldspar porphyry with 5% pyrite, 3% pyrrhotite).

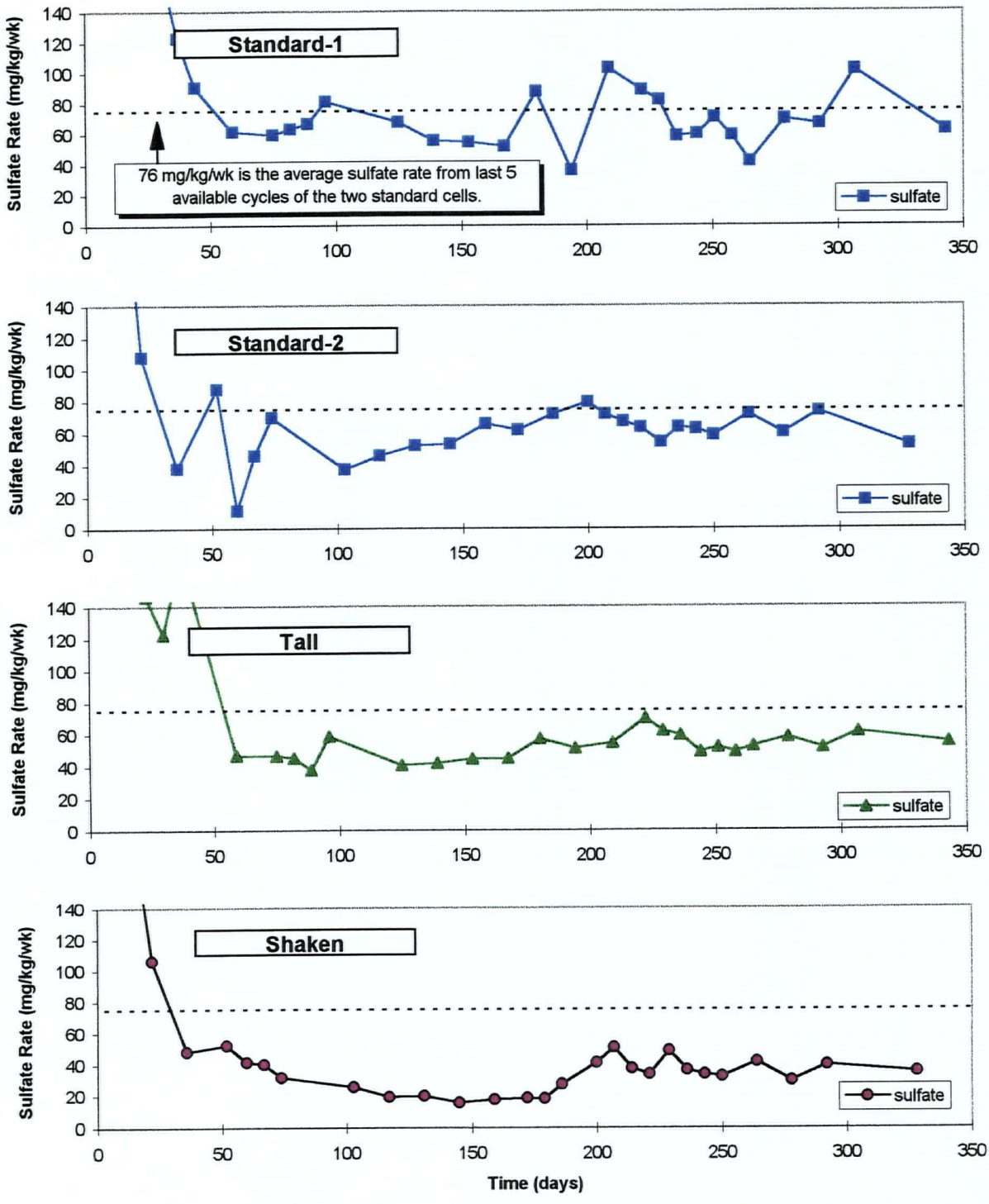


Figure 18: Sulfate production over time from standard, tall and shaken cells containing sample ABA-2 (feldspar porphyry with 7% pyrrhotite).

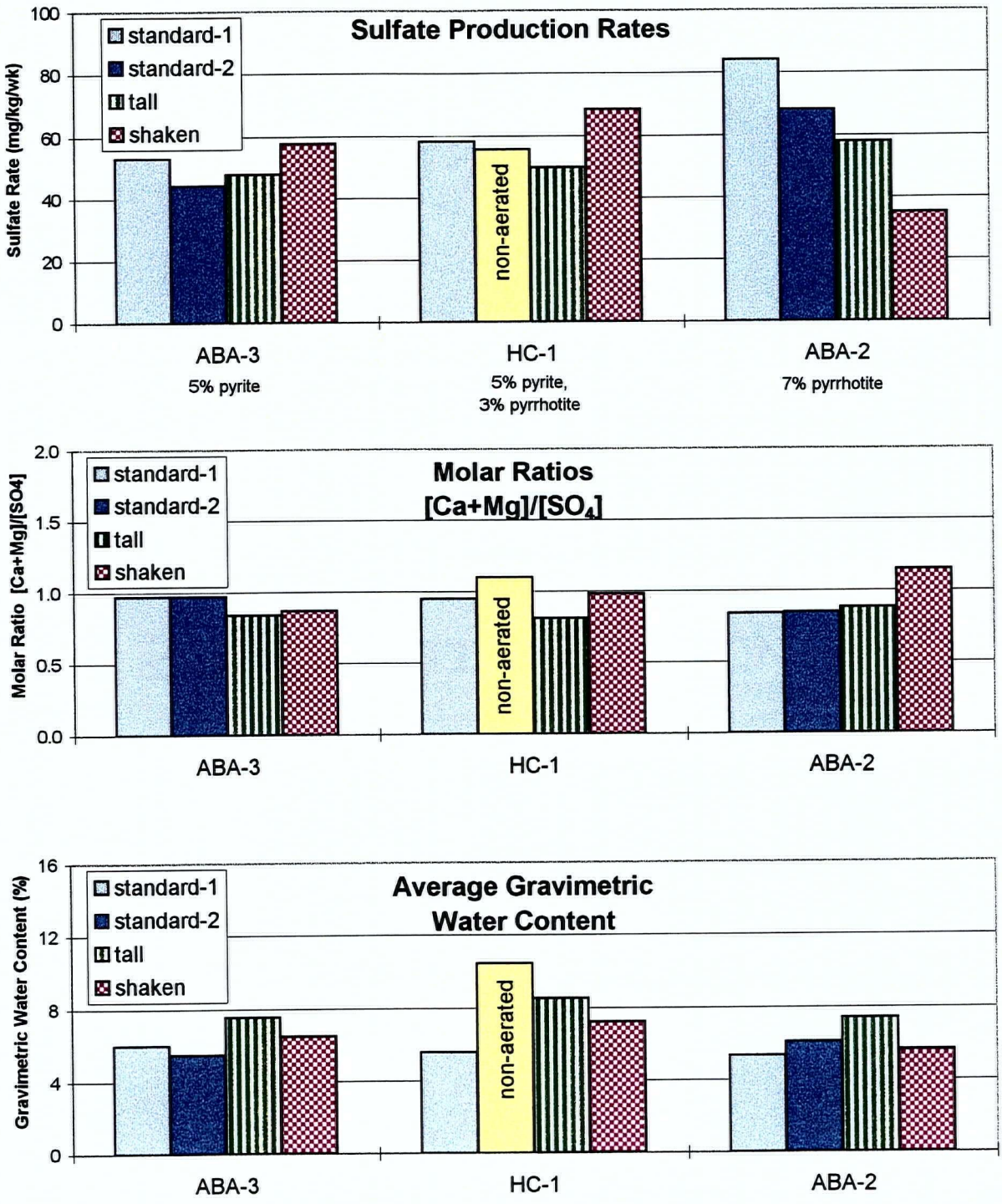


Figure 19: Sulfate production rate, molar ratio and gravimetric water content from standard, non-aerated, tall and shaken cells containing feldspar porphyry samples ABA-3, HC-1 and ABA-2.

rich samples, ABA-3 and HC-1, and the lowest sulfate production rate for the pyrrhotite-rich sample, ABA-2.

The trickle-leach cells containing feldspar porphyry returned the lowest carbonate molar ratios from the most reactive sample, ABA-2. The tall cell returned a carbonate molar ratio slightly lower than the standard cells for samples ABA-3 and HC-1 but a similar ratio for sample ABA-2.

The average gravimetric water content is an average of all moisture measurements taken at the end of each dry cycle and wet cycle. There does not appear to be a consistent correlation between reaction rates and overall moisture content for the three feldspar porphyry samples. Examination of the weekly moisture data (Appendix 4) shows that extreme moisture loss during a cycle does not invoke an immediate increase in sulfate production. However, the highly reactive sample ABA-2 does indicate an increase of sulfate production with increasing moisture loss. The tall cells were found to retain a greater amount of moisture than the standard and shaken cells on a week-to week basis. The moisture content of all the standard and shaken cells fluctuated throughout the testing while for the tall cells it remained comparatively steady.

All the sediment samples produced acidic leachate during testing. A leachate pH consistently below 6.5 has been chosen as the point of acidity for this study since the sediment samples recorded sharp pH decreases at about this value. Reaction rates of the sediment samples were determined using two methods. One method involved averaging the rates from week 6 to the week at which pH < 6.5 was reached. This method eliminated the results from the initial five weeks, which released high concentrations of sulfate, calcium and magnesium due to the dissolution of highly reactive grains (Price et al., 1997) and/or the storage of oxidation products created prior to testing. The second method involved averaging the rates for the five cycles

previous to the week at which pH < 6.5 was reached. Examination of the sulfate production rates for the trickle-leach cells revealed that they differed early in the testing but were relatively similar just before pH < 6.5. For this reason, the latter method was deemed most appropriate for providing long-term reaction rates that could be used for scaling up the results. Since the reaction rates of the sediment samples prior to pH < 6.5 are dependent upon the method used to determine the rates, only general observations are made from these tests.

A summary of reaction rates and carbonate molar ratios of the sedimentary samples, averaged for the last five available cycles prior to the point of acidity, are presented in Table 8.

Table 8: Summary of standard, tall and shaken cell results for sedimentary samples.

Sample	Pyrite (%)	Pyrrh. (%)	Sulfide (%)	NP (kg $CaCO_3$/ tonne)	Cell type	Days to pH < 6.5	SO_4 prod'n (mg/kg/wk)	NP depl'n (mg/kg/wk)	Molar ratio
HC-2	2	3	3.95	11.9	standard	201	47.7	54.5	1.08
					tall	208	67.2	59.0	0.85
					shaken	292	52.5	47.9	0.87
ABA-1	0	7	4.48	36.3	standard-1	194	114	132	1.12
					standard-2	138	123	142	1.10
					tall	181	132	154	1.18
					shaken	250	86.8	78.3	0.87

The shaken cells had the longest time to acidity for both sedimentary samples and returned low sulfate and NP rates. For the pyrrhotite-rich sample ABA-1, the shaken cell returned the lowest sulfate production rate and became acidic after 250 days while the trickle-leach cells only required 138 to 194 days. For sample HC-2, the shaken cell became acidic after 292 days while the trickle-leach cells only required 201 to 208 days. The patterns of sulfate production for the shaken cells containing sedimentary samples are similar to the shaken cells with feldspar

porphyry since they slowly decreased then slowly.

The rates of weathering for the sedimentary samples do not appear to have a clear correlation with the time to acidity. Although the shaken cell containing sample ABA-1 had the lowest sulfate production rate and longest time to acidity, the two standard cells had relatively similar sulfate production rates and differed in time to acidity by two months. It should be noted that the sulfate production rate is dependant upon the method used to calculate the rate prior to acidity, and that the time to acidity is dependant upon the pH used to represent acidic leachate.

5.1.2 Discussion

The standard, tall and shaken humidity cells returned weathering rates that were dependent upon the operating conditions and test protocol. The rate of calcium release for all the samples at any time correlates to the rate of sulfate production. It is considered that the volume of acid produced directly influenced the dissolution rate of the carbonate and Ca-bearing silicates. Since the rate of NP depletion is dependent on the rate of sulfide oxidation for the samples tested, only the influence of test protocol on the rate of sulfide oxidation is discussed.

The amount of sulfate released from humidity cells on a weekly basis can vary due to changes in the rate of sulfide oxidation and the influence of precipitation. The rate of sulfide oxidation within humidity cells may fluctuate due to changes in oxygen diffusion, ionic concentrations, bacteria-catalyzed oxidation, and the formation of micro-environments.

The oxygen diffusion rate may increase during the dry air portion of the cycle in comparison to the wet air portion of the cycle. The rate of oxygen diffusion in water is 2.5×10^{-5} cm^2/s at 25^oC (Perry and Chilton, 1973), which is five orders of magnitude less than in air. For this reason,

moisture content and tortuosity of air-filled pore spaces is an important factor in the rate of oxygen diffusion (Nicholson et al., 1989). Variations in the supply of oxygen, to the exposed sulfide surfaces during the course of a cycle, may alter the abiotic rate of sulfide oxidation.

The ionic concentration of pore water during the dry air portion of the cycle will increase as water evaporates and thereby increase the rate of precipitation. The rate of sulfide oxidation may be influenced by precipitation since a buildup of precipitate can slow the rate at which reactants reach sulfide surfaces (Nicholson et al., 1990).

Bacteria-catalyzed oxidation of the sulfides may also vary during the course of a humidity cell cycle due to changes in the moisture content and pore water acidity. Moisture enhances the biotic oxidation of sulfides by promoting the diffusion of weathering products (e.g. resolubilized precipitation products) and metabolic byproducts (e.g. ferric iron) between the microbes and the substrate (White and Sorini, 1997). The biotic oxidation rate will accelerate with an increase of the pore water acidity (Arkesteyn, 1980).

Micro-environments can form, in part, by the non-uniform distribution of sulfide and neutralizing minerals. Locations having a high concentration of sulfide minerals and low concentration of neutralizing minerals will generate acid that is not readily neutralized. The increased acidity will promote biotic oxidation of the sulfides. Micro-environments promoting biotic sulfide oxidation are also theorized to develop within fractures and cleavage planes of sulfide minerals (Robertson, 1999). Acidity may be shielded from neutralization within these narrow sulfide locations due to a chemical gradient.

Precipitation can create apparent fluctuations in the rate of sulfide oxidation. The retention of

sulfate as a secondary mineral precipitate will decrease the rate of sulfate release. Re-release of sulfate and iron would require minor changes to the water chemistry since the common hydrated iron-sulfate minerals are highly soluble (Nordstrom, 1982; Cravotta, 1994). Pratt et al. (1994) suggested that precipitation could also spall from a particle surface during the dry air cycle if allowed to dehydrate. The irregular supply of moisture to a humidity cell during a weekly cycle would be conducive to the formation and release of precipitation.

5.1.2.1 Tall vs. Standard Cells

The patterns of sulfate production as a function of time for the tall cells were relatively smooth and approached stabilization early in comparison to the standard cells. This smooth pattern is attributed to the moisture content in the tall cells being higher than the standard cells for all three samples. The high percentage of moisture retained by the tall cells may have controlled the rate of oxygen diffusion to the dissolved ferrous iron and exposed sulfide surfaces thereby smoothing the patterns of oxidation. A consistently high moisture content would also dampen changes to biotic sulfide oxidation and ionic concentration. A steady rate of biotic sulfide oxidation, in conjunction with a steady ionic concentration that could influence the amount of precipitate formed and dissolved, may have resulted in the relatively stable sulfide oxidation rates that were achieved early in the test period.

The tall cell was supplied with 500 mL of rinse water, the same rinse water volume of the standard cell, but contained 3 kg of sample in comparison to the 1 kg mass of the standard cell sample. This difference in the water to solid ratio resulted in leachate conductivity 2 to 3 times greater than the standard cell and suggests that the pore water may have had a higher ionic concentration following each leach. A higher concentration of ions may have caused the tall

cells to operate with a greater mass of precipitation than the standard cells. If precipitation controls the rate at which reactants are reaching sulfide surfaces, a consistent rate of sulfide oxidation may result.

The increase of sulfide oxidation rates with moisture loss for pyrrhotite-rich ABA-2 suggests that highly reactive samples are more sensitive to the operating conditions of kinetic tests. A high moisture loss for this sample may have increased the rate of oxygen diffusion to sulfide surfaces thereby increasing sulfide oxidation. The pore water concentration of ferrous iron for this sample, already high in comparison to the other feldspar porphyry samples, would be increased by a high moisture loss. A high ferrous iron concentration would increase the amount of ferrous iron at the water-air interface and possibly increase the rate at which it oxidized to the ferric form.

5.1.2.2 Trickle-leach vs. Shaken Cells

The sulfide oxidation rate initially fluctuated for the trickle-leach cells but slowly decreased then increased for the shaken cells. The smooth changes to the rate of sulfide oxidation from the shaken cells relative to the trickle-leach cells may be due to a reduced influence of precipitation on sulfate release. The shaken cell methodology ensured that sulfate and other reaction products created during a cycle were thoroughly rinsed. However, the trickle-leach cells released a greater cumulative amount of sulfate than the shaken cells suggesting that the rates of sulfide oxidation were different for the two cell types. The variation in oxidation rates is attributed to the formation of micro-environments.

The establishment of micro-environments is considered to occur early within trickle-leach cells

and to be hindered by the continuous particle disturbance of the shaken method. In addition to the delayed formation of micro-environments, the diffusion of oxygen may have been a factor in the patterns of oxidation. The fine material on the bottom of the shaken cells would hold water tenaciously and thereby decrease the rate of oxygen diffusion to a high percentage of the dissolved ferrous iron and exposed sulfide surfaces.

The oxidizing environment within the accumulated fines of the shaken cells would be conceivably quite different from the well-mixed samples of the trickle-leach cells. Due to the high surface area of the segregated fine fraction, a minor change in the oxidation environment here may be capable of significantly influencing the rate of sulfide oxidation. The fine material of the shaken cells may have a concentration of liberated sulfide minerals (Lapakko, 1994b, Price and Kwong, 1997). The oxidation of fine material that is high in sulfides may affect the oxidizing environment by generating high concentrations of H^+ and Fe^{3+} that, in turn, affects the bacterial catalysis of sulfide oxidation. For the two pyritic samples, the shaken cells may have eventually formed oxidation conditions in the fine material that resulted in greater oxidation rates than those of the trickle-leach cells. For the pyrrhotite sample, the low oxidation rate of the shaken cell suggests that pyrrhotite oxidation is more sensitive than pyrite to the retention of reaction products (H^+ and Fe^{3+}) and/or the supply of oxygen.

The shaken cells containing sedimentary samples required a longer period of time to reach acidity ($pH < 6.5$) than the trickle-leach cells and returned low rates of oxidation and neutralization. If the onset of acidity for the sedimentary samples occurs when an increasing rate of acid generation exceeds the dissolution rate of NP minerals, the slow sulfide oxidation rate of the shaken cells may have delayed acidity. Another possibility is that acidity occurred for these

samples when the neutralization rate decreased, possibly due to a buildup of precipitated secondary minerals on the exposed surfaces of neutralizing minerals. In this instance, the slower creation of reaction products by the shaken method and their continuous removal would also delay the onset of acidity.

The trickle-leach and shaken cell results show that an attempt to measure weathering rates more precisely can, in some cases, drastically influence the processes being measured. The shaken cell dramatically altered the distribution of fine material by allowing it to accumulate on the cell bottom and produced results that are difficult to interpret. Simply flooding and draining a sample without agitation can also alter the distribution of fines unless the rinse water is added and drained extremely slowly (White, 1997). Trickle leaching allows the rate of weathering to be influenced to a greater degree by the micro-environments that become established.

5.2 Non-aerated Cell

5.2.1 Results

Sulfate production rates for the non-aerated cell (sample HC-1) and the other trickle-leach cells are presented in Figure 17. Results of the non-aerated cell are plotted in Appendix 4 and are tabulated in Appendix 11.

The non-aerated cell returned a final sulfate production rate very similar to the standard cell at 56 and 58 mg/kg/wk, respectively. The sulfate production rate decreased relatively smoothly for the first 100 days then stabilized after only 200 days. The cumulative sulfate production of the non-aerated cell at 260 days was 1960 mg/kg, which is significantly lower than the production for the standard, tall and shaken cells that ranged from 2500 to 2570 mg/kg.

5.2.2 Discussion

The rate of sulfide oxidation for the non-aerated cell slowly decreased and then increased in a manner very similar to the rate for the shaken cell. The low amount of cumulative sulfate production by the non-aerated cell in comparison to the other trickle-leach cells suggests that the rate of sulfide oxidation was initially retarded. The slow oxidation rate is attributed to the high moisture content of the non-aerated cell that would hinder the transfer of oxygen to the dissolved ferrous iron and sulfide surfaces for oxidation. Since the final oxidation rate is similar to the trickle-leach cells, any influence of high moisture on the availability of oxygen for ferrous iron and sulfide oxidation was only temporary.

As suggested for the tall cells, the high moisture content may have decreased the influence of precipitation on sulfate release and resulted in the relatively stable sulfide oxidation rates that were achieved early in the test period.

The non-aerated test results suggest that keeping the moisture content high and constant will quickly lead to a stable oxidation rate not different from a rate determined over long periods using dry/wet cycles. This finding indicates that eliminating the dry and wet air flow of a trickle-leach cell may result in more reliable reaction rates being returned in a shorter period of time. Verification of this test result is required, especially with highly reactive pyrrhotite-rich samples.

5.3 Simulated Precipitation Cells

5.3.1 Results

Graphic comparisons of the simulated precipitation cell results are presented in Appendix 5. The results of these six cells that contained sample HC-1 are tabulated in Appendix 12. Since low

volumes of flush water were used for these tests, the term sulfate release rate is used rather than sulfate production rate.

The air supply to the cells was turned off two weeks prior to the simulated precipitation leaching. Sulfate release over time from the simulated precipitation cells are shown in Figure 20 and the molar ratio over time from these cells are shown in Figure 21. The average sulfate production rate of the HC-1 standard humidity cell using the last five available cycles is shown on the plots to assist with comparison of the results.

The first leach of the simulated precipitation, starting with a 0.5 week leach frequency, produced low rates of sulfate release for the 50-mL and 100-mL cells was seen to decrease while the trend for the 500-mL cell increased. Eight leaches in total were applied during the 0.5-week leach frequency. The sulfate release for the 50-mL and 100-mL cells slowly moved towards stabilization during this period with the 50-mL cells having the least dramatic fluctuations. Although the sulfate release rates appeared to be stabilizing about the standard humidity cell sulfate production rate of 58 mg/kg/wk, the 0.5-week leach frequency was not maintained long enough to confirm this.

The carbonate molar ratio for the 50-mL and 100-mL cells during the 0.5-week leach frequency appeared to be unchanged from previous weeks whereas it steadily increased for the 500-mL cell. The final carbonate molar ratio recorded for the 500-mL cell at the 0.5-week leach frequency was 1.5.

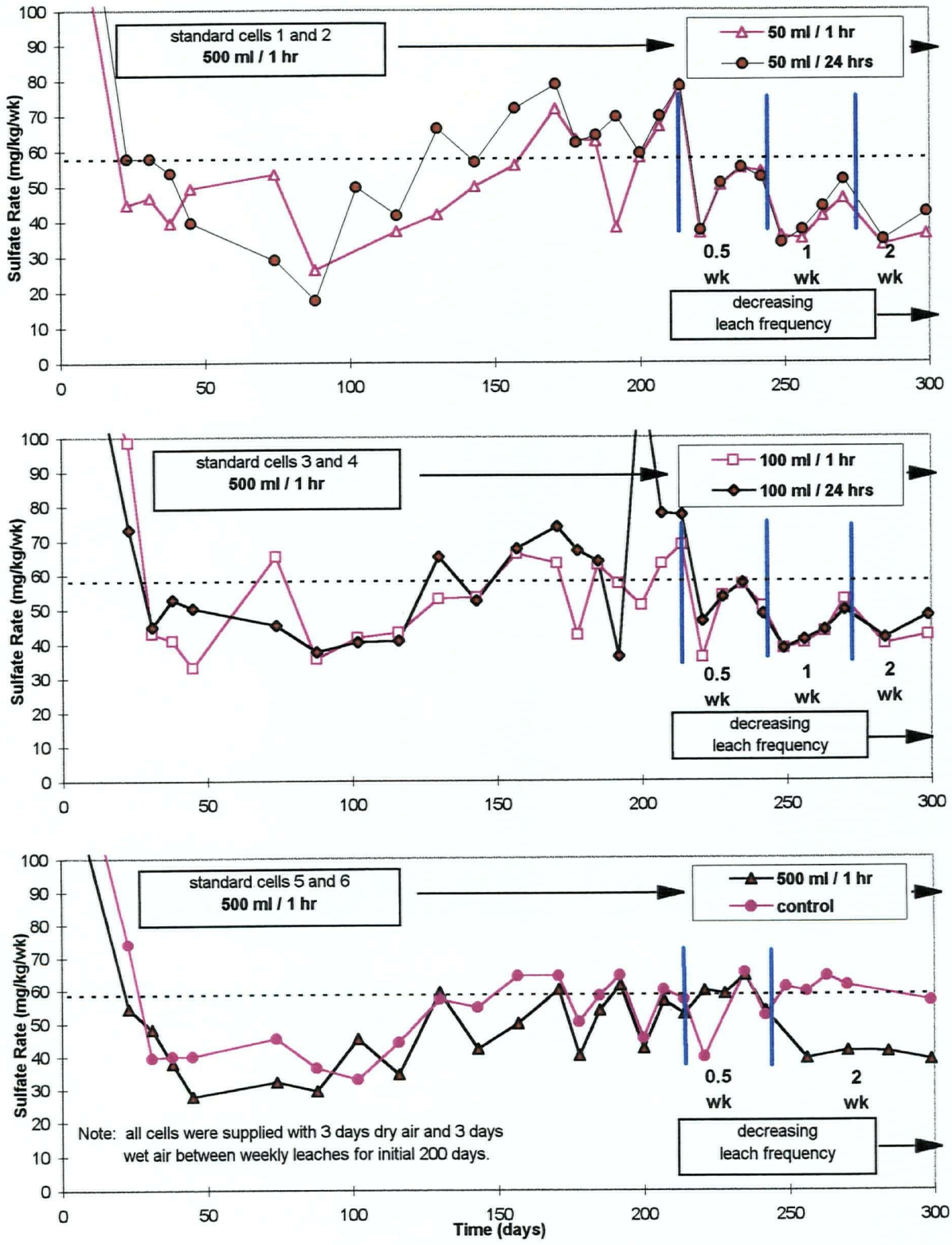


Figure 20: Sulfate release over time from simulated precipitation cells containing sample HC-1.

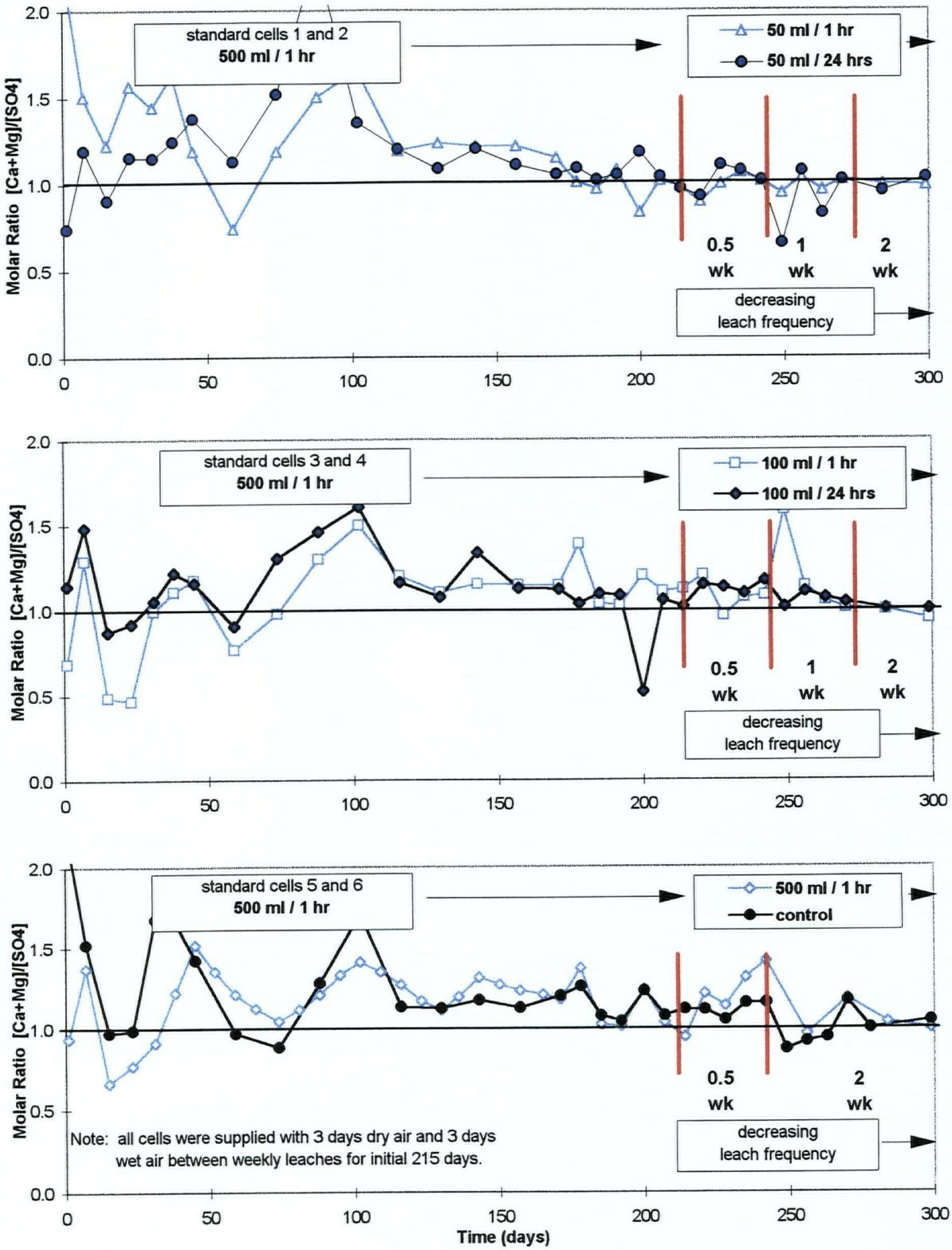


Figure 21: Molar ratio over time from simulated precipitation cells containing sample HC-1.

The 1-week leach frequency used for the 50-mL and 100-mL cells caused the sulfate release to decrease sharply for the initial leach then it steadily increased. It is unclear whether the rate of sulfate release would have stabilized at a similar value for these cells if this frequency were maintained. For the 50-mL cells, the 24-hour leach increased the rate of sulfate release in comparison to the 1-hour leach. The carbonate molar ratio for the 50-mL and 100-mL cells became relatively stable at 1.0. The 24-hr leach created greater fluctuations in the carbonate molar ratio than was seen with the 1-hr leach.

Switching to a 2-week leach frequency elicited a sharp decrease in sulfate release for the 50, 100 and 500-mL cells. The 50 and 100-mL cells had two leaches at the 2-week frequency while the 500-mL cell had four. The four 50 and 100-mL cells all increased their sulfate release by the second leach with the 24-hour leaches releasing the highest amount of sulfate. The leachate conductivity of the 100-mL cells became greater than 1000 μS/cm during this leach frequency, the same conductivity as the 50-mL cells when leach duration began influencing sulfate release rates. The 500-mL cell appears to have a relatively stable sulfate release rate at 40 mg/kg/wk. The carbonate molar ratios for all the cells are relatively stable at 1.0 for this leach frequency.

The control cell, which was maintained with a weekly 500-mL trickle leach, had a relatively stable sulfate release rate at 61 mg/kg/wk when terminated. This rate is comparable to the standard humidity cell sulfate production rate for sample HC-1 at 58 mg/kg/wk. The carbonate molar ratio of the control cell was relatively stable at 1.0.

5.3.2 Discussion

The sulfate release rates for the simulated precipitation cells did not become stable at any time,

except during the 2-week leach frequency for the 500-mL cell. The carbonate molar ratios were relatively stable with repeated leaches at each leach frequency except for the 500-mL cell during the 0.5-week leach frequency. Despite the lack of steady sulfate release rates, certain patterns are apparent and provide insights into the influences of leach volume, duration and frequency.

The sharp decrease in sulfate release for the 50 and 100-mL cells when the rinse water volume was initially decreased is explained by the influence of rinse water volume on pore water sulfate concentrations. The volume of pore water within the simulated precipitation cells between leaches was approximately 100 mL. Assuming the pore water completely mixes with the applied rinse water, a 50-mL leach would only remove one third of the solutes while a 100-mL leach would remove one half. A smaller dilution of pore water may also explain the initial decrease in sulfate release from all the simulated precipitation cells when the leach frequency was reduced. A decrease in leach frequency translates to a lower weekly volume of rinse water being applied and therefore a smaller dilution of the pore water.

Despite the volume of rinse water used during the 0.5 and 1-week leach frequency, all the cells appear to eventually return a sulfate release rate similar to the rate for the standard trickle-leach humidity cells. It is considered that maintaining a constant pore water volume, using a consistent volume of rinse water, and leaching with a regular frequency will establish a constant oxidizing environment within the cell. For all the cells, changing the leach volume and/or frequency may have influenced the pore water chemistry and precipitation thus disrupting the established oxidizing environment. The results suggest that regular leaching of the HC-1 sample, at least once a week, will release an amount of sulfate approximately equal to the amount of sulfate produced for a wide range of leach volumes.

The 2-week leach frequency affected the sulfate release rate of the 500-mL cell in that it became lower than the average sulfate production rates for the HC-1 trickle-leach humidity cells. Previous studies (Day et al., 1997; Soregaroli and Lawrence, 1998) have also shown that the release of reaction products will decrease as the time between leaches increases. Saturation of the 500-mL of rinse water is not considered to have caused excessive precipitation to occur since the 50-mL and 100-mL cells removed an equal amount of sulfate during the same leach frequency of two weeks. A possible factor in the low sulfate release rates may be slow precipitation kinetics that may benefit from the longer time between flushes and enhance precipitation. Another factor may be a decrease in the solubility of secondary mineral precipitates with time. For example, freshly precipitated amorphous $Fe(OH)_3$ will recrystallize with time towards more stable phases (see review by Murray (1979)) and become more resistant to removal (Langmuir and Whittemore, 1971; Whittemore and Langmuir, 1975). An increase in retained precipitation from either of these factors could also decrease the oxidation rate by removing ferrous and ferric iron from solution and by acting as a barrier between reactants.

An extended leach duration apparently aids the dissolution of precipitates since the 24-hour leaches removed more sulfate than the 1-hour leaches during the 2-week leach frequency. There was a minor increase of sulfate removal with increased leach duration for the 50-mL cells that was not seen for the 100-mL cells during the 1-week leach frequency. The 24-hr leach may have prolonged convection at the mineral surfaces thereby enhancing the transport of ions from the secondary minerals. It is noteworthy that leach duration began influencing the rate of sulfate release for the 50 and 100-mL cells only once the leachate water conductivity reached ~ 1000 µS/cm. It is uncertain whether this conductivity marks the occurrence of significant precipitation or if the ionic concentration of the pore water influenced the rate of secondary mineral

dissolution. The application of a mineral-equilibrium model such as MINTEQ (Allison et al., 1990) may help resolve this. The leach frequencies of 1 and 2-weeks were discontinued too early to determine if the 1 and 24-hr duration would have returned different release rates in the long-term.

The influence of leach volume on the neutralization of generated acid was quite apparent with the 500-mL cell during the 0.5-week leach frequency. The high volume of water (1 litre a week) increased the rate of neutralization depletion past the rate of all the other trickle-leach cells. It was previously concluded for this sample that the rate of NP depletion was controlled by the rate of acid generation (similarity of sulfate and NP depletion patterns). The high carbonate molar ratio of 1.5 suggests that a high flush volume can dissolve a greater amount of carbonate minerals than the acid from sulfide oxidation, and therefore control the rate of NP depletion.

The non-aerated method that was used for the simulated precipitation cells was successful in returning similar rate patterns from cells having a similar leach volume and frequency. The patterns of sulfate release for the two 50-mL cells were virtually identical for the 0.5-week leach frequency, as were the two 100-mL cells for the 0.5 and 1-week leach frequencies. These comparative patterns show that a non-aerated cell can provide results that are easier to reproduce than the standard humidity cell.

5.4 50-kg Cells

5.4.1 Results

Stacked profiles of pH, conductivity, sulfate production, carbonate molar ratio and leachate volume over time is shown for the HC-1 50-kg cell in Figure 22 and for the HC-2 50-kg cell in

Figure 23. The results of the HC-1 and HC-2 50-kg cells are tabulated in Appendix 13.

To compare the weathering rates of the 50-kg samples to the 1-kg samples, units are reported on a surface area basis ($mg/m^2/wk$). Conversion to the surface area units was calculated using the specific surface areas reported in Table 3, and the formula presented in Section 4.4.

The sample size and grain size distribution of the 50-kg cells prevented them from being operated under similar conditions as the smaller humidity cells. The airflow from the 50-kg cells was maintained at approximately 0.5 L/min, the same rate as the smaller humidity cells. Due to the volume of rock and the high amount of moisture contained, the air pressure had to be high to maintain this airflow rate throughout the week. Since changes to moisture content were not measured, the typical amount of moisture lost during the dry cycle is unknown. The volume of rinse water applied weekly was 500 mL and the typical volume of leachate recovered was greater than 500 mL. The humid air cycle was therefore adding excessive moisture to the cells, an operating condition that never occurred with the standard humidity cells.

The typical leachate volume became less than the rinse water volume once the dry/wet air cycle was discontinued at 221 days. Leachate drained from the cells throughout the week with approximately 70 to 75% of the total volume being released in the first 24 hours. The feldspar porphyry (HC-1) drained the fastest with approximately 95% of the total leachate volume being released by day 5 in comparison to the sedimentary sample (HC-2) releasing approximately 90%.

The sulfate production rates of the two 50-kg samples were very similar throughout the test period. These two samples also returned comparable sulfate production rates to the standard humidity cells suggesting that the operating conditions of the two 50-kg cells were similar.

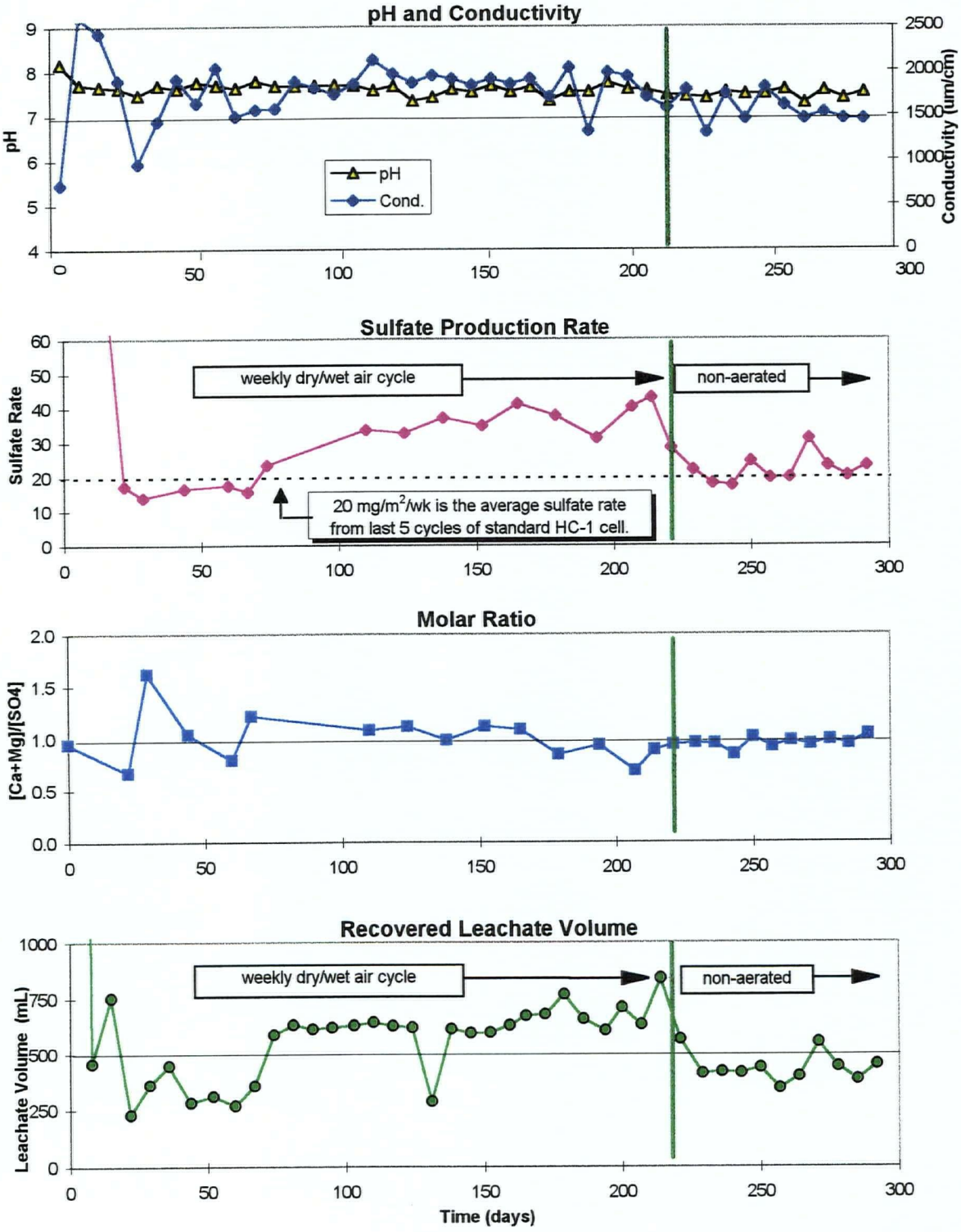


Figure 22: pH, conductivity, sulfate production, molar ratio, and recovered leachate volume over time from 50-kg cell containing feldspar porphyry sample HC-1.

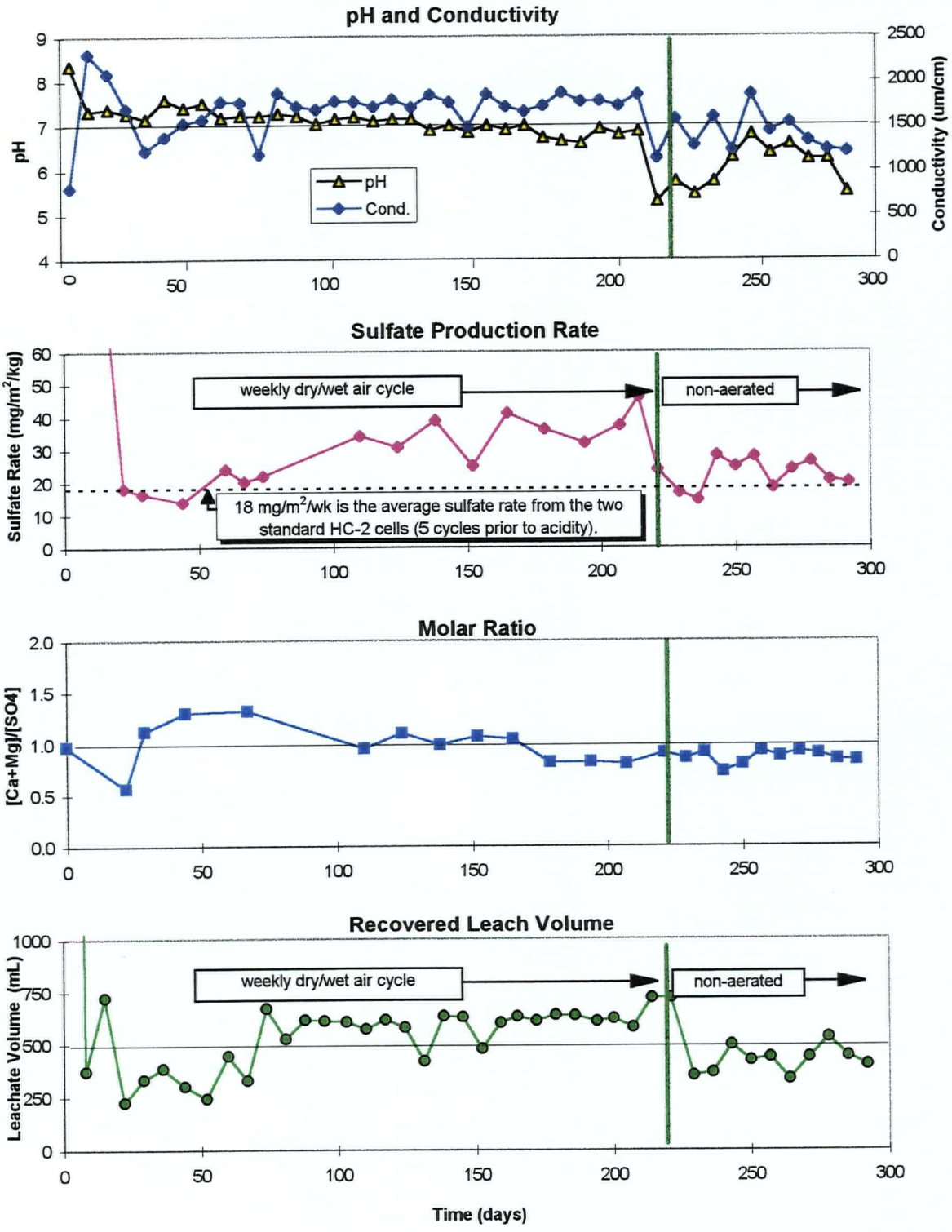


Figure 23: pH, conductivity, sulfate production, molar ratio, and recovered leachate volume over time from 50-kg cell containing sedimentary sample HC-2.

The 50-kg cell containing feldspar porphyry sample HC-1 produced neutral leachate throughout the test period. During the dry/wet air cycles, the sulfate production fluctuated between 30 and 40 mg/m^2/wk while the carbonate molar ratio slowly decreased. Once the air was turned off, the rate of sulfate production decreased and the carbonate molar ratio became steady. The final 5-cycle average of sulfate production was 23 mg/m^2/wk, which is comparable to the standard cell rate of 20 mg/m^2/wk. The final 5-cycle average of the carbonate molar ratio was 0.97, greater than the average trickle-leach carbonate molar ratio of 0.88.

The average sulfate production rate of the HC-2 50-kg cell for the five cycles prior to acidity was 39 mg/m^2/wk in comparison to the 18 mg/m^2/wk returned from the standard cell. Despite the higher sulfate production, the HC-2 50-kg sedimentary sample took 221 days to reach acidity whereas the standard and tall trickle-leach cells required only 201 and 208 days respectively. The carbonate molar ratio steadily decreased during this time to 0.84. Once acidic leachate was produced, the dry/wet air cycles were discontinued and the sulfate production rate decreased. The final (post-acidity) 5-cycle average of sulfate production from the 50-kg cell after 313 days was 19 mg/m^2/wk and the carbonate molar ratio was 0.87.

A concern for the 50-kg cells was that the low volume of flush water applied weekly would extend the time required to remove the initial concentrations of sulfate, calcium and magnesium. High concentrations of these ions are common during the first 3-5 weeks of standard humidity cell testing. Delaying their release would artificially elevate the rates of sulfate production and NP depletion. The initial concentration peak was either due to the high reactivity of newly exposed minerals and/or weathering products formed prior to the test due. Newly exposed minerals can be highly reactive due to irregularities on the crystal faces. Crystal irregularities are

favourable sites for mineral dissolution since the ions and atoms are not completely surrounded by other crystal units and have a lower binding energy to the crystal surface (Zhang and Nancollas, 1990). If the concentration peak is due to the high reactivity of fresh mineral surfaces, the released reaction products from the 50-kg cells should be similar to the smaller cells when compared on a surface area basis. The cumulative release of sulfate for the first 5 weeks of testing for all the cells, on a mass and surface area basis, are presented in Table 9.

Table 9: Cumulative sulfate release at five weeks for samples HC-1 and HC-2.

	Sulfate assay		Contained sulfate	Cumulative sulfate released at 5 weeks	
Sample	(%)	Cell type	(mg)	(mg/kg)	(mg/m^2)
HC-1	0.02	standard	200	822	282
		tall	600	757	259
		shaken	200	1039	356
		50-kg	10,000	192	384
HC-2	0.02	standard	200	786	302
		tall	600	873	336
		shaken	200	1142	439
		50-kg	10,000	188	427

The 50-kg cells released far less sulfate than the 1 to 3-kg cells despite containing more quantitatively. The contained sulfate is therefore not occurring as readily soluble sulfate salts produced by weathering prior to comminution. The sulfate is most likely present as known Red Mountain minerals such as barite (Morin and Hutt, 1996) and gypsum (Rhys et al., 1995). These minerals would represent a negligible source of sulfate compared to oxidizing sulfides and would not significantly increase the sulfate production rate. An examination of the cumulative sulfate released during the initial 5 weeks on a surface area basis reveals that release from the 50-kg cells is comparable to the smaller cells. The similar release of sulfate on a surface area basis

suggests that highly reactive fines were responsible for the initial concentration peaks.

5.4.2 Discussion

The 50-kg cells were originally supplied with dry/wet air cycles to create an operating condition similar to the standard humidity cells. Conditions were dissimilar however with the 50-kg cells expelling a volume of leachate greater than the volume of rinse water applied. Turning off the air to the 50-kg cells created an operating condition much easier to duplicate on a weekly basis, as was previously shown by the simulated precipitation cells. The HC-1 50-kg cell and non-aerated cell returned comparable sulfide oxidation rates when reported on a surface area basis, which is attributed to the similar operating conditions. It is possible that turning off the air supply did not significantly decrease sulfide oxidation but the decreased flush volume limited the sulfate release. Certainly repeating the experiment with a greater volume of rinse water would help differentiate sulfate production from sulfate release.

The rate of sulfide oxidation for each of the 50-kg cells when supplied with dry/wet cycles is almost twice the rate returned from the respective 1-kg humidity cells. If the excess moisture gained during the wet cycle was kept in a state of flux, by capillarity or gravity, precipitation may have been removed as efficiently as a long-duration leach. A kinetic test study by Day et al. (1997) found that humidity cell sulfate release rates were greater from a continuous trickle leach than a weekly flood method. The continuous movement of pore water from the trickle leach method may help remove weathering products and ensure fresh sulfide surfaces for oxidation. The movement of pore water may also increase the rate of sulfide oxidation by continually moving ferrous iron to the water-air interface to be oxidized to the ferric form, then returning the ferric iron to the exposed sulfide surfaces. The non-oxidative dissolution of pyrrhotite, shown by

Janzen et al. (1997) to be a significant contributor of ferrous iron release, may also be enhanced by pore water convection.

A major influence on the rate of sulfide oxidation for the 50-kg cells is thought to be the distribution of sulfide and neutralizing minerals. The mineral distribution for the 50-kg samples is expected to be much less homogeneous than for the finer grained (-¼") samples. Therefore, these coarser samples may have a higher number of micro-environments that are greater in size. Bacterial catalysis of sulfide oxidation within these micro-environments is considered to be increased by dry/wet air cycles. This conclusion is based on the comparison of moisture content and sulfate production rates for the HC-1 standard, tall and shaken humidity cells. For these cells, it appeared unlikely that manipulating the airflow or humidity could have doubled the rate of sulfate production. Solely leaching the 50-kg cells once a week and maintaining a high moisture content apparently negates the influence of micro-environments.

Measuring specific surface area by using geometric estimates is not as direct a method as the BET analysis, which uses an adsorptive gas. The BET analysis has been shown to return greater specific surface areas than estimated geometrically because of irregularities that occur on the particle surfaces (Parks, 1990; Janzen et al., 1997). The study of pyrrhotite by Janzen et al. (1997) found that a given grain size has one kind of surface irregularity that dominates and affects the specific surface area. The study also concluded that the specific surface area of pyrrhotite may change with different size reduction methods. The geometric estimates of surface area for the HC-1 sample proved useful in normalizing the sulfate production rates and scaling up the results. A direct surface area measurement may be more critical when scaling up laboratory reaction rates to field conditions since the fine particles will be created by a different method

(i.e., blasting versus crushing and grinding).

5.5 NP Columns

5.5.1 Results

Results from the NP columns are graphically compared to the standard, tall and shaken cells in Appendix 6. The NP column results are tabulated in Appendix 14.

The two sedimentary columns produced acidic leachate (pH < 6.5) during the test period while the leachate from the three feldspar porphyry samples remained neutral. All the columns were observed to have precipitation fronts that steadily progressed towards the bottom of the columns as the tests continued (Figure 24). The material above the precipitation front was orange-brown in colour while the material below it had small orange-brown patches occurring locally. For the sedimentary columns, the leachate pH dropped below 6.5 once the precipitation front was observed to reach the bottom of the column.

The three feldspar porphyry columns were not operated to the desired endpoint of pH < 6.5. To estimate the results of these column tests had they been operated to a pH < 6.5, observations from the sedimentary columns were considered. It was assumed that the leachate from the feldspar porphyry columns would have a pH of 6.5 once the precipitation front reached the column bottom. To apply this assumption, the distance from the top of the sample to the oxidation front was measured. It was estimated that 42% of sample ABA-3, 43% of HC-1 and 25% of ABA-2 had iron oxide precipitate. The time required for the precipitation front to reach the column bottom was then calculated and the reaction rates, which were all relatively steady, were extrapolated to this point in time. The resultant estimates of the % sulfide and % NP that would

Figure 24: NP columns showing precipitation fronts of the samples HC-1, HC-2, ABA-1, ABA-2, and ABA-3 from left to right.

have been depleted if the tests were operated until leachate pH < 6.5 are presented in Table 10.

Table 10: % sulfide and % NP depleted at the point of leachate pH < 6.5 for NP columns.

		Depletion at point of pH < 6.5	
		Sulfide	NP
Rock type	Sample	(%)	(%)
feldspar porphyry	ABA-3	5.9*	86*
	HC-1	3.0*	47*
	ABA-2	4.3*	71*
sedimentary	HC-2	2.2	67
	ABA-1	4.0	72

* estimated

The HC-2 sedimentary sample with 3% pyrrhotite and 2% pyrite took 226 days to produce acidic leachate from a column while the ABA-1 sedimentary sample with 7% pyrrhotite required 350 days. The percentage of sulfide sulfur and NP depleted at pH < 6.5 for the sedimentary columns as compared to the other cell types are shown in Figure 25.

The amount of sulfate produced by the two sedimentary columns at the point of pH < 6.5, is very similar to the average humidity cell sulfate production for these samples. The HC-2 column produced 2,800 mg/kg of sulfate at the point of pH < 6.5, very similar to the average humidity cell sulfate production of 2,460 mg/kg. The total sulfate produced by the HC-2 column at pH < 6.5 is also similar to the sulfate produced by the HC-2 50-kg cell at this pH when reported on a surface area basis. The HC-2 column produced 1,080 mg/m^2 of sulfate at pH < 6.5 as compared to the 1,200 mg/m^2 of sulfate produced by the HC-2 50-kg cell. The ABA-1 column produced 5,680 mg/kg of sulfate at the point of pH < 6.5, again similar to the average humidity cell sulfate production for this sample at 6,040 mg/kg.

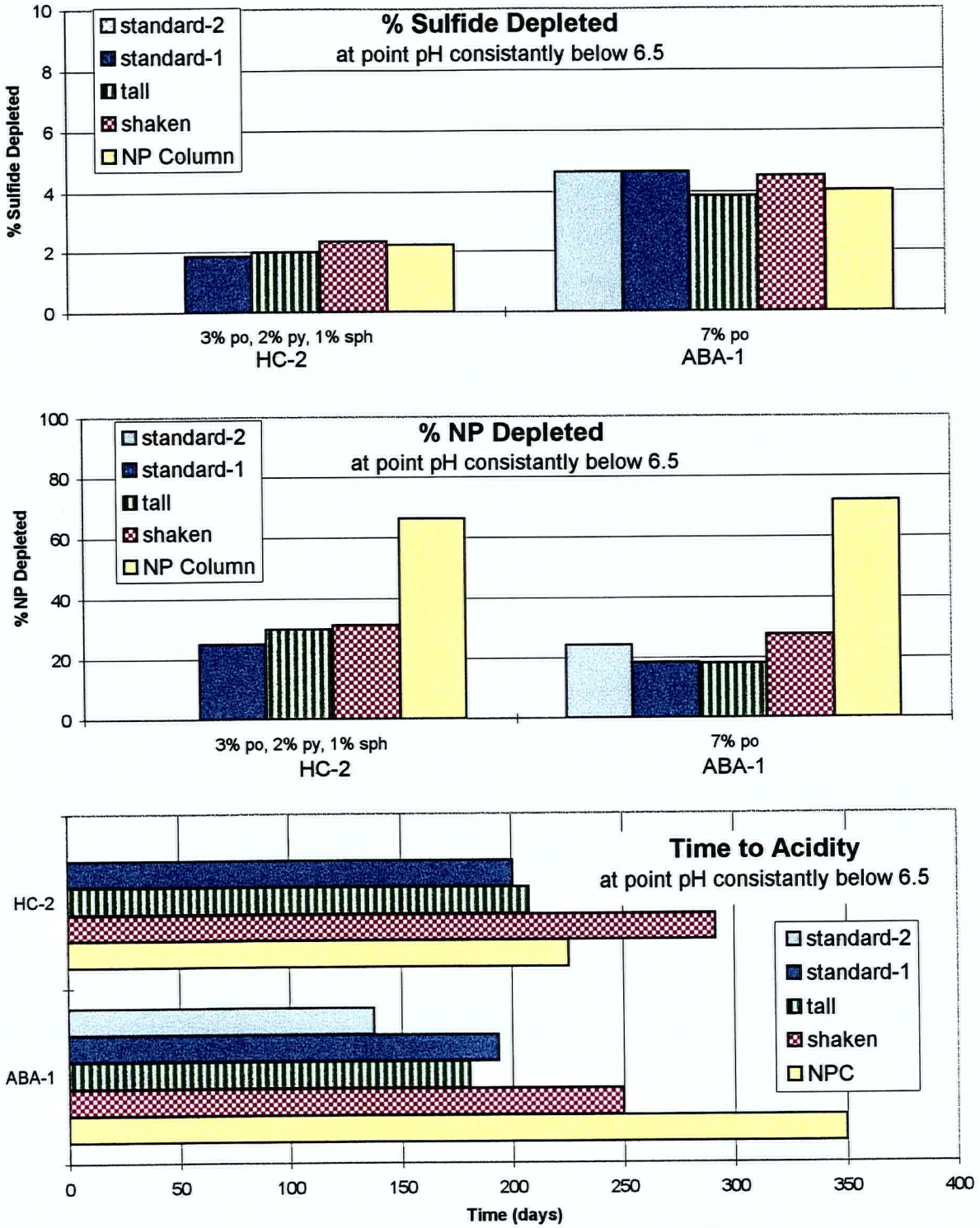


Figure 25: % sulfide depleted, % NP depleted and time to acidity from humidity cells and NP columns for sedimentary samples HC-2 and ABA-1.

The HC-2 column depleted a third as much NP as the ABA-1 column. The cumulative NP depleted at the point of pH < 6.5 for the HC-2 column was 7,920 mg/kg as compared to the ABA-1 column with 24,400 mg/kg of NP depleted. The same proportions are seen in the initial NP determinations with the HC-2 sample having a third as much NP as the ABA-1 sample, at 11.9 kg $CaCO_3$/t and 36.3 kg $CaCO_3$/t, respectively.

5.5.2 Discussion

The column experiments succeeded in accelerating the NP depletion rates in relation to the humidity cells. Results show that the rate at which NP was depleted from the two sedimentary samples depended upon the amount of contained NP (i.e., the exposed surface area of neutralizing minerals) and the volume of acidified rinse water. It is assumed that the NP minerals were reasonably similar for the two sedimentary samples in respect to type, mode of occurrence and relative abundance. Unlike the humidity cells, the rate of sulfide oxidation did not appear to have an influence on the rate of NP depletion.

When a sample contains more acid producing minerals than neutralizing minerals, it is predicted to become acidic once the available NP is depleted. For this reason, an estimate of available NP is typically used to predict when acid drainage will occur for net-acid-containing samples. As previously discussed (Section 2.4), the available NP has been tied to specific percentages (Ferguson and Morin, 1991; Rescan, 1992), specific amounts (Morin and Hutt, 1996, 1997) and by applying mineral reactivity factors to the contained neutralizing minerals (Li, 1997). However, the column tests containing sedimentary samples have a point of acidity best predicted by a cumulative sulfate production rather than NP depletion. This holds true regardless of the sulfate production rate, as evidenced by the various times taken by the cells to reach acidity.

An explanation for the link between acidity and sulfate production is provided by the findings of Bradham and Caruccio (1990). They found that acidity is determined by the balance of acid and alkalic water production. Therefore, the rate of sulfide oxidation would have to increase or the rate of neutralization decrease for acidity to occur since the NP minerals were not depleted. It is possible that the accumulation of reaction products will increase the rate of oxidation (e.g., standard versus shaken cell for sample ABA-2) to a point where the alkalic water production is insufficient. Alternatively, the rate of oxidation could remain constant and a buildup of reaction products on the exposed surfaces of neutralizing minerals could decrease their rate of dissolution. Both of these scenarios permit the onset of acidity to be related back to a specific amount of oxidized sulfide. The results suggest that measurements of cumulative sulfate production (acid production) may provide a better estimate of time to acidity than NP depletion.

5.6 20-tonne (Field) Cells

5.6.1 Results

Graphic comparisons of the two 20-tonne test results on a monthly basis are presented in Appendix 7. For each month of operation, the plotted parameters include daily averages of pH, conductivity, outflow, inflow (mm of precipitation * crib open surface area), internal temperature, and air temperature. The daily averages of water flow, pH, and conductivity are tabulated in Appendix 15 and the daily averages of internal temperature and air temperature are tabulated in Appendix 16. The chemistry of the collected water samples is tabulated in Appendix 17.

A summary of the 1996 data showing pH, conductivity, carbonate molar ratio and water outflow is presented in Figure 26. Both of the cribs produced neutral drainage during the seasons that

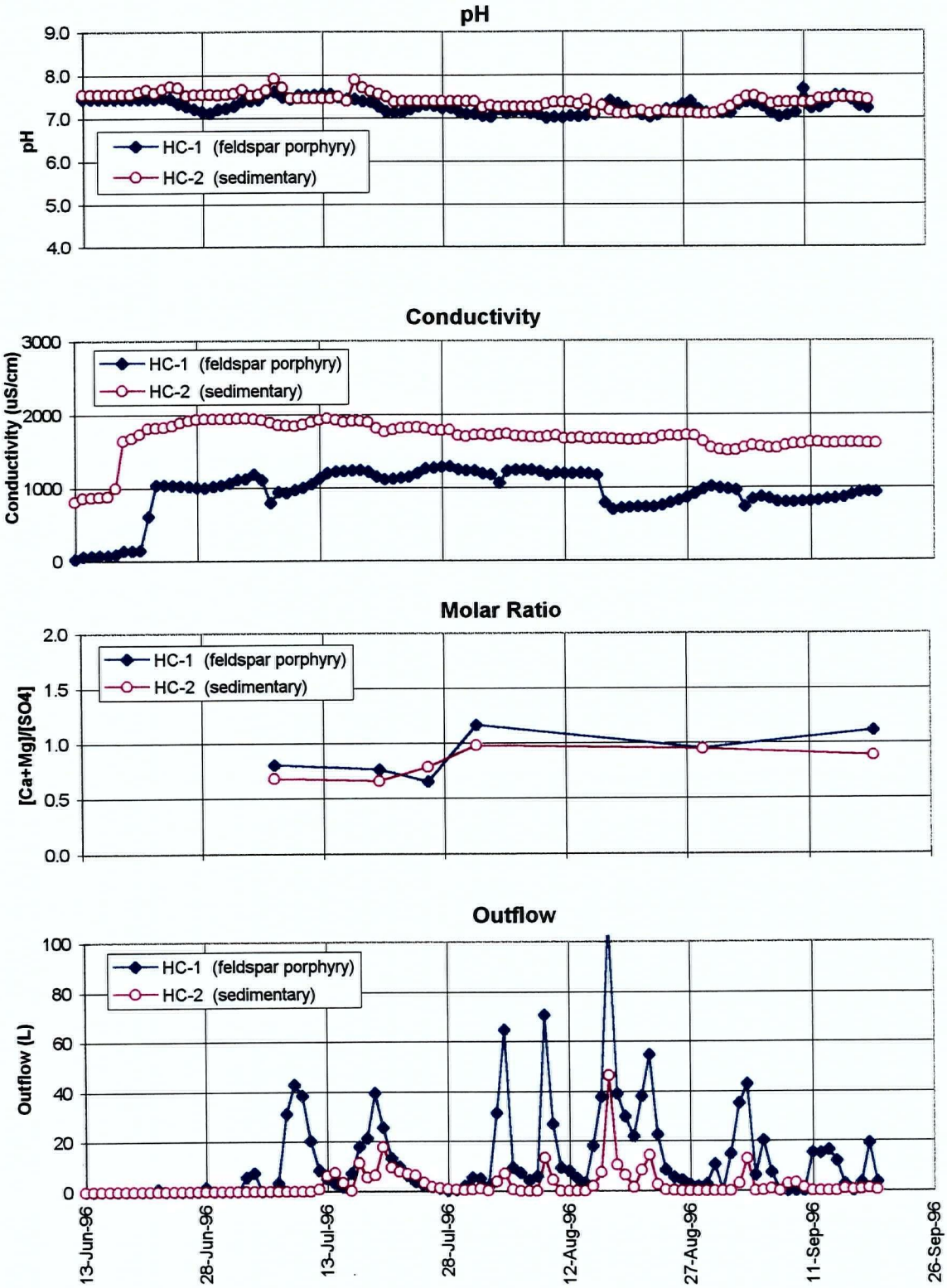


Figure 26: pH, conductivity, molar ratio and outflow from June 13 to September 19, 1996 from the two 20-tonne (field) cells containing samples HC-1 and HC-2.

they were operational. The major increase of conductivity for the cribs in June of 1996 is attributed to the melting of internal ice and the displacement of distilled water used to submerse the probes. The first decrease in conductivity for the cribs occurs during the first week of July 1996 and follows two large storms that produced very little outflow. These decreases in conductivity correspond with an increase of internal temperature above $0^{o}C$ suggesting that the continued melting of internal ice released blocked rainwater.

The conductivity of the feldspar porphyry crib HC-1 is seen to decrease during major storm events. A general observation for this crib is that the conductivity remains unchanged or slightly decreases during the initial 40 to 70 L of outflow from a storm event before showing a noticeable decrease.

The overall trend of conductivity for the sedimentary crib HC-2 gradually decreased from early July to September then became relatively stable. The conductivity of crib HC-2 also decreased during storm events but is only evident for the months of June and July and is more subtle than the HC-1 crib. At the end of August, the conductivity decreased but did not correlate with a large outflow of water.

The carbonate molar ratio had a similar pattern for both cribs. The initial water samples, taken on October 31st, 1995, returned a carbonate molar ratio of 0.58 for HC-1 and 0.57 for HC-2. The carbonate molar ratios of June 1996 are also quite low but increased during a large storm event in August 1996, measuring 1.23 for HC-1 and 1.27 for HC-2. The carbonate molar ratios of the final water samples, taken September 19th, 1996, are 0.94 for HC-1 and 0.84 for HC-2.

5.6.1.1 Water Storage and Discharge

When the tipping buckets were first installed on August 7, 1995, water was trickling from the HC-1 feldspar porphyry crib while the first outflow from the HC-2 sedimentary crib was recorded on September 10, 1995. Since the precipitation at the project site is similar to the Stewart Airport (Rescan, 1994), the rainfall prior to August 7th, 1995 was assumed to be equal to the Stewart Airport which corresponds to approximately 640 L of water volume for each crib.

The close relationship between rainstorms and crib outflow is readily apparent by examining the daily inflow and outflow of the cribs in Appendix 7. As the amount of water stored within each cell increased, the lag time between a storm event and the outflow of water became shorter. The feldspar porphyry crib HC-1 reached field capacity (saturation of fine material followed by free drainage that has practically ceased) during mid-July of 1996 since the measured volume of water entering this crib began to equal the volume of water flowing out. The degree of saturation (volume of water stored relative to the volume of voids) for crib HC-1 at field capacity is approximately 17% (Figure 27). This measurement of % saturation at field capacity for the HC-1 sample is in agreement with the data by Dawson and Morgenstern (1995) when plotted against the estimated HC-1 void ratio of 0.74 (Figure 28). The degree of saturation recorded for the HC-1 cell remained relatively constant from mid-July to mid-September suggesting that the amount of water lost to runoff, evaporation and/or leakage is insignificant. The sedimentary crib HC-2 was still storing water at the end of the test period with a final degree of saturation of 28%. Using the data by Dawson and Morgenstern (1995), and the estimated HC-2 void ratio of 0.53, field capacity should be reached for this crib when the degree of saturation reaches approximately 42%.

The measured amount of water entering the cribs from August 7th, 1995 to September 19th, 1996, is 2940 L. The stored water estimate for the HC-1 crib is 1620 litres and for the HC-2 crib is 2650 litres. From June 13th to September 19th, 1996, water was released from the HC-1 crib 77% of the days and from the HC-2 crib 62% of the days.

5.6.1.2 Estimate of Sulfate Production Rates

The amount of sulfate released by each cell during the operating seasons was determined from the conductivity measurements as correlated with a best-fit line (Figure 29). An average conductivity was calculated for each active day of each cell, then used to calculate daily sulfate concentrations. The daily sulfate concentration was then applied to the day's outflow volume to provide a daily sulfate release. The amount of sulfate released from August 7, 1995 to the end of the 1996 season, using conductivity, totaled 618 g for the HC-1 crib and 306 g for the HC-2 crib. These amounts do not represent the entire sulfate produced since sulfate is stored within the pore water and occurs as precipitate.

To estimate the amount of pore water sulfate, the volume of stored water and an estimate of its sulfate concentration are required. Assuming the sulfate concentration of the stored water is equal to the final water sample, the pore water of the HC-1 crib contained 1310 g of sulfate and the HC-2 crib 2730 g. Not accounting for sulfate stored as precipitate, the average sulfate production rate for the HC-1 crib during the two years of operation was 2.2 $mg/m^2/wk$ for the HC-1 sample and 3.7 $mg/m^2/wk$ for the HC-2 sample. These two 20-tonne sulfate production rates are an order of magnitude less than the HC-1 and HC-2 laboratory trickle-leach humidity cell rates at 19 $mg/m^2/wk$ and 22 $mg/m^2/wk$, respectively.

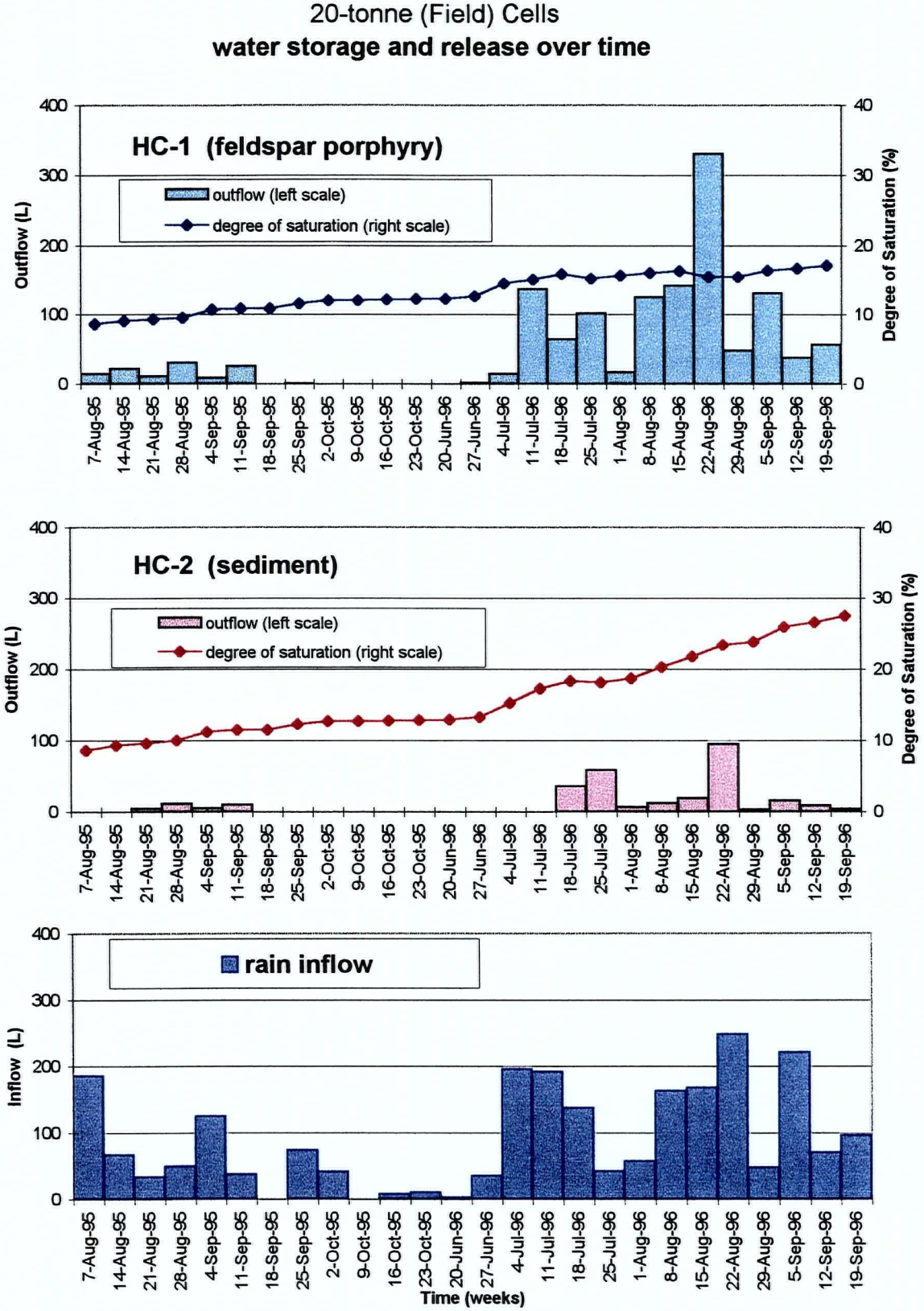


Figure 27: Weekly water inflow, outflow and degree of saturation from August 7 to October 31, 1995 and from June 13 to September 19, 1996 for the two 20-tonne (field) cells.

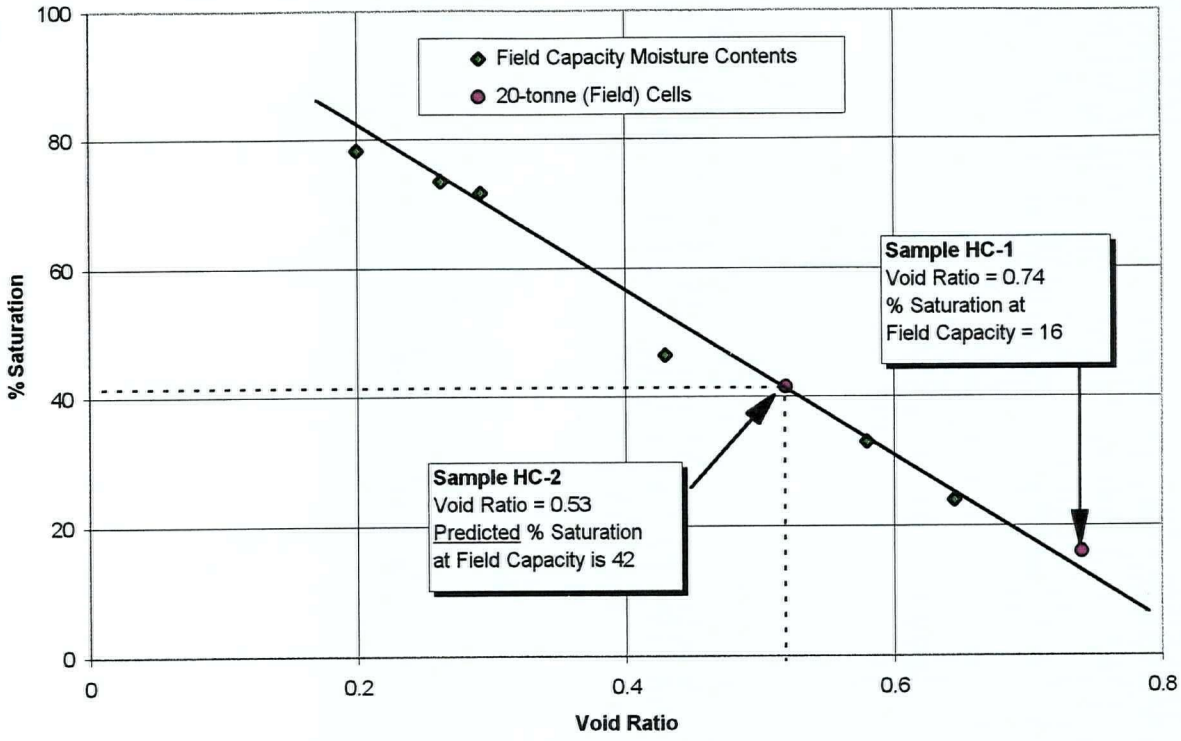


Figure 28: Void ratio versus % saturation at field capacity moisture contents (after Dawson and Morgenstern, 1995) with point locations of the 20-tonne (field) cell samples HC-1 and HC-2.

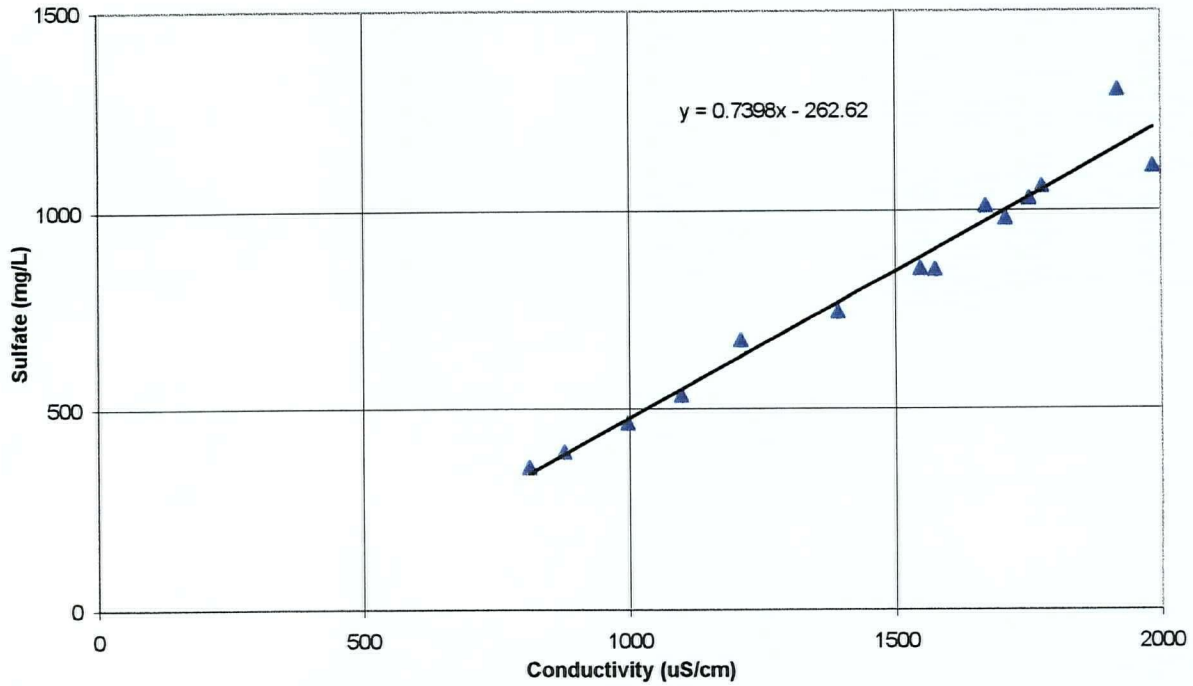


Figure 29: Sulfate versus conductivity for 1995 and 1996 water samples collected from 20-tonne (field) cells containing samples HC-1 and HC-2.

5.6.1.3 Correction of Laboratory Sulfate Production Rates for Field Temperatures

The internal temperatures of the cribs were recorded from November 1st, 1994 to August 7th, 1995 and from June 13th, 1996 to September 19th, 1996. Temperature changes within the HC-1 crib lagged behind the external air temperature by two to three days. The HC-2 crib temperature responded to air temperature changes slightly slower than the HC-1 crib. The maximum internal temperature was similar for both the cribs at 8.5°C. The collected crib temperature data for each year was separated into two periods; time during which the internal temperature was primarily above freezing and time when the internal temperature was primarily below freezing. An average temperature was calculated for these periods and then used to estimate the missing data. The HC-1 crib had an estimated 435 days at -6.4 °C and 249 days at 2.0 °C. The HC-2 crib had an estimated 435 days at -6.3 °C and 249 days at 1.6 °C.

The Arrhenius equation was used to correct the laboratory sulfide oxidation rates for the effect of field temperatures. This equation requires sulfide activation energies that are sensitive to pH. The activation energies used for pyrite at pH 7-8 is 88,000 J/mol (Nicholson et al., 1988) and for pyrrhotite at pH 6 is 100,000 J/mol (Nicholson and Scharer, 1994). These values were averaged together for an activation energy of 94,000 J/mol since both samples, HC-1 and HC-2, contain approximately 50% pyrite and 50% pyrrhotite. The predicted sulfate production rates of the 20-tonne cribs, based on the laboratory rates (average of trickle-leach rates) corrected by the Arrhenius equation, are presented in Table 11. These rates are approximately an order of magnitude smaller than the measured 20-tonne sulfate production rates.

Table 11: Sulfate production rates from laboratory (average of standard cell rates) corrected for field temperatures and from field for samples HC-1 and HC-2.

	Sulfate production rates		
	Laboratory rates corrected for field temperatures		
Sample	pH 7 E_a mg/m^2/wk	pH 4 E_a mg/m^2/wk	Field mg/m^2/wk
HC-1	0.26	1.6	2.2
HC-2	0.29	1.8	3.7

Although the water exiting from the cribs was consistently above pH 7, calculations using activation energies at pH 4 were also examined. At this pH, the activation energy for pyrite is 57,000 J/mol (McKibben and Barnes, 1986) and for pyrrhotite is 52,000 J/mol (Nicholson and Scharer, 1994). These activation energies, when averaged together, predicted a sulfate production rate of 1.6 mg/m^2/wk for the HC-1 crib and 1.8 mg/m^2/wk for the HC-2 crib. These predictions are much closer to the measured rates for cribs HC-1 and HC-2.

5.6.1.1 Predicted Time to Acidity for Field Cells

The sulfate production rates may be used to predict the time to acidity as previously discussed for the NP columns. It is theorized that a specific amount of acid is produced prior to the onset of acidity. The cumulative amount of sulfate produced at the point of acidity (pH < 6.5) by the NP columns was 1860 mg/m^2 for HC-1 and 1020 mg/m^2 for HC-2. Applying the field rates of sulfate production, the predicted time to acidity for the HC-1 crib is 23 years and for the HC-2 crib is 6 years.

The rate of NP depletion, typically used for time to acidity, was based on estimates of the average carbonate molar ratio. The initial carbonate molar ratios may have been low due to the limited amount of water stored within the cribs during 1995. This low moisture content would hamper

the neutralization of acidic water forming on the surfaces of sulfide minerals. It is also possible that the pattern of the 1996 carbonate molar ratios, initially low then increasing to about unity, may reoccur every year due to a buildup of acidity during the months of non-flushing. A crude estimate of the carbonate molar ratio for each crib was performed by averaging the six measured ratios from 1996 (3 high and 3 low values). This method provided an average carbonate molar ratio of 0.81 for the HC-1 crib and 0.83 for the HC-2 crib, both of which are lower than the typical laboratory carbonate molar ratio. These ratios were then applied to the sulfate production rates to calculate NP depletion rates. Predictions of the time to acidity using the NP depletion rates (Table 12) are all significantly greater than those obtained from the sulfate production method.

5.6.2 Discussion

The sulfide oxidation rates of the cribs during 1995 are expected to have been greater than the rates for 1996 due to changes in the moisture content. The 50-kg cells indicated that the oxidation rates of coarsely broken samples, such as used to fill the cribs, should decrease as the contained moisture increased. For the HC-1 cell, the operating condition is thought to have become similar to the laboratory non-aerated method when field capacity was reached. The HC-2 crib, although it did not reach field capacity, may have achieved uniform pore water chemistry at the end of 1996 since the conductivity began to stabilize.

A difficult factor to estimate for the cribs is the amount of sulfate stored as secondary mineral precipitate. The minor amount of water released from the cribs during 1995 may have promoted an early accumulation of precipitation. The simulated precipitation tests indicated that flushing events of a long duration can help remove any stored precipitate. The removal of precipitation

would also be aided by the preferential flow of water through the fine-grained material during light rainfall as evidenced by Newman et al. (1997). Since the fine material of the cribs contains most of the oxidizing surface area, preferential water flow through the fines would help ensure an efficient flush of the reaction products. A study by Garvie et al. (1997) found that water infiltrating their waste pile dump would have to interact with all the oxidation sites to explain the measured oxygen and temperature profiles. It is therefore considered reasonable to assume that the amount of precipitate stored within the cribs is equal to the precipitate stored within the humidity cells on a surface area basis.

The calculated sulfate production rate for sample HC-2 is twice as high as the rate calculated for sample HC-1. This difference in sulfate production rates from these two samples is at odds with the comparative sulfate rates for these samples at both the 1-kg and 50-kg sizes. A possible explanation for the dissimilar sulfate production rates in the field is an inaccurate estimate of the average pore water conductivity. Since the HC-2 field cell has a high water storage capacity, the calculation of the HC-2 sulfate production is very sensitive to the pore water conductivity estimate.

Another possibility as to why the sedimentary sample appears to oxidize faster than the feldspar porphyry sample in the field but not in the laboratory is a variation in the oxidizing environments. The HC-2 field sample released a minor amount of water and hence a minor amount of the reaction products produced. This limited flushing would increase the amount of ferric iron available within the HC-2 crib for sulfide oxidation in comparison to the HC-1 sample. The oxidizing environment within the HC-2 crib may also be influenced by the slow storage of water allowing pockets of fine material to remain undersaturated. The results of the

50-kg cells indicate that sulfide oxidation is promoted within undersaturated conditions.

Yet another possibility, for the discrepancy of sulfate production rates in the field, is differences in the exposed sulfide surface area. It was shown by Lapakko (1994b) that sulfide content can vary for a given grain size when comparing field to laboratory samples. Also, Janzen et al. (1997) found that the specific surface area of pyrrhotite for a given grain size can change with different size reduction methods, therefore blasting versus mechanical crushing of the soft sedimentary sample may have affected the reactivity of pyrrhotite. Operating the cribs for a longer period, sulfur assays of the various size fractions, and measuring specific surface area by BET analysis would have certainly helped to determine the relative importance of the factors discussed.

The sulfate production rates calculated for the two cribs, on a surface area basis, are greater than the temperature-corrected humidity cell rates. The field rates of sulfate production are greater than the laboratory sulfate rates even though sulfate stored as precipitated minerals is not included and the temperature correction was performed using pH 4 activation energies. As previously discussed, greater exposure of sulfide surfaces within the fine fraction, the non-homogeneous distribution of sulfides, and high concentrations of ferric iron may be involved. If the majority of the sulfate production occurred in oxidation "hot spots", using the pH 4 activation energy may be justified. A laboratory test measuring the sensitivity of a sample's sulfide oxidation rate to temperature may prove to be more critical for predictive purposes than a precise measurement of the rate itself.

Table 12 Kinetic test results and predictions of time to acidity

Rock Type	Sample ID	Pyrite (%)	Pyrr. (%)	Sulfide S (%)	NP (kg $CaCO_3$/ tonne)	Cell type	Averages for the last available 5 cycles: pH	SO_4 (mg/kg/wk)	NP depl'n (mg/kg/wk)	[Ca+Mg] / [SO_4]	% S depleted	% NP depleted	Years for sulfide S depletion	Predicted time for onset of acidity: Years for NP depletion to 8 kg $CaCO_3$/t [1]	Years for 50 % NP depletion	Based on NP Column testwork: Years for depletion of available NP	Years for release of buffered AP
Feldspar Porphyry	ABA-3	5	-	3.11	25.0	regular - 1	7.4	53.2	53.9	0.97	3.0	18.3	35	6.1	4.5	7.6	1.9
						regular - 2	7.2	44.5	45.4	0.97	3.2	20.7	42	7.2	5.3	9.1	2.3
						tall	7.4	48.1	42.3	0.84	2.9	15.8	39	7.7	5.7	9.7	2.1
						shaken	7.4	57.8	42.8	0.87	3.4	21.4	32	7.6	5.6	9.6	1.8
						NPC	7.9	48.7	110	2.32	2.9	43.3	38	--	--	--	--
	HC-1	5	3	5.82	44.6	regular	7.0	58.3	58.0	0.95	1.7	9.5	60	12	7.4	6.9	1.8
						leach only	7.5	55.7	63.6	1.10	1.2	7.1	63	11	6.7	6.3	1.9
						tall	7.4	49.9	42.3	0.81	1.6	9.2	70	17	10	9.5	2.1
						shaken	7.5	68.5	70.2	0.98	1.6	9.7	51	10	6.1	5.7	1.5
						NPC	7.9	54.3	111	1.97	1.5	21.7	64	--	--	--	--
						50-kg	7.5	11.4	11.2	0.94	0.5	1.6	310	63	38	36	1.6
						20-tonne [2]	7.3	0.77	0.78	0.97	0.04	0.17	4500	900	550	520	23
	ABA-2	-	7	4.74	33.1	regular - 1	7.5	84.1	73.9	0.84	3.0	19.1	34	6.5	4.3	6.1	1.5
						regular - 2	7.4	68.1	60.0	0.85	2.8	22.4	42	8.0	5.3	7.5	1.8
						tall	7.4	57.9	53.1	0.88	2.4	14.8	49	9.1	6.0	8.5	2.1
						shaken	7.4	34.9	41.7	1.15	1.7	18.1	82	12	7.6	11	3.5
						NPC	7.9	57.0	122	2.05	2.1	36.5	50	--	--	--	--

Rock Type	Sample ID	Pyrite (%)	Pyrr. (%)	Sulfide S (%)	NP (kg $CaCO_3$/ tonne)	Cell type	Averages for the 5 cycles prior to pH consistantly less than 6.5: pH	SO_4 (mg/kg/wk)	NP depl'n (mg/kg/wk)	[Ca+Mg] / [SO_4]	% S depleted at pH < 6.5	% NP depleted at pH < 6.5	Years for sulfide S depletion [3]	Predicted time for onset of acidity: Years for NP depletion to 8 kg $CaCO_3$/t [1]	Years for 50 % NP depletion	Based on NP Column testwork: Years for depletion of available NP	Years for release of buffered AP	**Actual time to pH < 6.5 (years)**
Sediment	HC-2	2	3	3.95	11.9	regular	6.7	47.7	54.5	1.08	1.8	24.9	50	1.4	2.1	2.7	0.6	**0.6**
						tall	6.8	67.2	59.0	0.85	1.9	29.7	35	1.3	1.9	2.5	0.6	**0.6**
						shaken	6.5	52.5	47.9	0.87	2.3	31.1	45	1.6	2.4	3.1	0.7	**0.8**
						NPC	7.4	98.1	98.5	1.33	2.1	65.0	24	--	--	--	--	**0.7**
						50-kg	6.8	17.2	13.9	0.78	0.4	4.4	140	5.4	8.2	11	0.5	**0.6**
						20-tonne [2]	7.4	1.41	1.26	0.86	--	--	1400	59	91	120	5.8	**--**
	ABA-1	-	7	4.48	36.3	regular - 1	6.6	114	132	1.12	4.6	18.5	24	4.1	2.6	3.7	0.4	**0.5**
						regular - 2	6.6	123	142	1.10	4.5	24.2	22	3.8	2.5	3.5	0.3	**0.4**
						tall	6.5	132	154	1.18	3.8	18.1	20	3.5	2.3	3.2	0.5	**0.5**
						shaken	6.5	86.8	78.3	0.87	4.4	27.5	31	7.0	4.5	6.3	0.6	**0.7**
						NPC	7.6	144	156	1.36	4.1	70.7	19	--	--	--	--	**0.9**

NOTES:

[1] 8 kg $CaCO_3$/t of NP was determined by Morin and Hutt (1996) to be the average amount of NP unavailable in Red Mountain samples.

[2] 20-tonne SO_4 rate estimated from conductivity over two-year operating period and NP rate is estimated from the average 1996 molar ratio.

[3] Based on average SO_4 release rates for the last available 5 cycles (i.e. after onset of acidity).

6.0 CONCLUSIONS AND RECOMMENDATIONS

A research program to evaluate acid generation potential was carried out on samples collected from the Red Mountain project in North-western British Columbia. These samples were all shown to be net acid producers from the static ABA tests. The following conclusions and recommendations relate to the three main objectives of this study.

The first objective of this research was to develop specific test protocols that can be used for ARD prediction evaluations. The conclusions and recommendations on test protocols are:

1. Test results indicate that non-aerated, trickle leach cells provide rates of weathering that are similar to the standard humidity cell. This test protocol has the following advantages over the humidity cell:
   - improved repeatability of results,
   - less expensive apparatus,
   - easier to operate, and
   - may require less time to obtain rates of weathering.

2. The influence of temperature on weathering rates is strongly dependent on the estimated activation energy that depends on an estimated pH. The effective pH is unmeasureable and is not likely the same as the discharge pH. Therefore, tests should be operated at field temperatures rather than correcting humidity cell data by applying the Arrhenius equation.

3. Test results indicate that oxidation rates, when reported on a surface area basis, can

increase with particle size. The higher oxidation rate for coarse material is attributed to the transfer of oxygen for sulfide oxidation; the heterogeneity of the sample that may be responsible for "hot spots" may also be a factor. Kinetic tests conducted using coarse material may provide weathering rates that are more relevant than those obtained from conventional minus ¼" material.

4. Water addition to kinetic tests should:
   - be of sufficient volume to remove weathering products,
   - not be an excessive volume that may artificially inflate NP depletion, and
   - not be conducted in a manner that disrupts the oxidizing environment (i.e. shaken method that involved sample agitation is inappropriate).

5. Large-scale field tests may be impractical for determining scale-up parameters due to the excessively long period required to obtain meaningful results. Even after two years, operating conditions were changing making the results difficult to interpret.

The second objective of this research project was to provide more confidence in scaling up of laboratory results to predict the weathering characteristics of a waste dump. The conclusions and findings of scaling up laboratory data are:

1. The laboratory rates of weathering, corrected for temperature and surface area, could not be scaled up to predict field results with confidence. The inability to scale-up is believed to be caused by inadequate hydrogeological assumptions and deficiencies in the experimental protocols.

1a. Correcting the laboratory oxidation rates for field temperatures (using an activation energy based on the field drainage pH of 7.0) returned oxidation rates an order of magnitude lower than the field cell weathering rates.

1b. Particle size was found to influence sulfide oxidation rates within laboratory humidity cells. The relevance of laboratory oxidation rates to the field cells that contain coarser material is unknown.

1c. NP depletion rates of the field scale tests varied in relation to sulfate production rates. For the standard humidity cells, NP depletion rates corresponded to sulfate production rates. Therefore, it is uncertain if the standard humidity cell properly reproduced the relative rates of acid generation and neutralization as seen in the field.

1d. Scaling up the laboratory weathering rates would have been improved by:

- promoting the removal of weathering products from the field cells by controlling the flush water volume and frequency,
- conducting sulfur analyses of the various size fractions to indicate the concentration of liberated sulfide minerals,
- more accurate measurement of specific surface area by BET analysis, and
- operating the field cells for a longer period of time (trends in data were difficult to identify for a large sample over the two year period that the test was maintained).

2. NP depletion is typically used to estimate the time to acidity. Based on the test results, measurements of cumulative acid production may provide a better estimate of lag time than NP depletion.

   2a. The cumulative amount of Mg and Ca released at the point of acidity was greater for the NP columns than the humidity cells. Therefore estimates based on NP depletion (e.g. assuming 50% unavailable NP, or 8 kg $CaCO_3$/tonne as unavailable NP) may be variable. The available NP may not be constant and may be affected by the test protocols that could also explain discrepancies in estimating time to acidity.

   2b. Results indicate that time to acidity seems to relate better to measurements of cumulative sulfate production (acid production).

   2c. Using the acid production method, the predicted lag time for the sedimentary material is 6 years and for the feldspar porphyry material is 23 years. Using methods that estimate available NP, the predicted lag time for the sedimentary material is 60 to 120 years and for the feldspar porphyry material is 520 to 900 years.

The third objective of the study was to provide the operators of the Red Mountain project with precise prediction data thereby allowing for a more cost effective and confident development of the waste management plan. The conclusions and recommendations of generating precise prediction data are:

1. Precision of prediction data from kinetic testing is improved by incorporating field parameters such as particle size and temperature. Using field parameters during testing

removes the error incurred by estimating their influences on waste pile weathering rates.

2. Non-aerated trickle-leach test results were similar to those obtained from humidity cells but were more reproducible than the humidity cell results. Despite the improved precision of laboratory results, the significance was lost during scale-up to site conditions. Therefore,
   - only when the models used to scale-up laboratory test data are validated will the generation of precise test data become meaningful and cost-effective, and
   - extensive laboratory kinetic test programs that attempt to account for variations in waste pile rock types are unwarranted and create a false impression of confidence.

Additional Research/Work

- Evaluate the ability of non-aerated kinetic tests to provide weathering rates similar to those obtained from standard humidity cells.
- Evaluate the influence of temperature and particle size on rates of weathering.
- Conduct studies to determine the suitable water additions for samples of varying mineralogical composition.
- Conduct studies to determine if the onset of acidity can be linked to a cumulative acid production as compared to methods that use NP depletion.
- Use results from this research project to help validate kinetic models, such as the one developed by Dr. Ed Trujillo, Chemical and Fuels Engineering Department, University of Utah, since extensive testing was conducted on a limited number of samples.

7.0 REFERENCES

Allison, J.D., Brown, D.S. and Novo-Gradac, K.J., 1990. MINTEQA2\PRODEFA2. A Geochemical Model for Environmental Systems: Version 3.0 User's Manual. U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, Georgia.

Anderson, R.G., 1993. "A Mesozoic Stratigraphic and Plutonic Framework for Northwestern Stikina (Iskut River area), Northwestern British Columbia, Canada". In: Mesozoic Paleogeography of the Western United States, G. Dunne and K. McDougall (eds.), Society of Economic Paleontologists and Mineralogists, Volume II, Pacific Section, pp. 477-494.

APHA, AWWA, WPCF, 1989. Standard Methods for the Examination of Water and Wastewater, 17th ed., (American Public Health Association, Washington, D.C.).

Arkesteyn, G. J. M. W., 1980. "Pyrite Oxidation in Acid Sulphate Soils: The Role of Microorganisms". Plant and Soil 54, pp. 119-134.

Barnett, R.L., 1991. Petrographic-metallurgical Electron Microprobe Investigation of Selected samples (20) from the Red Mountain Prospect, British Columbia. Unpublished company report, Lac Minerals Inc., Vancouver, British Columbia, 65 p.

Bethune, K.J. and Lockington, D.A., 1997. "Acid Mine Drainage: Comparison of Laboratory Testing to Mine Site Conditions". In: Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, British Columbia, pp. 305-317.

Bigham, J.M., Schwertmann, S., Carlson, L. and Murad, E., 1990. "A Poorly Crystallized Oxyhydroxysulfate of Iron Formed by Bacterial Oxidation of FE (II) in Acid Mine Waters". Geochim. Cosmochim. Acta 54, pp. 2743-2758.

Bradham, W.S. and Caruccio, F.T., 1990. "A Comparative Study of Tailings Analysis Using Acid/Base Accounting, Cells, Columns and Soxhlets". In: Proceedings of the Second International Conference on Abatement of Acidic Drainage, Montréal, Quebéc, Vol. 1, pp. 157-173.

Brodie, M.J., Broughton, L.M. and Robertson, A.MacG., 1991. "A Conceptual Rock Classification System for Waste Management and a Laboratory Method for ARD Prediction from Rock Piles". In: Proceedings of the Second International Conference on Abatement of Acidic Drainage, Montréal, Quebéc, Vol. 3, pp. 119-136.

Busenberg, E. and Clemency, C., 1976. "The Dissolution Kinetics of Feldspars at 25°C and 1 Atmosphere CO_2 Partial Pressure". Geochim. Cosmochim. Acta 40, pp. 41-49.

Busenburg, E. and Plummer, L.N., 1986. A Comparative Study of the Dissolution and Crystal Growth Kinetics of Calcite and Aragonite. U.S. Geol. Surv. Bull. 1578, pp. 139-168.

Caruccio, F.T., 1968. "An Evaluation of Factors Affecting Acid Mine Drainage Production and the Ground Water Interactions in Selected Areas of Western Pennsylvania". In: Proceedings of the Second Symposium on Coal Mine Drainage Research, Monroeville, Pennsylvania, pp.107-151.

Cravotta, C.A., 1994. "Secondary Iron-sulfate Minerals as Sources of Sulfate and Acidity: Geochemical Evolution of Acidic Ground Water at a Reclaimed Surface Coal Mine in Pennsylvania". In: Environmental Geochemistry of Sulfide Oxidation, ACS Symposium Series 550, American Chemical Society, Washington, DC, pp. 343-364.

Davis, G.B. and Ritchie, A.I.M., 1986. "A Model of Oxidation in Pyritic Mine Wastes. I. Equations and Approximate solution". Appl. Math. Modeling10, pp. 314-322.

Dawson, R.F. and Morgenstern, N.R., 1995. Liquefaction Flowslides in Rocky Mountain Coal Mine Waste Dumps, Phase 3, Final Report. Report by University of Alberta to CANMET SSC File No. 23440-3-9135/01=XSG, 200p.

Day, S.J., Hope, G. and Kuit, W., 1997. "Waste Rock Management Planning for the Kudz Ze Kayah Project, Yukon Territory: 1. Predictive Static and Kinetic Test Work". In: Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, British Columbia, pp. 81-97.

Eger, P. and Lapakko, K.A., 1981. "The Leaching and Reclamation of Low-grade Mineralized Stockpiles". In: Proceedings of 1981 Symposium on Surface Mining Hydrology, Sedimentology and Reclamation, Lexington, Kentucky, pp. 157-166.

Eger, P. and Lapakko, K.A., 1985. Heavy Metals Study: Progress Report on the Field Leaching and Reclamation Program: 1977-1983. Minnesota Department of Natural Resources, Division of Minerals, St. Paul, Minnesota, 53p.

Ehrlich, H.L., 1981. Geomicrobiology. Marcel Dekker, New York.

Feasby, D.G. and Jones, R.K., 1994. Results of a Workshop on Mine Reclamation, Toronto, Ontario, March 10-11, 1994, CANMET Publication, 1994.

Feasby, D.G., Tremblay, G.A. and Weatherell, C.J., 1997. "A Decade of Technology Improvement to the Challenge of Acid Drainage - A Canadian Perspective". In: Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, British Columbia, pp. i-ix.

Ferguson, K.D. and Morin, K.M., 1991. "The Prediction of Acid Rock Drainage - Lessons from the Database". In: Proceedings of the Second International Conference on the Abatement of Acidic Drainage. Montréal, Quebéc, pp. 83-106.

Flann, R.C. and Lukaszewski, G.M., 1970. The Oxidation of Pyrrhotite in Ores and Concentrates. Presentation at Austral. Inst. Mining Metall., Regional Mtg., Tennant Creek, Australia.

Ford, C., 1993. Petrographic Report of Selected Samples (7) from the Red Mountain Project, British Columbia. Unpublished company report, Lac Minerals Inc., Vancouver, British Columbia, 20 p.

Garvie, A.M., Bennett, J.W. and Ritchie, A.I.M., 1997. "Quantifying the Spatial Dependence of the Sulfide Oxidation Rate in a Waste Rock Dump at Mt. Lyell, Tasmania". In: Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, British Columbia, pp. 333-349.

Geocon, 1995. Economic Evaluation of Acid Mine Drainage Technologies. MEND Report, Project 5.8.1, January 1995.

Greig, C.J., Anderson, R.G., Daubeny, P.H. and Bull, K.F., 1994. "Geology of the Cambria Icefield: Regional Setting for Red Mountain Gold Deposit, Northwestern British Columbia". In: Current Research 1994-A, Geological Survey of Canada, pp. 45-56.

Hillel, D., 1982. Introduction to Soil Physics. Academic Press, Inc., Toronto, 364p.

Jambor, J.L. and Blowes, D.W. (eds.), 1994. Environmental Geochemistry of Sulfide Mine-Wastes, Mineralogical Association of Canada, Short Course Handbook, Vol. 22, pp. 133-162.

Janzen, M.P., Nicholson, R.V. and Scharer, J.M., 1997. "The Role of Enhanced Surface Area, Crystal Structure and Trace Metal Content on Pyrrhotite Oxidation Rates in Tailings". In: Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, British Columbia, pp. 399-415.

Jaynes, D.B., Rogowski, A.S. and Pionke, H.B., 1984. "Acid Mine Drainage from Reclaimed Coal Strip Mines. I. Model Description". Water Resources Research 20, pp. 233-242.

Kakovsky, I.A. and Kosikov, Ye., M., 1975. "Study of the Kinetics of Oxidation of some Sulfide Minerals". Obogashch. Rud. 20, pp. 18-21 (in Russian).

Kleinmann, R.L.P., Crerar, D.A. and Pacelli, R.R., 1981. "Biogeochemistry of Acid Mine Drainage and Methods to Control Acid Formation". Mining Engineering, March, pp. 300-305.

Kwong, Y.T.J. and Ferguson, K.D., 1997. "Mineralogical Changes During NP Determinations and Their Implications". In: Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, British Columbia, pp. 435-447.

Langmuir, D. and Whittemore, D.O., 1971. "Variations in the Stability of Precipitated Ferric Oxyhydroxides". In: Non-equilibrium Systems in Natural Water Chemistry, R.E. Carver (ed.), Adv. in Chem. Ser. 106, Am. Chem. Soc., pp. 209-234.

Lapakko, K.A., 1980. Kinetics and Mechanisms of the Oxidative Dissolution of Metal Silicate Minerals Present in the Duluth Gabbro. M.S. Thesis. University of Minnesota, Minneapolis, Minnesota, 199p.

Lapakko, K.A., 1994a. "Evaluation of Neutralization Potential Determinations for Metal Mine Waste and a Proposed Alternative". In: Proceedings of the International Land Reclamation and Mine Drainage Conference and the Third International Conference on the Abatement of Acidic Drainage, Pittsburgh, Pennsylvania, Vol. 1, pp. 129-137.

Lapakko, K.A., 1994b. "Comparison of Duluth Complex Rock Dissolution in the Laboratory and Field". In: Proceedings of the International Land Reclamation and Mine Drainage Conference and the Third International Conference on the Abatement of Acidic Drainage, Pittsburgh, Pennsylvania, Vol. 1, pp. 419-428.

Lawrence, R.W., 1990. "Prediction of the Behaviour of Mining and Processing Wastes in the Environment". In: Proceedings of the Western Regional Symposium on Mining and Mineral Processing Wastes, Berkeley, California, pp. 115-121.

Lawrence, R.W. and Wang, Y., 1996. Determination of Neutralization Potential for Acid Rock Drainage Prediction. MEND/NEDEM Report 1.16.3 (Canadian Centre for Mineral and Energy Technology, Ottawa), 149p.

Levenspiel, O., 1972. Chemical Reaction Engineering. Wiley, New York.

Li, M.G., 1997. "Neutralization Potential Versus Observed Mineral Dissolution in Humidity Cell Tests for Louvicourt Tailings". In: Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, British Columbia, pp. 149-163.

Lin, Cheng-Kuo, Trujillo, E.M. and White, W.W., 1997. "A Three-dimensional, Three-phase Geochemical Kinetic Model for Acid Rock Drainage". In: Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, British Columbia, pp. 479-495.

López, D.L., Smith, L. and Beckie, R., 1997. "Modeling Water Flow in Waste Rock Piles Using Kinematic Wave Theory". In: Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, British Columbia, pp. 497-513.

McKibben, M.A. and Barnes, H.L., 1986. "Oxidation of Pyrite in Low Temperature Acidic Solutions: Rate Laws and Surface Textures". Geochim. Cosmochim. Acta 50, pp. 1509-1520.

McLaren, W.A., 1986. "Modeling of Flow Through a Mine Waste Dump". In: Proceedings of the International Symposium on Flow-through Rock Drains, British Columbia Technical and Review Committee on Reclamation, pp. 161-172.

Morin, K.A. and Hutt, N.M., 1994. "Observed Preferential Depletion of Neutralization Potential over Sulfide Minerals in Kinetic Tests: Site Specific Criteria for Safe NP/AP Ratios". In: Proceedings of the International Land Reclamation and Mine Drainage Conference and the Third International Conference on the Abatement of Acidic Drainage, Pittsburgh, Pennsylvania, Vol. 1, pp. 148-156.

Morin, K.A. and Hutt, N.M., 1995. "MINEWALL 2.0: A Technique for Predicting Water Chemistry in Open-Pit and Underground Mines". In: Proceedings of Sudbury '95, Mining and the Environment, Sudbury, Ontario, pp. 1007-1016.

Morin, K.A. and Hutt, N.M., 1996. Static and Kinetic Testwork for Predictions of Acidic Drainage and Metal Leaching at the Red Mountain Project, British Columbia, Canada. A report completed for Royal Oak Mines Inc., April, 1996.

Morin, K.A. and Hutt, N.M., 1997. Environmental Geochemistry of Minesite Drainage: Practical Theory and Case Studies. MDAG Publishing, Vancouver.

Morin, K.A., Hutt, N.M. and McArthur, R., 1995. "Statistical Assessment of Past Water Chemistry to Predict Future Chemistry at Noranda Minerals' Bell Mine". In: Proceedings of Sudbury '95, Mining and the Environment, Sudbury, Ontario, pp. 1007-1016.

Moses, C.O. and Herman, J.S., 1991. "Pyrite Oxidation at Circumneutral pH". Geochim. Cosmochim. Acta 55, pp. 471-482.

Moses, C.O., Nordstrom, D.K., Herman, J.S. and Mills, A., 1987. "Aqueous Pyrite Oxidation by Dissolved Oxygen and by Ferric Iron". Geochim. Cosmochim. Acta, 51, pp. 1561-1572.

Murray, J.W., 1979. "Iron Oxides". In: Marine Minerals, R.G. Burns (ed.), Reviews in Mineralogy 6, Mineral. Soc. Amer., pp. 47-98.

Nelson, M., 1978. Kinetics and Mechanisms of the Oxidation of Ferrous Sulfide. Ph.D. Thesis, Stanford University, Palo Alto, California.

Newman, L.L., Herasymuik, G.M., Barbour, S.L., Fredlund, D.G. and Smith, T., 1997. "The Hydrology of Waste Rock Dumps and a Mechanism for Undersaturated Preferential Flow". In: Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, British Columbia, pp. 551-565.

Nicholson, R.V., Gillham, R.W., Cherry, J.A. and Reardon, E.J., 1989. "Reduction of Acid Generation in Mine Tailings Through the Use of Moisture-retaining Cover Layers as Oxygen Barriers". Can. Geotech. J. 26, pp. 1-8.

Nicholson, R.V., Gillham, R.W. and Reardon, E.J., 1988. "Pyrite Oxidation in Carbonate-buffered Solutions: 1. Experimental Kinetics". Geochim. Cosmochim. Acta 52, pp. 1077-1085.

Nicholson, R.V., Gillham, R.W. and Reardon, E.J., 1990. "Pyrite Oxidation in Carbonate-buffered Solution: 2. Rate Control by Oxide Coatings". Geochim. Cosmochim. Acta 54, pp. 395-402.

Nicholson, R.V. and Scharer, J.M., 1994. "Laboratory Studies of Pyrrhotite Oxidation Kinetics". In: Environmental Geochemistry of Sulfide Oxidation, C.N. Alpers and D.W. Blowes (eds.), Am. Chem. Soc. Symp. Series 550, pp. 14-30.

Nordstrom, D.K., 1982. "Aqueous Pyrite Oxidation and the Consequent Formation of Secondary Iron Minerals". In: Acid Sulfate Weathering, J.A. Kittrick, D.S. Fanning, and L.R. Hossner (eds.), Soil Sci. Soc. America Spec. Pub. 10, pp. 37-56.

Norecol Environmental Consultants Ltd., 1991. New Methods for the Determination of Key Mineral Species in Acid Generation Prediction by Acid Base Accounting. MEND/NEDEM Report 1.16.1c, Canadian Centre for Mineral and Energy Technology, Ottawa.

Parks, G.A., 1990. "Surface Energy and Adsorption at Mineral-water Interfaces: An Introduction". In: Mineral-water Interface Geochemistry. M.F. Hochella and A.F. White (eds.), Reviews in Mineralogy 23, Mineral. Soc. Amer., pp. 133-175.

Perkins, E.H., Gunter, W.D., Nesbitt, H.W. and St-Arnaud, L.C., 1997. "Critical Review of Classes of Geochemical Computer Models Adaptable for Prediction of Acidic Drainage from Mine Waste Rock". In: Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, British Columbia, pp. 587-601.

Perry, R.H. and Chilton, C.H., 1973. Chemical Engineer's Handbook. Fifth Edition, McGraw-Hill Book Company, pp. 3-222, 3-223, Table 3-249.

Pool, D.L. and Balderrama, R.M., 1994. "Evaluation of Humidity Cell Parameters: Their Effect on Precision and Repeatability". In: Proceedings of the International Land Reclamation and Mine Drainage Conference and the Third International Conference on the Abatement of Acidic Drainage, Pittsburgh, Pennsylvania, Vol. 2, pp. 326-333.

Pratt, A.R., Nesbitt, H.W. and Muir, I.J., 1994. "Generation of Acids in Mine Waste Waters: Oxidative Leaching of Pyrrhotite in Dilute H_2SO_4 solutions (pH 3.0)". Geochim. Cosmochim. Acta 58, pp. 5147-5149.

Price, W.A., 1997. Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia. Draft Report, Reclamation Section, Energy and Minerals Division, Ministry of Employment and Investment, Smithers, British Columbia, April 1997, 159p.

Price, W.A. and Kwong, Y.T.J., 1997. "Waste Rock Weathering, Sampling and Analysis: Observations from the British Columbia Ministry of Employment and Investment Database". In: Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, British Columbia, pp. 31-45.

Price, W.A., Morin, K.A. and Hutt, N.M., 1997. "Guidelines for the Prediction of Acid Rock Drainage and Metal Leaching for Mines in British Columbia: Part II. Recommended Procedures for Static and Kinetic Testing". In: Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, British Columbia, pp. 15-29.

Rauch, H.W. and White, W.B., 1977. "Dissolution Kinetics of Carbonate Rocks 1. Effects of Lithology on Dissolution Rate". Wat. Resour. Res. 13(2), pp. 381-394.

Rescan Environmental Services Ltd., 1990. Kutcho Creek Project: Acid Generation Testwork, Phase II, September 1990. Prepared for Sumac Mines Ltd. and Homestake Mineral Development Company with additional funding by the Mineral Development Agreement MEMPR.

Rescan Environmental Services Ltd., 1992. Kutcho Creek Project: Blending and Segregation Acid Generation Testwork, Final Report, March 1992. Prepared for Sumac Mines Ltd. and Homestake Mineral Development Company with additional funding by the Mineral Development Agreement MEMPR.

Rescan Environmental Services Ltd., 1994. Red Mountain Project: Submittal for Mine Development Certificate. Prepared for Lac Minerals Ltd., Vancouver, British Columbia.

Rhys, D.A., Sieb, M., Frostad, S.R., Swanson, C.L., Prefontaine, M.A., Mortensen, J.K. and Smit, H.Q., 1995. "Geology and Setting of the Red Mountain Gold-Silver Deposits, Northwestern British Columbia". In: Porphyry Deposits of the Northwestern Cordillera of North America. T.G. Schroeter (ed.), C.I.M. Special Volume 46, pp. 811-828.

Ritchie, A.I.M., 1993. "Rates of Mechanisms That Govern Pollutant Generation from Pyritic Wastes". In: Environmental Geochemistry of Sulfide Oxidation, C.N. Alpers and D.W. Blowes (eds.), Am. Chem. Soc. Symp. Series 550, pp. 14-30.

Ritchie, A.I.M., 1994. "The Waste-Rock Environment". In: Environmental Geochemistry of Sulfide Mine-Wastes, Mineralogical Association of Canada, D.W. Blowes and J.L. Jambor (eds.), Short Course Handbook, Vol. 22, pp. 133-162.

Robertson, A.M. and Barton-Bridges, J., 1990. "Cost Effective Method of Long-term Acid Mine Drainage Control from Waste Rock Piles". In: Proceedings of GAC-MAC Conference on AMD, Vancouver, British Columbia.

Robertson, A.M., 1999. Personal communication with Andy Robertson, Robertson GeoConsultants Inc., Vancouver, British Columbia.

Sato, M., 1960a. "Oxidation of Sulfide Ore Bodies, I., Geochemical Environments in Terms of Eh and pH". Econ. Geol. 55, pp. 928-961.

Sato, M., 1960b. "Oxidation of Sulfate Ore Bodies, II., Oxidation Mechanisms of Sulfide Minerals at 25°C". Econ. Geol. 55, pp. 1202-1231.

Sherlock, E.J., Lawrence, R.W. and Poulin, R., 1995. "On the Neutralization of Acid Rock Drainage by Carbonate and Silicate Minerals". Environ. Geol. 25, pp. 43-54.

Sobek, A.A., Schuller, W.A., Freeman, J.R. and Smith, R.M., 1978. Field and Laboratory Methods Applicable to Overburdens and Minesoils. Report EPA-600/2-78-054, U.S. National Technical Information Report PB-280, 495 p.

Soregaroli, B.A. and Lawrence, R.W., 1998. "Update on Waste Characterization Studies". In: Mine Design Operations & Closure Conference, Polson, Montana.

Stumm, W. and Morgan, J.J., 1981. Aquatic Chemistry, An Introduction Emphasizing Chemical Equilibria in Natural Waters. 2nd ed., Wiley-Interscience, New York, 583 p.

Thompson, A., 1994a. Report No. 1 - Petrography of 27 'Type' Samples, Red Mountain Project, Stewart, British Columbia. Unpublished company report, Lac Minerals Inc., Vancouver, British Columbia, 58 p.

Thompson, A., 1994b. Report No. 2 - Petrography of 37 Samples from Sections 1500N and 1800N, Red Mountain Project, Stewart, British Columbia. Unpublished company report, Lac Minerals Inc., Vancouver, British Columbia, 39 p.

Thompson, A., 1994c. Report No. 4 - Brief Petrographic Descriptions of 21 Samples, Including Selected Samples from Hole 103, Red Mountain Project, Stewart, British Columbia. Unpublished company report, Lac Minerals Inc., Vancouver, British Columbia, 10 p.

Thompson, A., 1994d. Report No. 5 - Summary of Alteration Mineralogy, Red Mountain Project, Stewart, British Columbia. Unpublished company report, Lac Minerals Inc., Vancouver, British Columbia, 6 p.

Vancouver Petrographics, 1994. Petrographic Report on 19 Thin Sections from the Red Mountain Porphyry Au Deposit, Stewart, British Columbia. Report prepared for Lac Minerals Inc., Vancouver, British Columbia, 21 p.

Vaughan, D.J. and Craig, J.R., 1978. Mineral Chemistry of Metal Sulphides. Cambridge University Press, Cambridge, UK.

Wen, C.Y., 1968. "Noncatalytic Solid-fluid Reaction Models". Ind. Eng. Chem. 60(9), pp. 34-54.

White, W.W. III, 1998. Telephone communication with William White, U.S. Bureau of Land Management, Utah State Office, Salt Lake City, Utah, U.S.A.

White, W.W. III, Lapakko, K.A. and Cox, R.L., 1998. "Effects of Protocol Variables and Sample Mineralogy on Static-test NP". In: Proceedings of the Eleventh Annual Conference of the Society of Mineral Analysts, Elko, NV, April 7-10, 1997, pp. 187-233.

White, W.W. III and Sorini, S.S., 1993. Standard Test Method for Accelerated Weathering of Solid Waste Using a "Modified" Humidity Cell. Draft Method, May 7, 1993. Test method under the jurisdiction of ASTM Committee D-34 on Waste Management, Subcommittee D-34.02 on Physical and Chemical Characterization, Task Group D34.02.01.

White, W.W. III and Sorini, S.S., 1997. "Standard Test Method for Accelerated Weathering of Solid Materials Using a Modified Humidity Cell". ASTM Standards, v. 11.04, Method 5744-96, pp. 259-271.

Whittemore, D.O. and Langmuir, D., 1975. "The Solubility of Ferric Oxyhydroxides in Natural Waters". Ground Water 13, pp. 360-365.

Zhang, J.W. and Nancollas, G.H., 1990. "Mechanisms of Growth and Dissolution of Sparingly Soluble Salts". In: Mineral-water Interface Geochemistry. M.F. Hochella and A.F. White (eds.), Reviews in Mineralogy 23, Mineral. Soc. Amer., pp. 365-396.

APPENDIX 1

SPECIFIC SURFACE AREA CALCULATIONS

HC-1 1-kg

Specific Surface Area = 29.16 cm^2/g

Mesh #	Opening (in.)	Opening (mm)	Average particle diameter (mm)	Sample mass Sample 1 (g)	Sample mass Sample 2 (g)	Percent of total mass (%)	Percent of total surface area (%)
	0.265	6.35		0.0	0.0	0.00	
4	0.187	4.75	5.55	234.8	228.7	23.26	3.18
6	0.132	3.35	4.05	206.0	215.0	21.13	3.96
8	0.0937	2.38	2.87	175.6	174.3	17.56	4.65
12	0.0661	1.68	2.03	104.3	104.5	10.48	3.92
16	0.0469	1.19	1.44	65.1	55.0	6.03	3.19
20	0.0331	0.841	1.02	51.6	49.1	5.05	3.78
28	0.0234	0.594	0.718	38.2	43.5	4.10	4.34
35	0.0165	0.419	0.507	29.7	32.7	3.13	4.70
48	0.0117	0.297	0.358	22.3	23.8	2.31	4.91
65	0.0083	0.211	0.254	14.7	16.4	1.56	4.67
100	0.0059	0.150	0.181	17.3	19.3	1.84	7.73
150	0.0041	0.104	0.127	9.7	9.5	0.96	5.76
200	0.0029	0.074	0.089	9.4	8.2	0.88	7.54
270	0.0021	0.053	0.064	5.7	4.1	0.49	5.88
325	0.0017	0.043	0.048	3.8	3.6	0.37	5.87
400	0.0015	0.038	0.041	4.2	2.9	0.36	6.68
Pan			0.019	5.4	4.2	0.48	19.25
			Total	**997.8**	**994.8**	**100.00**	**100.00**

HC-2 1-kg

Specific Surface Area = 25.99 cm^2/g

Mesh #	Opening (in.)	Opening (mm)	Average particle diameter (mm)	Sample mass Sample 1 (g)	Sample mass Sample 2 (g)	Percent of total mass (%)	Percent of total surface area (%)
	0.265	6.35		0.0	0.0	0.00	0
4	0.187	4.75	5.55	262.7	255.4	26.06	3.98
6	0.132	3.35	4.05	223.6	223.9	22.51	4.71
8	0.0937	2.38	2.87	168.6	172.8	17.17	5.08
12	0.0661	1.68	2.03	97.6	99.8	9.93	4.15
16	0.0469	1.19	1.44	62.5	66.7	6.50	3.84
20	0.0331	0.841	1.02	38.3	38.4	3.86	3.22
28	0.0234	0.594	0.718	34.3	33.7	3.42	4.05
35	0.0165	0.419	0.507	25.1	24.7	2.50	4.20
48	0.0117	0.297	0.358	18.5	17.3	1.80	4.27
65	0.0083	0.211	0.254	12.4	12.2	1.24	4.13
100	0.0059	0.150	0.181	14.6	13.9	1.43	6.74
150	0.0041	0.104	0.127	8.7	8.0	0.84	5.61
200	0.0029	0.074	0.089	8.2	8.2	0.82	7.87
270	0.0021	0.053	0.064	6.0	5.7	0.59	7.86
325	0.0017	0.043	0.048	4.8	5.9	0.54	9.51
400	0.0015	0.038	0.041	3.7	2.5	0.31	6.53
Pan			0.019	5.2	4.3	0.48	14.23
			Total	**994.8**	**993.4**	**100.00**	**100.00**

ABA-1 1-kg

Specific Surface Area = 35.80 cm^2/g

Mesh #	Opening (in.)	Opening (mm)	Average particle diameter (mm)	Sample mass Sample 1 (g)	Sample mass Sample 2 (g)	Percent of total mass (%)	Percent of total surface area (%)
	0.265	6.35		0.0	0.0	0.00	0
4	0.187	4.75	5.55	218.8	254.6	23.85	2.77
6	0.132	3.35	4.05	193.9	211.3	20.41	3.25
8	0.0937	2.38	2.87	180.0	172.8	17.77	4.00
12	0.0661	1.68	2.03	99.9	97.3	9.93	3.16
16	0.0469	1.19	1.44	70.5	67.2	6.94	3.12
20	0.0331	0.841	1.02	43.6	40.1	4.22	2.68
28	0.0234	0.594	0.718	39.7	34.1	3.72	3.34
35	0.0165	0.419	0.507	30.3	25.3	2.80	3.57
48	0.0117	0.297	0.358	21.9	17.5	1.98	3.57
65	0.0083	0.211	0.254	16.3	12.4	1.45	3.67
100	0.0059	0.150	0.181	18.5	15.4	1.71	6.10
150	0.0041	0.104	0.127	11.5	8.8	1.02	5.19
200	0.0029	0.074	0.089	14.6	10.5	1.26	9.16
270	0.0021	0.053	0.064	12.7	13.0	1.29	13.14
325	0.0017	0.043	0.048	10.6	6.9	0.88	11.84
400	0.0015	0.038	0.041	3.0	1.8	0.24	3.85
Pan			0.019	5.7	4.6	0.52	17.61
			Total	**991.5**	**993.6**	**100.00**	**100.00**

ABA-2 1-kg

Specific Surface Area = 31.40 cm^2/g

Mesh #	Opening (in.)	Opening (mm)	Average particle diameter (mm)	Sample mass Sample 1 (g)	Sample mass Sample 2 (g)	Percent of total mass (%)	Percent of total surface area (%)
	0.265	6.35		0.0	0.0	0.00	0
4	0.187	4.75	5.55	253.6	250.7	25.35	3.28
6	0.132	3.35	4.05	192.7	196.6	19.57	3.47
8	0.0937	2.38	2.87	171.6	169.8	17.16	4.30
12	0.0661	1.68	2.03	101.3	98.6	10.05	3.56
16	0.0469	1.19	1.44	70.4	66.7	6.89	3.45
20	0.0331	0.841	1.02	42.5	42.2	4.26	3.01
28	0.0234	0.594	0.718	38.2	38.2	3.84	3.85
35	0.0165	0.419	0.507	28.9	29.0	2.91	4.13
48	0.0117	0.297	0.358	20.5	21.0	2.09	4.19
65	0.0083	0.211	0.254	14.7	15.0	1.49	4.22
100	0.0059	0.150	0.181	17.7	18.0	1.79	7.14
150	0.0041	0.104	0.127	10.3	10.7	1.06	5.97
200	0.0029	0.074	0.089	10.9	11.0	1.10	8.89
270	0.0021	0.053	0.064	12.3	11.4	1.19	13.48
325	0.0017	0.043	0.048	7.0	7.6	0.73	10.98
400	0.0015	0.038	0.041	1.4	1.5	0.15	2.59
Pan			0.019	3.4	3.7	0.36	13.50
			Total	**997.4**	**991.7**	**100.00**	**100.00**

ABA-3 1-kg

Specific Surface Area = 28.33 cm^2/g

Mesh #	Opening (in.)	Opening (mm)	Average particle diameter (mm)	Sample mass Sample 1 (g)	Sample mass Sample 2 (g)	Percent of total mass (%)	Percent of total surface area (%)
	0.265	6.35		0.0	0.0	0.00	0
4	0.187	4.75	5.55	249.6	245.0	24.86	3.55
6	0.132	3.35	4.05	211.6	209.5	21.16	4.14
8	0.0937	2.38	2.87	172.8	170.2	17.24	4.77
12	0.0661	1.68	2.03	99.3	99.6	10.00	3.91
16	0.0469	1.19	1.44	68.5	70.1	6.97	3.85
20	0.0331	0.841	1.02	41.0	42.7	4.21	3.28
28	0.0234	0.594	0.718	36.3	37.3	3.70	4.09
35	0.0165	0.419	0.507	27.0	28.5	2.79	4.37
48	0.0117	0.297	0.358	18.9	20.3	1.97	4.36
65	0.0083	0.211	0.254	13.5	14.4	1.40	4.38
100	0.0059	0.150	0.181	16.1	17.5	1.69	7.42
150	0.0041	0.104	0.127	9.3	9.6	0.95	5.93
200	0.0029	0.074	0.089	9.1	9.6	0.94	8.38
270	0.0021	0.053	0.064	11.0	13.0	1.21	15.07
325	0.0017	0.043	0.048	5.7	5.6	0.57	9.38
400	0.0015	0.038	0.041	1.1	0.5	0.08	1.57
Pan			0.019	2.8	2.7	0.28	11.54
			Total	**993.6**	**996.1**	**100.00**	**100.00**

HC-1 50-kg

Specific Surface Area = 4.98 cm^2/g

Mesh #	Opening (in.)	Opening (mm)	Average particle diameter (mm)	Sample mass (g)	Percent of total mass (%)	Percent of total surface area (%)
	1.50	38.1		0	0.00	0
	1.00	25.5	31.8	22100	44.20	6.18
	0.500	12.8	19.1	13900	27.80	6.46
	0.265	6.35	9.55	7100	14.20	6.61
4	0.187	4.75	5.55	1605	3.21	2.57
6	0.132	3.35	4.05	1458	2.92	3.20
8	0.0937	2.38	2.87	1212	2.42	3.76
12	0.0661	1.68	2.03	723.0	1.45	3.17
16	0.0469	1.19	1.44	415.9	0.83	2.58
20	0.0331	0.841	1.02	348.7	0.70	3.05
28	0.0234	0.594	0.72	282.9	0.57	3.50
35	0.0165	0.419	0.507	216.1	0.43	3.79
48	0.0117	0.297	0.358	159.6	0.32	3.96
65	0.0083	0.211	0.254	107.7	0.22	3.77
100	0.0059	0.150	0.181	126.7	0.25	6.24
150	0.0041	0.104	0.127	66.5	0.13	4.65
200	0.0029	0.074	0.089	60.9	0.12	6.09
270	0.0021	0.053	0.064	33.9	0.07	4.75
325	0.0017	0.043	0.048	25.6	0.05	4.74
400	0.0015	0.038	0.041	24.6	0.05	5.39
Pan			0.019	33.2	0.07	15.55
			Total	**50,000**	**100.00**	**100.00**

HC-2 50-kg

Specific Surface Area = 4.37 cm^2/g

Mesh #	Opening (in.)	Opening (mm)	Average particle diameter (mm)	Sample mass (g)	Percent of total mass (%)	Percent of total surface area (%)
	1.50	38.1		0	0.00	0
	1.00	25.5	31.8	22300	44.60	7.08
	0.500	12.8	19.1	12770	25.54	6.74
	0.265	6.35	9.55	8910	17.82	9.42
4	0.187	4.75	5.55	1569	3.14	2.85
6	0.132	3.35	4.05	1355	2.71	3.38
8	0.0937	2.38	2.87	1034	2.07	3.64
12	0.0661	1.68	2.03	597.7	1.20	2.97
16	0.0469	1.19	1.44	391.2	0.78	2.75
20	0.0331	0.841	1.02	232.2	0.46	2.31
28	0.0234	0.594	0.718	205.9	0.41	2.90
35	0.0165	0.419	0.507	150.8	0.30	3.01
48	0.0117	0.297	0.358	108.4	0.22	3.06
65	0.0083	0.211	0.254	74.5	0.15	2.96
100	0.0059	0.150	0.181	86.3	0.17	4.83
150	0.0041	0.104	0.127	50.6	0.10	4.02
200	0.0029	0.074	0.089	49.7	0.10	5.64
270	0.0021	0.053	0.064	35.4	0.07	5.63
325	0.0017	0.043	0.048	32.4	0.06	6.82
400	0.0015	0.038	0.041	18.8	0.04	4.68
Pan			0.019	28.8	0.06	15.29
			Total	**50,000**	**100.00**	**100.00**

HC-1 20-tonne

Specific Surface Area = 3.53 cm^2/g

Mesh #	Opening (in.)	Opening (mm)	Average particle diameter (mm)	Sample mass (kg)	Percent of total mass (%)	Percent of total surface area (%)
	3.00	76.2	130	3048.0	42.79	2.01
	2.00	50.8	60	502.5	7.05	0.89
	1.06	26.9	38.90	748.0	10.50	1.69
	0.742	18.8	22.90	1311.0	18.40	5.04
	0.530	13.5	16.20	378.0	5.31	2.06
	0.350	8.89	11.20	188.0	2.64	1.48
	0.265	6.73	7.81	220.0	3.09	2.48
4	0.187	4.75	5.74	169.3	2.38	2.60
6	0.132	3.35	4.05	153.8	2.16	3.34
8	0.0937	2.38	2.87	127.8	1.79	3.93
12	0.0661	1.68	2.03	76.3	1.07	3.31
16	0.0469	1.19	1.44	43.9	0.62	2.69
20	0.0331	0.841	1.02	36.8	0.52	3.19
28	0.0234	0.594	0.718	29.9	0.42	3.66
35	0.0165	0.419	0.507	22.8	0.32	3.96
48	0.0117	0.297	0.358	16.8	0.24	4.14
65	0.0083	0.211	0.254	11.4	0.16	3.94
100	0.0059	0.150	0.181	13.4	0.19	6.53
150	0.0041	0.104	0.127	7.0	0.10	4.86
200	0.0029	0.074	0.089	6.4	0.09	6.36
270	0.0021	0.053	0.064	3.6	0.05	4.97
325	0.0017	0.043	0.048	2.7	0.04	4.96
400	0.0015	0.038	0.041	2.6	0.04	5.64
Pan			0.019	3.5	0.05	16.26
			Total	**7,124**	**100.00**	**100.00**

HC-2 20-tonne

Specific Surface Area = 3.79 cm^2/g

Mesh #	Opening (in.)	Opening (mm)	Average particle diameter (mm)	Sample mass (g)	Percent of total mass (%)	Percent of total surface area (%)
	3.00	76.2	110	1325.0	25.28	1.27
	2.00	50.8	60	627.0	11.96	1.18
	1.06	26.9	38.9	753.0	14.36	2.15
	0.742	18.8	22.9	630.0	12.02	3.05
	0.530	13.5	16.2	610.0	11.64	4.18
	0.350	8.89	11.2	337.0	6.43	3.34
	0.265	6.73	7.81	394.0	7.52	5.60
4	0.187	4.75	5.55	147.5	2.81	2.95
6	0.132	3.35	4.05	127.4	2.43	3.49
8	0.0937	2.38	2.87	97.2	1.85	3.76
12	0.0661	1.68	2.03	56.2	1.07	3.07
16	0.0469	1.19	1.44	36.8	0.70	2.84
20	0.0331	0.841	1.02	21.8	0.42	2.38
28	0.0234	0.594	0.718	19.4	0.37	2.99
35	0.0165	0.419	0.507	14.2	0.27	3.10
48	0.0117	0.297	0.358	10.2	0.19	3.16
65	0.0083	0.211	0.254	7.0	0.13	3.06
100	0.0059	0.150	0.181	8.1	0.15	4.99
150	0.0041	0.104	0.127	4.8	0.09	4.15
200	0.0029	0.074	0.089	4.7	0.09	5.82
270	0.0021	0.053	0.064	3.3	0.06	5.82
325	0.0017	0.043	0.048	3.0	0.06	7.04
400	0.0015	0.038	0.041	1.8	0.03	4.83
Pan			0.019	2.7	0.05	15.79
			Total	**5,242**	**100.00**	**100.00**

APPENDIX 2

SAMPLE ANALYSES

Project: **RED MOUNTAIN PROJECT**
Sample: **HC-1**
Rock Type: feldspar porphyry
Sulfide Estimates: 5% pyrite, 3% pyrrhotite, 0.5% sphalerite

Metal Analysis (ppm)

Aluminum	Al	19200
Antimony	Sb	12
Arsenic	As	708
Barium	Ba	10
Beryllium	Be	*0.5*
Bismuth	Bi	2
Cadmium	Cd	24
Calcium	Ca	8100
Chromium	Cr	38
Cobalt	Co	17
Copper	Cu	314
Iron	Fe	81500
Lead	Pb	72
Lithium	Li	0
Magnesium	Mg	17500
Manganese	Mn	395
Mercury	Hg	*1*
Molybdenum	Mo	*1*
Nickel	Ni	18
Phosphorus	P	1430
Potassium	K	3100
Selenium	Se	
Silver	Ag	2.0
Sodium	Na	200
Strontium	Sr	40
Thallium	Tl	10
Tin	Sn	
Titanium	Ti	100
Tungsten	W	*10*
Vanadium	V	108
Zinc	Zn	2980

Note: values below detection limit shown in italics

ABA Results

Paste pH	8.35
S (Total) (%)	5.84
S (sulfate) (%)	0.02
S (sulfide) (%)	5.82
AP (kg CaCO3/tonne)	182
NP (kg CaCO3/tonne)	44.6
C (%)	0.329
CO_3 NP (kg $CaCO_3$/tonne)	27
Net NP (kg $CaCO_3$/tonne)	-137
NPR	0.25

Whole Rock Analysis

Al_2O_3 (%)	16.40
CaO (%)	1.37
Cr_2O_3 (%)	0.02
Fe_2O_3 (%)	12.58
K_2O (%)	5.55
MgO (%)	3.83
MnO (%)	0.07
Na_2O (%)	1.77
P_2O_5 (%)	0.36
SiO_2 (%)	51.13
TiO_2 (%)	0.52
LOI (%)	6.25
TOTALS (%)	99.85
Sulfate (%)	0.02
S (Total) (%)	5.84

Project: **RED MOUNTAIN PROJECT**
Sample: **HC-2**
Rock Type: 2/3 sediment, 1/3 feldspar porphyry
Sulfide Estimates: 3% pyrrhotite, 2% pyrite, 1% sphalerite

Metal Analysis (ppm)

Aluminum	Al	21600
Antimony	Sb	6
Arsenic	As	574
Barium	Ba	50
Beryllium	Be	*0.5*
Bismuth	Bi	2
Cadmium	Cd	65
Calcium	Ca	5500
Chromium	Cr	104
Cobalt	Co	14
Copper	Cu	224
Iron	Fe	63500
Lead	Pb	54
Lithium	Li	0
Magnesium	Mg	24300
Manganese	Mn	875
Mercury	Hg	*1*
Molybdenum	Mo	*1*
Nickel	Ni	51
Phosphorus	P	1180
Potassium	K	1600
Selenium	Se	
Silver	Ag	1.2
Sodium	Na	100
Strontium	Sr	17
Thallium	Tl	10
Tin	Sn	
Titanium	Ti	800
Tungsten	W	*10*
Vanadium	V	138
Zinc	Zn	5610

ABA Results

Paste pH	8.35
S (Total) (%)	3.97
S (sulfate) (%)	0.02
S (sulfide) (%)	3.95
AP (kg CaCO3/tonne)	123
NP (kg CaCO3/tonne)	11.9
C (%)	0.113
CO_3 NP (kg $CaCO_3$/tonne)	9.4
Net NP (kg $CaCO_3$/tonne)	-112
NPR	0.10

Whole Rock Analysis

Al_2O_3 (%)	15.78
CaO (%)	1.16
Cr_2O_3 (%)	0.03
Fe_2O_3 (%)	9.86
K_2O (%)	5.66
MgO (%)	4.76
MnO (%)	0.15
Na_2O (%)	2.03
P_2O_5 (%)	0.32
SiO_2 (%)	54.49
TiO_2 (%)	0.55
LOI (%)	4.58
TOTALS (%)	99.37
Sulfate (%)	0.02
S (Total) (%)	3.97

Note: values below detection limit shown in italics

Project: **RED MOUNTAIN PROJECT**
Sample: **ABA-1**
Rock Type: sediment
Sulfide Estimates: 7% pyrrhotite

Metal Analysis (ppm)

Aluminum	Al	16700
Antimony	Sb	6
Arsenic	As	764
Barium	Ba	30
Beryllium	Be	*0.5*
Bismuth	Bi	2
Cadmium	Cd	11
Calcium	Ca	9700
Chromium	Cr	117
Cobalt	Co	15
Copper	Cu	226
Iron	Fe	69900
Lead	Pb	28
Lithium	Li	0
Magnesium	Mg	18500
Manganese	Mn	575
Mercury	Hg	*1*
Molybdenum	Mo	*1*
Nickel	Ni	75
Phosphorus	P	1130
Potassium	K	1800
Selenium	Se	
Silver	Ag	0.6
Sodium	Na	100
Strontium	Sr	26
Thallium	Tl	10
Tin	Sn	
Titanium	Ti	600
Tungsten	W	*10*
Vanadium	V	78
Zinc	Zn	1220

Note: values below detection limit shown in italics

ABA Results

Paste pH	8.06
S (Total) (%)	4.56
S (sulfate) (%)	0.08
S (sulfide) (%)	4.48
AP (kg CaCO3/tonne)	140
NP (kg CaCO3/tonne)	36.3
C (%)	0.388
CO_3 NP (kg $CaCO_3$/tonne)	32
Net NP (kg $CaCO_3$/tonne)	-104
NPR	0.26

Whole Rock Analysis

Al_2O_3 (%)	14.68
CaO (%)	1.75
Cr_2O_3 (%)	0.03
Fe_2O_3 (%)	10.89
K_2O (%)	4.98
MgO (%)	3.90
MnO (%)	0.09
Na_2O (%)	1.93
P_2O_5 (%)	0.31
SiO_2 (%)	55.38
TiO_2 (%)	0.55
LOI (%)	5.21
TOTALS (%)	99.70
Sulfate (%)	0.08
S (Total) (%)	4.56

Project: **RED MOUNTAIN PROJECT**
Sample: **ABA-2**
Rock Type: feldspar porphyry
Sulfide Estimates: 7% pyrrhotite

Metal Analysis (ppm)

Aluminum	Al	22900
Antimony	Sb	2
Arsenic	As	170
Barium	Ba	40
Beryllium	Be	*0.5*
Bismuth	Bi	2
Cadmium	Cd	1
Calcium	Ca	13000
Chromium	Cr	47
Cobalt	Co	17
Copper	Cu	169
Iron	Fe	73600
Lead	Pb	26
Lithium	Li	0
Magnesium	Mg	21300
Manganese	Mn	685
Mercury	Hg	*1*
Molybdenum	Mo	*1*
Nickel	Ni	20
Phosphorus	P	1360
Potassium	K	1800
Selenium	Se	
Silver	Ag	0.2
Sodium	Na	400
Strontium	Sr	45
Thallium	Tl	10
Tin	Sn	
Titanium	Ti	700
Tungsten	W	*10*
Vanadium	V	148
Zinc	Zn	88

Note: values below detection limit shown in italics

ABA Results

Paste pH	8.22
S (Total) (%)	4.78
S (sulfate) (%)	0.04
S (sulfide) (%)	4.74
AP (kg CaCO3/tonne)	148
NP (kg CaCO3/tonne)	33.1
C (%)	0.334
CO_3 NP (kg $CaCO_3$/tonne)	28
Net NP (kg $CaCO_3$/tonne)	-115
NPR	0.22

Whole Rock Analysis

Al_2O_3 (%)	16.99
CaO (%)	2.38
Cr_2O_3 (%)	0.01
Fe_2O_3 (%)	11.66
K_2O (%)	4.36
MgO (%)	4.29
MnO (%)	0.12
Na_2O (%)	3.04
P_2O_5 (%)	0.33
SiO_2 (%)	50.55
TiO_2 (%)	0.54
LOI (%)	5.59
TOTALS (%)	99.86
Sulfate (%)	0.04
S (Total) (%)	4.78

Project: **RED MOUNTAIN PROJECT**
Sample: **ABA-3**
Rock Type: feldspar porphyry
Sulfide Estimates: 5% pyrite

Metal Analysis (ppm)

Aluminum	Al	16600
Antimony	Sb	4
Arsenic	As	272
Barium	Ba	50
Beryllium	Be	*0.5*
Bismuth	Bi	2
Cadmium	Cd	1
Calcium	Ca	8500
Chromium	Cr	146
Cobalt	Co	14
Copper	Cu	122
Iron	Fe	49200
Lead	Pb	26
Lithium	Li	0
Magnesium	Mg	19600
Manganese	Mn	600
Mercury	Hg	*1*
Molybdenum	Mo	*1*
Nickel	Ni	85
Phosphorus	P	1020
Potassium	K	1300
Selenium	Se	
Silver	Ag	0.2
Sodium	Na	400
Strontium	Sr	35
Thallium	Tl	10
Tin	Sn	
Titanium	Ti	800
Tungsten	W	*10*
Vanadium	V	84
Zinc	Zn	60

Note: values below detection limit shown in italics

ABA Results

Paste pH	8.01
S (Total) (%)	3.13
S (sulfate) (%)	0.02
S (sulfide) (%)	3.11
AP (kg CaCO3/tonne)	97
NP (kg CaCO3/tonne)	25
C (%)	0.149
CO_3 NP (kg $CaCO_3$/tonne)	12
Net NP (kg $CaCO_3$/tonne)	-72
NPR	0.26

Whole Rock Analysis

Al_2O_3 (%)	16.04
CaO (%)	2.42
Cr_2O_3 (%)	0.04
Fe_2O_3 (%)	8.10
K_2O (%)	4.32
MgO (%)	4.80
MnO (%)	0.19
Na_2O (%)	3.29
P_2O_5 (%)	0.26
SiO_2 (%)	56.11
TiO_2 (%)	0.59
LOI (%)	4.12
TOTALS (%)	100.30
Sulfate (%)	0.02
S (Total) (%)	3.13

APPENDIX 3

MODIFIED ABA PROCEDURE

The Modified Acid Base Accounting Procedure used for this study is as follows:

1. Place 2-3 g of pulverized sample (80% minus 200 mesh) into a watch glass
2. Add 3 to 4 drops of 25% HCl
3. Rate fizz as none, slight, moderate or strong
4. Measure 2.0 g of pulverized sample into a 250 ml conical flask and add approximately 90 ml of distilled water
5. At the beginning of the test (time=0), add a volume of certified 1N HCl to the flask according to the fizz rating as follows:

	Volume of 1.0 N HCl (mL)	
Fizz Rating	at time = 0 hrs	at time = 2 hrs
None	1.0	1.0
Slight	2.0	1.0
Moderate	2.0	2.0
Strong	3.0	2.0

6. Agitate the contents of the flask for a total of 24 hours by placing on a shaking table. After two hours of agitation, add the second volume of HCl as indicated above. Check the pH of all the flask solutions after 22 hours. If the pH is greater than 2.5, add enough HCl to bring the pH down to 2.0-2.5. If the pH is less than 2.0, repeat the test using the volume of HCl as indicated by using the next lower fizz rating.
7. At the end of 24 hours, add distilled water to the flask to make a pulp volume of 125 ml. Check the pH to ensure that it is still in the range of 2.0-2.5
8. If the pH is in the correct range, titrate the contents of the flask using certified 0.5N NaOH to pH 8.3
9. Calculate the NP of the sample as follows:

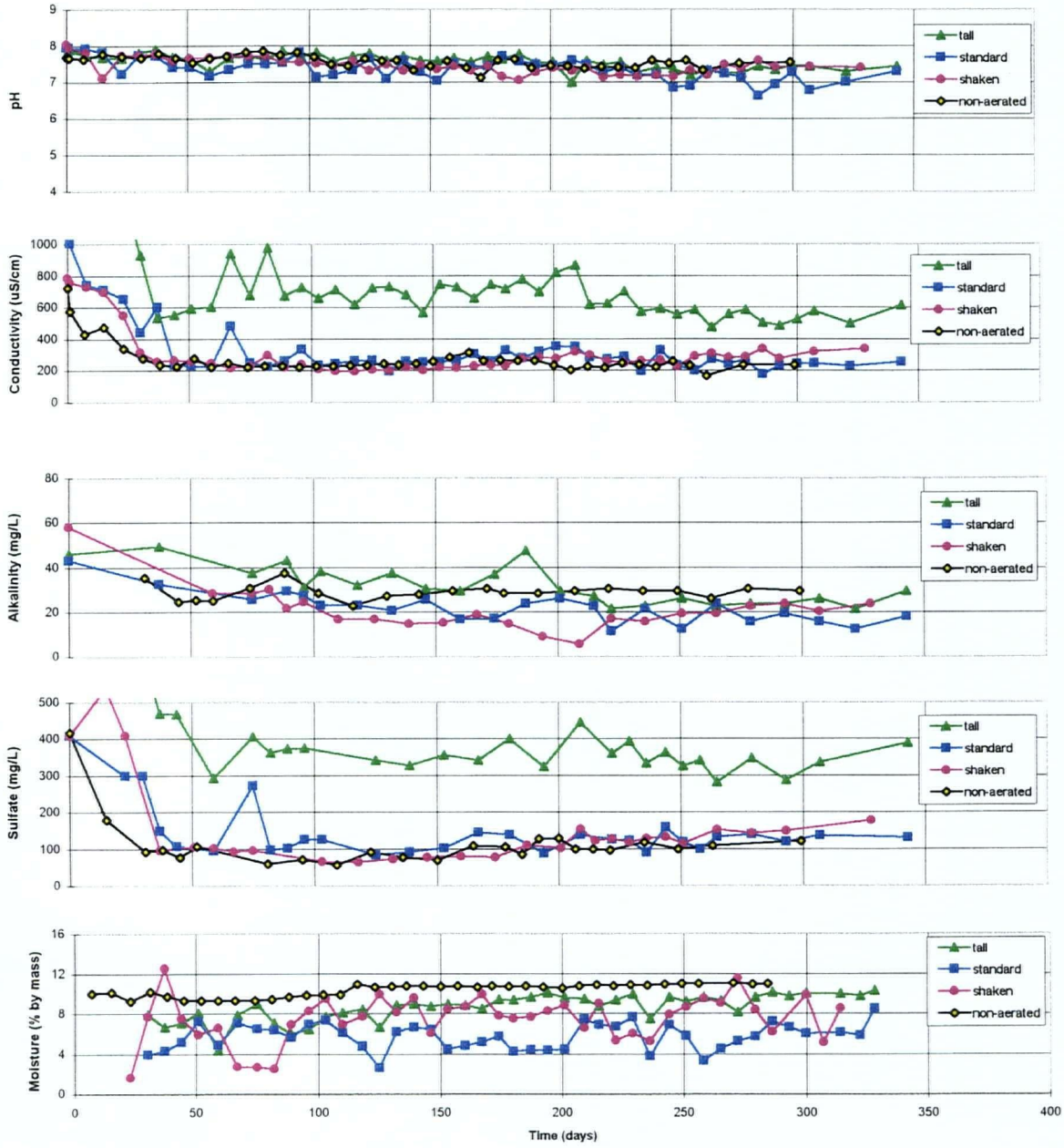
$$\text{Modified NP (kg } CaCO_3/t) = \frac{(\text{N x vol (mL) of HCl}) - (\text{N x vol (mL) NaOH}) \times 50}{\text{weight of sample (g)}}$$

APPENDIX 4

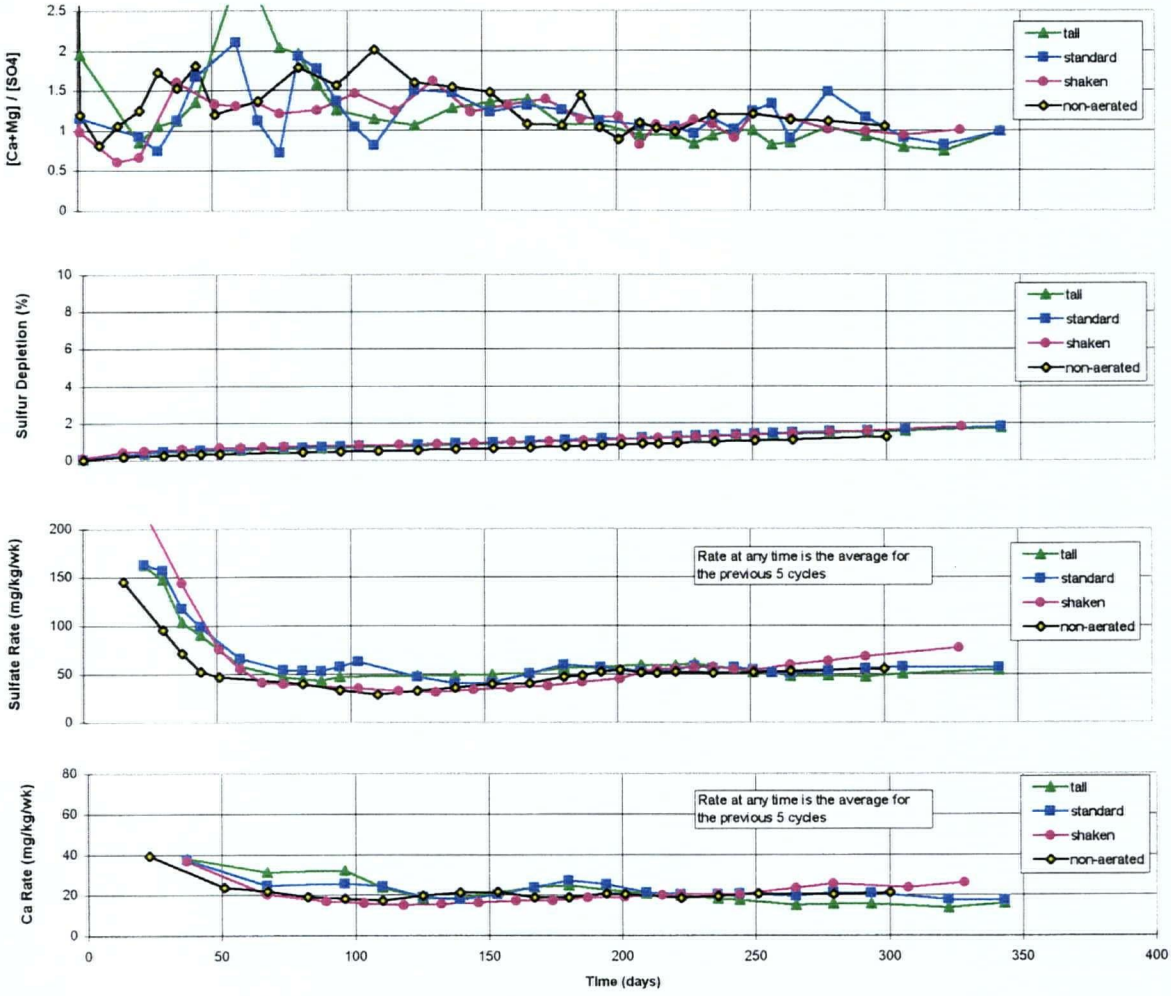
GRAPHIC COMPARISONS

STANDARD, NON-AERATED, TALL, AND SHAKEN CELLS

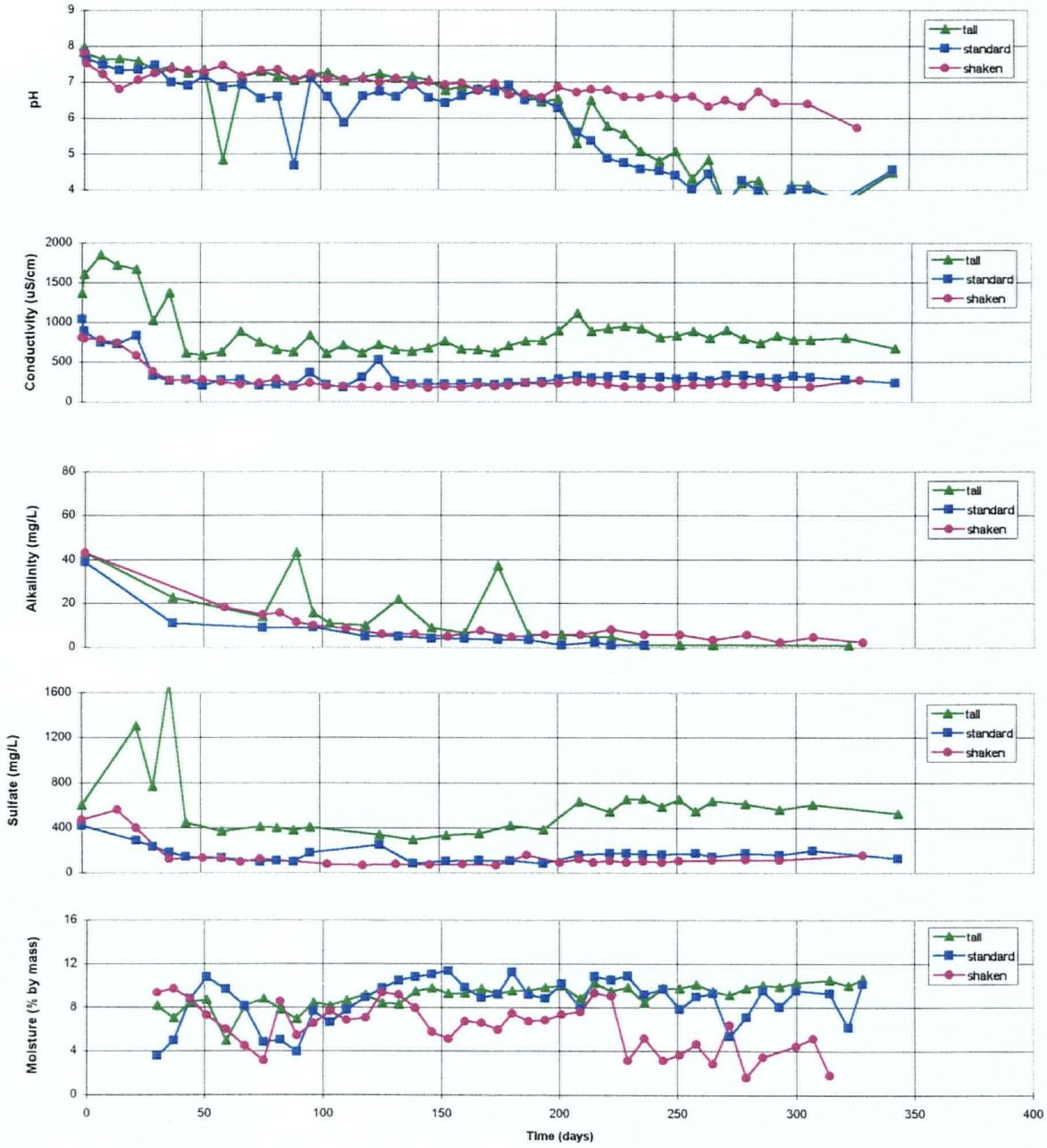
Project: **RED MOUNTAIN**
Sample: **HC-1**
Rock Type: **feldspar porphyry**
Mineralization: **5% pyrite, 3% pyrrhotite, 0.5% sphalerite**



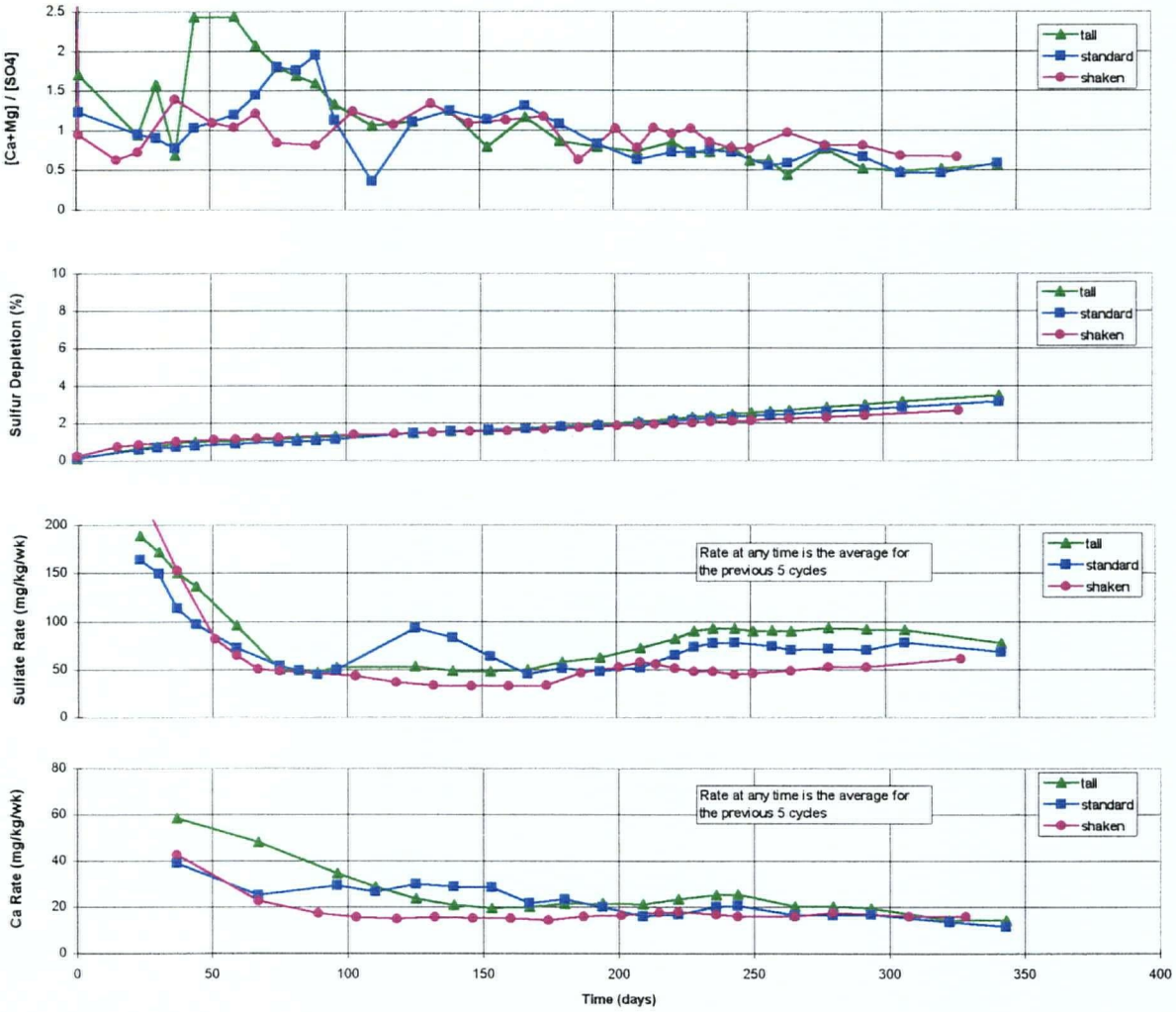
Project: **RED MOUNTAIN**
Sample: **HC-1**
Rock Type: **feldspar porphyry**
Mineralization: **5% pyrite, 3% pyrrhotite, 0.5% sphalerite**



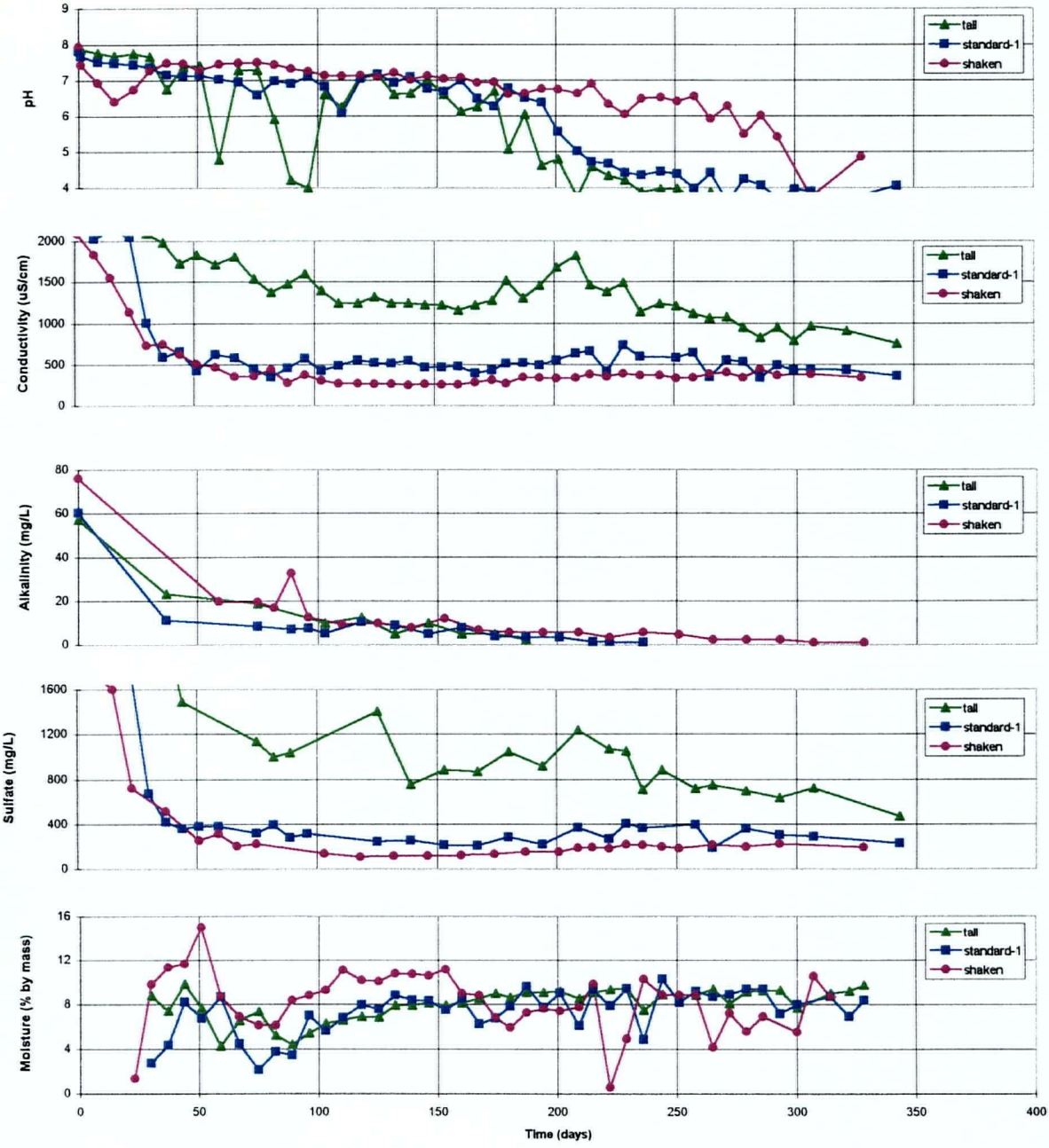
Project: **RED MOUNTAIN**
Sample: **HC-2**
Rock Type: **sediment**
Mineralization: **3% pyrrhotite, 2% pyrite, 1% sphalerite**



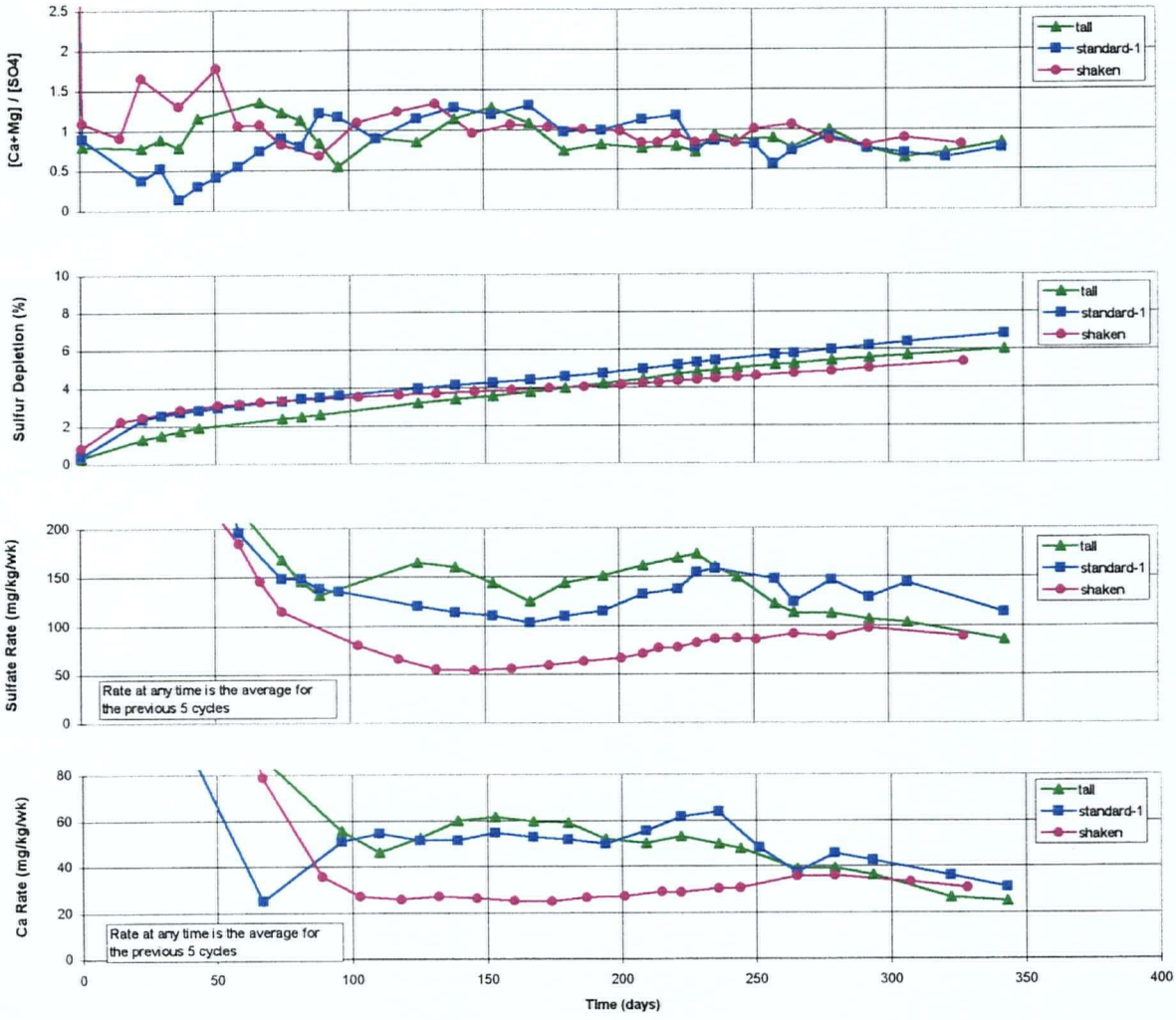
Project: **RED MOUNTAIN**
Sample: **HC-2**
Rock Type: **sediment**
Mineralization: **3% pyrrhotite, 2% pyrite, 1% sphalerite**



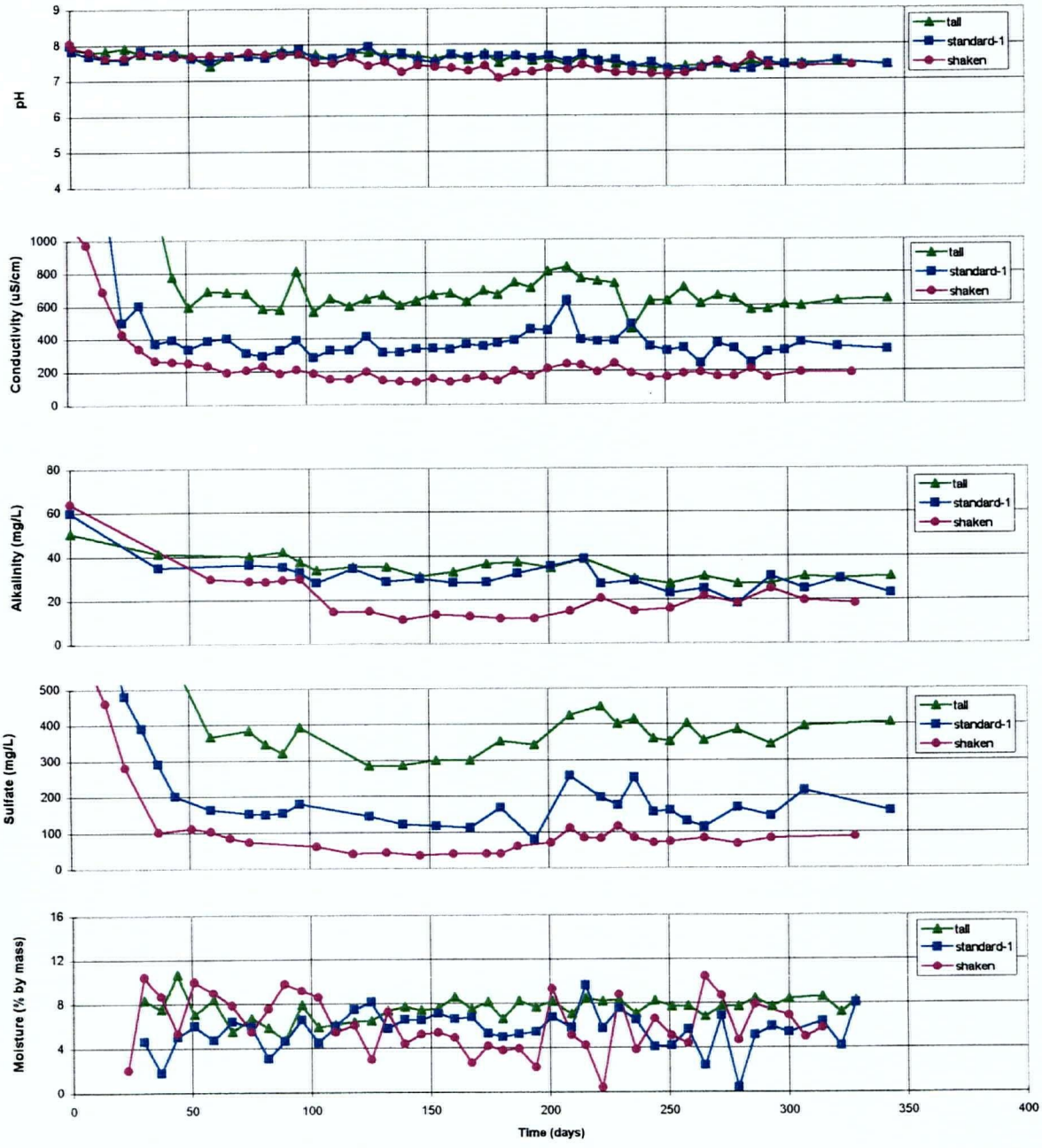
Project: **RED MOUNTAIN**
Sample: **ABA-1**
Rock Type: **sediment**
Mineralization: **7% pyrrhotite**



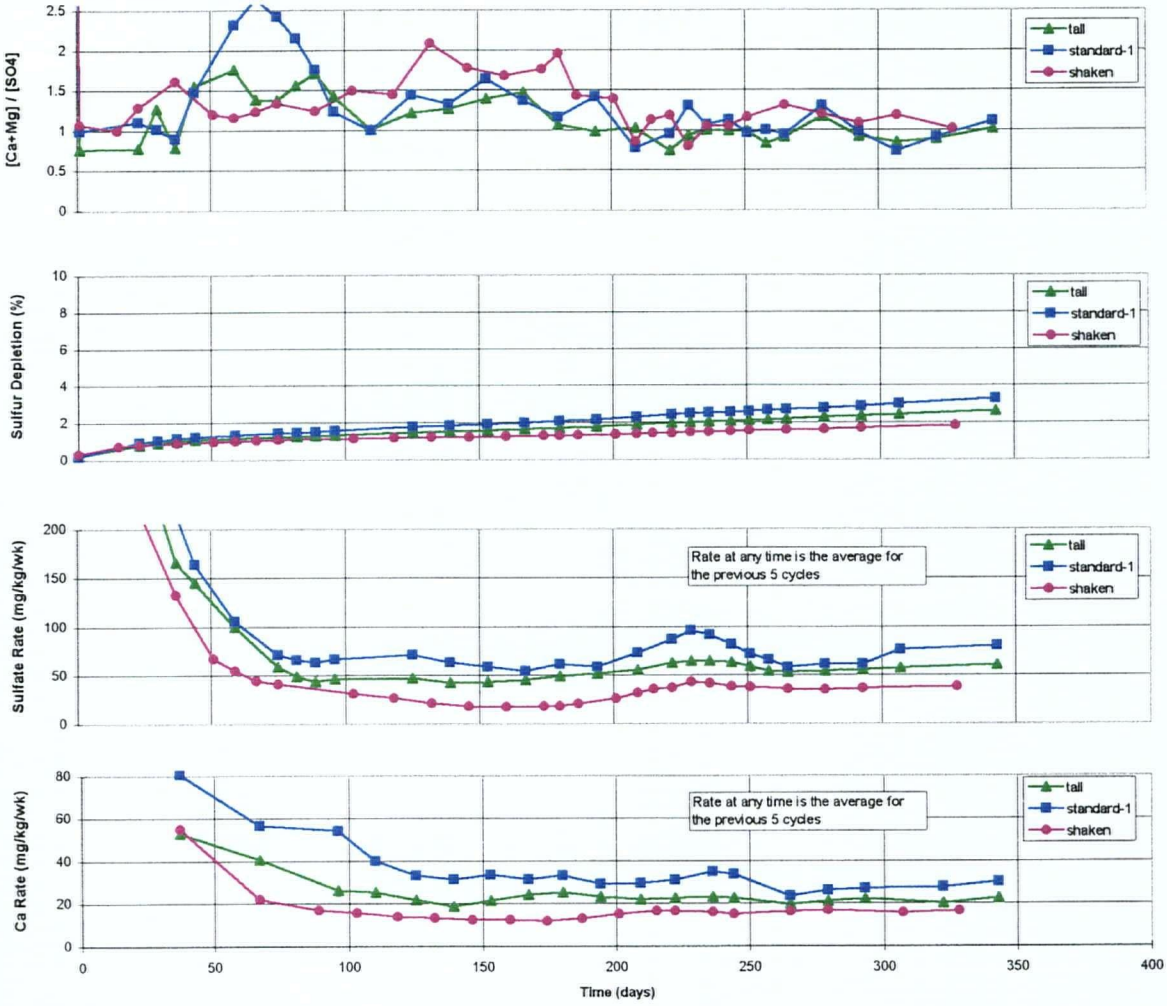
Project: **RED MOUNTAIN**
Sample: **ABA-1**
Rock Type: **sediment**
Mineralization: **7% pyrrhotite**



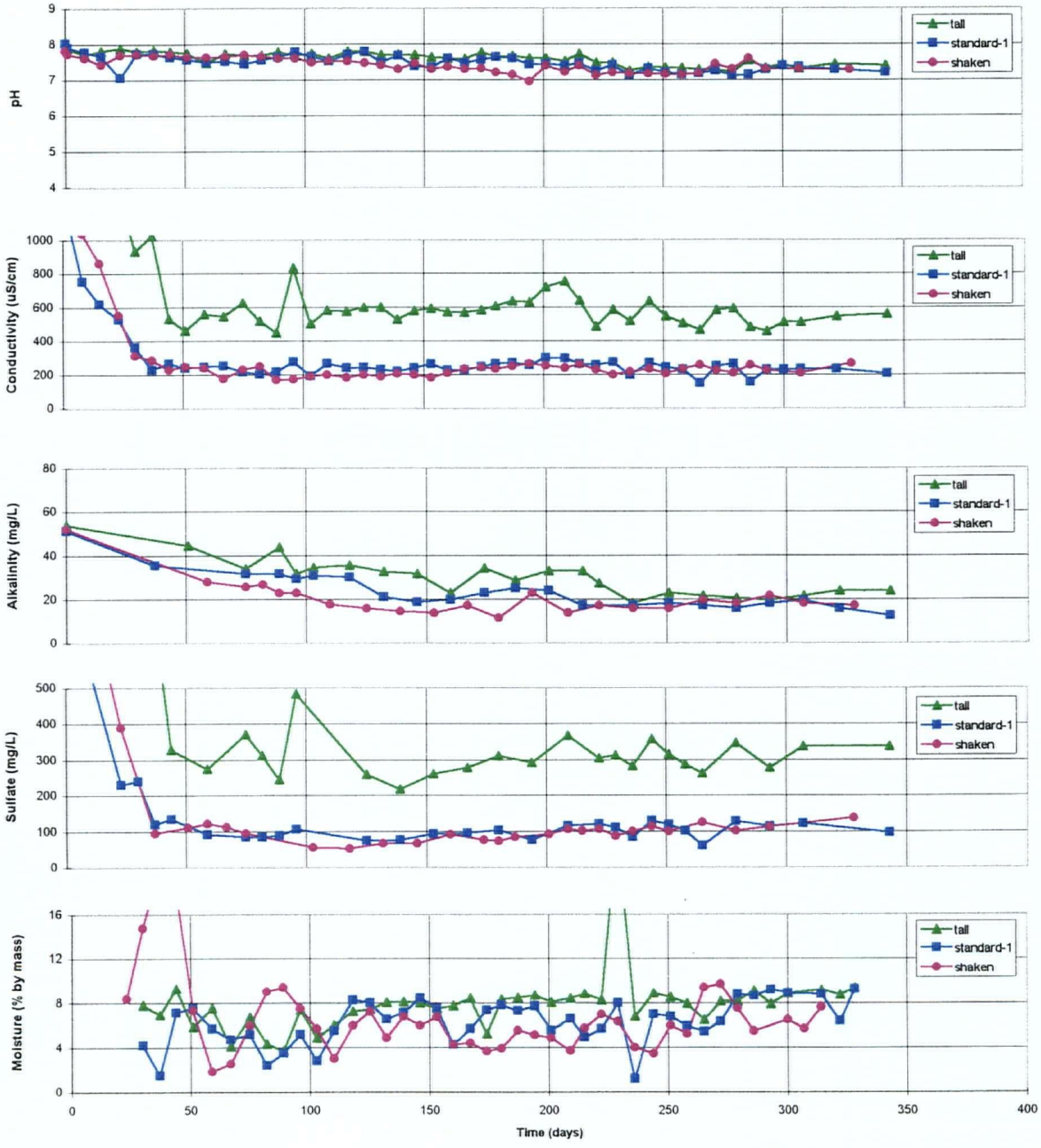
Project: **RED MOUNTAIN**
Sample: **ABA-2**
Rock Type: **feldspar porphyry**
Mineralization: **7% pyrrhotite**



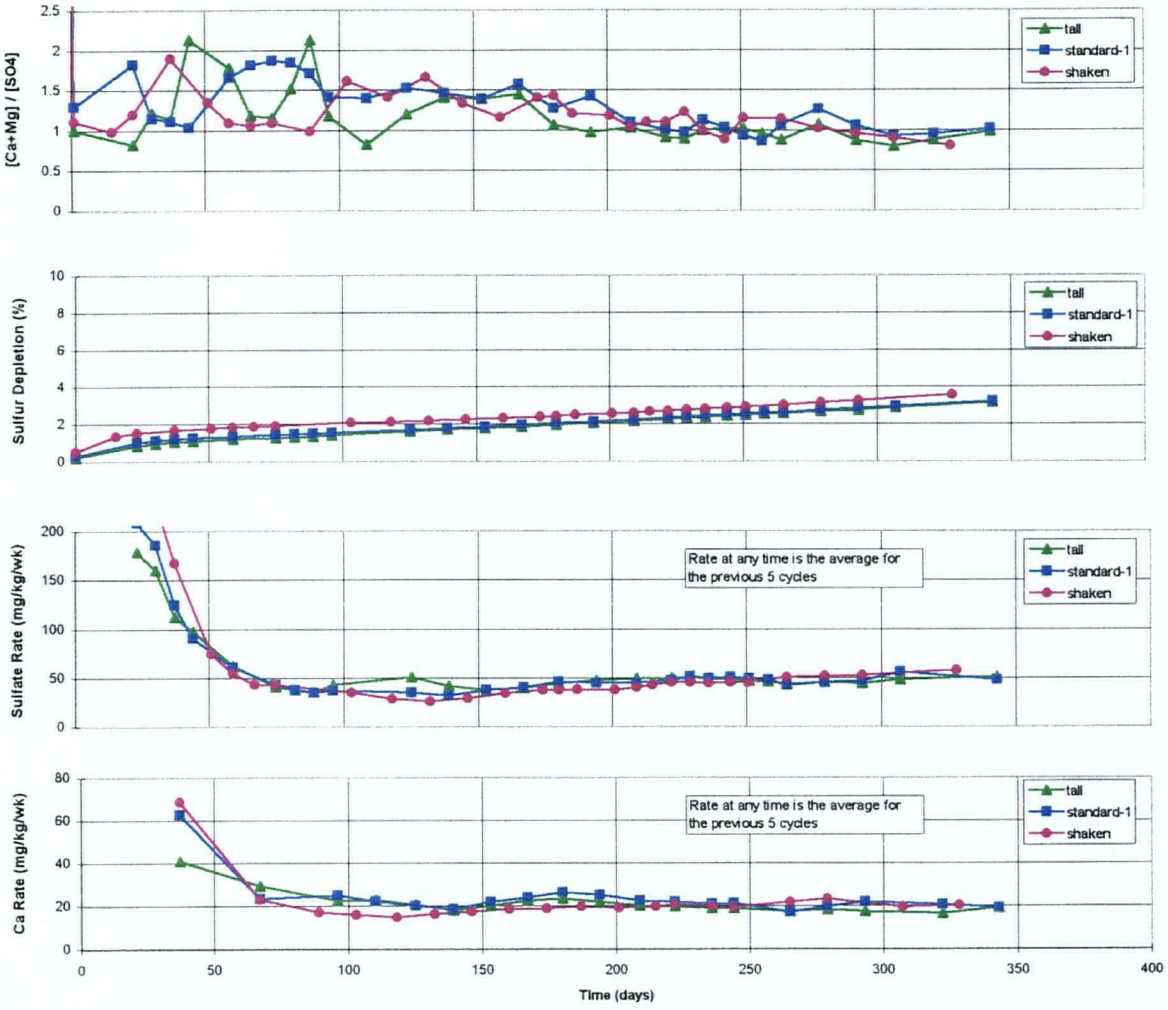
Project: **RED MOUNTAIN**
Sample: **ABA-2**
Rock Type: **feldspar porphyry**
Mineralization: **7% pyrrhotite**



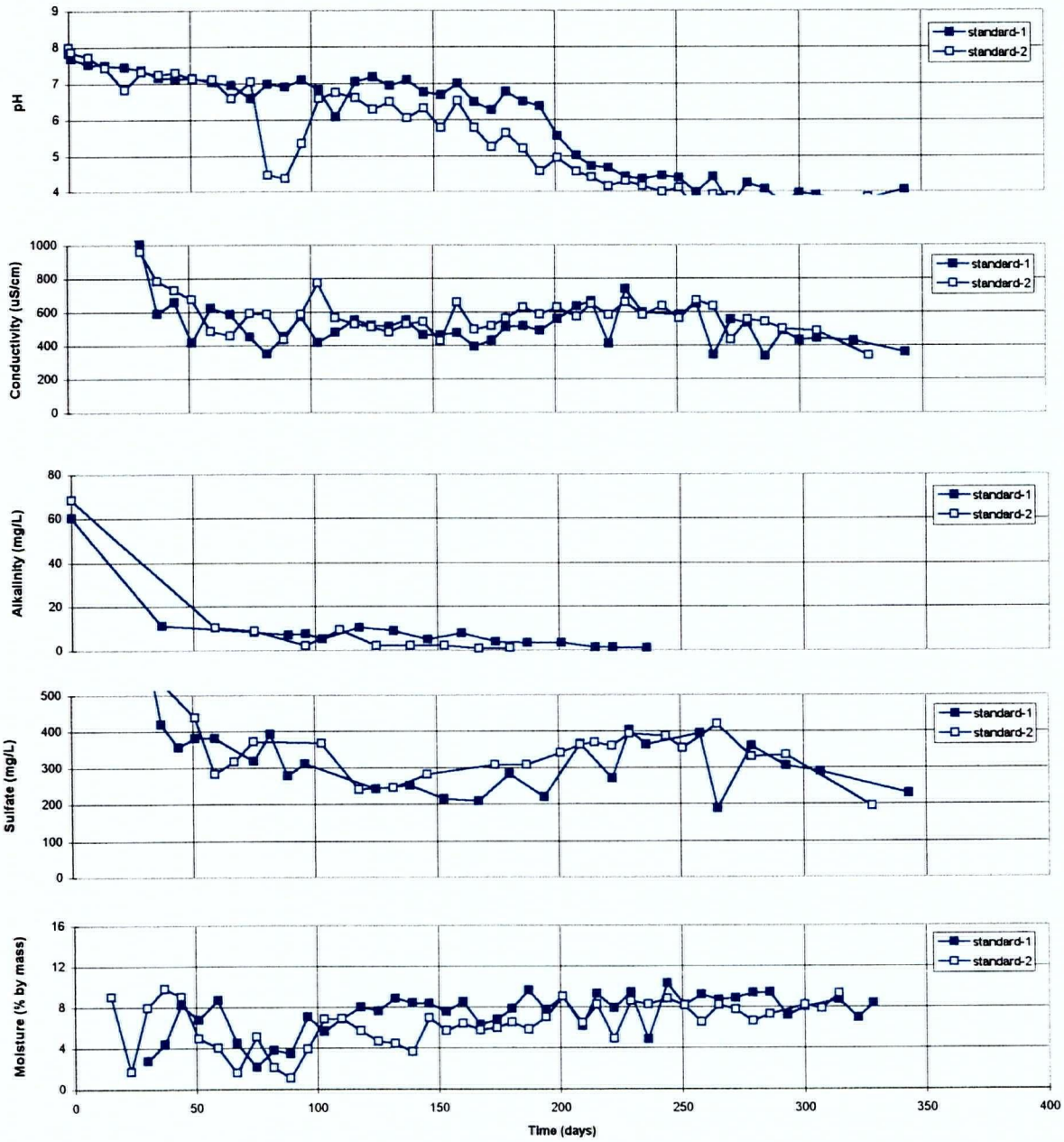
Project: **RED MOUNTAIN**
Sample: **ABA-3**
Rock Type: **feldspar porphyry**
Mineralization: **5% pyrite**



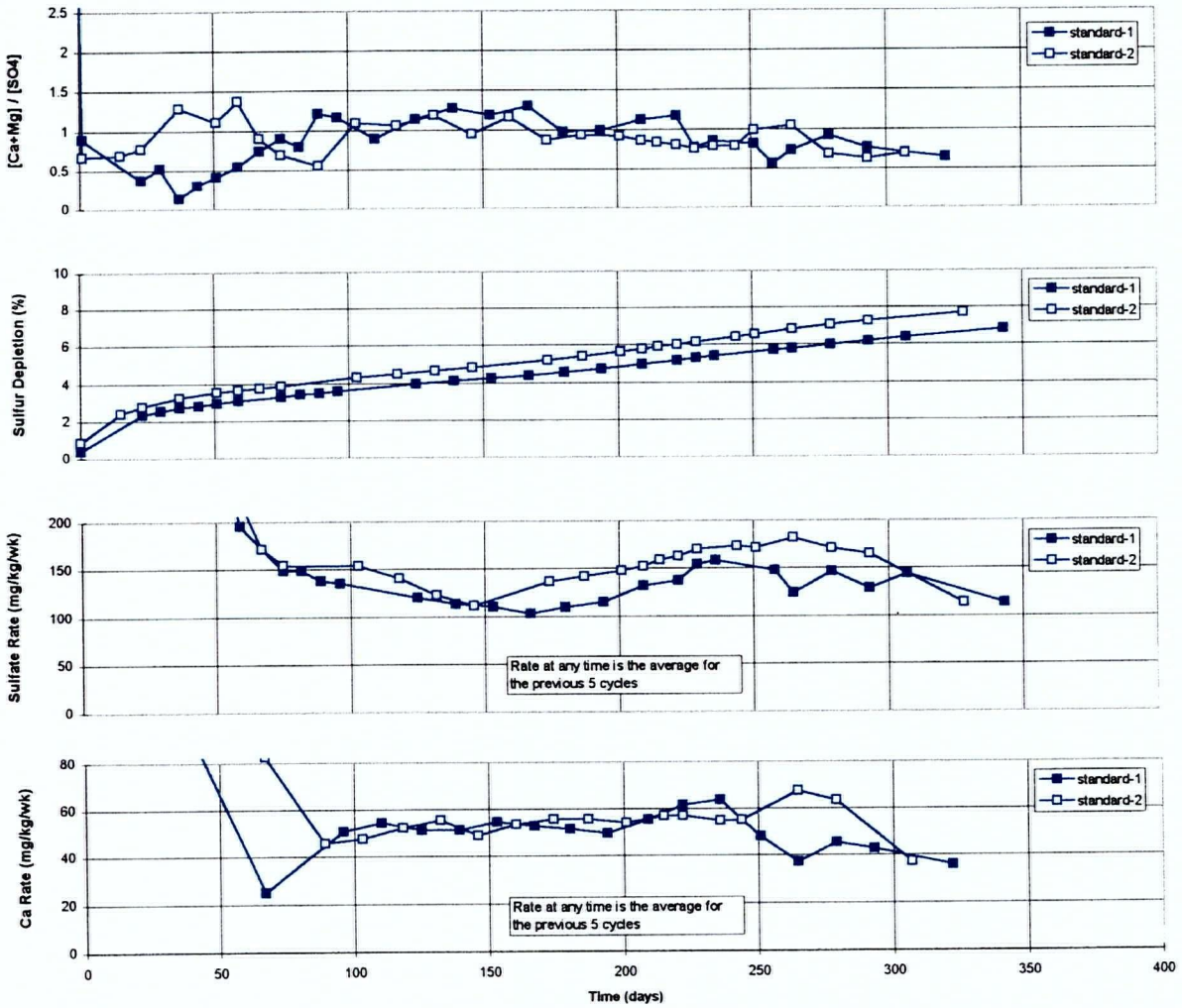
Project: **RED MOUNTAIN**
Sample: **ABA-3**
Rock Type: **feldspar porphyry**
Mineralization: **5% pyrite**



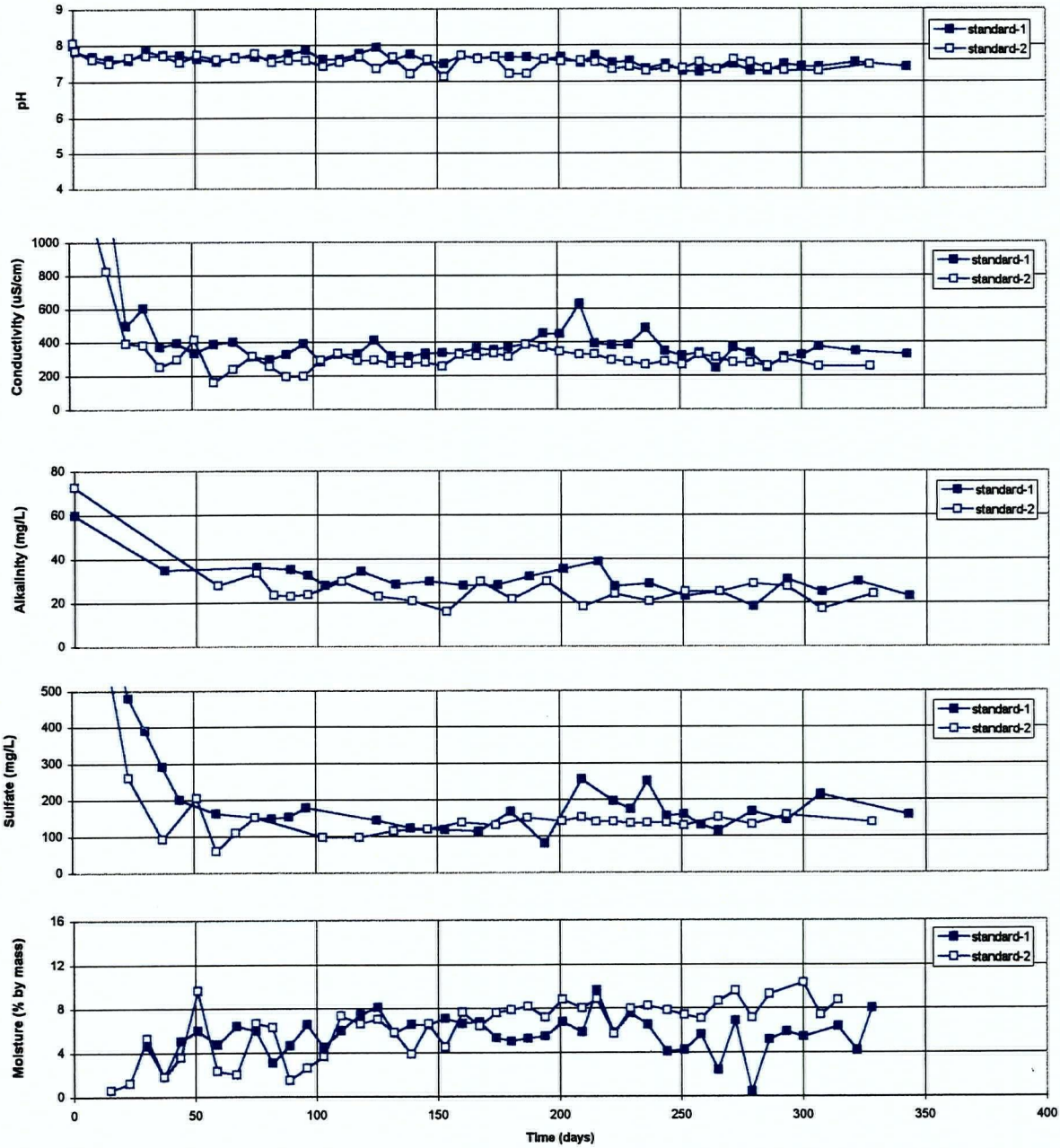
Project: **RED MOUNTAIN PROJECT**
Sample: **ABA-1**
Rock Type: **sediment**



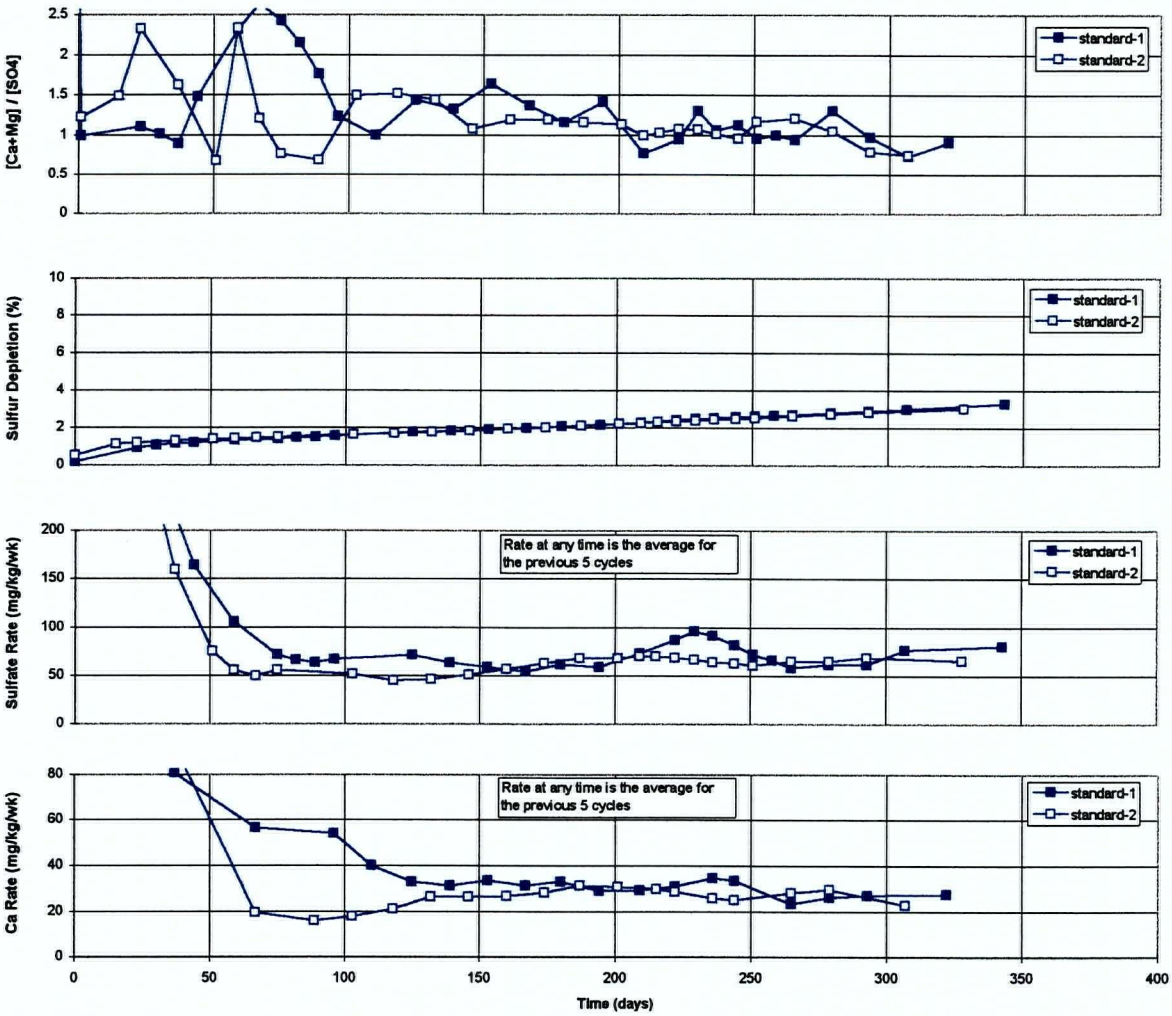
Project: **RED MOUNTAIN PROJECT**
Sample: **ABA-1**
Rock Type: **sediment**



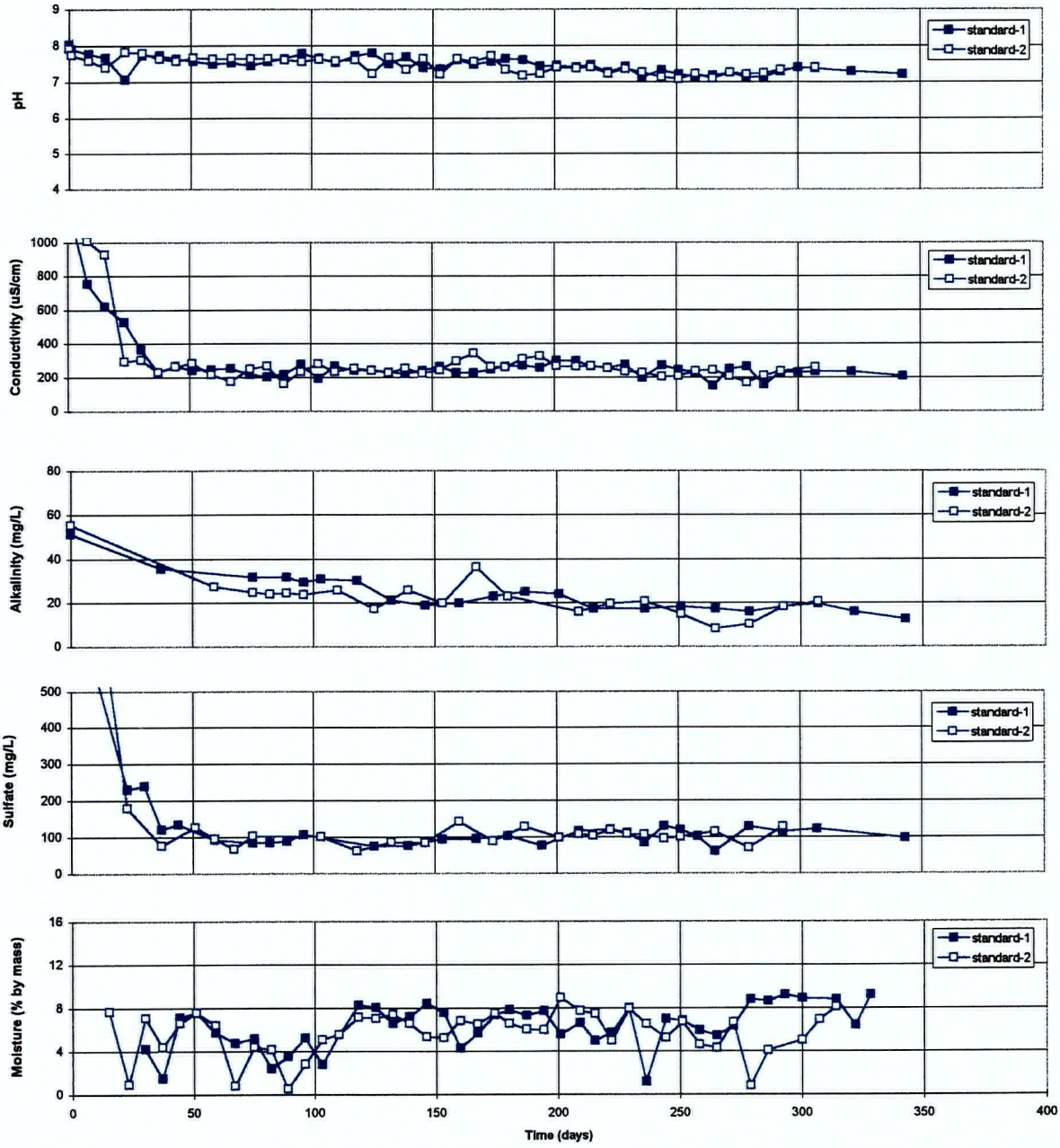
Project: **RED MOUNTAIN PROJECT**
Sample: **ABA-2**
Rock Type: **feldspar porphyry**



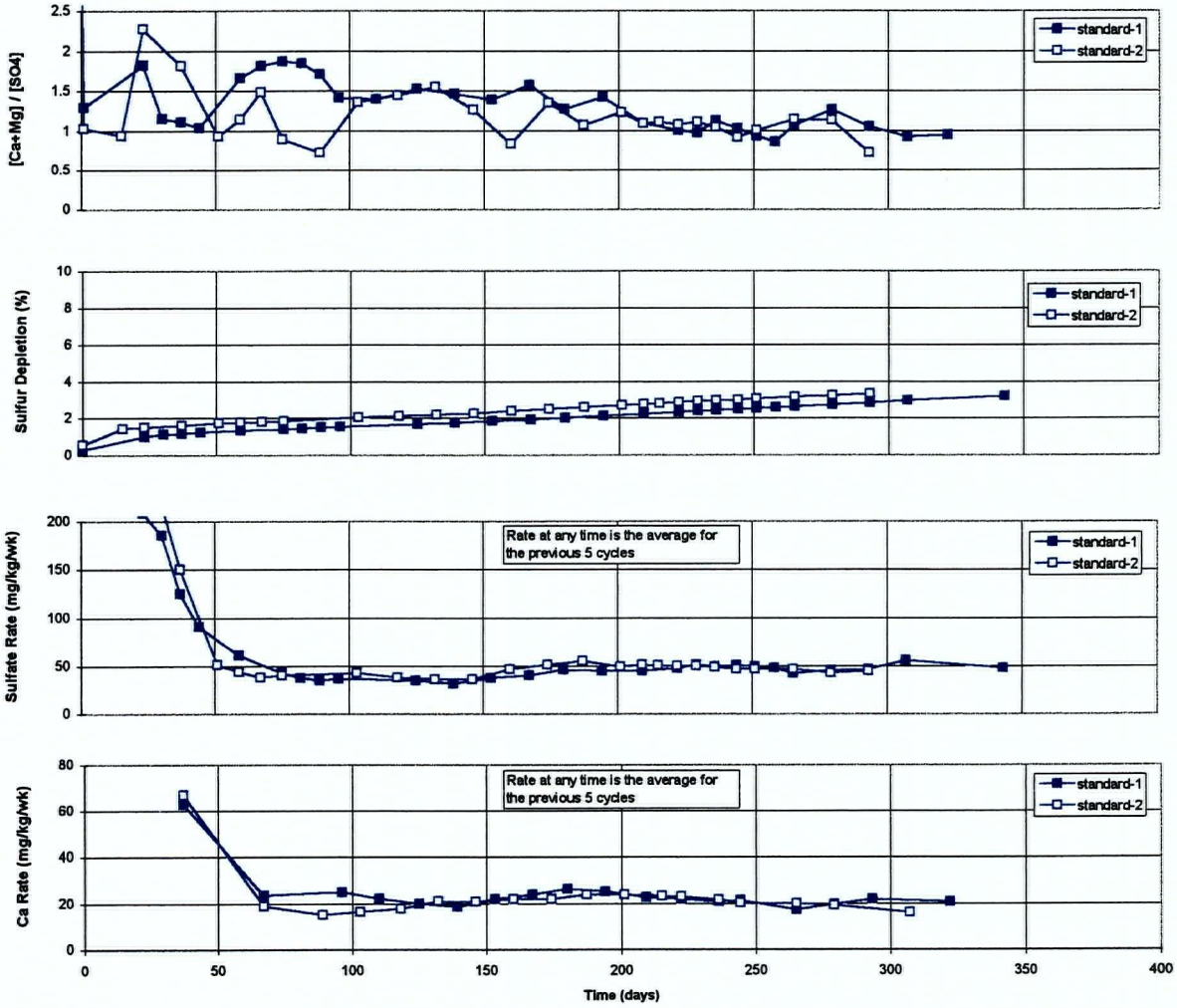
Project: **RED MOUNTAIN PROJECT**
Sample: **ABA-2**
Rock Type: **feldspar porphyry**



Project: **RED MOUNTAIN PROJECT**
Sample: **ABA-3**
Rock Type: **feldspar porphyry**



Project: **RED MOUNTAIN PROJECT**
Sample: **ABA-3**
Rock Type: **feldspar porphyry**

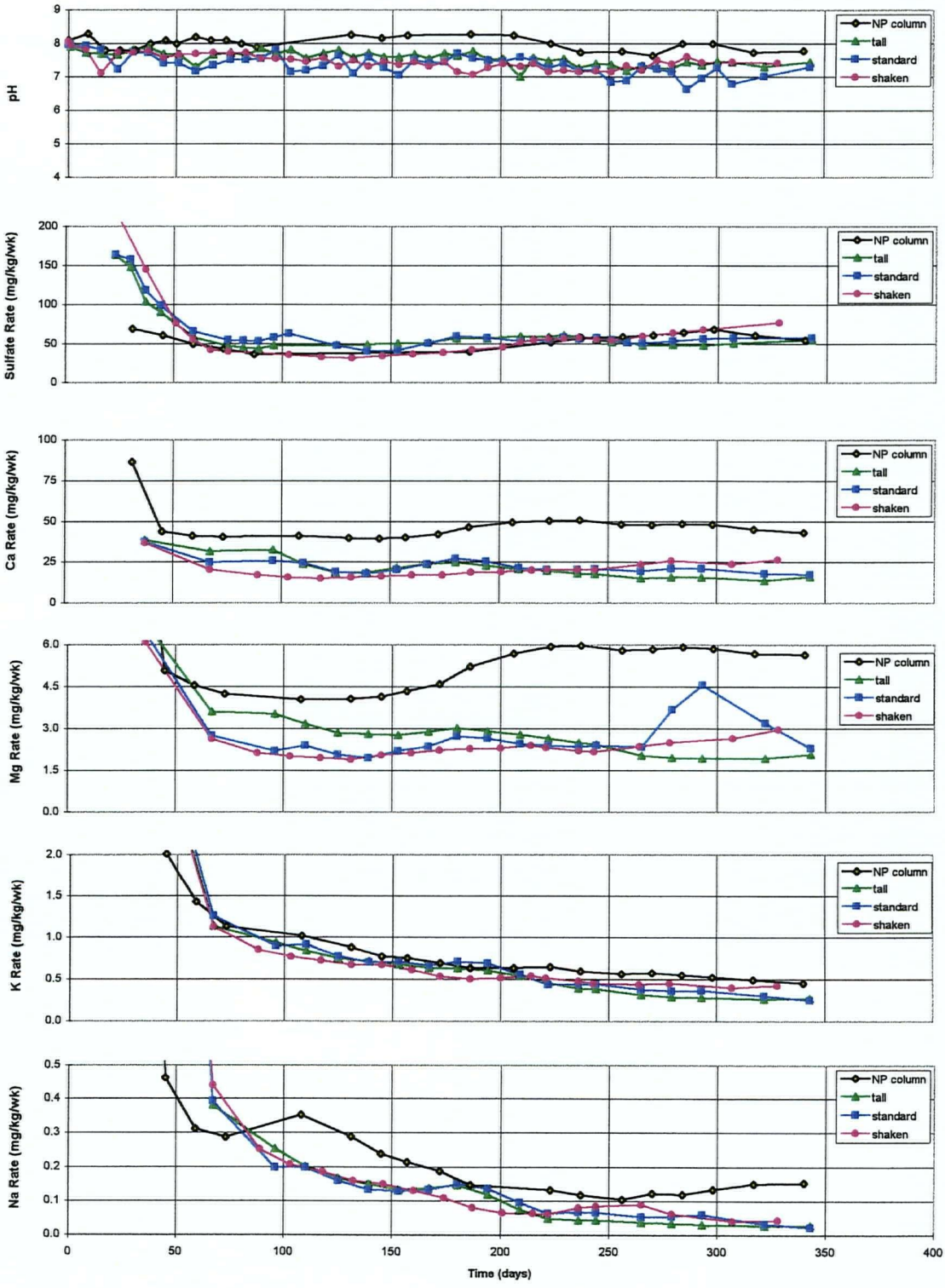


APPENDIX 5

GRAPHIC COMPARISONS

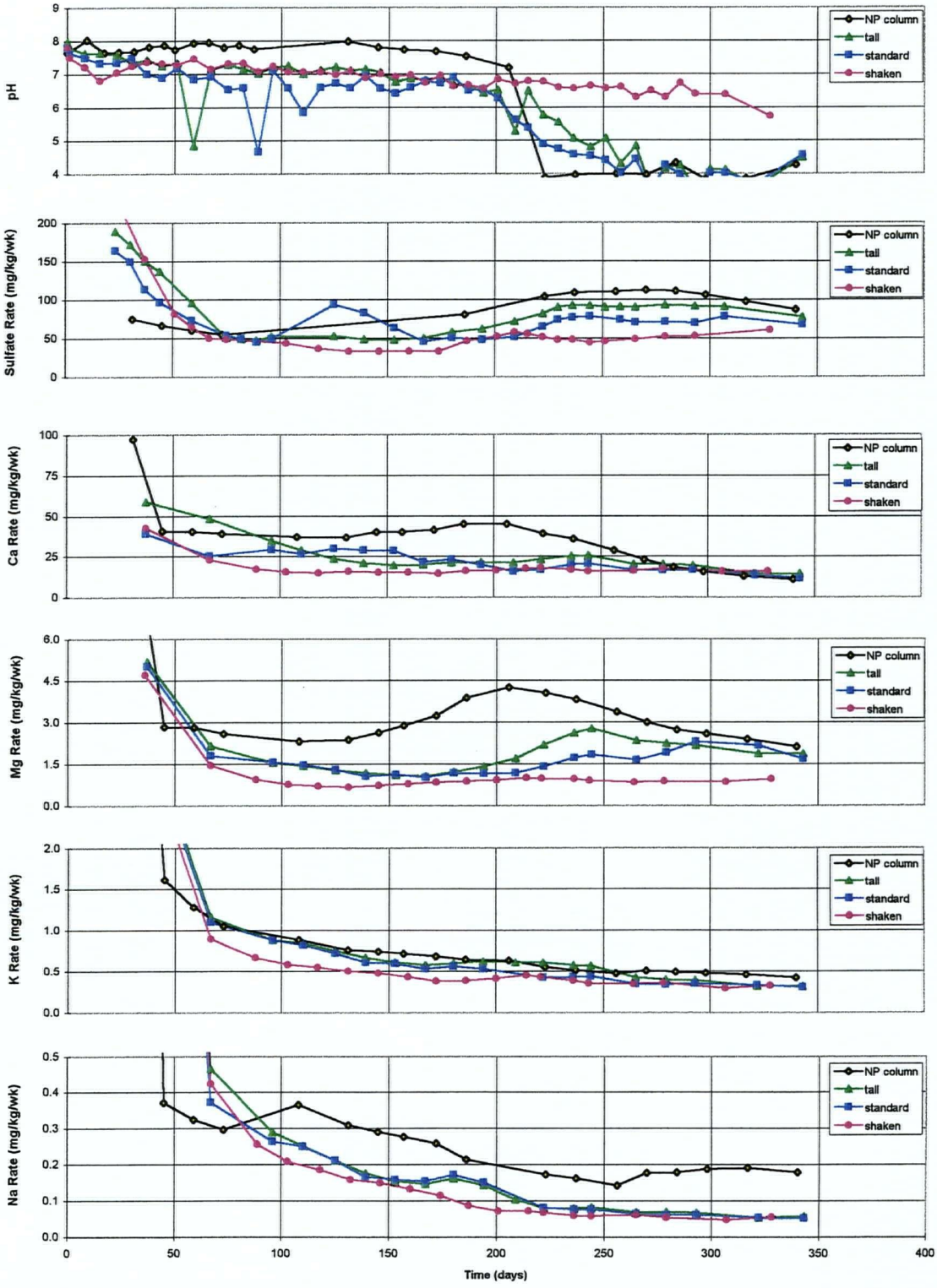
NP COLUMNS TO STANDARD, TALL, AND SHAKEN CELLS

Project: **RED MOUNTAIN**
Sample: **HC-1**
Rock Type: **feldspar porphyry**
Mineralization: **5%pyrite, 3%pyrrhotite, 0.5%sphalerite**



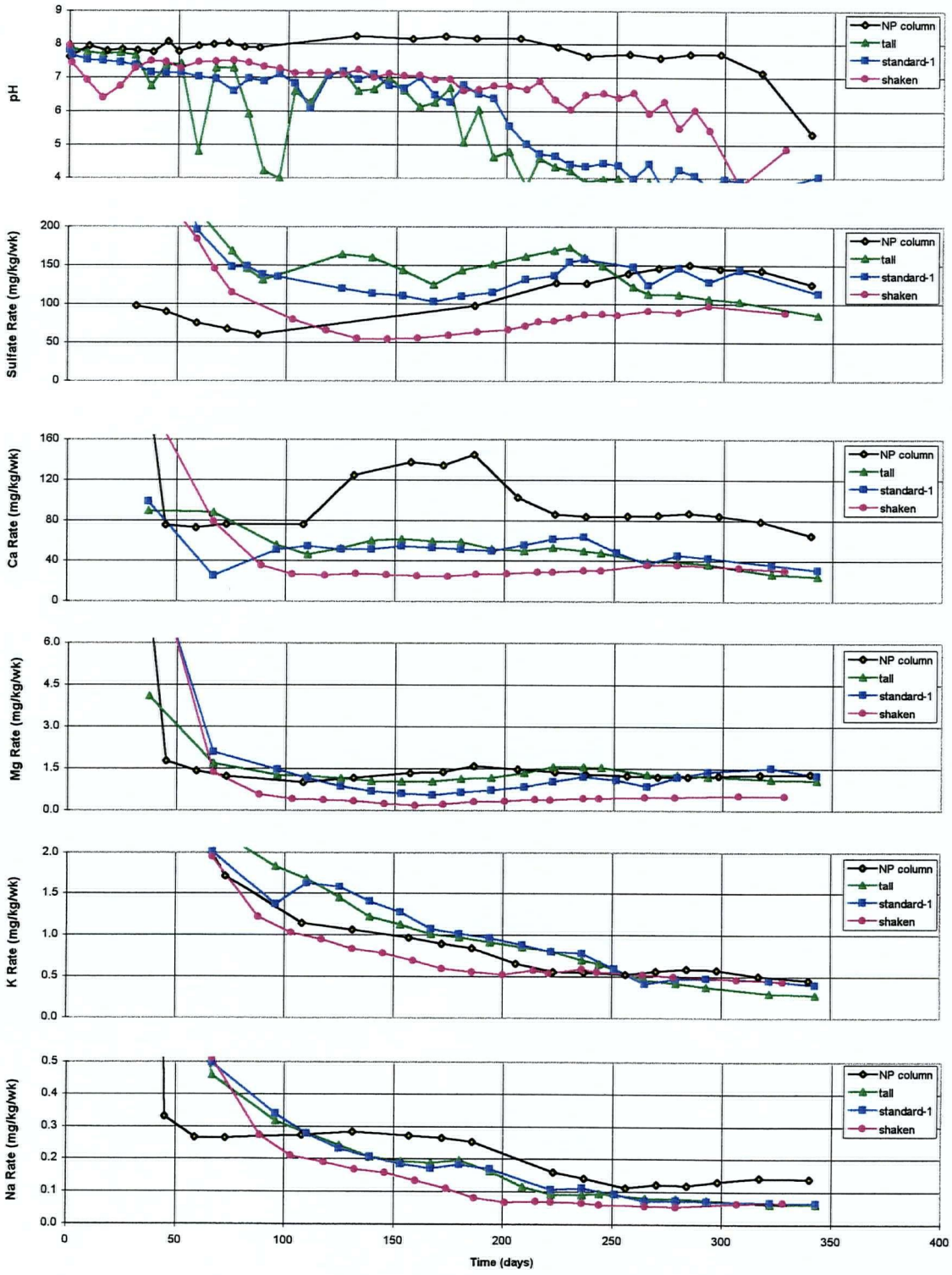
Note: Rate at any time is the average of the previous 5 cycles

Project: **RED MOUNTAIN**
Sample: **HC-2**
Rock Type: **sediment**
Mineralization: **3%pyrrhotite, 2%pyrite, 1%sphalerite**



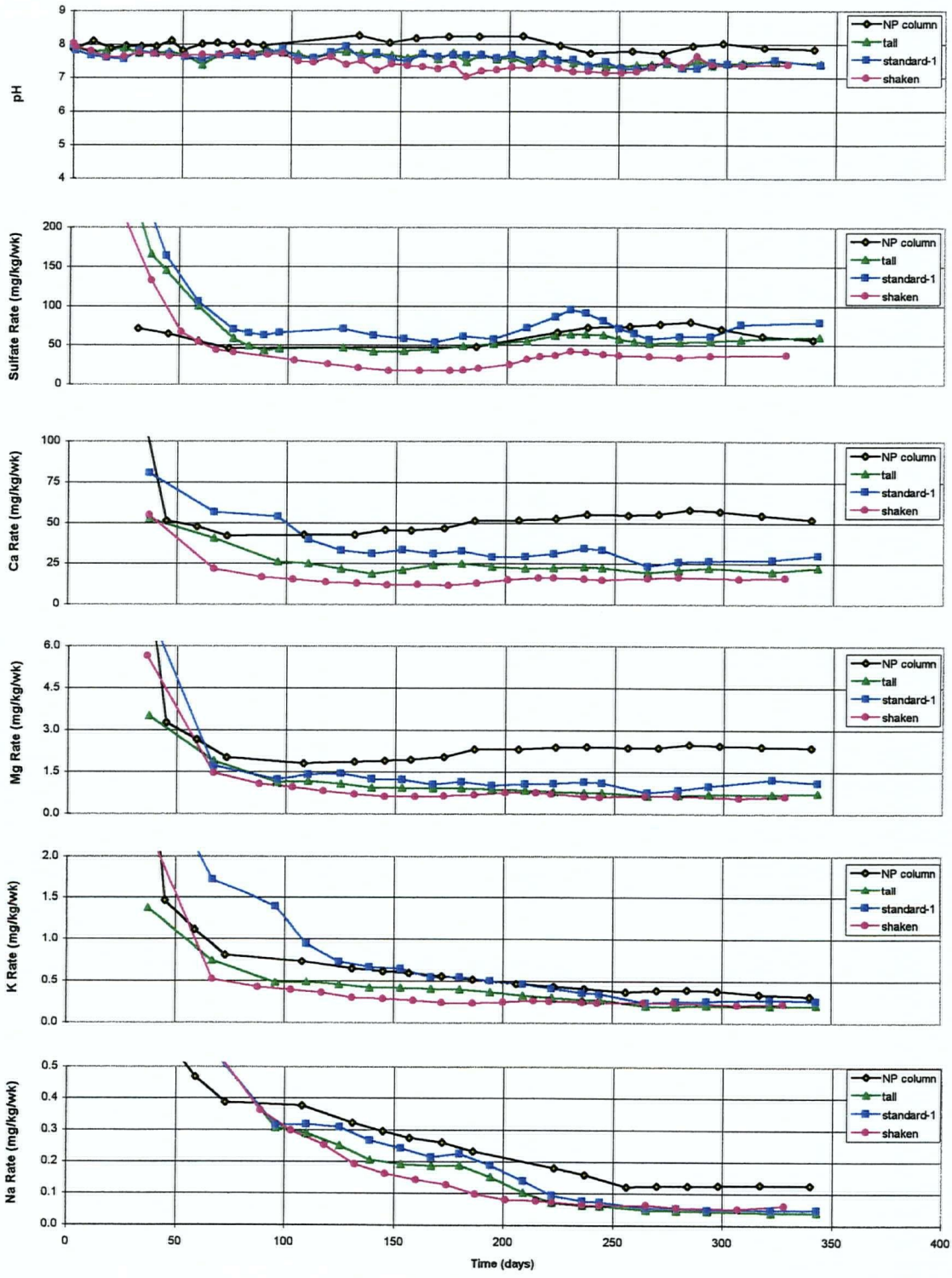
Note: Rate at any time is the average of the previous 5 cycles

Project: **RED MOUNTAIN**
Sample: **ABA-1**
Rock Type: **sediment**
Mineralization: **7%pyrrhotite**



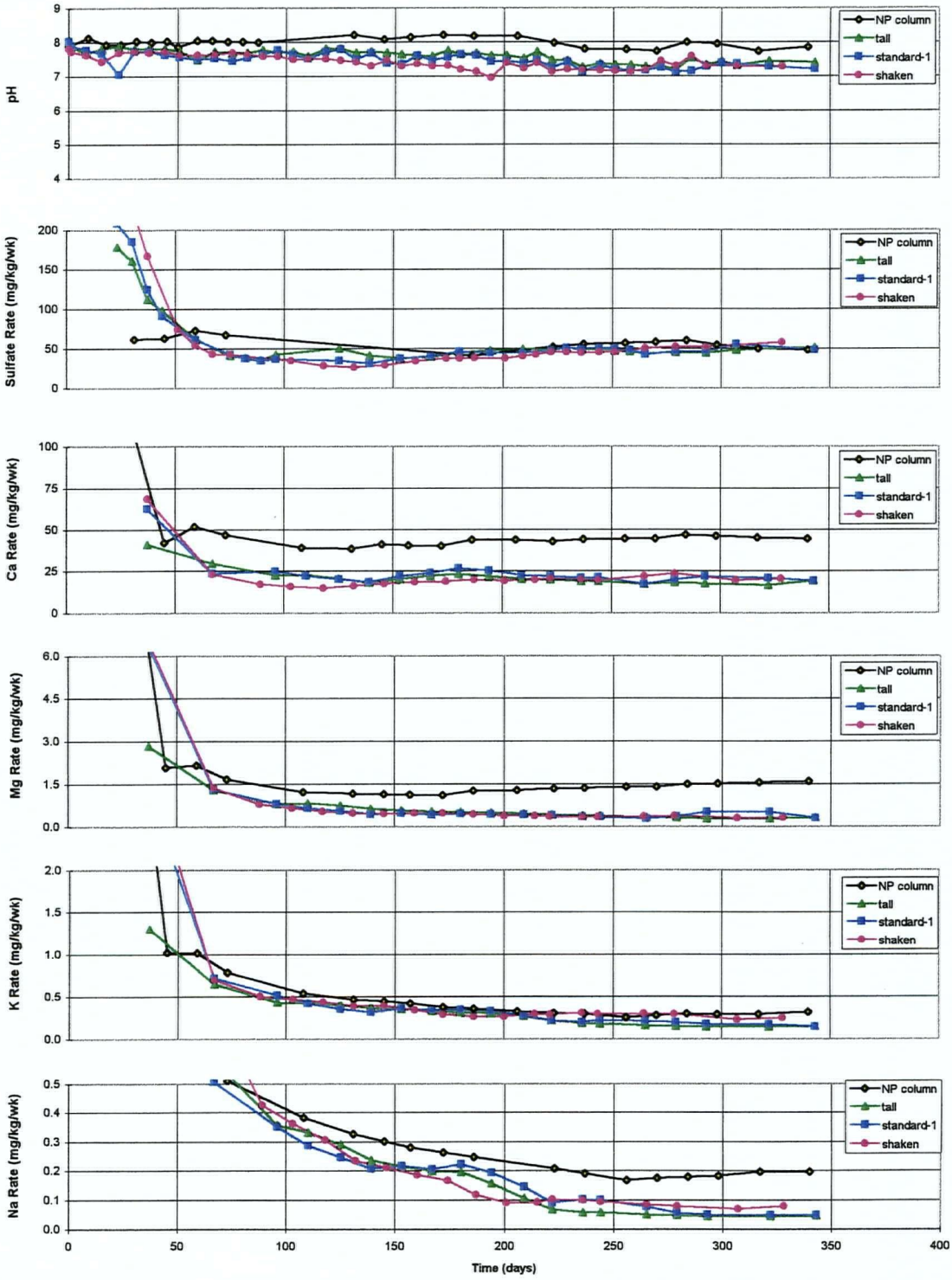
Note: Rate at any time is the average of the previous 5 cycles

Project: **RED MOUNTAIN**
Sample: **ABA-2**
Rock Type: **feldspar porphyry**
Mineralization: **7%pyrrhotite**



Note: Rate at any time is the average of the previous 5 cycles

Project: **RED MOUNTAIN**
Sample: **ABA-3**
Rock Type: **feldspar porphyry**
Mineralization: **5%pyrite**



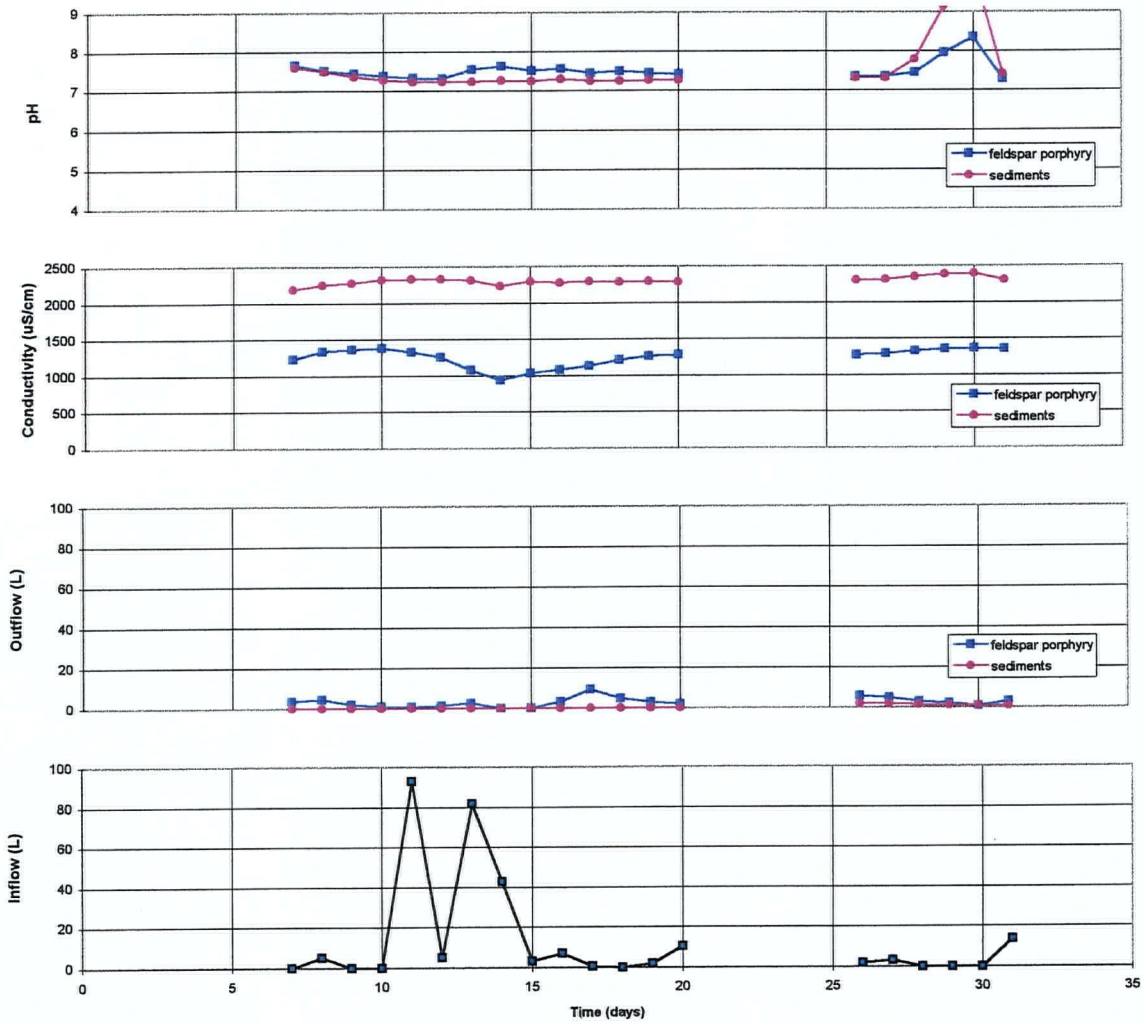
Note: Rate at any time is the average of the previous 5 cycles

APPENDIX 6

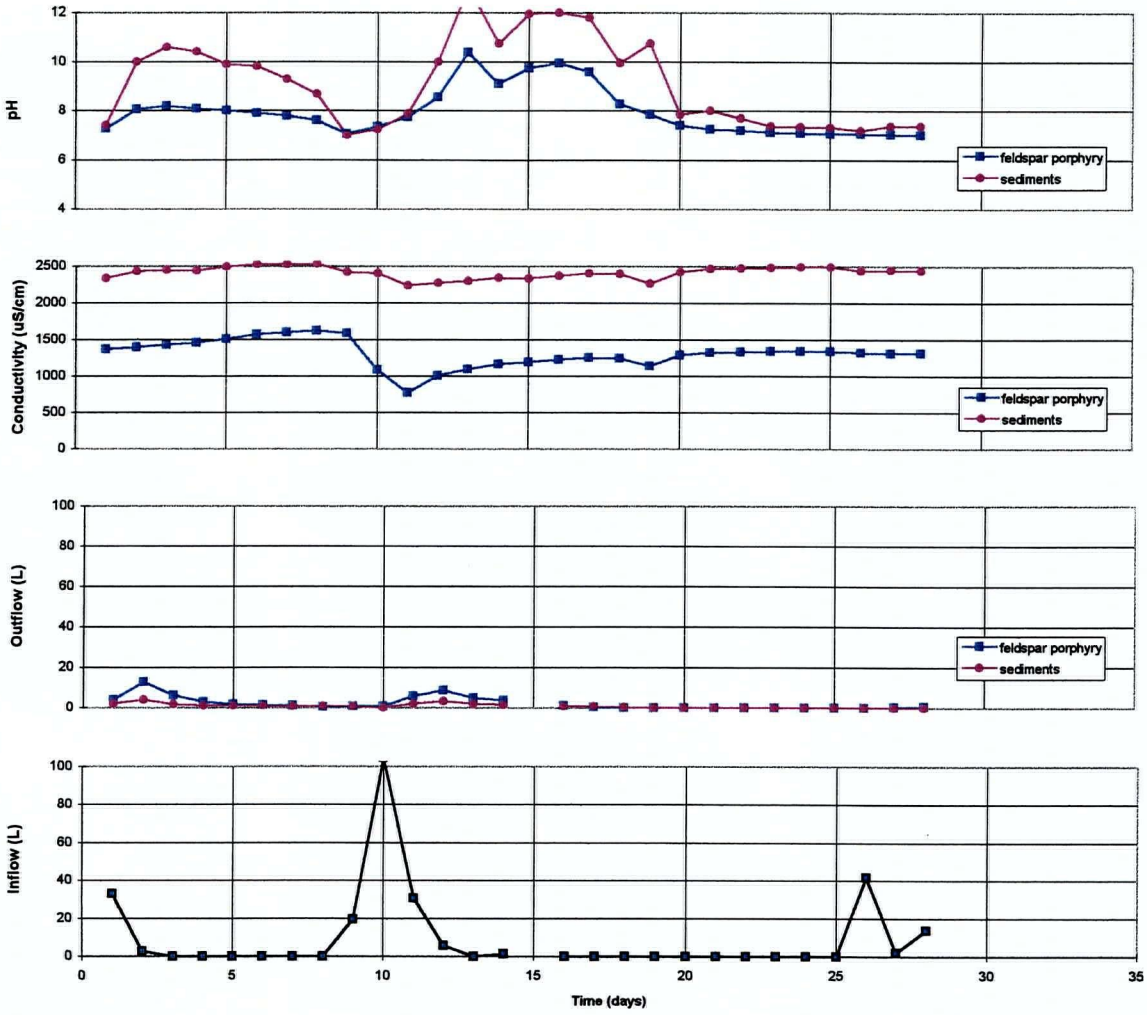
GRAPHIC COMPARISONS

20-TONNE (FIELD) CELLS

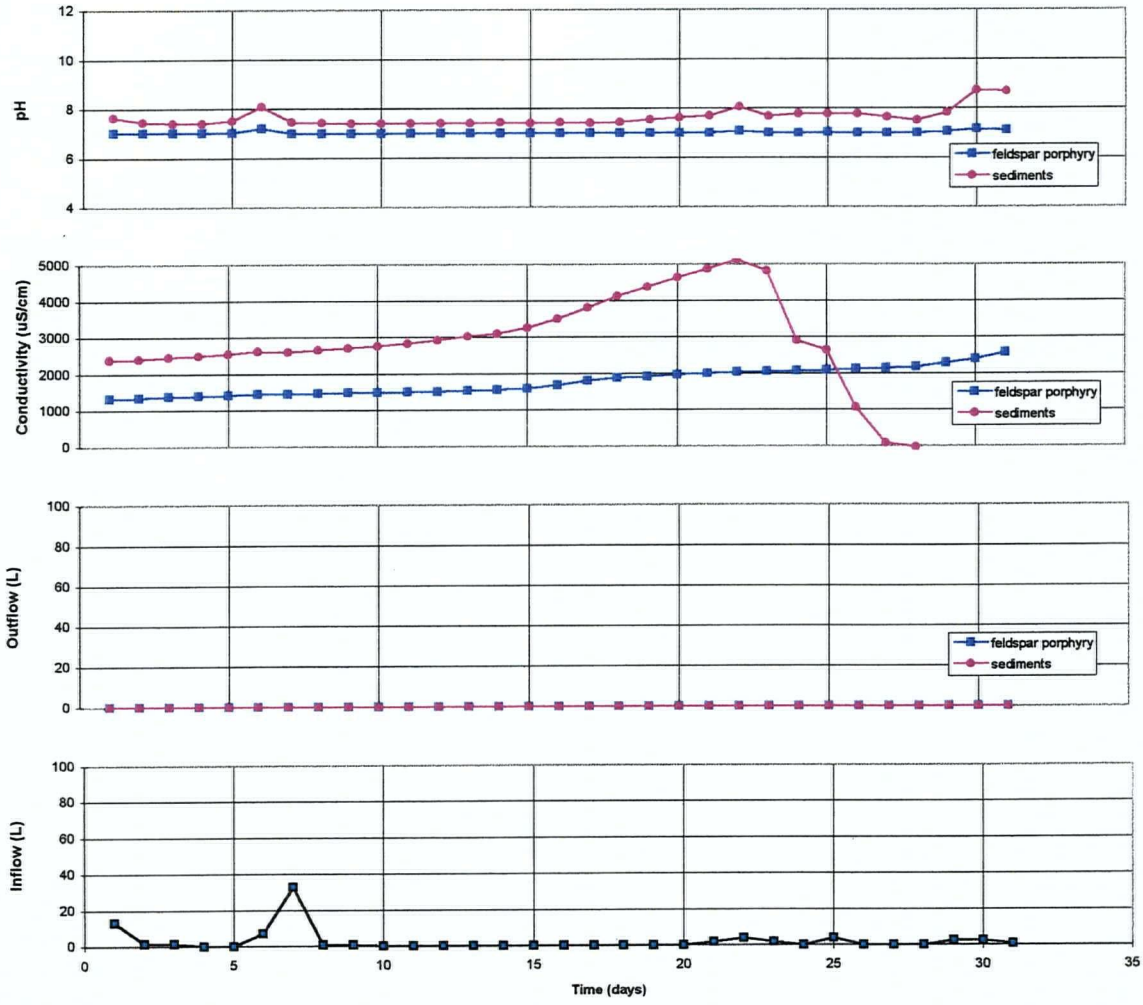
Project: **RED MOUNTAIN PROJECT**
Cell Type: **20 tonne**
Date: **August, 1995**



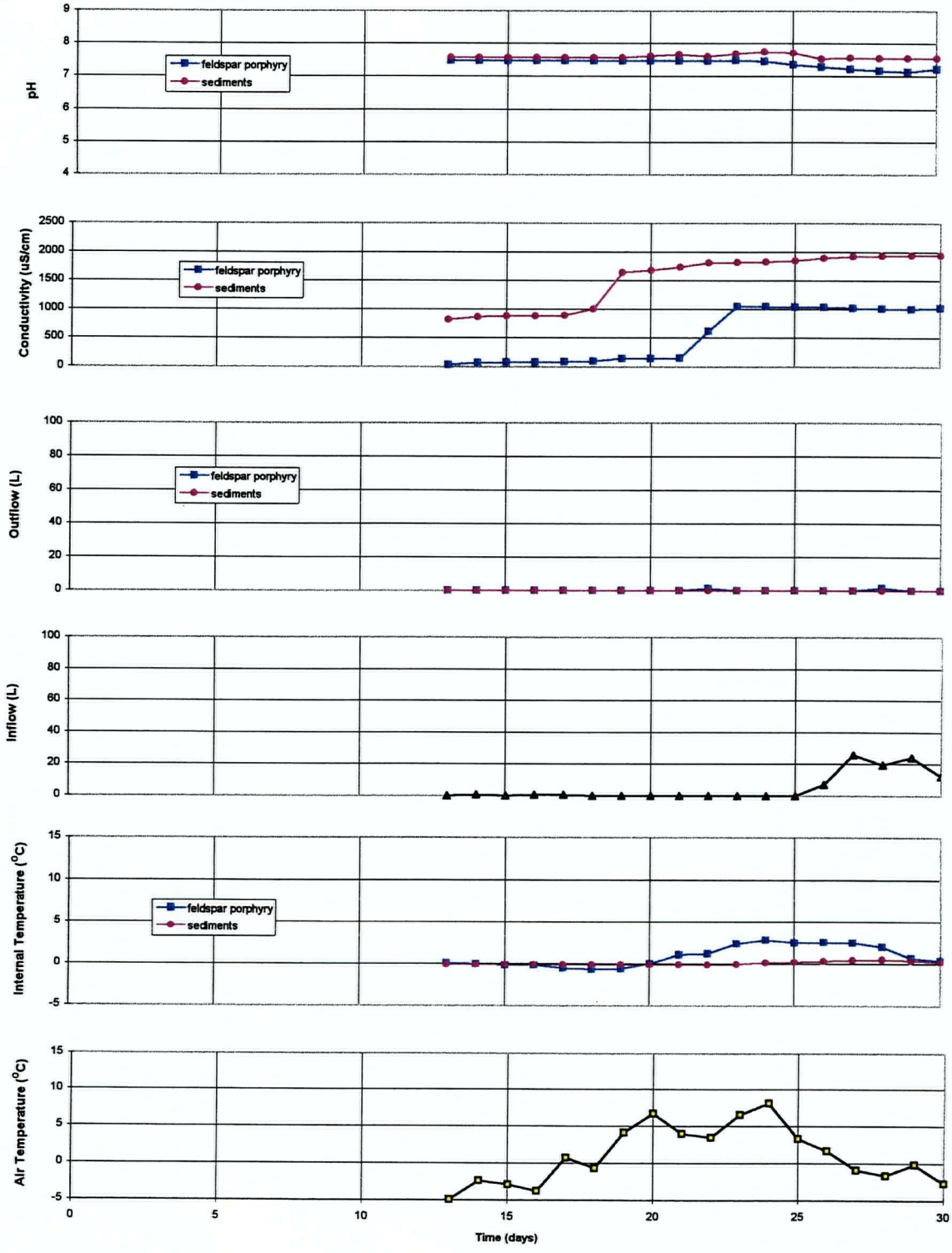
Project: **RED MOUNTAIN PROJECT**
Cell Type: **20 tonne**
Date: **September, 1995**



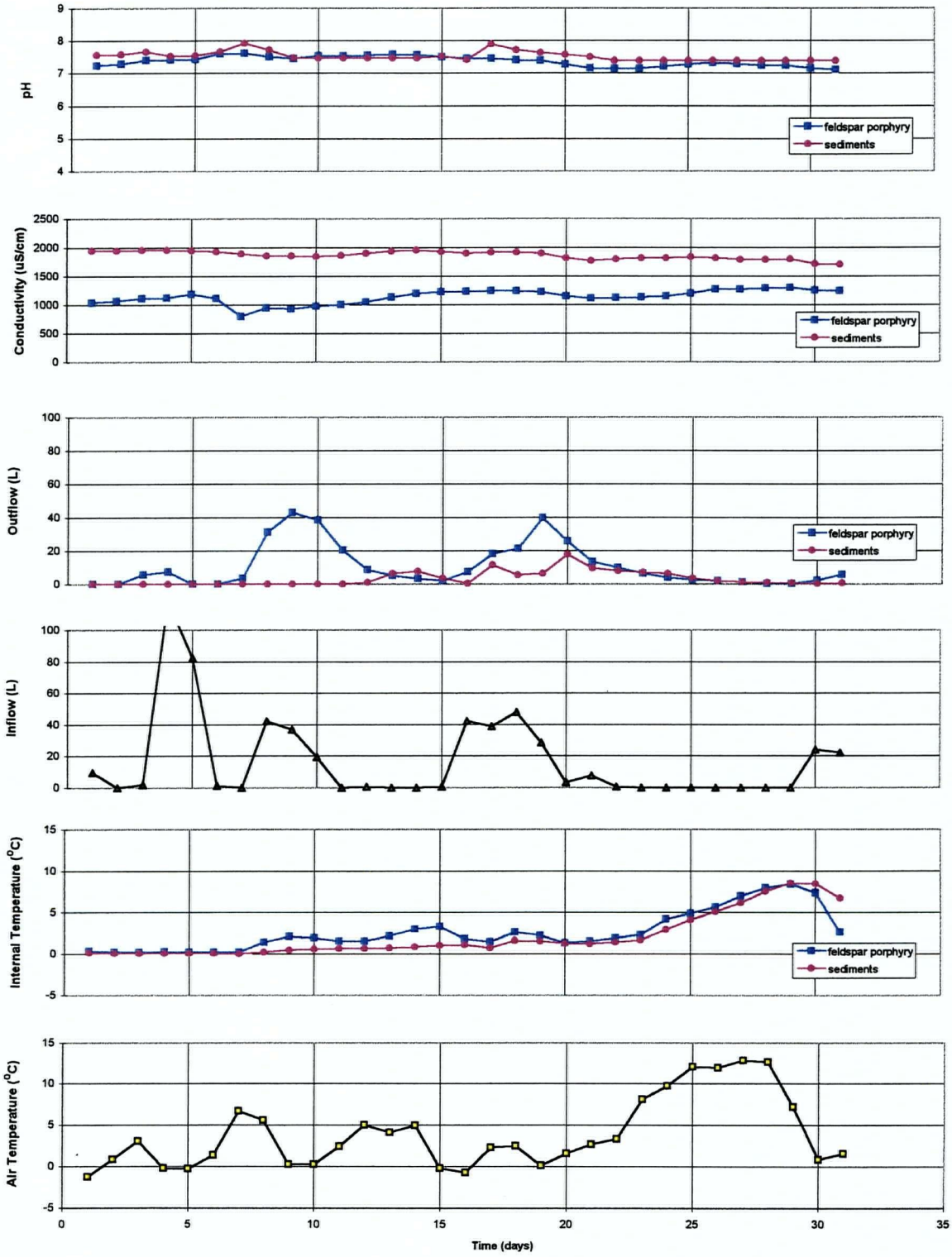
Project: **RED MOUNTAIN PROJECT**
Cell Type: **20 tonne**
Date: **October, 1995**



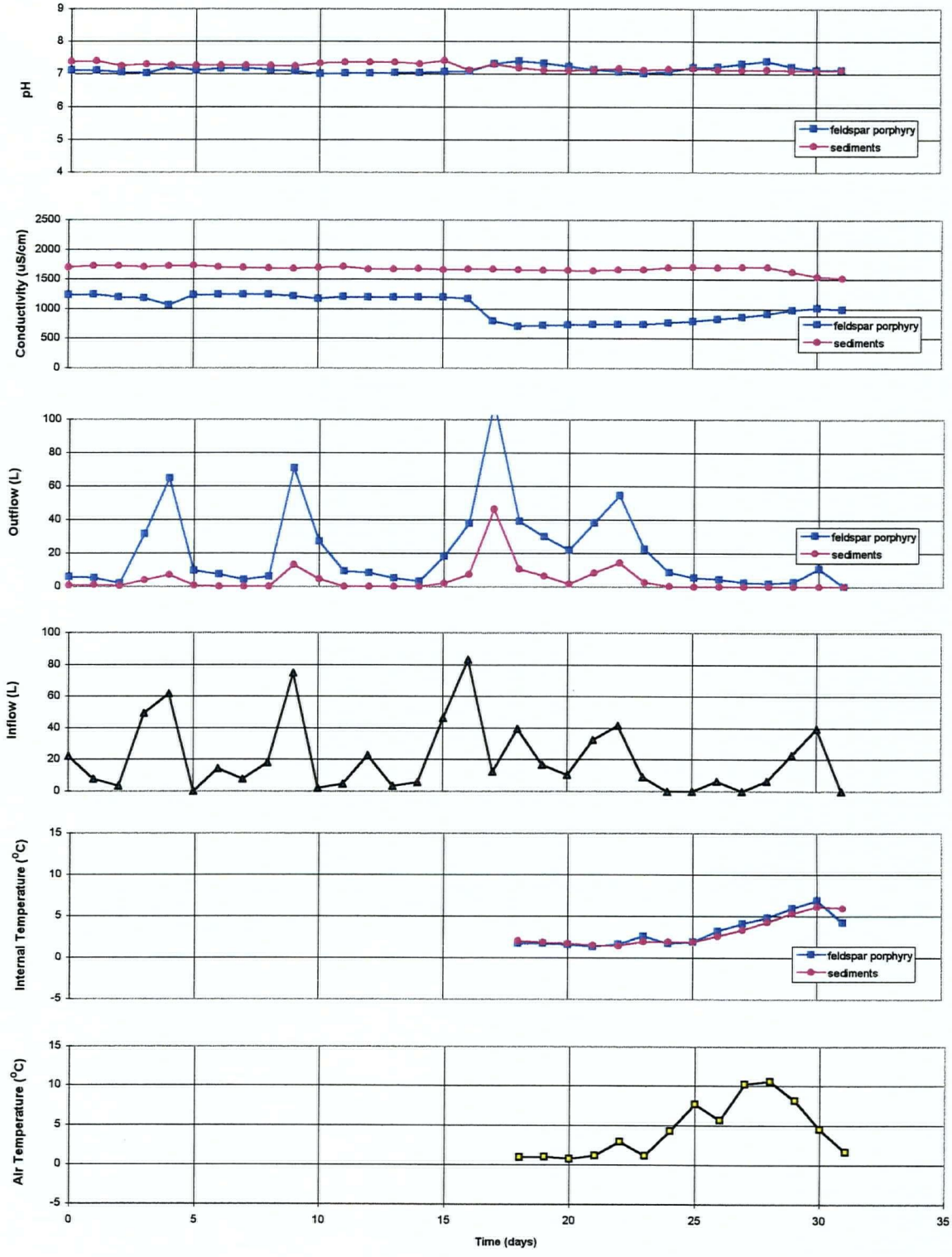
Project: **RED MOUNTAIN PROJECT**
Cell Type: **20 tonne**
Date: **June, 1996**



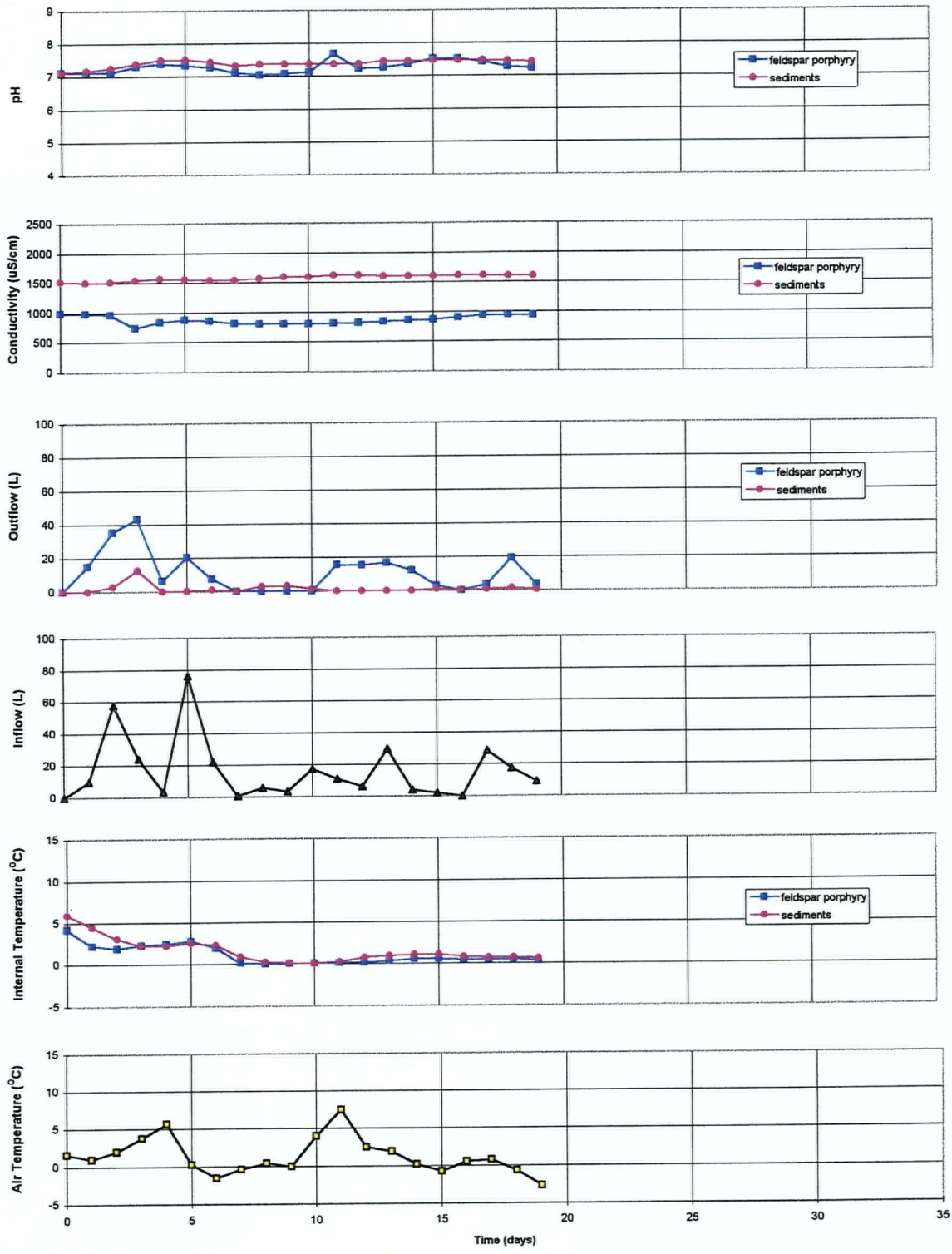
Project: **RED MOUNTAIN PROJECT**
Cell Type: **20 tonne**
Date: **July, 1996**



Project: **RED MOUNTAIN PROJECT**
Cell Type: **20 tonne**
Date: **August, 1996**



Project: **RED MOUNTAIN PROJECT**
Cell Type: **20 tonne**
Date: **September, 1996**



APPENDIX 7

TABULATED RESULTS

STANDARD CELLS

Sample: HC-1
Cell Type: standard
Test Conditions: 1 kg cell with dry/wet air cycles - 500 mL trickle leach
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
Date	Cycle	Days	volume (L)	pH	Conduct. (uS/cm)	Alkalinity (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	End, 3-day dry (%)	End, 3-day wet (%)	End of leach (%)
10-Jan-96	0	0	0.357	8.0	1275	43	410	665	120.0	75.00	93.00			
11-Jan-96	1	1	0.349	8.0	1009			144	25.0	18.90	17.70			
18-Jan-96	2	8	0.417	7.9	743									
25-Jan-96	3	15	0.441	7.8	713									
2-Feb-96	4	23	0.370	7.2	655		300							
9-Feb-96	5	30	0.462	7.7	444							3.5	4.4	10.4
16-Feb-96	6	37	0.438	7.7	606	33		56	9.0	4.00	1.40	3.8	4.8	10.1
23-Feb-96	7	44	0.452	7.4	237		107					4.4	5.9	9.8
1-Mar-96	8	51	0.465	7.4	232							6.8	7.7	10.2
9-Mar-96	9	59	0.428	7.2	228		94					4.6	5.2	9.8
17-Mar-96	10	67	0.214	7.4	483			78	5.1	2.50	0.58	6.4	7.8	11.3
25-Mar-96	11	75	0.447	7.5	251	26						6.9	6.1	10.2
1-Apr-96	12	82	0.442	7.5			98					6.1	6.7	10.2
8-Apr-96	13	89	0.436	7.5	265	30	102					5.3	6.0	10.1
15-Apr-96	14	96	0.448	7.8	336	27	126	61	6.5	2.30	0.48	6.7	7.2	10.2
22-Apr-96	15	103	0.458	7.2	236	23	126					7.6	7.2	10.2
29-Apr-96	16	110	0.450	7.2	245			32	3.5	1.40	0.31	6.2	6.0	9.9
7-May-96	17	118	0.440	7.3	262	23						4.7	4.8	9.5
14-May-96	18	125	0.429	7.7	267		83	44	4.8	1.80	0.33	2.2	3.0	9.3
21-May-96	19	132	0.456	7.1	196	21						5.7	6.8	9.8
28-May-96	20	139	0.450	7.6	260		92	48	5.1	1.63	0.27	6.6	6.8	9.9
4-Jun-96	21	146	0.453	7.3	256	26						6.1	6.8	10.2
11-Jun-96	22	153	0.440	7.1	256		103	45	4.8	1.30	0.27	4.4	4.6	9.7
18-Jun-96	23	160	0.446	7.5	265	17						4.7	5.0	9.7
25-Jun-96	24	167	0.449	7.4	309		145	69	6.1	1.56	0.36	4.6	5.8	9.8
2-Jul-96	25	174	0.448	7.5	260	17						5.6	5.9	10.0
8-Jul-96	26	180	0.436	7.7	330		139	61	7.0	1.79	0.34	4.2	4.4	9.7
15-Jul-96	27	187	0.443	7.6	282	24						4.0	4.9	9.5
22-Jul-96	28	194	0.434	7.5	321		89	35	4.0	1.10	0.18	4.2	4.6	9.7
29-Jul-96	29	201	0.435	7.5	357	26						4.1	4.9	10.0
6-Aug-96	30	209	0.469	7.6	352		139	52	6.1	0.97	0.14	7.0	7.8	10.0
12-Aug-96	31	215	0.461	7.5	287	23						6.5	7.3	10.0
19-Aug-96	32	222	0.458	7.3	276	11	126	46	5.5	0.83	0.10	6.6	6.8	10.0
26-Aug-96	33	229	0.468	7.4	291		123					7.5	7.9	10.1
2-Sep-96	34	236	0.405	7.2	197	22	90	37	3.7	1.14	0.23	6.6	1.0	9.6
10-Sep-96	35	244	0.462	7.2	329		159	56	6.8	1.06	0.12	6.8	7.1	10.0
17-Sep-96	36	251	0.451	6.9	236	12	119					5.8	5.9	10.0
24-Sep-96	37	258	0.429	6.9	202		100					3.0	3.6	9.7
1-Oct-96	38	265	0.400	7.3	274	24	132	41	5.2	0.62	0.08	4.5	4.6	9.5
8-Oct-96	39	272	0.446	7.2	247							5.2	5.4	9.7
15-Oct-96	40	279	0.396	7.2	271	16	141	61	16.0	1.08	0.21	5.5	6.0	9.8
22-Oct-96	41	286	0.425	6.6	179							7.0	7.5	9.8
29-Oct-96	42	293	0.458	7.0	229	19	120	43	9.3	0.81	0.10	6.6	6.8	10.1
5-Nov-96	43	300	0.454	7.3	247							5.8	6.3	10.0
12-Nov-96	44	307	0.458	6.8	248	16	138						7.2	
19-Nov-96	45	314	0.454									6.2	6.2	10.1
27-Nov-96	46	322	0.453	7.0	232	12		38	5.1	0.53	0.04	6.0	5.7	10.1
3-Dec-96	47	328	0.379									8.2	8.8	
10-Dec-96	48	335	0.443											
18-Dec-96	49	343	0.462	7.3	257	18	131	45	5.3	0.63	0.06			

Sample: HC-1
Cell Type: standard
Test Conditions: 1 kg cell with dry/wet air cycles - 500 mL trickle leach

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	237	43	27	33					146	0.08		771	1.73				3.89	5.05
1	1	288	52	33	39					280	0.16		932	2.09	1130.3			0.90	1.16
2	8	340	61	40	45					428	0.24		1101	2.47				0.85	1.10
3	15	388	69	46	50	70.4	12.14	8.83	7.99	572	0.33		1255	2.81		198.7	226.2	0.80	1.02
4	23	422	75	49	53	56.2	9.65	6.88	6.10	683	0.39	97.1	1363	3.06		163.4	180.4	0.73	0.93
5	30	456	80	53	55	51.0	8.71	6.03	5.18	792	0.45		1471	3.30		150.6	163.5	0.75	0.95
6	37	481	84	54	56	37.5	6.33	4.08	3.24	867	0.49		1549	3.47	77.6	114.2	120.0	0.78	0.99
7	44	508	88	56	57	32.7	5.27	3.11	2.17	915	0.52	48.4	1634	3.66		94.8	103.5	1.38	1.68
8	51	540	91	58	57	29.4	4.31	2.30	1.30	962	0.55		1725	3.87		75.8	91.4	1.60	1.88
9	59	571	94	59	57	28.9	3.71	1.82	0.80	1002	0.57	35.2	1813	4.07		62.1	87.6	1.85	2.11
10	67	587	95	59	57	24.8	2.75	1.26	0.39	1023	0.58		1860	4.17	40.5	43.7	73.4	1.96	2.17
11	75	620	97	60	58	25.7	2.40	1.11	0.31	1066	0.61		1952	4.38		36.6	74.3	1.83	2.05
12	82	651	100	61	58	26.3	2.20	1.00	0.26	1109	0.63	43.3	2040	4.57		35.7	74.8	1.70	1.94
13	89	679	102	62	58	25.8	2.09	0.91	0.21	1154	0.66	44.5	2122	4.76		35.3	73.1	1.54	1.77
14	96	707	105	63	58	25.8	2.21	0.90	0.20	1210	0.69	56.4	2202	4.94	80.4	39.3	73.6	1.16	1.37
15	103	728	108	64	59	27.4	2.51	0.98	0.21	1268	0.72	57.7	2265	5.08		47.7	78.8	0.89	1.04
16	110	742	109	65	59	24.4	2.40	0.92	0.20	1318	0.75		2308	5.17	42.5	50.4	71.1	0.69	0.81
17	118	759	111	66	59	21.0	2.19	0.82	0.17	1361	0.78		2357	5.28		48.9	61.7	0.94	1.11
18	125	778	113	66	59	19.2	2.07	0.77	0.16	1397	0.80	35.6	2413	5.41	55.7	47.2	56.5	1.27	1.50
19	132	799	115	67	59	17.9	1.95	0.73	0.14	1437	0.82		2474	5.55		44.0	52.9	1.26	1.49
20	139	821	118	68	59	18.0	1.95	0.70	0.13	1478	0.84	41.4	2538	5.69	63.5	40.8	53.1	1.25	1.47
21	146	842	120	69	59	19.3	2.08	0.71	0.13	1522	0.87		2600	5.83		39.6	56.8	1.14	1.35
22	153	861	122	69	59	20.5	2.19	0.70	0.13	1567	0.89	45.3	2658	5.96	58.2	41.3	60.2	1.05	1.23
23	160	887	124	70	60	21.8	2.27	0.68	0.13	1623	0.93		2732	6.13		45.2	63.8	1.10	1.28
24	167	918	127	71	60	23.8	2.36	0.66	0.13	1688	0.96	65.1	2821	6.32	88.8	50.3	69.2	1.14	1.31
25	174	947	130	71	60	25.3	2.49	0.66	0.14	1751	1.00		2906	6.51		54.7	73.5	1.10	1.28
26	180	974	133	72	60	27.2	2.73	0.71	0.15	1812	1.03	70.7	2985	6.69	92.3	59.7	79.2	1.05	1.25
27	187	995	136	73	60	27.5	2.80	0.72	0.15	1863	1.06		3048	6.83		60.8	80.2	1.01	1.20
28	194	1010	137	73	60	25.4	2.66	0.69	0.14	1901	1.09	38.6	3093	6.94	45.2	57.3	74.4	0.94	1.12
29	201	1029	139	74	60	22.9	2.54	0.64	0.12	1951	1.11		3149	7.06		54.1	67.7	0.92	1.09
30	209	1053	142	74	60	21.3	2.46	0.56	0.10	2016	1.15	57.0	3222	7.22	63.7	52.9	63.4	0.90	1.07
31	215	1076	145	75	60	20.5	2.38	0.49	0.08	2077	1.19		3290	7.38		53.0	61.0	0.89	1.06
32	222	1097	148	75	61	20.4	2.40	0.44	0.06	2135	1.22	57.7	3353	7.52	63.1	54.4	61.0	0.88	1.05
33	229	1116	150	75	61	21.3	2.48	0.43	0.06	2192	1.25	57.6	3410	7.65		58.2	63.5	0.81	0.96
34	236	1131	151	76	61	20.5	2.34	0.43	0.07	2229	1.27	36.4	3454	7.74	43.7	55.6	60.9	0.99	1.15
35	244	1157	154	76	61	20.8	2.40	0.44	0.07	2302	1.31	64.3	3532	7.92	68.0	57.3	61.9	0.85	1.01
36	251	1180	157	77	61	20.3	2.36	0.43	0.06	2356	1.34	53.7	3601	8.07		54.2	60.5	1.03	1.24
37	258	1200	160	77	61	20.0	2.35	0.42	0.06	2399	1.37	42.9	3661	8.21		51.3	59.8	1.10	1.33
38	265	1216	162	77	61	19.4	2.34	0.38	0.05	2452	1.40	52.8	3710	8.32	49.6	50.4	58.3	0.75	0.90
39	272	1239	166	78	61	21.0	2.96	0.36	0.05	2513	1.43		3787	8.49		55.2	64.6	0.90	1.20
40	279	1263	173	78	61	21.2	3.69	0.36	0.05	2568	1.47	55.8	3873	8.68	86.5	53.2	68.2	1.04	1.49
41	286	1285	178	78	61	21.0	4.20	0.36	0.06	2624	1.50		3951	8.86		53.6	69.9	0.96	1.34
42	293	1305	182	79	61	21.0	4.56	0.37	0.06	2679	1.53	54.9	4017	9.01	66.8	56.0	71.4	0.86	1.17
43	300	1324	186	79	61	21.5	4.89	0.38	0.06	2737	1.56		4080	9.15		57.1	74.0	0.78	1.03
44	307	1343	189	80	61	20.7	4.60	0.37	0.05	2800	1.60	63.2	4140	9.28		57.6	70.7	0.70	0.91
45	314	1360	192	80	61	19.4	3.89	0.34	0.04	2862	1.63		4196	9.41		58.8	64.6	0.69	0.87
46	322	1378	195	80	61	17.9	3.19	0.30	0.03	2924	1.67		4249	9.53	46.0	58.3	58.0	0.67	0.82
47	328	1393	197	80	61	17.6	2.82	0.27	0.03	2974	1.70		4295	9.63		59.1	55.6	0.72	0.88
48	335	1412	199	81	61	17.6	2.54	0.26	0.02	3033	1.73		4352	9.76		59.2	54.4	0.77	0.93
49	343	1433	201	81	61	17.5	2.30	0.25	0.02	3094	1.77	53.0	4414	9.90	54.4	57.0	53.3	0.82	0.98

Sample: HC-2
Cell Type: standard
Test Conditions: 1 kg cell with dry/wet air cycles - 500 mL trickle leach
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
Date	Cycle	Days	volume (L)	pH	Conduct. (uS/cm)	Alkalinity (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	End, 3-day dry (%)	End, 3-day wet (%)	End of leach (%)
10-Jan-96	0	0	0.348	7.8	1039	39	420	603	87.0	50.00	78.00			
11-Jan-96	1	1	0.353	7.7	891			161	23.0	15.80	15.30			
18-Jan-96	2	8	0.430	7.5	743									
25-Jan-96	3	15	0.433	7.3	726									
2-Feb-96	4	23	0.381	7.4	830		290							
9-Feb-96	5	30	0.438	7.5	332		230					3.4	3.6	10.8
16-Feb-96	6	37	0.437	7.0	265	11	180	50	5.0	3.00	1.10	4.4	5.5	10.8
23-Feb-96	7	44	0.479	6.9	280		142					8.3	9.3	11.0
1-Mar-96	8	51	0.487	7.2	201							10.3	11.2	11.2
9-Mar-96	9	59	0.458	6.9	273		133					9.0	10.4	11.3
17-Mar-96	10	67	0.464	6.9	282			64	3.2	2.00	0.59	7.6	8.6	11.2
25-Mar-96	11	75	0.429	6.5	204	9	97					5.0	4.5	10.4
1-Apr-96	12	82	0.438	6.6			104					4.2	5.8	10.4
8-Apr-96	13	89	0.423	4.7	204		98					3.3	4.5	10.3
15-Apr-96	14	96	0.454	7.1	369	9	177	76	4.3	2.20	0.67	7.4	7.9	10.3
22-Apr-96	15	103	0.448	6.6	217							7.3	5.9	10.3
29-Apr-96	16	110	0.423	5.9	178			29	1.6	1.20	0.37	8.0	7.5	10.5
7-May-96	17	118	0.474	6.6	306	5						8.7	9.1	10.7
14-May-96	18	125	0.455	6.7	521		249	109	3.3	1.60	0.44	9.0	10.6	15.1
21-May-96	19	132	0.464	6.6	260	5						9.9	10.9	12.9
28-May-96	20	139	0.468	7.0	221		83	40	1.9	1.17	0.29	10.5	10.9	13.0
4-Jun-96	21	146	0.469	6.6	229	4						10.8	11.3	13.1
11-Jun-96	22	153	0.468	6.4	224		99	43	2.2	1.10	0.31	11.1	11.6	13.1
18-Jun-96	23	160	0.460	6.6	222	4						9.5	10.2	13.0
25-Jun-96	24	167	0.460	6.8	233		112	57	2.4	1.15	0.40	8.5	9.2	12.8
2-Jul-96	25	174	0.457	6.7	217	3						9.0	9.4	12.9
8-Jul-96	26	180	0.480	6.9	234		106	43	2.8	1.24	0.35	10.9	11.5	12.7
15-Jul-96	27	187	0.452	6.5	238	3						8.9	9.3	12.6
22-Jul-96	28	194	0.461	6.5	251		81	25	1.9	0.86	0.19	8.3	9.3	12.6
29-Jul-96	29	201	0.474	6.3	284	1						9.7	10.5	12.7
6-Aug-96	30	209	0.459	5.6	326		155	36	3.0			6.5	9.2	12.2
12-Aug-96	31	215	0.491	5.4	304	2						9.5	12.2	12.3
19-Aug-96	32	222	0.471	4.9	314	1	171	45	4.0	0.94	0.15	10.5	10.5	12.4
26-Aug-96	33	229	0.478	4.7	331		170					10.5	11.2	12.6
2-Sep-96	34	236	0.444	4.6	302	1	164	45	3.9	0.89	0.17	10.5	7.8	12.7
10-Sep-96	35	244	0.465	4.5	311		162	42	4.2	0.94	0.17	9.5	9.8	12.5
17-Sep-96	36	251	0.445	4.4	288							7.8	7.8	12.4
24-Sep-96	37	258	0.455	4.0	316		171					8.9	9.0	12.7
1-Oct-96	38	265	0.425	4.4	266		143	30	3.2	0.60	0.11	9.3	9.3	12.5
8-Oct-96	39	272	0.423	3.5	331							5.1	5.5	12.4
15-Oct-96	40	279	0.440	4.3	332		174	47	6.4	0.96	0.17	6.9	7.3	12.2
22-Oct-96	41	286	0.458	4.0	298							8.9	10.1	12.3
29-Oct-96	42	293	0.448	3.6	296		156	34	5.7	0.80	0.12	8.0	8.1	12.3
5-Nov-96	43	300	0.462	4.0	323							9.3	9.7	12.6
12-Nov-96	44	307	0.448	4.0	305		197						8.6	
19-Nov-96	45	314	0.460									9.0	9.5	12.6
27-Nov-96	46	322	0.459	3.7	279			26	4.1	0.71	0.12	6.5	5.8	12.2
3-Dec-96	47	328	0.445									9.7	10.6	
10-Dec-96	48	335	0.441											
18-Dec-96	49	343	0.432	4.6	236		128	26	3.3	0.69	0.12			

Sample: HC-2
Cell Type: standard
Test Conditions: 1 kg cell with dry/wet air cycles - 500 mL trickle leach

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	210	30	17	27					146	0.12		650	5.46				3.45	4.26
1	1	267	38	23	33					283	0.24		826	6.94	1231.1			1.00	1.23
2	8	326	47	29	38					436	0.37		1009	8.48				0.94	1.15
3	15	377	54	33	42	77.9	10.87	7.42	6.96	575	0.48		1164	9.78		200.2	239.8	0.87	1.06
4	23	413	58	36	45	61.8	8.51	5.78	5.33	686	0.58	96.6	1273	10.70		164.2	189.6	0.78	0.95
5	30	444	62	39	46	54.7	7.40	5.00	4.49	786	0.66	100.8	1368	11.49		149.4	167.5	0.75	0.90
6	37	466	64	40	47	38.8	5.01	3.33	2.78	865	0.73	78.6	1431	12.03	63.6	113.1	117.7	0.67	0.78
7	44	492	66	41	47	32.2	3.81	2.48	1.83	933	0.78	68.1	1504	12.64		96.7	96.3	0.90	1.03
8	51	520	68	43	48	27.8	2.87	1.82	1.10	1000	0.84		1582	13.29		82.6	81.3	0.99	1.11
9	59	547	70	44	48	26.2	2.30	1.42	0.66	1061	0.89	53.3	1658	13.94		73.0	75.0	1.09	1.20
10	67	577	72	45	48	25.1	1.80	1.10	0.37	1114	0.94		1739	14.61	70.3	62.1	70.2	1.34	1.45
11	75	606	73	46	49	25.7	1.63	0.99	0.32	1156	0.97	36.4	1817	15.27		53.6	71.1	1.66	1.80
12	82	636	75	46	49	26.6	1.53	0.92	0.29	1202	1.01	45.5	1900	15.97		49.5	72.9	1.62	1.76
13	89	667	76	47	49	27.2	1.47	0.86	0.26	1243	1.04	41.4	1985	16.68		44.7	74.1	1.79	1.95
14	96	702	78	48	49	29.2	1.56	0.88	0.26	1323	1.11	80.3	2079	17.47	94.4	49.6	79.6	1.03	1.13
15	103	725	80	49	50	28.8	1.58	0.87	0.26	1411	1.18		2143	18.01		57.6	78.6	0.65	0.71
16	110	738	80	50	50	26.3	1.46	0.82	0.25	1501	1.26		2177	18.29	33.5	68.9	71.9	0.33	0.36
17	118	770	81	50	50	26.0	1.32	0.75	0.23	1610	1.35		2263	19.02		79.4	70.6	0.72	0.76
18	125	820	83	51	50	29.7	1.29	0.71	0.21	1723	1.45	113.4	2394	20.11	130.4	93.4	79.5	1.05	1.10
19	132	855	84	52	50	29.7	1.14	0.64	0.18	1800	1.51		2485	20.88		92.8	79.0	1.08	1.14
20	139	873	85	52	51	28.8	1.06	0.60	0.17	1839	1.54	38.8	2536	21.31	50.5	83.4	76.3	1.16	1.25
21	146	893	86	53	51	30.2	1.11	0.61	0.16	1882	1.58		2588	21.75		74.2	80.0	1.09	1.18
22	153	913	87	53	51	28.5	1.12	0.59	0.16	1928	1.62	46.3	2643	22.21	54.6	63.7	75.9	1.04	1.13
23	160	936	88	54	51	23.2	1.03	0.55	0.15	1977	1.66		2705	22.73		50.7	62.2	1.14	1.22
24	167	962	89	54	51	21.5	1.01	0.53	0.15	2028	1.70	51.5	2775	23.32	70.1	45.6	57.9	1.22	1.31
25	174	985	90	55	51	22.3	1.07	0.53	0.16	2078	1.74		2837	23.84		47.7	60.2	1.10	1.20
26	180	1005	92	55	52	23.2	1.18	0.56	0.17	2129	1.79	59.4	2894	24.32	66.8	50.8	63.0	0.97	1.08
27	187	1021	93	56	52	22.2	1.18	0.55	0.17	2171	1.82		2937	24.68		50.0	60.5	0.87	0.97
28	194	1032	94	56	52	19.9	1.15	0.52	0.15	2209	1.85	37.3	2969	24.95	32.5	47.7	54.5	0.74	0.83
29	201	1047	95	57	52	17.5	1.16	0.50	0.13	2264	1.90		3010	25.30		48.6	48.5	0.62	0.70
30	209	1063	96	57	52	15.7	1.16	0.46	0.11	2336	1.96	62.2	3057	25.69	41.1	51.5	44.1	0.56	0.63
31	215	1083	98	58	52	15.5	1.24	0.43	0.09	2415	2.03		3114	26.17		57.3	44.0	0.60	0.68
32	222	1104	100	58	52	16.7	1.40	0.42	0.08	2496	2.10	80.5	3175	26.68	60.7	65.0	47.6	0.63	0.72
33	229	1126	102	58	52	18.7	1.60	0.43	0.08	2577	2.16	81.2	3236	27.20		73.7	53.4	0.64	0.73
34	236	1146	103	59	52	19.8	1.72	0.43	0.08	2650	2.22	72.8	3293	27.68	57.1	77.1	56.6	0.66	0.75
35	244	1165	105	59	52	20.4	1.83	0.43	0.08	2725	2.29	65.9	3350	28.15	49.8	77.9	58.6	0.62	0.72
36	251	1182	107	60	52	19.3	1.78	0.40	0.07	2799	2.35		3400	28.57		74.6	55.6	0.55	0.64
37	258	1198	109	60	52	18.2	1.73	0.38	0.07	2877	2.42	77.8	3445	28.95		74.1	52.6	0.48	0.56
38	265	1210	110	60	52	16.5	1.63	0.35	0.06	2938	2.47	60.8	3483	29.27	37.5	70.1	47.9	0.50	0.59
39	272	1227	112	61	52	15.7	1.69	0.33	0.06	3005	2.52		3532	29.68		69.0	46.3	0.58	0.70
40	279	1247	115	61	53	16.4	1.91	0.34	0.06	3081	2.59	76.5	3595	30.21	63.3	71.2	48.9	0.65	0.79
41	286	1266	118	61	53	16.7	2.12	0.35	0.06	3157	2.65		3653	30.70		71.5	50.6	0.59	0.73
42	293	1281	120	62	53	16.7	2.31	0.35	0.06	3227	2.71	69.9	3701	31.10	48.6	69.9	51.3	0.52	0.67
43	300	1296	123	62	53	17.1	2.52	0.37	0.06	3308	2.78		3748	31.50		74.1	53.2	0.44	0.55
44	307	1309	125	62	53	16.5	2.56	0.38	0.06	3397	2.85	88.2	3791	31.86		78.3	51.9	0.37	0.46
45	314	1322	127	63	53	15.0	2.41	0.36	0.06	3481	2.92		3832	32.20		79.9	47.4	0.37	0.46
46	322	1334	129	63	53	13.3	2.17	0.33	0.05	3559	2.99		3870	32.52	32.9	78.1	42.1	0.37	0.46
47	328	1346	131	63	53	12.9	2.06	0.33	0.05	3628	3.05		3906	32.82		80.2	40.8	0.40	0.50
48	335	1357	132	64	53	12.3	1.89	0.32	0.05	3690	3.10		3941	33.12		76.4	38.4	0.44	0.54
49	343	1368	134	64	53	11.5	1.68	0.31	0.05	3746	3.14	48.4	3975	33.40	29.7	67.9	35.7	0.49	0.59

Sample: ABA-1
Cell Type: standard-1
Test Conditions: 1 kg cell with dry/wet air cycles - 500 mL trickle leach
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
			volume		Conduct.	Alkalinity	SO_4	Ca	Mg	K	Na	End, 3-day dry	End, 3-day wet	End of leach
Date	Cycle	Days	(L)	pH	(uS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(%)	(%)	(%)
10-Jan-96	0	0	0.292	7.8	2680	60	1700	2553	219.0	87.00	118.00			
11-Jan-96	1	1	0.308	7.7	2355			558	47.0	19.80	21.80			
18-Jan-96	2	8	0.459	7.5	2030									
25-Jan-96	3	15	0.427	7.5	2120									
2-Feb-96	4	23	0.389	7.4	2050		1700							
9-Feb-96	5	30	0.447	7.4	1005		670					2.6	2.9	10.2
16-Feb-96	6	37	0.447	7.2	587	11	420	16	5.0	6.80	1.20	3.7	5.0	10.0
23-Feb-96	7	44	0.474	7.1	655		357					7.7	8.7	10.4
1-Mar-96	8	51	0.456	7.1			381					6.5	7.0	10.5
9-Mar-96	9	59	0.459	7.0	624		381					8.1	9.2	10.6
17-Mar-96	10	67	0.444	7.0	584			101	4.7	2.50	1.10	3.4	5.5	10.0
25-Mar-96	11	75	0.414	6.6	452	8	318					2.2	2.1	9.4
1-Apr-96	12	82	0.436	7.0			392					3.6	4.0	9.6
8-Apr-96	13	89	0.420	6.9	457	7	278					3.2	3.8	9.8
15-Apr-96	14	96	0.448	7.1	573	7	311	147	2.5	4.20	0.56	6.9	7.1	9.8
22-Apr-96	15	103	0.439	6.8	420	5						6.2	5.0	10.0
29-Apr-96	16	110	0.412	6.1	481			100	1.9	3.60	0.57	6.6	6.9	10.7
7-May-96	17	118	0.477	7.1	551	10						7.1	8.9	11.4
14-May-96	18	125	0.466	7.2	519		241	112	1.6	3.10	0.45	7.1	8.0	10.6
21-May-96	19	132	0.471	6.9	512	9						8.6	9.1	10.8
28-May-96	20	139	0.468	7.1	550		251	132	1.1	2.79	0.37	8.8	7.9	11.1
4-Jun-96	21	146	0.463	6.8	464	5						8.0	8.6	11.0
11-Jun-96	22	153	0.456	6.7	463		214	104	1.3	2.30	0.37	7.5	7.5	10.9
18-Jun-96	23	160	0.468	7.0	476	8						8.5	8.5	10.9
25-Jun-96	24	167	0.449	6.5	395		208	111	1.1	1.88	0.37	5.8	6.7	10.7
2-Jul-96	25	174	0.457	6.3	431	4						6.2	7.2	10.6
8-Jul-96	26	180	0.463	6.8	511		283	112	1.8	2.33	0.42	7.8	7.8	10.5
15-Jul-96	27	187	0.479	6.5	516	3						9.4	9.8	10.7
22-Jul-96	28	194	0.463	6.4	490		219	88	1.5	1.73	0.25	7.6	7.8	10.9
29-Jul-96	29	201	0.475	5.6	557	3						8.5	9.5	10.9
6-Aug-96	30	209	0.456	5.0	634		366	168	2.2	1.61		5.3	6.9	10.4
12-Aug-96	31	215	0.476	4.7	662	1						9.1	9.4	10.8
19-Aug-96	32	222	0.466	4.7	412	1	270	127	2.9	1.83	0.20	7.6	8.1	10.6
26-Aug-96	33	229	0.468	4.4	736		403					9.0	9.8	10.8
2-Sep-96	34	236	0.435	4.4	595	1	363	125	2.7	1.58	0.31	4.8	4.8	10.4
10-Sep-96	35	244	0.129	4.4								8.5	12.0	10.8
17-Sep-96	36	251	0.465	4.4	583			125	3.0	1.13	0.20	8.0	8.3	10.9
24-Sep-96	37	258	0.475	4.0	646		394					9.0	9.4	11.1
1-Oct-96	38	265	0.359	4.4	343		187	55	1.3	0.74	0.10	8.6	8.8	11.0
8-Oct-96	39	272	0.472	3.6	556							8.6	9.1	10.9
15-Oct-96	40	279	0.476	4.2	534		359	131	3.9	1.30	0.20	9.2	9.5	11.0
22-Oct-96	41	286	0.409	4.1	336							9.2	9.6	10.8
29-Oct-96	42	293	0.455	3.7	489		305	91	3.9	1.12	0.16	6.8	7.5	10.8
5-Nov-96	43	300	0.466	4.0	431							7.6	8.3	10.8
12-Nov-96	44	307	0.468	3.9	442		289						8.9	
19-Nov-96	45	314	0.473									8.3	9.1	10.8
27-Nov-96	46	322	0.474	3.7	429			67	2.8	0.86	0.13	7.1	6.7	10.8
3-Dec-96	47	328	0.441									8.0	8.7	
10-Dec-96	48	335	0.455											
18-Dec-96	49	343	0.465	4.0	361		229	69	2.6	0.87	0.16			

Sample: ABA-1
Cell Type: standard-1
Test Conditions: 1 kg cell with dry/wet air cycles - 500 mL trickle leach

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	745	64	25	34					496	0.36		2129	5.86				3.60	4.11
1	1	917	78	32	41					1020	0.75		2619	7.21	3430.3			0.79	0.90
2	8	1124	96	39	49					1801	1.32		3209	8.84				0.63	0.72
3	15	1270	109	46	55	244.7	21.06	9.45	9.63	2528	1.85		3627	9.99		948.0	699.1	0.48	0.55
4	23	1360	118	50	59	187.2	16.32	7.58	7.40	3190	2.33	579.1	3889	10.71		819.7	535.6	0.33	0.38
5	30	1416	124	55	61	156.5	13.91	6.79	6.23	3489	2.55	299.6	4053	11.16		698.3	448.8	0.45	0.52
6	37	1423	126	58	62	98.3	9.21	5.07	3.99	3677	2.69	187.7	4080	11.24	27.1	516.5	284.0	0.09	0.14
7	44	1441	128	60	62	61.6	6.21	4.06	2.52	3846	2.81	169.2	4133	11.39		397.6	179.8	0.25	0.30
8	51	1468	130	62	63	38.4	4.13	3.26	1.49	4020	2.94	173.7	4209	11.60		290.1	113.2	0.37	0.42
9	59	1504	133	64	63	27.9	2.91	2.67	0.88	4195	3.07	153.0	4310	11.87		195.4	81.9	0.50	0.55
10	67	1549	135	65	64	25.1	2.09	2.01	0.50	4350	3.18		4431	12.21	105.7	162.8	71.6	0.69	0.75
11	75	1595	136	66	64	31.7	1.94	1.62	0.46	4481	3.28	115.1	4554	12.55		148.2	87.4	0.85	0.90
12	82	1650	138	68	65	38.4	1.80	1.39	0.42	4652	3.40	170.9	4696	12.94		148.5	103.6	0.76	0.80
13	89	1707	139	69	65	44.0	1.63	1.29	0.38	4769	3.49	116.8	4844	13.34		138.0	116.9	1.17	1.21
14	96	1772	140	71	65	50.7	1.47	1.37	0.34	4908	3.59	139.3	5013	13.81	169.4	135.0	133.0	1.13	1.17
15	103	1827	141	73	65	54.0	1.29	1.53	0.30	5037	3.68		5153	14.19		133.6	140.4	1.01	1.04
16	110	1868	142	74	66	54.4	1.14	1.62	0.28	5151	3.77		5259	14.49	106.3	133.9	141.0	0.87	0.90
17	118	1918	143	76	66	52.2	0.97	1.61	0.25	5274	3.86		5389	14.85		120.9	134.7	0.98	1.01
18	125	1970	144	78	66	51.3	0.86	1.58	0.23	5386	3.94	112.4	5523	15.21	133.7	120.0	132.0	1.12	1.14
19	132	2028	144	79	66	49.7	0.77	1.48	0.22	5502	4.02		5669	15.62		115.5	127.6	1.19	1.21
20	139	2090	145	80	66	51.2	0.68	1.40	0.20	5620	4.11	117.5	5826	16.05	156.7	113.3	130.9	1.26	1.28
21	146	2144	145	81	67	53.8	0.64	1.34	0.19	5727	4.19		5965	16.43		112.1	137.3	1.22	1.24
22	153	2192	146	82	67	54.7	0.61	1.27	0.18	5825	4.26	97.7	6086	16.77	121.2	110.2	139.4	1.17	1.19
23	160	2242	146	83	67	54.3	0.57	1.18	0.18	5924	4.33		6214	17.12		107.5	138.3	1.22	1.25
24	167	2292	147	84	67	52.8	0.54	1.07	0.17	6017	4.40	93.5	6341	17.47	126.9	103.0	134.4	1.28	1.30
25	174	2343	148	85	67	50.7	0.57	1.00	0.17	6130	4.48		6472	17.83		102.0	129.1	1.09	1.11
26	180	2395	148	86	67	51.6	0.65	1.01	0.18	6261	4.58	152.8	6605	18.20	155.4	109.8	131.7	0.95	0.97
27	187	2443	149	87	68	51.7	0.69	1.00	0.18	6381	4.66		6728	18.53		114.4	132.1	0.96	0.98
28	194	2484	150	88	68	49.7	0.72	0.96	0.17	6482	4.74	101.4	6833	18.82	104.8	114.9	127.3	0.96	0.99
29	201	2544	151	89	68	51.9	0.79	0.95	0.16	6621	4.84		6989	19.25		124.3	133.3	1.05	1.08
30	209	2621	152	90	68	55.6	0.84	0.88	0.14	6788	4.96	146.0	7184	19.79	171.3	131.7	142.5	1.10	1.13
31	215	2691	153	90	68	59.2	0.92	0.82	0.12	6939	5.07		7365	20.29		135.7	152.0	1.11	1.14
32	222	2750	154	91	68	61.5	1.03	0.80	0.11	7065	5.16	125.7	7519	20.71	153.5	136.9	158.1	1.13	1.17
33	229	2809	156	92	68	65.1	1.15	0.80	0.11	7254	5.30	188.6	7672	21.13		154.3	167.8	0.75	0.78
34	236	2864	157	93	68	63.8	1.21	0.78	0.11	7412	5.42	157.9	7812	21.52	140.9	158.1	164.8	0.83	0.86
35	244	2880	157	93	68	51.8	1.08	0.67	0.10	7460	5.45		7854	21.64		134.4	134.0	0.80	0.83
36	251	2938	159	93	68	48.0	1.09	0.59	0.09	7638	5.58		8006	22.05	151.2	135.9	124.6	0.78	0.81
37	258	2981	160	94	69	44.8	1.02	0.51	0.09	7825	5.72	187.0	8117	22.36		147.8	116.3	0.55	0.57
38	265	3000	160	94	69	37.2	0.86	0.41	0.07	7893	5.77	67.2	8168	22.50	51.4	124.2	96.6	0.71	0.73
39	272	3044	161	95	69	35.1	0.87	0.37	0.06	8021	5.86		8283	22.82		118.6	91.5	0.82	0.86
40	279	3107	163	95	69	45.4	1.19	0.47	0.07	8192	5.99	171.0	8447	23.27	163.8	146.5	118.5	0.88	0.92
41	286	3152	165	96	69	42.8	1.23	0.46	0.07	8328	6.09		8567	23.60		138.0	112.3	0.80	0.85
42	293	3193	167	96	69	42.6	1.38	0.47	0.07	8467	6.19	138.9	8678	23.91	111.0	128.3	112.2	0.72	0.77
43	300	3233	168	97	69	46.5	1.63	0.52	0.08	8605	6.29		8784	24.20		142.6	123.2	0.69	0.74
44	307	3270	170	97	69	45.2	1.70	0.52	0.08	8741	6.39	135.2	8883	24.47		143.9	120.0	0.66	0.70
45	314	3305	171	98	69	39.6	1.62	0.48	0.07	8872	6.49		8976	24.73		135.9	105.7	0.63	0.68
46	322	3336	173	98	69	35.8	1.52	0.45	0.07	8997	6.58		9060	24.96	74.3	130.1	96.0	0.61	0.65
47	328	3366	174	98	69	34.6	1.45	0.44	0.07	9109	6.66		9140	25.18		128.4	92.4	0.64	0.68
48	335	3397	175	99	69	32.8	1.35	0.42	0.06	9219	6.74		9223	25.41		122.6	87.8	0.68	0.72
49	343	3429	176	99	69	31.0	1.25	0.39	0.06	9325	6.82	93.3	9308	25.64	74.7	113.7	82.7	0.72	0.77

Sample: ABA-1
Cell Type: standard-2
Test Conditions: 1 kg cell with dry/wet air cycles - 500 mL trickle leach
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
			volume		Conduct.	Alkalinity	SO_4	Ca	Mg	K	Na	End, 3-day dry	End, 3-day wet	End of leach
Date	Cycle	Days	(L)	pH	(uS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(%)	(%)	(%)
25-Jan-96	0	0	0.558	8.0	2410	68	2100	2611	225.0	91.00	123.00			
26-Jan-96	1	1	0.313	7.9	2345			463	43.0	18.10	22.00			
2-Feb-96	2	8	0.462	7.7	2280									
9-Feb-96	3	15	0.479	7.4	2040		1500					8.9	9.1	11.7
16-Feb-96	4	22	0.415	6.8	1227		1200					0.9	2.5	10.4
23-Feb-96	5	29	0.476	7.3	958							7.3	8.6	10.8
1-Mar-96	6	36	0.477	7.2	782		537	281	4.4	7.70	1.40	9.6	10.0	11.3
9-Mar-96	7	44	0.460	7.3	729							8.5	9.5	11.0
17-Mar-96	8	52	0.445	7.1	672		439					4.2	5.7	10.2
25-Mar-96	9	60	0.427	7.1	488	10	283					4.4	3.6	9.5
1-Apr-96	10	67	0.420	6.6			317	116	2.0	4.60	0.61	0.9	2.3	9.5
8-Apr-96	11	74	0.435	7.0	591	9	372					4.7	5.5	9.7
15-Apr-96	12	81	0.410	4.5	585							1.1	3.1	9.4
22-Apr-96	13	88	0.413	4.4	437			83	2.0	4.10	0.70	0.9	1.2	9.1
29-Apr-96	14	95	0.416	5.4	584	2						3.7	4.2	9.4
7-May-96	15	103	0.460	6.6	773		367	163	2.8	4.60	0.68	6.4	7.1	9.7
14-May-96	16	110	0.462	6.8	564	9						6.7	7.0	9.8
21-May-96	17	117	0.450	6.6	528		240	104	1.5	3.10	0.39	5.6	5.7	9.9
28-May-96	18	124	0.438	6.3	511	2						4.3	5.0	9.7
4-Jun-96	19	131	0.440	6.5	478		245	119	1.5	3.10	0.37	4.2	4.6	9.5
11-Jun-96	20	138	0.431	6.1	527	2						3.2	4.1	9.7
18-Jun-96	21	145	0.440	6.3	540		281	108	2.2	2.70	0.41	6.9	6.9	9.6
25-Jun-96	22	152	0.453	5.8	429	2						5.4	6.0	9.7
2-Jul-96	23	159	0.452	6.5	655			139	2.7	2.90	0.49	6.1	6.6	10.2
8-Jul-96	24	165	0.449	5.8	497	1						5.7	5.7	9.8
15-Jul-96	25	172	0.457	5.3	516		308	108	2.0	1.86	0.27	5.5	6.3	9.8
22-Jul-96	26	179	0.462	5.6	560	1						6.2	6.7	9.9
29-Jul-96	27	186	0.447	5.2	625		308	116	2.3	2.58	0.22	5.6	5.9	10.0
6-Aug-96	28	194	0.467	4.6	585							6.6	7.3	10.0
12-Aug-96	29	200	0.481	5.0	626		341	127	2.4	1.57	0.24	9.0	9.0	10.2
19-Aug-96	30	207	0.458	4.6	570		362					6.1	6.8	9.9
26-Aug-96	31	214	0.473	4.4	647		369	124	2.9	1.63	0.19	7.9	8.5	10.2
2-Sep-96	32	221	0.441	4.1	582		360	116	2.7	1.66	0.18	4.9	4.9	9.9
10-Sep-96	33	229	0.478	4.3	656		393					8.3	8.8	10.0
17-Sep-96	34	236	0.471	4.2	580			124	2.9	1.27	0.18	8.1	8.3	10.2
24-Sep-96	35	243	0.479	4.0	631		386	123	2.8	0.99	0.16	8.5	9.0	10.3
1-Oct-96	36	250	0.469	4.1	561		354					7.9	8.3	10.2
8-Oct-96	37	257	0.455	3.5	667							6.2	6.6	10.3
15-Oct-96	38	264	0.469	3.9	633		419	175	4.3	1.58	0.28	7.9	8.3	10.4
22-Oct-96	39	271	0.441	3.9	437							7.5	7.9	10.0
29-Oct-96	40	278	0.455	3.5	553		330	88	3.7	1.14	0.16	6.4	6.7	10.1
5-Nov-96	41	285	0.465	3.7	542							7.1	7.4	10.1
12-Nov-96	42	292	0.469	3.7	499		334						8.3	
19-Nov-96	43	299	0.471									8.1	8.2	10.3
27-Nov-96	44	307	0.469	3.5	486			76	3.0	0.94	0.19	7.9	7.7	10.3
3-Dec-96	45	313	0.459									8.9	9.7	
10-Dec-96	46	320	0.462											
18-Dec-96	47	328	0.465	3.8	339		194	55	2.6	0.68	0.14			

Sample: ABA-1
Cell Type: standard-2
Test Conditions: 1 kg cell with dry/wet air cycles - 500 mL trickle leach

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	1456	125	51	69					1171	0.86		4159	11.46				2.98	3.41
1	1	1600	139	56	75					1765	1.29		4577	12.61	2924.8			0.58	0.67
2	8	1798	155	64	84					2551	1.86		5138	14.15				0.60	0.68
3	15	1984	168	70	90	246.8	20.04	9.21	10.14	3269	2.39	717.9	5660	15.59		979.1	700.1	0.62	0.70
4	22	2131	177	75	94	215.0	16.29	7.85	8.19	3767	2.75	498.5	6061	16.70		826.2	605.2	0.71	0.77
5	29	2282	182	80	97	199.6	13.75	7.08	6.85	4181	3.06		6463	17.80		726.5	556.0	0.88	0.93
6	36	2416	184	84	98	163.2	9.12	5.47	4.43	4437	3.24	256.1	6807	18.75	344.1	534.3	446.0	1.26	1.29
7	44	2527	186	87	98	141.7	6.04	4.49	2.81	4661	3.41		7090	19.53		410.3	379.6	1.18	1.21
8	52	2615	188	90	99	119.3	3.65	3.63	1.57	4856	3.55	171.1	7317	20.16		300.4	313.6	1.09	1.11
9	60	2682	189	92	99	101.5	2.24	3.05	0.85	4977	3.64	105.7	7490	20.63		222.9	263.1	1.33	1.37
10	67	2731	190	94	99	82.6	1.33	2.55	0.42	5110	3.74	133.2	7615	20.98	125.4	171.3	212.2	0.88	0.90
11	74	2777	190	96	99	66.3	1.10	2.22	0.35	5272	3.85	161.8	7733	21.30		153.9	170.6	0.68	0.70
12	81	2815	191	98	100	54.6	0.96	2.01	0.30	5424	3.97		7833	21.58		144.4	140.5	0.61	0.63
13	88	2849	192	99	100	45.6	0.87	1.87	0.28	5577	4.08		7922	21.82	89.2	140.1	117.6	0.54	0.56
14	95	2901	193	101	100	43.7	0.87	1.82	0.28	5730	4.19		8054	22.19		150.6	112.9	0.80	0.83
15	103	2976	194	103	101	47.6	0.93	1.81	0.28	5899	4.31	147.8	8247	22.72	169.0	153.4	122.9	1.07	1.10
16	110	3037	195	105	101	50.7	0.96	1.78	0.27	6039	4.41		8406	23.16		149.2	130.8	1.06	1.08
17	117	3084	196	106	101	52.3	0.93	1.71	0.26	6147	4.49	108.0	8526	23.49	119.9	140.6	134.7	1.04	1.06
18	124	3133	197	108	101	55.1	0.90	1.64	0.23	6253	4.57		8650	23.83		131.5	141.6	1.10	1.13
19	131	3185	197	109	101	55.4	0.83	1.56	0.21	6361	4.65	107.9	8784	24.20	133.8	122.7	141.9	1.17	1.19
20	138	3234	198	110	102	51.7	0.76	1.43	0.18	6475	4.73		8910	24.55		115.1	132.5	1.04	1.06
21	145	3282	199	112	102	48.9	0.75	1.31	0.17	6598	4.82	123.7	9033	24.88	123.0	111.8	125.4	0.92	0.95
22	152	3338	200	113	102	50.7	0.84	1.29	0.18	6729	4.92		9177	25.28		116.2	130.3	1.03	1.06
23	159	3400	201	114	102	53.5	0.95	1.28	0.19	6862	5.02		9340	25.73	162.3	121.7	137.8	1.13	1.17
24	165	3456	203	115	102	55.7	1.06	1.25	0.19	6997	5.11		9483	26.12		130.8	143.8	0.98	1.01
25	172	3505	203	116	102	55.8	1.08	1.17	0.19	7138	5.22	140.8	9610	26.47	127.3	136.5	144.1	0.84	0.87
26	179	3557	204	117	103	56.7	1.09	1.14	0.17	7280	5.32		9743	26.84		140.3	146.3	0.87	0.90
27	186	3609	205	118	103	55.8	1.07	1.11	0.15	7418	5.42	137.7	9877	27.21	134.0	141.9	144.2	0.90	0.93
28	194	3666	207	119	103	53.0	1.02	1.01	0.12	7569	5.53		10024	27.61		141.5	136.9	0.90	0.93
29	200	3727	208	120	103	54.2	1.04	0.95	0.11	7733	5.65	191.3	10182	28.05	183.9	147.2	139.8	0.89	0.92
30	207	3784	209	121	103	55.8	1.10	0.93	0.11	7899	5.77	165.7	10330	28.46		152.2	144.1	0.83	0.86
31	214	3843	210	121	103	57.1	1.17	0.88	0.10	8073	5.90	174.4	10483	28.88	152.3	158.6	147.8	0.81	0.84
32	221	3894	212	122	103	57.0	1.21	0.79	0.10	8232	6.02	158.9	10616	29.24	133.0	162.9	147.6	0.77	0.80
33	229	3951	213	123	103	57.1	1.25	0.74	0.09	8420	6.15	164.2	10765	29.65		170.1	148.1	0.73	0.76
34	236	4010	214	123	103	55.0	1.26	0.69	0.09	8603	6.29		10916	30.07	151.9	169.2	142.9	0.76	0.79
35	243	4068	216	124	103	55.3	1.28	0.64	0.08	8788	6.42	184.9	11069	30.49	153.0	172.9	143.7	0.76	0.79
36	250	4134	217	124	104	56.7	1.32	0.60	0.08	8954	6.55	166.0	11240	30.97		171.3	147.3	0.95	0.99
37	257	4206	219	125	104	60.7	1.42	0.58	0.09	9130	6.67		11427	31.48		174.6	157.8	0.98	1.02
38	264	4288	221	126	104	67.4	1.60	0.60	0.10	9326	6.82	196.6	11641	32.07	213.7	181.3	175.2	1.00	1.04
39	271	4346	223	126	104	67.3	1.68	0.60	0.10	9491	6.94		11793	32.49		177.6	175.3	0.84	0.88
40	278	4386	224	127	104	63.5	1.75	0.61	0.10	9642	7.05	150.3	11900	32.78	107.2	170.7	166.2	0.64	0.68
41	285	4426	226	127	104	58.3	1.77	0.60	0.10	9796	7.16		12006	33.07		168.4	153.1	0.61	0.66
42	292	4464	228	128	104	51.6	1.73	0.57	0.09	9953	7.28	156.6	12108	33.36		164.5	136.3	0.59	0.63
43	299	4501	229	128	104	42.6	1.63	0.52	0.08	10097	7.38		12208	33.63		154.0	113.4	0.62	0.66
44	307	4537	230	129	104	37.1	1.52	0.47	0.08	10227	7.48		12303	33.89	83.1	143.0	99.1	0.66	0.70
45	313	4568	232	129	104	36.5	1.48	0.46	0.08	10342	7.56		12387	34.12		140.0	97.4	0.66	0.71
46	320	4597	233	130	104	34.3	1.41	0.43	0.08	10444	7.63		12464	34.34		129.6	91.7	0.67	0.72
47	328	4623	234	130	104	30.9	1.30	0.38	0.08	10534	7.70	78.9	12533	34.53	60.3	113.1	82.6	0.68	0.73

Sample: ABA-2
Cell Type: standard-1
Test Conditions: 1 kg cell with dry/wet air cycles - 500 mL trickle leach
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
			volume		Conduct.	Alkalinity	SO_4	Ca	Mg	K	Na	End, 3-day dry	End, 3-day wet	End of leach
Date	Cycle	Days	(L)	pH	(uS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(%)	(%)	(%)
10-Jan-96	0	0	0.215	8.0	2130	60	1100	1669	199.0	69.00	120.00			
11-Jan-96	1	1	0.299	7.8	1836			335	34.0	14.10	18.50			
18-Jan-96	2	8	0.460	7.7	1541									
25-Jan-96	3	15	0.429	7.6	1371									
2-Feb-96	4	23	0.377	7.6			480							
9-Feb-96	5	30	0.449	7.8	601		390					4.5	4.7	10.0
16-Feb-96	6	37	0.423	7.7		35	290	98	6.0	3.40	1.90	1.2	2.4	9.2
23-Feb-96	7	44	0.452	7.7	393		201					4.5	5.5	9.4
1-Mar-96	8	51	0.456	7.6	335							5.7	6.3	9.7
9-Mar-96	9	59	0.434	7.5	387		162					3.9	5.6	9.5
17-Mar-96	10	67	0.460	7.7	400			169	2.2	4.80	0.75	6.2	6.6	9.5
25-Mar-96	11	75	0.451	7.7	313	36	151					6.4	5.5	9.3
1-Apr-96	12	82	0.427	7.6			148					2.7	3.4	9.1
8-Apr-96	13	89	0.436	7.7	327	35	153					4.3	4.9	9.2
15-Apr-96	14	96	0.453	7.9	391	32	179	86	3.6	1.80	0.74	6.1	6.9	9.2
22-Apr-96	15	103	0.439	7.6	284	28						5.0	4.0	9.2
29-Apr-96	16	110	0.426	7.6	327			62	3.0	1.50	0.69	6.0	5.9	9.3
7-May-96	17	118	0.470	7.8	330	34						7.1	7.8	9.4
14-May-96	18	125	0.471	7.9	412		144	81	3.3	1.70	0.68	7.8	8.4	9.9
21-May-96	19	132	0.452	7.6	316	28						5.0	6.4	9.5
28-May-96	20	139	0.455	7.8	314		122	64	2.0	1.24	0.42	6.4	6.6	9.7
4-Jun-96	21	146	0.459	7.6	335	30						6.4	6.6	9.8
11-Jun-96	22	153	0.467	7.5	338		117	75	2.9	1.30	0.51	7.1	7.1	9.8
18-Jun-96	23	160	0.461	7.7	332	28						6.4	6.8	9.8
25-Jun-96	24	167	0.463	7.6	364		112	61	1.7	0.99	0.45	6.5	7.0	9.9
2-Jul-96	25	174	0.448	7.7	354	28						4.6	6.0	9.5
8-Jul-96	26	180	0.450	7.7	370		167	76	2.9	1.23	0.48	4.8	5.2	9.4
15-Jul-96	27	187	0.461	7.7	388	32						4.5	5.9	9.3
22-Jul-96	28	194	0.456	7.6			79	44	1.6	0.94	0.25	5.1	5.8	9.7
29-Jul-96	29	201	0.471	7.7	448	35						5.9	7.5	9.5
6-Aug-96	30	209	0.460	7.5	629		255	78	2.7	0.86	0.20	5.5	6.1	9.5
12-Aug-96	31	215	0.492	7.7	392	39						9.1	10.2	10.0
19-Aug-96	32	222	0.455	7.5	381	27	195	73	2.6	0.83	0.15	5.4	6.1	9.5
26-Aug-96	33	229	0.472	7.6	383		174					7.1	7.9	9.8
2-Sep-96	34	236	0.233	7.4	484	28	251	106	3.1	0.87	0.20	6.5	6.5	9.6
10-Sep-96	35	244	0.440	7.5	348		155	69	2.3	0.76	0.17	3.7	4.4	9.3
17-Sep-96	36	251	0.443	7.3	321	23	159					4.0	4.3	9.2
24-Sep-96	37	258	0.456	7.3	338		129					5.4	5.8	9.3
1-Oct-96	38	265	0.369	7.3	244	25	113	42	1.4	0.43	0.09	1.6	3.1	8.5
8-Oct-96	39	272	0.470	7.5	367							6.7	7.0	9.2
15-Oct-96	40	279	0.415	7.3	336	18	167	86	2.7	0.72	0.14	0.3	0.6	8.1
22-Oct-96	41	286	0.403	7.3	249							4.9	5.4	8.6
29-Oct-96	42	293	0.460	7.5	314	31	144	54	2.8	0.65	0.10	5.7	6.0	8.9
5-Nov-96	43	300	0.456	7.4	322							5.2	5.5	9.1
12-Nov-96	44	307	0.475	7.4	373	25	214						8.2	
19-Nov-96	45	314	0.465									6.1	6.6	9.4
27-Nov-96	46	322	0.464	7.5	346	30		68	2.6	0.59	0.11	4.4	3.9	8.9
3-Dec-96	47	328	0.448									7.5	8.5	
10-Dec-96	48	335	0.449											
18-Dec-96	49	343	0.454	7.4	328	23	157	69	2.3	0.57	0.10			

Sample: ABA-2
Cell Type: standard-1
Test Conditions: 1 kg cell with dry/wet air cycles - 500 mL trickle leach

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	359	43	15	26					237	0.16		1074	3.25				3.64	4.36
1	1	459	53	19	31					519	0.36		1366	4.13	2044.4			0.85	0.99
2	8	591	66	25	38					882	0.62		1751	5.29				0.87	1.02
3	15	694	76	29	43	156.5	15.40	6.50	8.21	1154	0.81		2049	6.19		428.4	455.1	0.91	1.05
4	23	767	82	32	47	124.2	12.01	5.12	6.33	1335	0.93	158.1	2258	6.82		334.4	360.2	0.96	1.11
5	30	832	87	34	49	110.4	10.43	4.50	5.40	1510	1.05	175.2	2443	7.38		297.2	319.3	0.89	1.01
6	37	874	90	36	50	80.6	7.21	3.22	3.58	1633	1.14	122.8	2557	7.72	114.3	216.7	231.5	0.81	0.89
7	44	926	92	37	50	65.1	5.11	2.47	2.37	1724	1.20	90.8	2697	8.15		163.7	183.9	1.38	1.48
8	51	987	94	39	51	56.9	3.57	2.02	1.50	1807	1.26		2857	8.63		126.8	157.1	1.77	1.85
9	59	1052	96	41	52	55.5	2.58	1.83	0.96	1877	1.31	61.5	3027	9.15		105.4	149.6	2.24	2.32
10	67	1130	97	43	52	56.4	1.72	1.73	0.55	1949	1.36		3226	9.75	173.8	83.0	148.1	2.59	2.65
11	75	1197	98	45	52	59.5	1.41	1.75	0.45	2017	1.41	59.5	3398	10.26		70.7	154.8	2.36	2.42
12	82	1251	99	47	53	59.9	1.22	1.70	0.38	2080	1.45	63.2	3539	10.69		65.6	155.1	2.07	2.14
13	89	1298	100	48	53	57.3	1.14	1.56	0.33	2147	1.50	66.7	3661	11.06		62.7	148.1	1.67	1.76
14	96	1337	102	48	53	53.8	1.22	1.39	0.31	2228	1.55	81.2	3766	11.38	104.3	66.4	139.7	1.15	1.23
15	103	1369	103	49	54	46.5	1.34	1.14	0.32	2303	1.61		3853	11.64		68.8	121.9	1.04	1.12
16	110	1396	105	50	54	39.8	1.40	0.94	0.32	2371	1.65		3924	11.86	71.3	70.9	105.3	0.92	0.99
17	118	1429	106	51	54	34.6	1.41	0.79	0.31	2443	1.70		4014	12.13		70.6	92.4	1.12	1.20
18	125	1467	108	51	54	33.0	1.44	0.73	0.31	2511	1.75	67.8	4116	12.44	101.8	70.8	88.4	1.35	1.44
19	132	1500	109	52	55	31.8	1.35	0.70	0.29	2571	1.79		4203	12.70		66.7	85.1	1.31	1.39
20	139	1529	110	53	55	31.1	1.25	0.66	0.27	2627	1.83	55.5	4280	12.93	76.6	63.0	83.0	1.26	1.32
21	146	1561	111	53	55	32.2	1.22	0.65	0.25	2682	1.87		4364	13.18		60.3	85.6	1.40	1.48
22	153	1596	112	54	55	33.4	1.23	0.64	0.24	2736	1.91	54.6	4457	13.47	93.1	58.6	88.6	1.54	1.64
23	160	1628	113	54	56	32.0	1.13	0.59	0.22	2789	1.94		4540	13.72		55.6	84.8	1.43	1.50
24	167	1656	114	55	56	31.1	1.05	0.55	0.21	2841	1.98	51.9	4614	13.94	73.9	53.9	82.2	1.31	1.37
25	174	1687	115	55	56	31.4	1.07	0.53	0.22	2903	2.02		4695	14.18		55.3	83.1	1.18	1.24
26	180	1721	117	56	56	32.8	1.14	0.54	0.22	2978	2.08	87.7	4786	14.46	106.1	61.1	86.9	1.09	1.16
27	187	1748	118	56	56	31.3	1.07	0.52	0.21	3035	2.12		4859	14.68		61.6	82.8	1.17	1.24
28	194	1768	118	57	56	29.0	1.01	0.50	0.19	3071	2.14	36.0	4913	14.84	53.2	58.1	76.7	1.34	1.42
29	201	1797	119	57	57	29.1	1.05	0.49	0.17	3150	2.20		4989	15.07		63.6	77.2	0.88	0.93
30	209	1833	121	58	57	29.3	1.07	0.46	0.14	3267	2.28	102.7	5084	15.36	83.1	72.8	77.7	0.73	0.78
31	215	1870	122	58	57	29.9	1.06	0.43	0.11	3378	2.36		5182	15.66		79.9	79.2	0.81	0.85
32	222	1903	123	58	57	31.0	1.09	0.41	0.09	3466	2.42	88.7	5270	15.92	88.0	86.3	82.1	0.90	0.95
33	229	1946	124	59	57	35.4	1.22	0.40	0.09	3548	2.47	82.1	5381	16.26		95.5	93.7	1.23	1.30
34	236	1970	125	59	57	34.6	1.16	0.36	0.08	3607	2.52	58.4	5446	16.45	64.6	91.4	91.4	1.01	1.06
35	244	2001	126	59	57	33.5	1.11	0.35	0.07	3675	2.56	59.7	5526	16.69	70.1	81.6	88.4	1.07	1.13
36	251	2027	127	60	57	30.5	1.00	0.31	0.07	3745	2.61	70.4	5596	16.91		71.5	80.5	0.91	0.96
37	258	2050	128	60	57	28.6	0.92	0.29	0.06	3804	2.65	58.8	5657	17.09		65.7	75.3	0.95	1.00
38	265	2066	128	60	57	23.4	0.76	0.24	0.05	3846	2.68	41.7	5698	17.22	40.9	57.8	61.7	0.89	0.94
39	272	2096	129	60	57	24.4	0.81	0.25	0.05	3912	2.73		5777	17.45		59.3	64.5	1.10	1.15
40	279	2132	130	61	57	26.2	0.85	0.25	0.05	3981	2.78	69.4	5871	17.74	94.0	61.2	69.1	1.24	1.30
41	286	2160	131	61	57	26.5	0.90	0.25	0.05	4044	2.82		5947	17.97		59.7	70.1	1.08	1.15
42	293	2185	133	61	57	26.9	1.00	0.26	0.05	4110	2.87	66.3	6014	18.17	67.5	61.2	71.4	0.90	0.98
43	300	2211	134	61	57	29.0	1.15	0.29	0.05	4192	2.92		6085	18.38		69.1	77.3	0.77	0.83
44	307	2240	135	62	57	28.8	1.21	0.29	0.05	4293	2.99	101.7	6163	18.62		76.3	77.1	0.68	0.73
45	314	2270	137	62	58	27.7	1.23	0.29	0.05	4387	3.06		6243	18.86		81.3	74.3	0.76	0.82
46	322	2301	138	62	58	27.5	1.22	0.28	0.05	4476	3.12		6327	19.11	73.4	84.1	73.9	0.85	0.91
47	328	2332	139	63	58	29.5	1.22	0.28	0.05	4557	3.18		6408	19.36		89.3	78.7	0.91	0.97
48	335	2363	140	63	58	30.4	1.18	0.27	0.05	4632	3.23		6489	19.61		88.1	80.9	0.98	1.03
49	343	2394	141	63	58	30.0	1.10	0.26	0.05	4703	3.28	62.3	6572	19.85	72.3	79.7	79.6	1.05	1.11

Sample: ABA-2
Cell Type: standard-2
Test Conditions: 1 kg cell with dry/wet air cycles - 500 mL trickle leach
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
Date	Cycle	Days	volume (L)	pH	Conduct. (uS/cm)	Alkalinity (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	End, 3-day dry (%)	End, 3-day wet (%)	End of leach (%)
25-Jan-96	0	0	0.566	8.1	1604	73	1300	1852	206.0	66.00	118.00			
26-Jan-96	1	1	0.292	7.8	1411			467	43.0	15.60	213.00			
2-Feb-96	2	8	0.423	7.6	1218									
9-Feb-96	3	15	0.409	7.5	824		560					0.3	0.8	9.9
16-Feb-96	4	22	0.416	7.7	392		260					0.5	2.0	9.1
23-Feb-96	5	29	0.458	7.7	382							4.4	6.2	9.7
1-Mar-96	6	36	0.418	7.7	251		91	55	4.0	2.10	1.80	1.7	1.9	9.0
9-Mar-96	7	44	0.463	7.5	295							3.3	3.8	3.8
17-Mar-96	8	52	0.489	7.7	415		205					9.4	9.8	9.9
25-Mar-96	9	60	0.225	7.6	161	28	58					2.6	2.1	9.2
1-Apr-96	10	67	0.420	7.6			109	49	3.4	1.40	0.80	2.0	2.0	9.3
8-Apr-96	11	74	0.462	7.8	315	33	151					6.6	6.8	9.4
15-Apr-96	12	81	0.418	7.5	254	23						6.2	6.4	9.2
22-Apr-96	13	88	0.428	7.6	193	23		32	2.0	1.20	0.67	1.0	1.9	9.2
29-Apr-96	14	95	0.384	7.6	196	24						2.2	2.9	9.1
7-May-96	15	103	0.444	7.4	292		96	55	2.8	1.40	0.75	3.4	3.8	9.0
14-May-96	16	110	0.477	7.5	332	30						6.9	7.7	9.6
21-May-96	17	117	0.473	7.7	288		97	57	2.6	1.10	0.62	6.5	6.7	9.6
28-May-96	18	124	0.472	7.4	292	23						6.5	7.6	9.7
4-Jun-96	19	131	0.459	7.7	271		114	64	2.5	1.10	0.47	5.6	6.0	9.7
11-Jun-96	20	138	0.451	7.2	271	21						3.3	4.3	9.3
18-Jun-96	21	145	0.452	7.6	280		118	49	2.5	1.00	0.45	6.6	6.5	9.7
25-Jun-96	22	152	0.454	7.1	254	16						4.3	4.6	9.5
2-Jul-96	23	159	0.478	7.7	326		138	64	2.6	0.90	0.48	7.3	8.0	9.9
8-Jul-96	24	165	0.466	7.6	316	30						6.1	6.7	10.0
15-Jul-96	25	172	0.475	7.7	334		130	60	2.6	0.69	0.25	7.5	7.6	10.3
22-Jul-96	26	179	0.479	7.2	314	22						7.7	7.9	10.5
29-Jul-96	27	186	0.479	7.2	385		150	68	2.6	1.09	0.22	8.1	8.2	10.5
6-Aug-96	28	194	0.474	7.6	368	30						6.8	7.6	10.4
12-Aug-96	29	200	0.487	7.6	343		140	62	2.5	0.75	0.21	8.7	8.9	10.7
19-Aug-96	30	207	0.476	7.6	325	18	151					7.9	8.1	10.5
26-Aug-96	31	214	0.484	7.5	325		139	56	2.1	0.55	0.15	8.8	9.0	10.7
2-Sep-96	32	221	0.456	7.3	291	24	139	59	2.0	0.59	0.13	5.7	5.7	10.3
10-Sep-96	33	229	0.463	7.4	282		134					7.8	8.1	10.6
17-Sep-96	34	236	0.467	7.3	266	20	136	54	2.1	0.73	0.15	8.1	8.4	10.4
24-Sep-96	35	243	0.460	7.4	282		136	51	2.0	0.48	0.11	7.7	7.8	10.8
1-Oct-96	36	250	0.460	7.4	266	25	127					7.3	7.5	10.6
8-Oct-96	37	257	0.461	7.5	326							6.4	7.7	10.7
15-Oct-96	38	264	0.472	7.3	309	25	152	73	2.1	0.56	0.15	8.5	8.8	10.6
22-Oct-96	39	271	0.482	7.6	278							9.2	9.9	11.0
29-Oct-96	40	278	0.458	7.5	274	28	131	54	1.9	0.56	0.11	6.8	7.4	10.5
5-Nov-96	41	285	0.480	7.4	259							9.0	9.5	10.8
12-Nov-96	42	292	0.468	7.3	298	27	157						8.9	
19-Nov-96	43	299	0.488									9.8	10.9	10.9
27-Nov-96	44	307	0.487	7.3	255	17		44	1.6	0.45	0.10	7.6	7.1	10.5
3-Dec-96	45	313	0.445									8.6	8.9	
10-Dec-96	46	320	0.446											
18-Dec-96	47	328	0.435	7.5	254	24	138	53	2.1	0.57	0.11			

Sample: ABA-2
Cell Type: standard-2
Test Conditions: 1 kg cell with dry/wet air cycles - 500 mL trickle leach

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	1048	117	37	67					736	0.51		3102	9.37				3.42	4.05
1	1	1184	129	42	129					1043	0.73		3495	10.56	2746.1			1.06	1.23
2	8	1347	144	47	201					1384	0.97		3963	11.97				1.14	1.32
3	15	1470	155	52	254	197.1	18.03	6.62	87.21	1613	1.12	228.9	4319	13.05		409.4	567.6	1.30	1.49
4	22	1562	163	55	290	163.5	14.88	5.50	70.88	1721	1.20	108.1	4581	13.84		313.5	470.4	2.03	2.33
5	29	1625	169	57	310	139.2	12.60	4.70	58.64	1801	1.26		4761	14.38		257.3	400.2	1.88	2.14
6	36	1648	170	58	310	92.7	8.26	3.16	36.32	1839	1.28	38.0	4825	14.58	64.4	159.4	266.1	1.45	1.62
7	44	1672	172	59	311	63.3	5.48	2.19	21.40	1908	1.33		4894	14.79		101.9	181.0	0.87	0.97
8	52	1698	174	59	312	43.0	3.56	1.50	11.00	2008	1.40	87.7	4965	15.00		74.8	122.4	0.61	0.68
9	60	1709	175	60	312	27.2	2.11	0.95	4.14	2021	1.41	11.4	4997	15.10		55.3	76.7	2.09	2.33
10	67	1730	176	60	312	19.4	1.38	0.66	0.49	2067	1.44	45.8	5054	15.27	57.4	48.9	54.1	1.08	1.20
11	74	1750	178	61	313	18.8	1.32	0.61	0.42	2137	1.49	69.7	5110	15.44		54.8	52.5	0.69	0.77
12	81	1765	179	62	313	17.6	1.21	0.56	0.35	2194	1.53		5154	15.57		54.1	49.1	0.66	0.73
13	88	1779	179	62	313	15.8	1.06	0.51	0.29	2247	1.57		5192	15.68	37.8	46.4	44.0	0.62	0.69
14	95	1796	180	63	314	17.3	1.12	0.55	0.31	2289	1.60		5237	15.82		53.5	48.0	0.95	1.04
15	103	1820	182	63	314	17.6	1.05	0.54	0.30	2332	1.63	37.3	5303	16.02	58.0	51.5	48.4	1.38	1.49
16	110	1847	183	64	314	18.9	1.04	0.54	0.29	2378	1.66		5375	16.24		46.9	51.6	1.39	1.50
17	117	1874	184	64	315	21.1	1.08	0.53	0.29	2423	1.69	45.9	5448	16.46	72.6	44.6	57.2	1.41	1.52
18	124	1902	185	65	315	24.0	1.14	0.54	0.29	2473	1.72		5524	16.69		44.0	64.7	1.38	1.47
19	131	1932	187	65	315	26.5	1.19	0.54	0.28	2526	1.76	52.4	5603	16.93	78.3	46.0	71.1	1.35	1.43
20	138	1957	188	66	315	27.4	1.20	0.52	0.26	2578	1.80		5671	17.13		49.3	73.6	1.17	1.25
21	145	1979	189	66	315	26.5	1.17	0.49	0.24	2631	1.83	53.3	5731	17.31	60.0	50.7	71.1	1.00	1.08
22	152	2005	190	67	316	26.2	1.15	0.48	0.22	2689	1.88		5800	17.52		53.2	70.4	1.06	1.14
23	159	2036	191	67	316	26.7	1.16	0.46	0.21	2755	1.92	66.0	5882	17.77	81.7	56.4	71.5	1.11	1.19
24	165	2065	192	67	316	27.3	1.21	0.44	0.21	2818	1.96		5959	18.00		60.2	73.4	1.11	1.19
25	172	2093	194	68	316	28.0	1.23	0.41	0.19	2880	2.01	61.8	6036	18.23	76.4	62.1	75.0	1.11	1.19
26	179	2124	195	68	316	29.7	1.25	0.41	0.17	2947	2.05		6117	18.48		64.9	79.5	1.10	1.17
27	186	2156	196	69	316	31.1	1.27	0.43	0.15	3018	2.10	71.9	6204	18.74	86.7	67.8	83.2	1.09	1.16
28	194	2187	197	69	316	30.3	1.23	0.42	0.12	3087	2.15		6286	18.99		66.4	80.9	1.08	1.15
29	200	2217	199	70	317	30.6	1.23	0.42	0.11	3155	2.20	79.6	6367	19.23	94.1	67.5	81.5	1.06	1.13
30	207	2245	200	70	317	30.5	1.20	0.41	0.10	3227	2.25	71.9	6442	19.46		69.5	81.2	0.94	1.00
31	214	2273	201	70	317	29.8	1.16	0.38	0.09	3294	2.30	67.2	6514	19.68	72.0	69.6	79.2	0.97	1.03
32	221	2299	202	70	317	28.6	1.09	0.33	0.08	3358	2.34	63.4	6585	19.89	71.1	67.9	76.1	1.02	1.08
33	229	2326	202	71	317	27.7	1.04	0.30	0.08	3420	2.38	54.3	6654	20.10		66.6	73.6	1.01	1.07
34	236	2351	203	71	317	26.0	0.96	0.29	0.07	3483	2.43	63.6	6721	20.31	67.2	63.8	68.9	0.95	1.01
35	243	2374	204	71	317	25.1	0.93	0.27	0.06	3546	2.47	62.6	6784	20.49	62.6	62.0	66.5	0.90	0.96
36	250	2401	205	72	317	25.0	0.91	0.27	0.06	3604	2.51	58.4	6855	20.71		60.3	66.3	1.10	1.17
37	257	2431	206	72	317	25.6	0.92	0.26	0.06	3669	2.56		6934	20.95		60.4	68.0	1.13	1.19
38	264	2466	207	72	317	28.0	0.96	0.26	0.06	3740	2.61	71.8	7025	21.22	90.3	64.1	74.1	1.15	1.21
39	271	2496	208	72	317	29.1	0.95	0.25	0.06	3809	2.66		7105	21.47		65.0	76.8	1.08	1.13
40	278	2521	209	73	317	29.4	0.94	0.25	0.06	3869	2.70	60.0	7171	21.66	65.5	64.5	77.4	0.99	1.05
41	285	2546	210	73	317	28.9	0.93	0.26	0.06	3938	2.75		7236	21.86		66.7	76.3	0.86	0.91
42	292	2569	211	73	317	27.5	0.90	0.26	0.06	4011	2.80	73.5	7297	22.04		68.5	72.5	0.75	0.79
43	299	2592	212	73	317	25.1	0.87	0.25	0.05	4086	2.85		7357	22.23		69.1	66.5	0.73	0.77
44	307	2613	212	73	317	22.6	0.81	0.23	0.05	4159	2.90		7414	22.40	49.7	68.1	60.0	0.71	0.75
45	313	2634	213	74	318	22.5	0.82	0.23	0.05	4223	2.95		7469	22.57		71.0	59.7	0.77	0.82
46	320	2656	214	74	318	22.1	0.81	0.23	0.05	4287	2.99		7529	22.75		69.8	58.5	0.85	0.90
47	328	2679	215	74	318	21.5	0.81	0.22	0.05	4347	3.03	52.5	7590	22.93	53.8	65.2	57.0	0.92	0.98

Sample: ABA-3
Cell Type: standard-1
Test Conditions: 1 kg cell with dry/wet air cycles - 500 mL trickle leach
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
			volume		Conduct.	Alkalinity	SO_4	Ca	Mg	K	Na	End, 3-day dry	End, 3-day wet	End of leach
Date	Cycle	Days	(L)	pH	(uS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(%)	(%)	(%)
10-Jan-96	0	0	0.311	8.0	1614	51	800	1104	126.0	50.00	107.00			
11-Jan-96	1	1	0.311	7.9	1184			301	32.0	14.40	21.80			
18-Jan-96	2	8	0.457	7.8	754									
25-Jan-96	3	15	0.419	7.7	621									
2-Feb-96	4	23	0.385	7.1	527		230							
9-Feb-96	5	30	0.456	7.7	365		240					4.1	4.3	10.4
16-Feb-96	6	37	0.420	7.7	229	35	120	49	4.0	2.00	1.40	0.7	2.3	9.3
23-Feb-96	7	44	0.466	7.6	267		134					6.6	7.6	10.1
1-Mar-96	8	51	0.467	7.6	239							7.1	8.0	10.2
9-Mar-96	9	59	0.437	7.5	246		91					5.0	6.3	9.9
17-Mar-96	10	67	0.440	7.5	254			62	2.2	1.40	1.00	4.1	5.4	9.7
25-Mar-96	11	75	0.443	7.4	217	32	83					5.5	4.9	9.3
1-Apr-96	12	82	0.424	7.6			83					2.0	2.8	9.2
8-Apr-96	13	89	0.425	7.6	214	32	88					3.0	4.0	9.2
15-Apr-96	14	96	0.440	7.8	276	29	105	59	1.7	1.10	0.70	4.8	5.5	9.1
22-Apr-96	15	103	0.420	7.7	191	31						3.2	2.3	8.9
29-Apr-96	16	110	0.213	7.5	266			50	1.3	0.80	0.67	5.6	5.4	9.6
7-May-96	17	118	0.468	7.7	239	30						7.9	8.6	10.3
14-May-96	18	125	0.468	7.8	243		74	45	1.2	0.80	0.52	7.7	8.3	10.1
21-May-96	19	132	0.455	7.5	228	21						6.4	6.7	10.1
28-May-96	20	139	0.460	7.7	219		76	45	0.8	0.75	0.41	7.1	7.2	10.1
4-Jun-96	21	146	0.468	7.4	238	19						7.8	9.0	10.2
11-Jun-96	22	153	0.454	7.4	262		93	52	1.1	0.80	0.50	7.0	8.1	10.2
18-Jun-96	23	160	0.436	7.6	224	20						4.0	4.5	9.7
25-Jun-96	24	167	0.453	7.5	227		95	61	0.8	0.65	0.43	5.1	6.2	9.6
2-Jul-96	25	174	0.463	7.6	245	23						7.1	7.6	10.0
8-Jul-96	26	180	0.482	7.6	262		103	53	1.0	0.75	0.49	6.8	8.8	10.0
15-Jul-96	27	187	0.462	7.6	271	25						7.0	7.6	10.2
22-Jul-96	28	194	0.471	7.4	255		75	43	0.8	0.60	0.26	7.5	8.0	9.8
29-Jul-96	29	201	0.453	7.4	301	24						5.2	5.9	10.0
6-Aug-96	30	209	0.458	7.4	297		115	51	0.9	0.40	0.20	6.3	6.9	10.0
12-Aug-96	31	215	0.443	7.5	264	17						4.6	5.3	9.9
19-Aug-96	32	222	0.454	7.3	257		120	49	0.8	0.45	0.14	5.1	6.3	9.9
26-Aug-96	33	229	0.472	7.4	272		110					7.6	8.4	10.2
2-Sep-96	34	236	0.409	7.1	196	17	83	38	0.5	0.46	0.39	1.2	1.2	9.6
10-Sep-96	35	244	0.465	7.3	268		129	54	0.9	0.65	0.17	6.5	7.5	10.0
17-Sep-96	36	251	0.458	7.2	242	18	118					6.7	6.9	10.1
24-Sep-96	37	258	0.454	7.2	228		101					5.5	6.4	10.1
1-Oct-96	38	265	0.393	7.2	150	17	60	26	0.4	0.35	0.09	5.2	5.6	10.0
8-Oct-96	39	272	0.456	7.3	248							6.1	6.6	10.1
15-Oct-96	40	279	0.476	7.1	264	16	128	65	1.3	0.43	0.15	8.5	9.0	10.4
22-Oct-96	41	286	0.426	7.2	156							8.3	8.9	10.4
29-Oct-96	42	293	0.479	7.3	228	18	113	47	1.6	0.40	0.09	8.8	9.6	10.7
5-Nov-96	43	300	0.474	7.4	228							8.6	9.2	10.8
12-Nov-96	44	307	0.463	7.4	232	19	121						8.2	
19-Nov-96	45	314	0.475									8.4	9.1	10.8
27-Nov-96	46	322	0.474	7.3	232	16		43	0.6	0.33	0.12	6.6	6.2	10.4
3-Dec-96	47	328	0.450									9.0	9.4	
10-Dec-96	48	335	0.456											
18-Dec-96	49	343	0.466	7.2	207	12	97	40	0.6	0.29	0.09			

Sample: ABA-3
Cell Type: standard-1
Test Conditions: 1 kg cell with dry/wet air cycles - 500 mL trickle leach

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	343	39	16	33					249	0.26		1021	4.08				3.31	3.93
1	1	437	49	20	40					453	0.48		1296	5.18	1927.4			1.10	1.29
2	8	552	61	25	48					689	0.73		1632	6.53				1.17	1.37
3	15	635	70	29	54	136.3	14.34	6.48	9.61	845	0.90		1878	7.51		278.1	400.1	1.29	1.51
4	23	693	76	32	58	106.4	11.13	5.04	7.39	933	0.99	77.5	2046	8.19		208.3	312.2	1.56	1.82
5	30	738	80	34	60	92.2	9.56	4.34	6.25	1043	1.11	109.4	2178	8.71		185.3	270.0	0.99	1.15
6	37	759	82	35	61	62.6	6.36	2.91	4.00	1093	1.16	50.4	2236	8.95	58.4	124.4	182.8	0.98	1.11
7	44	783	83	36	61	45.1	4.33	2.02	2.54	1155	1.23	62.4	2304	9.22		90.7	130.6	0.94	1.04
8	51	809	85	37	62	33.8	2.92	1.40	1.54	1208	1.29		2375	9.50		70.6	96.6	1.18	1.29
9	59	835	86	37	62	27.6	2.01	1.01	0.92	1248	1.33	34.8	2444	9.78		61.1	77.3	1.55	1.66
10	67	862	87	38	63	23.4	1.31	0.72	0.51	1286	1.37		2516	10.06	63.3	46.0	64.0	1.71	1.81
11	75	889	88	39	63	24.0	1.13	0.65	0.46	1323	1.41	32.1	2588	10.35		42.3	64.7	1.77	1.87
12	82	915	89	39	63	24.2	0.98	0.59	0.41	1358	1.45	35.2	2655	10.62		37.3	64.7	1.75	1.84
13	89	940	90	40	64	24.2	0.86	0.54	0.37	1395	1.49	37.4	2722	10.89		34.5	64.0	1.63	1.71
14	96	966	90	40	64	24.9	0.80	0.51	0.35	1442	1.54	46.2	2790	11.16	68.1	36.7	65.5	1.35	1.41
15	103	989	91	40	64	24.7	0.76	0.49	0.33	1482	1.58		2850	11.40		38.2	64.9	1.34	1.41
16	110	1000	91	41	65	22.1	0.65	0.42	0.29	1501	1.60		2878	11.51	27.7	35.7	58.0	1.34	1.40
17	118	1022	92	41	65	20.8	0.59	0.37	0.26	1540	1.64		2936	11.74		35.3	54.5	1.39	1.45
18	125	1043	92	41	65	20.0	0.54	0.35	0.25	1574	1.68	34.6	2991	11.96	55.0	34.8	52.3	1.46	1.52
19	132	1064	93	42	65	18.9	0.49	0.32	0.23	1609	1.71		3044	12.18		32.5	49.4	1.44	1.49
20	139	1084	93	42	65	18.5	0.44	0.31	0.21	1643	1.75	35.0	3097	12.39	53.3	31.3	48.1	1.42	1.46
21	146	1107	94	42	66	20.8	0.47	0.35	0.22	1683	1.79		3156	12.62		35.3	54.1	1.38	1.42
22	153	1131	94	43	66	21.7	0.47	0.36	0.22	1725	1.84	42.2	3217	12.87	61.1	37.1	56.2	1.34	1.39
23	160	1155	95	43	66	22.4	0.44	0.35	0.21	1766	1.88		3280	13.12		38.4	57.9	1.44	1.48
24	167	1183	95	43	66	23.9	0.42	0.34	0.21	1809	1.93	43.1	3351	13.40	70.7	40.2	61.4	1.54	1.57
25	174	1209	95	44	67	25.0	0.43	0.33	0.21	1855	1.98		3419	13.68		42.3	64.3	1.38	1.42
26	180	1235	96	44	67	26.3	0.45	0.34	0.22	1905	2.03	58.0	3485	13.94	77.0	45.6	67.7	1.23	1.27
27	187	1257	96	44	67	26.0	0.43	0.33	0.21	1946	2.07		3542	14.17		45.4	66.9	1.29	1.33
28	194	1277	97	45	67	25.1	0.42	0.32	0.19	1981	2.11	35.3	3594	14.38	52.2	44.3	64.6	1.38	1.42
29	201	1299	97	45	67	23.8	0.43	0.31	0.17	2024	2.16		3649	14.60		44.3	61.4	1.19	1.22
30	209	1322	97	45	67	22.5	0.41	0.27	0.15	2077	2.21	46.1	3709	14.84	52.7	44.4	58.1	1.06	1.10
31	215	1344	98	45	67	21.8	0.39	0.24	0.11	2129	2.27		3766	15.06		44.8	56.3	1.02	1.05
32	222	1366	98	45	67	21.9	0.38	0.22	0.09	2183	2.33	54.5	3823	15.29	57.2	47.5	56.3	0.98	1.01
33	229	1387	98	46	68	21.9	0.37	0.20	0.09	2235	2.38	51.9	3876	15.50		50.8	56.4	0.95	0.97
34	236	1402	99	46	68	20.8	0.33	0.20	0.10	2269	2.42	34.0	3916	15.66	39.7	49.0	53.3	1.10	1.12
35	244	1427	99	46	68	21.1	0.33	0.22	0.10	2329	2.48	52.5	3980	15.92	56.5	50.5	54.2	1.00	1.03
36	251	1448	99	46	68	20.2	0.32	0.23	0.10	2383	2.54	54.0	4033	16.13		49.5	51.9	0.91	0.93
37	258	1464	100	47	68	19.0	0.30	0.23	0.09	2429	2.59	45.8	4074	16.30		47.8	48.7	0.84	0.86
38	265	1474	100	47	68	17.0	0.27	0.21	0.08	2453	2.61	23.6	4100	16.40	26.2	42.3	43.6	1.04	1.07
39	272	1495	100	47	68	18.0	0.30	0.21	0.06	2496	2.66		4154	16.62		44.0	46.3	1.16	1.20
40	279	1526	101	47	68	19.7	0.35	0.20	0.06	2557	2.72	60.9	4234	16.94	80.0	45.4	50.7	1.22	1.26
41	286	1550	101	47	68	20.4	0.41	0.18	0.05	2608	2.78		4296	17.18		44.9	52.6	1.12	1.16
42	293	1572	102	48	68	21.7	0.51	0.18	0.05	2662	2.83	54.1	4356	17.42	59.5	46.6	56.3	1.00	1.05
43	300	1594	103	48	68	24.0	0.61	0.19	0.05	2717	2.89		4413	17.65		52.9	62.5	0.94	0.99
44	307	1615	103	48	68	24.0	0.63	0.18	0.05	2773	2.95	56.0	4467	17.87		55.6	62.6	0.89	0.93
45	314	1636	104	48	68	22.0	0.59	0.18	0.05	2829	3.01		4521	18.08		54.4	57.4	0.91	0.94
46	322	1656	104	48	68	20.7	0.51	0.17	0.05	2881	3.07		4573	18.29	45.6	53.2	53.9	0.93	0.95
47	328	1675	104	48	68	20.6	0.42	0.16	0.05	2929	3.12		4621	18.49		53.5	53.2	0.95	0.97
48	335	1694	105	48	68	19.9	0.35	0.15	0.05	2976	3.17		4669	18.68		51.7	51.3	0.97	0.99
49	343	1712	105	49	68	19.0	0.29	0.14	0.05	3021	3.22	39.6	4717	18.87	41.8	48.1	48.7	0.99	1.01

Sample: ABA-3
Cell Type: standard-2
Test Conditions: 1 kg cell with dry/wet air cycles - 500 mL trickle leach
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
			volume		Conduct.	Alkalinity	SO_4	Ca	Mg	K	Na	End, 3-day dry	End, 3-day wet	End of leach
Date	Cycle	Days	(L)	pH	(uS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(%)	(%)	(%)
25-Jan-96	0	0	0.577	7.9	1190	55	900	1206	135.0	53.00	110.00			
26-Jan-96	1	1	0.309	7.8	1100			292	30.0	12.90	20.20			
2-Feb-96	2	8	0.451	7.6	1010									
9-Feb-96	3	15	0.472	7.4	930		580					7.5	7.9	11.1
16-Feb-96	4	22	0.415	7.8	294		180					0.1	1.8	9.9
23-Feb-96	5	29	0.470	7.8	302							6.5	7.7	9.9
1-Mar-96	6	36	0.443	7.6	228		75	52	2.9	1.60	1.30	4.0	4.8	9.4
9-Mar-96	7	44	0.446	7.6	262							6.2	7.0	9.9
17-Mar-96	8	52	0.468	7.7	284		126					7.3	7.8	9.9
25-Mar-96	9	60	0.455	7.6	217	27	95					6.8	6.0	9.5
1-Apr-96	10	67	0.415	7.7			67	39	1.5	1.20	0.75	0.6	1.0	8.9
8-Apr-96	11	74	0.431	7.6	249	25	102					4.1	4.7	9.0
15-Apr-96	12	81	0.434	7.6	266	24						3.7	4.6	18.8
22-Apr-96	13	88	0.412	7.6	163	24		29	1.1	1.00	0.65	0.4	0.7	8.5
29-Apr-96	14	95	0.418	7.6	232	24						2.5	3.1	8.6
7-May-96	15	103	0.457	7.6	281		101	54	2.0	1.10	0.73	4.7	5.5	8.6
14-May-96	16	110	0.464	7.6	234	26						5.0	6.0	8.9
21-May-96	17	117	0.474	7.6	254		61	35	1.0	0.80	0.45	7.0	7.2	9.0
28-May-96	18	124	0.468	7.2	240	17						7.0	7.1	7.1
4-Jun-96	19	131	0.470	7.7	224		85	53	1.1	0.80	0.46	7.4	7.5	9.4
11-Jun-96	20	138	0.462	7.3	254	26						6.6	6.6	9.2
18-Jun-96	21	145	0.451	7.6	221		83	42	1.0	0.70	0.43	5.3	5.3	9.2
25-Jun-96	22	152	0.449	7.2	241	20						5.0	5.4	9.4
2-Jul-96	23	159	0.466	7.6	295		142	48	1.0	0.51	0.39	6.5	7.1	9.5
8-Jul-96	24	165	0.452	7.6	344	36						6.4	6.5	10.4
15-Jul-96	25	172	0.466	7.7	264		88	48	0.9	0.48	0.25	7.5	7.5	10.0
22-Jul-96	26	179	0.459	7.3	260	23						6.2	6.9	10.0
29-Jul-96	27	186	0.454	7.2	310		127	55	0.9	0.72	0.18	5.8	6.3	9.7
6-Aug-96	28	194	0.453	7.2	327							5.9	6.1	9.8
12-Aug-96	29	200	0.484	7.4	266		98	49	0.8	0.57	0.19	8.5	9.3	9.9
19-Aug-96	30	207	0.469	7.4	262	16	107					7.7	7.8	9.8
26-Aug-96	31	214	0.466	7.4	266		102	46	0.8	0.45	0.17	7.3	7.6	10.0
2-Sep-96	32	221	0.444	7.2	252	19	118	52	0.7	0.51	0.16	5.0	5.0	9.6
10-Sep-96	33	229	0.471	7.4	233		107					7.8	8.0	9.8
17-Sep-96	34	236	0.458	7.3	226	20	106	45	0.7	0.42	0.14	6.4	6.6	9.6
24-Sep-96	35	243	0.448	7.1	202		94	35	0.5	0.36	0.08	5.1	5.4	9.7
1-Oct-96	36	250	0.459	7.1	207	15	100					6.6	6.8	9.9
8-Oct-96	37	257	0.444	7.2	237							4.5	4.7	9.5
15-Oct-96	38	264	0.440	7.1	241	8	114	53	0.7	0.38	0.13	4.1	4.4	9.5
22-Oct-96	39	271	0.461	7.3	206							6.4	6.9	9.6
29-Oct-96	40	278	0.407	7.2	169	10	70	32	0.6	0.40	0.07	0.7	0.9	8.9
5-Nov-96	41	285	0.468	7.2	209							3.9	4.2	9.0
12-Nov-96	42	292	0.433	7.3	237	18	128						3.7	
19-Nov-96	43	299	0.449									4.7	5.3	9.3
27-Nov-96	44	307	0.447	7.4	260	20		43	0.7	0.39	0.11	7.2	6.6	9.7

Sample: ABA-3
Cell Type: standard-2
Test Conditions: 1 kg cell with dry/wet air cycles - 500 mL trickle leach

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	695	78	31	63					519	0.55		2061	8.24				3.22	3.81
1	1	785	87	35	70					764	0.81		2324	9.30	1845.5			0.88	1.03
2	8	896	98	39	77					1074	1.14		2646	10.58				0.85	0.99
3	15	988	107	43	83	136.6	13.72	5.94	9.15	1347	1.44	273.8	2915	11.66		386.6	398.4	0.81	0.94
4	22	1050	113	46	87	112.7	11.17	4.86	7.41	1422	1.51	74.7	3092	12.37		287.4	328.0	1.97	2.27
5	29	1097	117	48	89	96.8	9.42	4.13	6.20	1482	1.58		3225	12.90		232.5	281.1	1.88	2.14
6	36	1120	118	48	90	66.8	6.21	2.76	4.00	1515	1.61	33.3	3288	13.15	63.0	150.3	192.8	1.66	1.82
7	44	1141	119	49	90	47.8	4.10	1.88	2.55	1560	1.66		3347	13.39		94.6	136.4	1.16	1.26
8	52	1163	120	50	91	33.0	2.47	1.21	1.44	1619	1.72	51.6	3405	13.62		51.4	92.8	0.87	0.94
9	60	1182	121	50	91	24.4	1.51	0.82	0.80	1662	1.77	37.8	3457	13.83		44.2	67.2	1.07	1.14
10	67	1198	122	51	91	18.7	0.91	0.58	0.42	1690	1.80	27.8	3500	14.00	43.1	38.3	50.5	1.40	1.49
11	74	1213	122	51	92	17.3	0.78	0.53	0.37	1734	1.85	44.0	3541	14.16		40.3	46.4	0.84	0.89
12	81	1227	123	52	92	16.3	0.68	0.51	0.34	1778	1.89		3578	14.31		41.3	43.6	0.76	0.81
13	88	1239	123	52	92	14.9	0.59	0.48	0.31	1820	1.94		3610	14.44	31.8	39.1	39.8	0.69	0.73
14	95	1257	124	53	93	15.0	0.57	0.46	0.29	1862	1.98		3656	14.62		40.0	39.8	0.98	1.04
15	103	1281	125	53	93	16.2	0.61	0.45	0.29	1909	2.03	40.4	3721	14.89	57.3	42.5	43.1	1.28	1.36
16	110	1302	126	54	93	17.2	0.63	0.44	0.28	1946	2.07		3776	15.10		41.2	45.7	1.32	1.39
17	117	1319	126	54	93	17.7	0.62	0.42	0.27	1975	2.10	28.9	3819	15.28	43.4	38.3	46.9	1.38	1.44
18	124	1339	127	54	94	19.4	0.63	0.42	0.26	2009	2.14		3873	15.49		36.8	51.2	1.45	1.50
19	131	1364	127	55	94	20.9	0.60	0.40	0.24	2049	2.18	39.9	3937	15.75	64.4	36.3	54.7	1.50	1.55
20	138	1386	128	55	94	20.9	0.53	0.38	0.22	2088	2.22		3994	15.98		35.9	54.6	1.36	1.41
21	145	1405	128	55	94	20.6	0.48	0.36	0.21	2125	2.26	37.4	4043	16.17	49.2	35.8	53.5	1.21	1.26
22	152	1425	128	56	94	21.3	0.48	0.34	0.20	2176	2.32		4096	16.38		40.2	55.3	0.96	1.00
23	159	1448	129	56	95	21.7	0.47	0.31	0.20	2242	2.39	66.2	4154	16.62	57.9	46.6	56.2	0.81	0.84
24	165	1469	129	56	95	21.7	0.47	0.29	0.19	2294	2.44		4210	16.84		50.4	56.1	1.00	1.03
25	172	1492	130	56	95	21.7	0.46	0.26	0.17	2335	2.49	41.0	4268	17.07	57.7	50.9	56.3	1.31	1.35
26	179	1515	130	57	95	22.7	0.45	0.25	0.15	2385	2.54		4328	17.31		53.4	58.7	1.15	1.18
27	186	1540	131	57	95	23.7	0.44	0.27	0.13	2442	2.60	57.6	4393	17.57	64.2	54.8	61.1	1.04	1.07
28	194	1564	131	57	95	23.2	0.41	0.27	0.11	2493	2.66		4453	17.81		50.2	59.9	1.11	1.14
29	200	1588	131	57	95	23.6	0.40	0.28	0.09	2541	2.71	55.4	4514	18.06	71.1	49.3	60.8	1.20	1.23
30	207	1610	132	58	95	23.6	0.39	0.28	0.09	2591	2.76	50.2	4571	18.29		51.1	60.8	1.07	1.09
31	214	1631	132	58	95	23.2	0.39	0.27	0.08	2638	2.81	47.6	4627	18.51	55.2	50.7	59.6	1.08	1.11
32	221	1654	132	58	95	22.8	0.37	0.25	0.08	2691	2.87	52.4	4686	18.74	59.1	49.7	58.6	1.06	1.08
33	229	1677	133	58	95	22.7	0.36	0.23	0.08	2741	2.92	44.1	4744	18.98		49.6	58.2	1.09	1.11
34	236	1698	133	59	96	21.4	0.33	0.21	0.07	2790	2.97	48.5	4797	19.19	52.9	48.4	55.0	1.02	1.04
35	243	1713	133	59	96	20.2	0.30	0.20	0.06	2832	3.02	42.1	4837	19.35	40.1	46.9	51.7	0.89	0.91
36	250	1732	134	59	96	19.6	0.28	0.19	0.06	2878	3.06	45.9	4885	19.54		46.5	50.3	0.98	1.01
37	257	1753	134	59	96	19.2	0.28	0.18	0.05	2925	3.12		4939	19.75		45.6	49.2	1.05	1.08
38	264	1776	134	59	96	19.8	0.28	0.17	0.05	2975	3.17	50.2	4998	19.99	59.6	46.8	50.8	1.12	1.14
39	271	1796	134	59	96	19.7	0.27	0.17	0.05	3018	3.21		5049	20.19		45.6	50.3	1.11	1.14
40	278	1809	135	60	96	19.1	0.28	0.17	0.05	3046	3.24	28.5	5082	20.33	33.6	42.9	49.0	1.10	1.13
41	285	1825	135	60	96	18.6	0.29	0.17	0.04	3092	3.29		5124	20.50		43.0	47.7	0.84	0.87
42	292	1842	135	60	96	17.7	0.29	0.17	0.04	3148	3.35	55.4	5166	20.66		44.5	45.4	0.70	0.72
43	299	1860	136	60	96	16.6	0.28	0.18	0.04										
44	307	1879	136	60	96	16.1	0.28	0.17	0.04										

APPENDIX 8

TABULATED RESULTS

TALL CELLS

Sample: HC-1
Cell Type: tall
Test Conditions: 3 kg cell with dry/wet air cycles - 500 mL trickle leach
Crush Size: minus 6mm
Cell Description: 10 cm diam x 40 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
Date	Cycle	Days	volume (L)	pH	Conduct. (uS/cm)	Alkalinity (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	End, 3-day dry (%)	End, 3-day wet (%)	End of leach (%)
10-Jan-96	0	0	0.652	8.1	1240	46	580	759	153.0	89.00	105.00			
11-Jan-96	1	1	0.691	7.9	1486			425	81.0	54.00	57.00			
18-Jan-96	2	8	0.488	7.7	1731									
25-Jan-96	3	15	0.429	7.7	1527									
2-Feb-96	4	23	0.362	7.7	1342		1000							
9-Feb-96	5	30	0.445	7.8	930		650					6.6	9.3	11.5
16-Feb-96	6	37	0.375	7.9	534	49	470	178	26.0	10.40	3.70	6.6	6.7	11.2
23-Feb-96	7	44	0.389	7.7	553							6.6	7.6	11.0
1-Mar-96	8	51	0.422	7.7	593							8.0	8.1	10.3
9-Mar-96	9	59	0.303	7.3	606		294					4.2	4.5	10.3
17-Mar-96	10	67	0.427	7.7	942			340	33.6	8.40	2.60	7.6	8.2	10.3
25-Mar-96	11	75	0.449	7.7	676	37	407					9.0	9.0	10.3
1-Apr-96	12	82	0.402	7.6			362					7.0	7.1	10.2
8-Apr-96	13	89	0.359	7.9	673	43	374					5.9	6.1	10.1
15-Apr-96	14	96	0.376	7.7	729	31	376	162	21.3	6.20	1.32	6.4	6.5	10.0
22-Apr-96	15	103	0.420	7.8	658	38						7.8	7.6	10.0
29-Apr-96	16	110	0.447	7.6	716			133	23.3	5.40	1.31	8.1	8.1	10.0
7-May-96	17	118	0.440	7.7	620	32						8.4	8.5	10.0
14-May-96	18	125	0.399	7.8	724		342	122	17.7	5.10	1.04	6.5	6.9	10.1
21-May-96	19	132	0.455	7.6	733	37						8.8	8.9	10.2
28-May-96	20	139	0.450	7.7	682		328	144	18.8	4.58	0.81	8.9	9.1	10.2
4-Jun-96	21	146	0.448	7.6	568	31						8.7	8.8	10.2
11-Jun-96	22	153	0.451	7.6	749		356	167	20.1	4.20	0.89	8.9	9.1	10.3
18-Jun-96	23	160	0.446	7.7	730	30						8.8	8.8	10.4
25-Jun-96	24	167	0.440	7.6	658		342	167	18.8	4.00	1.07	8.5	8.6	10.3
2-Jul-96	25	174	0.462	7.7	749	37						9.4	9.5	10.4
8-Jul-96	26	180	0.461	7.6	719		400	146	19.8	4.00	0.81	9.3	9.4	10.4
15-Jul-96	27	187	0.463	7.8	782	48						9.7	9.7	10.5
22-Jul-96	28	194	0.477	7.5	700		325	119	16.2	3.40	0.35	10.0	10.1	10.6
29-Jul-96	29	201	0.461	7.6	820	30						9.6	9.7	10.6
6-Aug-96	30	209	0.460	7.0	869		447	145	18.8	3.07	0.31	9.4	9.6	10.6
12-Aug-96	31	215	0.439	7.6	620	27						8.7	8.9	10.6
19-Aug-96	32	222	0.458	7.5	626	22	361	116	16.4	2.44	0.26	9.3	9.5	10.6
26-Aug-96	33	229	0.474	7.6	703		395					9.8	10.1	10.7
2-Sep-96	34	236	0.399	7.3	575	23	334	105	15.3	2.42	0.30	7.5	7.5	10.6
10-Sep-96	35	244	0.466	7.4	593		365	126	16.7	2.86	0.30	9.6	9.8	10.6
17-Sep-96	36	251	0.450	7.4	556	26	327					9.1	9.3	10.6
24-Sep-96	37	258	0.467	7.2	586		342					9.3	10.1	10.9
1-Oct-96	38	265	0.451	7.3	477	23	283	82	10.8	1.36	0.18	9.2	9.4	10.7
8-Oct-96	39	272	0.418	7.3	559							8.1	8.2	10.7
15-Oct-96	40	279	0.465	7.3	585	24	348	128	14.2	2.19	0.24	9.6	9.7	10.6
22-Oct-96	41	286	0.479	7.5	505							10.0	10.3	10.7
29-Oct-96	42	293	0.466	7.4	488	24	289	91	12.6	1.83	0.16	9.7	9.9	10.7
5-Nov-96	43	300	0.471	7.5	528							10.1	10.1	10.7
12-Nov-96	44	307	0.465	7.4	577	26	337						10.0	
19-Nov-96	45	314	0.470									9.9	10.1	10.8
27-Nov-96	46	322	0.469	7.3	502	22		90	12.8	1.63	0.19	9.8	9.7	10.8
3-Dec-96	47	328	0.426									10.2	10.4	
10-Dec-96	48	335	0.456											
18-Dec-96	49	343	0.463	7.5	614	30	390	135	15.7	2.09	0.20			

Sample: HC-1
Cell Type: tall
Test Conditions: 3 kg cell with dry/wet air cycles - 500 mL trickle leach

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	165	33	19	23					126	0.07		550	1.23				3.14	4.18
1	1	263	52	32	36					284	0.16		872	1.95	2253.5			1.49	1.96
2	8	324	63	39	43					412	0.24		1071	2.40				1.14	1.49
3	15	371	72	44	49	95.9	17.95	11.68	12.02	540	0.31		1223	2.74		193.2	314.0	0.87	1.14
4	23	404	78	48	52	72.7	13.47	8.64	8.76	661	0.38	105.6	1330	2.98		162.8	237.5	0.66	0.85
5	30	438	83	51	54	63.6	11.61	7.29	7.21	757	0.43	96.5	1437	3.22		147.3	207.1	0.84	1.06
6	37	460	86	52	54	38.3	6.68	3.90	3.55	816	0.47	58.7	1506	3.38	69.0	103.5	123.4	0.91	1.13
7	44	488	90	53	55	32.0	5.17	2.72	2.17	869	0.50		1592	3.57		88.9	101.2	1.27	1.54
8	51	525	94	54	55	30.0	4.34	1.96	1.26	919	0.52		1701	3.81		73.7	92.9	1.76	2.10
9	59	555	97	55	55	29.4	3.84	1.49	0.73	949	0.54	26.0	1789	4.01		56.0	89.3	2.44	2.87
10	67	603	102	57	56	31.3	3.60	1.13	0.38	999	0.57		1930	4.33	123.2	45.6	93.2	2.33	2.71
11	75	648	107	58	56	34.6	3.75	1.08	0.35	1060	0.60	53.3	2060	4.62		44.8	101.9	1.74	2.04
12	82	681	110	59	56	35.5	3.76	1.03	0.31	1108	0.63	48.4	2159	4.84		43.9	104.4	1.66	1.96
13	89	706	113	60	57	33.4	3.53	0.93	0.27	1153	0.66	44.7	2233	5.01		43.0	98.0	1.33	1.58
14	96	726	116	60	57	32.4	3.52	0.93	0.25	1200	0.68	47.1	2295	5.14	61.8	47.5	95.6	1.03	1.26
15	103	747	119	61	57	27.9	3.30	0.88	0.22	1251	0.71		2359	5.29		49.1	83.4	0.96	1.20
16	110	767	122	62	57	23.8	3.17	0.84	0.20	1305	0.74		2423	5.43	63.9	49.0	72.6	0.89	1.15
17	118	785	125	63	57	20.3	2.95	0.77	0.18	1356	0.77		2482	5.57		48.3	62.8	0.87	1.10
18	125	802	128	63	57	18.6	2.84	0.75	0.17	1402	0.80	45.5	2532	5.68	50.3	48.4	58.3	0.86	1.06
19	132	822	131	64	58	18.6	2.86	0.74	0.16	1453	0.83		2594	5.82		49.1	58.3	0.95	1.17
20	139	843	133	65	58	18.8	2.81	0.71	0.15	1502	0.86	49.2	2660	5.96	65.7	48.7	58.6	1.05	1.28
21	146	867	136	65	58	19.4	2.70	0.69	0.14	1553	0.89		2730	6.12		48.2	59.8	1.09	1.32
22	153	892	139	66	58	21.3	2.77	0.68	0.13	1606	0.92	53.5	2805	6.29	75.3	50.0	64.7	1.13	1.35
23	160	917	142	67	58	23.0	2.88	0.66	0.13	1658	0.95		2880	6.46		51.3	69.4	1.15	1.37
24	167	941	145	67	58	23.9	2.88	0.63	0.14	1708	0.98	50.1	2952	6.62	72.6	51.2	71.5	1.17	1.39
25	174	965	148	68	58	24.3	2.91	0.62	0.14	1765	1.01		3025	6.78		52.7	72.9	1.01	1.22
26	180	988	151	69	58	24.9	3.02	0.63	0.15	1827	1.04	71.7	3093	6.94	80.1	56.4	74.8	0.88	1.07
27	187	1008	154	69	59	23.9	2.97	0.62	0.14	1883	1.07		3156	7.08		56.9	72.1	0.88	1.07
28	194	1027	156	70	59	22.7	2.91	0.60	0.12	1934	1.10	51.7	3214	7.21	57.9	56.9	68.8	0.88	1.08
29	201	1047	159	70	59	21.9	2.89	0.58	0.10	1994	1.14		3276	7.34		58.8	66.6	0.82	1.00
30	209	1069	162	71	59	20.9	2.79	0.54	0.07	2062	1.18	60.0	3343	7.50	59.1	59.4	63.7	0.78	0.94
31	215	1088	165	71	59	20.2	2.70	0.50	0.06	2121	1.21		3402	7.63		58.9	61.7	0.78	0.95
32	222	1106	167	71	59	19.6	2.65	0.46	0.05	2177	1.24	55.1	3456	7.75	54.6	58.7	60.1	0.77	0.95
33	229	1124	170	72	59	19.4	2.63	0.43	0.04	2239	1.28	62.4	3510	7.87		60.9	59.3	0.67	0.83
34	236	1138	172	72	59	18.1	2.50	0.39	0.04	2283	1.30	44.4	3553	7.97	43.3	57.9	55.6	0.75	0.94
35	244	1157	174	73	59	17.6	2.44	0.39	0.04	2340	1.34	49.6	3613	8.10	52.2	55.5	54.0	0.83	1.01
36	251	1174	176	73	59	16.6	2.30	0.36	0.04	2389	1.36	49.0	3664	8.22		52.0	51.0	0.82	1.00
37	258	1189	178	73	59	16.1	2.20	0.35	0.04	2442	1.39	53.2	3710	8.32		51.7	49.3	0.68	0.83
38	265	1201	180	73	59	15.1	2.03	0.31	0.04	2485	1.42	42.6	3747	8.40	37.6	47.8	46.1	0.70	0.85
39	272	1216	182	74	59	15.2	1.97	0.30	0.03	2529	1.44		3791	8.50		47.7	46.2	0.80	0.96
40	279	1236	184	74	59	15.7	1.95	0.29	0.03	2583	1.47	53.9	3850	8.63	58.7	48.5	47.3	0.88	1.04
41	286	1253	186	74	59	15.9	1.94	0.28	0.03	2634	1.50		3902	8.75		48.9	47.7	0.83	0.99
42	293	1267	188	75	59	15.7	1.93	0.28	0.03	2678	1.53	44.9	3946	8.85	43.4	47.2	47.2	0.76	0.93
43	300	1282	190	75	59	16.1	2.01	0.29	0.03	2728	1.56		3990	8.95		48.6	48.5	0.70	0.86
44	307	1296	192	75	59	15.9	2.05	0.30	0.03	2780	1.59	52.3	4033	9.04		50.2	48.4	0.64	0.79
45	314	1310	194	75	59	14.8	2.01	0.28	0.03	2834	1.62		4077	9.14		50.3	45.3	0.62	0.77
46	322	1324	196	76	59	13.7	1.93	0.26	0.03	2890	1.65		4120	9.24	38.0	49.9	42.3	0.60	0.74
47	328	1339	198	76	59	14.3	1.98	0.26	0.03	2943	1.68		4165	9.34		52.8	43.9	0.68	0.83
48	335	1357	200	76	59	15.1	2.03	0.27	0.03	3000	1.71		4220	9.46		54.5	46.1	0.76	0.91
49	343	1378	203	76	59	16.0	2.06	0.27	0.03	3060	1.75	52.6	4282	9.60	54.3	54.5	48.5	0.83	0.99

Sample: HC-2
Cell Type: tall
Test Conditions: 3 kg cell with dry/wet air cycles - 500 mL trickle leach
Crush Size: minus 6mm
Cell Description: 10 cm diam x 40 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
Date	Cycle	Days	volume (L)	pH	Conduct. (uS/cm)	Alkalinity (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	End, 3-day dry (%)	End, 3-day wet (%)	End of leach (%)
10-Jan-96	0	0	0.686	8.0	1365	43	600	825	132.0	76.00	104.00			
11-Jan-96	1	1	0.703	7.8	1608			438	67.0	48.00	43.00			
18-Jan-96	2	8	0.421	7.6	1850									
25-Jan-96	3	15	0.411	7.7	1720									
2-Feb-96	4	23	0.350	7.6	1671		1300							
9-Feb-96	5	30	0.457	7.3	1021		760					7.6	8.7	10.5
16-Feb-96	6	37	0.383	7.4	1368	22	1700	452	21.0	11.50	4.80	7.0	7.0	12.1
23-Feb-96	7	44	0.435	7.3	610		443					8.0	8.9	10.6
1-Mar-96	8	51	0.432	7.3	580							8.6	8.7	10.6
9-Mar-96	9	59	0.319	4.8	621		366					4.8	5.1	10.4
17-Mar-96	10	67	0.420	7.1	885			312	13.0	6.90	2.60	8.0	8.2	10.4
25-Mar-96	11	75	0.440	7.3	746	14	408					8.8	8.7	10.4
1-Apr-96	12	82	0.419	7.2			397					7.8	7.9	10.4
8-Apr-96	13	89	0.389	7.0	627	43	379					6.8	7.0	10.2
15-Apr-96	14	96	0.430	7.2	834	15	405	207	10.3	6.30	1.76	8.4	8.4	10.2
22-Apr-96	15	103	0.424	7.3	601	11						8.2	8.0	10.2
29-Apr-96	16	110	0.436	7.0	711			150	8.5	5.00	1.46	8.6	8.6	10.2
7-May-96	17	118	0.462	7.1	610	10						9.1	9.2	10.2
14-May-96	18	125	0.447	7.2	718		340	143	8.1	4.60	1.25	8.0	8.7	10.4
21-May-96	19	132	0.431	7.1	651	22						8.1	8.4	10.4
28-May-96	20	139	0.450	7.2	634		293	140	7.5	4.11	0.96	9.4	9.6	10.3
4-Jun-96	21	146	0.466	7.1	672	9						9.7	9.8	10.4
11-Jun-96	22	153	0.457	6.8	757		333	100	6.2	3.40	0.87	9.1	9.3	10.4
18-Jun-96	23	160	0.458	6.9	659	7						9.3	9.3	10.4
25-Jun-96	24	167	0.469	6.8	653		350	158	7.0	3.74	1.06	9.7	9.7	10.4
2-Jul-96	25	174	0.457	6.9	618	37						9.1	9.3	10.5
8-Jul-96	26	180	0.466	6.7	705		419	135	9.8	4.08	1.10	9.4	9.6	10.5
15-Jul-96	27	187	0.461	6.7	761	6						9.5	9.5	10.5
22-Jul-96	28	194	0.476	6.4	767		386	112	9.0	3.68	0.47	9.8	9.9	10.6
29-Jul-96	29	201	0.469	6.5	888	6						9.9	10.0	10.7
6-Aug-96	30	209	0.442	5.3	1110		630	169	15.0	4.09	0.51	8.6	8.9	10.6
12-Aug-96	31	215	0.482	6.5	883	5						10.2	10.3	10.6
19-Aug-96	32	222	0.456	5.8	921	5	541	163	17.9	3.80	0.57	9.4	9.5	10.7
26-Aug-96	33	229	0.465	5.6	945		651					9.8	9.9	10.7
2-Sep-96	34	236	0.425	5.1	915	1	655	168	18.6	3.41	0.48	8.4	8.4	10.7
10-Sep-96	35	244	0.466	4.8	804		587	164	19.3	3.62	0.57	9.7	9.9	10.7
17-Sep-96	36	251	0.439	5.1	823	1	653					9.5	9.9	10.7
24-Sep-96	37	258	0.474	4.3	882		546					9.9	10.3	10.9
1-Oct-96	38	265	0.452	4.8	797	1	638	99	11.4	1.94	0.36	9.4	9.5	10.8
8-Oct-96	39	272	0.441	3.6	898							9.0	9.2	10.9
15-Oct-96	40	279	0.464	4.2	786		610	169	17.3	3.11	0.55	9.5	10.0	10.9
22-Oct-96	41	286	0.467	4.3	731							9.9	10.1	10.9
29-Oct-96	42	293	0.460	3.6	822		558	100	13.0	2.38	0.36	9.8	9.9	11.0
5-Nov-96	43	300	0.469	4.1	777							10.2	10.2	11.0
12-Nov-96	44	307	0.463	4.1	775		604						10.2	
19-Nov-96	45	314	0.395									10.4	10.6	11.2
27-Nov-96	46	322	0.394	3.6	804	1		101	13.4	2.15	0.40	10.0	9.9	11.2
3-Dec-96	47	328	0.438									10.6	10.6	
10-Dec-96	48	335	0.458											
18-Dec-96	49	343	0.464	4.5	668		526	104	13.4	2.44	0.44			

Sample: HC-2
Cell Type: tall
Test Conditions: 3 kg cell with dry/wet air cycles - 500 mL trickle leach

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	189	30	17	24					137	0.12		596	5.01				3.30	4.17
1	1	291	46	29	34					319	0.27		918	7.71	2249.4			1.36	1.70
2	8	353	54	34	39					452	0.38		1106	9.29				1.11	1.35
3	15	414	61	39	43	105.1	14.21	10.04	8.78	606	0.51		1285	10.80		218.8	321.4	0.95	1.12
4	23	466	65	42	45	84.4	10.67	7.48	6.44	758	0.64	132.8	1435	12.06		188.9	255.1	0.82	0.94
5	30	534	70	45	47	80.6	9.25	6.40	5.38	873	0.73	115.7	1625	13.65		171.8	239.9	1.42	1.58
6	37	592	73	46	47	58.5	5.18	3.43	2.65	1090	0.92	216.8	1780	14.96	155.3	150.0	167.7	0.64	0.69
7	44	652	75	48	48	58.2	4.14	2.62	1.80	1154	0.97	64.2	1943	16.32		136.6	162.7	2.26	2.43
8	51	707	78	49	49	57.1	3.32	1.98	1.17	1213	1.02		2090	17.57		118.0	156.5	2.27	2.43
9	59	744	79	50	49	54.1	2.74	1.56	0.78	1252	1.05	34.1	2189	18.40		96.0	146.8	2.28	2.44
10	67	788	81	51	49	48.0	2.14	1.16	0.47	1306	1.10		2306	19.38	102.2	81.8	128.9	1.93	2.07
11	75	830	83	52	50	43.8	1.92	1.04	0.41	1366	1.15	52.4	2419	20.32		50.7	117.6	1.68	1.80
12	82	866	85	53	50	39.4	1.71	0.93	0.35	1421	1.19	55.4	2516	21.14		49.1	105.6	1.57	1.68
13	89	896	86	54	50	34.8	1.52	0.84	0.30	1470	1.23	49.1	2598	21.83		47.5	93.4	1.48	1.59
14	96	926	87	55	50	34.4	1.54	0.87	0.29	1528	1.28	58.1	2678	22.50	80.3	52.3	92.4	1.23	1.33
15	103	951	89	55	51	31.8	1.49	0.87	0.27	1583	1.33		2746	23.08		53.9	85.6	1.10	1.20
16	110	973	90	56	51	28.6	1.42	0.84	0.25	1637	1.37		2806	23.58	59.7	54.3	77.5	0.97	1.06
17	118	996	91	57	51	25.2	1.31	0.78	0.22	1692	1.42		2868	24.10		52.7	68.4	0.99	1.08
18	125	1017	93	58	51	23.4	1.27	0.75	0.21	1743	1.46	50.7	2926	24.59	58.3	53.0	63.9	1.01	1.10
19	132	1037	94	58	51	21.6	1.20	0.70	0.19	1788	1.50		2982	25.06		50.6	59.1	1.07	1.17
20	139	1058	95	59	52	20.8	1.16	0.66	0.18	1832	1.54	44.0	3039	25.54	57.2	48.4	56.9	1.15	1.25
21	146	1077	96	59	52	20.2	1.13	0.63	0.16	1881	1.58		3090	25.97		47.4	55.2	0.92	1.01
22	153	1092	97	60	52	19.3	1.09	0.61	0.15	1932	1.62	50.7	3132	26.32	42.0	47.9	52.8	0.72	0.79
23	160	1112	98	60	52	19.0	1.05	0.58	0.14	1984	1.67		3185	26.77		48.2	51.8	0.91	0.98
24	167	1137	99	61	52	19.9	1.05	0.57	0.15	2039	1.71	54.7	3252	27.32	66.3	50.0	54.0	1.08	1.16
25	174	1159	100	62	52	20.1	1.08	0.57	0.15	2097	1.76		3313	27.84		52.9	54.8	0.91	1.00
26	180	1180	102	62	53	21.2	1.20	0.59	0.16	2162	1.82	75.9	3371	28.33	68.5	57.9	58.0	0.77	0.87
27	187	1199	103	63	53	21.9	1.31	0.61	0.16	2224	1.87		3425	28.78		60.2	60.3	0.74	0.83
28	194	1217	105	63	53	21.6	1.39	0.62	0.14	2285	1.92	61.3	3475	29.20	50.4	62.1	59.7	0.70	0.79
29	201	1239	106	64	53	21.0	1.55	0.62	0.12	2365	1.99		3538	29.73		67.2	59.0	0.66	0.76
30	209	1263	109	65	53	20.9	1.70	0.60	0.10	2458	2.06	81.1	3609	30.33	62.4	72.1	59.3	0.64	0.74
31	215	1290	111	65	53	22.1	1.92	0.60	0.09	2552	2.14		3687	30.98		77.9	63.1	0.68	0.79
32	222	1315	114	66	53	23.2	2.17	0.60	0.08	2634	2.21	82.2	3760	31.60	73.1	81.9	67.0	0.72	0.85
33	229	1341	117	66	53	24.8	2.45	0.60	0.08	2735	2.30	100.9	3836	32.23		89.8	72.1	0.61	0.72
34	236	1364	119	67	53	25.1	2.61	0.57	0.08	2827	2.37	92.8	3906	32.83	70.4	92.5	73.7	0.62	0.73
35	244	1390	122	67	53	25.3	2.76	0.56	0.08	2919	2.45	79.7	3982	33.47	66.5	92.2	74.6	0.67	0.80
36	251	1411	125	68	53	23.4	2.65	0.51	0.08	3014	2.53	95.5	4044	33.99		89.9	69.5	0.52	0.62
37	258	1430	127	68	53	22.3	2.55	0.48	0.07	3100	2.60	86.3	4101	34.47		90.7	66.4	0.53	0.63
38	265	1445	129	69	53	20.2	2.33	0.42	0.07	3196	2.68	96.1	4146	34.84	44.4	89.8	60.2	0.37	0.44
39	272	1464	131	69	54	19.4	2.23	0.40	0.07	3288	2.76		4204	35.33		89.6	57.8	0.52	0.61
40	279	1490	134	69	54	20.1	2.23	0.40	0.07	3383	2.84	94.4	4280	35.97	76.5	92.8	59.6	0.66	0.78
41	286	1511	136	70	54	20.2	2.22	0.39	0.07	3474	2.92		4342	36.49		91.9	59.6	0.55	0.66
42	293	1527	138	70	54	19.4	2.17	0.39	0.07	3559	2.99	85.5	4389	36.88	46.6	91.8	57.5	0.43	0.52
43	300	1542	140	71	54	19.6	2.24	0.40	0.07	3650	3.06		4437	37.28		90.7	58.2	0.41	0.50
44	307	1558	142	71	54	18.7	2.22	0.40	0.07	3743	3.14	93.2	4484	37.68		91.0	56.0	0.40	0.49
45	314	1571	144	71	54	16.1	2.04	0.36	0.06	3820	3.21		4524	38.02		87.6	48.8	0.41	0.50
46	322	1584	146	71	54	14.2	1.86	0.32	0.05	3896	3.27		4565	38.36	35.4	82.1	43.2	0.42	0.52
47	328	1599	148	72	54	14.5	1.91	0.32	0.06	3977	3.34		4610	38.74		83.6	44.2	0.44	0.53
48	335	1615	150	72	54	14.5	1.91	0.32	0.06	4060	3.41		4658	39.14		82.0	44.2	0.46	0.55
49	343	1631	152	73	54	14.2	1.86	0.32	0.06	4141	3.48	71.2	4706	39.55	42.7	77.4	43.3	0.47	0.58

Sample: ABA-1
Cell Type: tall
Test Conditions: 3 kg cell with dry/wet air cycles - 500 mL trickle leach
Crush Size: minus 6mm
Cell Description: 10 cm diam x 40 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
Date	Cycle	Days	volume (L)	pH	Conduct. (uS/cm)	Alkalinity (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	End, 3-day dry (%)	End, 3-day wet (%)	End of leach (%)
10-Jan-96	0	0	0.685	8.0	2840	57	1800	2685	271.0	98.00	132.00			
11-Jan-96	1	1	0.716	7.9	2540			542	48.0	19.60	23.00			
18-Jan-96	2	8	0.506	7.8	2240									
25-Jan-96	3	15	0.450	7.7	2390									
2-Feb-96	4	23	0.386	7.8	2540		2100							
9-Feb-96	5	30	0.462	7.7	2090		1900					8.6	8.9	10.5
16-Feb-96	6	37	0.387	6.8	1980	23	2200	696	15.0	20.20	4.20	7.4	7.4	11.5
23-Feb-96	7	44	0.490	7.4	1722		1491					9.4	10.2	10.3
1-Mar-96	8	51	0.421	7.4	1830							7.6	7.7	9.9
9-Mar-96	9	59	0.330	4.8	1706							4.0	4.5	9.4
17-Mar-96	10	67	0.403	7.3	1805			670	10.9	15.40	2.90	6.1	7.0	9.7
25-Mar-96	11	75	0.430	7.3	1536	19	1137					7.4	7.3	9.5
1-Apr-96	12	82	0.364	5.9			1001					5.1	5.3	9.5
8-Apr-96	13	89	0.344	4.2	1477		1035					4.1	4.7	9.2
15-Apr-96	14	96	0.370	4.0	1596			234	10.2	15.00	2.34	5.4	5.5	9.2
22-Apr-96	15	103	0.397	6.6	1393	10						6.4	6.1	9.3
29-Apr-96	16	110	0.400	6.3	1238			460	8.6	10.00	1.75	6.6	6.6	9.3
7-May-96	17	118	0.421	7.1	1242	12						6.8	7.0	9.2
14-May-96	18	125	0.422	7.2	1314			483	7.8	9.00	1.56	6.6	7.1	9.4
21-May-96	19	132	0.443	6.6	1237	5						7.8	8.0	9.5
28-May-96	20	139	0.443	6.6	1240		753	346	6.7	7.48	1.15	7.8	8.0	9.6
4-Jun-96	21	146	0.445	7.0	1219	10						8.0	8.2	9.7
11-Jun-96	22	153	0.440	6.6	1220		883	458	7.0	6.70	1.31	7.8	8.0	9.6
18-Jun-96	23	160	0.443	6.1	1154	5						8.1	8.2	9.7
25-Jun-96	24	167	0.455	6.3	1216		870	380	7.1	6.16	1.31	8.5	8.6	9.8
2-Jul-96	25	174	0.463	6.7	1271	5						8.9	9.1	9.9
8-Jul-96	26	180	0.453	5.1	1517		1046	308	7.8	5.89	1.16	8.6	8.6	9.9
15-Jul-96	27	187	0.467	6.1	1301	2						9.0	9.1	9.9
22-Jul-96	28	194	0.468	4.6	1451		918	300	7.2	5.16	0.56	9.0	9.1	10.0
29-Jul-96	29	201	0.460	4.8	1677							9.1	9.2	10.1
6-Aug-96	30	209	0.450	3.7	1823		1238	377	12.0	5.72	0.58	8.3	8.7	10.0
12-Aug-96	31	215	0.477	4.6	1463							8.7	9.5	10.1
19-Aug-96	32	222	0.469	4.3	1377		1072	336	10.5	4.51	0.63	9.3	9.4	10.1
26-Aug-96	33	229	0.470	4.2	1490		1048					9.4	9.4	10.1
2-Sep-96	34	236	0.414	3.9	1132		707	262	8.2	3.48	0.57	7.4	7.4	10.0
10-Sep-96	35	244	0.459	4.0	1235		884	303	10.6	4.04	0.64	8.8	8.9	10.0
17-Sep-96	36	251	0.462	4.0	1203							8.6	9.1	10.0
24-Sep-96	37	258	0.451	3.7	1113		716					8.8	8.8	10.3
1-Oct-96	38	265	0.470	3.9	1059		747	230	7.2	2.04	0.43	9.3	9.4	10.2
8-Oct-96	39	272	0.433	3.2	1072							8.0	8.1	10.1
15-Oct-96	40	279	0.465	3.6	945		698	276	8.7	2.97	0.59	9.0	9.2	10.1
22-Oct-96	41	286	0.463	3.7	825							9.2	9.2	10.2
29-Oct-96	42	293	0.466	3.2	951		635	190	7.5	2.10	0.38	9.2	9.3	10.1
5-Nov-96	43	300	0.421	3.5	792							7.5	7.7	10.1
12-Nov-96	44	307	0.462	3.4	961		720						9.2	
19-Nov-96	45	314	0.461									8.8	9.2	10.2
27-Nov-96	46	322	0.460	3.2	906			172	7.6	1.85	0.45	9.2	9.1	10.2
3-Dec-96	47	328	0.463									9.6	9.8	
10-Dec-96	48	335	0.461											
18-Dec-96	49	343	0.457	3.6	756		470	154	6.5	1.76	0.37			

Sample: ABA-1
Cell Type: tall
Test Conditions: 3 kg cell with dry/wet air cycles - 500 mL trickle leach

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	613	62	22	30					411	0.30		1789	4.93				3.58	4.17
1	1	742	73	27	36					858	0.63		2160	5.95	2594.5			0.69	0.79
2	8	839	80	30	39					1187	0.87		2430	6.69				0.70	0.79
3	15	929	86	33	41	147.6	11.04	5.12	5.16	1491	1.09		2678	7.38		503.9	414.9	0.72	0.78
4	23	1011	89	36	43	121.1	8.30	4.12	3.82	1761	1.29	236.2	2897	7.98		410.8	337.3	0.73	0.78
5	30	1113	92	39	44	116.7	7.14	3.88	3.22	2053	1.50	292.5	3167	8.73		383.2	321.6	0.84	0.89
6	37	1203	94	42	44	89.6	4.10	2.83	1.72	2337	1.71	284.0	3400	9.37	232.8	287.6	241.2	0.76	0.79
7	44	1316	97	45	45	92.7	3.19	2.79	1.21	2581	1.89	243.5	3691	10.17		271.0	245.2	1.11	1.15
8	51	1412	99	47	46	93.8	2.53	2.70	0.86	2778	2.03		3939	10.85		250.2	245.1	1.17	1.21
9	59	1486	100	49	46	92.4	2.08	2.55	0.63	2922	2.14		4130	11.38		225.8	239.8	1.24	1.27
10	67	1576	101	51	46	87.5	1.67	2.29	0.46	3087	2.26		4361	12.01	202.2	195.5	225.9	1.31	1.35
11	75	1656	103	53	47	83.5	1.55	2.15	0.42	3249	2.38	142.4	4569	12.59		168.0	215.3	1.18	1.22
12	82	1711	104	55	47	72.8	1.36	1.92	0.36	3371	2.46	121.6	4711	12.98		145.6	187.9	1.08	1.13
13	89	1751	105	57	47	62.4	1.25	1.78	0.32	3490	2.55	118.6	4815	13.26		131.2	161.4	0.80	0.83
14	96	1780	107	59	48	55.5	1.27	1.83	0.32	3612	2.64		4892	13.48	77.5	130.6	144.1	0.56	0.61
15	103	1825	108	60	48	48.5	1.27	1.80	0.30	3739	2.73		5012	13.81		126.8	126.6	0.87	0.91
16	110	1887	109	62	48	46.1	1.22	1.68	0.28	3861	2.82		5170	14.24	158.1	122.2	120.3	1.21	1.24
17	118	1953	110	63	48	47.0	1.16	1.54	0.25	3983	2.91		5341	14.71		119.0	122.3	1.29	1.33
18	125	2021	111	64	49	52.5	1.15	1.45	0.24	4100	3.00		5515	15.19	174.4	118.7	136.2	1.39	1.43
19	132	2082	112	66	49	58.8	1.11	1.32	0.22	4217	3.08		5672	15.63		117.6	151.7	1.25	1.29
20	139	2133	113	67	49	59.8	1.06	1.22	0.21	4329	3.16	111.2	5804	15.99	132.0	114.7	154.0	1.10	1.14
21	146	2193	114	68	49	59.5	1.03	1.16	0.20	4450	3.25		5958	16.41		114.6	153.1	1.18	1.21
22	153	2260	115	69	49	61.4	1.04	1.12	0.19	4579	3.35	129.6	6130	16.89	172.4	119.3	157.9	1.24	1.28
23	160	2322	116	70	50	60.2	1.03	1.06	0.19	4709	3.44		6289	17.33		121.7	154.9	1.15	1.18
24	167	2379	117	71	50	59.5	1.03	1.00	0.19	4841	3.54	132.0	6438	17.74	148.7	124.7	153.1	1.05	1.08
25	174	2432	119	71	50	59.9	1.06	0.97	0.19	4989	3.65		6576	18.11		132.0	154.3	0.86	0.89
26	180	2479	120	72	50	59.0	1.13	0.97	0.20	5147	3.76	184.4	6697	18.45	141.6	143.5	152.2	0.71	0.74
27	187	2526	121	73	50	54.9	1.16	0.94	0.18	5300	3.87		6820	18.79		148.3	142.1	0.74	0.77
28	194	2573	122	74	50	51.8	1.17	0.91	0.16	5443	3.98	143.2	6942	19.12	121.7	151.1	134.4	0.78	0.82
29	201	2625	124	75	50	50.6	1.25	0.89	0.14	5608	4.10		7078	19.50		157.9	131.7	0.75	0.79
30	209	2682	125	76	50	49.8	1.35	0.85	0.11	5794	4.24	162.6	7227	19.91	130.4	161.0	130.2	0.73	0.77
31	215	2738	127	77	51	51.8	1.47	0.83	0.10	5977	4.37		7376	20.32		166.1	135.8	0.74	0.78
32	222	2791	129	77	51	52.9	1.56	0.80	0.09	6145	4.49	167.5	7514	20.70	138.1	169.0	138.8	0.75	0.79
33	229	2838	130	78	51	52.9	1.63	0.77	0.09	6309	4.61	164.3	7637	21.04		173.2	139.1	0.68	0.72
34	236	2874	131	78	51	49.8	1.57	0.70	0.09	6407	4.68	97.5	7733	21.30	95.1	159.7	130.9	0.89	0.94
35	244	2920	133	79	51	47.7	1.53	0.65	0.09	6542	4.78	118.4	7855	21.64	107.5	149.6	125.7	0.82	0.87
36	251	2963	134	79	51	43.7	1.42	0.57	0.09	6665	4.87		7969	21.95		133.8	115.3	0.84	0.88
37	258	3001	136	80	51	40.9	1.35	0.52	0.08	6773	4.95	107.5	8069	22.23		122.1	108.0	0.85	0.90
38	265	3037	137	80	51	38.8	1.28	0.46	0.08	6890	5.04	117.0	8164	22.49	94.8	112.9	102.4	0.74	0.78
39	272	3074	138	81	51	38.9	1.28	0.43	0.08	6994	5.11		8260	22.76		114.2	102.6	0.84	0.88
40	279	3117	139	81	51	39.3	1.27	0.41	0.08	7102	5.19	108.1	8373	23.07	112.5	112.0	103.5	0.95	1.00
41	286	3153	141	81	51	37.9	1.22	0.39	0.08	7205	5.27		8468	23.33		108.0	99.9	0.84	0.89
42	293	3182	142	82	51	36.2	1.21	0.37	0.07	7304	5.34	98.6	8547	23.54	78.6	106.2	95.4	0.72	0.76
43	300	3208	143	82	52	34.2	1.19	0.36	0.07	7399	5.41		8616	23.74		101.8	90.4	0.66	0.70
44	307	3236	144	82	52	32.4	1.20	0.35	0.07	7509	5.49	110.8	8691	23.94		103.1	86.1	0.60	0.64
45	314	3263	145	83	52	29.3	1.16	0.32	0.06	7612	5.56		8763	24.14		102.1	78.1	0.63	0.68
46	322	3289	146	83	52	26.6	1.11	0.29	0.06	7707	5.63		8834	24.34	61.9	97.7	71.2	0.67	0.71
47	328	3315	147	83	52	26.6	1.13	0.29	0.06	7795	5.70		8903	24.53		98.3	71.2	0.70	0.75
48	335	3340	148	83	52	26.3	1.13	0.29	0.07	7875	5.76		8969	24.71		95.3	70.5	0.74	0.79
49	343	3363	149	84	52	24.7	1.07	0.27	0.06	7947	5.81	62.6	9031	24.88	54.9	85.0	66.2	0.79	0.84

Sample: ABA-2
Cell Type: tall
Test Conditions: 3 kg cell with dry/wet air cycles - 500 mL trickle leach
Crush Size: minus 6mm
Cell Description: 10 cm diam x 40 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
			volume		Conduct.	Alkalinity	SO_4	Ca	Mg	K	Na	End, 3-day dry	End, 3-day wet	End of leach
Date	Cycle	Days	(L)	pH	(uS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(%)	(%)	(%)
10-Jan-96	0	0	0.664	8.0	2040	51	1300	2008	214.0	61.00	115.00			
11-Jan-96	1	1	0.697	7.9	2070			357	34.0	14.10	18.10			
18-Jan-96	2	8	0.476	7.8	2100									
25-Jan-96	3	15	0.429	7.8	2030									
2-Feb-96	4	23	0.386	7.9	1725		1300							
9-Feb-96	5	30	0.459	7.7	1081		800					8.2	8.3	10.2
16-Feb-96	6	37	0.395	7.8	1249	41	1300	394	19.0	7.00	5.50	7.4	7.6	11.2
23-Feb-96	7	44	0.514	7.8	775							10.2	11.1	10.4
1-Mar-96	8	51	0.417	7.7	592							7.0	7.1	12.9
9-Mar-96	9	59	0.439	7.4	688		366					8.3	8.4	9.8
17-Mar-96	10	67	0.373	7.7	681			201	8.8	3.90	2.70	5.4	5.6	9.4
25-Mar-96	11	75	0.416	7.8	675	40	384					6.7	6.7	9.1
1-Apr-96	12	82	0.392	7.7			346					5.8	5.8	9.2
8-Apr-96	13	89	0.352	7.8	576	42	320					4.6	4.8	8.9
15-Apr-96	14	96	0.448	7.7	808	37	393	217	9.4	3.80	2.23	7.9	7.9	8.9
22-Apr-96	15	103	0.394	7.7	559	33						6.0	5.7	9.0
29-Apr-96	16	110	0.425	7.6	642			130	7.4	3.20	1.78	6.0	6.1	8.9
7-May-96	17	118	0.419	7.8	594	35						6.1	6.5	8.8
14-May-96	18	125	0.430	7.8	639		284	133	6.7	3.00	1.49	6.1	6.8	8.9
21-May-96	19	132	0.436	7.7	663	35						7.2	7.4	9.0
28-May-96	20	139	0.440	7.7	601		285	140	6.2	2.76	1.17	7.6	7.7	9.0
4-Jun-96	21	146	0.445	7.7	630	31						7.3	7.5	9.0
11-Jun-96	22	153	0.447	7.6	665		300	163	6.4	2.80	1.29	7.5	7.6	9.0
18-Jun-96	23	160	0.472	7.7	675	33						8.6	8.5	9.1
25-Jun-96	24	167	0.448	7.6	623		300	174	5.6	2.40	1.24	7.4	7.6	9.1
2-Jul-96	25	174	0.464	7.8	691	36						8.1	8.1	9.2
8-Jul-96	26	180	0.416	7.5	666		353	146	6.1	2.50	1.12	6.6	6.6	9.0
15-Jul-96	27	187	0.463	7.7	741	37						8.2	8.2	9.0
22-Jul-96	28	194	0.449	7.5	705		342	131	5.2	2.22	0.55	7.6	7.7	9.1
29-Jul-96	29	201	0.462	7.6	807	35						8.1	8.2	9.1
6-Aug-96	30	209	0.440	7.4	833		424	172	5.6	1.85	0.46	6.8	7.3	9.0
12-Aug-96	31	215	0.472	7.7	763	39						8.2	8.6	9.1
19-Aug-96	32	222	0.466	7.6	748		450	132	4.8	1.84	0.37	8.0	8.3	9.1
26-Aug-96	33	229	0.466	7.4	733		400					8.3	8.3	9.2
2-Sep-96	34	236	0.429	7.4		30	415	164	4.9	1.74	0.39	7.1	7.1	9.1
10-Sep-96	35	244	0.466	7.3	630		360	141	4.9	1.71	0.40	8.1	8.3	9.1
17-Sep-96	36	251	0.441	7.3	626	27	352					7.6	7.8	9.1
24-Sep-96	37	258	0.364	7.4	711		402					7.7	7.8	9.3
1-Oct-96	38	265	0.443	7.4	609	31	355	128	4.2	1.06	0.26	6.1	7.5	9.0
8-Oct-96	39	272	0.456	7.4	657							7.5	7.9	9.1
15-Oct-96	40	279	0.454	7.3	640	27	385	179	5.0	1.64	0.36	7.6	7.8	9.1
22-Oct-96	41	286	0.471	7.5	571							8.3	8.5	9.1
29-Oct-96	42	293	0.449	7.4	574	27	344	124	4.4	1.36	0.23	7.6	7.8	9.2
5-Nov-96	43	300	0.469	7.4	601							8.2	8.5	9.2
12-Nov-96	44	307	0.467	7.5	595	31	395						8.4	
19-Nov-96	45	314	0.479									8.4	8.8	9.2
27-Nov-96	46	322	0.478	7.5	627	30		140	4.9	1.29	0.27	7.3	7.1	9.1
3-Dec-96	47	328	0.450									8.0	8.4	
10-Dec-96	48	335	0.455											
18-Dec-96	49	343	0.462	7.4	636	31	406	163	5.0	1.46	0.27			

Sample: ABA-2
Cell Type: tall
Test Conditions: 3 kg cell with dry/wet air cycles - 500 mL trickle leach

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	444	47	14	25					288	0.20		1307	3.95				3.71	4.36
1	1	527	55	17	30					590	0.41		1548	4.68	1681.7			0.66	0.76
2	8	585	60	19	32					796	0.56		1712	5.17				0.67	0.77
3	15	638	64	20	34	90.5	7.85	3.22	3.99	982	0.68		1862	5.63		324.0	258.9	0.69	0.77
4	23	687	67	22	35	73.9	6.10	2.48	3.01	1149	0.80	146.2	1997	6.03		262.2	210.0	0.70	0.78
5	30	746	71	23	37	70.4	5.46	2.21	2.60	1272	0.89	122.4	2159	6.52		229.6	198.8	1.16	1.27
6	37	798	73	24	37	52.6	3.50	1.38	1.49	1443	1.01	171.0	2299	6.95	140.0	165.8	146.1	0.73	0.79
7	44	857	76	25	38	52.9	3.09	1.20	1.17	1612	1.12		2459	7.43		158.6	145.2	0.84	0.91
8	51	899	78	26	39	50.6	2.69	1.03	0.91	1706	1.19		2570	7.77		140.8	137.7	1.05	1.14
9	59	935	80	26	39	48.2	2.39	0.92	0.75	1760	1.23	46.9	2669	8.06		118.7	130.5	1.63	1.76
10	67	960	81	27	40	40.5	1.89	0.74	0.56	1806	1.26		2736	8.26	58.6	101.2	109.0	1.29	1.38
11	75	989	82	27	40	35.1	1.61	0.65	0.48	1859	1.30	46.6	2812	8.49		76.8	94.4	1.28	1.37
12	82	1016	83	28	40	29.2	1.31	0.55	0.38	1905	1.33	45.2	2885	8.72		53.9	78.5	1.45	1.55
13	89	1041	84	28	40	26.2	1.15	0.49	0.33	1942	1.35	37.5	2952	8.92		43.5	70.3	1.60	1.71
14	96	1073	86	29	41	26.1	1.14	0.48	0.31	2001	1.40	58.7	3039	9.18	86.8	45.6	70.0	1.33	1.42
15	103	1096	87	29	41	26.4	1.17	0.49	0.30	2049	1.43		3100	9.37		47.2	71.0	1.14	1.23
16	110	1114	88	30	41	25.2	1.17	0.49	0.29	2097	1.46		3151	9.52	50.4	47.5	67.8	0.92	1.01
17	118	1133	89	30	42	22.7	1.09	0.46	0.26	2140	1.49		3201	9.67		45.8	61.4	1.01	1.10
18	125	1152	90	31	42	21.6	1.07	0.46	0.25	2181	1.52	40.7	3252	9.83	51.7	46.4	58.4	1.12	1.22
19	132	1172	91	31	42	19.1	0.98	0.43	0.22	2222	1.55		3306	9.99		43.1	51.9	1.15	1.24
20	139	1192	92	32	42	18.7	0.94	0.42	0.21	2264	1.58	41.8	3361	10.15	55.2	41.9	50.7	1.18	1.26
21	146	1215	93	32	42	19.5	0.92	0.41	0.19	2308	1.61		3421	10.34		41.0	52.6	1.24	1.33
22	153	1239	94	32	43	21.2	0.94	0.42	0.19	2352	1.64	44.7	3486	10.53	64.6	42.4	57.0	1.30	1.39
23	160	1266	94	33	43	22.7	0.94	0.41	0.19	2399	1.67		3556	10.74		43.7	60.7	1.35	1.43
24	167	1291	95	33	43	24.0	0.92	0.40	0.19	2444	1.70	44.8	3625	10.95	68.5	44.4	63.7	1.39	1.47
25	174	1316	96	33	43	24.8	0.91	0.40	0.19	2495	1.74		3690	11.15		46.1	65.8	1.18	1.25
26	180	1337	97	34	43	25.1	0.92	0.39	0.19	2544	1.77	57.1	3744	11.31	63.2	48.6	66.5	0.99	1.06
27	187	1358	98	34	43	24.5	0.91	0.38	0.18	2597	1.81		3802	11.48		50.5	65.0	0.96	1.02
28	194	1378	99	35	43	23.1	0.87	0.37	0.15	2649	1.85	51.2	3854	11.64	52.3	51.3	61.3	0.92	0.98
29	201	1401	100	35	44	22.5	0.87	0.36	0.13	2708	1.89		3916	11.83		54.2	59.9	0.95	1.01
30	209	1426	100	35	44	22.0	0.83	0.33	0.10	2770	1.93	54.4	3982	12.03	58.1	55.0	58.4	0.97	1.03
31	215	1450	101	35	44	22.7	0.82	0.31	0.08	2838	1.98		4045	12.22		58.9	60.2	0.83	0.88
32	222	1470	102	36	44	22.5	0.80	0.30	0.07	2908	2.03	69.9	4100	12.39	54.4	62.2	59.6	0.70	0.75
33	229	1493	103	36	44	23.2	0.79	0.29	0.07	2970	2.07	62.1	4160	12.57		64.4	61.3	0.89	0.94
34	236	1517	103	36	44	23.2	0.77	0.27	0.06	3030	2.11	59.4	4222	12.75	61.6	64.4	61.2	0.95	1.00
35	244	1539	104	36	44	22.6	0.76	0.27	0.06	3086	2.15	48.9	4280	12.93	50.7	63.2	59.5	0.94	0.99
36	251	1559	105	37	44	21.2	0.71	0.25	0.06	3137	2.19	51.7	4333	13.09		58.1	55.9	0.93	0.98
37	258	1575	105	37	44	20.3	0.67	0.23	0.05	3186	2.22	48.8	4375	13.22		54.0	53.6	0.79	0.83
38	265	1594	106	37	44	19.5	0.64	0.20	0.05	3239	2.26	52.4	4425	13.37	49.8	52.1	51.5	0.87	0.91
39	272	1617	107	37	44	19.5	0.64	0.19	0.05	3295	2.30		4486	13.55		51.5	51.4	1.00	1.04
40	279	1644	107	37	44	21.1	0.66	0.20	0.05	3353	2.34	58.2	4557	13.77	70.8	53.5	55.5	1.12	1.17
41	286	1668	108	38	44	21.8	0.67	0.20	0.04	3410	2.38		4620	13.96		54.6	57.4	1.00	1.05
42	293	1687	109	38	44	22.3	0.69	0.21	0.04	3462	2.41	51.5	4669	14.11	49.1	55.1	58.7	0.87	0.92
43	300	1707	110	38	44	22.5	0.71	0.22	0.04	3519	2.45		4722	14.27		56.2	59.3	0.83	0.88
44	307	1727	110	38	44	22.0	0.72	0.22	0.04	3581	2.50	61.5	4776	14.43		57.2	58.0	0.80	0.85
45	314	1749	111	39	44	20.9	0.72	0.21	0.04	3644	2.54		4834	14.60		58.3	55.3	0.82	0.87
46	322	1771	112	39	44	20.1	0.71	0.20	0.04	3708	2.59		4893	14.78	51.7	57.9	53.1	0.84	0.89
47	328	1793	113	39	44	21.3	0.74	0.21	0.04	3768	2.63		4951	14.96		61.3	56.5	0.88	0.93
48	335	1817	113	39	44	22.1	0.75	0.21	0.04	3830	2.67		5013	15.15		62.0	58.3	0.92	0.97
49	343	1842	114	39	44	22.3	0.74	0.21	0.04	3892	2.71	54.7	5079	15.35	57.8	60.5	58.9	0.96	1.01

Sample: ABA-3
Cell Type: tall
Test Conditions: 3 kg cell with dry/wet air cycles - 500 mL trickle leach
Crush Size: minus 6mm
Cell Description: 10 cm diam x 40 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
			volume		Conduct.	Alkalinity	SO_4	Ca	Mg	K	Na	End, 3-day dry	End, 3-day wet	End of leach
Date	Cycle	Days	(L)	pH	(uS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(%)	(%)	(%)
10-Jan-96	0	0	0.696	8.1	1739	54	800	1451	159.0	56.00	116.00			
11-Jan-96	1	1	0.705	7.9	1746			301	32.0	14.80	22.20			
18-Jan-96	2	8	0.413	7.7	1752									
25-Jan-96	3	15	0.428	7.8	1521									
2-Feb-96	4	23	0.379	7.9	1294		1000							
9-Feb-96	5	30	0.455	7.8	933		670					7.7	7.9	9.8
16-Feb-96	6	37	0.372	7.8	1024		710	313	14.0	6.40	6.10	6.9	7.1	11.0
23-Feb-96	7	44	0.477	7.8	533		328					8.8	9.7	10.3
1-Mar-96	8	51	0.387	7.7	460	45						5.5	6.2	9.5
9-Mar-96	9	59	0.421	7.5	559		274					7.5	7.6	9.5
17-Mar-96	10	67	0.339	7.7	544			149	6.1	3.70	3.10	3.9	4.3	9.3
25-Mar-96	11	75	0.441	7.7	626	34	370					6.8	6.7	9.2
1-Apr-96	12	82	0.350	7.7			312					4.2	4.4	9.2
8-Apr-96	13	89	0.330	7.8	449	44	244					3.6	3.9	8.9
15-Apr-96	14	96	0.433	7.7	834	32	482	223	7.3	3.50	2.84	7.3	7.5	8.9
22-Apr-96	15	103	0.368	7.7	501	34						4.8	4.9	8.9
29-Apr-96	16	110	0.428	7.6	583			118	5.1	2.80	1.95	6.0	6.1	8.9
7-May-96	17	118	0.439	7.8	576	35						7.1	7.4	8.9
14-May-96	18	125	0.444	7.8	598		258	122	4.1	2.50	1.63	7.3	7.5	9.1
21-May-96	19	132	0.454	7.7	601	33						8.0	8.0	9.2
28-May-96	20	139	0.534	7.7	530		218	122	3.5	2.12	1.21	8.0	8.2	9.1
4-Jun-96	21	146	0.453	7.7	580	32						7.9	8.1	9.2
11-Jun-96	22	153	0.444	7.6	594		261	145	3.5	2.20	1.37	7.5	7.6	9.2
18-Jun-96	23	160	0.441	7.6	572	23						7.8	7.7	9.3
25-Jun-96	24	167	0.468	7.6	568		277	162	3.0	1.88	1.21	8.3	8.5	9.3
2-Jul-96	25	174	0.466	7.8	582	34						8.5	2.0	2.8
8-Jul-96	26	180	0.462	7.7	606		310	132	3.2	1.99	1.16	8.2	8.4	9.4
15-Jul-96	27	187	0.467	7.7	636	28						8.4	8.5	9.4
22-Jul-96	28	194	0.466	7.6	629		292	114	2.7	1.70	0.52	8.7	8.7	9.5
29-Jul-96	29	201	0.448	7.6	719	33						7.9	8.1	9.5
6-Aug-96	30	209	0.462	7.5	754		368	153	2.8	1.49	0.44	8.4	8.4	9.5
12-Aug-96	31	215	0.469	7.7	639	33						8.7	9.0	9.6
19-Aug-96	32	222	0.454	7.5	484	27	304	112	2.3	1.02	0.36	8.2	8.3	9.5
26-Aug-96	33	229	0.465	7.5	587		313					38.7	8.8	9.6
2-Sep-96	34	236	0.411	7.3	517	18	283	114	2.2	1.16	0.37	6.8	6.8	9.5
10-Sep-96	35	244	0.477	7.4	635		358	148	2.6	1.34	0.44	8.7	9.0	9.4
17-Sep-96	36	251	0.465	7.3	545	23	315					8.4	8.6	9.5
24-Sep-96	37	258	0.445	7.3	504		287					7.7	8.2	9.8
1-Oct-96	38	265	0.406	7.3	464	22	262	93	1.8	0.74	0.24	6.3	6.7	9.5
8-Oct-96	39	272	0.457	7.3	583							7.9	8.4	9.6
15-Oct-96	40	279	0.448	7.2	594	20	347	151	2.1	1.17	0.37	8.1	8.2	9.6
22-Oct-96	41	286	0.447	7.6	480							9.0	9.2	9.6
29-Oct-96	42	293	0.433	7.3	457	19	278	98	1.6	0.98	0.27	7.8	7.9	9.6
5-Nov-96	43	300	0.468	7.4	513							8.8	8.9	9.7
12-Nov-96	44	307	0.466	7.3	513	22	338						8.9	
19-Nov-96	45	314	0.474									9.1	9.2	9.8
27-Nov-96	46	322	0.473	7.5	544	24		121	2.0	0.95	0.32	8.8	8.7	9.7
3-Dec-96	47	328	0.464									9.2	9.5	
10-Dec-96	48	335	0.462											
18-Dec-96	49	343	0.464	7.4	559	24	338	135	2.1	1.08	0.29			

Sample: ABA-3
Cell Type: tall
Test Conditions: 3 kg cell with dry/wet air cycles - 500 mL trickle leach

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	337	37	13	27					186	0.20		994	3.98				4.35	5.14
1	1	407	44	16	32					385	0.41		1202	4.81	1455.1			0.85	1.00
2	8	449	48	18	35					509	0.54		1323	5.29				0.81	0.93
3	15	493	52	20	37	72.8	6.98	3.23	4.70	645	0.69		1447	5.79		214.2	211.0	0.77	0.88
4	23	532	55	21	39	59.3	5.37	2.48	3.55	771	0.82	110.5	1555	6.22		178.1	170.6	0.74	0.82
5	30	579	57	22	40	56.5	4.74	2.19	3.05	872	0.93	101.5	1684	6.73		160.2	160.8	1.11	1.22
6	37	617	59	23	41	40.9	2.82	1.30	1.67	960	1.02	88.0	1788	7.15	104.2	111.8	113.9	1.06	1.14
7	44	661	61	24	42	41.2	2.44	1.13	1.33	1013	1.08	52.2	1904	7.62		97.9	113.0	1.99	2.14
8	51	691	62	25	42	38.5	2.00	0.94	1.01	1051	1.12		1984	7.94		79.1	104.5	1.84	1.97
9	59	717	63	25	43	36.1	1.70	0.82	0.81	1090	1.16	33.6	2055	8.22		62.0	97.3	1.66	1.78
10	67	734	64	26	43	29.4	1.28	0.64	0.58	1126	1.20		2100	8.40	39.4	48.0	78.8	1.11	1.19
11	75	759	65	26	44	26.0	1.10	0.58	0.51	1181	1.26	47.6	2166	8.66		40.6	69.6	1.09	1.15
12	82	780	66	27	44	22.0	0.89	0.49	0.42	1217	1.30	36.4	2223	8.89		37.7	58.8	1.43	1.52
13	89	803	66	27	44	20.7	0.80	0.44	0.37	1244	1.32	26.8	2283	9.13		35.5	55.1	2.01	2.12
14	96	835	68	28	45	22.3	0.80	0.43	0.35	1313	1.40	69.5	2368	9.47	84.8	42.3	59.1	1.11	1.17
15	103	856	68	28	45	23.7	0.84	0.44	0.35	1366	1.45		2423	9.69		46.6	62.8	0.96	1.02
16	110	873	69	28	45	22.8	0.82	0.42	0.33	1418	1.51		2468	9.87	45.1	47.6	60.5	0.77	0.82
17	118	890	70	29	45	21.4	0.77	0.40	0.30	1464	1.56		2515	10.06		48.1	56.7	0.92	0.98
18	125	908	70	29	46	20.5	0.74	0.40	0.29	1503	1.60	38.2	2563	10.25	47.7	50.3	54.4	1.13	1.20
19	132	927	71	29	46	17.9	0.65	0.37	0.25	1539	1.64		2611	10.44		43.8	47.4	1.23	1.29
20	139	949	71	30	46	18.0	0.62	0.37	0.24	1577	1.68	38.8	2668	10.67	56.9	41.2	47.6	1.34	1.41
21	146	969	72	30	46	18.7	0.58	0.35	0.22	1614	1.72		2721	10.88		37.9	49.1	1.34	1.40
22	153	990	73	31	46	20.0	0.57	0.35	0.21	1652	1.76	38.6	2777	11.11	55.8	37.6	52.3	1.33	1.39
23	160	1013	73	31	47	20.9	0.54	0.34	0.20	1692	1.80		2835	11.34		37.8	54.5	1.37	1.42
24	167	1038	73	31	47	22.2	0.52	0.32	0.20	1735	1.85	43.2	2900	11.60	65.2	39.3	57.8	1.40	1.45
25	174	1061	74	31	47	22.5	0.49	0.31	0.19	1781	1.90		2959	11.84		40.6	58.3	1.20	1.24
26	180	1081	74	32	47	23.2	0.50	0.31	0.19	1828	1.95	55.7	3012	12.05	61.7	44.2	60.0	1.02	1.06
27	187	1100	75	32	47	22.7	0.49	0.31	0.18	1875	2.00		3062	12.25		45.9	58.8	0.98	1.02
28	194	1118	75	32	47	21.7	0.48	0.30	0.16	1920	2.05	45.4	3108	12.43	46.1	47.1	56.2	0.94	0.97
29	201	1138	76	33	48	20.6	0.47	0.29	0.13	1970	2.10		3160	12.64		48.3	53.4	0.97	1.00
30	209	1162	76	33	48	20.1	0.44	0.27	0.11	2026	2.16	49.6	3220	12.88	53.1	49.2	52.2	1.00	1.03
31	215	1182	77	33	48	20.2	0.42	0.24	0.08	2079	2.21		3274	13.10		50.1	52.3	0.95	0.98
32	222	1199	77	33	48	19.8	0.40	0.22	0.07	2125	2.26	46.0	3318	13.27	43.8	50.0	51.1	0.88	0.91
33	229	1217	77	33	48	19.7	0.39	0.20	0.06	2173	2.31	48.5	3363	13.45		50.6	51.0	0.87	0.89
34	236	1232	78	33	48	18.9	0.37	0.18	0.06	2212	2.36	38.8	3403	13.61	40.3	48.5	48.7	0.97	1.00
35	244	1256	78	34	48	18.9	0.36	0.18	0.06	2269	2.42	49.8	3464	13.86	53.0	48.5	48.7	0.99	1.02
36	251	1276	78	34	48	18.2	0.34	0.17	0.06	2318	2.47	48.8	3516	14.06		46.5	47.0	0.99	1.02
37	258	1292	79	34	48	18.1	0.34	0.17	0.05	2360	2.51	42.5	3558	14.23		45.8	46.7	0.93	0.96
38	265	1305	79	34	48	17.2	0.32	0.15	0.05	2396	2.55	35.5	3591	14.36	32.5	43.3	44.3	0.85	0.88
39	272	1324	79	34	48	17.8	0.32	0.15	0.05	2442	2.60		3638	14.55		44.7	45.7	0.96	0.99
40	279	1346	79	34	48	18.1	0.30	0.15	0.05	2494	2.66	51.8	3696	14.78	57.7	45.0	46.5	1.04	1.07
41	286	1365	80	35	48	17.8	0.29	0.14	0.05	2541	2.71		3744	14.97		44.6	45.6	0.96	0.98
42	293	1379	80	35	48	17.3	0.27	0.14	0.04	2581	2.75	40.1	3780	15.12	36.4	44.1	44.4	0.85	0.87
43	300	1395	80	35	48	18.0	0.28	0.15	0.05	2629	2.80		3822	15.29		46.6	46.2	0.81	0.83
44	307	1412	81	35	48	17.7	0.27	0.16	0.05	2681	2.86	52.5	3865	15.46		47.8	45.4	0.78	0.80
45	314	1430	81	35	48	16.8	0.27	0.15	0.05	2735	2.91		3912	15.65		48.1	43.2	0.82	0.84
46	322	1449	81	35	48	16.5	0.27	0.14	0.04	2788	2.97		3961	15.84	42.9	48.1	42.3	0.86	0.88
47	328	1469	81	35	48	18.0	0.29	0.15	0.05	2840	3.02		4011	16.04		51.9	46.2	0.89	0.92
48	335	1489	82	36	48	18.8	0.31	0.15	0.05	2892	3.08		4063	16.25		52.7	48.2	0.93	0.95
49	343	1510	82	36	49	19.0	0.31	0.15	0.05	2945	3.14	45.8	4116	16.47	46.9	51.2	48.8	0.96	0.98

APPENDIX 9

TABULATED RESULTS

SHAKEN CELLS

Sample: HC-1
Cell Type: shaken
Test Conditions: 1 kg cell with dry/wet air cycles - flooded, 1 hr soak, lifted and swirled for 30 sec, drained, fines returned
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
			volume		Conduct.	Alkalinity	SO_4	Ca	Mg	K	Na	End, 3-day dry	End, 3-day wet	End of leach
Date	Cycle	Days	(L)	pH	(uS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(%)	(%)	(%)
25-Jan-96	0	0	0.565	8.1	792	58	410	722	133.0	79.00	99.00			
26-Jan-96	1	1	0.292	8.0	763			145	26.0	18.70	17.90			
2-Feb-96	2	8	0.412	7.8	733									
9-Feb-96	3	15	0.387	7.1	698		540							
16-Feb-96	4	22	0.356	7.8	553		410					1.3	2.1	14.2
23-Feb-96	5	29	0.456	7.8	318							8.9	6.6	13.4
1-Mar-96	6	36	0.490	7.8	259		97	53	7.5	3.30	1.50	11.7	13.4	13.5
9-Mar-96	7	44	0.418	7.6	269							7.1	8.0	13.8
17-Mar-96	8	52	0.479	7.7	259		106					5.5	6.4	11.9
25-Mar-96	9	60	0.446	7.7	248	29	102					6.9	6.3	11.6
1-Apr-96	10	67	0.429	7.7			93	44	5.1	2.10	0.59	2.4	3.1	11.2
8-Apr-96	11	74	0.396	7.7	229	29	97					2.4	2.9	10.8
15-Apr-96	12	81	0.414	7.7	301	30						0.3	4.7	11.1
22-Apr-96	13	88	0.466	7.6	225	22		35	4.7	1.80	0.50	7.2	6.7	11.6
29-Apr-96	14	95	0.481	7.6	240	25						7.6	8.9	11.3
7-May-96	15	103	0.491	7.5	213		67	34	4.1	1.50	0.36	8.1	11.1	11.0
14-May-96	16	110	0.474	7.5	202	17						6.0	7.9	11.1
21-May-96	17	117	0.476	7.6	196		64	27	3.8	1.40	0.35	7.7	7.9	12.1
28-May-96	18	124	0.499	7.3	207	17						10.0	10.0	11.9
4-Jun-96	19	131	0.459	7.5	203		73	42	4.4	1.40	0.30	7.4	8.9	11.3
11-Jun-96	20	138	0.472	7.3	223	15						9.2	10.0	11.5
18-Jun-96	21	145	0.478	7.5	204		77	32	4.6	1.40	0.29	6.0	6.2	10.8
25-Jun-96	22	152	0.474	7.4	223	15						8.2	8.7	11.2
2-Jul-96	23	159	0.467	7.4	218		81	37	4.5	1.08	0.23	8.6	9.0	11.8
8-Jul-96	24	165	0.473	7.3	232	19						9.7	10.1	12.0
15-Jul-96	25	172	0.465	7.4	237		77	37	4.6	0.80	0.14	7.4	8.4	10.9
22-Jul-96	26	179	0.462	7.2	234	15						7.5	7.6	10.8
29-Jul-96	27	186	0.455	7.1	280		111	44	5.3	1.35	0.13	7.7	7.8	11.1
6-Aug-96	28	194	0.465	7.3	287	9						8.1	8.4	11.2
12-Aug-96	29	200	0.464	7.4	277		102	42	4.9	1.10	0.15	8.9	8.9	11.3
19-Aug-96	30	207	0.450	7.3	321	6	154					6.0	7.2	11.0
26-Aug-96	31	214	0.470	7.4	302		123	46	5.5	1.08	0.12	8.7	9.3	11.2
2-Sep-96	32	221	0.441	7.2	264	17	128	47	4.5	1.08	0.12	5.4	5.4	10.5
10-Sep-96	33	229	0.446	7.2	249		119					6.0	6.2	10.4
17-Sep-96	34	236	0.437	7.2	262	16	130	50	5.1	1.11	0.31	5.2	5.3	10.5
24-Sep-96	35	243	0.454	7.2	266		132	42	4.9	0.78	0.20	7.9	8.0	11.5
1-Oct-96	36	250	0.446	7.2	226	19	115					8.3	9.1	11.4
8-Oct-96	37	257	0.458	7.3	294							9.5	9.6	12.9
15-Oct-96	38	264	0.449	7.2	313	19	153	64	5.7	1.08	0.14	9.0	9.2	13.5
22-Oct-96	39	271	0.477	7.5	284							11.4	11.8	13.2
29-Oct-96	40	278	0.463	7.4	288	23	144	52	5.4	0.92	0.08	8.4	8.5	11.3
5-Nov-96	41	285	0.438	7.6	342							6.0	6.4	12.0
12-Nov-96	42	292	0.464	7.4	279	24	150						8.9	
19-Nov-96	43	299	0.479									9.3	10.5	11.7
27-Nov-96	44	307	0.478	7.5	321	20		53	6.3	0.85	0.09	5.6	4.7	11.5
3-Dec-96	45	313	0.478									8.5	8.7	
10-Dec-96	46	320	0.472											
18-Dec-96	47	328	0.463	7.4	342	24	179	64	6.7	1.02	0.10			

Sample: HC-1
Cell Type: shaken
Test Conditions: 1 kg cell with dry/wet air cycles - flooded, 1 hr soak, lifted and swirled for 30 sec, drained, fines returned

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	408	75	45	56					231	0.13		1329	2.98				4.23	5.51
1	1	450	83	50	61					364	0.21		1466	3.29	959.0			0.77	0.99
2	8	502	92	56	67					568	0.32		1635	3.66				0.61	0.79
3	15	544	99	61	72	63.6	11.18	7.81	7.29	777	0.44	208.9	1769	3.97		254.6	205.2	0.48	0.62
4	22	576	104	65	74	53.5	9.31	6.40	5.89	923	0.53	146.0	1871	4.19		220.1	172.3	0.53	0.67
5	29	608	109	68	77	48.5	8.30	5.55	4.99	1039	0.59		1973	4.42		194.8	155.5	0.68	0.85
6	36	634	113	69	77	36.9	6.09	3.84	3.24	1086	0.62	47.5	2053	4.60	80.2	144.5	117.4	1.31	1.62
7	44	656	116	70	78	29.9	4.70	2.72	2.08	1129	0.64		2118	4.75		109.0	94.1	1.20	1.47
8	52	679	119	72	78	25.5	3.78	1.97	1.29	1179	0.67	44.4	2189	4.91		76.1	79.4	1.10	1.33
9	60	699	122	73	79	22.8	3.17	1.50	0.79	1225	0.70	39.8	2251	5.05		55.6	70.0	1.09	1.31
10	67	718	124	74	79	20.2	2.63	1.13	0.44	1265	0.72	39.9	2307	5.17	56.2	41.6	61.5	1.14	1.35
11	74	734	126	75	79	18.4	2.32	0.98	0.34	1303	0.74	38.4	2356	5.28		39.9	55.7	1.01	1.22
12	81	750	128	75	79	17.9	2.22	0.92	0.29	1340	0.76		2403	5.39		40.0	53.9	1.02	1.23
13	88	766	130	76	80	17.1	2.12	0.85	0.25	1378	0.79		2453	5.50	49.8	38.7	51.4	1.02	1.25
14	95	783	132	77	80	16.7	2.09	0.82	0.23	1414	0.81		2503	5.61		37.9	50.5	1.11	1.34
15	103	800	134	78	80	15.9	2.00	0.77	0.21	1447	0.83	28.8	2554	5.73	43.8	35.5	47.9	1.22	1.46
16	110	814	136	78	80	15.5	1.98	0.75	0.20	1478	0.84		2597	5.82		34.0	47.0	1.12	1.36
17	117	827	138	79	80	14.9	1.94	0.72	0.18	1508	0.86	30.5	2637	5.91	39.6	32.7	45.4	1.01	1.25
18	124	844	140	80	80	15.1	1.92	0.70	0.17	1543	0.88		2688	6.03		32.0	45.7	1.21	1.45
19	131	864	142	80	81	15.6	1.90	0.67	0.16	1576	0.90	33.5	2745	6.15	56.6	31.5	47.0	1.38	1.62
20	138	881	144	81	81	16.2	1.97	0.67	0.15	1612	0.92		2797	6.27		32.9	48.8	1.18	1.42
21	145	896	146	82	81	16.4	2.04	0.67	0.15	1648	0.94	36.8	2845	6.38	47.3	34.1	49.5	1.00	1.23
22	152	913	148	82	81	17.1	2.11	0.65	0.14	1686	0.96		2895	6.49		35.5	51.5	1.05	1.28
23	159	930	150	83	81	17.1	2.12	0.61	0.13	1724	0.98	37.9	2947	6.61	51.9	36.2	51.6	1.10	1.32
24	165	947	153	83	81	17.3	2.21	0.59	0.12	1761	1.01		2999	6.72		38.1	52.3	1.12	1.35
25	172	965	155	84	81	17.2	2.21	0.53	0.11	1797	1.03	35.8	3051	6.84	51.9	38.1	52.2	1.15	1.39
26	179	983	157	84	81	17.9	2.23	0.50	0.09	1840	1.05		3107	6.97		39.5	54.1	1.03	1.24
27	186	1003	159	85	81	18.7	2.28	0.50	0.08	1891	1.08	50.5	3167	7.10	60.0	42.2	56.2	0.95	1.14
28	194	1023	162	85	81	18.7	2.27	0.50	0.07	1940	1.11		3227	7.24		43.3	56.1	0.97	1.16
29	200	1043	164	86	82	19.1	2.30	0.51	0.06	1988	1.13	55.2	3285	7.37	67.8	45.3	57.2	0.99	1.18
30	207	1063	166	86	82	19.6	2.34	0.54	0.06	2057	1.17	69.2	3344	7.50		52.0	58.7	0.69	0.82
31	214	1084	169	87	82	20.2	2.40	0.54	0.06	2115	1.21	57.8	3409	7.64	64.7	54.9	60.4	0.90	1.07
32	221	1105	171	87	82	20.3	2.31	0.51	0.06	2171	1.24	56.5	3469	7.78	60.1	56.1	60.4	0.88	1.02
33	229	1127	173	88	82	20.6	2.26	0.49	0.07	2224	1.27	46.4	3532	7.92		56.8	61.0	0.98	1.14
34	236	1148	175	88	82	20.5	2.19	0.48	0.08	2281	1.30	56.8	3596	8.06	63.9	57.1	60.4	0.92	1.08
35	243	1168	177	89	82	20.4	2.17	0.45	0.08	2341	1.34	59.9	3653	8.19	56.9	55.2	60.0	0.76	0.91
36	250	1190	180	89	82	20.5	2.12	0.43	0.09	2392	1.37	51.2	3717	8.34		54.0	59.9	1.03	1.21
37	257	1216	182	89	82	21.5	2.21	0.42	0.09	2454	1.40		3793	8.50		54.9	62.9	1.01	1.18
38	264	1244	185	90	82	23.5	2.36	0.43	0.09	2522	1.44	68.7	3875	8.69	82.5	59.6	68.6	1.00	1.15
39	271	1272	187	90	82	24.7	2.44	0.43	0.07	2593	1.48		3955	8.87		62.4	71.8	0.94	1.09
40	278	1296	190	91	82	25.7	2.50	0.45	0.06	2660	1.52	66.7	4026	9.03	70.6	63.8	74.6	0.87	1.01
41	285	1319	192	91	82	25.9	2.53	0.45	0.05	2724	1.55		4093	9.18		66.4	75.2	0.85	1.00
42	292	1343	195	92	82	25.5	2.58	0.44	0.05	2794	1.59	69.6	4165	9.34		68.0	74.5	0.84	0.99
43	299	1368	198	92	82	24.8	2.65	0.42	0.04	2868	1.64		4241	9.51		69.2	73.1	0.81	0.97
44	307	1394	201	92	83	23.7	2.64	0.40	0.04	2946	1.68		4316	9.68	66.3	68.5	70.2	0.79	0.94
45	313	1421	204	93	83	25.0	2.83	0.41	0.04	3026	1.73		4397	9.86		73.2	74.2	0.81	0.96
46	320	1449	207	93	83	26.1	2.96	0.42	0.04	3107	1.77		4481	10.05		76.6	77.5	0.84	0.99
47	328	1479	210	94	83	26.4	2.95	0.42	0.04	3190	1.82	72.5	4568	10.24	76.1	77.1	78.2	0.86	1.01

Sample: HC-2
Cell Type: shaken
Test Conditions: 1 kg cell with dry/wet air cycles - flooded, 1 hr soak, lifted and swirled for 30 sec, drained, fines returned
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
			volume		Conduct.	Alkalinity	SO_4	Ca	Mg	K	Na	End, 3-day dry	End, 3-day wet	End of leach
Date	Cycle	Days	(L)	pH	(uS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(%)	(%)	(%)
25-Jan-96	0	0	0.597	7.8	811	43	470	715	99.0	61.00	81.00			
26-Jan-96	1	1	0.309	7.5	796			162	22.0	15.80	15.40			
2-Feb-96	2	8	0.414	7.2	781									
9-Feb-96	3	15	0.408	6.8	738		560							
16-Feb-96	4	22	0.341	7.1	584		400							
23-Feb-96	5	29	0.471	7.3	383							9.0	9.8	11.9
1-Mar-96	6	36	0.482	7.4	269		121	63	4.4	2.60	1.40	9.0	10.4	11.3
9-Mar-96	7	44	0.449	7.3	275							8.7	8.9	11.1
17-Mar-96	8	52	0.459	7.3	280		130					6.7	7.8	11.6
25-Mar-96	9	60	0.440	7.5	250	18	124					6.4	5.5	9.9
1-Apr-96	10	67	0.461	7.2			95	44	2.4	1.60	0.59	4.9	4.0	10.9
8-Apr-96	11	74	0.411	7.3	237	15	122					2.8	3.5	10.3
15-Apr-96	12	81	0.439	7.3	285	15						8.3	8.7	10.0
22-Apr-96	13	88	0.478	7.1	188	11		31	1.6	1.30	0.49	5.4	5.4	9.6
29-Apr-96	14	95	0.461	7.2	236	10						6.4	6.6	9.4
7-May-96	15	103	0.467	7.1	204		77	37	1.6	1.20	0.38	7.4	7.9	9.3
14-May-96	16	110	0.469	7.1	194	8						6.2	7.4	10.1
21-May-96	17	117	0.460	7.1	182		68	28	1.4	1.10	0.36	6.8	7.2	11.3
28-May-96	18	124	0.478	7.0	183	6						9.2	9.5	11.1
4-Jun-96	19	131	0.474	7.1	184		76	40	1.4	1.00	0.30	8.8	9.6	10.2
11-Jun-96	20	138	0.439	6.9	207	6						12.0	3.8	8.2
18-Jun-96	21	145	0.446	7.0	175		69	28	2.0	1.00	0.32	5.6	5.8	9.2
25-Jun-96	22	152	0.453	6.9	190	5						4.6	5.7	9.0
2-Jul-96	23	159	0.459	7.0	179		74	32	1.7	0.80	0.25	6.5	6.9	9.8
8-Jul-96	24	165	0.477	6.8	210	7						5.4	7.7	9.1
15-Jul-96	25	172	0.464	7.0	197		67	30	1.7	0.61	0.15	5.6	6.3	9.4
22-Jul-96	26	179	0.473	6.6	199	5						7.0	7.8	9.4
29-Jul-96	27	186	0.471	6.7	238		157	38	2.1	1.05	0.15	6.1	7.3	9.8
6-Aug-96	28	194	0.487	6.6	231	6						5.1	8.5	9.7
12-Aug-96	29	200	0.463	6.9	228		92	36	1.9	0.89	0.16	7.3	7.3	9.0
19-Aug-96	30	207	0.480	6.7	250	6	119					6.2	9.0	9.6
26-Aug-96	31	214	0.491	6.8	233		90	35	2.3	0.89	0.13	8.8	9.8	9.8
2-Sep-96	32	221	0.482	6.8	218	8	108	40	1.9	0.79	0.11	9.0	9.0	9.9
10-Sep-96	33	229	0.472	6.6	189		92					2.6	3.6	5.4
17-Sep-96	34	236	0.487	6.6	195	6	99	32	1.9	0.74	0.13	4.7	5.5	5.7
24-Sep-96	35	243	0.459	6.6	181		91	27	1.6	0.57	0.13	3.0	3.3	5.8
1-Oct-96	36	250	0.468	6.6	192	6	108					3.6	3.7	5.8
8-Oct-96	37	257	0.478	6.6	210							4.4	4.8	6.3
15-Oct-96	38	264	0.453	6.3	212	3	111	42	1.9	0.89	0.13	2.4	3.2	7.2
22-Oct-96	39	271	0.493	6.5	226							6.2	6.5	6.1
29-Oct-96	40	278	0.450	6.3	216	6	116	36	2.0	0.66	0.08	1.4	1.8	5.7
5-Nov-96	41	285	0.456	6.7	233							3.2	3.6	7.4
12-Nov-96	42	292	0.465	6.4	186	2	112						4.7	
19-Nov-96	43	299	0.470									4.1	4.7	6.7
27-Nov-96	44	307	0.470	6.4	189	5		34	1.8	0.65	0.13	5.4	4.9	5.8
3-Dec-96	45	313	0.469									1.3	2.3	
10-Dec-96	46	320	0.456											
18-Dec-96	47	328	0.400	5.7	272	2	156	39	2.7	0.88	0.12			

Sample: HC-2
Cell Type: shaken
Test Conditions: 1 kg cell with dry/wet air cycles - flooded, 1 hr soak, lifted and swirled for 30 sec, drained, fines returned

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	427	59	36	48					281	0.24		1311	11.02				3.65	4.48
1	1	477	66	41	53					435	0.37		1465	12.31	1071.9			0.78	0.95
2	8	536	74	47	58					654	0.55		1643	13.81				0.64	0.78
3	15	586	80	51	62	74.1	9.58	6.82	6.52	883	0.74	228.4	1793	15.07		280.9	224.9	0.52	0.63
4	22	621	84	54	65	61.6	7.78	5.50	5.20	1019	0.86	136.3	1897	15.94		234.9	186.3	0.62	0.73
5	29	660	87	56	67	56.2	6.80	4.77	4.42	1142	0.96		2010	16.89		207.8	168.6	0.76	0.88
6	36	690	89	57	67	42.6	4.70	3.23	2.85	1200	1.01	58.3	2095	17.60	84.8	153.0	126.0	1.25	1.39
7	44	716	91	58	68	35.1	3.42	2.29	1.86	1256	1.05		2167	18.21		117.1	101.9	1.11	1.24
8	52	741	93	59	68	29.3	2.47	1.59	1.14	1316	1.10	52.2	2235	18.78		82.0	83.6	0.99	1.09
9	60	762	94	60	69	26.1	1.92	1.21	0.74	1370	1.15	47.7	2294	19.28		64.8	73.2	0.94	1.04
10	67	782	95	61	69	22.6	1.44	0.89	0.42	1414	1.19	43.8	2349	19.74	55.3	50.2	62.5	1.11	1.21
11	74	799	96	62	69	20.0	1.21	0.77	0.34	1464	1.23	50.1	2394	20.12		48.7	55.1	0.78	0.85
12	81	814	97	62	69	18.6	1.07	0.71	0.29	1513	1.27		2436	20.47		48.6	50.8	0.77	0.83
13	88	829	98	63	70	17.2	0.94	0.66	0.26	1561	1.31		2476	20.81	40.2	47.6	46.9	0.75	0.81
14	95	845	98	63	70	16.5	0.86	0.63	0.23	1601	1.34		2518	21.16		46.2	44.9	0.92	1.00
15	103	862	99	64	70	15.5	0.77	0.58	0.21	1637	1.37	31.5	2565	21.55	40.5	43.3	41.9	1.15	1.24
16	110	877	100	65	70	15.3	0.73	0.57	0.20	1671	1.40		2606	21.90		40.2	41.2	1.08	1.16
17	117	890	100	65	70	14.8	0.70	0.55	0.19	1702	1.43	31.3	2641	22.19	34.9	36.9	39.8	0.99	1.07
18	124	906	101	66	71	15.0	0.68	0.52	0.17	1737	1.46		2684	22.56		34.3	40.4	1.13	1.21
19	131	925	102	66	71	15.7	0.67	0.50	0.16	1773	1.49	36.0	2734	22.98	50.2	33.4	42.0	1.26	1.34
20	138	940	102	66	71	15.7	0.69	0.49	0.16	1805	1.52		2775	23.32		33.5	42.0	1.13	1.22
21	145	953	103	67	71	15.1	0.72	0.47	0.15	1836	1.54	30.8	2810	23.61	34.9	32.9	40.8	0.97	1.09
22	152	966	104	67	71	15.2	0.76	0.45	0.14	1868	1.57		2847	23.93		33.1	41.3	1.01	1.11
23	159	981	105	68	71	14.9	0.78	0.43	0.13	1902	1.60	33.9	2887	24.26	39.9	33.0	40.6	1.04	1.13
24	165	996	106	68	71	14.5	0.84	0.41	0.13	1935	1.63		2927	24.60		33.5	39.8	1.06	1.15
25	172	1010	107	68	71	14.3	0.85	0.38	0.11	1967	1.65	31.1	2965	24.92	38.1	33.3	39.3	1.07	1.17
26	179	1026	107	69	71	15.0	0.85	0.37	0.10	2020	1.70		3009	25.29		37.9	41.1	0.73	0.80
27	186	1044	108	69	72	15.9	0.88	0.39	0.09	2093	1.76	73.9	3058	25.70	48.8	46.4	43.5	0.58	0.63
28	194	1062	109	70	72	16.1	0.89	0.40	0.08	2154	1.81		3107	26.11		50.4	44.1	0.71	0.78
29	200	1078	110	70	72	16.5	0.91	0.41	0.07	2197	1.84	49.7	3153	26.49	52.9	52.2	45.1	0.94	1.02
30	207	1095	111	70	72	17.1	0.95	0.44	0.07	2254	1.89	57.1	3200	26.89		57.4	46.8	0.72	0.79
31	214	1112	112	71	72	17.4	1.00	0.45	0.07	2298	1.93	44.2	3247	27.29	47.7	55.7	47.6	0.93	1.03
32	221	1132	113	71	72	17.6	0.98	0.43	0.07	2350	1.97	52.1	3299	27.72	52.1	51.3	48.2	0.89	0.96
33	229	1149	114	72	72	17.4	0.97	0.40	0.06	2393	2.01	38.0	3345	28.11		47.9	47.6	0.94	1.02
34	236	1164	115	72	72	16.7	0.95	0.38	0.06	2442	2.05	48.2	3388	28.47	42.8	47.7	45.8	0.78	0.85
35	243	1177	116	72	72	15.8	0.89	0.35	0.06	2483	2.09	41.7	3422	28.76	34.0	44.7	43.3	0.71	0.78
36	250	1192	117	73	72	15.4	0.83	0.33	0.06	2534	2.13	50.5	3463	29.10		45.9	42.0	0.71	0.77
37	257	1209	118	73	72	15.1	0.82	0.33	0.06	2586	2.17		3511	29.50		45.9	41.1	0.81	0.88
38	264	1228	118	73	72	15.9	0.84	0.34	0.06	2637	2.21	50.3	3562	29.93	51.2	48.6	43.3	0.91	0.98
39	271	1248	119	74	72	16.7	0.84	0.35	0.06	2693	2.26		3614	30.37		50.2	45.2	0.82	0.89
40	278	1264	120	74	72	17.4	0.88	0.35	0.05	2745	2.30	52.2	3658	30.74	44.2	52.3	47.2	0.74	0.81
41	285	1280	121	74	72	17.7	0.89	0.35	0.05	2797	2.35		3702	31.11		52.5	47.9	0.75	0.81
42	292	1296	122	75	72	17.4	0.90	0.34	0.05	2849	2.39	52.0	3747	31.49		52.5	47.2	0.75	0.82
43	299	1313	123	75	72	16.8	0.90	0.32	0.05	2906	2.44		3791	31.86		53.8	45.8	0.69	0.75
44	307	1328	124	75	72	15.7	0.85	0.29	0.05	2966	2.49		3834	32.22	38.0	53.2	42.8	0.63	0.68
45	313	1345	125	76	73	16.3	0.89	0.31	0.05	3031	2.55		3880	32.61		57.3	44.4	0.62	0.68
46	320	1362	126	76	73	16.4	0.94	0.32	0.06	3098	2.60		3927	33.00		60.4	45.0	0.61	0.67
47	328	1378	127	76	73	15.9	0.95	0.32	0.05	3161	2.65	54.6	3971	33.37	38.0	60.7	43.6	0.60	0.67

Sample: ABA-1
Cell Type: shaken
Test Conditions: 1 kg cell with dry/wet air cycles - flooded, 1 hr soak, lifted and swirled for 30 sec, drained, fines returned
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
			volume		Conduct.	Alkalinity	SO_4	Ca	Mg	K	Na	End, 3-day dry	End, 3-day wet	End of leach
Date	Cycle	Days	(L)	pH	(uS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(%)	(%)	(%)
25-Jan-96	0	0	0.593	8.0	2340	76	1900	2442	229.0	88.00	119.00			
26-Jan-96	1	1	0.312	7.4	2087			738	51.0	22.30	22.00			
2-Feb-96	2	8	0.422	6.9	1833									
9-Feb-96	3	15	0.405	6.4	1553		1600							
16-Feb-96	4	22	0.372	6.8	1135		720					0.9	1.8	13.2
23-Feb-96	5	29	0.494	7.3	736							8.7	11.0	13.1
1-Mar-96	6	36	0.507	7.5	749		515	272	4.9	6.10	1.70	11.3	11.4	13.0
9-Mar-96	7	44	0.469	7.5	625							11.5	11.8	12.1
17-Mar-96	8	52	0.463	7.3	505		250					7.2	22.9	12.9
25-Mar-96	9	60	0.444	7.5	466	20	311					9.2	8.2	12.3
1-Apr-96	10	67	0.475	7.5			200	87	1.3	2.80	0.63	6.5	7.3	11.8
8-Apr-96	11	74	0.431	7.5	360	19	223					6.1	6.2	11.7
15-Apr-96	12	81	0.427	7.4	434	17						5.9	6.3	11.7
22-Apr-96	13	88	0.486	7.3	276	33		49	0.8	2.30	0.47	9.1	7.6	12.0
29-Apr-96	14	95	0.485	7.3	376	12						8.7	8.9	11.3
7-May-96	15	103	0.496	7.1	303		134	60	0.8	1.90	0.36	8.3	10.2	10.7
14-May-96	16	110	0.480	7.1	272	9						10.6	11.5	11.5
21-May-96	17	117	0.479	7.2	270		106	53	0.7	1.80	0.39	9.4	11.0	11.5
28-May-96	18	124	0.472	7.1	264	10						9.6	10.5	12.1
4-Jun-96	19	131	0.484	7.2	262		114	62	0.6	1.60	0.30	10.4	11.1	11.5
11-Jun-96	20	138	0.476	7.0	248	8						9.7	11.8	11.8
18-Jun-96	21	145	0.480	7.1	266		118	47	0.1	1.50	0.30	9.7	11.5	11.5
25-Jun-96	22	152	0.481	7.1	254	12						11.0	11.2	11.5
2-Jul-96	23	159	0.457	7.1	254		120	52	0.6	1.22	0.23	7.2	10.7	11.5
8-Jul-96	24	165	0.481	6.9	282	7						7.4	10.2	10.7
15-Jul-96	25	172	0.454	7.0	310		130	55	0.6	0.94	0.14	5.3	8.3	11.5
22-Jul-96	26	179	0.447	6.6	267	6						5.5	6.4	12.0
29-Jul-96	27	186	0.461	6.6	348		151	62	0.8	1.41	0.14	7.3	7.2	11.5
6-Aug-96	28	194	0.465	6.8	342	6						7.2	8.0	11.2
12-Aug-96	29	200	0.460	6.8	330		149	60	0.7	0.98	0.16	6.7	8.1	11.5
19-Aug-96	30	207	0.456	6.6	338	6	185					7.3	8.2	11.4
26-Aug-96	31	214	0.474	6.9	379		194	66	1.0	1.41	0.15	9.5	10.2	11.5
2-Sep-96	32	221	0.390	6.3	353	3	184	71	0.9	1.24	0.15	0.6	0.6	10.7
10-Sep-96	33	229	0.430	6.1	385		215					4.9	4.9	10.9
17-Sep-96	34	236	0.479	6.5	370	6	210	76	1.1	1.51	0.14	9.8	10.7	11.7
24-Sep-96	35	243	0.460	6.5	368		195	66	0.9	0.83	0.10	8.7	8.9	11.8
1-Oct-96	36	250	0.472	6.4	330	5	181					7.7	9.9	11.5
8-Oct-96	37	257	0.470	6.6	342							8.6	9.1	11.3
15-Oct-96	38	264	0.415	5.9	383	2	210	91	1.1	1.26	0.14	3.9	4.4	12.1
22-Oct-96	39	271	0.451	6.3	399							7.2	7.2	11.2
29-Oct-96	40	278	0.443	5.5	338	2	198	70	1.1	1.02	0.09	5.4	5.7	10.7
5-Nov-96	41	285	0.441	6.0	442							6.4	7.4	12.1
12-Nov-96	42	292	0.563	5.4	368	2	224						8.1	
19-Nov-96	43	299	0.439									5.5	5.5	10.7
27-Nov-96	44	307	0.438	3.8	378	1		77	1.2	1.03	0.19	10.7	10.4	10.8
3-Dec-96	45	313	0.438									8.4	8.9	
10-Dec-96	46	320	0.446											
18-Dec-96	47	328	0.455	4.9	336	1	192	63	1.2	0.98	0.11			

Sample: ABA-1
Cell Type: shaken
Test Conditions: 1 kg cell with dry/wet air cycles - flooded, 1 hr soak, lifted and swirled for 30 sec, drained, fines returned

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	1448	136	52	71					1127	0.82		4183	11.52				3.08	3.56
1	1	1679	152	59	77					1689	1.23		4826	13.29	4496.7			0.98	1.10
2	8	1951	169	67	85					2406	1.76		5579	15.37				0.91	1.01
3	15	2174	183	74	91	338.7	21.81	9.99	9.36	3054	2.23	647.8	6192	17.06		899.3	937.4	0.83	0.91
4	22	2344	191	78	94	285.1	17.63	8.30	7.54	3321	2.43	267.5	6654	18.33		698.3	786.1	1.53	1.66
5	29	2525	198	83	97	259.8	15.06	7.41	6.41	3626	2.65		7134	19.65		603.3	712.3	1.42	1.51
6	36	2663	201	86	98	196.8	9.79	5.37	4.11	3887	2.84	261.2	7490	20.63	355.5	439.7	532.8	1.27	1.31
7	44	2768	203	88	99	159.0	6.45	4.13	2.65	4067	2.97		7762	21.38		323.0	424.6	1.42	1.46
8	52	2852	204	91	99	128.2	4.06	3.20	1.62	4183	3.06	101.3	7976	21.97		213.6	337.5	1.72	1.77
9	60	2911	205	92	100	104.4	2.53	2.55	0.98	4321	3.16	120.9	8128	22.39		184.1	271.6	1.03	1.06
10	67	2952	206	93	100	78.7	1.36	1.95	0.51	4416	3.23	94.9	8234	22.68	105.9	145.4	202.7	1.04	1.07
11	74	2984	206	95	100	59.2	0.99	1.59	0.40	4512	3.30	96.0	8316	22.91		115.0	152.3	0.80	0.82
12	81	3010	206	96	100	45.8	0.74	1.36	0.32	4597	3.36		8384	23.10		100.4	117.6	0.74	0.76
13	88	3034	207	97	101	35.5	0.56	1.21	0.27	4684	3.42		8445	23.27	61.2	97.5	91.2	0.66	0.68
14	95	3061	207	98	101	30.0	0.46	1.13	0.24	4760	3.48		8513	23.45		87.8	76.9	0.84	0.86
15	103	3090	208	99	101	26.9	0.40	1.02	0.21	4826	3.53	58.1	8589	23.66	66.5	79.9	69.0	1.07	1.10
16	110	3117	208	100	101	25.9	0.38	0.98	0.20	4884	3.57		8658	23.85		72.4	66.5	1.13	1.15
17	117	3143	208	100	101	25.8	0.36	0.94	0.19	4935	3.61	50.8	8723	24.03	65.0	65.6	66.0	1.20	1.23
18	124	3170	209	101	101	26.4	0.35	0.88	0.18	4987	3.65		8792	24.22		58.8	67.5	1.25	1.28
19	131	3200	209	102	102	27.1	0.33	0.83	0.17	5042	3.69	55.1	8869	24.43	76.2	54.8	69.2	1.31	1.33
20	138	3226	209	103	102	27.1	0.29	0.81	0.16	5097	3.73		8934	24.61		54.1	69.0	1.13	1.14
21	145	3248	209	103	102	26.2	0.23	0.78	0.16	5154	3.77	56.6	8991	24.77	56.5	53.9	66.5	0.96	0.96
22	152	3272	209	104	102	25.9	0.19	0.74	0.14	5211	3.81		9051	24.93		55.2	65.5	1.00	1.01
23	159	3296	210	105	102	25.2	0.18	0.69	0.13	5266	3.85	54.8	9111	25.10	60.6	55.8	63.8	1.04	1.06
24	165	3322	210	105	102	25.1	0.19	0.66	0.13	5326	3.89		9177	25.28		58.5	63.5	1.03	1.05
25	172	3347	210	106	102	24.9	0.21	0.59	0.11	5385	3.94	59.0	9241	25.46	63.6	59.2	63.1	1.02	1.03
26	179	3373	210	106	102	25.6	0.27	0.55	0.09	5448	3.98		9307	25.64		60.5	65.2	1.00	1.02
27	186	3401	211	107	102	26.6	0.31	0.55	0.08	5517	4.03	69.6	9380	25.84	73.0	63.1	67.8	0.99	1.01
28	194	3430	211	107	103	26.8	0.32	0.54	0.07	5587	4.08		9453	26.04		64.3	68.3	0.98	1.00
29	200	3457	211	108	103	27.1	0.33	0.52	0.07	5656	4.13	80.0	9523	26.24	82.2	66.0	69.3	0.97	0.99
30	207	3486	212	108	103	27.9	0.35	0.55	0.07	5740	4.20	84.4	9597	26.44		71.0	71.2	0.82	0.84
31	214	3517	212	109	103	28.9	0.38	0.57	0.07	5832	4.26	91.9	9677	26.66	80.2	76.9	73.9	0.82	0.84
32	221	3545	213	110	103	28.7	0.38	0.54	0.07	5904	4.32	71.8	9748	26.85	70.8	77.3	73.5	0.93	0.95
33	229	3577	213	110	103	29.4	0.39	0.55	0.07	5996	4.38	80.9	9829	27.08		81.8	75.2	0.82	0.84
34	236	3613	214	111	103	30.3	0.42	0.59	0.06	6097	4.46	100.5	9922	27.33	93.2	85.8	77.5	0.87	0.89
35	243	3643	214	111	103	30.6	0.43	0.55	0.06	6186	4.52	89.8	10000	27.55	77.7	86.8	78.3	0.81	0.83
36	250	3679	215	112	103	31.3	0.42	0.51	0.06	6272	4.58	85.5	10089	27.79		85.5	80.2	0.99	1.01
37	257	3717	215	112	103	33.5	0.45	0.52	0.06	6364	4.65		10188	28.07		89.4	85.7	1.01	1.04
38	264	3755	215	113	103	35.7	0.47	0.52	0.06	6451	4.72	87.2	10285	28.33	96.4	91.0	91.3	1.04	1.06
39	271	3791	216	113	103	35.7	0.46	0.48	0.05	6543	4.78		10378	28.59		89.3	91.2	0.95	0.97
40	278	3823	216	114	103	35.8	0.48	0.49	0.05	6631	4.85	87.8	10457	28.81	79.7	88.9	91.6	0.85	0.87
41	285	3854	217	114	103	35.1	0.48	0.49	0.05	6723	4.91		10539	29.03		90.3	89.9	0.82	0.84
42	292	3895	218	115	103	35.6	0.52	0.50	0.06	6850	5.01	126.0	10645	29.32		97.2	91.2	0.79	0.81
43	299	3929	218	115	103	34.7	0.53	0.49	0.06	6945	5.08		10730	29.56		98.9	88.9	0.83	0.85
44	307	3962	219	116	104	33.2	0.52	0.46	0.06	7038	5.14		10816	29.80	75.8	96.2	85.2	0.88	0.90
45	313	3994	219	116	104	34.3	0.54	0.47	0.07	7127	5.21		10898	30.02		99.4	88.1	0.85	0.87
46	320	4024	220	117	104	34.0	0.55	0.47	0.07	7216	5.27		10975	30.24		98.5	87.4	0.82	0.84
47	328	4053	220	117	104	30.6	0.52	0.43	0.07	7303	5.34	76.4	11049	30.44	64.7	88.2	78.7	0.79	0.81

Sample: ABA-2
Cell Type: shaken
Test Conditions: 1 kg cell with dry/wet air cycles - flooded, 1 hr soak, lifted and swirled for 30 sec, drained, fines returned
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
			volume		Conduct.	Alkalinity	SO_4	Ca	Mg	K	Na	End, 3-day dry	End, 3-day wet	End of leach
Date	Cycle	Days	(L)	pH	(uS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(%)	(%)	(%)
25-Jan-96	0	0	0.665	8.0	1229	64	690	1681	211.0	68.00	111.00			
26-Jan-96	1	1	0.290	7.9	1101			229	27.0	12.00	16.40			
2-Feb-96	2	8	0.428	7.8	972									
9-Feb-96	3	15	0.401	7.6	688		460							
16-Feb-96	4	22	0.379	7.6	430		280					1.3	2.8	12.7
23-Feb-96	5	29	0.502	7.8	338							9.8	11.0	10.8
1-Mar-96	6	36	0.475	7.7	265		101	61	4.2	1.50	1.80	7.0	10.3	12.1
9-Mar-96	7	44	0.422	7.7	260							4.7	5.9	11.0
17-Mar-96	8	52	0.534	7.7	253		111					9.5	10.4	11.5
25-Mar-96	9	60	0.463	7.7	235	30	102					9.4	8.5	10.8
1-Apr-96	10	67	0.474	7.7			84	39	2.5	0.90	0.80	7.8	7.9	11.6
8-Apr-96	11	74	0.436	7.8	208	29	72					5.1	5.8	10.3
15-Apr-96	12	81	0.489	7.7	231	28						6.1	9.0	10.3
22-Apr-96	13	88	0.490	7.7	188	29		31	1.9	0.90	0.66	9.4	10.1	10.4
29-Apr-96	14	95	0.487	7.7	211	30						8.4	9.9	10.1
7-May-96	15	103	0.486	7.5	186		60	34	2.0	0.70	0.51	7.4	9.7	9.8
14-May-96	16	110	0.456	7.5	153	14						4.8	6.1	9.2
21-May-96	17	117	0.474	7.6	151		40	22	1.3	0.70	0.47	5.9	6.2	10.6
28-May-96	18	124	0.405	7.4	196	15						2.5	3.4	8.9
4-Jun-96	19	131	0.473	7.5	146		42	34	1.5	0.60	0.29	6.7	7.8	8.8
11-Jun-96	20	138	0.443	7.2	137	11						4.3	4.3	8.9
18-Jun-96	21	145	0.450	7.4	135		34	23	1.3	0.60	0.34	4.9	5.6	8.7
25-Jun-96	22	152	0.457	7.4	156	13						5.1	5.7	9.1
2-Jul-96	23	159	0.450	7.3	136		39	25	1.4	0.57	0.30	4.5	5.3	10.2
8-Jul-96	24	165	0.430	7.3	151	12						2.3	2.9	9.2
15-Jul-96	25	172	0.459	7.4	165		40	27	1.4	0.36	0.17	3.6	4.7	8.5
22-Jul-96	26	179	0.450	7.0	143	11	40					3.5	4.0	9.0
29-Jul-96	27	186	0.453	7.2	201		60	33	1.7	0.66	0.17	3.4	4.4	8.7
6-Aug-96	28	194	0.432	7.2	168	11						2.0	2.4	9.5
12-Aug-96	29	200	0.509	7.3	216		69	37	1.8	0.55	0.18	8.0	10.7	9.9
19-Aug-96	30	207	0.457	7.3	243	15	111					4.0	6.3	9.3
26-Aug-96	31	214	0.441	7.4	236		84	37	1.4	0.53	0.14	4.0	4.4	9.3
2-Sep-96	32	221	0.408	7.3	193	20	82	38	1.5	0.64	0.15	0.4	0.4	8.9
10-Sep-96	33	229	0.484	7.2	245		115					8.6	8.9	9.5
17-Sep-96	34	236	0.438	7.2	187	15	83	34	1.3	0.54	0.14	3.5	4.1	9.2
24-Sep-96	35	243	0.486	7.2	158		69	28	1.2	0.43	0.12	6.3	6.9	9.9
1-Oct-96	36	250	0.445	7.2	163	16	72					5.0	5.2	9.7
8-Oct-96	37	257	0.431	7.2	184							4.2	4.5	10.7
15-Oct-96	38	264	0.506	7.3	190	22	82	42	1.6	0.60	0.15	9.3	11.5	9.5
22-Oct-96	39	271	0.486	7.5	168							8.4	9.0	9.4
29-Oct-96	40	278	0.448	7.3	165	18	66	31	1.2	0.43	0.06	4.5	4.9	9.1
5-Nov-96	41	285	0.465	7.7	211							7.8	8.1	11.0
12-Nov-96	42	292	0.481	7.4	158	25	82						8.9	
19-Nov-96	43	299	0.459									6.8	7.1	10.2
27-Nov-96	44	307	0.458	7.4	192	19		39	1.3	0.53	0.17	5.2	4.7	9.1
3-Dec-96	45	313	0.458									5.7	5.9	
10-Dec-96	46	320	0.459											
18-Dec-96	47	328	0.468	7.4	188	18	86	34	1.5	0.49	0.10			

Sample: ABA-2
Cell Type: shaken
Test Conditions: 1 kg cell with dry/wet air cycles - flooded, 1 hr soak, lifted and swirled for 30 sec, drained, fines returned

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	1118	140	45	74					459	0.32		3375	10.20				5.85	7.06
1	1	1184	148	49	79					636	0.44		3574	10.80	1386.7			0.90	1.07
2	8	1268	158	53	84					866	0.60		3822	11.55				0.87	1.04
3	15	1333	165	56	89	100.2	11.47	5.06	6.88	1050	0.73	184.3	4014	12.13		276.0	298.0	0.84	1.00
4	22	1381	170	58	91	83.8	9.43	4.13	5.61	1156	0.81	106.1	4156	12.56		222.0	248.5	1.10	1.29
5	29	1429	174	60	94	75.0	8.21	3.57	4.83	1252	0.87		4293	12.97		191.4	221.5	1.19	1.37
6	36	1458	176	61	95	54.7	5.64	2.41	3.22	1300	0.91	48.0	4374	13.21	80.7	132.7	160.1	1.45	1.61
7	44	1481	178	61	95	41.5	3.93	1.63	2.14	1345	0.94		4439	13.41		93.1	119.9	1.26	1.40
8	52	1508	180	62	96	33.1	2.80	1.11	1.41	1404	0.98	51.9	4513	13.64		66.9	94.5	1.08	1.20
9	60	1528	181	62	97	27.1	2.05	0.78	0.93	1451	1.01	41.3	4570	13.81		54.3	76.3	1.05	1.16
10	67	1547	182	63	97	21.8	1.46	0.52	0.57	1491	1.04	39.8	4622	13.96	51.2	44.0	60.5	1.11	1.23
11	74	1563	183	63	97	19.3	1.28	0.46	0.47	1522	1.06	31.4	4665	14.09		41.0	53.7	1.21	1.34
12	81	1579	184	64	98	18.6	1.20	0.45	0.42	1556	1.09		4711	14.23		40.0	51.4	1.17	1.29
13	88	1594	185	64	98	16.8	1.07	0.43	0.36	1588	1.11		4753	14.36	41.8	35.9	46.5	1.13	1.24
14	95	1610	186	65	98	16.4	1.02	0.42	0.33	1619	1.13		4796	14.49		33.6	45.1	1.24	1.36
15	103	1627	187	65	98	15.5	0.95	0.39	0.30	1648	1.15	25.5	4841	14.63	39.7	30.6	42.8	1.36	1.49
16	110	1639	188	65	99	14.9	0.90	0.38	0.28	1671	1.17		4877	14.73		28.9	41.1	1.34	1.47
17	117	1650	189	66	99	13.8	0.82	0.35	0.25	1690	1.18	19.0	4905	14.82	28.7	26.0	37.8	1.32	1.45
18	124	1661	189	66	99	13.0	0.75	0.32	0.22	1707	1.19		4936	14.91		23.0	35.6	1.64	1.77
19	131	1677	190	66	99	13.1	0.70	0.30	0.19	1727	1.20	19.9	4979	15.04	43.2	20.9	35.6	1.94	2.08
20	138	1690	190	66	99	12.7	0.65	0.29	0.18	1743	1.22		5013	15.15		19.0	34.4	1.80	1.95
21	145	1700	191	67	99	12.2	0.62	0.28	0.16	1759	1.23	15.3	5042	15.23	28.3	17.5	33.0	1.62	1.77
22	152	1711	192	67	100	12.3	0.62	0.27	0.15	1775	1.24		5072	15.32		17.1	33.3	1.58	1.72
23	159	1722	192	67	100	12.3	0.63	0.27	0.14	1793	1.25	17.5	5102	15.41	30.7	17.2	33.3	1.54	1.68
24	165	1734	193	67	100	11.6	0.63	0.26	0.14	1810	1.26		5133	15.51		17.2	31.6	1.58	1.72
25	172	1746	193	67	100	11.6	0.63	0.24	0.13	1828	1.27	18.4	5166	15.61	33.7	17.5	31.5	1.62	1.76
26	179	1760	194	68	100	12.2	0.66	0.23	0.11	1846	1.29	18.0	5203	15.72		18.0	33.3	1.80	1.95
27	186	1774	195	68	100	13.0	0.69	0.24	0.10	1873	1.31	27.2	5244	15.84	40.5	20.2	35.4	1.32	1.43
28	194	1790	196	68	100	13.4	0.69	0.23	0.08	1901	1.33		5285	15.97		21.7	36.5	1.30	1.41
29	200	1808	197	69	100	15.0	0.76	0.25	0.08	1936	1.35	40.9	5335	16.12	59.3	25.3	40.5	1.29	1.39
30	207	1825	197	69	100	15.9	0.77	0.26	0.08	1987	1.39	50.7	5381	16.26		31.8	42.9	0.80	0.86
31	214	1842	198	69	100	16.4	0.76	0.26	0.08	2024	1.41	37.0	5424	16.39	43.4	35.6	44.2	1.06	1.12
32	221	1857	199	69	100	16.5	0.73	0.26	0.07	2058	1.43	33.4	5465	16.51	41.3	36.8	44.4	1.11	1.18
33	229	1875	199	70	100	17.0	0.71	0.26	0.07	2113	1.47	48.7	5512	16.65		42.4	45.4	0.75	0.80
34	236	1889	200	70	101	15.7	0.62	0.25	0.06	2149	1.50	36.3	5551	16.77	39.6	41.4	42.0	0.98	1.05
35	243	1903	200	70	101	15.1	0.59	0.24	0.06	2183	1.52	33.5	5588	16.88	36.4	38.1	40.3	0.97	1.04
36	250	1918	201	70	101	14.8	0.59	0.23	0.06	2215	1.54	32.0	5627	17.00		37.1	39.4	1.09	1.16
37	257	1934	202	70	101	14.9	0.59	0.23	0.06	2248	1.57		5670	17.13		37.1	39.7	1.16	1.24
38	264	1955	202	71	101	16.1	0.64	0.24	0.06	2290	1.60	41.5	5726	17.30	56.5	35.3	42.8	1.23	1.31
39	271	1973	203	71	101	16.6	0.66	0.24	0.06	2326	1.62		5773	17.44		35.2	44.4	1.18	1.26
40	278	1986	204	71	101	16.7	0.65	0.24	0.05	2355	1.64	29.5	5810	17.55	36.9	34.4	44.5	1.13	1.20
41	285	2002	204	71	101	16.9	0.65	0.24	0.05	2390	1.67		5851	17.68		34.9	44.9	1.07	1.14
42	292	2019	205	72	101	17.0	0.64	0.24	0.05	2429	1.69	39.4	5895	17.81		36.2	45.2	1.02	1.08
43	299	2036	205	72	101	16.2	0.59	0.22	0.05	2467	1.72		5940	17.95		35.5	42.9	1.07	1.13
44	307	2054	206	72	101	15.7	0.56	0.22	0.05	2505	1.75		5988	18.09	41.3	34.9	41.7	1.12	1.18
45	313	2071	207	72	101	16.8	0.60	0.23	0.06	2544	1.77		6033	18.23		37.8	44.5	1.06	1.13
46	320	2087	207	73	101	17.0	0.61	0.23	0.06	2583	1.80		6077	18.36		38.7	45.1	1.00	1.07
47	328	2103	208	73	101	16.4	0.62	0.23	0.06	2623	1.83	35.2	6119	18.49	37.3	37.8	43.5	0.95	1.02

Sample: ABA-3
Cell Type: shaken
Test Conditions: 1 kg cell with dry/wet air cycles - flooded, 1 hr soak, lifted and swirled for 30 sec, drained, fines returned
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
			volume		Conduct.	Alkalinity	SO_4	Ca	Mg	K	Na	End, 3-day dry	End, 3-day wet	End of leach
Date	Cycle	Days	(L)	pH	(uS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(%)	(%)	(%)
25-Jan-96	0	0	0.547	7.8	1308	52	900	1228	134.0	55.00	108.00			
26-Jan-96	1	1	0.298	7.7	1173			318	34.0	16.80	23.00			
2-Feb-96	2	8	0.404	7.6	1038									
9-Feb-96	3	15	0.398	7.4	861		620							
16-Feb-96	4	22	0.375	7.7	552		390					7.9	8.8	22.2
23-Feb-96	5	29	0.447	7.7	312							14.2	15.4	20.3
1-Mar-96	6	36	0.489	7.7	287		94	67	4.6	2.20	2.70	18.9	21.0	20.7
9-Mar-96	7	44	0.467	7.7	230							18.5	18.7	19.5
17-Mar-96	8	52	0.435	7.6	246		110					12.1	2.6	9.4
25-Mar-96	9	60	0.374	7.6	239	28	122					1.9	1.8	8.9
1-Apr-96	10	67	0.415	7.7			112	46	2.1	1.20	0.99	2.2	2.9	9.5
8-Apr-96	11	74	0.452	7.7	230	26	95					5.8	6.1	10.0
15-Apr-96	12	81	0.482	7.7	250	27						8.5	9.5	10.2
22-Apr-96	13	88	0.506	7.6	169	23		29	1.2	1.00	0.80	9.8	9.0	10.5
29-Apr-96	14	95	0.487	7.6	171	23						7.5	7.5	9.6
7-May-96	15	103	0.461	7.5	189		55	35	1.2	0.90	0.60	5.3	6.1	8.8
14-May-96	16	110	0.461	7.5	200	18						2.1	3.9	9.2
21-May-96	17	117	0.482	7.5	181		52	29	1.0	0.90	0.57	5.8	6.1	9.9
28-May-96	18	124	0.469	7.5	197	16						7.0	7.5	9.9
4-Jun-96	19	131	0.445	7.4	189		67	45	0.9	0.80	0.36	4.7	5.0	9.1
11-Jun-96	20	138	0.467	7.3	206	14						6.2	7.4	9.2
18-Jun-96	21	145	0.466	7.5	200		66	35	1.0	0.80	0.45	3.9	8.1	9.0
25-Jun-96	22	152	0.467	7.3	182	14						6.7	6.7	9.5
2-Jul-96	23	159	0.451	7.4	210		91	42	1.1	0.60	0.39	4.0	4.5	8.9
8-Jul-96	24	165	0.453	7.3	231	17						3.7	5.1	8.9
15-Jul-96	25	172	0.446	7.3	244		76	43	0.9	0.44	0.21	3.5	3.8	8.8
22-Jul-96	26	179	0.452	7.2	234	11	73					3.8	4.0	8.3
29-Jul-96	27	186	0.459	7.1	248		84	41	0.8	0.67	0.17	5.5	5.6	9.0
6-Aug-96	28	194	0.454	7.0	263	23						5.0	5.3	9.1
12-Aug-96	29	200	0.450	7.4	252		92	44	0.8	0.57	0.23	4.8	4.9	8.9
19-Aug-96	30	207	0.439	7.2	238	14	106					3.4	4.0	9.0
26-Aug-96	31	214	0.459	7.4	260		101	45	0.8	0.70	0.21	5.6	5.9	9.0
2-Sep-96	32	221	0.489	7.1	229	17	105	47	0.7	0.60	0.25	7.0	7.0	9.5
10-Sep-96	33	229	0.463	7.2	197		87					6.2	6.4	9.1
17-Sep-96	34	236	0.438	7.2	214	16	100	40	0.7	0.78	0.22	3.9	4.1	9.0
24-Sep-96	35	243	0.448	7.2	234		114	41	0.7	0.49	0.14	1.9	5.0	8.9
1-Oct-96	36	250	0.459	7.2	204	16	100					5.7	6.2	9.3
8-Oct-96	37	257	0.458	7.1	232							3.7	6.7	10.1
15-Oct-96	38	264	0.474	7.2	257	19	125	58	0.9	0.77	0.22	8.3	10.4	11.0
22-Oct-96	39	271	0.487	7.5	225							9.0	10.4	10.8
29-Oct-96	40	278	0.468	7.3	210	18	101	42	0.7	0.48	0.10	7.4	7.7	10.0
5-Nov-96	41	285	0.440	7.6	255							5.1	5.8	11.3
12-Nov-96	42	292	0.477	7.3	227	22	112						8.4	
19-Nov-96	43	299	0.454									6.2	6.8	9.8
27-Nov-96	44	307	0.453	7.3	209	18		45	0.6	0.55	0.21	5.8	5.5	9.9
3-Dec-96	45	313	0.453									7.6	7.7	
10-Dec-96	46	320	0.476											
18-Dec-96	47	328	0.489	7.3	267	17	138	45	0.8	0.55	0.14			

Sample: ABA-3
Cell Type: shaken
Test Conditions: 1 kg cell with dry/wet air cycles - flooded, 1 hr soak, lifted and swirled for 30 sec, drained, fines returned

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	672	73	30	59					492	0.52		1983	7.93				3.27	3.86
1	1	766	83	35	66					732	0.78		2262	9.05	1950.2			0.95	1.11
2	8	875	95	41	74					1021	1.09		2579	10.32				0.90	1.06
3	15	961	104	45	79	135.1	14.16	6.99	9.53	1267	1.35	246.6	2832	11.33		361.8	396.4	0.84	0.98
4	22	1024	110	48	84	112.1	11.60	5.72	7.79	1414	1.51	146.1	3015	12.06		293.1	328.2	1.03	1.20
5	29	1076	114	50	87	97.6	9.93	4.89	6.64	1522	1.62		3165	12.66		248.5	285.3	1.16	1.33
6	36	1109	117	51	88	68.5	6.65	3.27	4.39	1568	1.67	45.9	3256	13.02	91.2	167.0	198.9	1.71	1.90
7	44	1138	119	52	89	51.2	4.62	2.26	2.99	1615	1.72		3336	13.34		115.6	147.1	1.45	1.61
8	52	1162	120	53	90	38.1	3.10	1.52	1.94	1663	1.77	41.9	3403	13.61		74.8	108.0	1.23	1.35
9	60	1182	121	54	90	29.0	2.07	1.02	1.24	1709	1.82	40.0	3455	13.82		54.4	81.2	1.01	1.10
10	67	1201	122	54	91	22.9	1.37	0.69	0.76	1755	1.87	46.5	3507	14.03	51.4	43.0	63.0	0.99	1.06
11	74	1219	123	55	91	20.2	1.11	0.59	0.59	1798	1.91	42.9	3556	14.22		42.5	55.2	1.02	1.09
12	81	1236	123	55	92	18.5	0.92	0.53	0.49	1839	1.96		3601	14.40		42.4	50.1	0.98	1.05
13	88	1250	124	56	92	17.1	0.78	0.50	0.42	1877	2.00		3640	14.56	39.2	41.6	46.0	0.93	0.99
14	95	1266	125	56	92	16.9	0.72	0.50	0.40	1909	2.03		3681	14.72		40.0	45.1	1.18	1.25
15	103	1282	125	57	93	15.8	0.64	0.47	0.36	1934	2.06	22.2	3724	14.90	37.3	34.8	42.2	1.53	1.61
16	110	1297	126	57	93	15.1	0.58	0.45	0.33	1959	2.09		3763	15.05		31.2	40.3	1.44	1.52
17	117	1311	126	57	93	14.6	0.53	0.43	0.30	1984	2.11	25.1	3800	15.20	37.0	28.1	38.7	1.34	1.41
18	124	1328	127	58	93	15.1	0.50	0.41	0.27	2012	2.14		3845	15.38		26.2	39.9	1.49	1.56
19	131	1348	127	58	93	16.0	0.46	0.39	0.23	2041	2.17	29.8	3897	15.59	51.8	25.8	41.9	1.61	1.67
20	138	1367	127	59	94	17.0	0.46	0.40	0.22	2072	2.21		3945	15.78		27.7	44.3	1.44	1.50
21	145	1383	128	59	94	17.3	0.45	0.39	0.21	2103	2.24	30.7	3988	15.95	42.7	28.9	45.1	1.27	1.33
22	152	1401	128	59	94	18.1	0.45	0.37	0.19	2140	2.28		4035	16.14		31.2	47.1	1.18	1.23
23	159	1420	129	59	94	18.4	0.46	0.34	0.19	2181	2.32	41.0	4085	16.34	49.4	33.9	47.9	1.11	1.16
24	165	1439	129	60	94	18.8	0.48	0.33	0.19	2219	2.36		4135	16.54		36.5	49.0	1.22	1.27
25	172	1458	130	60	94	18.9	0.47	0.29	0.17	2253	2.40	33.9	4184	16.74	49.6	37.1	49.2	1.36	1.40
26	179	1477	130	60	95	19.4	0.46	0.26	0.14	2286	2.43	33.0	4233	16.93		37.5	50.5	1.38	1.43
27	186	1496	131	60	95	19.6	0.43	0.26	0.12	2324	2.48	38.6	4282	17.13	48.6	37.9	50.8	1.17	1.21
28	194	1515	131	61	95	19.1	0.39	0.25	0.10	2364	2.52		4332	17.33		36.6	49.4	1.16	1.20
29	200	1535	131	61	95	19.2	0.38	0.26	0.09	2405	2.56	48.3	4383	17.53	59.5	37.3	49.6	1.15	1.18
30	207	1555	132	61	95	19.3	0.37	0.27	0.09	2452	2.61	46.6	4433	17.73		39.9	49.8	1.01	1.04
31	214	1575	132	62	95	19.6	0.36	0.29	0.09	2498	2.66	46.4	4486	17.94	53.2	42.6	50.6	1.07	1.10
32	221	1598	132	62	95	20.5	0.36	0.29	0.10	2550	2.72	51.4	4545	18.18	58.9	45.1	52.6	1.07	1.10
33	229	1619	133	62	95	20.6	0.35	0.29	0.11	2590	2.76	35.2	4597	18.39		45.2	53.0	1.20	1.23
34	236	1636	133	63	95	19.6	0.33	0.30	0.10	2634	2.80	43.8	4642	18.57	45.1	44.4	50.4	0.96	0.99
35	243	1655	133	63	95	19.4	0.32	0.29	0.09	2685	2.86	51.1	4689	18.76	47.3	45.3	49.8	0.86	0.89
36	250	1676	134	63	95	19.5	0.32	0.28	0.09	2731	2.91	45.9	4744	18.98		45.2	50.2	1.12	1.15
37	257	1700	134	63	96	19.7	0.33	0.28	0.08	2782	2.96		4806	19.22		45.2	50.7	1.12	1.15
38	264	1727	134	64	96	21.8	0.36	0.30	0.09	2842	3.03	59.2	4876	19.51	70.5	50.3	55.9	1.11	1.14
39	271	1752	135	64	96	23.1	0.37	0.29	0.08	2897	3.08		4939	19.76		52.5	59.4	1.06	1.09
40	278	1771	135	64	96	23.4	0.38	0.29	0.08	2944	3.14	47.3	4989	19.96	50.5	51.8	60.0	1.00	1.03
41	285	1790	135	64	96	22.9	0.36	0.28	0.07	2991	3.19		5038	20.15		52.0	58.7	0.96	0.99
42	292	1811	136	65	96	22.2	0.35	0.27	0.07	3044	3.24	53.4	5091	20.36		52.4	57.0	0.93	0.96
43	299	1831	136	65	96	20.7	0.32	0.25	0.07	3097	3.30		5142	20.57		51.2	53.2	0.91	0.93
44	307	1851	136	65	96	19.4	0.29	0.23	0.07	3153	3.36		5194	20.78	45.6	49.8	49.7	0.88	0.90
45	313	1872	137	65	96	20.1	0.29	0.24	0.08	3210	3.42		5247	20.99		53.3	51.5	0.85	0.87
46	320	1893	137	66	96	20.6	0.30	0.25	0.08	3274	3.49		5302	21.21		56.6	52.8	0.81	0.84
47	328	1915	137	66	96	20.3	0.31	0.25	0.08	3341	3.56	59.0	5358	21.43	49.6	57.8	52.0	0.78	0.81

APPENDIX 10

TABULATED RESULTS

NON-AERATED CELL

Sample: HC-1
Cell Type: non-aerated
Test Conditions: 1 kg cell, no air applied - 500 mL trickle leach
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high

			Leachate				Water analysis					Gravimetric water content		
Date	Cycle	Days	volume (L)	pH	Conduct. (uS/cm)	Alkalinity (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	End, 3-day dry (%)	End, 3-day wet (%)	End of leach (%)
23-Feb-96	0	0	0.167	7.7	724		418	669	128.0	78.00	96.00			
24-Feb-96	1	1	0.279	7.7	578			128	25.0	17.70	16.90			
1-Mar-96	2	7	0.492	7.6	432			70	10.8	5.03	3.01	10.7	9.3	10.2
9-Mar-96	3	15	0.498	7.8	476		180					10.1	10.1	9.7
17-Mar-96	4	23	0.478	7.7	341			58	8.2	2.79	0.67	9.4	9.1	10.3
25-Mar-96	5	31	0.493	7.7	280	35	93					10.2	10.2	10.1
1-Apr-96	6	38	0.490	7.8			98					10.0	9.5	10.3
8-Apr-96	7	45	0.488	7.7	226	25	77					9.4	9.2	10.0
15-Apr-96	8	52	0.488	7.5	279	25	107	45	5.4	1.96	0.34	9.6	9.1	9.9
22-Apr-96	9	59	0.491	7.7	222	25						9.4	9.2	10.0
29-Apr-96	10	66	0.490	7.7	249			39	5.2	1.80	0.53	9.4	9.3	10.0
7-May-96	11	74	0.488	7.8	225	31						9.4	9.4	10.0
14-May-96	12	81	0.491	7.9	232		60	37	4.7	1.60	0.36	9.5	9.5	10.0
21-May-96	13	88	0.489	7.7	230	37						9.7	9.6	10.1
28-May-96	14	95	0.489	7.8	223		71	39	4.5	1.42	0.28	9.9	9.8	10.2
4-Jun-96	15	102	0.487	7.7	231	29						10.0	9.8	10.2
11-Jun-96	16	109	0.302	7.5	232		56	39	4.8	1.50	0.38	10.0	9.9	12.1
18-Jun-96	17	116	0.492	7.5	233	23						11.1	10.9	11.2
25-Jun-96	18	123	0.491	7.7	235		91	53	4.6	1.27	0.31	10.7	10.6	11.6
2-Jul-96	19	130	0.488	7.6	246	27						10.7	10.7	11.2
8-Jul-96	20	136	0.491	7.6	239		77	41	5.2	1.25	0.28	10.8	10.7	11.1
15-Jul-96	21	143	0.491	7.3	247	28						10.9	10.7	11.1
22-Jul-96	22	150	0.488	7.5	260		69	35	4.6	1.06	0.15	10.8	10.7	11.2
29-Jul-96	23	157	0.489	7.6	286	30						10.8	10.7	11.6
6-Aug-96	24	165	0.488	7.4	316		109	41	4.9	0.71	0.10	10.7	10.6	11.2
12-Aug-96	25	171	0.488	7.1	262	31						10.8	10.7	11.1
19-Aug-96	26	178	0.489	7.6	266	28	106	39	4.9	0.77	0.10	10.8	10.7	11.2
26-Aug-96	27	185	0.489	7.6	265		85					10.8	10.7	11.1
2-Sep-96	28	192	0.493	7.4	262	28	127	47	4.7	0.71	0.10	10.7	10.7	11.1
10-Sep-96	29	200	0.484	7.5	234		129	40	4.7	0.90	0.09	10.6	10.5	11.1
17-Sep-96	30	207	0.492	7.4	205	30	99					10.8	10.7	11.2
24-Sep-96	31	214	0.490	7.4	226		99					11.0	10.8	11.3
1-Oct-96	32	221	0.490	7.4	220	31	97	33	4.1	0.46	0.06	10.8	10.7	11.2
8-Oct-96	33	228	0.491	7.4	249							10.9	10.8	11.4
15-Oct-96	34	235	0.491	7.4	238	30	118	51	4.8	0.75	0.12	11.0	10.7	11.3
22-Oct-96	35	242	0.491	7.6	224							11.0	10.9	11.3
29-Oct-96	36	249	0.494	7.5	259	30	99	40	5.9	0.49	0.05	11.1	11.0	11.4
5-Nov-96	37	256	0.491	7.6	235							11.1	10.9	11.4
12-Nov-96	38	263	0.493	7.3	170	26	109						11.0	
19-Nov-96	39	270	0.492									11.1	11.0	11.5
27-Nov-96	40	278	0.492	7.5	239	31		45	5.0	0.56	0.10	11.0	10.8	11.3
3-Dec-96	41	284	0.486									11.1	10.9	
10-Dec-96	42	291	0.491											
18-Dec-96	43	299	0.493	7.6	237	30	122	45	5.3	0.56	0.06			

Sample: HC-1
Cell Type: non-aerated
Test Conditions: 1 kg cell, no air applied - 500 mL trickle leach

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	112	21	13	16					70	0.04		369	0.83				3.84	5.05
1	1	148	28	18	21					164	0.09		487	1.09	826.1			0.91	1.20
2	7	182	34	20	22					292	0.17		595	1.33	126.1			0.65	0.81
3	15	214	38	22	23	47.6	7.94	4.37	3.32	382	0.22	78.5	694	1.56		145.4	151.8	0.85	1.06
4	23	242	42	24	23	39.5	6.37	3.25	2.26	447	0.26		779	1.75	74.9	114.7	125.1	1.02	1.26
5	31	269	46	25	24	35.4	5.56	2.70	1.74	493	0.28	40.1	862	1.93		95.5	111.5	1.41	1.73
6	38	294	49	26	24	27.7	3.97	1.55	0.62	541	0.31	48.0	939	2.11		71.2	85.6	1.26	1.54
7	45	318	52	27	24	24.9	3.44	1.25	0.36	578	0.33	37.6	1010	2.27		52.8	76.6	1.50	1.82
8	52	339	55	28	24	23.7	3.13	1.09	0.23	631	0.36	52.3	1076	2.41	65.9	47.1	72.3	1.01	1.21
9	59	360	58	29	25	23.0	2.96	1.05	0.22	677	0.39		1138	2.55		44.8	69.8	1.06	1.28
10	66	379	60	30	25	22.1	2.82	1.00	0.22	718	0.41		1197	2.68	58.4	45.1	66.9	1.12	1.37
11	74	398	63	31	25	20.2	2.56	0.90	0.21	753	0.43		1253	2.81		41.3	61.1	1.27	1.54
12	81	416	65	32	25	19.1	2.43	0.85	0.20	783	0.45	29.4	1308	2.93	54.9	39.7	57.9	1.48	1.79
13	88	434	67	32	25	18.5	2.36	0.81	0.20	815	0.47		1364	3.06		35.8	55.9	1.39	1.67
14	95	454	69	33	26	18.2	2.28	0.76	0.18	849	0.48	34.7	1421	3.19	56.7	33.5	54.9	1.32	1.57
15	102	473	72	34	26	18.2	2.22	0.73	0.16	880	0.50		1477	3.31		31.5	54.6	1.47	1.76
16	109	484	73	34	26	17.3	2.09	0.68	0.15	897	0.51	16.9	1513	3.39	35.5	28.8	52.0	1.67	2.01
17	116	507	75	35	26	18.2	2.10	0.66	0.15	933	0.53		1579	3.54		30.1	54.2	1.50	1.75
18	123	533	78	36	26	19.7	2.10	0.63	0.15	978	0.56	44.7	1653	3.71	74.4	32.7	57.9	1.40	1.60
19	130	556	80	36	26	20.5	2.14	0.62	0.15	1019	0.58		1721	3.86		33.9	60.0	1.34	1.57
20	136	576	83	37	26	21.3	2.26	0.61	0.15	1057	0.60	44.1	1782	3.99	71.0	36.3	62.6	1.28	1.54
21	143	595	85	37	27	22.7	2.45	0.64	0.15	1093	0.62		1838	4.12		40.2	67.0	1.25	1.51
22	150	612	87	38	27	21.6	2.44	0.60	0.13	1126	0.64	33.7	1890	4.24	52.0	39.7	64.1	1.22	1.48
23	157	630	90	38	27	20.0	2.45	0.57	0.11	1170	0.67		1946	4.36		39.5	60.3	1.02	1.24
24	165	650	92	39	27	18.9	2.38	0.50	0.09	1223	0.70	46.5	2006	4.50	52.4	40.8	57.1	0.90	1.08
25	171	670	94	39	27	18.8	2.35	0.44	0.07	1276	0.73		2065	4.63		43.7	56.6	0.89	1.07
26	178	689	97	39	27	18.8	2.35	0.41	0.06	1327	0.76	51.8	2122	4.76	57.6	46.9	56.8	0.88	1.07
27	185	710	99	40	27	19.6	2.37	0.38	0.05	1369	0.78	41.6	2185	4.90		48.5	58.9	1.21	1.44
28	192	733	101	40	27	20.6	2.37	0.36	0.05	1432	0.82	62.5	2252	5.05	67.5	52.3	61.2	0.89	1.03
29	200	752	104	40	27	20.4	2.34	0.38	0.05	1494	0.85	54.7	2310	5.18	50.6	54.2	60.8	0.74	0.89
30	207	771	106	41	27	19.7	2.25	0.37	0.04	1543	0.88	48.7	2366	5.30		51.9	58.5	0.91	1.09
31	214	788	108	41	27	19.3	2.19	0.35	0.04	1591	0.91	48.5	2418	5.42		51.3	57.4	0.86	1.03
32	221	804	110	41	27	18.4	2.12	0.33	0.04	1639	0.94	47.5	2466	5.53	48.8	52.5	54.7	0.82	0.98
33	228	825	112	42	27	17.9	2.10	0.32	0.04	1692	0.97		2527	5.67		50.6	53.4	0.94	1.10
34	235	850	115	42	27	19.5	2.17	0.31	0.04	1749	1.00	57.9	2599	5.83	72.3	51.1	57.8	1.04	1.20
35	242	872	117	42	27	20.3	2.26	0.30	0.04	1803	1.03		2666	5.98		52.0	60.1	1.01	1.20
36	249	892	120	43	27	20.8	2.42	0.29	0.04	1852	1.06	48.9	2727	6.12	61.4	52.1	62.0	0.97	1.21
37	256	912	123	43	27	21.6	2.57	0.29	0.04	1903	1.09		2790	6.25		52.8	64.6	0.95	1.17
38	263	933	126	43	27	21.7	2.67	0.28	0.04	1956	1.12	53.7	2853	6.40		53.0	65.2	0.94	1.13
39	270	955	128	43	27	21.0	2.72	0.26	0.04	2011	1.15		2917	6.54		52.4	63.7	0.94	1.13
40	278	977	131	44	27	20.3	2.61	0.25	0.04	2067	1.18		2983	6.69	57.3	51.5	61.7	0.95	1.12
41	284	999	133	44	27	21.3	2.60	0.26	0.04	2124	1.21		3048	6.83		54.5	64.1	0.92	1.10
42	291	1021	136	44	27	21.7	2.55	0.27	0.04	2183	1.25		3114	6.98		56.0	64.8	0.90	1.08
43	299	1043	138	44	28	21.3	2.46	0.27	0.04	2243	1.28	52.6	3180	7.13	58.0	55.7	63.6	0.89	1.06

APPENDIX 11

TABULATED RESULTS

SIMULATED PRECIPITATION CELLS

Sample: HC-1
Cell Type: simulated precipitation; 50 mL over 1 hr
Test Conditions: 1 kg cell with dry/wet air cycles, 500 mL trickle leach for 200 days then no air supplied; at 221 days 50 mL/1 hr leach , frequency varied
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

		Days since	Leachate				Water analysis					Gravimetric water content		
		previous	volume		Conduct.	Alkalinity	SO_4	Ca	Mg	K	Na	End, 3-day dry	End, 3-day wet	End of leach
Date	Days	leach	(L)	pH	(uS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(%)	(%)	(%)
23-Feb-96	0	0	0.183	7.8	711			685	134.0	82.00	96.00			
24-Feb-96	1	1	0.228	7.7	566			156	25.9	17.40	10.70			
1-Mar-96	7	6	0.470	7.7	421		231					9.2	9.5	12.0
9-Mar-96	15	8	0.453	7.5	443			73	11.0	4.01	1.30	6.3	7.0	11.3
17-Mar-96	23	8	0.405	7.5	299		126					0.8	1.7	10.8
25-Mar-96	31	8	0.437	7.4	291	22	122					5.0	4.9	10.4
1-Apr-96	38	7	0.416	7.5			95					0.8	1.9	10.0
8-Apr-96	45	7	0.440	7.6	288	27	112					4.3	4.9	9.9
15-Apr-96	52	7	0.458	7.8	345	28						1.1	4.0	9.5
22-Apr-96	59	7	0.430	7.5	218	24		30	4.7	1.90	0.60	2.5	2.3	9.1
29-Apr-96	66	7	0.412	7.4	247	30						3.8	3.9	9.1
7-May-96	74	8	0.458	7.4	326		133	55	6.5	2.20	0.58	5.2	5.6	9.1
14-May-96	81	7	0.468	7.6	292	22						5.7	6.9	9.4
21-May-96	88	7	0.446	7.3	207		59	31	3.6	1.10	0.28	4.2	4.9	9.6
28-May-96	95	7	0.446	7.3	286	26						4.5	5.1	9.5
4-Jun-96	102	7	0.452	7.4	219			44	2.8	1.30	0.28	4.9	5.4	9.5
11-Jun-96	109	7	0.467	7.2	260	15						6.7	6.9	9.6
18-Jun-96	116	7	0.453	7.5	217		82	33	4.6	1.30	0.30	4.4	4.6	9.6
25-Jun-96	123	7	0.444	7.3	236	19						4.4	4.6	9.5
2-Jul-96	130	7	0.459	7.3	221		91	39	4.7	1.01	0.23	5.7	6.2	9.7
8-Jul-96	136	6	0.465	7.6	288	27						6.7	6.8	9.8
15-Jul-96	143	7	0.474	7.5	286		105	44	5.6	0.92	0.18	7.3	7.5	9.8
22-Jul-96	150	7	0.467	6.8	257	18						6.4	6.7	9.9
29-Jul-96	157	7	0.461	7.4	325		121	51	6.2	1.35	0.15	6.2	6.4	9.8
6-Aug-96	165	8	0.467	7.4	296	16						7.2	7.3	10.0
12-Aug-96	171	6	0.472	7.6	319		130	52	6.2	1.04	0.19	7.6	7.8	10.0
19-Aug-96	178	7	0.454	7.5	266	19	139					5.7	5.8	9.8
26-Aug-96	185	7	0.464	7.5	296		135	45	5.7	0.93	0.11	6.7	6.9	10.0
2-Sep-96	192	7	0.428	7.0	201	11	89	34	3.7	0.65	0.49	3.1	3.1	9.9
10-Sep-96	200	8	0.539	7.2	248		123					6.4	6.9	10.0
17-Sep-96	207	7	0.623	7.1	226	22	107	37	5.0	0.87	0.11	4.9	5.3	10.0
24-Sep-96	214	7	0.565	7.2	298		139	47	5.9	0.77	0.09	9.8	9.7	10.3
27-Sep-96	217	3	0.046	7.8	672	52	395							
1-Oct-96	221	4	0.047	7.8	672	52	395	146	18.5	1.69	0.42	10.1	13.1	13.2
4-Oct-96	224	3	0.048	7.7	809	45	550							
8-Oct-96	228	4	0.046	7.4	844		516	196	24.8	1.87	0.30	13.1	13.2	
11-Oct-96	231	3	0.048	7.5	772	44	573							
15-Oct-96	235	4	0.048				571	217	25.2	2.17	0.31	13.1		13.4
19-Oct-96	239	4	0.048	7.1	821	24	582							
22-Oct-96	242	3	0.050	7.8	792	68	519	184	23.7	2.07	0.25		13.3	
29-Oct-96	249	7	0.048	7.2	1025	38	738	235	32.8	2.31	0.32	13.2	13.2	
5-Nov-96	256	7	0.048	7.0	1039	21	731	261	32.7	2.25	0.31	13.3	13.2	13.3
12-Nov-96	263	7	0.048	7.4	1147	23	855	281	36.7	2.30	2.60		13.2	
19-Nov-96	270	7	0.048	7.3	1181	31	968	340	43.0	2.22	2.20	13.3	13.2	
3-Dec-96	284	14	0.047	7.4	1451	31	1399	492	52.0	2.98	0.53	13.1	13.1	
18-Dec-96	299	15	0.047	7.3	1665	28	1657	546	79.8	2.92	0.59			

Sample: HC-1
Cell Type: simulated precipitation; 50 mL over 1 hr
Test Conditions: 1 kg cell with dry/wet air cycles, 500 mL trickle leach for 200 days then no air supplied; at 221 days 50 mL/1 hr leach , frequency varied

		Cumulative mass flux				Extraction rates				Sulfur			Neutralization			Molar ratio	
Days	Days since previous leach	Ca (mg/kg)	Mg (mg/kg)	K (mg/kg)	Na (mg/kg)	Ca (mg/kg/wk)	Mg (mg/kg/wk)	K (mg/kg/wk)	Na (mg/kg/wk)	Cum. SO_4 flux (mg/kg)	Sulfur depleted (%)	SO_4 prod. rate (mg/kg/wk)	Cum. NP depletion (mg/kg)	NP depleted (%)	NP depl'n rate (mg/kg/wk)	[Ca] / [SO_4]	[Ca+Mg] / [SO_4]
0	0	126	25	15	18					38	0.02		415	0.93		7.97	10.53
1	1	161	30	19	20	249.0	41.3	27.77	17.08	88	0.05		529	1.19	793.3	1.71	2.18
7	6	215	39	24	23					196	0.11	126.6	699	1.57		1.19	1.51
15	8	248	44	26	23	28.9	4.4	1.59	0.51	277	0.16		802	1.80	90.3	0.98	1.22
23	8	275	48	27	24					328	0.19	44.7	886	1.99		1.25	1.57
31	8	300	52	29	24					381	0.22	46.7	966	2.17		1.15	1.44
38	7	322	55	30	25					421	0.24	39.5	1033	2.32		1.30	1.63
45	7	341	58	31	25					470	0.27	49.3	1094	2.45		0.95	1.19
52	7	358	61	32	25					524	0.30		1147	2.57		0.76	0.95
59	7	371	63	33	26	12.9	2.0	0.82	0.26	577	0.33		1188	2.66	40.6	0.59	0.74
66	7	389	65	34	26					629	0.36		1241	2.78		0.80	0.97
74	8	414	68	35	26	22.1	2.6	0.88	0.23	690	0.39	53.3	1317	2.95	65.9	0.99	1.19
81	7	434	71	36	26					735	0.42		1377	3.09		1.08	1.28
88	7	448	72	36	27	13.8	1.6	0.49	0.12	761	0.43	26.3	1418	3.18	41.2	1.26	1.50
95	7	464	74	37	27					790	0.45		1466	3.29		1.39	1.59
102	7	484	75	37	27	19.9	1.3	0.59	0.13	822	0.47		1521	3.41	55.0	1.50	1.65
109	7	502	77	38	27					858	0.49		1573	3.53		1.21	1.40
116	7	517	79	38	27	14.9	2.1	0.59	0.14	895	0.51	37.1	1619	3.63	46.0	0.97	1.19
123	7	533	81	39	27					933	0.53		1667	3.74		1.00	1.21
130	7	551	83	39	27	17.9	2.2	0.46	0.11	975	0.56	41.8	1721	3.86	53.7	1.03	1.23
136	6	571	85	40	27					1021	0.58		1779	3.99		1.02	1.22
143	7	591	88	40	27	20.8	2.7	0.44	0.09	1070	0.61	49.7	1842	4.13	63.1	1.01	1.22
150	7	614	91	41	28					1123	0.64		1909	4.28		1.01	1.22
157	7	637	94	41	28	23.5	2.9	0.62	0.07	1179	0.67	55.8	1980	4.44	70.6	1.01	1.21
165	8	661	96	42	28					1238	0.71		2052	4.60		0.98	1.18
171	6	686	99	42	28	28.7	3.4	0.57	0.10	1299	0.74	71.6	2125	4.77	85.8	0.96	1.15
178	7	708	102	43	28					1362	0.78	63.1	2192	4.91		0.84	1.01
185	7	729	105	43	28	20.9	2.6	0.43	0.05	1425	0.81	62.6	2255	5.06	63.1	0.80	0.97
192	7	743	106	44	28	14.5	1.6	0.28	0.21	1463	0.83	38.1	2298	5.15	42.9	0.92	1.08
200	8	762	109	44	28					1529	0.87	58.0	2355	5.28		0.69	0.83
207	7	785	112	45	28	23.0	3.1	0.54	0.07	1596	0.91	66.6	2426	5.44	70.5	0.83	1.01
214	7	812	115	45	28	26.6	3.3	0.44	0.05	1674	0.96	78.6	2506	5.62	80.2	0.81	0.98
217	3	816	116	45	28					1692	0.97	42.1	2519	5.65		0.59	0.71
221	4	823	117	45	28	12.0	1.5	0.14	0.03	1711	0.98	32.4	2540	5.69	36.2	0.89	1.07
224	3	831	118	45	28					1737	0.99	61.7	2565	5.75		0.75	0.90
228	4	840	119	45	28	15.7	2.0	0.15	0.02	1761	1.01	41.4	2592	5.81	47.5	0.91	1.10
231	3	850	120	45	29					1788	1.02	64.4	2622	5.88		0.86	1.04
235	4	861	121	46	29	18.2	2.1	0.18	0.03	1816	1.04	47.9	2653	5.95	54.2	0.91	1.09
239	4	870	122	46	29					1844	1.05	49.2	2682	6.01		0.83	0.99
242	3	879	124	46	29	21.3	2.7	0.24	0.03	1870	1.07	60.2	2710	6.08	64.7	0.85	1.03
249	7	891	125	46	29	11.4	1.6	0.11	0.02	1905	1.09	35.6	2745	6.15	34.9	0.76	0.94
256	7	903	127	46	29	12.5	1.6	0.11	0.01	1940	1.11	34.9	2782	6.24	37.7	0.86	1.03
263	7	917	128	46	29	13.5	1.8	0.11	0.13	1981	1.13	41.2	2823	6.33	41.2	0.79	0.96
270	7	933	130	46	29	16.3	2.1	0.11	0.11	2028	1.16	46.3	2873	6.44	49.1	0.84	1.02
284	14	956	133	46	29	11.6	1.2	0.07	0.01	2094	1.20	33.1	2941	6.59	34.2	0.84	0.99
299	15	982	137	46	29	11.9	1.74	0.06	0.01	2171	1.24	36.1	3020	6.77	36.9	0.79	0.98

Sample: HC-1
Cell Type: simulated precipitation; 50 mL over 24 hrs
Test Conditions: 1 kg cell with dry/wet air cycles, 500 mL trickle leach for 200 days then no air supplied; at 221 days 50 mL/24 hr leach, frequency varied
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

		Days since	Leachate				Water analysis					Gravimetric water content		
Date	Days	previous leach	volume (L)	pH	Conduct. (uS/cm)	Alkalinity (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	End, 3-day dry (%)	End, 3-day wet (%)	End of leach (%)
23-Feb-96	0	0	0.184	7.5	726			732	144.0	77.00	95.00			
24-Feb-96	1	1	0.285	7.5	600			161	26.3	18.60	10.60			
1-Mar-96	7	6	0.449	7.5	474		292					10.9	11.1	15.8
9-Mar-96	15	8	0.444	7.5	419			69	10.3	4.58	1.22	6.8	7.1	12.0
17-Mar-96	23	8	0.406	7.6	488		163					0.2	1.5	10.5
25-Mar-96	31	8	0.447	7.5	330	26	148					5.9	5.7	10.2
1-Apr-96	38	7	0.440	7.6			122					4.9	5.6	10.2
8-Apr-96	45	7	0.407	7.3	240	19	97					0.3	1.3	9.8
15-Apr-96	52	7	0.437	7.6	319	22						2.8	3.8	9.6
22-Apr-96	59	7	0.422	7.5	199	19		33	4.5	1.90	0.61	3.9	2.8	9.3
29-Apr-96	66	7	0.047	7.5	271	30						3.5	3.4	9.2
7-May-96	74	8	0.442	7.5	233		75	40	4.5	2.00	0.48	3.1	4.0	9.0
14-May-96	81	7	0.468	7.7	274	25						5.3	6.5	9.4
21-May-96	88	7	0.440	7.3	218		40	32	4.1	1.60	0.36	3.6	4.4	9.6
28-May-96	95	7	0.468	7.3	200	22						2.9	7.0	9.5
4-Jun-96	102	7	0.465	7.5	252		107	51	5.6	1.62	0.32	6.2	6.9	9.5
11-Jun-96	109	7	0.475	7.3	283	20						7.6	7.8	9.6
18-Jun-96	116	7	0.456	7.6	240		91	37	5.1	1.50	0.32	3.3	3.5	9.1
25-Jun-96	123	7	0.421	7.3	216	15						0.7	1.4	9.1
2-Jul-96	130	7	0.463	7.3	279		143	54	6.5	1.42	0.29	6.0	6.2	9.5
8-Jul-96	136	6	0.475	7.6	322	27						6.9	7.6	9.8
15-Jul-96	143	7	0.472	7.6	318		120	50	6.1	1.07	0.19	7.1	7.3	9.7
22-Jul-96	150	7	0.460	7.0	261	11						5.9	6.2	9.8
29-Jul-96	157	7	0.479	7.4	373		150	58	6.8	1.58	0.16	7.4	8.3	9.8
6-Aug-96	165	8	0.452	6.9	341	19						4.5	5.4	9.6
12-Aug-96	171	6	0.475	7.5	330		142	52	6.2	1.05	0.16	7.1	7.8	9.8
19-Aug-96	178	7	0.467	7.4	274	19	133					5.1	7.3	10.0
26-Aug-96	185	7	0.469	7.5	310		137	48	6.1	0.95	0.11	6.1	7.3	9.8
2-Sep-96	192	7	0.466	7.3	297	23	149	55	6.1	0.99	0.24	6.9	6.9	9.8
10-Sep-96	200	8	0.550	7.3	255		123					6.6	7.2	9.9
17-Sep-96	207	7	0.539	7.3	251	24	129	46	5.9	1.10	0.11	6.0	6.2	9.9
24-Sep-96	214	7	0.569	7.3	281		137	46	5.6	0.70	0.10	9.7	9.6	10.3
27-Sep-96	217	3	0.048	7.7	692	62	395							
1-Oct-96	221	4	0.046	7.7	692	62	395	156	17.5	1.70	0.28	10.1	10.2	
4-Oct-96	224	3	0.049	7.7	862	83	548							
8-Oct-96	228	4	0.047				508	217	27.5	2.23	0.39	13.0	13.1	
11-Oct-96	231	3	0.048	7.8	882	84	567							
15-Oct-96	235	4	0.048				588	215	24.8	2.21	0.31	13.1		13.4
19-Oct-96	239	4	0.049	7.7	860	80	558							
22-Oct-96	242	3	0.050	7.7	799	74	511	177	23.6	2.05	0.25		13.2	
29-Oct-96	249	7	0.048	7.7	1006	45	710	140	32.0	2.21	0.29	13.1	13.1	
5-Nov-96	256	7	0.047	7.5	1121	60	800	296	36.3	2.45	0.37	13.1	13.1	13.2
12-Nov-96	263	7	0.048	7.5	1234	51	915	264	30.2	2.48	0.36		13.1	
19-Nov-96	270	7	0.048	7.4	1353	45	1071	372	49.0	2.47	2.40	13.2	13.1	
3-Dec-96	284	14	0.045	7.5	1572	35	1532	520	53.0	3.15	0.56	13.0	12.9	
18-Dec-96	299	15	0.047	7.4	1840	34	1910	663	94.0	3.20	0.65			

Sample: HC-1
Cell Type: simulated precipitation; 50 mL over 24 hrs
Test Conditions: 1 kg cell with dry/wet air cycles, 500 mL trickle leach for 200 days then no air supplied; at 221 days 50 mL/24 hr leach, frequency varied

	Days since	Cumulative mass flux				Extraction rates				Sulfur			Neutralization			Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod. rate	Cum. NP depletion	NP depleted	NP depl'n rate	[Ca]	[Ca+Mg]
Days	previous leach	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	134	26	14	17					221	0.13		445	1.00		1.46	1.93
1	1	180	34	19	20	321.2	52.5	37.11	21.15	433	0.25		591	1.32	1019.9	0.52	0.66
7	6	232	42	25	23					565	0.32	152.9	754	1.69		0.95	1.19
15	8	262	47	27	24	26.8	4.0	1.78	0.47	665	0.38		849	1.90	83.5	0.73	0.91
23	8	288	50	28	24					732	0.42	57.9	929	2.08		0.93	1.15
31	8	313	54	30	25					798	0.46	57.8	1008	2.26		0.92	1.15
38	7	336	57	31	25					852	0.49	53.7	1078	2.42		1.00	1.24
45	7	354	60	33	25					891	0.51	39.5	1134	2.54		1.11	1.38
52	7	371	62	34	26					931	0.53		1187	2.66		1.02	1.26
59	7	385	64	34	26	13.9	1.9	0.80	0.26	967	0.55		1229	2.76	42.7	0.92	1.13
66	7	387	65	34	26					971	0.55		1235	2.77		1.09	1.31
74	8	405	67	35	26	15.5	1.7	0.77	0.19	1004	0.57	29.0	1287	2.89	45.9	1.28	1.52
81	7	422	69	36	26					1031	0.59		1337	3.00		1.50	1.80
88	7	436	70	37	26	14.1	1.8	0.70	0.16	1049	0.60	17.6	1380	3.09	42.7	1.92	2.32
95	7	455	73	38	27					1083	0.62		1438	3.22		1.36	1.62
102	7	479	75	38	27	23.7	2.6	0.75	0.15	1133	0.65	49.7	1508	3.38	70.0	1.14	1.35
109	7	500	78	39	27					1180	0.67		1571	3.52		1.07	1.28
116	7	516	80	40	27	16.9	2.3	0.68	0.15	1221	0.70	41.5	1623	3.64	51.8	0.98	1.20
123	7	536	83	40	27					1271	0.73		1681	3.77		0.93	1.13
130	7	561	86	41	27	25.0	3.0	0.66	0.13	1337	0.76	66.2	1756	3.94	75.0	0.91	1.09
136	6	585	89	42	27					1399	0.80		1830	4.10		0.95	1.14
143	7	609	91	42	28	23.6	2.9	0.51	0.09	1456	0.83	56.6	1901	4.26	70.9	1.00	1.20
150	7	634	94	43	28					1518	0.87		1975	4.43		0.96	1.15
157	7	662	98	44	28	27.8	3.3	0.76	0.08	1590	0.91	71.8	2058	4.61	82.9	0.93	1.11
165	8	686	101	44	28					1656	0.95		2132	4.78		0.90	1.08
171	6	711	104	45	28	28.8	3.4	0.58	0.09	1723	0.98	78.6	2206	4.95	86.2	0.88	1.05
178	7	734	106	45	28					1785	1.02	62.2	2276	5.10		0.90	1.08
185	7	757	109	46	28	22.5	2.9	0.45	0.05	1850	1.06	64.3	2345	5.26	68.2	0.84	1.02
192	7	783	112	46	28	25.6	2.8	0.46	0.11	1919	1.10	69.4	2420	5.43	75.8	0.89	1.05
200	8	810	115	47	28					1987	1.13	59.2	2503	5.61		0.99	1.18
207	7	835	119	47	28	24.8	3.2	0.59	0.06	2056	1.17	69.6	2579	5.78	75.2	0.86	1.04
214	7	861	122	48	28	26.2	3.2	0.40	0.06	2134	1.22	78.0	2657	5.96	78.7	0.81	0.97
217	3	866	122	48	28					2153	1.23	44.4	2672	5.99		0.61	0.73
221	4	873	123	48	28	12.5	1.4	0.14	0.02	2171	1.24	31.7	2693	6.04	37.1	0.95	1.12
224	3	882	124	48	28					2198	1.25	62.1	2720	6.10		0.82	0.98
228	4	893	126	48	28	18.0	2.3	0.18	0.03	2222	1.27	42.1	2751	6.17	54.4	1.03	1.24
231	3	903	127	48	28					2249	1.28	63.0	2782	6.24		0.91	1.10
235	4	913	128	48	28	18.0	2.1	0.18	0.03	2277	1.30	49.2	2813	6.31	53.6	0.88	1.04
239	4	923	129	48	28					2304	1.32	47.5	2841	6.37		0.84	1.01
242	3	932	130	48	28	20.4	2.7	0.24	0.03	2330	1.33	59.0	2868	6.43	62.4	0.83	1.01
249	7	938	132	48	28	6.7	1.5	0.11	0.01	2363	1.35	33.8	2891	6.48	23.0	0.47	0.65
256	7	952	134	49	28	13.9	1.7	0.11	0.02	2401	1.37	37.4	2933	6.58	41.7	0.89	1.07
263	7	965	135	49	28	12.7	1.5	0.12	0.02	2445	1.40	44.0	2971	6.66	37.8	0.69	0.82
270	7	983	137	49	29	17.9	2.4	0.12	0.12	2497	1.42	51.6	3025	6.78	54.6	0.83	1.01
284	14	1006	140	49	29	11.7	1.2	0.07	0.01	2565	1.46	34.5	3094	6.94	34.2	0.81	0.95
299	15	1038	144	49	29	14.7	2.08	0.07	0.01	2656	1.52	42.2	3191	7.15	45.3	0.83	1.03

Sample: HC-1
Cell Type: simulated precipitation; 100 mL over 1 hr
Test Conditions: 1 kg cell with dry/wet air cycles, 500 mL trickle leach for 200 days then no air supplied; at 221 days 100 mL/1 hr leach, frequency varied
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

		Days since	Leachate				Water analysis					Gravimetric water content		
Date	Days	previous leach	volume (L)	pH	Conduct. (uS/cm)	Alkalinity (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	End, 3-day dry (%)	End, 3-day wet (%)	End of leach (%)
23-Feb-96	0	0	0.177	7.5	670			688	133.0	74.00	91.00			
24-Feb-96	1	1	0.280	7.5	561			163	27.5	17.50	11.10			
1-Mar-96	7	6	0.481	7.5	451		239					10.5	11.0	12.4
9-Mar-96	15	8	0.394	7.4	279			40	5.4	3.73	0.87	0.4	0.9	11.0
17-Mar-96	23	8	0.465	7.5	424		242					6.7	8.0	11.0
25-Mar-96	31	8	0.448	7.5	274	25	110					6.6	6.0	10.5
1-Apr-96	38	7	0.431	7.6			95					2.2	3.3	9.9
8-Apr-96	45	7	0.385	7.5	216	22	86					1.0	2.2	9.6
15-Apr-96	52	7	0.495	7.7	356	27						7.3	10.5	9.7
22-Apr-96	59	7	0.449	7.5	208	20		31	4.7	1.80	0.63	5.8	5.2	9.8
29-Apr-96	66	7	0.412	7.6	232	30						6.6	6.5	9.6
7-May-96	74	8	0.476	7.4	419		157	54	6.1	2.10	0.55	7.5	7.9	9.4
14-May-96	81	7	0.463	7.7	149	21						6.0	6.8	9.7
21-May-96	88	7	0.457	7.4	231		78	35	4.4	1.50	0.35	5.8	6.2	9.9
28-May-96	95	7	0.461	7.4	248	22						6.4	6.7	9.9
4-Jun-96	102	7	0.459	7.5	245		91	48	5.3	1.50	0.32	6.2	6.6	9.9
11-Jun-96	109	7	0.460	7.4	269	23						6.3	6.8	10.1
18-Jun-96	116	7	0.451	7.7	255		96	39	5.5	1.50	0.33	6.3	6.6	10.1
25-Jun-96	123	7	0.440	7.4	228	19						3.6	4.0	9.6
2-Jul-96	130	7	0.453	7.4	244		117	45	5.4	1.10	0.25	5.4	5.8	9.9
8-Jul-96	136	6	0.478	7.5	288	26						7.5	8.1	9.9
15-Jul-96	143	7	0.472	7.6	296		113	45	5.6	0.92	0.17	7.4	7.8	9.9
22-Jul-96	150	7	0.470	7.4	294	26						6.6	7.5	9.9
29-Jul-96	157	7	0.483	7.5	350		137	55	6.4	1.43	0.15	8.5	8.8	9.9
6-Aug-96	165	8	0.462	7.2	330	17						6.4	6.6	10.0
12-Aug-96	171	6	0.460	7.6	300		118	47	5.6	1.12	0.15	6.4	6.5	9.9
19-Aug-96	178	7	0.429	7.4	248	19	99					2.8	3.1	9.5
26-Aug-96	185	7	0.466	7.5	318		135	48	6.2	0.96	0.12	6.3	6.8	9.6
2-Sep-96	192	7	0.448	7.2	262	20	128	46	5.3	0.98	0.08	5.1	5.1	9.8
10-Sep-96	200	8	0.546	7.3	225		107					4.0	5.0	9.7
17-Sep-96	207	7	0.560	7.3	250	19	113	43	5.6	0.85	0.11	6.2	6.5	9.9
24-Sep-96	214	7	0.587	7.4	279		117	45	5.9	0.69	0.09	9.6	9.5	10.1
27-Sep-96	217	3	0.096	7.4	469	42								
1-Oct-96	221	4	0.095	7.8	467	62	212	89	11.2	1.20	0.20	9.9	10.0	10.2
4-Oct-96	224	3	0.095	7.4	564	39	310							
8-Oct-96	228	4	0.096	7.7	503	59	254	95	12.1	1.22	0.18	10.0	7.8	
11-Oct-96	231	3	0.096	7.5	543	41	308							
15-Oct-96	235	4	0.096	7.8	516	63	284	117	12.6	1.43	0.17	10.2		10.5
19-Oct-96	239	4	0.097	7.4	492	36	281							
22-Oct-96	242	3	0.097	7.8	496	59	245	93	11.8	1.35	0.17		10.4	
29-Oct-96	249	7	0.095	7.3	684	33	407	237	19.1	1.49	0.15	10.4	10.3	
5-Nov-96	256	7	0.097	7.6	742	33	415	164	19.9	1.71	0.18	10.4	10.3	10.5
12-Nov-96	263	7	0.095	7.3	779	32	457	166	21.2	1.56	0.19		10.3	
19-Nov-96	270	7	0.095	7.5	804	29	552	192	24.4	1.45	0.27	10.4	10.3	
3-Dec-96	284	14	0.094	7.4	1056	24	843	289	37.0	2.00	0.31	10.2	10.2	
18-Dec-96	299	15	0.094	7.1	1113	19	965	310	41.8	1.86	0.31			

Sample: HC-1
Cell Type: simulated precipitation; 100 mL over 1 hr
Test Conditions: 1 kg cell with dry/wet air cycles, 500 mL trickle leach for 200 days then no air supplied; at 221 days 100 mL/1 hr leach, frequency varied

	Days since	Cumulative mass flux				Extraction rates				Sulfur			Neutralization			Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod. rate	Cum. NP depletion	NP depleted	NP depl'n rate	[Ca]	[Ca+Mg]
Days	previous leach	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	[SO_4]	[SO_4]
0	0	122	23	13	16					239	0.14		401	0.90		1.22	1.61
1	1	167	31	18	19	319.1	53.8	34.26	21.73	462	0.26		547	1.23	1020.4	0.49	0.63
7	6	216	39	23	22					576	0.33	134.1	701	1.57		1.02	1.29
15	8	232	41	25	22	13.8	1.9	1.29	0.30	671	0.38		750	1.68	42.2	0.40	0.49
23	8	250	44	26	23					784	0.45	98.5	804	1.80		0.38	0.47
31	8	266	46	28	23					833	0.48	43.1	855	1.92		0.81	0.99
38	7	281	48	29	23					874	0.50	41.0	903	2.02		0.90	1.11
45	7	295	50	30	24					907	0.52	33.1	943	2.12		0.95	1.18
52	7	311	52	31	24					959	0.55		993	2.23		0.75	0.94
59	7	325	55	31	24	13.9	2.1	0.81	0.28	1013	0.58		1037	2.32	43.5	0.61	0.77
66	7	342	57	32	25					1070	0.61		1090	2.44		0.73	0.89
74	8	368	60	33	25	22.5	2.5	0.88	0.23	1145	0.65	65.4	1166	2.61	66.8	0.83	0.98
81	7	388	62	34	25					1200	0.68		1228	2.75		0.91	1.09
88	7	404	64	35	25	16.0	2.0	0.69	0.16	1235	0.71	35.6	1276	2.86	48.3	1.08	1.30
95	7	424	66	36	25					1274	0.73		1333	2.99		1.18	1.41
102	7	446	69	36	26	22.0	2.4	0.69	0.15	1316	0.75	41.7	1398	3.14	65.1	1.27	1.50
109	7	466	71	37	26					1359	0.78		1459	3.27		1.12	1.34
116	7	483	74	38	26	17.6	2.5	0.68	0.15	1402	0.80	43.3	1513	3.39	54.2	0.98	1.20
123	7	502	76	38	26					1449	0.83		1569	3.52		0.95	1.15
130	7	522	79	39	26	20.4	2.4	0.50	0.11	1502	0.86	53.0	1630	3.65	61.1	0.92	1.11
136	6	544	81	39	26					1557	0.89		1695	3.80		0.94	1.13
143	7	565	84	40	26	21.2	2.6	0.43	0.08	1610	0.92	53.3	1759	3.94	64.1	0.96	1.15
150	7	588	87	40	26					1669	0.95		1829	4.10		0.96	1.15
157	7	615	90	41	26	26.5	3.1	0.69	0.07	1735	0.99	66.1	1908	4.28	79.1	0.96	1.15
165	8	638	93	41	26					1794	1.02		1979	4.44		0.96	1.15
171	6	660	95	42	27	25.2	3.0	0.60	0.08	1848	1.06	63.3	2043	4.58	75.4	0.96	1.14
178	7	680	98	42	27					1891	1.08	42.5	2105	4.72		1.15	1.39
185	7	703	101	43	27	22.4	2.9	0.45	0.06	1954	1.12	62.9	2173	4.87	67.8	0.85	1.03
192	7	723	103	43	27	20.6	2.4	0.44	0.04	2011	1.15	57.3	2234	5.01	61.4	0.86	1.03
200	8	748	106	44	27					2069	1.18	51.1	2307	5.17		1.00	1.20
207	7	772	109	44	27	24.1	3.1	0.48	0.06	2133	1.22	63.2	2380	5.34	73.1	0.91	1.11
214	7	798	112	45	27	26.4	3.5	0.40	0.05	2201	1.26	68.6	2460	5.52	80.3	0.92	1.12
217	3	804	113	45	27					2217	1.27		2480	5.56		0.98	1.18
221	4	813	114	45	27	14.8	1.9	0.20	0.03	2237	1.28	35.4	2505	5.62	44.8	1.01	1.22
224	3	822	115	45	27					2267	1.29	68.5	2532	5.68		0.71	0.86
228	4	831	117	45	27	16.0	2.0	0.21	0.03	2291	1.31	42.8	2559	5.74	48.4	0.90	1.09
231	3	841	118	45	27					2321	1.32	69.2	2590	5.81		0.83	0.98
235	4	852	119	45	27	19.7	2.1	0.24	0.03	2348	1.34	47.9	2623	5.88	58.2	0.99	1.16
239	4	862	120	45	27					2375	1.36	47.5	2653	5.95		0.90	1.07
242	3	871	121	46	27	21.0	2.7	0.30	0.04	2399	1.37	55.2	2681	6.01	63.4	0.91	1.10
249	7	894	123	46	27	22.4	1.8	0.14	0.01	2437	1.39	38.5	2744	6.15	63.5	1.40	1.58
256	7	910	125	46	27	15.9	1.9	0.17	0.02	2478	1.41	40.1	2792	6.26	47.6	0.95	1.14
263	7	925	127	46	27	15.8	2.0	0.15	0.02	2521	1.44	43.4	2839	6.37	47.7	0.87	1.06
270	7	944	129	46	27	18.3	2.3	0.14	0.03	2573	1.47	52.6	2895	6.49	55.4	0.83	1.01
284	14	971	133	46	27	13.6	1.7	0.09	0.01	2653	1.51	39.6	2977	6.67	41.2	0.82	1.00
299	15	1000	137	47	27	13.6	1.83	0.08	0.01	2743	1.57	42.2	3066	6.87	41.5	0.77	0.94

Sample: HC-1
Cell Type: simulated precipitation; 100 mL over 24 hrs
Test Conditions: 1 kg cell with dry/wet air cycles, 500 mL trickle leach for 200 days then no air supplied; at 221 days 100 mL/24 hr leach, frequency varied
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

		Days since	Leachate				Water analysis					Gravimetric water content		
Date	Days	previous leach	volume (L)	pH	Conduct. (uS/cm)	Alkalinity (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	End, 3-day dry (%)	End, 3-day wet (%)	End of leach (%)
23-Feb-96	0	0	0.141	7.6	759			701	129.0	79.00	94.00			
24-Feb-96	1	1	0.297	7.6	597			184	29.3	20.60	13.00			
1-Mar-96	7	6	0.481	7.6	435		254					9.6	10.7	12.4
9-Mar-96	15	8	0.327	7.5	450			65	10.1	5.84	1.57	0.6	1.9	10.9
17-Mar-96	23	8	0.427	7.7	403		196					2.3	3.2	10.1
25-Mar-96	31	8	0.330	7.5	337	24	156					6.1	6.2	10.2
1-Apr-96	38	7	0.433	7.6			122					3.4	4.3	10.2
8-Apr-96	45	7	0.437	7.6	273	29	115					3.6	4.7	9.9
15-Apr-96	52	7	0.438	7.6	375	20						0.7	5.1	9.8
22-Apr-96	59	7	0.429	7.5	229	19		34	5.1	2.10	0.60	4.0	3.2	9.8
29-Apr-96	66	7	0.444	7.6	301	30						5.5	5.4	9.7
7-May-96	74	8	0.471	7.6	291		110	50	5.9	2.20	0.54	7.1	7.5	9.6
14-May-96	81	7	0.478	7.7	275	24						7.3	7.9	10.0
21-May-96	88	7	0.448	7.5	252		84	43	4.9	1.80	0.36	5.3	5.5	10.0
28-May-96	95	7	0.469	7.5	295	30						7.0	7.2	10.0
4-Jun-96	102	7	0.444	7.6	242		91	52	5.4	1.70	0.32	4.1	4.5	9.8
11-Jun-96	109	7	0.451	7.4	295	23						4.8	5.9	10.1
18-Jun-96	116	7	0.449	7.6	226		91	36	4.9	1.50	0.29	3.2	3.4	9.8
25-Jun-96	123	7	0.420	7.4	250	21						1.5	2.3	9.8
2-Jul-96	130	7	0.460	7.5	294		142	53	6.4	1.33	0.25	6.3	6.5	10.1
8-Jul-96	136	6	0.475	7.6	305	31						6.8	8.1	10.1
15-Jul-96	143	7	0.477	7.6	321		110	51	6.2	1.04	0.18	7.3	8.1	10.2
22-Jul-96	150	7	0.468	7.3	297	19						7.1	8.0	10.5
29-Jul-96	157	7	0.457	7.5	368		148	58	6.9	1.57	0.17	6.2	6.7	10.3
6-Aug-96	165	8	0.475	7.4	376	20						8.0	8.4	10.4
12-Aug-96	171	6	0.480	7.6	330		132	52	5.8	1.11	0.15	8.6	9.0	10.4
19-Aug-96	178	7	0.472	7.5	297	20	142					7.7	8.4	10.5
26-Aug-96	185	7	0.477	7.6	335		134	51	6.1	1.05	0.11	8.5	9.1	10.6
2-Sep-96	192	7	0.398	7.3	209	23	91	35	3.7	1.12	0.17	0.7	0.7	10.5
10-Sep-96	200	8	0.577	7.3	420		237					8.8	9.1	10.7
17-Sep-96	207	7	0.560	7.3	284	25	139	51	6.2	0.99	0.10	7.2	7.3	10.5
24-Sep-96	214	7	0.586	7.4	285		132	47	5.5	0.80	0.09	10.4	10.3	10.9
27-Sep-96	217	3	0.098	7.7	612	57								
1-Oct-96	221	4	0.097	7.9	541	77	275	113	12.6	1.39	0.22	10.7	10.9	
4-Oct-96	224	3	0.097	7.8	619	82	315							
8-Oct-96	228	4	0.096	7.8	495	73	239	110	12.0	1.56	0.19	10.9	10.6	
11-Oct-96	231	3	0.099	7.7	597	68	319							
15-Oct-96	235	4	0.099	7.9	533	81	264	114	12.2	1.57	0.20	11.0		11.1
19-Oct-96	239	4	0.099	7.8	505	66	252							
22-Oct-96	242	3	0.099	7.8	470	71	238	96	11.4	1.54	0.16		11.0	
29-Oct-96	249	7	0.098	7.4	681	52	393	136	18.2	1.69	0.18	11.0	10.9	
5-Nov-96	256	7	0.096	7.5	743	31	428	163	20.7	1.48	0.17	11.0	10.9	11.1
12-Nov-96	263	7	0.098	7.6	758	54	447	165	20.6	1.73	0.24		10.9	
19-Nov-96	270	7	0.095	7.6	795	41	520	188	22.9	1.61	0.30	11.0	11.0	

Sample: HC-1
Cell Type: simulated precipitation; 100 mL over 24 hrs
Test Conditions: 1 kg cell with dry/wet air cycles, 500 mL trickle leach for 200 days then no air supplied; at 221 days 100 mL/24 hr leach, frequency varied

	Days	Cumulative mass flux				Extraction rates				Sulfur			Neutralization			Molar ratio	
	since	Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4	Sulfur	SO_4	Cum. NP	NP	NP	[Ca]	[Ca+Mg]
Days	previous leach	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	flux (mg/kg)	depleted (%)	prod. rate (mg/kg/wk)	depletion (mg/kg)	depleted (%)	depl'n rate (mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	99	18	11	13					102	0.06		322	0.72		2.31	3.01
1	1	153	27	17	17	382.9	61.0	42.87	27.05	248	0.14		494	1.11	1209.4	0.90	1.14
7	6	213	36	24	21					371	0.21	142.5	683	1.53		1.18	1.48
15	8	234	40	26	21	18.6	2.9	1.67	0.45	444	0.25		750	1.68	58.5	0.69	0.87
23	8	260	44	28	22					528	0.30	73.2	830	1.86		0.73	0.92
31	8	278	46	29	22					579	0.33	45.0	887	1.99		0.84	1.05
38	7	299	50	31	23					632	0.36	52.9	954	2.14		0.97	1.22
45	7	319	53	32	23					682	0.39	50.3	1015	2.28		0.93	1.16
52	7	336	55	34	23					732	0.42		1068	2.40		0.83	1.03
59	7	351	57	35	24	14.6	2.2	0.90	0.26	781	0.45		1114	2.50	45.5	0.73	0.90
66	7	369	60	35	24					830	0.47		1171	2.62		0.91	1.10
74	8	393	63	37	24	20.6	2.4	0.91	0.22	882	0.50	45.3	1241	2.78	61.6	1.09	1.30
81	7	415	65	37	24					928	0.53		1307	2.93		1.15	1.37
88	7	434	67	38	24	19.2	2.2	0.81	0.16	966	0.55	37.6	1364	3.06	57.2	1.23	1.46
95	7	457	70	39	25					1007	0.57		1430	3.21		1.30	1.54
102	7	480	72	40	25	23.1	2.4	0.76	0.14	1047	0.60	40.4	1498	3.36	67.7	1.37	1.61
109	7	499	75	41	25					1088	0.62		1557	3.49		1.16	1.38
116	7	516	77	41	25	16.1	2.2	0.67	0.13	1129	0.64	40.8	1606	3.60	49.5	0.95	1.16
123	7	534	79	42	25					1178	0.67		1663	3.73		0.92	1.11
130	7	559	82	42	25	24.4	2.9	0.61	0.11	1243	0.71	65.3	1736	3.89	73.1	0.90	1.07
136	6	583	85	43	25					1303	0.74		1810	4.06		0.99	1.19
143	7	608	88	44	25	24.3	3.0	0.50	0.09	1355	0.77	52.4	1883	4.22	73.0	1.11	1.34
150	7	633	91	44	26					1416	0.81		1960	4.39		1.01	1.21
157	7	660	94	45	26	26.5	3.2	0.72	0.08	1483	0.85	67.7	2039	4.57	79.3	0.94	1.12
165	8	686	97	45	26					1550	0.88		2117	4.75		0.94	1.12
171	6	711	100	46	26	29.1	3.2	0.62	0.08	1613	0.92	73.9	2191	4.91	86.2	0.95	1.12
178	7	735	103	47	26					1680	0.96	67.1	2263	5.07		0.87	1.04
185	7	759	106	47	26	24.3	2.9	0.50	0.05	1744	1.00	63.9	2336	5.24	72.8	0.91	1.09
192	7	773	107	47	26	13.9	1.5	0.45	0.07	1780	1.02	36.2	2377	5.33	40.9	0.92	1.08
200	8	798	110	48	26					1917	1.09	119.6	2451	5.49		0.44	0.52
207	7	827	114	49	26	28.5	3.5	0.55	0.06	1995	1.14	77.8	2536	5.69	85.7	0.88	1.06
214	7	854	117	49	26	27.5	3.2	0.47	0.05	2072	1.18	77.4	2619	5.87	82.2	0.85	1.02
217	3	862	118	49	26					2092	1.19		2642	5.92		0.94	1.12
221	4	873	119	49	26	19.1	2.1	0.23	0.04	2119	1.21	46.4	2674	6.00	56.5	0.99	1.17
224	3	884	120	49	26					2149	1.23	71.2	2706	6.07		0.85	1.00
228	4	894	121	50	26	18.4	2.0	0.26	0.03	2172	1.24	40.0	2737	6.14	54.3	1.10	1.30
231	3	905	122	50	26					2204	1.26	73.5	2770	6.21		0.84	0.99
235	4	917	124	50	26	19.7	2.1	0.27	0.03	2230	1.27	45.6	2803	6.28	58.0	1.04	1.22
239	4	927	125	50	26					2254	1.28	43.5	2834	6.35		1.01	1.19
242	3	936	126	50	26	22.2	2.6	0.36	0.04	2278	1.30	55.0	2862	6.42	66.3	0.97	1.16
249	7	950	128	50	26	13.3	1.8	0.17	0.02	2316	1.32	38.5	2903	6.51	40.7	0.83	1.01
256	7	965	130	51	26	15.6	2.0	0.14	0.02	2357	1.34	40.9	2950	6.61	47.1	0.91	1.11
263	7	982	132	51	26	16.2	2.0	0.17	0.02	2401	1.37	43.9	2999	6.72	48.8	0.89	1.07
270	7	999	134	51	26	17.9	2.2	0.15	0.03	2451	1.39	49.6	3053	6.84	53.9	0.87	1.04

Sample: HC-1
Cell Type: simulated precipitation; 500 mL over 1 hr
Test Conditions: 1 kg cell with dry/wet air cycles, 500 mL trickle leach for 200 days then no air supplied; at 221 days frequency varied - trickle leached
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

		Days since	Leachate				Water analysis					Gravimetric water content		
		previous	volume		Conduct.	Alkalinity	SO_4	Ca	Mg	K	Na	End, 3-day dry	End, 3-day wet	End of leach
Date	Days	leach	(L)	pH	(uS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(%)	(%)	(%)
23-Feb-96	0	0	0.192	7.9	649			666	119.0	79.00	89.00			
24-Feb-96	1	1	0.271	7.7	521			142	25.6	15.60	9.60			
1-Mar-96	7	6	0.467	7.6	393		203					8.1	9.1	11.9
9-Mar-96	15	8	0.411	7.5	276			39	5.4	3.75	0.87	1.3	2.4	10.6
17-Mar-96	23	8	0.432	7.7	373		144					3.0	3.8	10.2
25-Mar-96	31	8	0.469	7.6	291	24	117					8.2	7.8	10.2
1-Apr-96	38	7	0.449	7.5			84					4.8	5.3	10.3
8-Apr-96	45	7	0.426	7.5	187	20	65					2.7	3.6	10.2
15-Apr-96	52	7	0.489	7.7	339	27						7.0	9.7	10.0
22-Apr-96	59	7	0.456	7.6	201	24		30	4.6	1.90	0.63	6.6	5.9	9.9
29-Apr-96	66	7	0.417	7.6	202	27						4.9	5.1	9.7
7-May-96	74	8	0.437	7.5	243		84	31	3.4	1.70	0.42	3.3	4.2	9.5
14-May-96	81	7	0.470	7.6	260	20						6.3	7.5	9.9
21-May-96	88	7	0.445	7.3	200		66	27	3.8	1.20	0.32	4.3	5.4	10.0
28-May-96	95	7	0.467	7.3	229	14						6.7	7.1	9.9
4-Jun-96	102	7	0.465	7.6	248		97	48	5.5	1.50	0.38	6.9	7.5	10.0
11-Jun-96	109	7	0.452	7.2	215	12						5.4	5.6	10.0
18-Jun-96	116	7	0.447	7.5	209		77	33	4.7	1.20	0.32	4.7	4.7	9.9
25-Jun-96	123	7	0.425	7.3	188	14						1.6	3.0	9.8
2-Jul-96	130	7	0.463	7.3	280		128	49	6.3	1.01	0.29	6.6	7.0	10.1
8-Jul-96	136	6	0.458	7.7	315	40						5.1	6.1	10.2
15-Jul-96	143	7	0.473	7.6	261		89	40	5.3	0.86	0.18	7.1	7.5	10.0
22-Jul-96	150	7	0.463	7.2	234	15						6.1	6.8	10.1
29-Jul-96	157	7	0.457	7.4	313		109	46	6.1	1.36	0.15	6.0	6.5	10.1
6-Aug-96	165	8	0.492	7.4	349	22						8.2	9.6	10.3
12-Aug-96	171	6	0.490	7.5	285		105	43	5.2	0.90	0.16	9.0	9.6	10.3
19-Aug-96	178	7	0.461	7.2	202	11	87					6.4	6.9	10.2
26-Aug-96	185	7	0.480	7.2	271		112	39	5.3	0.71	0.10	8.7	8.9	10.3
2-Sep-96	192	7	0.478	7.2	260	18	128	45	5.4	0.87	0.14	8.6	8.6	10.3
10-Sep-96	200	8	0.473	7.2	218		102					7.9	8.6	10.3
17-Sep-96	207	7	0.476	7.4	254	25	119	42	5.7	0.77	0.12	8.8	9.0	10.3
24-Sep-96	214	7	0.487	7.3	228		108	35	4.6	0.54	0.08	10.2	10.1	10.5
27-Sep-96	217	3	0.494	7.3	189		72							
1-Oct-96	221	4	0.493	7.4	144	27	49	22	2.8	0.46	0.06	10.3	10.5	10.6
4-Oct-96	224	3	0.495	7.2	171	21	66							
8-Oct-96	228	4	0.494	7.4	148	30	53	24	2.9	0.52	0.06	10.5	10.6	
11-Oct-96	231	3	0.495	7.3	164	22	65							
15-Oct-96	235	4	0.553	7.3	150	26	58	30	3.0	0.50	0.07	10.5		10.7
19-Oct-96	239	4	0.499	7.4	156	25	59							
22-Oct-96	242	3	0.495	7.5	139	25	49	26	2.9	0.54	0.05		10.7	
5-Nov-96	256	14	0.493	7.3	321	18	159	53	6.6	0.62	0.05	10.8	10.7	11.0
19-Nov-96	270	14	0.491	7.2	363	19	169	70	8.1	0.64	0.11	10.6	10.6	11.0
3-Dec-96	284	14	0.479	7.0	338	16	172	62	7.4	0.66	0.09	10.6	10.5	
18-Dec-96	299	15	0.491	7.1	324	18	169	58	7.3	0.56	0.07			

Sample: HC-1
Cell Type: simulated precipitation; 500 mL over 1 hr
Test Conditions: 1 kg cell with dry/wet air cycles, 500 mL trickle leach for 200 days then no air supplied; at 221 days frequency varied - trickle leached

		Cumulative mass flux				Extraction rates				Sulfur			Neutralization			Molar ratio	
Days	Days since previous leach	Ca (mg/kg)	Mg (mg/kg)	K (mg/kg)	Na (mg/kg)	Ca (mg/kg/wk)	Mg (mg/kg/wk)	K (mg/kg/wk)	Na (mg/kg/wk)	Cum. SO_4 flux (mg/kg)	Sulfur depleted (%)	SO_4 prod. rate (mg/kg/wk)	Cum. NP depletion (mg/kg)	NP depleted (%)	NP depl'n rate (mg/kg/wk)	[Ca] / [SO_4]	[Ca+Mg] / [SO_4]
0	0	128	23	15	17					149	0.08		413	0.93		2.06	2.66
1	1	166	30	19	20	269.7	48.6	29.63	18.23	282	0.16		538	1.21	875.1	0.70	0.90
7	6	208	37	24	22					377	0.21	110.6	674	1.51		1.07	1.37
15	8	224	39	25	22	14.0	1.9	1.35	0.31	448	0.26		723	1.62	43.1	0.54	0.66
23	8	241	41	27	23					510	0.29	54.4	773	1.73		0.63	0.77
31	8	257	44	28	23					565	0.32	48.0	825	1.85		0.74	0.91
38	7	273	46	30	24					603	0.34	37.7	873	1.96		0.99	1.22
45	7	287	48	31	24					630	0.36	27.7	917	2.06		1.22	1.51
52	7	302	51	32	24					664	0.38		965	2.16		1.08	1.35
59	7	316	53	33	24	13.7	2.1	0.87	0.29	698	0.40		1008	2.26	42.8	0.97	1.21
66	7	329	54	33	25					731	0.42		1047	2.35		0.92	1.12
74	8	342	56	34	25	11.8	1.3	0.65	0.16	768	0.44	32.1	1087	2.44	35.0	0.89	1.05
81	7	356	57	35	25					803	0.46		1128	2.53		0.93	1.12
88	7	368	59	35	25	12.0	1.7	0.53	0.14	833	0.48	29.4	1165	2.61	37.1	0.98	1.21
95	7	386	61	36	25					871	0.50		1217	2.73		1.10	1.33
102	7	408	64	37	26	22.3	2.6	0.70	0.18	916	0.52	45.1	1284	2.88	66.4	1.19	1.41
109	7	426	66	37	26					955	0.55		1339	3.00		1.12	1.35
116	7	441	68	38	26	14.7	2.1	0.54	0.14	990	0.56	34.4	1385	3.10	45.5	1.03	1.27
123	7	458	71	38	26					1033	0.59		1438	3.22		0.96	1.17
130	7	481	74	39	26	22.7	2.9	0.47	0.13	1092	0.62	59.2	1507	3.38	68.7	0.92	1.11
136	6	501	76	39	26					1142	0.65		1569	3.52		0.98	1.20
143	7	520	79	40	26	18.9	2.5	0.41	0.09	1184	0.68	42.1	1626	3.65	57.6	1.08	1.31
150	7	540	81	40	26					1230	0.70		1687	3.78		1.04	1.27
157	7	561	84	41	26	21.0	2.8	0.62	0.07	1280	0.73	49.8	1751	3.93	64.0	1.01	1.23
165	8	583	87	41	26					1332	0.76		1817	4.07		1.00	1.21
171	6	604	89	42	27	24.6	3.0	0.51	0.09	1384	0.79	60.0	1880	4.22	73.7	0.98	1.18
178	7	623	92	42	27					1424	0.81	40.1	1938	4.34		1.13	1.37
185	7	642	94	42	27	18.7	2.5	0.34	0.05	1478	0.84	53.7	1995	4.47	57.3	0.84	1.02
192	7	663	97	43	27	21.5	2.6	0.42	0.07	1539	0.88	61.2	2059	4.62	64.5	0.84	1.01
200	8	684	100	43	27					1587	0.91	42.2	2122	4.76		1.02	1.24
207	7	704	102	44	27	20.0	2.7	0.37	0.06	1644	0.94	56.6	2183	4.89	61.2	0.85	1.04
214	7	721	105	44	27	17.1	2.2	0.26	0.04	1696	0.97	52.6	2235	5.01	51.9	0.78	0.95
217	3	735	106	44	27					1732	0.99	83.1	2278	5.11		0.95	1.15
221	4	746	108	44	27	19.0	2.4	0.40	0.05	1756	1.00	42.2	2311	5.18	57.4	1.08	1.30
224	3	757	109	45	27					1789	1.02	76.3	2345	5.26		0.84	1.01
228	4	769	111	45	27	20.8	2.5	0.45	0.05	1815	1.04	45.8	2380	5.34	62.3	1.09	1.30
231	3	782	112	45	27					1847	1.05	75.0	2420	5.43		1.00	1.18
235	4	799	114	45	27	29.0	2.9	0.48	0.07	1879	1.07	56.1	2468	5.53	84.6	1.24	1.45
239	4	813	115	46	27					1909	1.09	51.5	2509	5.63		1.14	1.34
242	3	826	117	46	27	30.0	3.3	0.62	0.06	1933	1.10	56.5	2547	5.71	88.9	1.27	1.51
256	14	852	120	46	27	13.1	1.6	0.15	0.01	2011	1.15	39.2	2626	5.89	39.4	0.80	0.96
270	14	886	124	47	27	17.2	2.0	0.16	0.03	2094	1.20	41.5	2729	6.12	51.2	0.99	1.18
284	14	916	127	47	27	14.8	1.8	0.16	0.02	2177	1.24	41.2	2817	6.32	44.4	0.87	1.04
299	15	945	131	47	27	13.3	1.7	0.13	0.02	2260	1.29	38.7	2903	6.51	40.1	0.82	0.99

Sample: HC-1
Cell Type: simulated precipitation; control
Test Conditions: 1 kg cell with dry/wet air cycles for 29 cycles then no air supplied - 500 mL trickle leach
Crush Size: minus 6mm
Cell Description: 10 cm diam x 20 cm high, upflow air type

		Days since	Leachate				Water analysis					Gravimetric water content		
Date	Days	previous leach	volume (L)	pH	Conduct. (uS/cm)	Alkalinity (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	End, 3-day dry (%)	End, 3-day wet (%)	End of leach (%)
23-Feb-96	0	0	0.158	7.4	708			728	149.0	88.00	101.00			
24-Feb-96	1	1	0.302	7.2	587			172	26.9	17.20	9.80			
1-Mar-96	7	6	0.471	7.0	466		241					9.5	10.3	12.5
9-Mar-96	15	8	0.322	7.6	434			72	10.0	5.82	1.54	0.5	0.9	10.4
17-Mar-96	23	8	0.430	7.6	398		197					3.0	3.9	10.7
25-Mar-96	31	8	0.431	7.6	263	23	105					4.3	4.1	10.4
1-Apr-96	38	7	0.420	7.5			95					1.6	2.4	10.0
8-Apr-96	45	7	0.407	7.5	249	27	98					0.2	1.0	9.7
15-Apr-96	52	7	0.446	7.5	320	21						4.7	5.0	9.7
22-Apr-96	59	7	0.443	7.6	226	24		34	5.3	2.10	0.67	5.2	4.4	9.7
29-Apr-96	66	7	0.424	7.6	248	29						5.0	4.9	9.5
7-May-96	74	8	0.454	7.5	264		114	35	4.2	1.80	0.45	4.9	5.4	9.2
14-May-96	81	7	0.431	7.7	238	24						1.3	2.6	9.1
21-May-96	88	7	0.445	7.5	237		82	36	4.7	1.60	0.37	3.9	4.7	9.4
28-May-96	95	7	0.466	7.4	258	21						6.1	6.4	9.5
4-Jun-96	102	7	0.438	7.5	229		75	45	5.0	1.50	0.31	3.6	4.1	9.8
11-Jun-96	109	7	0.466	7.4	274	18						6.9	7.6	9.7
18-Jun-96	116	7	0.460	7.6	244		96	37	5.0	1.40	0.32	5.7	5.7	9.5
25-Jun-96	123	7	0.455	7.4	219	16						5.0	5.4	9.6
2-Jul-96	130	7	0.475	7.4	260		120	47	5.6	1.12	0.25	7.5	8.0	9.8
8-Jul-96	136	6	0.482	7.5	280	23						7.9	8.5	9.9
15-Jul-96	143	7	0.484	7.7	299		113	46	5.6	0.94	0.16	8.4	8.6	9.8
22-Jul-96	150	7	0.468	7.6	285	32						6.4	7.5	9.9
29-Jul-96	157	7	0.486	7.6	341		132	52	6.0	1.35	0.14	8.6	9.2	9.8
6-Aug-96	165	8	0.478	7.6	342	26						7.2	8.1	9.9
12-Aug-96	171	6	0.491	7.7	304		112	47	5.4	0.96	0.15	9.0	9.3	9.9
19-Aug-96	178	7	0.479	7.5	229	23	105					7.7	8.2	9.9
26-Aug-96	185	7	0.481	7.6	298		121	45	5.6	0.86	0.11	8.3	8.5	9.9
2-Sep-96	192	7	0.480	7.3	296	26	134	49	5.6	0.82	0.10	8.4	8.4	9.8
10-Sep-96	200	8	0.466	7.4	210		111					6.4	6.7	9.8
17-Sep-96	207	7	0.485	7.4	266	30	124	46	5.8	0.88	0.11	8.5	8.7	9.9
24-Sep-96	214	7	0.490	7.4	275		116	45	5.6	0.64	0.09	9.8	9.7	10.2
1-Oct-96	221	7	0.493	7.4	214	27	81	31	3.9	0.46	0.07	10.1	10.0	10.2
8-Oct-96	228	7	0.494	7.4	278			46	5.0	0.80	0.10	10.2	10.1	
15-Oct-96	235	7	0.494	7.3	280	23	132	55	5.2	0.78	0.09	10.3	10.2	10.4
22-Oct-96	242	7	0.493	7.4	168		106	43	4.9	0.69	0.06	10.4	10.3	10.4
29-Oct-96	249	7	0.494	7.5	284	26	123	36	5.2	0.66	0.06	10.3	10.3	10.5
5-Nov-96	256	7	0.491	7.4	249	20	121	38	5.0	0.56	0.04	10.4	10.3	10.6
12-Nov-96	263	7	0.493	7.4	238	27	130	42	5.5	0.60	0.05		10.5	
19-Nov-96	270	7	0.494	7.5	275	27	124	51	5.7	0.55	0.10	10.5	10.4	10.7
27-Nov-96	278	8	0.494	7.5	268	27		43	5.6	0.57	0.06	10.5	10.4	10.6
3-Dec-96	284	6	0.493									10.5	10.4	
10-Dec-96	291	7	0.494											
18-Dec-96	299	8	0.493	7.5	233	26	131	48	5.5	0.55	0.06			

Sample: HC-1
Cell Type: simulated precipitation; control
Test Conditions: 1 kg cell with dry/wet air cycles for 29 cycles then no air supplied - 500 mL trickle leach

	Days since	Cumulative mass flux				Extraction rates				Sulfur			Neutralization			Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod. rate	Cum. NP depletion	NP depleted	NP depl'n rate	[Ca]	[Ca+Mg]
Days	previous leach	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	115	24	14	16					31	0.02		386	0.86		9.05	12.10
1	1	167	32	19	19	363.4	56.8	36.34	20.70	96	0.05		549	1.23	1143.4	1.90	2.39
7	6	225	40	25	22					210	0.12	132.5	729	1.63		1.21	1.52
15	8	248	44	26	22	20.3	2.8	1.64	0.43	280	0.16		800	1.79	62.3	0.79	0.97
23	8	276	48	29	23					365	0.21	74.0	887	1.99		0.80	0.98
31	8	302	51	31	23					410	0.23	39.6	966	2.16		1.36	1.67
38	7	324	54	32	24					450	0.26	39.9	1035	2.32		1.34	1.66
45	7	343	57	34	24					490	0.28	39.9	1094	2.45		1.14	1.42
52	7	361	60	35	24					535	0.31		1150	2.58		0.95	1.18
59	7	376	62	36	25	15.1	2.3	0.93	0.30	582	0.33		1197	2.68	47.3	0.77	0.97
66	7	390	64	37	25					629	0.36		1242	2.78		0.75	0.92
74	8	406	66	37	25	13.9	1.7	0.72	0.18	681	0.39	45.3	1290	2.89	41.7	0.74	0.88
81	7	422	68	38	25					723	0.41		1336	3.00		0.87	1.05
88	7	438	70	39	26	16.0	2.1	0.71	0.16	759	0.43	36.5	1385	3.10	48.7	1.05	1.28
95	7	457	72	40	26					796	0.45		1441	3.23		1.24	1.48
102	7	476	75	40	26	19.7	2.2	0.66	0.14	829	0.47	32.9	1499	3.36	58.4	1.44	1.70
109	7	495	77	41	26					868	0.50		1557	3.49		1.15	1.38
116	7	512	79	42	26	17.0	2.3	0.64	0.15	913	0.52	44.1	1609	3.61	52.0	0.93	1.13
123	7	531	82	42	26					962	0.55		1667	3.74		0.93	1.13
130	7	554	84	43	26	22.3	2.7	0.53	0.12	1019	0.58	57.0	1733	3.89	66.9	0.94	1.12
136	6	576	87	43	26					1075	0.61		1801	4.04		0.96	1.15
143	7	599	90	44	27	22.3	2.7	0.46	0.08	1130	0.64	54.7	1868	4.19	66.9	0.98	1.17
150	7	621	92	44	27					1187	0.68		1936	4.34		0.96	1.15
157	7	647	95	45	27	25.3	2.9	0.66	0.07	1251	0.71	64.2	2011	4.51	75.3	0.95	1.13
165	8	670	98	45	27					1309	0.75		2082	4.67		0.97	1.16
171	6	693	101	46	27	26.9	3.1	0.55	0.09	1365	0.78	64.2	2151	4.82	80.2	1.01	1.20
178	7	716	103	46	27					1415	0.81	50.3	2217	4.97		1.05	1.26
185	7	737	106	47	27	21.6	2.7	0.41	0.05	1473	0.84	58.2	2282	5.12	65.2	0.89	1.08
192	7	761	109	47	27	23.5	2.7	0.39	0.05	1537	0.88	64.3	2352	5.27	69.9	0.88	1.04
200	8	783	111	47	27					1589	0.91	45.3	2418	5.42		1.03	1.23
207	7	805	114	48	27	22.3	2.8	0.43	0.05	1649	0.94	60.1	2485	5.57	67.3	0.89	1.08
214	7	827	117	48	27	22.1	2.7	0.31	0.04	1721	0.96	71.8	2552	5.72	66.5	0.93	1.12
221	7	842	119	48	27	15.3	1.9	0.23	0.03	1761	1.00	39.7	2598	5.83	46.1	0.92	1.12
228	7	865	121	49	27	22.7	2.5	0.40	0.05	1807	1.03		2665	5.98	67.1	0.89	1.05
235	7	892	124	49	27	27.2	2.6	0.41	0.04	1872	1.07	65.2	2744	6.15	78.5	1.00	1.16
242	7	914	126	50	27	21.2	2.4	0.34	0.03	1925	1.10	52.3	2807	6.29	63.0	0.97	1.16
249	7	931	129	50	27	17.8	2.6	0.33	0.03	1985	1.13	60.8	2862	6.42	55.1	0.70	0.87
256	7	950	131	50	27	18.7	2.5	0.28	0.02	2045	1.17	59.5	2919	6.54	56.9	0.75	0.92
263	7	971	134	50	27	20.7	2.7	0.30	0.02	2109	1.20	64.1	2982	6.69	63.0	0.78	0.94
270	7	996	137	51	27	25.2	2.8	0.27	0.05	2170	1.24	61.3	3056	6.85	74.6	0.99	1.17
278	8	1017	140	51	27	18.6	2.4	0.25	0.03	2232	1.27		3121	7.00	56.4	0.82	1.00
284	6	1039	142	51	27					2295	1.31		3187	7.15		0.84	1.01
291	7	1062	145	52	28					2359	1.35		3256	7.30		0.86	1.03
299	8	1086	148	52	28	20.7	2.4	0.24	0.03	2424	1.38	56.5	3326	7.46	61.6	0.88	1.05

APPENDIX 12

TABULATED RESULTS

50-KG CELLS

Sample: HC-1
Cell Type: 50 kg
Test Conditions: 50 kg cell with dry/wet air cycles for 31 cycles then no air applied - 500 mL trickle leach
Crush Size: minus 4cm
Cell Description: 30 cm diam x 75 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
			volume		Conduct.	Alkalinity	SO_4	Ca	Mg	K	Na	End, 3-day dry	End, 3-day wet	End of leach
Date	Cycle	Days	(L)	pH	(uS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(%)	(%)	(%)
25-Jan-96	0	0	14.465	8.2	727	81	380	121	17.0	7.90	8.10			
2-Feb-96	1	8	0.455	7.7	2610									
9-Feb-96	2	15	0.752	7.7	2430		2700							
16-Feb-96	3	22	0.228	7.6	1900		1900							
23-Feb-96	4	29	0.360	7.5	962		970							
1-Mar-96	5	36	0.446	7.7	1441			648	80.0	10.80	16.60			
9-Mar-96	6	44	0.281	7.6	1920		1678							
17-Mar-96	7	52	0.308	7.8	1650									
25-Mar-96	8	60	0.268	7.7	2040	39	1853							
1-Apr-96	9	67	0.355	7.6			1103	435	74.0	10.30	13.70			
8-Apr-96	10	74	0.585	7.8	1572	39	1001							
15-Apr-96	11	81	0.630	7.7	1582	33								
22-Apr-96	12	88	0.612	7.7	1890	32								
29-Apr-96	13	95	0.620	7.7	1819			642	122.0	12.50	18.80			
7-May-96	14	103	0.627	7.7	1747	31								
14-May-96	15	110	0.641	7.7	1860		1312	440	90.8	9.70	14.20			
21-May-96	16	117	0.626	7.6	2130	28								
28-May-96	17	124	0.618	7.7	1980		1319	464	89.2	10.25	16.00			
4-Jun-96	18	131	0.286	7.4	1880	38								
11-Jun-96	19	138	0.611	7.4	1960		1516	474	88.8	8.60	14.50			
18-Jun-96	20	145	0.594	7.6	1920	28								
25-Jun-96	21	152	0.594	7.5	1850		1461	533	88.0	8.46	14.60			
2-Jul-96	22	159	0.629	7.7	1920	35								
8-Jul-96	23	165	0.669	7.5	1860		1317	452	85.6	11.30	16.00			
15-Jul-96	24	172	0.677	7.7	1920	33								
22-Jul-96	25	179	0.766	7.3	1716		1225	330	60.0	6.82	5.00			
29-Jul-96	26	186	0.656	7.5	2040	31								
6-Aug-96	27	194	0.606	7.6	1330		1469	427	87.2	8.45	4.50			
12-Aug-96	28	200	0.706	7.8	1990	41								
19-Aug-96	29	207	0.629	7.6	1940	32	1595	360	59.0	6.16	4.00			
26-Aug-96	30	214	0.838	7.6	1716		1281							
2-Sep-96	31	221	0.564	7.5	1592	42	1254	397	56.4	6.73	5.00			
10-Sep-96	32	229	0.411	7.4	1795		1528	450	94.4	9.39	5.90			
17-Sep-96	33	236	0.418	7.4	1313	31	1081	330	59.2	5.85	4.40			
24-Sep-96	34	243	0.488	7.6	1748		1542	294	75.0	5.60	4.60			
1-Oct-96	35	250	0.414	7.5	1315	44	1050	291	47.0	4.04	3.00			
8-Oct-96	36	257	0.438	7.5	1819		1392	480	64.1	5.32	5.01			
15-Oct-96	37	264	0.345	7.5	1619	44	1423	437	64.8	6.30	4.30			
22-Oct-96	38	271	0.397	7.6	1466	35	1245	403	62.0	5.75	3.80			
29-Oct-96	39	278	0.551	7.3	1540	35	1400	414	80.0	5.32	4.36			
5-Nov-96	40	285	0.443	7.6	1470	34	1304	412	73.4	5.57	4.30			
12-Nov-96	41	292	0.384	7.4	1464	32	1313	410	63.6	5.52	4.10			
19-Nov-96	42	299	0.541	7.5		39	1278	425	75.0	5.14	1.71			

Sample: HC-1
Cell Type: 50 kg
Test Conditions: 50 kg cell with dry/wet air cycles for 31 cycles then no air applied - 500 mL trickle leach

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	35	5	2	2					110	0.06		108	0.24				0.76	0.94
1	8	37	5	2	2					124	0.07		114	0.26				0.35	0.43
2	15	42	6	2	3					165	0.09	40.6	129	0.29				0.29	0.36
3	22	44	6	3	3	2.9	0.37	0.08	0.10	173	0.10	8.6	135	0.30		20.1	8.7	0.55	0.67
4	29	48	7	3	3	3.1	0.40	0.08	0.10	180	0.10	7.0	147	0.33		17.0	9.4	1.34	1.62
5	36	54	7	3	3	3.6	0.46	0.08	0.11	192	0.11		164	0.37	17.4	16.0	11.0	1.17	1.41
6	44	57	8	3	3	3.9	0.49	0.08	0.11	201	0.11	8.3	175	0.39		15.1	11.8	0.85	1.04
7	52	60	8	3	3	3.5	0.45	0.06	0.09	212	0.12		185	0.41		9.0	10.5	0.74	0.91
8	60	63	9	3	3	3.5	0.46	0.06	0.09	222	0.13	8.7	193	0.43		9.0	10.7	0.63	0.79
9	67	66	9	3	3	3.3	0.47	0.06	0.09	230	0.13	7.8	203	0.46	9.9	9.2	10.3	0.95	1.21
10	74	72	10	3	3	3.3	0.53	0.07	0.10	242	0.14	11.7	221	0.50		9.2	10.5	1.17	1.51
11	81	79	11	3	4	4.1	0.69	0.09	0.12	255	0.15		244	0.55		10.2	13.0	1.22	1.58
12	88	86	13	3	4	4.9	0.88	0.11	0.15	269	0.15		267	0.60		11.0	16.0	1.26	1.64
13	95	94	14	4	4	6.1	1.12	0.13	0.18	284	0.16		293	0.66	26.1	12.3	20.0	1.30	1.70
14	103	101	16	4	4	6.7	1.25	0.14	0.20	299	0.17		316	0.71		13.5	21.9	1.04	1.38
15	110	106	17	4	4	6.7	1.28	0.14	0.20	316	0.18	16.8	335	0.75	18.9	14.5	22.0	0.80	1.08
16	117	112	18	4	5	6.5	1.26	0.13	0.20	333	0.19		353	0.79		15.1	21.4	0.82	1.09
17	124	118	19	4	5	6.2	1.21	0.13	0.20	349	0.20	16.3	372	0.83	18.9	15.6	20.5	0.84	1.11
18	131	120	19	4	5	5.2	1.02	0.11	0.17	357	0.20		381	0.85		14.3	17.1	0.79	1.04
19	138	126	21	4	5	5.1	1.00	0.11	0.17	376	0.21	18.5	400	0.90	18.9	15.2	16.9	0.75	0.98
20	145	132	22	4	5	5.2	0.97	0.10	0.16	393	0.22		419	0.94		15.4	16.9	0.81	1.05
21	152	138	23	4	5	5.3	0.96	0.10	0.16	411	0.23	17.4	440	0.99	20.2	15.6	17.2	0.88	1.11
22	159	145	24	5	6	5.4	0.96	0.10	0.16	428	0.24		460	1.03		15.8	17.4	0.85	1.10
23	165	151	25	5	6	6.2	1.12	0.12	0.19	446	0.25	20.6	479	1.07	23.2	18.3	20.2	0.82	1.08
24	172	156	26	5	6	6.1	1.10	0.12	0.18	463	0.26		497	1.11		18.0	19.9	0.74	0.96
25	179	161	27	5	6	6.0	1.07	0.12	0.16	482	0.27	18.8	513	1.15	16.4	18.2	19.3	0.65	0.84
26	186	166	28	5	6	5.7	1.05	0.12	0.14	499	0.29		530	1.19		18.3	18.5	0.67	0.89
27	194	171	29	5	6	5.3	1.01	0.12	0.11	517	0.30	15.6	547	1.23	15.1	17.8	17.5	0.70	0.93
28	200	177	30	5	6	5.2	0.99	0.11	0.08	539	0.31		565	1.27		18.6	17.1	0.62	0.80
29	207	181	31	5	6	5.1	0.94	0.10	0.06	559	0.32	20.1	579	1.30	14.4	19.2	16.5	0.54	0.69
30	214	188	32	5	6	5.3	0.95	0.10	0.06	580	0.33	21.5	599	1.34		19.7	17.2	0.71	0.89
31	221	192	32	5	6	5.2	0.89	0.09	0.06	594	0.34	14.1	613	1.37	13.8	19.0	16.7	0.76	0.94
32	229	196	33	6	7	4.9	0.83	0.09	0.06	607	0.35	11.0	626	1.40	10.9	18.0	15.7	0.71	0.95
33	236	198	33	6	7	4.2	0.70	0.08	0.05	616	0.35	9.0	635	1.42	8.9	15.0	13.5	0.73	0.95
34	243	201	34	6	7	3.9	0.70	0.07	0.05	631	0.36	15.0	645	1.45	10.2	14.1	12.7	0.46	0.65
35	250	204	35	6	7	3.2	0.59	0.06	0.04	640	0.37	8.7	652	1.46	7.6	11.6	10.3	0.67	0.84
36	257	208	35	6	7	3.1	0.57	0.05	0.04	652	0.37	12.2	665	1.49	12.8	11.2	10.1	0.83	1.01
37	264	211	36	6	7	3.1	0.52	0.05	0.04	662	0.38	9.8	675	1.51	9.4	11.0	9.8	0.74	0.92
38	271	214	36	6	7	3.1	0.52	0.04	0.03	672	0.38	9.9	685	1.53	10.0	11.1	10.0	0.78	0.97
39	278	219	37	6	7	3.5	0.55	0.05	0.04	687	0.39	15.4	700	1.57	15.1	11.2	11.0	0.71	0.94
40	285	222	38	6	7	3.7	0.61	0.05	0.04	699	0.40	11.5	711	1.60	11.8	11.8	11.8	0.76	0.98
41	292	226	38	6	7	3.5	0.59	0.05	0.04	709	0.40	10.1	721	1.62	9.9	11.4	11.2	0.75	0.94
42	299	230	39	6	7	3.8	0.66	0.05	0.03	723	0.41	13.8	736	1.65	14.9	12.2	12.3	0.80	1.03

Sample: HC-2
Cell Type: 50 kg
Test Conditions: 50 kg cell with dry/wet air cycles for 31 cycles then no air applied - 500 mL trickle leach
Crush Size: minus 4cm
Cell Description: 30 cm diam x 75 cm high, upflow air type

			Leachate				Water analysis					Gravimetric water content		
Date	Cycle	Days	volume (L)	pH	Conduct. (uS/cm)	Alkalinity (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	End, 3-day dry (%)	End, 3-day wet (%)	End of leach (%)
25-Jan-96	0	0	14.402	8.4	809	78	400	134	17.0	6.30	9.00			
2-Feb-96	1	8	0.371	7.3	2310									
9-Feb-96	2	15	0.723	7.4	2090		2600							
16-Feb-96	3	22	0.224	7.3	1698		1800							
23-Feb-96	4	29	0.332	7.2	1225		1092							
1-Mar-96	5	36	0.384	7.6	1378			513	51.0	9.10	14.10			
9-Mar-96	6	44	0.300	7.4	1530		1171							
17-Mar-96	7	52	0.241	7.5	1573									
25-Mar-96	8	60	0.443	7.2	1781	15	1369							
1-Apr-96	9	67	0.328	7.2			1353	618	76.0	10.00	18.00			
8-Apr-96	10	74	0.670	7.2	1188	13	720							
15-Apr-96	11	81	0.524	7.3	1870	14								
22-Apr-96	12	88	0.615	7.2	1717	12								
29-Apr-96	13	95	0.610	7.0	1686			437	42.8	8.90	15.10			
7-May-96	14	103	0.605	7.2	1776	11								
14-May-96	15	110	0.571	7.2	1771			432	55.6	10.00	17.70			
21-May-96	16	117	0.615	7.1	1714	11								
28-May-96	17	124	0.578	7.2	1798		1170	445	56.3	9.71	19.60			
4-Jun-96	18	131	0.419	7.2	1708	10								
11-Jun-96	19	138	0.633	6.9	1850		1356	468	55.6	8.10	16.60			
18-Jun-96	20	145	0.629	7.0	1768	8								
25-Jun-96	21	152	0.478	6.9	1484		1155	450	40.0	7.08	13.70			
2-Jul-96	22	159	0.602	7.0	1855	8								
8-Jul-96	23	165	0.631	6.9	1716		1234	432	63.2	10.20	17.30			
15-Jul-96	24	172	0.611	7.0	1658	9								
22-Jul-96	25	179	0.638	6.7	1726		1252	333	56.0	7.34	6.30			
29-Jul-96	26	186	0.635	6.7	1874	7								
6-Aug-96	27	194	0.608	6.6	1772		1328	364	55.4	8.28	7.30			
12-Aug-96	28	200	0.620	6.9	1781	8								
19-Aug-96	29	207	0.580	6.8	1727	7	1417	377	57.0	7.39	8.20			
26-Aug-96	30	214	0.718	6.9	1850		1408							
2-Sep-96	31	221	0.718	5.3	1137	2	732	234	26.2	4.79	5.40			
10-Sep-96	32	229	0.351	5.8	1574		1208	359	43.0	6.73	6.10			
17-Sep-96	33	236	0.364	5.5	1277	3	880	289	27.6	4.78	5.40			
24-Sep-96	34	243	0.496	5.8	1596		1250	307	42.5	4.69	5.60			
1-Oct-96	35	250	0.421	6.3	1074	5	744	210	22.3	3.09	3.50			
8-Oct-96	36	257	0.435	6.8	1851		1409	471	45.0	4.60	4.60			
15-Oct-96	37	264	0.333	6.4	1446	6	1210	372	41.5	6.28	5.30			
22-Oct-96	38	271	0.435	6.6	1538	7	1212	394	43.4	5.90	5.05			
29-Oct-96	39	278	0.531	6.3	1330	5	1090	338	42.6	4.78	4.81			
5-Nov-96	40	285	0.441	6.3	1232	5	1025	296	38.8	4.78	3.40			
12-Nov-96	41	292	0.399	5.5	1209	2	1100	314	40.4	4.77	4.80			
19-Nov-96	42	299	0.468	5.4		2	1100	358	47.8	5.09	1.34			

Sample: HC-2
Cell Type: 50 kg
Test Conditions: 50 kg cell with dry/wet air cycles for 31 cycles then no air applied - 500 mL trickle leach

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	0	39	5	2	3					115	0.10		117	0.98				0.80	0.97
1	8	40	5	2	3					126	0.11		121	1.02				0.34	0.40
2	15	44	6	2	3					164	0.14	37.6	134	1.12				0.26	0.31
3	22	46	6	2	3	2.3	0.25	0.06	0.09	172	0.14	8.1	138	1.16		18.1	6.8	0.48	0.56
4	29	49	6	2	3	2.5	0.26	0.06	0.09	179	0.15	7.3	147	1.23		15.5	7.2	0.96	1.12
5	36	53	6	2	3	2.8	0.29	0.06	0.09	188	0.16		158	1.33	11.5	14.1	8.1	1.09	1.27
6	44	56	7	2	3	3.1	0.32	0.06	0.10	195	0.16	6.1	168	1.41		13.3	9.0	1.11	1.30
7	52	59	7	2	3	2.7	0.28	0.05	0.08	201	0.17		176	1.48		7.0	8.0	1.07	1.27
8	60	64	8	2	3	3.3	0.36	0.06	0.09	213	0.18	10.6	191	1.61		7.6	9.8	1.04	1.24
9	67	68	8	2	4	3.5	0.40	0.06	0.10	222	0.19	8.9	204	1.71	12.2	7.9	10.5	1.10	1.32
10	74	76	9	3	4	4.2	0.49	0.07	0.12	232	0.19	9.7	227	1.90		8.1	12.6	1.91	2.28
11	81	81	10	3	4	4.8	0.56	0.08	0.14	240	0.20		243	2.04		8.5	14.2	1.61	1.91
12	88	87	10	3	4	5.5	0.64	0.10	0.17	250	0.21		260	2.19		9.6	16.5	1.36	1.60
13	95	92	11	3	4	5.7	0.64	0.10	0.18	262	0.22		276	2.32	15.5	9.7	16.9	1.15	1.33
14	103	98	11	3	4	5.8	0.64	0.11	0.19	273	0.23		292	2.45		10.0	17.1	1.07	1.27
15	110	103	12	3	5	5.2	0.58	0.11	0.19	285	0.24		306	2.58	14.9	10.4	15.5	1.00	1.21
16	117	108	13	3	5	5.2	0.60	0.11	0.20	299	0.25		323	2.71		11.4	15.5	0.95	1.15
17	124	113	13	3	5	5.1	0.60	0.11	0.20	312	0.26	13.5	338	2.84	15.6	12.0	15.2	0.91	1.10
18	131	117	14	3	5	4.8	0.59	0.10	0.20	323	0.27		350	2.94		11.9	14.4	0.87	1.04
19	138	123	15	3	6	5.0	0.63	0.10	0.20	340	0.29	17.2	368	3.09	17.7	13.4	15.2	0.83	0.99
20	145	129	15	4	6	5.2	0.62	0.10	0.20	356	0.30		385	3.23		14.1	15.6	0.88	1.03
21	152	133	16	4	6	5.0	0.56	0.09	0.18	367	0.31	11.0	397	3.34	12.3	13.6	14.8	0.94	1.07
22	159	138	16	4	6	5.0	0.56	0.09	0.17	381	0.32		413	3.47		13.8	14.9	0.89	1.06
23	165	144	17	4	6	5.5	0.64	0.10	0.19	397	0.33	18.2	430	3.61	19.8	15.2	16.4	0.84	1.04
24	172	148	18	4	6	5.3	0.64	0.10	0.18	412	0.35		444	3.73		14.8	15.8	0.74	0.93
25	179	153	18	4	6	4.9	0.67	0.10	0.16	428	0.36	16.0	458	3.85	13.6	14.9	15.1	0.64	0.82
26	186	157	19	4	7	5.0	0.73	0.11	0.15	444	0.37		472	3.97		16.0	15.4	0.65	0.82
27	194	162	20	4	7	4.6	0.72	0.11	0.12	461	0.39	14.1	486	4.08	12.1	15.9	14.6	0.66	0.82
28	200	166	20	4	7	4.5	0.70	0.10	0.10	478	0.40		500	4.20		16.1	14.1	0.65	0.81
29	207	171	21	4	7	4.4	0.69	0.10	0.09	494	0.41	16.4	514	4.32	13.7	16.4	13.9	0.64	0.80
30	214	175	22	5	7	4.4	0.67	0.09	0.09	514	0.43	20.2	527	4.43		17.2	13.9	0.52	0.64
31	221	178	22	5	7	4.2	0.60	0.09	0.09	525	0.44	10.5	537	4.51	10.0	16.1	13.1	0.77	0.91
32	229	181	22	5	7	3.8	0.53	0.08	0.08	533	0.45	7.4	545	4.58	6.6	14.5	11.8	0.71	0.85
33	236	183	23	5	7	3.3	0.42	0.06	0.07	540	0.45	6.4	551	4.63	6.1	12.1	9.9	0.79	0.91
34	243	186	23	5	7	3.0	0.37	0.06	0.06	552	0.46	12.4	560	4.71	9.4	11.3	9.0	0.59	0.72
35	250	188	23	5	7	2.5	0.29	0.04	0.05	558	0.47	6.3	565	4.75	5.2	8.6	7.4	0.68	0.80
36	257	192	24	5	7	2.6	0.29	0.04	0.04	571	0.48	12.3	577	4.85	11.9	8.9	7.8	0.80	0.93
37	264	194	24	5	7	2.7	0.30	0.04	0.04	579	0.49	8.0	585	4.91	7.3	9.1	8.0	0.74	0.87
38	271	198	24	5	7	3.0	0.33	0.04	0.04	589	0.49	10.5	595	5.00	10.1	9.9	8.8	0.78	0.92
39	278	201	25	5	7	3.1	0.34	0.04	0.04	601	0.50	11.6	606	5.09	10.8	9.7	9.1	0.74	0.90
40	285	204	25	5	7	3.2	0.37	0.05	0.04	610	0.51	9.0	614	5.16	7.9	10.3	9.6	0.69	0.84
41	292	206	25	5	7	2.9	0.35	0.04	0.04	619	0.52	8.8	621	5.22	7.6	9.6	8.8	0.69	0.83
42	299	210	26	5	7	3.1	0.39	0.05	0.04	629	0.53	10.3	631	5.31	10.2	10.0	9.3	0.78	0.95

APPENDIX 13

TABULATED RESULTS

NP COLUMNS

Sample: HC-1
Cell Type: NP Column
Test Conditions: 5 kg column, closed system purged with nitrogen, continuous trickle leach with water of pH 3.0
Crush Size: minus 6mm
Cell Description: 5 cm diam x 188 cm high

		Leachate				Water analysis					Gravimetric water content		
Date	Days	volume (L)	pH	Conduct. (uS/cm)	Alkalinity (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	End, 3-day dry (%)	End, 3-day wet (%)	End of leach (%)
12-Jan-96	21	6.95	8.1	688		192	583	105.0	58.00	40.00			
21-Jan-96	30	3.85	8.3	486	101								
29-Jan-96	38	3.43	7.8	377		112	67	8.0	3.80	0.90			
5-Feb-96	45	3.84	7.8	325	87								
12-Feb-96	52	2.35	7.8	395		82	72	8.0	3.20	0.70			
19-Feb-96	59	3.82	8.0	344	99								
26-Feb-96	66	3.62	8.1	342	85	82	58	7.0	2.10	0.50			
2-Mar-96	71	3.39	8.0	301	88								
11-Mar-96	80	1.86	8.2	601	103	82	86	8.3	2.00	0.34			
18-Mar-96	87	1.98	8.1	427	114								
25-Mar-96	94	3.54	8.1	269	94	62	69	6.9	1.80	0.66			
1-Apr-96	101	3.58	8.0		92								
8-Apr-96	108	3.49	7.9	344	90	62							
29-Apr-96	129	6.60					79	7.7	1.90	0.66			
22-May-96	152	5.02	8.3	553	102		112	12.4	1.81	0.41			
5-Jun-96	166	2.63	8.2	659	116		159	18.6	1.90	0.45			
17-Jun-96	178	5.10	8.3	483	99		86	10.0	1.60	0.36			
2-Jul-96	193	6.37					96	10.3	1.19	0.31			
16-Jul-96	207	5.86	8.3	511	121	101	94	10.8	0.96	0.19			
5-Aug-96	227	7.17	8.3	553	116		87	10.6	1.10				
22-Aug-96	244	5.59	8.0	586	116	96	106	13.4	1.21	0.19			
5-Sep-96	258	5.41	7.7	529		154	98	11.5	1.17	0.23			
24-Sep-96	277	7.16	7.8	452	112	119	83	10.0	1.02	0.21			
8-Oct-96	291	6.50	7.7	434	104	109	81	10.2	1.01	0.34			
22-Oct-96	305	5.04	8.0	472	110	132	90	11.0	0.74	0.12			
5-Nov-96	319	5.80	8.0	399	100	105	81	10.1	0.75	0.28			
24-Nov-96	338	7.62	7.8	372	94	85	71	9.6	0.80	0.35			
17-Dec-96	361	9.54	7.8	335	86	66	62	8.9	0.68	0.22			

Sample: HC-1
Cell Type: NP Column
Test Conditions: 5 kg column, closed system purged with nitrogen, continuous trickle leach with water of pH 3.0

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	21	810	146	81	56					267	0.15		2629	5.89				7.29	9.45
1	30	1061	189	104	71					384	0.22		3435	7.70				5.13	6.60
2	38	1107	195	107	72					461	0.26	67.2	3572	8.01	120.4			1.44	1.72
3	45	1160	201	110	73	102.0	16.08	8.48	4.95	535	0.31		3731	8.37		78.3	321.4	1.72	2.05
4	52	1194	205	111	73	86.6	13.30	6.91	3.91	574	0.33	38.5	3831	8.59	100.2	69.3	271.5	2.11	2.49
5	59	1244	211	113	73	79.8	11.91	6.01	3.27	637	0.36		3979	8.92		68.1	248.7	1.90	2.26
6	66	1286	216	115	74	43.7	5.09	2.01	0.46	696	0.40	59.4	4105	9.20	126.0	60.7	130.4	1.70	2.03
7	71	1334	221	116	74	48.3	5.49	1.94	0.43	751	0.43		4249	9.53		61.7	143.5	2.11	2.48
8	80	1366	224	117	74	41.3	4.57	1.44	0.31	782	0.45	23.7	4342	9.73	72.2	49.3	122.1	2.52	2.92
9	87	1397	227	118	74	40.6	4.42	1.29	0.29	810	0.46		4431	9.93		47.3	119.9	2.58	3.00
10	94	1446	232	119	75	40.5	4.25	1.14	0.29	854	0.49	43.9	4573	10.25	142.4	43.6	118.8	2.67	3.11
11	101	1498	237	120	75	42.4	4.26	1.09	0.31	899	0.51		4724	10.59		40.6	123.7	2.80	3.26
12	108	1550	242	122	76	40.9	4.03	1.02	0.33	942	0.54	43.3	4877	10.94		36.1	118.9	2.93	3.40
13	129	1655	252	124	77	41.2	4.05	1.02	0.35	1032	0.59		5180	11.62	100.9	35.8	119.8	2.77	3.21
14	152	1767	265	126	77	39.9	4.07	0.88	0.29	1108	0.63		5513	12.36	101.3	32.0	116.5	3.58	4.24
15	166	1851	275	127	77	39.4	4.15	0.77	0.24	1151	0.66		5763	12.92	124.8	28.8	115.6	4.68	5.58
16	178	1939	285	128	78	40.1	4.34	0.75	0.21	1240	0.71		6024	13.51	152.6	31.1	118.2	2.35	2.79
17	193	2061	298	130	78	42.0	4.59	0.70	0.19	1361	0.78		6384	14.31	168.1	34.5	124.1	2.44	2.87
18	207	2171	311	131	78	46.3	5.22	0.64	0.15	1479	0.84	59.2	6712	15.05	163.9	40.1	137.5	2.23	2.66
19	227	2296	326	133	79	49.3	5.69	0.64	0.14	1620	0.92		7087	15.89	131.2	47.8	146.9	2.12	2.54
20	244	2414	341	134	79	50.6	5.94	0.65	0.13	1728	0.99	44.2	7445	16.69	147.5	51.8	151.0	2.65	3.20
21	258	2520	353	135	79	50.9	5.99	0.60	0.12	1894	1.08	83.3	7762	17.40	158.3	57.2	152.0	1.53	1.82
22	277	2639	367	137	79	48.2	5.80	0.57	0.10	2065	1.18	62.8	8118	18.20	131.3	58.7	144.5	1.67	2.01
23	291	2744	381	138	80	47.8	5.85	0.58	0.12	2206	1.26	70.8	8436	18.92	159.1	60.6	143.7	1.78	2.15
24	305	2835	392	139	80	48.4	5.93	0.55	0.12	2340	1.34	66.5	8709	19.53	136.4	64.5	145.6	1.64	1.97
25	319	2929	404	140	80	48.1	5.86	0.53	0.13	2461	1.40	60.9	8992	20.16	141.7	68.5	144.4	1.85	2.23
26	338	3037	418	141	81	45.2	5.69	0.49	0.15	2591	1.48	47.7	9324	20.90	122.0	60.9	136.6	2.00	2.45
27	361	3156	435	142	81	43.0	5.64	0.45	0.15	2717	1.55	38.3	9689	21.73	111.4	54.3	130.9	2.25	2.79

Sample: HC-2
Cell Type: NP Column
Test Conditions: 5 kg column, closed system purged with nitrogen, continuous trickle leach with water of pH 3.0
Crush Size: minus 6mm
Cell Description: 5 cm diam x 188 cm high

		Leachate				Water analysis					Gravimetric water content		
Date	Days	volume (L)	pH	Conduct. (uS/cm)	Alkalinity (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	End, 3-day dry (%)	End, 3-day wet (%)	End of leach (%)
12-Jan-96	21	7.99	7.7	815		212	744	90.0	57.00	56.00			
21-Jan-96	30	3.76	8.0	397									
29-Jan-96	38	3.48	7.7	406		112	66	4.0	3.00	0.60			
5-Feb-96	45	3.65	7.7	289									
12-Feb-96	52	2.37	7.7	375		112	68	5.0	2.70	0.60			
19-Feb-96	59	3.72	7.8	314									
26-Feb-96	66	3.60	7.9	319		82	52	4.0	1.70	0.50			
2-Mar-96	71	3.69	7.8	281									
11-Mar-96	80	3.60	7.9	299		82	63	3.7	1.50	0.35			
18-Mar-96	87	2.52	8.0	316									
25-Mar-96	94	3.35	7.8	292		82	59	3.9	1.50	0.51			
1-Apr-96	101	3.46	7.9										
8-Apr-96	108	3.44	7.8	314									
29-Apr-96	129	7.08					71	4.3	1.60	0.78			
22-May-96	152	5.15	8.0	547	61		110	7.5	1.61	0.51			
5-Jun-96	166	5.49	7.8	453	56		100	6.9	1.40	0.43			
17-Jun-96	178	4.80	7.7	479	49		75	7.7	1.40	0.48			
2-Jul-96	193	6.30	7.7	472	57		85	8.3	1.18	0.46			
16-Jul-96	207	6.02	7.6	524	51	187	83	8.4	0.95	0.29			
5-Aug-96	227	6.40	7.2	555	16		75	7.8	0.96				
22-Aug-96	244	5.16	3.9	559		266	59	7.0	0.95	0.21			
5-Sep-96	258	5.46	4.0	462		218	43	5.4	0.94	0.36			
24-Sep-96	277	7.16	4.0	425		211	29	5.0	0.90	0.31			
8-Oct-96	291	6.50	4.0	413		192	23	4.4	1.17	0.59			
22-Oct-96	305	5.03	4.3	390		176	25	4.4	0.69	0.17			
5-Nov-96	319	5.90	3.8	364		148	20	3.8	0.53	0.21			
24-Nov-96	338	7.87	3.9	346		135	18	3.5	0.71	0.35			
17-Dec-96	361	9.58	4.3	309		121	14	2.8	0.58	0.22			

Sample: HC-2
Cell Type: NP Column
Test Conditions: 5 kg column, closed system purged with nitrogen, continuous trickle leach with water of pH 3.0

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	21	1189	144	91	89					339	0.28		3568	29.98				8.42	10.10
1	30	1493	179	114	111					461	0.39		4475	37.61				6.00	7.15
2	38	1539	182	116	111					539	0.45	68.3	4602	38.67	110.6			1.41	1.56
3	45	1588	185	118	112	116.5	12.08	7.80	6.46	620	0.52		4738	39.81		82.0	341.3	1.44	1.59
4	52	1621	188	119	112	97.5	9.89	6.32	5.06	673	0.57	53.0	4828	40.57	90.4	75.5	284.6	1.46	1.63
5	59	1665	191	121	112	87.7	8.68	5.46	4.21	746	0.63		4954	41.63		75.0	255.3	1.48	1.67
6	66	1703	194	122	113	40.7	2.85	1.62	0.37	805	0.68	59.0	5059	42.51	105.6	66.9	113.5	1.52	1.71
7	71	1745	197	123	113	43.6	3.12	1.57	0.38	865	0.73		5177	43.51		69.2	122.0	1.68	1.87
8	80	1790	199	124	113	40.4	2.82	1.28	0.32	924	0.78	45.9	5302	44.55	96.8	60.8	112.8	1.84	2.02
9	87	1821	201	125	113	40.1	2.73	1.18	0.31	965	0.81		5386	45.26		58.4	111.6	1.79	1.97
10	94	1861	204	126	114	39.1	2.58	1.05	0.30	1020	0.86	55.0	5496	46.19	109.7	54.8	108.5	1.73	1.91
11	101	1904	207	127	114	40.3	2.56	1.02	0.31	1086	0.91	66.0	5617	47.20		56.2	111.5	1.59	1.76
12	108	1950	210	128	115	38.8	2.43	0.94	0.32	1161	0.97		5744	48.27		56.0	107.2	1.49	1.64
13	129	2051	216	130	116	37.2	2.32	0.88	0.36	1332	1.12		6020	50.59	92.2	58.3	102.7	1.40	1.54
14	152	2164	223	132	116	36.9	2.38	0.76	0.31	1471	1.24		6336	53.24	96.0	54.5	102.2	1.96	2.18
15	166	2274	231	134	117	40.2	2.63	0.74	0.29	1633	1.37		6642	55.81	153.0	59.6	111.4	1.63	1.81
16	178	2346	238	135	117	40.2	2.88	0.72	0.28	1787	1.50		6852	57.58	122.9	63.7	112.3	1.12	1.31
17	193	2453	249	136	118	41.4	3.23	0.68	0.26	2006	1.68		7163	60.20	145.2	69.6	116.9	1.17	1.36
18	207	2553	259	138	118	45.1	3.88	0.64	0.21	2232	1.87	113.0	7455	62.65	145.9	80.8	128.8	1.07	1.24
19	227	2649	269	139	119	45.3	4.25	0.63	0.20	2522	2.12		7737	65.01	98.5	98.1	130.7	0.79	0.93
20	244	2710	276	140	119	39.1	4.05	0.55	0.17	2796	2.35	112.8	7919	66.54	75.0	104.4	114.6	0.53	0.64
21	258	2757	282	141	119	36.0	3.82	0.51	0.16	3034	2.55	119.0	8060	67.74	70.9	109.1	105.7	0.47	0.57
22	277	2798	289	142	120	28.8	3.36	0.47	0.14	3336	2.80	111.3	8194	68.86	49.2	110.8	85.9	0.33	0.42
23	291	2828	295	144	120	22.9	3.00	0.50	0.18	3586	3.01	125.0	8292	69.68	49.2	112.8	69.8	0.29	0.38
24	305	2853	299	144	120	18.3	2.73	0.49	0.18	3763	3.16	88.5	8373	70.37	40.6	111.4	57.2	0.34	0.44
25	319	2877	304	145	121	15.6	2.58	0.48	0.19	3938	3.31	87.5	8451	71.02	38.8	106.6	49.7	0.32	0.43
26	338	2905	309	146	121	13.0	2.39	0.46	0.19	4150	3.48	78.1	8545	71.80	34.5	97.7	42.4	0.32	0.42
27	361	2932	315	147	122	11.2	2.13	0.42	0.18	4382	3.68	70.6	8634	72.55	27.2	87.2	36.7	0.28	0.37

Sample: ABA-1
Cell Type: NP Column
Test Conditions: 5 kg column, closed system purged with nitrogen, continuous trickle leach with water of pH 3.0
Crush Size: minus 6mm
Cell Description: 5 cm diam x 188 cm high

		Leachate				Water analysis					Gravimetric water content		
Date	Days	volume (L)	pH	Conduct. (uS/cm)	Alkalinity (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	End, 3-day dry (%)	End, 3-day wet (%)	End of leach (%)
12-Jan-96	21	8.08	7.6	1997		282	2705	118.0	104.00	64.00			
21-Jan-96	30	3.82	8.0	706	101								
29-Jan-96	38	3.52	7.8	600		142	125	3.0	68.00	0.60			
5-Feb-96	45	3.66	7.9	504	91								
12-Feb-96	52	2.41	7.8	593		142	120	3.0	5.50	0.50			
19-Feb-96	59	3.81	7.8	461	110								
26-Feb-96	66	3.74	8.1	394	89	122	95	2.0	3.30	0.40			
2-Mar-96	71	3.46	7.8	401	99								
11-Mar-96	80	1.36	8.0	649	103	122	196	2.6	3.50	0.51			
18-Mar-96	87	2.64	8.0	553	114								
25-Mar-96	94	3.01	8.0	432	94	112	120	1.9	2.20	0.51			
1-Apr-96	101	3.52	7.9		92								
8-Apr-96	108	3.48	7.9	456	97	112							
29-Apr-96	129	7.21					137	1.6	1.70	0.46			
22-May-96	152	7.31	8.3	1127	107			3.4	2.31	0.68			
5-Jun-96	166	5.51											
17-Jun-96	178	5.30	8.2	647	96		151	2.7	1.40	0.39			
2-Jul-96	193	6.41	8.3	670	114		163	2.6	1.18	0.44			
16-Jul-96	207	6.11	8.2	671	111	212	154	2.6	0.81	0.22			
5-Aug-96	227	6.25	8.2	777	100		153	2.5	0.82				
22-Aug-96	244	5.39	7.9	770	108	345	196	2.7	1.13	0.23			
5-Sep-96	258	5.78	7.7	569		189	140	2.1	1.33	0.21			
24-Sep-96	277	7.44	7.7	688	115	317	178	2.3	1.03	0.20			
8-Oct-96	291	6.75	7.6	594	87	258	143	1.9	1.06	0.29			
22-Oct-96	305	5.15	7.7	577	78	262	137	2.1	0.81	0.15			
5-Nov-96	319	6.00	7.7	497	64	211	120	2.4	0.73	0.27			
24-Nov-96	338	8.17	7.2	435	31	182	100	2.3	0.69	0.28			
17-Dec-96	361	9.85	5.3	376	2	172	72	2.2	0.60	0.18			

Sample: ABA-1
Cell Type: NP Column
Test Conditions: 5 kg column, closed system purged with nitrogen, continuous trickle leach with water of pH 3.0

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization		
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)
0	21	4371	191	168	103					456	0.33		11725	32.3	
1	30	5452	237	234	128					618	0.45		14620	40.3	
2	38	5540	239	282	129					718	0.52	87.5	14849	40.9	200.3
3	45	5630	241	309	129	367.1	14.74	40.97	7.44	822	0.60		15083	41.6	
4	52	5688	243	311	129	297.3	11.74	32.32	5.81	890	0.65	68.0	15233	42.0	150.7
5	59	5770	245	315	130	257.6	9.93	26.98	4.81	991	0.72		15446	42.6	
6	66	5841	246	317	130	75.5	1.78	16.19	0.33	1082	0.79	91.0	15630	43.1	184.0
7	71	5941	248	319	130	85.1	1.83	8.00	0.34	1166	0.85		15889	43.8	
8	80	5995	248	320	130	73.0	1.43	2.36	0.27	1199	0.88	25.7	16025	44.1	106.0
9	87	6078	250	322	131	78.1	1.38	2.13	0.27	1261	0.92		16239	44.7	
10	94	6150	251	323	131	76.1	1.23	1.72	0.27	1329	0.97	68.0	16424	45.2	185.5
11	101	6239	252	325	131	79.6	1.18	1.51	0.28	1408	1.03		16651	45.9	
12	108	6330	253	326	132	73.6	1.04	1.23	0.26	1485	1.09	77.0	16884	46.5	
13	129	6528	255	328	132	76.2	1.01	1.14	0.27	1671	1.22		17388	47.9	168.0
14	152	6732	260	332	133	70.4	1.17	1.06	0.28	1883	1.38		17925	49.1	163.3
15	166	6918	264	334	134	74.6	1.27	1.03	0.28	2062	1.51		18817	50.3	
16	178	7078	267	335	134	76.3	1.33	0.97	0.27	2251	1.65		19229	51.5	240.5
17	193	7287	270	337	135	78.8	1.39	0.90	0.27	2502	1.83		19766	52.9	250.4
18	207	7476	273	338	135	85.1	1.59	0.84	0.25	2761	2.02	129.5	20250	54.3	242.0
19	227	7667	276	339	135	87.3	1.48	0.66	0.20	3109	2.27		20742	55.6	172.0
20	244	7878	279	340	136	86.2	1.38	0.56	0.16	3481	2.54	153.2	21282	57.1	222.7
21	258	8040	282	342	136	84.2	1.31	0.55	0.14	3699	2.70	109.0	21697	58.3	207.5
22	277	8305	285	343	136	84.8	1.26	0.53	0.11	4171	3.05	173.9	22374	60.1	249.4
23	291	8498	288	344	136	85.2	1.20	0.56	0.12	4519	3.30	174.0	22868	61.5	246.8
24	305	8639	290	345	137	87.2	1.21	0.59	0.12	4789	3.50	135.0	23230	62.5	181.0
25	319	8783	293	346	137	84.5	1.26	0.58	0.13	5042	3.69	126.5	23602	63.5	186.1
26	338	8946	296	347	137	79.3	1.29	0.51	0.14	5340	3.90	109.8	24027	64.7	156.4
27	361	9088	301	349	138	65.3	1.31	0.45	0.14	5679	4.15	103.2	24399	65.7	113.5

Sample: ABA-2
Cell Type: NP Column
Test Conditions: 5 kg column, closed system purged with nitrogen, continuous trickle leach with water of pH 3.0
Crush Size: minus 6mm
Cell Description: 5 cm diam x 188 cm high

		Leachate				Water analysis					Gravimetric water content		
		volume		Conduct.	Alkalinity	SO_4	Ca	Mg	K	Na	End, 3-day dry	End, 3-day wet	End of leach
Date	Days	(L)	pH	(uS/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(%)	(%)	(%)
12-Jan-96	21	7.01	7.9	1039		162	1083	104.0	47.00	60.00			
21-Jan-96	30	3.74	8.1	432	86								
29-Jan-96	38	3.44	7.9	384		102	75	5.0	2.50	1.00			
5-Feb-96	45	3.62	8.0	342	89								
12-Feb-96	52	3.62	8.0	405		102	78	5.0	2.20	0.80			
19-Feb-96	59	3.67	8.0	359	96								
26-Feb-96	66	3.58	8.1	344	86	72	67	4.0	1.60	0.80			
2-Mar-96	71	1.71	7.8	401	94								
11-Mar-96	80	3.68	8.0	342	103	82	77	3.2	1.30	0.51			
18-Mar-96	87	2.62	8.1	392	114								
25-Mar-96	94	3.05	8.0	318	94	82	71	3.3	1.30	0.73			
1-Apr-96	101	3.48	8.0		92								
8-Apr-96	108	3.44	8.0	339	88								
29-Apr-96	129	7.08					80	3.2	1.30	0.65			
22-May-96	152	6.32	8.3	508	88		109	5.0	1.27	0.54			
5-Jun-96	166	5.55	8.1	415	86		103	3.9	1.00	0.44			
17-Jun-96	178	5.05	8.2	426	87		80	4.0	1.10	0.46			
2-Jul-96	193	6.55	8.2	435	107		94	4.2	0.84	0.48			
16-Jul-96	207	6.33	8.2	487	110	92	93	4.4	0.66	0.27			
5-Aug-96	227	5.13	8.3	632	104		115	5.3	0.83				
22-Aug-96	244	5.31	8.0	641	115	235	139	5.7	0.87	0.28			
5-Sep-96	258	5.32	7.8	540		172	122	4.8	0.88	0.26			
24-Sep-96	277	7.22	7.8	466	116	125	101	4.4	0.62	0.18			
8-Oct-96	291	6.60	7.7	449	109	112	94	4.2	0.79	0.29			
22-Oct-96	305	5.03	8.0	480	117	132	102	4.6	0.64	0.17			
5-Nov-96	319	5.90	8.0	402	107	98	95	4.0	0.48	0.23			
24-Nov-96	338	8.08	7.9	374	101	84	87	3.9	0.48	0.24			
17-Dec-96	361	9.76	7.9	350	96	78	76	3.7	0.39	0.16			

Sample: ABA-2
Cell Type: NP Column
Test Conditions: 5 kg column, closed system purged with nitrogen, continuous trickle leach with water of pH 3.0

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4 flux	Sulfur depleted	SO_4 prod'n rate	Cum. NP depletion	NP depleted	NP depl'n rate	SO_4 prod'n rate	NP depl'n rate	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg)	(%)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	21	1518	146	66	84					227	0.16		4400	13.3				16.04	18.58
1	30	1951	187	84	107					326	0.23		5652	17.1				10.53	12.16
2	38	2003	190	86	108					396	0.28	61.3	5795	17.5	125.4			1.76	1.96
3	45	2058	194	88	108	157.5	13.95	6.40	7.04	470	0.33		5949	18.0		70.9	451.7	1.80	1.99
4	52	2115	197	89	109	134.7	11.62	5.31	5.58	544	0.38	74.0	6105	18.4	156.2	71.6	385.0	1.84	2.03
5	59	2168	201	91	109	119.7	10.09	4.59	4.66	608	0.42		6252	18.9		70.2	341.1	2.00	2.20
6	66	2216	203	92	110	51.5	3.28	1.47	0.60	659	0.46	51.0	6384	19.3	131.8	64.8	142.3	2.23	2.45
7	71	2241	205	92	110	50.4	3.10	1.34	0.55	685	0.48		6450	19.5		61.3	138.9	2.24	2.43
8	80	2297	207	93	111	47.8	2.67	1.12	0.47	746	0.52	47.4	6602	19.9	117.9	55.2	130.6	2.25	2.41
9	87	2336	209	94	111	44.2	2.29	0.93	0.42	789	0.55		6706	20.3		49.0	120.2	2.17	2.32
10	94	2379	211	95	111	42.3	2.03	0.81	0.39	839	0.58	50.0	6823	20.6	116.7	46.2	114.2	2.08	2.24
11	101	2431	213	96	112	43.0	1.92	0.77	0.37	897	0.63		6961	21.0		47.6	115.4	2.13	2.29
12	108	2484	215	97	112	46.0	2.00	0.80	0.40	955	0.67		7103	21.5		51.1	123.4	2.19	2.34
13	129	2597	220	99	113	42.8	1.82	0.73	0.38	1076	0.75		7405	22.4	100.7	47.1	114.7	2.24	2.39
14	152	2735	226	100	114	43.0	1.87	0.65	0.32	1186	0.83		7776	23.5	112.9	42.8	115.2	3.01	3.23
15	166	2849	230	101	114	45.7	1.91	0.62	0.30	1284	0.90		8080	24.4	152.0	43.3	122.2	2.80	2.98
16	178	2930	234	102	115	45.4	1.95	0.60	0.27	1375	0.96		8298	25.1	127.7	43.5	121.6	2.15	2.32
17	193	3053	240	103	116	46.9	2.04	0.56	0.26	1494	1.04		8629	26.1	154.4	44.4	125.7	2.49	2.67
18	207	3171	246	104	116	51.5	2.31	0.52	0.23	1610	1.12	58.0	8947	27.0	158.8	47.9	138.4	2.43	2.62
19	227	3289	251	105	116	51.7	2.32	0.47	0.21	1778	1.24		9264	28.0	111.2	55.3	139.0	1.69	1.82
20	244	3437	257	106	116	52.7	2.39	0.43	0.18	2027	1.41	102.5	9659	29.2	162.4	66.7	141.7	1.42	1.52
21	258	3566	262	107	117	55.7	2.42	0.41	0.16	2210	1.54	91.5	10005	30.2	172.9	73.1	149.3	1.70	1.81
22	277	3712	268	108	117	54.9	2.38	0.37	0.12	2391	1.67	66.7	10396	31.4	144.1	74.8	147.2	1.94	2.08
23	291	3836	274	109	117	55.4	2.37	0.39	0.12	2539	1.77	74.0	10729	32.4	166.7	77.4	148.5	2.01	2.16
24	305	3939	279	110	118	58.3	2.48	0.40	0.12	2671	1.86	66.0	11005	33.2	137.9	80.1	156.2	1.85	1.99
25	319	4051	283	110	118	57.3	2.46	0.38	0.13	2787	1.94	58.0	11305	34.2	150.0	70.9	153.6	2.33	2.49
26	338	4192	290	111	118	54.7	2.41	0.34	0.13	2923	2.04	50.1	11683	35.3	139.2	62.4	146.8	2.49	2.67
27	361	4340	297	112	119	52.3	2.37	0.32	0.13	3075	2.14	46.3	12084	36.5	122.0	57.0	140.7	2.34	2.53

Sample: ABA-3
Cell Type: NP Column
Test Conditions: 5 kg column, closed system purged with nitrogen, continuous trickle leach with water of pH 3.0
Crush Size: minus 6mm
Cell Description: 5 cm diam x 188 cm high

		Leachate				Water analysis					Gravimetric water content		
Date	Days	volume (L)	pH	Conduct. (uS/cm)	Alkalinity (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	End, 3-day dry (%)	End, 3-day wet (%)	End of leach (%)
12-Jan-96	21	8.75	7.9	882		152	850	85.0	35.00	60.00			
21-Jan-96	30	4.08	8.1	349	75								
29-Jan-96	38	3.75	7.9	320		112	61	3.0	1.80	0.80			
05-Feb-96	45	1.45	7.9	300	68								
12-Feb-96	52	2.47	8.0	388		102	82	4.0	1.90	0.90			
19-Feb-96	59	4.25	8.0	275	75								
26-Feb-96	66	4.24	8.0	251	65	92	59	3.0	1.30	0.90			
02-Mar-96	71	4.26	7.9	248	66								
11-Mar-96	80	4.18	8.1	275	103	92	66	1.6	0.90	0.46			
18-Mar-96	87	2.65	8.1	306	114								
25-Mar-96	94	3.11	8.0	268	94	92	65	2.4	1.00	0.80			
01-Apr-96	101	3.51	8.0		92								
08-Apr-96	108	3.48	8.0	297	69								
29-Apr-96	129	7.25					71	2.0	0.90	0.60			
22-May-96	152	5.43	8.2	488	76		108	3.1	1.01	0.63			
05-Jun-96	166	5.47	8.1	369	72		98	2.2	0.80	0.51			
17-Jun-96	178	4.36	8.2	419	74		79	2.7	0.80	0.57			
02-Jul-96	193	4.43	8.2	455	94		101	2.9	0.72	0.65			
16-Jul-96	207	6.05	8.2	446	93	87	88	2.9	0.54	0.36			
05-Aug-96	227	5.60	8.2	470	84		86	2.7	0.55				
22-Aug-96	244	5.60	8.0	502	89	164	103	3.2	0.68	0.36			
05-Sep-96	258	5.23	7.8	436		120	93	2.8	0.70	0.36			
24-Sep-96	277	7.12	7.8	405	89	93	82	2.6	0.19	0.28			
08-Oct-96	291	6.50	7.8	398	89	94	82	2.7	0.76	0.41			
22-Oct-96	305	4.99	8.0	398	89	112	86	3.1	0.58	0.28			
05-Nov-96	319	5.50	8.0	353	81	88	81	2.8	0.48	0.35			
24-Nov-96	338	7.84	7.8	335	79	70	74	2.8	0.61	0.42			
17-Dec-96	361	9.70	7.9	330	78	74	70	2.6	0.39	0.26			

Sample: ABA-3
Cell Type: NP Column
Test Conditions: 5 kg column, closed system purged with nitrogen, continuous trickle leach with water of pH 3.0

		Cumulative mass flux				Extraction rates - 5 cycle moving average				Sulfur			Neutralization			5 cycle moving average		Molar ratio	
		Ca	Mg	K	Na	Ca	Mg	K	Na	Cum. SO_4	Sulfur	SO_4	Cum. NP	NP	NP	SO_4	NP	[Ca]	[Ca+Mg]
Cycle	Days	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	(mg/kg/wk)	flux (mg/kg)	depleted (%)	prod'n rate (mg/kg/wk)	depletion (mg/kg)	depleted (%)	depl'n rate (mg/kg/wk)	prod'n rate (mg/kg/wk)	depl'n rate (mg/kg/wk)	$[SO_4]$	$[SO_4]$
0	21	1488	149	61	105					266	0.28		4335	17.3				13.42	15.63
1	30	1859	185	76	130					374	0.40		5413	21.7				8.28	9.60
2	38	1905	187	78	130					458	0.49	73.5	5537	22.1	108.3			1.31	1.41
3	45	1926	188	78	131	127.8	11.42	4.93	7.48	489	0.52		5593	22.4		65.0	366.9	1.60	1.73
4	52	1966	190	79	131	108.1	9.29	4.03	5.89	539	0.57	50.0	5703	22.8	109.5	61.6	308.8	1.93	2.08
5	59	2026	193	80	132	99.2	8.13	3.54	4.95	622	0.66		5865	23.5		65.6	281.8	1.74	1.89
6	66	2076	195	82	133	42.2	2.09	1.03	0.55	700	0.75	78.0	6000	24.0	135.7	63.4	114.2	1.54	1.67
7	71	2129	197	82	133	47.6	2.22	1.03	0.59	778	0.83		6142	24.6		67.9	128.3	1.63	1.73
8	80	2185	199	83	134	51.8	2.16	1.02	0.59	855	0.91	59.9	6285	25.1	111.7	73.2	138.5	1.72	1.79
9	87	2219	200	84	134	50.6	1.98	0.93	0.57	904	0.96		6377	25.5		73.0	134.8	1.71	1.79
10	94	2260	201	84	134	46.7	1.68	0.78	0.51	961	1.02	57.0	6484	25.9	107.3	67.8	123.8	1.70	1.80
11	101	2307	203	85	135	46.1	1.49	0.70	0.46	1025	1.09		6608	26.4		65.0	121.5	1.76	1.86
12	108	2355	204	86	135	42.6	1.32	0.61	0.42	1088	1.16		6735	26.9		58.6	112.1	1.82	1.92
13	129	2458	207	87	136	39.0	1.22	0.54	0.38	1219	1.30		7004	28.0	89.9	52.0	102.7	1.89	1.98
14	152	2575	211	88	137	38.3	1.17	0.47	0.33	1316	1.40		7311	29.2	93.6	44.4	100.7	2.90	3.03
15	166	2682	213	89	138	41.1	1.14	0.45	0.30	1413	1.51		7590	30.4	139.1	43.9	107.5	2.65	2.74
16	178	2751	215	90	138	40.4	1.14	0.42	0.28	1490	1.59		7772	31.1	106.2	42.3	105.8	2.15	2.27
17	193	2841	218	90	139	40.0	1.12	0.38	0.26	1568	1.67		8006	32.0	109.4	39.5	104.7	2.77	2.90
18	207	2947	221	91	139	43.9	1.27	0.36	0.25	1673	1.78	52.5	8287	33.1	140.5	40.7	115.2	2.43	2.56
19	227	3043	224	92	139	43.7	1.29	0.32	0.23	1814	1.93		8541	34.2	88.7	46.5	114.7	1.64	1.73
20	244	3159	228	92	140	42.8	1.35	0.30	0.21	1997	2.13	75.4	8844	35.4	125.0	52.4	112.6	1.51	1.58
21	258	3256	231	93	140	44.2	1.37	0.30	0.19	2123	2.26	63.0	9100	36.4	127.8	55.4	116.2	1.86	1.95
22	277	3373	235	93	141	44.4	1.40	0.25	0.17	2255	2.40	48.6	9407	37.6	113.3	57.3	116.7	2.12	2.23
23	291	3479	238	94	141	44.4	1.40	0.28	0.18	2378	2.53	61.5	9688	38.8	140.6	58.8	116.8	2.09	2.21
24	305	3565	241	95	141	46.8	1.51	0.30	0.18	2489	2.65	55.5	9916	39.7	113.8	60.6	123.4	1.84	1.95
25	319	3654	244	95	142	46.3	1.52	0.29	0.18	2586	2.75	48.5	10152	40.6	117.8	55.0	122.0	2.21	2.33
26	338	3770	249	96	142	45.0	1.56	0.29	0.20	2696	2.87	40.5	10460	41.8	113.0	50.1	119.0	2.54	2.70
27	361	3906	254	97	143	44.4	1.59	0.32	0.20	2839	3.02	43.5	10821	43.3	109.8	48.7	117.8	2.27	2.41

APPENDIX 14

DAILY AVERAGES

WATER FLOW, pH AND CONDUCTIVITY

20-TONNE (FIELD) CELLS

DAILY AVERAGES OF WATER FLOW, pH AND CONDUCTIVITY FOR FIELD CELLS

Date	Inflow (L)	HC-1 field cell pH	HC-1 field cell Conductivity (uS/cm)	HC-1 field cell Outflow (L)	HC-2 field cell pH	HC-2 field cell Conductivity (uS/cm)	HC-2 field cell Outflow (L)
7-Aug-95	0.00	7.7	1226	3.47	7.6	2189	0.00
8-Aug-95	5.20	7.5	1334	4.31	7.5	2253	0.00
9-Aug-95	0.00	7.5	1361	2.02	7.4	2280	0.00
10-Aug-95	0.00	7.4	1382	0.80	7.3	2319	0.00
11-Aug-95	92.95	7.3	1326	0.66	7.2	2336	0.00
12-Aug-95	5.20	7.3	1257	1.21	7.2	2334	0.00
13-Aug-95	81.90	7.5	1079	2.38	7.2	2313	0.00
14-Aug-95	42.90	7.6	937	0.00	7.3	2233	0.00
15-Aug-95	3.25	7.5	1034	0.00	7.3	2299	0.00
16-Aug-95	7.15	7.6	1078	3.12	7.3	2280	0.00
17-Aug-95	0.65	7.5	1134	9.22	7.3	2293	0.00
18-Aug-95	0.00	7.5	1210	4.91	7.3	2284	0.00
19-Aug-95	1.95	7.4	1260	2.94	7.3	2297	0.00
20-Aug-95	10.40	7.4	1280	1.92	7.3	2285	0.00
26-Aug-95	1.95	7.4	1270	5.85	7.3	2306	1.98
27-Aug-95	3.25	7.3	1285	4.81	7.3	2313	1.97
28-Aug-95	0.00	7.4	1321	2.90	7.8	2346	1.39
29-Aug-95	0.00	8.0	1350	1.86	9.2	2383	1.06
30-Aug-95	0.00	8.3	1363	0.63	10.2	2396	0.85
31-Aug-95	13.65	7.3	1347	2.83	7.4	2305	0.70
1-Sep-95	33.15	7.3	1368	3.91	7.4	2329	2.03
2-Sep-95	2.60	8.1	1395	12.85	10.0	2432	3.79
3-Sep-95	0.00	8.2	1426	6.07	10.6	2443	1.50
4-Sep-95	0.00	8.1	1454	2.81	10.4	2441	1.01
5-Sep-95	0.00	8.0	1512	1.72	9.9	2492	1.01
6-Sep-95	0.00	7.9	1568	1.32	9.8	2523	0.92
7-Sep-95	0.00	7.8	1596	0.95	9.3	2530	0.71
8-Sep-95	0.00	7.6	1621	0.47	8.7	2531	0.63
9-Sep-95	19.50	7.1	1588	0.65	7.0	2423	0.52
10-Sep-95	104.65	7.3	1092	0.74	7.3	2402	0.13
11-Sep-95	30.55	7.7	770	5.66	7.9	2238	1.86
12-Sep-95	5.85	8.6	1013	8.45	10.0	2272	3.13
13-Sep-95	0.00	10.4	1093	4.89	13.0	2302	1.80
14-Sep-95	1.30	9.1	1165	3.52	10.7	2340	1.27
15-Sep-95	0.00	9.7	1194	1.85	11.9	2336	0.89
16-Sep-95	0.00	9.9	1228	0.87	12.0	2367	0.65
17-Sep-95	0.00	9.6	1258	0.44	11.8	2400	0.49
18-Sep-95	0.00	8.3	1245	0.02	9.9	2395	0.17
19-Sep-95	0.00	7.8	1144	0.01	10.7	2267	0.07
20-Sep-95	0.00	7.4	1290	0.00	7.8	2420	0.00
21-Sep-95	0.00	7.2	1320	0.00	8.0	2464	0.00
22-Sep-95	0.00	7.2	1333	0.00	7.7	2474	0.00
23-Sep-95	0.00	7.1	1344	0.00	7.4	2486	0.00
24-Sep-95	0.00	7.1	1344	0.00	7.3	2494	0.00
25-Sep-95	0.00	7.1	1342	0.00	7.3	2494	0.00
26-Sep-95	41.60	7.0	1328	0.08	7.2	2438	0.00
27-Sep-95	1.95	7.0	1319	0.17	7.4	2448	0.00
28-Sep-95	13.65	7.0	1315	0.60	7.4	2437	0.00
1-Oct-95	13.00	7.0	1323	0.00	7.6	2381	0.00
2-Oct-95	1.30	7.0	1340	0.00	7.5	2397	0.00

DAILY AVERAGES OF WATER FLOW, pH AND CONDUCTIVITY FOR FIELD CELLS

		HC-1 field cell			HC-2 field cell		
Date	Inflow (L)	pH	Conductivity (uS/cm)	Outflow (L)	pH	Conductivity (uS/cm)	Outflow (L)
3-Oct-95	1.30	7.0	1369	0.00	7.4	2457	0.00
4-Oct-95	0.00	7.0	1390	0.00	7.4	2493	0.00
5-Oct-95	0.00	7.0	1422	0.00	7.5	2552	0.00
6-Oct-95	7.15	7.2	1449	0.00	8.1	2609	0.00
7-Oct-95	33.15	7.0	1451	0.00	7.5	2589	0.00
8-Oct-95	0.65	7.0	1471	0.00	7.4	2643	0.00
9-Oct-95	0.65	7.0	1484	0.00	7.4	2707	0.00
10-Oct-95	0.00	7.0	1492	0.00	7.4	2764	0.00
11-Oct-95	0.00	7.0	1497	0.00	7.4	2825	0.00
12-Oct-95	0.00	7.0	1506	0.00	7.4	2910	0.00
13-Oct-95	0.00	7.0	1538	0.00	7.4	3024	0.00
14-Oct-95	0.00	7.0	1549	0.00	7.4	3100	0.00
15-Oct-95	0.00	7.0	1591	0.00	7.4	3243	0.00
16-Oct-95	0.00	7.0	1675	0.00	7.4	3491	0.00
17-Oct-95	0.00	7.0	1798	0.00	7.4	3800	0.00
18-Oct-95	0.00	7.0	1870	0.00	7.4	4114	0.00
19-Oct-95	0.00	7.0	1911	0.00	7.5	4359	0.00
20-Oct-95	0.00	7.0	1960	0.00	7.6	4622	0.00
21-Oct-95	1.95	7.0	1990	0.00	7.7	4862	0.00
22-Oct-95	3.90	7.1	2030	0.00	8.1	5115	0.00
23-Oct-95	1.95	7.0	2047	0.00	7.7	4808	0.00
24-Oct-95	0.00	7.0	2072	0.00	7.8	2902	0.00
25-Oct-95	3.90	7.0	2091	0.00	7.8	2634	0.00
26-Oct-95	0.00	7.0	2112	0.00	7.8	1052	0.00
27-Oct-95	0.00	7.0	2140	0.00	7.6	70	0.00
28-Oct-95	0.00	7.0	2174	0.00	7.5	-33	0.00
29-Oct-95	2.60	7.0	2284	0.00	7.8	-1650	0.00
30-Oct-95	2.60	7.1	2391	0.00	8.7	-896	0.00
31-Oct-95	0.65	7.1	2556	0.00	8.7	-2437	0.00

DAILY AVERAGES OF WATER FLOW, pH AND CONDUCTIVITY FOR FIELD CELLS

Date	Inflow (L)	HC-1 field cell pH	HC-1 field cell Conductivity (uS/cm)	HC-1 field cell Outflow (L)	HC-2 field cell pH	HC-2 field cell Conductivity (uS/cm)	HC-2 field cell Outflow (L)
13-Jun-96	0.00	7.5	26	0.01	7.6	812	0.00
14-Jun-96	0.65	7.5	62	0.00	7.6	863	0.04
15-Jun-96	0.00	7.5	70	0.00	7.6	872	0.00
16-Jun-96	0.65	7.5	76	0.00	7.6	878	0.00
17-Jun-96	0.65	7.5	80	0.00	7.6	886	0.09
18-Jun-96	0.00	7.5	92	0.00	7.6	999	0.00
19-Jun-96	0.00	7.5	142	0.00	7.6	1643	0.00
20-Jun-96	0.00	7.5	141	0.00	7.6	1677	0.00
21-Jun-96	0.00	7.5	153	0.00	7.7	1734	0.00
22-Jun-96	0.00	7.5	616	1.11	7.6	1814	0.00
23-Jun-96	0.00	7.5	1044	0.00	7.7	1819	0.00
24-Jun-96	0.00	7.5	1045	0.00	7.7	1827	0.00
25-Jun-96	0.00	7.4	1037	0.00	7.7	1849	0.00
26-Jun-96	7.15	7.3	1032	0.00	7.5	1892	0.00
27-Jun-96	26.00	7.2	1020	0.00	7.6	1923	0.00
28-Jun-96	19.50	7.2	1007	1.61	7.6	1932	0.00
29-Jun-96	24.05	7.1	999	0.00	7.6	1943	0.00
30-Jun-96	12.35	7.2	1019	0.00	7.5	1944	0.00
01-Jul-96	9.75	7.2	1038	0.00	7.6	1946	0.00
02-Jul-96	0.00	7.3	1066	0.00	7.6	1946	0.00
03-Jul-96	1.95	7.4	1112	5.80	7.7	1952	0.00
04-Jul-96	118.30	7.4	1123	7.40	7.5	1951	0.00
05-Jul-96	82.55	7.4	1184	0.00	7.6	1942	0.00
06-Jul-96	1.30	7.6	1107	0.00	7.7	1927	0.00
07-Jul-96	0.00	7.6	794	3.38	7.9	1891	0.00
08-Jul-96	42.25	7.5	941	31.26	7.7	1854	0.00
09-Jul-96	37.05	7.4	928	42.87	7.5	1849	0.00
10-Jul-96	19.50	7.5	973	38.41	7.5	1842	0.00
11-Jul-96	0.00	7.5	1000	20.28	7.5	1866	0.00
12-Jul-96	0.65	7.5	1049	8.57	7.5	1898	0.94
13-Jul-96	0.00	7.6	1128	5.07	7.5	1931	6.30
14-Jul-96	0.00	7.6	1197	3.13	7.5	1953	7.49
15-Jul-96	0.65	7.5	1223	1.75	7.5	1928	3.40
16-Jul-96	42.25	7.4	1228	7.18	7.4	1897	0.27
17-Jul-96	39.00	7.4	1239	17.99	7.9	1915	11.40
18-Jul-96	48.10	7.4	1243	21.26	7.7	1913	5.53
19-Jul-96	28.60	7.4	1221	39.60	7.6	1899	6.48
20-Jul-96	3.25	7.3	1151	25.70	7.6	1817	17.77
21-Jul-96	7.80	7.2	1115	13.32	7.5	1764	9.57
22-Jul-96	0.65	7.1	1123	9.91	7.4	1793	7.89
23-Jul-96	0.00	7.1	1133	6.36	7.4	1812	6.97
24-Jul-96	0.00	7.2	1150	3.88	7.4	1819	6.38
25-Jul-96	0.00	7.3	1199	2.39	7.4	1831	3.48
26-Jul-96	0.00	7.3	1264	1.75	7.4	1814	1.75
27-Jul-96	0.00	7.3	1271	1.16	7.4	1784	1.18
28-Jul-96	0.00	7.2	1289	0.30	7.4	1786	0.80
29-Jul-96	0.00	7.2	1292	0.38	7.4	1796	0.55
30-Jul-96	24.05	7.2	1250	2.23	7.4	1714	0.38
31-Jul-96	22.10	7.1	1236	5.65	7.4	1700	0.72

Date	Inflow (L)	HC-1 field cell pH	HC-1 field cell Conductivity (uS/cm)	HC-1 field cell Outflow (L)	HC-2 field cell pH	HC-2 field cell Conductivity (uS/cm)	HC-2 field cell Outflow (L)
01-Aug-96	7.80	7.1	1239	5.11	7.4	1725	1.08
02-Aug-96	3.25	7.0	1195	1.75	7.3	1731	0.27
03-Aug-96	49.40	7.0	1181	31.31	7.3	1709	3.85
04-Aug-96	61.75	7.2	1062	64.73	7.3	1729	7.11
05-Aug-96	0.00	7.1	1228	9.46	7.3	1737	0.58
06-Aug-96	14.30	7.2	1244	7.27	7.3	1705	0.00
07-Aug-96	7.80	7.2	1244	4.28	7.3	1699	0.00
08-Aug-96	18.20	7.1	1245	5.96	7.3	1691	0.00
09-Aug-96	74.75	7.1	1219	70.88	7.3	1683	13.16
10-Aug-96	1.95	7.0	1172	26.90	7.3	1703	4.39
11-Aug-96	4.55	7.0	1205	9.32	7.4	1714	0.00
12-Aug-96	22.75	7.0	1193	8.15	7.4	1672	0.00
13-Aug-96	3.25	7.0	1192	5.15	7.4	1674	0.00
14-Aug-96	5.85	7.0	1199	3.31	7.3	1686	0.00
15-Aug-96	46.15	7.1	1195	18.22	7.4	1667	1.93
16-Aug-96	83.20	7.1	1171	37.84	7.1	1672	7.39
17-Aug-96	12.35	7.3	794	109.77	7.3	1674	46.36
18-Aug-96	39.65	7.4	701	39.06	7.2	1667	10.50
19-Aug-96	16.90	7.3	719	29.84	7.1	1657	6.38
20-Aug-96	10.40	7.2	729	21.92	7.1	1652	1.56
21-Aug-96	32.50	7.1	734	38.12	7.1	1649	8.35
22-Aug-96	41.60	7.1	734	54.62	7.2	1666	14.36
23-Aug-96	9.10	7.0	735	22.61	7.1	1660	2.52
24-Aug-96	0.00	7.1	760	8.62	7.2	1699	0.39
25-Aug-96	0.00	7.2	795	5.49	7.2	1704	0.11
26-Aug-96	6.50	7.2	831	4.52	7.1	1702	0.05
27-Aug-96	0.00	7.3	864	2.65	7.1	1711	0.01
28-Aug-96	6.50	7.4	914	2.00	7.1	1707	0.00
29-Aug-96	22.75	7.2	979	2.81	7.1	1626	0.00
30-Aug-96	39.65	7.1	1014	10.71	7.1	1543	0.00
31-Aug-96	0.15	7.1	991	0.15	7.1	1516	0.00
01-Sep-96	9.75	7.1	982	14.91	7.2	1503	0.01
02-Sep-96	57.85	7.1	964	35.26	7.3	1507	2.95
03-Sep-96	24.05	7.3	739	43.02	7.4	1542	12.76
04-Sep-96	3.25	7.4	840	6.43	7.5	1569	0.00
05-Sep-96	76.05	7.3	870	20.29	7.5	1554	0.26
06-Sep-96	22.10	7.3	850	7.43	7.4	1536	0.95
07-Sep-96	0.65	7.1	806	0.00	7.3	1539	0.00
08-Sep-96	5.85	7.0	802	0.00	7.4	1569	2.81
09-Sep-96	3.25	7.1	803	0.00	7.4	1590	3.24
10-Sep-96	17.55	7.1	804	0.00	7.4	1595	1.35
11-Sep-96	11.05	7.7	812	15.43	7.4	1616	0.02
12-Sep-96	6.50	7.2	819	15.14	7.4	1615	0.00
13-Sep-96	29.90	7.3	839	16.43	7.4	1603	0.00
14-Sep-96	3.90	7.3	851	12.03	7.4	1603	0.00
15-Sep-96	1.95	7.5	862	2.74	7.5	1604	0.82
16-Sep-96	0.00	7.5	901	0.02	7.5	1606	0.45
17-Sep-96	28.60	7.4	935	3.42	7.5	1610	0.68
18-Sep-96	17.55	7.3	940	19.15	7.4	1602	1.15
19-Sep-96	9.10	7.2	936	3.57	7.4	1597	0.43

APPENDIX 15

DAILY AVERAGES

EXTERNAL AIR TEMPERATURES AND INTERNAL TEMPERATURES

20-TONNE (FIELD) CELLS

DAILY AVERAGES OF EXTERNAL AIR AND INTERNAL TEMPERATURES OF THE 20 TONNE (FIELD) CELLS

Date	Air Temp. (°C)	Internal HC-1 Temp. (°C)	Internal HC-2 Temp. (°C)	Date	Air Temp. (°C)	Internal HC-1 Temp. (°C)	Internal HC-2 Temp. (°C)	Date	Air Temp. (°C)	Internal HC-1 Temp. (°C)	Internal HC-2 Temp. (°C)
1-Dec-94	-16.5	-11.8	-11.2	1-Jan-95	-2.6	-6.9	-6.7	1-Feb-95	-5.9	-7.0	-6.8
2-Dec-94	-17.0	-19.5	-17.4	2-Jan-95	-0.6	-6.3	-6.6	2-Feb-95	-6.3	-6.4	-6.4
3-Dec-94	-5.8	-19.4	-18.1	3-Jan-95	1.0	-6.3	-6.0	3-Feb-95	-6.4	-6.1	-6.2
4-Dec-94	-9.7	-18.3	-16.9	4-Jan-95	-0.6	-6.3	-5.7	4-Feb-95	-2.5	-5.6	-6.0
5-Dec-94	-10.9	-17.1	-15.8	5-Jan-95	-4.6	-7.4	-6.1	5-Feb-95	-2.9	-5.1	-5.3
6-Dec-94	-12.2	-15.9	-14.9	6-Jan-95	-9.5	-7.3	-6.4	6-Feb-95	-5.6	-5.1	-5.0
7-Dec-94	-9.7	-14.9	-14.1	7-Jan-95	-9.7	-10.8	-9.4	7-Feb-95	1.9	-5.0	-5.0
8-Dec-94	-13.6	-14.1	-13.4	8-Jan-95	-6.8	-11.4	-11.6	8-Feb-95	-4.7	-4.5	-4.7
9-Dec-94	-10.2	-13.5	-13.0	9-Jan-95	-7.6	-7.1	-8.8	9-Feb-95	-3.7	-4.6	-4.6
10-Dec-94	-5.6	-13.0	-12.5	10-Jan-95	-4.9	-7.7	-7.9	10-Feb-95	-7.7	-4.7	-4.7
11-Dec-94	-6.1	-12.3	-11.6	11-Jan-95	-5.8	-7.5	-7.6	11-Feb-95	-16.5	-11.5	-11.6
12-Dec-94	-7.8	-11.1	-10.6	12-Jan-95	-7.2	-7.3	-7.2	12-Feb-95	-16.7	-19.6	-19.7
13-Dec-94	-7.4	-10.1	-9.7	13-Jan-95	-8.0	-8.3	-8.0	13-Feb-95	-16.0	-17.2	-18.0
14-Dec-94	-9.6	-9.3	-9.1	14-Jan-95	-8.2	-8.1	-8.1	14-Feb-95	-20.5	-19.6	-18.6
15-Dec-94	-11.5	-9.3	-9.1	15-Jan-95	-8.4	-8.0	-8.1	15-Feb-95	-22.7	-20.7	-20.2
16-Dec-94	-9.0	-10.3	-10.1	16-Jan-95	-12.6	-8.0	-8.2	16-Feb-95	-16.3	-22.3	-21.7
17-Dec-94	-6.5	-9.0	-9.4	17-Jan-95	-9.8	-8.2	-8.5	17-Feb-95	-11.3	-22.1	-21.5
18-Dec-94	-5.8	-7.8	-8.7	18-Jan-95	-8.3	-9.3	-9.2	18-Feb-95	-4.9	-20.6	-19.4
19-Dec-94	-6.5	-7.5	-7.9	19-Jan-95	-7.1	-9.1	-9.1	19-Feb-95	-5.4	-15.4	-14.6
20-Dec-94	-9.1	-7.1	-7.4	20-Jan-95	-4.9	-7.4	-8.3	20-Feb-95	-8.7	-8.2	-9.7
21-Dec-94	-6.2	-7.0	-7.4	21-Jan-95	-1.6	-7.0	-7.1	21-Feb-95	-11.9	-7.6	-8.2
22-Dec-94	-9.7	-7.1	-7.3	22-Jan-95	-0.4	-6.5	-6.4	22-Feb-95	-11.9	-8.5	-9.0
23-Dec-94	-6.8	-7.4	-7.5	23-Jan-95	0.3	-6.2	-5.9	23-Feb-95	-4.5	-9.3	-9.7
24-Dec-94	-9.8	-7.6	-7.6	24-Jan-95	-3.2	-5.8	-5.5	24-Feb-95	-14.2	-9.2	-9.4
25-Dec-94	-9.7	-8.4	-8.0	25-Jan-95	-3.9	-5.5	-5.3	25-Feb-95	-16.3	-9.3	-9.6
26-Dec-94	-11.2	-8.9	-8.5	26-Jan-95	-4.7	-5.3	-5.2	26-Feb-95	-8.5	-9.9	-10.4
27-Dec-94	-11.6	-9.8	-9.2	27-Jan-95	-6.2	-5.0	-5.1	27-Feb-95	-7.7	-10.9	-11.1
28-Dec-94	-9.5	-10.3	-10.1	28-Jan-95	-3.4	-7.2	-6.9	28-Feb-95	-7.6	-10.7	-11.0
29-Dec-94	-3.2	-10.5	-10.4	29-Jan-95	-7.0	-6.8	-6.7				
30-Dec-94	-0.9	-10.4	-10.0	30-Jan-95	-5.9	-7.8	-7.0				
31-Dec-94	0.1	-7.8	-8.8	31-Jan-95	-3.3	-7.6	-7.2				

DAILY AVERAGES OF EXTERNAL AIR AND INTERNAL TEMPERATURES OF THE 20 TONNE (FIELD) CELLS

Date	Air Temp. (°C)	Internal HC-1 Temp. (°C)	Internal HC-2 Temp. (°C)	Date	Air Temp. (°C)	Internal HC-1 Temp. (°C)	Internal HC-2 Temp. (°C)	Date	Air Temp. (°C)	Internal HC-1 Temp. (°C)	Internal HC-2 Temp. (°C)
01-Mar-95	-3.8	-10.6	-10.6	01-Apr-95	-6.3	-3.7	-4.1	01-May-95	-1.0	-3.4	-4.0
02-Mar-95	-7.3	-9.7	-9.8	02-Apr-95	-3.0	-4.0	-4.3	02-May-95	-1.6	-2.8	-3.2
03-Mar-95	-17.8	-15.3	-13.0	03-Apr-95	-4.7	-3.9	-4.2	03-May-95	0.7	-2.4	-2.7
04-Mar-95	-16.4	-20.7	-20.8	04-Apr-95	-7.6	-4.0	-4.3	04-May-95	0.5	-2.3	-2.5
05-Mar-95	-15.4	-17.1	-18.6	05-Apr-95	-7.2	-5.5	-4.9	05-May-95	-1.4	-2.1	-2.3
06-Mar-95	-18.4	-18.3	-17.8	06-Apr-95	-5.4	-7.3	-6.4	06-May-95	4.1	-1.8	-2.1
07-Mar-95	-17.1	-18.4	-18.3	07-Apr-95	-3.6	-4.8	-5.8	07-May-95	6.0	-1.4	-1.8
08-Mar-95	-16.0	-16.7	-17.2	08-Apr-95	-5.8	-4.5	-5.1	08-May-95	7.4	0.1	-0.9
09-Mar-95	-5.4	-15.5	-16.0	09-Apr-95	-7.3	-4.5	-5.0	09-May-95	5.5	1.4	-0.5
10-Mar-95	-4.4	-12.6	-13.1	10-Apr-95	-8.2	-7.6	-6.3	10-May-95	-1.7	2.1	-0.2
11-Mar-95	-8.0	-11.0	-11.1	11-Apr-95	-7.4	-7.4	-6.9	11-May-95	1.4	1.2	-0.1
12-Mar-95	-9.5	-8.8	-9.3	12-Apr-95	-5.9	-7.4	-7.2	12-May-95	7.9	1.6	0.0
13-Mar-95	-6.1	-8.0	-8.6	13-Apr-95	-5.9	-7.7	-7.5	13-May-95	3.7	2.1	0.1
14-Mar-95	-4.2	-7.6	-7.8	14-Apr-95	-7.2	-7.3	-7.3	14-May-95	-0.3	1.2	0.4
15-Mar-95	-6.1	-7.0	-7.2	15-Apr-95	-5.4	-7.1	-7.2	15-May-95	-0.4	0.3	0.4
16-Mar-95	-6.7	-6.3	-6.6	16-Apr-95	-6.7	-6.9	-7.0	16-May-95	-3.6	0.0	0.2
17-Mar-95	-4.3	-6.4	-6.6	17-Apr-95	-5.7	-6.6	-6.8	17-May-95	-4.6	-1.7	-0.1
18-Mar-95	-4.1	-6.1	-6.2	18-Apr-95	-7.5	-6.5	-6.6	18-May-95	-4.7	-3.3	-0.2
19-Mar-95	-12.9	-5.8	-6.1	19-Apr-95	-6.3	-7.1	-6.6	19-May-95	-3.6	-3.8	-0.2
20-Mar-95	-11.9	-13.6	-11.8	20-Apr-95	-3.2	-7.1	-6.8	20-May-95	1.8	-4.2	-0.3
21-Mar-95	-7.8	-8.9	-10.5	21-Apr-95	-2.1	-6.9	-6.5	21-May-95	3.2	-3.5	-0.4
22-Mar-95	-8.6	-9.0	-9.7	22-Apr-95	-1.6	-6.3	-6.0	22-May-95	1.8	-2.5	-0.5
23-Mar-95	-13.4	-8.9	-9.4	23-Apr-95	-3.5	-4.8	-5.4	23-May-95	4.4	-1.7	-0.5
24-Mar-95	-12.6	-9.5	-9.7	24-Apr-95	0.3	-3.7	-4.6	24-May-95	8.4	-0.6	-0.5
25-Mar-95	-6.0	-10.2	-10.3	25-Apr-95	1.2	-3.3	-3.8	25-May-95	9.4	-0.4	-0.4
26-Mar-95	-3.4	-9.9	-9.9	26-Apr-95	0.9	-1.5	-2.4	26-May-95	7.9	-0.2	-0.4
27-Mar-95	-1.8	-9.3	-9.0	27-Apr-95	0.3	-3.0	-3.2	27-May-95	2.9	0.4	-0.3
28-Mar-95	-0.5	-8.4	-7.9	28-Apr-95	2.6	-2.1	-3.1	28-May-95	0.2	1.5	-0.3
29-Mar-95	-2.2	-7.3	-6.8	29-Apr-95	-0.1	-1.1	-1.8	29-May-95	-1.5	1.7	-0.3
30-Mar-95	-1.9	-5.1	-5.7	30-Apr-95	-3.0	-4.5	-4.3	30-May-95	-2.1	0.4	-0.3
31-Mar-95	-5.0	-3.8	-4.2	31-Dec-94	0.1	-7.8	-8.8	31-May-95	-0.8	0.0	-0.2

DAILY AVERAGES OF EXTERNAL AIR AND INTERNAL TEMPERATURES OF THE 20 TONNE (FIELD) CELLS

Date	Air Temp. (°C)	Internal HC-1 Temp. (°C)	Internal HC-2 Temp. (°C)	Date	Air Temp. (°C)	Internal HC-1 Temp. (°C)	Internal HC-2 Temp. (°C)	Date	Air Temp. (°C)	Internal HC-1 Temp. (°C)	Internal HC-2 Temp. (°C)
1-Jun-95	-0.4	0.0	-0.2					01-Jul-96	-1.21	0.30	0.13
2-Jun-95	-1.9	0.0	-0.2					02-Jul-96	0.85	0.17	0.06
3-Jun-95	4.1	-0.2	-0.2					03-Jul-96	3.06	0.16	0.03
4-Jun-95	0.8	-0.1	-0.2					04-Jul-96	-0.19	0.22	0.05
5-Jun-95	-2.1	-0.1	-0.2					05-Jul-96	-0.27	0.17	0.06
6-Jun-95	3.0	-0.1	-0.2					06-Jul-96	1.36	0.14	0.03
7-Jun-95	9.6	-0.1	-0.2					07-Jul-96	6.69	0.17	0.01
8-Jun-95	8.3	2.1	-0.1					08-Jul-96	5.60	1.37	0.16
9-Jun-95	11.8	5.1	3.8					09-Jul-96	0.26	2.04	0.40
10-Jun-95	6.6	5.5	5.1					10-Jul-96	0.24	1.90	0.57
11-Jun-95	-0.8	5.1	5.0					11-Jul-96	2.41	1.48	0.62
12-Jun-95	2.7	4.1	4.4					12-Jul-96	5.02	1.53	0.59
13-Jun-95	0.2	2.2	3.7	13-Jun-96	-4.92	0.07	-0.14	13-Jul-96	4.10	2.12	0.65
14-Jun-95	0.2	0.7	2.8	14-Jun-96	-2.38	-0.08	-0.14	14-Jul-96	4.92	2.93	0.82
15-Jun-95	0.1	0.7	2.3	15-Jun-96	-2.84	-0.18	-0.14	15-Jul-96	-0.17	3.24	1.02
16-Jun-95	3.9	0.8	1.9	16-Jun-96	-3.73	-0.22	-0.14	16-Jul-96	-0.72	1.75	1.06
17-Jun-95	1.2	1.3	1.6	17-Jun-96	0.74	-0.57	-0.14	17-Jul-96	2.30	1.42	0.70
18-Jun-95	5.1	1.3	1.6	18-Jun-96	-0.64	-0.70	-0.14	18-Jul-96	2.50	2.58	1.55
19-Jun-95	7.4	2.1	2.1	19-Jun-96	4.10	-0.63	-0.14	19-Jul-96	0.16	2.19	1.49
20-Jun-95	5.3	3.2	2.9	20-Jun-96	6.69	-0.04	-0.13	20-Jul-96	1.57	1.32	1.27
21-Jun-95	6.9	3.9	3.6	21-Jun-96	3.99	1.05	-0.14	21-Jul-96	2.64	1.49	1.20
22-Jun-95	1.0	4.6	4.4	22-Jun-96	3.47	1.17	-0.13	22-Jul-96	3.32	1.87	1.36
23-Jun-95	-0.5	3.9	4.3	23-Jun-96	6.51	2.38	-0.11	23-Jul-96	8.12	2.26	1.64
24-Jun-95	-1.4	2.3	3.5	24-Jun-96	8.11	2.81	0.11	24-Jul-96	9.71	4.14	2.88
25-Jun-95	-0.4	1.0	2.5	25-Jun-96	3.33	2.53	0.20	25-Jul-96	12.07	4.87	4.11
26-Jun-95	6.1	0.8	1.9	26-Jun-96	1.66	2.60	0.31	26-Jul-96	11.96	5.59	5.02
27-Jun-95	10.2	1.4	2.2	27-Jun-96	-0.87	2.53	0.44	27-Jul-96	12.87	6.90	6.08
				28-Jun-96	-1.65	2.01	0.49	28-Jul-96	12.64	7.90	7.52
				29-Jun-96	-0.18	0.65	0.39	29-Jul-96	7.19	8.34	8.43
				30-Jun-96	-2.62	0.39	0.18	30-Jul-96	0.86	7.33	8.38
								31-Jul-96	1.53	2.54	6.66

DAILY AVERAGES OF EXTERNAL AIR AND INTERNAL TEMPERATURES OF THE 20 TONNE (FIELD) CELLS

Date	Air Temp. (°C)	Internal HC-1 Temp. (°C)	Internal HC-2 Temp. (°C)	Date	Air Temp. (°C)	Internal HC-1 Temp. (°C)	Internal HC-2 Temp. (°C)
01-Aug-96	-1.21	0.30	0.13	01-Sep-96	0.96	2.21	4.48
02-Aug-96	0.85	0.17	0.06	02-Sep-96	1.98	1.91	3.09
03-Aug-96	3.06	0.16	0.03	03-Sep-96	3.81	2.24	2.17
04-Aug-96	-0.19	0.22	0.05	04-Sep-96	5.65	2.42	2.20
05-Aug-96	-0.27	0.17	0.06	05-Sep-96	0.23	2.79	2.49
06-Aug-96	1.36	0.14	0.03	06-Sep-96	-1.52	1.94	2.27
07-Aug-96	6.69	0.17	0.01	07-Sep-96	-0.37	0.13	0.86
08-Aug-96	5.60	1.37	0.16	08-Sep-96	0.39	-0.01	0.21
09-Aug-96	0.26	2.04	0.40	09-Sep-96	-0.07	0.05	0.13
10-Aug-96	0.24	1.90	0.57	10-Sep-96	3.99	0.08	0.06
11-Aug-96	2.41	1.48	0.62	11-Sep-96	7.46	0.09	0.25
12-Aug-96	5.02	1.53	0.59	12-Sep-96	2.47	0.14	0.74
13-Aug-96	4.10	2.12	0.65	13-Sep-96	1.92	0.29	0.95
14-Aug-96	4.92	2.93	0.82	14-Sep-96	0.19	0.52	1.07
15-Aug-96	-0.17	3.24	1.02	15-Sep-96	-0.78	0.52	1.06
16-Aug-96	-0.72	1.75	1.06	16-Sep-96	0.57	0.43	0.82
17-Aug-96	2.30	1.42	0.70	17-Sep-96	0.78	0.43	0.70
18-Aug-96	2.50	2.58	1.55	18-Sep-96	-0.67	0.46	0.67
19-Aug-96	0.16	2.19	1.49	19-Sep-96	-2.67	0.24	0.54
20-Aug-96	1.57	1.32	1.27				
21-Aug-96	2.64	1.49	1.20				
22-Aug-96	3.32	1.87	1.36				
23-Aug-96	8.12	2.26	1.64				
24-Aug-96	9.71	4.14	2.88				
25-Aug-96	12.07	4.87	4.11				
26-Aug-96	11.96	5.59	5.02				
27-Aug-96	12.87	6.90	6.08				
28-Aug-96	12.64	7.90	7.52				
29-Aug-96	7.19	8.34	8.43				
30-Aug-96	0.86	7.33	8.38				
31-Aug-96	1.53	2.54	6.66				

APPENDIX 16

WATER CHEMISTRY

20-TONNE (FIELD) CELLS

WATER CHEMISTRY OF 20-TONNE (FIELD) CELLS

20-tonne (Field) Cell	Date	pH	Conductivity (umhos/cm)	Total Dissolved Solids (mg/L)	Total Suspended Solids (mg/L)	Alkalinity to pH 4.5 (mg CaCO3/L)	Acidity to pH 8.3 (mg CaCO3/L)	Hardness - CALC (mg/L)	Sulphate (mg/L)
HC-1	Oct 31, 95	7.2	1576	1309	<1	66	7.7	627	852
HC-1	Jul 07, 96	7.5	811	606	8	48	4.2	280	354
HC-1	Jul 20, 96	7.2	997	794	<1	60	5.6	354	464
HC-1	Jul 26, 96	7.4	1393	1188	<1	56	5.2	500	743
HC-1	Aug 01, 96	7.1	1210	968	8	56	6.0	800	674
HC-1	Aug 29, 96	8.0	1098	848	<1	62	2.6	526	534
HC-1	Sep 09, 96	7.7	877	717	<1	61	3.0	448	391
HC-2	Oct 31, 95	7.0	1985	1693	<1	58	10.0	562	1110
HC-2	Jul 07, 96	7.5	1708	1498	4	52	5.4	664	981
HC-2	Jul 20, 96	7.4	1777	1592	<1	52	4.6	690	1060
HC-2	Jul 26, 96	7.4	1753	1552	4	52	5.2	670	1030
HC-2	Aug 01, 96	7.4	1920	1656	<1	52	6.0	1317	1302
HC-2	Aug 29, 96	7.4	1548	1374	<1	46	5.6	782	854
HC-2	Sep 09, 96	7.4	1671	1563	3	47	4.0	858	1010

WATER CHEMISTRY OF 20-TONNE (FIELD) CELLS

Total Metals

20-tonne (Field) Cell	Date	Beryllium (mg/L)	Boron (mg/L)	Sodium (mg/L)	Magnesium (mg/L)	Aluminium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Vanadium (mg/L)	Chromium (mg/L)	Manganese (mg/L)	Iron (mg/L)	Nickel (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Zinc (mg/L)
HC-1	Oct 31, 95	-0.05	75	29600	38500	24.0	15600	182000	-1	2.6	539	160	11.50	1.70	4.4	128
HC-1	Jul 07, 96	-0.05	40	10100	18000	58.0	4000	89300	-1	3.6	398	130	5.90	1.07	5.0	34
HC-1	Jul 20, 96	-0.05	54	12300	23000	42.0	4530	110000	-1	2.3	462	140	7.20	3.67	2.9	40
HC-1	Jul 26, 96	-0.05	73	20500	31100	34.0	6770	151000	-1	2.8	542	120	9.10	4.33	5.3	46
HC-1	Aug 01, 96	0.06	66	42900	57000	42.3	9520	234000	-1	1.3	471	100	1.30	7.00	4.1	52
HC-1	Aug 29, 96	-0.05	69	16600	21000	-0.5	4840	178000	3	-0.5	373	30	0.95	5.90	2.4	64
HC-1	Sep 09, 96	0.08	19	10200	15500	2.2	2090	156000	-1	0.8	367	30	0.84	4.60	2.1	40
HC-2	Oct 31, 95	-0.05	78	74200	80400	24.0	25200	149000	-1	2.6	2340	100	9.30	5.16	4.5	94
HC-2	Jul 07, 96	-0.05	60	27800	48200	30.0	5510	199000	-1	1.6	1840	170	8.60	2.81	2.0	48
HC-2	Jul 20, 96	-0.05	51	23400	43500	41.0	7620	218000	-1	2.5	1780	170	7.30	4.98	2.2	48
HC-2	Jul 26, 96	-0.05	67	23800	40200	29.0	11100	272000	-1	2.9	2060	160	7.90	2.88	3.2	70
HC-2	Aug 01, 96	-0.05	55	66500	95700	13.2	13100	374000	-1	1.4	2030	120	2.20	8.80	0.9	60
HC-2	Aug 29, 96	-0.05	58	18500	35600	213.0	5920	279000	-1	-0.5	1280	90	1.95	6.30	3.0	118
HC-2	Sep 09, 96	-0.05	30	16400	30100	24.6	5080	323000	-1	-0.5	1180	90	1.69	4.20	2.0	44

Dissolved Metals

20-tonne (Field) Cell	Date	Beryllium (mg/L)	Boron (mg/L)	Sodium (mg/L)	Magnesium (mg/L)	Aluminium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Vanadium (mg/L)	Chromium (mg/L)	Manganese (mg/L)	Iron (mg/L)	Nickel (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Zinc (mg/L)
HC-1	Oct 31, 95	-0.05	70	29000	38000	19.0	15500	180000	-1	1.9	529	90	10.20	1.57	3.7	116
HC-1	Jul 07, 96	-0.05	39	9630	17100	40.0	3930	83900	-1	1.0	394	100	5.90	0.73	2.8	32
HC-1	Jul 20, 96	-0.05	49	12100	21700	41.0	4520	106000	-1	-0.5	455	130	6.30	1.15	2.4	38
HC-1	Jul 26, 96	-0.05	65	20500	30500	32.0	6670	150000	-1	-0.5	487	50	7.50	1.47	5.0	44
HC-1	Aug 01, 96	-0.05	46	41500	53100	39.1	8860	233000	-1	-0.5	463	60	1.17	7.00	3.6	33
HC-1	Aug 29, 96	-0.05	65	16100	20900	-0.5	4060	176000	-1	-0.5	343	60	0.92	5.30	2.1	58
HC-1	Sep 09, 96	-0.05	15	9640	14700	-0.5	2070	155000	-1	-0.5	366	10	0.70	3.40	1.3	40
HC-2	Oct 31, 95	-0.05	74	58600	63100	20.0	20200	121000	-1	0.8	2180	80	7.40	2.03	3.6	92
HC-2	Jul 07, 96	-0.05	60	25900	46000	30.0	5510	190000	-1	1.0	1800	160	8.40	2.28	1.6	47
HC-2	Jul 20, 96	-0.05	50	22500	41500	30.0	6330	208000	-1	-0.5	1780	170	6.90	4.31	2.2	42
HC-2	Jul 26, 96	-0.05	66	22700	39900	28.0	7230	203000	-1	-0.5	2010	150	7.80	2.86	3.1	70
HC-2	Aug 01, 96	-0.05	55	58500	94900	11.0	12500	371000	-1	-0.5	1860	110	2.11	8.00	0.9	47
HC-2	Aug 29, 96	-0.05	52	17900	32300	-0.5	5200	260000	-1	-0.5	1170	60	0.73	3.20	-0.1	115
HC-2	Sep 09, 96	-0.05	25	15700	28200	9.0	4850	297000	-1	-0.5	1140	50	1.67	4.00	1.5	42

WATER CHEMISTRY OF 20-TONNE (FIELD) CELLS

Total Metals

20-tonne (Field) Cell	Date	Arsenic (mg/L)	Selenium (mg/L)	Strontium (mg/L)	Molybdenum (mg/L)	Silver (mg/L)	Cadmium (mg/L)	Antimony (mg/L)	Tellurium (mg/L)	Barium (mg/L)	Mercury (mg/L)	Lead (mg/L)	Uranium (mg/L)
HC-1	Oct 31, 95	-2	14	4100	7.03	0.09	1.9	122.0	1.30	40.2	-0.2	0.40	2.08
HC-1	Jul 07, 96	-2	6	1870	4.36	-0.01	0.9	70.3	0.40	46.0	-0.2	0.50	1.07
HC-1	Jul 20, 96	3	6	2290	5.79	0.02	0.4	91.0	0.30	43.2	-0.2	1.20	1.40
HC-1	Jul 26, 96	5	20	3340	7.60	-0.01	0.8	105.0	-0.2	51.5	-0.2	0.50	2.71
HC-1	Aug 01, 96	-1	17	4360	5.64	0.05	0.7	75.6	0.10	38.9	-0.05	0.63	1.78
HC-1	Aug 29, 96	9	17	2480	4.93	-0.01	0.4	91.5	-0.07	50.6	-0.05	0.06	1.62
HC-1	Sep 09, 96	5	1	1970	3.74	0.03	0.6	100.0	-0.07	54.7	-0.05	0.21	1.00
HC-2	Oct 31, 95	-2	-5	2310	2.72	-0.01	1.5	14.7	-0.2	18.0	-0.2	0.40	0.51
HC-2	Jul 07, 96	3	-5	2940	1.90	0.02	1.3	11.9	-0.2	19.8	-0.2	0.40	0.38
HC-2	Jul 20, 96	7	-5	2790	1.71	-0.01	1.3	10.6	-0.2	19.9	-0.2	0.80	0.40
HC-2	Jul 26, 96	4	-5	2980	1.61	-0.01	1.9	11.6	-0.2	21.0	-0.2	0.40	0.56
HC-2	Aug 01, 96	-1	4	4590	1.55	0.03	1.4	11.8	0.18	18.6	-0.05	0.18	0.40
HC-2	Aug 29, 96	3	7	2290	1.55	0.03	1.0	10.4	-0.07	22.0	0.09	0.21	0.28
HC-2	Sep 09, 96	-1	-1	2430	1.22	-0.01	1.5	9.5	-0.07	24.6	-0.05	0.39	0.28

Dissolved Metals

20-tonne (Field) Cell	Date	Arsenic (mg/L)	Selenium (mg/L)	Strontium (mg/L)	Molybdenum (mg/L)	Silver (mg/L)	Cadmium (mg/L)	Antimony (mg/L)	Tellurium (mg/L)	Barium (mg/L)	Mercury (mg/L)	Lead (mg/L)	Uranium (mg/L)
HC-1	Oct 31, 95	-2	14	3390	5.64	-0.01	0.4	121.0	0.30	40.0	-0.2	-0.2	2.07
HC-1	Jul 07, 96	-2	6	1850	3.22	-0.01	0.3	69.6	-0.2	44.5	-0.2	0.20	1.01
HC-1	Jul 20, 96	-2	6	2260	5.52	0.02	0.4	90.7	-0.2	43.0	-0.2	0.90	1.33
HC-1	Jul 26, 96	-2	16	3330	7.51	-0.01	0.7	100.0	-0.2	46.4	-0.2	0.50	2.70
HC-1	Aug 01, 96	-1	15	4200	5.22	-0.01	0.6	71.7	-0.07	38.0	-0.05	0.38	1.53
HC-1	Aug 29, 96	4	15	2370	4.89	-0.01	0.4	90.4	-0.07	49.0	-0.05	-0.05	1.17
HC-1	Sep 09, 96	3	1	1950	3.21	-0.01	0.5	98.8	-0.07	52.2	-0.05	-0.05	0.72
HC-2	Oct 31, 95	-2	-5	2050	2.28	-0.01	0.8	14.4	-0.2	18.0	-0.2	-0.2	0.32
HC-2	Jul 07, 96	2	-5	2700	1.41	0.02	1.3	11.5	-0.2	18.8	-0.2	0.20	0.27
HC-2	Jul 20, 96	-2	-5	2600	1.46	-0.01	1.1	9.6	-0.2	17.5	-0.2	0.40	0.19
HC-2	Jul 26, 96	2	-5	2890	1.44	-0.01	1.7	11.1	-0.2	20.6	-0.2	0.40	0.49
HC-2	Aug 01, 96	-1	4	4450	1.39	-0.01	0.9	10.6	0.13	18.3	-0.05	0.09	0.38
HC-2	Aug 29, 96	3	6	2180	1.51	-0.01	0.9	10.2	-0.07	21.3	0.09	0.18	0.25
HC-2	Sep 09, 96	-1	-1	2340	1.09	-0.01	1.5	9.0	-0.07	21.7	-0.05	-0.05	0.10