

APPENDIX III.2
GEOCHEMISTRY REPORT

EXECUTIVE SUMMARY

A geochemical characterization of host rock and processed kimberlite has been ongoing since June 1999 as part of the baseline environmental work for the Snap Lake Diamond Project. This report summarizes the principal findings of the geochemistry work completed up to October 2001 and presents conclusions based on this work.

The following principal conclusions can be drawn from the geochemical baseline program:

- Snap Lake kimberlite is non-potentially acid generating due to its low sulphide sulphur content and substantial excess neutralization potential.
- Runoff or discharge from any disposal alternative for processed kimberlite will be neutral or slightly alkaline, and contain low metal concentrations.
- Granite with no visible sulphides (pyrite and/or pyrrhotite) is non-acid generating due to its low sulphur content. Mixtures of metavolcanics and granites located in the vicinity of the metavolcanic unit that contains sulphur in excess of 0.3 percent by weight (wt%) should be classified as potentially acid generating. Granite that does not contain extensive fracturing and/or is located away from the metavolcanic unit is not acid generating, and is appropriate for use in construction.
- Runoff or discharge from any disposal alternative for granite will be neutral and contain low metal concentrations.
- Metavolcanic material with a sulphur concentration in excess of 0.3 wt% is considered potentially acid generating. This material accounts for approximately one-third of all metavolcanic samples collected. For the remainder, acid generation is unlikely due to the low sulphur content.
- Grainsize reduction of metavolcanic rocks appears to reduce the likelihood of acid generation relative to the bulk material due to enhanced exposure of carbonates.
- The runoff from any disposal alternative for low-sulphur metavolcanics will be neutral and will contain low metal concentrations. Long-term testing has demonstrated that the discharge from metavolcanics with an elevated sulphur content (*i.e.*, greater than 0.8 wt%) can be acidic and contain high metal concentrations.
- Significant excess neutralization capacity is present in the proposed mixture to be placed in the north pile. This is true even for a mixture consisting of high-sulphur

metavolcanic rock and low-carbonate kimberlite. Long-term testing indicates that the discharge from such a mixture is neutral with low metal concentrations.

- Leach testing of alkaline materials (cemented paste backfill, cement, grout, and concrete) indicates that resulting discharges are alkaline and can contain a limited number of metals at elevated concentrations, most notably aluminum, copper, and lead.
- Groundwater samples generally are neutral to weakly alkaline and show low to moderate total dissolved solids concentrations. Total dissolved solids levels are generally lowest in the upper metavolcanic units, but increase with depth and with transition to granitic material. Trace metal concentrations in groundwater are generally elevated with respect to those of Snap Lake.
- A comparison between groundwater data and average long-term kinetic testing results shows good agreement.
- Mine water concentrations in the north drift are consistent with those from groundwater. Most trace metals exhibit a relatively consistent increase in concentration along the floor of the north drift. The concentration trends are not as pronounced for inflow samples, but a general increase can be observed along the flowpath. For most of these constituents, inflow concentrations are similar to the floor water concentrations, suggesting conservative behaviour.
- Dissolved concentrations for trace metals in the sumps and north drift floor/inflows generally are very similar.
- A number of metals in the sump solids exhibit an increasing trend. However, the corresponding dissolved trends are less systematic. In general, it does not appear that an increasing trend in solids concentrations is accompanied by a decreasing trend in dissolved concentration. This is likely due to recirculation of sump water and periodic mucking out of the sumps.
- Surface waters range from alkaline (north and south pit) to circumneutral (bulk sample mine rock pad runoff) to acidic (bogs 1 and 2 and ramp development rock runoff). It is likely that the low-pH conditions observed in the runoff from the ramp development pad are representative of displaced swamp water.
- A comparison between runoff from the bulk sample mine rock pad and results from the kinetic testing for the metavolcanics shows that the range of trace metal concentrations in the runoff is captured by the range of kinetic testing results.

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1.0 INTRODUCTION

As part of the baseline environmental work for the Snap Lake Diamond Project, a geochemical characterization program of mine rock and processed kimberlite (PK) has been ongoing since June 1999. This report summarizes the principal findings of the geochemistry work available as of August 2001 and presents conclusions derived from this investigation.

Section 1 of this report presents the objectives of the geochemical characterization and provides an overview of program development. Section 2 presents background information relevant to the Snap Lake Diamond Project and the geochemical investigation. Section 3 provides a summary of the methods of assessment. The results of the testing are presented and discussed in Sections 4 through 7 for kimberlite, granite, metavolcanics, and alkaline materials (paste backfill, grout, cement, and concrete), respectively. In Section 8, baseline geochemical water quality is presented. Section 9 discusses potential impacts. The conclusions of the geochemistry baseline report are provided in Section 10 and Section 11 contains the references.

1.1 Objectives

The primary objective of the geochemical characterization program was to provide sufficient data for proper evaluation of potential environmental impacts and mitigation alternatives as part of the environmental assessment (EA). More specific objectives include the following:

- development of a defensible geochemical database, sufficient to address geochemical implications for the site at a level consistent with that required for pre-feasibility; feasibility, water licensing, site licensing, and the EA;
- development of estimates of the potential for generation of acidic and metal leaching;
- identification and development of appropriate environmental management strategies/options, material handling strategies/options or mitigation measures (if required); and,
- development of a geochemical assessment report for submission with the overall EA.

1.2 Program Development

Prior to June of 1999, geochemical information on solid materials was limited to a document by Mills (1998), who prepared a brief geochemical report focusing on the rock material to be extracted as part of the 1998 bulk sample program. This report is available upon request. No geochemical information from the Snap Lake site was available on the quality of various discharges commonly associated with mining and processing operations, such as mine water, process water, stockpile seepage, mine runoff, *etc.*

A comprehensive geochemical program was developed in 1999 and was refined in subsequent years, to meet the objectives stated in the previous section. The following factors were taken into consideration for development, refinement, and modification of the geochemical characterization program:

- the mine geology and environment;
- the mine plan, tonnage, and disposal options for the various materials;
- the requirement for selection of adequate and representative samples (spatially and compositionally);
- the requirement for selection of proper testing procedures (suitable for the Snap Lake site and amenable to comparisons with similar sites); and,
- regulatory requirements and expectations.

The geochemical characterization program naturally evolved in a dynamic fashion in response to advances in technical understanding, project developments (*e.g.*, changes in mine planning), regulatory requests, and other requirements.

The first phase of the project consisted of a review of available site data. This was followed by identification and collection of representative samples that were submitted to the laboratory for preliminary static test work. Based on the results of the static test work, long-term kinetic test work was initiated, and additional sampling was undertaken. As site development commenced, monitoring of surface and underground water quality and on-site conditions was initiated. The on-site monitoring continues to be conducted.

1.3 Chronologic Overview

The 1999 data review and screening level study consisted of five components:

- review of borehole logs and geologic background information;
- review of preliminary site and mine plan;
- preliminary identification of working units and associated geologic units;
- selection and collection of initial samples based on lithologic unit descriptions and mine plan; and,
- static testing of selected samples.

The follow-up work in 1999 consisted of:

- initiation of kinetic testing on selected initial samples;
- re-evaluation of mine plan and possible bench height intervals;
- selection of composite samples based on bench heights and spatial distribution in the proposed pit;

- identification and selection of samples from the potential areas of underground workings;
- completion of static test work on selected samples; and,
- initiation of additional kinetic test work on selected samples based on results of initial and follow-up static test work.

The 2000 geochemistry program consisted of five components:

- additional initiation of kinetic test work to investigate possible interactions between various rock units and with acidic leachate;
- completion of static test work on development rock originating from the ramp constructed for the bulk underground sample;
- initiation of monitoring of seepage/runoff water quality from the stockpiled development rock in the catchment area of the water management pond (WMP);
- additional on-site monitoring, including ongoing assessment of bulk sample development rock from the 1999 bulk sample program and collection of water quality monitoring data as per the water licence for the advanced exploration program (AEP); and,
- development of a mine water quality assessment program.

The 2001 geochemistry program consisted of the following:

- continuation of selected kinetic test cells;
- continuation of on-site monitoring at water licence locations;
- implementation of mine water quality assessment program;
- implementation of a sequential leach program on samples of mine rock, cemented paste material, and cement pillar material;
- leach testing of cement and grout;
- evaluation of explosives use and leachability (desk study);
- collection of seep and floor samples in the mine workings to assess potential changes in mine water quality as the water migrates along the mine floor; and,
- sampling and testing of granite rock extracted as part of the AEP.

2.0 BACKGROUND

2.1 Site Overview

The site is described in detail in Section 3 of the EA. With respect to the geochemical evaluation presented in this baseline report, some of the important aspects of the Snap Lake site include:

- location of the various mine facilities;
- climate/hydrology/hydrogeology;
- site geology;
- mine plan;
- north pile management plan; and,
- tonnage and sulphide content of the extracted rock.

Snap Lake is located about 220 kilometres (km) north (N) and 52° east (E) of Yellowknife. The Snap Lake site is located along the western edge of Snap Lake. Kimberlite subcrops on the northwest peninsula of Snap Lake and dips below the lake.

2.2 Overview of Mining, Processing, and Waste Management

In 1998, during the initial site engineering investigation, the original mine plan called for an open pit to a depth of approximately 70 metres (m), with production of approximately 11 million tonnes (Mt) of host rock. Subsequent mine plans considered a smaller open pit, and finally the open pit was eliminated from the mining plans altogether. The selected mine plan calls for the kimberlite dyke to be mined exclusively by underground mining methods (Section 2 of the EA).

A portion of the ramp and some test drifts were excavated as part of the AEP in 2000 and 2001. Pre-production development will begin during construction of the process plant and surface facilities once all applicable permits are obtained. Proposed locations of site facilities are shown in Figure 3.1-4 of the Project Description (Section 3 of the EA).

The proposed north pile management plan (Appendix III.1 of the EA) will result in placement of development rock back underground in the form of paste backfill and/or concrete pillars. This will reduce the amount of mine rock disposed on the surface. Most of the development rock placement will occur during the early and late years of mining (Golder Associates 2001).

Approximately 100,000 tonnes of ramp development rock were produced as part of the initial AEP. This material, consisting primarily of metavolcanic rock, was placed within the catchment area of the WMP, and is being monitored for runoff and seepage quality.

This rock will be relocated to the base of the north pile in the initial stages of operations and covered with PK. Approximately 20,000 tonnes of additional rock were produced as part of subsequent AEP work. This rock consisted of granites, and was tested for chemical stability. Granite that did not contain visible sulphides was considered appropriate for construction purposes and was used accordingly.

The current long-term mine plan calls for underground mining of more than 22.8 Mt of kimberlite. During operations, an average of 3,000 tonnes per day (tpd) of kimberlite ore will be mined. The kimberlite ore will contain 15 to 25 percent (%) dilution rock originating from the hanging wall and footwall. The dilution rock will consist of primarily granite, and some metavolcanic. Initially, the kimberlite will be brought to surface where it will be crushed and processed. In later years, crushing will occur underground. The processed fine-grained kimberlite will be thickened to a paste and used for cemented mine backfill or placed in a containment facility (the north pile) as a paste. The coarse PK material will either be incorporated in the paste, or will be used as granular material for construction of the berms of the north pile.

The north pile will be constructed in stages and will ultimately have a maximum area of 90 hectares (ha), and a maximum thickness of greater than 10 m. Starter berms will be constructed early in the mine life. These starter berms will be composed of non-potentially acid generating (non-PAG) mine rock or quarry rock.

It is currently estimated that, of the 22.8 Mt of PK produced, approximately 50% will be used as mine backfill, with the remainder being deposited on the north pile (Golder Associates 2001). Waste rock from the first few years of mining and any metavolcanic rock currently present on the site will be relocated to the base of the north pile and covered with up to 10 m of PK.

2.3 Site Geology and Lithologies

The project site is located in the Slave Geological Province of the Canadian Shield. A description of the regional bedrock geology of the area is provided by Henderson (1944). Detailed geologic mapping of the northwest peninsula area was conducted by Stubleby Geoscience (1999).

The regional geology consists of Archean-aged granitic rocks, overlain locally by relatively small bodies of metavolcanic rocks. These are cut by diabase dykes and sills of Proterozoic age. The major structures in the area are two east-west trending, roughly vertically-oriented faults: the Snap Fault and the Crackle Fault. The surface expression of these faults is characterized by quartz-hematite veining. Intersecting the Snap Fault is an unnamed north-south (N-S) trending fault that divides a granodiorite/granite assemblage to the west and metavolcanic rocks to the east. Interpretations of

magnetically-defined lineaments in the area indicate that bedrock fracture sets occur in three or four different orientations. It has been possible to correlate a few of the N-S oriented lineaments with fracture zones intersected in drill core and in the underground development. The kimberlite dyke subcrops in metavolcanic host rocks on the northwest peninsula, directly beneath overburden till, and dips at approximately 15° beneath Snap Lake.

There is little published information on the local surficial geology. Based on aerial photograph review, site reconnaissance observations, and test pit and borehole information, the surficial geology of the area consists of a veneer of Quaternary morainal deposits (till) that contain cobbles and boulders mixed with a finer-grained matrix of sand and silt with some gravel. The till is generally thin (average approximately 2 m thick) but can be thicker (maximum 6 m) in topographical depressions. Felsenmeer (literally: “sea of rocks” or “boulder sea”, a chaotic, block-like assemblage of fractured rocks or rock surfaces) can be found in topographic depressions. The area was described as a rolling boulder plain by geologists of the Geological Survey of Canada (Henderson 1944). Bedrock outcrops are common.

With respect to the geochemical characterization program and evaluation of potential environmental impacts, there are three main lithologic units of interest: kimberlite, granite, and metavolcanics. The next three sections briefly discuss their characteristics and distribution.

2.3.1 Kimberlite

The orebody consists of a diamond-bearing, hypabyssal, macrocrystic, serpentinized kimberlite dyke that subcrops on the northwest peninsula of Snap Lake. The hypabyssal origin refers to the fact that the Snap Lake kimberlite formed under conditions intermediate between plutonic and volcanic as the result of gradual intrusion of a kimberlite magma. This type of genesis is relatively rare for kimberlites; more commonly, they are present in the form of a diatreme, a steeply dipping breccia pipe piercing overlying strata. The intrusion of a diatreme is generally considered to be a violent event (at least by geologic standards). The Diavik and EKATI™ kimberlites belong to the diatreme-type deposits, and are extracted using open pit methods.

The Snap Lake kimberlite dyke averages 2 to 3 m in true thickness, and dips to the northeast in a shallow, antiformal fashion at about 11 to 15 degrees. The kimberlite dyke as currently outlined, measures approximately 2,000 m along strike and approximately 2,800 m down dip. Within a radius of approximately 300 m from the northwest peninsula, the kimberlite dyke is hosted by a metavolcanic unit equivalent to the Yellowknife Supergroup. The kimberlite contains a significant amount of carbonates (3 to 5 wt%), which occur as calcite and dolomite, while sulphides are rare (LRC

1999a,b; LRC 2000a,b; LRC 2001). A more detailed description of the mineralogical composition of the Snap Lake kimberlite is presented in Section 4.1.3 of this document.

2.3.2 Granite

At distances greater than 300 m from the northwest peninsula, the kimberlite dyke is hosted by an Archean variably-foliated granitoid suite. This granite represents the vast majority of the development and dilution rock after year 4 of operations. The bulk of intrusive rocks in the Snap Lake area are designated as a multiphase suite (multiphase granitoid [MG]). Biotite $\pm$ hornblende granodiorite, granite, and tonalite are the dominant phases, and muscovite-bearing pegmatite or granitic dykes transect each. A subdivision of this unit (multiphase granitoid fractured [MGF]) is distinguished along the Snap-Crackle fault zone by the presence of quartz $\pm$ hematite-filled fault-related fractures and joints. This MGF unit also contains some sulphide minerals as observed in the borehole logs and microscopic mineralogic examination.

Granitic material is also present as layers and intrusions within the metavolcanics of the northwest peninsula. Granites occurring with the metavolcanics are generally less than 3-m thick. The margins between the granite and the metavolcanic are often filled in with finely-veined, disseminated or massive sulphide. Massive sulphide is rare, however, and where it occurs, it is generally less than 10 centimetres (cm) in thickness, with a maximum thickness of about 30 cm. A more detailed description of the mineralogical composition of the Snap Lake granite is presented in Section 5.1.3 of this document.

2.3.3 Metavolcanic

The metavolcanics consist mainly of well-foliated, high-grade amphibolites, a metamorphic rock mainly composed of amphibole. The metavolcanic unit surfaces over much of the northwest peninsula from west of the kimberlite subcrop to below Snap Lake. As paraphrased from Stublely (1999), the metavolcanic rocks are dominated by finely-layered and foliated amphibolite consisting predominantly of fine-grained hornblende $\pm$ biotite and plagioclase-rich layers. Within the metavolcanic unit, a small amount of pyrite and pyrrhotite, and less commonly chalcopryrite and other sulphides, is locally concentrated in layer-parallel zones. Mineralogical evaluation completed on the samples confirms the composition of this unit and suggests that pyrite is the dominant sulphide form, followed by chalcopryrite (LRC 1999a,b; LRC 2000a,b; LRC 2001). A more detailed description of the mineralogical composition of the Snap Lake volcanics is presented in Section 6.1.3 of this document.

2.4 Site Hydrologic and Hydrogeologic Conditions

The quality and quantity of site surface water and groundwater flows have a direct impact on the ultimate quality of any water discharged from the site. A water balance and water quality estimates for the various site waters were developed in support of the evaluation of potential impacts to Snap Lake, and are provided in Sections 3 and 9.4 of the EA. Key flow-related factors that affect discharge water quality include:

- rate of mine-water inflow (connection between Snap Lake and the underground mine);
- precipitation and evaporation; and,
- low average annual temperature and presence of permafrost.

The rate of mine water inflow (and subsequent mine discharge) is significant with respect to the overall site runoff. On an annual basis, the mine water inflow approximates the average flow through the Snap Lake basin that results from natural runoff in the Snap Lake catchment area. In other words, a quantity of water equivalent to the entire Snap Lake water volume cycles through the mine once very year. This has significant implications with respect to changes in the observed groundwater quality in the mine workings as the infiltrating lake water may have the effect of diluting and/or replacing the existing connate water in the rock mass, in particular during the early phases of mining. For the purpose of this document, connate water is considered the water trapped in the rock mass above the kimberlite deposit prior to interaction with Snap Lake water.

The average annual precipitation for the Snap Lake site is 334.9 millimetres (mm) with 147.9 mm as rain and 187 mm as snow (Golder Associates 2001). The presence of permafrost results in much of the precipitation reporting as runoff, thus migration of any discharge is expected to be most prominent in the upper, active zone of the site stratigraphic sequence.

The mean monthly air temperature ranges from -27.3 degrees Celsius ($^{\circ}\text{C}$) in January to 15.1°C in July (Air Section of the EA, Section 7.2.2.1.4). Seven months have mean air temperatures below 0°C . This has important implications with respect to geochemical reaction rates, including sulphide oxidation, and geochemical evolution of site waters. The low temperatures during much of the year reduce the rates at which geochemical reactions occur. As a rule of thumb, rates of chemical reactions typically decrease by a factor of about two for each 10°C decrease in temperature when the reaction occurs not far from standard temperature. Diavik (1998a) conducted a series of paired kinetic tests to evaluate this issue. They found that, for sulphate and major ions, release rates adhered to the general relationship. However, for leaching of trace metals, no systematic temperature effects could be identified. The absence of flowing water during most of the year effectively limits transport of any reaction products to the summer months.

3.0 METHODOLOGY

3.1 Sampling Program

Sample collection was completed during two phases in 1999, with follow-up samples collected as part of the 2000 geochemistry program, 2001 geochemistry program, and AEP water licence monitoring requirements. In this section, an overview of the various sampling campaigns is presented. Table III.2-1 summarizes the sampling and analysis efforts for the geochemical characterization program. A more detailed description of sample locations and sample characteristics is located in Appendix B and can be provided upon request. Due to small discrepancies caused by quality assurance and quality control (QA/QC) samples such as duplicates and blanks, there may be minor differences in sample numbers throughout the geochemistry report.

1999 Data Review and Screening Level Study

The first sample collection phase in 1999 was based on review of borehole logs. A total of 105 core samples were collected to represent the various lithologic units and depths across the site in June 1999. Of these 105 samples, a subset was selected for further analysis based on their location with respect to the originally-anticipated open pit and underground configurations. Samples were also selected to represent the range of sulphide contents that might be present on site, with the sulphide contents based on visual observation as noted in the borehole logs. It should be noted that for this first phase of testing, a disproportionately large number of samples with elevated sulphide were selected for analysis, as this material was considered to be of the greatest environmental concern.

1999 Follow-up Work

Based on the initial characterization results, a more focused follow-up sample collection and testing program was initiated in August 1999. This second phase involved the collection of 132 composite, rock samples from the metavolcanic unit of the northwest peninsula at locations representing the proposed open pit and underground mine workings.

Additional samples were included to represent possible underground development rock. These samples were selected from locations adjacent to intersections with kimberlite from boreholes some distance from the northwest peninsula.

Kimberlite samples were selected from the kimberlite of the northwest dyke, either from the bulk samples of the northwest peninsula or from remnants of kimberlite present in the northwest dyke (NWD) boreholes located over Snap Lake.

Lastly, samples of PK were obtained from the bulk sample processing completed at the Lupin Mine Tahera plant in 1999 on the kimberlite extracted from bulk sample pits located on the northwest peninsula. Process water samples from the Lupin plant were also collected.

2000 Geochemistry Program

Sampling for the year 2000 geochemistry program and AEP water licence requirements included collection of samples from the rock excavated from the ramp, and samples of host rock located on site from previous site activity (1999 bulk sample host rock pile and winter roads). Water quality samples and paste pH measurements on the excavated mine ramp development rock were also collected as part of the year 2000 program. Surface water samples from near the rock stockpiles, site runoff locations, bulk sample pits, and locations in the peat bog were also obtained.

2001 Geochemistry Program

The 2001 geochemistry work focussed on the definition of potential mine water quality from the underground workings. As part of this program, ports and seeps within the mine were sampled for water quality. Solid samples from the mine and development rock included samples of drill cuttings and sludges from the mine and mine sump, and samples of the granitic development rock. Samples of drill cuttings, cemented paste backfill, and grout were tested for potential leachate characteristics, whereas the ramp development rock samples were analyzed to determine acid base accounting (ABA) characteristics. In addition, PK samples resulting from on-site dense media separation (DMS) were collected and characterized. Ongoing monitoring of site waters and runoff was completed as part of the AEP water licence requirements.

Water from the mine floor and mine seeps was collected to identify geochemical trends in drainage from the north drift. Water samples were collected from the floor of the north drift along its entire length. To characterize mine inflows, seeps, drillholes, and portals along the length of the north drift were also sampled. A total of five sumps were included.

3.2 Testing Procedures

The methods used for predicting the acid-generating potential (AP) and metal-leaching rates include on-site monitoring, static testing, and laboratory kinetic tests. Each type of test used for the Snap Lake Diamond Project is briefly summarized below. For a more extensive and generic description of the various test methodologies, including their strengths and weaknesses, refer to Price (1997).

3.2.1 Static Testing

Static testing is typically the first step in the assessment and prediction of acidic drainage and metal leaching. These tests, which generally include ABA, whole-rock chemistry, static-leach tests, and mineralogical analysis, focus on the geochemical characterization of the sample. Information from static tests is used in concert with results from kinetic testing to predict long-term impacts.

3.2.1.1 Acid Base Accounting

The objective of ABA is to determine the balance between acid producing and acid consuming components in a material. Both the Department of Indian Affairs and Northern Development (DIAND) (1992) and Price (1997) guidelines were consulted when evaluating which type of ABA testing and evaluation criteria should be used. The Price (1997) guidelines for prediction of metal leaching and acid rock drainage at minesites in British Columbia are more recent and present more stringent criteria for classification of ABA. Therefore, the Price protocols and criteria were used for assessing the ABA characteristics of the Snap Lake samples.

The standard ABA test is comprised of two individual measurements:

- determination of the amount of acid-neutralization potential that may be generated by a sample by measuring the bulk neutralizing potential (NP) and/or the carbonate neutralization potential (CaNP); and,
- determination of the amount of AP in a sample by measuring total sulphur and/or sulphur species.

ABA is used to determine whether a material is PAG. If necessary, this assessment can be further refined with more detailed testing, such as mineralogical and kinetic testing and other site-specific characterization. The ABA was conducted at British Columbia Research Institute (BCRI), Vancouver, British Columbia. BCRI used the methods recommended in Price (1997) in which the determination of NP is determined by the Sobek method (Sobek *et al.* 1978) and carbonate CaNP is calculated from the carbonate content. The Sobek NP represents the NP that can be expected from all buffering minerals, including relatively refractory phases such as silicates. CaNP represents the neutralizing capacity that is readily available (generally from carbonate minerals only).

The ABA screening criteria used for evaluation of AP were based upon Price (1997). Although largely empirical, these criteria have found wide acceptance by the industry and regulatory community. They are presented in Table III.2-2.

Samples with an NP:AP ratio greater than four are not considered to be acid generating and no further testing of acid rock drainage (ARD) generation potential is generally required. However, metal leaching may be an issue of concern even in the absence of any AP.

An additional approach to determining the acid generation potential of a geologic material or mining waste is the use of net neutralization potential (NNP). The NNP is calculated as the difference between the NP and AP. NNP values greater than +20 kilograms of calcium carbonate per tonne (kg CaCO₃/tonne) are generally considered indicative of a lack of acid generation potential; values between -20 and +20 kg CaCO₃/tonne are considered inconclusive, and samples with values lower than -20 kg CaCO₃/tonne are thought to be acid generating.

A final rule of thumb presented by Price (1997) evaluates acid generation potential using the sulphide sulphur content and the paste pH. Materials with a sulphide sulphur content less than 0.3 wt% and a paste pH greater than 5.5 are considered non-PAG and require no further environmental testing. Exceptions occur where the rock matrix consists of base poor minerals (*e.g.*, quartz), or where the sulphide minerals contain metals that may leach under weakly acidic to alkaline conditions.

For the purpose of this document, the acid generation potential of the samples will be evaluated using the NP:AP ratio as per the Price (1997) guidance. The NNP criterion and sulphide cut-off/paste pH approach will be evaluated to provide corroborating evidence for the validity of the NP:AP method.

3.2.1.2 Whole Rock Chemistry

Whole rock chemical analysis is used to determine the major oxide and trace metal composition of a sample. Since this analysis provides no indication of the leachability of a sample, the results from the chemical analysis are commonly combined with those from leaching tests to predict metal leaching rates. Although it is unlikely that the rate of leaching will remain constant over time, this type of calculation can provide a basis for assessing treatment needs.

The whole rock chemistry of the Snap Lake Diamond Project samples was assessed by a combination of whole rock analysis using x-ray fluorescence (XRF), trace metal analysis by aqua regia digest, inductively-coupled plasma (ICP), and atomic emission analysis of the leachate. It should be noted that incomplete sample digestion may result in underestimation of the amounts of some components, notably chromium and barium. Whole rock analysis and trace metal analysis were conducted by BCRI (subcontracted to ACME Analytical in Vancouver, British Columbia).

3.2.1.3 Mineralogy

The mineralogical and textural characteristics of a sample play a key role in its short-term and long-term environmental behaviour. Mineralogical analysis was conducted by Dr. John Jambor of LRC Consulting in Tsawwassen, British Columbia. The mineralogical evaluation included mineral identification by transmitted and reflected light microscopy, x-ray diffractometry (XRD) and microprobe analysis. Eleven samples were submitted for mineralogical investigation before and after completion of the kinetic testing to evaluate any mineralogical changes that might have occurred. Details of the mineralogical evaluation methods are provided in Appendix C and are available upon request.

3.2.1.4 Short-term Leachate Extraction Testing

Short-term static leachate extraction tests are used to determine the readily-soluble component of a sample. There are a number of different test procedures, which vary primarily in the duration of the test, the degree of grainsize reduction, the solid to solution ratio, and the nature of the extractant. These tests are useful for indicating the short-term leaching characteristics and potential for metal release from a sample. Long-term processes, such as dissolution of more recalcitrant minerals and sulphide oxidation, cannot be adequately represented by single-stage short-term leach tests.

A modified version of the British Columbia (BC) solid waste extraction procedure (SWEP), using distilled water as the leaching agent and a 4:1 solution to solid ratio by weight, was used on the samples for the Snap Lake Diamond Project to facilitate comparisons with other, similar projects, in particular the Diavik project. The extractions were performed by BCRI, and ALS Chemex in North Vancouver, BC analyzed the leachates.

3.2.1.5 Sequential Leach Testing

Sequential leach tests were conducted on four types of solids: each of the three major rock types, and a sample representative of cemented paste backfill (PK with 1% to 2% cement). The objective of the sequential leach testing was to subject the four samples to a quasi-dynamic leach environment in an attempt to identify solubility controls and long-term leachability.

It was considered particularly pertinent that a cemented paste backfill was subjected to a dynamic environment to observe its long-term leaching characteristics, as the timing of paste backfill preparation was such that it precluded initiation of kinetic testing. Similarly, in response to concerns raised by third-party reviewers, one kimberlite sample was subjected to sequential leach testing using an alkaline lixiviant in an attempt to simulate interaction with a grout/cement-impacted water. Sequential leach testing of

kimberlite, granite, and metavolcanic, using a standard leachant, was largely conducted for comparative purposes.

Prior to the sequential leach testing, each sample was analyzed for whole rock chemistry and ABA. Each solid was then subjected to two sequential leach tests, designated as type I and type II. For all leach tests, a solid to solution ratio of approximately one to four on a weight basis was applied. The lixiviant for all tests, with the exception of the alkaline leach, was distilled/deionized water. To evaluate the short-term leachability of kimberlite under alkaline conditions, the pH of the distilled/deionized (DI) water was raised to 12 by the addition of slaked lime ($\text{Ca}[\text{OH}]_2$). The extractions were performed by BCRI, and ALS Chemex analyzed the leachates.

Type I Sequential Leach Testing

The intent of the Type I sequential leach test was to evaluate solubility controls on constituent leaching. For this test, leachate from the first leaching step (and each subsequent leaching step thereafter) was used to sequentially leach five fresh solid samples. In theory, this type of leach test could be considered complete when leachate concentrations of the constituents of interest no longer increased. Leachate results for these tests constitute the “A” series, and are labelled as A1, A2, A3, A4, and A5.

Type II Sequential Leach Testing

The intent of the type II sequential leach test was to evaluate the amount of leachable constituents present in each sample. For this test, a single solids sample was subjected to four consecutive leaches, each with a fresh lixiviant. This type of test could be considered complete when the leachate no longer contained concentrations of the constituent of interest above a pre-determined threshold (*e.g.*, water quality criterion, detection limit). Leachate results for these tests represent the “1” series, and are labelled as B1, C1, D1, and E1.

3.2.2 Kinetic Testing

Kinetic tests are repetitive leaching tests designed to simulate enhanced weathering and provide rates for acid generation, acid neutralization, and metal leaching. The types of kinetic tests used for the Snap Lake Diamond Project were columnar cells, using a modified version of the standard humidity cell as described in Price (1997), as well as standard humidity cells.

3.2.2.1 Standard Kinetic Testing

The standard humidity cell consists of approximately 1 kg of sample placed in a test cell as indicated in Figure III.2-1 (Price 1997). Prior to placement into the test cell, the sample is wetted, flushed, and rinsed. This is followed by a weekly cycle of dry air, humid air, and flushing. The flushing takes place by adding 500 millilitres (mL) of the lixiviant (DI water) to the top of the cell and allowing it to soak the samples for a specified period. The leachate resulting from the flushing is filtered and analyzed for a limited set of standard parameters on a weekly basis, as well as for a more comprehensive suite of analytes at greater time intervals. The results of humidity cell testing are particularly suited for development of reaction rates, but can also be used to make inferences with respect to long-term water quality.

During the early stages of the geochemical characterization program, the standard humidity cell was modified by incorporating column cells. The primary reason for incorporation of column cells was to facilitate comparisons with data obtained from other sites, in particular Diavik. Modifications relative to humidity cells included a slight increase in the sample size, and an increase in the amount of contact time between water and solids. Instead of a weekly rinse, the columns were flushed with three 500 mL portions of distilled/deionized water over three days (*i.e.*, 500 mL over 24 hours). The primary function of column cells is generally considered to be the simulation of drainage chemistry. All kinetic testing was conducted by BCRI. Metal analysis on the leachate samples was performed by ALS Chemex.

3.2.2.2 Kinetic Test Work with Variable Input Solution

Based on the results of the site data and kinetic test work initiated in 1999, a supplemental kinetic test program was implemented in May 2000 to assess the effects of acidic input solutions on overall leachate chemistry. The rationale for this testing was the realization that a very small portion of the metavolcanics had the potential to locally generate acidic conditions.

A standard humidity cell for rock was used with the associated protocols as described earlier and in Price (1997). However, some samples were pre-washed with acidic solution and/or an acidic weekly flush solution was used. Whenever a cell with modified input solution or pre-washing was constructed, a replicate control cell with standard solution was included in the test program using a split of the same material.

One set of cells was constructed using a mixture of kimberlite and metavolcanic to evaluate the interaction between an alkaline leachate and PAG rock material. For these cells, the standard mass of 1 kg was increased to 1.5 kg to allow for sufficient quantities of both materials.

3.2.3 Field Testing

Ongoing field testing consists of monthly monitoring of runoff water quality from the ramp development rock pad, and from the 1999 bulk sample mine rock pad (BSMRP). Past field testing included assessment of paste pH at a number of locations around the ramp development rock pile as well as pH measurements of various ponded waters around the site.

Paste pH measurements were conducted in the field by combining approximately equal amounts of the less than 2 mm fractions of rock with distilled water in a 500 mL container. This mixture was thoroughly homogenized and the pH of the resulting slurry was measured.

Field assessment of water quality from surface and mine seepage locations in August 2000 included field measurements of alkalinity, acidity, temperature, pH, and Eh (oxidation reduction potential). These measurements were completed within 30 minutes of sample collection.

Samples of mine water that were collected in 2001 include those obtained as part of the AEP water licence monitoring program, as well as additional samples of water seeping into the mine. The latter samples were collected from the ports installed in the mine, and from the mine floor and sump. Samples were assessed for pH, Eh, alkalinity, and temperature in the field.

The large majority of water samples collected and measured in the field were submitted for laboratory analysis of total metals, dissolved metals, major ions, and certain miscellaneous parameters related to specific mining activities (*e.g.*, nitrate and ammonia resulting from blasting). Water samples were submitted to one or more of the following laboratories depending on analytical requirements and project logistics: Taiga Environmental Laboratory in Yellowknife, Enviro-Test Laboratories (ETL) in Edmonton, ALS Environmental in Vancouver, and ACZ in Steamboat Springs, Colorado.

3.3 Testing Program

This section describes the test work on the kimberlite, granite, metavolcanics, and alkaline materials that has been completed, or is currently ongoing, as part of the baseline geochemical program.

3.3.1 Kimberlite

To facilitate interpretation, all test samples that consisted of, or contained, kimberlite were subdivided into seven groups:

1. unprocessed kimberlite samples (13 samples);
2. PK – tails and grits (10 samples);
3. PK – thickener underflow (four samples);
4. kimberlite and metavolcanic (two samples);
5. PK paste (two samples);
6. DMS underflow (five samples); and,
7. AEP underground kimberlite (five samples).

The first set of kimberlite samples represents kimberlite rock that has not undergone any processing. Tails and grits are the coarser fraction of the PK that may either be placed by truck on the north pile, or included in the paste. This material will likely be available for use as cover material over any PAG rock, or as neutralization material. Thickener underflow (the fine-grained fraction of the PK) will be sent as paste to the north pile or as paste backfill to the mine.

The kimberlite and metavolcanic samples consist of a mixture of these two lithologies as collected from drill core. They contain a large amount of metavolcanic material mixed with smaller quantities of kimberlite.

Processed kimberlite paste samples represent material from the on-site process plant thickened to the consistency of paste. One of the two paste samples consists of uncemented paste, while the other consists of cemented paste. The DMS underflow samples represent the high-density material that was extracted as part of the processing work for the AEP program. It will not be possible to segregate this fraction once operations commence, and thus it represents a material that will not exist as a separate entity during operations. Instead, it will be part of the general PK stream that will report to the north pile or to the mine as backfill.

Five kimberlite samples were collected as part of the AEP water licence program.

Static Test Work

Static test work completed on kimberlite included (see also Table III.2-1):

- 41 total sulphur analyses;
- 38 ABA analyses;
- 25 whole rock and total metals analyses;

- mineralogical analysis of 15 samples;
- 14 leachate extraction (SWEP) tests;
- 27 water quality analyses of process plant water; and,
- three sequential leach tests on kimberlite and kimberlite paste.

Kinetic Test Work

Kinetic test work on kimberlite that has been completed, or is ongoing, includes (see also Table III.2-3 for details on testing protocols and material characteristics):

- Two humidity cells on tails and grits (HC 1) and thickener underflow (HC 2). HC 1 is ongoing; HC 2 was terminated at 29 weeks.
- Two column tests on unprocessed kimberlite (column 2) and tails and grits (column 1). Both were terminated at 26 weeks due to stable chemistry.
- One column test on a kimberlite/metavolcanic mixture terminated at 26 weeks due to stable chemistry (column 12).
- Four humidity cell tests were initiated to investigate the effects of acidic input water on kimberlite leachate concentrations: HC 25 through HC 28. One standard humidity cell serves as a baseline (HC 25), the other three consist of one cell with acid-washed solids using a standard leaching solution (HC 26), one cell with standard solids and an acidic leaching solution (HC 27), and one cell with acid-washed solids and an acidic leaching solution (HC 28). HC 25 through HC 27 were terminated after 26 weeks; HC 28 was terminated after 46 weeks.
- Three humidity cell tests were initiated to investigate the effects of acidic input water on kimberlite diluted with metavolcanic material: HC 29 through HC 31. In these test cells, 0.5 kg of kimberlite is overlain by 1 kg of metavolcanic rock. One standard humidity cell serves as a baseline (HC 29), the other two consist of one cell with acid-washed solids using a standard leaching solution (HC 30), and one cell with acid-washed solids and an acidic leaching solution (HC 31). All three were terminated after 46 weeks.

3.3.2 Granite

To facilitate interpretation, all static test samples that consisted primarily of granitic rock were subdivided into six groups:

1. samples containing granitic (GT) or multiphase granitoid (MG) and metavolcanic material (10 samples);
2. samples consisting of granite but located within or near the metavolcanic unit (15 samples);
3. granite samples located a significant distance (>300 m) from the metavolcanic unit on the northwest peninsula (14 samples);

4. granite samples collected to evaluate quarry/construction rock (22 samples);
5. rock from the quarry and esker that was used to construct a reef during the AEP (now called “reef rock”) (seven samples); and,
6. granite samples consisting of underground construction material (eight samples).

The granitic samples located a significant distance away from the metavolcanic unit (group 3) represent material that is currently used in construction and will continue to be used as such in the future. Group 3 granite also represents rock likely to be encountered during much of the underground development. These samples consist of relatively pure granite without the presence of fracturing or metavolcanic material. Group 4 samples originated from the granite quarry and were analyzed with the specific objective of determining their suitability as construction material. Reef rock samples (group 5) were representative of granite used in construction of an artificial reef within Snap Lake. The underground construction samples (group 6) consisted of ramp development rock extracted as part of the AEP program.

Static Test Work

The following static test work was conducted on granite (see also Table III.2-1):

- 76 total sulphur analyses;
- 73 ABA analyses;
- 34 whole rock and total metals analyses;
- mineralogical analysis of six samples;
- 10 leachate extraction (SWEP) tests; and,
- one sequential leach test.

Kinetic Test Work

Kinetic test work to date includes the following (see also Table III.2-3 for details on testing protocols and material characteristics):

- two column tests: one was terminated after 28 weeks (column 5); one was terminated after 26 weeks but split into two for further testing (column 9); and,
- the split column (column 9) was continued as HC 20 (unmodified input solution) and HC 21 (acid washed with unmodified input solution). HC 20 is currently ongoing; HC 21 was terminated after 26 weeks.

3.3.3 Metavolcanics

A significant amount of characterization work was conducted on the metavolcanic unit as part of the 1999 and 2000 programs. The emphasis on characterization of metavolcanics

was prompted by the realization that this material had the highest potential for environmental impacts. Some of the kinetic test work was extended into the year 2001 and will continue as part of the baseline geochemical program.

To facilitate interpretation, the samples that consisted primarily of metavolcanic rock were subdivided into seven groups:

1. former open pit benches – reconfigured pit layout, prior to November, 2000 (11 samples);
2. former open pit benches – 1998 proposed original pit configuration excluding samples in reconfigured pit (68 samples);
3. samples selected for their high sulphide concentrations (20 samples);
4. samples excluding high sulphur material (59 samples);
5. ramp development material (25 samples);
6. ramp development material – less than 2 mm fraction (seven samples); and,
7. samples from the 1999 BSMRP (seven samples).

Group 1 and 2 samples were selected to characterize the metavolcanics from the northwest peninsula. Samples were collected from every hole of the ore reserve characterization grid (NWP98 grid) that intersected possible open pit configurations (as investigated in the early stages of mine planning). The samples were composited at about 10 m intervals (possible bench heights) from surface to top of kimberlite. Group 1 samples are a subset gathered from a preliminary open pit configuration that fall within the boundaries of a reconfigured open pit design developed later. Group 2 comprises the remainder of the composite samples collected from the original open pit configuration. As mentioned previously, there will no longer be an open pit. However, test results from groups 1 and 2 can still be used to develop estimates of potential impacts from disposal of metavolcanic host rock and dilution of kimberlite ore by metavolcanic rock.

Groups 3 and 4 represent samples collected from a range of boreholes throughout the site to further characterize the metavolcanic unit. As the presence of sulphides represents the greatest environmental concern, the sample set from group 3 contains a higher proportion of sulphidic material than would be encountered during normal operations.

As part of the year 2000 geochemistry program and AEP water licence requirements, ramp development rock samples (group 5) were freshly extracted from the ramp and collected from the top of the rock pile (within one week of extraction). The ramp development rock samples contained a significant amount (up to 40% volume) of fine-grained material. Additional analyses on the less than 2-mm fraction were conducted on seven of the group 5 samples. These seven samples are collectively designated as group 6. Samples from the 1999 BSMRPs (group 7) were collected as part of the year

2000 program. These samples were collected within 0.3 m of the surface and serve to represent rock subjected to weathering for one year.

Static Test Work

Analytical work for the static test program included (see also Table III.2-1):

- 198 total sulphur analyses;
- 196 ABA analyses;
- 162 whole rock and total metals analyses;
- mineralogical analysis of 25 samples;
- 55 leachate extraction (SWEP) tests; and,
- one sequential extraction test.

Kinetic Test Work

Kinetic test work on metavolcanic samples was composed of three components (see also Table III.2-3 for details on testing protocols and material characteristics):

1. Ten column tests were performed. Four were terminated after 26 weeks: columns 6, 7, 8, 13; one terminated after 2 weeks: column 15; four ongoing: columns 3, 10, 11, 14; one terminated and split into two for further testing after 32 weeks: column 4.
2. The split column (column 4) was continued as HC 18 (unmodified input solution) and HC 19 (acid washed with unmodified input solution). Both were terminated after 26 weeks.
3. Three humidity cell tests were initiated to investigate the effects of acidic input water on metavolcanics: HC 22 through HC 24. One standard humidity cell serves as a baseline (HC 22), the other two consist of one cell with acid-washed solids using a standard leaching solution (HC 23), and one cell with acid-washed solids and an acidic leaching solution (HC 24). All three were terminated after 26 weeks.

3.3.4 Grout, Cement, and Concrete

Static test work conducted on alkaline materials included the following (see also Table III.2-1):

- four total sulphur analyses;
- four ABA analyses;
- four whole rock and total metals analyses; and,
- 12 leachate extraction (SWEP) tests.

3.4 Quality Assurance and Quality Control

QA/QC protocols were followed to ensure the integrity of the results. The protocols included the use of internal laboratory standards and other QA samples, as well as analysis of field duplicates, field blanks, and external laboratory standards. In addition, aliquots of samples were submitted to multiple laboratories for QA/QC purposes.

For the kinetic testing, two blank control cells were used. Both were humidity cells containing silica sand (HC 32 and HC Blank). The input solutions for these two cells were the acidic solution and standard solution, respectively. HC Blank was started at the onset of the kinetic testing program; HC 32 was initiated when the use of acidic input solutions commenced. Both cells are currently ongoing and will continue to do so until the long-term testing program is terminated.

Evaluation of the QA/QC results for the test work completed as part of the geochemistry program indicates that the data produced are of sufficient quality to be used for their intended purposes. QA/QC results are reported in the individual appendices, which are available upon request.

4.0 RESULTS: KIMBERLITE

4.1 Static Testing

4.1.1 Acid Base Accounting

Results of the ABA testing for the kimberlite categories are provided in Table III.2-4 and Figures III.2-2 through III.2-8. Appendix D contains a more detailed overview of the ABA results.

Figure III.2-2 illustrates the relationship between total sulphur and sulphide sulphur for all samples, whereas Figure III.2-3 provides the same information for samples that have less than 0.20 wt% sulphide sulphur. Sobek (bulk) NP versus (vs.) CaNP is plotted in Figure III.2-4. Figure III.2-5 presents the AP and NP results of all kimberlite samples, while Figure III.2-6 shows the results for the samples having an AP less than 30 kilograms per tonne (kg/tonne) as CaCO_3 . Figure III.2-7 compares the NNP (= NP-AP) and NPR (=NP/AP) for all samples. Figure III.2-8 shows the relationship between paste pH and sulphur content.

For convenience, the designations of the seven groups of kimberlite samples are repeated below:

1. unprocessed kimberlite samples (10 samples);
2. PK – tails and grits (eight samples);
3. PK – thickener underflow (four samples);
4. kimberlite and metavolcanic (two samples);
5. PK paste (one sample);
6. DMS underflow (five samples); and,
7. AEP underground kimberlite (five samples).

Based on Table III.2-4 and Figures III.2-2 through III.2-8, the principal observations with respect to the ABA characteristics of kimberlite are:

- The kimberlite contains very low amounts of total and sulphide sulphur (generally less than 0.3 wt%, Figures III.2-2 and III.2-3). With the exception of a very small number of samples, the sulphide sulphur content is equal to the total sulphur content, with little or no sulphate sulphur and/or residual sulphur present. Conservatively, the total sulphur value was therefore used to calculate AP in this document.
- The bulk NP and CaNP values generally are high (Figure III.2-4). The high values for CaNP are consistent with the large amounts of carbonates observed during the mineralogic analysis. For all samples but one, the bulk NP is higher than the CaNP,

suggesting that not all NP is present in the form of carbonates (dolomite and calcite). Most likely, the non-readily available NP is represented by silicate minerals, in particular serpentine. Serpentine is considered to weather at an “intermediate” rate (Plumlee 1999), so some buffering from serpentine should be expected.

- All kimberlite samples tested from groups 1, 2, 3, 5, and 7 have a net acid-consuming potential with both the NP:AP and CaNP:AP ratio greater than four (Figures III.2-5 and III.2-6). According to the Price (1997) screening criteria, these samples are therefore classified as non-acid generating. Mills (1998) obtained identical results for the one kimberlite sample included in his study.
- The NP:AP range for the non-PAG samples is between 26 and 1,224, while the CaNP:AP range is between 16 and 240 (Table III.2-4).
- For the two composite kimberlite and metavolcanic samples tested (group 4), one had an NP:AP ratio of 8.2 and the other had an NP:AP ratio of 3.7 (Table III.2-4). One composite sample would therefore be classified as non-PAG and the other would have a low potential to generate acid.
- As the specific gravity of sulphide minerals is higher than that of the silicate-rich kimberlite, metavolcanic, or granitic material, DMS underflow samples (group 6) contain a higher proportion of sulphide than the PK as a whole. Four of the five DMS samples are classified as PAG, with NP:AP ratios between 0.1 and 1.5.
- During full-scale operations, the DMS material will not be segregated from the PK. Instead, the DMS material will be fully mixed with the PK, but will represent less than 0.1% of the total (Mike Schmidt, pers. comm). The contribution of the DMS material to the overall sulphide content in the PK was calculated using the maximum observed sulphide content of the DMS material. When the maximum sulphide content of 7.6 wt% is assumed for all DMS material, the overall sulphide content for host rock stockpiled in the PK will be less than 0.3 wt%. In combination with the high carbonate content of the bulk PK, the resulting mixture of bulk PK and DMS material will be non-acid generating.
- The NNP values of virtually all samples are greater than +20 kg CaCO₃/tonne (Figure III.2-7). Agreement between the NP:AP and NNP approaches is excellent: all samples that are classified as having a potential to generate acid based on their NP:AP ratio also have an NNP value less than + 20 kg CaCO₃/tonne. These samples are limited to groups 4 (kimberlite + metavolcanic) and 6 (DMS samples).

- All samples but one with an NP/AP <4 and NNP <+20 kg CaCO₃/tonne have a sulphide sulphur content greater than 0.3 wt%. Similarly, all samples but one that are designated non-PAG have a sulphide sulphur content less than 0.3 wt%.
- All values for paste pH are well above 5.5 (between 7.6 and 11.3), including those of samples with sulphur concentrations in excess of 0.3 wt% (Figure III.2-8). The highest value for paste pH (11.3) is found for the cemented paste sample. In this case, the elevated paste pH value is undoubtedly caused by the addition of cement.
- Based on the above observations, paste pH may not be a reliable indicator of acid generation potential, but the combination of NP/AP, NNP, and sulphur content appears to be internally consistent.
- In summary, kimberlite is non-PAG due to its low sulphide sulphur content and high neutralization potential. Mixtures with metavolcanics can be classified as PAG depending on the relative proportion of kimberlite vs. metavolcanic. Kimberlite resulting from the DMS process also can be categorized as acid forming, although this material will not be produced during operations.

4.1.2 Whole Rock and Trace Element Chemistry

Results of the whole rock chemistry analyses indicate significant average concentrations of nickel (858 milligrams per litre, mg/L), chromium (550 mg/L), cobalt (65 mg/L), Ba (1,104 mg/L), and manganese (1,154 mg/L) in the kimberlite unit. Two kimberlite samples (67406 and 67408) had slightly elevated molybdenum concentrations with respect to the remaining samples. A complete summary of the whole rock and trace element analytical results is provided in Appendix E and is available upon request. Trace elemental results presented by Mills (1998) show the same suite of elevated constituents.

4.1.3 Mineralogic Analysis

The mineralogic analysis of the kimberlite indicates that the kimberlite is highly altered. No olivine, the main constituent of “fresh” kimberlite, was detected. The kimberlite mineral assemblage consists mainly of serpentine (lizardite) and dolomite, accompanied by lesser amounts of calcite. The smectite and sulphide content of the kimberlite is low. The principal sulphides minerals are pyrite and chalcopyrite. Other sulphides identified include pyrrhotite, millerite, siegenite, and possibly violarite.

The mineralogic analysis of the kimberlite samples was accompanied by a qualitative evaluation of potential environmental impacts. It was observed that the net neutralization potential of the kimberlite was very high given the relative proportions of sulphides and carbonates. It was further noted that, even in the absence of carbonates, the overall low

sulphide content would prolong the period prior to potential development of acidic discharges. In the presence of carbonates, however, this prolongation was considered favourable in enabling micro-domain participation also of any aluminosilicate minerals in mitigating the effects of sulphide oxidation.

Four kimberlite-containing samples (two kimberlite columns; one PK humidity cell; one kimberlite/metavolcanic column) were submitted for mineralogical investigation after completion of the kinetic testing. The material showed no macroscopic evidence of the formation of secondary precipitates. Microscopic investigation revealed that the alteration of sulphides and depletion of carbonates were mineralogically minimal rather than appreciable (LRC 1999a,b; LRC 2000a,b; LRC 2001). The various reports prepared as part of the mineralogic investigation are located in Appendix C, which is available upon request.

4.1.4 Solid Waste Extraction Procedure Testing

Table III.2-5 summarizes the SWEP testing results by providing averages for four kimberlite groups. Complete results are located in Appendix F, which is available upon request. The results indicate that:

- the pH of all SWEP leachates is alkaline; and,
- metal concentrations are generally low, with highest average values generally found for the thickener and underflow samples.

4.1.5 Sequential Leach Testing

The sequential leach test results for the kimberlite are summarized in Table III.2-6. This table shows the concentration ranges of selected constituents for the type I and II leach sequences. Appendix G contains a detailed description of these results and is available upon request.

The following summary of the key sequential leach test results:

- for most constituents, concentrations show an increasing trend throughout the type I testing;
- concentration stabilization was observed for a few parameters during the type I testing, most notably nitrate, aluminum and arsenic in both the DI water and alkaline leach;
- concentration trends for the type II testing vary widely;
- type II testing results in higher values for leachate pH, both for the DI leach and the alkaline leach. The pH values for the alkaline leach are higher than those for the DI leach;

- for the large majority of constituents, concentrations in the alkali leach are similar to those in the DI leach. Type I leaching tends to result in higher concentrations than type II leaching; and,
- in general, the sequential leach results compare favourably with the long-term concentrations from the kinetic testing, albeit that the sequential leaching generally generates higher values for pH. For some parameters (*e.g.*, aluminum, copper, molybdenum), the sequential leaching results in higher concentrations.

4.2 Kinetic Testing

4.2.1 Kinetic Testing – Standard Input Solution

Table III.2-7 contains a summary of leachate water quality from the standard humidity cells and columns for selected parameters. Figures III.2-9 and III.2-10 present the pH and nickel results, respectively. Appendix H contains analytical data and graphical summaries on leachate concentrations for selected chemical parameters and is available upon request.

In summary, the kinetic test results from the kimberlite unit for the standard set-up and input solution are as follows:

- the pH of the leachate from all cells remains at or near neutral (Figure III.2-9);
- under the neutral pH conditions observed, leachate from the kimberlite columns has low metal concentrations (Table III.2-7);
- long-term nickel concentrations in leachates show a typical metal trend of declining values, with leachates from column 2 (unprocessed kimberlite) exhibiting the highest long-term concentrations (Figure III.2-10);
- depletion calculations using the rates observed from the kinetic testing (Table III.2-8) indicate that sulphur depletion will occur well before depletion of the NP; and,
- the test results confirm that the kimberlite is non-PAG in the short- and long-term. The reaction rates observed in the laboratory testing and, accordingly, the calculated depletion times, should be used as an approximation only. Under field conditions, many factors, such as compaction, weathering, and climate may result in reaction rates that are different from those determined based on the laboratory results.

4.2.2 Kinetic Testing – Variable Input Solution

In this section, the results from kimberlite-containing humidity cells with variable input solution are presented. These cells include HC 25 (control cell), HC 26 (acid wash, standard input), HC 27 (acid input), and HC 28 (acid wash, acid input). Table III.2-9 contains a summary of leachate water quality from the humidity cells and columns for selected parameters. Results from the layered kimberlite/metavolcanic cells (HC 29

through HC 31) are presented for comparison as well, and are discussed in more detail in the Section 4.2.3 below. Figures III.2-11, III.2-12, and III.2-13 show the pH, aluminum, and nickel results, respectively. Appendix I contains analytical data and graphical summaries on leachate concentrations for selected chemical parameters and is available upon request.

In summary, the kinetic test results from the kimberlite unit for the variable input solution are as follows:

- the long-term pH of the leachate from all four cells is at or near neutral (Figure III.2-11). This despite the use of a pH 3 input solution in cells HC 27 and HC 28, which suggests that the kimberlite contains significant buffering capacity, even after stripping a large portion of the NP in the acid wash (HC 28);
- under the neutral pH conditions observed, leachate from the kimberlite columns generally has low metal concentrations (Table III.2-9);
- long-term aluminum and nickel concentrations (Figures III.2-12 and III.2-13, respectively) in leachates from all cells show declining trends over time, with leachates from HC 28 (acid wash + acid input) exhibiting the highest values;
- use of acidic input appears to have a more significant effect on leachate quality from kimberlite than acid washing, although the latter does result in a substantial removal of NP; and,
- depletion calculations using the rates observed from the kinetic testing (Table III.2-8) indicate that sulphur depletion will occur well before depletion of the NP. This confirms that the kimberlite is non-acid generating in the short- and long-term, even under acidic conditions. The reaction rates observed in the laboratory testing and, accordingly, the calculated depletion times, should be used as an approximation only. Under field conditions, many factors, such as compaction, weathering, and climate may result in reaction rates that are different from those determined based on the laboratory results.

4.2.3 Kinetic Testing – Kimberlite Dilution and Interaction with Host Rock

An estimate of the acid generation potential of a PK incorporating 20% dilution by metavolcanic rock was developed using static and kinetic test results. Assuming that the metavolcanic rock conservatively contains 7.4 wt% sulphide sulphur (upper 95th percentile of all metavolcanic samples) and the kimberlite contains 7.1 wt% carbonate (lower 5th percentile of all kimberlite samples), the CaNP:AP ratio of a 20:80 metavolcanic/PK mixture would be approximately two. Based on the lower 5th percentile NP value for the kimberlite (349 milligrams per kilogram (mg/kg) as CaCO_3), the NP:AP ratio of such a mixture would be about six. These calculations indicate that most, if not all, dilution of the kimberlite by metavolcanic would yield a net non-PAG material. Based on the samples analyzed to date and the current understanding of the ore

deposit geology, the total volume of PK diluted with metavolcanic rock will be non-PAG with significant excess neutralizing capacity.

This conclusion was further evaluated by designing three humidity cells containing kimberlite material (0.5 kg) overlain by metavolcanic (1 kg). These cells include HC 29 (control cell), HC 30 (acid wash, standard input), and HC 31 (acid wash, acid input). The ratio of metavolcanic to kimberlite in the test cells (2:1 by weight) represents a ratio that is substantially greater than that occurring in the north pile, and that the test cells therefore are likely to overestimate the effect of dilution by metavolcanic on discharge quality.

Table III.2-9 contains a summary of leachate water quality from the humidity cells and columns for selected parameters. Results from the kimberlite cells with variable input are presented for comparison and were discussed in more detail in the previous section. Figures III.2-14, III.2-15, and III.2-16 show the pH, aluminum, and nickel results, respectively. Appendix J contains analytical data and graphical summaries on leachate concentrations for selected chemical parameters and is available upon request.

In summary, the kinetic test results from the mixed kimberlite/metavolcanic cells are as follows:

- the long-term pH of the leachate from two out of three cells is at or near neutral (Figure III.2-14). In HC 29 and HC 30, the kimberlite contains sufficient NP, even after acid washing, that any acidity generated by the metavolcanic is buffered. In cell HC 31, the buffering capacity of the kimberlite is exceeded by the acidic input solution, and a long-term leachate pH close to 3 (which is similar to that of the input solution) is observed;
- under the neutral pH conditions observed, leachate from the layered kimberlite/metavolcanic columns generally has low metal concentrations (Table III.2-9);
- long-term aluminum (Figure III.2-15) and nickel (Figure III.2-16) concentrations generally show declining trends, albeit that concentrations in leachates from HC 31 (acid input + acid wash) are maintained at elevated levels;
- use of acidic input appears to have a more significant effect on leachate quality from the kimberlite/metavolcanic mixture than acid washing;
- long-term leachate from the standard mixed kimberlite/metavolcanic cell (HC 29) generally contains lower metal concentrations than leachate from the corresponding standard kimberlite cell (HC 25), despite a higher sulphur content and lower NP/AP ratio, while their leachate pH is identical. Some exceptions to this are aluminum and zinc. A comparison with other standard kimberlite and metavolcanic cells suggests that both the aluminum and zinc likely primarily originate from the metavolcanic;

- long-term leachate from the acid wash only mixed kimberlite/metavolcanic cell (HC 30) also generally contains lower metal concentrations than leachate from the corresponding kimberlite cell (HC 26), despite a substantial reduction in NP. The main exception once again is aluminum. The leachate pH of HC 30 is slightly lower than the pH from HC 26;
- long-term leachate from the acid wash + acid input mixed kimberlite metavolcanic cell (HC 31) generally contains higher metal concentrations than leachate from the corresponding kimberlite cell (HC 28), while the leachate pH is substantially lower. Some exceptions to this are sulphate, molybdenum, and nickel. The latter two constituents are likely primarily associated with the kimberlite;
- depletion calculations using the rates observed from the kinetic testing (Table III.2-8) indicate that sulphur depletion will occur well before depletion of the neutralization potential. This confirms that the kimberlite is non-PAG in the short- and long-term, even when mixed with metavolcanic material and acid washed. Depletion calculations using alkalinity could not be performed for HC 31, as no alkalinity was present under the acidic conditions present in the humidity cell. If allowed to recover (*i.e.*, a standard input solution would be used instead of an acidic solution), the leachate quality should improve due to the large amount of available buffering capacity remaining, and be similar to the one observed in HC 30; and,
- the reaction rates observed in the laboratory testing and, accordingly, the calculated depletion times, should be used as an approximation only. Under field conditions, many factors, such as compaction, weathering, and climate may result in reaction rates that are different from those determined based on the laboratory results.

4.2.4 Process Water Quality

Table III.2-10 summarizes the analytical results of 24 process water samples. The samples consisted of six process water samples from the Lupin Mine, where bulk kimberlite samples were processed in 1999, and six decant and twelve “whole” (decant mixed with underflow) samples from the Snap Lake pilot process plant. The Snap Lake process plant samples are part of the AEP water licence sampling (Station 1735-09). It should be noted that the results from the Lupin samples are presented for completeness only, and that the results from the Snap Lake processing should be used to evaluate process water quality. The complete analytical results are located in Appendix K and are available upon request.

The results indicate that:

- the pH of all process water samples is alkaline;
- the pH increases from process water from Lupin plant to the decant from the Snap Lake process plant discharge, to the whole fraction of the Snap Lake process plant discharge;

- values for total suspended solids (TSS) are elevated in “whole” Snap Lake process water as is expected because the plant underflow was included in the sample; and,
- the water qualities of Snap Lake decant and “whole” Snap Lake process water are similar, although concentrations in the whole fraction are generally higher.

4.3 Comparison with Other Kimberlites

As mentioned previously, the Snap Lake ore body represents a relatively unusual form of kimberlite. The Snap Lake kimberlite is volcanogenic, and formed as the result of steady intrusion of a kimberlite magma, whereas, more commonly, kimberlite genesis involves the relatively rapid formation of a diatreme, such as is the case for the Diavik and EKATI™ deposits. In this section, the Snap Lake kimberlites are compared to the Diavik and EKATI™ kimberlites to demonstrate the differences in environmental stability and corresponding potential for adverse environmental impacts. This evaluation is conducted by comparing the results from the long-term kinetic testing.

The Snap Lake kimberlite is relatively homogeneous, and contains only minor amounts of xenoliths (*i.e.*, inclusions of pre-existing rock). This is consistent with its gradual mode of emplacement. The Diavik and EKATI™ kimberlites, on the other hand, contain xenoliths of overlying sediments, which in the case of Diavik consist of mudstones and siltstones (Diavik 1998a,b). The mudstone and siltstone xenoliths exhibit evidence of biological activity at the time of kimberlite emplacement, including wood fragments and biogenic sulphide minerals. The sedimentary materials comprise about 2 to 5% of the kimberlite material.

The average nickel (858 mg/L), chromium (550 mg/L), and cobalt (65 mg/L) concentrations in Snap Lake kimberlites are lower than those observed in the Diavik kimberlites, with the latter having average values of 1,377, 1,830, and 75 mg/L, respectively (Diavik 1998a,b). Similarly, sulphide sulphur concentrations are higher in Diavik kimberlites, with values up to 3 wt% recorded (Diavik 1998a,b). By comparison, sulphide sulphur values in Snap Lake kimberlite do not exceed 0.3 wt%. The various EKATI™ pipes generally also show higher metal concentrations than the Snap Lake kimberlites (BHP 2000). Values for nickel, chromium, cobalt can be up to approximately 1,600, 1,500, and 80 mg/L, respectively. Sulphide sulphur concentrations in EKATI™ kimberlite material can be up to approximately 0.7 wt%.

Table III.2-11 presents the range of kinetic test results from the five Snap Lake kimberlites, two Diavik kimberlite samples, and five EKATI™ kimberlite samples (BHP 1995). The first Diavik sample (stage 1 kimberlite) is a volcanoclastic kimberlite, a xenolith-free sample representative of the bulk of the Diavik kimberlite material (Diavik 1998a,b). The second Diavik sample (stage 1 mudstone) represents a mudstone-rich kimberlite. The five EKATI™ samples represent kimberlites from a number of different

pipes. All ranges in Table III.2-11 were calculated using the last five weeks of kinetic testing results, or the last three results if sampling occurred at a lower frequency.

The long-term results for the Diavik volcanoclastic kimberlite resemble those of the Snap Lake samples. With a few exceptions early in the testing program, alkaline conditions are maintained throughout the test, while most metal concentrations generally are within the range observed for the Snap Lake samples. However, cobalt, copper, manganese, and particularly molybdenum appear to be leached at higher concentrations. Higher sulphate concentrations suggest that oxidation of pyrite is occurring, although dissolution of gypsum is considered a possible source as well (Diavik 1998a,b). The low iron values indicate that any iron released through sulphide oxidation precipitates due to the alkaline conditions. Overall, the stage 1 kimberlite sample is considered non-PAG.

The long-term results for the mudstone-rich kimberlite are dramatically different. Low-pH conditions prevail throughout the entire testing period. Combined with significant generation of sulphate and iron, this suggests that sulphide oxidation is actively occurring. The low pH also results in leaching of metals at elevated concentrations.

Both Diavik kimberlite samples were submitted for mineralogical testing after extended periods of accelerated weathering in the columns. Secondary reaction products such as jarosite and gypsum were observed in both materials, albeit that the degree of alterations was much higher in the mudstone sample. In the latter, essentially all of the original pyrite in the upper part of the column had been leached, consistent with the aqueous chemistry observed for the column.

A similar mineralogical investigation was performed on three Snap Lake kimberlite samples (two columns; one humidity cell) after completion of the kinetic testing. The material showed no macroscopic evidence of the formation of secondary precipitates. Microscopic investigation revealed that the alteration of sulphides and depletion of carbonates were mineralogically minimal rather than appreciable (LRC 1999a,b; LRC 2000a,b; LRC 2001).

The comparison between the Snap Lake and Diavik kimberlites clearly demonstrates the different environmental behaviour of the two materials. Although the Snap Lake kimberlite is similar to the volcanogenic component of the Diavik kimberlite, the presence of sulphide-rich siltstone and mudstone xenoliths within the Diavik kimberlites causes the latter to have a significantly higher potential for environmental impacts. Oxidation of sulphides in the siltstone/mudstone xenoliths can lead to generation of acid rock drainage, a low-pH, high-sulphate, and high-metal solution, within Diavik kimberlites.

The comparison between the Snap Lake and EKATI™ kimberlite shows more similarities. Although the high end of the EKATI™ leachate concentration range generally is higher than that of the Snap Lake kimberlite leachates, differences between these two kimberlite types are less pronounced. The most notable exceptions to this trend are chromium, copper, and zinc, all of which occur in long-term EKATI™ leachates in higher concentrations than measured in Snap Lake leachates. Also of note is the fact that certain EKATI™ kimberlites are capable of generating a leachate that is considerable more alkaline than those from the Snap Lake kimberlites.

5.0 RESULTS: GRANITE

5.1 Static Testing

5.1.1 Acid Base Accounting

Results of the ABA testing for the granite categories are provided in Table III.2-12 and Figures III.2-17 through III.2-23. Appendix C contains a more detailed overview of the ABA results and is available upon request.

Figure III.2-17 illustrates the relationship between total sulphur and sulphide sulphur for all samples, whereas Figure III.2-18 provides the same information for samples that have less than 2 wt% sulphide sulphur. Sobek (bulk) NP vs. carbonate NP is plotted in Figure III.2-19. Figure III.2-20 presents the AP and NP results of all granite samples, while Figure III.2-21 shows the results for the samples having an AP less than 10 kg CaCO₃/tonne. Figure III.2-22 compares the NNP (= NP-AP) and NPR (=NP/AP) for all samples. Figure III.2-23 shows the relationship between paste pH and sulphur content.

For convenience, the designations of the six groups of the granite samples are repeated below:

1. samples containing GT or MG and metavolcanic material (10 samples);
2. samples consisting of granite but located within or near the metavolcanic unit (15 samples);
3. granite samples located a significant distance (>300 m) from the metavolcanic unit on the northwest peninsula (14 samples);
4. granite samples collected to evaluate quarry/construction rock (22 samples);
5. rock from the quarry and esker that was used to construct a reef during the AEP (now called “reef rock”) (seven samples); and,
6. granite samples consisting of underground construction material (eight samples).

Based on Table III.2-12 and Figures III.2-17 through III.2-23, the principal observations with respect to the ABA characteristics of granite are:

- The granite contains low amounts of total and sulphide sulphur (generally less than 0.4 wt%, Figures III.2-17 and III.2.18). The sulphide sulphur content is equal to the total sulphur content, with essentially no sulphate sulphur and residual sulphur present. Conservatively, the total sulphur value was used to calculate AP.
- The bulk NP and CaNP are generally low (Figure III.2-19). For all samples but one, the bulk NP is substantially higher than the CaNP. The upper limit for CaNP for the large majority of samples is approximately 5 kg CaCO₃/tonne. The low values for

CaNP are consistent with the trace amounts of carbonates observed during the mineralogic analysis.

- All granite samples from groups four and five are classified as non-PAG with NP/AP ratios greater than four (Figures III.2-20 and III.2-21). Three quarry/construction rock samples (group 3) have NP/AP ratios between 3.3 and four, and should also be considered as having little or no potential to generate acid when their very low sulphur contents are taken into account. One sample from group 3 has an NP/AP value of 1.2, but the very low sulphur content and alkaline paste pH suggest that acid generation from this sample is very unlikely. Therefore, granite from groups 3 through 5 (sample located away from the metavolcanic unit and used as construction rock) are considered non-PAG as a group.
- The majority of samples from groups 1 and 2 (granite either including metavolcanic material or located in close proximity to metavolcanics) have some potential to generate acid based on the fact that their NP/AP ratios are less than four. However, in most cases, the sulphur content is below 0.3 wt% while the paste pH for all samples is in excess of 5.5 (Figure III.2-23). This suggests that the number of samples that can be realistically expected to generate acid is likely to be relatively small.
- Very few samples have NNP values greater than +20 kg CaCO₃/tonne (Figure III.2-22). The large majority of NNP values is between -20 and +20 kg CaCO₃/tonne, the uncertain range. This despite the fact that most NP/AP ratios are greater than four, all values for paste pH are alkaline, and most sulphur concentrations are less than 0.3 wt%. NNP values less than -20 kg CaCO₃ show good correlation with sulphur values in excess of 0.3 wt% and NP/AP ratios close to zero. It is therefore safe to state that samples with a negative value for NNP are likely to be acid generating. However, in the uncertain range, the NNP is not a good predictor of acid generation potential.
- In summary, granite is largely non-PAG due to its low sulphur content. Mixtures with metavolcanics and granites located in the vicinity of the metavolcanic unit that contain sulphur in excess of 0.3 wt% should be classified as PAG. Granite samples representative of material selected for construction purposes are not acid generating, and, consequently, this material is deemed appropriate for use in construction.

5.1.2 Whole Rock Chemistry

The whole rock analyses for the granite samples show values that are typical for granites as presented in Price (1997). The results indicate that the granitic unit has a lower iron and magnesium content than the metavolcanics, and is relatively enriched in silica. Tables with analytical results are located in Appendix E and are available upon request.

5.1.3 Mineralogic Analysis

The mineralogic analysis of the granite showed that this material predominantly consists of albite, with subordinate K-feldspar (microcline) and quartz. Chlorite is present sparingly as patches and among interstices. The association of chlorite with minor rutile suggests that the chlorite may have been derived from alteration of biotite. Minor apatite is present and sulphides are sparse, consisting of pyrite and chalcopyrite. Traces of carbonate, probably calcite, were observed. It was concluded that, despite the small size and sparseness of the carbonate grains, they would contribute significantly to the NP of the mineral assemblage because the quartz, albite, and K-feldspar are relatively inert (LRC 1999a,b; LRC 2000a,b; LRC 2001).

Two granite-containing samples (one granite column; one GT/metavolcanic column) were submitted for mineralogical investigation after completion of the kinetic testing. The material showed no macroscopic evidence of the formation of secondary precipitates. Microscopic investigation revealed that the alteration of sulphides and depletion of carbonates were mineralogically minimal rather than appreciable (LRC 1999a,b; LRC 2000a,b; LRC 2001). The various reports prepared as part of the mineralogic investigation are located in Appendix C and are available upon request.

5.1.4 Solid Waste Extraction Procedure Testing

Table III.2-13 summarizes the SWEP testing results by providing averages for two granite groups. Complete results are located in Appendix F and are available upon request. The results indicate that:

- the pH of all SWEP leachates is alkaline; and,
- there is no systematic difference between average concentrations in leachates from granite located near the metavolcanic unit and granite samples that include metavolcanics.

5.1.5 Sequential Leach Testing

The sequential leach test results for the granite are summarized in Table III.2-14. This table shows the concentration ranges of selected constituents for the type I and II leach sequences. Appendix G contains a detailed description of these results, including graphical representations of leach trends and is available upon request.

The following is a summary of the key sequential leach test results:

- for most constituents, concentrations show an increasing trend throughout the type I testing;

- concentration stabilization was observed for a few parameters during the type I testing, most notably aluminum;
- concentration trends for the type II testing vary widely;
- type I and II testing generally result in similar values for leachate pH;
- for the large majority of constituents, concentrations in the type II leach are lower than those in the type I leach; and,
- the leachate pH of the sequential leaches is higher by at least one order of magnitude than the leachate pH from the kinetic testing. For most parameters, the sequential leaching results in higher concentrations.

5.2 Kinetic Testing

5.2.1 Kinetic Testing – Standard Input Solution

Table III.2-15 contains a summary of leachate water quality from the standard columns (column 5 and 9) for selected parameters. Figures III.2-24 and III.2-25 present the pH and molybdenum results, respectively. Appendix L contains analytical data and graphical summaries of leachate concentrations for selected chemical parameters and is available upon request.

In summary, the kinetic test results from the granite unit for the standard set-up and input solution indicate that:

- the pH of the leachate from all cells remains at or near neutral (Figure III.2-24);
- under the neutral pH conditions observed, leachate from the granite columns have low metal concentrations (Table III.2-15);
- molybdenum (Figure III.2-25) concentrations show a typical decline over time, with concentrations in leachates from column 9 (granite + metavolcanics) being significantly elevated with respect to those in column 5 (granite only);
- depletion calculations using the rates observed from the kinetic testing (Table III.2-8) indicate that sulphur depletion will occur before depletion of the NP; and,
- this confirms that the granite is non-PAG in the short- and long-term. The reaction rates observed in the laboratory testing and, accordingly, the calculated depletion times, should be used as an approximation only. Under field conditions, many factors, such as compaction, weathering, and climate may result in reaction rates that are different from those determined based on the laboratory results.

5.2.2 Kinetic Testing – Variable Input Solution

After 20 weeks, column 9 (predominantly granitic material with minor amounts of metavolcanic material) was split into HC 20 and HC 21. HC 20 was operated as a standard humidity cell, whereas the solids used for HC 21 were washed with an acidic

solution to reduce or remove remaining carbonate alkalinity. A standard lixiviant was then applied for the duration of the testing. Table III.2-15 presents a summary of the results, and Figures III.2-26 and III.2-27 show the pH and molybdenum concentrations of the two cells, respectively. The full results are found in Appendix M; Appendix M is available upon request.

In summary, the kinetic test results from the granite unit for the variable input solution are as follows:

- the pH of the leachate from all cells remains at or near neutral (Figure III.2-26);
- a typical decline in concentration is observed for molybdenum (Figure III.2-27), with both columns showing similar values;
- no significant difference is observed between the humidity cells with the unmodified and acid-washed sample. Very little NP appears to be removed in the acid washing, suggesting that the overall composition of the granite sample was not altered to any significant degree. This is consistent with the similar leachate qualities obtained from both cells; and,
- depletion calculations using the rates observed from the kinetic testing (Table III.2-8) indicate that sulphur depletion will occur before depletion of the neutralization potential. This confirms that the granite is non-PAG in the short- and long-term, even when acid washed. The reaction rates observed in the laboratory testing and, accordingly, the calculated depletion times, should be used as an approximation only. Under field conditions, many factors, such as compaction, weathering, and climate may result in reaction rates that are different from those determined based on the laboratory results.

5.2.3 Comparison between Columns and Humidity Cells

As mentioned previously, column 9 was dismantled after 20 weeks, and a split of the original charge was continued in a standard humidity cell (HC 20). This provides an opportunity to evaluate any differences in leaching behaviour between the column and the humidity cell.

For virtually all parameters, the transition between column and humidity cell was relatively seamless. Trends established in the column were largely maintained in the humidity cells, with leachate concentrations being very similar (*e.g.*, for pH, sulphate, nickel, copper, iron). No spikes in concentrations were observed at the onset of humidity cell testing. Exceptions to the general trend were the alkalinity and calcium, which showed a decrease upon start-up of the humidity cell and did not recover to values observed in the original column. These results suggest that the leaching behaviour in the column and humidity cell was similar, and that either one could be used to make inferences with respect to long-term environmental behaviour of this particular sample.

6.0 RESULTS: METAVOLCANICS

6.1 Static Testing

6.1.1 Acid Base Accounting

Results of the ABA testing for the metavolcanic categories are provided in Table III.2-16 and Figures III.2-28 through III.2-34. Appendix D contains a more detailed overview of the ABA results and is available upon request.

Figure III.2-28 illustrates the relationship between total sulphur and sulphide sulphur for all samples, whereas Figure III.2-29 provides the same information for samples that have less than 1.0 wt% sulphide sulphur. Sobek (bulk) NP vs. carbonate NP is plotted in Figure III.2-30. Figure III.2-31 presents the AP and NP results of all metavolcanic samples, while Figure III.2-32 shows the results for the samples having an AP less than 100 kg/tonne as CaCO_3 . Figure III.2-33 compares the NNP (= NP-AP) and NPR (=NP/AP) for all samples. Figure III.2-34 shows the relationship between paste pH and sulphur content.

For convenience, the designations of the seven groups of the metavolcanic samples are repeated below:

1. former open pit benches (reconfigured pit layout, prior to November, 2000 [11 samples]);
2. former open pit benches – 1998 proposed original pit configuration excluding samples in reconfigured pit (68 samples);
3. samples selected for their high sulphide concentrations (20 samples);
4. samples excluding high sulphur material (59 samples);
5. ramp development material (25 samples);
6. ramp development material – less than 2 mm fraction (seven samples); and,
7. samples from the 1999 BSMRP (seven samples).

Based on Table III.2-16 and Figures III.2-28 through III.2-34, the principal observations with respect to the ABA characteristics of the metavolcanics are:

- The metavolcanics show the largest variation in ABA characteristics of the three rock types investigated. Their sulphur contents range from non-detect to 29 wt%, while NP ranges from approximately 4 to 270 kg CaCO_3 /tonne. Highest sulphur values are observed in group 3 (high-sulphide samples); highest NP values are found in group 6 (less than 2 mm fraction).

- The sulphide sulphur content is equal to the total sulphur content, with essentially no sulphate sulphur and residual sulphur present (Figures III.2-28 and III.2-29). Conservatively, the total sulphur value was used to calculate AP. The large range in sulphur values is consistent with the mineralogic observation that the sulphide content of the metavolcanic samples varies widely.
- For all samples, the bulk NP is higher than the CaNP. The large range in CaNP values is consistent with the mineralogic observation that the carbonate content of the metavolcanic samples varies widely.
- Virtually all samples from groups 1 through 5 and 7 are classified as PAG using the NP/AP threshold of four (Figures III.2-31 and III.2-32). However, a more detailed evaluation indicates the following:
 - Approximately half of the samples in groups 1 and 2 have sulphur contents less than 0.3 wt%. Furthermore, all values for paste pH are alkaline (Figure III.2-34), suggesting that only a portion of these samples has the potential to generate acidity.
 - In group 3, all samples have sulphur contents significantly greater than 0.3 wt%. In addition, the NP/AP ratios are the lowest of any group. Despite their alkaline values for paste pH, these samples should therefore be considered likely to generate acid.
 - In group 4, only nine out of 59 samples have sulphur contents in excess of 0.3 wt%. In addition, the paste pH values are more alkaline than for the other groups. As a group, therefore, this material has a relatively low propensity to generate acid.
 - In group 5, only one sample exceeds 0.3 wt% sulphur. Paste pH values are once again alkaline. These samples have a low potential for acid generation.
 - Group 6 is equally split between samples with NP/AP >4 and samples with NP/AP <4. On average, the fine fraction has a slightly higher sulphide content (by a factor of two), but a substantially higher NP and CaNP (by a factor of 6 and 14, respectively). This results in higher NP/AP ratios than those observed for the same bulk sample. In such samples, the NP/AP balance favours the NP, and the samples are classified as non-PAG. When the NP/AP balance favours the AP, as is the case for a few low-sulphur, low-NP samples, the sulphur content is less than 0.3 wt%, which suggests that these samples also have a low propensity to generate acid.
 - In group 7, all but two samples are classified as PAG based on their NP/AP ratio. All samples have a sulphur content in excess of 0.3 wt%.
- Very few samples have NNP values >+20 kg CaCO₃/tonne (Figure III.2-33). The large majority of NNP values is between -20 and +20 kg CaCO₃/tonne, the uncertain range. NNP values less than -20 kg CaCO₃ show good correlation with sulphur values in excess of 0.3 wt% and NP/AP ratios close to zero. It is therefore safe to state that samples with a negative value for NNP are likely to be acid generating.

However, in the uncertain range, the NNP is not a good predictor of acid generation potential. Samples with NNP $>+20$ kg CaCO_3 /tonne also have NP/AP values >4 , confirming that this material is non-PAG.

- The ABA results are generally in good agreement with those obtained by Mills (1998). Of the eight metavolcanic samples characterized by Mills (1998), three would be classified as non-PAG, two as having low potential to generate acid, two as possibly acid generating, and one as likely acid generating. Details of the sampling and analyses completed by Mills are located in Appendix A, which is available upon request.
- The ABA results are also consistent with observations from the mineralogical evaluation. Screening of the as-received samples revealed a pronounced segregation of carbonate minerals in the fine (less than 60 mesh) fraction. This segregation was interpreted to be related predominantly to fracture control of carbonate deposition. Any sulphides present showed the same effect, but to a considerably lesser extent because most of the sulphides occurred as disseminated grains. The net effect of this segregation is that the finer fraction has a reduced propensity for acid generation relative to the bulk metavolcanics.
- In summary, metavolcanic material with a sulphur concentration in excess of 0.3 wt% must be considered PAG. This material accounts for approximately one-third of all metavolcanic samples collected. For the remainder, it is believed that acid generation is unlikely due to the low sulphur content. Grainsize reduction of metavolcanic rocks appears to reduce the likelihood of acid generation relative to the bulk material due to enhanced exposure of carbonates.

6.1.2 Whole Rock Chemistry

The results for whole rock analysis and total metal analysis show considerable concentrations of copper, zinc, nickel, cobalt, manganese, iron, and occasionally slightly elevated concentrations of arsenic associated with the high sulphur samples. Analytical results are provided in Appendix E, which is available upon request.

6.1.3 Mineralogic Analysis

The mineralogic analysis of the metavolcanics has determined that this lithology largely consists of amphibole, chlorite, and biotite, with interspersed quartz and albite. Other minerals, present in smaller amounts, are stilpnomelane, titanite (sphene), garnet, hematite, ilmenite, and others. Carbonates include calcite and dolomite. In decreasing order of abundance, observed sulphides are pyrite, chalcopyrite, marcasite, and pyrrhotite. Of these sulphides, pyrrhotite is considered to be the most susceptible to

oxidation. The relative proportions of the carbonates vs. sulphides vary widely, resulting in an equally-large range of acid generation potentials.

Screening of the as-received samples revealed a pronounced segregation of carbonate minerals in the fine (less than 60 mesh) fraction. This segregation was interpreted to be related predominantly to fracture control of carbonate deposition. The fracture-controlled veinlets of carbonates are more readily detached and broken during crushing, and carbonates therefore concentrate in the fines. This concentration is a positive effect insofar as such material is liberated, and therefore immediately available for attenuation of potential acidity. Any sulphides present showed the same effect, but to a considerably lesser extent because most of the sulphides occurred as disseminated grains.

Seven metavolcanic-containing samples (five metavolcanic columns; one granite/metavolcanic column; one kimberlite/metavolcanic column) were submitted for mineralogical investigation after completion of the kinetic testing. The material showed no macroscopic evidence of the formation of secondary precipitates. Microscopic investigation revealed that the alteration of sulphides and depletion of carbonates were mineralogically minimal rather than appreciable (LRC 1999a,b; LRC 2000a,b; LRC 2001). The various reports prepared as part of the mineralogic investigation are presented in Appendix C, which is available upon request.

6.1.4 Solid Waste Extraction Procedure Testing

Table III.2-17 summarizes the SWEP testing results by providing averages for six metavolcanic groups. Complete results are located in Appendix F, which is available upon request. The results indicate that:

- the pH of all SWEP leachates is alkaline;
- metal concentrations are generally low; and,
- the SWEP leachates from the high-sulphide group are the most distinct in that they have a lower pH, lower aluminum concentrations, and higher total dissolved solids (TDS), cobalt, copper, manganese, and nickel concentrations than the leachates from the other metavolcanic groups.

6.1.5 Sequential Leach Testing

The sequential leach test results for the metavolcanics are summarized in Table III.2-18. This table shows the concentration ranges of selected constituents for the type I and II leach sequences. Appendix G contains a detailed description of these results, including graphical representations of leach trends and is available upon request.

The following is a summary of the key sequential leach test results:

- for most constituents, concentrations show an increasing trend throughout the type I testing;
- concentration trends for the type II testing vary, but a majority show increasing concentrations as the test progresses;
- type II testing results in higher values for leachate pH;
- type II leaching tends to result in higher concentrations than type I leaching. This is counter to the trends found for the kimberlite and granite; and,
- in general, the sequential leach results compare favourably with the long-term concentrations from the kinetic testing, albeit that the sequential leaching generates higher values for pH by at least one order of magnitude. For some parameters (*e.g.*, aluminum, copper, lead), the sequential leaching results in higher concentrations when the results from column 3 (high sulphide sample) are not taken into account.

6.2 Kinetic Testing

6.2.1 Kinetic Testing – Standard Input Solution

Table III.2-19 contains a summary of leachate water quality from the humidity cells and columns for selected parameters. Figures III.2-35, III.2-36, and III.2-37 present a summary of the pH, aluminum, and nickel results, respectively, from week 0 up to a maximum of week 55 of testing. Appendix N contains analytical data and graphical summaries of leachate concentrations for selected chemical parameters and is available upon request.

In summary, the kinetic test results from the metavolcanic unit for the standard set-up and input solution are:

- with the exception of column 3, the pH of the leachate from all cells remains at or near neutral (Figure III.2-35);
- under the neutral pH conditions observed, leachate from the metavolcanic columns has low metal concentrations (Table III.2-19);
- the pH of leachate from column 3, containing 9.9 percent sulphide is substantially lower (approaching 4) than is observed in the other columns;
- as illustrated by aluminum (Figure III.2-36) and nickel (Figure III.2-37), metal concentrations generally decrease over time. The principal exception is column 3, which shows an increase in concentration as the testing progresses;
- the average concentrations presented in Table III.2-19 are disproportionally affected by the results from column 3, and therefore do not adequately represent “average” weathering behaviour of metavolcanic rock;

- depletion calculations using the rates observed from the kinetic testing (Table III.2-8) indicate that sulphur depletion will occur before depletion of the NP in seven out of the nine metavolcanic columns: columns 4, 6, 7, 8, 11, 13, 14, and 15. In columns 3 and 10, the reverse is the case: the NP will be removed before the sulphur, resulting in residual sulphur;
- the first set of metavolcanic samples (columns 4, 6, 7, 8, 11, 13, 14, and 15) is considered non-acid generating in the short- and long-term. The second set (columns 3 and 10) is considered PAG. Based on the ABA characteristics of the two sample groups, it appears that the threshold between PAG and non-PAG may be between a sulphur content of 0.8 and 1.0 wt% and an NP/AP ratio of 0.3 and 0.8; and,
- the reaction rates observed in the laboratory testing and, accordingly, the calculated depletion times and thresholds, should be used as an approximation only. Under field conditions, many factors, such as compaction, weathering, and climate may result in reaction rates that are different from those determined based on the laboratory results.

6.2.2 Kinetic Testing – Variable Input Solution

In this section, the results from metavolcanic-containing humidity cells with variable input solution are presented. These cells include HC 22 (control cell), HC 23 (acid wash, standard input), and HC 24 (acid wash, acid input). In addition, after 30 weeks, column 4 was split into HC 18 and HC 19. HC 18 was operated as a standard humidity cell, whereas the solids used for HC 19 were washed with an acidic solution to reduce or remove remaining carbonate alkalinity. A standard lixiviant was then applied for the duration of the testing. Table III.2-20 contains a summary of leachate water quality from the humidity cells and columns for selected parameters. Figures III.2-38, III.2-39, and III.2-40 show the pH, aluminum, and nickel results, respectively. Appendix O contains leachate analytical data on leachate for selected chemical parameters and is available upon request.

In summary, the kinetic test results from the metavolcanic unit for the variable input solution are as follows:

- With the exception of HC 24, the pH of the leachate from all cells remains at or near neutral (Figure III.2-38).
- Under the neutral pH conditions observed, leachate from the metavolcanic columns has low metal concentrations (Table III.2-20).
- The pH of leachate from HC 24 (acid washed + acid input) is substantially lower (approximately 2.5) than is observed in the other cells.

-
- Metal concentrations in leachates from HC 24 are significantly higher than those in leachates from the other humidity cells.
 - Long-term metal concentrations in leachates from HC 24 show significantly elevated levels, as illustrated by aluminum and nickel (Figures III.2-39 and III.2-40, respectively).
 - Very little difference is found between the leachates of HC 22 and HC 23. However, the difference between HC 22/HC 23 and HC 24, is much more pronounced.
 - Therefore, use of acidic input appears to have a more significant effect on leachate quality from metavolcanic material than acid washing. This results from the fact that acid washing of the metavolcanic sample has little impact on the small amount of NP present. Instead, it appears that sulphide is removed preferentially over NP, which explains the apparent increase in the NP/AP ratio. It is therefore the use of an acidic input solution that governs leachate quality rather than the effect of acid washing.
 - Depletion calculations using the rates observed from the kinetic testing (Table III.2-8) indicate that sulphur depletion will occur before depletion of the neutralization potential in HC 18, HC 19, and HC 23. In HC 22, the reverse is the case: the NP will be removed before the sulphur, resulting in residual sulphur. Depletion calculations using alkalinity could not be performed for HC 24, as no alkalinity was present under the acidic conditions present in the humidity cell. If allowed to recover (*i.e.*, a standard input solution would be used instead of an acidic solution), it is anticipated that the leachate quality would improve somewhat, but would likely not reach the water quality of HC 23 as little or no available buffering capacity would remain.
 - The first set of metavolcanic samples (HC 18, 19, and 23) is considered non-PAG in the short- and long-term. The results for HC 22 are considered inconclusive. Despite the fact that residual pyrite will be present after removal of all NP, it is unclear whether this sample will indeed generate acid due to its low sulphur content. Results from similar metavolcanic samples suggest that the sample will likely be non-PAG.
 - The reaction rates observed in the laboratory testing and, accordingly, the calculated depletion times and thresholds, should be used as an approximation only. Under field conditions, many factors, such as compaction, weathering, and climate may result in reaction rates that are different from those determined based on the laboratory results.

6.2.3 Comparison Between Columns and Humidity Cells

Column 4 was dismantled after 30 weeks, and a split of the original charge was continued in a standard humidity cell (HC-18). This provides an opportunity to evaluate any differences in leaching behaviour between the column and the humidity cell.

For virtually all parameters, the transition between column and humidity cell was relatively seamless. Trends established in the column were largely maintained in the humidity cells, with leachate concentrations being very similar (*e.g.*, for pH, sulphate, nickel, calcium). In a few cases, small, temporary spikes in concentrations were observed at the onset of humidity cell testing (*e.g.*, for copper, iron and zinc), but in general, concentrations decreased to the levels achieved at the termination of the column testing. One exception was the alkalinity, which decreased at the start-up of the humidity cell and did not recover to values observed in the original column. These results suggest that the leaching behaviour in the column and humidity cell was similar, and that either one could be used to make inferences with respect to long-term environmental behaviour of this particular sample.

7.0 RESULTS: CEMENTED BACKFILL, GROUT, CEMENT, AND CONCRETE

Grouting and cement can impact on water quality. Cement used in the mine will be limited to use in grout, use in concrete pillars, and as a minor component of paste backfill. To some extent, the cured cement and paste backfill will act as a hydraulic barrier to groundwater flow. This will limit interaction between these materials and mine water, with diffusion-controlled exchange of chemicals likely being the main mechanism. During the early stages of pillar placement, interaction between mine water and uncured cement will likely have the most impact on overall mine water discharge quality. Curing is generally thought to result in formation of a more stable mineral assemblage as well as a reduced opportunity for ingress of solutions.

The water quality currently observed in the mine sumps and discharge from the underground workings reflects impacts from use of cement and grout during the AEP. It is anticipated that future grout use will be relatively minor and limited to areas where discrete water bearing zones occur (*e.g.*, faults). Current conditions reflect a use of grout (consisting mostly of cement) that is enhanced relative to future use, and likely represent a “worst case” condition with respect to water quality impacts from grout and cement use in the mine. To evaluate current observed concentrations in the sump and further assess potential impacts from concrete and grout, the following leach testing was conducted:

- cemented paste backfill: type I and II sequential leach testing and SWEP testing;
- grout: modified SWEP testing after 24-hour and 7-day curing;
- cement: modified SWEP testing after 24-hour and 7-day curing; and,
- concrete (prepared with both granite and metavolcanic): modified SWEP testing after 24-hour and 7-day curing.

The next sections summarize the results from the leach testing. A more detailed description, graphs, and tables for the sequential paste leaching is located in Appendix G. Appendix P contains similar information for the single stage leach testing of cement, grout, and concrete. Both appendices are available upon request.

7.1.1 Cemented Paste Backfill Sequential Leach Testing

The cemented paste backfill (backfill) used for the leach testing consisted of two PK samples with 1 to 2% cement added. Selected leach results from the backfill are presented in Table III.2-21. Included in this table are the concentration ranges observed for the Type I and II leaching sequences, the results for the A1 leach (the very first leach of the sequential testing), and the average results for 3 SWEP tests performed on the second PK sample. The following is a summary of the key results:

- for most constituents, concentrations show an increasing trend throughout the type I testing;
- concentration stabilization was observed for a few parameters during the type I testing, most notably aluminum, barium, chromium, and molybdenum;
- concentration trends for the type II testing vary widely;
- type II testing generally results in lower values for leachate pH;
- type I leaching tends to result in higher concentrations than type II leaching;
- good agreement is found between the average results from the 3 SWEP tests and the ranges observed in the sequential testing;
- in general, the sequential leach results for the cemented paste backfill are distinct from those of the other sequential leach testing. In terms of pH, the greatest similarity is found with the alkaline kimberlite leaches, but metal concentrations are quite different; and,
- in most cases, metals leachability is much higher for the cemented paste than for the alkaline-leached kimberlite. Aluminum is a noteworthy exception to this general observation, and shows an opposite behaviour. The differences between the cemented paste backfill and the DI kimberlite, granite, and metavolcanic are even more pronounced.

7.1.2 Solid Waste Extraction Procedure Testing of Grout, Cement, and Concrete

A summary of SWEP test results from grout, cement, and concrete for selected parameters is presented in Tables III.2-22 (cement, grout) and III.2-23 (concrete prepared with granitic and metavolcanic aggregate). The samples were subjected to the leach testing after 24 hours and 7 days of curing to evaluate any changes in environmental stability over time.

The following is a summary of the most important observations:

- the pH for all leachates is similar and highly alkaline. A small reduction in pH (0.2 to 0.3 units) is observed between the 24-hour and 7-day leaches;
- the small reduction in pH is accompanied by an increase of the alkalinity in the leachates. This suggests that some of the alkalinity is readily available (possibly in the form of portlandite) and will likely be removed during water-rock interaction. However, the ABA results for these samples show a substantial excess NP, and these materials are considered incapable of generating any acid rock drainage; and,
- in general, there is little difference in leachability between the 24-hour and 7-day cured samples. However, minor reductions in leachability of the 7-day sample relative to the 24-hour sample are frequently observed. The most notable exception to this general trend is lead in the granitic concrete, whose leachability increases by an order of magnitude in the 6-day interval between the two leaches.

8.0 BASELINE WATER QUALITY

8.1 Snap Lake

The Snap Lake baseline water quality is discussed in detail in Section 9.4 of the EA, and is summarized in Table III.2-24 to provide a frame of reference relative to the baseline groundwater quality.

Snap Lake is a clear, soft-water lake, of neutral to slightly acidic pH with low nutrient concentrations and TDS. Most metals are present in very low concentrations. Table III.2-24 presents the ranges of major ion and metal concentrations in Snap Lake measured between 1998 and 2001.

8.2 Groundwater

The baseline groundwater quality was assessed through a review of the results of the mine water sampling program completed as part of the 2001 hydrogeology and geochemistry program. Samples used in the assessment of baseline water quality conditions were those collected from underground ports and seeps. The data are subdivided according to lithology (kimberlite, granite, or metavolcanic). A discussion of the groundwater quality measured from each of these units is provided below.

Results from the groundwater sampling program are provided in Appendix Q, which is available upon request, and summarized in Table III.2-25. General trends in the major ion distribution of the groundwater from the three main units are shown in the Piper plot provided in Figure III.1-41. This figure expresses the water composition in terms of relative percentages of the major cations (calcium, magnesium, and sodium plus potassium), and major anions (bicarbonate, carbonate, sulphate, and chloride) on the two triangular portions of the diagram. Data from the two ternaries are then projected onto the central portion of the diagram to aid in the identification of water quality groupings and trends.

Overall, the groundwater samples show weak to moderate concentrations of dissolved solids, with TDS ranging from 5 mg/L to 1,630 mg/L. The TDS levels are generally lowest in the upper metavolcanic units, but increase with depth and with transition to granitic material. The Piper diagram shows that granite groundwaters tend to be dominated by calcium and chloride, whereas in metavolcanic and kimberlite groundwater, bicarbonate, calcium and magnesium predominate.

The predominance of calcium and chloride in granite groundwaters is consistent with the same observation by Pearson (1987) regarding deep groundwaters of the Canadian Shield. The increase in TDS levels with depth has been noted in the literature as well

(*e.g.*, Frape and Fritz 1987). According to these authors, most of the salinity associated with the Shield groundwaters appears to be derived from intense water-rock interaction with the local host rock.

Trace metal concentrations in the groundwater samples are generally elevated with respect to those of Snap Lake for most parameters (see Table III.2-24). Some exceptions include cadmium, cobalt, mercury, and zinc. For most trace metals, concentrations in the groundwater samples range from approximately 10 to 20 times those observed in Snap Lake.

8.2.1 Kimberlites

Four kimberlite samples were collected from seeps in the mine in June and August 2001 (Table III.2-25). The following are the principal observations:

- kimberlite groundwater samples were slightly alkaline in nature (pH 7.8 to 8.1) and contained moderate TDS concentrations ranging from 120 to 660 mg/L;
- relative to the other two groundwater types, highest average concentrations in kimberlite groundwater were observed for magnesium. This is consistent with the more mafic character of the kimberlite, in particular the presence of serpentine, a magnesium-silicate;
- highest average concentrations for trace metals were found for boron, chromium, and nickel, all of which are common constituents of mafic rocks such as kimberlite; and,
- a comparison between the average kimberlite groundwater data and average long-term kinetic testing results shows excellent agreement. A few minor exceptions are sodium, chromium, and iron whose concentrations in groundwater are higher than observed in the long-term leachates.

8.2.2 Granites

Nine groundwater samples were taken from various underground locations from granite formations between May and June of 2001. The following are the principal observations:

- granite groundwater samples were near-neutral to alkaline in nature (pH 7.5 to 11.8) and contained the highest TDS concentrations of the three groundwater types, with values ranging from 360 to 1,630 mg/L. Two highly alkaline samples (pH 11.0 and 11.8) likely reflect an impact from grout/cement;
- relative to the other two groundwater types, highest average concentrations in granite groundwater were observed for calcium, potassium and sodium, consistent with the more felsic character of the granite, in particular the presence of K-feldspar and albite. In addition, chloride concentrations were highest in granitic groundwater;

- highest average concentrations for trace metals were found for aluminum, barium, iron, manganese, molybdenum, rubidium, and strontium, all of which are common constituents of felsic rocks such as granite; and,
- a comparison between the average granite groundwater data and average long-term kinetic testing results shows good agreement. A few minor exceptions are sodium, sulphate, copper, iron and manganese, whose concentrations in groundwater are higher than observed in the long-term leachates.

8.2.3 Metavolcanics

Groundwater samples from the metavolcanic unit were collected at 19 locations (including boreholes and seeps) within the mine. Samples were taken in August 2000, and January, May, June, and August of 2001. The following are the principal observations:

- the metavolcanic groundwater samples had moderate TDS values and were slightly alkaline to alkaline, with pH values ranging from 7.7 to 8.7. Although the TDS concentrations ranged from a low of 70 to a high of 1,420 mg/L, the typical range was from 250 to 350 mg/L, with a median TDS value of 270 mg/L;
- metavolcanic groundwater did not contain average trace metal concentrations that were higher than those for kimberlite or granite groundwater, despite the fact that certain trace metals are “enriched” in the metavolcanics relative to the kimberlite and granite. This suggests that the effectiveness of leaching of metavolcanic by groundwater may be limited and/or that geochemical controls may provide an upper limit for trace metal levels in groundwater; and,
- a comparison between the average metavolcanic groundwater data and average long-term kinetic testing results (minus those from the high-sulphide column 3) shows excellent agreement. One minor exception is sodium, whose concentration in groundwater is higher than observed in the long-term leachates.

8.3 Mine Water

To characterize the existing mine water, changes in mine water quality upon interaction with mining materials, and potential future changes to mine water, a characterization program was implemented as part of the AEP. This program consisted of collection of water samples from the mine floor, seeps/portals, and various sumps, and was supplemented with laboratory testing to help define potential limits with respect to leachable fractions. The results of the laboratory leach testing were discussed earlier in the various sections pertaining to the sequential leaching.

The primary goal of the water sampling campaign was to identify geochemical trends in drainage from the north drift. Water samples were collected from the floor of the north

drift along its entire length at approximately equally spaced locations. To characterize mine inflows, seeps, drillholes and portals along the length of the north drift were also sampled. The various sampling locations were identified by rock type.

This sampling campaign also included collection of water and solids from the active sumps. A total of five sumps (sump 1, 2, 3, 5 and 8) were sampled. Sump 8 is located at the lowest mine elevation. At the time of sample collection, mining was occurring in the lower level north and south drifts. Sump 8 water quality is therefore representative of discharge from the lower mine. Because sumps 6 and 7 are no longer operational, water from sump 8 is pumped directly to sump 5. Sump 5 also receives drainage from the upper level north and south drifts and recirculation overflow from the mud tank. Water is pumped from sump 5 to sump 1 via sumps 3, 2 and the mud tank. Sump 4 is no longer in operation. Sump 1 is ultimately discharged to the processed kimberlite containment (PKC) area via an underground end of pipe (UEOP). Recirculation of some water also occurs via the mud tank to sump 5. Sump solids are mucked out and removed from the underground workings on a routine basis.

In the next two sections, selected analytical results are presented in graphical format. Analytical results and an expanded series of concentration graphs are located in Appendix R, which is available upon request. Section 8.3.1 discusses the north drift sampling (*i.e.*, floor and inflow sampling). Section 8.4.2 describes the sump sampling.

8.3.1 North Drift Water Quality

Selected water quality data for samples collected along the floor of the north drift are presented in Figure III.2-42. North drift drainage flows from sample location UGNF-8 (underground north floor) to UGNF-10. Water quality data for inflows (dissolved parameters) to the north drift (portal, drillhole and seep samples) are presented in Figure III.2-43. Inflows are plotted in order of the direction of drainage flow from the end of the drift underground north ceiling (UGNC-08) to its entrance portal (P-06). Water quality data for the granite portal (GRA-P), located on the lower mine level, are included for comparison. Inflow data for kimberlite, metavolcanic, and granite sampling locations are represented by diamond, square, and triangular symbols, respectively. Circles denote sampling locations for which a unique designation could not be obtained (*i.e.*, miscellaneous sample in the north drift).

The following are the principal observations:

- As water flows along the floor of the north drift from station UGNF-8 to UGNF-10, the pH decreases from approximately 12 to approximately 8. The highly alkaline water at UGNF-8 is attributed to the presence of grout on the mine floor at this location. The decrease in pH is consistent with the precipitation of, what appears to

be, calcium carbonate, on the north drift floor, as well as dilution by inflows with a pH between approximately 8 and 9.

- With the exception of P-06, mine inflow pH values range from 7.9 to 9.2. A systematic trend similar to that of the pit floor is not as obvious, although an overall decrease in pH can be observed. Alkaline drainage from portal P-06 (pH = 12) is also attributed to the presence of grout in this drillhole.
- A general increasing trend is observed for both conductivity and TDS along the north drift flow path (not shown). Major ion concentrations (calcium, chloride, magnesium, sodium and sulphate) also generally increase (see Figures III.2-42 and III.2-43 for sulphate). This trend suggests the absence of effective solubility controls on major ion concentrations.
- Dissolved iron is non-detectable (<5 micrograms per litre (µg/L)) in all floor water samples. Dissolved iron in mine inflows is generally low, ranging from non-detectable to 43 µg/L. The one exception is the kimberlite portal (KIM-1) for which dissolved iron was 240 µg/L. Iron staining on mine walls suggests that iron concentrations in mine inflows quickly decrease as the result of precipitation of iron hydroxides. The alkaline character of inflows indicates that this precipitation does not exceed the inflows' buffering ability.
- Most trace metals exhibit a relatively consistent increase in concentration along the floor of the north drift (*e.g.*, arsenic, manganese, nickel). The trends in concentration are not as pronounced for inflow samples, but a general increase can be observed along the flowpath, thereby explaining the floor water trends. For most of these constituents, inflow concentrations are similar to the floor water concentrations, suggesting conservative behaviour.
- Dissolved aluminum shows a reverse trend (*i.e.*, an order of magnitude decrease from 140 µg/L to 14 µg/L). Mine inflow data indicate that, of the locations sampled, only KIM-1 and P-06 contribute significant aluminum (greater than 10 µg/L). The apparent stabilization of aluminum concentrations between UGNF-4 and UGNF-10 suggests a possible solubility control, most likely aluminum hydroxide [Al(OH)₃].
- Figure III.2-43 permits a cursory identification of water quality trends by rock type. Due to the limited number of samples for each rock, these trends may not be representative of conditions throughout the underground workings. These data indicate enrichment in arsenic, chromium, boron, and chloride in kimberlite inflows relative to the other rock types. The metavolcanic inflows record the highest lead concentrations, whereas manganese and molybdenum are highest in inflows from the

granite sample. These observations are very consistent with the groundwater results from ports and seeps.

- Similarly, agreement is found between the concentration ranges for the constituents presented in Figure III.2-43 and those found in the groundwater samples from ports and seeps.

8.3.2 Sump Water and Solids Quality

Selected water quality data for dissolved parameters in the sumps are plotted in Figure III.2-44. Solids compositions in the sumps are presented in Figure III.2-45. Sumps are shown in order of the direction of flow. Water quality data for the UEOP and PKC are included for comparison.

The following are the principal observations:

- in general, the pH decreases along the flow path. Values are within the same range as for north drift floor water and inflow;
- the turbidity and TSS concentrations (not shown) of all five sumps are high and highly variable between sumps. Specific conductivity and TDS concentrations (not shown) are also high, but exhibit less variability between sumps;
- major ion concentrations are relatively constant between sumps, and are generally higher in the sumps than in water from the floor of the north drift (see Figure III.2-44 for sulphate);
- dissolved concentrations for trace metals in the sumps and north drift floor/inflows generally are very similar. However, exceptions include iron and zinc, which are present in significantly higher concentration in the sumps;
- between sumps 5 and 2, a number of metals in the sump solids exhibit an increasing trend including Al, As, Cu, Fe, Pb, Mo, Ti, and Zn. However, the corresponding dissolved trends are less systematic. In general, it does not appear that an increasing trend in solids concentrations is accompanied by a decreasing trend in dissolved concentration, as would be expected if attenuation through adsorption and/or precipitation were taking place;
- since a percentage of the sump water is recirculated within the mine (from the mud overflow tank back to sump 5), concentration of constituents in the sumps is expected. In addition, the periodic mucking out of individual sumps is likely to disrupt any systematic geochemical trends, in particular those of the particulate material; and,
- dissolved concentrations in the UEOP and PKC generally are consistent with the trends established by the sumps.

8.4 Surface Water

Through the AEP water licence (NWTWB 1999) monitoring program and the AEP ARD plan, surface runoff water is monitored on site. As part of the ARD plan, an annual geochemical assessment of site conditions is required. Surface water samples were also collected as part of the EA baseline work.

The year 2000 geochemical assessment was conducted in August. Results from this assessment, as well as from EA-related surface water monitoring efforts, are summarized in Table III.2-26. Complete results are located in Appendix S, which is available upon request. All AEP water licence and AEP ARD sample results may also be found on the Public Registry of the Mackenzie Valley Land and Water Board.

Table III.2-26 includes the results for five samples from the north pit and six samples from the south pit (pit #3). Both pits were excavated as part of the 1999 bulk sampling program. Eight runoff samples were collected from the BSMRP. The BSMRP, located between the two pits, consists of material extracted from the north and south pits, including metavolcanics, granite, and some minor kimberlite. Bog 1 is a small boggy seep located near dam 1 of the of the PKC; the seep resulted from cutting into the peat bog material for dam construction. Bog 2 is located approximately 100 m northwest of the AEP rock crushing area. Bogs 1 and 2 are two swampy areas, both of which are located at a significant distance from host rock piles. Runoff (seven samples) was collected from the ramp development rockpile and was labelled pad runoff. The rockpile consisted of metavolcanic and granitic material.

The principal results and conclusions of the on-site surface water assessment and monitoring are as follows:

- Observed values for pH range from alkaline (north and south pit) to circumneutral (BSMRP runoff) to acidic (bogs 1 and 2 and ramp development rock runoff).
- The pH values for the bogs are considered representative of natural background. The low values are likely due to the presence of organic acids.
- It is considered likely that the low-pH conditions observed in the runoff from the ramp development pad are representative of displaced bog water. This hypothesis is supported by the following conclusions.
- A pH survey of two bog waters at the site conducted during the year 2000 geochemical assessment revealed a range between 4.9 and 6.1.
- Based on visual observation, it was evident that placement of ramp development rock on soft sediments results in displacement of the bog water into depressions along the side of the rock pile.

-
- The ABA results from ramp development rock (metavolcanic group 5) indicate that their sulphur content is very low (<0.3 wt%) while paste pH values are alkaline. This material was therefore designated non-PAG.
 - Visual evidence for acid generation in the rock pile was absent during the year 2000 geochemical assessment.
 - The low dissolved iron concentrations in the runoff are inconsistent with the acidity being generated through sulphide oxidation. Further corroboration is provided by the fact that dissolved iron concentrations in the natural bogs are higher than those in the runoff, despite the fact that the runoff pH is lower.
 - Portions of the rock excavated from the north and south pits (metavolcanic group 7) are designated PAG based on their ABA characteristic. However, runoff from the BSMRP shows circumneutral values for pH during the year 2000 geochemical assessment.
 - Highest trace metal concentrations are generally observed in the ramp development pad runoff. As discussed earlier, the low pH of this sample appears to be caused by displaced bog water. As a consequence, the elevated trace metal concentrations likely result from interaction between the low-pH bog water and material on the rock pile.
 - Major ion concentrations in bogs 1 and 2 are within the range of Snap Lake values (Table III.2-24). However, naturally-occurring trace metal concentrations in bogs 1 and 2 generally are higher than those in Snap Lake, with aluminum and iron being the most prominent. Zinc is the main exception, with higher concentrations in Snap Lake than in the two bogs.
 - Elevated concentrations of ammonia, nitrate + nitrite, and chloride are observed in the ramp development pad runoff. This may be due to placement of mucked out sump material on the pile, with the nitrogen species likely originating from explosives used in the mine.
 - A comparison between runoff from the BSMRP and results from the kinetic testing for the metavolcanics (Table III.2-19) shows that the range of trace metal concentrations in the runoff is captured by the range of kinetic testing results.

9.0 EXPECTED ISSUES ASSOCIATED WITH GEOLOGIC MATERIALS, MINE ROCK, AND AMENDMENTS

This section summarizes the findings of the baseline study in terms of expected water quality in contact with geologic materials, mine wastes, and the use of amendments. Results for kimberlite, granite, metavolcanic, paste backfill, cement, grout, and concrete are discussed.

9.1 Kimberlite

9.1.1 Kimberlite

The results from the geochemical characterization indicate that the kimberlite unit can be classified as not potentially acid generating (non-PAG). These results also demonstrate that kimberlite contains significant buffering capacity in the form of carbonate minerals.

9.1.2 Kimberlite Diluted with Metavolcanic

When kimberlite is mixed with PAG material (*e.g.*, metavolcanic), the kinetic test work suggests that alkaline conditions and low metal concentrations in discharges are maintained. Small amounts of metavolcanic material incorporated into the PK are therefore not expected to result in degradation of water quality with respect to that of pure kimberlite.

9.2 Granite

9.2.1 Granite Not Associated with Metavolcanics and Faulting

The results from the geochemical characterization indicate that the massive, unfractured granite located away from the metavolcanics can be classified as non-PAG. Despite the absence of significant buffering capacity, the sulphide content of these granites is so low as to not be capable of generating acid.

The kinetic test work further indicates that, in general, leachates are neutral, and metal concentrations in leachate from the granite are low.

9.2.2 Granite Associated with Metavolcanics and Faulting

Granitic samples associated with the metavolcanic unit and faulting generally contain more sulphur than those from undisturbed granite. In the absence of any significant carbonate and bulk NP, many of these samples are considered likely acid generating or PAG based on the ABA screening criteria developed by Price (1997). There does not

appear to be any distinct correlation between acid generation potential and the proportion in which the two lithologies occur within the mixed granite/metavolcanic unit. However, in general, the granitic component has less potential for acid generation than the metavolcanic component.

Long-term kinetic test results indicate that the water quality produced from the weathering of granitic material associated with metavolcanics/faulting will not represent a significant environmental concern because leachates are neutral, and metal concentrations are low.

9.3 Metavolcanics

The results from the geochemical characterization indicate that the metavolcanics have a lack of NP, and in particular CaNP. Sulphide contents vary widely, and can be high. Relatively small zones of high-sulphide rock can be of significant consequence as they serve to raise the sulphur content of any composite materials.

The ABA results suggest that metavolcanics with a sulphur concentration in excess of 0.3 wt% must be considered PAG. This material accounts for approximately one-third of all metavolcanic samples collected. For the remainder, it is believed that acid generation is unlikely due to the low sulphur content. Grainsize reduction of metavolcanic rocks appears to reduce the likelihood of acid generation relative to the bulk material due to enhanced exposure of carbonates.

Long-term leachates from the metavolcanic kinetic tests generally exhibit near-neutral pH and low trace metal concentrations. However, the test results from a high-sulphur sample (9.9 wt%) demonstrate that long-term generation of acid rock drainage is possible. The leachate from this sample is acidic, and contains elevated concentrations of aluminum, cadmium, cobalt, copper, iron, nickel, lead, and zinc.

9.4 PAG Rock Distribution

The distribution and modes of occurrence of the sulphide mineralization impede straightforward spatial characterization. Sulphides within the metavolcanic and granitic units occur both in massive and disseminated form. The highest-grade sulphide occurrences (from greater than 5% sulphide by volume to massive sulphide) are present sporadically throughout the metavolcanic and granitic units, and appear to be associated with the larger quartz veins. The width of the massive sulphide veins seldom exceeds 30 cm, while the width of zones of elevated sulphide values can be from 2 to 4 m. Disseminated sulphide appears to be largely associated with foliation within the metavolcanic unit.

Due to the discontinuous nature of the sulphide distribution and limitations resulting from the spacing of available data, the spatial distribution of PAG and non-PAG material cannot currently be predicted with any reasonable degree of certainty. However, an attempt was made to determine the sulphide content of the rock most likely to be included as dilution rock during kimberlite extraction. This is important, as the presence of sulphides is often structurally controlled (*e.g.*, in veins, fractures), and the contact between kimberlite and host rock could potentially act as such a control. This then would result in dilution rock containing sulphide concentrations that are elevated relative to those of the bulk host rock.

To evaluate this issue, the sulphide contents of the host rock (granite, metavolcanic) immediately above and below the kimberlite were identified using the year 2000 and 2001 drill logs. These sulphide contents represented visual estimates obtained during logging of the cores.

The sulphide contents of the host rock immediately above and below the kimberlites are presented in Table III.2-27. This table also includes the year 2000 and 2001 average values for all granite and metavolcanic samples as determined visually during the core logging. For comparison, the average sulphide concentrations for the individual rock types as determined from ABA are also presented. For the purpose of this table, it was assumed that all total sulphur (as determined from the ABA), was present as pyrite.

Table III.2-27 shows that dilution rock located immediately above and below the kimberlite has sulphide concentrations that are not elevated with respect to the overall characteristics of the granite and metavolcanic units, as determined both from visual observation and from the ABA. This indicates that sulphides are not preferentially concentrated along the kimberlite/host rock interface. The average sulphide contents derived from ABA are higher than those observed from the cores. This likely reflects a bias toward collection of high-sulphide samples for the ABA. It should also be noted that visual approximation of sulphide contents is a semi-quantitative effort at best. In light of this, the agreement between visual estimates and ABA results should be considered quite good.

9.5 Paste Backfill

Sequential leach testing of cemented paste backfill has identified that paste backfill can contribute significant amounts of alkalinity and trace metals. It should be noted that paste backfill will likely act as a hydraulic barrier, which will limit interaction between paste and groundwater seeping in to the underground.

9.6 Grout, Cement, and Concrete

Leach testing of grout, cement, and concrete has identified that these materials can contribute significant amounts of alkalinity and trace metals.

10.0 CONCLUSIONS

The following conclusions can be drawn from the geochemical baseline program:

- the bulk kimberlite is non-PAG due to its low sulphide sulphur content and substantial excess neutralization potential;
- the bulk discharge from any disposal alternative for PK is expected to be neutral or slightly alkaline, and contain low metal concentrations;
- granite is largely non-PAG due to its low sulphur content. Mixtures with metavolcanics and granites located in the vicinity of the metavolcanic unit that contain sulphur in excess of 0.3 wt% should be classified as PAG. Granite that does not contain extensive fracturing and/or is located away from the metavolcanic unit is not acid generating, and is deemed appropriate for use in construction;
- the bulk discharge from any disposal alternative for granite is expected to be neutral and contain low metal concentrations;
- metavolcanic material with a sulphur concentration in excess of 0.3 wt% is considered PAG. This material accounts for approximately one-third of all metavolcanic samples collected. For the remainder, it is believed that acid generation is unlikely due to the low sulphur content;
- grainsize reduction of metavolcanic rocks appears to reduce the likelihood of acid generation relative to the bulk material due to enhanced exposure of carbonates;
- the runoff from any disposal alternative for low-sulphur metavolcanics is expected to be neutral and contain low metal concentrations. Long-term testing has demonstrated that the runoff from metavolcanics with an elevated sulphur content (*i.e.*, >0.8 wt%) can be acidic and contain high metal concentrations;
- significant excess neutralization capacity is present in the proposed mixture to be placed in the north pile (80/20 kimberlite/metavolcanic). This is true even for a mixture consisting of high-sulphur metavolcanic rock and low-carbonate kimberlite. Long-term testing indicates that the runoff from such a mixture is neutral with low metal concentrations;
- leach testing of alkaline materials (cemented paste backfill, cement, grout, concrete) indicates that resulting discharges are alkaline and can contain a limited number of metals at elevated concentrations, most notably aluminum, copper, and lead;
- groundwater from port and seep samples generally are neutral to weakly alkaline and show low to moderate TDS concentrations. TDS levels are generally lowest in the upper metavolcanic units, but increase with depth and with transition to granitic material. Trace metal concentrations in groundwater are generally elevated with respect to those of Snap Lake;
- a comparison between groundwater data and average long-term kinetic testing results shows good agreement;
- water concentrations in the north drift are consistent with those from groundwater and ports and seeps. Most trace metals exhibit a relatively consistent increase in

concentration along the floor of the north drift. The concentration trends are not as pronounced for inflow samples, but a general increase can be observed along the flowpath. For most of these constituents, inflow concentrations are similar to the floor water concentrations, suggesting conservative behaviour;

- dissolved concentrations for trace metals in the sumps and north drift floor/inflows generally are very similar;
- a number of metals in the sump solids exhibit an increasing trend. However, the corresponding dissolved trends are less systematic. In general, it does not appear that an increasing trend in solids concentrations is accompanied by a decreasing trend in dissolved concentration. This is likely due to recirculation of sump water and periodic mucking out of the sumps;
- surface waters range from alkaline (north and south pit) to circumneutral (BSMRP runoff) to acidic (bogs 1 and 2 and ramp development rock runoff). It is considered likely that the low-pH conditions observed in the runoff from the ramp development pad are representative of bog water; and,
- a comparison between runoff from the BSMRP and results from the kinetic testing for the metavolcanics shows that the range of trace metal concentrations in the runoff is captured by the range of kinetic testing results.

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12.0 UNITS AND ACRONYMS

UNITS

cm	centimetre
°C	degrees Celsius
ha	hectare
kg	kilogram
kg CaCO ₃ /tonne	kilogram calcium carbonate per tonne
kg/tonne	kilogram per tonne
km	kilometre
m	metre
mg/kg	milligram per kilogram
mg/L	milligram per litre
mL	millilitre
mm	millimetre
Mt	million tonne
mg/L	milligrams per Litre
tpd	tonnes per day
µg/L	microgram/L
wt%	percent by weight

ACRONYMS

ABA	acid base accounting
AEP	advanced exploration program
AP	acid-generating potential

ARD	acid rock drainage
BC	British Columbia
BCRI	British Columbia Research Institute
BSMRP	bulk sample mine rock pad
CaNP	carbonate neutralization potential
DI	deionized water
DIAND	Department of Indian Affairs and Northern Development
DMS	dense media separation
E	east
EA	environmental assessment
Eh	oxidation reduction potential
ETL	Enviro-Test Laboratories
GRA-P	granite portal
ICP	inductively-coupled plasma atomic emission
KIM-1	kimberlite portal
LRC	Leslie Research Consulting
max	maximum
MG	multiphase granitoid
MGF	multiphase granitoid fractured
min	minimum
N	north
NNP	net neutralization potential (neutralizing potential minus acid-generating potential)
non-PAG	not potentially acid generating

NP	neutralizing potential
NPR	neutralizing potential divided by acid-generating potential
N-S	north-south
NTWB	Northwest Territories Water Board
NWD	northwest dyke
NWP98 grid	ore reserve characterization grid
P-06	entrance portal
PAG	potentially acid generating
PK	processed kimberlite
PKC	processed kimberlite containment
QA/QC	quality assurance / quality control
S	south
s.u.	standard units
SWEP	modified short-term leachate extraction
TDS	total dissolved solids
TSS	total suspended solids
UEOP	underground end of pipe
UGNC	underground north ceiling
UGNF	underground north floor
vs.	versus
WMP	water management pond
XRD	x-ray diffractometry
XRF	x-ray fluorescence

TABLES

Table III.2-1
Summary of Geochemical Characterization Program

May/June 1999	Total Sulphur	ABA	Whole Rock	Mineralogy	Trace Elements	Leachate (SWEP)	Sequential Leach		Kinetic Testing (Column)	Kinetic Testing (Humidity Cell)	Water Chemistry
							Type I	Type II			
Granite	14	14	14	2	14	2	-	-	-	-	-
Kimberlite	24	17	17	8	17	7	-	-	-	-	-
Metavolcanic	56	56	56	5	56	8	-	-	-	-	-
Groundwater	-	-	-	-	-	-	-	-	-	-	-
Surface Water	-	-	-	-	-	-	-	-	-	-	-
Mine Water	-	-	-	-	-	-	-	-	-	-	-
Process Water	-	-	-	-	-	-	-	-	-	-	-
Total	94	87	87	15	87	17	0	0	0	0	0

August 1999	Total Sulphur	ABA	Whole Rock	Mineralogy	Trace Elements	Leachate (SWEP)	Sequential Leach		Kinetic Testing (Column)	Kinetic Testing (Humidity Cell)	Water Chemistry
							Type I	Type II			
Granite	24	18	18	1	18	8	-	-	2	-	-
Kimberlite	4	4	4	1	4	2	-	-	3	2	-
Metavolcanic	101	85	86	4	86	36	-	-	10	-	-
Groundwater	-	-	-	-	-	-	-	-	-	-	-
Surface Water	-	-	-	-	-	-	-	-	-	-	30
Mine Water	-	-	-	-	-	-	-	-	-	-	-
Process Water	-	-	-	-	-	-	-	-	-	-	6
Total	129	107	108	6	108	46	0	0	15	2	36

2000	Total Sulphur	ABA	Whole Rock	Mineralogy	Trace Elements	Leachate (SWEP)	Sequential Leach		Kinetic Testing (Column)	Kinetic Testing (Humidity Cell)	Water Chemistry
							Type I	Type II			
Granite	1	2	1	2	1	-	-	-	-	2	-
Kimberlite	-	2	-	4	-	-	-	-	-	7	-
Metavolcanic	40	54	19	14	19	9	-	-	-	5	-
Overburden	-	6	2	-	2	-	-	-	-	-	-
Groundwater	-	-	-	-	-	-	-	-	-	-	1
Surface Water	-	-	-	-	-	-	-	-	-	-	24
Mine Water	-	-	-	-	-	-	-	-	-	-	-
Process Water	-	-	-	-	-	-	-	-	-	-	8
Total	41	64	22	20	22	9	0	0	0	14	33

2001	Total Sulphur	ABA	Whole Rock	Mineralogy	Trace Elements	Leachate (SWEP)	Sequential Leach		Kinetic Testing (Column)	Kinetic Testing (Humidity Cell)	Water Chemistry
							Type I	Type II			
Granite	37	39	1	1	4	-	1	1	-	-	-
Kimberlite	13	15	4	2	8	2	2	2	-	-	-
Metavolcanic	1	1	1	2	2	2	1	1	-	-	-
Cemented Paste Backfill	-	-	-	-	-	3	1	1	-	-	-
Overburden	1	1	-	-	-	-	-	-	-	-	-
Cement, Grouts and Concretes	4	4	4	-	8	12	-	-	-	-	-
Groundwater	-	-	-	-	-	-	-	-	-	-	28
Surface Water	-	-	-	-	-	-	-	-	-	-	-
Mine Water	-	-	-	-	-	-	-	-	-	-	29
Process Water	-	-	-	-	-	-	-	-	-	-	13
Total	56	60	10	5	22	19	5	5	0	0	70

TOTALS	Total Sulphur	ABA	Whole Rock	Mineralogy	Trace Elements	Leachate (SWEP)	Sequential Leach		Kinetic Testing (Column)	Kinetic Testing (Humidity Cell)	Water Chemistry
							Type I	Type II			
Granite	76	73	34	6	37	10	1	1	2	2	0
Kimberlite	41	38	25	15	29	11	2	2	3	9	0
Metavolcanic	198	196	162	25	163	55	1	1	10	5	0
Cemented Paste Backfill	0	0	0	0	0	3	1	1	0	0	0
Overburden	1	7	2	0	2	0	0	0	0	0	0
Cement, Grouts and Concretes	4	4	4	0	8	12	0	0	0	0	0
Groundwater	0	0	0	0	0	0	0	0	0	0	29
Surface Water	0	0	0	0	0	0	0	0	0	0	54
Mine Water	0	0	0	0	0	0	0	0	0	0	29
Process Water	0	0	0	0	0	0	0	0	0	0	27
Total	320	318	227	46	239	91	5	5	15	16	139

Note: ABA = acid base accounting; SWEP = modified short-term leachate extraction.
Refer to the Appendices for accompanying analyses (available upon request).
Refer to the List of Acronyms preceding the Appendices for definitions.

Table III.2-2
Acid Rock Drainage Screening Criteria (from Price, 1997)

Potential for ARD	Initial Screening Criteria	Comments
Likely	NP:AP <1	Likely acid generating, unless sulphide minerals are non-reactive
Possibly	1<NP:AP<2	Possibly acid generating if NP is insufficiently reactive or is depleted at a rate faster than sulphides
Low	NP:AP 2-4	Not potentially acid generating unless significant preferential exposure of sulphides along fractures planes, or extremely reactive sulphides in combination with insufficiently reactive NP
None	NP:AP >4	

Note: ARD = acid rock drainage; NP = neutralizing potential; AP = acid-generating potential.

Table III.2-3
Summary of Kinetic Testing Methodologies and Material Characteristics

Column Number	Sample ID	Group	Start Date	Status	End Date	Total S (wt %)	NP (kg CaCO ₃ /tonne)	CaNP (kg CaCO ₃ /tonne)	NP:AP	CaNP:AP	Notes
Kimberlites											
Column 2	67417	Unprocessed	4-Aug-99	Completed	1-Mar-00	0.07	335	96.7	268.0	77.3	
Column 1	67421	Tails and Grits	4-Aug-99	Completed	1-Mar-00	0.05	340	128.0	362.7	136.6	
HC 1	67420	Tails and Grits	26-Jul-99	Ongoing	-	0.13	357.5	178.4	114.4	57.1	
HC 2	67422	Thickener Underflow	26-Jul-99	Completed	28-Feb-00	0.05	335.0	116.5	268	93.2	
Column 12	67459	With Metavolcanics	22-Sep-99	Completed	22-Mar-00	0.15	38.6	15.9	8.2	3.4	
Granites											
Column 9	66977	Granites Including Metavolcanics	22-Sep-99	Completed	22-Mar-00	0.11	12.4	2.7	3.6	0.8	
HC 20	66977	Granites Including Metavolcanics	15-May-00	Ongoing	-	0.11	12.4	2.7	3.6	0.8	Continuation of Column 9 (Unmodified)
HC 21	66977	Granites Including Metavolcanics	15-May-00	Completed	13-Nov-00	0.14	15.0	2.2	3.4	0.50	-Continuation of Column 9 (Acid Wash Only) -ABA test performed again after acid washing completed
Column 5	67361	Granites Located Near Metavolcanic Unit	4-Aug-99	Completed	1-Mar-00	0.17	12.9	3.2	2.9	0.7	
Metavolcanics											
Column 10	66983	Open Pit Benches - Reconfigured	22-Sep-99	Ongoing	-	1.04	8.5	1.1	0.3	0.0	
Column 6	66951	Open Pit Benches -Original Configuration (Excluding Samples from Reconfigured Pit)	22-Sep-99	Completed	22-Mar-00	0.03	17.2	8.0	18.3	8.5	
Column 7	66957	Open Pit Benches -Original Configuration (Excluding Samples from Reconfigured Pit)	22-Sep-99	Completed	22-Mar-00	0.14	8.5	2.7	1.9	0.6	
Column 11	67457	Open Pit Benches -Original Configuration (Excluding Samples from Reconfigured Pit)	22-Sep-99	Ongoing	-	0.29	20.6	5.9	2.3	0.7	
Column 13	67494	Open Pit Benches -Original Configuration (Excluding Samples from Reconfigured Pit)	22-Sep-99	Completed	22-Mar-00	0.48	11.7	1.1	0.8	0.1	
Column 14	67498	Open Pit Benches -Original Configuration (Excluding Samples from Reconfigured Pit)	22-Sep-99	Ongoing	-	0.43	10.7	1.1	0.8	0.1	
Column 15	67500	Open Pit Benches -Original Configuration (Excluding Samples from Reconfigured Pit)	22-Sep-99	Completed	6-Oct-99	0.62	10.9	1.1	0.6	0.1	
Column 3	67325	Selected Samples Containing High Sulphides	4-Aug-99	Ongoing	-	9.9	15.2	1.1	0.05	0.0	
Column 4	67326	Selected Samples Excluding High Sulphides	4-Aug-99	Completed	1-Mar-00	0.18	8.7	1.6	1.5	0.3	
Column 8	66972	Selected Samples Excluding High Sulphides	22-Sep-99	Completed	22-Mar-00	0.76	20.9	1.1	0.9	0.0	
HC 18	67326	Selected Samples Excluding High Sulphides	15-May-00	Completed	13-Nov-00	0.18	8.7	1.6	1.5	0.3	Continuation of Column 4 (unmodified)
HC 19	67326	Selected Samples Excluding High Sulphides	15-May-00	Completed	13-Nov-00	0.29	9.8	3.5	1.1	0.38	-Continuation of Column 4 (acid wash only) -ABA test performed again after acid washing completed
Combinations											
HC 22	200001	Combination of Column 10(#66979), 66981 and 67747	15-May-00	Completed	13-Nov-00	0.36	12.6	1.1	1.1	0.05	Control
HC 23	200003	Combination of Column 10(#66979), 66981 and 67747	15-May-00	Completed	13-Nov-00	0.23	9.3	1.7	1.3	0.24	Acid Wash Only
HC 24	200003	Combination of Column 10(#66979), 66981 and 67747	15-May-00	Completed	13-Nov-00	0.23	9.3	1.7	1.3	0.24	Acid Wash + Acidic Input
HC 25	200002	Combination of 67429, 67430, 67433, 67434	15-May-00	Completed	13-Nov-00	0.05	318.6	131.4	254.9	105.15	Unmodified
HC 26	200004	Combination of 67429, 67430, 67433, 67434	15-May-00	Completed	13-Nov-00	0.07	78.0	33.4	35.7	15.28	Acid Wash Only
HC 27	200002	Combination of 67429, 67430, 67433, 67434	15-May-00	Completed	13-Nov-00	0.05	318.6	131.4	254.9	105.15	Acidic Input Only (not acid washed)
HC 28	200004	Combination of 67429, 67430, 67433, 67434	15-May-00	Completed	3-Apr-01	0.07	78.0	33.4	35.7	15.28	Acid Wash + Acidic Input
HC 29	200001+200002	Combination of HC22 and HC25	15-May-00	Completed	3-Apr-01	0.26	114.6	44.5	14.5	5.6	Control
HC 30	200003+200004	HC 23 and HC 26	15-May-00	Completed	3-Apr-01	0.18	32.2	12.3	5.8	5.3	Acid Wash Only
HC 31	200003+200004	HC 24 and HC28	15-May-00	Completed	3-Apr-01	0.18	32.2	12.3	5.8	5.3	Acid Wash + Acidic Input
Blanks											
HC 32			15-May-00	Ongoing	-						Blank humidity cell (acidic input)
HC Blank			26-Jul-99	Ongoing	-						Blank humidity cell

Note:

kg CaCO₃/tonne = kilogram calcium carbonate per tonne

CaNP = carbonate neutralization potential

ABA = acid base accounting.

NP = neutralizing potential

AP = acid-generating potential

Refer to the Appendices for accompanying analyses (available upon request).

Refer to the List of Acronyms for definitions.

Values reported as less than detection are represented in this table at the detection limit. See Appendices for more detail (available upon request).

Calculations of CaNP:AP and NP:AP based on detection limit values where values are reported below detection.

Table III.2-4
Summary of Acid Base Accounting Results for Kimberlite

KimberliteGroup	Number of Samples	Averages					
		Sulphur (wt.%)	NP*	CaNP*	AP*	NP:AP	CaNP:AP
All Samples	35	0.41	263	105	11.1	155	48
Unprocessed	10	0.18	362	183	4.5	260	75
Processed: Tails and Grits	8	0.09	297	115	2.3	163	63
Processed: Thickener Underflow	4	0.09	334	110	1.8	197	65
With Metavolcanic	2	0.14	27	9.6	4.4	6.0	2.1
Processed Paste	1	0.12	221	53	2.5	89	21
DMS Underflow	5	2.12	24	6.9	66	2.6	0.5
AEP Underground Samples	5	0.09	298	73	2.6	124	30

Note: * units expressed in kg CaCO₃/tonne

Values reported as less than detection are represented in this Table at the detection limit.

Statistical calculations assume that values reported less than the detection limit are represented at the detection limit.

Calculations of CaNP:AP and NP:AP based on detection limit values where values are reported below detection.

Refer to Appendix C for a complete list of values and detection limits (available upon request).

Refer to the List of Acronyms for definitions.

Table III.2-5
Summary of SWEP Testing Results for Kimberlite

Parameter	Kimberlite Group Averages			
	Unprocessed	Processed: Tails and Grits	Processed: Thickener and Underflow	With Metavolcanics
No. of Samples	4	3	1	1
pH	8.8	8.7	8.7	9.4
Alkalinity (mg/L as CaCO ₃)	24	32	30	21
TDS (mg/L)	98	130	174	62
SO ₄ (mg/L)	29.5	36.0	59.6	1.4
Cl (mg/L)	0.24	0.22	0.73	0.28
Total P (mg/L)	0.02	0.01	0.07	0.02
PO ₄ (mg/L-P)	0.02	0.01	0.02	0.02
NH ₃ (mg/L-N)	0.04	0.01	0.01	0.19
NO ₃ (mg/L-N)	0.01	0.04	0.01	0.01
Al (mg/L)	0.019	0.005	0.009	0.413
As (µg/L)	0.63	0.50	1.00	0.50
Cd (µg/L)	0.05	0.05	0.05	0.05
Co (µg/L)	0.08	0.08	0.36	0.04
Cr (µg/L)	0.31	0.42	0.25	0.25
Cu (µg/L)	0.70	0.43	1.00	0.20
Fe (mg/L)	0.05	0.04	0.13	0.08
Hg (µg/L)	0.5	0.5	0.5	0.5
K (mg/L)	2.90	3.48	7.05	1.50
Mn (µg/L)	0.94	1.08	2.70	0.60
Mo (µg/L)	10.73	18.53	43.80	0.60
Na (mg/L)	2.00	1.00	2.20	1.05
Ni (µg/L)	2.95	4.93	10.00	0.20
Pb (µg/L)	1.00	1.00	1.00	1.00
Zn (µg/L)	1.06	0.25	0.25	0.25

Notes:

- Values reported as less than detection were entered as 1/2 the detection limit for the purpose of calculating averages.
- Italicized, light shaded values indicate all values reported in average were less than detection and the value presented is 1/2 the detection limit.
- Refer to Appendix F for a complete list of values and detection limits (available upon request).
- Refer to the List of Acronyms for definitions.

Table III.2-6
Summary of Sequential Leach Testing Results for Kimberlite

Sample ID	Deionized Water Leach		Alkali Leach ⁽¹⁾	
	Type I (Fresh Solids)	Type II (Fresh Lixiviant)	Type I (Fresh Solids)	Type II (Fresh Lixiviant)
pH	7.9-8.8	9.2-9.3	8.6-10.3	10.9-11.5
Alkalinity (mg/L CaCO ₃)	28-63	24-26	36-110	90-200
SO ₄ (mg/L)	9.3-80	2.3-11	9.2-84	<1-4
Cl (mg/L)	2.1-8.8	0.60-0.87	2.0-9.4	0.40-1.7
Total P (mg/L)	0.01-0.70	<0.01-0.02	<0.01-0.03	<0.01-0.03
PO ₄ (mg/L-P)	-	-	-	-
NH ₃ (mg/L-N)	0.89-2.7	0.14-0.48	1.6-2.8	0.10-0.55
NO ₃ (mg/L-N)	0.64-1.6	0.27-0.45	0.33-0.70	<0.02-0.21
Al (mg/L)	3-6	3-14	2-7	19-44
As (µg/L)	0.4-0.5	0.2-0.3	0.3-0.7	<0.1-0.3
Cd (µg/L)	<0.05	<0.05	<0.05	<0.05
Co (µg/L)	<0.1-0.3	<0.1	<0.1-0.2	<0.1
Cr (µg/L)	<0.5	<0.5	<0.5-1.3	1.6-22
Cu (µg/L)	1.1-4.6	0.3-0.6	1.6-7.4	0.3-1.6
Fe (mg/L)	<0.01	<0.01-0.01	<0.01	<0.01
Hg (µg/L)	<1	<1	<1	<1
K (mg/L)	1.8-6.6	1.1-1.2	1.9-6.4	1.6-1.9
Mn (µg/L)	0.33-1.9	0.24-1.6	0.06-1.7	<0.05-0.24
Mo (µg/L)	12.7-58	<1-3.1	12-62	<1-2.9
Na (mg/L)	4.2-17.1	0.29-1.41	4-17	0.2-1.4
Ni (µg/L)	2.4-17	<1.0-1.2	<0.5-16	<0.5-<1
Pb (µg/L)	<0.05-0.06	<0.05	<0.05	<0.05-0.06
Zn (µg/L)	<1-9	1-14	2-4	<1-4

Note: a. For the alkali leach, deionized water was adjusted to a pH of 12 with Ca(OH)₂

"<" indicates concentration below analytical detection limits.

Refer to Appendix G for a complete list of values and detection limits (available upon request).

Refer to the List of Acronyms for definitions.

Table III.2-7
Summary of Kinetic Testing Results for Kimberlite – Standard Input Solution

Parameter	Column 1	Column 2	HC 1	HC 2	Column 12	Summary Average
Total S (wt%) ^a	0.05	0.07	0.13	0.05	0.15	0.09
NP:AP ^a	363	268	114	268	8.2	204
pH	8.1	8.2	8.0	8.1	8.0	8.1
Alkalinity (mg/L as CaCO ₃)	71.7	131	44.3	31.3	60.0	67.7
SO ₄ (mg/L)	23.4	27.2	3.8	10.4	23.8	17.7
Cl (mg/L)	0.14	0.19	0.10	0.34	0.10	0.17
Total P (mg/L)	0.10	0.06	0.01	0.01	0.01	0.04
PO ₄ (mg/L-P)	0.02	0.03	0.01	0.01	0.01	0.01
NH ₃ (mg/L-N)	0.01	0.01	0.01	0.01	0.01	0.01
NO ₃ (mg/L-N)	0.130	0.250	0.003	0.001	1.88	0.45
Al (mg/L)	0.003	0.003	0.009	0.016	0.012	0.009
As (µg/L)	<i>0.50</i>	<i>0.50</i>	1.00	0.67	<i>0.50</i>	0.63
Cd (µg/L)	<i>0.05</i>	<i>0.05</i>	0.05	<i>0.05</i>	<i>0.05</i>	0.05
Co (µg/L)	0.28	0.45	0.54	0.29	0.19	0.35
Cr (µg/L)	0.67	1.50	1.00	0.50	0.33	0.80
Cu (µg/L)	1.3	1.6	0.7	1.1	0.3	1.0
Fe (mg/L)	0.007	<i>0.005</i>	0.050	0.023	0.007	0.018
Hg (µg/L)	<i>0.50</i>	<i>0.50</i>	<i>0.50</i>	<i>0.50</i>	<i>0.50</i>	0.50
K (mg/L)	8.7	3.9	6.7	4.6	5.2	5.9
Mn (µg/L)	1.6	4.1	2.5	2.7	5.0	3.18
Mo (µg/L)	7.7	3.2	13.3	9.1	2.8	7.2
Na (mg/L)	2.0	2.3	0.65	0.55	2.1	1.5
Ni (µg/L)	19	51	15	4.3	1.7	18.2
Pb (µg/L)	<i>1.00</i>	1.33	1.00	<i>1.00</i>	2.67	1.4
Zn (µg/L)	0.83	3.08	0.25	0.42	1.58	1.23

Note: a. Solid-phase values measured at initiation of kinetic testing

Italicized, light shaded values indicate all values reported in average were less than detection and the values presented are ½ the detection limit.

Leachate analytical values for the individual columns/humidity cells are averages from the last five weeks for pH, alkalinity and SO₄ or from the last three sampling events for the remaining leachate parameters (where sampling was less frequent).

The values under the "Summary Average" heading are the averages of the five cells.

Statistical calculations assume that values reported less than the detection limit are represented at ½ the detection limit.

Refer to Appendix H for a complete list of values and detection limits (available upon request).

Refer to the List of Acronyms for definitions.

Number of samples are outlined in Table III.2-1 and Appendix H (available upon request).

Table III.2-8
Depletion Calculations and Long-Term Predictions of Acid Generation

Column Number	Group	Total S (wt %)	NP (kg CaCO ₃ /tonne)	CaNP (kg CaCO ₃ /tonne)	NP:AP	CaNP:AP	Notes	NP Depletion (years)	Sulphur Depletion (years)	Long-Term Prediction
Kimberlites										
Column 2	Unprocessed	0.07	335	96.7	268.0	77.3		252	3.5	non acid generating
Column 1	Tails and Grits	0.05	340	128.0	362.7	136.6		359	1.7	non acid generating
HC 1	Tails and Grits	0.13	357.5	178.4	114.4	57.1		641	9.3	non acid generating
HC 2	Thickener Underflow	0.05	335.0	116.5	268	93.2		275	0.13	non acid generating
Column 12	With Metavolcanics	0.15	38.6	15.9	8.2	3.4		71.4	8.0	non acid generating
Granites										
Column 9	Granites Including Metavolcanics	0.11	12.4	2.7	3.6	0.8		42.0	21.0	non acid generating
HC 20	Granites Including Metavolcanics	0.11	12.4	2.7	3.6	0.8	Continuation of Column 9 (Unmodified)	90.8	21.6	non acid generating
HC 21	Granites Including Metavolcanics	0.14	15.0	2.2	3.4	0.50	-Continuation of Column 9 (Acid Wash Only) -ABA test performed again after acid washing completed	241	34.7	non acid generating
Column 5	Granites Located Near Metavolcanic Unit	0.17	12.9	3.2	2.9	0.7		35.1	34.1	non acid generating
Metavolcanics										
Column 10	Open Pit Benches - Reconfigured	1.04	8.5	1.1	0.3	0.0		41.8	43.8	acid generating
Column 6	Open Pit Benches -Original Configuration (Excluding Samples from Reconfigured Pit)	0.03	17.2	8.0	18.3	8.5		41.7	5.8	non acid generating
Column 7	Open Pit Benches -Original Configuration (Excluding Samples from Reconfigured Pit)	0.14	8.5	2.7	1.9	0.6		35.6	12.7	non acid generating
Column 11	Open Pit Benches -Original Configuration (Excluding Samples from Reconfigured Pit)	0.29	20.6	5.9	2.3	0.7		64.8	17.6	non acid generating
Column 13	Open Pit Benches -Original Configuration (Excluding Samples from Reconfigured Pit)	0.48	11.7	1.1	0.8	0.1		71.4	29.1	non acid generating
Column 14	Open Pit Benches -Original Configuration (Excluding Samples from Reconfigured Pit)	0.43	10.7	1.1	0.8	0.1		24.2	10.7	non acid generating
Column 15	Open Pit Benches -Original Configuration (Excluding Samples from Reconfigured Pit)	0.62	10.9	1.1	0.6	0.1		19.7	18.1	non acid generating
Column 3	Selected Samples Containing High Sulphides	9.9	15.2	1.1	0.05	0.0		18.6	70.5	acid generating
Column 4	Selected Samples Excluding High Sulphides	0.18	8.7	1.6	1.5	0.3		31.6	24.1	non acid generating
Column 8	Selected Samples Excluding High Sulphides	0.76	20.9	1.1	0.9	0.0		45.9	16.6	non acid generating
HC 18	Selected Samples Excluding High Sulphides	0.18	8.7	1.6	1.5	0.3	Continuation of Column 4 (unmodified)	60.9	10.7	non acid generating
HC 19	Selected Samples Excluding High Sulphides	0.29	9.8	3.5	1.1	0.38	-Continuation of Column 4 (acid wash only) -ABA test performed again after acid washing completed	139	54.3	non acid generating
Combinations										
HC 22	Combination of Column 10(#66979), 66981 and 67747	0.36	12.6	<1.1	1.1	0.05	Control	43.6	60.8	inconclusive
HC 23	Combination of Column 10(#66979), 66981 and 67747	0.23	9.3	1.7	1.3	0.24	Acid Wash Only	150	30.7	non acid generating
HC 24	Combination of Column 10(#66979), 66981 and 67747	0.23	9.3	1.7	1.3	0.24	Acid Wash + Acidic Input	-	-	not applicable
HC 25	Combination of 67429, 67430, 67433, 67434	0.05	318.6	131.4	254.9	105.15	Unmodified	221	0.67	non acid generating
HC 26	Combination of 67429, 67430, 67433, 67434	0.07	78.0	33.4	35.7	15.28	Acid Wash Only	138	2.6	non acid generating
HC 27	Combination of 67429, 67430, 67433, 67434	0.05	318.6	131.4	254.9	105.15	Acidic Input Only (not acid washed)	198	0.40	non acid generating
HC 28	Combination of 67429, 67430, 67433, 67434	0.07	78.0	33.4	35.7	15.28	Acid Wash + Acidic Input	209	4.8	non acid generating
HC 29	Combination of HC22 and HC25	0.26	114.6	44.5	14.5	5.6	Control	304	40.8	non acid generating
HC 30	HC 23 and HC 26	0.18	32.2	12.3	5.8	5.3	Acid Wash Only	525	19.6	non acid generating
HC 31	HC 24 and HC28	0.18	32.2	12.3	5.8	5.3	Acid Wash + Acidic Input	-	-	not applicable

Note:

"<" indicates concentration below analytical detection limits.

kg CaCO₃/tonne = kilogram calcium carbonate per tonne

CaNP = carbonate neutralization potential

ABA = acid base accounting.

NP = neutralizing potential

AP = acid-generating potential

Refer to the Appendices for accompanying analyses (available upon request).

Refer to the List of Acronyms for definitions.

Values reported as less than detection are represented in this table at the detection limit. See Appendices for more detail (available upon request).

Calculations of CaNP:AP and NP:AP based on detection limit values where values are reported below detection.

Table III.2-9
Summary of Kinetic Testing Results for Kimberlite - Variable Input Solution

Parameter	Kimberlite				Layered Kimberlite/Metavolcanic		
	HC 25	HC 26	HC 27	HC 28	HC 29	HC 30	HC 31
Total S (wt%) ^a	0.05	0.07	0.05	0.07	0.26	0.18	0.18
NP:AP ^a	255	35.7	255	35.7	14.5	5.8	5.8
pH	8.2	7.4	6.7	6.8	8.23	6.96	2.88
Alkalinity (mg/L as CaCO ₃)	66.7	19.0	62.3	11.0	28.3	3.67	0.00
SO ₄ (mg/L)	9.4	10.6	9.6	6.4	4.8	7.2	8.8
Cl (mg/L)	0.50	0.79	158	170	0.38	0.80	175
Total P (mg/L)	0.01	4.2	0.12	1.4	0.01	0.78	0.28
PO ₄ (mg/L-P)	0.01	5.4	0.10	1.8	0.01	1.1	0.27
NH ₃ (mg/L-N)	0.01	0.01	0.01	0.02	0.01	0.01	0.06
NO ₃ (mg/L-N)	0.018	0.002	0.008	0.002	0.094	0.007	0.001
Al (mg/L)	0.006	0.018	0.004	0.175	23.0	13.0	3430
As (µg/L)	1.00	10.0	0.83	3.67	0.67	1.67	0.50
Cd (µg/L)	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	0.05	0.05	0.05	0.12
Co (µg/L)	0.25	0.25	2.8	5.8	0.07	0.15	28.1
Cr (µg/L)	1.33	1.67	0.42	1.25	0.33	0.33	6.67
Cu (µg/L)	0.4	0.3	0.3	1.7	0.7	0.6	116
Fe (mg/L)	0.023	0.050	0.078	0.300	0.023	0.033	10.35
Hg (µg/L)	<i>0.50</i>	<i>0.50</i>	<i>0.50</i>	<i>0.50</i>	<i>0.50</i>	<i>0.50</i>	<i>0.50</i>
K (mg/L)	7.5	5.9	9.5	9.9	3.1	1.5	4.4
Mn (µg/L)	2.8	6.0	65.4	141	1.5	2.0	168
Mo (µg/L)	11.3	17.3	23.3	12.8	5.4	6.3	2.3
Na (mg/L)	0.28	0.13	0.38	0.20	0.38	0.13	0.33
Ni (µg/L)	11.7	21.0	83	319	1.8	5.0	209
Pb (µg/L)	<i>1.00</i>	<i>1.00</i>	<i>1.00</i>	1.00	1.00	1.00	2.33
Zn (µg/L)	0.33	1.5	0.33	1.8	8.58	0.25	77.5

Note: a. Solid-phase values measured at initiation of kinetic testing

Italicized, light shaded values indicate all values reported in average were less than detection and the values presented are ½ the detection limit.

Leachate analytical values for the individual columns/humidity cells are averages from the last five weeks for pH, alkalinity and SO₄ or from the last three sampling events for the remaining leachate parameters (where sampling was less frequent).

Statistical calculations assume that values reported less than the detection limit are represented at ½ the detection limit.

Refer to Appendix M for a complete list of values and detection limits (available upon request).

Refer to the List of Acronyms for definitions.

Number of samples are outlined in Table III.2-1 and Appendix M (available upon request).

Table III.2-10
Summary of Process Water Quality

Parameter	Units	Process Water (n=28)								
		Lupin (n=6)			SNP 1735-09 Decant (n=8)			SNP 1735-09 Whole (n=14)		
		min	max	average	min	max	average	min	max	average
Conventional Parameters										
pH	pH	6.8	8.3	7.5	7.4	8.7	8.0	8.5	9.2	8.7
Alkalinity	mg/L	26.6	66.6	45.1	61.0	83.5	68.3	35.0	75.2	56.7
Total Dissolved Solids	mg/L	275	839	587	305	1270	823	-	-	-
Total Suspended Solids	mg/L	28.0	102.0	51.2	1.5	17.0	7.3	78.0	603000	233348
Total Hardness	mg/L	156	589	354	180	748	440	-	-	-
Dissolved Organic Carbon	mg/L	-	-	-	3.0	3.2	3.1	-	-	-
Conductivity	uS/cm	346	1040	732	551	1960	1190	-	-	-
Nutrients										
Ammonia	mg/L	0.3	0.7	0.4	0.6	24.4	12.3	5.5	5.5	5.5
Nitrate + Nitrite	mg/L	1.5	2.5	1.9	17.7	62.0	42.7	-	-	-
Total Phosphorus	mg/L	0.1	0.2	0.2	0.03	0.1	0.1	-	-	-
Orthophosphate	mg/L	0.004	0.1	0.026	-	-	-	-	-	-
Total Kjeldahl Nitrogen	mg/L	1.1	1.3	1.2	7.1	46.0	26.6	-	-	-
Total Organic Carbon	mg/L	2.7	11.0	5.0	3.3	3.3	3.3	-	-	-
Major Ions										
Bicarbonate	mgCO ₃ /L	26.6	66.1	44.9	75.0	80.0	77.5	-	-	-
Carbonate	mg/L	-	-	-	2.5	2.5	-	-	-	-
Calcium	mg/L	25.0	91.4	60.8	26.0	123.0	69.1	-	-	-
Chloride	mg/L	15.4	38.3	20.7	22.0	264.0	93.1	-	-	-
Fluoride	mg/L	-	-	-	1.1	2.1	1.6	-	-	-
Magnesium	mg/L	22.7	87.7	49.0	27.9	107.0	65.0	-	-	-
Potassium	mg/L	9.3	19.2	14.8	10.2	26.1	20.5	-	-	-
Silica	mg/L	10.9	18.4	15.4	19.9	334.0	177.0	-	-	-
Sodium	mg/L	8.0	24.2	17.7	15.7	70.8	44.1	-	-	-
Sulphate	mg/L	30.0	507.0	284.7	65.0	375.0	205.0	-	-	-
Dissolved Metals										
Aluminium	ug/L	15.0	15.0	15.0	3.9	15.0	10.8	5.0	15.0	13.3
Antimony	ug/L	1.3	1.9	1.6	1.9	10.0	5.4	1.1	7.7	3.1
Arsenic	ug/L	0.1	0.1	0.1	1.8	2.0	1.9	2.2	2.2	2.2
Barium	ug/L	26.9	93.4	63.7	27.9	120.0	83.7	35.1	1340.0	268.1
Beryllium	ug/L	0.1	2.0	0.4	0.1	0.1	0.1	0.1	0.3	0.1
Bismuth	ug/L	0.1	0.1	0.1	0.1	2.5	1.1	0.1	2.5	2.1
Boron	ug/L	-	-	-	832	1090	961	1810	1810	1810
Cadmium	ug/L	0.1	0.5	0.3	0.1	0.4	0.2	0.1	0.2	0.1
Cesium	ug/L	0.1	0.2	0.1	0.2	1.5	0.9	0.2	0.8	0.4
Chromium	ug/L	0.2	1.0	0.6	0.03	1.2	0.6	0.2	0.6	0.3
Cobalt	ug/L	0.2	1.6	0.9	0.1	1.3	0.7	0.1	3.6	0.8
Copper	ug/L	0.1	0.8	0.5	0.5	1.3	0.9	0.6	1.4	1.1
Iron	ug/L	20.0	62.0	38.0	2.5	15.0	10.0	15.0	59.0	24.8
Lead	ug/L	0.1	0.6	0.2	0.03	0.4	0.2	0.1	1.2	0.4
Lithium	ug/L	22.9	37.0	31.8	10.0	51.2	31.4	13.1	132.0	35.0
Manganese	ug/L	4.7	32.8	19.3	0.8	29.5	12.3	0.9	3910.0	653.6
Mercury	ug/L	0.005	0.005	0.005	0.020	0.070	0.045	-	-	-
Molybdenum	ug/L	62.7	285.0	194.1	39.6	223.0	129.7	8.0	66.2	47.5
Nickel	ug/L	8.6	107.0	61.0	3.2	75.8	42.4	2.1	234.0	44.8
Rubidium	ug/L	-	-	-	20.1	57.0	40.0	22.6	70.0	37.8
Selenium	ug/L	0.5	10.0	4.1	0.2	0.8	0.4	0.2	0.2	0.2
Silver	ug/L	0.05	0.1	0.05	0.05	0.1	0.1	0.05	0.1	0.06
Strontium	ug/L	161.0	541.0	350.7	389.0	2250.0	1044.8	299.0	4570.0	1116.5
Thallium	ug/L	0.1	0.4	0.2	0.1	3.5	1.4	0.1	5.2	1.0
Titanium	ug/L	0.8	3.4	2.4	0.3	1.9	1.2	0.2	9.4	2.2
Uranium	ug/L	0.4	1.3	0.9	0.1	1.4	0.7	0.1	13.0	2.3
Vanadium	ug/L	0.1	1.5	0.8	0.8	2.1	1.2	0.4	6.3	1.8
Zinc	ug/L	5.0	5.0	5.0	1.6	5.0	3.8	5.0	518.0	90.5

Notes:

Shaded values undergoing QA/QC review

Lupin: Process water from Snap Lake kimberlite processed at the Lupin mine site

SNP 1735-09: Advanced exploration project water licence sample of decanted and whole fraction of discharge from the pilot process plant.

Values reported as less than detection are represented in this table at the detection limit. See Appendix K for more detail (available upon request).

Statistical calculations assume that values reported less than the detection limit are represented at 1/2 the detection limit.

Refer to Appendix K for accompanying analyses (available upon request).

Refer to the List of Acronyms for definitions.

Number of samples are outlined in Table III.2-1 and Appendix K. The number of analyses for any given parameter may vary from the number of samples as indicated in the Appendices (available upon request).

Table III.2-11
Comparison Between Snap Lake and Other Kimberlites

	SNAP LAKE ^a (n=5)	DIAVIK		EKATI (n=5)
		Stage 1 Kimberlite (n=1)	Stage 1 Mudstone (n=1)	
Total Sulphur (Wt %)	0.05-0.15	0.42	3.50	0.001-0.7
NP:AP ratio	8.2-363	36.5	0.38	7.7-14,496
pH (pH units)	8.0-8.2	8.38	3.5	8.0-10.8
SO ₄ (mg/L)	3.8-27.2	691	8,765	3.2-48.0
Al (mg/L)	0.003-0.016	< 0.001	69.7	0.009-0.22
Co (µg/L)	0.19-0.54	3.1	2,713	0.12-0.54
Cr (µg/L)	0.33-1.5	1.0	27.3	1.7-3.9
Cu (µg/L)	0.3-1.6	4.2	217	3.5-9.5
Fe (mg/L)	<0.01-0.05	< 0.01	0.39	0.0023-0.3
K (mg/L)	3.9-8.7	-	-	4.4-15.6
Mn (µg/L)	1.6-5.0	9.3	23,700	0.62-8.2
Mo (µg/L)	2.8-13.3	131	0.2	1.1-13.7
Ni (µg/L)	1.7-51	3.7	19,500	1.6-15
Zn (µg/L)	0.25-1.58	3.4	11,600	4.6-22

Notes: a. Refer to Table III.2-7 for more details concerning the Snap Lake Humidity cell results.
Refer to Appendix H for a complete list of Snap Lake values and detection limits (available upon request).
Refer to the List of Acronyms for definitions.
Number of Snap Lake samples are outlined in Table III.2-1 and Appendix H (available upon request).

Table III.2-12
Summary of Acid Base Accounting Results for Granite

Granite Group	Number of Samples	Averages					
		Sulphur (wt.%)	NP*	CaNP*	AP*	NP:AP	CaNP:AP
All Samples	70	0.39	11	2.2	12	10.4	1.9
Granitic Samples Including Metavolcanics	8	1.96	15	3.1	61	2.8	0.6
Granitic Samples Near Metavolcanics	15	0.63	9.0	3.0	20	5.0	1.7
Granitic Samples Away from Metavolcanics	10	0.05	16	3.0	1.6	23	3.6
Quarry/Construction Rock	22	0.04	8.8	1.4	1.3	9.7	1.5
Reef Rock (Quarry and Esker)	7	0.03	9.6	2.1	0.8	14	3.3
Underground Construction Material	8	0.03	9.2	1.3	1.1	11	1.5

Note: * units expressed in kg CaCO₃/tonne

Values reported as less than detection are represented in this Table at the detection limit.

Statistical calculations assume that values reported less than the detection limit are represented at the detection limit.

Calculations of CaNP:AP and NP:AP based on detection limit values where values are reported below detection.

Refer to the Appendix C for a complete list of values and detection limits (available upon request).

Refer to the List of Acronyms for definitions.

Table III.2-13
Summary of SWEP Testing Results for Granite

Parameter	Granite Group Averages	
	Samples that Include Metavolcanics	Granitic Samples Located Near the Metavolcanic Unit
No. of Samples	4	6
pH	9.4	8.9
Alkalinity (mg/L as CaCO ₃)	11	11
TDS (mg/L)	26	45
SO ₄ (mg/L)	0.5	2.1
Cl (mg/L)	0.22	0.27
Total P (mg/L)	0.08	0.03
PO ₄ (mg/L-P)	0.01	0.01
NH ₃ (mg/L-N)	0.17	0.03
NO ₃ (mg/L-N)	0.01	0.01
Al (mg/L)	0.674	0.610
As (µg/L)	<i>0.50</i>	0.67
Cd (µg/L)	<i>0.05</i>	<i>0.05</i>
Cr (µg/L)	0.75	0.46
Cu (µg/L)	0.33	0.62
Fe (mg/L)	0.27	0.14
Hg (µg/L)	<i>0.5</i>	<i>0.5</i>
K (mg/L)	1.36	0.80
Mn (µg/L)	3.35	2.64
Mo (µg/L)	3.33	7.54
Na (mg/L)	1.34	1.09
Ni (µg/L)	0.50	0.20
Pb (µg/L)	1.75	1.50
Zn (µg/L)	3.13	1.25

Notes:

- Values reported as less than detection were entered as 1/2 the detection limit for the purpose of calculating averages.
- Italicized, light shaded values indicate all values reported in average were less than detection and the value presented is 1/2 the detection limit.
- Refer to Appendix F for a complete list of values and detection limits (available upon request).
- Refer to the List of Acronyms for definitions.

Table III.2-14
Summary of Sequential Leach Testing Results for Granite

Sample ID	Type I (Fresh Solids)	Type II (Fresh Lixiviant)
pH	8.9-9.4	8.2-9.4
Alkalinity (mg/L CaCO ₃)	20-47	7-13
SO ₄ (mg/L)	0.55-2.5	0.27-<1
Cl (mg/L)	0.9-4.4	<0.2-0.3
Total P (mg/L)	0.04-0.06	0.03-0.04
PO ₄ (mg/L-P)	-	-
NH ₃ (mg/L-N)	0.09-0.24	0.03-0.06
NO ₃ (mg/L-N)	0.49-0.54	<0.02-0.58
Al (mg/L)	1.6-2.7	1.4-1.8
As (µg/L)	1.4-1.6	0.2-0.5
Cd (µg/L)	<0.05	<0.05
Co (µg/L)	0.2-0.7	<0.1-0.3
Cr (µg/L)	<0.5-1	<0.5
Cu (µg/L)	0.7-2.3	0.06-1.1
Fe (mg/L)	1.0-3.5	0.6-1.6
Hg (µg/L)	<1	<1
K (mg/l)	6.1-16.7	3.2-4.2
Mn (µg/L)	23.9-123	16-43
Mo (µg/L)	7.6-44	4-7.8
Na (mg/L)	2.8-11	1.1-1.5
Ni (µg/L)	<0.5-1	<0.5-<1
Pb (µg/L)	0.9-3.5	0.43-1.0
Zn (µg/L)	12-26	11-27

Note: "<" indicates concentration below analytical detection limits.

Refer to Appendix G for a complete list of values and detection limits (available upon request).

Refer to the List of Acronyms for definitions.

Table III.2-15
Summary of Kinetic Testing Results for Granite

Parameter	Column 5	Column 9	HC 20	HC 21	Summary Average
Total S (wt%) ^a	0.17	0.11	0.11	0.14	0.13
NP:AP ^a	2.9	3.6	3.6	3.4	3.4
pH	7.4	7.9	7.17	6.90	7.34
Alkalinity (mg/L as CaCO ₃)	17.5	38.7	7.33	2.00	16.4
SO ₄ (mg/L)	2.8	6.2	0.1	1.7	2.7
Cl (mg/L)	0.10	0.10	0.13	0.10	0.11
Total P (mg/L)	0.02	0.01	0.01	0.03	0.02
PO ₄ (mg/L-P)	0.01	0.01	0.01	0.02	0.01
NH ₃ (mg/L-N)	0.01	0.02	0.03	0.01	0.02
NO ₃ (mg/L-N)	0.007	0.058	0.021	0.005	0.023
Al (mg/L)	0.021	0.011	0.056	0.014	0.026
As (µg/L)	1.33	<i>0.50</i>	<i>0.50</i>	<i>0.50</i>	0.71
Cd (µg/L)	<i>0.05</i>	0.17	<i>0.05</i>	<i>0.05</i>	0.08
Co (µg/L)	0.09	0.17	<i>0.05</i>	0.15	0.11
Cr (µg/L)	0.33	0.50	<i>0.25</i>	<i>0.25</i>	0.33
Cu (µg/L)	0.7	0.7	0.5	0.2	0.5
Fe (mg/L)	<i>0.005</i>	<i>0.005</i>	<i>0.012</i>	0.013	0.009
Hg (µg/L)	<i>0.50</i>	<i>0.50</i>	<i>0.50</i>	<i>0.50</i>	0.50
K (mg/L)	0.73	2.9	0.67	0.58	1.2
Mn (µg/L)	1.8	25.7	3.7	3.0	8.6
Mo (µg/L)	1.0	95.3	7.4	7.6	27.8
Na (mg/L)	1.38	2.22	0.08	0.05	0.93
Ni (µg/L)	0.20	0.87	0.33	0.57	0.49
Pb (µg/L)	2.00	<i>1.33</i>	<i>1.00</i>	<i>1.00</i>	1.33
Zn (µg/L)	0.50	3.08	2.42	2.50	2.13

Note: a. Solid-phase values measured at initiation of kinetic testing

Italicized, light shaded values indicate all values reported in average were less than detection and the values presented are ½ the detection limit.

Leachate analytical values for the individual columns/humidity cells are averages from the last five weeks for pH, alkalinity and SO₄ or from the last three sampling events for the remaining leachate parameters (where sampling was less frequent).

The values under the "Summary Average" heading are the averages of the four cells.

Statistical calculations assume that values reported less than the detection limit are represented at ½ the detection limit.

Refer to Appendices L and M for a complete list of values and detection limits (available upon request).

Refer to the List of Acronyms for definitions.

Number of samples are outlined in Table III.2-1 and Appendices L and M (available upon request).

Table III.2-16
Summary of Acid Base Accounting Results for Metavolcanics

Metavolcanic Group	Number of Samples	Averages					
		Sulphur (wt.%)	NP*	CaNP*	AP*	NP:AP	CaNP:AP
All Samples	181	1.2	19	4.2	38	3.5	0.7
Open Pit Benches – Reconfigured	9	0.6	15	1.5	18	2.8	0.4
Open Pit Benches – Original Configuration (Excluding samples from reconfigured pit)	62	0.3	13	2.6	10	2.3	0.6
Selected Samples Containing High Sulphides	20	8.9	24	7.1	277	0.1	0.0
Selected Samples Excluding High Sulphur Samples	51	0.2	19	2.5	6.1	6.3	1.0
Ramp Development Rock	25	0.2	13	1.9	5.3	3.5	0.5
Ramp Development Rock (minus 2 mm fraction)	7	0.3	75	26	11	5.9	2.0
Bulk Sample Rock Pad (BSMRP)	7	0.5	44	13	16	3.0	1.0

Note: * units expressed in kg CaCO₃/tonne

Values reported as less than detection are represented in this Table at the detection limit.

Statistical calculations assume that values reported less than the detection limit are represented at the detection limit.

Calculations of CaNP:AP and NP:AP based on detection limit values where values are reported below detection.

Refer to Appendix C for a complete list of values and detection limits (available upon request).

Refer to the List of Acronyms for definitions.

Table III.2-17
Summary of SWEP Testing Results for Metavolcanics

Parameter	Metavolcanic Group Averages					
	Open Pit Benches - Reconfigured Pit Configuration	Open Pit Benches - Original Configuration	Selected Samples Containing High Sulphides	Selected Samples - Excluding High Sulphur Samples	Ramp Rock	Bulk Sample Mine Rock Pad
No. of Samples	4	27	6	8	9	2
pH	9.3	9.5	7.2	9.2	8.5	9.1
Alkalinity (mg/L as CaCO ₃)	9	13	14	12	25	22
TDS (mg/L)	43	46	85	33	26	23
SO ₄ (mg/L)	0.7	0.7	9.7	0.8	0.5	4.7
Cl (mg/L)	0.10	0.20	0.27	0.25	4.94	0.22
Total P (mg/L)	0.02	0.06	0.02	0.07	0.05	0.05
PO ₄ (mg/L-P)	0.01	0.01	0.01	0.01	0.05	0.05
NH ₃ (mg/L-N)	0.08	0.08	0.17	0.16	0.79	0.06
NO ₃ (mg/L-N)	0.01	0.01	0.03	0.03	2.14	0.05
Al (mg/L)	0.85	0.83	0.10	0.63	0.50	0.18
As (µg/L)	<i>0.50</i>	0.70	<i>0.50</i>	0.69	0.72	<i>0.50</i>
Cd (µg/L)	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>	<i>0.05</i>
Co (µg/L)	0.27	0.26	3.92	0.20	0.29	0.07
Cr (µg/L)	0.63	0.94	0.42	0.66	0.28	<i>0.25</i>
Cu (µg/L)	0.63	0.90	1.63	0.64	0.42	0.70
Fe (mg/L)	0.47	0.46	0.10	0.23	0.11	0.05
Hg (µg/L)	<i>0.5</i>	<i>0.5</i>	<i>0.5</i>	<i>0.5</i>	<i>0.5</i>	<i>0.5</i>
K (mg/L)	0.98	1.46	3.34	1.01	2.22	2.33
Mn (µg/L)	5.30	5.48	38.15	1.99	31.88	0.78
Mo (µg/L)	0.65	0.61	0.65	2.90	0.68	3.50
Na (mg/L)	1.34	1.06	1.18	1.27	1.20	0.73
Ni (µg/L)	0.75	0.91	2.32	0.73	1.02	0.60
Pb (µg/L)	<i>1.00</i>	1.41	1.17	<i>1.00</i>	2.11	<i>1.00</i>
Zn (µg/L)	1.00	1.13	1.96	2.66	4.36	<i>0.25</i>

Note:

- Values reported as less than detection were entered as 1/2 the detection limit for the purpose of calculating averages.
- Italicized, light shaded values indicate all values reported in average were less than detection and the value presented is 1/2 the detection limit.
- Refer to Appendix F for a complete list of values and detection limits (available upon request).
- Refer to the List of Acronyms for definitions.

Table III.2-18
Summary of Sequential Leach Testing Results for Metavolcanics

Sample ID	Type I (Fresh Solids)	Type II (Fresh Lixiviant)
PH	8.5-8.9	9.1-9.6
Alkalinity (mg/L CaCO ₃)	20-41	19-22
SO ₄ (mg/L)	11-58	1.5-10
Cl (mg/L)	24-124	<0.2-1.4
Total P (mg/L)	0.01-0.07	0.02-0.03
PO ₄ (mg/L-P)	-	-
NH ₃ (mg/L-N)	2.4-9.9	0.16-0.75
NO ₃ (mg/L-N)	5.8-30	<0.02-0.31
Al (mg/L)	0.05-0.23	0.84-1.52
As (µg/L)	0.4-0.6	0.5-0.7
Cd (µg/L)	<0.05	<0.05
Co (µg/L)	<0.1-0.1	0.7-2.3
Cr (µg/L)	<0.5	2.2-6.2
Cu (µg/L)	0.5-0.8	1.4-5.8
Fe (mg/L)	<0.01-0.02	0.74-2.2
Hg (µg/L)	<1	<1
K (mg/L)	7.2-30	3.1-3.3
Mn (µg/L)	2.9-13.7	9.2-28.9
Mo (µg/L)	11.9-52	<1-3.6
Na (mg/L)	4.6-22.3	1.1-1.7
Ni (µg/L)	<0.5-<1	1.2-4
Pb (µg/L)	<0.05-0.1	3.8-14.5
Zn (µg/L)	<1-7	6-15

Note: "<" indicates concentration below analytical detection limits.

Refer to Appendix G for a complete list of values and detection limits (available upon request).

Refer to the List of Acronyms for definitions.

Table III.2-19
Summary of Kinetic Testing Results for Metavolcanics – Standard Input Solution

Parameter	Column 3	Column 4	Column 6	Column 7	Column 8	Column 10	Column 11	Column 13	Column 14	Summary Average
Total S (wt%) ^a	9.9	0.18	0.03	0.14	0.76	1.04	0.29	0.48	0.43	1.5
NP:AP ^a	0.05	1.5	18.3	1.9	0.9	0.3	2.3	0.8	0.8	3.0
pH	4.2	7.4	7.9	7.6	7.4	7.3	8.1	7.7	7.8	7.3
Alkalinity (mg/L as CaCO ₃)	0.3	16	54	20	15	11	61	25	42	27
SO ₄ (mg/L)	200	5.0	2.1	13.4	53.6	23.0	4.4	29.4	50.2	42.3
Cl (mg/L)	0.35	0.10	0.10	0.10	0.14	0.10	0.10	0.10	0.10	0.13
Total P (mg/L)	0.01	0.25	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.04
PO ₄ (mg/L-P)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
NH ₃ (mg/L-N)	4.4	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.49
NO ₃ (mg/L-N)	0.003	0.007	1.37	0.056	12.7	0.404	0.239	0.006	0.012	1.64
Al (mg/L)	2.02	0.011	0.019	0.014	0.006	0.005	0.035	0.020	0.005	0.237
As (µg/L)	0.80	0.67	3.00	1.67	0.50	0.50	0.50	0.50	0.50	0.96
Cd (µg/L)	1.45	0.07	0.05	0.05	0.05	0.05	0.05	0.07	0.05	0.21
Co (µg/L)	424	0.31	0.22	0.11	0.57	0.10	0.06	0.44	1.23	47.5
Cr (µg/L)	0.25	0.25	0.25	0.25	0.25	0.25	0.33	0.25	0.25	0.26
Cu (µg/L)	2413	0.4	0.2	0.7	0.4	0.9	0.5	0.6	1.1	268.7
Fe (mg/L)	1.6	0.005	0.005	0.007	0.007	0.013	0.005	0.007	0.005	0.184
Hg (µg/L)	0.34	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.48
K (mg/L)	46	0.27	4.9	0.50	1.4	2.0	2.8	5.7	8.9	8.1
Mn (µg/L)	801	4.7	4.5	5.7	9.0	12.2	12.9	23.3	41.3	102
Mo (µg/L)	0.04	0.2	1.8	3.8	5.6	0.7	0.5	3.0	5.5	2.3
Na (mg/L)	3.43	1.33	2.05	1.68	2.1	1.73	1.98	1.58	2.37	2.1
Ni (µg/L)	119	19	0.2	0.2	0.4	0.4	0.1	2.6	10.9	17.0
Pb (µg/L)	1.57	2.67	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.25
Zn (µg/L)	476	0.50	0.25	2.33	2.42	1.08	0.25	1.08	0.33	53.8

Note: a. Solid-phase values measured at initiation of kinetic testing

Italicized, light shaded values indicate all values reported in average were less than detection and the values presented are ½ the detection limit.

Leachate analytical values for the individual columns/humidity cells are averages from the last five weeks for pH, alkalinity and SO₄ or from the last three sampling events for the remaining leachate parameters (where sampling was less frequent).

The values under the "Summary Average" heading are the averages of the nine cells.

Statistical calculations assume that values reported less than the detection limit are represented at ½ the detection limit.

Refer to Appendix N for a complete list of values and detection limits (available upon request).

Refer to the List of Acronyms for definitions.

Number of samples are outlined in Table III.2-1 and Appendix N (available upon request).

Table III.2-20
Summary of Kinetic Testing Results for Metavolcanics – Variable Input Solution

Parameter	HC 18	HC 19	HC 22	HC 23	HC 24
Total S (wt%) ^a	0.18	0.29	0.36	0.23	0.23
NP:AP ^a	1.5	1.1	1.1	1.3	1.3
pH	6.7	6.8	7.2	6.9	2.5
Alkalinity (mg/L as CaCO ₃)	4.3	1.0	11.7	1.5	0
SO ₄ (mg/L)	2.3	2.3	2.7	3.5	3.9
Cl (mg/L)	0.27	0.10	0.10	0.10	170
Total P (mg/L)	0.01	0.04	0.01	0.09	0.02
PO ₄ (mg/L-P)	0.01	0.03	0.01	0.09	0.02
NH ₃ (mg/L-N)	0.01	0.01	0.06	0.02	0.08
NO ₃ (mg/L-N)	0.002	0.001	0.037	0.003	0.001
Al (mg/L)	0.002	0.002	26.3	10.3	6850
As (µg/L)	<i>0.50</i>	<i>0.50</i>	<i>0.50</i>	0.67	<i>0.50</i>
Cd (µg/L)	0.13	<i>0.05</i>	<i>0.05</i>	<i>0.50</i>	0.17
Co (µg/L)	0.08	0.24	0.04	0.09	41.1
Cr (µg/L)	<i>0.25</i>	<i>0.25</i>	<i>0.25</i>	<i>0.25</i>	10.5
Cu (µg/L)	1.9	0.2	0.4	0.4	256
Fe (mg/L)	0.008	0.008	0.017	0.020	12.38
Hg (µg/L)	<i>0.50</i>	<i>0.50</i>	<i>0.50</i>	<i>0.50</i>	<i>0.50</i>
K (mg/L)	0.06	0.03	1.1	0.37	2.5
Mn (µg/L)	2.0	2.6	1.5	1.7	148
Mo (µg/L)	0.1	<i>0.1</i>	1.3	0.8	1.0
Na (mg/L)	<i>0.03</i>	<i>0.03</i>	0.22	0.82	0.22
Ni (µg/L)	5.1	20	0.3	1.0	80
Pb (µg/L)	<i>1.00</i>	<i>1.00</i>	<i>1.00</i>	1.33	24
Zn (µg/L)	16.6	0.83	0.83	0.67	80.8

Note: a. Solid-phase values measured at initiation of kinetic testing

Italicized, light shaded values indicate all values reported in average were less than detection and the values presented are ½ the detection limit.

Leachate analytical values for the individual columns/humidity cells are averages from the last five weeks for pH, alkalinity and SO₄ or from the last three sampling events for the remaining leachate parameters (where sampling was less frequent).

Statistical calculations assume that values reported less than the detection limit are represented at ½ the detection limit.

Refer to Appendix O for a complete list of values and detection limits (available upon request).

Refer to the List of Acronyms for definitions.

Number of samples are outlined in Table III.2-1 and Appendix O (available upon request).

Table III.2-21
Summary of Leach Testing Results for Cemented Paste

Sample ID	Type I (Fresh Solids)	Type II (Fresh Lixiviant)	A1 Leach	Average of 3 SWEF Tests
PH	11.8-12.2	11.4-11.9	11.8	11.9
Alkalinity (mg/L CaCO ₃)	760-980	50-490	760	520
SO ₄ (mg/L)	2.7-5.3	13.2-43	5.34	8.14
Cl (mg/L)	8.6-33	0.76-2.3	8.64	3.13
Total P (mg/L)	0.01-0.09	<0.010	0.013	0.13
PO ₄ (mg/L-P)	-	-	-	-
NH ₃ (mg/L-N)	6.6-23	0.20-1.3	6.6	1.5
NO ₃ (mg/L-N)	0.53-1.0	0.26-0.37	0.53	2.14
Al (mg/L)	0.47-0.59	0.60-0.66	0.47	0.59
As (µg/L)	0.7-1.2	0.4-0.9	0.7	1.0
Cd (µg/L)	<0.3-0.4	<0.05-0.1	<0.3	<1
Co (µg/L)	<0.5-0.6	<0.1-0.2	<0.5	<2
Cr (µg/L)	313-392	79.6-265	313	183
Cu (µg/L)	5.1-16.8	0.9-4.6	5.1	18
Fe (mg/L)	<0.01-0.01	<0.01	<0.01	<0.03
Hg (µg/L)	<1	<1	<1	<1
K (mg/L)	19.0-47.5	10.1-14.3	19.0	13.0
Mn (µg/L)	<0.3-0.6	0.22-1.4	<0.3	<2
Mo (µg/L)	81.1-118	11-58	81.1	113
Na (mg/L)	19.2-68	1.8-7.1	19.2	14.3
Ni (µg/L)	<3-<5	<1	<3	<10
Pb (µg/L)	0.4-0.6	<0.05-0.1	0.4	<2
Zn (µg/L)	<5-10	3-15	<5	<5

Note: "<" indicates concentration below analytical detection limits.

Refer to Appendix G for a complete list of values and detection limits (available upon request).

Refer to the List of Acronyms for definitions.

Table III.2-22
Summary of SWEP Testing Results for Cement and Grout

Parameter	Cement		Grout	
	24-Hour	7-Day	24-Hour	7-Day
pH	12.8	12.5	12.7	12.5
Alkalinity (mg/L CaCO ₃)	2820	2940	2450	2470
SO ₄ (mg/L)	<1	2.3	1.4	2.2
Cl (mg/L)	0.28	<0.2	135	132
Total P (mg/L)	0.03	0.05	0.01	0.03
PO ₄ (mg/L-P)	-	-	-	-
NH ₃ (mg/L-N)	0.06	<0.02	0.07	<0.02
NO ₃ (mg/L-N)	<0.02	<0.02	<0.02	<0.02
Al (mg/L)	0.48	0.32	0.60	0.28
As (µg/L)	<1	<1	<1	<1
Cd (µg/L)	<0.5	<0.5	<0.5	<0.5
Co (µg/L)	<1	<1	1	<1
Cr (µg/L)	<5	<5	8	11
Cu (µg/L)	3	<1	3	<1
Fe (mg/L)	0.02	<0.01	<0.01	<0.01
Hg (µg/L)	<1	<1	<1	<1
K (mg/L)	543	588	340	471
Mn (µg/L)	2.5	3.1	2.3	2.1
Mo (µg/L)	1.3	<2	1.4	<2
Na (mg/L)	197	195	147	213
Ni (µg/L)	<1	<5	<5	<5
Pb (µg/L)	11.8	9.5	14.2	10.3
Zn (µg/L)	<10	<10	<10	<10

Notes: "<" indicates concentration below analytical detection limits.

Refer to Appendix P for a complete list of values and detection limits (available upon request).

Refer to the List of Acronyms for definitions.

Table III.2-23
Summary of SWEP Testing Results for Granitic and Metavolcanic Concrete

Parameter	Granitic Concrete		Metavolcanic Concrete	
	24-Hour	7-Day	24-Hour	7-Day
pH	12.6	12.4	12.7	12.4
Alkalinity (mg/L CaCO ₃)	2100	2580	2000	2540
SO ₄ (mg/L)	1.4	1.8	1.2	1.5
Cl (mg/L)	0.28	<0.02	1.0	-
Total P (mg/L)	<0.01	<0.02	0.01	<0.02
PO ₄ (mg/L-P)	-	-	-	-
NH ₃ (mg/L-N)	0.07	0.04	0.4	0.17
NO ₃ (mg/L-N)	<0.02	0.08	<0.02	0.10
Al (mg/L)	0.44	0.52	0.45	0.44
As (µg/L)	<1	<1	<1	<1
Cd (µg/L)	<0.5	<0.5	<0.5	<0.5
Co (µg/L)	<1	<1	<1	<1
Cr (µg/L)	<5	<5	<5	<5
Cu (µg/L)	3	<1	4	<1
Fe (mg/L)	<0.01	<0.01	<0.01	<0.01
Hg (µg/L)	<1	<1	<1	<1
K (mg/L)	111	117	121	152
Mn (µg/L)	1.4	0.6	1.7	0.7
Mo (µg/L)	0.8	<2	0.7	<2
Na (mg/L)	46	42	46	46
Ni (µg/L)	<5	<5	<5	<5
Pb (µg/L)	18.3	195	16.9	12.5
Zn (µg/L)	<10	<10	<10	<10

Notes: "<" indicates concentration below analytical detection limits.

Refer to Appendix P for a complete list of values and detection limits (available upon request).

Refer to the List of Acronyms for definitions.

Table III.2-24
Summary of Baseline Snap Lake Water Quality (1998-2001)

Parameter	Range
pH	6.3 – 6.9
Alkalinity (mg/L as CaCO ₃)	4 –10
SO ₄ (mg/L)	1.31 – 36
Cl (mg/L)	0.2 – <1.0
Total P (mg/L)	<0.001 – 0.026
PO ₄ (mg/L-P)	<0.001 –0.005
NH ₃ (mg/L-N)	0.002 – 0.086
NO ₃ (mg/L-N)	<0.006 – 0.038
Na (mg/L)	0.44 – 1
Mg (mg/L)	0.48 – 1.01
Ca (mg/L)	0.93 – 2.43
K (mg/L)	0.32 – 0.78
Al (mg/L)	1.9 – <30
As (µg/L)	<0.03 – <0.2
Cd (µg/L)	<0.05 – 0.1
Co (µg/L)	<0.1 – 0.2
Cr (µg/L)	<0.06 – 0.8
Cu (µg/L)	0.4 – 4.4
Fe (mg/L)	<0.005 – 0.041
Hg (µg/L)	<0.01 – <0.02
Mn (µg/L)	< 0.1 – 10
Mo (µg/L)	<0.06 – <1
Ni (µg/L)	0.09 – 3.72
Pb (µg/L)	<0.05 – 1.4
Zn (µg/L)	<0.5 – 24.2

Notes: "<" indicates concentration below analytical detection limits.

Refer to Appendix S for a complete list of values and detection limits (available upon request).

Refer to the List of Acronyms for definitions.

Table III.2-25
Summary of Groundwater Quality

Parameter	Units	Groundwater Baseline ^a											
		Metavolcanic (n = 16) ^a			Kimberlite (n = 4) ^b			Granite (n = 9) ^c			All (n = 29) ^d		
		min	max	median	min	max	median	min	max	median	min	max	median
Conventional Parameters													
pH	pH	7.7	8.7	8.0	7.8	8.1	8.0	7.5	11.8	9.2	7.5	11.8	8.1
Alkalinity	mg/L	34	132	108	85	89	87	47	356	80	34	356	90
Total Dissolved Solids	mg/L	70	1420	270	120	660	425	360	1630	920	70	1630	345
Total Hardness	mg/L	36.0	567.0	124.0	55.0	325.0	256.5	189.0	756.0	286.0	36.0	756.0	181.0
Dissolved Organic Carbon	mg/L	2.0	5.0	3.0	-	-	-	2.0	6.0	4.0	2.0	6.0	4.0
Conductivity	uS/cm	174.0	1580.0	485.0	198.0	1050.0	889.0	646.0	2900.0	1130.0	174.0	2900.0	661.0
Nutrients													
Ammonia	mg/L	0.2	2.0	0.7	0.01	0.5	0.4	0.7	25.4	4.1	0.01	25.4	0.8
Nitrate + Nitrite	mg/L	<0.006	0.193	0.019	0.007	0.187	0.017	0.009	22.2	2.4	<0.006	22.2	0.06
Total Phosphorus	mg/L	0.008	0.181	0.099	0.022	0.279	0.076	0.013	0.3	0.1	0.008	0.29	0.09
Dissolved Phosphorus	mg/L	0.003	0.182	0.078	0.022	0.279	0.073	0.003	0.1	0.035	0.003	0.28	0.07
Orthophosphate	mg/L	<0.001	0.159	0.098	0.021	0.203	0.057	0.002	0.1	0.003	<0.001	0.20	0.02
Total Kjeldahl Nitrogen	mg/L	0.4	2.7	0.6	0.1	0.6	0.4	0.7	14.6	3.2	0.1	14.6	0.7
Total Organic Carbon	mg/L	2.0	6.0	3.0	2.0	3.0	2.5	3.0	7.0	4.0	2.0	7.0	3.0
Major Ions													
Bicarbonate	mgCO ₃ /L	40.0	155.0	134.0	104.0	108.0	106.0	5.0	148.0	83.5	5.0	155.0	117.0
Carbonate	mg/L	<5	13.0	<5	<5	<5	<5	<5	75.0	29.0	<5	75.0	27.5
Calcium	mg/L	12.0	137.0	39.2	17.7	74.4	57.8	62.9	274.0	110.0	12.0	274.0	58.7
Chloride	mg/L	4.0	431.0	77.0	6.0	261.0	208.0	121.0	599.0	248.0	4.0	599.0	138.0
Fluoride	mg/L	0.6	1.0	0.8	0.8	1.0	0.9	0.3	0.9	0.6	0.3	1.0	0.8
Hydroxide	mg/L	<5	<5	<5	<5	<5	<5	<5	78.0	<5	<5	78.0	<5
Magnesium	mg/L	1.6	54.4	6.4	2.7	33.7	27.3	0.2	27.7	7.8	0.2	54.4	7.6
Potassium	mg/L	1.6	6.1	3.1	1.9	3.2	3.1	3.3	18.9	9.3	1.6	18.9	3.3
Silica	mg/L	9.8	16.2	15.8	13.6	16.4	15.0	3.6	16.9	12.5	3.6	16.9	15.2
Sodium	mg/L	16.8	88.8	37.6	24.6	56.9	51.1	25.5	127.0	76.7	16.8	127.0	48.2
Sulphate	mg/L	1.3	21.2	3.0	16.1	23.1	19.2	6.2	78.6	10.0	1.3	78.6	8.4
Dissolved Metals													
Aluminium	ug/L	0.4	<30	1.4	0.8	30.0	1.8	1.2	40.2	7.2	0.4	40.2	3.7
Antimony	ug/L	<0.03	0.7	0.2	0.1	0.1	0.1	0.1	1.0	0.2	<0.03	1.0	0.2
Arsenic	ug/L	0.1	0.8	0.4	0.1	1.6	1.2	0.4	3.3	1.1	0.1	3.3	0.7
Barium	ug/L	3.1	93.3	11.6	6.1	39.5	35.3	21.6	238	55.4	3.1	238	20.0
Beryllium	ug/L	<0.2	<0.5	<0.2	<0.2	<0.5	<0.2	<0.2	<0.5	<0.2	<0.2	<0.5	<0.2
Bismuth	ug/L	<0.03	<5	<0.03	<0.03	<0.05	<0.03	<0.03	0.2	<0.03	<0.03	<5	<0.03
Boron	ug/L	37.0	321.0	56.0	57.0	329.0	247.5	16.0	94.0	64.0	16.0	329.0	61.0
Cadmium	ug/L	<0.05	<0.1	<0.05	<0.05	<0.1	<0.05	<0.05	<0.1	<0.05	<0.05	<0.1	<0.05
Cesium	ug/L	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	0.9	0.5	<0.1	0.9	0.4
Chromium	ug/L	<0.06	1.9	0.9	0.5	9.9	3.1	<0.06	3.5	0.1	<0.06	9.9	0.9
Cobalt	ug/L	<0.1	0.4	<0.1	<0.1	0.6	0.4	<0.1	0.2	0.2	<0.1	0.6	0.2
Copper	ug/L	<0.6	2.8	1.1	<0.6	4.2	3.0	<0.6	24.6	2.8	<0.6	24.6	2.1
Iron	ug/L	<5	56.0	43.0	<5	240.0	133.0	<5	3460.0	21.0	<5	3460.0	40.5
Lead	ug/L	<0.05	1.8	0.5	<0.1	2.2	0.7	<0.05	1.4	0.2	<0.05	2.2	0.4
Lithium	ug/L	13.3	57.2	22.7	24.9	42.1	35.0	18.0	86.6	45.2	13.3	86.6	29.1
Manganese	ug/L	1.5	37.4	8.9	3.1	12.0	9.3	0.1	252.0	7.1	0.1	252.0	8.7
Mercury	ug/L	<0.01	0.1	0.0	<0.02	<0.02	<0.02	<0.02	0.5	0.1	<0.01	0.5	0.0
Molybdenum	ug/L	1.8	7.1	3.8	2.0	2.6	2.3	2.6	11.0	5.6	1.8	11.0	3.8
Nickel	ug/L	<0.06	19.8	0.5	1.1	29.7	4.9	0.1	4.8	0.8	<0.06	29.7	0.8
Rubidium	ug/L	<1	8.0	2.0	1.0	2.0	1.5	2.0	44.0	23.0	<1	44.0	2.0
Selenium	ug/L	0.1	14 ^e	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	0.1	14 ^e	0.3
Silver	ug/L	<0.1	<0.2	<0.1	<0.1	<0.2	<0.1	<0.1	<0.2	<0.1	<0.1	<0.2	<0.1
Strontium	ug/L	180	1570	436	230	1490	1295	879	3970	1760	180	3970	745
Thallium	ug/L	<0.03	<0.1	<0.03	<0.03	<0.05	<0.03	<0.03	0.1	<0.03	<0.03	0.1	<0.03
Titanium	ug/L	0.3	2.4	1.6	0.4	3.3	1.9	<0.1	2.1	1.3	<0.1	3.3	1.5
Uranium	ug/L	<0.05	1.2	<0.05	<0.05	<0.1	<0.05	<0.05	1.0	0.1	<0.05	1.2	0.1
Vanadium	ug/L	0.3	2.4	0.8	0.1	2.8	1.8	0.6	4.5	1.8	0.1	4.5	1.0
Zinc	ug/L	0.8	2.1	1.3	<2	3.6	2.9	<0.8	9.3	3.4	<0.8	9.3	1.5

Notes:

(a) n = 15 for As, B; n = 14 for Alkalinity, Ca, K, Mg, Na, SO₄, Cl⁻, NH₃, NO₃/NO₂, pH, Hardness, Conductivity, Total P, and Dissolved P; n = 13 for HCO₃⁻, Hg, Sr, Colour, TKN, TOC, Bicarbonate, Carbonate; n = 12 for Bi, Ce, Ti, Tl, TDS; n = 11 for SiO₂, F; n=10 for orthophosphate; and, n = 9 for TOC, Hydroxide.

(b) n = 2 for Hg, SiO₂, Sr, Colour, TOC, F

(c) n = 8 for Hg, SiO₂, Sr, DOC; and, n = 7 for Hardness, F

(d) n = 28 for As, B; n = 27 for Alkalinity, Ca, K, Mg, Na, SO₄, Cl⁻, NH₃, NO₃/NO₂, pH, Conductivity, Total P, Dissolved P; n=26 for HCO₃⁻, TKN, Bicarbonate, Carbonate; n=25 for Bi, Ce, Ti, Tl, Hardness, TDS n=24 for Colour, TOC; n = 23 for Hg, Sr, Orthophosphate; n = 22 for Hydroxide; n = 21 for SiO₂; n= 20 for F; and n = 17 for DOC

(e) Shaded values undergoing QA/QC review

<= less than detection limit (see glossary for definition)

Values reported as less than detection are represented in this table at the detection limit. See Appendix Q for more detail (available upon request).

Statistical calculations based on detection limit values where values are reported below detection.

Refer to Appendix Q for accompanying analyses (available upon request).

Refer to the List of Acronyms for definitions.

Number of samples are outlined in Table III.2-1 and Appendix Q (available upon request).

Table III.2-26
Summary of Selected Surface Water Quality

Parameter	Units	North Pit (n=5)			South Pit (n=6)			Bulk Sample Mine Rock Piles (n=8)			Bogs 1 and 2 (n=2)			Pad Runoff (Ramp Development Pile) (n=3)		
		Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average
Field Parameters																
pH	pH	8.37	8.52	8.45	7.96	8.51	8.2	6.5	6.97	6.8	5.45	5.97	5.71	-	-	-
Eh	mV	175	430	303	175	436	279	145	412	236	364	437	401	-	-	-
Conductivity	uS/cm	216	216	216	228	241	235	255	418	335	-	-	-	-	-	-
Alkalinity	mg/L	41	41	41	44	48	46	30	30	30	5	21	13	-	-	-
Conventional Parameters																
pH	pH	7.87	8.23	8.00	7.55	8.06	7.7	6.41	7.01	6.70	5.79	5.79	5.79	4.01	6.62	4.99
Alkalinity	mg/L	45.9	56.1	53.1	34.8	44.2	40.3	10.6	36.2	20.0	5.2	5.2	5.2	0.15	117	26
Total Dissolved Solids	mg/L	107	141	124	132	351	248	203	716	382	51	144	98	2170	5100	3635
Total Suspended Solids	mg/L	7	7	7	14	902	366	9	37	21	6	20	13	3	55	19
Total Hardness	mg/L	83.5	100	93.8	89	121	104	123	364	204	10.1	10.1	10.1	2970	2970	2970
Dissolved Organic Carbon	mg/L	3.1	4.5	3.7	3.9	4.5	4.2	7	11.1	9.05	25.4	29.8	27.6	22	22.1	22.1
Conductivity	uS/cm	194	223	209	224	249	234	280	736	436	33.1	33.1	33.1	4600	7100	5850
Turbidity	NTU	2.8	55.4	24.2	5.7	638	321.9	1.2	30.5	15.2	1.8	7.9	4.9	6.1	6.9	6.5
Major Ions																
Calcium	mg/L	17.8	22.1	20.3	18.1	23.6	20.9	21.4	67.8	37	2.15	2.15	2.15	393	973	683
Chloride	mg/L	1.4	2	1.7	1.2	30.6	13.7	5.9	134	49.1	4	4	4	632	1500	1066
Fluoride	mg/L	0.32	0.37	0.35	0.28	0.39	0.34	0.1	0.6	0.27	0.08	0.08	0.08	0.12	0.13	0.13
Magnesium	mg/L	9.5	11	10.5	10.3	16.7	12.5	16.8	47.2	27.0	1.16	1.16	1.16	67.3	132	99.7
Potassium	mg/L	2.59	3.01	2.77	2.86	7.07	4.61	2.25	4.4	3.16	1.14	1.14	1.14	43.9	61.8	52.9
Sodium	mg/L	3.28	3.92	3.53	5.34	8.41	6.77	3.51	6.16	4.55	2.55	2.55	2.55	56.4	60.7	58.6
Sulphate	mg/L	29	44	38.3	31	100	79.3	12	131	73	19	19	19	1.5	74.3	37.9
Nutrients/Biological Parameters																
Ammonia-N	mg/L	0.0025	0.173	0.069	0.03	0.155	0.078	0.291	1.28	0.63	0.01	0.021	0.017	128	128	128
Nitrate + Nitrite N	mg/L	0.502	1.17	0.836	0.41	2.38	1.40	2.95	8.31	5.63	0.03	0.032	0.031	186	365	275.5
Nitrate-N	mg/L	1.06	1.06	1.06	1.56	1.56	1.56	4.78	4.78	4.78	-	-	-	-	-	-
Nitrite-N	mg/L	0.024	0.024	0.024	0.03	0.03	0.03	0.408	0.408	0.408	-	-	-	-	-	-
Total Phosphorous	mg/L	0.023	0.045	0.030	0.016	1.69	0.72	0.019	0.029	0.024	0.02	0.065	0.044	0.14	0.20	0.17
Dissolved Phosphorous	mg/L	0.008	0.022	0.014	0.008	0.101	0.065	0.009	0.02	0.013	0.01	0.034	0.024	0.1	0.15	0.12
Ortho-Phosphate	mg/L	0.002	0.003	0.003	0.013	0.061	0.031	0.002	0.004	0.003	0.004	0.012	0.008	0	0	0.002
Tot-Kjeldahl-N	mg/L	0.21	1	0.61	0.65	1.1	0.88	0.75	0.86	0.81	-	-	-	69.7	69.7	69.7
Total Organic Carbon	mg/L	3.1	4.6	4.0	4.5	6.7	5.6	7.6	11.5	9.6	25.3	29.9	27.6	22	27.3	24.65
Dissolved Metals																
Aluminium	ug/L	15	43.2	24.4	15	697	249	34	76.4	49.8	404	643	523.5	15	9260	1600
Antimony	ug/L	1.1	2.2	1.5	0.8	3.2	1.6	0.5	1.9	1.0	0.5	0.7	0.6	0.05	1.2	0.45
Arsenic	ug/L	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	-	-	-	1	1	1
Barium	ug/L	13.3	78.1	35.3	10.1	266	95.4	24.1	76.6	53	5.5	16.1	10.8	10	1790	552
Beryllium	ug/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.125
Bismuth	ug/L	0.05	2.5	0.87	0.05	2.5	0.87	0.05	2.5	0.87	2.5	2.5	2.5	0.05	5	2.5
Cadmium	ug/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.2	0.1	0.05	0.1	0.08	0.05	1.3	0.46
Cesium	ug/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	1.6	0.56
Chromium	ug/L	0.3	1.6	0.9	0.5	1.1	0.7	0.15	1.2	0.62	1	3.1	2.1	0.15	3.8	1.25
Cobalt	ug/L	0.3	0.6	0.4	0.3	1	0.6	5.1	12.2	8.1	1.1	5.7	3.4	0.05	24.9	10.8
Copper	ug/L	1.7	2.1	1.9	2.4	6.1	3.8	7.2	8.1	7.7	2.5	8	5.3	0.1	3.2	1.47
Iron	mg/L	0.015	0.032	0.021	0.015	0.209	0.080	0.037	0.16	0.09	0.79	4.24	2.52	0.02	1.01	0.50
Lead	ug/L	0.2	0.4	0.3	0.4	0.7	0.5	0.2	0.7	0.4	0.2	0.5	0.4	0.05	6.1	1.6
Lithium	ug/L	1	1.9	1.4	2.1	3.3	2.8	1.9	2.5	2.1	3	3.2	3.1	0.5	74.8	24.7
Manganese	ug/L	0.9	7.6	3.1	1.2	53.1	26.7	166	555	314	17.5	82.9	50.2	10.8	1750	862
Mercury	ug/L	0.005	0.005	0.005	0.005	0.005	0.005	0	0.005	0.004	-	-	-	0.01	0.01	0.005
Molybdenum	ug/L	13.2	17.2	14.9	32.4	51.4	42.7	2.1	4.3	3	0.2	1.9	1.1	0.05	3.6	1
Nickel	ug/L	6.5	19.6	14.8	1.9	4.2	2.9	11.3	19.2	14.4	1.2	7.2	4.2	0.4	36	12.5
Selenium	ug/L	0.5	0.5	0.5	0.5	1.2	0.9	1	2	1.3	0.5	0.5	0.5	0.5	4	1.5
Silver	ug/L	0.05	0.1	0.07	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.2	0.14
Strontium	ug/L	76.6	98.3	85.0	75.6	84.4	79.4	76.1	234	129.4	10.4	32	21.2	24.6	8060	2273
Thallium	ug/L	0.05	0.1	0.07	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.3	0.13
Titanium	ug/L	0.5	1.8	1.0	0.8	10.3	4.0	1	1.6	1.3	3.8	14.1	9.0	0.15	1.2	0.6
Uranium	ug/L	3.1	4.2	3.5	0.6	1.6	1.1	0.1	0.2	0.2	0.1	0.6	0.4	0.05	2	0.55
Vanadium	ug/L	1.4	1.9	1.7	1	1.3	1.1	0.3	0.6	0.4	0.4	2.9	1.7	0.05	1.1	0.39
Zinc	ug/L	5	28.3	12.8	5	91.3	33.8	5	40.5	21.8	5	5	5	5	138	58

Note:

Values reported as less than detection are represented in this table at the detection limit. See Appendix S for more detail

Statistical calculations based on detection limit values where values are reported below detection.

Refer to Appendix S for accompanying analyses (available upon request).

Refer to the List of Acronyms for definitions.

Number of samples are outlined in Table III.2-1 and Appendix S (available upon request).

The number of analyses for any given parameter may vary from the number of samples as indicated in the appendices (available upon request).

Table III.2-27
Sulphide Content of Dilution Rock (in wt%)

	Visual Observation				Acid Base Accounting	
Year	Dilution Rock Above Kimberlite	Dilution Rock Below Kimberlite	All Granite	All Metavolcanics	Granite	Metavolcanics
2000	0.25	0.28	0.08	1.04	1.3	2.3
2001	0.12	0.16	0.16	1.08		

FIGURES

Figure III.2-1
Standard Humidity Cell Design (from Price, 1997)

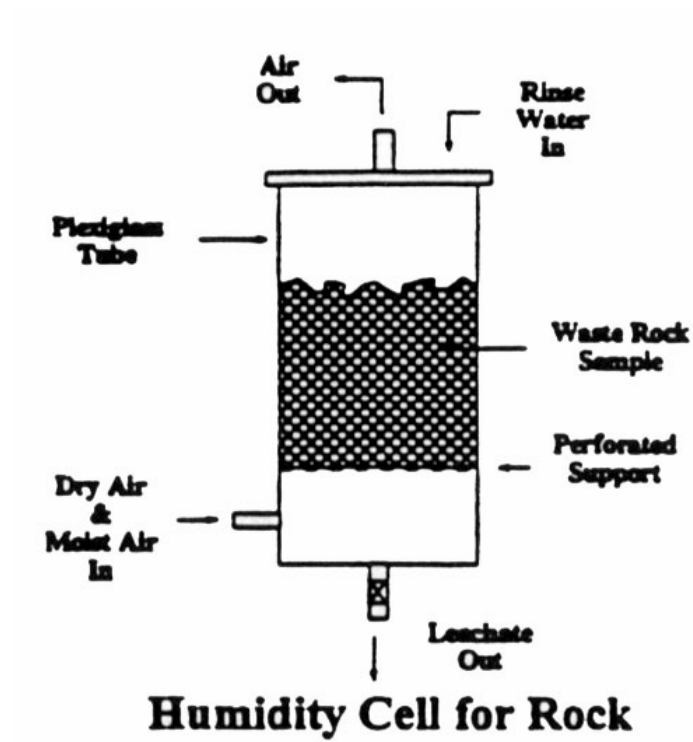


Figure III.2-2
Total Sulphur vs. Sulphide Sulphur - Kimberlite

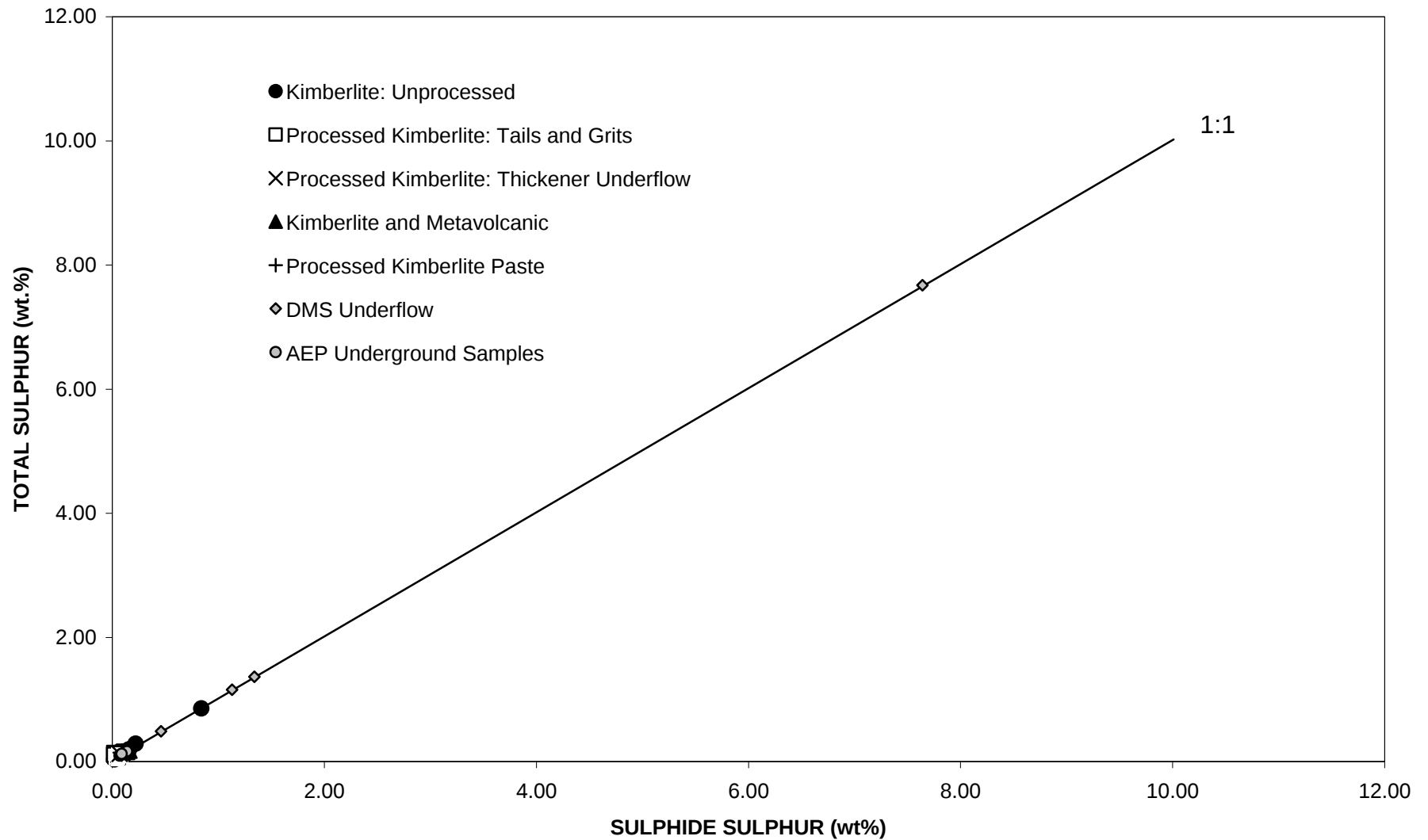


Figure III.2-3
Total Sulphur vs. Sulphide Sulphur (Sulphide Sulphur < 0.2 wt%) - Kimberlite

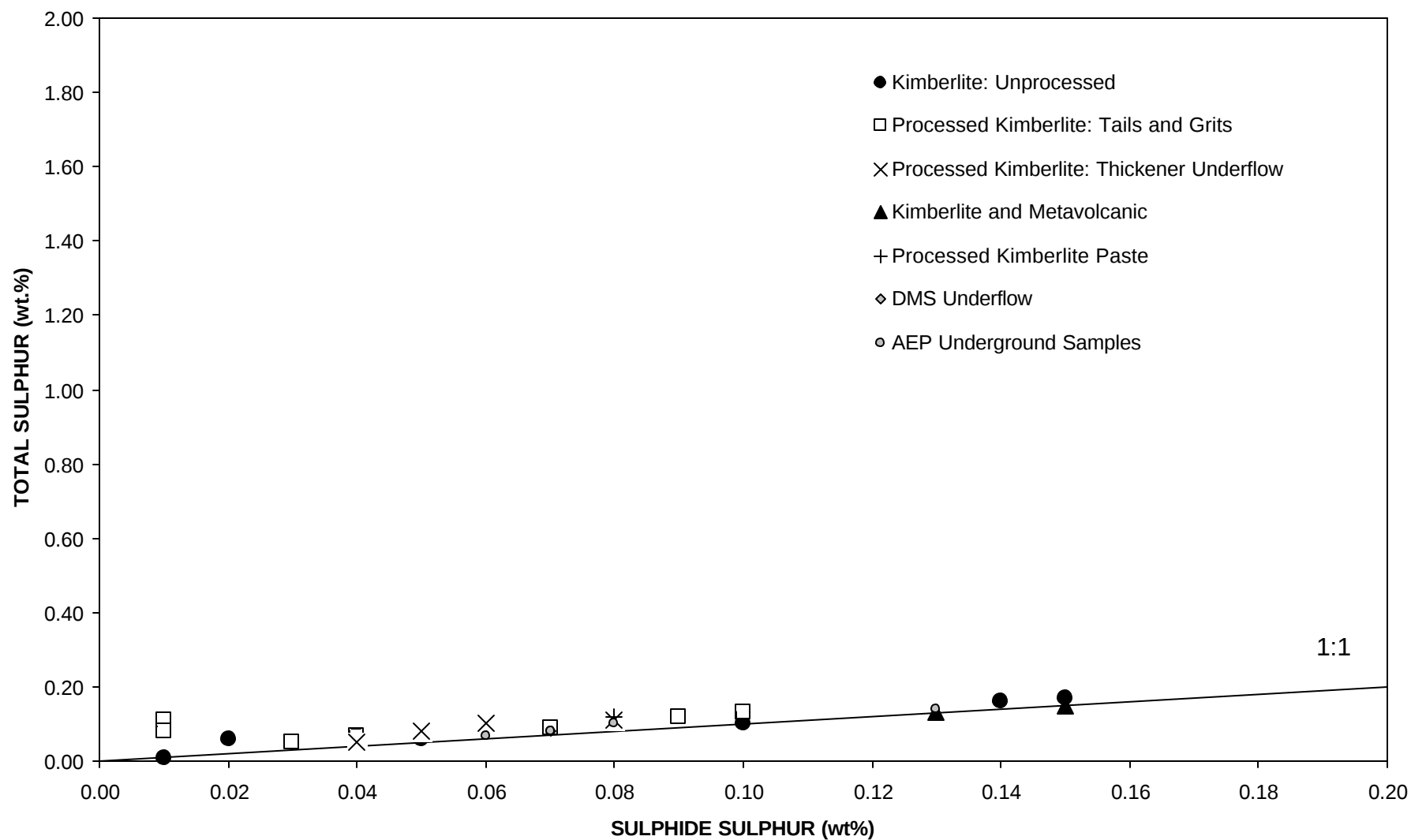


Figure III.2-4
Bulk NP vs. CaNP - Kimberlite

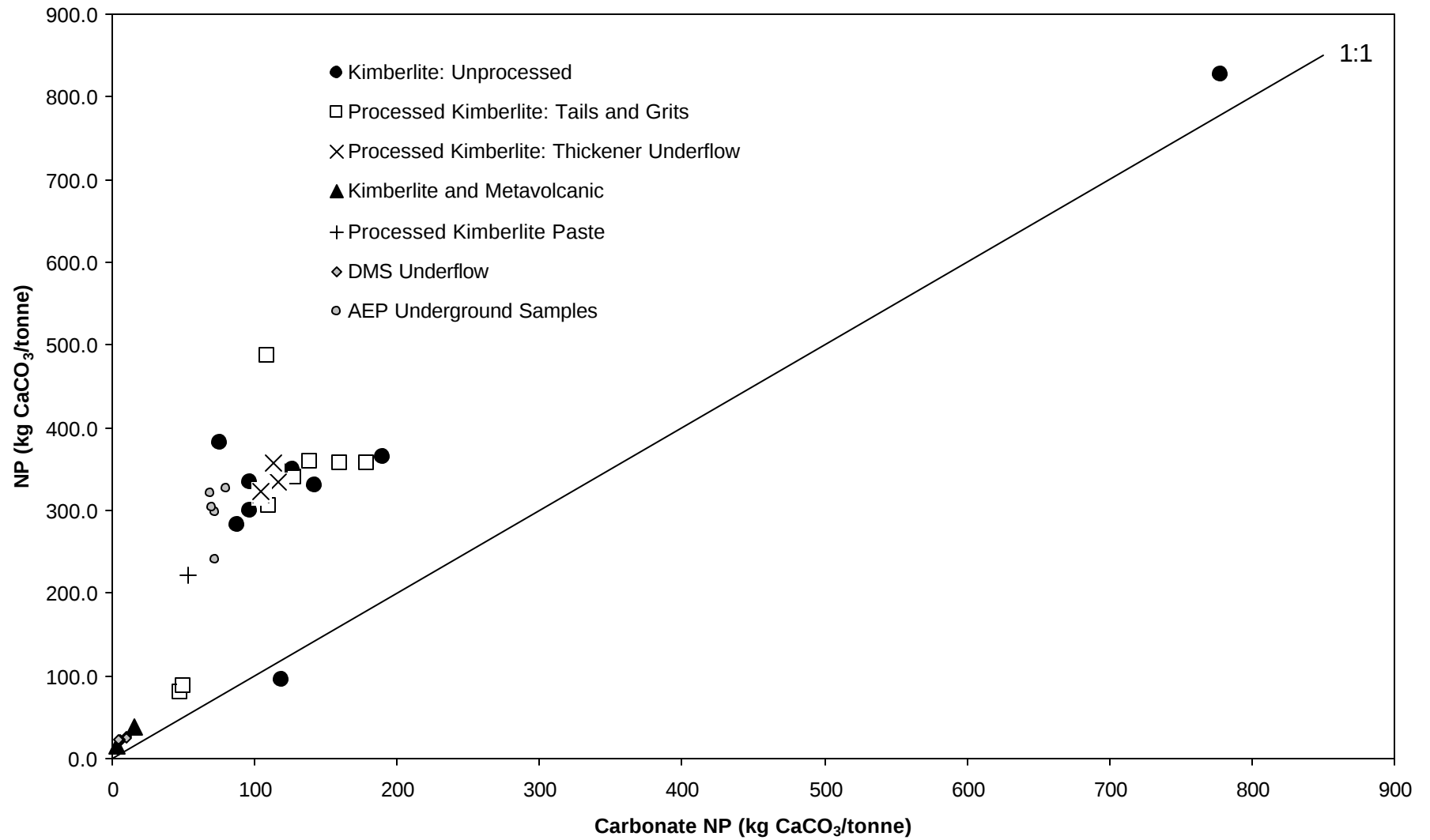


Figure III.2-5
AP vs. NP - Kimberlite

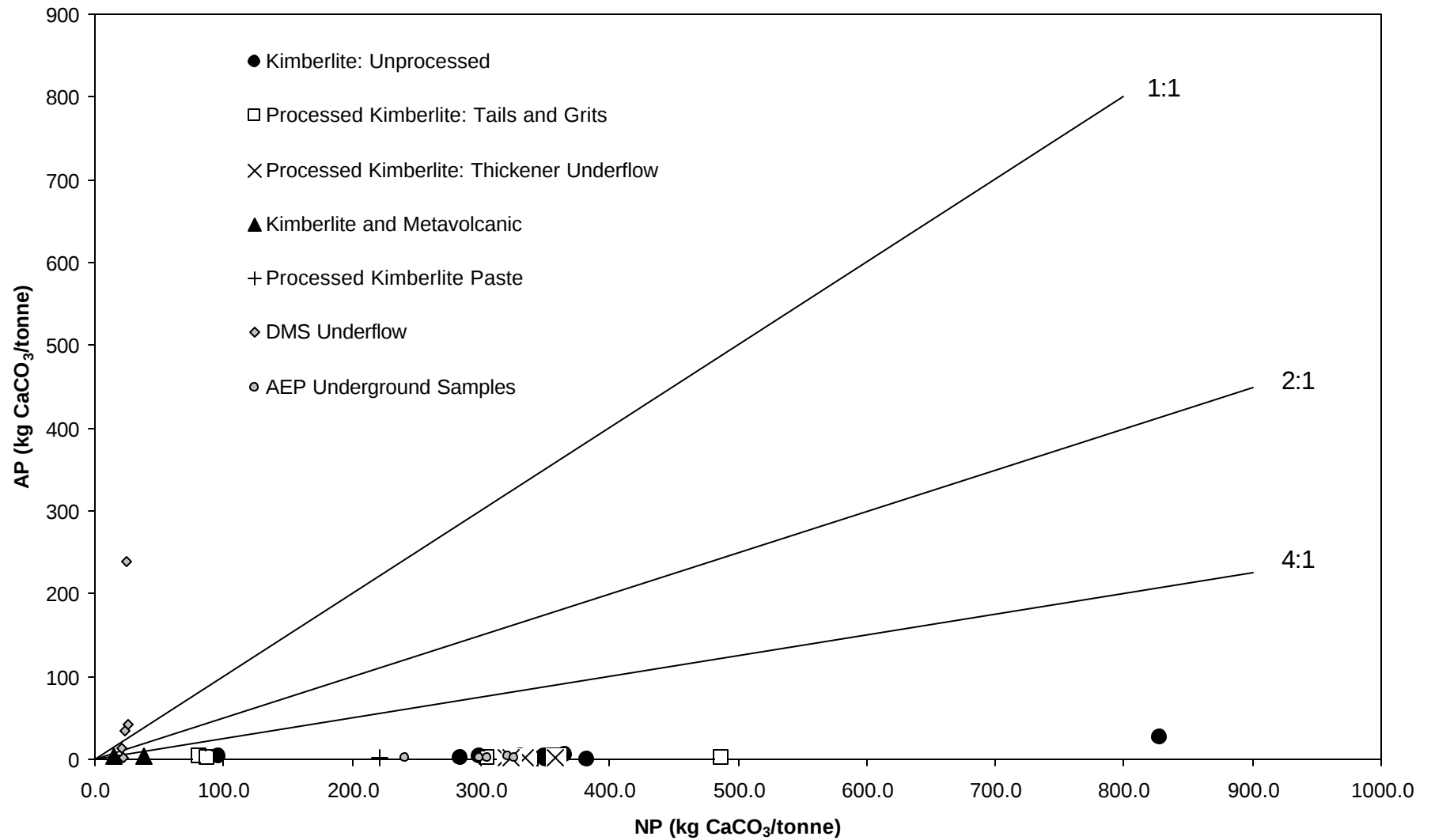


Figure III.2-6
AP vs. NP (AP < 30 kg CaCO₃/tonne) - Kimberlite

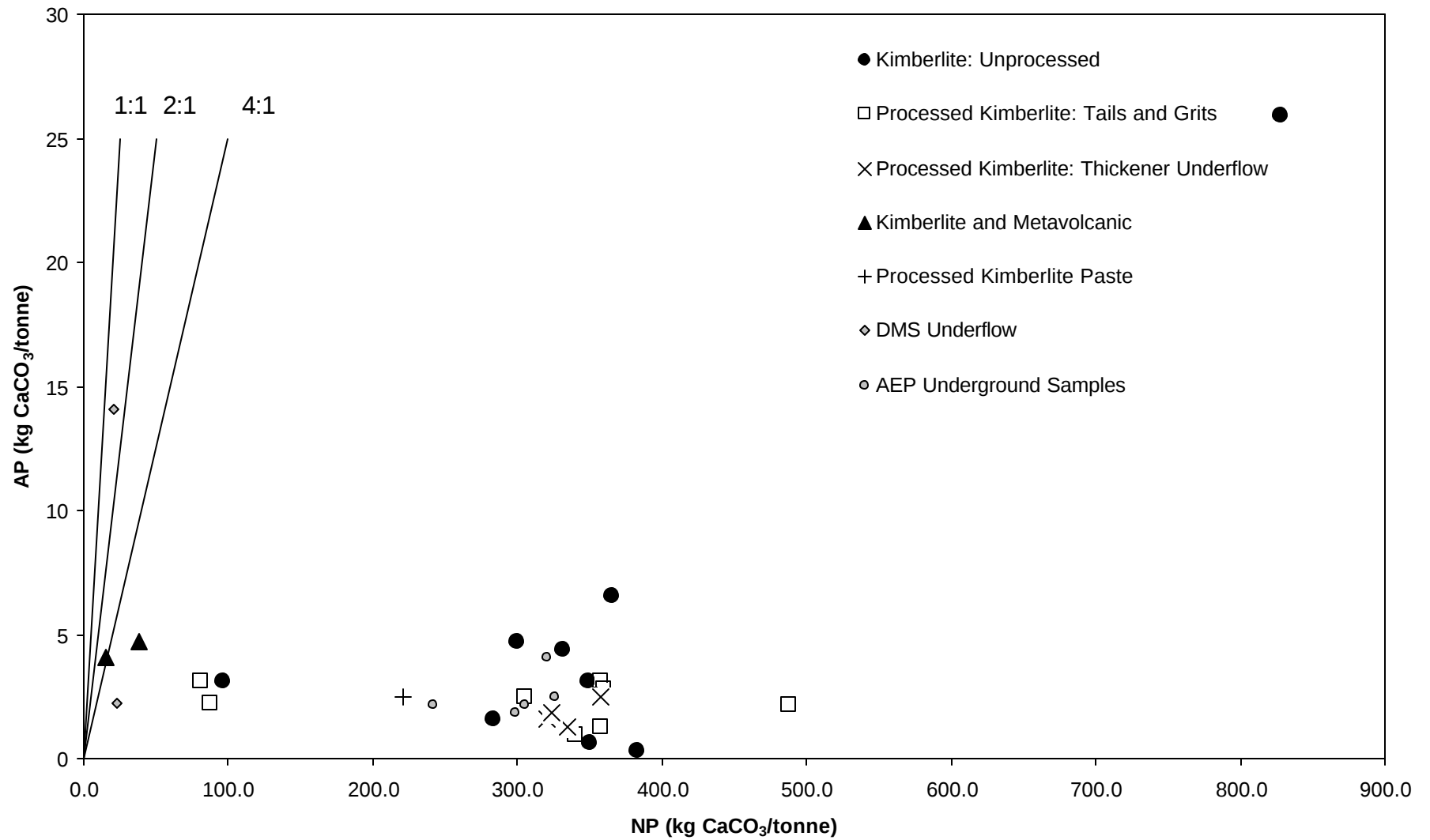


Figure III.2-7
NNP vs. NP/AP - Kimberlite

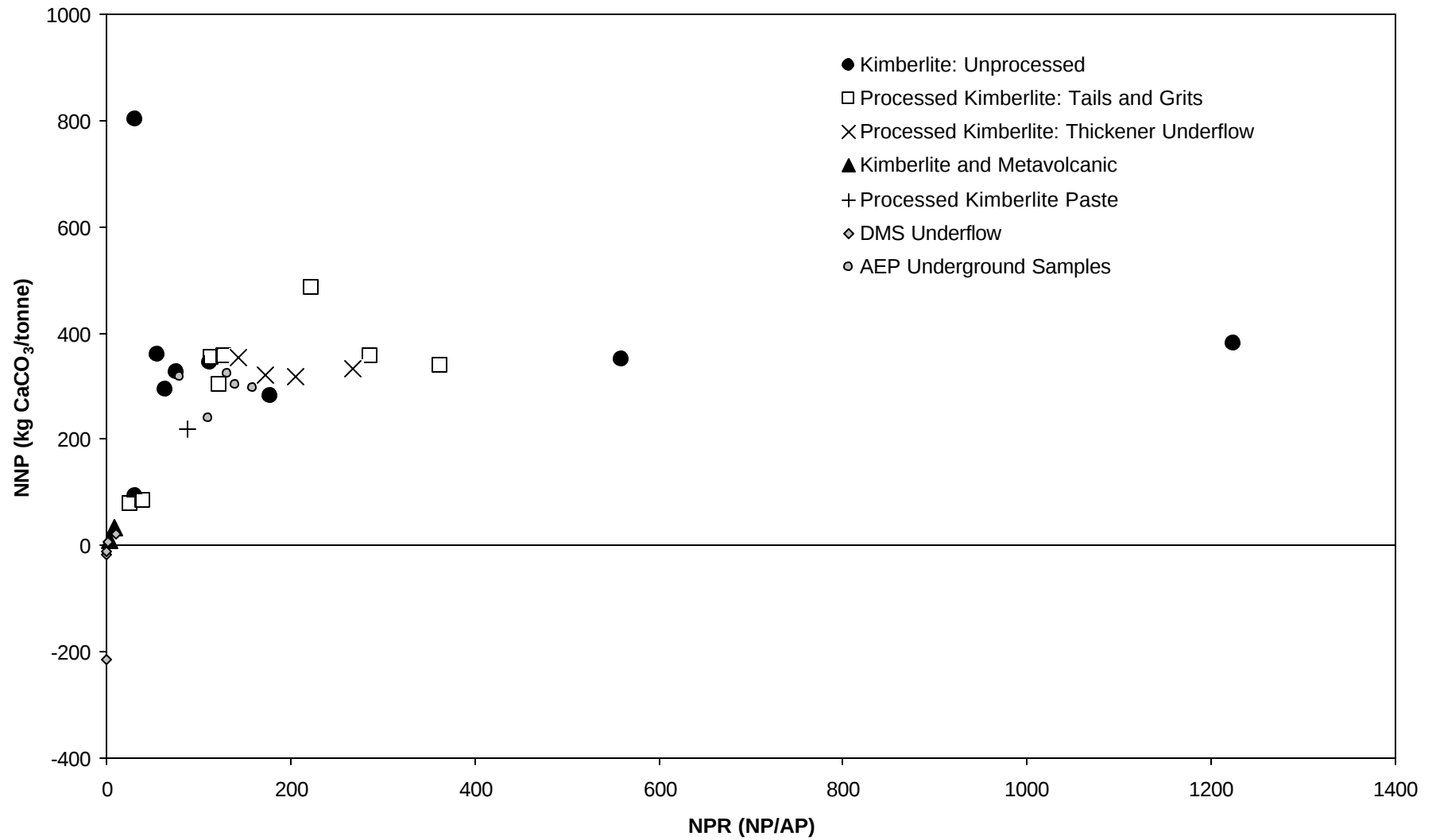


Figure III.2-8
Paste pH vs. Total Sulphur - Kimberlite

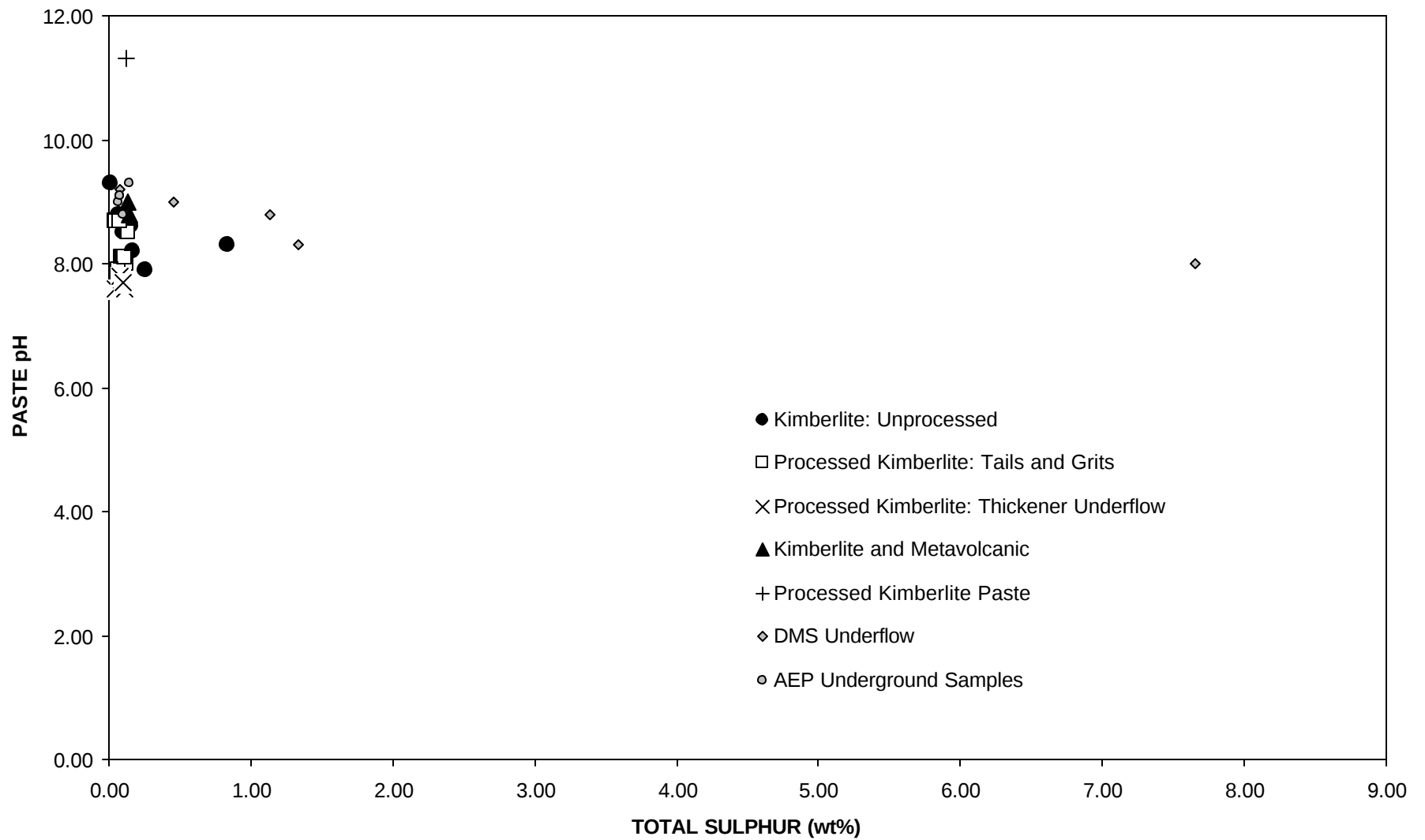


Figure III.2-9
Kinetic Testing Results Kimberlite - Standard Input Solution
pH

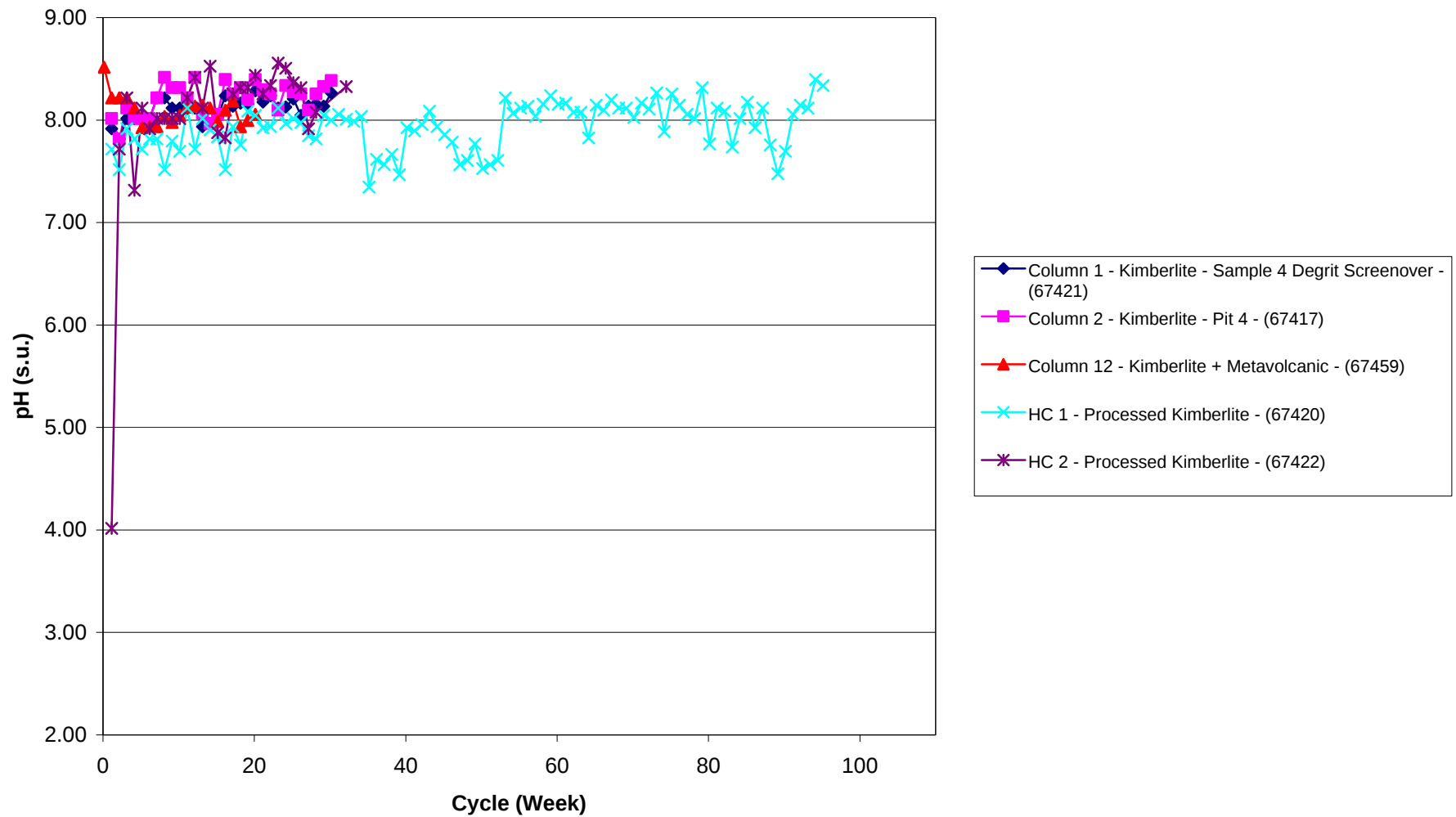


Figure III.2-10
Kinetic Testing Results Kimberlite - Standard Input Solution
Nickel

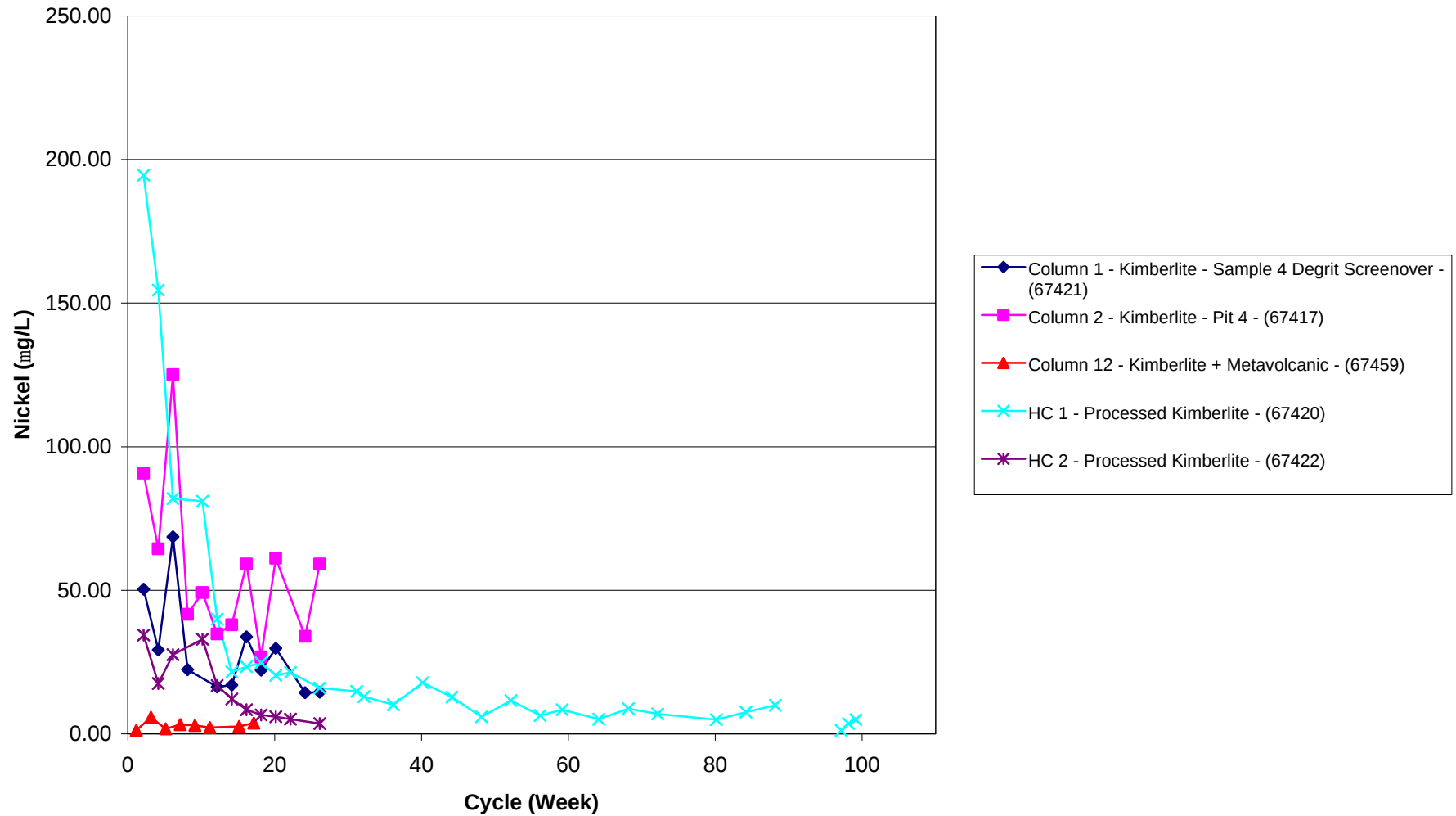


Figure III.2-11
Kinetic Testing Results Kimberlite - Variable Input Solution
pH

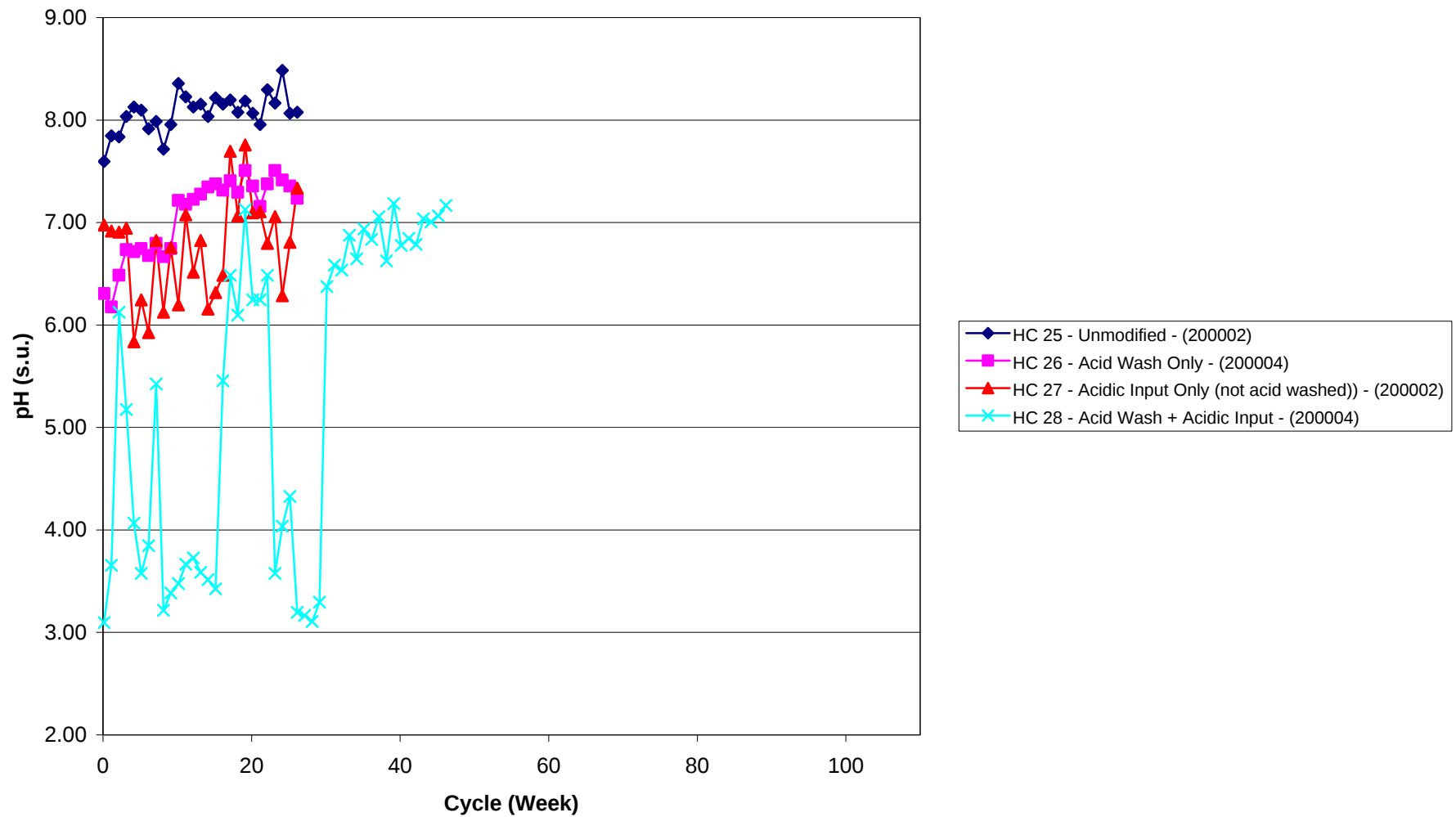


Figure III.2-12
Kinetic Testing Results Kimberlite - Variable Input Solution
Aluminum

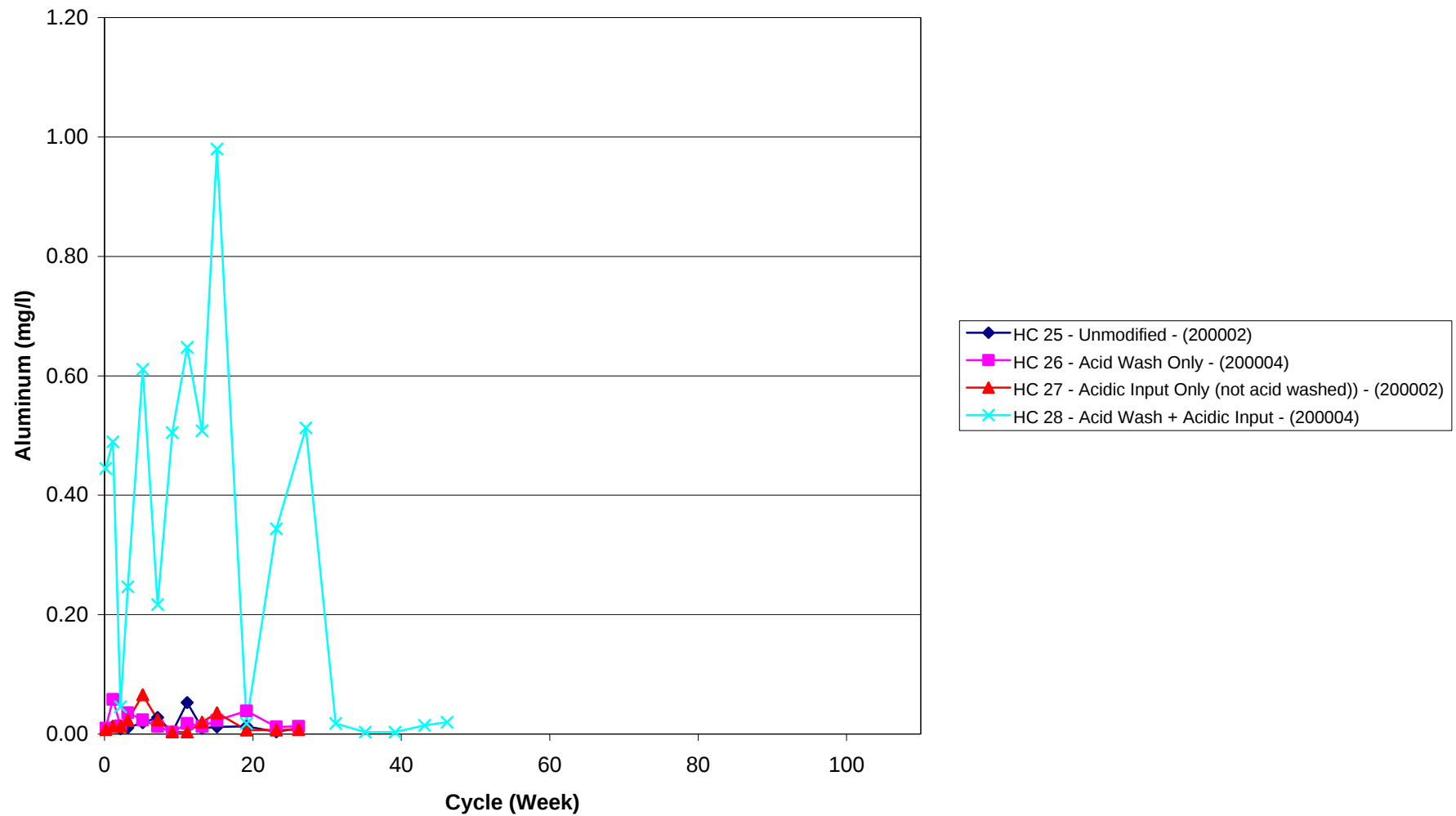


Figure III.2-13
Kinetic Testing Results Kimberlite - Variable Input Solution
Nickel

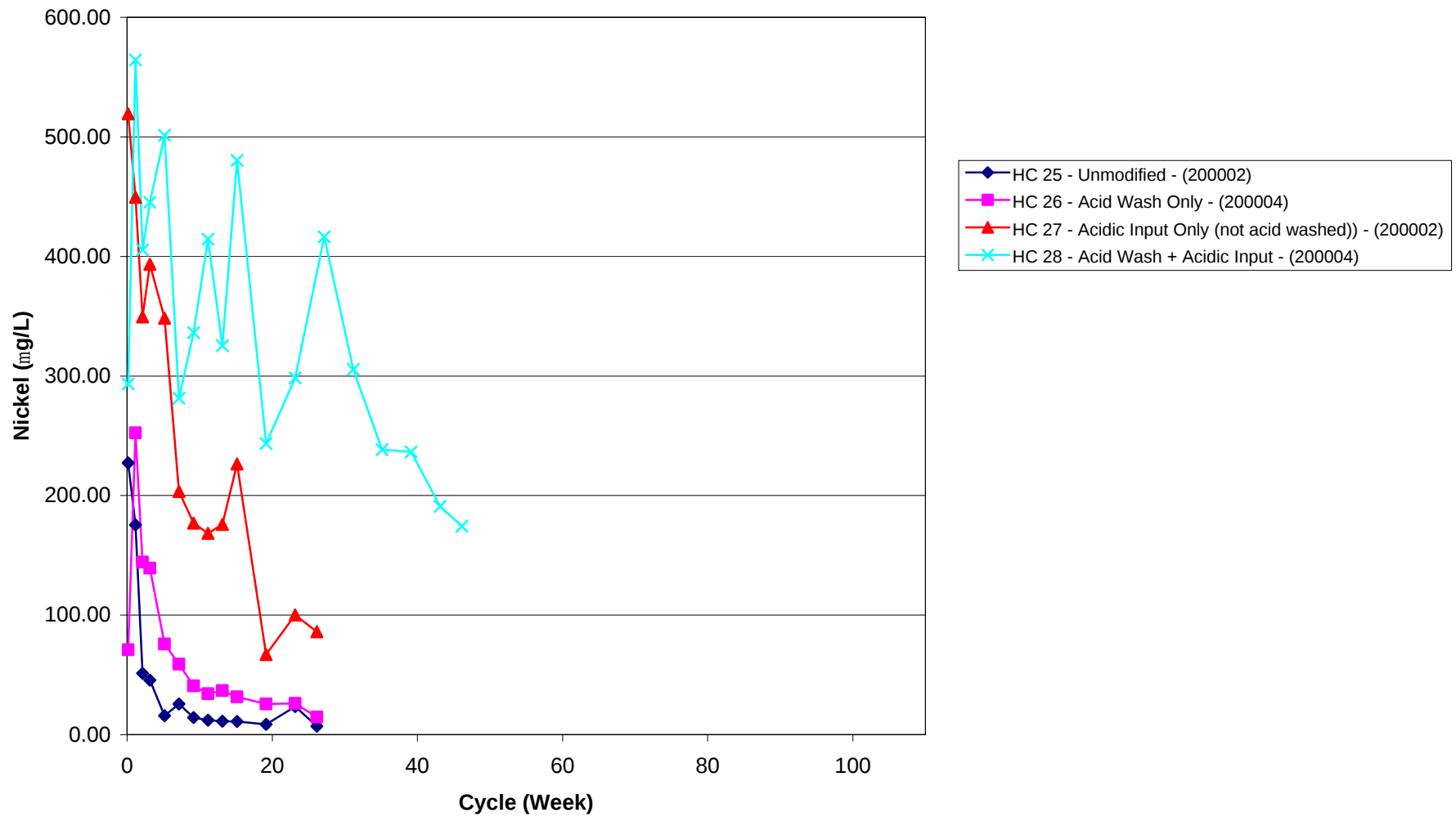


Figure III.2-14
Kinetic Testing Results Layered Kimberlite/Metavolcanic
pH

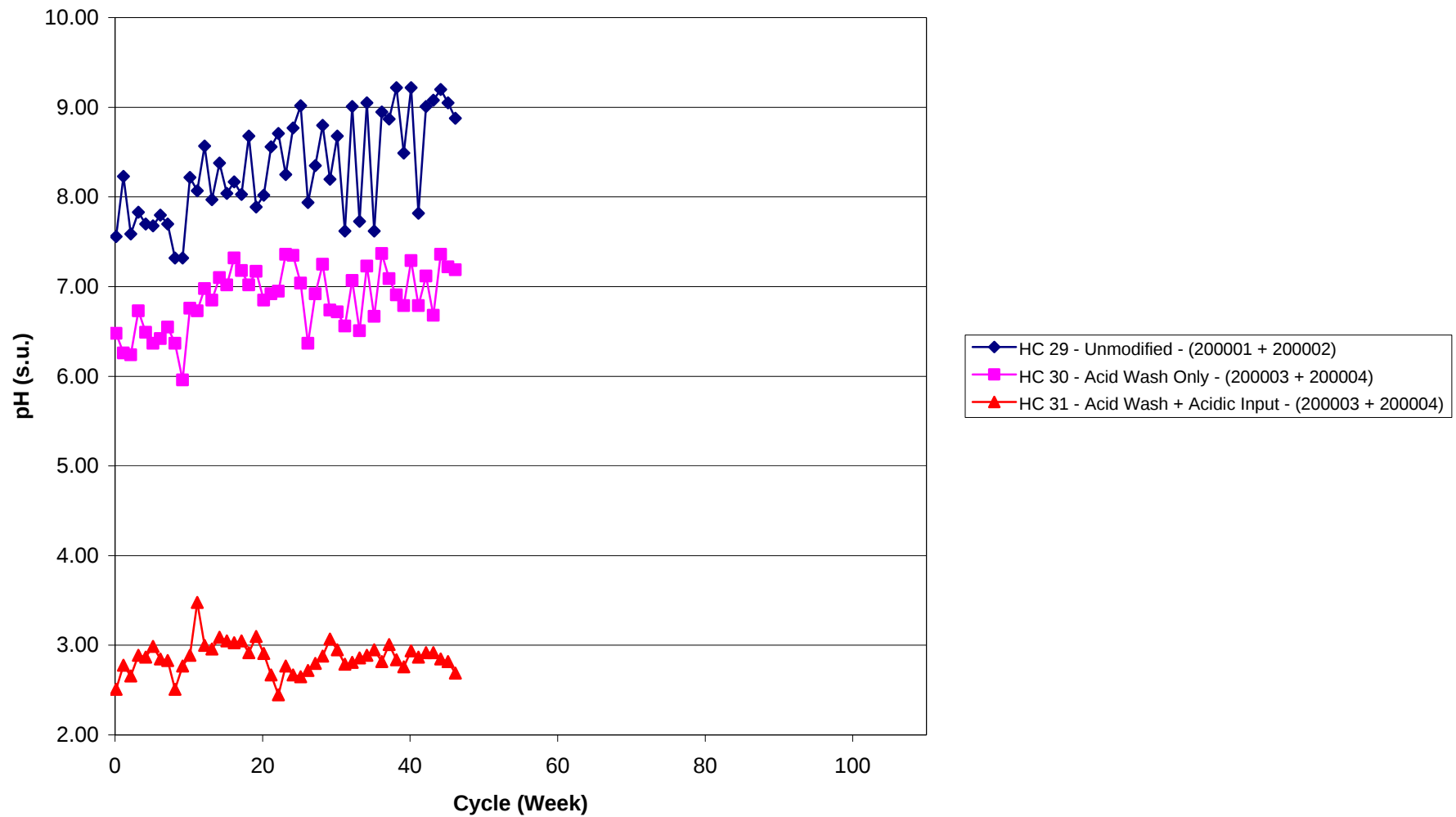


Figure III.2-15
Kinetic Testing Results Layered Kimberlite/Metavolcanic
Aluminum

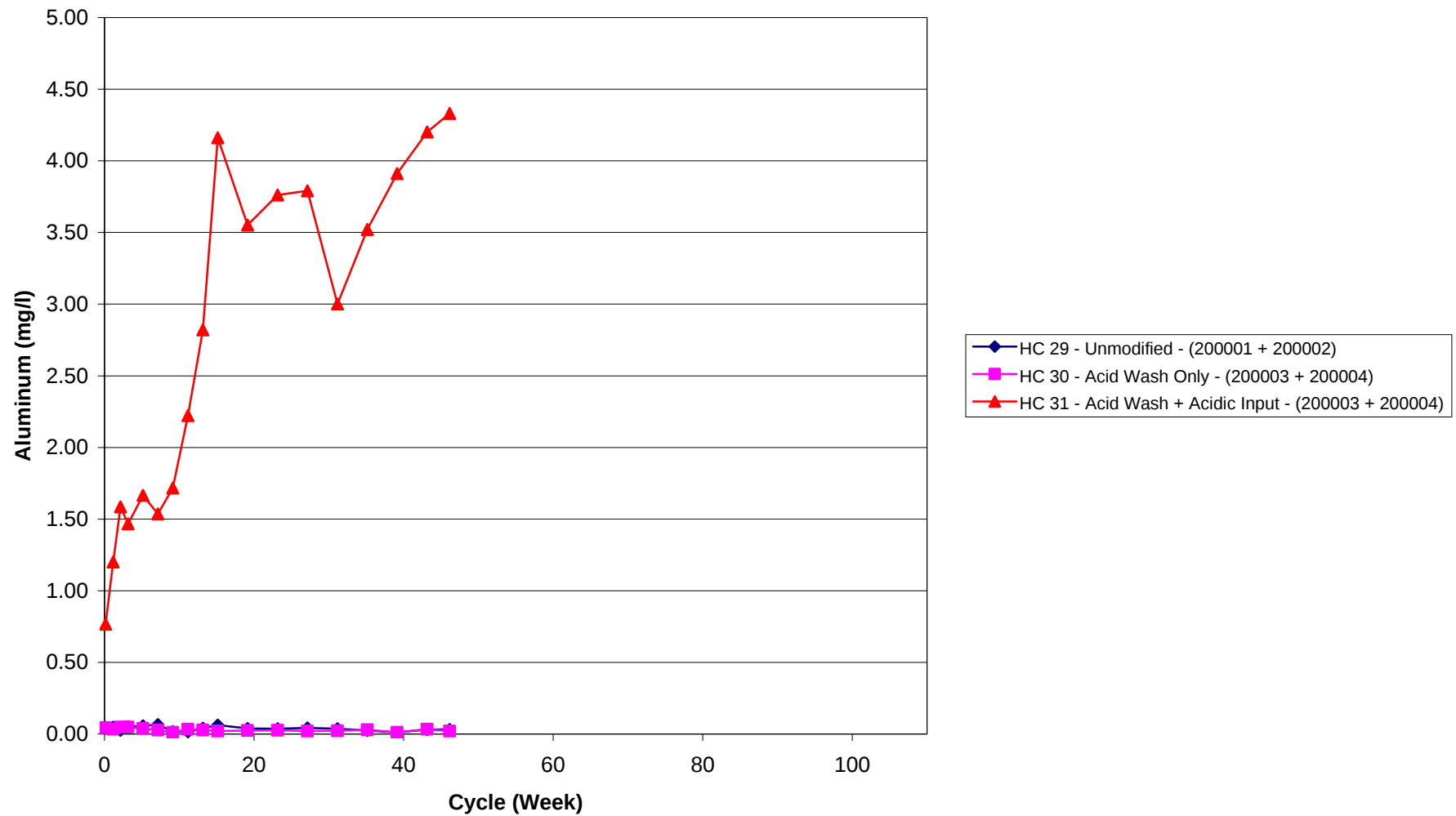


Figure III.2-16
Kinetic Testing Results Layered Kimberlite/Metavolcanic
Nickel

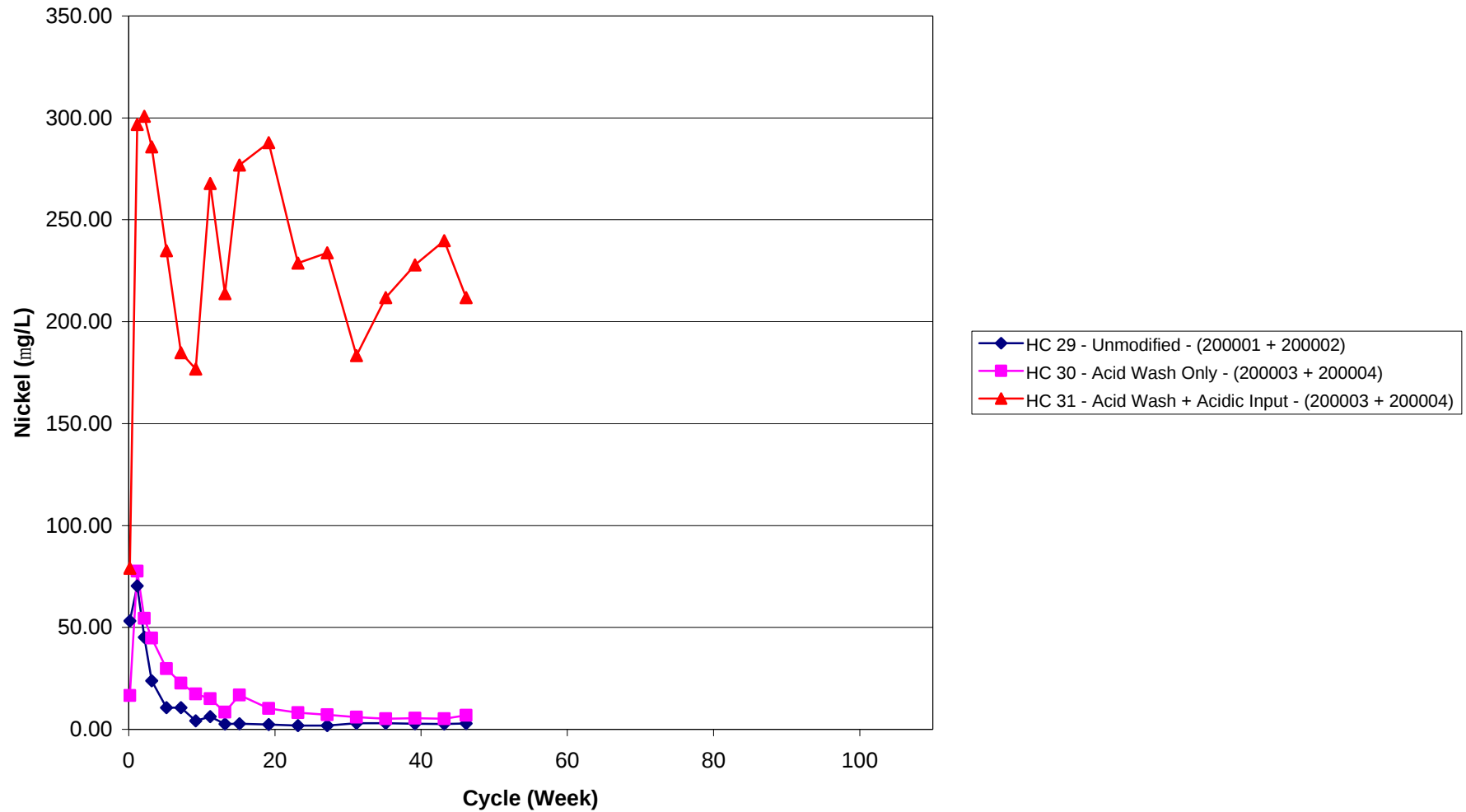


Figure III.2-17
Total Sulphur vs. Sulphide Sulphur - Granite

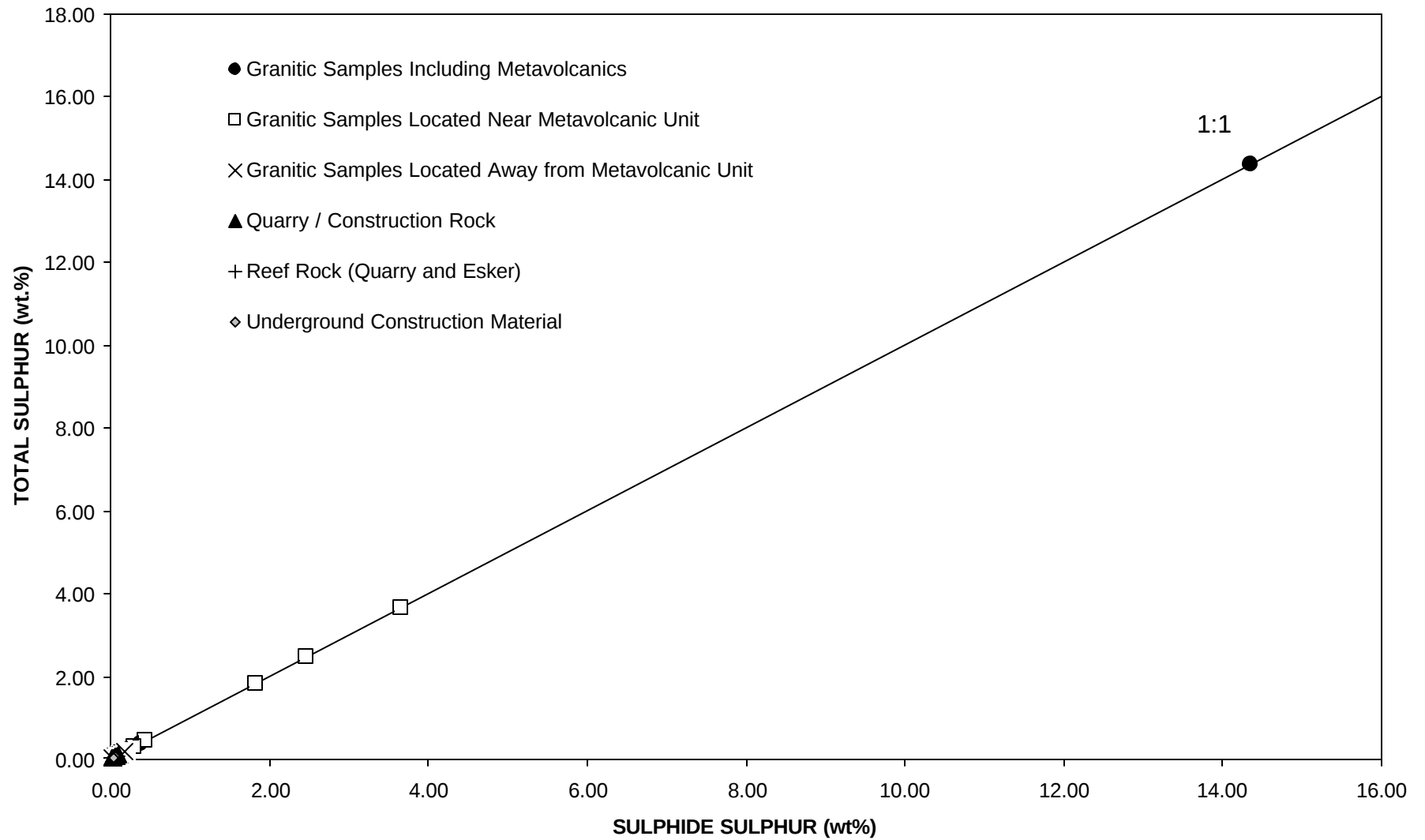


Figure III.2-18
Total Sulphur vs. Sulphide Sulphur (Sulphide Sulphur < 2 wt%) - Granite

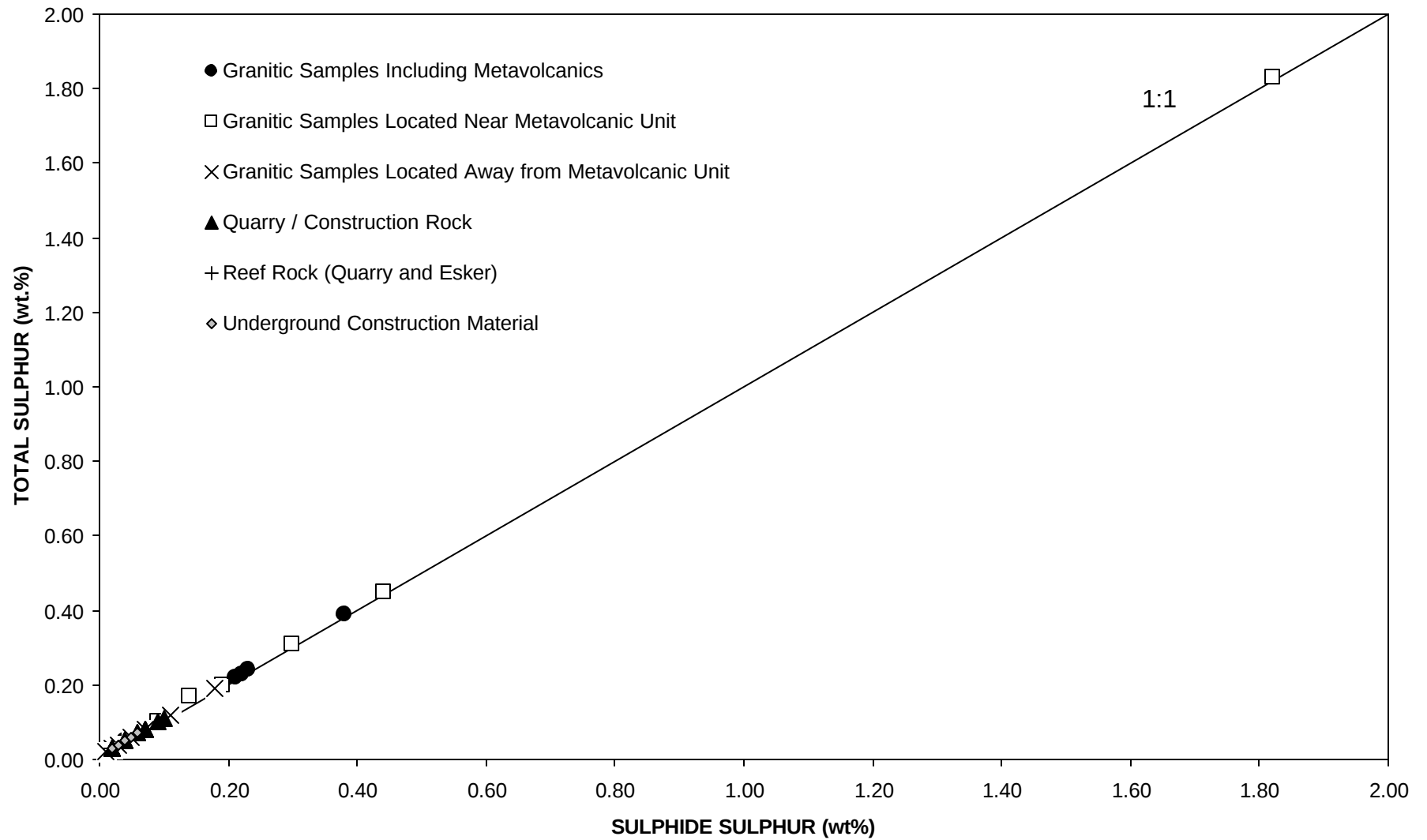


Figure III.2-19
Bulk NP vs. Carbonate NP - Granite

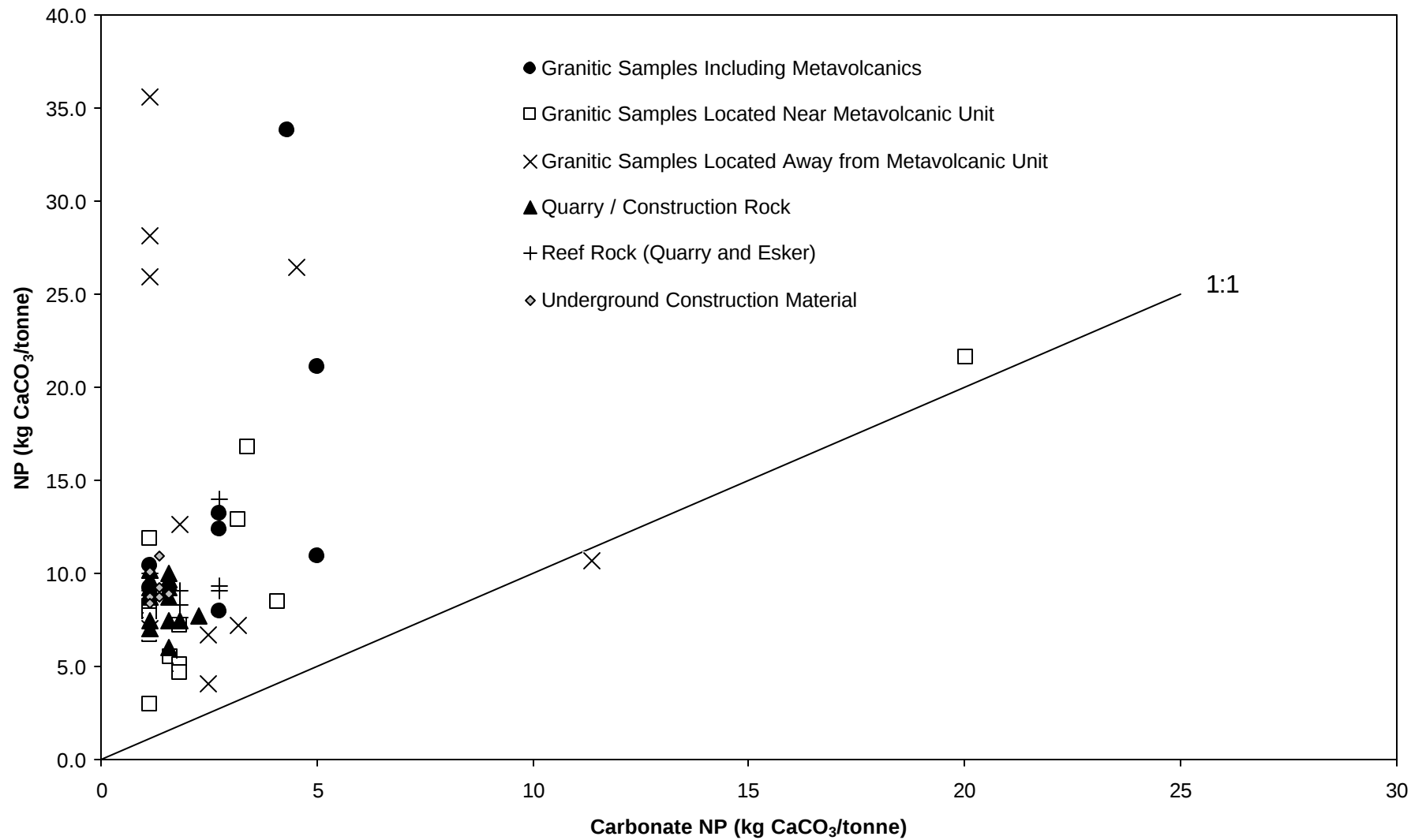


Figure III.2-20
AP vs. NP - Granite

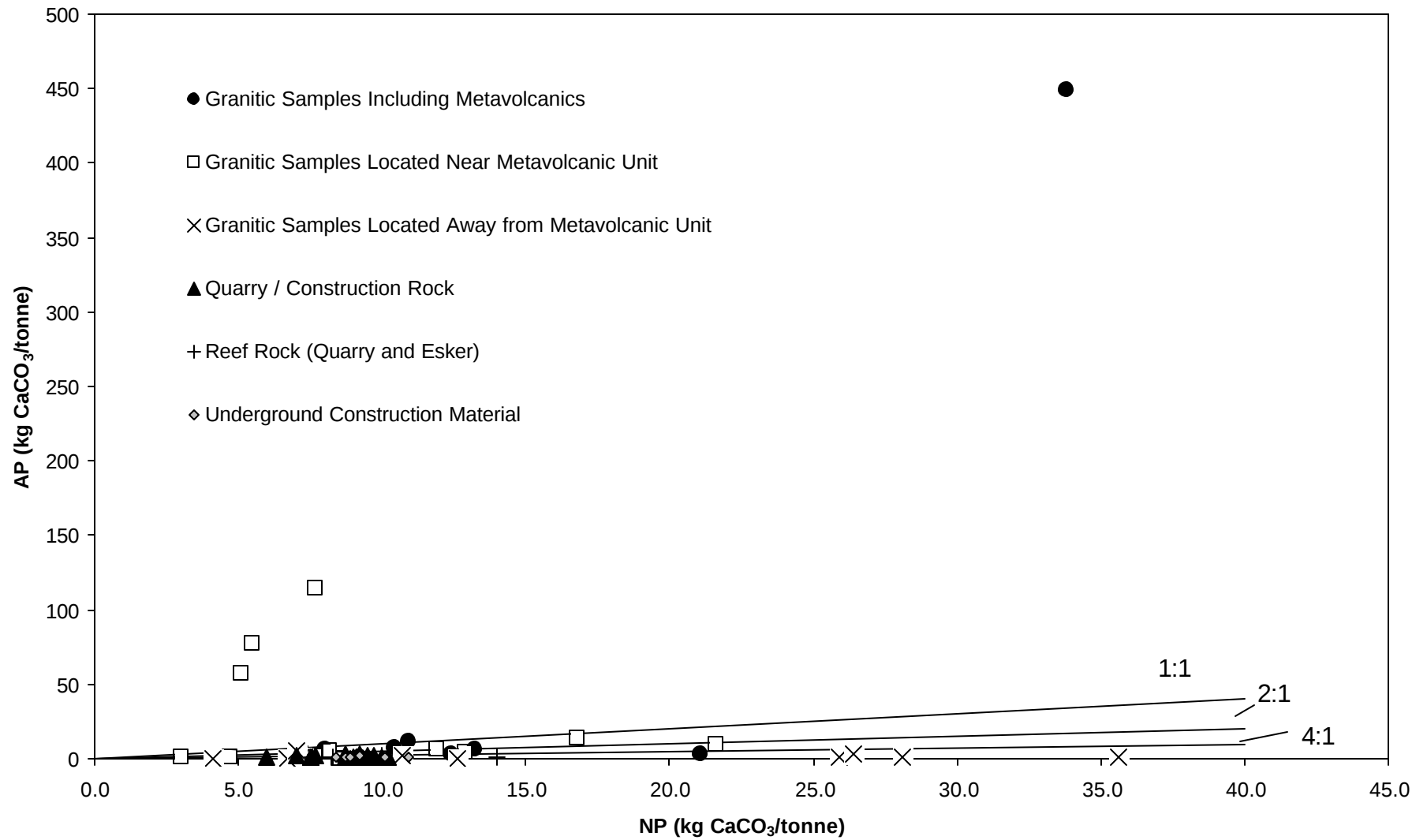


Figure III.2-21
AP vs. NP (AP < 10 kg CaCO₃/tonne) - Granite

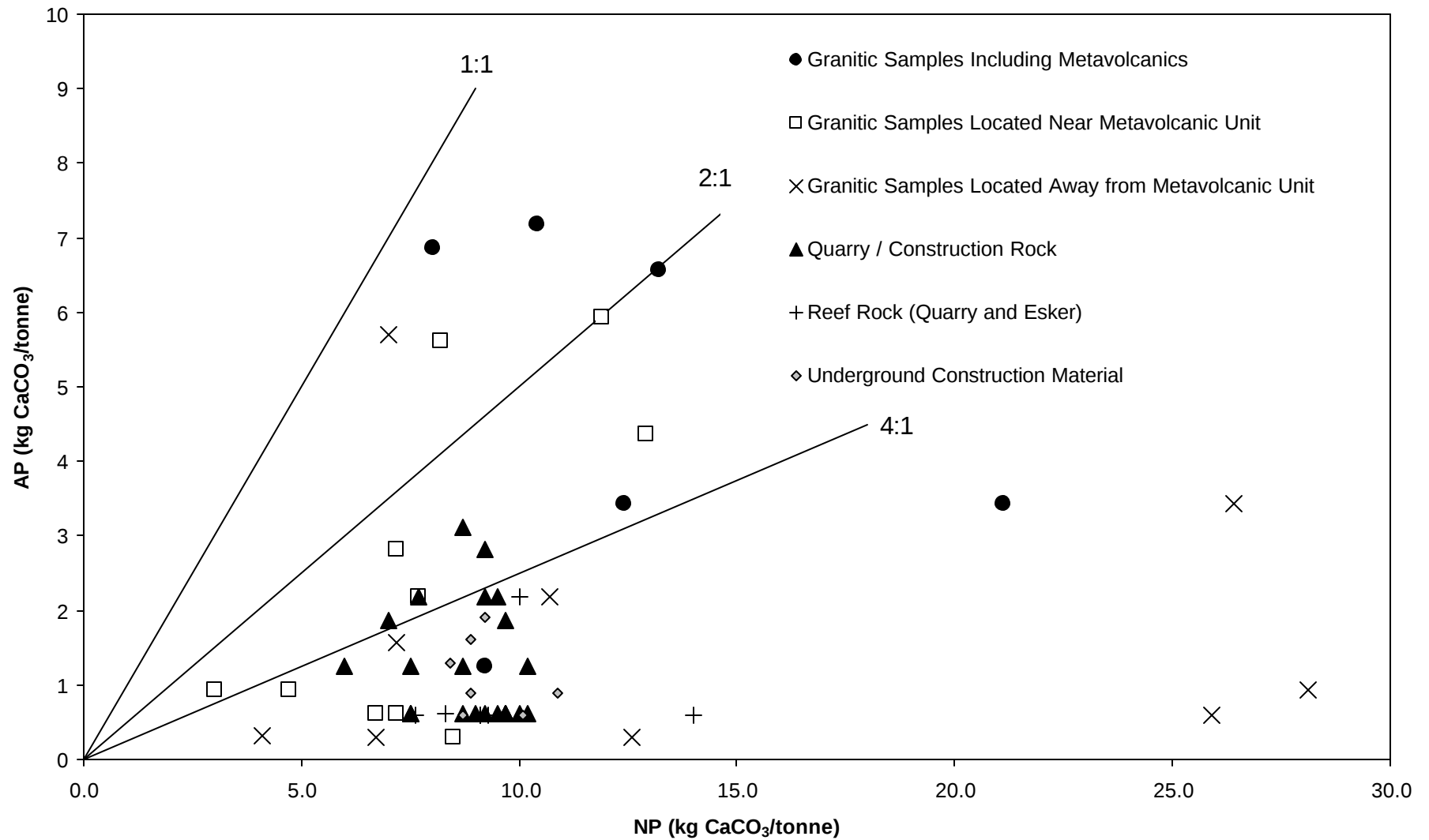
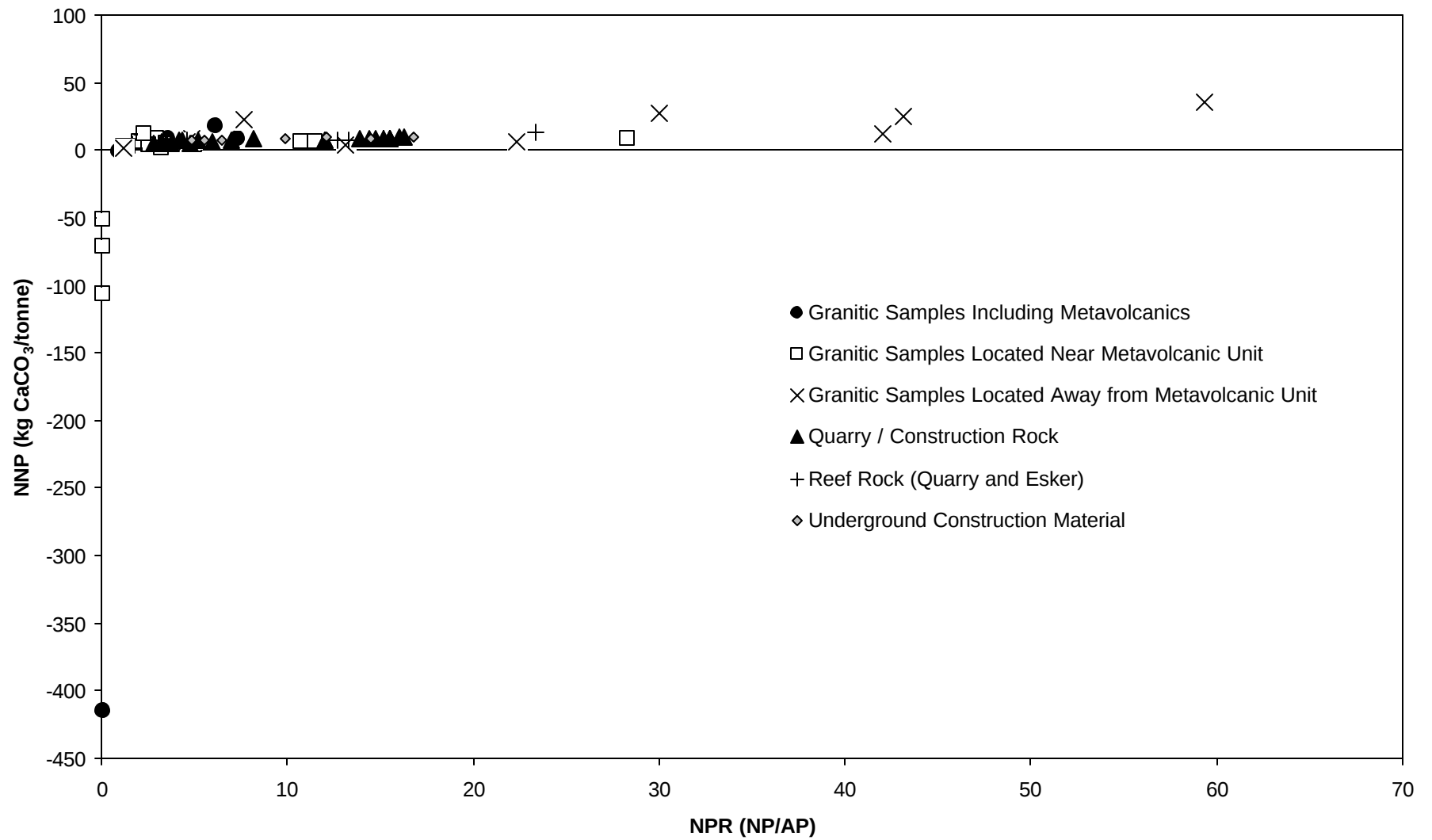


Figure III.2-22
NNP vs. NP/AP - Granite



Paste pH vs. Total Sulphur - Granite

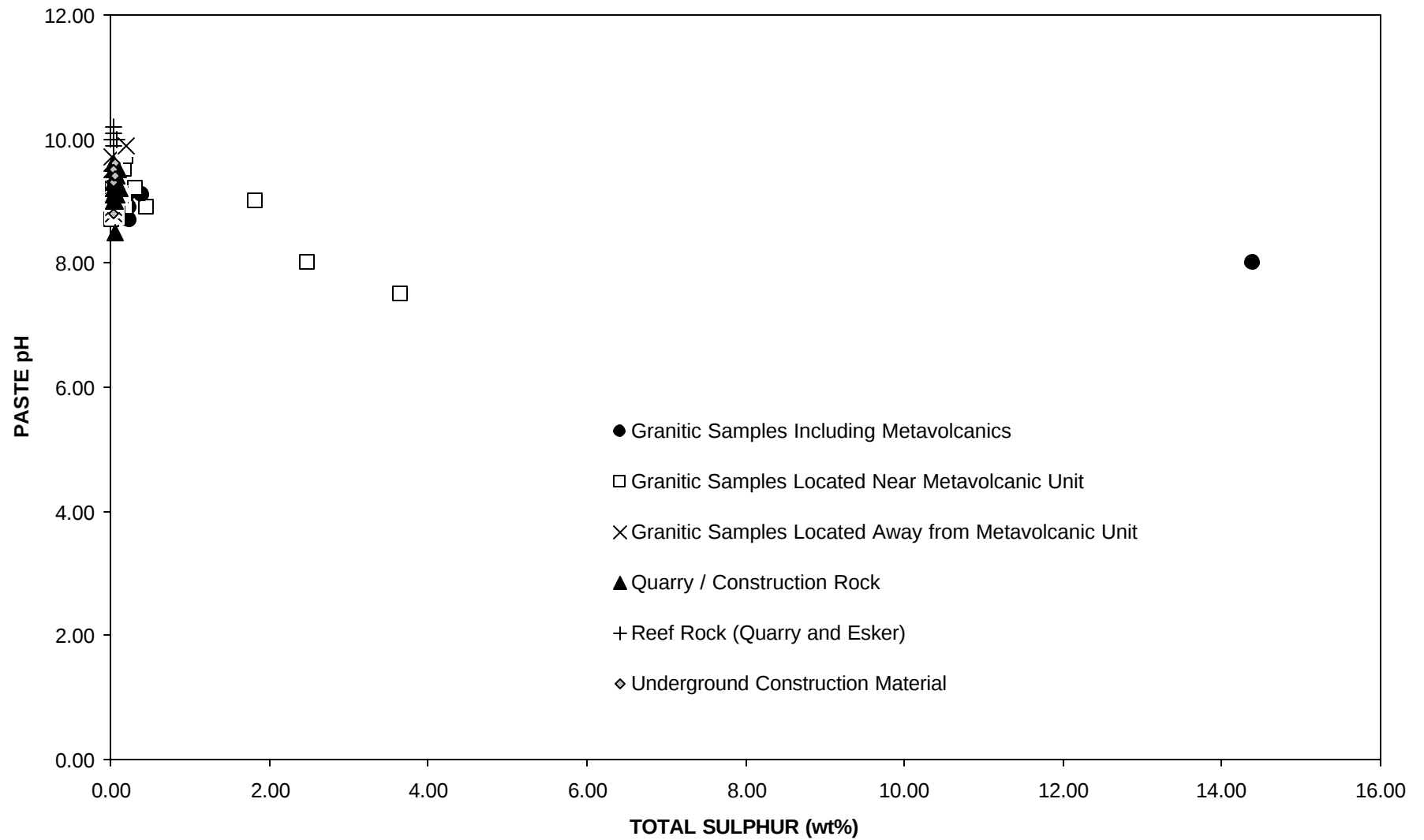


Figure III.2-24
Kinetic Testing Results Granite - Standard Input Solution
pH

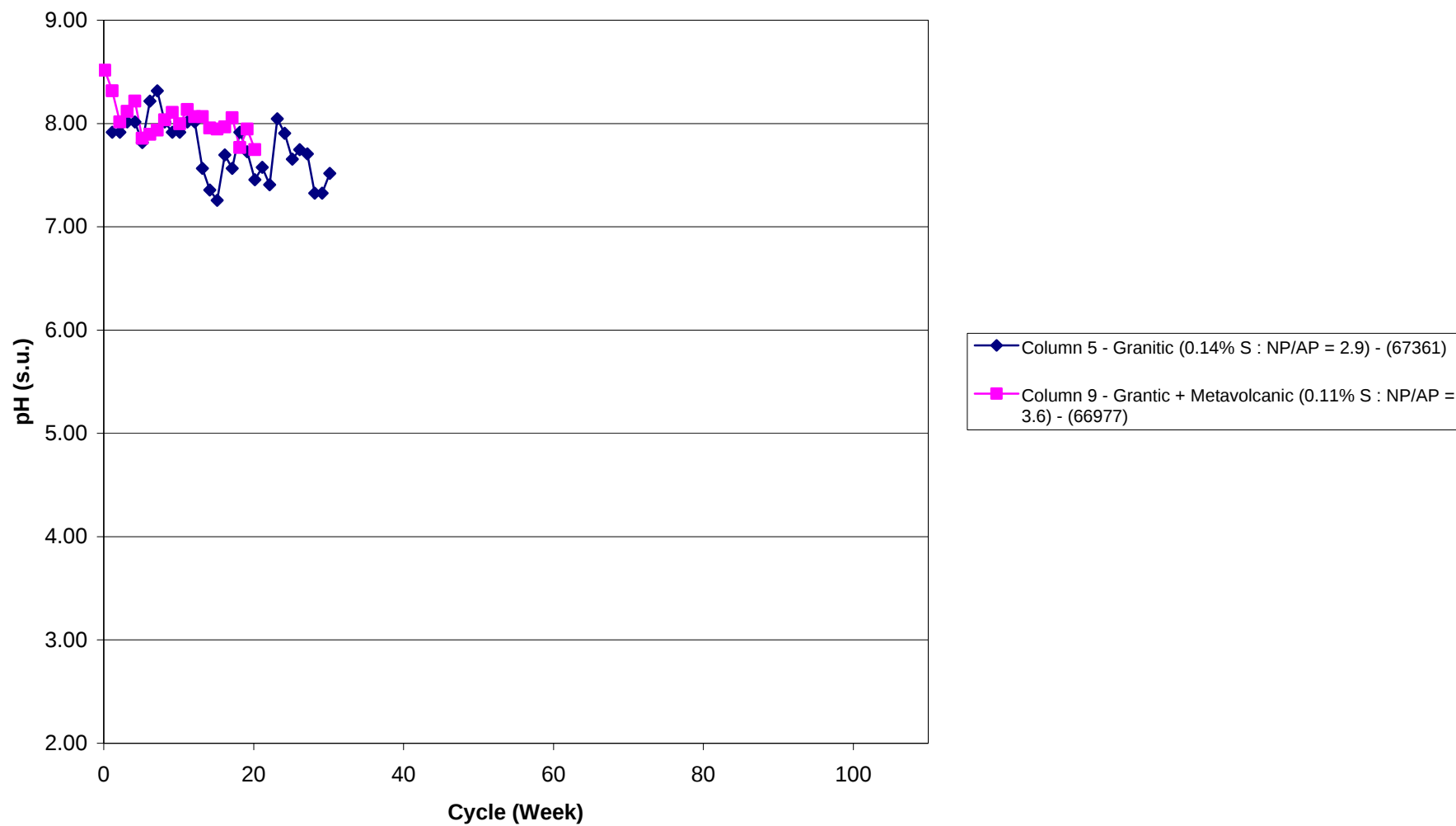


Figure III.2-25
Kinetic Testing Results Granite - Standard Input Solution
Molybdenum

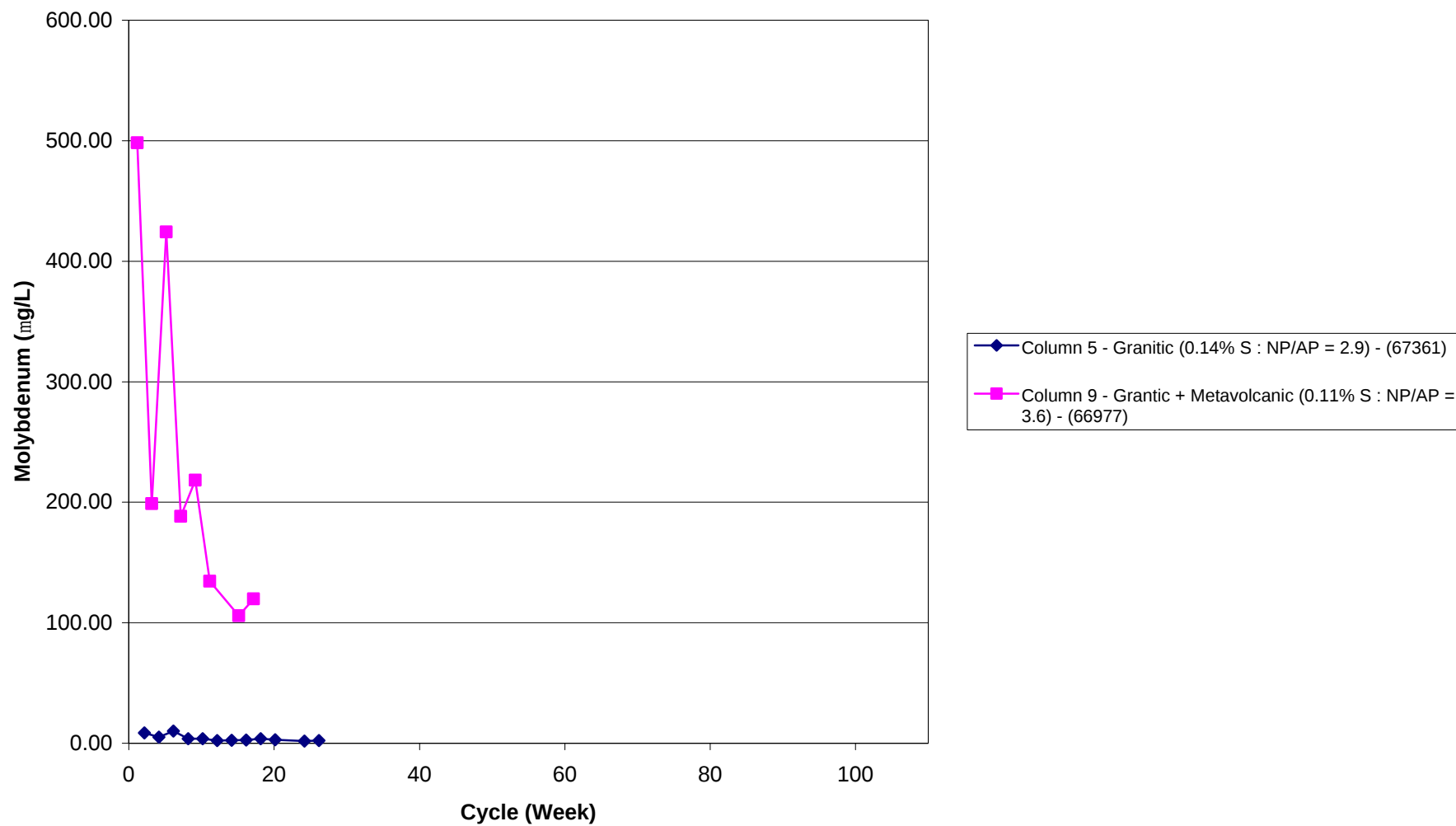


Figure III.2-26
Kinetic Testing Results Granite - Variable Input Solution
pH

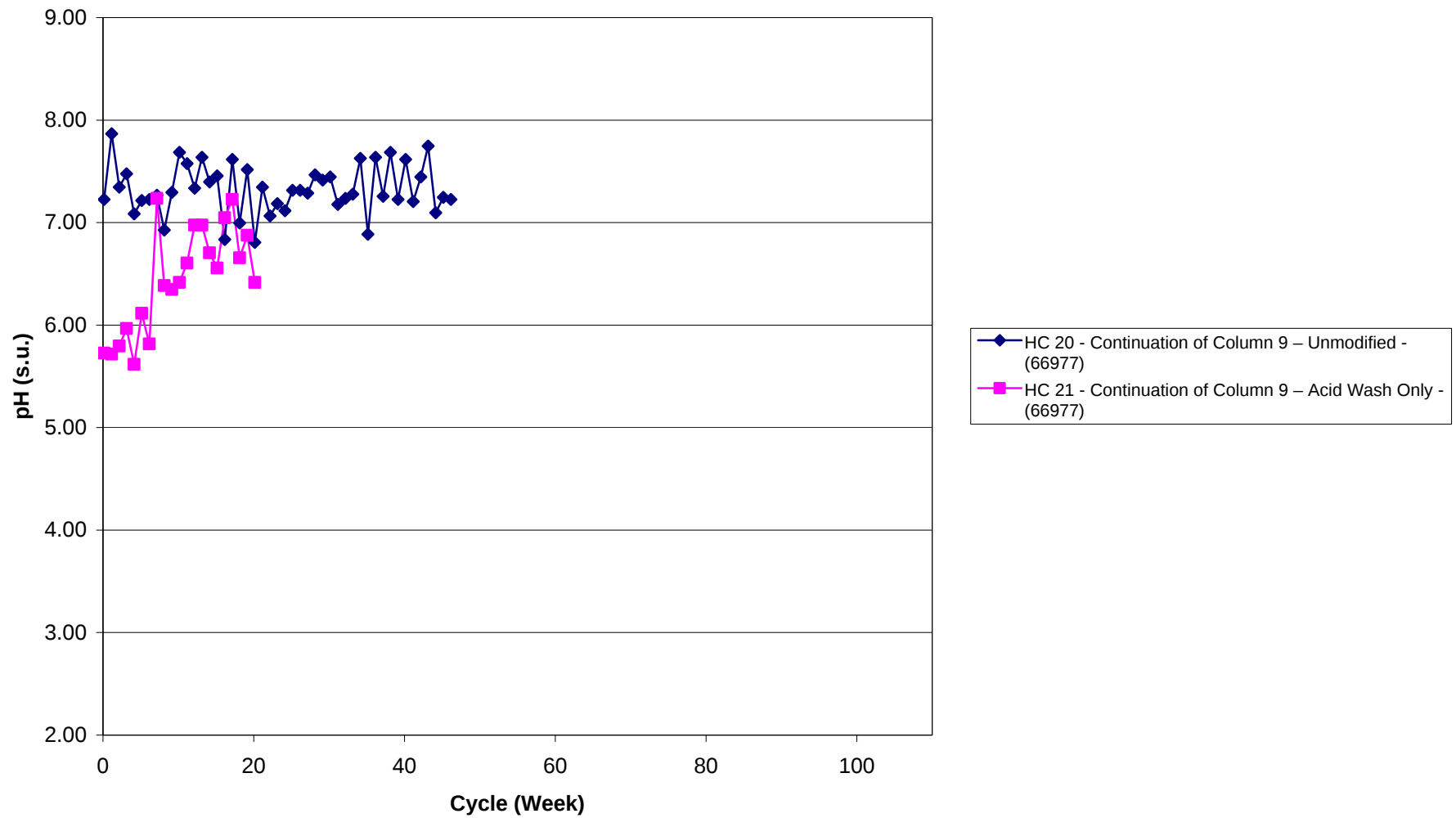


Figure III.2-27
Kinetic Testing Results Granite - Variable Input Solution
Molybdenum

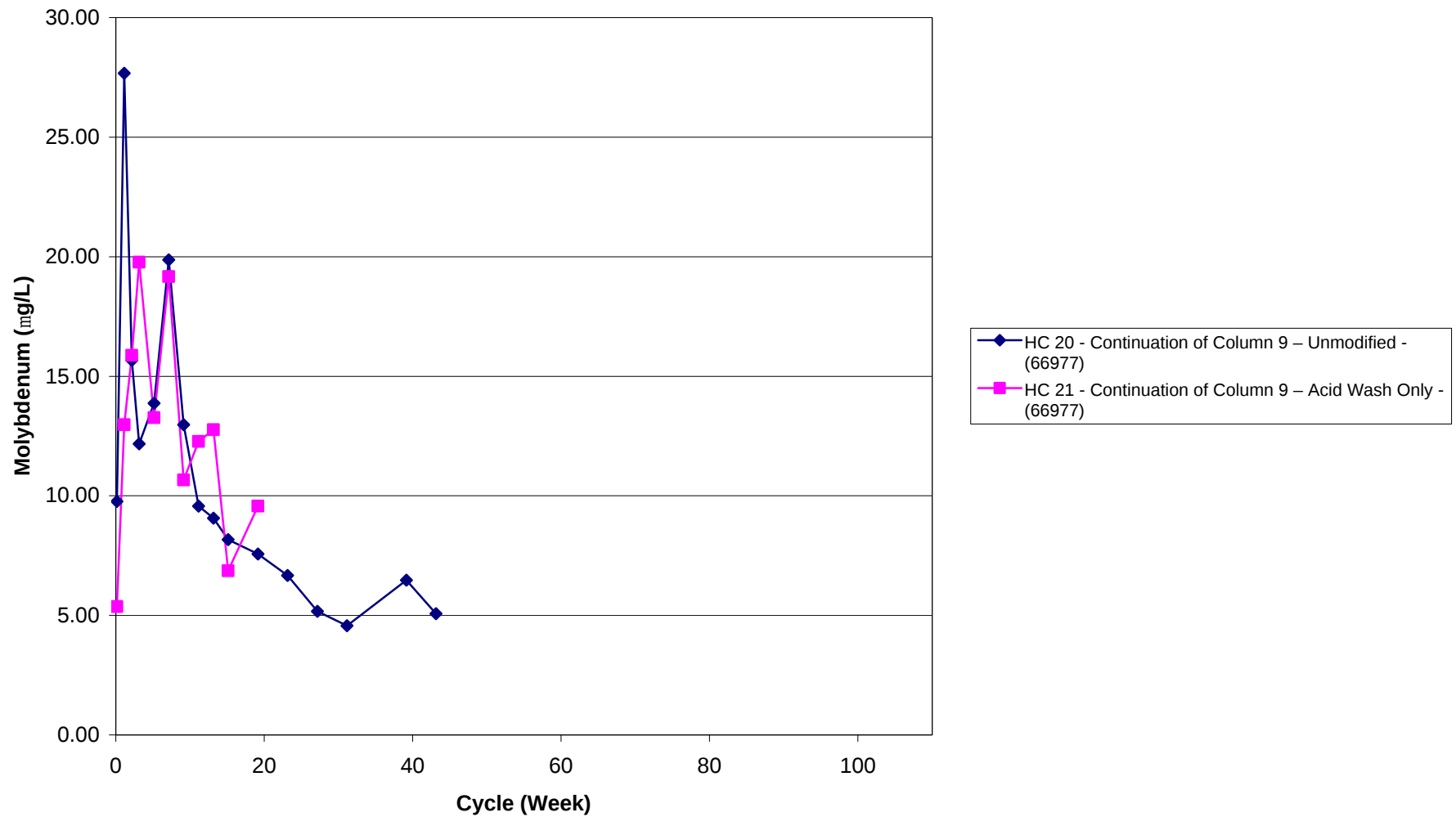


Figure III.2-28
Total Sulphur vs. Sulphide Sulphur - Metavolcanics

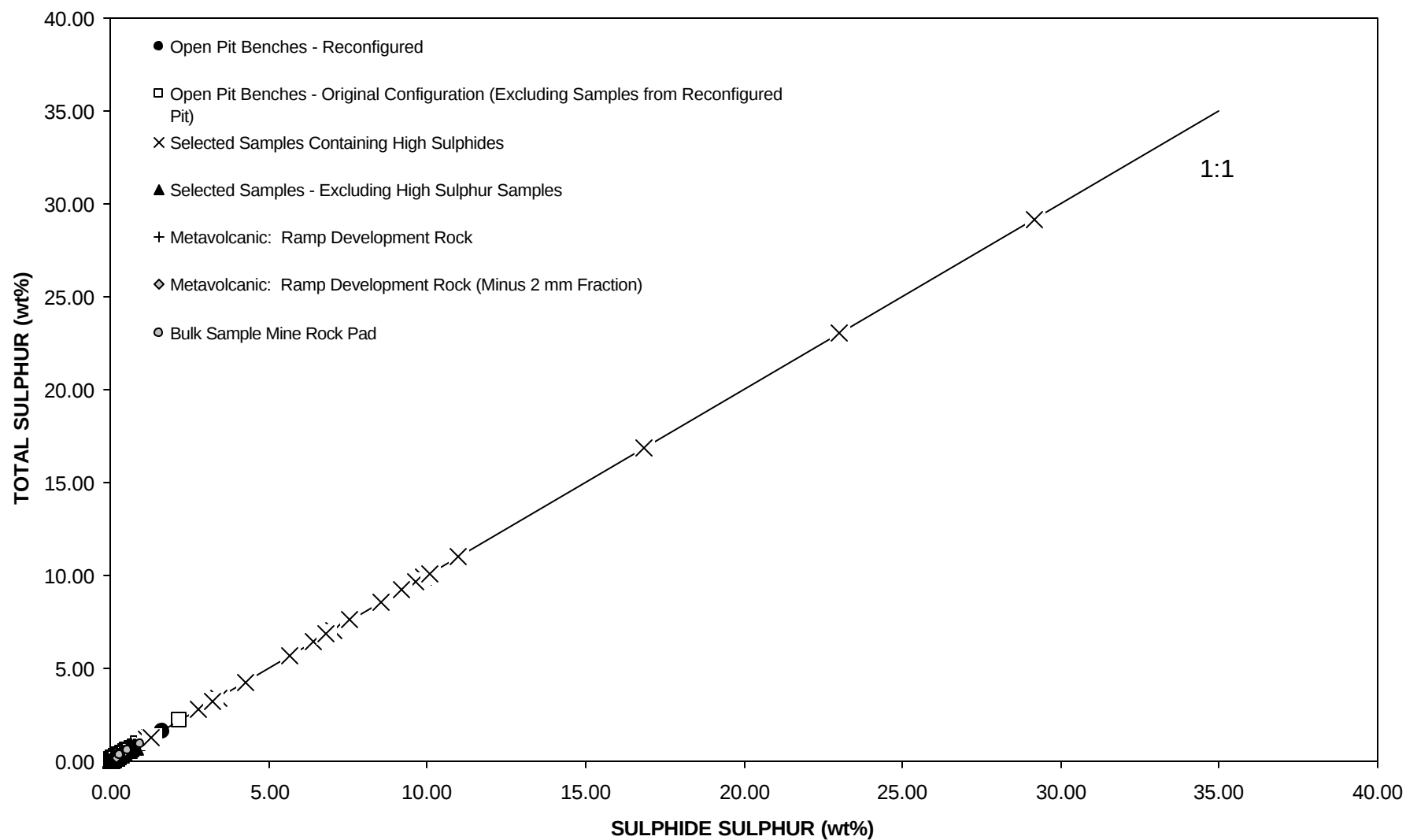


Figure III.2-29
Total Sulphur vs. Sulphide Sulphur (Sulphide Sulphur < 1.0 wt%) - Metavolcanics

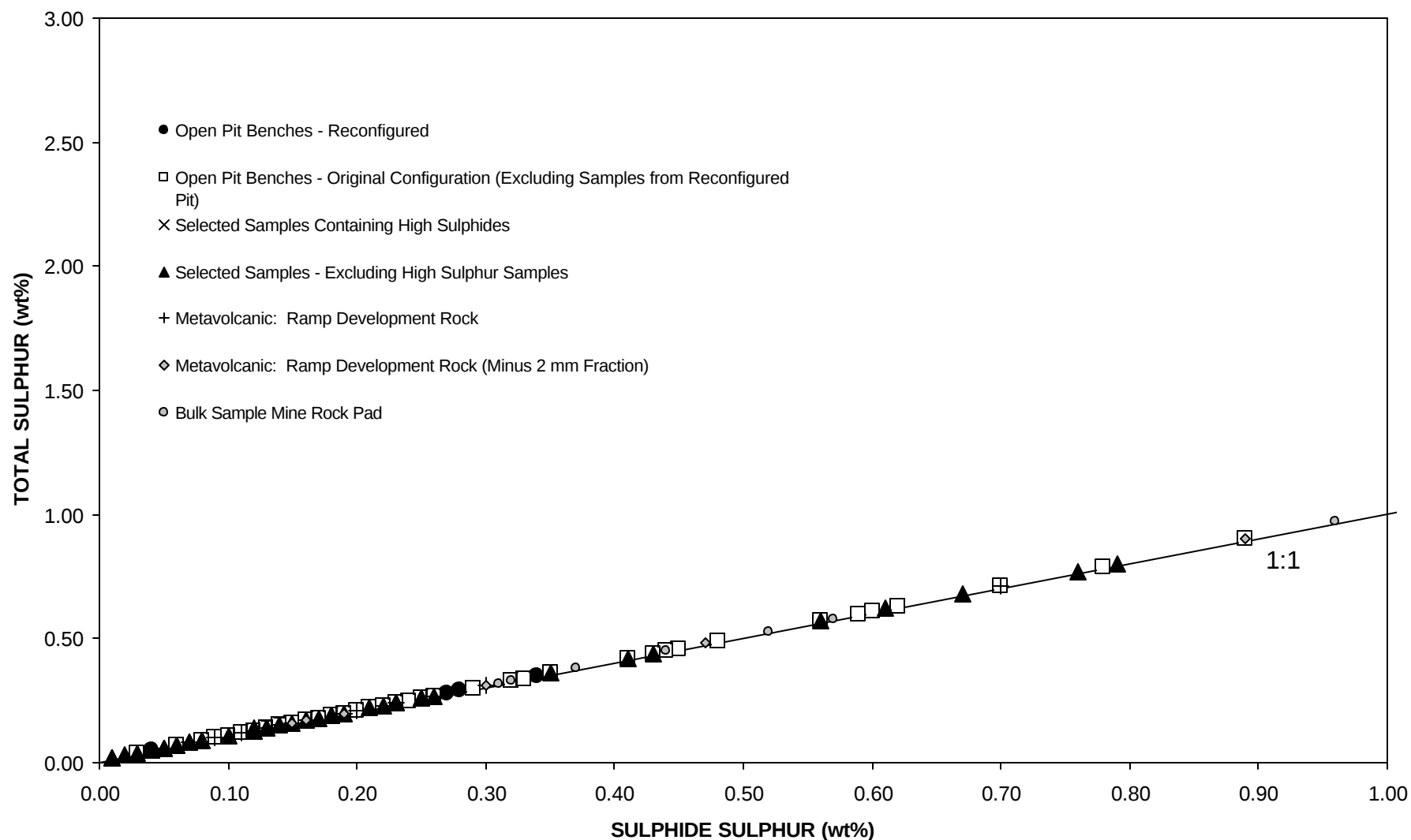


Figure III.2-30
Bulk NP vs. Carbonate NP - Metavolcanics

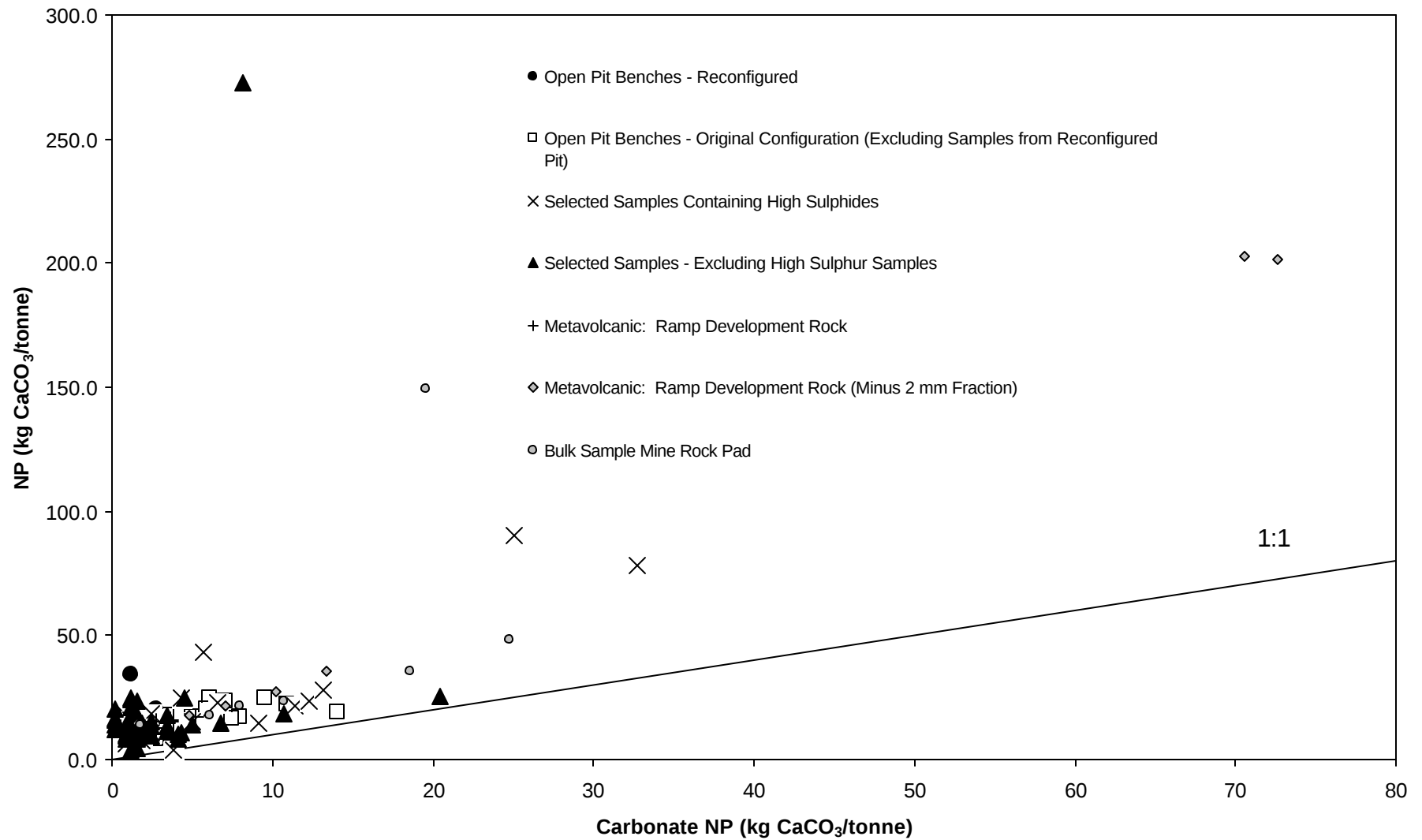


Figure III.2-31
AP vs. NP - Metavolcanics

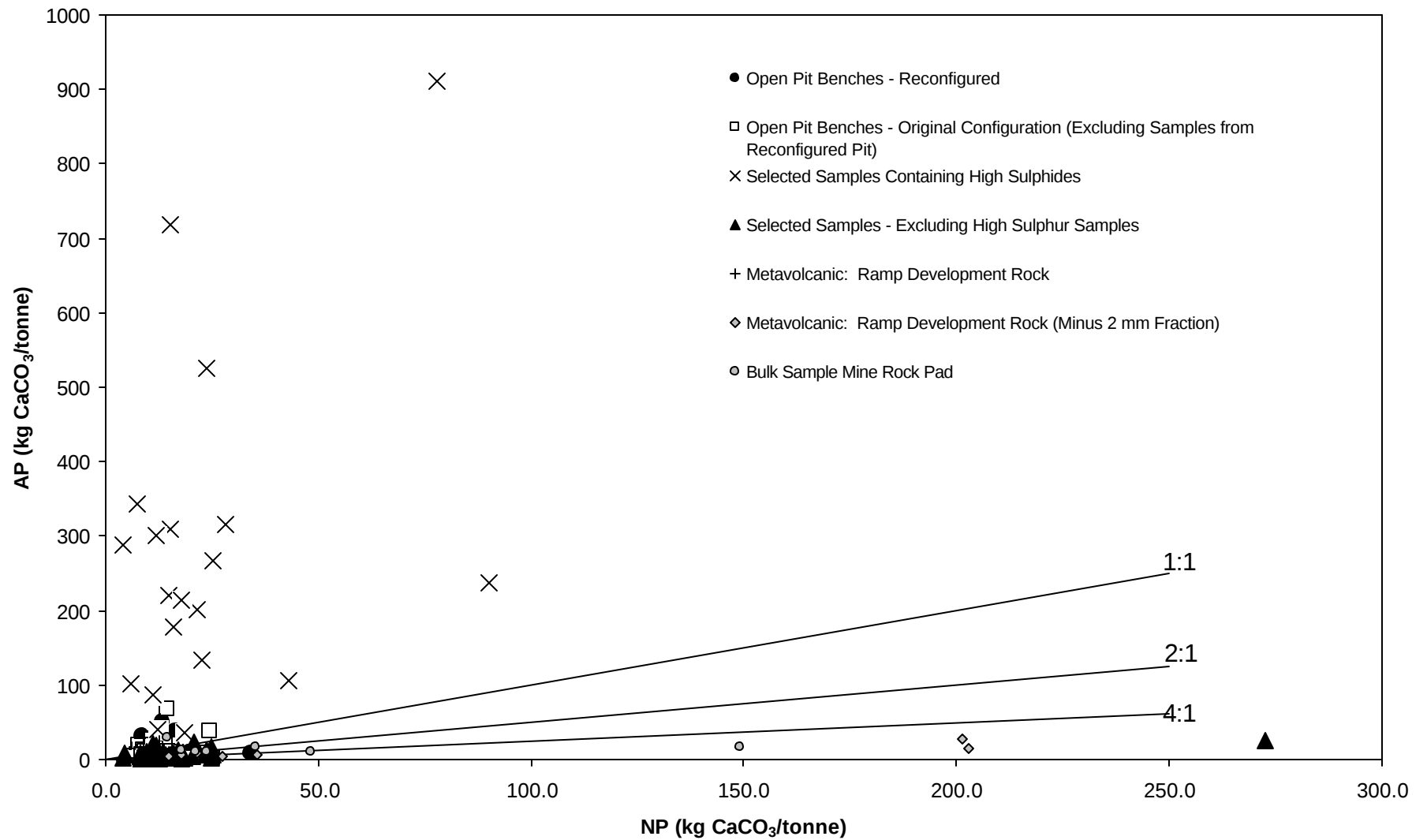


Figure III.2-32
AP vs. NP (AP < 100 kg CaCO₃/tonne) - Metavolcanics

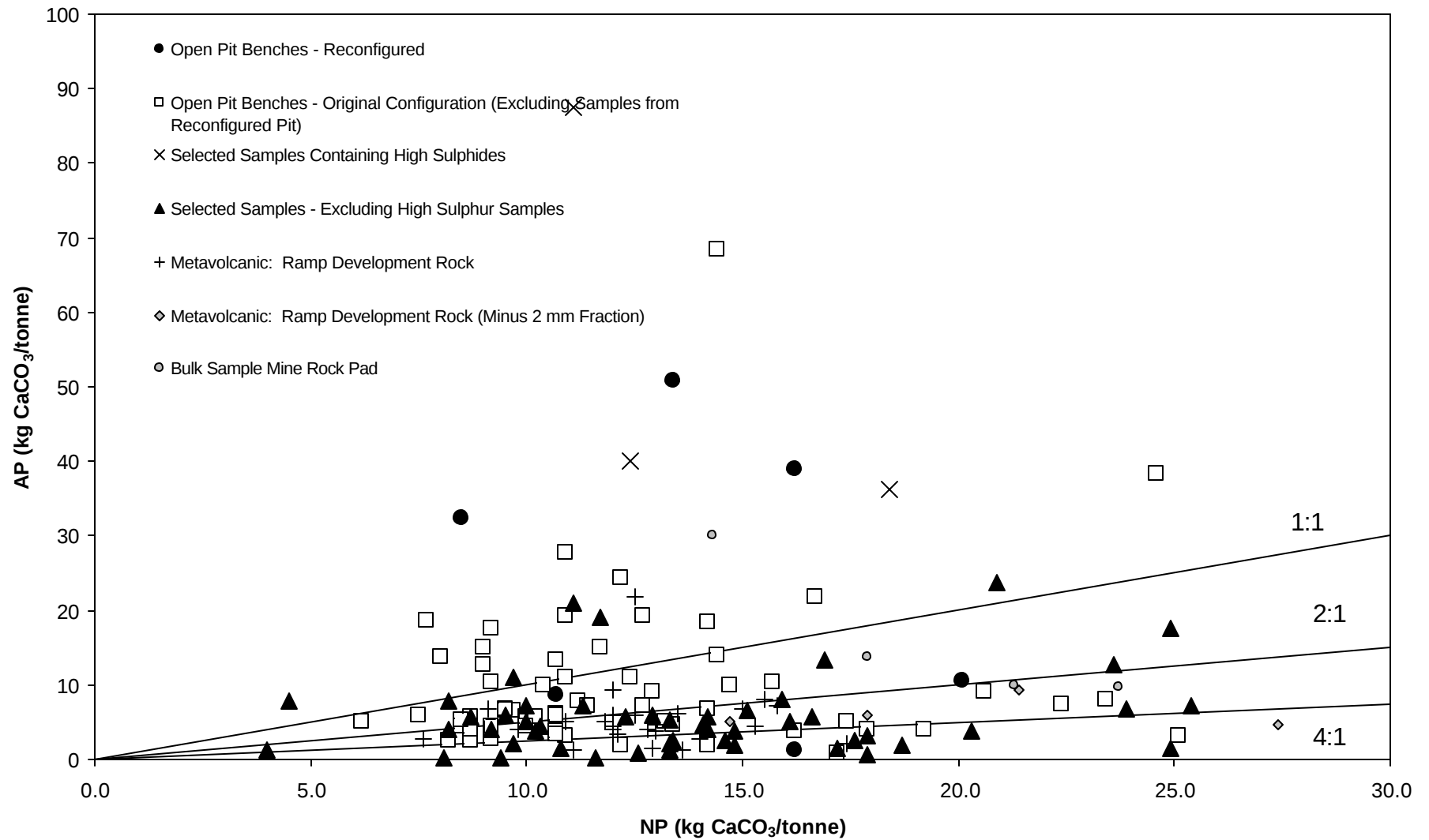


Figure III.2-33
NNP vs. NP/AP - Metavolcanics

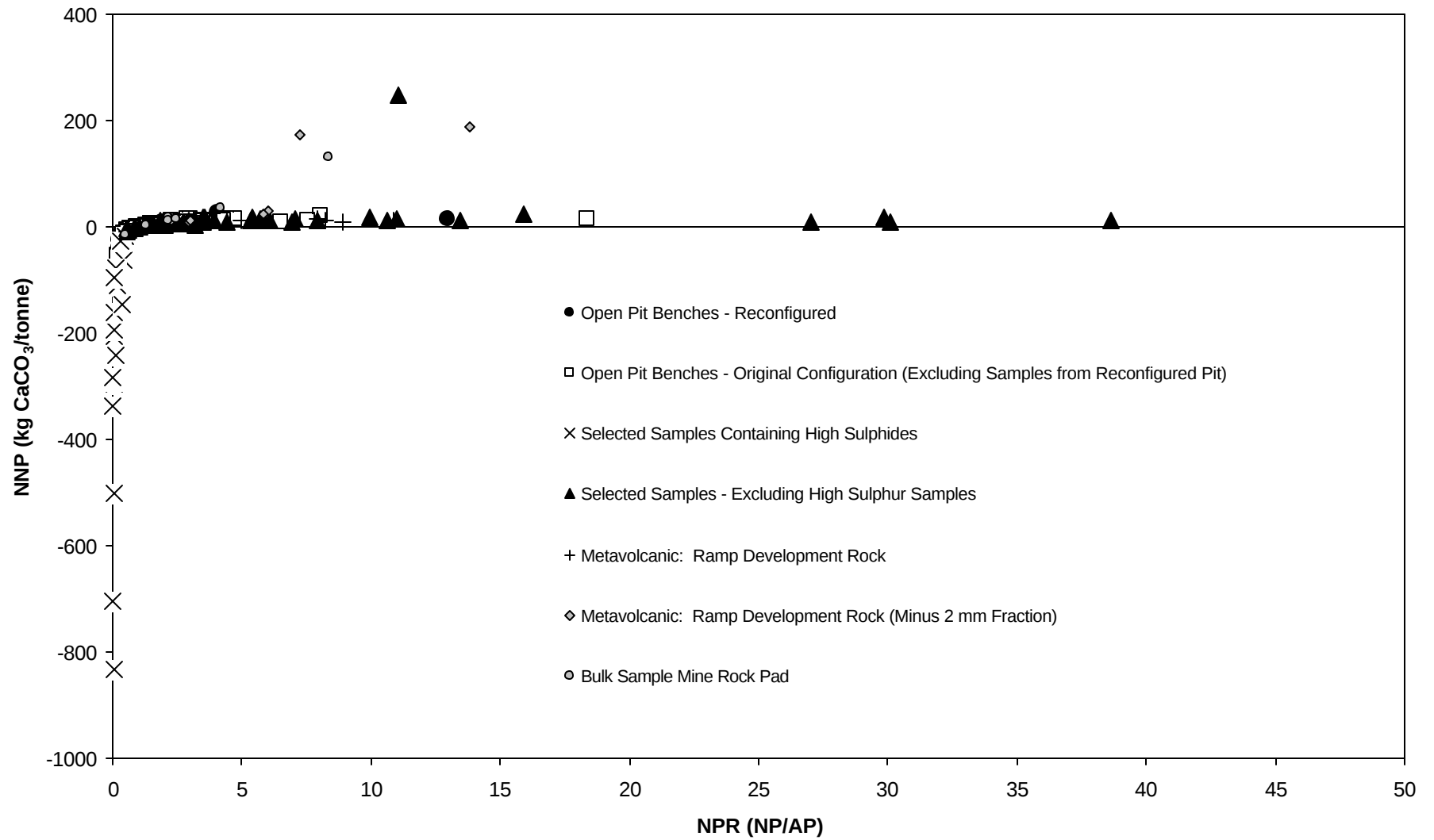


Figure III.2-34
Paste pH vs. Total Sulphur - Metavolcanics

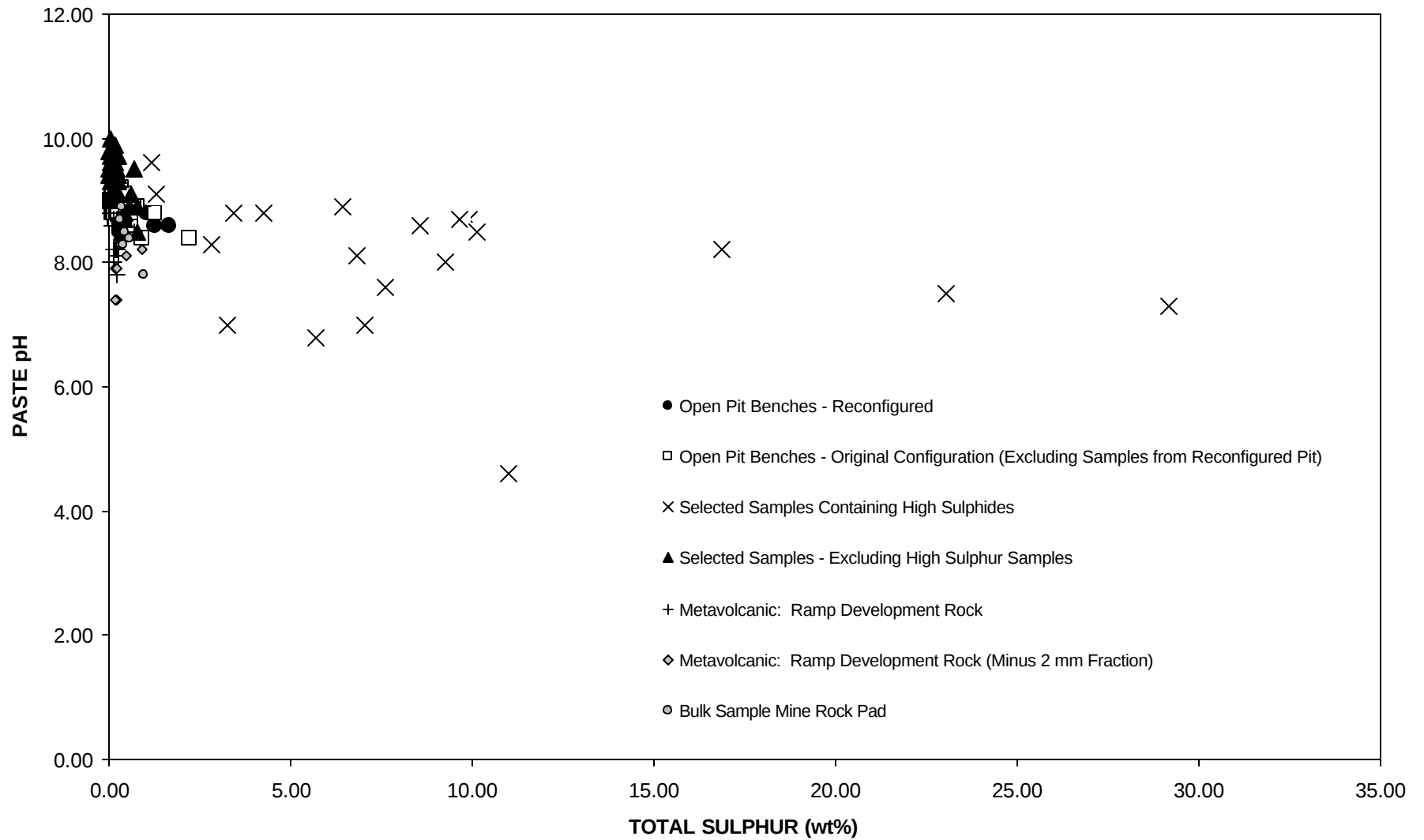


Figure III.2-35
Kinetic Testing Results for Metavolcanics - Standard Input Solution
pH

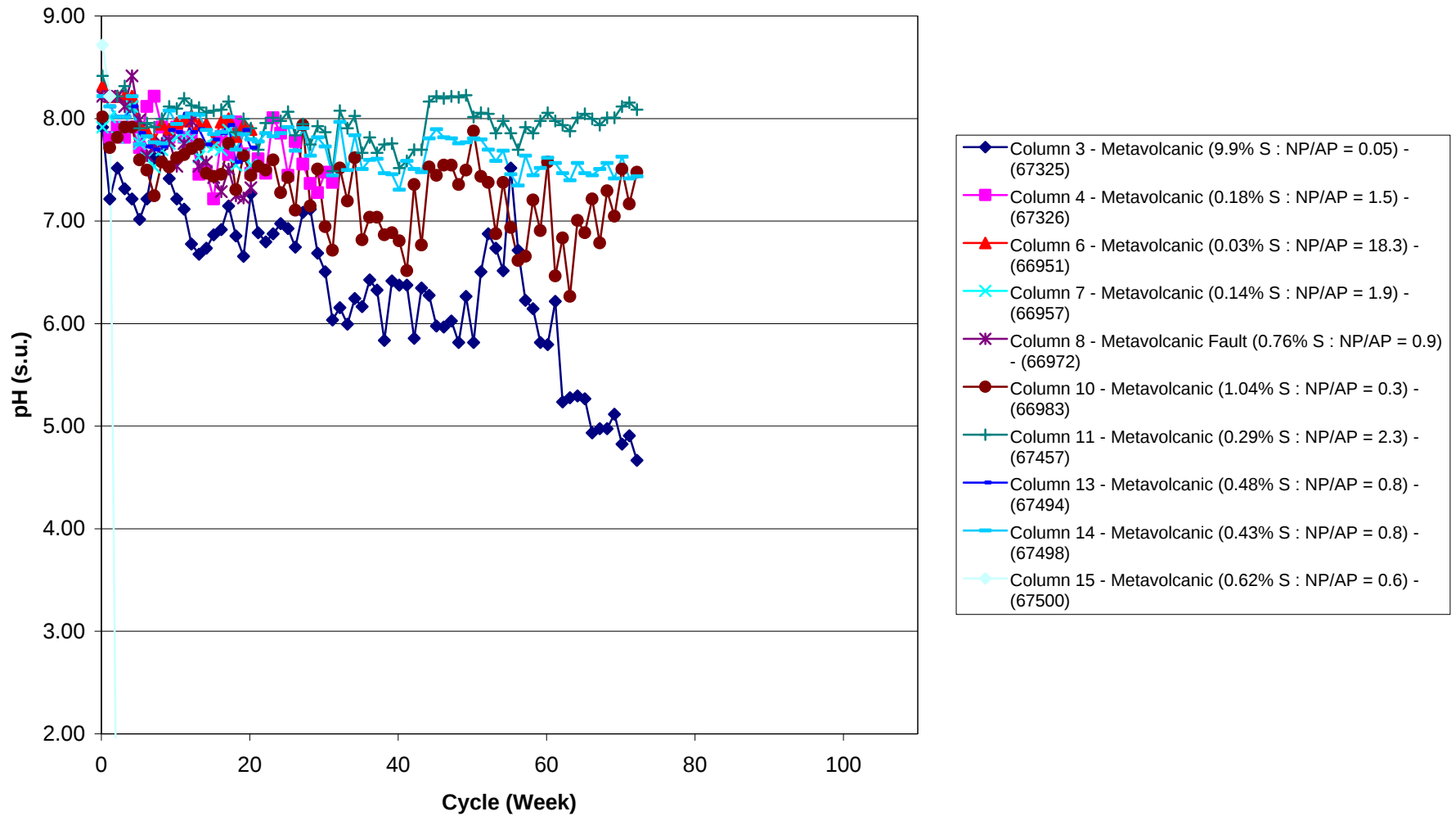


Figure III.2-36
Kinetic Testing Results Metavolcanics - Standard Input Solution
Aluminum

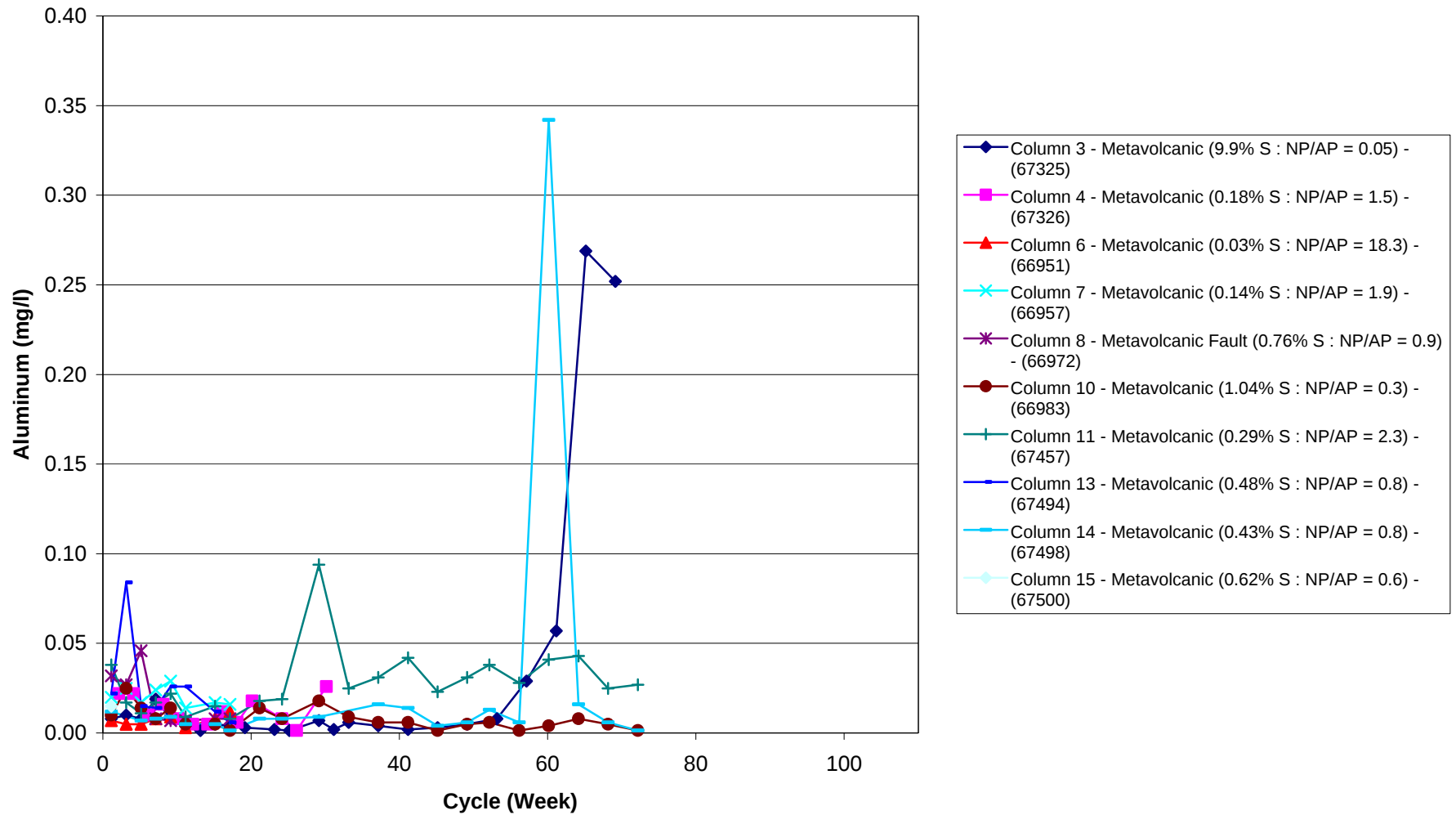


Figure III.2-37
Kinetic Testing Results Metavolcanics - Standard Input Solution
Nickel

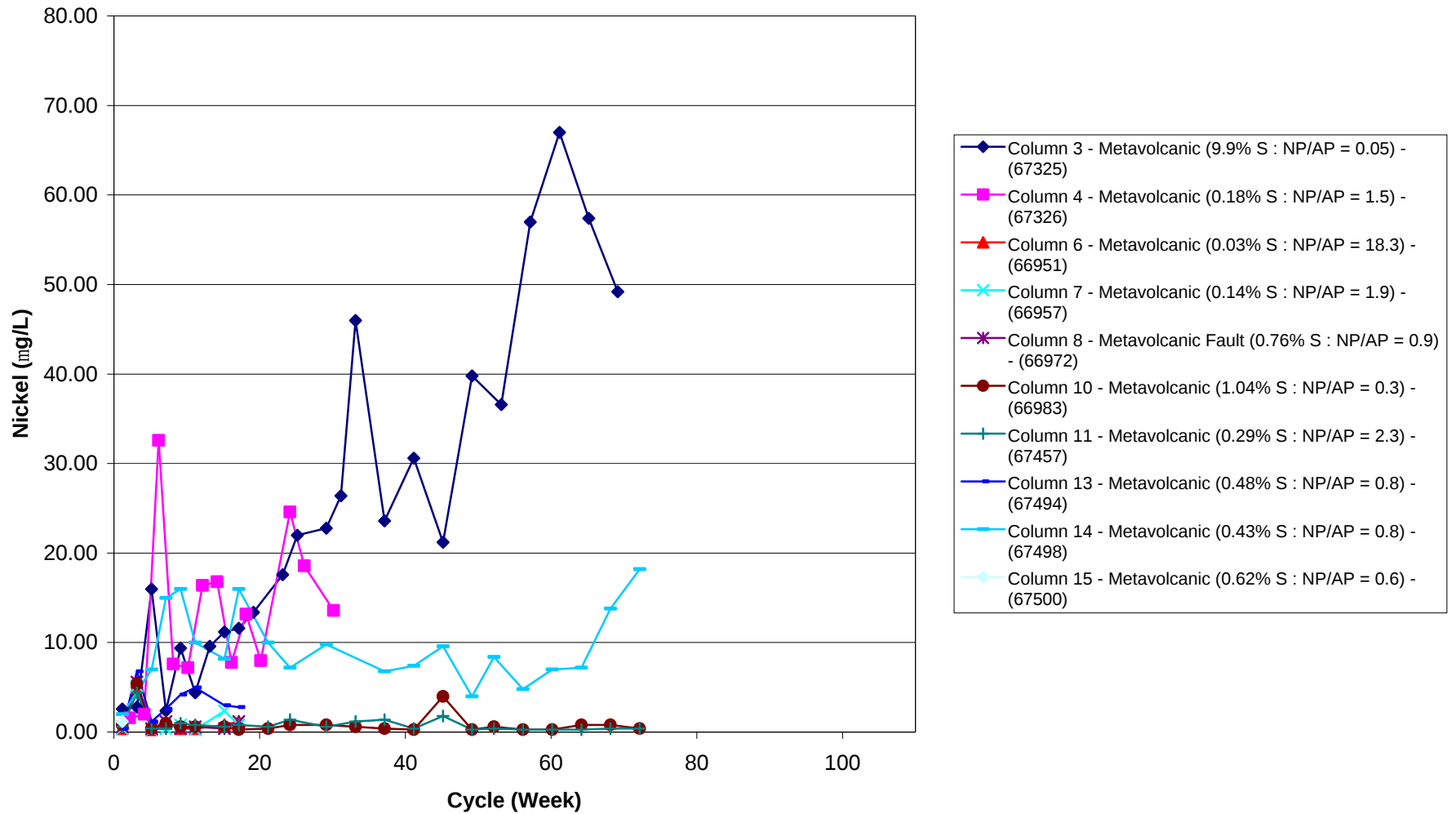


Figure III.2-38
Kinetic Testing Results Metavolcanics - Variable Input Solution
pH

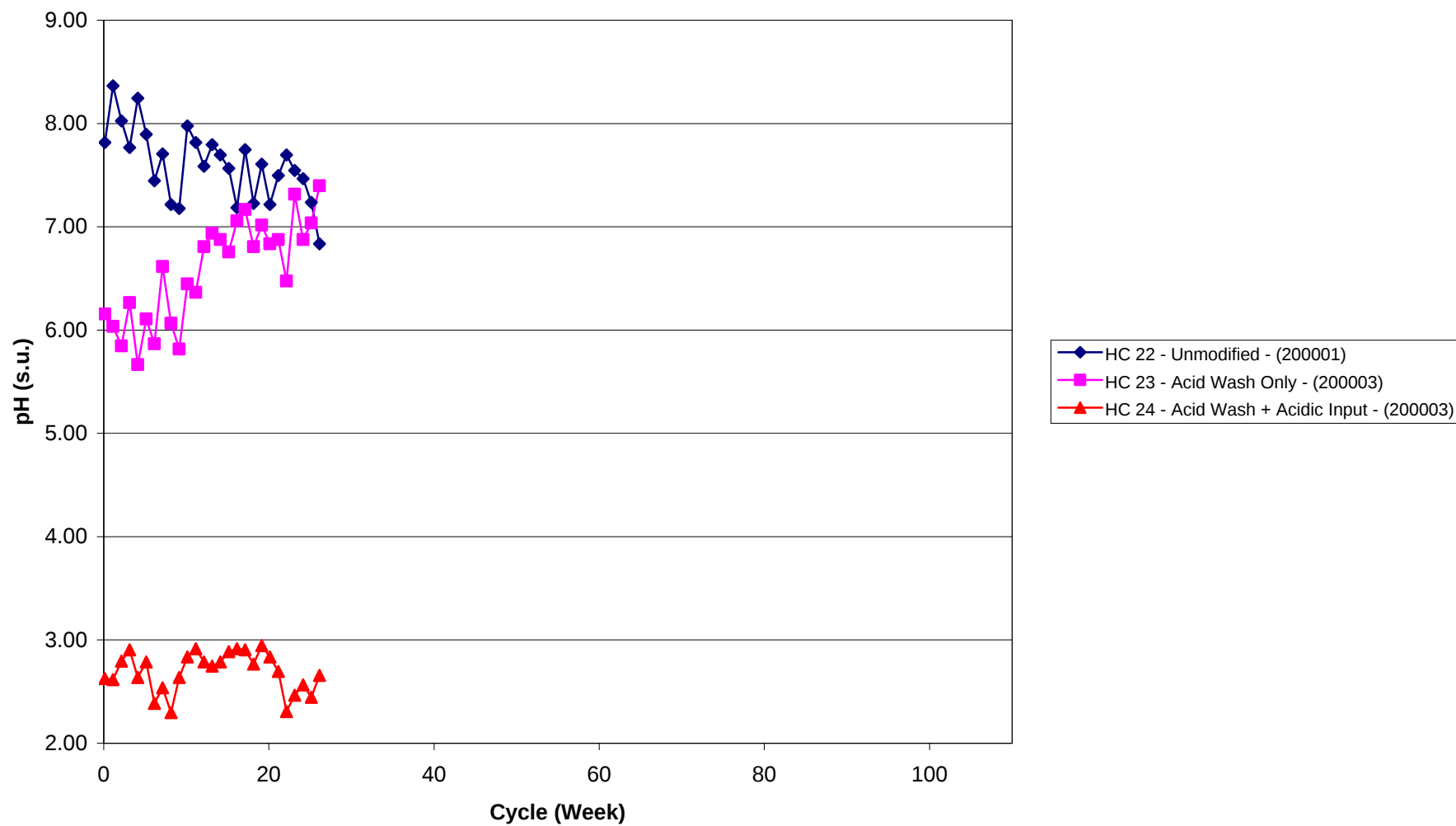


Figure III.2-39
Kinetic Testing Results Metavolcanics - Variable Input Solution
Aluminum

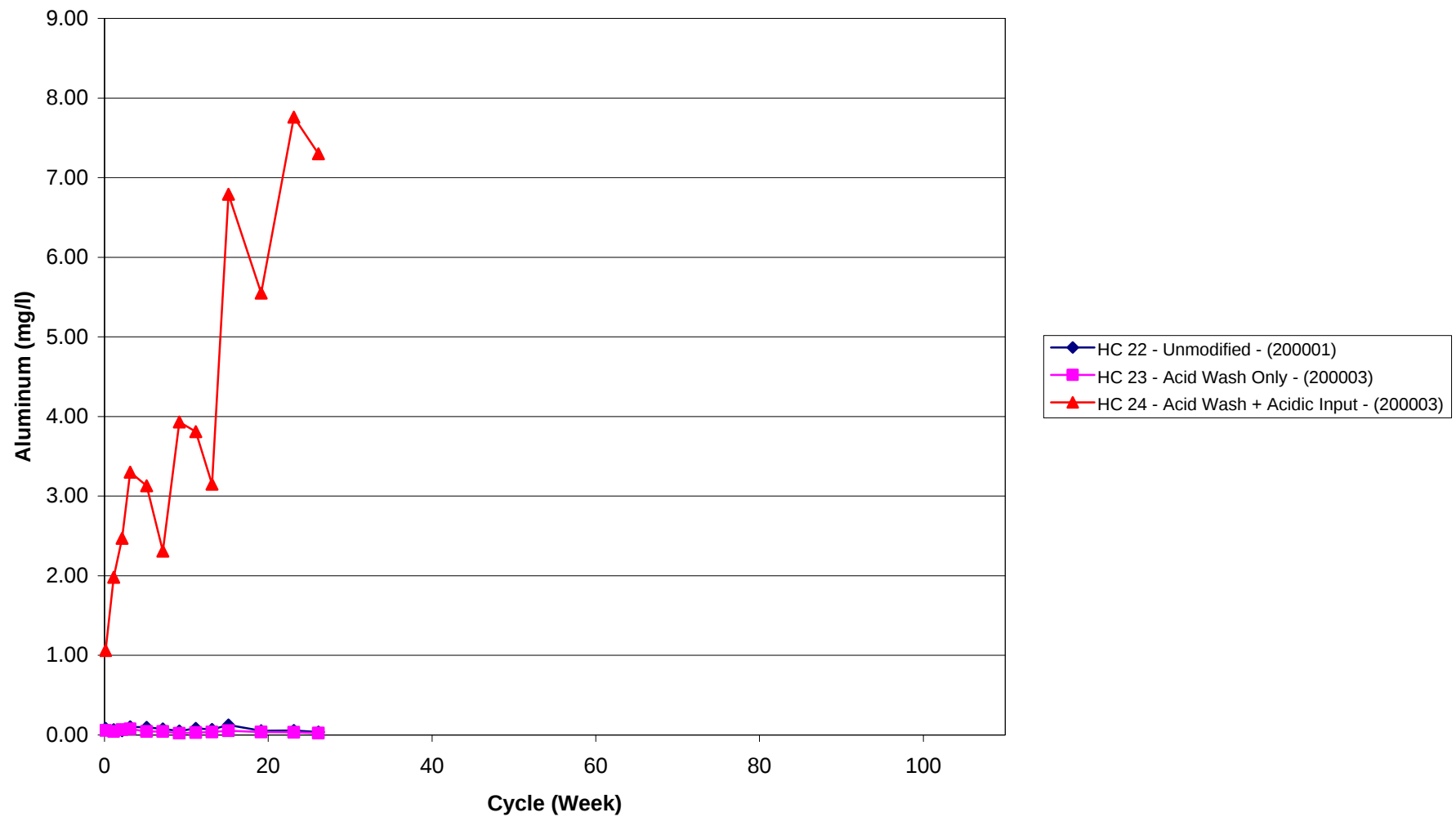


Figure III.2-40
Kinetic Testing Results Metavolcanics - Variable Input Solution
Nickel

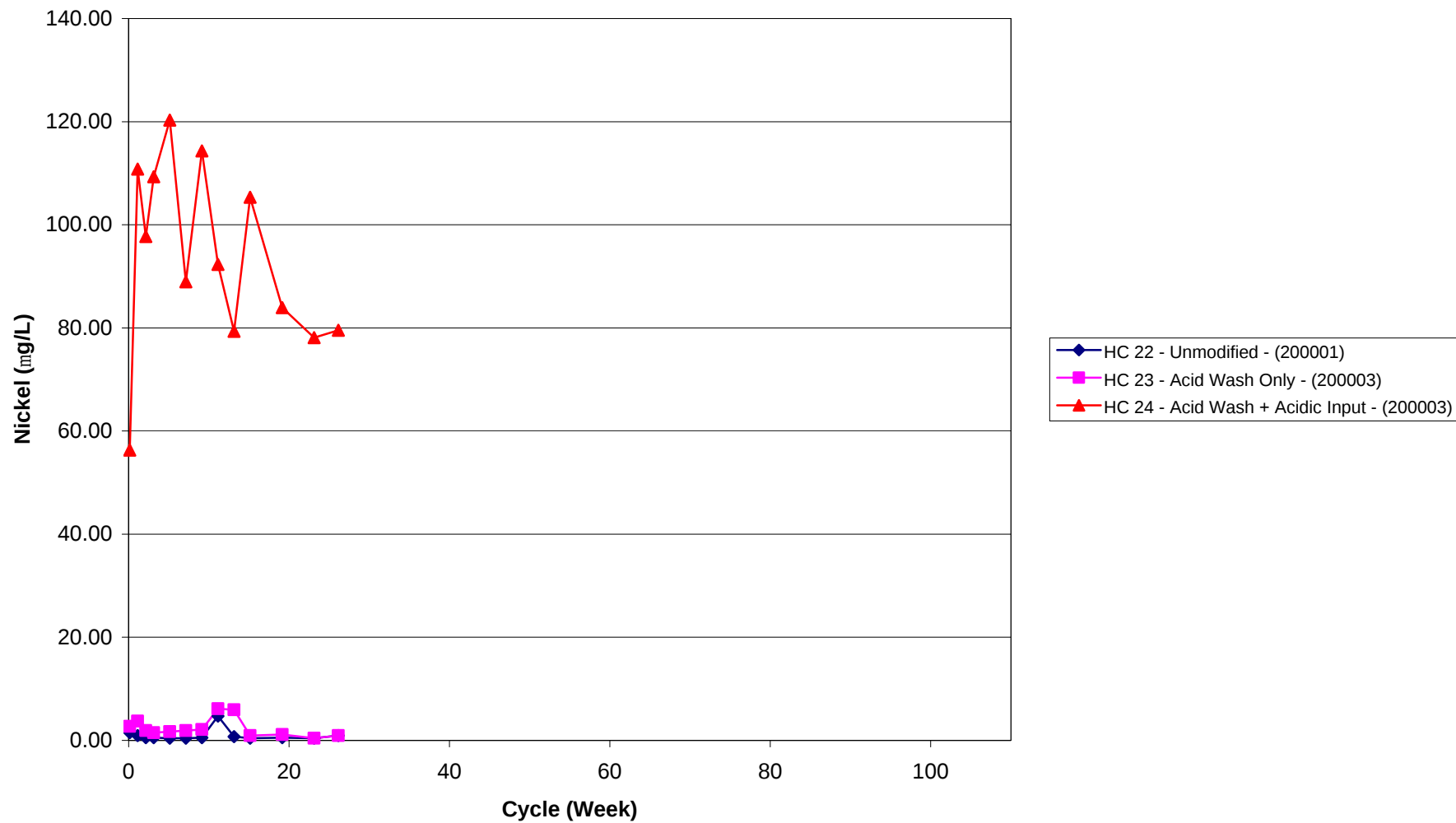
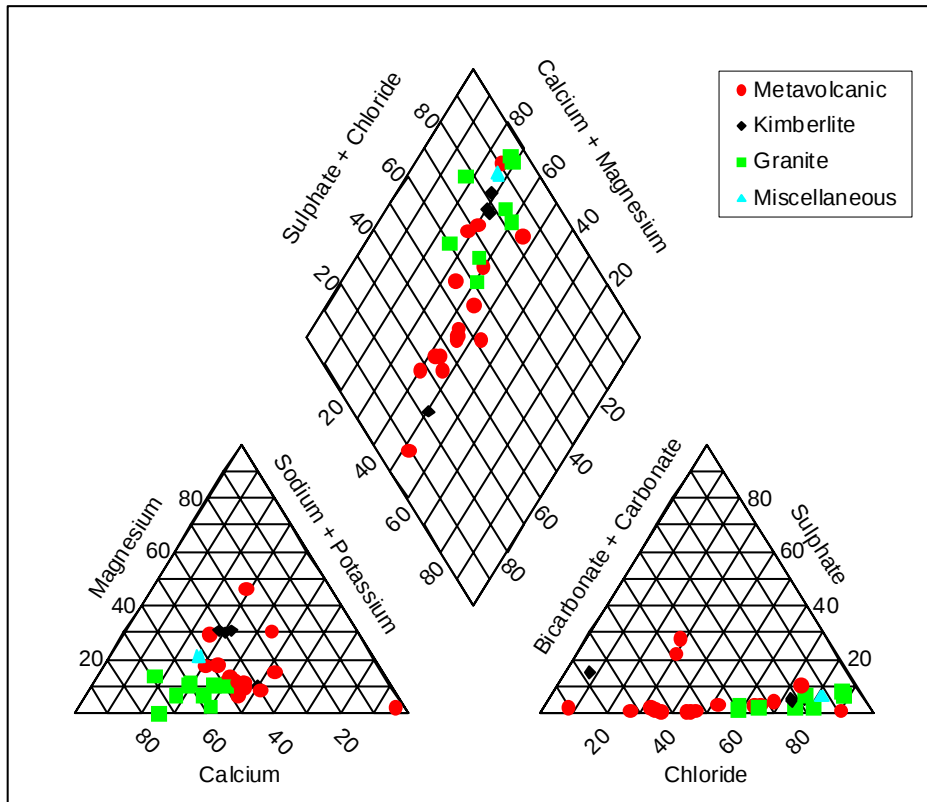


Figure III.2-41
Piper Plot Showing Major Ion Trends in Baseline Groundwater Quality Data



SO_4 : Sulphate
 Cl : Chloride
 HCO_3 Bicarbonate
 CO_3 : Carbonate
 Mg : Magnesium
 Ca : Calcium
 Na : Sodium
 K : Potassium

Figure III.2-42
Selected North Drift Floor Water Quality - Dissolved Parameters

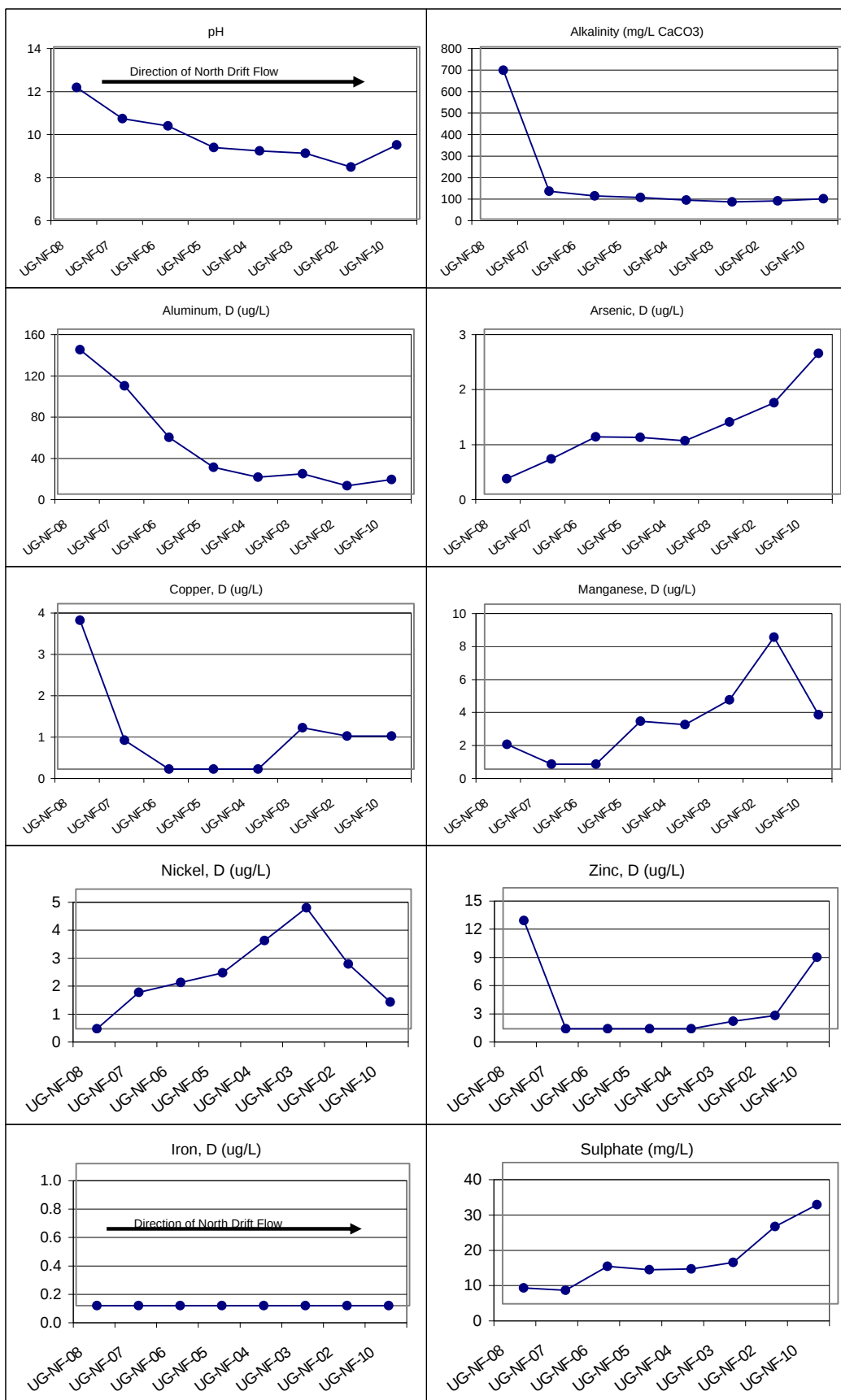


Figure III.2-42
Selected North Drift Floor Water Quality - Dissolved Parameters

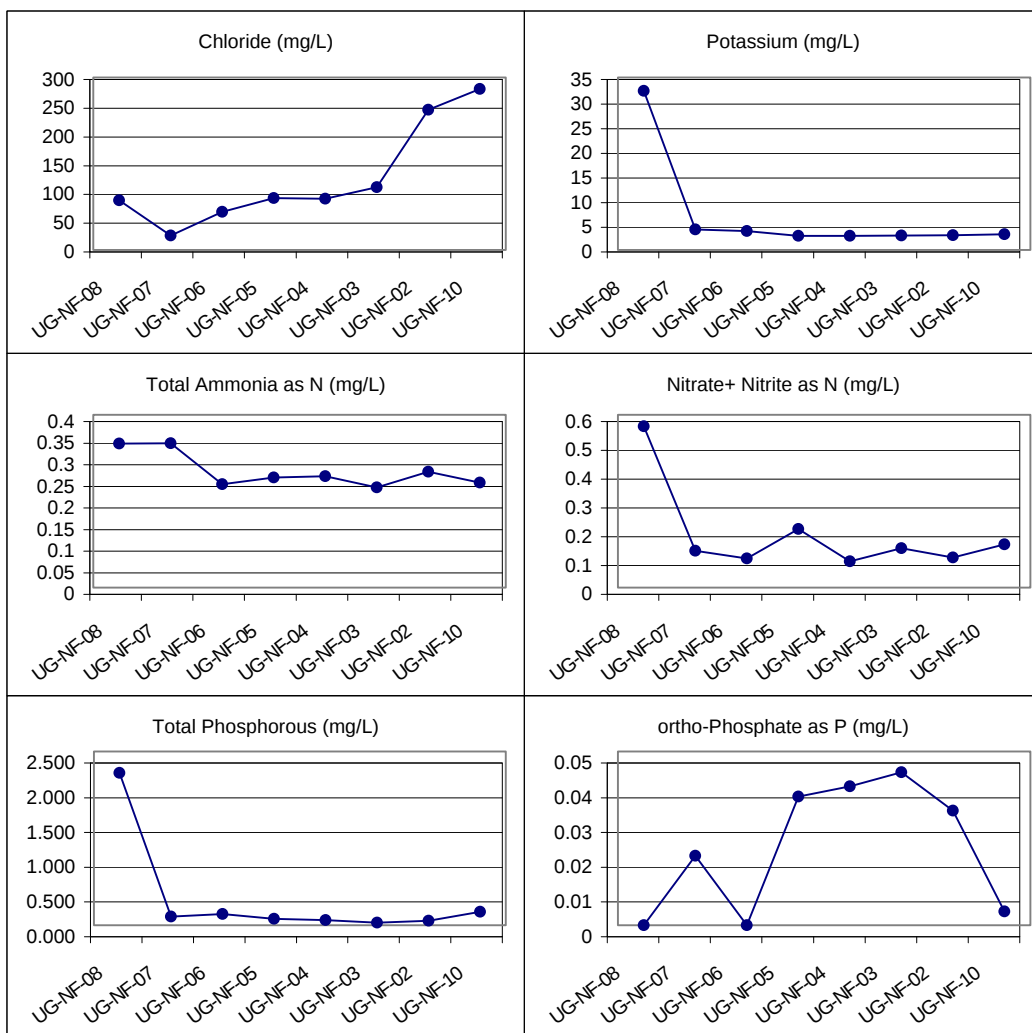
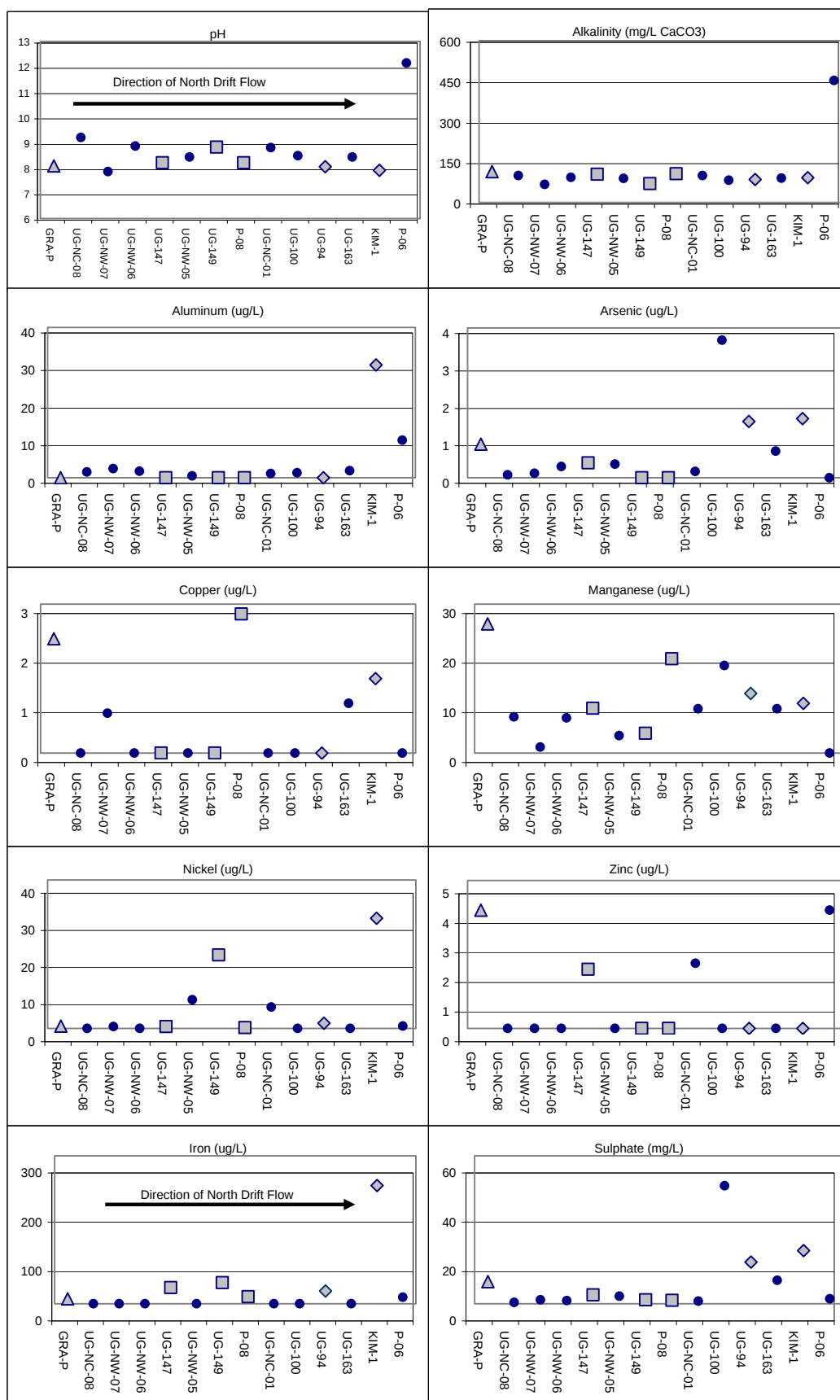
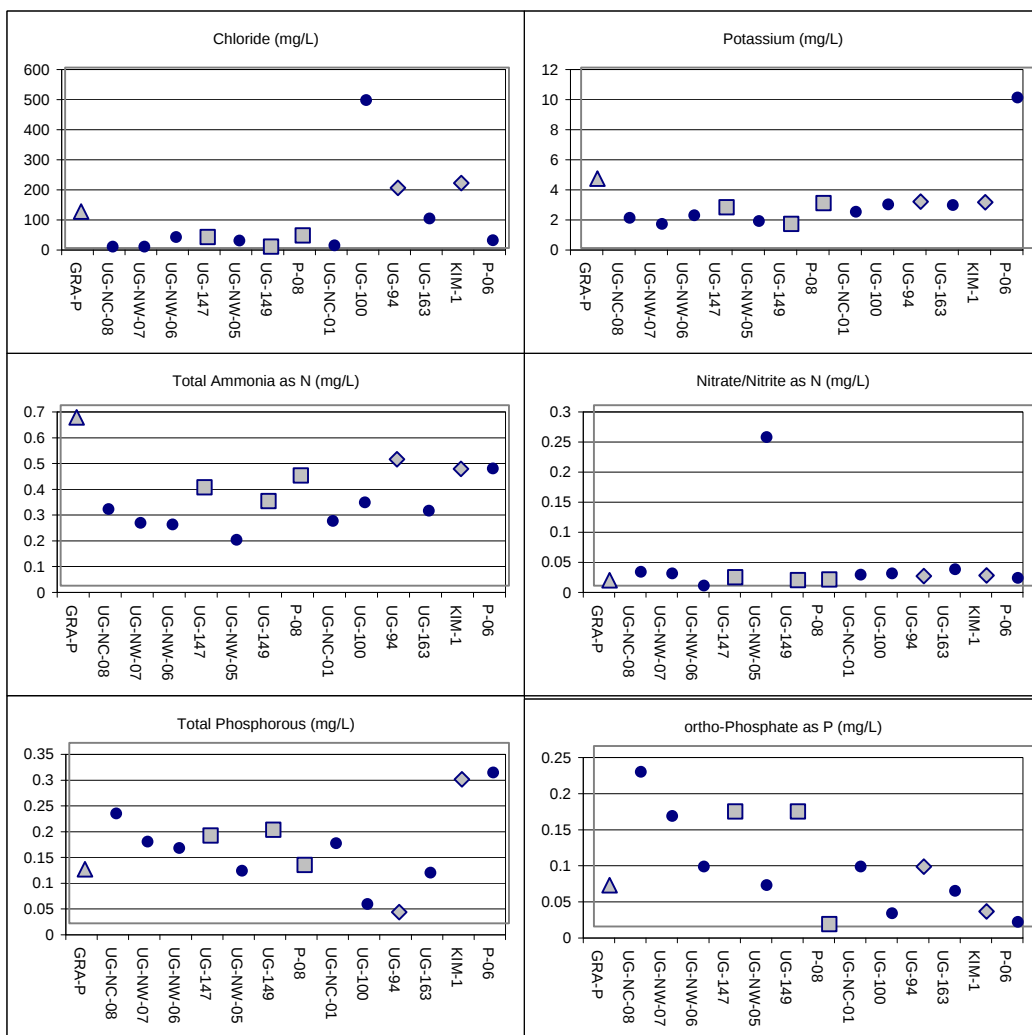


Figure III.2-43
Selected North Drift Mine Inflow Water Quality - Dissolved Parameters



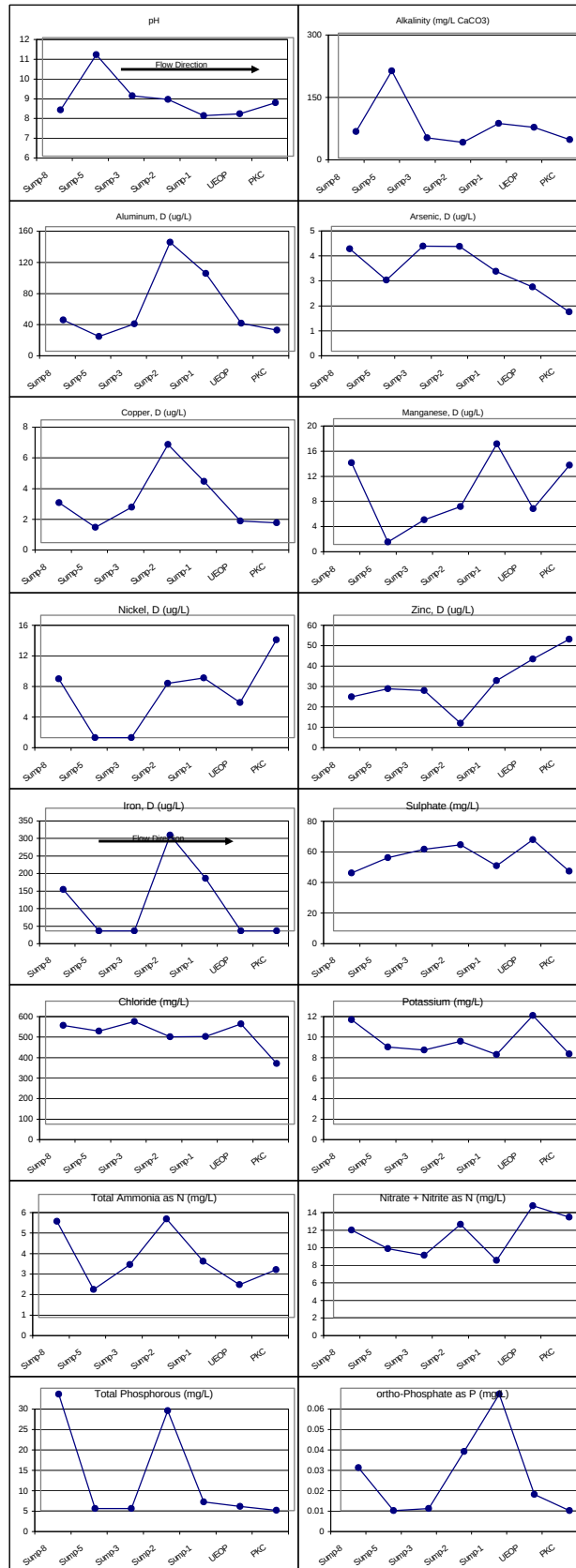
Note: diamond - kimberlite; square - metavolcanic; triangle - granite; circle - miscellaneous northdrift location

Figure III.2-43
Selected North Drift Mine Inflow Water Quality - Dissolved Parameters



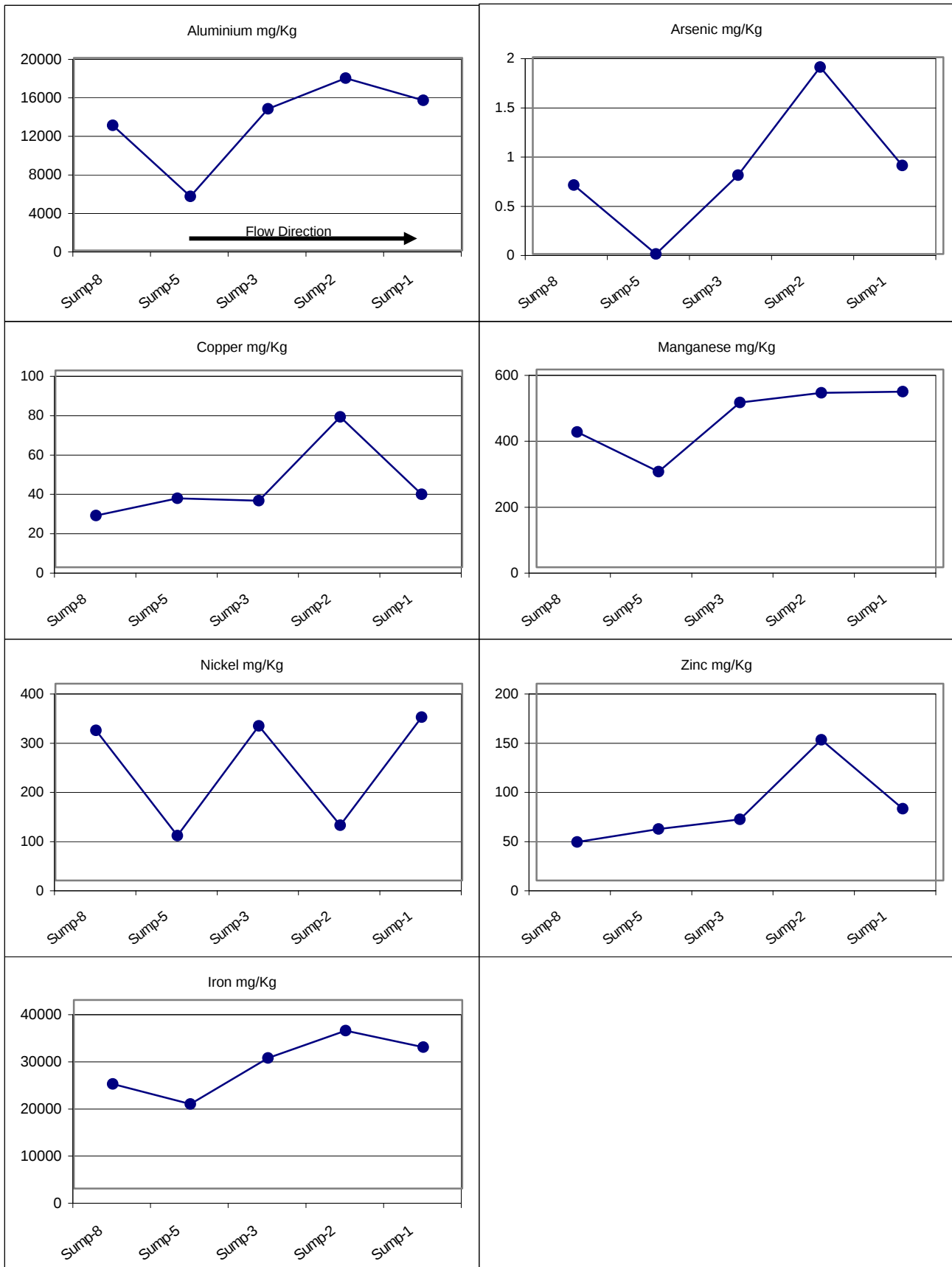
Note: diamond - kimberlite; square - metavolcanic; triangle - granite; circle - miscellaneous northdrift location

Figure III.2-44
Selected Sump Water Quality - Dissolved Parameters



Note: UEOP = discharge from the mine to the processed kimberlite containment area; PKC = processed kimberlite containment area.

Figure III.2-45
Selected Sump Solids Quality



APPENDICES
AVAILABLE UPON REQUEST

Appendix A	Mills (1999) Geochemistry Report on Bulk Sample Pits
Appendix B	Sample Locations and Characteristics
Appendix C	Acid Base Accounting Results
Appendix D	Whole Rock Chemical Analysis Results
Appendix E	Mineralogy Reports
Appendix F	SWEP Testing Results Kimberlite, Granite, and Metavolcanics
Appendix G	Sequential Extraction Results
Appendix H	Kinetic Testing Results Kimberlite – Standard Input Solution
Appendix I	Kinetic Testing Results Kimberlite – Variable Input Solution
Appendix J	Kinetic Testing Results Layered Kimberlite/Metavolcanic
Appendix K	Process Water Quality
Appendix L	Kinetic Testing Results Granite – Standard Input Solution
Appendix M	Kinetic Testing Results Granite – Variable Input Solution
Appendix N	Kinetic Testing Results Metavolcanics – Standard Input Solution
Appendix O	Kinetic Testing Results Metavolcanics – Variable Input Solution
Appendix P	SWEP Testing Results Cement, Grout, and Concrete
Appendix Q	Groundwater Quality
Appendix R	North Drift Mine Water Quality
Appendix S	Surface Water Quality
Appendix T	QA/QC Samples