Wolfden Resources Inc.

ULU PROJECT

Review of Field Column Kinetic Test Data

FINAL REPORT

Prepared by:

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Date: December 29, 2004

Mr. Jim Cassie, M. Sc., P. Eng.
BGC Engineering Inc.
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Calgary, AB T2P 3G2

Dear Mr. Cassie,

Re: Ulu Project – Review of Field Column Kinetic Test Data – Final Report

This report is based on a draft report, dated January 13, 2003, that was prepared for Kinross Gold Corporation (formerly Echo Bay Mines Ltd.). At your request, that draft report has been reviewed and finalized for the new site owner, Wolfden Resources Inc. No new data has been added, and no new analyses have been conducted, although editing suggestions have been incorporated for improved clarity.

As requested, I have forwarded 4 hardcopies and one electronic copy to David Stevenson of Wolfden Resources Inc., and one copy to Lorax Environmental Services Ltd in Vancouver, Please find enclosed a hardcopy for your files, and one copy for Gartner Lee Ltd in Calgary, as requested.

We trust this report meets your requirements at this time.

Yours truly,
Mehling Environmental Management Inc.

Peri Mehling, MSc., P.Eng.
Senior Consultant

Encl. 2 Paper copies of final report

EXECUTIVE SUMMARY

This report provides a compilation and interpretation of data provided by Kinross Gold Corporation from two field columns at the Ulu Mine Project site. The report also compares the field test results with the conclusions presented in the Klohn-Crippen Consultants Ltd. (Klohn) reported entitled "Ulu Project – Kintetic Testing of Sulphide-Rich Material from Ulu" dated April 1998, which considered early results from the two field columns as well as results from a series of laboratory kinetic tests conducted on coarse ore, fine ore (to simulate tailings) and waste rock.

The key findings, and implication for ore and waste rock management, are as follows:

- Klohn's NPR threshold values to avoid acidic drainage of 3 and 7 for 22 ^{O}C and 4 ^{O}C respectively, calculated from humidity cell results on high-sulphide samples of coarse ore, fine ore (simulated tailings), and waste rock, are considered conservative due to the relatively large volumes of water used in a humidity cell test as compared to field conditions. Lag times before the onset of acidic conditions associated with these thresholds are likely to be in the order of decades.
- Results from the field columns tests conducted on coarse ore samples suggest that threshold NPRs to avoid acidic drainage may be as low as 1.3 and 2.0. The reduced threshold NPR values (as compared to the humidity cell test results) are attributed to the reduced NP depletion rate, as a result of lower flushing volumes and frequency under field conditions. However, these field column NPR threshold values should be viewed with caution as all oxidation products may not be released as they are produced, and the sulphate release rates may continue to increase as products build up and become available for release on subsequent flush events. Confirmation and use of these lower threshold NPR values would require continued test work (allowing for stabilization of oxidation rates), or dismantling and analysis of field columns.
- High arsenic concentrations, and elevated zinc concentrations are anticipated from ore located in the active layer on site at neutral pH. These arsenic concentrations may be of concern as they occasionally exceeded the federal *Metal Mining Effluent Regulations* maximum allowable values, particularly in the later stages of the 5 year test.
- Given that ore stockpiles are anticipated to be milled quickly, and are not likely to be stored for more than one year before transport to an offsite mill, the predicted arsenic and zinc concentrations and the predicted delay until the onset of acidic conditions are unlikely to result in significant adverse affects on the environment.
- Minimal metal leaching from waste rock was anticipated by Klohn (1996) based on the geological model (which suggests low levels of mineralization in the waste rock) and the lack of a metal leaching problem associated with the single, high sulphide

waste rock kinetic test sample. However, the limited metal database for waste rock samples precludes a quantitative assessment of metal content in waste materials at this time. Greater clarity of the potential quantity of waste rock that might contain elevated metal levels may be determined by review of the 7305 ICP's referred to the BHP geology report (1993).

- Any waste material that contains arsenic, such as waste rock adjacent to the ore, may have a potential to leach arsenic at elevated concentrations at neutral pH, and should be assessed and/or managed accordingly. Zinc may also be a potential metal leaching concern if present in waste materials in similar quantities and form as the tested coarse and fine ore samples.
- Should acidic conditions eventually develop, leaching of other metals may occur. For example, copper values in the waste rock are noted as being slightly more elevated than ore samples.
- Under field conditions, a threshold NPR of 3 is considered a reasonably conservative means of classifying PAG waste materials to avoid the onset of acid generation. From the existing database, this appears to be consistent with a total sulphur cutoff of 0.2%.
- Based on the ABA database compiled to date, and a threshold NPR of 3 for separating PAG and NPAG material, gabbro and diabase material for the most part are likely to be NPAG, greywacke may be PAG or NPAG depending on the sulphur content, mafic volcanics are likely to be PAG, basalt material is highly variable but generally PAG and all ore and altered material are PAG. Note that the database is dominated by surface samples, and deeper materials may not maintain the indicated trends. Also note that the samples may have been biased to those containing visible sulphides.
- The onset of acidic conditions, and/or predicted metal leaching, may not necessarily result in significant adverse affects on the environment. Impact assessments are required to assess potential impacts, and typically take into account the mass of material maintained in a frozen state, volume and grainsize of the stockpiled material, site temperatures, the tendency for water to flow through channels and bypass many of the rock surfaces potentially holding stored oxidation products, and the volume of runoff and leachate that may contact the stockpile materials. MEMI recommends that impact assessments for specific site conditions be conducted to quantitatively define potential impacts from waste rock storage.

TABLE OF CONTENTS

LIST OF TABLES

Tables 8, 9 and 10 are inserted after the report text.

LIST OF FIGURES

LIMITATIONS OF REPORT

Mehling Environmental Management Inc. (MEMI) prepared this report for the account of Wolfden Resources Inc. (Wolfden). The material in it reflects the judgement of MEMI staff in light of the information available to MEMI at the time of draft report preparation in January 2003. Any use which a Third Party makes of this report, or any reliance on decisions to be based on it, is the responsibility of such Third Parties. MEMI accepts no responsibility for damages, if any suffered by any Third Party as a result of decisions made or actions based on this report.

As mutual protection to our client, the public, and ourselves, all reports and drawings are submitted for the confidential information of Wolfden. The authorization for use and/or publication of data, statements, conclusions or abstracts from or regarding our reports and drawings is reserved pending written approval by Wolfden and MEMI.

1.0 INTRODUCTION

Mehling Environmental Management Inc. (MEMI) was originally retained by Kinross Gold Corporation (Kinross), formerly Echo Bay Mines Ltd. (Echo Bay), to summarize the field column test work for the Ulu Mine Project and compare the field test work with the conclusions presented in the Klohn-Crippen Consultants Ltd. (Klohn) report entitled "Ulu Project – Kinetic Testing of Sulphide-Rich Material from Ulu" dated April 1998. The 1998 Klohn report considered early results from the same two field columns, as well as results from a series of laboratory kinetic tests conducted on coarse ore, fine ore (to simulate tailings) and waste rock. A draft report was produced on January 13, 2004, but was not finalized.

At the request of BGC Engineering Inc., Calgary, Alberta, the draft report has been reviewed and finalized for the new site owner, Wolfden Resources Inc. No new data has been added, and no new analyses have been conducted, although editing suggestions have been incorporated for improved clarity.

The scope of work for this project included:

- A review of reports, data and study information related to Acid Rock Drainage/Metal Leaching (ARD/ML) as provided by Kinross, including site geology, rock types, rock characteristics and kinetic tests;
- Compilation and interpretation of data from two field columns collected and provided by Kinross. The interpretation was to focus on comparison of field leach rates to sulphate production and neutralization depletion rates estimated in the preliminary assessment undertaken by Klohn-Crippen Consultants Ltd. (Klohn); and,
- Completion of a column test report, including discussion of potential implications for mine waste management.

Specific reports provided by Kinross and reviewed for acid base accounting (ABA) data and kinetic test results were:

- "Ulu Project, Northwest Territories, Environmental Overview" prepared for BHP Minerals Ltd. of Vancouver, B.C. by Rescan Environmental Services Ltd. (Rescan) of Vancouver, B.C., dated December 1991;
- "Ulu Project, Preliminary Assessment of Acid Rock Drainage Potential" prepared for Echo Bay Mines Ltd. – Lupin Operation (EBM-Lupin), by Klohn-Crippen Consultants Ltd. (Klohn) of Calgary, Alberta, dated October 1996; and,
- "Ulu Project, Kinetic Testing of Sulfide-Rich Material from Ulu" prepared for Echo Bay Mines Ltd., by Klohn, dated April 1998.

2.0 BACKGROUND

The following project description was taken from Klohn, 1998:

"The Ulu property is located 45 km north of the Arctic Circle and 135 km north of the Lupin Mine in the Mackenzie Mining District, Northwest Territories. Echo Bay Mines – Lupin Operation acquired the property from BHP Minerals Canada Ltd. in 1995, intending to develop it to provide ore for milling at the Lupin Mine. The tentative mine plan involves stockpiling ore materials at the Ulu site year-round and transporting them to the Lupin Mine when winter roads are operational. Waste rock excavated to reach the orebody is used for construction of ore pads for temporary ore storage and camp pads at the Ulu site."

2.1 Deposit Geology and Mineralogy

The following geological description is from Klohn, 1996:

"The Ulu deposit is an Archean epigenetic lode-gold occurrence located within the High Lake greenstone belt of the north-central Slave Province. Pillowed to massive mafic volcanic rocks and co-magmatic gabbro sills are interlayered with greywacke-mudstone turbidite sequences that form a tight north-trending anticline bound on all sides by late Archean granite. Mineralization is hosted in discordant quartz veins concentrated along the axial trace of the anticline. Regional metamorphism to the lower amphibolite facies has converted the sedimentary package largely to biotite schist. Mafic metavolcanic and metagabbro rocks proximal to mineralization are similar in mineralogy and bulk chemistry and are classified as sub-alkaline, high-iron tholeiites (Carpenter, 1994). Gold mineralization is commonly hosted in metavolcanics (e.g., the Flood Zone), less commonly in metagabbro (e.g., the Gnu Zone) and rarely within metasediments (e.g. the Sediment Core Zone).

In the Flood Zone, where most recent work has been focused and where initial mining development will probably commence, the ore mineralization is associated with pervasive silicification and feldspar alteration. Gold occurs adjacent to acicular arsenopyrite in the silica-feldspar altered mafic metavolcanic wallrock and breccia. Pyrrhotite occurs as late anhedral grains that may be found vein-forming and cross-cutting the arsenopyrite-gold mineralization. Pyrite with or without trace amounts of chalcopyrite occurs in late quartz stockwork selvage and fractures. Marcasite, goethite and limonite are present as late weathering products. The hangingwall metavolcanic show retrograde metamorphism and propylitic alteration characterized by actinolite, epidote and minor chlorite, quartz and sericite. Late quartz-actinolite-carbonate veins are occasionally found overprinting the metamorphic assemblages. The footwall rocks exhibit pervasive biotite and albite alteration with quartz, epidote and chlorite as minor constituents."

3.0 PREVIOUS ARD ASSESSMENTS

3.1 Static Test Results (Klohn, 1996)

Klohn (1996) reviewed previously available data and furnished new field observations and an interpretation of static test data, incorporating acid-base accounting (ABA) test results from a new suite of 32 samples collected by Klohn staff and Echo Bay geologists. Conclusions and recommendation for further work were made based on a synthesis of all acquired data.

The ABA testwork conducted prior to Klohn's participation consisted of

- 1990 testing performed as part of the environmental overview by Rescan (1991), which attempted "...to characterize the ARD potential of the various lithologies occurring in the Ulu property through the analysis of 15 samples"; and,
- 14 samples analyzed in 1992 by BHP Minerals (1993), which "...specifically addressed the ARD characteristics of the ore material and rocks in the hanging wall exposed in a trench in the NW Flood Zone."

ABA methods used in these studies were not specified in Klohn (1996), or in the referenced reports.

Klohn (1996) noted the following conclusions from the previous work:

> "...the ore material is potentially acid-generating while most barren rocks are not. Rocks in the contact zones with ore mineralization generally have a lower NP/AP [Neutralization Potential/Acid Potential] ratio. The sulfide content appears to be the primary factor determining whether or not the ratio is to fall below the safety threshold values recommended by the regulatory agencies (NP/AP = 3/1 according to the U.S. Environmental Protection Agency; and NP/AP = 4/1 according to the B.C. ARD Guidelines)"

Klohn (1996) also noted that these results were consistent with Klohn's preliminary ARD assessment developed on the basis of the deposit geology and prevalent mineralogy, as follows:

> "Mesothermal lode gold deposits are ranked low in overall susceptibility to give rise to ARD problems among the seven common deposit types investigated by Kwong (1993). In the Ulu deposit, with the possible exception of metasediment-hosted mineralization, the basic to ultra-basic character of the barren host rocks is likely to render prospective waste rock not susceptible to acid generation in spite of the scarcity of carbonate minerals. Due to pervasive silica and feldspar alteration and the presence of pyrrhotite in the mineralized zones, however, the ore material is likely to be net acid-generating. Whether or not an ore stockpile would generate acid in the temporary storage pad will depend on the pyrrhotite oxidation rate under climatic conditions at the site. To avoid contaminating benign waste rock that can be used for construction purposes, care should be taken to characterize and isolate sulphide-bearing sub-ore material that may be net acid-generating."

Klohn (1996) supplemented the previous ARD testwork with the ABA analysis of 32 samples, using ABA procedures modified from the Coastech Research (1990) method (Modified ABA). The 32 samples included:

- "16 composite chips samples of the portal under construction, including 4 collected by Klohn-Crippen personnel while working on the site (Ulu-KC-1 to 4), 4 previously collected by an EBM-Lupin geologist (Ulu KC-5 to 8), and 8 subsequently collected by an EBM-Lupin geologist from the camp pads (Ulu KC-25 to 32);
- 8 composite pulp samples covering two mineralized zones encountered in diamond drill hole 96UL-20; both the ore material and its immediate wallrock alteration were included (Ulu-KC-9 to 16);
- The fresh interior (KC-Ulu-17) and 1 alteration rind (KC-Ulu-18) of a grab sample collected by an EBM-Lupin geologist from the Ore Zone Surface;
- 6 barren country rocks (3 gabbro, 2 biotite schist, and 1 mafic volcanic rock) samples from drill cores 96-UL-1 to 4 by a mine geologist (Ulu-KC-19 to 24)"

Klohn (1996) drew "... the following conclusions with regard to the acid rock drainage potential of rocks hosting the gold mineralization at Ulu:

1. With few exceptions, most rocks in the Ulu property do not contain any significant carbonate content but mafic silicates may contribute a neutralization potential in the order of 20 kg $CaCO_3$ equivalent/tonne.
2. Regardless of rock type and extent of mineralization, the total sulfur content is the most important parameter determining whether or not a sample is classified as potentially acid-generating (PAG).
3. Because the apparently very slow sulfide oxidation rate occurring at the site, a threshold total sulfur content of 0.9 wt.% and a NPR [Neutralization Potential Ration, or NP/AP] of >1 are recommended as appropriate discriminators to differentiate PAG from non-PAG rocks. [These parameters were revised following kinetic tests as reported in Klohn, 1998, see below.]
4. Both PAG and non-PAG rocks occur in the vicinity of the portal under construction. Care should be taken to isolate sulfide-rich rocks and not use them for construction purposes.
5. Based on the apparent paucity of sulfide-rich material and very slow sulfide-oxidation rate, the waste rock [that had been] used in construction of camp pads from underground is unlikely to be acid generating, especially if the waste rock was well mixed in the process."

Klohn (1996) recommended the following work be undertaken "... to confirm the preliminary ARD assessment based on the results of ABA testing as well as to identify and help avoid potential metal leaching problems:

1. Design and conduct kinetic tests to substantiate (a) the slow sulfide oxidation rate apparently occurring at the site; and (b) the appropriateness of using a

lower than recommended NPR as a PAG discriminator for the site [i.e. an NPR of 1]; as well as elucidate potential metal leaching problems, especially arsenic. [Arsenic was noted as being potentially mobile even under non-acidic conditions.]

2. Involve field geologists in ARD assessment in this case, especially utilize their expertise in mineral identification to avoid employing rocks with more than 2.5% pyrrhotite or 2% pyrite or 4.5% arsenopyrite by volume or their combined equivalents in the construction of the prospective ore pad. [These specific values were selected as equivalent to a threshold value of 0.9% sulphur, consistent with a NPR value of 1. Material identified as sulphide-rich was to be "... stockpiled on a low permeability structure and later capped in-situ or utilized as an ore dilutent in the milling process." Klohn noted that a low permeability structure was to be present for ore stockpiling, and that a neutralization pond was to be available to address low pH leachate, should it occur.]
3. Continue to collect samples for ABA analysis as the project progresses until a database is built up that will allow the identification and application of more readily acquirable surrogate parameters for ARD assessment."

3.2 Kinetic Tests (Klohn, 1998)

On behalf of Echo Bay, Klohn designed and conducted a kinetic test program to investigate the possibility of ARD/ML resulting from stockpiling ore at Ulu prior to its transport by winter-road to Lupin for processing. The test program (Klohn, 1998) involved:

- humidity-cell tests on the coarse fraction (>1.5 mm) of a crushed composite ore sample at both 4°C and 22°C (i.e. room temperature);
- field-column tests on two duplicate samples of the same coarse ore fraction as used in the above tests;
- a humidity-cell test on the <1.5 mm fraction of the same crushed composite ore sample used in the above test at 22°C. This fine fraction accounted for about 16% by weight of the composite sample, and was labeled 'tailings' as it was apparently considered likely to represent the tailings that would be produced by processing the ore through a mill; and,
- humidity-cell tests on a waste rock composite sample at both 4°C and 22°C (i.e. room temperature).

Grain size effects, temperature control of reaction rates and influence of flushing events on leachate chemistry were considered in the interpretation of test results (Klohn, 1998). All samples were described as being "sulphide-rich", and presumably were selected to represent relatively reactive material for the site, although there was no discussion of the kinetic test samples relative to the overall characteristics of the site (See Section 3.1.1 for further discussion).

Klohn (1998) noted significant differences in mineralogy between the ore and waste rock composites, as follows:

> "The ore composite contains more quartz and biotite and less hornblende and plagioclase than the waste rock. Although the total sulfide content of the two composites is similar (i.e. within the error of visual estimates), pyrrhotite and arsenopyrite are the dominant sulphide minerals in the ore composite while pyrite predominates in the waste rock tested. All sulphides are fresh and carbonate is rare in all of the test composites."

The similarity in sulphide content between the ore and waste rock sample, the low carbonate-NP content of all three test materials, and the lack of arsenopyrite in the specific waste rock sample submitted for kinetic testing were supported by the metals and ABA analyses conducted by Klohn on the test samples, as summarized in Tables 1 and 2 below

The analytical data also indicated that similar NPR pre-test values existed in all 3 samples, and that there was virtually no sulphate-sulphur in any of the samples. Also sulphide and arsenic appeared to report preferentially to the fine (tailings) fraction of ore, as compared to the coarse fraction of the ore.

Table 1: Solids Metals Analyses (Klohn, 1998)

Sample	As (ppm)	Ca (%)	Cr (ppm)	Cu (ppm)	Mg (%)	Pb (ppm)	Zn (ppm)
ORE							
pre-test	7780	1.03	38	60	0.68	2	86
post-test @ 4°C	9590	1.06	50	60	0.72	<5	65
post-test @ RT	9870	1.09	60	75	0.75	5	90
WASTE ROCK							
pre-test	556	1.07	59	103	1.16	<2	44
post-test @ 4°C	90	1.07	60	110	1.11	<5	40
post-test @ RT	90	1.04	80	125	1.11	<5	40
TAILINGS							
pre-test	>10000	1.17	47	75	0.75	6	84
post-test @ RT	10670	1.07	50	80	0.72	10	90

Note: RT = room temperature of approx. 22 °C

Table 2: ABA Data (Klohn, 1998)

Sample	Paste pH	% Total S	% S (Sulfate)	AP kg/t	NP kg/t	NNP kg/t	NP/AP (NPR)	Carb-NP kg/t
ORE								
pre-test	8.70	1.14	<0.01	35	32	-3	0.9	6
post-test @ 4°C	9.21	1.14	<0.01	35	31	-4	0.9	5
post-test @ RT	8.97	1.22	<0.01	38	25	-13	0.7	5
WASTE ROCK								
pre-test	9.32	1.17	<0.01	36	28	-8	0.8	4
post-test @ 4°C	9.31	1.19	<0.01	37	28	-9	0.8	6
post-test @ RT	9.16	1.17	<0.01	36	25	-11	0.7	4
TAILINGS								
pre-test	8.12	1.63	<0.01	51	49	-2	1.0	9
post-test @ RT	8.56	1.55	<0.01	48	45	-3	0.9	8

Notes: AP = Acid Potential in kg $CaCO_3$/tonne
NP = Neutralization Potential in kg $CaCO_3$/tonne
NNP = Net Neutralization Potential in kg $CaCO_3$/tonne = NP – AP
Carb-NP = Carbonate NP in kg $CaCO_3$/tonne, calculated from carbonate analysis

The two ore, two waste rock and one tailings humidity cells were run for either 40 or 41 weeks. The two field column tests were run for one complete cycle of changing seasons, yielding three data points. Results as reported in Klohn (1998) are summarized below.

3.2.1 Summary of Coarse Ore Kinetic Test Results

Table 3 compares the results of weathering of Ulu ore under different conditions, as provided in Klohn, 1998:

Table 3: Results of Weathering of Ulu Ore under Different Conditions
(from Klohn, 1998)

	Cell @ $4^{o}C$	Cell @ $22^{o}C$	Field Column #1	Field Column #2
S depletion rate (mM/kg/week)	0.012	0.052	0.004	0.004
NP depletion rate (mM $CaCO_3$/kg/week)	0.060	0.116	Not calculated due to remnant salt	
Time for S depletion (years)	563	132	1707	1726
Time for total NP depletion (years)	102	53	Not calculated	
As loading rate (mg/kg/week)	0.01 to 0.063 decreasing with time	0.01 to 0.153 decreasing with time	0.001 to 0.004	0.001 to 0.003
Zn loading rate (mg/kg/week)	0.01 to 0.0961 erratic	0.0006 to 0.1061 erratic	0.0002 to 0.0009	0.0002 to 0.0004

Klohn, 1998 stated that "the sulphide-sulphur depletion rate for the humidity cells was calculated based on the average sulfate release rate measured between weeks 10 and 30 and since the sulphate production rates appear to slowly decrease with time this may have resulted in an underestimate of the time to deplete all sulphides. For the field columns, the sulphide sulphur depletion rate was obtained by dividing the cumulative sulphate release rate by 52 weeks. The NP depletion rate was calculated from the total weekly release, on a molar basis, of Ca+Mg+0.5Na+0.5K." It was noted that salt water had been used as a drilling fluid which apparently contaminated the ore sample (Klohn, 1998). For the humidity cell, the NP depletion rates were measured from weeks 10 to 30 when all the remnant salts had been leached, however, the field columns still contained remnant salts, therefore NP depletion rates could not be calculated.

Both humidity cell tests, at $4^{o}C$ and $22^{o}C$, suggested that the coarse ore sample would eventually become acidic, with NP being depleted prior to sulphide, although the lag times for these samples to produce acidic drainage were estimated to be lengthy (50 to 100 years).

Metal loading or leaching rates from the coarse ore were noted as being much lower in the field tests as compared to the humidity cell tests. This was attributed to the lower average reaction temperature and the lower frequency of flushing events under field conditions. Arsenic and zinc loading rates were highlighted.

3.2.2 Summary of Fine Ore Kinetic Test Results

Table 4 shows the results of humidity cell testing of prospective Ulu tailings (fine-grained portion <1.5 mm fraction of bulk ore composite) at 22 ^{O}C as presented in Klohn, 1998:

Table 4: Results of Weathering of Prospective Ulu Tailings (Fine-Grained Ore) at Room Temperature (Klohn, 1998)

	Cell @ 22^{O}C
S depletion rate (mM/kg/week)	0.119
NP depletion rate (mM $CaCO_3$/kg/week)	0.305
Time for S depletion (years)	82
Time for total NP depletion (years)	31
As loading rate (mg/kg/wk)	0.28 – 0.61 (decreases slightly)
Zn loading rate (mg/kg/wk)	0.001 – 0.209 (erratic)

The following summary of the results of weathering of Ulu tailings at room temperature were extracted from Klohn 1998:

> "Compared to the weathering of Ulu ore under the same conditions, the sulfate depletion rate is twice as fast and the NP depletion rate nearly three times faster. Thus even though the tailings contains more sulfides and has a higher NP than the Ulu ore, it takes less time for the tailings to exhaust its sulphide content and NP than the coarser-grained ore. It is estimated that net acid generation will occur in about 30 years if the tailings is subjected to weathering at room temperature. The calculated As loading rates are at least four times higher than those calculated for the Ulu ore while the erratic Zn release rates are only two times higher. Evidently, grain size plays a significant role in mineral weathering and associated metal leaching."

3.2.3 Summary of Waste Rock Kinetic Test Results

Table 5 compares the results of weathering of Ulu waste rock under different conditions (from Klohn, 1998):

Table 5: Comparison of the Results of Weathering of Ulu Waste Rock Under Different Conditions (Klohn, 1998)

	Cell @ 4°C	Cell @ 22°C
S depletion rate (mM/kg/week)	0.010	0.044
NP depletion rate (mM $CaCO_3$/kg/week)	0.079	0.087
Time for S depletion (years)	698	159
Time for total NP depletion (years)	68	62

No significant release of trace elements was detected in the waste rock leachates (Klohn, 1998). Klohn (1998) states that "similar to what has been observed in the weathering of Ulu ore samples, temperature does not greatly affect the NP depletion rate but the sulphide-S depletion rate at room temperature is four times as high as that obtained at 4°C. On a molar basis, NP depletion proceeds faster than sulfide oxidation under both temperature conditions. Thus, although the waste rock composite has a NPR of about 1, sustained weathering will eventually lead to net acid generation. This will occur in about 60 years with weathering at room temperature and about 70 years at 4°C."

3.2.4 Conclusions from Kinetic Test Results

The following conclusions arising from the kinetic tests was taken from Klohn, 1998:

> "From the weathering of the Ulu composites [in humidity cells] under different settings, it is evident that temperature affects the rate of sulfide oxidation more than that of the depletion of neutralization potential (NP) in a sample. Since NP depletion has invariably occurred faster than sulfide oxidation, only materials with a neutralization potential ratio (NPR) of greater than 3 will not lead to net acid generation with prolonged weathering at 22°C. Under colder conditions, the NPR required to eliminate the possibility of ARD can be as high as 7. However, in the latter case, the amount of acid released on an annual basis is so low that it should not cause any significant impact.
>
> A lower average reaction temperature and a lower frequency of flushing events account for the relatively low sulfide oxidation and metal leaching rates observed with the field-column testing of the Ulu ore compared to the humidity cell testing results. Metal leaching with the Ulu waste rock is largely insignificant but variable amounts of As and Zn can be leached from the Ulu ore depending on the grain size of the test sample, the ambient temperature for reaction and the frequency of flushing. Based on the kinetic test results, it is estimated that stockpiling of coarse ore at the Ulu site up to 50 years will not lead to net acid generation or intense metal leaching. To avoid unnecessary metal leaching problems, however, it is

recommended that ore temporarily stockpiled at the Ulu site should not be pulverized to less than 1.5 mm in diameter."

Recommendations for further work included:

- Extension of the field test program for another two years, since insufficient data was collected from the field columns to establish long-term trends.
- That additional samples be collected from the deeper parts of the deposit for testing (including kinetic tests), as testing had been limited to samples collected from the shallow parts of the Ulu deposit.

3.3 Discussion of Previous ARD Assessments

3.3.1 Representativeness of Kinetic Test Samples

MEMI reviewed the Klohn 1996 static test database to compare ore and waste rock characteristics to the materials selected for the humidity cell and field column tests discussed above. The 1996 database contained 10 samples described as ore or as being from a mineralized zone, and 37 samples that could be classified as waste rock. The range and average of these materials are shown on Table 6. Humidity cell sample characteristics are also shown in Table 6, and in more detail on Table 2.

Table 6 indicates that the total sulphur content of the coarse ore sample used in the kinetic tests was higher than the mean of the 10 samples from the ore or mineralized zone database. This confirms Klohn's 1998 contention that the humidity cell test samples can be considered 'high sulphide' samples, although several individual ore samples displayed higher sulphide content. As well as displaying higher sulphur content, the coarse ore sample also displayed slightly higher NP than the mean of the 10 ore samples in the database. The NNP result of -3 kg/t and NPR of 0.9 for the ore sample was the same or similar to the mean result of -3 kg/t NNP and 0.8 NPR for the 10 ore and mineralized zone samples in the database.

The fine ore or tailings sample also displayed similar NNP and NPR values. However, the sulphur content was at the higher end of the ore database range, at 1.63%, and the NP was greater than the ore database range, at 49 kg/t.

Given the characteristics of the coarse ore and fine ore or tailings samples, the humidity cell and field tests are likely to provide reasonable worst case results, rather than average or expected results.

The waste rock composite used in the kinetic tests had a total sulphur content of 1.17% which was significantly higher than the mean of 0.68% for 37 waste rock sample results presented in Klohn 1996. This again confirmed Klohn's 1998 contention that the humidity cell test samples can be considered 'high sulphide' samples, although several individual waste rock samples displayed higher sulphide content. The NP of the waste rock composite was nearly identical to the mean NP from the waste rock database, although individual samples displayed lower NP values. The NPR for the waste rock composite was 0.8, slightly lower than the database mean of 1.3. Thus the results from the humidity cell tests on the selected waste rock sample are likely to represent reasonable worst case results, rather than average or expected results. However, the range in NPR results of 0.1 to 137 for the 37 waste rock samples indicates the waste rock characteristics are highly variable.

Table 6: Summary of Ore and Waste Rock Static Test Database and Kinetic Test Samples

Sample	% Total S	AP kg/t	NP kg/t	NNP kg/t	NP/AP (NPR)
ORE or MINERALIZED ZONE					
1996 Database					
Min / max	0.15 to 2.24	5 to 70	16 to 33	-40 to 25	0.1 to 137
Mean	0.94	29	26	-3	0.8
Humidity Cell Ore pre-test	1.14	35	32	-3	0.9
Humidity Cell Tailings pre-test	1.63	51	49	-2	1.0
WASTE ROCK					
1996 Database					
Min / max	0.01 to 3.91	0.3 to 122	10.4 to 85	-109 to 78	0.1 to 137
Mean	0.68	21	27	6	1.3
Humidity Cell Waste Rock pre-test	1.17	36	28	-8	0.8

As no metals data were available for the sample suite presented in Klohn 1996, metal content, in particular arsenic content, could not be compared. Therefore it is not clear whether the low arsenic content of the waste rock composite of 556 ppm (Table 1) is consistent throughout the waste rock materials.

Greater clarity of the potential quantity of waste rock that might contain elevated metal levels may be determined by review of the 7305 ICP's mentioned in the BHP geology report (1993).

3.3.2 Humidity Cell Reaction Rates

Comparison to results from other kinetic humidity cells from the International Kinetic Database (Morin, 1999) are shown in Figure 1, and indicate that both the NP and sulphate depletion rates for the ore, waste rock, and fine grained ore are comparatively low.

3.3.3 Threshold NPR Values

MEMI attempted to determine the source of Klohn's selected NPR thresholds for eventual acidic drainage of 3 at 22°C and 7 under colder conditions. Table 7 provides ratios of Klohn's reported NP depletion rates and S depletion rates for the various humidity cell tests, which can typically be used to calculate the threshold NPR values for material that will not lead to net acid generation with prolonged weathering under the specific test conditions (Morin and Hutt, 1997).

Table 7: Comparison of NP and S Depletion Rate Ratios

	Ore	Waste Rock	Tailings
Cell @ 4°C	5.0	7.9	
Cell @ 22°C	2.2	2.0	2.6

As Table 7 indicates, Klohn's threshold NPR values of 3 and 7 for site materials under the two temperature conditions could not be exactly duplicated. However the above values appear to be reasonably close. Given the calculated values in Table 7, it appears that Klohn's selected threshold NPR value of 3 for materials at 22°C may be slightly conservative.

Klohn's selected threshold values based on humidity cell results are also considered by MEMI to be conservative relative to actual field conditions. This is because NP depletion can depend on the rate of flushing, i.e. the amount water moving through the humidity cell or field column. Since buffering minerals tend to be soluble in water, more so than sulphides, greater flows can mean greater dissolution of buffering minerals, beyond that need to neutralize acidity produced by sulphide oxidation, particularly where sulphide oxidation rates are low, as at Ulu. The relatively large volumes of water used in a humidity cell test (as compared to field conditions) can result in an overestimation of field NP depletion rates and an overestimation of the NPR threshold for eventual generation of acidic drainage in the field. Thus Klohn's selected threshold values of 3 and 7 for materials at 4°C and 22°C are likely conservative for field conditions, where flushing rates are lower through most of the year.

3.3.4 ARD Potential by Rock Type

MEMI also reviewed the existing database to assess the influence of rock type on ARD potential as defined by Klohn's selected NPR threshold value of 3 for 22 $^{\circ}C$. MEMI tabulated the 15 samples from the 1990 testwork performed as part of the environmental overview by Rescan and reported in "Ulu Project, Northwest Territories, Environmental Overview" dated December 1991 numbered ARD-1 to ARD-15 and the 32 samples from the 1996 testwork performed by Klohn and reported in "Echo Bay Mines Ltd. – Lupin Operation, Ulu Project, Preliminary Assessment of Acid Rock Drainage Potential" dated October 1996 numbered Ulu KC-1 to Ulu KC-32, by rock type if a description was provided. The generalized rock types or units were: 1) Intrusive – gabbro and diabase, 2) volcanics, 3) greywacke and biotite schist, 4) basalt/porphyry/band tuff, 5) mineralized zone, and 6) other – unspecified. The ABA data by rock type is provided in Table 8, located at the end of the text of this report.

As only % total sulphur was available for the 1990 samples and since sulphate-sulphur was negligible in the 1996 samples, MEMI calculated acid potential (AP) in kg $CaCO_3$/tonne by multiplying total sulphur % by 31.25. The neutralization potential (NP) for the 15 1990 samples was originally presented in kg H_2SO_4/tonne, therefore MEMI converted the NP to kg $CaCO_3$/tonne by dividing the NP presented by 30.625 and multiplying by 31.25. Upon making these changes to the 1990 samples, discrepancies were noted in some of the reported AP's, which would affect both calculated NNP and NPR values. MEMI makes no claims as to accuracy of the numbers presented in Table 8, as MEMI has used the % total sulphur and NP's presented in the Klohn 1996 report. If the % total sulphur or the NP's presented in Klohn (1996) are incorrect, then Table 8 in this report is also incorrect. It was assumed that all ABA analyses were conducted in a similar manner, although the actual method used to develop the 1990 data was not identified.

The database indicated the following trends by rock type, as compared to Klohn's NPR threshold criteria of 3:

- Seven samples were classified as gabbro/diabase. The total sulphur content for this group ranged from 0.02% to 0.29%. Only two samples had an NPR of less than 3 (2.5 and 2.9), with a mean NP/mean AP ratio for the seven samples of 5.7. Therefore, gabbro and diabase waste rock can be classified as likely not potentially acid generating (NPAG).
- The two mafic volcanic samples with a total sulphur content of 0.74% and 0.93% and NPR's of 1.5 and 0.6, respectively, would be classified as potentially acid generating (PAG).
- Of the two greywacke samples, one had a total sulphur content of 0.25% and an NPR of 2. The other sample had a total sulphur content of 0.17% and an NPR of 3.8. While 50% of greywacke samples would be classified as PAG and 50%

would be classified as NPAG, the differences between the samples are small, such that one might conservatively assume all greywacke to be PAG.

- The two biotite schist samples with NPR's of 6.4 and 9.6 would be classified as NPAG.
- The total sulphur content of the seventeen samples of basalt/porphyry/band tuff ranged from 0.01% to 1.49%, and the NPR of these samples ranged from 0.5 to 137, indicating a high variability in sample mineralogy. Due to the high variability, and a mean NP/ mean AP ratio of 2.7, all basalt samples might conservatively be classified as PAG. It should be noted that 6 of the 17 samples were collected from the camp pads and the NPR's of these 6 samples ranged from 0.5 to 2.4 which would indicate that at least some of the material used for camp pads construction would be classified as PAG on the basis of Klohn's revised threshold NPR criteria of 3.
- Ten samples from the mineralized zone produced total sulphur contents ranging from 0.15% to 2.24%, with a mean NP/mean AP ratio of 0.9. Therefore all mineralized or altered rock should be considered as PAG.
- The other unspecified samples were mainly from the portal area. Total sulphur ranged from 0.2% to 3.91% with a mean of 2.2%. The mean NP/mean AP ratio was 0.3. These materials would be considered as PAG.

In summary, based on the ABA database compiled to date, and a threshold NPR of 3 for separating PAG and NPAG material, gabbro and diabase material for the most part are likely to be NPAG, greywacke may be PAG or NPAG depending on the sulphur content, mafic volcanics are likely to be PAG, basalt material is highly variable but generally PAG and all ore and altered material are PAG. Note that the database is dominated by surface samples, and deeper materials may not maintain the indicated trends. Also note that the samples may have been biased to those containing visible sulphides.

3.3.5 Identification of PAG material

Based on preliminary work, Klohn (1996) indicated that % total sulphur was the critical parameter in determining acid generating potential, and proposed a cutoff of 0.9% total sulphur to identify potentially PAG material assuming a threshold NPR criteria of 1. Klohn noted that the selection of such a lower than typical threshold NPR criteria would require confirmation using kinetic tests. Subsequent kinetic testwork conducted by Klohn (1998) did not support the use of an NPR threshold criteria of 1. Klohn (1998) concluded that "... only materials with a neutralization potential ratio (NPR) of greater than 3 will not lead to net acid generation with prolonged weathering at 22^{o}C. Under colder conditions, the NPR required to eliminate the possibility of ARD can be as high as 7. However, in the latter case, the amount of acid released on an annual basis is so low that it should not cause any significant impact."

The increase in Klohn's threshold NPR values for PAG material was carried forward by MEMI in a similar manner conducted by Klohn in 1996. Total Sulphur was graphed versus NPR from the ABA database (Table 8) to show the % total sulphur "cut-off" consistent with threshold NPR values of 3 and 7 (Figure 20).

As Figure 20 indicates, all but one sample with an NPR of less than 3 had a total sulphur greater than 0.2%. The one exception (ARD-10) was described (Table 8) as a fresh gabbro from 171 m to 172.06 m along the drillhole 90VD66. This sample contained 0.13% total sulphur content and reported an NPR of 2.5.

Thus a total sulphur cutoff of 0.2% appears to be consistent with the threshold NPR criteria of 3 identified by Klohn (1998) for material that will not lead to prolonged weathering at 22°C. Even materials below this threshold may not generate acidic drainage for decades, as indicated by the field column tests on coarse ore samples with an NPR of approximately 1.

4.0 EXTENDED FIELD COLUMN TEST

As recommended by Klohn (1998), the field column testing program was continued beyond 1998. Leachate collection was undertaken by Echo Bay staff, and results were provided to MEMI for inclusion in this report.

4.1 Field Column Setup

As described by Klohn (1998), the field setup consisted of two field columns each containing a 15-kg subsample of the coarse ore composite. The field columns were installed in an open area near the termination of the winter road at Lupin. Each field column consisted of two staggered 18-L plastic pails. The upper pail with a perforated bottom contained the 15-kg test sample and the lower pail served as a leachate collector. The system was held upright in a slot in a broad-base wood frame made up of two pallets tied together with iron wire.

4.2 Column Maintenance and Leachate Collection

As described by Klohn (1998), the physical integrity of the field columns was to be inspected monthly during the dry season and during each sampling event in the wet season. Either pail could be replaced if serious disintegration was observed, and replacement pail(s) were to be thoroughly cleaned prior to being used. Each inspection was also to ensure that the field columns were well supported in the wood-frame base such that they would not topple over in a strong wind.

Leachate collection was to be conducted weekly in each column, as soon as spring freshet began, although collection was dependent on precipitation – a minimum of 200 ml filtrate was required for chemical analysis. The collection method was to follow the steps given below (Klohn, 1998):

1. Pull out the waste rock (upper) container in the column assembly and sit it on a clean plastic sheet.
2. Decant the leachate in the collector (lower) pail into a clean, plastic sampling container; measure its volume, pH, conductivity and temperature; filter it through a 0.45 µm cellulose acetate filter, ship a subsample (minimum 200 ml, preferably 500 ml) together with a data record sheet to Klohn (Calgary).
3. With a rubber policeman or spatula and using a minimum amount of water (<20 ml), return all the fine solids collected in the lower pail and filter paper to the upper pail.
4. Re-assemble the column system and put it back in the wood-frame support.

4.3 1998 – 2002 Monitoring and Sampling

Echo Bay field staff monitored and sampled the field columns at least three times over each summer season (June to September) from 1998 to 2002. The following parameters were measured in the field at time of sample collection: volume of water, pH, conductivity, and air temperature. The samples were not filtered in the field, however on June 6, 1998 "sharkskin" filter paper was placed in the bottom of the sample columns to hold in the solids. The leachate samples collected were sent to Norwest Labs of Edmonton, Alberta, for analysis of total metals and dissolved sulphate. Of note, the samples collected from 1998 to 2000 were not analyzed until November 2000. This resulted in the 1998 and 1999 samples being analysed well past the recommended holding time of 6 months for metals and the 1998, 1999 and 2000 samples being analysed past the recommended holding time of 28 days for sulphates.

4.4 Field Column Results

The analytical data for the two field columns containing the coarse ore composite sample are provided on Tables 9 and 10 (located at the end of the text). These tables include the three data points from 1997 reported in Klohn 1998, as well as the Echo Bay data provided through to the end of 2002. Volumes of sample leachate collected in 2002 were not provided, such that calculated leach rates and the cumulative leach rates are presented only to the end of 2001. Figures 2 through 7 show the concentrations, release rates and cumulative released load trends over time for various parameters for both Field Columns 1 and 2, in a manner similar to Klohn (1996). Graphs of individual parameters (concentrations and loadings) versus time are shown on Figures 2 though 15.

Field columns differ from humidity cells in that flushing rates are low, such that all oxidation products may not be removed in the leachate. Oxidation products, such as sulphate and soluble metal salts, may remain in the field column, building up an increasing store of salts over time that become available for dissolution in subsequent flushing events. Thus, while the concentrations in the field column tests may more closely reflect actual dump leachate quality than humidity cell test concentrations, field column leaching rates may not reflect internal oxidation or reaction rates, and estimates or extrapolations using these values should be viewed with caution. As noted by Klohn (1998), the actual concentrations and released loading rates from the field columns are influenced by temperatures, and the frequency and volume of flushing.

As indicated on Table 9 and 10, and Figures 2, 5 and 8, pH was neutral to slightly alkaline in the leachate collected from both columns. Values ranged from 6.9 to 7.9 for leachate collected from Field Column #1 and from 6.7 to 8.0 for Field Column #2. Although erratic, the pH showed a slightly downward trend over the period 1997 to 2001 in both columns.

Dissolved sulphate concentrations generally increased over the period and ranged from 74 mg/l to 665 mg/l in leachate collected from Field Column #1 and 74 mg/l to 480 mg/l in leachate collected from Field Column #2 (Figure 2, 5 and 9). No particular trend was seen for timing of seasonally high sulphate concentrations, although concentration highs may be occurring more frequently during the early spring/summer sampling events. Arsenic concentrations ranged from 0.17 mg/l to 1.74 mg/l in leachate collected from Column #1 and 0.11 mg/l to 0.97 mg/l in leachate collected from Column #2, both with slightly increasing trends, Column #1 more obviously so (Figures 2, 5 and 10). Zinc concentrations (Figures 2, 5 and 11) were erratic, especially in Column #1. Values ranged from 0.013 mg/L to 0.332 mg/l in Column #1, and 0.009 mg/l to 0.044 in Column #2. No specific trends were apparent, although Column #2 zinc concentrations may be slowly decreasing.

Similar to the sulphate concentrations, the calculated sulphate release rates (i.e. loads) generally showed an increasing trend for both field columns. The graphs (Figures 3, 6 and 12) indicate reduced release rates for the first sampling event of each year, suggesting a decrease in the sulphide oxidation rate during the winter season, consistent with lower winter temperatures. Over the entire period the sulphate release rates varied from 0.004 mM/kg/wk to 0.129 mM/kg/wk in Field Column #1 and 0.003 mM/kg/wk to 0.176 mM/kg/wk in Field Column #2.

The NP release rates from the field columns were estimated from released moles of Ca + Mg + .5Na + .5K, the protocol used by Klohn (1998). Klohn (1998) found that the 1997 NP release rates appeared to be influenced by absorbed salt in the columns due to the use of salt water as a drilling fluid, such that no actual values were presented in their report. Results from the sampling event in June 1998 (Column #1) also appeared to be influenced by absorbed salt (i.e. contained elevated Ca and Na concentrations). However results from the sampling event in July 1998 in both columns showed a significant drop in Ca and Na concentrations, and the start of an overall generally increasing trend in the NP release rates, suggesting that the salt influence became minor at that point.

The arsenic release rates, although fairly low and erratic, showed an increasing trend (Figures 3 and 14). Values ranged from 0.0004 mg/kg/wk to 0.016 mg/kg/wk for Column #1 and 0.0002 mg/kg/wk to 0.026 mg/kg/wk for Column #2. Arsenic release rates appeared to increase at the later part of each season's sampling events. Zinc release rates were very low and also showed an increasing trend, particularly in Column #1 (Figures 3 and 15). Values ranged from 0.00005 mg/kg/wk to 0.0025 mg/kg/wk for Column #1 and 0.00003 mg/kg/wk to 0.0008 mg/kg/wk for Column #2. Zinc release rates were more erratic and did not appear to show significant seasonal trends.

Following the protocols in Klohn (1998), the S and NP depletion rates were calculated to estimate the time required for total S and NP depletion. The S depletion rates were calculated for the period from January 1997 to September 2001 (i.e. from the total cumulative leach rates over the entire test period) and the NP depletion rates were calculated from cumulated leach rates for the period from August 1998 (when all the remnant salts appeared to have been released) to September 2001. These rates, along with the arsenic and zinc loading rates, are shown on Table 11 along with the values provided by Klohn from the 1997 data.

The estimated years to depletion are not necessarily valid for field columns, where sulphate and ions considered representative of neutralizing reactions may not be completely flushed from the columns because of the limited precipitation. Although leachate from the field column tests is considered unlikely to represent internal reaction rates, the sulphur depletion and NP depletion rates can be manipulated in a manner similar to humidity cell results to suggest neutralization potential ratios (NPR) for materials that would likely not lead to net acid generation with prolonged weathering. Manipulation of the field column data suggests such threshold NPR values may be in the order of 1.3 for Column #1 and 2.0 for Column #2.

As shown in Table 11, the expanded collection of data from the field columns shows some differing results compared to those found on the basis of the first three sampling events by Klohn (1998). Most significantly, the longer-term sulphate release rates for Column #1 and Column #2 are 5.5 and 3.75 times higher, respectively, than those rates calculated from the 1997 data. This may be due to more rapid oxidation of sulphides, but may also be due increasing quantities of sulphate salts being stored in the field columns and becoming available for flushing as the test proceeded. Assuming the influence of salt contamination is minor, and that sulphur and NP depletion rates continue in a similar manner and reflect actual reaction rates, the estimated times for depletion suggest that these columns would eventually produce acidic drainage, but only after more than 200 years.

It is considered possible that sulphur release rates would continue to accelerate as increasing quantities of sulphate salts are stored in the field columns and become available for flushing. This means that the predicted lag times to onset of acidic drainage may continue to decrease as the field column matures. However, comparisons with humidity cell results (section 4.5) suggests that the sulphate release rates may be predominantly controlled by site temperatures and that the longer-term rates from the field columns are appropriate for expected site temperatures.

Table 11: Comparison of Field Column Rates

	1997 (Klohn, 1998)		1997 - 2001	
	Field Column #1	Field Column #2	Field Column #1	Field Column #2
S depletion rate (mM/kg/week)	0.004	0.004	0.022	0.015
NP depletion rate (mM $CaCO_3$/kg/week)	Not calculated due to remnant salt		0.029	0.03
Threshold NPR	N/A	N/A	1.3	2.0
Time for S depletion (years)	1707	1726	310	450
Time for total NP depletion (years)	Not calculated		211	207
As loading rate (mg/kg/week)	0.001 – 0.004	0.001 – 0.003	0.0004 – 0.016 increasing	0.0002 – 0.026 slightly increasing
Zn loading rate (mg/kg/wk)	0.0002 – 0.0009	0.0002 – 0.0004	0.00005 – 0.0025 increasing	0.02 - 0.0008 slightly increasing
SO4 conc. (mg/l) mean	84 – 240 172	88 – 209 149	74 – 665 270	74 – 480 269
As conc. (mg/l) mean	0.25 - 0.40 0.32	0.20 – 0.45 0.30	0.17 – 1.74 0.47	0.11 – 0.97 0.33
Zn conc. (mg/l) mean	0.05 – 0.16 0.09	0.01 – 0.04 0.03	0.0132 – 0.332 0.069	0.009 – 0.0439 0.023

The longer-term results also show wider ranges in arsenic and zinc release rates, and substantially increased maximum rates. The release rates for both metals appear to be increasing over time, possibly reflecting increases in actual reaction rates, but more likely as a result of greater quantities of retained salts in the field columns being available for flushing as the test proceeds. It is expected that these metals leaching rates may continue to increase as the field column matures.

The wider ranges and generally increasing release rates are reflected in the wider range and generally increasing sulphate, arsenic and zinc concentrations, also shown in Table

11. Actual arsenic concentrations exiting the field columns occasionally exceed the federal *Metal Mining Effluent Regulations* maximum allowable values (i.e. a maximum of 1 mg/l total arsenic, monthly average of 0.5 mg/l total arsenic). These field columns contain only the coarse fraction (> 1.5 mm) of the composite ore sample. Inclusion of the fine 'tailings' fraction would be expected to further increase these concentrations.

4.5 Comparison with Humidity Cells

The results from the extended field column tests on the coarse ore composite are compared to results from humidity cells tests on the same coarse ore composite sample at 4 ^{O}C and 22 ^{O}C on Table 12. Results from the humidity cells conducted on the fine fraction of the ore ('tailings') at 22 ^{O}C, and on waste rock at 4 ^{O}C and 22 ^{O}C are also shown.

The results indicate that the sulphur release rate for the field columns calculated for the full field test program fell within the range in the humidity cell rates generated on the same material at 4 ^{O}C, and 22 ^{O}C. The average sulphur release rate for the field columns was 0.0185 mM/kg/wk, which was approximately 1.5 times higher than the coarse ore cell at 4 ^{O}C and 0.36 times the rate at 22 ^{O}C. This is consistent with the site climate, described as "experiencing very cool summers, with January temperatures often below –30^{O}C "(Rescan, 1991). Site temperatures are therefore likely to be closer to 4 ^{O}C than 22^{O}C for most of the year. The sulphur release rate for the field columns also fell between rates estimated for waste rock with similar sulphide content tested in humidity cells at 4 ^{O}C and 22 ^{O}C. These results suggest that the sulphide oxidation rates for the Ulu materials are primarily influenced by temperature and grain size, rather than other test variables such as flushing rate or volume.

This conclusion differs from those made by Klohn (1998) based on the early field column results. Early results indicated "...much lower sulphide oxidation rate compared to controlled weathering in the laboratory..." attributed to the dual effects of an overall lower mean temperature and less frequent flushing in the field.

The NP depletion rates for the field columns were lower than NP depletion rates for the same material tested in humidity cells at 4 ^{O}C and 22 ^{O}C. The field column rate of 0.03 mM $CaCO_3$/kg/week was about half the NP depletion rate of the ore humidity cell at 4 ^{O}C, and about 25% of the NP depletion rate of the ore humidity cell at 22 ^{O}C. This suggests that the reduced volume and frequency of flushing in the field columns had a significant effect in reducing NP depletion rates as compared to humidity cell results, while having essentially no effect on sulphur depletion rates.

Table 12: Comparison of the Results of Weathering of Ulu Ore and Waste Rock under Different Conditions

	Ore					Waste Rock	
	Field Column #1	Field Column #2	Cell @ 4°C	Cell @ 22°C	Tailings Cell 22°C	Cell @ 4°C	Cell @ 22°C
S depletion rate (mM/kg/week)	0.022	0.015	0.012	0.052	0.119	0.010	0.044
NP depletion rate (mM $CaCO_3$/kg/week)	0.029	0.03	0.060	0.116	0.305	0.079	0.087
Threshold NPR	1.3	2.0	5.0	2.2	2.6	7.9	2.0
Time for S depletion (years)	310	450	563	132	82	698	159
Time for total NP depletion (years)	211	207	102	53	31	68	62
As loading rate (mg/kg/week)	0.0004 to 0.016 increasing	0.0002 to 0.026 slightly increasing	0.02to 0.063 decreases with time	0.02 to 0.153 decreases with time	0.28 to 0.61 decreases slightly		
Zn loading rate (mg/kg/week)	0.00005 to 0.0025 increasing	0.0008 to 0.04 increasing	0.03 to 0.0961 erratic	0.0006 to 0.1061 erratic	0.001 to 0.209 erratic		
SO4 conc. (mg/l) range/mean	74 to 665 270	74 to 480 269	3.3 to 26 7	10 to145 25	28 to- 857 78	0.7 to 18 7	13 to 69 25
As conc. (mg/l) range/mean	0.17 to 1.74 0.47	0.11 to 0.97 0.33	0.05 to 0.25 0.10	0.05 to 0.6 0.22	0.35 to 2.5 1.7	0.05 to.05 0.05	0.05 to.05 0.05
Zn conc. (mg/l) 1 range/mean	0.0132 to 0.332 0.069	0.009 to 0.0439 0.023	0.01 to 0.38 0.046	0.01 to 0.43 0.07	0.01 to 0.84 0.12	0.01 to 23 0.88	0.01 to 0.67 0.06

Note 1: The maximum Zn concentration for waste rock at 4° C of 23 mg/l occurred only on cycle 17 and may be a lab error. The next highest value was 0.13 mg/l.

As noted previously, S and NP release rates from the column are not necessarily representative of the internal reaction rates, as all oxidation and neutralization products may not be flushed from the field column between each sampling event. Thus threshold NPR values estimated from field column results should be viewed with caution. The calculated values of 1.3 and 2.0 are similar to the threshold NPR value of 2.2 estimated from the humidity cell on the same material at 22 °C, and much lower than the threshold NPR value of 5.0 calculated from the humidity cell on the same material at 4 °C. This suggests that threshold NPR values to avoid the onset of acid generation proposed by Klohn (1998) may be conservative, due to the substantially lower NP depletion rates resulting from less frequent flushing under field conditions as compared to humidity cell test conditions. Specifically, Klohn's suggested threshold values of 3 based on humidity cell tests at 22 °C on waste rock, coarse and fine ore; and 7 based on humidity cell test at 4 °C appear to be conservative given temperature and flushing conditions at the site, but longer term testing under site field conditions and/or dismantling and flushing of the field columns would be required to confirm this.

The NP production rates to sulphate production rates for all sampling events on all tests conducted on the coarse ore composite sample are shown on Figure 16. NP to sulphate production ratios of 1 and 3 are indicated on the graph. The figure indicates that the ratios between NP and sulphur production rates for the field columns lay between 1 and 3, and were generally closer to 1 than to 3. This may indicate that NP depletion in the field is controlled more by acid neutralization than by NP solubility, which appears to influence humidity cell results. Coarse ore tested in the humidity cell at 22 °C generally showed a slightly higher ratio, and at 4 °C generally had a NP to sulphate production ratio of greater than 3. The graph also shows that the field tests typically provided lower NP production rates compared to the humidity cell tests, but not lower sulphate production rates.

Figure 17 is similar to Figure 16 except that the results for the fine ore (tailings) cell and waste rock cells are also included within the limited axes. The field test columns produced the lowest NP to sulphate production rate ratios. Ratios were typically highest for coarse ore and waste rock cells at 4 °C, closely followed by the fine-grained ore (tailings) at 22 °C. The tailings cell produced the highest NP and sulphate production rate values. Ratios for the ore and waste rock cells at 22 °C were higher than the field column test, but not as high as the other tests.

The field columns were consistent with the humidity cell tests in that all tests on the coarse ore sample indicated that NP would be depleted prior to sulphide, such that the material would eventually produce acidic drainage. The projected time for acid generation from the field columns was substantially longer, primarily due to the apparent slower loss of NP from reduced flushing under field conditions.

As shown on Table 12, arsenic and zinc release or loading rates were substantially lower (1 to 3 orders of magnitude) from the field columns as compared to the humidity cells conducted on the coarse ore composite sample. The field release rates appear to be increasing over time, whereas release rates from the humidity cells appeared to be decreasing over time. The increasing rates in the field cells may indicate that the field cells are immature, i.e. the leach rates will continue to increase as oxidation products store up in the column, and become available for later flush events.

Comparative arsenic production rates are also shown on Figure 18. Figure 19 includes arsenic production rates for the waste rock and fine ore tailings tests, and indicates that substantially higher arsenic rates produced by the fine ore fraction.

Despite the lower arsenic and zinc loading rates demonstrated by the field columns, concentrations are elevated compared to humidity cell concentrations. Table 12 indicates that average arsenic concentrations from the field columns of 0.33 and 0.47 mg/l were 2 to 4 times higher than average concentrations produced from the humidity cell tests on the same coarse ore material. This may be a result of the reduced flushing rate in the field. Maximum concentrations released from the field columns (1.74 and 0.97 mg/l respectively) approached the average concentrations produced from the fine ore test cell at 22 ^{O}C. These concentrations may be of concern as they occasionally exceed the federal *Metal Mining Effluent Regulations* maximum allowable values (i.e. a maximum of 1 mg/l total arsenic, monthly average of 0.5 mg/l total arsenic).

As indicated on Table 12, average zinc concentrations released from the field columns were similar to, or slightly lower than, those released from the humidity cell tests on the same coarse ore sample.

4.6 Conclusions from Review of Field Column Data

Review of the extended field column test results on duplicate coarse ore samples indicated the following:

- pH generally showed a downward trend over the period for both columns.
- Sulphate release rates tended to increase in the later sampling events each year, suggesting lower oxidation rates occurred during the winter months.
- The sulphate release rates generally showed an increasing trend for both field columns, which was opposite to the trend for both ore and waste rock humidity cells. It is considered possible that sulphur release rates would continue to accelerate as increasing quantities of sulphate salts are stored in the field columns and become available for flushing. This means that the predicted lag times to onset of acidic drainage may continue to decrease as the field column mature.
- Whereas the early field column results reported by Klohn (1998) gave rise to a much lower sulphide oxidation rate compared to controlled weathering in the laboratory, the longer-term field rates were comparable with rates from the humidity cell tests on both coarse ore and waste rock, and were appropriate for expected site temperatures. This suggests that the sulphate release rates for Ulu materials may be predominantly influenced by site temperatures and grain size, rather than other test variables such as flushing rates or volumes.
- The NP release rate for field columns are less than half that of the coarse ore humidity cell at 4^{O}C. This suggests that the reduced volume and frequency of flushing under the field columns had a significant effect in reducing NP

dissolution and depletion rates as compared to humidity cell results, while having essentially no effect on sulphur depletion rates.

- Klohn's NPR threshold values to avoid acidic drainage, calculated from humidity cell results, were 3 and 7 for 22°C and 4°C respectively. These values are likely conservative due to the relatively large volumes of water used in a humidity cell test as compared to field conditions.
- The field column threshold NPRs to avoid acidic drainage, at 1.3 and 2.0, were lower than those predicted from humidity cells. This is due to the reduced NP depletion rate, as a result of lower flushing volumes and frequency under field conditions. Field column values should be reviewed with caution as all oxidation products may not be released as they are produced, and the sulphate release rates may continue to increase as products build up and become available for release on subsequent flush events. Confirmation of lower threshold NPR values would require continued test work (allowing for stabilization of oxidation rates), or dismantling and analysis of field column to confirm).
- Arsenic and zinc release or loading rates under field conditions were less than those in the humidity cell tests on similar coarse ore material, but showed an increasing trend which may indicate that the release rates were limited in the field columns by incomplete flushing. It is expected that these metals leaching rates may continue to increase as the field column matures.
- Arsenic loading rates showed seasonal trends, with higher release rates measured later in each year, suggesting lower oxidation rates occurred during the winter months. Zinc release rates were more erratic and did not appear to show significant seasonal trends.
- The field columns displayed higher arsenic concentrations than the humidity cells, with average arsenic concentrations (0.33 and 0.47 mg/l) that were 2 to 4 times higher than average concentrations produced from the humidity cell tests on the same coarse ore material. The higher concentrations are likely due to the reduced volume and frequency of flushing under field conditions.
- Zinc concentrations released from the field columns were similar to those released from humidity cell tests on similar coarse ore material, but demonstrated greater variability and range.
- Materials tested in the humidity cells and field columns tended to contain relatively high sulphide content relative to the general sample populations. Thus the results may be considered to a represent reasonable worst case for the grainsize tested. All tested samples had NPR values of 1.0 or less, and were projected to eventually produce acidic drainage, albeit after a lag time of decades or more.
- Both the NP and sulphate depletion rates for the ore, waste rock, and fine grained ore are low relative to kinetic test results from the International Kinetic Database (Morin, 1999).

5.0 SUMMARY

Acid rock drainage and metal leaching assessment testwork conducted to date for the Ulu Project consists of:

- Static testing on whole ore samples (Rescan, 1991; Klohn, 1996 and 1998);
- Kinetic testing (Klohn, 1998);
  - Coarse ore (>1.5 mm fraction) humidity cell @ 22 degrees C;
  - Same coarse ore (>1.5 mm fraction) humidity cell @ 4 degrees C;
  - Fine ore (<1.5 mm fraction)(called tailings) humidity cell @ 22 degrees C;
  - Field column testing (Klohn, 1998; Echo Bay, 2002) on the same coarse ore sample (>1.5 mm fraction).

The results to date indicate that, with respect to acid generating potential:

- Compared to kinetic test results from other sites (as compiled in the International Kinetic Database, Morin,1999), the reactivity of the Ulu site materials, in terms of NP and sulphur leaching rates, are low.
- Coarse and fine ore with NPR<3 is considered potentially acid generating (PAG) at 22 degrees C under humidity cell test conditions with prolonged weathering (Klohn, 1998).
- Under colder conditions, the NPR required to eliminate the possibility of ARD from coarse ore under humidity cell conditions can be as high as 7, however the amount of acid released on an annual basis is expected so low that it should not cause any significant impact (Klohn, 1998).
- These NPR thresholds, based on humidity cell conditions, are considered conservative by MEMI for field conditions where lower flushing rates and volumes are expected to reduce NP depletion rates. Field conditions do not appear to affect sulphur depletion rates.
- Results from the field columns suggest that threshold NPRs to avoid acidic drainage may be as low as 1.3 and 2.0. The reduced threshold NPR values (as compared to the humidity cell test results) are attributed to the reduced NP depletion rate, as a result of lower flushing volumes and frequency under field conditions. However, these field column NPR threshold values should be viewed with caution as all oxidation products may not be released as they are produced, and the sulphate release rates may continue to increase as products build up and become available for release on subsequent flush events. Confirmation and use of these lower threshold NPR values would require continued test work (allowing for stabilization of oxidation rates), or dismantling and analysis of field columns.
- Under field conditions, a threshold NPR of 3 is considered a reasonably conservative means of classifying PAG waste materials to avoid the onset of acid generation. From the existing database, this appears to be consistent with a total sulphur cutoff of 0.2%.

- The coarse ore field column did not produce acidic drainage in 5 years of testing. Lag times to produce acidic drainage, even for relatively high sulphide samples (i.e. 1.2 to 1.5 % total sulphur) and fine grainsizes (< 1.5 mm), are likely to be in the order of decades.
- Given the characteristics of the coarse ore and fine ore or tailings samples used in the kinetic tests relative to the current sample database, the humidity cell and field tests appear to provide reasonable worst case results, rather than average or expected results from ore materials.
- Given the characteristics of the selected waste rock sample used in the humidity cell tests relative to the current sample database, the results from the waste rock humidity cell tests are likely to represent reasonable worst case results, rather than average or expected results for waste materials. However, waste rock characteristics appear to be highly variable, as demonstrated by the range in NPR results of 0.1 to 137 for the 37 waste rock samples in the current database, such that a portion of the waste rock may be more reactive than the tested samples.
- The characteristics of ore samples collected to date, along deposit mineralogy, suggest that all ore will likely have a NPR<3, therefore all ore should be classified as PAG.
- Based on the ABA database compiled to date, and a threshold NPR of 3 for separating PAG and NPAG material, gabbro and diabase material for the most part are likely to be NPAG, greywacke may be PAG or NPAG depending on the sulphur content, mafic volcanics are likely to be PAG, basalt material is highly variable but generally PAG and all ore and altered material are PAG.
- The onset of acidic conditions, and/or predicted metal leaching, may not necessarily result in significant adverse affects on the environment. Impact assessments are required to assess potential impacts, and typically take into account the mass of material maintained in a frozen state, volume and grainsize of the stockpiled material, site temperatures, the tendency for water to flow through channels and bypass many of the rock surfaces potentially holding stored oxidation products, and the volume of runoff and leachate that may contact the stockpile materials. MEMI recommends that impact assessments for specific site conditions be conducted to quantitatively define potential impacts associated with temporary and/or permanent storage of ore or waste rock on site.

With respect to the metal leaching potential:

- Arsenic and zinc leaching may be of concern at neutral pH. Arsenic leaching from ore samples under field conditions at neutral pH appears to occur rapidly, and achieved concentrations in the field in the range of 0.5 mg/L to 2 mg/L, i.e. may exceed the federal <u>*Metal Mining Effluent Regulations*</u> maximum allowable values. However, release or loading rates under field conditions are low relative to humidity cell results, such that impacts to the receiving environment may not be significant.

Quantitative predictions are required to determine the significance of potential impacts.

- Klohn (1998) did not consider metal leaching to be a potential problem for waste rock materials, based on the waste rock kinetic test results and the geological description of the ore deposit. However, the current database is limited, and metal content may be elevated in portions of the waste rock, for example in rock in close proximity to the ore body. The potential for metals, such as arsenic and zinc, leaching from waste rock at neutral pH should be considered in impact predictions.
- Metal leaching under acidic conditions have not been assessed, as acidic conditions are not predicted to occur for decades. If acidic conditions should eventually develop, leaching rates of other metals, such as copper, are expected to increase.

6.0 IMPLICATIONS FOR ORE AND MINE WASTE MANAGEMENT

Significant findings from the two extended field column tests conducted on the coarse ore material, that have potential implications for ore and waste rock management include the following:

6.1 Implications for Ore Stockpiles

- Given the characteristics of the coarse ore and fine ore or tailings samples, the humidity cell and field tests are likely to provide reasonable worst case results, rather than average or expected results.
- High arsenic concentrations, and elevated zinc concentrations are anticipated from coarse ore (>1.5 mm) materials located in the active layer on site at neutral pH. These arsenic concentrations may be of concern as they occasionally exceeded the federal *Metal Mining Effluent Regulations* maximum allowable values, particularly in the later stages of the 5 year test.
- Actual ore stockpiles that include some finer (<1.5 mm) material would produce higher arsenic and zinc release rates, higher zinc and arsenic concentrations, higher sulphate and NP depletion rates and more rapid onset of acid generating conditions than suggested by the field columns conducted solely on the coarse ore fraction.
- Klohn's NPR threshold values to avoid acidic drainage, calculated from humidity cell results, of 3 and 7 for 22 ^{O}C and 4 ^{O}C respectively, are considered conservative due to the relatively large volumes of water used in a humidity cell test as compared to field conditions. Lag times before the onset of acidic conditions associated with these thresholds are likely to be in the order of decades.
- Results from the field columns suggest that threshold NPRs to avoid acidic drainage may be as low as 1.3 and 2.0. The reduced threshold NPR values (as compared to the humidity cell test results) are attributed to the reduced NP

depletion rate, as a result of lower flushing volumes and frequency under field conditions. However, these field column NPR threshold values should be viewed with caution as all oxidation products may not be released as they are produced, and the sulphate release rates may continue to increase as products build up and become available for release on subsequent flush events. Confirmation and use of these lower threshold NPR values would require continued test work (allowing for stabilization of oxidation rates), or dismantling and analysis of field columns.

- Given that ore stockpiles are anticipated to be milled quickly, and are not likely to be stored for more than one year before transport to an offsite mill, the predicted arsenic and zinc concentrations and the predicted delay until the onset of acidic conditions are unlikely to result in significant adverse affects on the environment.
- Potential impacts from limited metal leaching over the proposed ore stockpile turnover period can be estimated from humidity cell and field column leach rates, combined with the volume and grainsize of the stockpiled material, site temperatures, the tendency for water to flow through channels and bypass many of the rock surfaces potentially holding stored oxidation products, and the volume of precipitation that may contact the stockpile materials.

6.2 Implications for Waste Rock Piles

- The results from the humidity cell tests on the selected higher sulphide waste rock sample are likely to represent reasonable worst case results, rather than average or expected results. However, the range in NPR results of 0.1 to 137 for the 37 waste rock samples indicates the waste rock characteristics are highly variable.
- Based on the ABA database compiled to date, and a threshold NPR of 3 for separating PAG and NPAG material, gabbro and diabase material for the most part are likely to be NPAG, greywacke may be PAG or NPAG depending on the sulphur content, mafic volcanics are likely to be PAG, basalt material is highly variable but generally PAG and all ore and altered material are PAG. Note that the database is dominated by surface samples, and deeper materials may not maintain the indicated trends. Also note that the samples may have been biased to those containing visible sulphides.
- Extrapolating the field column results on coarse ore to the waste rock, and assuming the waste rock responds in a similar manner to field conditions, suggests that an on site waste rock pile would likely display slower NP release rates and similar sulphate release rates to those shown by the waste rock humidity cells. The lower NP release rates would be attributed to the less frequent and lower volume flushing experienced by waste material exposed in the field.
- These results indicate that Klohn's NPR threshold values to avoid acidic drainage, calculated from humidity cell results, of 3 and 7 for 22^{o}C and 4^{o}C respectively, are likely conservative due to the relatively large volumes of water

used in a humidity cell test as compared to field conditions. Lag time before the onset of acidic conditions, associated with these thresholds, are likely to be in the order of decades or more.

- Threshold NPRs to avoid acidic drainage calculated from coarse ore field columns may be applicable to waste rock, with similar caveats as mentioned above for ore stockpiles. Field column NPR thresholds of 1.3 and 2.0 should be viewed with caution as all oxidation products may not be released as they are produced, and the sulphate release rates may continue to increase as products build up and become available for release on subsequent flush events. Confirmation of lower threshold NPR values would require continued test work (allowing for stabilization of oxidation rates), or dismantling and analysis of field columns.
- Based on the geologic description of the ore deposit, Klohn (1996) anticipates that the waste rock will contain limited mineralization, such that metal leaching would not be significant. This was supported by humidity cell test on a composite waste rock samples (Klohn, 1998) at neutral pH values. However, any waste material that contains arsenic, such as waste rock adjacent to the ore, may have a potential to leach As at elevated concentrations, and should be assessed and/or managed accordingly. Zinc may also be a potential metal leaching concern if present in waste materials in similar quantities and form as the tested coarse and fine ore samples.
- Should acidic conditions eventually develop, leaching of other metals may occur. For example, copper values in the waste rock are noted as being slightly more elevated than ore samples.
- Under field conditions, a threshold NPR of 3 is considered a reasonably conservative means of classifying PAG waste materials to avoid the onset of acid generation. From the existing database, this appears to be consistent with a total sulphur cutoff of 0.2%.
- The onset of acidic conditions, and/or predicted metal leaching, may not necessarily result in significant adverse affects on the environment. Impact assessments are required to assess potential impacts, and typically take into account the mass of material maintained in a frozen state, volume and grainsize of the stockpiled material, site temperatures, the tendency for water to flow through channels and bypass many of the rock surfaces potentially holding stored oxidation products, and the volume of runoff and leachate that may contact the stockpile materials. MEMI recommends that impact assessments for specific site conditions be conducted to quantitatively define potential impacts from waste rock storage.

7.0 RECOMMENDATIONS

- ABA and metal content monitoring should continue during operations, particularly at deeper depths, to confirm if rock type trends identified from the current database remain consistent.
- Additional ABA and metal content sampling of the constructed camp pads should be undertaken to determine their susceptibility for ARD and metal leaching.
- Quantification of the low levels of mineralization in waste rock assumed by Klohn (1996) on the basis of the geological model should be confirmed. This, in conjuction with the lack of a metal leaching problem associated with the single, high sulphide waste rock kinetic test sample, is the basis for anticipating no significant metal leaching from waste rock. However, the limited metal database for waste rock samples precludes a quantitative assessment of arsenic and zinc content in waste materials at this time. For example, metals content may be elevated in waste in close proximity to the ore deposit. Metal content of waste materials should be confirmed by operational monitoring. Greater clarity of the potential quantity of waste rock that might contain elevated metal levels may be determined by review of the 7305 ICP's referred to the BHP geology report (1993).
- The field column tests on coarse ore should continue to determine if lower threshold NPR values may be valid for the site conditions. Alternatively, dismantling of the field columns should be conducted to analytically determine the amounts of soluble salts held in the columns and not flushed out under site conditions. This data could be extrapolated to the waste rock to assess whether lower threshold NPR values might be valid for identifying PAG waste rock quantities stored permanently on site.
- Since the onset of acidic conditions, and/or predicted metal leaching, may not necessarily result in significant adverse affects on the environment, impact assessments should be undertaken to assess potential impacts. These quantitative assessments typically take into account the mass of material maintained in a frozen state, volume and grainsize of the stockpiled material, site temperatures, the tendency for water to flow through channels and bypass many of the rock surfaces potentially holding stored oxidation products, and the volume of runoff and leachate that may contact the stockpile materials.
- Should quantitative impact assessments indicate potential for adverse long-term impacts, field column kinetic tests could potentially be conducted on waste material to confirm metal leaching rates and NPR thresholds for the different types of waste rock and varying composition with depth. However, on the basis of the field column tests conducted on coarse ore, waste rock columns would require several years to develop information supportive of lower threshold NPR values.

We trust this report meets your current requirements.

MEHLING ENVIRONMENTAL MANAGEMENT INC.
Per.

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TABLES

ECHO BAY MINES LTD.
Ulu Project

Table 8: ABA Database by Rock Type

Sample #	Rock Type	Desciption	Vert. Depth (m)	% S	$\%SO_4$-S	kg CaCO3/tonne AP	NP	NNP	NPR
Intrusive - Gabbro & Diabase									
ARD-1	gabbro	adjacent to zone, 89VD04, 20.0-20.8m	0.8	0.24		7.5	21.96939	14.5	2.9
ARD-3	diabase	fresh, Mod Mg, 89VD14, 37.9-38.9m	30	0.29		9.1	51.94898	42.9	5.7
ARD-9	diabase	hanging wall, 90VD43, 319-320m	240	0.02		0.6	53.38776	52.8	85.4
ARD-10	gabbro	fresh, 90VD66, 171-172.06m		0.13		4.1	10.35714	6.3	2.5
Ulu KC-22	gabbro	BH96-4, 3-23m		0.22	0.01	7	25	18	3.6
Ulu KC-23	gabbro	BH96-3, 3-40m		0.13	0.01	4	18	14	4.4
Ulu KC-24	gabbro	BH96-1, 25-52m		0.06	0.01	2	15	13	8.0
		count		**7**					
		min.		**0.02**		**0.6**	**10.36**	**6.3**	**2.5**
		max.		**0.29**		**9.1**	**53.39**	**52.8**	**85.4**
		mean		**0.16**		**5**	**28**	**23**	**5.7**
Volcanics									
ARD-2	mafic volcanic	low grade, 1% As, 0.5% Po, 89VD05, 60.6-61.6m	30	0.74		23.1	35.66327	12.5	1.5
Ulu KC-19	mafic volcanic	BH96-2, 11-12m		0.93	0.01	29	18	-11	0.6
		count		**2**					
		min.		**0.74**		**23.1**	**18**	**-11**	**0.6**
		max.		**0.93**		**29**	**35.66**	**12.5**	**1.5**
		mean		**0.84**		**26**	**27**	**1**	**1.0**
Greywacke & Biotite Schist									
ARD-8	greywacke	footwall, 90VD44, 409.54-410.54m	360	0.17		5.3	20.44898	15.1	3.8
ARD-13	greywacke	fresh, 90VD62, 363-364m	260	0.25		7.8	15.79592	8.0	2.0
Ulu KC-20	biotite schist	BH96-2, 34-38m		0.11	0.01	3	22	19	6.4
Ulu KC-21	biotite schist	BH96-2, 38-42m		0.07	0.01	2	21	19	9.6
		count		**4**					
		min.		**0.07**		**2**	**15.79592**	**8.0**	**2.0**
		max.		**0.25**		**8**	**22**	**19**	**9.6**
		mean		**0.15**		**5**	**20**	**15**	**4.2**
Basalt/Porphyry/Band Tuff									
ARD-4	band tuff	below zone, tr. Po, calcite, 89VD22, 171-172m	120	0.04		1.3	23.4898	22.2	19
ARD-5	q-f porphy	footwall, 1% Po, 90VD31, 377.78-378.1m	325	0.02		0.6	27.7449	27.1	44
ARD-6	basalt	hanging wall, 1% qtz stringers, 89VD10, 17.38-18.38m	10	0.01		0.3	42.70408	42.4	137
ARD-7	basalt	footwall, 1% qtz stringers, 0.5% Po, 89VD10, 36.05-37.05m	12	0.25		7.8	30.07143	22.3	3.8
ARD-11	basalt	fresh, tr. qtz stringers, 90VD62, 199-200m	150	0.12		3.8	19.64286	15.9	5.2
ARD-12	f-porphy	fresh, 90VD62, 253-254m	180	0.01		0.3	39.23469	38.9	126
ARD-14	basalt	country rock, 7-8% qtz-carb strg, 90VD62, 91.1-92.1m	35	0.22		6.9	84.78571	77.9	12
ARD-15	basalt	country rock, 4-5% qtz stingers, 90VD72, 207.5-208.5m		0.57		17.8	40.73469	22.9	2.3
Ulu KC-1	basalt	portal, working face		0.26	0.005	8	45	37	5.5
Ulu KC-2	basalt & gabbro	portal, N ramp		0.09	0.01	3	27	24	9.6
Ulu KC-4	basalt & gabbro	portal, S ramp		0.49	0.01	15	22	7	1.4
Ulu KC-25	basalt	EBM-Ulu ARD-1 camp pads		1.49	0.01	47	22	-25	0.5
Ulu KC-26	basalt	EBM-Ulu ARD-2 camp pads		0.58	<0.01	18	19	1	1.0
Ulu KC-27	basalt	EBM-Ulu ARD-3 camp pads		0.80	0.01	25	23	-2	0.9
Ulu KC-28	basalt	EBM-Ulu ARD-4 camp pads		0.31	<0.01	10	23	13	2.4
Ulu KC-29	Qtz-feld porphyry + basalt	EBM-Ulu ARD-5 camp pads		0.73	0.01	23	23	0	1.0
Ulu KC-31	basalt + minor QFP	EBM-Ulu ARD-7 camp pads		0.32	<0.01	10	19	9	1.9
		count		**17**					
		min.		**0.01**		**0**	**19**	**-25**	**0.5**
		max.		**1.49**		**47**	**84.79**	**77.9**	**137**
		mean		**0.37**		**12**	**31**	**20**	**2.7**
Mineralized Zone									
Ulu KC-9	altered basalt	BH96-20, 117.9-118.9		0.15	0.01	5	30	25	6.4
Ulu KC-10	altered basalt	BH96-20, 166.8-167.8		0.28	0.01	9	26	17	3.0
Ulu KC-11	altered basalt	BH96-20, 167.8-169.2		0.93	0.02	29	33	4	1.1
Ulu KC-12	altered basalt	BH96-20, 169.2-170.1		1.17	0.01	37	33	-4	0.9
Ulu KC-13	mineralized zone	BH96-20, 173.3-175.0		2.24	0.01	70	30	-40	0.4
Ulu KC-14	quartz vein	BH96-20, 184.4-185.9		1.60	0.01	50	18	-32	0.4
Ulu KC-15	altered sediment	BH96-20, 85.9-187.6		0.28	0.02	9	24	15	2.7
Ulu KC-16	altered graywacke	BH96-20, 198.9-200.8		0.22	0.03	7	16	9	2.3
Ulu KC-17	fresh interior of grab ore sample	ore zone surface		1.19	0.06	37	23	-14.19	0.6
Ulu KC-18	Alteration rind of grab ore sample	ore zone surface		1.29	0.03	40	26	-14.31	0.6
		count		**10**					
		min.		**0.15**		**5**	**16**	**-40**	**0.4**
		max.		**2.24**		**70**	**33**	**25**	**6.4**
		mean		**0.94**		**29**	**26**	**-3**	**0.9**
Other - Unspecified									
Ulu KC-3	sulphide (po+py)-rich	portal, N ramp		3.91	0.02	122	13	-109.2	0.1
Ulu KC-5	EBM-Ulu pulp 18701	portal material		2.65	0.01	83	21	-62	0.3
Ulu KC-6	EBM-Ulu pulp 18702	portal material		2.80	0.01	88	14	-74	0.2
Ulu KC-7	EBM-Ulu pulp 18703	portal material		3.15	0.01	98	21	-77	0.2
Ulu KC-8	EBM-Ulu pulp 18704	portal material		2.29	0.02	72	24	-48	0.3
Ulu KC-30	EBM-Ulu ARD-6	camp pads		0.37	<0.01	12	20	8	1.7
Ulu KC-32	EBM-Ulu ARD-8	camp pads		0.20	0.01	6	19	13	3.0
		count		**7**					
		min.		**0.20**		**6**	**13**	**-109**	**0.1**
		max.		**3.91**		**122**	**24**	**13**	**3.0**
		mean		**2.20**		**69**	**19**	**-50**	**0.3**

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Table 9: Ulu Project - Field Column #1 Test Data

Sample Weight (kg) 15

Sample ID	Sample Date	Field: Weeks Between	Field: Cummulative Weeks	Field: pH	Field: Conductivity	Field: H2O Volume	Field: Temp. (air)	Lab: pH	Lab: Conductivity	Lab: Acidity	Lab: T-Alkalinity as CaCO3	Lab: Sulphate Dissolved	Lab: Ammonium-N Dissolved	Lab: Cyanide Strong Acid Dissociable	Aluminum Total	Antimony Total	Arsenic Hydride Total	Arsenic Total	Barium Total	Beryllium Total	Bismuth Total	Boron Total	Cadmium Total	Calcium Total	Chromium Total	Cobalt Total
ICP-SOLIDS																										
ULU1[1]	Wednesday, January 15, 1997														ppm	ppm		ppm	ppm	ppm	ppm		ppm	ppm	ppm	ppm
															15300	<2		7780	90	<5	<2		<.5	10300	36	31
ICP-LEACHATE					uS/cm	L	C		uS/cm	mg CaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ULU1[1]	Wednesday, June 18, 1997	22	22	7.67	9140	1.400	11.4	7.67	8500	16	49	84			<1	0.05		0.25	<0.01	<0.001			0.003	130	<0.02	<0.02
ULU1[1]	Wednesday, August 27, 1997	10	32	7.26	3250	0.450	11.3	7.74	3200	7.1	40	192			<1	0.05		0.40	<0.01	<0.001			<0.001	96	<0.02	<0.02
ULU1[1]	Friday, September 12, 1997	2.3	34.3			0.400		7.70	4750	7.5	45	240			<1	0.05		0.30	<0.01	<0.001			<0.001	165	<0.02	<0.02
ULU1	Saturday, June 06, 1998	38	72.3	7.66	1820	3.350	13					131			0.053	0.029		0.48	0.034	<0.0006	<0.008	0.045	<0.0006	61.2	<0.0009	0.007
ULU1	Monday, July 13, 1998	5.3	77.6	7.75	355	1.600	9					89.5			0.104	0.01		0.55	0.0277	<0.0006	<0.008	0.013	<0.0006	28	<0.0009	0.0009
ULU1	Friday, August 21, 1998	5.5	83.1	7.85	272	1.775	16					65.7			0.046	0.017		0.27	0.0462	<0.0006	<0.008	0.004	<0.0006	36.4	<0.0009	<0.0008
ULU1	Wednesday, September 16, 1998	3.7	86.8	7.7	280	0.926	1					73.7			0.064	0.025		0.38	0.0628	<0.0006	<0.008	0.003	<0.0006	40.3	0.0011	<0.0008
ULU1	Tuesday, June 15, 1999	38.5	125.3	6.96	611	2.160	8					236			<0.009	0.011		0.17	0.0466	<0.0006	<0.008	<0.002	<0.0006	91.3	<0.0009	0.0057
ULU1	Saturday, August 07, 1999	7.5	132.8	7.58	292	1.200	6					94.9			0.041	0.009		0.23	0.0222	<0.0006	<0.008	<0.002	<0.0006	41.7	<0.0009	<0.0008
ULU1	Wednesday, September 08, 1999	4.5	137.3	7.25	248	1.940	5					90.4			0.029	0.009		0.2	0.0119	<0.0006	<0.008	<0.002	<0.0006	42.5	<0.0009	<0.0008
ULU1	Tuesday, July 18, 2000	44.5	181.8	7.92	498	1.275	-					199			0.029	0.01		0.2	0.0551	<0.0006	<0.008	<0.002	<0.0006	71.4	<0.0009	<0.0008
ULU1	Tuesday, August 22, 2000	5	186.8	7.86	1062	0.725	-					573			<0.009	0.01		0.88	0.0999	<0.0006	<0.008	0.003	<0.0006	212	<0.0009	0.0018
ULU1	Sunday, September 17, 2000	4.5	191.3	7.4	933	1.185	2					454			<0.009	0.007		0.83	0.0936	<0.0006	<0.008	<0.002	<0.0006	161	<0.0009	0.0018
ULU1	Wednesday, July 04, 2001	41	232.3	7.43	1004	4.650	20					665			0.702	0.008	0.499	0.53	0.039	<0.0006	<0.008	0.024	<0.0006	234	<0.0009	0.0067
ULU1	Thursday, August 02, 2001	4.3	236.6	7.29	664	2.115	-					379			0.034	<0.006	0.444	0.43	0.0302	<0.0006	<0.008	0.017	<0.0006	145	<0.0009	0.0019
ULU1	Saturday, September 01, 2001	4.3	240.9	6.98	663	1.320	-					403			0.023	0.006	0.407	0.35	0.0382	<0.0006	<0.008	0.014	<0.0006	143	<0.0009	<0.0008
ULU1	Sunday, July 07, 2002	44	284.9				-	6.76	5340		564	578			0.12	0.012		1.74	0.065	<0.001	<0.005	0.027	<0.0001	32.4	<0.005	0.015
ULU1	Friday, August 16, 2002	5.7	290.6				-	6.04	1010		10	283	30.8	0.116	0.026	0.0078		0.86	0.021		<0.0005	0.016	0.00004	117	<0.0005	0.0046
Maximum				7.92	9140							665			1	0.05	0.499	1.74	0.0999	0.001	0.008	0.045	0.003	234	0.02	0.02
Minimum				6.86	248							74			0.009	0.006	0.407	0.17	0.01	<0.0006	<0.0005	<0.002	<0.00004	28	<0.0005	<0.0008
ULU1 LEACH RATES												mg/kg/wk			mg/kg/wk	mg/kg/wk		mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk
ULU1[1]	Wednesday, June 18, 1997											0.36			0.0042	0.00021		0.0011	0.00004	0.000004			0.000013	0.55	0.00008	0.000085
ULU1[1]	Wednesday, August 27, 1997											0.58			0.0030	0.00015		0.0012	0.00003	0.000003			0.000003	0.29	0.00006	0.000060
ULU1[1]	Friday, September 12, 1997											2.78			0.0116	0.00058		0.0035	0.00012	0.000012			0.000012	1.91	0.00023	0.000232
ULU1	Saturday, June 06, 1998											0.77			0.0003	0.00017		0.0028	0.0002	0.000004	0.00005	0.00026	0.000004	0.36	0.000005	0.000041
ULU1	Monday, July 13, 1998											1.80			0.0021	0.00020		0.0070	0.0006	0.000012	0.00016	0.00026	0.000012	0.56	0.000018	0.000018
ULU1	Friday, August 21, 1998											1.84			0.0010	0.00037		0.0058	0.00099	0.000018	0.00017	0.00009	0.000013	0.78	0.000019	0.000017
ULU1	Wednesday, September 16, 1998											1.23			0.0011	0.00042		0.0063	0.00105	0.000010	0.00013	0.00005	0.000010	0.67	0.000018	0.000013
ULU1	Tuesday, June 15, 1999											0.88			0.0000	0.00004		0.0006	0.00017	0.000002	0.00003	0.00001	0.000002	0.34	0.000003	0.000021
ULU1	Saturday, August 07, 1999											1.01			0.0004	0.00010		0.0025	0.00024	0.000006	0.00009	0.00002	0.000006	0.44	0.000010	0.000009
ULU1	Wednesday, September 08, 1999											2.60			0.0008	0.00026		0.0057	0.00034	0.000017	0.00023	0.00006	0.000017	1.22	0.000026	0.000023
ULU1	Tuesday, July 18, 2000											0.38			0.0001	0.00002		0.0004	0.00011	0.000001	0.00002	0.00000	0.000001	0.14	0.000002	0.000002
ULU1	Tuesday, August 22, 2000											5.54			0.0001	0.00010		0.0085	0.00097	0.000006	0.00008	0.00003	0.000006	2.05	0.000009	0.000017
ULU1	Sunday, September 17, 2000											8.15			0.0002	0.00012		0.016	0.00164	0.000011	0.00014	0.00004	0.000011	2.83	0.000016	0.000032
ULU1	Wednesday, July 04, 2001											5.03			0.0053	0.00006	0.0038	0.0040	0.00029	0.000005	0.00006	0.00018	0.000005	1.77	0.000007	0.000066
ULU1	Thursday, August 02, 2001											12.4			0.0011	0.00020	0.0146	0.0141	0.00099	0.000020	0.00026	0.00056	0.000020	4.75	0.000030	0.000062
ULU1	Saturday, September 01, 2001											8.2			0.0005	0.00012	0.0083	0.0072	0.00078	0.000012	0.00016	0.00028	0.000012	2.93	0.000016	0.000016
Maximum												12.4			0.0116	0.00058	0.0146	0.016	0.00164	0.00002	0.00026	0.00056	0.00002	4.75	0.00023	0.000231884
Minimum												0.36			0.00003	0.00002	0.0038	0.0004	0.00003	<0.000001	<0.00002	<0.000004	<0.000001	0.14	<0.000002	<0.000002
ULU1 CUMULATIVE LEACH RATES												mg/kg			mg/kg	mg/kg		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
ULU1[1]	Wednesday, June 18, 1997											7.84			0.093	0.005		0.023	0.001	0.0001			0.00028	12.1	0.00187	0.00187
ULU1[1]	Wednesday, August 27, 1997											13.5			0.123	0.006		0.035	0.001	0.0001			0.00031	15.0	0.00247	0.00247
ULU1[1]	Friday, September 12, 1997											20.0			0.150	0.008		0.043	0.002	0.0002			0.00034	19.4	0.00300	0.00300
ULU1	Saturday, June 06, 1998											49.3			0.162	0.014		0.151	0.009	0.0003	0.0018	0.0101	0.00047	33.1	0.00320	0.00456
ULU1	Monday, July 13, 1998											58.8			0.173	0.015		0.188	0.012	0.0003	0.0026	0.0114	0.00053	36.1	0.00330	0.00466
ULU1	Friday, August 21, 1998											69.0			0.178	0.017		0.220	0.018	0.0004	0.0036	0.0119	0.00061	40.4	0.00340	0.00475
ULU1	Wednesday, September 16, 1998											73.5			0.182	0.019		0.243	0.021	0.0005	0.0041	0.0121	0.00064	42.9	0.00347	0.00480
ULU1	Tuesday, June 15, 1999											107			0.184	0.020		0.268	0.028	0.0005	0.0052	0.0124	0.00073	56.0	0.00360	0.00562
ULU1	Saturday, August 07, 1999											115			0.187	0.021		0.286	0.030	0.0006	0.0059	0.0125	0.00078	59.3	0.00367	0.00569
ULU1	Wednesday, September 08, 1999											127			0.191	0.022		0.312	0.031	0.0007	0.0069	0.0128	0.00085	64.8	0.00379	0.00579
ULU1	Tuesday, July 18, 2000											144			0.193	0.023		0.329	0.036	0.0007	0.0076	0.0130	0.00091	70.9	0.00387	0.00586
ULU1	Tuesday, August 22, 2000											171			0.194	0.023		0.372	0.041	0.0007	0.0080	0.0131	0.00093	81.2	0.00391	0.00595
ULU1	Sunday, September 17, 2000											208			0.194	0.024		0.445	0.048	0.0008	0.0086	0.0133	0.00098	93.9	0.00395	0.00609
ULU1	Wednesday, July 04, 2001											414			0.412	0.026		0.609	0.060	0.0010	0.0111	0.0207	0.00117	166	0.00426	0.00879
ULU1	Thursday, August 02, 2001											458			0.417	0.027		0.670	0.065	0.0011	0.0122	0.0231	0.00125	187	0.00439	0.00905
ULU1	Saturday, September 01, 2001											503			0.419	0.028		0.701	0.068	0.0011	0.0129	0.0243	0.00131	199	0.00447	0.00912

Note:
[1] - Data from Klohn, 1998. Dissolved metals, not total metals.

ECHO BAY MINES LTD.
Table 9: Ulu Project - Field Column #1 Test Data

Sample Weight (kg) 15

	Sample Date	Weeks Between	Cummulative Weeks	Copper Total	Iron Total	Lead Total	Lithium Total	Magnesium Total	Manganese Total	Molybdenum Total	Nickel Total	Phosphorus Total	Potassium Total	Selenium Total	Silicon Total	Silver Total	Sodium Total	Strontium Total	Sulphur Total	Thallium Total	Tin Total	Titanium Total	Uranium Total	Vanadium Total	Zinc Total	Zirconium Total
ICP-SOLIDS				ppm	ppm	ppm		ppm	ppm	ppm	ppm	ppm	ppm			ppm	ppm	ppm	ppm			ppm	ppm	ppm	ppm	
ULU1[1]	Wednesday, January 15, 1997			80	47100	2		6600	395	1	11	690	6700			< 0.2	700	6	11400			0.14	10	119	86	
ICP-LEACHATE				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ULU1[1]	Wednesday, June 18, 1997	22	22	< 0.01	< 1	< 0.05		19.0	4.1	0.01	< 0.01	< 1	40			< 0.01	1510	0.41				< 1		< 0.01	0.16	
ULU1[1]	Wednesday, August 27, 1997	10	32	< 0.01	< 1	< 0.05		11.0	1.8	< 0.01	< 0.01	< 1	20			< 0.01	550	0.19				< 1		< 0.01	0.05	
ULU1[1]	Friday, September 12, 1997	2.3	34.3	< 0.01	< 1	< 0.05		20	3.0	0.01	< 0.01	< 1	30			< 0.01	850	0.34				< 1		< 0.01	0.07	
ULU1	Saturday, June 06, 1998	38	72.3	0.014	0.077	0.003	0.035	7.42	1.38	0.005	0.008	0.11	12.2	0.009	1.9	< 0.001	296	0.111	44.9	< 0.004	< 0.003	0.0021		0.003	0.099	
ULU1	Monday, July 13, 1998	5.3	77.6	0.007	0.073	< 0.002	0.021	1.64	0.0882	0.003	0.003	< 0.03	6.2	< 0.004	1.53	< 0.001	47.4	0.0402	29.9	< 0.004	< 0.003	0.0031		< 0.001	0.015	
ULU1	Friday, August 21, 1998	5.5	83.1	0.01	0.025	< 0.002	0.023	1.74	0.0379	0.002	0.002	< 0.03	6.9	0.007	1.56	< 0.001	18.6	0.0471	27.6	< 0.004	< 0.003	0.0009		0.001	0.0132	
ULU1	Wednesday, September 16, 1998	3.7	86.8	0.008	0.11	< 0.002	0.03	1.99	0.0164	0.002	0.005	< 0.03	12.1	< 0.004	2.06	< 0.001	15.1	0.0507	23.1	< 0.004	< 0.003	0.0013		0.002	0.027	
ULU1	Tuesday, June 15, 1999	38.5	125.3	0.011	0.026	< 0.002	0.031	5.03	1.22	0.001	0.006	< 0.03	15	< 0.004	1.12	< 0.001	46.2	0.107	79.7	< 0.004	< 0.003	< 0.0004		< 0.001	0.332	
ULU1	Saturday, August 07, 1999	7.6	132.9	0.009	0.018	0.003	0.024	2.01	0.0844	0.001	0.003	< 0.03	11.3	< 0.004	1.43	< 0.001	16.7	0.0473	31.6	< 0.004	< 0.003	< 0.0004		< 0.001	0.0229	
ULU1	Wednesday, September 08, 1999	4.5	137.8	0.005	0.013	< 0.002	0.016	1.6	0.0587	0.001	0.002	< 0.03	8.5	0.007	1.03	< 0.001	6	0.0421	29.8	< 0.004	< 0.003	< 0.0004		< 0.001	0.0341	
ULU1	Tuesday, July 18, 2000	44.5	181.8	0.006	0.012	< 0.002	0.019	2.96	0.002	< 0.001	0.002	< 0.03	11.6	0.013	1.72	< 0.001	14	0.0757	65.4	< 0.004	< 0.003	< 0.0004		0.001	0.0236	
ULU1	Tuesday, August 22, 2000	5	186.8	0.012	0.024	< 0.002	0.034	7.09	0.0467	0.002	0.005	< 0.03	21.7	0.005	1.78	< 0.001	23.1	0.157	190	< 0.004	< 0.003	< 0.0004		0.002	0.0483	
ULU1	Sunday, September 17, 2000	4.5	191.3	0.013	0.028	0.004	0.032	6.45	0.0527	< 0.001	0.004	< 0.03	20.9	0.009	1.27	< 0.001	22.5	0.119	147	< 0.004	< 0.003	< 0.0004		0.002	0.142	
ULU1	Wednesday, July 04, 2001	41	232.3	0.009	0.472	< 0.002	0.035	4.28	0.624	< 0.001	0.008	0.04	20.9	0.013	2.65	< 0.001	6.8	0.174	210	0.007	< 0.003	< 0.0004		< 0.001	0.0163	
ULU1	Thursday, August 02, 2001	4.3	236.6	0.011	0.014	< 0.002	0.03	2.34	0.166	0.001	0.008	< 0.03	15.3	< 0.004	1.98	< 0.001	3	0.107	122	< 0.004	< 0.003	< 0.0004		< 0.001	0.0623	
ULU1	Saturday, September 01, 2001	4.3	240.9	0.008	0.008	< 0.002	0.035	2.59	0.0947	< 0.001	0.006	< 0.03	19.3	0.007	1.7	< 0.001	3.2	0.103	126	< 0.004	0.004	< 0.0004		< 0.001	0.0366	
ULU1	Sunday, July 07, 2002	44	284.9	0.059	0.3	0.0015	0.02	1.52	0.013	< 0.01	0.016		124	< 0.002	2.04	< 0.001	34.8	0.021	204	< 0.0005		0.0074	< 0.005	0.001	0.056	< 0.01
ULU1	Friday, August 16, 2002	5.7	290.6	0.021	<0.1	0.0003	0.029	3.2	0.373	0.002	0.0074		22.5	0.0007	1.69	< 0.0001	5.5	0.093	84.8	< 0.00005		0.004	< 0.0005	0.0007	0.033	< 0.001
Maximum				0.059	1	0.05	0.036	20	4.1	0.01	0.016	1	124	0.013	2.65	< 0.01	1510	0.41	210	0.007	0.004	1		0.01	0.332	
Minimum				0.01	0.008	0.0003	0.015	1.52	0.002	< 0.001	0.002	< 0.03	6.2	0.0007	1.03	< 0.0001	3	0.021	23	< 0.00005	< 0.003	< 0.0004		< 0.0007	0.0132	
ULU1-LEACH RATES				mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk		mg/kg/wk	mg/kg/wk	
ULU1[1]	Wednesday, June 18, 1997			0.000042	0.0042	0.000212		0.061	0.017	0.00004	0.00004	0.0042	0.17			0.00004	6.41	0.0017				0.004		0.00004	0.0007	
ULU1[1]	Wednesday, August 27, 1997			0.000030	0.0030	0.000150		0.033	0.005	0.00003	0.00009	0.0030	0.06			0.00003	1.65	0.0006				0.003		0.00003	0.0002	
ULU1[1]	Friday, September 12, 1997			0.000116	0.0116	0.000580		0.232	0.035	0.00012	0.00012	0.0116	0.35			0.00012	9.86	0.0039				0.01		0.0001	0.0008	
ULU1	Saturday, June 06, 1998			0.000062	0.0005	0.000018	0.00021	0.044	0.008	0.00003	0.00004	0.0006	0.07	0.00005	0.0112	0.00001	1.74	0.0007	0.26	0.00002	0.00002	0.00001		0.0000	0.0006	
ULU1	Monday, July 13, 1998			0.00014	0.0015	0.000040	0.0004	0.033	0.002	0.000060	0.00006	0.0006	0.12	0.00008	0.0308	0.00002	0.9540	0.0008	0.60	0.00008	0.00006	0.000062		0.000020	0.0003	
ULU1	Friday, August 21, 1998			0.00022	0.0005	0.000043	0.0005	0.037	0.001	0.000043	0.00004	0.0006	0.19	0.00015	0.0336	0.00002	0.4002	0.0010	0.59	0.00009	0.00006	0.000019		0.000022	0.0003	
ULU1	Wednesday, September 16, 1998			0.00013	0.0018	0.000033	0.0005	0.033	0.000	0.000033	0.00008	0.0005	0.20	0.00007	0.0344	0.00002	0.2519	0.0008	0.39	0.00007	0.00005	0.000022		0.000033	0.0004	
ULU1	Tuesday, June 15, 1999			0.00004	0.0001	0.000007	0.0001	0.019	0.005	0.000004	0.00002	0.0001	0.06	0.00001	0.0042	0.00000	0.1728	0.0004	0.30	0.00001	0.00001	0.000001		0.000004	0.0012	
ULU1	Saturday, August 07, 1999			0.00010	0.0002	0.000032	0.0003	0.021	0.001	0.000011	0.00003	0.0003	0.12	0.00004	0.0153	0.00001	0.1781	0.0005	0.34	0.00004	0.00003	0.000004		0.000011	0.0002	
ULU1	Wednesday, September 08, 1999			0.00014	0.0004	0.000057	0.0004	0.046	0.002	0.000029	0.00006	0.0009	0.24	0.00020	0.0296	0.00003	0.1724	0.0012	0.86	0.00011	0.00009	0.000011		0.000029	0.0010	
ULU1	Tuesday, July 18, 2000			0.00001	0.0000	0.000004	0.0000	0.006	0.000	0.000002	0.00000	0.0001	0.02	0.00002	0.0033	0.00000	0.0267	0.0001	0.12	0.00001	0.00001	0.000001		0.000002	0.00005	
ULU1	Tuesday, August 22, 2000			0.00012	0.0002	0.000019	0.0003	0.069	0.000	0.000019	0.00005	0.0003	0.21	0.00005	0.0172	0.00001	0.2233	0.0015	1.84	0.00004	0.00003	0.000004		0.000018	0.0006	
ULU1	Sunday, September 17, 2000			0.00023	0.0005	0.000070	0.0006	0.113	0.001	0.000018	0.00007	0.0005	0.37	0.00016	0.0223	0.00002	0.3950	0.0021	2.58	0.00007	0.00005	0.000007		0.000035	0.0025	
ULU1	Wednesday, July 04, 2001			0.00007	0.0036	0.000015	0.0003	0.032	0.005	0.000008	0.00006	0.0003	0.16	0.00010	0.0200	0.00001	0.0514	0.0013	1.59	0.00005	0.00002	0.000003		0.000008	0.0001	
ULU1	Thursday, August 02, 2001			0.00036	0.0005	0.000068	0.0010	0.077	0.005	0.000033	0.00026	0.0010	0.50	0.00013	0.0649	0.00003	0.0984	0.0035	4.00	0.00013	0.00010	0.000013		0.000033	0.0020	
ULU1	Saturday, September 01, 2001			0.00016	0.0002	0.000041	0.0007	0.053	0.002	0.000020	0.00012	0.0006	0.39	0.00014	0.0348	0.00002	0.0655	0.0021	2.58	0.00008	0.00008	0.000008		0.000020	0.0008	
Maximum				0.00036	0.0116	0.00058	0.0010	0.232	0.035	0.00012	0.0003	0.0116	0.50	0.00020	0.0649	< 0.00012	9.86	0.0039	4.00	0.00013	0.0001	0.01		0.0001	0.0025	
Minimum				0.00001	0.00002	0.000004	0.00004	0.006	0.000004	< 0.000002	0.000	< 0.0001	0.02	0.00001	0.0033	< 0.000002	0.0267	0.0001	0.12	< 0.000008	< 0.00001	< 0.000001		< 0.000002	0.00005	
ULU1-CUMULATIVE LEACH RATES				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg		mg/kg	mg/kg	
ULU1[1]	Wednesday, June 18, 1997			0.00093	0.093	0.0047		1.77	0.38	0.0009	0.0009	0.093	3.7			0.0009	141	0.038				0.093		0.0009	0.015	
ULU1[1]	Wednesday, August 27, 1997			0.00123	0.123	0.0062		2.10	0.44	0.0012	0.0012	0.123	4.3			0.0012	157	0.044				0.123		0.0012	0.016	
ULU1[1]	Friday, September 12, 1997			0.00150	0.150	0.0075		2.64	0.52	0.0015	0.0015	0.150	5.1			0.0015	160	0.053				0.150		0.0015	0.018	
ULU1	Saturday, June 06, 1998			0.00463	0.167	0.0082	0.0080	4.29	0.82	0.0026	0.0028	0.175	7.9	0.0020	0.424	0.0017	246	0.078	10.0	0.0009	0.0007	0.150		0.0022	0.040	
ULU1	Monday, July 13, 1998			0.00537	0.175	0.0084	0.0103	4.47	0.83	0.0029	0.0032	0.178	8.5	0.0024	0.588	0.0018	251	0.082	13.2	0.0013	0.0010	0.151		0.0023	0.042	
ULU1	Friday, August 21, 1998			0.00656	0.178	0.0086	0.0130	4.67	0.84	0.0032	0.0034	0.181	9.6	0.0033	0.772	0.0019	253	0.088	16.5	0.0016	0.0013	0.151		0.0024	0.044	
ULU1	Wednesday, September 16, 1998			0.00705	0.185	0.0087	0.0149	4.80	0.84	0.0033	0.0037	0.183	10.3	0.0035	0.899	0.0020	254	0.091	17.9	0.0020	0.0016	0.151		0.0025	0.045	
ULU1	Tuesday, June 15, 1999			0.00863	0.188	0.0090	0.0193	5.52	1.02	0.0034	0.0046	0.187	12.5	0.0041	1.06	0.0022	261	0.106	29.4	0.0026	0.0020	0.151		0.0027	0.093	
ULU1	Saturday, August 07, 1999			0.00935	0.190	0.0093	0.0212	5.68	1.02	0.0035	0.0048	0.190	13.4	0.0044	1.17	0.0022	262	0.110	31.9	0.0029	0.0022	0.151		0.0027	0.095	
ULU1	Wednesday, September 08, 1999			0.01000	0.192	0.0095	0.0232	5.89	1.03	0.0037	0.0051	0.194	14.5	0.0053	1.31	0.0024	263	0.116	35.8	0.0035	0.0026	0.151		0.0029	0.099	
ULU1	Tuesday, July 18, 2000			0.01051	0.193	0.0097	0.0248	6.14	1.03	0.0037	0.0052	0.196	15.5	0.0064	1.45	0.0024	264	0.122	41.3	0.0038	0.0028	0.151		0.0030	0.10	
ULU1	Tuesday, August 22, 2000			0.01109	0.194	0.0098	0.0264	6.48	1.03	0.0038	0.0055	0.198	16.5	0.0067	1.54	0.0025	265	0.129	50.6	0.0040	0.0030	0.151		0.0031	0.10	
ULU1	Sunday, September 17, 2000			0.01212	0.196	0.0101	0.0290	6.99	1.04	0.0039	0.0058	0.200	18.2	0.0074	1.64	0.0026	267	0.139	62.1	0.0043	0.0032	0.151		0.0032	0.11	
ULU1	Wednesday, July 04, 2001			0.01491	0.342	0.0107	0.0398	8.32	1.23	0.0042	0.0083	0.213	24.6	0.0114	2.46	0.0029	269	0.193	127	0.0065	0.0042	0.151		0.0035	0.12	
ULU1	Thursday, August 02, 2001			0.01646	0.344	0.0110	0.0440	8.65	1.25	0.0044	0.0094	0.217	26.8	0.0120	2.74	0.0030	270	0.208	144	0.0070	0.0046	0.151		0.0037	0.13	
ULU1	Saturday, September 01, 2001			0.01716	0.345	0.0112	0.0471	8.88	1.26	0.0044	0.0099	0.219	28.5	0.0126	2.89	0.0031	270	0.217	156	0.0074	0.0049	0.151		0.0038	0.13	

Note:
[1] - Data from Klohn, 1998. Dissolved metals, not total metals.

ECHO BAY MINES LTD.
Table 9: Ulu Project - Field Column #1 Test Data

Sample Weight (kg) 15

	Sample Date	Weeks Between	Cummulative Weeks	Solids Total Suspended	Temperature of observed pH	Bicarbonate	Calcium Dissolved	Carbonate	Hardness as CaCO3	Hydroxide	Magnesium Dissolved	P-Alkalinity as CaCO3	Ca	Mg	Ca+Mg+0.5Na+0.5K	mMCa+Mg+.5Na+.5K	mMSO4	mMS
ICP-SOLIDS																		
ULU[1]	Wednesday, January 15, 1997														ppm	mM CaCO3/kg		mM S/kg
															20800	638		356
ICP-LEACHATE				mg/L	C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L			mg/L			
ULU1[1]	Wednesday, June 18, 1997	22	22															
ULU1[1]	Wednesday, August 27, 1997	10	32												924			
ULU1[1]	Friday, September 12, 1997	2.3	34.3												392			
ULU1	Saturday, June 06, 1998	38	72.3												625			
ULU1	Monday, July 13, 1998	5.3	77.6												223			
ULU1	Friday, August 21, 1998	5.5	83.1												56			
ULU1	Wednesday, September 16, 1998	3.7	86.8												52			
ULU1	Tuesday, June 15, 1999	38.5	125.3												56			
ULU1	Saturday, August 07, 1999	7.5	132.8												127			
ULU1	Wednesday, September 08, 1999	4.5	137.3												58			
ULU1	Tuesday, July 18, 2000	44.5	181.8												51			
ULU1	Tuesday, August 22, 2000	5	186.8												87			
ULU1	Sunday, September 17, 2000	4.5	191.3												241			
ULU1	Wednesday, July 04, 2001	41	232.3												189			
ULU1	Thursday, August 02, 2001	4.3	236.6												252			
ULU1	Saturday, September 01, 2001	4.3	240.9												156			
ULU1	Sunday, July 07, 2002	44	284.9		26.8	810	32.4	< 6	85.5	< 5	1.1	< 5			157			
ULU1	Friday, August 16, 2002	5.7	290.6	< 1	20.6	< 5	122	12	319	<5	3.4	<5			113			
															134			
Maximum																		
Minimum																		
ULU1 LEACH RATES													mM/kg/wk	mM/kg/wk	mg/kg/wk	mM CaCO3/kg/wk	mM SO4/kg/wk	
ULU1[1]	Wednesday, June 18, 1997																	
ULU1[1]	Wednesday, August 27, 1997												0.014	0.0033	3.9	0.16	0.004	
ULU1[1]	Friday, September 12, 1997												0.007	0.0014	1.2	0.05	0.006	
ULU1	Saturday, June 06, 1998												0.048	0.0085	7.2	0.28	0.029	
ULU1	Monday, July 13, 1998												0.009	0.0018	1.3	0.05	0.008	
ULU1	Friday, August 21, 1998												0.014	0.0014	1.1	0.04	0.019	
ULU1	Wednesday, September 16, 1998												0.020	0.0015	1.1	0.03	0.019	
ULU1	Tuesday, June 15, 1999												0.017	0.0014	0.9	0.03	0.013	
ULU1	Saturday, August 07, 1999												0.009	0.0008	0.5	0.01	0.009	
ULU1	Wednesday, September 08, 1999												0.011	0.0009	0.6	0.02	0.011	
ULU1	Tuesday, July 18, 2000												0.030	0.0019	1.5	0.04	0.027	
ULU1	Tuesday, August 22, 2000												0.003	0.0002	0.2	0.00	0.004	
ULU1	Sunday, September 17, 2000												0.051	0.0028	2.3	0.06	0.058	
ULU1	Wednesday, July 04, 2001												0.071	0.0047	3.3	0.09	0.085	
ULU1	Thursday, August 02, 2001												0.044	0.0013	1.9	0.05	0.052	
ULU1	Saturday, September 01, 2001												0.119	0.0032	5.1	0.13	0.129	
															3.2	0.08	0.086	
Maximum																		
Minimum																		
ULU1 CUMULATIVE LEACH RATES															mg/kg	mM CaCO3/kg	mM SO4/kg	mM S/kg
ULU1[1]	Wednesday, June 18, 1997																	
ULU1[1]	Wednesday, August 27, 1997														86.2	3.5	0.08	0.00
ULU1[1]	Friday, September 12, 1997														96.0	3.9	0.14	0.00
ULU1	Saturday, June 06, 1998														115	4.6	0.21	0.00
ULU1	Monday, July 13, 1998														164	6.5	0.51	0.31
ULU1	Friday, August 21, 1998														170	6.7	0.61	0.41
ULU1	Wednesday, September 16, 1998														177	6.8	0.72	0.51
ULU1	Tuesday, June 15, 1999														180	6.9	0.77	0.56
ULU1	Saturday, August 07, 1999														198	7.5	1.12	0.92
ULU1	Wednesday, September 08, 1999														203	7.6	1.20	1.00
ULU1	Tuesday, July 18, 2000														210	7.8	1.32	1.12
ULU1	Tuesday, August 22, 2000														217	8.0	1.50	1.29
ULU1	Sunday, September 17, 2000														229	8.3	1.78	1.58
ULU1	Wednesday, July 04, 2001														244	8.7	2.17	1.94
ULU1	Thursday, August 02, 2001														322	10.7	4.31	3.97
ULU1	Saturday, September 01, 2001														344	11.2	4.87	4.50
															358	11.6	5.24	4.85

S depletion rate (mM/kg/wk)	#REF!
NP depletion rate (mM CaCO3/kg/wk)	0.029
Time for total S depletion (years)	#REF!
Time for total NP depletion (years)	211

Note:
[1] - Data from Klohn, 1998. Dissolved metals, not total metals.

ECHO BAY MINES LTD.
Table 10: Ulu Project - Field Column #2 Test Data

Sample Weight (kg) 15

Sample	Sample Date	Weeks Between	Cummulative Weeks	Field pH	Field Conductivity	Field H2O Volume	Field Temp. (air)	Lab pH	Lab Conductivity	Lab Acidity	Lab T-Alkalinity as CaCO3	Lab Sulphate Dissolved	Lab Ammonium N-Dissolved	Lab Cyanide Strong Acid Dissociable
ICP-SOLIDS														
ULU[1]	Wednesday, January 15, 1997													
ICP LEACHATE					uS/cm	(L)	C		uS/cm	mg CaCO3/L	mg/L	mg/L	mg/L	mg/L
ULU2[1]	Wednesday, June 18, 1997	22	22	7.72	10100	1.650	11.3	7.59	9000	19	39	88		
ULU2[1]	Wednesday, August 27, 1997	10	32	7.62	2220	0.450	11.3	7.46	2100	9.0	23	151		
ULU2[1]	Friday, September 12, 1997	2.3	34.3			0.400		7.81	3700	21	54	209		
ULU2	Monday, July 13, 1998	43.3	77.6	7.53	374	1.230	9					130		
ULU2	Friday, August 21, 1998	5.5	83.1	7.35	243	1.630	16					74.4		
ULU2	Wednesday, September 16, 1998	3.7	86.8	7.66	827	0.950	1					239		
ULU2	Tuesday, June 15, 1999	38.5	125.3	6.8	670	2.200	8					268		
ULU2	Saturday, August 07, 1999	7.5	132.8	7.5	403	1.640	6					171		
ULU2	Wednesday, September 08, 1999	4.5	137.3	7.44	602	1.845	5					249		
ULU2	Tuesday, July 18, 2000	44.5	181.8	7.96	526	1.325	-					249		
ULU2	Tuesday, August 22, 2000	5	186.8	7.84	889	0.750	-					440		
ULU2	Sunday, September 17, 2000	4.6	191.3	7.46	928	1.800	2					480		
ULU2	Wednesday, July 04, 2001	41	232.3	6.73	906	2.975	20							
ULU2	Thursday, August 02, 2001	4.3	236.6	7.22	798	2.374	-					460		
ULU2	Saturday, September 01, 2001	4.3	240.9	7.07	532	1.415	-					308		
ULU2	Sunday, July 07, 2002	44	284.9				-	7.06	921		34	423		
ULU2	Friday, August 16, 2002	5.7	290.6				-	6.57	723		17	367	0.1	0.014
Maximum				7.96	10100							480		
Minimum				6.73	243							74		
ULU2 LEACHRATES												mg/kg/wk		
ULU2[1]	Wednesday, June 18, 1997											0.44		
ULU2[1]	Wednesday, August 27, 1997											0.45		
ULU2[1]	Friday, September 12, 1997											2.42		
ULU2	Monday, July 13, 1998											0.25		
ULU2	Friday, August 21, 1998											1.47		
ULU2	Wednesday, September 16, 1998											4.09		
ULU2	Tuesday, June 15, 1999											1.02		
ULU2	Saturday, August 07, 1999											2.49		
ULU2	Wednesday, September 08, 1999											6.81		
ULU2	Tuesday, July 18, 2000											0.49		
ULU2	Tuesday, August 22, 2000											4.40		
ULU2	Sunday, September 17, 2000											12.8		
ULU2	Wednesday, July 04, 2001													
ULU2	Thursday, August 02, 2001											16.9		
ULU2	Saturday, September 01, 2001											6.76		
Maximum												16.9		
Minimum												0.25		
ULU2 CUMULATIVE LEACHRATES												mg/kg		
ULU2[1]	Wednesday, June 18, 1997											9.68		
ULU2[1]	Wednesday, August 27, 1997											14.2		
ULU2[1]	Friday, September 12, 1997											19.8		
ULU2	Monday, July 13, 1998											30.4		
ULU2	Friday, August 21, 1998											38.5		
ULU2	Wednesday, September 16, 1998											53.7		
ULU2	Tuesday, June 15, 1999											93.0		
ULU2	Saturday, August 07, 1999											112		
ULU2	Wednesday, September 08, 1999											142		
ULU2	Tuesday, July 18, 2000											164		
ULU2	Tuesday, August 22, 2000											186		
ULU2	Sunday, September 17, 2000											244		
ULU2	Wednesday, July 04, 2001											244		
ULU2	Thursday, August 02, 2001											317		
ULU2	Saturday, September 01, 2001											345		

Sample	Sample Date	Aluminum Total	Antimony Total	Arsenic Hydride Total	Arsenic Total	Barium Total	Beryllium Total	Bismuth Total	Boron Total	Cadmium Total	Calcium Total	Chromium Total	Cobalt Total
ICP-SOLIDS													
ULU[1]	Wednesday, January 15, 1997	ppm	ppm		ppm	ppm	ppm	ppm		ppm	ppm	ppm	ppm
		15300	< 2		7780	90	< 5	< 2		< .5	10300	38	31
ICP LEACHATE		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ULU2[1]	Wednesday, June 18, 1997	< 1	0.05		0.20	< 0.01	< 0.001			0.002	135	< 0.02	< 0.02
ULU2[1]	Wednesday, August 27, 1997	< 1	0.10		0.46	< 0.01	< 0.001			< 0.001	71	< 0.02	< 0.02
ULU2[1]	Friday, September 12, 1997	< 1	0.10		0.25	< 0.01	< 0.001			< 0.001	120	< 0.02	< 0.02
ULU2	Monday, July 13, 1998	0.053	0.02		0.36	0.047	< 0.0006	< 0.008	0.024	< 0.0006	37	< 0.0009	0.0021
ULU2	Friday, August 21, 1998	0.036	0.016		0.26	0.0417	< 0.0006	< 0.008	< 0.002	< 0.0006	33.9	0.0009	< 0.0008
ULU2	Wednesday, September 16, 1998	< 0.009	0.033		0.25	0.0614	< 0.0006	< 0.008	0.019	< 0.0006	85.9	< 0.0009	0.0028
ULU2	Tuesday, June 15, 1999	< 0.009	0.012		0.14	0.0432	< 0.0006	< 0.008	0.007	< 0.0006	101	< 0.0009	0.0069
ULU2	Saturday, August 07, 1999	< 0.009	0.009		0.23	0.0537	< 0.0006	< 0.008	< 0.002	< 0.0006	89.6	< 0.0009	< 0.0008
ULU2	Wednesday, September 08, 1999	< 0.009	0.012		0.18	0.0503	< 0.0006	< 0.008	< 0.002	< 0.0006	96.9	< 0.0009	< 0.0008
ULU2	Tuesday, July 18, 2000	< 0.009	0.008		0.11	0.0427	< 0.0006	< 0.008	< 0.002	< 0.0006	102	< 0.0009	< 0.0008
ULU2	Tuesday, August 22, 2000	< 0.009	0.012		0.42	0.0599	< 0.0006	< 0.008	< 0.002	< 0.0006	180	< 0.0009	< 0.0008
ULU2	Sunday, September 17, 2000	< 0.009	0.006		0.97	0.0293	< 0.0006	< 0.008	< 0.002	< 0.0006	161	< 0.0009	< 0.0008
ULU2	Wednesday, July 04, 2001	0.621	< 0.006	0.564	0.56	0.0308	< 0.0006	< 0.008	0.016	< 0.0006	193	< 0.0009	0.0034
ULU2	Thursday, August 02, 2001	0.017	< 0.006	0.323	0.29	0.04	< 0.0006	< 0.008	0.015	< 0.0006	170	< 0.0009	0.0012
ULU2	Saturday, September 01, 2001	0.013	< 0.006	0.391	0.34	0.0288	< 0.0006	< 0.008	0.012	< 0.0006	113	< 0.0009	< 0.0008
ULU2	Sunday, July 07, 2002	0.025	0.0064		0.294	0.032	< 0.0001	< 0.0005	0.015	0.00005	187	< 0.0005	0.0013
ULU2	Friday, August 16, 2002	0.035	0.0071		0.177	0.029		< 0.0005	0.017	0.00004	134	< 0.0005	0.0007
Maximum		1	0.1	0.564	0.97	0.0614	0.001	0.008	0.024	0.002	193	0.02	0.02
Minimum		0.009	0.006	0.323	0.11	0.01	< 0.0001	< 0.0005	< 0.002	< 0.00004	34	< 0.0005	< 0.0007
ULU2 LEACHRATES		mg/kg/wk	mg/kg/wk		mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk
ULU2[1]	Wednesday, June 18, 1997	0.005	0.0003		0.0010	0.0001	0.000005			0.000010	0.676	0.00010	0.00010
ULU2[1]	Wednesday, August 27, 1997	0.003	0.0003		0.0014	0.00003	0.000003			0.000003	0.213	0.00006	0.00006
ULU2[1]	Friday, September 12, 1997	0.012	0.0012		0.0029	0.0001	0.000012			0.000012	1.391	0.00023	0.00023
ULU2	Monday, July 13, 1998	0.0001	0.00004		0.0007	0.0001	0.000001	0.00002	0.00005	0.000001	0.070	0.00000	0.000004
ULU2	Friday, August 21, 1998	0.0007	0.00032		0.0051	0.00082	0.000012	0.00016	0.00004	0.000012	0.670	0.00002	0.000016
ULU2	Wednesday, September 16, 1998	0.0002	0.00056		0.0043	0.00105	0.000010	0.00014	0.00033	0.000010	1.470	0.00002	0.000048
ULU2	Tuesday, June 15, 1999	0.00003	0.00005		0.0005	0.00016	0.000002	0.00003	0.00003	0.000002	0.386	0.00000	0.000026
ULU2	Saturday, August 07, 1999	0.0001	0.00013		0.0034	0.00078	0.000009	0.00012	0.00003	0.000009	1.016	0.00001	0.000012
ULU2	Wednesday, September 08, 1999	0.0002	0.00033		0.0049	0.00137	0.000016	0.00022	0.00005	0.000016	2.649	0.00002	0.000022
ULU2	Tuesday, July 18, 2000	0.0000	0.00002		0.0002	0.00008	0.000001	0.00002	0.00010	0.000001	0.202	0.00000	0.000002
ULU2	Tuesday, August 22, 2000	0.0001	0.00012		0.0042	0.00060	0.000006	0.00008	0.00002	0.000006	1.800	0.00001	0.000008
ULU2	Sunday, September 17, 2000	0.0002	0.00015		0.026	0.00078	0.000016	0.00021	0.00005	0.000016	4.827	0.00002	0.000021
ULU2	Wednesday, July 04, 2001	0.0030	0.00003	0.0027	0.0027	0.00015	0.000003	0.00004	0.00008	0.000003	0.934	0.00000	0.000016
ULU2	Thursday, August 02, 2001	0.0006	0.00022	0.0119	0.011	0.00147	0.000022	0.00029	0.00055	0.000022	6.257	0.00003	0.000044
ULU2	Saturday, September 01, 2001	0.0003	0.00013	0.0088	0.0075	0.00063	0.000013	0.00018	0.00026	0.000013	2.479	0.00002	0.000018
Maximum		0.0116	0.0012	0.0119	0.026	0.00147	0.00002	0.00029	0.00055	0.00002	6.26	0.00023	0.00023
Minimum		0.00002	0.00002	0.0027	0.0002	0.00003	< 0.000001	< 0.00002	< 0.000004	< 0.000001	0.07	< 0.000002	< 0.000002
ULU2 CUMULATIVE LEACHRATES		mg/kg	mg/kg		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
ULU2[1]	Wednesday, June 18, 1997	0.110	0.006		0.022	0.001	0.00011			0.00022	14.8	0.0022	0.0022
ULU2[1]	Wednesday, August 27, 1997	0.140	0.009		0.036	0.001	0.00014			0.00025	17.0	0.0028	0.0028
ULU2[1]	Friday, September 12, 1997	0.167	0.011		0.042	0.002	0.00017			0.00028	20.2	0.0033	0.0033
ULU2	Monday, July 13, 1998	0.171	0.013		0.072	0.006	0.00022	0.0007	0.0020	0.00033	23.2	0.0034	0.0035
ULU2	Friday, August 21, 1998	0.175	0.015		0.100	0.010	0.00028	0.0015	0.0022	0.00039	26.9	0.0035	0.0036
ULU2	Wednesday, September 16, 1998	0.175	0.017		0.116	0.014	0.00032	0.0020	0.0034	0.00043	32.3	0.0035	0.0038
ULU2	Tuesday, June 15, 1999	0.177	0.018		0.136	0.020	0.00041	0.0032	0.0044	0.00052	47.2	0.0037	0.0048
ULU2	Saturday, August 07, 1999	0.178	0.019		0.161	0.026	0.00047	0.0041	0.0046	0.00058	54.8	0.0038	0.0049
ULU2	Wednesday, September 08, 1999	0.179	0.021		0.184	0.032	0.00055	0.0051	0.0049	0.00066	66.7	0.0039	0.0050
ULU2	Tuesday, July 18, 2000	0.180	0.022		0.193	0.036	0.00060	0.0056	0.0051	0.00071	75.7	0.0040	0.0050
ULU2	Tuesday, August 22, 2000	0.180	0.022		0.214	0.039	0.00063	0.0062	0.0052	0.00074	84.7	0.0040	0.0051
ULU2	Sunday, September 17, 2000	0.181	0.023		0.331	0.043	0.00070	0.0071	0.0054	0.00081	106	0.0041	0.0052
ULU2	Wednesday, July 04, 2001	0.304	0.024		0.442	0.049	0.00082	0.0087	0.0086	0.00093	145	0.0043	0.0058
ULU2	Thursday, August 02, 2001	0.307	0.025		0.488	0.055	0.00092	0.0100	0.0109	0.00103	172	0.0045	0.0060
ULU2	Saturday, September 01, 2001	0.308	0.026		0.520	0.058	0.00097	0.0107	0.0121	0.00108	182	0.0045	0.0061

Note:
1 - Data from Klohn, 1998. Dissolved metals, not total metals.

ECHO BAY MINES LTD.
Table 10: Ulu Project - Field Column #2 Test Data

Sample Weight (kg) 15

	Sample Date	Weeks Between	Cummulative Weeks	Copper Total	Iron Total	Lead Total	Lithium Total	Magnesium Total	Manganese Total	Molybdenum Total	Nickel Total	Phosphorus Total	Potassium Total	Selenium Total	Silicon Total	Silver Total	Sodium Total	Strontium Total	Sulphur Total	Thallium Total	Tin Total	Titanium Total	Uranium Total	Vanadium Total	Zinc Total	Zirconium Total
ICP-SOLIDS				ppm	ppm	ppm		ppm	ppm	ppm	ppm	ppm	ppm			ppm	ppm	ppm	ppm			ppm	ppm	ppm	ppm	
ULU[1]	Wednesday, January 15, 1997			60	47100	2		6800	395	1	11	690	6700			< 0.2	700	8	11400			0.14	10	119	86	
ICP-LEACHATE				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ULU2[1]	Wednesday, June 18, 1997	22	22	< 0.01	< 1	< 0.05		20	4.9	< 0.01	< 0.01	< 1	45			< 0.01	1630	0.42				< 1		< 0.01	0.04	
ULU2[1]	Wednesday, August 27, 1997	10	32	< 0.01	< 1	< 0.05		8.0	1.55	< 0.01	< 0.01	< 1	15			< 0.01	360	0.11				< 1		< 0.01	0.01	
ULU2[1]	Friday, September 12, 1997	2.3	34.3	< 0.01	< 1	< 0.05		15.0	3.3	< 0.01	< 0.01	< 1	20			< 0.01	660	0.21				< 1		< 0.01	0.03	
ULU2	Monday, July 13, 1998	43.3	77.6	0.031	0.055	< 0.002	0.025	2.23	0.393	0.003	0.003	< 0.03	7.7	< 0.004	1.67	< 0.001	43.9	0.0484	44.6	< 0.004	< 0.003	0.0016		0.002	0.0299	
ULU2	Friday, August 21, 1998	5.5	83.1	0.024	0.016	< 0.002	0.017	1.68	0.0037	< 0.001	0.002	< 0.03	5.5	< 0.004	0.768	< 0.001	16.6	0.0382	25.1	< 0.004	< 0.003	< 0.0004		0.002	0.0207	
ULU2	Wednesday, September 16, 1998	3.7	86.8	0.026	0.034	0.003	0.047	4.48	0.45	0.003	0.007	< 0.03	18.5	< 0.004	2.18	< 0.001	57.7	0.0927	82.8	0.005	< 0.003	< 0.0004		0.001	0.0439	
ULU2	Tuesday, June 15, 1999	38.5	125.3	0.042	0.015	< 0.002	0.034	5.14	0.962	0.001	0.006	< 0.03	16.4	0.016	1.22	< 0.001	49.9	0.105	93.4	< 0.004	< 0.003	< 0.0004		< 0.001	0.0438	
ULU2	Saturday, August 07, 1999	7.5	132.8	0.023	0.013	< 0.002	0.026	2.7	0.0369	0.005	0.003	< 0.03	13.7	< 0.004	1.51	< 0.001	13.7	0.0639	55.3	< 0.004	< 0.003	< 0.0004		0.002	0.0244	
ULU2	Wednesday, September 08, 1999	4.5	137.3	0.014	0.024	0.003	0.026	3.12	0.004	< 0.001	0.003	< 0.03	15.8	< 0.004	1.54	< 0.001	13	0.0803	78.4	0.006	< 0.003	< 0.0004		< 0.001	0.0216	
ULU2	Tuesday, July 18, 2000	44.5	181.8	0.016	0.014	< 0.002	0.02	3.39	0.0014	< 0.001	0.002	< 0.03	15.1	< 0.004	1.32	< 0.001	13.4	0.0822	82	< 0.004	< 0.003	< 0.0004		0.001	0.0137	
ULU2	Tuesday, August 22, 2000	5	186.8	0.022	0.013	< 0.002	0.02	4.22	0.0054	0.001	0.005	< 0.03	17.7	< 0.004	1.42	< 0.001	7.9	0.118	151	< 0.004	< 0.003	< 0.0004		0.001	0.0176	
ULU2	Sunday, September 17, 2000	4.5	191.3	0.019	0.022	< 0.002	0.023	4.57	0.0056	0.002	0.005	< 0.03	18.8	< 0.004	1.53	< 0.001	9.8	0.116	153	0.005	< 0.003	< 0.0004		0.002	0.0146	
ULU2	Wednesday, July 04, 2001	41	232.3	0.015	0.035	< 0.002	0.026	4.22	0.249	< 0.001	0.007	0.22	19.5	< 0.004	1.84	< 0.001	5.9	0.138	166	< 0.004	< 0.003	< 0.0004		< 0.001	0.0187	
ULU2	Thursday, August 02, 2001	4.3	236.6	0.013	0.01	< 0.002	0.03	2.63	0.0556	< 0.001	0.007	< 0.03	19	0.01	1.98	< 0.001	3	0.119	147	< 0.004	< 0.003	< 0.0004		< 0.001	0.0198	
ULU2	Saturday, September 01, 2001	4.3	240.9	0.008	0.008	< 0.002	0.024	1.63	0.007	< 0.001	0.003	< 0.03	16.1	< 0.004	1.52	< 0.001	1.8	0.0793	94.5	< 0.004	< 0.003	< 0.0004		< 0.001	0.0146	
ULU2	Sunday, July 07, 2002	44	284.9	0.019	0.24	0.0014	0.024	3.39	0.0065	< 0.001	0.0027		21.2	0.0009	1.89	< 0.0001	4.3	0.121	145	< 0.00005		0.0048	< 0.0005	0.0004	0.013	< 0.001
ULU2	Friday, August 16, 2002	5.7	290.6	0.01	0.2	0.0002	0.023	2.2	0.018	0.002	0.0021		14.8	< 0.0002	1.63	< 0.0001	2.3	0.107	114	< 0.00005		0.0046	< <0.0005	0.0003	0.009	< 0.001
Maximum				0.042	1	0.05	0.047	20	4.9	0.01	0.01	1	45	0.016	2.18	< 0.01	1630	0.42	166	0.006	0.003	1		0.01	0.0439	
Minimum				0.01	0.008	0.0002	0.017	1.63	0.001	< 0.001	0.002	< 0.03	5.5	0.0002	0.77	< 0.0001	2	0.038	25	< 0.00005	< 0.003	< 0.0004		< 0.0003	0.0090	
ULU2 LEACHRATES				mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk	mg/kg/wk		mg/kg/wk	mg/kg/wk	
ULU2[1]	Wednesday, June 18, 1997			0.00005	0.005	0.00025		0.10	0.025	0.00005	0.0001	0.005	0.23			0.00005	8.15	0.002				0.005		0.00005	0.0002	
ULU2[1]	Wednesday, August 27, 1997			0.00003	0.003	0.00015		0.02	0.005	0.00003	0.0000	0.003	0.05			0.00003	1.08	0.000				0.003		0.00003	0.00003	
ULU2[1]	Friday, September 12, 1997			0.00012	0.012	0.00058		0.17	0.038	0.00012	0.0001	0.012	0.23			0.00012	7.65	0.002				0.012		0.00012	0.00035	
ULU2	Monday, July 13, 1998			0.00006	0.0001	0.00000	0.00005	0.00	0.0007	0.00001	0.0000	0.0001	0.01	0.00001	0.003	0.000002	0.08	0.0001	0.084	0.00001	0.00001	0.0000		0.000004	0.0001	
ULU2	Friday, August 21, 1998			0.00047	0.00032	0.00004	0.0003	0.03	0.0001	0.000020	0.0000	0.0006	0.11	0.00008	0.015	0.00002	0.33	0.0008	0.50	0.00008	0.00008	0.000008		0.000040	0.0004	
ULU2	Wednesday, September 16, 1998			0.00045	0.00058	0.00005	0.0008	0.08	0.0077	0.000051	0.0001	0.0005	0.32	0.00007	0.037	0.00002	0.99	0.0016	1.42	0.00009	0.00005	0.000007		0.000017	0.0008	
ULU2	Tuesday, June 15, 1999			0.00018	0.00006	0.00001	0.0001	0.02	0.0037	0.000004	0.0000	0.0001	0.06	0.00006	0.005	0.00000	0.19	0.0004	0.36	0.00002	0.00001	0.000002		0.000004	0.0002	
ULU2	Saturday, August 07, 1999			0.00034	0.00019	0.00003	0.0004	0.04	0.0005	0.000044	0.0000	0.0004	0.20	0.00006	0.022	0.00001	0.20	0.0009	0.81	0.00006	0.00004	0.000006		0.000029	0.0004	
ULU2	Wednesday, September 08, 1999			0.00038	0.00066	0.00008	0.0007	0.09	0.0001	0.000027	0.0001	0.0008	0.43	0.00011	0.042	0.00003	0.36	0.0022	2.14	0.00015	0.00008	0.000011		0.000027	0.0008	
ULU2	Tuesday, July 18, 2000			0.00003	0.00003	0.00000	0.0000	0.01	0.0000	0.000002	0.0000	0.0001	0.03	0.00001	0.003	0.00000	0.03	0.0002	0.16	0.00001	0.00001	0.000001		0.000002	0.00003	
ULU2	Tuesday, August 22, 2000			0.00022	0.00013	0.00002	0.0002	0.04	0.0001	0.000010	0.0001	0.0003	0.18	0.00004	0.014	0.00001	0.08	0.0012	1.51	0.00004	0.00003	0.000004		0.000010	0.0002	
ULU2	Sunday, September 17, 2000			0.00051	0.00059	0.00005	0.0006	0.12	0.0001	0.000053	0.0001	0.0008	0.50	0.00011	0.041	0.00003	0.26	0.0031	4.08	0.00013	0.00008	0.000011		0.000053	0.0004	
ULU2	Wednesday, July 04, 2001			0.00007	0.00017	0.00001	0.0001	0.02	0.0012	0.000005	0.0000	0.0011	0.09	0.00002	0.009	0.00000	0.03	0.0007	0.80	0.00002	0.00001	0.000002		0.000005	0.0001	
ULU2	Thursday, August 02, 2001			0.00048	0.00037	0.00007	0.0011	0.10	0.0020	0.000037	0.0003	0.0011	0.70	0.00037	0.073	0.00004	0.11	0.0044	5.41	0.00015	0.00011	0.000015		0.000037	0.0007	
ULU2	Saturday, September 01, 2001			0.00018	0.00018	0.00004	0.0005	0.04	0.0002	0.000022	0.0001	0.0007	0.35	0.00009	0.033	0.00002	0.04	0.0017	2.07	0.00009	0.00007	0.000009		0.000022	0.0003	
Maximum				0.00051	0.0116	0.00057971	0.0011	0.174	0.038	0.00012	0.0003	0.012	0.70	0.00037	0.0729	< 0.00012	8.15	0.0044	5.41	0.00016	0.0001	0.01		0.0001	0.0008	
Minimum				0.00003	0.00003	0.000004	0.00004	0.004	0.000003	< 0.000002	0.000	< 0.0001	0.01	0.00001	0.0026	< 0.000002	0.0266	0.0001	0.08	< 0.000008	< 0.00001	< 0.000001		< 0.000002	0.00003	
ULU2 CUMULATIVE LEACHRATES				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg		mg/kg	mg/kg	
ULU2[1]	Wednesday, June 18, 1997			0.001	0.110	0.0055		2.20	0.54	0.0011	0.0011	0.110	4.95			0.0011	179.3	0.046				0.110		0.0011	0.004	
ULU2[1]	Wednesday, August 27, 1997			0.001	0.140	0.0070		2.44	0.59	0.0014	0.0014	0.140	5.40			0.0014	190.1	0.050				0.140		0.0014	0.005	
ULU2[1]	Friday, September 12, 1997			0.002	0.167	0.0083		2.64	0.67	0.0017	0.0017	0.167	5.93			0.0017	207.7	0.055				0.167		0.0017	0.008	
ULU2	Monday, July 13, 1998			0.004	0.171	0.0085	0.0021	3.02	0.71	0.0018	0.0019	0.168	6.56	0.0003	0.129	0.0017	211.3	0.059	3.65	0.0003	0.0002	0.167		0.0018	0.008	
ULU2	Friday, August 21, 1998			0.007	0.173	0.0087	0.0039	3.21	0.71	0.0020	0.0021	0.172	7.16	0.0008	0.212	0.0019	213.1	0.063	6.38	0.0008	0.0006	0.167		0.0020	0.010	
ULU2	Wednesday, September 16, 1998			0.008	0.175	0.0089	0.0069	3.49	0.73	0.0022	0.0026	0.174	8.33	0.0010	0.350	0.0019	216.8	0.069	11.6	0.0011	0.0008	0.167		0.0021	0.013	
ULU2	Tuesday, June 15, 1999			0.015	0.177	0.0092	0.0119	4.24	0.86	0.0024	0.0036	0.179	10.7	0.0034	0.529	0.0021	224.1	0.084	25.3	0.0017	0.0012	0.167		0.0023	0.019	
ULU2	Saturday, August 07, 1999			0.017	0.179	0.0094	0.0147	4.54	0.88	0.0027	0.0038	0.182	12.2	0.0038	0.694	0.0022	225.6	0.091	31.4	0.0021	0.0015	0.167		0.0025	0.022	
ULU2	Wednesday, September 08, 1999			0.019	0.182	0.0098	0.0179	4.92	0.88	0.0028	0.0042	0.186	14.2	0.0043	0.884	0.0023	227.2	0.101	41.0	0.0026	0.0019	0.167		0.0026	0.025	
ULU2	Tuesday, July 18, 2000			0.020	0.183	0.0100	0.0197	5.22	0.88	0.0029	0.0043	0.188	15.5	0.0046	1.00	0.0024	228.4	0.109	48.3	0.0032	0.0022	0.167		0.0027	0.026	
ULU2	Tuesday, August 22, 2000			0.021	0.184	0.0101	0.0207	5.43	0.88	0.0029	0.0046	0.190	16.4	0.0048	1.07	0.0024	228.8	0.115	55.8	0.0034	0.0023	0.167		0.0027	0.027	
ULU2	Sunday, September 17, 2000			0.024	0.186	0.0103	0.0234	5.98	0.88	0.0032	0.0052	0.193	18.7	0.0053	1.25	0.0026	229.9	0.128	74.2	0.0040	0.0027	0.167		0.0030	0.029	
ULU2	Wednesday, July 04, 2001			0.027	0.193	0.0107	0.0286	6.82	0.93	0.0034	0.0066	0.237	22.5	0.0061	1.82	0.0028	231.1	0.156	107	0.0048	0.0033	0.167		0.0032	0.032	
ULU2	Thursday, August 02, 2001			0.029	0.195	0.0110	0.0333	7.23	0.94	0.0035	0.0077	0.242	25.5	0.0077	1.93	0.0029	231.6	0.175	130	0.0054	0.0037	0.167		0.0033	0.035	
ULU2	Saturday, September 01, 2001			0.029	0.195	0.0112	0.0356	7.39	0.94	0.0036	0.0080	0.245	27.0	0.0081	2.08	0.0030	231.7	0.182	139	0.0058	0.0040	0.167		0.0034	0.037	

Note:
[1] - Data from Klohn, 1998. Dissolved metals, not total metals.

ECHO BAY MINES LTD.
Table 10: Ulu Project - Field Column #2 Test Data

Sample Weight (kg) 15

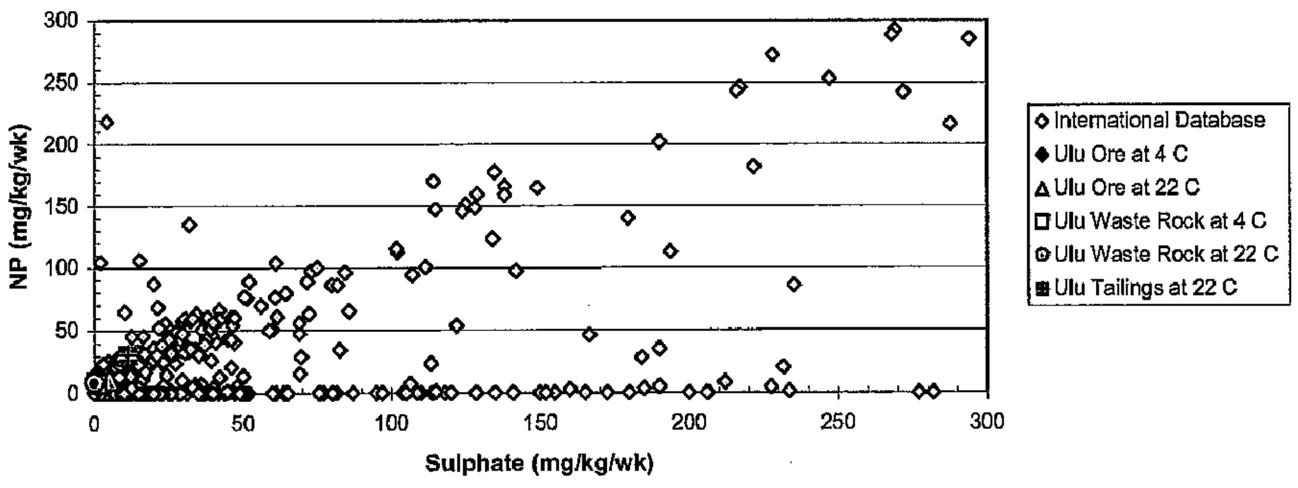
	Sample Date	Weeks Between	Cummulative Weeks		Solids Total Suspended	Temperature of observed pH	Bicarbonate	Calcium Dissolved		Carbonate	Hardness as CaCO3		Hydroxide	Magnesium Dissolved		P-Alkalinity as CaCO3	Ca	Mg	Ca+Mg+0.5Na+0.5K	mMCa+Mg+.5Na+.5K	mMSO4	mMS
ICP-SOLIDS																						
ULU[1]	Wednesday, January 15, 1997																					
																			ppm	mM CaCO3/kg		mM S/kg
																			20800	636		356
ICP-LEACHATE					mg/L	C	mg/L	mg/L		mg/L	mg/L		mg/L	mg/L		mg/L			mg/L			
ULU2[1]	Wednesday, June 18, 1997	22	22																			
ULU2[1]	Wednesday, August 27, 1997	10	32																993			
ULU2[1]	Friday, September 12, 1997	2.3	34.3																267			
ULU2	Monday, July 13, 1998	43.3	77.6																475			
ULU2	Friday, August 21, 1998	5.5	83.1																65			
ULU2	Wednesday, September 16, 1998	3.7	86.8																47			
ULU2	Tuesday, June 15, 1999	38.5	125.3																128			
ULU2	Saturday, August 07, 1999	7.5	132.8																139			
ULU2	Wednesday, September 08, 1999	4.5	137.3																83			
ULU2	Tuesday, July 18, 2000	44.5	181.8																114			
ULU2	Tuesday, August 22, 2000	5	186.8																120			
ULU2	Sunday, September 17, 2000	4.5	191.3																197			
ULU2	Wednesday, July 04, 2001	41	232.3																200			
ULU2	Thursday, August 02, 2001	4.3	236.6																210			
ULU2	Saturday, September 01, 2001	4.3	240.9																184			
ULU2	Sunday, July 07, 2002	44	284.9			25.8	42	190	<	6	469	<	5	3.37	<	5			124			
ULU2	Friday, August 16, 2002	5.7	290.6	<	1	20.6	21	140	<	6	360	<	5	2.4	<	5			203			
																			145			
Maximum																						
Minimum																						
ULU2 LEACHRATES																	mM/kg/wk	mM/kg/wk	mg/kg/wk	mM CaCO3/kg/wk	mM SO4/kg/wk	
ULU2[1]	Wednesday, June 18, 1997																					
ULU2[1]	Wednesday, August 27, 1997																0.017	0.0041	5.0	0.20	0.005	
ULU2[1]	Friday, September 12, 1997																0.005	0.0010	0.8	0.03	0.005	
ULU2	Monday, July 13, 1998																0.035	0.0072	5.5	0.21	0.025	
ULU2	Friday, August 21, 1998																0.002	0.0002	0.1	0.00	0.003	
ULU2	Wednesday, September 16, 1998																0.017	0.0014	0.9	0.03	0.015	
ULU2	Tuesday, June 15, 1999																0.037	0.0032	2.2	0.07	0.043	
ULU2	Saturday, August 07, 1999																0.010	0.0008	0.6	0.02	0.011	
ULU2	Wednesday, September 08, 1999																0.025	0.0016	1.3	0.03	0.026	
ULU2	Tuesday, July 18, 2000																0.066	0.0035	3.1	0.08	0.071	
ULU2	Tuesday, August 22, 2000																0.005	0.0009	0.2	0.01	0.005	
ULU2	Sunday, September 17, 2000																0.045	0.0017	2.0	0.05	0.046	
ULU2	Wednesday, July 04, 2001																0.120	0.0050	5.3	0.14	0.133	
ULU2	Thursday, August 02, 2001																0.023	0.0008	1.0	0.03	0.000	
ULU2	Saturday, September 01, 2001																0.156	0.0040	6.8	0.17	0.176	
																	0.062	0.0015	2.7	0.07	0.070	
Maximum																						
Minimum																						
ULU2 CUMULATIVE LEACHRATES																			mg/kg	mM CaCO3/kg	mM SO4/kg	mM S/kg
ULU2[1]	Wednesday, June 18, 1997																					
ULU2[1]	Wednesday, August 27, 1997																		109	4.4	0.10	0.00
ULU2[1]	Friday, September 12, 1997																		117	4.7	0.15	0.00
ULU2	Monday, July 13, 1998																		130	5.2	0.21	0.00
ULU2	Friday, August 21, 1998																		135	5.4	0.32	0.11
ULU2	Wednesday, September 16, 1998																		140	5.5	0.40	0.20
ULU2	Tuesday, June 15, 1999																		148	5.8	0.56	0.36
ULU2	Saturday, August 07, 1999																		169	6.4	0.97	0.79
ULU2	Wednesday, September 08, 1999																		178	6.6	1.16	0.98
ULU2	Tuesday, July 18, 2000																		192	7.0	1.46	1.28
ULU2	Tuesday, August 22, 2000																		203	7.3	1.71	1.51
ULU2	Sunday, September 17, 2000																		213	7.5	1.94	1.74
ULU2	Wednesday, July 04, 2001																		237	8.1	2.54	2.31
ULU2	Thursday, August 02, 2001																		278	9.2	2.64	3.34
ULU2	Saturday, September 01, 2001																		307	9.9	3.30	4.07
																			319	10.2	3.60	4.34

Note:
[1] - Data from Klohn, 1998. Dissolved metals, not total metals.

S depletion rate (mM/kg/wk)	0.015
NP depletion rate (mM CaCO3/kg/wk)	0.030
Time for total S depletion (years)	450
Time for total NP depletion (years)	207

FIGURES

Figure 1: Ulu Results Compared to International Humidity Cell Database



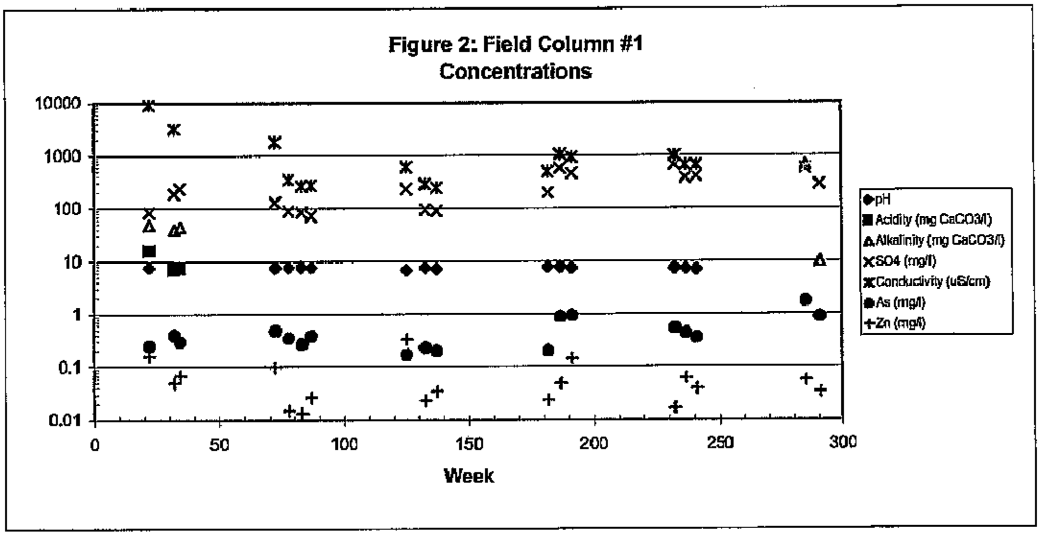


Figure 2: Field Column #1
Concentrations
10000
1000
100
10
1
0.1
0.01
0
50
100
150
200
250
300
Week
pH
Acidity (mg CaCO3/l)
Alkalinity (mg CaCO3/l)
SO4 (mg/l)
Conductivity (uS/cm)
As (mg/l)
Zn (mg/l)

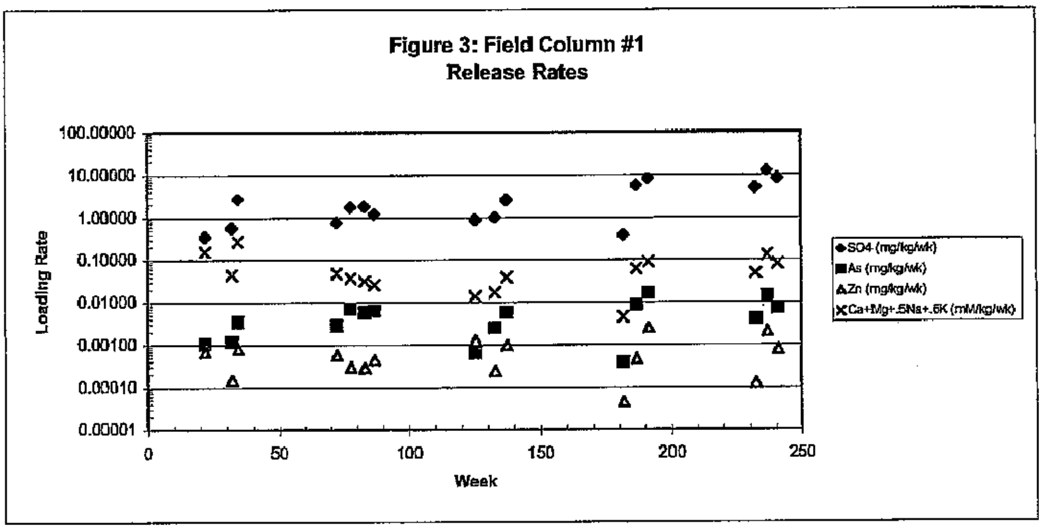


Figure 3: Field Column #1
Release Rates
Loading Rate
100.00000
10.00000
1.00000
0.10000
0.01000
0.00100
0.00010
0.00001
0
50
100
150
200
250
Week
SO4 (mg/kg/wk)
As (mg/kg/wk)
Zn (mg/kg/wk)
Ca+Mg+.5Na+.5K (mM/kg/wk)

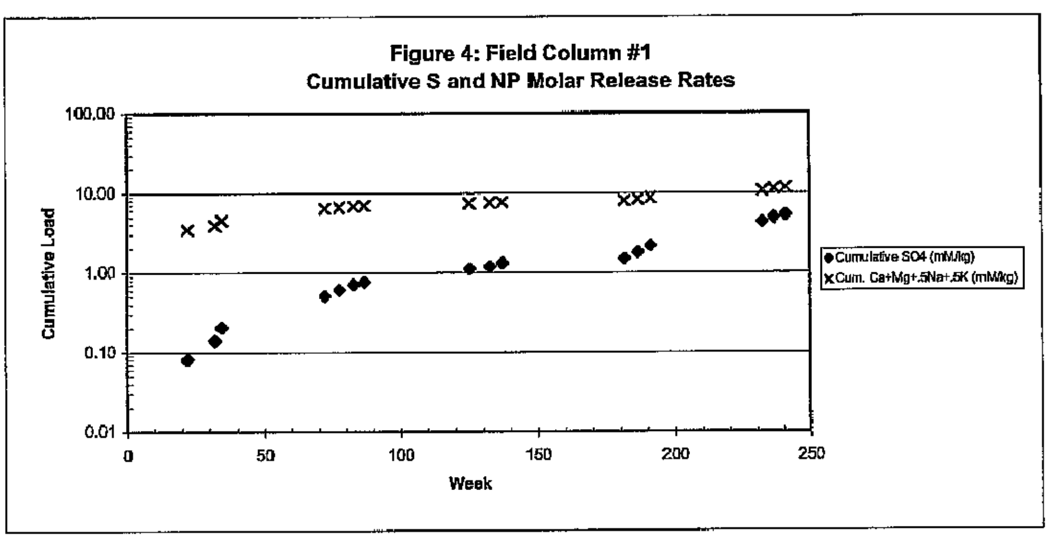


Figure 4: Field Column #1
Cumulative S and NP Molar Release Rates
Cumulative Load
100.00
10.00
1.00
0.10
0.01
0
50
100
150
200
250
Week
Cumulative SO4 (mM/kg)
Cum. Ca+Mg+.5Na+.5K (mM/kg)

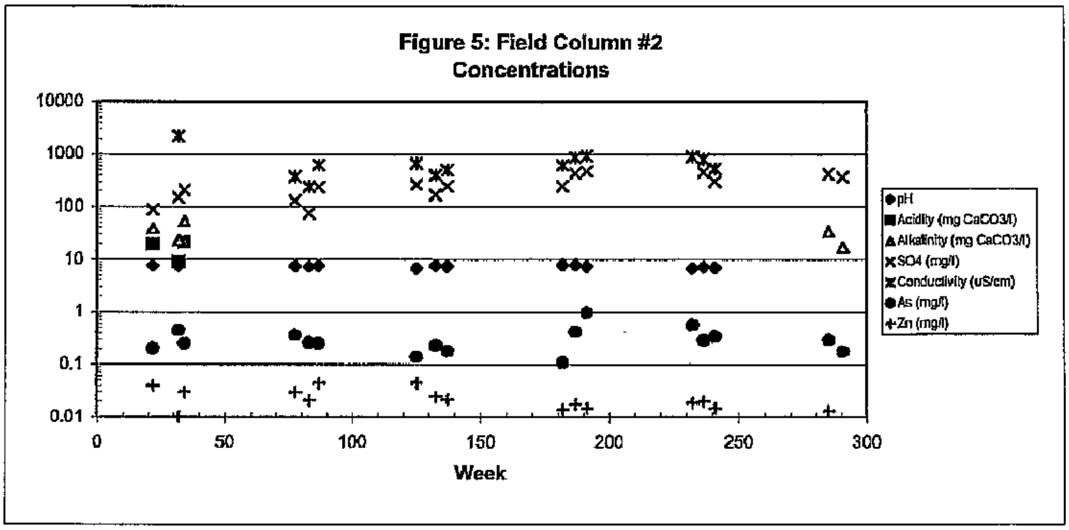


Figure 5: Field Column #2
Concentrations
10000
1000
100
10
1
0.1
0.01
0
50
100
150
200
250
300
Week
pH
Acidity (mg CaCO3/l)
Alkalinity (mg CaCO3/l)
SO4 (mg/l)
Conductivity (uS/cm)
As (mg/l)
Zn (mg/l)

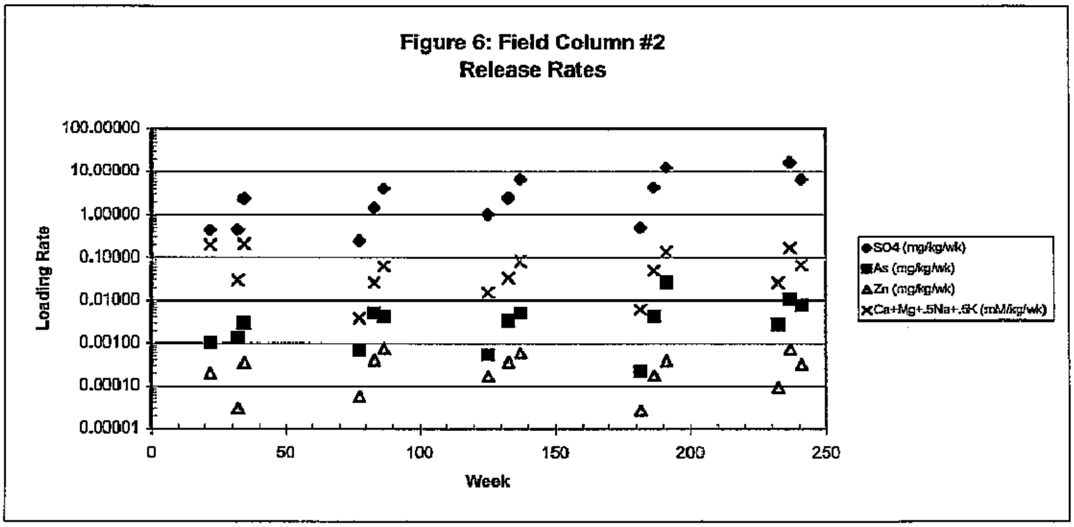


Figure 6: Field Column #2
Release Rates
100.00000
10.00000
1.00000
0.10000
0.01000
0.00100
0.00010
0.00001
Loading Rate
0
50
100
150
200
250
Week
SO4 (mg/kg/wk)
As (mg/kg/wk)
Zn (mg/kg/wk)
Ca+Mg+.5Na+.5K (mM/kg/wk)

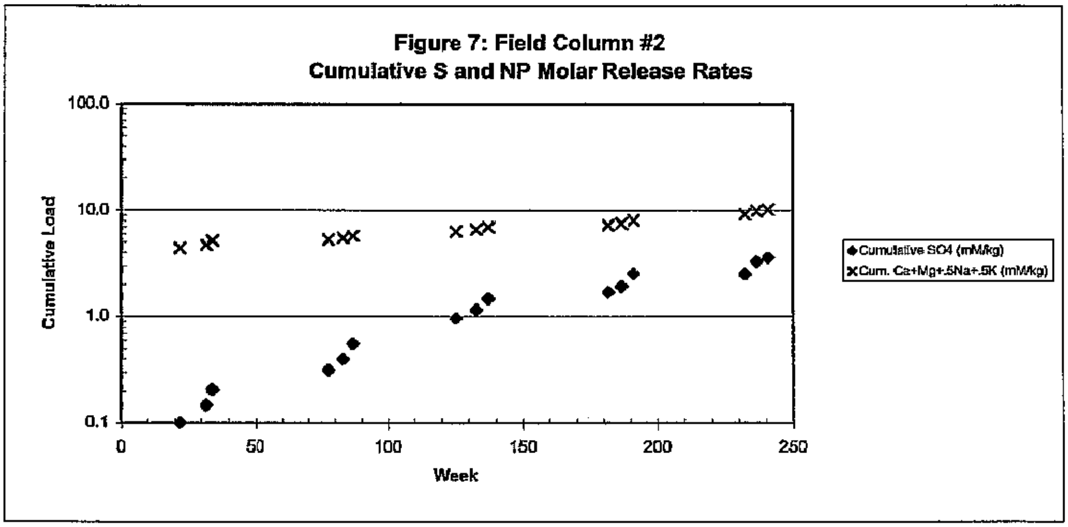


Figure 7: Field Column #2
Cumulative S and NP Molar Release Rates
100.0
10.0
1.0
0.1
Cumulative Load
0
50
100
150
200
250
Week
Cumulative SO4 (mM/kg)
Cum. Ca+Mg+.5Na+.5K (mM/kg)

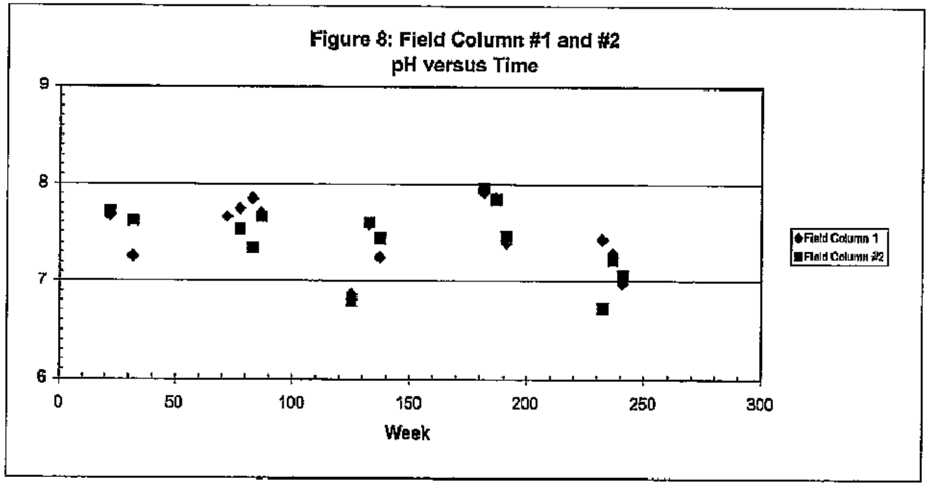


Figure 8: Field Column #1 and #2
pH versus Time
9
8
7
6
0
50
100
150
200
250
300
Week
Field Column 1
Field Column #2

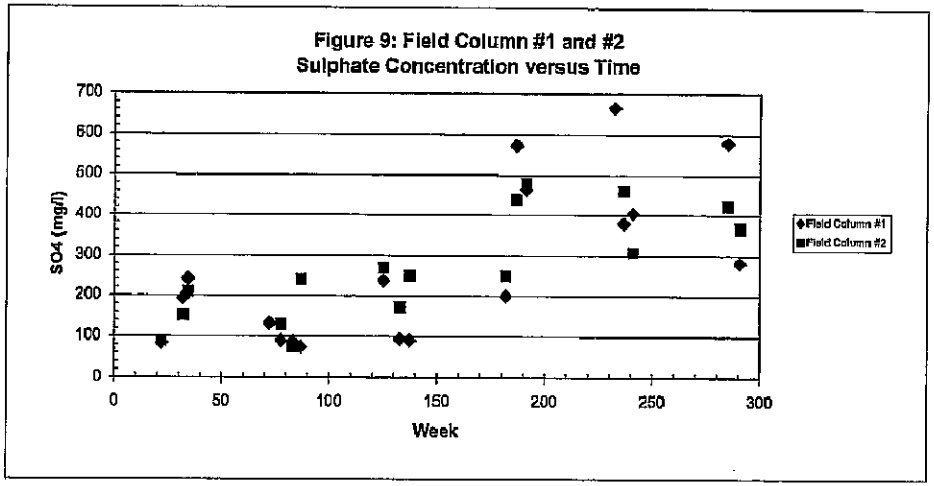


Figure 9: Field Column #1 and #2
Sulphate Concentration versus Time
SO4 (mg/l)
700
600
500
400
300
200
100
0
0
50
100
150
200
250
300
Week
Field Column #1
Field Column #2

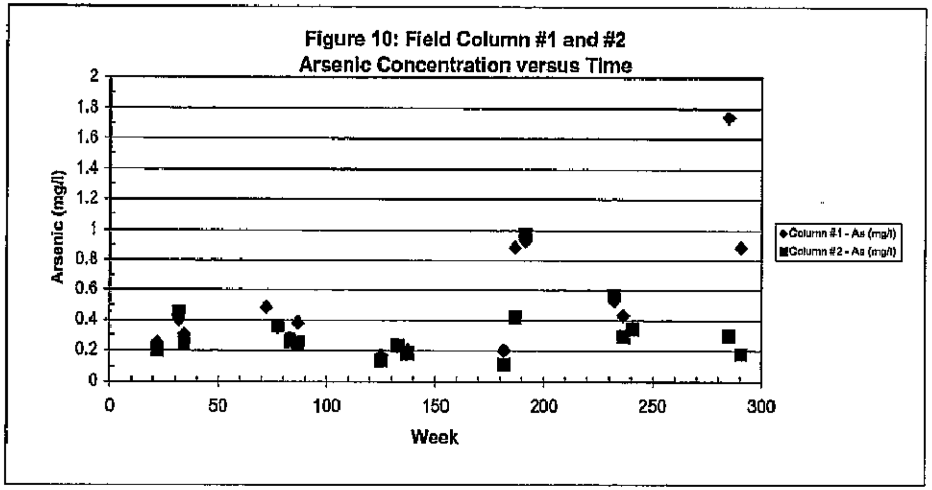


Figure 10: Field Column #1 and #2
Arsenic Concentration versus Time
Arsenic (mg/l)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
300
Week
Column #1 - As (mg/l)
Column #2 - As (mg/l)

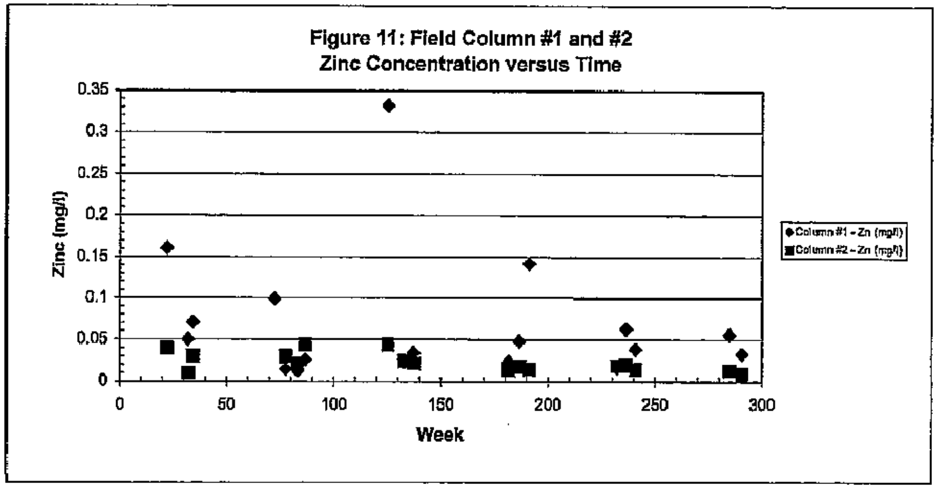


Figure 11: Field Column #1 and #2
Zinc Concentration versus Time
Zinc (mg/l)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150
200
250
300
Week
Column #1 - Zn (mg/l)
Column #2 - Zn (mg/l)

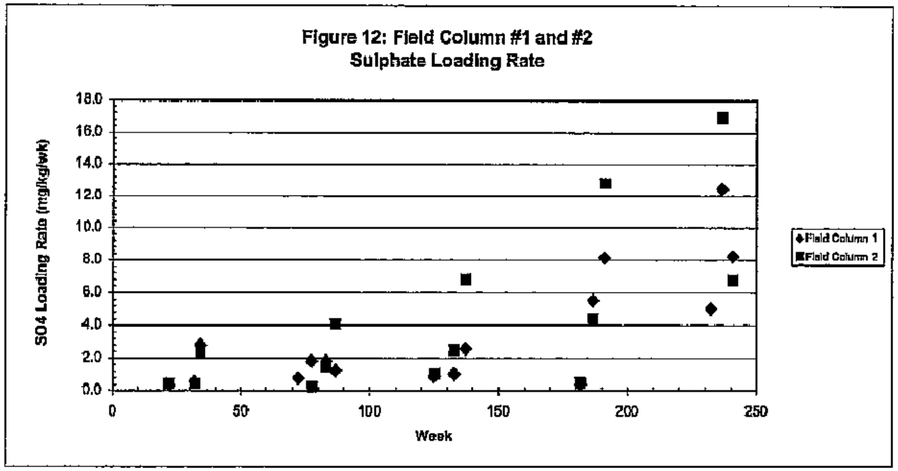


Figure 12: Field Column #1 and #2
Sulphate Loading Rate
SO4 Loading Rate (mg/kg/wk)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
50
100
150
200
250
Week
Field Column 1
Field Column 2

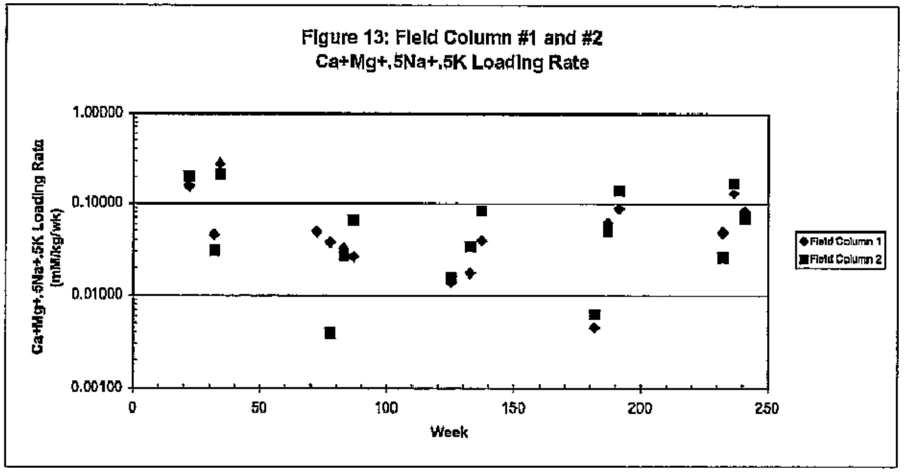


Figure 13: Field Column #1 and #2
Ca+Mg+.5Na+.5K Loading Rate
Ca+Mg+.5Na+.5K Loading Rate (mM/kg/wk)
1.00000
0.10000
0.01000
0.00100
0
50
100
150
200
250
Week
Field Column 1
Field Column 2

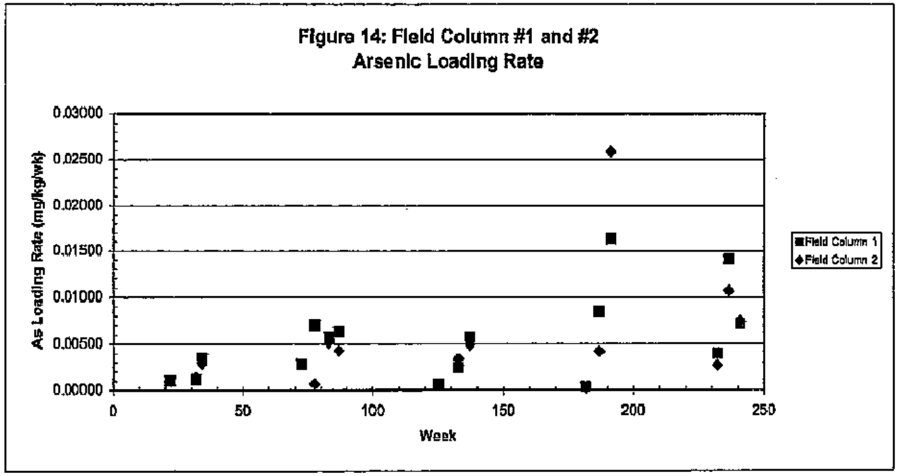


Figure 14: Field Column #1 and #2
Arsenic Loading Rate
As Loading Rate (mg/kg/wk)
0.03000
0.02500
0.02000
0.01500
0.01000
0.00500
0.00000
0
50
100
150
200
250
Week
Field Column 1
Field Column 2

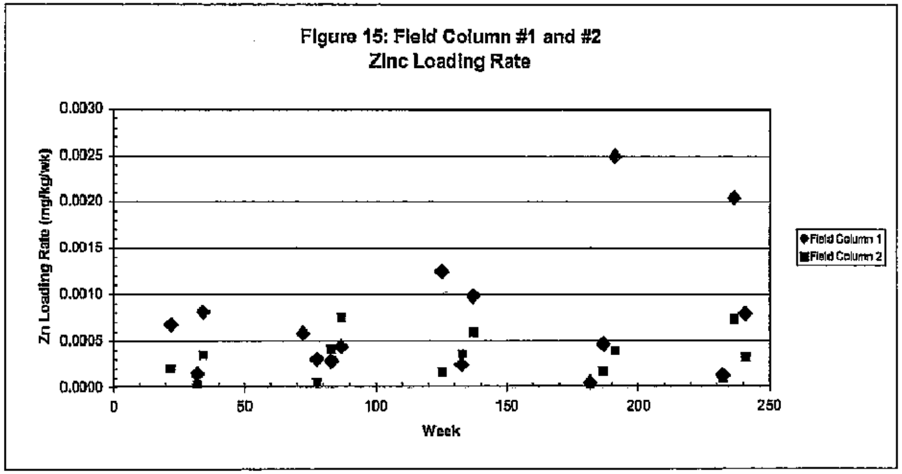


Figure 15: Field Column #1 and #2
Zinc Loading Rate
Zn Loading Rate (mg/kg/wk)
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
0
50
100
150
200
250
Week
Field Column 1
Field Column 2

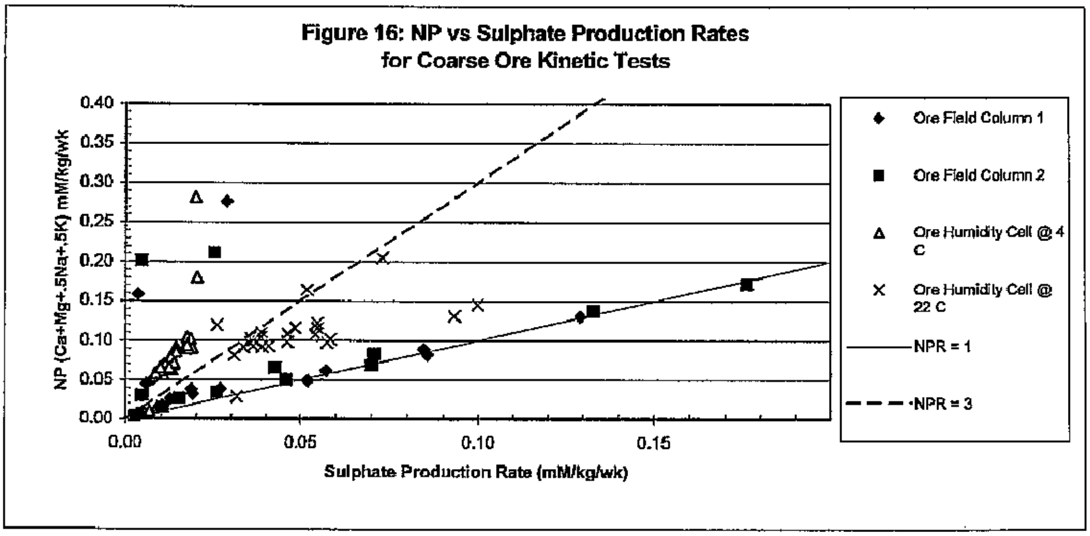


Figure 16: NP vs Sulphate Production Rates
for Coarse Ore Kinetic Tests
NP (Ca+Mg+.5Na+.5K) mM/kg/wk
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.00
0.05
0.10
0.15
Sulphate Production Rate (mM/kg/wk)
Ore Field Column 1
Ore Field Column 2
Ore Humidity Cell @ 4 C
Ore Humidity Cell @ 22 C
NPR = 1
NPR = 3

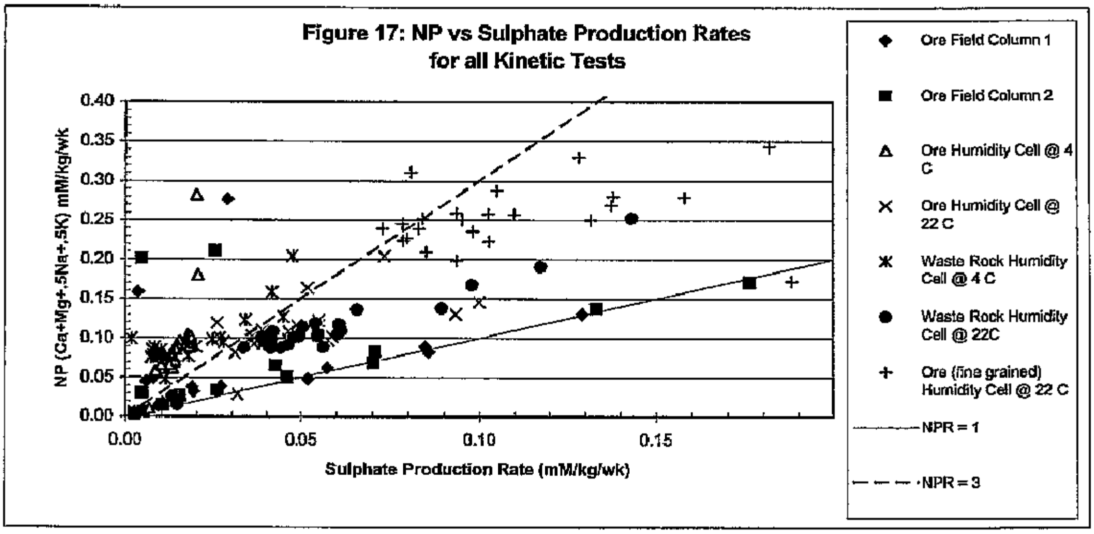


Figure 17: NP vs Sulphate Production Rates
for all Kinetic Tests
NP (Ca+Mg+.5Na+.5K) mM/kg/wk
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.00
0.05
0.10
0.15
Sulphate Production Rate (mM/kg/wk)
Ore Field Column 1
Ore Field Column 2
Ore Humidity Cell @ 4 C
Ore Humidity Cell @ 22 C
Waste Rock Humidity Cell @ 4 C
Waste Rock Humidity Cell @ 22C
Ore (fine grained) Humidity Cell @ 22 C
NPR = 1
NPR = 3

Figure 18: Sulphate vs Arsenic Production Rates for Coarse Ore Kinetic Tests

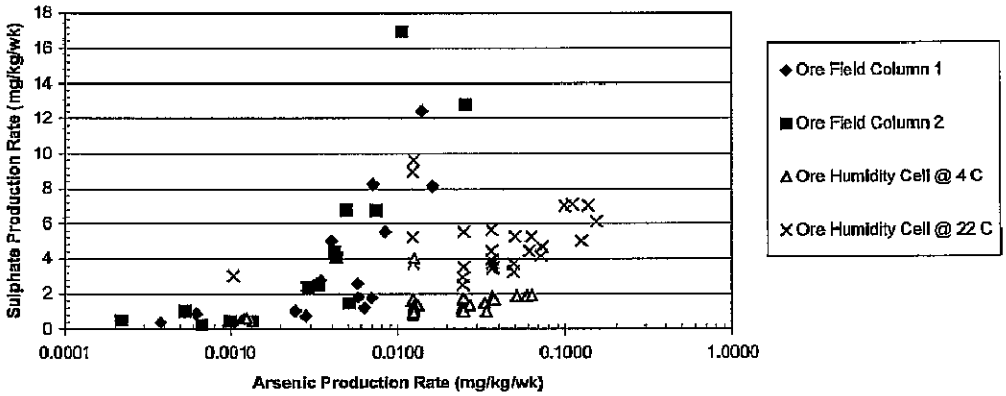


Figure 19: Sulphate vs Arsenic Production Rates for all Kinetic Tests

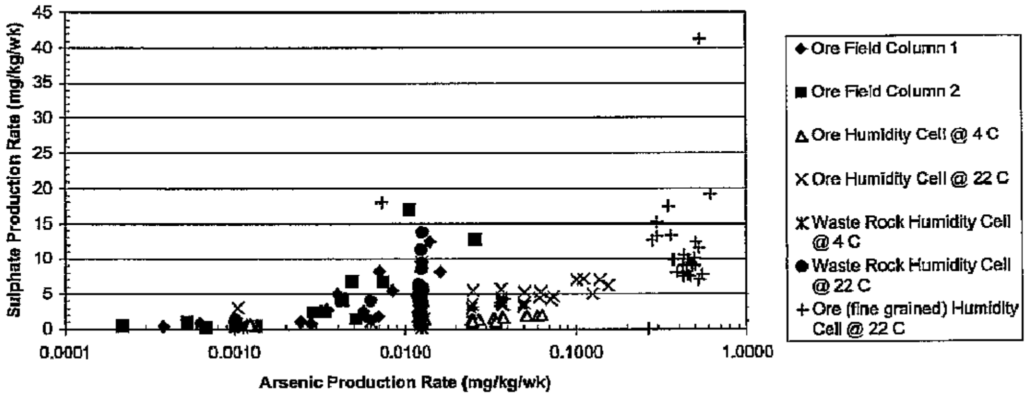


Figure 20: Total Sulphur vs NPR by Rock Type