APPENDIX 8.II

METAL LEACHING AND ACID/ALKALINE ROCK DRAINAGE

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8.II.1 INTRODUCTION

When minerals that naturally occur in ore and mine rock are disturbed by mining processes, exposure to the atmosphere (i.e., oxygen and water) can enhance natural rates of chemical weathering, which could result in the release of acidity, sulphate and trace metals to water that comes in contact with the disturbed materials.

The metal leaching (ML) and acid / alkaline rock drainage (A/ARD) potential of kimberlite, processed kimberlite (PK) and mine rock from the Gahcho Kué Project (Project) is based on the conclusions of the ongoing geochemical characterization program. The geochemical characterization program was initiated in 1996 in support of ongoing environmental baseline studies at the Project. The work has been completed in several stages, including Canamara (1996); Golder (2002); and AMEC (2008). This section of the environmental impact statement (EIS) report provides an update to the 2008 ML and A/ARD report (AMEC 2008), including the final results of kimberlite and mine rock kinetic tests discussed in AMEC (2008), and results from supplemental geochemical characterization initiated in 2010. The AMEC (2008) report has been updated where additional information has become available since 2008. The principal conclusions provided relate to the Project Description (Section 3 of the EIS) available as of August 2010.

The results of geochemical characterization of kimberlite, PK and mine rock were used to develop representative water quality inputs for water expected to come into contact with various site facilities. A summary of the water quality inputs that were assumed for use in the site water quality predictions is provided herein. Water quality predictions prepared in support of the Project Description (Section 3 of the EIS) available as of August 2010 are addressed in Golder 2010.

8.II.1.1 OBJECTIVES

The objective of this appendix to the EIS is to present and evaluate the results of the geochemical characterization programs in the context of potential environmental impacts and mitigation alternatives for the Project, according to the Project Description available at the date of preparation of this report. Specific objectives of the metal leaching and acid/alkaline rock drainage assessment program for the Project are as follows:

- Development of a geochemical dataset to address the geochemical implications of kimberlite, PK and mine rock management at the Project at a level consistent with that required for ongoing feasibility level engineering studies, and the EIS and subsequent water licensing and site licensing;

- Evaluation of the ML and A/ARD potential of kimberlite, PK and mine rock that will be produced during mining at the Project;
- Development of appropriate environmental management strategies/options, material handling strategies/options or mitigation measures (if required);
- Preparation of the ML A/ARD report (AMEC 2008) and subsequent revisions (this report) for submission with the overall EIS.

8.II.1.2 PROGRAM DEVELOPMENT

A comprehensive, defensible geochemical characterization program evolves dynamically in response to changes in the Project Description and advances in technical understanding. The focus of a typical geochemical characterization program is to develop a geochemical dataset that is spatially and compositionally representative of the materials that will be produced during the life-of-mine (Price 1997).

Preliminary geochemical characterization of kimberlite and mine rock took place in 1996 (Canamara 1996) and 2002 (Golder 2002). Prior to 2004, the geochemical dataset for the Project included 13 mine rock and 10 kimberlite samples. The objective of the sample programs presented in Canamara (1996); and Golder (2002) was to provide a screening level overview of the geochemical characteristics of kimberlite and mine rock. The programs were not intended to provide information required for the EIS.

The most detailed and recent geochemical assessment was initiated in 2004 and continued through 2008 (AMEC 2008), including the collection of total of 489 kimberlite, 40 PK and 1,274 mine rock samples. Sample selection and collection, and sample analysis were performed under the guidance of AMEC (2008). This report includes results from the AMEC (2008) program.

Additional geochemical testing of PK was initiated in 2010 to address changes to the Project Description that could affect the ML and A/ARD potential of PK.

The results of geochemical characterization presented in Canamara (1996); Golder (2002); AMEC (2008); and ongoing geochemical testing of PK (this report) were used to develop the geochemistry dataset for the Project. The geochemistry dataset was then evaluated in the context of the following factors:

- the mine geology and environment;
- the mine plan, tonnage, and disposal options for the various materials according to the Project Description as of August 2010 (Table 8.II-1);
- the requirement for selection of a sufficient number of adequate and representative samples (spatially and compositionally) according to the sample frequency recommended by MEND (2009); and Price (1997) (Table 8.II-2);
- the requirement for selection of proper laboratory testing procedures based on the proposed configuration of the Project and amenable to comparisons with similar sites in the North; and
- regulatory requirements and expectations.

Table 8.II-1 Summary of Mine Waste Tonnages and Management

Waste Stream	Quantities	Waste Management	Minimum Number of Samples (Price 1997)
Lake bed sediment & overburden	7.3 Mt	- Pond dyking and grading	80
		- Stockpiled for site reclamation	
Kimberlite	31.2 Mt	- Majority to process	>80
		- Barren included with mine Rock	
Mine rock	226.4 Mt	- West and south mine rock piles	>1000[a]
		- 5034 Pit (following completion of mining in pit)	
		- Site and dam construction	
		- Cover material for coarse and fine PK storage facilities.	
Fine PK	7.83 Mt	- Fine PKC Facility	Tailings are homogenized products, therefore at least one representative sample of each type of tailings is analyzed.
		- Hearne pit (following completion of mining in pit)	
Coarse PK	23.49 Mt	- Coarse PK Pile	
		- Possible deposition in mined out Hearne Pit	

[a] As noted by Price, 1997, larger pits "may lead to more than 1,000 ABA samples".

Mt = million tonnes.

Table 8.II-2 Suggested Initial Sampling Frequency Based on Tonnage when Sampling without Prior Information (adapted from Price 1997)

Tonnage of Unit (metric tonnes)	Minimum Number of Samples
<10,000	3
<100,000	8
<1,000,000	26
<10,000,000	80

8.II.2 BACKGROUND

The Project is a proposed diamond mine located at Kennady Lake, which is north of the north-eastern arm of Great Slave Lake. The site is about 280 kilometres (km) northeast of Yellowknife, Northwest Territories (NWT). The diamond-bearing kimberlite deposits located beneath Kennady Lake will be mined using open-pit mining methods, after sub-areas of Kennady Lake above the ore deposits have been dewatered.

With respect to the geochemical evaluation presented in this report, key components of the Project include:

- mine plan (i.e., sequence and rate of mining) and ore processing;
- waste management and location of the various mine facilities, including general site infrastructure, mine rock piles and PK containment facilities and
- Site geology.

8.II.2.1 MINING, PROCESSING AND WASTE MANAGEMENT

8.II.2.1.1 Mining

Approximately 30 million tonnes (Mt) of diamondiferous kimberlite will be mined from three ore bodies (5034, Hearne and Tuzo) using open pit mining methods. Mining will take place over a period of 11 years, preceded by a two to three year construction period. The ore bodies are located under the southern portion of Kennady Lake, which will be partially dewatered prior to the start of mining.

Key activities that will take place during the construction period include lake dewatering, construction of dykes and coffer dams and grading and construction of the plant site, site roads and core infrastructure. Mining will begin in the latter years of the construction phase. During the 11 year mine-life, open pit mining will be sequenced so that the 5034 pit will be mined first, followed by the Hearne and Tuzo ore bodies, respectively.

8.II.2.1.2 Processing

Run-of-mine kimberlite will be stored in temporary stockpiles prior to processing. Ore from the run-of-mine stockpile will be screened and crushed to separate particles according to size. The crushing circuit will include a primary, secondary and high pressure roller crusher (HPRC) stage. Ore will be sequentially crushed to achieve a particle size ranging between 1.0 and 28 millimetres (mm). Crushed ore will then be screened and washed to clean large particles, and remove very fine particles from the circuit.

The cleaned, crushed ore will then proceed to a dense-medium separation (DMS) circuit, where ferrosilicon and water will be added to the crushed ore to promote separate and concentration of diamonds. The ore/ferrosilicon mixture will be cycloned to separate heavier (potentially diamond-bearing) particles and ferrosilicon from lighter particles. The heavier fraction will be sent to the diamond recovery plant. Most of the ferrosilicon will be recovered from the heavier fraction and re-used in the process, with a small fraction reporting to the coarse processed kimberlite (Coarse PK) waste stream. The light particles with a size greater than 6 mm will be sent to a crusher. Light particles from the cyclone smaller than 1.0 mm will pass to the degrit circuit, where cyclones will separate the fines (defined by a grain size less than 0.25 mm) from the grits (defined by a grain size between 0.25 mm and 1.0 mm). The fine fraction less than 0.25 mm in diameter will be thickened with the addition of flocculent to form the Fine Processed Kimberlite (Fine PK) waste stream. Grits will be combined rejects, barren kimberlite from the DMS circuit (i.e., rock less than 6 mm in size) to form the “Coarse PK” waste stream.

8.II.2.1.3 Waste Management

Open pit mining is expected to result in the production of several mine waste streams:

- Lake bed sediment and overburden;
- Mine Rock (also referred to as “country rock”);
- Barren (non-diamondiferous) kimberlite rock;
- Fine PK and associated Process Water; and

- Coarse PK.

Table 8.II-1 provides a summary of the proposed waste management strategy for the Project site.

Lake-bottom sediment and till overlying the kimberlite ore bodies will be removed prior to mining. Lake-bottom sediment and till will be used for construction at the project site. Overburden will be used for constructing intermediate dykes and dams in Kennady Lake. Excess overburden not required for construction will be deposited in designated areas in the mine rock piles.

Mine rock constitutes the greatest mass of mine waste material at the Project. Non-acid generating (non-AG) mine rock will be used to construct site facilities and filter dykes. During operations, non-AG mine rock not required for use in construction will be stored in South and West mine rock storage facilities, located within and adjacent to Areas 6 and 5, respectively. Non-AG mine rock will be stored in the mined out 5034 pit once this facility becomes available. After the 5034 pit is full, mine rock will continue to be placed in the West mine rock pile. The mine rock piles will be progressively reclaimed; closure of the mine rock piles will include contouring and regarding.

All kimberlite waste streams will be contained within the disturbed Kennady Lake footprint. During the first two years of operation, fine PK will be stored Area 1 of Kennady Lake, adjacent to the northeast margin of the lake. During the next five years of operation, fine PK will be deposited in the Area 2 facility. Areas 1 and 2 will collectively be called the Fine PKC Facility. Coarse PK and mine rock will be used to progressively reclaim the Fine PKC Facility, with a one meter layer of coarse PK and an overlying one meter layer of non-AG rock. The Fine PKC Facility is anticipated to be complete by year 8 of operations, at which point, fine PK deposition will transition to the Hearne Pit. The Hearne pit is the preferred location for fine PK deposition, given the close proximity of 5034 to the Tuzo pit operations. In the latter years of the mine life, fine PK will also be discharged to portions of Areas 6 and 7. Progressive reclamation with coarse PK and mine rock will continue on an ongoing basis.

Coarse PK will be placed on land in a pile adjacent to Area 4. At closure, the coarse PK pile will be shaped and covered with a layer of mine rock of a minimum of 1 m to limit surface erosion. In later years, the coarse PK will be used for reclamation of the fine PKC facility, and may also be deposited in the mined out pits.

At closure, Kennady Lake will be allowed to recharge to its natural lake elevation, effectively flooding all of the materials (i.e., mine rock and fine PK) stored in the mined out open pits. It is expected that all surface mine waste storage facilities will freeze, minimizing the amount of seepage reporting to Kennady Lake.

8.II.2.2 SITE GEOLOGY

The three ore bodies at the Project comprise kimberlite pipes of varying grade of diamondiferous ore juxtaposed with each other and the mine rock. Some mine rock is interspersed within the ore bodies and consists of mainly granite, with lesser granodiorite, diabase and diorite.

The 5034 kimberlite is located underneath Kennady Lake and is an irregularly shaped body (Jacques Whitford 2000). Hypabyssal kimberlite is the major kimberlite unit within this pipe. Sulphides are present as stringers or fracture infillings in the 5034 kimberlite near the contact between the kimberlite and granodiorite mine rock. The mine rock around the kimberlite body is typically fresh to slightly altered granite and granodiorite (Canamera 1996; Jacques Whitford 2000).

The Hearne kimberlite is located underneath Kennady Lake and is a complex, irregularly shaped kimberlite pipe that trends in a north-south direction with approximate surface dimensions of 250 by 50 metres (m) (Jacques Whitford 2000). Both diatreme and hypabyssal kimberlite make up the Hearne pipe with granite, and altered granite composing the surrounding mine rock (Jacques Whitford 2000).

The Tuzo kimberlite has a near circular plan outline covering a surface area of about 14,000 square metres (m^2). The body is characterized by smooth, steep-sided pipe walls and is dominantly infilled with tuffisitic kimberlite breccia. The mine rock is dominated by granite with lesser amounts of diabase.

The following sections provide a brief description of the main lithological units that will be encountered during mining.

8.II.2.2.1 Kimberlite

As a group, the kimberlite samples include the different facies recognized at the Project; hypabyssal kimberlite, transitional hypabyssal kimberlite, tuffisitic kimberlite, and tuffisitic kimberlite breccia. According to AMEC (2008), geological descriptions in drill core logs make no reference to kimberlite facies for the majority of samples collected for geochemical characterization. Therefore, for the simplicity of text in AMEC (2008) and this report, the subset of kimberlite samples with no facies identified will be referred to as kimberlite (undifferentiated) and the term "kimberlite" will refer to all samples regardless of facies.

Kimberlite samples represent raw ore prior to processing. Kimberlite samples from the interior of the pipes are generally free of sulphides and calcite is present in the kimberlite as fracture fillings (AMEC 2008).

8.II.2.2.2 Mine Rock

Mine rock units recognized at the project include granite, gneissic granite, altered granite, granodiorite, altered granodiorite, diabase, and diorite. According to AMEC (2008), granite is by far the most common mine rock and will make up greater than 95 percent (%) of the mine rock during mining. The balance of the mine rock is comprised of granodiorite with minor volumes of diorite and diabase.

Fine-grained disseminated and fracture-fill pyrite is visible in portions of the granodiorite (Jacques Whitford 2000) and no carbonates were observed in the granodiorite (Canamera 1996).

8.II.3 METHODS

8.II.3.1 SAMPLE COLLECTION

This section provides a general overview of the sample collection programs undertaken in support of geochemical characterization of kimberlite, mine rock and PK. The Project geochemical database presented in this report includes 1,804 samples of exploration drill core and PK collected during several geochemical test programs, including Canamara (1996); Golder (2002); AMEC (2008) and supplemental testing conducted in support of changes to the project description.

No details are available regarding the collection of the Canamera (1996) sample collection program. The Canamara (1996) program was limited in scope, and included the collection of 10 samples for geochemical testing.

For the preliminary geochemical test program outlined in Golder (2002), ten (10) samples were collected by a geochemist to provide an initial screening level understanding of the geochemical conditions that might be present in the deposit.

The Golder (2002) program was not intended to provide EIS related data, and samples were selected to represent specific aspects of the material, as such these data do not represent the overall project materials.

An expanded testing plan was implemented for kimberlite and the surrounding rock (primarily granite) in 2004. The objective of the expanded geochemical program presented in AMEC (2008) was to choose representative samples of all the different types of materials that will be excavated or exposed at the Project site. Sample collection was based on the proposed outline of the open pits (exploration drill core samples of mine rock and kimberlite) and the proposed metallurgical process at the time of sampling (PK). In 2004 an expanded testing plan was implemented for kimberlite and mine rock. The objective of this geochemical program was to choose representative samples of all the different types of materials that will be excavated or exposed at the Project site. Sample collection began during the 2004 winter drilling program and continued through July 2008. In 2004 discrete samples were collected every 6 m of drilled core length. Sampling in subsequent years was changed to discrete samples every 6 m for mine rock and 12 m for kimberlite. Locations of each of the drill holes used for collecting geochemical samples are shown in Attachment 8.II.1.

The AMEC (2008) dataset, which represent the majority of the geochemical sample dataset, appears reasonable and consistent with current guidelines. The information in the AMEC (2008) dataset include the results of geochemical tests that are commonly used for the purpose of ARD and ML assessment, which are consistent with the current guidelines. This data can be relied on for the current assessment.

Samples of PK in the AMEC (2008) dataset, and subsequent testing conducted in 2010 (this report) comprise material that was produced during metallurgical test work. PK samples are considered to be more representative of the waste material to be managed on-site than the raw kimberlite samples due to the homogenization which occurs during processing.

The additional PK testing initiated in 2010 includes a total of 21 samples of PK provided by De Beers for geochemical testing. Nine PK samples (separated into coarse and fine fractions, respectively) were provided for analysis, for a total of 9 individual PK fines and 9 PK coarse samples. These nine samples were combined to make three composite samples: one coarse PK composite, and two PK fines composites. In total, 21 samples of PK were submitted for static geochemical testing in 2010, including acid base accounting (ABA), metal analysis, and short-term leach testing. Of the three composite samples, the coarse PK composite and one of the PK fine composites were submitted for humidity cell testing and submerged column tests.

8.II.3.2 SAMPLE ANALYSIS

The methods used for testing the acid rock drainage and metal leaching (ARD/ML) potential include static and kinetic laboratory tests, as recommended in the following guidance documents:

- Draft Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia (Price 1997).
- Guidelines for Acid Rock Drainage Prediction in the North (DIAND 1992).
- Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials. MEND Report 1.20.1 (MEND 2009).
- Global Acid Rock Drainage Guide (GARD Guide).internet site http://www.gardguide.com/ (INAP 2009).

Samples were submitted for a suite of analytical tests, including ABA, metal analysis, short-term leach testing and humidity cell testing. Table 8.II-3 summarizes the number of each analyses completed for each main rock type for the geochemical samples collected from the Project. Table 8.II-4 provides a list of the kinetic test sample location and status by rocktype with associated duration, sulphur content and ABA results.

Table 8.II-3 Number of Samples Analyzed for Gahcho Kué Project Geochemical Testing Programs

Material Type	Static Tests						Kinetic Tests	
	Mineralogy	WRA	Bulk Metals	ABA	NAG	SFE	Humidity Cells	Columns
Kimberlite								
Kimberlite	1	150	150	391	0	21	5	5
Hypabyssal Kimberlite	1	24	24	63	0	2	1	0
Hypabyssal Kimberlite Transitional Zone	0	4	4	9	0	1	0	0
Tuffisitic Kimberlite	1	12	12	21	0	1	0	0
Tuffisitic Kimberlite Breccia	1	10	10	24	0	2	1	0
Total Kimberlite	4	200	200	508	0	27	7	5
Processed Kimberlite								
Fine Processed Kimberlite	1	0	20[(a)]	23[(a)]	11[(a)]	11[(a)]	7	1
Coarse Processed Kimberlite	13	0	11	38	10	10	1	1

Table 8.II-3 Number of Samples Analyzed for Gahcho Kué Project Geochemical Testing Programs (continued)

Material Type	Static Tests						Kinetic Tests	
	Mineralogy	WRA	Bulk Metals	ABA	NAG	SFE	Humidity Cells	Columns
Total Processed Kimberlite	14	0	31	61	21	10	8	2
Mine Rock								
Granodiorite	0	1	1	6	0	0	1	0
Altered Granodiorite	0	0	0	16	0	0	0	0
Granite	3	874	874	1182	0	34	11	5
Altered Granite	0	3	3	10	0	0	0	0
Diabase	0	5	5	7	0	0	1	0
Gneissic Granite	0	9	9	9	0	0	0	0
Diorite	0	1	1	1	0	0	1	0
Pre-leached Granite	0	0	0	4	0	0	4	0
Total Mine Rock	3	893	893	1235	0	34	18	5
Total Samples Analyzed	**21**	**1093**	**1124**	**1804**	**0**	**71**	**33**	**12**

(a) Includes duplicate fine processed kimberlite composite sample analyzed in 2010.

Table 8.II-4 Summary of Gahcho Kué Project Kinetic Test Program

ID	Rock Type	Pit	Status	Test Length (weeks)	Total Sulphur (wt%)	NP (kg $CaCO_3$/t)	AP (kg $CaCO_3$/t)
Kimberlites							
HC 1	kimberlite	5034	complete	36	0.03	228.50	0.70
HC 2	kimberlite	5034	complete	36	0.02	88.70	0.60
HC 3	hypabyssal kimberlite	5034	complete	36	0.02	3.13	0.60
HC 4	tuffisitic kimberlite breccia	Hearne	complete	36	0.03	4.93	1.03
HC 5	kimberlite	Hearne	complete	36	0.07	5.73	2.29
HC 6	kimberlite	Hearne	complete	36	0.02	2.53	0.60
HC 11	kimberlite	5034	complete	36	0.02	2.83	0.60
Column 5	kimberlite	5034	complete	30	0.04	118.45	0.30
Column 7	kimberlite	5034	complete	30	0.03	67.68	0.94
Column 8	kimberlite	Hearne	complete	30	0.03	47.31	0.96
Column 9	kimberlite	5034	complete	30	0.03	68.76	1.00
Column 10	kimberlite	5034	complete	30	0.03	119.13	0.78
Processed kimberlite							
HC 22	fine PK	Hearne	complete	165	0.040	73.8	0.8
HC 23	fine PK	5034	complete	165	0.050	121.8	1.3

Table 8.II-4 Summary of Gahcho Kué Project Kinetic Test Program (continued)

ID	Rock Type	Pit	Status	Test Length (weeks)	Total Sulphur (wt%)	NP (kg $CaCO_3$/t)	AP (kg $CaCO_3$/t)
HC 24	fine PK	5034	complete	165	0.020	127.0	0.6
HC 25	fine PK	Hearne	complete	165	0.080	81.5	2.0
HC 26	fine PK	Hearne	complete	165	0.040	75.0	0.8
HC 27	fine PK	5034	complete	165	0.060	100.5	1.5
PK fines composite (T1)	fine PK	composite	ongoing	5	0.07	70.3	2.2
PK coarse composite (HC1)	Coarse PK	composite	ongoing	5	0.01	114	0.3
Mine rock							
HC 7	granite	Hearne	complete	36	0.05	6.0	1.5
HC 8	granite	Hearne	complete	207	0.03	4.9	1.0
HC 9	granite	Hearne	complete	207	0.07	5.7	2.3
HC 10	granite	Tuzo	complete	207	0.02	2.5	0.6
HC 12	granite	5034	complete	207	0.02	6.8	0.7
HC 13	granite	Hearne	complete	207	0.02	3.3	0.6
HC 14	diorite and granite	Hearne	complete	207	0.07	6.3	2.1
HC 15	granite	Hearne	complete	41	0.02	2.8	0.6
HC 16	granite	5034	complete	207	0.10	4.3	3.2
HC 17	granite	5034	complete	207	0.04	2.0	1.3
HC 18	granite	5034	complete	207	0.02	8.8	0.6
HC 19	granite and granodiorite	Hearne	complete	207	0.03	6.3	0.8
HC 20	granite	Hearne	complete	207	0.02	7.2	0.6
HC 21	diabase	Tuzo	complete	207	0.09	11.3	0.3
Column 1	granite	Hearne	complete	42	0.02	2.1	0.6
Column 2	granite	5034	complete	36	0.06	12.3	2.0
Column 3	granite	Hearne	complete	36	0.08	49.3	2.6
Column 4	granite	Hearne	complete	42	0.02	4.3	0.6
Column 6	granite	5034	complete	42	0.02	7.0	0.6
HC 28	pre-leached granite	Hearne	complete	160	0.02	0.0	0.6
HC 29	pre-leached granite	5034	complete	160	0.06	0.0	1.6
HC 30	pre-leached granite	5034	complete	160	0.03	0.8	0.9
HC 31	pre-leached granite	5034	complete	160	0.02	0.3	0.6

wt % = percent by weight; t = tonnes; NP = neutralization potential.

8.II.3.3 TESTING PROCEDURES

Samples were submitted for one or more of the following tests, as described in Attachment 8.II.2:

- Mineralogical analysis. including qualitative X-Ray Diffraction (XRD) and optical mineralogy of thin sections.
- Whole rock and bulk metal analysis, including aluminum, arsenic, barium, beryllium, boron, cadmium, calcium, lead, cobalt, copper, chromium, tin, iron, lithium, magnesium, manganese, mercury, nickel, potassium silver, selenium, silver, selenium, sodium, total sulfur, vanadium and zinc.
- ABA including paste pH, sulphur species (including total sulphur, sulphate sulphur, pyritic sulphur and non-extractable sulphur), acid generation potential (AGP) and acid neutralization potential (ANP), and carbonate content.
- Net Acid Generation (NAG) Testing.
- Shake Flask Extraction (SFE) leach testing, including analysis of leachate for major parameters and metals including aluminum, arsenic, barium, beryllium, boron, cadmium, calcium, lead, cobalt, copper, chromium, tin, iron, lithium, magnesium, manganese, mercury, nickel, potassium silver, selenium, silver, selenium, sodium, total sulfur, vanadium and zinc.
- Chemical analysis of process water for major parameters and metals including aluminum, arsenic, barium, beryllium, boron, cadmium, calcium, lead, cobalt, copper, chromium, tin, iron, lithium, magnesium, manganese, mercury, nickel, potassium silver, selenium, silver, selenium, sodium, total sulfur, vanadium and zinc.
- Kinetic Testing including:
- Humidity Cell tests (HCT) carried out using the standard humidity cell test approach described in ASTM D 5744-96-1996, including analysis of major parameters and metals.
- Column testing as described by Price (1997), including analysis of major parameters and metals.
- Submerged column testing, including analysis of major parameters and metals.

8.II.3.4 QUALITY ASSURANCE AND QUALITY CONTROL

Protocols for quality assurance/quality control (QA/QC) were followed to validate the integrity of the results. The protocols included the use of internal laboratory standards, duplicates, and other QA samples.

Evaluation of the QA/QC results for the test work completed as part of the geochemistry program indicated that the data produced are of sufficient quality to be used for their intended purposes. Results of duplicate samples were evaluated using scatter plots and calculation of relative % differences (RPD). Standards and blanks were graphically compared against expected values as an indication of analytical accuracy. QA/QC analyses are reported in Attachment 8.II.4 for ABA analysis, Attachment 8.II.5 for whole rock analysis, Attachment 8.II.7 for SFE, Attachment VIII for humidity cell analysis, and Attachment 8.II.9 for column testing.

8.II.4 RESULTS

8.II.4.1 KIMBERLITE

8.II.4.1.1 Static Testing

8.II.4.1.1.1 Mineralogy

In 2004, four kimberlite samples were submitted for optical mineralogy and XRD analysis (Petrascience 2004 – Attachment 8.II.3). A detailed summary of the results of mineralogical analysis is reported in Table 8.II-6.

Results showed that the samples were dominated by kimberlitic material, typically pervasively altered to a very fine-grained assemblage of clays plus minus (±) chlorite [$(Fe,Mg,Al)_6(Si,Al)_4O_{10}(OH)_8$] ± talc [$Mg_3Si_4O_{10}$] ± biotite [$K(Mg,Fe)_3AlSi_3O_{10}(F,OH)_2$]. The clays, as identified by Rietveld XRD, include vermiculite [$(Mg,Fe,Al)_3(Al,Si)_4O_{10}(OH)$], chlinochlore [$(Mg_5Al)(AlSi_3)O_{10}(OH)_8$], phlogopite [$KMg_3AlSi_3O_{10}(F,OH)_2$] and actinolite [$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$]. Olivine [$(Mg,Fe)_2SiO_4$] is preserved in some samples, typically partly to totally pseudomorphosed by serpentine, itself variously replaced by the clay ± chlorite ± talc ± biotite assemblage. Quartz [SiO_2], amphibole [$Ca_2(Fe,Mg)_5Si_8O_{22}(OH)_2$] and K-feldspar [$KAlSi_3O_8$] commonly occur in small amounts.

Trace unidentified carbonate minerals were identified in the tuffisitic kimberlite breccia sample.

According the mineralogical report, sulphide minerals are extremely rare in the samples (less than 2%) and mostly consist of pyrite [FeS_2] with lesser chalcopyrite [$CuFeS_2$] and trace pyrrhotite [$Fe_{(1-x)}S$].

Table 8.II-6 Summary of Gahcho Kué Project Kimberlite Mineralogy

	Mineral	Formula	Mineral Composition (%)			
			04-ARD-126-015	04-ARD-137-013	04-ARD-159-010	04-ARD-171-015
			Kimberlite	Hypabyssal Kimberlite	Tuffisitic Kimberlite Breccia	Tuffisitic Kimberlite
Semi-quantitative XRD	Vermiculite 2M	$(Mg,Fe,Al)_3(Al,Si)_4O_{10}(OH)$	27		19	
	Clinochlore II	$(Mg_5Al)(AlSi_3)O_{10}(OH)_8$	31	42	15	30
	Phlogopite 1M	$KMg_3AlSi_3O_{10}(F,OH)_2$	7.0	32	7.6	20
	Actinolite	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$	3.5		3.7	
	Pectolite 1A	$NaCa_2Si_3O_8(OH)$		12		8.0
	Natrolite	$Na_2Al_2Si_3O_{10}$	1.7			
	Talc 1A	$Mg_3Si_4O_{10}$	25		21	
	Lizardite	$Mg_3Si_2O_5$		13	2.2	8.0
	Monticellite	$CaMgSiO_4$		0.5		1.9
	Forsterite	Mg_2SiO_4		minor?		32
	Microcline intermediate	$KAlSi_3O_8$	2.9		24	
	Orthoclase	$KAlSi_3O_8$			3.7	
	Quartz	SiO_2			3.7	
	Hematite	Fe_2O_3			0.6	
	Perovskite	$CaTiO_3$		0.6		0.5
	Rutile	TiO_2	0.5			
	Titanite	$CaTiSiO_5$	1.8			
TOTAL			**100**	**100**	**100**	**100**
Mineral Phases Observed in Optical Microscopy			**Major:** Biotite [$K(Mg,Fe)_3AlSi_3O_{10}(F,OH)_2$], chlorite [$(Fe,Mg,Al)_6(Si,Al)_4O_{10}(OH)_8$], olivine [$(Mg,Fe)_2SiO_4$], serpentine [$((Mg,Fe)_3Si_2O_5(OH)_4)$] **Minor:** Titanite, Rutile	**Major:** Chlorite, biotite, serpentine, olivine, groundmass **Minor:** Titanite, rutile **Trace:** Magnetite [Fe_3O_4], pyrite [FeS_2]	**Major:** Groundmass, K-feldspar, biotite, chlorite **Minor:** Quartz, hematite [Fe2O3], ilmenite [$FeTiO_3$], rutile **Trace:** Magnetite, chalcopyrite [$CuFeS_2$], pyrite, carbonate	**Major:** Groundmass, chlorite, serpentine, biotite **Minor:** Amphibole [$Ca_2(Fe,Mg)_5Si_8O_{22}(OH)_2$], olivine **Trace:** Olivine, hematite [Fe_2O_3], perovskite [$CaTiO_3$], chalcopyrite [$CuFeS_2$]

% = percent

8.II.4.1.1.2 Acid Base Accounting

Results of ABA testing for the kimberlite are provided in Table 8.II-7 and Figures 8.II-1 to 8.II-3. Attachment 8.II.4 contains detailed ABA results.

Principal observations with respect to the ABA characteristics of kimberlite included:

- Paste pH values ranged from 7.1 to 11.0, with a median value of 8.64. Paste pH values were well above the screening criteria of pH 5.5 typically used to identify samples with a potential for acid generation (Price 1997). The average paste pH of the tuffisitic kimberlite breccia was the lowest of all the kimberlite facies (pH 8.22).
- The kimberlite samples contained between less than 0.01% and 0.75% total sulphur, with an average total sulphur concentration of 0.04%. Sulphur is primarily in the form of sulphide sulphur (Figure 8.II-1). Sulphide sulphur concentrations in the kimberlite ranged from less than 0.01 to 0.72%, with average concentrations of 0.03%. For the purpose of the evaluation in this report, AP was calculated using total sulphur.
- Of the 509 samples of kimberlite submitted for ABA, only 3 samples had sulphide sulphur concentrations in excess of 0.3% (a commonly used screening criteria to identify materials with a potential for acid generation (Price, 1997).
- The results of sulphur analysis were consistent with the mineralogical evaluation of kimberlite, which indicated that the sulphide mineral content of kimberlite is low.
- According to AMEC (2008), the presence of sulphide concentrations greater than 0.1 percent by weight (wt%) in kimberlite samples did not appear to be related with proximity to mine rock contacts.
- The neutralization potential of the kimberlites ranged from 2.4 to 600 kilogram (kg) $CaCO_3$/t, with an average value of 124 kg $CaCO_3$/t. Generally, the tuffistic kimberlite samples reported lower neutralization potential values (averages of 57.8 and 73.2 kg $CaCO_3$/t) than the other kimberlite types (averages of 123, 125 and 168 kg $CaCO_3$/t).
- The neutralization potential (NP) was greater than the carbonate NP for all but seven samples (Figure 8.II-2). On average, the carbonate NP was about one-tenth of the NP. A carbonate NP significantly lower than the neutralization potential indicates most of the bulk NP is attributable to non-carbonate minerals.
- The NP/AP ratio of the kimberlite samples ranged from 0.84 to 3416. Of the 509 samples submitted for ABA, only four samples had NP/AP ratios less than four. Three samples had an NP/AP between one and three, indicating an uncertain acid generating potential, including one tuffistic

kimberlite breccias and two undifferentiated kimberlite samples (Figure 8.II-3). One undifferentiated kimberlite sample had an NP/AP less than one (0.84) and would therefore is classified as PAG according to the guidance in Price (1997).

Table 8.II-7 Summary of Gahcho Kué Project Kimberlite Acid Base Accounting Results

Sample ID	Paste pH	CO_2	Total Sulphur	Sulphate	Sulphide	AP	NP	NP/AP	CaNP
		%	wt. %	wt. %	wt. %	kg $CaCO_3$/t	kg $CaCO_3$/t	kg $CaCO_3$/t	kg $CaCO_3$/t
Hypabyssal Kimberlite, n=63									
Minimum	8.0	0.04	<0.01	<0.01	<0.01	<0.3	37	14	0.91
Maximum	10	8.5	0.21	0.082	0.14	4.4	420	1808	194
Mean	9.0	0.75	0.039	0.012	0.028	0.88	168	350	17
Median	8.8	0.36	0.03	0.0073	0.015	0.48	145	220	8.2
Standard Deviation	0.7	1.3	0.039	0.013	0.03	0.94	107	369	29
Hypabyssal Kimberlite Transitional Zone, n=9									
Minimum	8.3	0.12	<0.01	<0.01	<0.01	<0.3	39	42	2.7
Maximum	10	1.9	0.06	0.06	0.03	0.94	259	1712	44
Mean	9.3	0.51	0.022	0.014	0.013	0.38	126	591	12
Median	9.6	0.28	0.02	0.005	0.01	0.3	99	290	6.4
Standard Deviation	0.74	0.58	0.016	0.018	0.0079	0.26	82	637	13
Kimberlite, n=391									
Minimum	7.1	<0.01	<0.01	<0.01	<0.01	<0.3	2.4	0.84	0.11
Maximum	11	18	0.75	0.08	0.72	23	600	3416	414
Mean	9.0	0.89	0.036	0.0096	0.031	0.99	123	292	20
Median	8.7	0.28	0.02	0.005	0.02	0.62	89	140	6.4
Standard Deviation	0.73	2.2	0.061	0.0098	0.058	1.9	104	445	50
Tuffisitic Kimberlite, n=21									
Minimum	8.3	<0.01	<0.01	<0.01	<0.01	<0.3	37	59	0.11
Maximum	8.7	0.14	0.03	0.0053	0.03	0.94	119	396	3.2
Mean	8.6	0.07	0.013	0.005	0.013	0.41	73	208	1.6
Median	8.6	0.08	0.01	0.005	0.01	0.3	62	188	1.8
Standard Deviation	0.13	0.034	0.0058	0.000073	0.0058	0.19	26	101	0.78

Table 8.II-7 Summary of Gahcho Kué Project Kimberlite Acid Base Accounting Results (continued)

Sample ID	Paste pH	CO_2	Total Sulphur	Sulphate	Sulphide	AP	NP	NP/AP	CaNP
		%	wt. %	wt. %	wt. %	kg $CaCO_3$/t	kg $CaCO_3$/t	kg $CaCO_3$/t	kg $CaCO_3$/t
Tuffisitic Kimberlite Breccia, n=25									
Minimum	7.5	0.04	<0.01	<0.01	<0.01	<0.3	28	1.5	0.91
Maximum	8.6	4.7	0.71	0.086	0.62	20	100	386	107
Mean	8.2	0.8	0.06	0.013	0.051	1.6	58	113	18
Median	8.2	0.26	0.03	0.01	0.02	0.62	65	104	5.9
Standard Deviation	0.27	1.3	0.14	0.016	0.12	3.8	22	95	29
All Kimberlite, n=509									
Minimum	7.1	<0.01	<0.01	<0.01	<0.01	<0.3	2.4	0.84	0.11
Maximum	11	18	0.75	0.09	0.72	23	600	3416	414
Mean	8.9	0.83	0.04	0.01	0.03	0.97	124	293	19
Median	8.7	0.27	0.02	0.01	0.02	0.63	90	147	6.1
Standard Deviation	0.7	2.0	0.06	0.01	0.06	1.90	102	424	46

Note: AP (Acid Potential) was calculated using total sulphur.

% = percent; wt % = percent by weight; kg/t = kilograms per tonne.

Figure 8.II-1 Total Sulphur Versus Sulphide Sulphur for Kimberlites

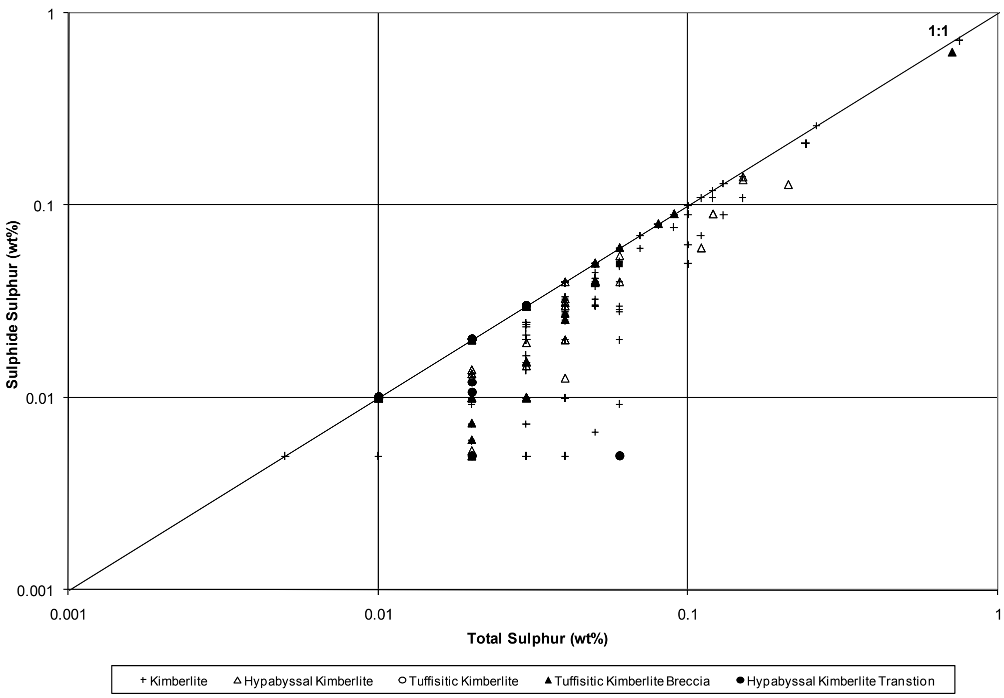


Figure 8.II-2 Total Neutralizing Potential Versus Carbonate Neutralizing Potential for Kimberlites

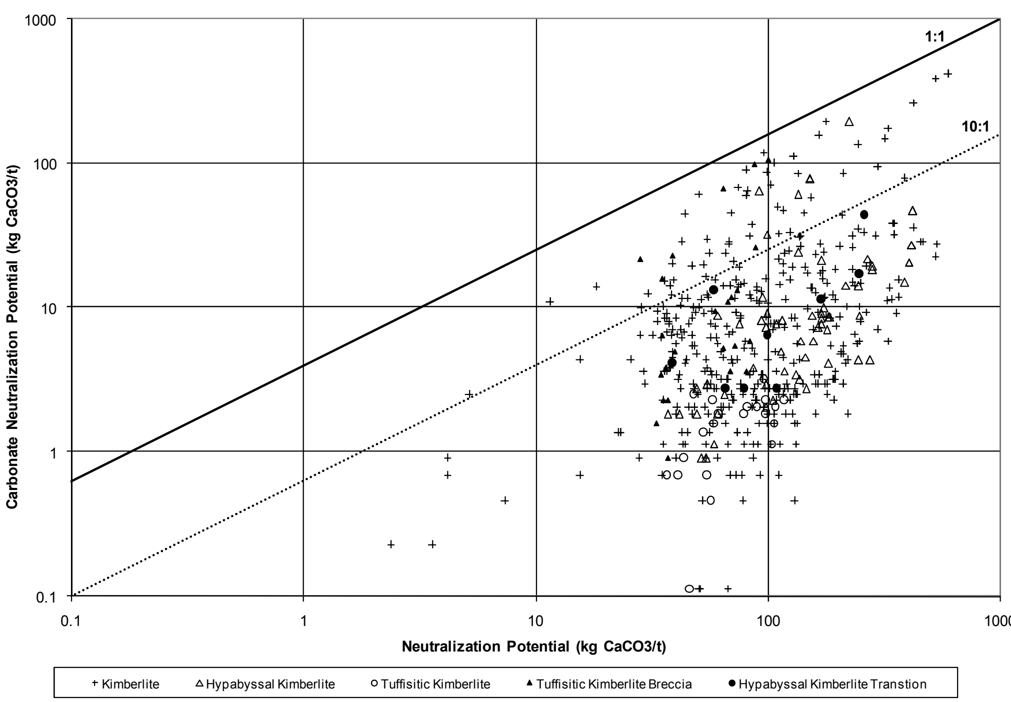
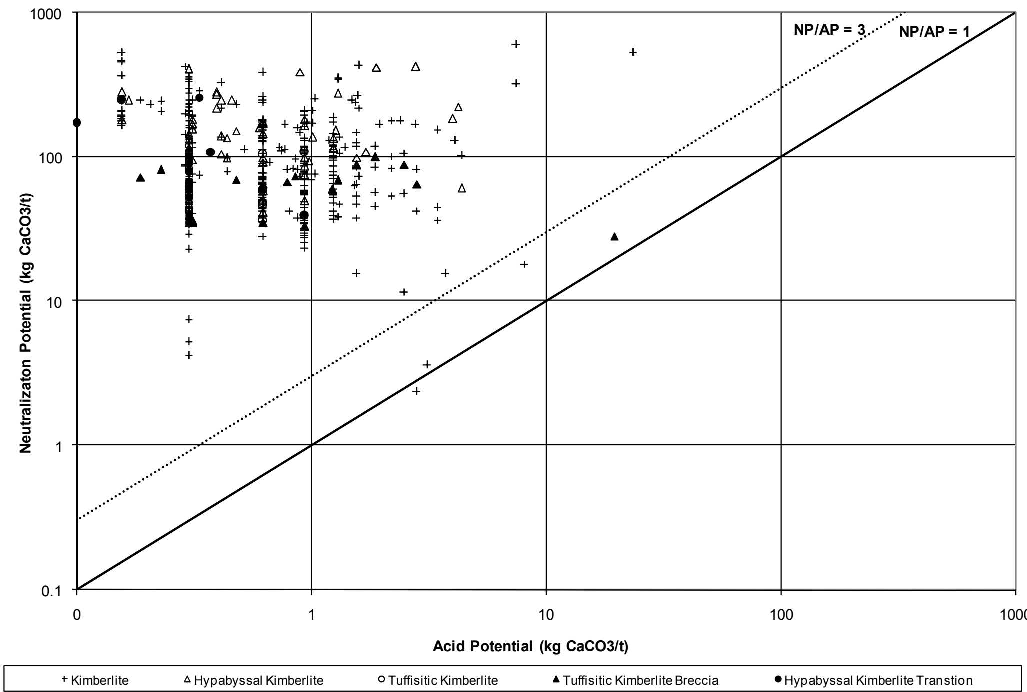


Figure 8.II-3 Acid Potential Versus Neutralizing Potential for Kimberlites



8.II.4.1.2 Whole Rock and Trace Element Chemistry

A complete record of the analytical results and a summary of the chemistry of the individual kimberlite facies are provided in Attachment 8.II.5. A summary of the whole rock results is presented in Table 8.II-8 and bulk metal results are reported in Table 8.II-9. Trace metal concentrations were compared to the average crustal abundances of elements in Price (1997). The purpose of this comparison was to identify metals that occur at elevated concentrations in the solid phase.

Magnesium, iron, and aluminum are the major metals in kimberlite. For all kimberlite facies, the average silica concentration was less than 50%. Overall, the chemical composition of kimberlites was similar to the average crustal abundances of ultrabasic and basaltic rocks presented in Price (1997).

Table 8.II-8 Summary of Gahcho Kué Project Kimberlite Whole Rock Results

Parameter	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Ba(F)	LOI	Total
Unit	%	%	%	%	%	%	%	%	%	%	%	%	%
Hypabyssal Kimberlite, n= 24													
Minimum	36	0.51	1.9	6.6	0.02	26	0.46	0.01	0.2	0.07	0.02	8.1	98
Maximum	44	0.74	4.8	9.0	0.14	36	6.4	1.2	1.6	0.56	0.15	16	100
Mean	39	0.6	3.5	7.7	0.1	30	3.2	0.24	0.89	0.33	0.097	12	99
Median	40	0.6	3.5	7.5	0.11	30	2.9	0.09	0.9	0.34	0.11	13	99
Standard Deviation	2.6	0.057	0.7	0.82	0.033	2.5	2.1	0.37	0.39	0.13	0.038	2.3	0.43
Kimberlite, n= 150													
Minimum	32	0.14	1.6	1.5	0.0059	0.5	0.15	0.01	0.07	0.02	0.01	0.62	98
Maximum	87	0.73	18	8.9	0.18	36	8.8	3.7	11	0.82	0.23	17	100
Mean	45	0.53	5.5	6.5	0.069	25	2.8	0.58	1.5	0.28	0.091	12	99
Median	43	0.56	4.5	6.8	0.07	28	1.8	0.3	0.95	0.28	0.09	13	99
Standard Deviation	8.9	0.12	3.0	1.7	0.043	8.4	2.1	0.74	1.5	0.13	0.039	3.5	0.4
Hypabyssal Kimberlite Transitional Zone, n = 4													
Minimum	37	0.62	3.1	7.9	0.12	28	2.1	0.03	0.8	0.37	0.1	8.7	98
Maximum	41	0.69	4.1	8.6	0.14	32	6.0	0.81	1.5	0.46	0.15	13	99
Mean	39	0.66	3.5	8.4	0.13	30	4.8	0.28	1.1	0.42	0.12	11	99
Median	38	0.67	3.5	8.5	0.13	30	5.4	0.15	1.1	0.43	0.12	11	99
Standard Deviation	2.0	0.031	0.43	0.35	0.012	2.0	1.8	0.36	0.29	0.038	0.021	1.8	0.34
Tuffisitic Kimberlite, n= 12													
Minimum	42	0.4	4.1	5.8	0.02	24	0.72	0.03	0.4	0.12	0.03	13	99
Maximum	45	0.61	7.5	7.1	0.07	30	1.6	0.58	1.3	0.4	0.1	15	100
Mean	44	0.5	5.8	6.5	0.049	27	1.2	0.28	0.75	0.22	0.058	14	99
Median	44	0.49	5.9	6.3	0.05	26	1.2	0.31	0.57	0.2	0.06	13	99
Standard Deviation	1.1	0.06	1.1	0.36	0.014	2.0	0.28	0.21	0.31	0.083	0.024	0.83	0.19
Tuffisitic Kimberlite Breccia, n= 10													
Minimum	47	0.37	7.1	4.3	0.01	13	1.4	0.15	1.5	0.15	0.05	9.1	99
Maximum	54	0.44	10	7.3	0.02	22	2.6	2.0	3.6	0.37	0.12	15	99
Mean	49	0.4	8.2	5.2	0.017	18	1.7	0.55	2.5	0.28	0.073	13	99
Median	49	0.41	8.2	5.2	0.02	19	1.6	0.42	2.5	0.27	0.075	13	99
Standard Deviation	2.2	0.028	1.0	0.86	0.0048	2.5	0.35	0.53	0.69	0.079	0.022	1.6	0.17
ALL KIMBERLITES, n=200													
Minimum	32	0.14	1.6	1.5	0.0059	0.5	0.15	0.01	0.07	0.02	0.01	0.62	98
Maximum	87	0.74	18	9.0	0.18	36	8.8	3.7	11	0.82	0.23	17	100
Mean	44	0.53	5.4	6.6	0.07	26	2.7	0.52	1.4	0.29	0.089	12	99
Median	43	0.56	4.4	6.9	0.07	28	1.7	0.27	0.96	0.28	0.09	13	99
Standard Deviation	8.0	0.11	2.8	1.6	0.044	7.8	2.0	0.68	1.4	0.12	0.039	3.2	0.4

% = percent

Table 8.II-9 Summary of Gahcho Kué Project Kimberlite Bulk Metal Results

Parameter	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	La	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Sr	Ti	Tl	U	Zn
Unit	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	%	%	ppm	%	ppm	ppm	%	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
PRICE CRUSTAL ABUNDANCE (1) (ppm)		82300	1.8	10		0.0085	41500	3.0	25	102	60	56300	20850	20	23300	950	1.2	23550	84	1050	14	0.2	0.05	370	5650	0.85	2.7	70
Hypabyssal Kimberlite, n= 24																												
Minimum	0.05	0.85	0.7	2.0	243	0.05	0.28	0.05	44	271	3.5	3.3	0.27	6.0	11	280	0.05	0.023	797	0.031	0.5	0.05	0.25	163	0.046	0.05	0.7	18
Maximum	0.1	2.1	10	573	1295	0.05	4.1	0.2	107	608	93	5.7	1.9	90	18	1277	4.4	0.83	1391	0.24	14	0.2	0.5	609	0.13	0.8	1.8	236
Mean	0.085	1.6	2.3	167	795	0.05	1.9	0.06	70	406	49	4.5	1.1	44	15	883	0.44	0.17	1114	0.13	6.3	0.083	0.28	353	0.085	0.16	1.2	47
Median	0.1	1.5	1.6	76	744	0.05	1.8	0.05	71	396	49	4.4	1.1	40	15	934	0.25	0.047	1110	0.14	7.8	0.075	0.25	318	0.087	0.1	1.2	42
Standard Deviation	0.023	0.31	2.2	179	325	1.4E-17	1.4	0.033	14	97	18	0.73	0.5	29	2.0	272	0.89	0.25	180	0.053	4.9	0.043	0.084	130	0.024	0.18	0.25	42
Kimberlite, n= 150																												
Minimum	0.05	0.33	0.25	0.5	10	0.05	0.06	0.05	2.4	29	0.6	0.74	0.04	4.0	0.28	55	0.05	0.005	2.1	0.011	0.5	0.05	0.25	4.0	0.002	0.05	0.3	10
Maximum	0.7	4.0	10	1747	1434	0.2	5.8	0.5	104	821	148	5.6	2.0	88	19	1556	88	2.3	1521	0.3	99	3.3	0.5	10000	0.23	4.0	4.8	226
Mean	0.08	1.7	1.6	103	617	0.054	1.5	0.058	54	281	38	3.6	0.75	49	12	612	1.4	0.18	872	0.11	6.6	0.12	0.26	422	0.075	0.13	1.1	37
Median	0.05	1.7	1.3	27	624	0.05	0.9	0.05	57	274	40	3.7	0.65	50	12	600	0.3	0.071	935	0.11	2.8	0.05	0.25	289	0.075	0.1	1.0	32
Standard Deviation	0.059	0.6	1.2	191	389	0.017	1.2	0.039	20	145	24	1.1	0.47	22	4.2	351	7.3	0.28	335	0.047	10	0.29	0.035	899	0.036	0.33	0.48	24
Hypabyssal Kimberlite Transitional Zone, n = 4																												
Minimum	0.1	1.4	1.0	7.0	820	0.05	1.0	0.05	73	355	45	4.8	0.92	7.0	13	1034	0.2	0.047	1137	0.15	1.8	0.05	0.25	357	0.056	0.05	1.3	38
Maximum	0.1	1.8	4.6	461	1387	0.05	4.2	0.1	81	452	71	5.7	2.0	68	15	1243	0.4	0.64	1374	0.2	14	0.1	0.5	710	0.12	0.2	1.8	56
Mean	0.1	1.6	2.0	154	1072	0.05	3.2	0.075	79	413	57	5.3	1.4	32	14	1157	0.3	0.24	1282	0.18	11	0.075	0.31	547	0.096	0.14	1.5	49
Median	0.1	1.6	1.3	74	1040	0.05	3.8	0.075	80	423	56	5.5	1.4	27	14	1176	0.3	0.14	1309	0.18	13	0.075	0.25	560	0.11	0.15	1.4	50
Standard Deviation	0	0.13	1.7	209	255	0	1.5	0.029	4.1	44	11	0.43	0.45	26	0.92	103	0.12	0.28	102	0.023	5.9	0.029	0.13	153	0.028	0.075	0.22	7.5
Tuffisitic Kimberlite, n= 12																												
Minimum	0.05	1.8	0.25	20	201	0.05	0.45	0.05	37	207	23	2.8	0.31	55	9.8	261	0.05	0.044	639	0.032	0.6	0.05	0.25	158	0.031	0.05	0.7	18
Maximum	0.1	3.1	3.5	106	576	0.05	0.87	0.05	68	354	55	4.0	1.2	73	14	618	0.2	0.24	833	0.14	9.5	0.1	0.25	393	0.088	0.1	1.5	37
Mean	0.054	2.5	0.88	40	387	0.05	0.64	0.05	46	272	36	3.2	0.56	63	12	350	0.13	0.076	717	0.077	1.8	0.054	0.25	248	0.053	0.054	1.1	27
Median	0.05	2.5	0.65	30	384	0.05	0.67	0.05	45	277	36	3.2	0.48	62	11	311	0.1	0.06	712	0.067	1.2	0.05	0.25	248	0.05	0.05	1.2	28
Standard Deviation	0.014	0.4	0.86	27	150	7.2E-18	0.12	7.2E-18	9.5	50	9.0	0.33	0.22	5.2	1.3	104	0.054	0.053	57	0.032	2.4	0.014	0	76	0.015	0.014	0.22	5.2
Tuffisitic Kimberlite Breccia, n= 10																												
Minimum	0.05	1.3	0.7	9.0	120	0.05	0.59	0.05	29	89	3.8	2.2	0.31	44	6.0	143	0.5	0.047	428	0.063	1.7	0.05	0.25	114	0.025	0.05	0.8	13
Maximum	0.1	2.7	1.5	23	438	0.1	1.3	0.3	45	222	46	4.4	0.54	78	9.3	258	4.2	0.11	692	0.15	32	0.05	0.5	254	0.048	0.1	1.6	27
Mean	0.055	2.1	1.0	14	228	0.055	0.97	0.075	36	145	22	2.8	0.41	60	8.1	184	1.1	0.078	582	0.11	6.1	0.05	0.3	179	0.036	0.09	1.1	19
Median	0.05	2.1	1.0	13	214	0.05	0.97	0.05	36	138	23	2.5	0.39	58	8.4	173	0.9	0.081	609	0.11	2.3	0.05	0.25	177	0.035	0.1	1.0	19
Standard Deviation	0.016	0.42	0.29	3.7	90	0.016	0.2	0.079	5.7	37	14	0.66	0.083	10	1.0	35	1.1	0.02	91	0.031	9.4	7.3E-18	0.11	46	0.0086	0.021	0.23	4.2
ALL KIMBERLITE n=200																												
Minimum	0.05	0.33	0.25	0.5	10	0.05	0.06	0.05	2.4	29	0.6	0.74	0.04	4.0	0.28	55	0.05	0.005	2.1	0.011	0.5	0.05	0.25	4.0	0.002	0.05	0.3	10
Maximum	0.7	4.0	10	1747	1434	0.2	5.8	0.5	107	821	148	5.7	2.0	90	19	1556	88	2.3	1521	0.3	99	3.3	0.5	10000	0.23	4.0	4.8	236
Mean	0.078	1.8	1.6	103	614	0.054	1.5	0.059	55	292	38	3.7	0.78	49	12	618	1.2	0.17	886	0.11	6.3	0.11	0.26	394	0.074	0.12	1.1	37
Median	0.05	1.8	1.3	32	603	0.05	0.89	0.05	57	279	40	3.7	0.65	55	12	596	0.3	0.065	920	0.12	2.5	0.05	0.25	285	0.073	0.1	1.1	31
Standard Deviation	0.053	0.59	1.4	181	383	0.015	1.2	0.04	20	142	23	1.1	0.48	22	4.0	360	6.3	0.26	323	0.048	9.3	0.26	0.052	783	0.034	0.29	0.43	26

Notes: (1) Typical crustal abundance for continental rocks taken from Price (1997).

>1 x	– Concentration greater than typical crustal abundance.
>5 x	– Concentration greater than 5 x the typical crustal abundance.
>10 x	– Concentration greater than 10 x the typical crustal abundance.

Results of the trace element chemistry analyses indicated average concentrations of nickel (885 milligrams per kilogram [mg/kg]), cobalt (53.4 mg/kg), chromium (292 mg/kg), magnesium (11.83%), selenium (0.26 mg/kg) and strontium (394 mg/kg) were elevated compared to average background concentrations in continental crust rock (Price 1997). Relative to kimberlite, tuffisitic kimberlite, and tuffisitic kimberlite breccia, the hypabyssal kimberlite and transitional hypabyssal kimberlite are enriched in mafic minerals (Annex D, Bedrock Geology, Terrain, Soil, and Permafrost Baseline) and associated elements including chromium, copper, iron, manganese, nickel, and zinc.

8.II.4.1.3 Shake Flask Extraction Testing

Attachment 8.II.7 presents detailed results of SFE of kimberlite samples. All SFE leachates had neutral to alkaline pH values, ranging from 7.95 to 10.6. There are no established guidelines for comparison of SFE leachate results. Table 8.II-10 provides the mean, median, standard deviation (SD), and range of select parameters in kimberlite SFE leachates.

Table 8.II-10 Average and Range of Values for Gahcho Kué Project Kimberlite Shake Flask Extraction Tests

Parameter	pH	SO_4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
Unit	**s.u.**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Hypabyssal Kimberlite, n = 2																					
04-ARD-137-011	10	3.0	0.007	<0.001	14	<0.001	<0.001	<0.001	<0.05	<0.001	0.06	<0.001	<0.0005	<0.001	<0.15	14	<0.001	19	0.24	<0.0005	<0.005
04-ARD-164-015	11	<1	0.006	<0.001	73	<0.001	<0.001	<0.001	0.08	<0.001	0.35	<0.001	<0.0005	<0.001	<0.15	44	<0.001	1.6	1.3	<0.0005	<0.005
Hypabyssal Kimberlite Transitional Zone, n = 1																					
04-ARD-171-001	9.0	6.0	0.007	0.001	5.7	<0.001	<0.001	<0.001	<0.05	<0.001	5.5	<0.001	0.0006	<0.001	<0.15	11	<0.001	7.9	0.071	<0.0005	<0.005
Kimberlite, n = 21																					
Mean	9.1	25	2.0	0.0059	15	0.017	0.0051	0.0016	2.8	0.001	15	0.021	0.016	0.11	0.16	13	<0.001	18	0.17	0.00053	0.0069
Median	9.0	9.0	0.067	0.001	8.0	0.001	0.001	0.001	0.22	0.001	9.0	0.004	0.0012	0.009	0.15	7.0	<0.001	16	0.093	0.0005	0.005
Standard Deviation	0.59	40	5.0	0.027	16	0.043	0.015	0.0033	6.6	0.00071	23	0.062	0.044	0.33	0.071	12	---	14	0.15	0.00035	0.0062
Minimum	8.0	<1	<0.005	<0.001	1.3	<0.001	<0.001	<0.001	<0.05	<0.001	0.23	<0.001	<0.0005	<0.001	<0.15	2.6	<0.001	0.81	0.018	<0.0005	<0.005
Maximum	10	163	19	0.087	57	0.15	0.046	0.01	27	0.002	103	0.22	0.17	1.2	0.3	41	<0.001	44	0.58	0.0011	0.022
Tuffisitic Kimberlite, n = 1																					
04-ARD-171-017	8.5	5.0	13	0.001	7.3	0.11	0.027	0.003	19	<0.001	71	0.14	0.0039	0.77	0.2	5.0	<0.001	17	0.099	<0.0005	0.019
Tuffisitic Kimberlite Breccia, n = 2																					
04-ARD-157-006	8.9	54	3.1	0.002	9.0	0.017	0.009	0.002	3.3	<0.001	20	0.02	0.035	0.13	<0.15	5.1	<0.001	27	0.098	<0.0005	0.005
04-ARD-159-012	8.6	104	0.014	<0.001	19	<0.001	<0.001	<0.001	0.06	<0.001	9.5	0.002	0.036	0.004	<0.15	6.0	<0.001	35	0.25	<0.0005	<0.005

s.u. = standard unit; mg/L = milligrams per litre; < = less than

8.II.4.1.4 Kinetic Testing

8.II.4.1.4.1 Humidity Cells

Tables 8.II-11a and 8.II-11b contain a summary of the average leachate chemistry for selected parameters from the standard humidity cells. Results are presented for both the first flush (the first five weeks) in Table 8.II-11a and steady state conditions (the last five weeks) in Table 8.II-11b. Figure 8.II-4 presents the concentrations of key parameters and pH values of the kimberlite humidity cells. Attachment 8.II.8 provides the weekly results and calculated parameters. The kimberlite material used to construct the humidity cells had sulphide concentrations that fell between the median and 90^{th} percentile of all kimberlite ABA sulphide values and between the 25^{th} percentile and median of all kimberlite ABA NP values.

The principal observations with respect to the kimberlite humidity cells are as follows:

- Neutral to alkaline pH values were maintained through the duration of the kimberlite kinetic tests. Kinetic test pH decreased very slightly over the duration of the test. Given the low total sulphur content of the humidity cell test samples, it is unlikely that the slight decrease in pH is a result of sulphide oxidation.
- The sulphate concentrations decreased with time in all kimberlite humidity cells. Concentrations were typically less than 5 milligrams per litre per week (mg/L/wk) after week 20 for all humidity cells with the exception of HC 6. HC 6 sulphate concentrations were less than 10 mg/L each week since week 19. The low sulphate concentrations support the conclusion that the decreasing pH is likely unrelated to sulphide oxidation.
- Concentrations of major ions including sodium, magnesium and calcium generally decreased over time after five weeks.
- Key metal concentrations including selenium, zinc and iron were below the detection limits in many samples. Arsenic concentrations peaked between weeks 18 and 30 in all samples, with maximum concentrations ranging from 0.005 to 0.014 mg/L.
- As presented in Table 8.II-11, trace metal concentrations in humidity cell test leachates were generally low. Copper, mercury and lead concentrations were less than the lower detection limit at steady state. Steady state concentrations of nickel and molybdenum were less than or equal to the detection limit in all but one humidity cell.
- Table 8.II-12 summarizes the expected NP, CaNP and sulphide depletion times in humidity cells assuming leaching rates remain

constant. In all cells except HC 11, the rate of NP consumption was greater than the rate of sulphate production, indicating that it is unlikely that acid generation would occur in the long-term. However, given the low sulphide content in HC 11 even upon complete depletion of NP, the rate of acid production is expected to be insufficient to produce appreciable amounts of acidity.

Table 8.II-11a First Flush Concentrations of Select Parameters in Kimberlite Humidity Cell Leachates

	pH	SO4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
First Flush																					
HC 1 - Kimberlite: Dec 14 - Jan 11, 2005																					
Minimum	7.8	<1	<0.005	<0.001	14	<0.001	<0.001	<0.001	<0.05	<0.001	5.5	<0.001	<0.0005	0.0013	<0.15	12	<0.001	<0.05	0.079	<0.0005	<0.005
Maximum	8.3	1.0	0.048	<0.001	30	<0.001	<0.001	<0.001	<0.05	<0.001	12	0.0021	<0.0005	0.002	<0.15	20	<0.001	5.3	0.21	<0.0005	<0.005
Average	8.1	1.0	0.019	<0.001	20	<0.001	<0.001	<0.001	<0.05	<0.001	8.5	0.0017	<0.0005	0.0018	<0.15	15	<0.001	2.9	0.13	<0.0005	<0.005
Median	8.1	1.0	0.005	<0.001	16	<0.001	<0.001	<0.001	<0.05	<0.001	8.4	0.002	<0.0005	0.002	<0.15	14	<0.001	3.4	0.09	<0.0005	<0.005
HC 2 - Kimberlite: December 14 - January 11, 2005																					
Minimum	8.4	6.0	0.016	0.001	4.7	<0.001	<0.001	<0.001	<0.05	<0.001	2.4	<0.001	0.0035	0.0011	<0.15	3.4	0.0011	2.5	0.048	<0.0005	<0.005
Maximum	8.8	14	0.076	0.002	7.5	<0.001	<0.001	<0.001	0.08	<0.001	4.0	<0.001	0.011	0.002	<0.15	6.1	0.003	12	0.075	<0.0005	<0.005
Average	8.5	8.8	0.048	0.0013	6.1	<0.001	<0.001	<0.001	0.067	<0.001	3.2	<0.001	0.0072	0.0017	<0.15	4.5	0.0024	7.7	0.063	<0.0005	<0.005
Median	8.5	8.0	0.051	0.001	6.2	<0.001	<0.001	<0.001	0.07	<0.001	3.2	<0.001	0.007	0.002	<0.15	3.9	0.003	9.3	0.065	<0.0005	<0.005
HC 3 - Hypabyssal Kimberlite: December 14 - January 11, 2005																					
Minimum	8.7	6.0	<0.005	<0.001	4.5	<0.001	<0.001	<0.001	<0.05	<0.001	0.45	<0.001	<0.0005	<0.001	<0.15	9.5	<0.001	15	0.087	<0.0005	<0.005
Maximum	8.9	12	0.061	0.002	10.0	0.002	<0.001	<0.001	<0.05	<0.001	0.56	<0.001	<0.0005	0.001	<0.15	12	0.001	19	0.16	<0.0005	<0.005
Average	8.8	8.6	0.024	0.0013	6.3	0.0013	<0.001	<0.001	<0.05	<0.001	0.49	<0.001	<0.0005	0.001	<0.15	11	0.001	18	0.11	<0.0005	<0.005
Median	8.8	8.0	0.005	0.001	4.5	0.001	<0.001	<0.001	<0.05	<0.001	0.47	<0.001	<0.0005	0.001	<0.15	11	0.001	19	0.089	<0.0005	<0.005
HC 4 - Tuffisitic Kimberlite Breccia: December 14 - January 11, 2005																					
Minimum	8.3	9.0	0.037	<0.001	4.1	<0.001	<0.001	<0.001	0.01	<0.001	1.8	<0.001	0.025	0.0012	<0.15	2.2	<0.001	6.9	0.048	<0.0005	<0.005
Maximum	8.6	45	0.12	0.001	9.3	<0.001	<0.001	<0.001	0.07	<0.001	4.0	<0.001	0.073	0.006	<0.15	4.4	0.003	25	0.1	0.0005	<0.005
Average	8.4	21	0.067	0.001	6.1	<0.001	<0.001	<0.001	0.043	<0.001	2.6	<0.001	0.041	0.0034	<0.15	3.4	0.0017	15	0.067	0.0005	<0.005
Median	8.4	18	0.043	0.001	4.8	<0.001	<0.001	<0.001	0.05	<0.001	2.1	<0.001	0.025	0.003	<0.15	3.6	0.001	14	0.054	0.0005	<0.005
HC 5 - Kimberlite: December 14 - January 11, 2005																					
Minimum	8.5	17	<0.005	<0.001	6.0	<0.001	0.001	<0.001	<0.05	<0.001	4.1	<0.001	0.0013	<0.001	<0.15	5.4	<0.001	14	0.08	<0.0005	<0.005
Maximum	8.8	36	0.05	<0.001	14	<0.001	<0.001	<0.001	<0.05	<0.001	7.8	<0.001	0.0025	<0.001	<0.15	9.6	<0.001	31	0.16	<0.0005	<0.005
Average	8.6	24	0.02	<0.001	8.7	<0.001	<0.001	<0.001	<0.05	<0.001	5.5	<0.001	0.0021	<0.001	<0.15	7.3	<0.001	20	0.11	<0.0005	<0.005
Median	8.6	20	0.005	<0.001	6.6	<0.001	<0.001	<0.001	<0.05	<0.001	4.5	<0.001	0.0024	<0.001	<0.15	7.0	<0.001	14	0.091	<0.0005	<0.005
HC 6 - Kimberlite: December 14 - January 11, 2005																					
Minimum	7.8	18	0.024	<0.001	8.6	<0.001	<0.001	<0.001	<0.05	<0.001	3.5	0.002	0.0066	0.0021	<0.15	2.2	<0.001	1.3	0.076	<0.0005	<0.005
Maximum	8.3	34	0.077	<0.001	16	0.003	0.001	<0.001	0.14	<0.001	6.8	0.0043	0.024	0.005	<0.15	3.4	0.001	9.3	0.14	<0.0005	<0.005
Average	8.0	26	0.056	<0.001	11	0.0017	0.001	<0.001	0.1	<0.001	4.9	0.0031	0.015	0.0034	<0.15	2.8	0.001	5.4	0.1	<0.0005	<0.005
Median	8.1	25	0.068	<0.001	10	0.001	0.001	<0.001	0.12	<0.001	4.4	0.003	0.015	0.003	<0.15	2.9	0.001	5.7	0.097	<0.0005	<0.005
HC 11 - Kimberlite: December 14 - January 11, 2005																					
Minimum	7.6	1.0	0.063	<0.001	3.7	<0.001	<0.001	<0.001	<0.05	<0.001	0.4	0.006	0.0014	<0.001	<0.15	1.1	<0.001	<0.05	0.043	0.0005	<0.005
Maximum	8.0	5.0	0.099	0.001	4.8	<0.001	<0.001	0.002	<0.05	<0.001	0.6	0.042	0.0026	<0.001	<0.15	2.1	<0.001	2.4	0.049	0.026	<0.005
Average	7.8	3.8	0.081	0.001	4.2	<0.001	<0.001	0.0013	<0.05	<0.001	0.51	0.029	0.0021	<0.001	<0.15	1.7	<0.001	1.1	0.046	0.017	<0.005
Median	7.7	5.0	0.08	0.001	4.0	<0.001	<0.001	0.001	<0.05	<0.001	0.54	0.04	0.0023	<0.001	<0.15	2.0	<0.001	0.96	0.047	0.024	<0.005

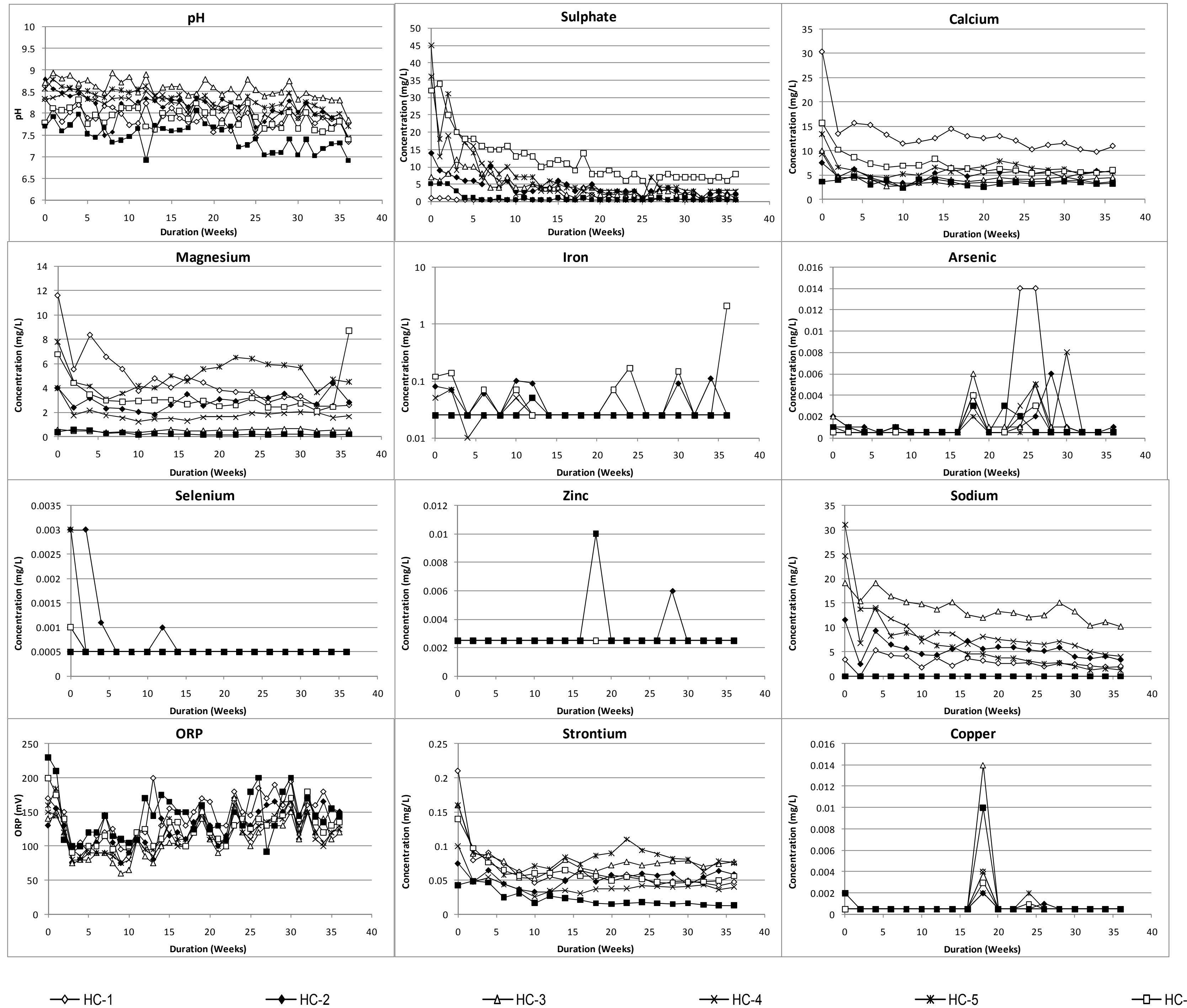
mg/L = milligrams per litre; < = less than

Table 8.II-11b Steady State Concentrations of Select Parameters in Kimberlite Humidity Cell Leachates

	pH	SO4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Steady State																					
HC 1 - Kimberlite: July 26 - August 23, 2005																					
Minimum	7.4	<1	<0.005	<0.001	9.8	<0.001	<0.001	<0.001	<0.05	<0.001	2.5	<0.001	<0.0005	<0.001	<0.15	5.7	<0.001	1.9	0.042	<0.0005	<0.005
Maximum	7.9	1.0	<0.005	<0.001	11	<0.001	<0.001	<0.001	<0.05	<0.001	2.6	0.001	<0.0005	<0.001	<0.15	6.7	<0.001	2.1	0.047	<0.0005	<0.005
Average	7.7	1.0	<0.005	<0.001	10	<0.001	<0.001	<0.001	<0.05	<0.001	2.5	0.001	<0.0005	<0.001	<0.15	6.4	<0.001	2.0	0.045	<0.0005	<0.005
Median	7.9	1.0	<0.005	<0.001	10	<0.001	<0.001	<0.001	<0.05	<0.001	2.5	0.001	<0.0005	<0.001	<0.15	6.7	<0.001	2.0	0.045	<0.0005	<0.005
HC 2 - Kimberlite: July 26 - August 23, 2005																					
Minimum	7.4	<1	0.006	<0.001	5.3	<0.001	<0.001	<0.001	<0.05	<0.001	2.7	<0.001	<0.0005	<0.001	<0.15	2.0	<0.001	3.3	0.055	<0.0005	<0.005
Maximum	8.0	3.0	0.26	0.001	5.8	0.001	<0.001	<0.001	0.11	<0.001	4.4	0.003	<0.0005	0.012	<0.15	2.1	<0.001	4.0	0.064	<0.0005	<0.005
Average	7.8	2.0	0.092	0.001	5.6	0.001	<0.001	<0.001	0.07	<0.001	3.3	0.0017	<0.0005	0.0047	<0.15	2.0	<0.001	3.7	0.059	<0.0005	<0.005
Median	7.9	2.0	0.011	0.001	5.6	0.001	<0.001	<0.001	0.05	<0.001	2.8	0.001	<0.0005	0.001	<0.15	2.0	<0.001	3.7	0.059	<0.0005	<0.005
HC 3 - Hypabyssal Kimberlite: July 26 - August 23, 2005																					
Minimum	7.9	1.0	<0.005	<0.001	4.1	<0.001	<0.001	<0.001	<0.05	<0.001	0.47	<0.001	<0.0005	<0.001	<0.15	7.8	<0.001	10	0.07	<0.0005	<0.005
Maximum	8.4	2.0	<0.005	<0.001	4.5	<0.001	<0.001	<0.001	<0.05	<0.001	0.53	<0.001	<0.0005	<0.001	<0.15	7.8	<0.001	11	0.077	<0.0005	<0.005
Average	8.2	1.2	<0.005	<0.001	4.3	<0.001	<0.001	<0.001	<0.05	<0.001	0.51	<0.001	<0.0005	<0.001	<0.15	7.8	<0.001	11	0.074	<0.0005	<0.005
Median	8.3	1.0	<0.005	<0.001	4.3	<0.001	<0.001	<0.001	<0.05	<0.001	0.52	<0.001	<0.0005	<0.001	<0.15	7.8	<0.001	10	0.074	<0.0005	<0.005
HC 4 - Tuffisitic Kimberlite Breccia: July 26 - August 23, 2005																					
Minimum	7.5	<1	0.025	<0.001	3.3	<0.001	<0.001	<0.001	<0.05	<0.001	1.6	<0.001	0.0008	<0.001	<0.15	1.4	<0.001	4.0	0.036	<0.0005	<0.005
Maximum	8.0	2.0	0.081	<0.001	4.1	<0.001	<0.001	<0.001	<0.05	<0.001	2.0	0.001	0.0011	0.002	<0.15	1.7	<0.001	5.0	0.043	<0.0005	<0.005
Average	7.7	1.2	0.047	<0.001	3.7	<0.001	<0.001	<0.001	<0.05	<0.001	1.7	0.001	0.00097	0.0013	<0.15	1.5	<0.001	4.5	0.04	<0.0005	<0.005
Median	7.8	1.0	0.035	<0.001	3.7	<0.001	<0.001	<0.001	<0.05	<0.001	1.7	0.001	0.001	0.001	<0.15	1.5	<0.001	4.4	0.04	<0.0005	<0.005
HC 5 - Kimberlite: July 26 - August 23, 2005																					
Minimum	7.7	1.0	<0.005	<0.001	5.1	<0.001	<0.001	<0.001	<0.05	<0.001	3.7	<0.001	<0.0005	<0.001	<0.15	3.8	<0.001	1.3	0.063	<0.0005	<0.005
Maximum	8.2	3.0	0.013	<0.001	5.7	<0.001	<0.001	<0.001	<0.05	<0.001	4.7	<0.001	<0.0005	<0.001	<0.15	4.3	<0.001	1.6	0.078	<0.0005	<0.005
Average	7.9	2.6	0.0077	<0.001	5.5	<0.001	<0.001	<0.001	<0.05	<0.001	4.3	<0.001	<0.0005	<0.001	<0.15	4.1	<0.001	1.4	0.072	<0.0005	<0.005
Median	8.0	3.0	0.005	<0.001	5.6	<0.001	<0.001	<0.001	<0.05	<0.001	4.5	<0.001	<0.0005	<0.001	<0.15	4.2	<0.001	1.3	0.075	<0.0005	<0.005
HC 6 - Kimberlite: July 26 - August 23, 2005																					
Minimum	7.4	6.0	0.011	<0.001	5.5	<0.001	<0.001	<0.001	<0.05	<0.001	2.1	0.001	<0.0005	<0.001	<0.15	2.8	<0.001	0.92	0.048	<0.0005	<0.005
Maximum	7.8	8.0	1.7	<0.001	6.0	0.02	0.008	<0.001	2.1	<0.001	8.7	0.016	<0.0005	0.078	<0.15	2.9	<0.001	1.3	0.056	<0.0005	<0.005
Average	7.6	6.8	0.57	<0.001	5.7	0.0073	0.0033	<0.001	0.74	<0.001	4.4	0.0063	<0.0005	0.027	<0.15	2.8	<0.001	1.1	0.051	<0.0005	<0.005
Median	7.6	7.0	0.039	<0.001	5.6	0.001	0.001	<0.001	0.05	<0.001	2.5	0.002	<0.0005	0.003	<0.15	2.8	<0.001	1.2	0.05	<0.0005	<0.005
HC 11 - Kimberlite: July 26 - August 23, 2005																					
Minimum	6.9	<1	0.059	<0.001	3.2	<0.001	<0.001	<0.001	<0.05	<0.001	0.19	0.004	<0.0005	<0.001	<0.15	0.3	<0.001	<0.05	0.013	0.004	<0.005
Maximum	7.3	<1	0.065	<0.001	3.5	<0.001	<0.001	<0.001	<0.05	<0.001	0.21	0.008	<0.0005	<0.001	<0.15	0.4	<0.001	0.09	0.014	0.0047	<0.005
Average	7.1	<1	0.062	<0.001	3.3	<0.001	<0.001	<0.001	<0.05	<0.001	0.2	0.006	<0.0005	<0.001	<0.15	0.37	<0.001	0.073	0.013	0.0044	<0.005
Median	7.2	<1	0.063	<0.001	3.3	<0.001	<0.001	<0.001	<0.05	<0.001	0.2	0.006	<0.0005	<0.001	<0.15	0.4	<0.001	0.08	0.013	0.0046	<0.005

mg/L = milligrams per litre; < = less than

Figure 8.II-4 Leachate Concentrations in Kimberlite Humidity Cells



Note: TDS not measured in humidity cell test leachates.

Table 8.II-12 Estimated Acid Potential and Neutralizing Potential Depletion Times for Kimberlite Humidity Cells

Humidity Cell ID	Lithology	Sulphide Sulphur (wt. %)	NP (kg $CaCO_3$/t)	Time to Depletion (Years)				
				Sulphide Sulphur	NP (emp)	CaNP (emp)	NP (SO_4)	CaNP (SO_4)
HC 1	Kimberlite	0.02	326	40	331	20	14954	909
HC 2	Kimberlite	0.02	188	11	151	5.0	2716	102
HC 3	Hypabyssal Kimberlite	0.01	442	7.8	192	4.6	7119	194
HC 4	Tuffisitic Kimberlite Breccia	0.02	148	23	131	3.9	3940	138
HC 5	Kimberlite	0.01	422	2.5	168	2.1	2483	42
HC 6	Kimberlite	0.04	52	6.2	111	16	406	60
HC 11	Kimberlite	0.05	4.1	120	34	3.2	464	52

wt % = percent by weight; kg/t = kilograms per tonne.

8.II.4.1.5 Column Tests

Tables 8.II-13a and 8.II-13b contain a summary of the column leachate concentrations for selected parameters. Results are presented for both the first flush (the first five weeks) in Table 8.II-13a and steady state conditions (the last five weeks) in Table 8.II-13b. Figure 8.II-5 presents the concentrations of key parameters, pH values and ORP values in the column leachates. Attachment 8.II.9 provides the detailed results.

The principal observations with respect to the kimberlite columns are as follows:

- Neutral to alkaline pH values were maintained through the duration of the kimberlite kinetic tests and pH values remained generally stable over time.
- The sulphate concentrations decreased after the first five weeks in kimberlite column leachates. Concentrations were typically less than 20 milligrams per litre (mg/L) after week ten.
- Concentrations of major ions including magnesium and calcium generally decreased over time after five weeks. Sodium concentrations in leachates decreased gradually over time during testing.
- Key metal concentrations including selenium, zinc and iron were below the detection limits in many samples. Arsenic concentrations generally increased over time.

Table 8.II-13a First Flush Concentrations of Select Parameters in Kimberlite Column Leachates

	pH	SO_4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Column 5 - Kimberlite: Jan 31, 2005 - Feb 28, 2005																					
Minimum	7.3	122	<0.005	0.002	34	<0.001	<0.001	<0.001	<0.05	<0.001	15	0.004	0.049	0.013	<0.15	11	0.002	50	0.41	0.021	<0.005
Maximum	8.5	1252	0.019	0.005	422	<0.001	0.009	0.003	0.15	<0.001	148	0.078	0.25	0.087	<0.15	29	0.017	146	4.6	0.026	<0.005
Average	7.7	531	0.01	0.003	170	<0.001	0.004	0.0017	0.083	<0.001	62	0.03	0.14	0.04	<0.15	18	0.0073	86	1.9	0.023	<0.005
Median	8.3	218	0.006	0.002	54	<0.001	0.002	0.001	0.05	<0.001	22	0.007	0.13	0.019	<0.15	14	0.003	63	0.65	0.021	<0.005
Column 7 - Kimberlite: Jan 31, 2005 - Feb 28, 2005																					
Minimum	7.9	100	<0.005	0.013	25	<0.001	<0.001	<0.001	<0.05	<0.001	14	<0.001	0.023	0.004	<0.15	17	<0.001	28	0.28	<0.0005	<0.005
Maximum	8.0	308	0.029	0.022	74	0.001	<0.001	0.001	0.11	<0.001	43	0.004	0.044	0.012	<0.15	23	0.003	45	0.81	<0.0005	<0.005
Average	8.0	181	0.013	0.017	45	0.001	<0.001	0.001	0.07	<0.001	25	0.002	0.032	0.0073	<0.15	20	0.0017	35	0.49	<0.0005	<0.005
Median	8.0	134	0.005	0.017	35	0.001	<0.001	0.001	0.05	<0.001	19	0.001	0.029	0.006	<0.15	19	0.001	32	0.38	<0.0005	<0.005
Column 8 - Kimberlite: Jan 31, 2005 - Feb 28, 2005																					
Minimum	7.8	310	<0.005	0.002	34	<0.001	<0.001	<0.001	<0.05	<0.001	13	0.005	0.54	0.005	<0.15	6.6	0.002	80	0.52	0.0008	<0.005
Maximum	7.9	1647	0.009	0.003	334	<0.001	0.001	0.002	0.2	<0.001	115	0.021	2.2	0.019	<0.15	18	0.019	242	5.2	0.0071	<0.005
Average	7.9	858	0.0063	0.0023	157	<0.001	0.001	0.0013	0.1	<0.001	54	0.012	1.3	0.013	<0.15	12	0.0083	153	2.4	0.0031	<0.005
Median	7.8	617	0.005	0.002	104	<0.001	0.001	0.001	0.06	<0.001	36	0.009	1.1	0.014	<0.15	12	0.004	138	1.6	0.0014	<0.005
Column 9 - Kimberlite: Jan 31, 2005 - Feb 28, 2005																					
Minimum	8.2	72	<0.005	0.016	14	<0.001	<0.001	<0.001	<0.05	<0.001	2.9	<0.001	0.012	<0.001	<0.15	18	0.003	38	0.21	<0.0005	<0.005
Maximum	8.2	273	0.008	0.044	78	0.003	<0.001	<0.001	<0.05	<0.001	17	0.002	0.043	0.002	<0.15	36	0.016	80	1.3	<0.0005	<0.005
Average	8.2	157	0.006	0.031	39	0.002	<0.001	<0.001	<0.05	<0.001	8.4	0.0013	0.027	0.0013	<0.15	26	0.0077	55	0.61	<0.0005	<0.005
Median	8.2	125	0.005	0.032	24	0.002	<0.001	<0.001	<0.05	<0.001	4.8	0.001	0.027	0.001	<0.15	24	0.004	48	0.38	<0.0005	<0.005
Column 10 - Kimberlite: Jan 31, 2005 - Feb 28, 2005																					
Minimum	8.4	3.0	0.009	0.001	2.7	0.001	<0.001	<0.001	<0.05	<0.001	0.06	<0.001	0.0005	<0.001	<0.15	20	<0.001	125	1.9	<0.0005	<0.005
Maximum	8.9	4.0	0.009	0.002	6.6	0.001	<0.001	<0.001	<0.05	<0.001	0.18	<0.001	0.001	<0.001	<0.15	35	<0.001	238	3.4	<0.0005	<0.005
Average	8.6	3.3	0.009	0.0013	4.4	0.001	<0.001	<0.001	<0.05	<0.001	0.12	<0.001	0.0007	<0.001	<0.15	27	<0.001	175	2.5	<0.0005	<0.005
Median	8.7	3.0	0.009	0.001	3.9	0.001	<0.001	<0.001	<0.05	<0.001	0.13	<0.001	0.0006	<0.001	<0.15	26	<0.001	161	2.2	<0.0005	<0.005

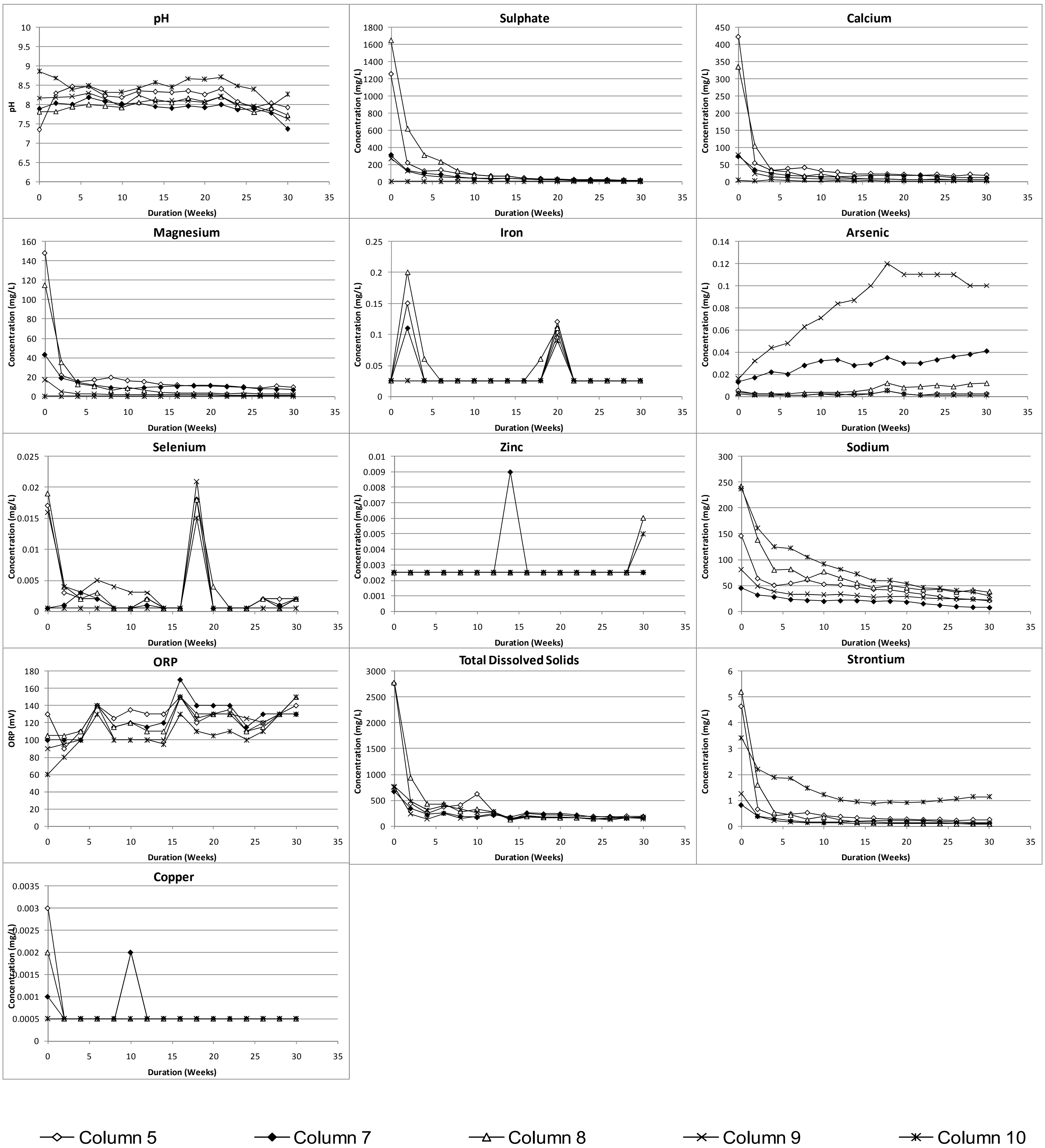
mg/L = milligrams per litre; < = less than; s.u. = standard unit.

Table 8.II-13b First Flush Concentrations of Select Parameters in Kimberlite Column Leachates

	pH	SO_4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Column 5 - Kimberlite: Aug 1, 1005 - Aug 29, 2005																					
Minimum	7.9	15	<0.005	0.002	17	<0.001	<0.001	<0.001	<0.05	<0.001	8.5	<0.001	0.0073	0.004	<0.15	8.4	0.002	20	0.22	0.015	<0.005
Maximum	8.0	22	0.011	0.002	22	<0.001	<0.001	<0.001	<0.05	<0.001	11	<0.001	0.0091	0.006	<0.15	9.7	0.002	24	0.25	0.021	<0.005
Average	8.0	19	0.007	0.002	19	<0.001	<0.001	<0.001	<0.05	<0.001	9.4	<0.001	0.0083	0.005	<0.15	9.2	0.002	22	0.24	0.018	<0.005
Median	7.9	19	0.005	0.002	19	<0.001	<0.001	<0.001	<0.05	<0.001	9.3	<0.001	0.0085	0.005	<0.15	9.6	0.002	23	0.25	0.018	<0.005
Column 7 - Kimberlite: Aug 1, 1005 - Aug 29, 2005																					
Minimum	7.4	13	<0.005	0.036	12	<0.001	<0.001	<0.001	<0.05	<0.001	6.8	<0.001	0.0014	<0.001	<0.15	17	0.001	7.3	0.12	<0.0005	<0.005
Maximum	7.9	17	<0.005	0.041	12	<0.001	<0.001	<0.001	<0.05	<0.001	7.3	<0.001	0.0019	<0.001	<0.15	19	0.002	9.4	0.14	<0.0005	<0.005
Average	7.6	15	<0.005	0.038	12	<0.001	<0.001	<0.001	<0.05	<0.001	7.1	<0.001	0.0017	<0.001	<0.15	18	0.0017	8.2	0.13	<0.0005	<0.005
Median	7.8	15	<0.005	0.038	12	<0.001	<0.001	<0.001	<0.05	<0.001	7.3	<0.001	0.0017	<0.001	<0.15	18	0.002	7.9	0.13	<0.0005	<0.005
Column 8 - Kimberlite: Aug 1, 1005 - Aug 29, 2005																					
Minimum	7.7	10	0.025	0.009	5.9	<0.001	<0.001	<0.001	<0.05	<0.001	2.4	<0.001	0.11	<0.001	<0.15	3.3	<0.001	37	0.084	0.0007	<0.005
Maximum	7.9	14	0.06	0.012	6.3	<0.001	<0.001	<0.001	<0.05	<0.001	2.6	<0.001	0.12	0.002	<0.15	3.6	0.002	41	0.094	0.001	0.006
Average	7.8	12	0.039	0.011	6.0	<0.001	<0.001	<0.001	<0.05	<0.001	2.5	<0.001	0.12	0.0013	<0.15	3.5	0.0017	39	0.089	0.0008	0.0053
Median	7.8	12	0.033	0.011	5.9	<0.001	<0.001	<0.001	<0.05	<0.001	2.4	<0.001	0.12	0.001	<0.15	3.6	0.002	38	0.09	0.0007	0.005
Column 9 - Kimberlite: Aug 1, 1005 - Aug 29, 2005																					
Minimum	7.6	12	<0.005	0.1	5.1	0.002	<0.001	<0.001	<0.05	<0.001	1.1	<0.001	0.0007	<0.001	<0.15	11	<0.001	22	0.077	<0.0005	<0.005
Maximum	8.0	17	<0.005	0.11	5.6	0.003	<0.001	<0.001	<0.05	<0.001	1.3	<0.001	0.001	<0.001	<0.15	12	0.002	24	0.091	<0.0005	<0.005
Average	7.8	15	<0.005	0.1	5.3	0.0023	<0.001	<0.001	<0.05	<0.001	1.2	<0.001	0.00083	<0.001	<0.15	12	0.0013	23	0.083	<0.0005	<0.005
Median	7.8	15	<0.005	0.1	5.2	0.002	<0.001	<0.001	<0.05	<0.001	1.3	<0.001	0.0008	<0.001	<0.15	11	0.001	23	0.082	<0.0005	<0.005
Column 10 - Kimberlite: Aug 1, 1005 - Aug 29, 2005																					
Minimum	8.0	3.0	0.006	0.001	2.4	<0.001	<0.001	<0.001	<0.05	<0.001	<0.05	<0.001	<0.0005	<0.001	<0.15	13	<0.001	30	1.1	<0.0005	<0.005
Maximum	8.4	6.0	0.007	0.001	3.0	<0.001	<0.001	<0.001	<0.05	<0.001	<0.05	<0.001	<0.0005	<0.001	<0.15	13	<0.001	40	1.1	<0.0005	0.005
Average	8.2	4.3	0.0067	0.001	2.6	<0.001	<0.001	<0.001	<0.05	<0.001	<0.05	<0.001	<0.0005	<0.001	<0.15	13	<0.001	36	1.1	<0.0005	0.005
Median	8.3	4.0	0.007	0.001	2.4	<0.001	<0.001	<0.001	<0.05	<0.001	<0.05	<0.001	<0.0005	<0.001	<0.15	13	<0.001	37	1.1	<0.0005	0.005

mg/L = milligrams per litre; < = less than; s.u. = standard unit.

Figure 8.II-5 Leachate concentrations in Kimberlite Columns



8.II.4.1.6 Comparison with Other Kimberlites

Table 8.II-14 presents a range of kimberlite kinetic test results from the seven Project kimberlite humidity cells, two Diavik Diamond Mine kimberlite humidity cell samples, five Snap Lake Mine humidity cell samples, and five Ekati Mine kimberlite humidity cell samples (Golder 2002).

The first Diavik Diamond Mine sample is a volcaniclastic kimberlite representative of the bulk of the kimberlite material at the Diavik Diamond Mine site. The second Diavik Diamond Mine sample represents a kimberlite rich material with mudstone xenoliths. The five Ekati Diamond Mine samples represent kimberlites from a number of different pipes. Results presented for the Project, Snap Lake Mine and Ekati Diamond Mine are the minimum and maximum (e.g., range) of the average values from the numerous humidity cells. The average was calculated using the steady state (last 5 measurements) concentrations.

The results suggest that the Project kimberlite kinetic leaching results are most similar to Snap Lake Mine samples and somewhat similar to Ekati Diamond Mine. The Project kimberlite results are the least similar to Diavik Diamond Mine kimberlite. Leachate pH values from all the projects were neutral to alkaline with the exception of mudstone rich kimberlite at Diavik Diamond Mine. Concentrations of aluminum, cobalt, chromium, and iron were similar between the current project and Ekati Diamond Mine; both of which were greater relative to Snap Lake Mine and less than Diavik Diamond Mine. Nickel and molybdenum concentrations were greater at Ekati Mine and Snap Lake Mine compared to the Project. While copper and zinc concentrations for the current project were less than at Ekati Diamond Mine and Diavik Diamond Mine, the higher detection limit hinders comparison with Snap Lake Mine

Table 8.II-14 Comparison of Selected Parameters at Steady State for Kimberlite Humidity Cells

Parameter	Units	Gahcho Kué Project (n=7)	Snap Lake Mine (n=5)	Diavik Diamond Mine		Range in Ekati Mine Samples (n=5)
				Stage 1 Kimberlite (n=1)	Stage 1 Mudstone (n=1)	
Total sulphur	wt %	0.02 to 0.05	0.05 to 0.15	0.42	3.5	0.001 to 0.7
NP/AP		4.1 to 442	8.2 to 363	6.5	0.38	7.7 to 14,496
pH		6.91 to 8.37	8.0 to 8.02	8.38	3.5	8.0 to 10.8
Sulphate	mg/L	<1 to 8.0	3.8 to 27.2	691	8,765	3.2 to 48.0
Aluminum	mg/L	<0.005 to 1.7	0.003 to 0.016	<0.001	69.7	0.009 to 0.22
Cobalt	µg/L	<1 to 8.0	0.19 to 0.54	3.1	2,713	0.12 to 0.54
Chromium	µg/L	<1 to 2.82	0.33 to 1.5	1	27.3	1.7 to 3.9
Copper	µg/L	<1-20	0.3 to 1.7	4.2	217	3.5 to 9.5
Iron	mg/L	<0.05 to 2.12	<0.01 to 0.05	<0.01	0.39	0.0023 to 0.3
Potassium	µg/L	30 to 780	3.9 to 837	-	-	4.4 to 15.6
Manganese	µg/L	<1 to 16	1.6 to 5.0	9.3	23,700	0.62 to 8.2
Molybdenum	µg/L	<0.5 to 1.1	2.8 to 13.3	131	0.2	1.1 to 13.7
Nickel	µg/L	<1 to 78	1.7 to 51	3.7	19,500	1.6 to 15
Zinc	µg/L	<5	0.25 to 1.58	3.4	11,600	4.6 to 22

Source: Golder 2002.

wt % = percent by weight; mg/L = milligrams per litre; µg/L = micrograms per litre; < = less than.

8.II.4.2 PROCESSED KIMBERLITE

The processing of kimberlite material is largely a mechanical process with few reagents. Processing of kimberlite involves four principle steps (AMEC 2008): multiple stages of crushing, scrubbing and screening, diamond recovery and disposal of reject material. PK is the residual material that remains after processing of the raw kimberlite ore. Samples of PK and process water were provided for geochemical testing by De Beers.

8.II.4.2.1 Static Testing

8.II.4.2.1.1 Mineralogical Analysis

In 2004, 12 coarse PK samples were submitted for optical mineralogy and XRD analysis (Petrascience 2004 – Attachment 8.II.3). Results showed that the samples were dominated by kimberlitic material, typically pervasively altered to a very fine-grained assemblage of clays, including vermiculite, chlinochlore, phlogopite and talc with minor (1% – 10%) actinolite, orthoclase [$KAlSi_3O_8$], quartz, hematite [Fe_2O_3] and lizardite [$Mg_3Si_2O_5$]. Carbonate concentrations range from 1.3 to 3.1%, consisting primarily of calcite [$CaCO_3$]. According to the mineralogical report, sulphide minerals are extremely rare in the samples (less than 2%) and mostly consist of pyrite with lesser chalcopyrite and trace pyrrhotite. A detailed mineralogy summary is reported in Table 8.II-15.

In 2010, two PK samples (fine and coarse) were submitted for XRD analysis (CEMI 2010 – Attachment 8.II.3). Similar to 2004 results, 2010 results showed that the coarse PK sample was dominated by clays, including montmorillonite (27%) [$(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2{\cdot}nH_2O$], talc (12%) and biotite (13%), with 11% quartz, 13% plagioclase [$NaAlSi_3O_8$ – $CaAl_2Si_2O_8$] and minor (1% - 10%) lizardite, potassium feldspar, diopside [$CaMgSi_2O_6$], magnetite [Fe_3O_4] and forsterite [Mg_2SiO_4] (Table 8.II-13). The coarse PK contains 1.3% carbonates, including 0.4% calcite and 0.9% dolomite. The presence of sulphide minerals was not observed.

The fine PK sample was dominated by montmorillonite (50%) with 11% talc, and minor (1% - 10%) biotite, lizardite, potassium feldspar, plagioclase, quartz, diopside, magnetite and forsterite (Table 8.II-13). Carbonate mineral concentrations are higher than those reported in the coarse PK in the same year, and include calcite (0.8%) and dolomite (1.4%) [$(Ca,Mg)CO_3$]. The presence of sulphide minerals was not observed.

Table 8.II-15 Summary of Gahcho Kué Project Processed Kimberlite Mineralogy

	Mineral	Formula	Mineral Composition (%)													
			Coarse Processed Kimberlite													Fine Processed Kimberlite
			2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2010	2010
			I-3	I-4	II-10	II-12	II-13	II-17	II-18	III-1	IV1+ IV2	V1+V2	VI-1	VIII-1	PK-Coarse Composite	PK-Fines Composite
Semi-quantitative XRD	Montmorillonite model	$(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2 \cdot nH_2O$													27	50
	Vermiculite 2M	$(Mg,Fe,Al)_3(Al,Si)_4O_{10}(OH)$	26	25	28	29	26	27	24	20	19	17	20	20		
	Clinochlore II	$(Mg_5Al)(AlSi_3)O_{10}(OH)_8$	26	25	31	27	34	21	25	28	30	31	24	31		
	Phlogopite 1M	$KMg_3AlSi_3O_{10}(F,OH)_2$	5.9	6.1	8.9	5.4	8.8	8.1	13	11	11	11	9.5	13		
	Biotite	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$													13	9.3
	Actinolite	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$	4.9	4.2		2.2				2.7			4.7			
	Pectolite 1A	$NaCa_2Si_3O_8(OH)$												0.8		
	Natrolite	$Na_2Al_2Si_3O_{10}$														
	Talc 1A	$Mg_3Si_4O_{10}$	28	28	19	22	26	22	22	19	16	17	19	11	12	11
	Lizardite	$Mg_3Si_2O_5$	?	?	5.4			15	10	9.2	11	11	8.9	13	5.4	4.1
	Diopside	$CaMgSi_2O_6$													1.9	1.7
	Monticellite	$CaMgSiO_4$							97							
	Forsterite	Mg_2SiO_4							1.0	2.5	4.1	4.0	2.2	4.8	4.2	2.4
	Plagioclase	$NaAlSi_3O_8 - CaAl_2Si_2O_8$													13	6.4
	K-Feldspar	$KAlSi_3O_8$													8.8	6.6
	Microcline intermediate	$KAlSi_3O_8$				7.7										
	Orthoclase	$KAlSi_3O_8$	4.5	4.5	4.7		3.1	3.1	1.7	2.6	3.0	3.9	3.7	2.8		
	Quartz	SiO_2	3.3	4.2	1.6	2.9		1.3		2.0	2.5	2.3	4.3	1.0	11	5.1
	Magnetite	Fe_3O_4													1.3	1.1
	Hematite	Fe_2O_3				3.5					0.5	0.4	0.3			
	Dolomite	$(Ca,Mg)CO_3$	0.9	1.1	0.2	0.3	0.3	2.1	0	0.4	1.2	0.4	0.9		0.9	1.4
	Calcite	$CaCO_3$	1.8	1.8	1.4	1.0	1.0	0.8	1.9	2.0	1.9	2.3	2.1	2.1	0.4	0.8
	Perovskite	$CaTiO_3$														
	Rutile	TiO_2					1.0		0.5	0.6		0.4	0.8	0.6		
	Anatase	TiO_2							0.7							
	Titanite	$CaTiSiO_5$														
	Jarosite	$K_2Fe_6^{3+}(SO_4)_4(OH)_{12}$													0.4	0.5
	TOTAL		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 8.II-15 Summary of Gahcho Kué Project Processed Kimberlite Mineralogy (continued)

Mineral	Formula	Mineral Composition (%)													
		Coarse Processed Kimberlite													Fine Processed Kimberlite
		2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2004	2010	2010
		I-3	I-4	II-10	II-12	II-13	II-17	II-18	III-1	IV1+ IV2	V1+V2	VI-1	VIII-1	PK-Coarse Composite	PK-Fines Composite
Mineral Phases Observed in Optical Microscopy		**Major:** Groundmass, chlorite [(Fe,Mg,Al)$_6$(Si,Al)$_4$O$_{10}$(OH)$_8$], talc, K-feldspar, biotite **Minor:** Carbonate **Trace:** Quartz, magnetite, pyrrhotite [FeS$_{(1-x)}$], rutile, hematite	**Major:** Groundmass, chlorite, serpentine, K-feldspar, biotite **Minor:** Carbonate, hematite **Trace**: Amphibole [Ca$_2$(Fe,Mg)$_5$Si$_8$O$_{22}$(OH)$_2$], quartz, magnetite, rutile, chalcopyrite [CuFeS$_2$]	**Major:** Groundmass, biotite, serpentine, chlorite **Minor:** K-feldspar **Trace**: Magnetite, hematite, carbonate, quartz, pyrrhotite, rutile, chalcopyrite	**Major:** Groundmass, chlorite, serpentine **Minor:** Biotite, amphibole, hematite **Trace:** Magnetite, pyrite [FeS$_2$], rutile	**Major**: Groundmass, chlorite, biotite **Minor:** K-feldspar, serpentine **Trace**: Quartz, hematite, magnetite, pyrite	**Major:** Groundmass, serpentine, biotite, chlorite **Minor**: K-feldspar, rutile, talc **Trace:** Carbonate, hematite, pyrite	**Optical mineralogy was not analyzed on this sample.**	**Major:** Groundmass, chlorite, serpentine, biotite **Minor:** Olivine, hematite, rutile, K-feldspar, carbonate, quartz, amphibole, magnetite **Trace:** Pyrrhotite, chalcopyrite, ilmenite [FeTiO$_3$]	**Major:** Groundmass, serpentine, biotite, olivine, K-feldspar, chlorite **Minor:** Rutile, carbonate **Trace:** Pyrrhotite, quartz, hematite, magnetite	**Major:** Groundmass, biotite, chlorite, serpentine, olivine, talc **Minor:** Rutile, K-feldspar, pyrite **Trace:** Carbonate, hematite, magnetite, plagioclase	**Major:** Groundmass, serpentine, biotite, chlorite, olivine **Minor**: Rutile, carbonate, talc, pyrrhotite **Trace:** Magnetite, chalcopyrite, hematite, quartz, amphibole, enargite [Cu$_3$AsS$_4$]	**Major:** Groundmass, serpentine, biotite, chlorite, olivine **Minor:** Rutile, pyrite **Trace:** Carbonate, magnetite, chalcopyrite, hematite, quartz, K-feldspar	**Optical mineralogy was not analyzed on this sample.**	**Optical mineralogy was not analyzed on this sample.**

8.II.4.2.1.2 Acid Base Accounting

Results of ABA testing for the PK are provided in Table 8.II-16 and Figures 8.II-6 to 8.II-8. Attachment 8.II.4 contains detailed ABA results.

The principal observations with respect to the ABA characteristics of PK are:

- The paste pH values of coarse PK samples ranged from 7.4 to 8.9 with an average of 8.0. The paste pH values of the fine PK were slightly higher than those in the coarse PK, ranging from 7.8 to 9.0, with an average value of 8.4.
- The coarse PK samples contained between less than 0.01% and 0.06% total sulphur, with an average total sulphur concentration of 0.03%, lower than the average reported in the kimberlites. The fine PK samples reported higher sulphur concentrations, ranging from 0.01% to 0.09%. Sulphur was primarily in the form of sulphide sulphur for both the coarse PK and fine PK (Figure 8.II-6). Sulphide sulphur concentrations in the coarse PK ranged from less than 0.01% to 0.06%, with average concentrations of 0.03%. Sulphide sulphur concentrations in the fine PK were similar to those in the coarse PK, ranging from 0.01 to 0.09%, with an average of 0.04%. The low sulphide sulphur concentrations in both the coarse and fine PK are supported by mineralogical results. AP was calculated using total sulphur.
- The neutralization potential of the coarse PK ranged from 9.4 kg to 171 kg $CaCO_3$/t, with an average value of 64 kg $CaCO_3$/t. Generally, the fine PK samples reported higher neutralization potential values, ranging from 23 kg to 249 kg $CaCO_3$/t, with an average value of 101 kg $CaCO_3$/t.
- Similar to kimberlite, NP was greater than the carbonate NP for all coarse and fine PK samples (Figure 8.II-7). On average, the carbonate NP was about one-tenth of the NP. A carbonate NP significantly lower than the neutralization potential indicates most of the neutralization potential is attributable to non-carbonate minerals.
- The NP/AP ratio for coarse PK ranged from 25 to 750, while the ratio ranged from 31 to 797 for fine PK. All fine and coarse PK samples are classified as not potentially acid generating (PAG) (Figure 8.II-8).
- The NAG-pH values of the coarse PK ranged from 5.13 to 8.72, and from 5.9 to 8.2 for the fine PK. All NAG-pH values exceeded 4.5, indicating the presence of sufficient NP to buffer the acidity generated by the complete oxidation of sulphide minerals. The results of NAG testing confirm the results of ABA, indicating both coarse PK and fine PK are non-acid generating.

Table 8.II-16 Summary of Acid Base Accounting Results from Processed Kimberlite

Sample ID	Paste pH	CO_2	Total Sulphur	Sulphate	Sulphide	AP	NP	NP/AP	CaNP	NAG-pH
		%	wt. %	wt. %	wt. %	kg $CaCO_3$/t	kg $CaCO_3$/t	kg $CaCO_3$/t	kg $CaCO_3$/t	
Fine Processed Kimberlite, n=22										
Minimum	7.8	0.42	0.01	<0.01	0.01	0.31	23	31	7.5	5.9
Maximum	9.0	0.65	0.09	0.03	0.09	2.8	249	797	40	8.2
Mean	8.4	0.51	0.047	0.011	0.038	1.2	101	139	16	7.1
Median	8.5	0.49	0.04	0.01	0.03	0.94	88	89	13	7.0
Standard Deviation	0.35	0.084	0.023	0.0061	0.024	0.73	43	171	8.0	0.71
Coarse Processed Kimberlite, n=39										
Minimum	7.4	0.11	<0.01	<0.01	<0.01	<0.3	9.4	25	2.5	5.1
Maximum	8.9	0.44	0.06	0.02	0.06	1.9	171	750	14	8.7
Mean	8.0	0.22	0.031	0.006	0.03	0.92	64	131	6.3	7.3
Median	8.0	0.21	0.03	0.005	0.03	0.94	54	56	5.0	7.4
Standard Deviation	0.34	0.072	0.015	0.0034	0.015	0.47	31	177	3.2	1.1

Note: AP (Acid Potential) was calculated using total sulphur.

% = percent; wt % = percent by weight; kg/t = kilograms per tonne; < = less than.

Figure 8.II-6 Total Sulphur Versus Sulphide Sulphur for Processed Kimberlites

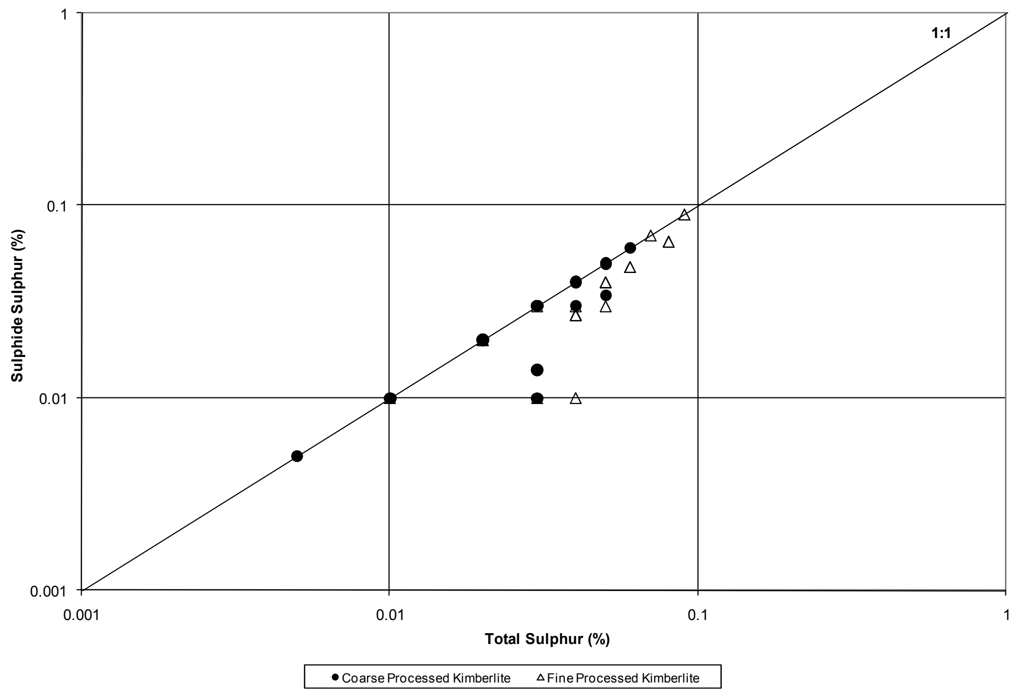


Figure 8.II-7 Total Neutralizing Potential Versus Carbonate Neutralizing Potential for Processed Kimberlites

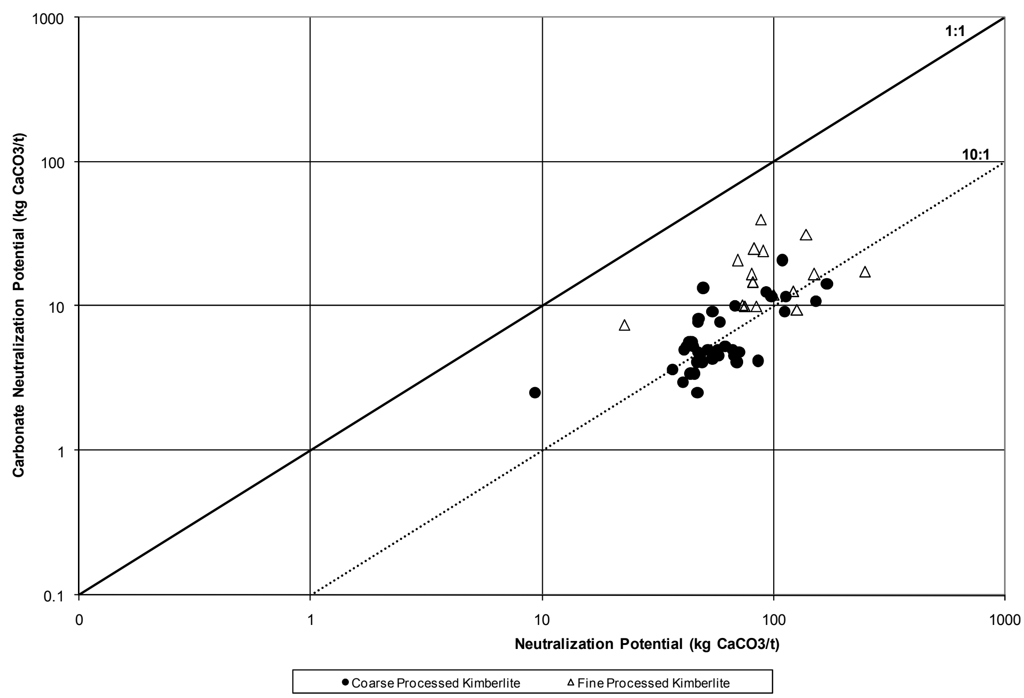
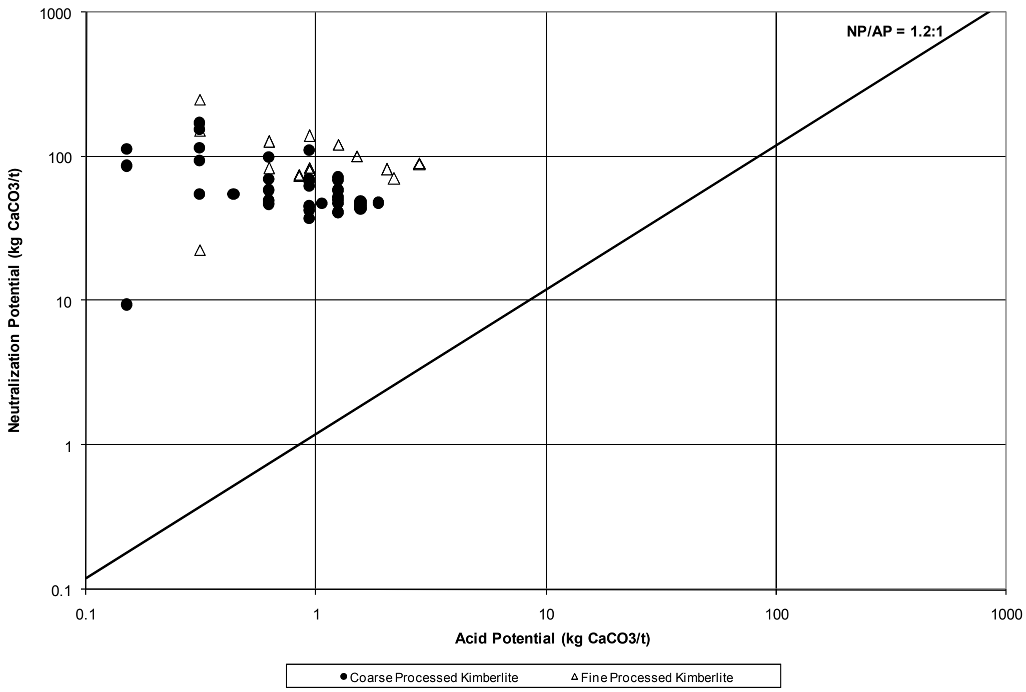


Figure 8.II-8 Acid Potential Versus Neutralizing Potential for Processed Kimberlites



8.II.4.2.2 Trace Element Chemistry

A complete record of the analytical results and a summary of the chemistry of the coarse and fine PK are provided in Attachment 8.II.5. A summary of the bulk metal results are reported in Table 8.II-18.

Results of the trace element chemistry analyses conducted on coarse PK samples indicate average concentrations of nickel (735 mg/kg), cobalt (45 mg/kg), chromium (292 mg/kg), boron (607 mg/kg) and bismuth (0.75 mg/kg) are higher when compared to average background concentrations in continental crust rock as provided in Price (1997). Bulk metal results of trace element chemistry conducted on fine PK samples indicate average concentrations of nickel (906 mg/kg), cobalt (56 mg/kg), chromium (313 mg/kg), boron (679 milligrams per gram [mg/g]) and bismuth (0.11 mg/kg), along with arsenic (7.5 mg/kg), copper (99 mg/kg), magnesium (10 mg/kg), molybdenum (6 mg/kg), antimony (0.6 mg/kg) and selenium (0.5 mg/kg) are higher when compared to average background concentrations in continental crust rock as provided in Price (1997).

Table 8.II-17 Summary of Gahcho Kué Project Processed Kimberlite Bulk Metal Results

Parameter	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	La	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Sr	Ti	Tl	U	Zn
Unit	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	%	%	ppm	%	ppm	ppm	%	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
PRICE CRUSTAL ABUNDANCE [1]	**---**	**8.23**	**1.80**	**10.00**	**---**	**0.01**	**4.15**	**3.00**	**25.00**	**102.00**	**60.00**	**5.63**	**2.09**	**20.00**	**2.33**	**950.00**	**1.20**	**2.36**	**84.00**	**0.11**	**14.00**	**0.20**	**0.05**	**370.00**	**0.57**	**0.85**	**2.70**	**70.00**
Fine Processed Kimberlite, n =																												
Minimum	0.1	0.73	1.0	96	<1	<0.1	0.44	<0.1	13	176	38	3.9	0.22	15	1.4	264	0.3	0.03	162	0.071	4.2	0.1	<0.5	34	0.061	<0.1	0.9	35
Maximum	0.9	2.3	23	1402	1.0	0.2	2.9	0.4	74	454	192	9.0	12600	62	17	942	15	0.43	1369	0.11	37	1.6	0.5	540	0.37	0.2	2.1	94
Mean	0.32	1.8	7.5	679	0.7	0.11	1.4	0.12	56	313	99	5.3	2620	33	10.0	551	6.0	0.085	906	0.064	13	0.6	0.5	248	0.19	0.13	1.3	62
Median	0.3	1.9	6.4	713	1.0	0.1	1.4	0.1	59	314	86	5.0	0.52	44	9.0	527	5.9	0.05	929	0.088	9.7	0.55	0.5	221	0.18	0.1	1.3	58
Standard Deviation	0.2	0.41	6.0	313	0	0.032	0.46	0.092	15	70	48	1.2	4286	15	3.6	183	4.6	0.089	287	0.011	10	0.49	0	119	0.1	0.045	0.25	13
Coarse Processed Kimberlite, n =																												
Minimum	0.1	0.65	<0.5	42	<1	<0.1	0.2	<0.1	4.1	94	5.2	1.3	0.2	9.8	0.68	136	0.2	0.04	21	0.046	0.8	<0.1	<0.5	15	0.042	<0.1	0.7	32
Maximum	0.4	2.7	1.3	1174	1.0	1.5	3.1	<0.1	73	637	49	5.1	1.3	91	18	980	1.3	0.32	1302	0.13	9.3	0.1	<0.5	442	0.13	0.2	1.5	55
Mean	0.22	1.8	0.84	607	1.0	0.34	1.2	<0.1	45	291	36	3.7	0.76	55	11	519	0.52	0.11	735	0.093	3.7	0.1	<0.5	272	0.09	0.12	1.1	40
Median	0.2	1.8	0.8	627	1.0	0.1	1.0	<0.1	47	285	34	3.8	0.77	53	11	503	0.5	0.1	793	0.096	3.0	0.1	<0.5	278	0.092	0.1	1.0	39
Standard Deviation	0.087	0.58	0.27	346	0	0.62	0.82	0.00	20	148	13	0.99	0.27	28	5.1	258	0.35	0.074	366	0.023	2.8	1.7E-17	0.00	135	0.024	0.044	0.25	7.0

Notes: 1) Typical crustal abundance for continental rocks taken from Price (1997).

>1 x − Concentration greater than typical crustal abundance.

>5 x − Concentration greater than 5 x the typical crustal abundance.

>10 x − Concentration greater than 10 x the typical crustal abundance.

< = less than; ppm = parts per million.

8.II.4.2.3 Shake Flask Extraction Testing

Table 8.II-18 provides the mean, median, SD, and range of values in the SFE testing of PK. Complete results are in Attachment 8.II.7. The results indicate that the pH of all leachates is alkaline (minimum value of 7.84). Mean concentrations of metals, sulphate and pH were generally similar in fine PK and coarse PK leachates. There are no established guidelines for comparison of SFE leachate results.

8.II.4.2.4 Process Water Analysis

Table 8.II-19 provides the mean, median, SD, and range of measured in process water. Process water consists of the water that was recycled through the pilot plant during the metallurgical tests conducted on each sample of kimberlite in 2010. The results of process water analysis are used to evaluate the mass load that is contributed to the fine PK slurry in water that has been recycled during processing. Complete results are in Attachment 8.II.6. Process water leachates were alkaline (minimum value of pH 7.92), with low metal and sulphate concentrations. Phosphorous concentrations varied from 0.034 to 0.089 mg/L.

Table 8.II-18 Average and Range of Values for Gahcho Kué Project Processed Kimberlite Shake Flask Extraction Tests

Parameter	pH	SO_4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
Unit	s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Fine Processed Kimberlite, n = 10																					
Minimum	8.0	5.0	0.0009	0.0006	19	<0.0005	0.000046	0.0006	<0.002	0.00003	5.3	0.0008	0.0036	0.0015	0.016	7.4	<0.00004	5.0	0.17	<0.000001	<0.001
Maximum	8.4	36	0.058	0.0062	44	0.0019	0.00035	0.0045	0.096	0.00018	16	0.014	0.064	0.01	0.059	31	0.00078	16	0.56	0.0024	0.006
Mean	8.2	16	0.017	0.0016	27	0.00093	0.00011	0.0022	0.023	0.000072	8.6	0.0036	0.025	0.0038	0.04	14	0.00021	8.7	0.3	0.00043	0.0018
Median	8.2	17	0.0066	0.001	25	0.0009	0.000077	0.002	0.016	0.000055	8.3	0.0029	0.018	0.0029	0.04	12	0.00018	7.9	0.28	0.00015	0.001
Standard Deviation	0.13	8.8	0.021	0.0017	7.1	0.00043	0.00011	0.0012	0.03	0.000048	3.0	0.0038	0.019	0.0027	0.014	7.0	0.00023	3.4	0.11	0.00082	0.0022
Coarse Processed Kimberlite, n = 10																					
Minimum	7.8	<1	0.0012	0.0005	8.1	<0.0005	0.000015	0.0007	<0.002	<0.00002	2.0	0.0003	0.0008	0.0003	<0.009	5.0	<0.00004	3.9	0.07	<0.000001	<0.001
Maximum	8.4	31	0.2	0.0034	50	0.0023	0.00056	0.0038	0.31	0.00006	25	0.003	0.027	0.0098	0.03	26	0.0011	41	0.88	0.0011	0.001
Mean	8.1	9.6	0.036	0.0016	18	0.00082	0.00013	0.0016	0.044	0.000032	8.3	0.0014	0.0079	0.0032	0.016	11	0.0003	19	0.28	0.00021	0.001
Median	8.1	5.0	0.0098	0.001	14	0.0006	0.000076	0.0013	0.013	0.00003	6.9	0.00095	0.0048	0.0023	0.011	9.5	0.00024	17	0.18	0.000033	0.001
Standard Deviation	0.18	11	0.062	0.001	12	0.00066	0.00016	0.001	0.11	0.000016	6.6	0.00099	0.0079	0.0026	0.0087	6.9	0.00029	13	0.26	0.00038	0

mg/L = milligrams per litre; < = less than; s.u. = standard unit.

Table 8.II-19 Average and Range of Values for Gahcho Kué Project Process Water Quality

Parameter	pH	SO_4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
Units	s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Process Water Quality, n=9																					
Minimum	7.9	16	0.005	0.0011	23	0.0021	0.00004	0.0014	0.001	<0.00002	3.0	0.0001	0.0033	0.0004	0.034	5.0	0.00014	3.9	0.13	0.00004	<0.001
Maximum	8.8	23	0.043	0.0016	30	0.0041	0.00011	0.0024	<0.002	0.00008	4.0	0.0075	0.0038	0.0021	0.089	7.8	0.00019	6.1	0.16	0.00023	<0.001
Average	8.4	20	0.013	0.0014	26	0.0027	0.00006	0.0018	0.0058	0.00003	3.6	0.0012	0.0036	0.0008	0.072	6.0	0.00016	4.9	0.14	0.00016	<0.001
Median	8.5	20	0.008	0.0014	27	0.0026	0.00005	0.0016	0.005	0.00003	3.7	0.0005	0.0036	0.0006	0.078	5.7	0.00016	4.7	0.14	0.00017	<0.001
Standard Deviation	0.28	2.7	0.012	0.0001	2.3	0.0007	0.00002	0.0003	0.0035	0.00002	0.30	0.0024	0.0002	0.0006	0.018	0.95	0.00002	0.62	0.010	0.00007	0

mg/L = milligrams per litre; < = less than; s.u. = standard unit.

8.II.4.2.5 Kinetic Testing

8.II.4.2.5.1 Humidity Cells

Attachment 8.II.8 provides detailed results of PK humidity cell tests. Figure 8.II-9 presents the concentrations of key parameters and pH values of the PK humidity cells. Tables 8.II-20a and 8.II-20b contain a summary of the average leachate chemistry for selected parameters from the standard humidity cells. Results are presented for both the first flush (the first five weeks) in Table 8.II-20a and steady state conditions (the last five weeks) in Table 8.II-20b. PK humidity cell testing was conducted on five cells in 2005. PK humidity cell tests initiated in 2010 are ongoing. The principal observations with respect to the PK humidity cell tests are:

- The humidity cell test results for coarse PK and fine PK are similar to the kimberlite humidity cell test results.
- PK humidity cell leachates were neutral to alkaline (Figure 8.II-9). The pH values of humidity cell 22 were less than the alkaline pH values from the other six humidity cells, but still neutral and likely results from different carbonate and silicate minerals contributing to the buffering capacity. ”Coarse PK composite (HC 1)” reported slightly more acidic pH values in the first flush (7.67 to 7.82) than the PK fine samples analyzed in 2005 and 2010 (7.8 to 9.3).
- Sulphide oxidation, as measured by the amount of sulphate in leachate, is very low with stable concentrations less than 5 mg/L (Table 8.II-18).
- Concentrations of major parameters including sodium, calcium and magnesium decreased to steady state conditions after the first flush from weeks 1 to 5.
- Metal concentrations in PK humidity cell test leachates were generally low; concentrations were similar to those measured in kimberlite humidity cell tests.
- Concentrations of key metals including arsenic and selenium decreased after the first flush (five weeks) to steady state conditions in PK humidity cell tests undertaken in 2005. The ongoing fine PK humidity cell (“fine PK composite2 (T1)”) reported similar results. The coarse PK humidity cell from 2010 reported elevated selenium concentrations in the first flush (less than 0.00004 – 0.00196 mg/L) relative to the fine cells (less than 0.001 – 0.00092 mg/L).
- Phosphorous concentrations were generally less than the analytical detection limit of 0.15 mg/L in the kinetic tests initiated in 2004. Phosphorous concentrations in Fine PK humidity cell test initiated in 2010 varied from 0.02 to 0.036 mg/L during the initial weeks of testing,

and phosphorous concentrations in the coarse PK humidity cell test varied from < 0.009 to 0.014 mg/L.

- Concentrations for several metals, including iron and zinc, are below the detection limit for most sampling events.
- Table 8.II-21 summarizes the predicted depletion NP, sulphide and CaNP depletion times in PK humidity cells completed in 2005. In all cells except humidity cell 25, the rate of NP consumption was greater than the rate of sulphate production, indicating there is currently sufficient consumption of neutralizing minerals to buffer acid generation. Sulphide and NP depletion rates have not been provided for PK humidity cell tests initiated in 2010, as insufficient data was available to complete depletion calculations at the date of preparation of this report.

Table 8.II-20a First Flush Concentrations in Leachate from Processed Kimberlite Humidity Cells

	pH	SO_4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	μs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
First Flush																					
HC 22 - Processed Kimberlite Fines: Oct 11, 2005 - Nov 8, 2005																					
Minimum	7.8	4.0	0.009	<0.001	6.8	0.001	<0.001	<0.001	<0.05	<0.001	1.5	<0.001	0.0009	0.002	<0.15	9.7	<0.001	7.1	0.071	<0.0005	<0.005
Maximum	8.4	10	0.12	<0.001	10.0	0.002	<0.001	0.002	0.15	<0.001	2.0	0.002	0.0033	0.005	<0.15	11	<0.001	12	0.097	<0.0005	0.013
Average	8.1	5.4	0.065	<0.001	8.4	0.0015	<0.001	0.0015	0.1	<0.001	1.8	0.0015	0.0021	0.0035	<0.15	10	<0.001	9.4	0.084	<0.0005	0.009
Median	8.2	4.0	0.065	<0.001	8.4	0.0015	<0.001	0.0015	0.1	<0.001	1.8	0.0015	0.0021	0.0035	<0.15	10	<0.001	9.4	0.084	<0.0005	0.009
HC 23 - Processed Kimberlite Fines: Oct 11, 2005 - Nov 8, 2005																					
Minimum	7.9	13	0.01	0.002	7.4	0.002	<0.001	0.001	<0.05	<0.001	1.8	0.001	0.0038	0.004	<0.15	7.1	<0.001	11	0.09	<0.0005	<0.005
Maximum	8.8	25	0.029	0.01	59	0.003	<0.001	0.002	<0.05	<0.001	13	0.002	0.0065	0.006	<0.15	30	<0.001	59	1.0	<0.0005	0.008
Average	8.4	18	0.02	0.006	33	0.0025	<0.001	0.0015	<0.05	<0.001	7.4	0.0015	0.0052	0.005	<0.15	18	<0.001	35	0.55	<0.0005	0.0065
Median	8.7	18	0.02	0.006	33	0.0025	<0.001	0.0015	<0.05	<0.001	7.4	0.0015	0.0052	0.005	<0.15	18	<0.001	35	0.55	<0.0005	0.0065
HC 24 - Processed Kimberlite Fines: Oct 11, 2005 - Nov 8, 2005																					
Minimum	8.3	2.0	<0.005	0.001	6.3	<0.001	<0.001	0.001	<0.05	<0.001	0.41	<0.001	<0.0005	<0.001	<0.15	11	<0.001	13	0.18	<0.0005	<0.005
Maximum	9.3	3.0	<0.005	0.002	29	<0.001	<0.001	0.003	<0.05	<0.001	2.6	<0.001	<0.0005	0.003	<0.15	32	<0.001	57	0.98	<0.0005	<0.005
Average	8.7	2.6	<0.005	0.0015	18	<0.001	<0.001	0.002	<0.05	<0.001	1.5	<0.001	<0.0005	0.002	<0.15	21	<0.001	35	0.58	<0.0005	<0.005
Median	9.1	3.0	<0.005	0.0015	18	<0.001	<0.001	0.002	<0.05	<0.001	1.5	<0.001	<0.0005	0.002	<0.15	21	<0.001	35	0.58	<0.0005	<0.005
HC 25 - Processed Kimberlite Fines: Oct 11, 2005 - Nov 8, 2005																					
Minimum	8.1	28	<0.005	0.002	12	<0.001	<0.001	<0.001	<0.05	<0.001	3.6	<0.001	0.0095	0.003	<0.15	7.7	<0.001	16	0.11	<0.0005	<0.005
Maximum	8.6	41	0.006	0.009	55	<0.001	<0.001	0.005	<0.05	<0.001	15	0.003	0.013	0.008	<0.15	18	<0.001	43	0.59	<0.0005	<0.005
Average	8.3	32	0.0055	0.0055	33	<0.001	<0.001	0.003	<0.05	<0.001	9.1	0.002	0.011	0.0055	<0.15	13	<0.001	29	0.35	<0.0005	<0.005
Median	8.4	28	0.0055	0.0055	33	<0.001	<0.001	0.003	<0.05	<0.001	9.1	0.002	0.011	0.0055	<0.15	13	<0.001	29	0.35	<0.0005	<0.005
HC 26 - Processed Kimberlite Fines: Oct 11, 2005 - Nov 8, 2005																					
Minimum	8.3	3.0	<0.005	<0.001	14	<0.001	<0.001	<0.001	<0.05	<0.001	1.8	<0.001	0.0009	0.002	<0.15	10	<0.001	13	0.13	<0.0005	<0.005
Maximum	8.8	10	0.01	<0.001	19	<0.001	<0.001	0.002	<0.05	<0.001	1.8	<0.001	0.0018	0.002	<0.15	11	<0.001	14	0.18	<0.0005	<0.005
Average	8.5	5.2	0.0075	<0.001	16	<0.001	<0.001	0.0015	<0.05	<0.001	1.8	<0.001	0.0014	0.002	<0.15	11	<0.001	13	0.16	<0.0005	<0.005
Median	8.7	4.0	0.0075	<0.001	16	<0.001	<0.001	0.0015	<0.05	<0.001	1.8	<0.001	0.0014	0.002	<0.15	11	<0.001	13	0.16	<0.0005	<0.005
HC 27 - Processed Kimberlite Fines: Oct 11, 2005 - Nov 8, 2005																					
Minimum	8.4	3.0	<0.005	0.001	8.0	<0.001	<0.001	0.001	<0.05	<0.001	1.2	<0.001	<0.0005	0.001	<0.15	9.2	<0.001	15	0.12	<0.0005	<0.005
Maximum	9.0	17	0.006	0.003	13	<0.001	<0.001	0.002	<0.05	<0.001	1.2	<0.001	0.002	0.002	<0.15	13	<0.001	25	0.18	<0.0005	<0.005
Average	8.7	8.6	0.0055	0.002	10	<0.001	<0.001	0.0015	<0.05	<0.001	1.2	<0.001	0.0013	0.0015	<0.15	11	<0.001	20	0.15	<0.0005	<0.005
Median	8.9	9.0	0.0055	0.002	10	<0.001	<0.001	0.0015	<0.05	<0.001	1.2	<0.001	0.0013	0.0015	<0.15	11	<0.001	20	0.15	<0.0005	<0.005

Table 8.II-20a First Flush Concentrations in Leachate from Processed Kimberlite Humidity Cells (continued)

	pH	SO4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	µs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
T-1: PK - Fines Composite - Processed Kimberlite Fines: July 29, 2010 - Aug 26, 2010																					
Minimum	7.9	31	0.0037	0.0013	20	0.0011	0.000089	0.001	<0.002	0.00002	6.7	0.0018	0.043	0.0029	0.02	15	0.00053	12	0.23	0.00007	<0.001
Maximum	8.1	137	0.044	0.0025	45	0.0024	0.0002	0.0041	0.062	0.00011	13	0.0082	0.074	0.0052	0.036	17	0.00092	19	0.5	0.00031	0.001
Average	8.0	65	0.015	0.0018	29	0.0016	0.00013	0.002	0.021	0.00005	9.3	0.0041	0.056	0.0039	0.025	16	0.00075	14	0.34	0.00017	0.001
Median	8.0	58	0.0069	0.0017	26	0.0016	0.00011	0.0018	0.007	0.00004	8.4	0.0022	0.052	0.0035	0.024	16	0.00073	14	0.3	0.00016	0.001
HC1: PK - Coarse Composite - Processed Kimberlite Coarse: July 29, 2010 - Aug 26, 2010																					
Minimum	7.7	5.0	0.0027	0.0006	8.0	0.0008	0.000034	<0.0005	<0.002	0.00002	3.4	0.0012	0.0021	0.0009	<0.009	7.6	<0.00004	17	0.11	0.000002	<0.001
Maximum	7.9	36	0.014	0.0013	19	0.0042	0.00019	0.004	0.012	0.00014	8.2	0.0084	0.0056	0.0022	0.014	12	0.002	36	0.27	0.00006	0.002
Average	7.8	12	0.0071	0.00094	14	0.002	0.000078	0.0015	0.0056	0.00006	5.8	0.0028	0.0031	0.0015	0.01	9.5	0.00067	26	0.19	0.000028	0.0012
Median	7.8	6.0	0.0047	0.0009	14	0.0016	0.000053	0.0009	0.003	0.00003	6.0	0.0014	0.0023	0.0014	0.009	9.3	0.00032	26	0.19	0.000019	0.001

s.u. = standard unit; µs/cm = microSiemens per centimetre; mg/L = milligrams per litre; < = less than.

Table 8.II-20b Steady State Concentrations in Leachate from Processed Kimberlite Humidity Cells

	pH	SO_4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	µs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Steady State																					
HC 22 - Processed Kimberlite Fines: Nov 4, 2008 - Dec 2, 2008																					
Minimum	7.4	<1	0.022	<0.0002	1.8	0.0004	<0.0002	0.0009	0.03	<0.0002	0.9	0.0007	0.0006	0.0015	<0.03	3.3	<0.0002	2.0	0.019	<0.0001	<0.001
Maximum	7.6	2.0	0.068	<0.0002	2.6	0.0008	<0.0002	0.0046	0.1	<0.0002	1.5	0.0014	0.0008	0.0035	<0.03	4.1	<0.0002	2.5	0.028	<0.0001	0.001
Average	7.5	1.2	0.045	<0.0002	2.2	0.0006	<0.0002	0.0028	0.065	<0.0002	1.2	0.0011	0.0007	0.0025	<0.03	3.7	<0.0002	2.3	0.024	<0.0001	0.001
Median	7.5	1.0	0.045	<0.0002	2.2	0.0006	<0.0002	0.0028	0.065	<0.0002	1.2	0.0011	0.0007	0.0025	<0.03	3.7	<0.0002	2.3	0.024	<0.0001	0.001
HC 23 - Processed Kimberlite Fines: Nov 4, 2008 - Dec 2, 2008																					
Minimum	8.1	<1	0.014	0.0009	5.3	0.0003	<0.0002	0.0011	0.03	<0.0002	1.3	0.0005	0.0007	0.001	<0.03	5.6	<0.0002	1.6	0.079	<0.0001	<0.001
Maximum	7.9	2.0	0.027	0.001	6.1	0.0004	<0.0002	0.0014	0.04	<0.0002	1.4	0.0006	0.0008	0.0017	<0.03	6.1	<0.0002	1.9	0.092	<0.0001	<0.001
Average	8.4	1.4	0.021	0.00095	5.7	0.00035	<0.0002	0.0013	0.035	<0.0002	1.3	0.00055	0.00075	0.0014	<0.03	5.8	<0.0002	1.7	0.086	<0.0001	<0.001
Median	8.4	1.0	0.021	0.00095	5.7	0.00035	<0.0002	0.0013	0.035	<0.0002	1.3	0.00055	0.00075	0.0014	<0.03	5.8	<0.0002	1.7	0.086	<0.0001	<0.001
HC 24 - Processed Kimberlite Fines: Nov 4, 2008 - Dec 2, 2008																					
Minimum	8.5	<1	0.004	0.0009	9.8	<0.0002	<0.0002	0.0012	<0.01	<0.0002	1.6	0.0003	<0.0001	0.0002	<0.03	7.3	<0.0002	5.2	0.24	<0.0001	<0.001
Maximum	8.3	2.0	0.007	0.0011	11	<0.0002	<0.0002	0.0018	<0.01	<0.0002	2.0	0.0005	<0.0001	0.0004	<0.03	7.8	<0.0002	6.2	0.27	<0.0001	<0.001
Average	8.7	1.2	0.0055	0.001	10	<0.0002	<0.0002	0.0015	<0.01	<0.0002	1.8	0.0004	<0.0001	0.0003	<0.03	7.5	<0.0002	5.7	0.25	<0.0001	<0.001
Median	8.7	1.0	0.0055	0.001	10	<0.0002	<0.0002	0.0015	<0.01	<0.0002	1.8	0.0004	<0.0001	0.0003	<0.03	7.5	<0.0002	5.7	0.25	<0.0001	<0.001

Table 8.II-20b Steady State Concentrations in Leachate from Processed Kimberlite Humidity Cells (continued)

	pH	SO_4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	μs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
HC 25 - Processed Kimberlite Fines: Nov 4, 2008 - Dec 2, 2008																					
Minimum	8.1	<1	0.017	0.0004	13	0.0002	<0.0002	0.001	0.02	<0.0002	4.8	0.0003	0.0008	0.0019	<0.03	5.7	<0.0002	1.1	0.14	<0.0001	<0.001
Maximum	8.1	2.0	0.02	0.0005	16	0.0003	<0.0002	0.0021	0.03	<0.0002	6.3	0.0009	0.0009	0.0024	<0.03	6.4	<0.0002	1.3	0.18	<0.0001	<0.001
Average	8.2	1.2	0.019	0.00045	14	0.00025	<0.0002	0.0016	0.025	<0.0002	5.6	0.0006	0.00085	0.0022	<0.03	6.1	<0.0002	1.2	0.16	<0.0001	<0.001
Median	8.2	1.0	0.019	0.00045	14	0.00025	<0.0002	0.0016	0.025	<0.0002	5.6	0.0006	0.00085	0.0022	<0.03	6.1	<0.0002	1.2	0.16	<0.0001	<0.001
HC 26 - Processed Kimberlite Fines: Nov 4, 2008 - Dec 2, 2008																					
Minimum	7.5	<1	0.029	0.0003	3.1	0.0003	<0.0002	0.0005	0.04	<0.0002	0.82	0.0006	0.0002	0.0016	<0.03	3.2	<0.0002	0.94	0.03	<0.0001	<0.001
Maximum	7.5	2.0	0.037	0.0003	3.3	0.0004	<0.0002	0.0023	0.05	<0.0002	0.86	0.0006	0.0003	0.002	<0.03	3.4	<0.0002	0.95	0.031	<0.0001	<0.001
Average	7.7	1.2	0.033	0.0003	3.2	0.00035	<0.0002	0.0014	0.045	<0.0002	0.84	0.0006	0.00025	0.0018	<0.03	3.3	<0.0002	0.95	0.031	<0.0001	<0.001
Median	7.7	1.0	0.033	0.0003	3.2	0.00035	<0.0002	0.0014	0.045	<0.0002	0.84	0.0006	0.00025	0.0018	<0.03	3.3	<0.0002	0.95	0.031	<0.0001	<0.001
HC 27 - Processed Kimberlite Fines: Nov 4, 2008 - Dec 2, 2008																					
Minimum	7.7	<1	0.02	0.0006	4.4	0.0003	<0.0002	0.0005	0.03	<0.0002	0.91	0.0006	<0.0001	0.0012	<0.03	3.9	<0.0002	2.1	0.07	<0.0001	<0.001
Maximum	7.7	2.0	0.033	0.0007	4.8	0.0005	<0.0002	0.0048	0.06	<0.0002	1.2	0.0011	<0.0001	0.0019	<0.03	4.4	<0.0002	2.1	0.076	<0.0001	<0.001
Average	8.1	1.2	0.027	0.00065	4.6	0.0004	<0.0002	0.0027	0.045	<0.0002	1.1	0.00085	<0.0001	0.0016	<0.03	4.1	<0.0002	2.1	0.073	<0.0001	<0.001
Median	8.4	1.0	0.027	0.00065	4.6	0.0004	<0.0002	0.0027	0.045	<0.0002	1.1	0.00085	<0.0001	0.0016	<0.03	4.1	<0.0002	2.1	0.073	<0.0001	<0.001

s.u. = standard unit; μs/cm = microSiemens per centimetre; mg/L = milligrams per litre; < = less than.

Figure 8.II-9 Leachate Concentrations in Processed Kimberlite Humidity Cells

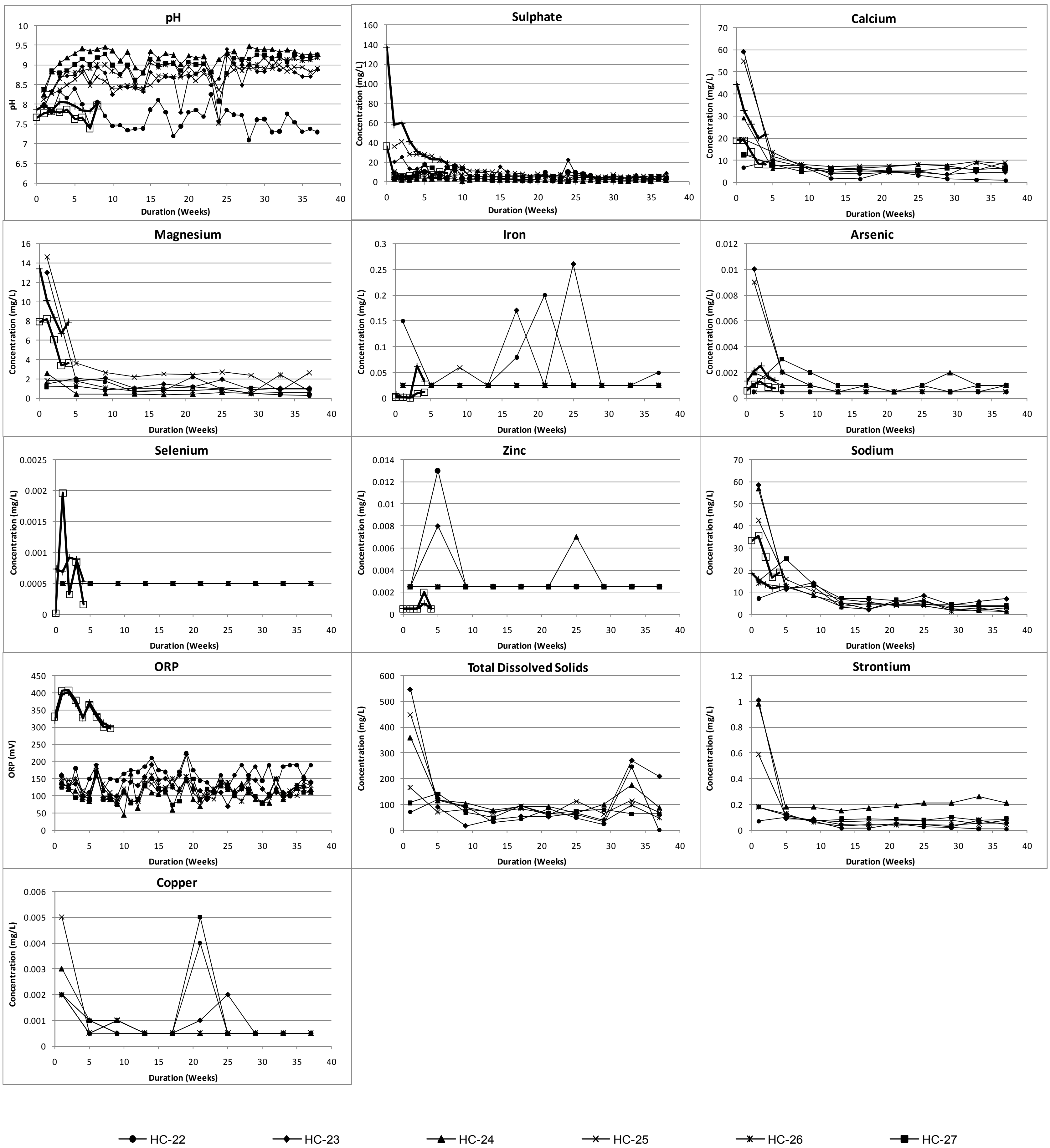


Table 8.II-21 Estimated Acid Potential and Neutralizing Potential Depletion Times for Processed Kimberlite Humidity Cells

Humidity Cell ID	Lithology	Sulphide Sulphur (wt. %)	NP (kg $CaCO_3$/t)	Time to Depletion (Years)				
				Sulphide Sulphur	NP (emp)	CaNP (emp)	NP (SO4)	CaNP (SO4)
HC 22	Processed Kimberlite Fines	0.027	87	49	261	34	4532	621
HC 23	Processed Kimberlite Fines	0.04	97	26	147	13	3465	354
HC 24	Processed Kimberlite Fines	0.02	203	19	85	3.8	4726	352
HC 25	Processed Kimberlite Fines	0.065	40	69	47	6.3	3088	548
HC 26	Processed Kimberlite Fines	0.027	89	29	171	19	3067	401
HC 27	Processed Kimberlite Fines	0.048	67	55	147	14	4219	496

Note: Depletion calculations are unavailable for humidity cells constructed in 2010 for 'T-1: PK - Fines Composite' and 'HC1: PK - Coarse Composite', due to the short time period the HCTs have been running (4 weeks).

wt % = percent by weight; kg/t = kilograms per tonne.

8.II.4.2.6 Submerged Column Tests

Submerged PK column tests were initiated in 2010, and were ongoing at the date of preparation of this report. The objective of the submerged column tests is to evaluate the effect of submerging fine and coarse PK, respectively, under a column of water. Leachate samples are collected from the top and bottom of the test column, and results are discussed in the context of the “top” and “bottom” samples.

Figure 8.II-10 and Table 8.II-22 present the concentrations of key parameters, pH values and ORP values in the column leachates as of August, 19. 2010. Due to the short test time, steady state trends are not evident. Attachment 8.II.9 provides detailed results. The principal observations with respect to the submerged PK columns are:

- The pH values of the column leachates were generally stable, ranging between 7.5 and 8.1. Samples collected from the bottoms of both columns reported marginally lower pH values than those collected from the top of the columns.
- Sulphate production increased through the first few weeks of testing. No concentration trends with grain size (i.e., coarse PK versus fine PK) were evident based on the initial results.
- Concentrations of major parameters including sodium, magnesium and calcium were highest in leachates collected from the bottom of the coarse PK column. Major parameter concentrations were less in the top and bottom samples collected from the fine PK column; there was no trend in concentration with respect to the top and bottom fine PK concentrations during the initial weeks of testing.
- Concentrations of key metals including arsenic and selenium were highest in leachates collected from the bottom of the coarse PK column (0.0016 – 0.0033 mg/L As, 0.004 – 0.0076 mg/L Se). Concentrations of key metals did not vary significantly between the top and bottom samples from the fine PK column (0.0002 – 0.0008 mg/L As, less than 0.00004 – 0.00091 mg/L Se).
- Phosphorous concentrations varied from <0.009 to 0.16 mg/L in water collected from the top of the fine PK column. Concentrations in the bottom of the fine PK column varied <0.009 to 0.148 mg/L. Concentrations were lower in the coarse PK column, ranging from < 0.009 to 0.009 mg/L in water collected from the top of the column, and <0.009 to 0.025 mg/L in samples collected from the bottom of the column.

- Iron concentrations were highest in leachates collected from the bottom of the fine PK column (less than 0.002 – 0.059 mg/L) compared to the other three leachate samples (less than 0.002 – 0.017 mg/L).
- Zinc concentrations reported no observable trends as of August 19, 2010.

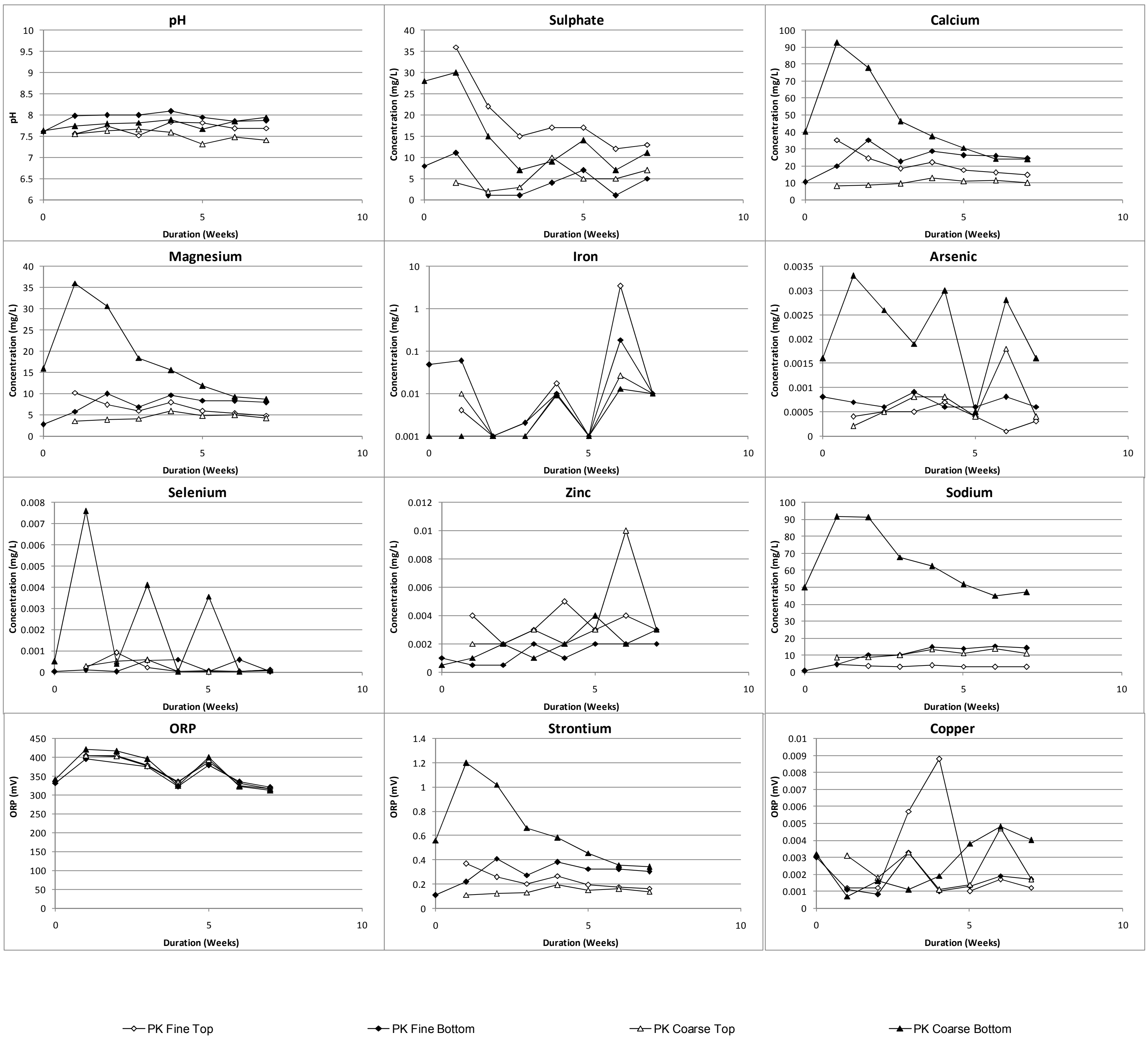
Submerged column tests will continue for a minimum of 20 weeks, at which time concentration trends will be evaluated for the purpose of determining if the tests should be continued. The initial results of submerged column tests indicate very little difference in concentration between the top and bottom leachate samples collected from fine PK. The initial results of coarse PK submerged column testing suggest that the highest metal concentrations could be associated with the pore water of coarse PK. Trends indicating diffusion of metals into the overlying column of water in the coarse PK column were not observed during the first weeks of testing.

Table 8.II-22 Concentrations in Leachate from Processed Kimberlite Submerged Column Tests

Parameters	pH	Sulphate	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Fine PK - Top																					
Minimum	7.52	15	0.0031	0.0004	18.3	0.0012	0.000103	0.0012	<0.002	0.00003	5.97	0.0085	0.00728	0.0013	<0.009	5.46	<0.00004	3.17	0.202	0.000024	0.002
Maximum	7.84	36	0.004	0.0007	35.2	0.002	0.000254	0.0088	0.017	0.00013	10.2	0.0251	0.0109	0.0045	0.16	5.93	0.00091	4.66	0.369	0.000469	0.005
Fine PK – Bottom																					
Minimum	7.6	1	0.0031	0.0006	10.3	0.0012	0.000032	0.0008	<0.002	0.00004	2.72	0.0015	0.00849	0.0003	<0.009	2.48	<0.00004	0.64	0.107	0.000008	<0.001
Maximum	8.09	11	0.0398	0.0009	35.3	0.0022	0.000137	0.0033	0.059	0.00014	9.97	0.0141	0.0189	0.0036	0.148	14.4	0.0006	14.7	0.411	0.000259	0.002
Coarse PK – Top																					
Minimum	7.55	2	0.0022	0.0002	8.2	0.0011	0.000108	0.0011	<0.002	0.00004	3.51	0.0044	0.00081	0.0027	<0.009	3.75	<0.00004	8.52	0.112	0.00002	0.002
Maximum	7.66	10	0.0054	0.0008	12.7	0.0024	0.000166	0.0033	0.01	0.0001	5.9	0.0117	0.00152	0.0038	0.009	5.97	0.00057	13.4	0.195	0.000187	0.003
Coarse PK - Bottom																					
Minimum	7.62	7	0.0027	0.0016	37.5	0.0013	0.000056	0.0007	<0.002	<0.00002	15.5	0.0022	0.00371	0.0011	<0.009	15.4	<0.00004	49.9	0.559	0.000008	<0.001
Maximum	7.88	30	0.0043	0.0033	92.5	0.006	0.000127	0.0032	0.009	0.00012	36	0.0091	0.00591	0.003	0.025	33.5	0.0076	91.5	1.2	0.000089	0.002

mg/L = milligrams per litre; < = less than.

Figure 8.II-10 Leachate concentrations in Processed Kimberlite Columns



8.II.4.2.7 Comparison of PK Geochemical Test Leachates

Table 8.II-23 compares the average concentrations in the initial weeks of the PK coarse and fine column tests to the results of humidity cell tests conducted on the same samples, and process water collected during metallurgical testing. General observations include the following:

- The pH values of all test leachates were alkaline. The lower pH values were reported in leachates collected from the tops of the submerged column tests (7.5 to 7.8) and the highest pH values were reported in leachates from the first flush of the PK fines humidity cells (7.8 to 9.3) and the process water (7.9 to 8.8).
- Sulphate concentrations were generally highest in the first flush of the humidity cells and lowest at steady state in the humidity cells.
- Concentrations of major parameters including calcium, sodium, magnesium and potassium were highest in leachates collected from the bottoms of the submerged columns, and collected during the first flush of both the fine and coarse humidity cells.
- Concentrations of several key metals including cobalt, copper, chromium, zinc and nickel were similar in all tests.
- Concentrations of arsenic and selenium were highest in leachates collected from the bottom of the coarse PK column, from the first flush of the coarse PK humidity cell and in process water.
- Concentrations of iron were highest in leachates collected from both the first flush and steady state PK fines humidity cells.

Table 8.II-23 Comparison of Processed Kimberlite Geochemical Test Leachates

		pH	SO_4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
		s.u.	µs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Process Water	Minimum	7.92	16	0.0052	0.0011	23	0.0021	0.000044	0.0014	0.001	<0.00002	3	0.0001	0.00327	0.0004	0.034	4.97	0.00014	3.94	0.13	0.000042	<0.001
	Maximum	8.81	23	0.0434	0.0016	30	0.0041	0.00011	0.0024	<0.002	0.00008	3.98	0.0075	0.0038	0.0021	0.089	7.84	0.00019	6.1	0.16	0.000228	<0.001
Submerged Column Tests - Fine PK	**Fine PK - Top**																					
	Minimum	7.52	15	0.0031	0.0004	18.3	0.0012	0.000103	0.0012	<0.002	0.00003	5.97	0.0085	0.00728	0.0013	<0.009	5.46	<0.00004	3.17	0.202	0.000024	0.002
	Maximum	7.84	36	0.004	0.0007	35.2	0.002	0.000254	0.0088	0.017	0.00013	10.2	0.0251	0.0109	0.0045	0.16	5.93	0.00091	4.66	0.369	0.000469	0.005
	Fine PK - Bottom																					
	Minimum	7.6	1	0.0031	0.0006	10.3	0.0012	0.000032	0.0008	<0.002	0.00004	2.72	0.0015	0.00849	0.0003	<0.009	2.48	<0.00004	0.64	0.107	0.000008	<0.001
	Maximum	8.09	11	0.0398	0.0009	35.3	0.0022	0.000137	0.0033	0.059	0.00014	9.97	0.0141	0.0189	0.0036	0.148	14.4	0.0006	14.7	0.411	0.000259	0.002
	Coarse PK - Top																					
	Minimum	7.55	2	0.0022	0.0002	8.2	0.0011	0.000108	0.0011	<0.002	0.00004	3.51	0.0044	0.00081	0.0027	<0.009	3.75	<0.00004	8.52	0.112	0.00002	0.002
	Maximum	7.66	10	0.0054	0.0008	12.7	0.0024	0.000166	0.0033	0.01	0.0001	5.9	0.0117	0.00152	0.0038	0.009	5.97	0.00057	13.4	0.195	0.000187	0.003
	Coarse PK - Bottom																					
	Minimum	7.62	7	0.0027	0.0016	37.5	0.0013	0.000056	0.0007	<0.002	<0.00002	15.5	0.0022	0.00371	0.0011	<0.009	15.4	<0.00004	49.9	0.559	0.000008	<0.001
	Maximum	7.88	30	0.0043	0.0033	92.5	0.006	0.000127	0.0032	0.009	0.00012	36	0.0091	0.00591	0.003	0.025	33.5	0.0076	91.5	1.2	0.000089	0.002
Humidity Cell Tests - First flush[(a)]	**PK Fines**																					
	Minimum	7.8	2	<0.005	<0.001	6.34	<0.001	<0.001	<0.001	<0.002	<0.001	0.41	<0.001	<0.0005	<0.001	<0.15	7.1	<0.001	7.11	0.071	<0.0005	<0.001
	Maximum	9.3	137	0.12	0.01	59.2	0.003	0.001	0.005	0.15	0.001	14.6	0.0082	0.0735	0.008	0.15	31.6	0.001	58.6	1.01	0.0005	0.013
	Coarse PK																					
	Minimum	7.67	5	0.0027	0.0006	7.99	0.0008	0.000034	<0.0005	<0.002	0.00002	3.4	0.0012	0.00213	0.0009	<0.009	7.61	<0.00004	16.7	0.11	0.000002	<0.001
	Maximum	7.87	36	0.0137	0.0013	19.1	0.0042	0.000193	0.004	0.012	0.00014	8.2	0.0084	0.00563	0.0022	0.014	12	0.00196	35.5	0.27	0.00006	0.002
Humidity Cell Tests - Steady State[(b)]	**PK Fines**																					
	Minimum	7.35	<1	0.004	<0.0002	1.8	<0.0002	<0.0002	0.0005	<0.01	<0.0002	0.82	0.0003	<0.0001	0.0002	<0.03	3.19	<0.0002	0.94	0.019	<0.0001	<0.001
	Maximum	8.25	2	0.068	0.0011	16	0.0008	<0.0002	0.0048	0.1	<0.0002	6.32	0.0014	0.0009	0.0035	<0.03	7.77	<0.0002	6.18	0.268	<0.0001	0.001

(a) First five weeks of sampling.

(b) Last five weeks of sampling.

µs/cm = microSiemens per centimetre; mg/L = milligrams per litre; < = less than; s.u. = standard unit.

8.II.4.3 MINE ROCK

8.II.4.3.1 Static Testing

8.II.4.3.1.1 Mineralogy

In 2004, three granite samples were submitted for qualitative optical mineralogy analysis (Petrascience 2004 – Attachment 8.II.3). Results are summarized in Table 8.II-24. Major mineral phases included potassium feldspar, quartz and plagioclase. One sample reported approximately 40% clay minerals. Sulphide minerals were reported in trace concentrations in two of the granite and mostly consist of pyrite with lesser chalcopyrite and trace pyrrhotite. Trace calcite was reported in one of the granite samples.

Table 8.II-24 Summary of Gahcho Kué Project Mine Rock Mineralogy

	04-ARD-139-004	04-ARD-199-002	04-ARD-191-06/07/08/09
	Granite	**Granite**	**Granite**
Mineral Phases Observed in Optical Microscopy	Major: K-feldspar [$KAlSi_3O_8$], quartz [SiO_2], biotite [$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$] Minor: Plagioclase [NaAlSi3O8 – CaAl2Si2O8], muscovite-sericite [$KAl_2(AlSi_3O_{10})(F,OH)_2$], Fe-Ti oxides, chlorite [$(Fe,Mg,Al)_6(Si,Al)_4O_{10}(OH)_8$] Trace: Pyrite [$FeS_2$], magnetite [$Fe_3O_4$]	Major: K-feldspar, quartz, biotite, plagioclase Minor: Muscovite-sericite, chlorite, magnetite Trace: Calcite [$CaCO_3$], pyrite	Major: Clay minerals, plagioclase, pyroxene [$(Ca,Mg,Fe)SiO_3$], olivine [$(Mg,Fe)_2SiO_4$] Minor: Quartz, biotite, chlorite, magnetite Trace: K-feldspar, pyrite, pyrrhotite [$FeS_{(1-x)}$], chalcopyrite [$CuFeS_2$]

Note: Semi-quantitative XRD was not conducted on these samples.

8.II.4.3.1.2 Acid Base Accounting

Results of ABA testing for the mine rock are provided in Table 8.II-25 and Figures 8.II-10 to 8.II-12. Attachment 8.II.4 contains detailed ABA results. All mine rock lithology results are presented together to reflect their treatment as a single waste management group. It is expected that granite will comprise greater than 95% of all mine rock.

The principal observations with respect to the ABA characteristics of mine rock are:

- The paste pH of all the mine rock samples was 5.5 or greater.
- Mine rock samples contained between less than 0.01% to 2.18% total sulphur, with an average concentration of 0.04%. Sulphur is primarily in the form of sulphide sulphur (Figure 8.II-10). Based on average concentrations, granite contains the lowest amounts of total and sulphide sulphur of all the mine rock lithologies (average concentration of 0.03 wt%). The low sulphide sulphur concentrations are supported by mineralogical results. The altered granite, altered granodiorite, and diorite have average sulphide sulphur concentrations of 0.28 wt%, 0.16 wt%, and 0.16 wt%, respectively.
- Eighteen of 1,236 mine rock samples (1%) had total sulphur concentrations greater than 0.3 wt%, which is a commonly used screening criteria to identify samples with a potential for acid generation. Ninety-one of 1,236 samples (7%) had sulphide sulphur concentrations greater than 0.1 wt%.
- Values for NP range from less than 0.1 to 272 kilogram $CaCO_3$ per tonne (kg $CaCO_3$/t) and carbonate NP values range from 0.11 to 138 kg $CaCO_3$/t.
- At NP values less than approximately 10 kg $CaCO_3$/t, the modified Sobek NP is typically 30% greater than the carbonate NP suggesting non-carbonate minerals are contributing to the overall NP at the lower range of values (Figure 8.II-11). At NP values greater than approximately 10 kg $CaCO_3$/t the modified Sobek NP is approximately equal to the carbonate NP.
- The NP/AP ratio of the mine rock samples ranged from 0.04 to 576. Approximately 13% of all mine rock samples had an NP/AP between one and three and had an uncertain acid generating potential (Figure 8.II-12). Additionally, 4% of mine rock samples had NP/AP values less than one and are classified as PAG.
- Although there is very little NP in the mine rock, there is generally very low concentrations of sulphide. Less than 10% of all the mine rock samples are classified as PAG and another 30% of samples have an uncertain PAG classification. This includes samples with less than

0.3 wt% total sulphur, which is generally considered to be the minimum concentrations of sulphur needed for acid generation. Fourteen of the 1,236 samples (1.1%) reported sulphide concentrations exceeding 0.3% and NP/AP ratios of less than three.

Table 8.II-25 Summary of Acid Base Accounting Results for Mine Rock Samples

Sample ID	Paste pH	CO_2	Total Sulphur	Sulphate	Sulphide	AP	NP	NP/AP	CaNP
		%	wt. %	wt. %	wt. %	kg $CaCO_3$/t	kg $CaCO_3$/t	kg $CaCO_3$/t	kg $CaCO_3$/t
Altered Granite, n= 10									
Minimum	7.5	0.02	0.01	<0.01	0.01	0.31	3.7	0.39	0.5
Maximum	9.4	1.3	0.42	0.015	0.41	13	54	43	30
Mean	8.1	0.37	0.23	0.01	0.23	7.0	17	8.6	8.5
Median	8.0	0.22	0.28	0.01	0.27	8.6	11	2.1	4.9
Standard Deviation	0.59	0.42	0.15	0.00	0.15	4.5	16	15	9.6
Diabase, n=7									
Minimum	8.4	0.01	0.08	<0.01	0.08	2.5	5.5	1.9	0.1
Maximum	9.5	0.75	0.15	<0.01	0.15	4.7	28	5.9	17
Mean	9.1	0.14	0.10	<0.01	0.10	3.2	12	3.5	3
Median	9.2	0.03	0.09	<0.01	0.09	2.8	10	3.3	0.7
Standard Deviation	0.38	0.27	0.02	<0.01	0.02	0.74	7.3	1.2	6.2
Gnessic Granite, n=9									
Minimum	8.7	<0.01	<0.01	<0.01	<0.01	<0.3	3.2	0.36	0.11
Maximum	9.6	0.16	0.29	0.01	0.29	9.1	7.7	16	3.6
Mean	9.2	0.04	0.061	0.006	0.061	1.9	4.2	8	1.0
Median	9.2	0.03	0.02	0.005	0.02	0.63	3.7	12	0.68
Standard Deviation	0.26	0.053	0.094	0.0017	0.094	2.95	1.4	6.0	1.2
Granite, n=1182									
Minimum	5.6	<0.01	<0.01	<0.01	<0.01	<0.3	<0.1	0.04	0.11
Maximum	10	6.1	2.2	0.027	2.2	68	207	576	137
Mean	9.0	0.11	0.035	0.0055	0.035	1.08	6	12	2.5
Median	9.1	0.06	0.01	0.005	0.01	0.3	4.4	8.3	1.4
Standard Deviation	0.43	0.34	0.101	0.0019	0.10	3.13	12	25	7.7

Table 8.II-25 Summary of Acid Base Accounting Results for Mine Rock Samples (continued)

Sample ID	Paste pH	CO_2	Total Sulphur	Sulphate	Sulphide	AP	NP	NP/AP	CaNP
		%	wt. %	wt. %	wt. %	kg $CaCO_3$/t	kg $CaCO_3$/t	kg $CaCO_3$/t	kg $CaCO_3$/t
Granodiorite, n=6									
Minimum	9.0	<0.1	0.01	0.005	0.010	0.30	8.0	1.0	2.3
Maximum	10	0.3	0.31	0.020	0.32	10	11	37	6.8
Mean	9.4	0.21	0.063	0.013	0.072	2.0	9.3	20	4.8
Median	9.5	0.23	0.01	0.010	0.025	0.45	9.0	23	5.2
Standard Deviation	0.3	0.093	0.12	0.0061	0.122	3.8	1.0	14	2.1
Altered Granodiorite, n=16									
Minimum	8.4	0.01	0.10	0.005	0.01	3.10	8.0	0.82	0.23
Maximum	9.0	4.5	0.31	0.17	0.30	10	272	54	102
Mean	8.8	0.97	0.173	0.063	0.11	5.39	77	15	22
Median	8.9	0.1	0.16	0.020	0.12	5.0	38	9.2	2.3
Standard Deviation	0.2	1.661	0.068	0.072	0.10	2.14	87	17	38
Fresh Granodiorite, n=5									
Minimum	9.0	<0.1	0.01	<0.01	<0.01	0.30	9.0	1.0	2.3
Maximum	10	0.30	0.31	0.02	0.32	10	11	37	6.8
Mean	9.5	0.2	0.07	0.014	0.08	2.2	10	23	4.5
Median	9.5	0.2	0.01	0.010	0.02	0.3	9.0	30	4.5
Standard Deviation	0.29	0.10	0.134	0.005	0.13	4.2	0.89	14	2.3
Diorite, n=1									
06-ARD-277-009	8.9	0.15	0.16	<0.01	0.16	5.0	12	2.3	3.4
All Granite, n=1236									
Minimum	5.6	<0.01	<0.01	<0.01	<0.01	<0.3	<0.1	0.04	0.11
Maximum	10	6.1	2.2	0.17	2.2	68	272	576	137
Mean	9.0	0.12	0.04	0.006	0.04	1.2	7.0	12	2.8
Median	9.1	0.06	0.02	0.005	0.01	0.31	4.5	8.3	1.4
Standard Deviation	0.43	0.39	0.10	0.01	0.102	3.21	17	25	9.0

Note: AP (Acid Potential) was calculated using total sulphur.

% = percent; wt % = percent by weight; kg/t = kilograms per tonne.

Figure 8.II-11 Concentration of Total Sulphur versus Sulphide Sulphur in Mine Rock Samples

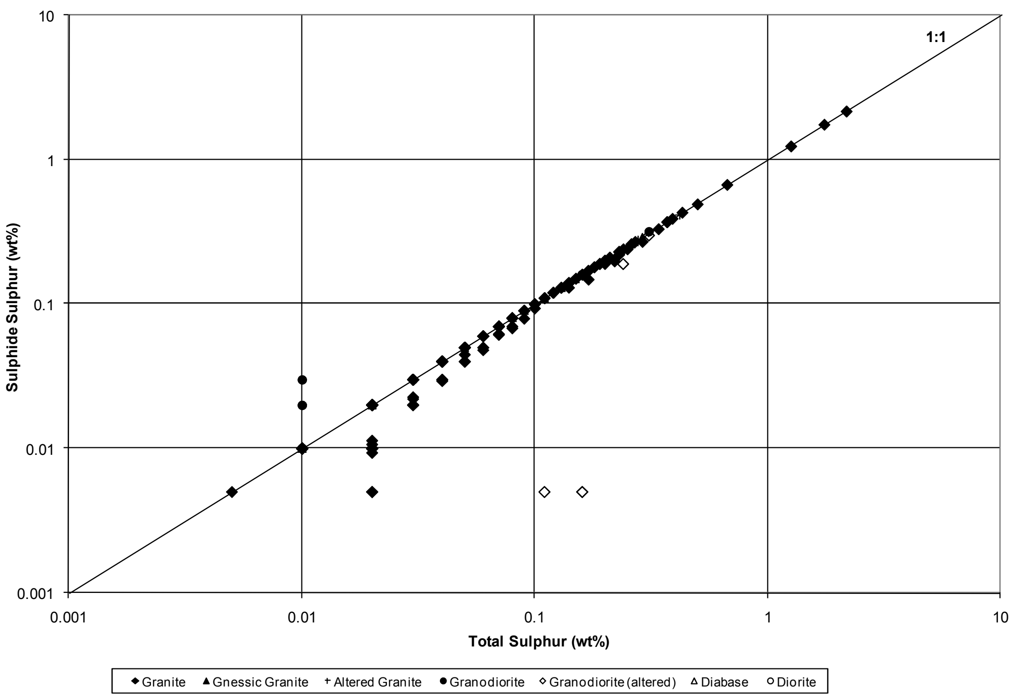


Figure 8.II-12 Neutralizing Potential versus Carbonate Neutralizing Potential for Mine Rock

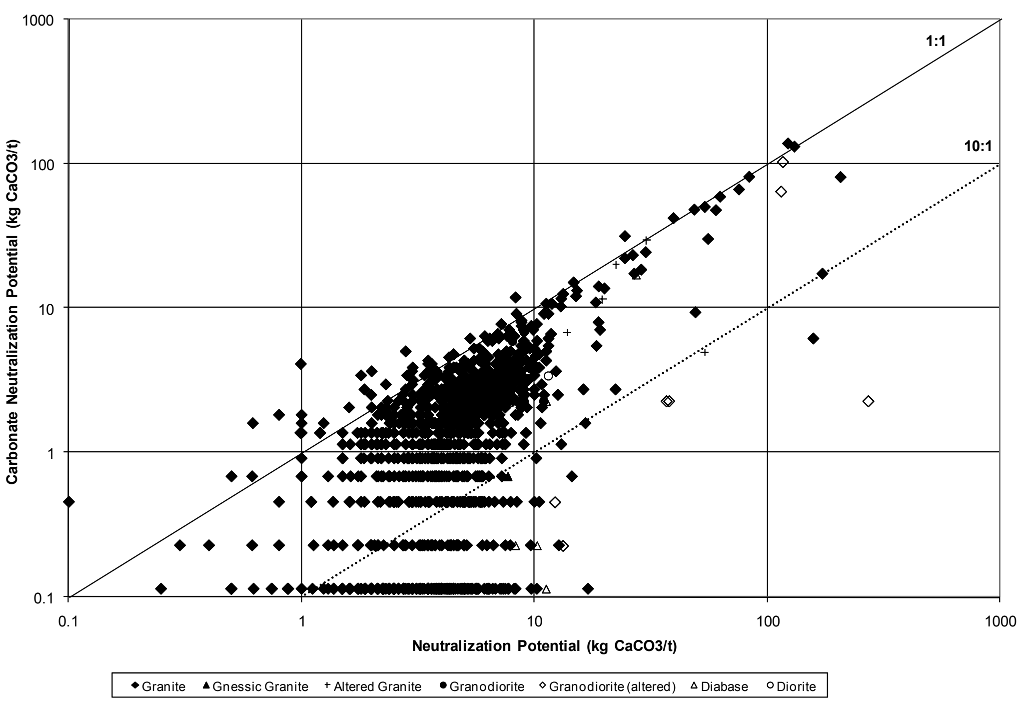
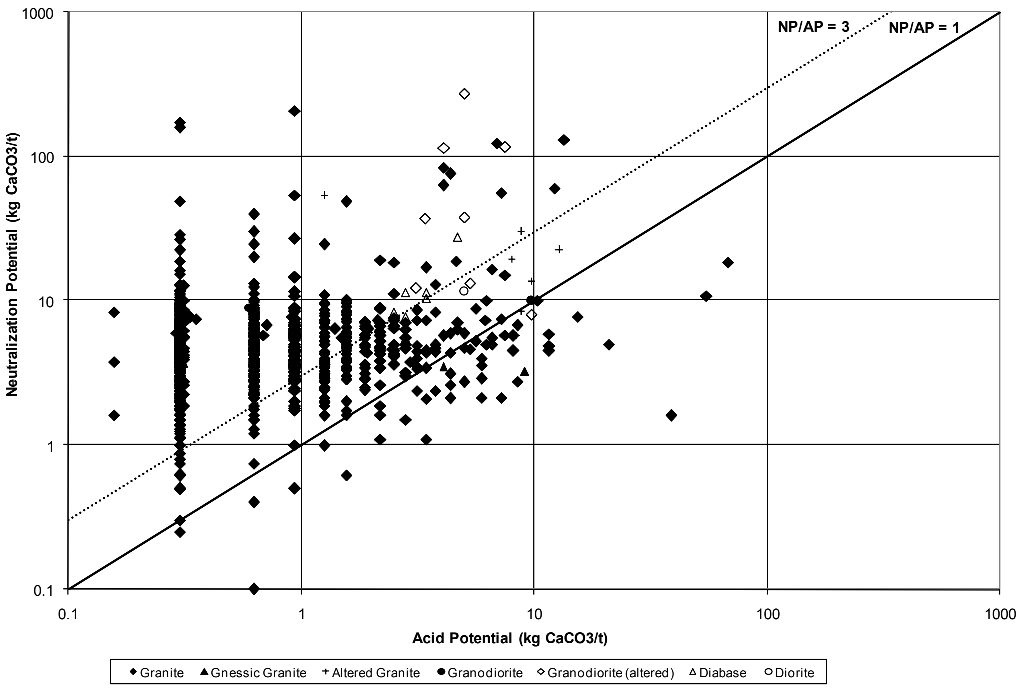


Figure 8.II-13 Neutralizing Potential versus Acid Potential for Mine Rock



8.II.4.3.2 Whole Rock and Trace Element Chemistry

A complete record of the analytical results and a summary of the chemistry of the mine rock are provided in Attachment 8.II.5. A summary of the whole rock results is presented in Table 8.II-26 and bulk metal results are reported in Table 8.II-27.

Results of the whole rock chemistry analyses indicate that the non-kimberlite units are enriched in molybdenum, zinc, silica, and aluminum relative to the kimberlite facies. Aluminum is the major element and the average silica concentration is greater than 50% for all mine rock lithologies, with a maximum of 70% for the granite.

The chemical composition of the granitic lithologies is similar to the average crustal abundances of granitic rocks presented in Price (1997). Total concentrations of nickel in the altered granite are greater than the other mine rock lithologies.

Table 8.II-26 Summary of Gahcho Kué Project Mine Rock Whole Rock Results

Parameter	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Ba(F)	LOI	Total
Unit	%	%	%	%	%	%	%	%	%	%	%	%	%
Altered Granite, n= 3													
Minimum	45	0.3	4.8	2.4	0.01	1.6	1.2	0.1	1.1	0.1	0.05	1.3	99
Maximum	67	1.1	17	8.3	0.1	26	6.0	3.3	5.3	0.36	0.11	14	100
Mean	56	0.64	13	5.8	0.047	11	2.9	2.1	2.9	0.26	0.083	5.4	99
Median	56	0.56	16	6.6	0.03	4.7	1.4	3.0	2.2	0.33	0.09	1.5	100
Standard Deviation	11	0.39	6.8	3.0	0.047	13	2.7	1.8	2.2	0.14	0.031	7.0	0.2
Gneissic Granite, n= 9													
Minimum	57	0.12	13	1.1	0.01	0.6	0.67	2.4	2.8	0.03	0.04	0.61	100
Maximum	73	1.0	18	7.9	0.1	4.5	4.5	4.5	4.9	0.38	0.18	1.8	100
Mean	67	0.51	16	4.1	0.037	2.1	2.0	3.6	3.7	0.12	0.097	1.1	100
Median	69	0.34	16	2.5	0.01	1.3	1.7	3.4	3.2	0.09	0.1	1.1	100
Standard Deviation	5.6	0.3	1.4	2.5	0.039	1.5	1.1	0.69	0.87	0.1	0.043	0.45	0.072
Granite, n= 874													
Minimum	37	0.07	3.0	0.67	0.0054	0.15	0.11	0.01	0.85	0.01	0.01	0.0097	98
Maximum	80	2.0	21	16	0.22	32	9.6	7.0	13	1.2	0.3	12	100
Mean	70	0.32	15	2.5	0.018	1.3	1.4	3.4	4.8	0.14	0.095	1.0	100
Median	70	0.29	15	2.3	0.01	0.91	1.3	3.4	4.9	0.12	0.09	0.77	100
Standard Deviation	4.2	0.16	1.4	1.5	0.019	1.9	0.94	1.0	1.7	0.11	0.034	1.1	0.23
Diorite, n= 1													
04-ARD-120-012	54	1.3	14	12	0.11	5.4	7.6	2.7	1.0	0.31	0.05	0.62	100
Granodiorite, n =1													
04-ARD-120-011	70	0.34	15	2.4	0.01	0.77	1.6	3.9	4.3	0.07	0.07	0.76	99
Diabase, n= 5													
Minimum	48	1.6	13	11	0.03	5.1	0.48	0.1	0.64	0.21	0.02	0.7	99
Maximum	50	2.1	16	16	0.22	8.0	9.7	3.6	5.4	0.3	0.02	7.3	100
Mean	49	1.8	14	15	0.17	6.3	7.2	2.0	1.8	0.24	0.02	2.7	100
Median	49	1.8	13	15	0.2	5.5	9.1	2.2	0.99	0.23	0.02	1.4	100
Standard Deviation	0.83	0.19	1.4	1.9	0.079	1.3	3.9	1.3	2.0	0.037	0	2.7	0.21

% = percent

Table 8.II-27 Summary of Gahcho Kué Project Mine Rock Bulk Metal Results

Parameter	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	La	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	Sr	Ti	Tl	U	Zn
Unit	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	%	%	ppm	%	ppm	ppm	%	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
PRICE CRUSTAL ABUNDANCE (1)	---	8.2	1.8	10	---	0.0085	4.2	3.0	25	102	60	5.6	2.1	20	2.3	950	1.2	2.4	84	0.11	14	0.2	0.05	370	0.57	0.85	2.7	70
Altered Granite, n= 3																												
Minimum	0.05	0.79	0.25	4.0	56	0.05	0.2	0.05	5.1	40	1.7	1.4	0.26	31	0.93	253	0.2	0.019	11	0.048	1.7	0.05	0.25	13	0.044	0.1	0.7	28
Maximum	0.1	2.1	2.3	26	842	0.3	0.95	0.05	68	244	47	3.5	1.2	75	10	459	2.7	0.083	909	0.13	2.0	0.1	0.25	295	0.17	0.3	1.3	60
Mean	0.067	1.4	1.5	12	405	0.15	0.59	0.05	29	115	18	2.4	0.74	47	4.2	329	1.6	0.048	318	0.1	1.9	0.083	0.25	111	0.10	0.17	1.0	44
Median	0.05	1.3	1.9	6.0	317	0.1	0.62	0.05	15	60	4.9	2.2	0.8	35	1.4	276	1.9	0.042	34	0.12	1.9	0.1	0.25	24	0.09	0.1	1.0	44
Standard Deviation	0.029	0.64	1.1	12	400	0.13	0.38	8.5E-18	34	112	25	1.0	0.46	24	5.3	113	1.3	0.032	512	0.046	0.15	0.029	0	160	0.061	0.12	0.3	16
Gneissic Granite, n= 9																												
Minimum	0.05	0.31	0.25	1.0	34	0.05	0.04	0.05	1.9	41	1.4	0.59	0.13	11	0.3	104	2.2	0.015	6.3	0.007	2.0	0.05	0.25	5.0	0.023	0.05	0.3	22
Maximum	0.05	3.3	0.6	13	296	0.1	0.53	0.1	26	209	65	4.8	2.0	34	2.1	532	7.6	0.046	99	0.13	5.2	0.2	0.25	27	0.37	1.0	1.0	93
Mean	0.05	1.3	0.33	5.0	129	0.056	0.18	0.056	11	91	17	2.2	0.73	26	1.0	274	4.3	0.025	32	0.041	3.3	0.15	0.25	12	0.15	0.35	0.52	57
Median	0.05	0.71	0.25	4.0	88	0.05	0.16	0.05	5.3	57	9.1	1.5	0.41	29	0.65	207	3.8	0.022	10	0.039	2.9	0.2	0.25	10	0.12	0.1	0.5	51
Standard Deviation	7.4E-18	1.0	0.15	3.8	98	0.017	0.15	0.017	8.8	66	22	1.4	0.67	8.3	0.69	143	1.8	0.011	34	0.038	1.1	0.061	0	7.0	0.12	0.37	0.2	22
Granite, n= 874																												
Minimum	0.05	0.18	0.25	0.5	4.0	0.05	0.02	0.05	1.0	17	0.7	0.39	0.04	4.0	0.08	48	0.2	0.003	1.6	0.003	0.6	0.05	0.25	3.0	0.0005	0.05	0.1	7.0
Maximum	2.1	4.6	8.7	187	1000	0.3	4.5	5.7	89	594	258	12	2.4	288	15	1100	403	0.41	1372	0.44	1008	124	0.9	475	0.39	1.8	9.2	2916
Mean	0.06	0.71	0.63	5.9	53	0.052	0.23	0.061	5.1	75	9.6	1.5	0.29	45	0.66	178	5.9	0.029	13	0.052	8.3	0.34	0.26	11	0.068	0.14	0.91	48
Median	0.05	0.63	0.5	4.0	38	0.05	0.18	0.05	4.1	67	4.9	1.3	0.24	44	0.5	161	4.9	0.025	6.1	0.045	5.4	0.1	0.25	8.0	0.065	0.1	0.7	43
Standard Deviation	0.083	0.38	0.62	9.0	62	0.012	0.31	0.19	6.2	43	21	0.75	0.23	24	0.88	98	14	0.02	67	0.044	37	4.2	0.055	22	0.055	0.12	0.86	100
Diorite, n= 1																												
04-ARD-120-012	0.1	1.0	0.9	2.0	323	0.1	1.0	0.05	24	49	60	3.4	0.45	29	1.1	242	5.0	0.099	9.4	0.15	3.6	0.3	0.25	33	0.15	0.1	2.2	54
Granodiorite, n =1																												
04-ARD-120-011	0.1	0.69	2.0	2.0	55	0.05	0.28	0.05	5.2	81	33	1.5	0.47	72	0.41	192	7.1	0.027	6.2	0.032	12	0.4	0.25	6.0	0.11	0.3	2.8	63
Diabase, n= 5																												
Minimum	0.05	1.4	0.25	7.0	10	0.05	0.28	0.05	22	16	1.5	4.5	0.09	9.0	0.71	253	0.7	0.005	20	0.079	0.9	0.05	0.25	10	0.008	0.05	0.1	48
Maximum	0.05	3.6	3.0	18	18	0.1	1.2	0.1	37	68	155	7.7	0.12	28	4.6	531	1.6	0.14	47	0.13	2.9	0.3	0.25	24	0.25	0.1	0.4	78
Mean	0.05	2.0	0.8	13	14	0.06	0.8	0.07	28	32	110	5.6	0.1	14	1.9	329	1.3	0.081	28	0.094	2.1	0.15	0.25	20	0.19	0.09	0.22	68
Median	0.05	1.6	0.25	13	16	0.05	0.85	0.05	24	21	131	4.8	0.1	11	0.85	290	1.4	0.088	22	0.091	2.1	0.1	0.25	22	0.23	0.1	0.2	68
Standard Deviation	0	0.9	1.2	4.3	3.7	0.022	0.32	0.027	6.4	22	62	1.4	0.013	8.0	1.7	115	0.36	0.049	11	0.018	0.74	0.1	0	5.7	0.1	0.022	0.11	12

Notes: 1) Typical crustal abundance for continental rocks taken from Price (1997).

>1 x − Concentration greater than typical crustal abundance.

>5 x − Concentration greater than 5 x the typical crustal abundance.

>10 x − Concentration greater than 10 x the typical crustal abundance.

ppm = parts per million; % = percent.

8.II.4.3.3 Shake Flask Extraction Testing

Table 8.II-28 provides the average, SD, and range of values in the SFE testing of the granite lithology (mean ± SD, [range]). Complete results are in Attachment 8.II.7.

The results indicate that the pH of all leachates is neutral to alkaline. The average concentrations of most key elements are less than the average concentrations from the kimberlite SFE. However, several elements, including antimony, lead and zinc had higher concentrations relative to the kimberlite results.

8.II.4.3.4 Kinetic Testing

8.II.4.3.4.1 Humidity Cells

Tables 8.II-29a and 8.II-29b contain a summary of the leachate chemistry for selected parameters from the standard humidity cells calculated from first flush (Table 8.II-29a) the steady-state rates (Table 8.II-29b). Figure 8.II-14 plots the pH and concentrations of key parameters. Attachment 8.II.8 provides the weekly results of the HC tests.

The principal observations with respect to the mine rock humidity cells are:

- Generally, the pH of the HC 5 ranges between 5.5 and 8.5, with the exception of granite cell HC 16, which ranges from 3.2 to 6.2. The pH values of the most leachates generally decrease slightly over time. The pH of leachate from HC 16 decreased after the first flush, until approximately 40 weeks, after which the pH values increased steadily over time.
- Sulphate concentrations were greatest in HC 16 compared to the other mine rock HCTs. Sulphate concentrations decreased steadily from week 31, and stabilizing at approximately 7 mg/L after week 118.
- Concentrations of major ions including sodium, magnesium and calcium generally decreased over time after 5 weeks.
- Key metal concentrations including selenium, zinc and iron were below the detection limits in most samples. In HC 16, zinc concentrations peaked to a maximum of 0.25 mg/L at 30 weeks then decreased over time to steady state values near the detection limit.
- Arsenic concentrations decreased after the first flush to a steady state concentration below the detection limit.

- Table 8.II-25 lists the average concentration of selected parameters in the first flush and at steady state. Mercury, chloride, phosphorus and chromium were less than the method detection limit (MDL) in all humidity cells. Cadmium, cobalt, iron, and nickel concentrations were less than method detection limit in all but one humidity cell. Metal concentrations in HC 16 are elevated, likely due to the acidic pH.
- The results indicate that for all humidity cells with the exception of HC 7, HC 9 and HC 14, sulphide sulphur will be depleted before NP (Table 8.II-30). The more conservative carbonate NP is predicted to deplete before sulphide sulphur in all cells with the exception of HC 12 and HC 15. Given the extremely low sulphur concentrations remaining at the point when carbonate NP is depleted, neutralization by non-carbonate NP minerals in the material will likely be sufficient to buffer any potential acidity generated from the oxidation of remaining sulphides to circum-neutral pH values.
- It is unlikely that acidic pH values (less than 4) will develop once the NP and carbonate NP have depleted due to the low sulphide concentrations of the samples that underwent humidity cell testing. The results of humidity cell testing suggest that it is unlikely that samples containing less than 0.1% have a long-term potential for acid generation.

Table 8.II-28 Summary of Gahcho Kué Project Mine Rock Shake Flask Extraction Tests

Parameter	pH	SO_4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
Unit	s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Granite, n = 34																					
Minimum	7.9	1.0	<0.005	<0.001	0.25	<0.001	<0.001	<0.001	<0.05	<0.001	0.27	<0.001	<0.0005	<0.001	<0.15	3.0	<0.001	1.8	0.003	<0.0005	<0.005
Maximum	9.8	38	6.3	0.048	35	0.003	0.003	0.005	6.9	0.057	7.6	0.15	0.033	0.003	1.5	48	<0.001	23	0.54	0.0038	0.06
Mean	8.7	6.1	1.5	0.0067	5.0	0.0011	0.0011	0.0017	0.82	0.0045	1.5	0.014	0.0053	0.0011	0.26	9.0	<0.001	5.3	0.06	0.0007	0.0079
Median	8.7	2.0	1.4	0.0045	3.3	0.001	0.001	0.001	0.49	0.001	0.78	0.007	0.0024	0.001	0.2	7.6	<0.001	3.9	0.024	0.0005	0.005
Standard Deviation	0.38	8.5	1.2	0.0083	6.8	0.001	0.0014	0.0014	1.4	0.013	1.4	0.026	0.0074	0.00096	0.31	7.6	---	4.7	0.11	0.0011	0.018

s.u. = standard unit; mg/L = milligrams per litre; < = less than

Table 8.II-29a First Flush Concentrations in Leachate from Mine Rock Humidity Cells

	pH	SO_4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	µs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
First Flush																					
HC 7 - Granite: Dec 14 - Jan 11, 2005																					
Minimum	7.4	<1	0.069	0.005	4.0	<0.001	<0.001	<0.001	<0.05	<0.001	0.45	0.006	0.0046	<0.001	<0.15	1.0	<0.001	<0.05	0.041	<0.0005	<0.005
Maximum	8.2	8.0	0.11	0.025	5.8	<0.001	<0.001	0.002	<0.05	<0.001	0.58	0.037	0.014	<0.001	<0.15	2.6	<0.001	3.2	0.05	0.0042	<0.005
Average	7.6	4.2	0.087	0.012	4.8	<0.001	<0.001	0.0013	<0.05	<0.001	0.51	0.025	0.0088	<0.001	<0.15	1.9	<0.001	1.3	0.045	0.0026	<0.005
Median	7.7	3.0	0.081	0.0056	4.6	<0.001	<0.001	0.001	<0.05	<0.001	0.51	0.033	0.0079	<0.001	<0.15	2.0	<0.001	0.6	0.043	0.003	<0.005
HC 8 - Granite: Dec 14 - Jan 11, 2005																					
Minimum	7.4	<1	0.056	<0.001	2.4	<0.001	<0.001	<0.001	<0.05	<0.001	0.19	0.004	0.0003	<0.001	<0.15	0.59	<0.001	<0.05	0.016	<0.0005	<0.005
Maximum	8.2	2.0	0.1	<0.001	4.1	<0.001	<0.001	0.001	0.08	<0.001	0.47	0.021	0.0019	<0.001	<0.15	2.5	<0.001	2.1	0.034	0.0006	<0.005
Average	7.6	1.4	0.08	<0.001	3.3	<0.001	<0.001	0.001	0.06	<0.001	0.35	0.011	0.0013	<0.001	<0.15	1.7	<0.001	0.8	0.028	0.00053	<0.005
Median	7.8	1.0	0.085	<0.001	3.5	<0.001	<0.001	0.001	0.05	<0.001	0.38	0.0086	0.0017	<0.001	<0.15	2.1	<0.001	0.22	0.033	0.0005	<0.005
HC 9 - Granite: Dec 14 - Jan 11, 2005																					
Minimum	7.4	8.0	0.059	<0.001	7.9	<0.001	<0.001	<0.001	<0.05	<0.001	0.94	0.02	0.0012	<0.001	<0.15	0.95	<0.001	<0.05	0.077	0.003	<0.005
Maximum	8.1	40	0.14	<0.001	13	<0.001	<0.001	<0.001	<0.05	<0.001	2.2	0.072	0.002	<0.001	<0.15	3.6	<0.001	6.2	0.14	0.0046	<0.005
Average	7.7	24	0.10	<0.001	9.6	<0.001	<0.001	<0.001	<0.05	<0.001	1.5	0.047	0.0016	<0.001	<0.15	2.2	<0.001	2.3	0.11	0.0038	<0.005
Median	7.7	21	0.1	<0.001	8.3	<0.001	<0.001	<0.001	<0.05	<0.001	1.4	0.05	0.0015	<0.001	<0.15	2.1	<0.001	0.73	0.1	0.0038	<0.005
HC 10 - Granite: Dec 14 - Jan 11, 2005																					
Minimum	7.2	1.0	0.047	0.0008	2.7	<0.001	<0.001	<0.001	<0.05	<0.001	0.53	0.004	0.0024	<0.001	<0.15	1.1	<0.001	<0.05	0.015	<0.0005	<0.005
Maximum	8.0	4.0	0.091	0.002	3.3	<0.001	<0.001	0.001	0.05	<0.001	0.68	0.046	0.0046	<0.001	<0.15	2.4	<0.001	2.6	0.021	0.0016	<0.005
Average	7.4	2.8	0.063	0.0016	3.0	<0.001	<0.001	0.001	0.05	<0.001	0.58	0.025	0.0033	<0.001	<0.15	2.0	<0.001	1.2	0.019	0.0011	<0.005
Median	7.5	3.0	0.05	0.002	3.1	<0.001	<0.001	0.001	0.05	<0.001	0.53	0.024	0.0029	<0.001	<0.15	2.4	<0.001	0.87	0.021	0.0013	<0.005

Table 8.II-29a First Flush Concentrations in Leachate from Mine Rock Humidity Cells (continued)

	pH	SO_4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	µs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
HC 12 - Granite: Dec 14 - Jan 11, 2005																					
Minimum	7.5	5.0	0.041	<0.001	5.7	<0.001	<0.001	<0.001	<0.05	<0.001	0.67	0.0081	0.01	<0.001	<0.15	1.3	<0.001	<0.05	0.073	<0.0005	<0.005
Maximum	8.0	20	0.11	0.0011	7.6	<0.001	<0.001	0.002	<0.05	<0.001	0.84	0.013	0.029	<0.001	<0.15	2.6	<0.001	4.9	0.09	0.0006	<0.005
Average	7.7	12	0.075	0.001	6.5	<0.001	<0.001	0.0013	<0.05	<0.001	0.78	0.011	0.02	<0.001	<0.15	2.1	<0.001	2.3	0.084	0.00053	<0.005
Median	7.7	12	0.074	0.001	6.3	<0.001	<0.001	0.001	<0.05	<0.001	0.82	0.011	0.02	<0.001	<0.15	2.3	<0.001	2.0	0.09	0.0005	<0.005
HC 13 - Granite: Dec 14 - Jan 11, 2005																					
Minimum	7.6	<1	0.081	<0.001	3.0	<0.001	<0.001	<0.001	<0.05	<0.001	0.24	0.006	0.0011	<0.001	<0.15	0.98	<0.001	0.4	0.017	<0.0005	<0.005
Maximum	8.3	3.0	0.13	0.002	5.3	<0.001	<0.001	0.002	0.06	<0.001	0.41	0.049	0.0039	<0.001	<0.15	2.5	0.001	2.3	0.02	0.0055	<0.005
Average	7.8	1.8	0.1	0.0013	3.9	<0.001	<0.001	0.0013	0.053	<0.001	0.33	0.028	0.0025	<0.001	<0.15	1.6	0.001	1.5	0.019	0.0036	<0.005
Median	7.9	1.0	0.1	0.001	3.4	<0.001	<0.001	0.001	0.05	<0.001	0.35	0.029	0.0025	<0.001	<0.15	1.4	0.001	1.7	0.019	0.0049	<0.005
HC 14 - Granite and Diorite: Dec 14 - Jan 11, 2005																					
Minimum	7.7	1.0	0.075	<0.001	3.2	<0.001	<0.001	<0.001	<0.05	<0.001	0.37	0.003	0.0027	<0.001	<0.15	1.3	<0.001	0.65	0.022	<0.0005	<0.005
Maximum	8.4	8.0	0.13	0.001	6.4	<0.001	<0.001	0.001	0.09	<0.001	1.1	0.083	0.0051	<0.001	<0.15	2.1	<0.001	2.3	0.047	0.0044	<0.005
Average	7.9	4.2	0.095	0.001	5.1	<0.001	<0.001	0.001	0.063	<0.001	0.71	0.048	0.004	<0.001	<0.15	1.7	<0.001	1.5	0.035	0.0027	<0.005
Median	7.9	4.0	0.081	0.001	5.7	<0.001	<0.001	0.001	0.05	<0.001	0.72	0.057	0.0042	<0.001	<0.15	1.8	<0.001	1.5	0.037	0.0032	<0.005
HC 15 - Granite: Dec 14 - Jan 11, 2005																					
Minimum	7.0	2.0	0.029	<0.001	0.83	<0.001	<0.001	<0.001	<0.05	<0.001	0.26	0.003	0.0009	<0.001	<0.15	1.2	<0.001	1.2	0.011	<0.0005	<0.005
Maximum	8.0	8.0	0.1	<0.001	1.4	<0.001	<0.001	<0.001	<0.05	<0.001	0.41	0.012	0.0015	<0.001	<0.15	2.4	0.001	3.0	0.018	<0.0005	0.005
Average	7.4	4.6	0.06	<0.001	1.1	<0.001	<0.001	<0.001	<0.05	<0.001	0.31	0.0074	0.0011	<0.001	<0.15	1.7	0.001	2.3	0.015	<0.0005	0.005
Median	7.7	3.0	0.051	<0.001	1.2	<0.001	<0.001	<0.001	<0.05	<0.001	0.27	0.0073	0.001	<0.001	<0.15	1.6	0.001	2.7	0.015	<0.0005	0.005
HC 16 - Granite: Dec 14 - Jan 11, 2005																					
Minimum	4.9	37	0.044	<0.001	7.6	<0.001	0.0024	<0.001	<0.05	0.0029	3.4	0.19	<0.0005	0.0092	<0.15	3.9	<0.001	0.68	0.07	<0.0005	0.056
Maximum	6.2	195	0.13	<0.001	44	<0.001	0.01	0.003	1.6	0.011	16	0.69	<0.0005	0.033	<0.15	9.6	<0.001	3.6	0.29	<0.0005	0.16
Average	5.2	106	0.098	<0.001	24	<0.001	0.0058	0.0017	0.64	0.0066	9.3	0.44	<0.0005	0.021	<0.15	6.6	<0.001	2.2	0.17	<0.0005	0.11
Median	5.2	87	0.12	<0.001	20	<0.001	0.005	0.001	0.28	0.006	8.3	0.45	<0.0005	0.02	<0.15	6.2	<0.001	2.3	0.15	<0.0005	0.11
HC 17 - Granite: Dec 14 - Jan 11, 2005																					
Minimum	7.0	2.0	0.032	<0.001	1.2	<0.001	<0.001	<0.001	<0.05	<0.001	0.27	0.004	0.0009	<0.001	<0.15	0.99	<0.001	0.95	0.012	<0.0005	<0.005
Maximum	8.0	7.0	0.099	<0.001	1.9	<0.001	<0.001	0.001	0.05	<0.001	0.43	0.025	0.0013	<0.001	<0.15	2.1	0.001	3.3	0.02	<0.0005	<0.005
Average	7.4	4.2	0.067	<0.001	1.6	<0.001	<0.001	0.001	0.05	<0.001	0.34	0.017	0.0011	<0.001	<0.15	1.5	0.001	2.1	0.017	<0.0005	<0.005
Median	7.8	3.0	0.07	<0.001	1.7	<0.001	<0.001	0.001	0.05	<0.001	0.33	0.022	0.0012	<0.001	<0.15	1.3	0.001	2.1	0.02	<0.0005	<0.005
HC 18 - Granite: Dec 14 - Jan 11, 2005																					
Minimum	7.7	<1	0.07	<0.001	2.3	<0.001	<0.001	<0.001	<0.05	<0.001	0.38	0.002	<0.0005	<0.001	<0.15	0.87	<0.001	0.61	0.016	<0.0005	<0.005
Maximum	8.5	2.0	0.13	<0.001	4.9	<0.001	<0.001	0.001	<0.05	<0.001	0.91	0.014	0.001	<0.001	<0.15	2.7	<0.001	3.8	0.043	<0.0005	<0.005
Average	8.0	1.4	0.11	<0.001	3.6	<0.001	<0.001	0.001	<0.05	<0.001	0.61	0.0069	0.0008	<0.001	<0.15	1.8	<0.001	2.5	0.03	<0.0005	<0.005
Median	8.3	1.0	0.13	<0.001	3.5	<0.001	<0.001	0.001	<0.05	<0.001	0.53	0.0047	0.0009	<0.001	<0.15	1.9	<0.001	3.2	0.032	<0.0005	<0.005

Table 8.II-29a First Flush Concentrations in Leachate from Mine Rock Humidity Cells (continued)

	pH	SO_4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	µs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
HC 19 - Granite and Granodiorite: Dec 14 - Jan 11, 2005																					
Minimum	7.8	<1	0.085	0.001	4.0	<0.001	<0.001	<0.001	<0.05	<0.001	0.32	0.005	0.0071	<0.001	<0.15	1.2	<0.001	0.39	0.019	0.0006	<0.005
Maximum	8.6	3.0	0.15	0.002	7.2	<0.001	<0.001	0.004	<0.05	<0.001	0.66	0.062	0.015	<0.001	<0.15	2.7	0.001	2.5	0.03	0.02	<0.005
Average	8.0	1.6	0.12	0.0014	6.1	<0.001	<0.001	0.002	<0.05	<0.001	0.49	0.037	0.012	<0.001	<0.15	2.0	0.001	1.5	0.025	0.013	<0.005
Median	8.1	1.0	0.12	0.0013	7.0	<0.001	<0.001	0.001	<0.05	<0.001	0.5	0.044	0.014	<0.001	<0.15	2.0	0.001	1.5	0.026	0.019	<0.005
HC 20 - Granite: Dec 14 - Jan 11, 2005																					
Minimum	7.6	<1	0.067	0.0014	3.4	<0.001	<0.001	<0.001	<0.05	<0.001	0.28	0.005	0.0033	<0.001	<0.15	1.3	<0.001	0.71	0.019	<0.0005	<0.005
Maximum	8.1	4.0	0.16	0.003	4.7	<0.001	<0.001	0.002	<0.05	<0.001	0.48	0.057	0.011	<0.001	<0.15	2.9	<0.001	2.6	0.027	0.0012	<0.005
Average	7.7	2.6	0.11	0.0021	4.2	<0.001	<0.001	0.0013	<0.05	<0.001	0.37	0.036	0.0067	<0.001	<0.15	2.0	<0.001	1.7	0.023	0.00087	<0.005
Median	7.6	3.0	0.088	0.002	4.6	<0.001	<0.001	0.001	<0.05	<0.001	0.34	0.047	0.0059	<0.001	<0.15	1.9	<0.001	1.9	0.024	0.0009	<0.005
HC 21 - Granite: Dec 14 - Jan 11, 2005																					
Minimum	7.4	27	0.087	<0.001	13	<0.001	<0.001	<0.001	<0.05	<0.001	1.6	0.007	0.001	<0.001	<0.15	2.0	<0.001	1.1	0.19	<0.0005	<0.005
Maximum	8.4	82	0.12	<0.001	30	<0.001	<0.001	<0.001	<0.05	<0.001	2.4	0.012	0.0024	<0.001	<0.15	4.6	<0.001	4.1	0.29	<0.0005	<0.005
Average	7.7	47	0.1	<0.001	20	<0.001	<0.001	<0.001	<0.05	<0.001	1.9	0.0091	0.0017	<0.001	<0.15	3.2	<0.001	2.6	0.23	<0.0005	<0.005
Median	7.9	40	0.098	<0.001	16	<0.001	<0.001	<0.001	<0.05	<0.001	1.7	0.0084	0.0016	<0.001	<0.15	3.0	<0.001	2.5	0.21	<0.0005	<0.005

s.u. = standard unit; mg/L = milligrams per litre; < = less than; µs/cm = microSiemens per centimetre.

Table 8.II-29b Steady State Concentrations in Leachate from Mine Rock Humidity Cells

	pH	SO_4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	µs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Steady State																					
HC 7 - Granite: Jul 26 - Aug 23, 2005																					
Minimum	7.0	<1	0.071	0.003	2.0	<0.001	<0.001	<0.001	<0.05	<0.001	0.13	<0.001	0.0006	<0.001	<0.15	0.3	<0.001	<0.05	0.008	<0.0005	<0.005
Maximum	7.5	<1	0.092	0.003	4.0	<0.001	<0.001	<0.001	<0.05	<0.001	0.24	<0.001	0.0012	<0.001	<0.15	0.4	<0.001	0.09	0.018	0.0008	<0.005
Average	7.2	<1	0.08	0.003	3.2	<0.001	<0.001	<0.001	<0.05	<0.001	0.2	<0.001	0.00097	<0.001	<0.15	0.33	<0.001	0.067	0.014	0.0007	<0.005
Median	7.3	<1	0.077	0.003	3.7	<0.001	<0.001	<0.001	<0.05	<0.001	0.23	<0.001	0.0011	<0.001	<0.15	0.3	<0.001	0.06	0.015	0.0008	<0.005
HC 8 - Granite: Nov 4 - Dec 2, 2008																					
Minimum	6.8	<1	0.008	<0.0002	1.3	<0.0002	<0.0002	0.0024	<0.01	<0.0002	0.07	0.0011	<0.0001	<0.0002	<0.03	0.14	<0.0002	0.03	0.0019	<0.0001	<0.001
Maximum	7.0	2.0	0.01	<0.0002	1.4	<0.0002	<0.0002	0.006	<0.01	<0.0002	0.12	0.0015	<0.0001	<0.0002	<0.03	0.15	<0.0002	0.06	0.0027	<0.0001	<0.001
Average	6.9	1.2	0.009	<0.0002	1.3	<0.0002	<0.0002	0.0042	<0.01	<0.0002	0.095	0.0013	<0.0001	<0.0002	<0.03	0.15	<0.0002	0.045	0.0023	<0.0001	<0.001
Median	6.9	1.0	0.009	<0.0002	1.3	<0.0002	<0.0002	0.0042	<0.01	<0.0002	0.095	0.0013	<0.0001	<0.0002	<0.03	0.15	<0.0002	0.045	0.0023	<0.0001	<0.001
HC 9 - Granite: Nov 4 - Dec 2, 2008																					
Minimum	6.9	<1	0.009	<0.0002	2.7	<0.0002	<0.0002	0.0067	<0.01	<0.0002	0.19	0.0006	0.0005	<0.0002	<0.03	0.2	<0.0002	0.04	0.003	<0.0001	0.001
Maximum	7.1	2.0	0.017	<0.0002	3.0	<0.0002	<0.0002	0.011	<0.01	<0.0002	0.3	0.0014	0.0005	0.0002	<0.03	0.21	<0.0002	0.07	0.0039	<0.0001	0.002
Average	7.0	1.4	0.013	<0.0002	2.8	<0.0002	<0.0002	0.0089	<0.01	<0.0002	0.25	0.001	0.0005	0.0002	<0.03	0.21	<0.0002	0.055	0.0035	<0.0001	0.0015
Median	7.0	1.0	0.013	<0.0002	2.8	<0.0002	<0.0002	0.0089	<0.01	<0.0002	0.25	0.001	0.0005	0.0002	<0.03	0.21	<0.0002	0.055	0.0035	<0.0001	0.0015

Table 8.II-29b Steady State Concentrations in Leachate from Mine Rock Humidity Cells (continued)

	pH	SO_4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	µs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
HC 10 - Granite: Nov 4 - Dec 2, 2008																					
Minimum	6.1	<1	0.004	<0.0002	0.45	<0.0002	<0.0002	0.0056	<0.01	0.0002	0.14	0.0048	<0.0001	<0.0002	<0.03	0.08	<0.0002	0.04	0.0024	<0.0001	0.001
Maximum	6.4	1.0	0.006	<0.0002	0.47	<0.0002	<0.0002	0.015	<0.01	0.0002	0.15	0.0067	<0.0001	<0.0002	<0.03	0.08	<0.0002	0.04	0.0025	<0.0001	0.002
Average	6.2	1.0	0.005	<0.0002	0.46	<0.0002	<0.0002	0.01	<0.01	0.0002	0.15	0.0058	<0.0001	<0.0002	<0.03	0.08	<0.0002	0.04	0.0025	<0.0001	0.0015
Median	6.2	1.0	0.005	<0.0002	0.46	<0.0002	<0.0002	0.01	<0.01	0.0002	0.15	0.0058	<0.0001	<0.0002	<0.03	0.08	<0.0002	0.04	0.0025	<0.0001	0.0015
HC 12 - Granite: Nov 4 - Dec 2, 2008																					
Minimum	6.4	<1	0.03	<0.0002	1.8	<0.0002	<0.0002	0.0048	0.02	<0.0002	0.43	0.0034	<0.0001	0.0004	<0.03	0.3	<0.0002	0.08	0.0066	<0.0001	0.002
Maximum	6.6	2.0	0.3	0.0002	2.3	0.0004	<0.0002	0.015	0.44	0.0023	0.81	0.013	0.0002	0.0005	<0.03	0.45	<0.0002	0.11	0.0098	<0.0001	0.007
Average	6.5	1.4	0.17	0.0002	2.0	0.0003	<0.0002	0.0099	0.23	0.0013	0.62	0.0082	0.00015	0.00045	<0.03	0.38	<0.0002	0.095	0.0082	<0.0001	0.0045
Median	6.5	1.0	0.17	0.0002	2.0	0.0003	<0.0002	0.0099	0.23	0.0013	0.62	0.0082	0.00015	0.00045	<0.03	0.38	<0.0002	0.095	0.0082	<0.0001	0.0045
HC 13 - Granite: Nov 4 - Dec 2, 2008																					
Minimum	6.4	<1	0.003	<0.0002	0.71	<0.0002	<0.0002	0.0035	<0.01	<0.0002	0.03	0.0041	<0.0001	<0.0002	<0.03	0.09	<0.0002	0.03	0.0009	<0.0001	0.001
Maximum	6.7	2.0	0.005	<0.0002	0.83	<0.0002	<0.0002	0.0038	<0.01	<0.0002	0.03	0.0044	<0.0001	<0.0002	<0.03	0.1	<0.0002	0.03	0.0011	<0.0001	0.001
Average	6.4	1.4	0.004	<0.0002	0.77	<0.0002	<0.0002	0.0037	<0.01	<0.0002	0.03	0.0043	<0.0001	<0.0002	<0.03	0.095	<0.0002	0.03	0.001	<0.0001	0.001
Median	6.4	1.0	0.004	<0.0002	0.77	<0.0002	<0.0002	0.0037	<0.01	<0.0002	0.03	0.0043	<0.0001	<0.0002	<0.03	0.095	<0.0002	0.03	0.001	<0.0001	0.001
HC 14 - Granite and Diorite: Nov 4 - Dec 2, 2008																					
Minimum	7.0	<1	0.015	<0.0002	2.1	<0.0002	<0.0002	0.0018	<0.01	<0.0002	0.04	0.0002	0.0003	<0.0002	<0.03	0.26	<0.0002	0.03	0.0024	<0.0001	<0.001
Maximum	7.2	2.0	0.019	<0.0002	2.2	<0.0002	<0.0002	0.0048	<0.01	<0.0002	0.04	0.0005	0.0003	<0.0002	<0.03	0.27	<0.0002	0.04	0.0027	<0.0001	0.001
Average	7.1	1.4	0.017	<0.0002	2.1	<0.0002	<0.0002	0.0033	<0.01	<0.0002	0.04	0.00035	0.0003	<0.0002	<0.03	0.27	<0.0002	0.035	0.0026	<0.0001	0.001
Median	7.1	1.0	0.017	<0.0002	2.1	<0.0002	<0.0002	0.0033	<0.01	<0.0002	0.04	0.00035	0.0003	<0.0002	<0.03	0.27	<0.0002	0.035	0.0026	<0.0001	0.001
HC 15 - Granite: Nov 4 - Dec 2, 2008																					
Minimum	6.3	1.0	0.016	<0.001	0.35	<0.001	<0.001	<0.001	<0.05	<0.001	0.11	0.006	<0.0005	<0.001	<0.15	0.3	<0.001	<0.05	0.004	<0.0005	<0.005
Maximum	7.2	3.0	0.02	<0.001	0.45	<0.001	<0.001	<0.001	<0.05	<0.001	0.16	0.009	<0.0005	<0.001	<0.15	0.4	<0.001	0.15	0.005	<0.0005	0.005
Average	6.5	1.4	0.018	<0.001	0.38	<0.001	<0.001	<0.001	<0.05	<0.001	0.13	0.0073	<0.0005	<0.001	<0.15	0.37	<0.001	0.093	0.0047	<0.0005	0.005
Median	6.4	1.0	0.019	<0.001	0.35	<0.001	<0.001	<0.001	<0.05	<0.001	0.13	0.007	<0.0005	<0.001	<0.15	0.4	<0.001	0.08	0.005	<0.0005	0.005
HC 16 - Granite: Nov 4 - Dec 2, 2008																					
Minimum	5.0	<1	0.023	<0.0002	0.25	<0.0002	0.0005	0.0064	<0.01	<0.0002	0.33	0.0064	<0.0001	0.0011	<0.03	0.29	<0.0002	0.04	0.0018	<0.0001	0.007
Maximum	5.1	3.0	0.024	<0.0002	0.28	<0.0002	0.0005	0.0067	<0.01	<0.0002	0.37	0.0069	<0.0001	0.0011	<0.03	0.29	<0.0002	0.04	0.002	<0.0001	0.007
Average	5.0	2.2	0.024	<0.0002	0.27	<0.0002	0.0005	0.0066	<0.01	<0.0002	0.35	0.0067	<0.0001	0.0011	<0.03	0.29	<0.0002	0.04	0.0019	<0.0001	0.007
Median	5.1	3.0	0.024	<0.0002	0.27	<0.0002	0.0005	0.0066	<0.01	<0.0002	0.35	0.0067	<0.0001	0.0011	<0.03	0.29	<0.0002	0.04	0.0019	<0.0001	0.007
HC 17 - Granite: Nov 4 - Dec 2, 2008																					
Minimum	5.7	<1	0.002	<0.0002	0.23	<0.0002	<0.0002	0.0007	<0.01	0.0007	0.08	0.033	<0.0001	0.0003	<0.03	0.09	<0.0002	0.04	0.0018	<0.0001	<0.001
Maximum	5.9	2.0	0.003	<0.0002	0.23	<0.0002	<0.0002	0.0044	<0.01	0.0007	0.08	0.037	<0.0001	0.0004	<0.03	0.1	<0.0002	0.06	0.002	<0.0001	0.001
Average	5.8	1.2	0.0025	<0.0002	0.23	<0.0002	<0.0002	0.0026	<0.01	0.0007	0.08	0.035	<0.0001	0.00035	<0.03	0.095	<0.0002	0.05	0.0019	<0.0001	0.001
Median	5.9	1.0	0.0025	<0.0002	0.23	<0.0002	<0.0002	0.0026	<0.01	0.0007	0.08	0.035	<0.0001	0.00035	<0.03	0.095	<0.0002	0.05	0.0019	<0.0001	0.001

Table 8.II-29b Steady State Concentrations in Leachate from Mine Rock Humidity Cells (continued)

	pH	SO_4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	µs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
HC 18 - Granite: Nov 4 - Dec 2, 2008																					
Minimum	7.4	<1	0.018	<0.0002	2.7	<0.0002	<0.0002	0.0026	<0.01	<0.0002	1.1	<0.0002	<0.0001	<0.0002	<0.03	0.2	<0.0002	0.04	0.0029	<0.0001	<0.001
Maximum	7.5	1.0	0.028	<0.0002	2.8	<0.0002	<0.0002	0.0051	0.01	<0.0002	1.2	0.0006	<0.0001	<0.0002	<0.03	0.22	<0.0002	0.04	0.0032	<0.0001	<0.001
Average	7.4	1.0	0.023	<0.0002	2.7	<0.0002	<0.0002	0.0039	0.01	<0.0002	1.2	0.0004	<0.0001	<0.0002	<0.03	0.21	<0.0002	0.04	0.0031	<0.0001	<0.001
Median	7.4	1.0	0.023	<0.0002	2.7	<0.0002	<0.0002	0.0039	0.01	<0.0002	1.2	0.0004	<0.0001	<0.0002	<0.03	0.21	<0.0002	0.04	0.0031	<0.0001	<0.001
HC 19 - Granite and Granodiorite: Nov 4 - Dec 2, 2008																					
Minimum	6.9	<1	0.028	<0.0002	1.6	<0.0002	<0.0002	0.0044	<0.01	<0.0002	0.04	0.0005	0.0003	<0.0002	<0.03	0.15	<0.0002	0.05	0.0016	<0.0001	0.002
Maximum	7.1	2.0	0.039	<0.0002	1.6	<0.0002	<0.0002	0.0055	<0.01	<0.0002	0.04	0.0026	0.0003	<0.0002	<0.03	0.15	<0.0002	0.05	0.0017	<0.0001	0.006
Average	7.0	1.4	0.034	<0.0002	1.6	<0.0002	<0.0002	0.005	<0.01	<0.0002	0.04	0.0016	0.0003	<0.0002	<0.03	0.15	<0.0002	0.05	0.0017	<0.0001	0.004
Median	7.0	1.0	0.034	<0.0002	1.6	<0.0002	<0.0002	0.005	<0.01	<0.0002	0.04	0.0016	0.0003	<0.0002	<0.03	0.15	<0.0002	0.05	0.0017	<0.0001	0.004
HC 20 - Granite: Nov 4 - Dec 2, 2008																					
Minimum	6.6	<1	0.02	<0.0002	1.1	<0.0002	<0.0002	0.0026	<0.01	0.0002	0.02	0.0027	0.0002	<0.0002	<0.03	0.11	<0.0002	0.04	0.0012	<0.0001	<0.001
Maximum	6.7	2.0	0.021	<0.0002	1.2	<0.0002	<0.0002	0.004	<0.01	0.0003	0.02	0.0033	0.0002	<0.0002	<0.03	0.11	<0.0002	0.05	0.0014	<0.0001	0.001
Average	6.7	1.2	0.021	<0.0002	1.1	<0.0002	<0.0002	0.0033	<0.01	0.00025	0.02	0.003	0.0002	<0.0002	<0.03	0.11	<0.0002	0.045	0.0013	<0.0001	0.001
Median	6.7	1.0	0.021	<0.0002	1.1	<0.0002	<0.0002	0.0033	<0.01	0.00025	0.02	0.003	0.0002	<0.0002	<0.03	0.11	<0.0002	0.045	0.0013	<0.0001	0.001
HC 21 - Granite: Nov 4 - Dec 2, 2008																					
Minimum	6.4	<1	0.003	<0.0002	0.53	<0.0002	<0.0002	0.0022	<0.01	<0.0002	0.17	0.0082	<0.0001	<0.0002	<0.03	0.21	<0.0002	0.04	0.0072	<0.0001	0.001
Maximum	6.5	2.0	0.005	<0.0002	0.68	<0.0002	<0.0002	0.0048	<0.01	<0.0002	0.25	0.0095	<0.0001	<0.0002	<0.03	0.22	<0.0002	0.06	0.01	<0.0001	0.002
Average	6.5	1.2	0.004	<0.0002	0.61	<0.0002	<0.0002	0.0035	<0.01	<0.0002	0.21	0.0089	<0.0001	<0.0002	<0.03	0.22	<0.0002	0.05	0.0086	<0.0001	0.0015
Median	6.5	1.0	0.004	<0.0002	0.61	<0.0002	<0.0002	0.0035	<0.01	<0.0002	0.21	0.0089	<0.0001	<0.0002	<0.03	0.22	<0.0002	0.05	0.0086	<0.0001	0.0015

s.u. = standard unit; mg/L = milligrams per litre; < = less than; µs/cm = microSiemens per centimetre.

Figure 8.II-14 Leachate Concentrations in Mine Rock Humidity Cells

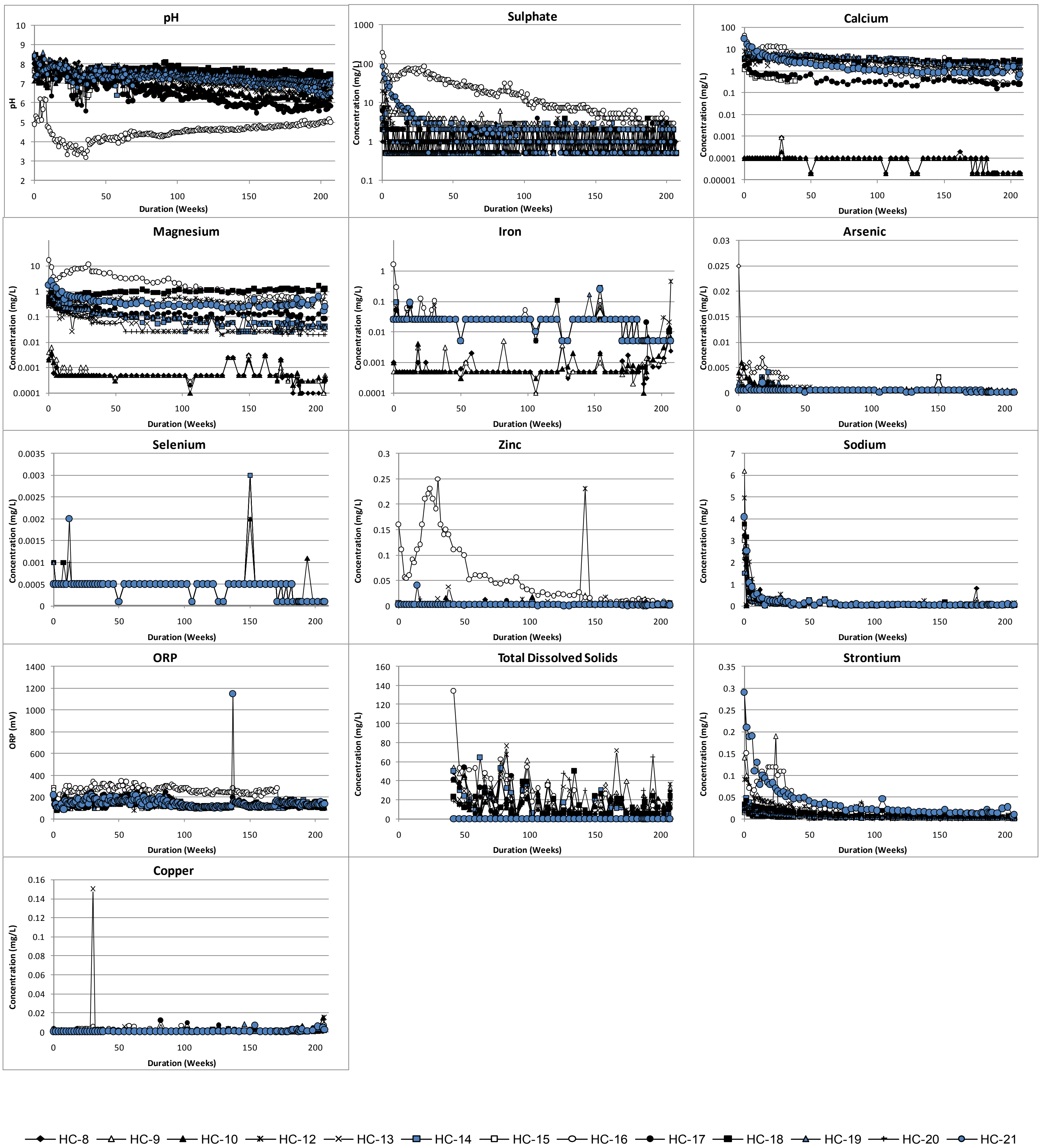


Table 8.II-30 Estimated Acid Potential and Neutralizing Potential Depletion Times for Mine Rock Humidity Cells

Humidity Cell ID	Lithology	Sulphide Sulphur (wt. %)	NP (kg $CaCO_3$/t)	Time to Depletion (Years)				
				Sulphide Sulphur	NP (emp)	CaNP (emp)	NP (SO4)	CaNP (SO4)
HC 7	Granite	0.02	5.2	48	15	6.9	247	119
HC 8	Granite	0.033	4.8	29	35	5.9	163	48
HC 9	Granite	0.073	2.5	59	28	0.6	172	31
HC 10	Granite	0.02	4.2	24	45	21	113	59
HC 12	Granite	0.023	9.6	15	74	17	213	66
HC 13	Granite	0.02	5.4	14	28	14	80	45
HC 14	Granite and Diorite	0.067	3.0	47	30	9.1	142	56
HC 15	Granite	0.02	4.7	25	545	82	115	17
HC 16	Granite	0.1	1.3	14	45	0	30	0
HC 17	Granite	0.04	1.6	35	34	7.5	59	15
HC 18	Granite	0.02	15	25	25	20	408	338
HC 19	Granite and Granodiorite	0.025	8.1	21	32	19	152	101
HC 20	Granite	0.02	12	20	62	14	263	75
HC 21	Granite	0.08	4.5	67	122	17	341	60

wt % = percent by weight; kg/t = kilograms per tonne; ID = identification

8.II.4.3.4.2 Pre-leached Granite

Generally, mine rock at the Project site has very low concentrations of total sulphur. Only 4% of all mine rock samples reported concentrations greater than 0.3 wt% sulphur. However, the mine rock has low neutralization potential values compared to kimberlite samples. To examine the potential leachate geochemistry from mine rock following neutralization potential depletion, four humidity cell tests were constructed with granite after complete removal of NP (confirmed by ABA) (Table 8.II-31). Tables 8.II-32a and 32b contain a summary of the leachate chemistry for selected parameters from the standard humidity cells. Results are presented for both the first flush (the first five weeks) in Table 8.II-32a and steady state conditions (the last five weeks) in Table 8.II-32b. Figure 8.II-15 plots the pH and concentrations of key parameters. Attachment 8.II.9 provides the weekly results of the HC tests. The principal observations with respect pre-leached granite humidity cells are:

- The pH of the pre-leached cells HC (HC 28 through HC 31) reported acidic pH values suggesting that there is little remaining readily available neutralization potential in these samples (Figure 8.II-15). The pH of HC 29 is similar to mine rock HC 16 with pH values between four and five. Leachate pH stabilized for all cells after approximately 25 weeks, though a slight increase in pH was observed over the last 50 weeks of testing. Results of the pre-leached humidity cells suggests that even after removal of carbonate and modified Sobek NP the granite mine rock, may buffer leachate to a pH between five and six, suggesting that non-carbonate minerals may contribute to overall neutralization.
- The concentrations of major elements including magnesium, sodium and calcium decreased to steady state concentrations after less than ten weeks.
- The concentrations of metals in the leachate were greater in the pre-leached granites than the unleached granites that underwent HCT for several elements including, iron and zinc. Metal concentrations decreased over time.
- Elevated concentrations of aluminum, copper, lead, iron, and zinc can occur in the leachate relative to mine rock that has not been leached, once the neutralizing potential of the mine rock is exhausted, although HC leachate chemistry is not a direct measure of predicted site water quality from NP depleted mine rock.

Table 8.II-31 Comparison of Acid Base Accounting Results for Pre-Leached mine Rock Humidity Cells

Sample	Paste pH		NP (kg $CaCO_3$/t)		Total Sulphur (wt. %)	
	Original	Post Leach	Original	Post Leach	Original	Post Leach
HC 28	9.4	5.6	4.5	0	4.5	0
HC 29	8.3	5.1	5.3	0	5.3	0
HC 30	8.9	6.9	4.3	0.8	4.3	0.8
HC 31	8.9	6.4	1.8	0.3	1.8	0.3

kg/t = kilograms per tonne; wt % = percent by weight.

Table 8.II-32a First Flush Concentrations in Leachate from Pre-leached Mine Rock Humidity Cells

	pH	SO4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
First Flush																					
HC 28 - Pre-leached Granite: Nov 15, 2005 - Dec 13, 2005																					
Minimum	2.9	1.0	0.42	<0.001	1.2	<0.001	<0.001	<0.001	0.28	<0.001	0.22	0.011	<0.0005	<0.001	<0.15	0.6	<0.001	<0.05	0.003	<0.0005	<0.005
Maximum	4.2	2.0	74	<0.001	365	0.051	0.035	0.043	88	0.038	67	2.5	<0.0005	0.068	1.4	50	<0.001	1.6	0.11	0.0028	0.67
Average	3.3	1.3	37	<0.001	183	0.026	0.018	0.022	44	0.02	34	1.3	<0.0005	0.035	0.78	25	<0.001	0.82	0.057	0.0017	0.34
Median	3.5	1.0	37	<0.001	183	0.026	0.018	0.022	44	0.02	34	1.3	<0.0005	0.035	0.78	25	<0.001	0.82	0.057	0.0017	0.34
HC 29 - Pre-leached Granite: Nov 15, 2005 - Dec 13, 2005																					
Minimum	3.1	2.0	0.54	<0.001	1.1	<0.001	0.002	0.003	0.42	<0.001	0.86	0.012	<0.0005	<0.001	<0.15	1.2	<0.001	0.25	0.005	<0.0005	0.039
Maximum	4.2	5.0	44	<0.001	141	0.015	0.034	0.14	25	0.023	79	1.3	<0.0005	0.065	<0.15	19	<0.001	1.6	0.17	0.0023	0.7
Average	3.5	3.3	22	<0.001	71	0.008	0.018	0.072	13	0.012	40	0.68	<0.0005	0.033	<0.15	10	<0.001	0.92	0.088	0.0014	0.37
Median	3.8	3.0	22	<0.001	71	0.008	0.018	0.072	13	0.012	40	0.68	<0.0005	0.033	<0.15	10	<0.001	0.92	0.088	0.0014	0.37
HC 30 - Pre-leached Granite: Nov 15, 2005 - Dec 13, 2005																					
Minimum	3.8	1.0	0.035	<0.001	1.6	<0.001	<0.001	<0.001	<0.05	<0.001	0.3	0.002	<0.0005	<0.001	<0.15	0.7	<0.001	0.52	0.011	<0.0005	<0.005
Maximum	4.8	11	6.5	0.001	248	<0.001	0.013	0.065	0.82	0.43	32	0.81	<0.0005	0.029	<0.15	1.6	<0.001	4.0	0.078	0.0022	0.2
Average	4.2	3.2	3.3	0.001	125	<0.001	0.007	0.033	0.44	0.22	16	0.41	<0.0005	0.015	<0.15	1.2	<0.001	2.3	0.045	0.0014	0.1
Median	4.5	1.0	3.3	0.001	125	<0.001	0.007	0.033	0.44	0.22	16	0.41	<0.0005	0.015	<0.15	1.2	<0.001	2.3	0.045	0.0014	0.1
HC 31 - Pre-leached Granite: Nov 15, 2005 - Dec 13, 2005																					
Minimum	3.4	<1	0.26	<0.001	0.99	<0.001	<0.001	<0.001	0.26	<0.001	0.27	0.005	<0.0005	<0.001	<0.15	0.2	<0.001	<0.05	0.002	<0.0005	<0.005
Maximum	4.4	2.0	31	<0.001	361	0.007	0.018	0.02	28	0.025	43	0.88	<0.0005	0.033	<0.15	2.0	<0.001	0.87	0.1	0.0015	0.19
Average	3.7	1.4	15	<0.001	181	0.004	0.0095	0.011	14	0.013	22	0.44	<0.0005	0.017	<0.15	1.1	<0.001	0.46	0.051	0.001	0.098
Median	3.9	1.0	15	<0.001	181	0.004	0.0095	0.011	14	0.013	22	0.44	<0.0005	0.017	<0.15	1.1	<0.001	0.46	0.051	0.001	0.098

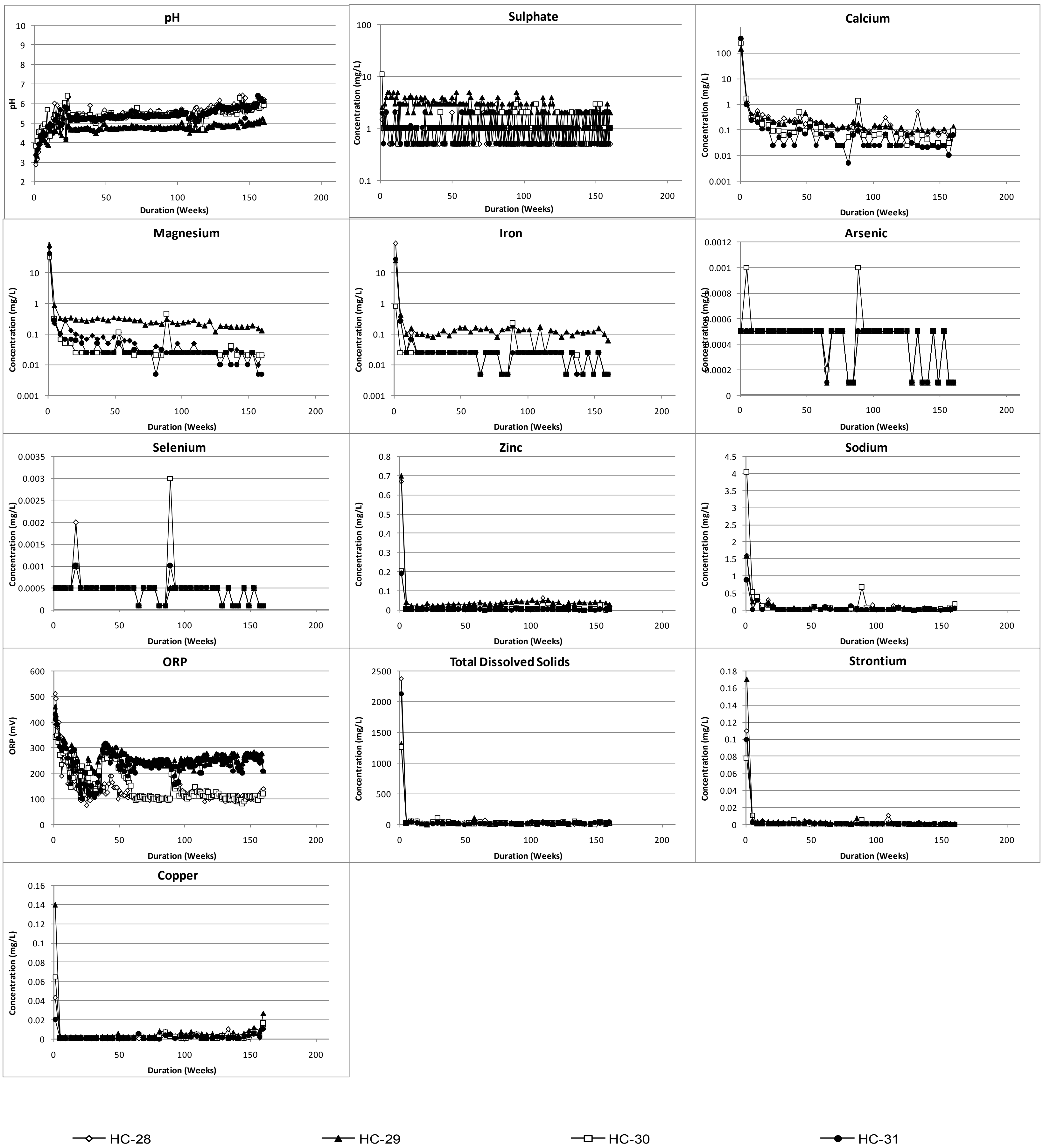
s.u. = standard unit; mg/L = milligrams per litre; < = less than.

Table 8.II-32b Steady State Concentrations in Leachate from Pre-leached Mine Rock Humidity Cells

	pH	SO4	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Steady State																					
HC 28 - Pre-leached Granite: Nov 4, 2008 - Dec 2, 2008																					
Minimum	6.1	<1	<0.001	<0.0002	0.04	<0.0002	<0.0002	0.0012	<0.01	<0.0002	0.01	0.0004	<0.0001	<0.0002	0.09	0.05	<0.0002	<0.01	<0.0002	<0.0001	0.001
Maximum	6.3	2.0	0.002	<0.0002	0.08	<0.0002	<0.0002	0.013	<0.01	<0.0002	0.02	0.0005	<0.0001	0.0002	0.19	0.06	<0.0002	0.05	0.0003	<0.0001	0.002
Average	6.2	1.2	0.0015	<0.0002	0.06	<0.0002	<0.0002	0.0071	<0.01	<0.0002	0.015	0.00045	<0.0001	0.0002	0.14	0.055	<0.0002	0.03	0.00025	<0.0001	0.0015
Median	6.3	1.0	0.0015	<0.0002	0.06	<0.0002	<0.0002	0.0071	<0.01	<0.0002	0.015	0.00045	<0.0001	0.0002	0.14	0.055	<0.0002	0.03	0.00025	<0.0001	0.0015
HC 29 - Pre-leached Granite: Nov 4, 2008 - Dec 2, 2008																					
Minimum	5.0	<1	0.005	<0.0002	0.06	<0.0002	0.0004	0.0089	0.06	<0.0002	0.13	0.0016	<0.0001	0.0007	<0.03	0.16	<0.0002	0.02	0.0007	<0.0001	0.031
Maximum	5.3	3.0	0.007	<0.0002	0.13	<0.0002	0.0005	0.027	0.1	<0.0002	0.15	0.0022	<0.0001	0.0009	0.1	0.16	<0.0002	0.1	0.0007	<0.0001	0.038
Average	5.1	1.6	0.006	<0.0002	0.095	<0.0002	0.00045	0.018	0.08	<0.0002	0.14	0.0019	<0.0001	0.0008	0.065	0.16	<0.0002	0.06	0.0007	<0.0001	0.035
Median	5.1	1.0	0.006	<0.0002	0.095	<0.0002	0.00045	0.018	0.08	<0.0002	0.14	0.0019	<0.0001	0.0008	0.065	0.16	<0.0002	0.06	0.0007	<0.0001	0.035
HC 30 - Pre-leached Granite: Nov 4, 2008 - Dec 2, 2008																					
Minimum	5.8	<1	<0.001	<0.0002	0.03	<0.0002	<0.0002	0.0039	<0.01	<0.0002	0.02	0.0007	<0.0001	<0.0002	<0.03	0.05	<0.0002	0.05	<0.0002	<0.0001	0.001
Maximum	6.0	2.0	0.002	<0.0002	0.09	<0.0002	<0.0002	0.016	<0.01	<0.0002	0.02	0.0007	<0.0001	0.0005	0.18	0.05	<0.0002	0.16	<0.0002	<0.0001	0.003
Average	5.9	1.2	0.0015	<0.0002	0.06	<0.0002	<0.0002	0.010	<0.01	<0.0002	0.02	0.0007	<0.0001	0.00035	0.11	0.05	<0.0002	0.11	<0.0002	<0.0001	0.002
Median	5.9	1.0	0.0015	<0.0002	0.06	<0.0002	<0.0002	0.010	<0.01	<0.0002	0.02	0.0007	<0.0001	0.00035	0.11	0.05	<0.0002	0.11	<0.0002	<0.0001	0.002
HC 31 - Pre-leached Granite: Nov 4, 2008 - Dec 2, 2008																					
Minimum	6.1	<1	<0.001	<0.0002	0.01	<0.0002	<0.0002	0.002	<0.01	<0.0002	<0.01	0.0003	<0.0001	<0.0002	<0.03	0.04	<0.0002	0.01	<0.0002	<0.0001	<0.005
Maximum	6.4	2.0	0.002	<0.0002	0.06	<0.0002	<0.0002	0.01	<0.01	<0.0002	<0.01	0.0003	<0.0001	<0.0002	<0.03	0.05	<0.0002	0.03	<0.0002	<0.0001	0.005
Average	6.2	1.2	0.0015	<0.0002	0.035	<0.0002	<0.0002	0.006	<0.01	<0.0002	<0.01	0.0003	<0.0001	<0.0002	<0.03	0.045	<0.0002	0.02	<0.0002	<0.0001	0.005
Median	6.2	1.0	0.0015	<0.0002	0.035	<0.0002	<0.0002	0.006	<0.01	<0.0002	<0.01	0.0003	<0.0001	<0.0002	<0.03	0.045	<0.0002	0.02	<0.0002	<0.0001	0.005

s.u. = standard unit; mg/L = milligrams per litre; < = less than.

Figure 8.II-15 Leachate Concentrations in Pre-leached Granite Humidity Cells



8.II.4.3.5 Column Tests

Tables 8.II-33a and 8.II-33b contain a summary of the leachate chemistry for selected parameters from the mine rock column cells calculated from the first flush using the first five sampling events (Table 8.II-33a) and for steady state rates using the last five sampling events (Table 8.II-33b). Figure 8.II-16 presents the concentrations of key parameters and pH values of the leachates. Attachment 8.II.9 provides the detailed results. The principal observations with respect to the mine rock columns are:

- The pH values of leachate from the columns ranged between a maximum of 8.2 and a minimum of 6.4. The pH values were generally stable except for a decline during week 20 to week 32, which is suspect as all columns display the same trend. Laboratory data for this period is considered suspect and was not included in further assessment of the data.
- Sulphate concentrations decreased throughout the test. TDS concentrations also rapidly decreased throughout the test.
- Overall, the concentrations of metals in leachate from the granite columns were very low. Concentrations for most parameters including sulphate, chloride, and TDS were less than the kimberlite column leach.

Table 8.II-33a First Flush Concentrations in Leachate from Mine Rock Column Tests

	pH	Sulphate	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Column 1 - Granite : Jan 31, 2005 - Feb 28, 2005																					
Minimum	7.3	1.0	0.039	0.002	8.8	<0.001	<0.001	<0.001	<0.05	<0.001	2.5	0.084	0.014	<0.001	<0.15	6.0	<0.001	3.4	0.078	<0.0005	<0.005
Maximum	7.5	9.0	0.047	0.004	13	<0.001	<0.001	0.003	<0.05	<0.001	3.9	0.36	0.035	0.001	<0.15	16	<0.001	15	0.11	0.0012	<0.005
Average	7.3	2.8	0.029	0.001	3.4	0.00052	0.00052	0.00055	0.034	0.00052	1.0	0.062	0.0027	0.00052	0.077	1.8	0.00094	0.77	0.027	0.00038	0.003
Median	7.3	6.0	0.042	0.003	9.7	<0.001	<0.001	0.001	<0.05	<0.001	2.8	0.3	0.016	0.001	<0.15	7.9	<0.001	5.4	0.081	0.0006	<0.005
Column 2 - Granite : Jan 31, 2005 - Feb 28, 2005																					
Minimum	7.5	24	0.041	0.004	17	<0.001	<0.001	<0.001	<0.05	<0.001	4.6	0.061	0.015	<0.001	<0.15	9.8	<0.001	8.0	0.21	0.0046	<0.005
Maximum	8.0	107	0.072	0.005	33	<0.001	<0.001	0.008	<0.05	<0.001	9.6	0.21	0.035	0.007	<0.15	17	<0.001	35	0.4	0.015	<0.005
Average	7.7	9.0	0.035	0.0027	9.4	0.00052	0.00052	0.00052	0.032	0.00052	2.4	0.035	0.0035	0.00052	0.077	3.1	0.001	1.6	0.11	0.01	0.0028
Median	7.8	25	0.045	0.004	20	<0.001	<0.001	0.001	<0.05	<0.001	5.9	0.17	0.022	0.001	<0.15	12	<0.001	13	0.26	0.0055	<0.005
Column 3 - Granite : Jan 31, 2005 - Feb 28, 2005																					
Minimum	7.2	1.0	<0.005	<0.001	57	<0.001	<0.001	<0.001	<0.05	<0.001	7.3	0.002	<0.0005	0.001	<0.15	51	<0.001	7.3	1.1	<0.0005	<0.005
Maximum	7.4	6.0	0.031	0.003	88	<0.001	<0.001	0.001	0.56	<0.001	25	0.019	<0.0005	0.006	<0.15	69	<0.001	61	1.6	<0.0005	<0.005
Average	7.3	1.3	0.0062	0.00063	17	0.00053	0.00053	0.00053	0.033	0.00053	2.7	0.0017	0.00027	0.00057	0.08	22	0.0011	2.2	0.36	0.00027	0.0028
Median	7.3	1.0	0.008	0.001	79	<0.001	<0.001	0.001	0.14	<0.001	14	0.012	<0.0005	0.002	<0.15	62	<0.001	21	1.6	<0.0005	<0.005
Column 4 - Granite : Jan 31, 2005 - Feb 28, 2005																					
Minimum	7.6	3.0	0.017	0.008	6.9	<0.001	<0.001	<0.001	<0.05	<0.001	1.9	0.015	0.0037	<0.001	<0.15	6.0	<0.001	4.6	0.079	<0.0005	<0.005
Maximum	8.0	7.0	0.075	0.016	15	<0.001	<0.001	0.002	<0.05	<0.001	4.4	0.18	0.0054	0.002	<0.15	10	<0.001	16	0.16	0.0037	<0.005
Average	7.8	1.2	0.063	0.003	9.4	0.00057	0.00053	0.00063	0.031	0.00053	1.4	0.036	0.00084	0.00053	0.08	1.8	0.0011	1.1	0.08	0.0033	0.003
Median	8.0	4.0	0.06	0.013	11	<0.001	<0.001	0.001	<0.05	<0.001	3.1	0.13	0.0044	0.001	<0.15	6.7	<0.001	9.6	0.13	0.0015	<0.005
Column 6 - Granite : Jan 31, 2005 - Feb 28, 2005																					
Minimum	7.8	21	0.025	0.004	18	0.002	<0.001	<0.001	<0.05	<0.001	5.2	0.076	0.0065	<0.001	<0.15	7.4	<0.001	3.8	0.3	0.0009	<0.005
Maximum	8.0	134	0.048	0.005	37	0.003	<0.001	0.002	<0.05	<0.001	10	0.22	0.01	0.002	<0.15	21	<0.001	24	0.4	0.0035	<0.005
Average	7.9	5.8	0.035	0.0039	9.6	0.00097	0.00052	0.00052	0.029	0.00052	2.2	0.019	0.0032	0.00052	0.077	2.4	0.00097	1.0	0.14	0.0022	0.0027
Median	7.9	38	0.031	0.004	21	0.002	<0.001	0.001	<0.05	<0.001	5.7	0.2	0.01	0.001	<0.15	10	<0.001	8.4	0.34	0.0019	<0.005

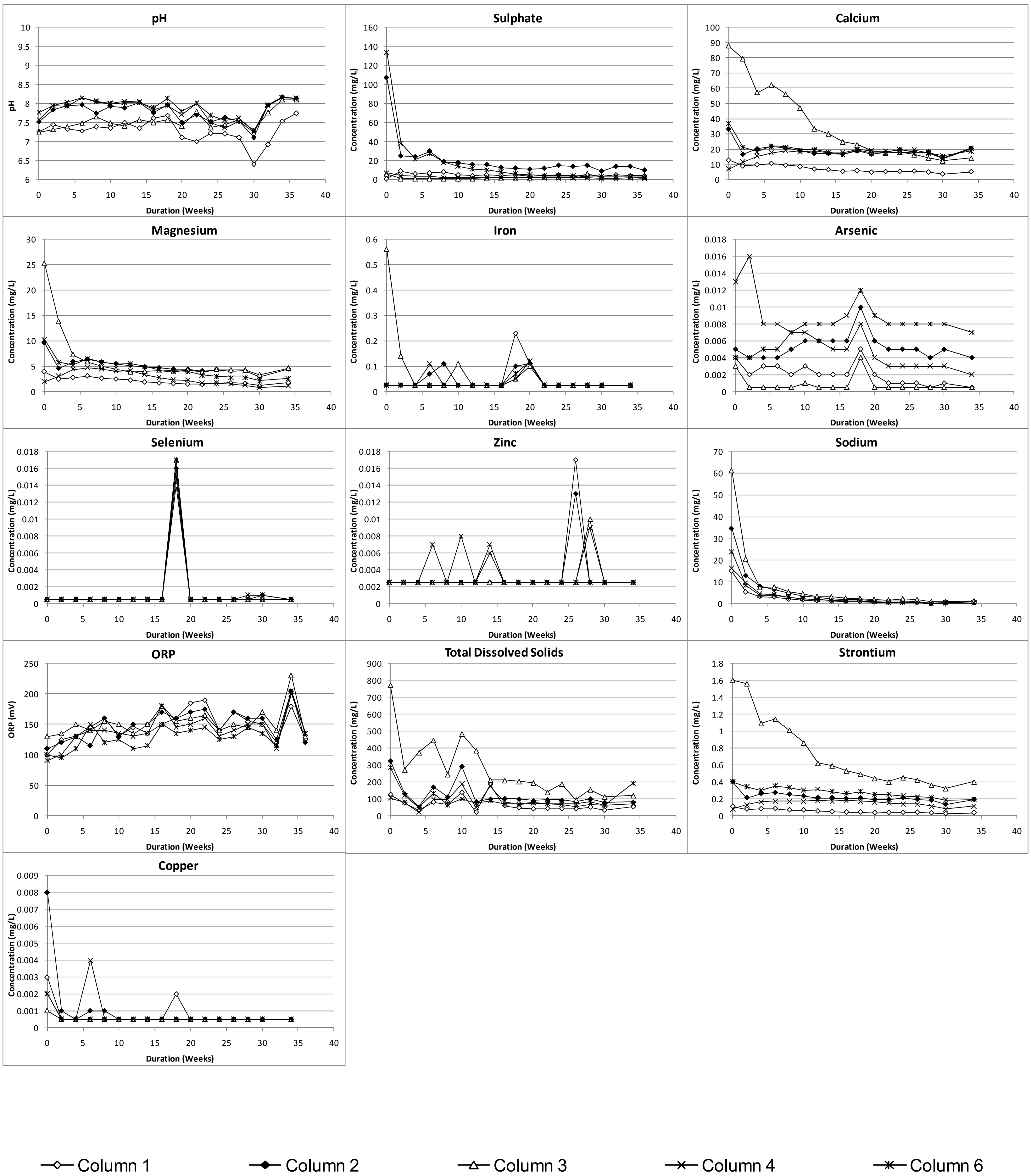
s.u. = standard unit; mg/L = milligrams per litre; < = less than.

Table 8.II-33b Steady State Concentrations in Leachate from Mine Rock Column Tests

	pH	Sulphate	Al	As	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Na	Sr	U	Zn
	s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Column 1 - Granite: Aug 29, 2005 - Sep 26, 2005																					
Minimum	6.4	3.0	0.054	<0.001	3.5	<0.001	<0.001	<0.001	<0.05	<0.001	1.1	<0.001	0.0019	<0.001	<0.15	1.6	<0.001	0.38	0.025	<0.0005	<0.005
Maximum	7.5	5.0	0.066	0.001	5.1	<0.001	<0.001	<0.001	<0.05	<0.001	1.8	<0.001	0.0028	<0.001	<0.15	1.8	<0.001	0.4	0.037	<0.0005	<0.005
Average	6.7	4.0	0.06	0.001	4.3	<0.001	<0.001	<0.001	<0.05	<0.001	1.5	<0.001	0.0024	<0.001	<0.15	1.7	<0.001	0.39	0.031	<0.0005	<0.005
Median	6.9	4.0	0.06	0.001	4.3	<0.001	<0.001	<0.001	<0.05	<0.001	1.5	<0.001	0.0024	<0.001	<0.15	1.7	<0.001	0.39	0.031	<0.0005	<0.005
Column 2 - Granite: Aug 29, 2005 - Sep 26, 2005																					
Minimum	7.1	9.0	0.059	0.004	14	<0.001	<0.001	<0.001	<0.05	<0.001	2.9	<0.001	0.0031	<0.001	<0.15	3.1	<0.001	0.62	0.13	0.0077	<0.005
Maximum	8.2	14	0.09	0.005	21	<0.001	<0.001	<0.001	<0.05	<0.001	4.5	<0.001	0.0053	<0.001	<0.15	3.5	0.001	0.78	0.19	0.014	<0.005
Average	7.5	12	0.075	0.0045	17	<0.001	<0.001	<0.001	<0.05	<0.001	3.7	<0.001	0.0042	<0.001	<0.15	3.3	0.001	0.7	0.16	0.011	<0.005
Median	8.0	14	0.075	0.0045	17	<0.001	<0.001	<0.001	<0.05	<0.001	3.7	<0.001	0.0042	<0.001	<0.15	3.3	0.001	0.7	0.16	0.011	<0.005
Column 3 - Granite: Aug 29, 2005 - Sep 26, 2005																					
Minimum	7.3	3.0	<0.005	<0.001	12	<0.001	<0.001	<0.001	<0.05	<0.001	3.3	<0.001	<0.0005	<0.001	<0.15	24	<0.001	0.88	0.32	<0.0005	<0.005
Maximum	8.1	3.0	0.006	<0.001	14	<0.001	<0.001	<0.001	<0.05	<0.001	4.6	<0.001	<0.0005	<0.001	<0.15	29	<0.001	1.2	0.4	<0.0005	<0.005
Average	7.6	3.0	0.0055	<0.001	13	<0.001	<0.001	<0.001	<0.05	<0.001	4.0	<0.001	<0.0005	<0.001	<0.15	26	<0.001	1.0	0.36	<0.0005	<0.005
Median	7.8	3.0	0.0055	<0.001	13	<0.001	<0.001	<0.001	<0.05	<0.001	4.0	<0.001	<0.0005	<0.001	<0.15	26	<0.001	1.0	0.36	<0.0005	<0.005
Column 4 - Granite: Aug 29, 2005 - Sep 26, 2005																					
Minimum	7.2	1.0	0.14	0.002	14	<0.001	<0.001	<0.001	<0.05	<0.001	0.77	<0.001	<0.0005	<0.001	<0.15	1.8	<0.001	0.37	0.078	0.0031	<0.005
Maximum	8.1	2.0	0.25	0.003	20	<0.001	<0.001	<0.001	<0.05	<0.001	1.1	<0.001	0.0012	<0.001	<0.15	2.2	<0.001	0.42	0.11	0.004	<0.005
Average	7.6	1.3	0.2	0.0025	17	<0.001	<0.001	<0.001	<0.05	<0.001	0.95	<0.001	0.00085	<0.001	<0.15	2.0	<0.001	0.4	0.094	0.0036	<0.005
Median	7.9	1.0	0.2	0.0025	17	<0.001	<0.001	<0.001	<0.05	<0.001	0.95	<0.001	0.00085	<0.001	<0.15	2.0	<0.001	0.4	0.094	0.0036	<0.005
Column 6 - Granite: Aug 29, 2005 - Sep 26, 2005																					
Minimum	7.3	3.0	0.089	0.007	15	<0.001	<0.001	<0.001	<0.05	<0.001	2.1	<0.001	0.0054	<0.001	<0.15	2.5	<0.001	0.44	0.18	0.0023	<0.005
Maximum	8.2	3.0	0.11	0.008	19	<0.001	<0.001	<0.001	<0.05	<0.001	2.6	<0.001	0.0058	<0.001	<0.15	2.6	0.001	0.55	0.19	0.0025	<0.005
Average	7.6	3.0	0.10	0.0075	17	<0.001	<0.001	<0.001	<0.05	<0.001	2.4	<0.001	0.0056	<0.001	<0.15	2.6	0.001	0.5	0.19	0.0024	<0.005
Median	8.0	3.0	0.10	0.0075	17	<0.001	<0.001	<0.001	<0.05	<0.001	2.4	<0.001	0.0056	<0.001	<0.15	2.6	0.001	0.5	0.19	0.0024	<0.005

s.u. = standard unit; mg/L = milligrams per litre; < = less than.

Figure 8.II-16 Leachate Concentrations in the Granite Columns



8.II.4.3.6 Comparison with Mine Rock at Other Diamond Projects

Table 8.II-31 summarizes average steady state results (based on the last five measurements) of kinetic tests for selected parameters from mine rock lithologies at other northern Canadian diamond projects (Golder, 2002). The mine rock includes granite from Ekati Diamond Mine, mudstone from Diavik Diamond Mine, granite and metavolcanics from Snap Lake Mine, and granite from the Project. The purpose of the comparison is to examine the range of mine rock leachate chemistry measured in kinetic tests at other northern Canadian projects.

The results suggest that the Project granitic kinetic leaching results are most similar to Ekati Diamond Mine, mine rock and low sulphur granites from Snap Lake Mine (e.g., with low amounts of metavolcanic). The Snap Lake Mine high sulphide metavolcanic and the Diavik Diamond Mine mudstone have lower pH values and tend to have higher metal concentrations than the Project granitic mine rock.

8.II.5 GEOCHEMICAL IMPLICATIONS OF MINE WASTE MANAGEMENT

8.II.5.1 MINE ROCK MANAGEMENT

Site development plans for the Project call for the use of mine rock as follows:

- Non-AG mine rock will be used to construct site facilities (i.e., roads, building foundations and the airstrip) and filter dykes.
- Non-AG mine rock not required for use in construction will be stored in South and West mine rock piles, located within and adjacent to Areas six and five, respectively. Non-AG rock will be stored in the mined out 5034 pit once this facility becomes available. After the 5034 pit is full, Non-AG rock will continue to be placed in the West mine rock pile.
- PAG mine rock produced during the life of the mine will be encapsulated in the south and west mine rock piles.

In comparison to other diamond mining projects in the North, mine rock from the Project has very low sulphur content (average 0.04%) (Table 8.II-31). However, mine rock from the Project also contains very little NP (average 7 t $CaCO_3$ / 1000 t). The results of kinetic testing show that for the single sample devoid of any carbonate NP (HC 16), the pH was quite low (generally <5). For some parameters the corresponding metal concentrations for this sample appeared to be elevated relative to the other Humidity Cell samples. The implications of these concentrations based on the amount of PAG rock potentially exposed are considered within the context of mine rock seepage source inputs to the water quality predictive model used to determine Project effects to Kennady Lake and downstream waterbodies (Appendix 8.I).

The metal leaching potential of mine rock, indicated by the results of short-term leach testing and kinetic testing, is generally low in comparison to other mining projects in the North (Table 8.II-34). Based on the geochemical testing completed and the mine plan to date it would be reasonable to use non-PAG materials for site development provided suitable monitoring and adaptive management programs are in place.

Table 8.II-34 Comparison of Selected Parameters at Steady State from Mine Rock Kinetic Tests

	Units	Ekati Diamond Mine		Diavik Diamond Mine	Snap Lake Mine			Gahcho Kué Project
		Granite	Granite	Mudstone	Granite/ metavolcanic (n=4)	Metavolcanic (n=8)	High S Metavolcanic	Granite (n=18)
Total sulphur	wt %	0.03	0.05	3.5	0.13 (0.11-0.17)	0.47 (0.03-1.04)	9.9	0.04 (0.02-0.2)
NP/AP		11[(a)]	7[(a)]	0.4	3.4 (2.90-3.60)	1.2 (0.3-18.3)	0.05	6.2 (0.53-22)
pH		9.1	9.4	3.5	7.3 (6.90-7.90)	7.4 (7.3-8.1)	4.2	6.6 (4.9-7.5)
SO_4	mg/L	1.1	1.8	8,765	2.7 (0.10-6.20)	29.3 (2.1-53.6)	200	1.3 (<1.0-3.0)
Aluminum	mg/L	159.5	149.1	69,700	0.03 (0.01-0.06)	8.5 (0.01-0.11)	2,020	0.030 (0.002-0.092)
Arsenic	µg/L	4.2	2.5		0.7 (0.50-1.33)	0.6 (0.5-3.0)	0.8	1.6 (<2-3)
Copper	µg/L	4.1	4.1	217	0.5 (0.20-0.70)	0.4 (0.2-1.10)	2413	5.4 (<1-15)
Lead	µg/L	4.4	4.9		1.3 (1.0-2.0)	1.8 (1.0-2.67)	1.6	0.6 (<0.2-2.3(
Nickel	µg/L	0.8	0.6	19,500	0.5 (0.2-0.87)	9.7 (0.1-19)	119	0.5 (<0.2-1.1)
Zinc	µg/L	5.5	5.4	11,600	2.1 (0.5-3.08)	1.46 (0.25-2.42)	4.8	2.6 (<1-7)

Source: Golder, 2002.

(a) The NP/AP and pH values for Ekati Mine diabase and granite kinetic tests are taken from the average acid base accounting and paste pH results for the respective lithology.

wt % = percent by weight; µg/L = micrograms per litre; mg/L = milligrams per litre; < = less than

8.II.5.1.1 Site Specific Mine Rock Classification Criteria

Based on the proposed site development plans, site specific criteria are required to classify non-AG and PAG rock for use in construction and for use during operations.

The acid potential of a sample is generally a function of sulphide mineral content. The results of ABA confirm that sulphide minerals are the dominant source of sulphur in most mine rock samples (Figure 8.II-11). Sulphide minerals identified in mine rock from the Project include trace quantities of pyrite, pyrrhotite and chalcopyrite. According to AMEC (2008), sulphide minerals generally occur as replacement minerals or as post-intrusive secondary infilling of fractures. The majority of sulphide minerals occur near the contract between altered mine rock and kimberlite (AMEC 2008).

The typical screening level sulphur criterion for classifying PAG rock at mine sites is 0.3% (Price 1997). Approximately 1.5% of the mine rock samples in the geochemistry dataset have total sulphur concentrations greater than 0.3 wt%.

The results of humidity cell testing suggest that mine rock containing greater than 0.1% total sulphur has some potential for generating acidity, owing to the lack of buffering capacity in mine rock. Granite mine rock HC 16 (total sulphur 0.1%) produced moderately acidic effluent for the duration of the test. In the other mine rock cells that had sulphur concentrations less than 0.1%; acidic drainage was not produced (AMEC 2008).

Figure 8.II-17 and Table 8.II-35 show the distribution of total sulphur for each proposed pit and the distribution between the seven mine rock lithologies. There is little difference in the statistical distribution of sulphur concentrations in mine rock collected from the 5034, Hearne and Tuzo pits, respectively. Most samples of granite, granodiorite and gneissic granite have total sulphur concentrations less than 0.1%. Granite will be the dominant mine rock lithology at the Project, comprising at least 95% of all mine rock. Although most samples of diabase, diorite, and altered granite in the geochemistry dataset contained greater than 0.1% sulphur, the relatively small number of samples these samples (in comparison to granite) limits the interpretation of AGP from these units.

Figure 8.II-17 Distribution of Total Sulphur in 5034, Hearne and Tuzo Mine Rock (AMEC 2008)

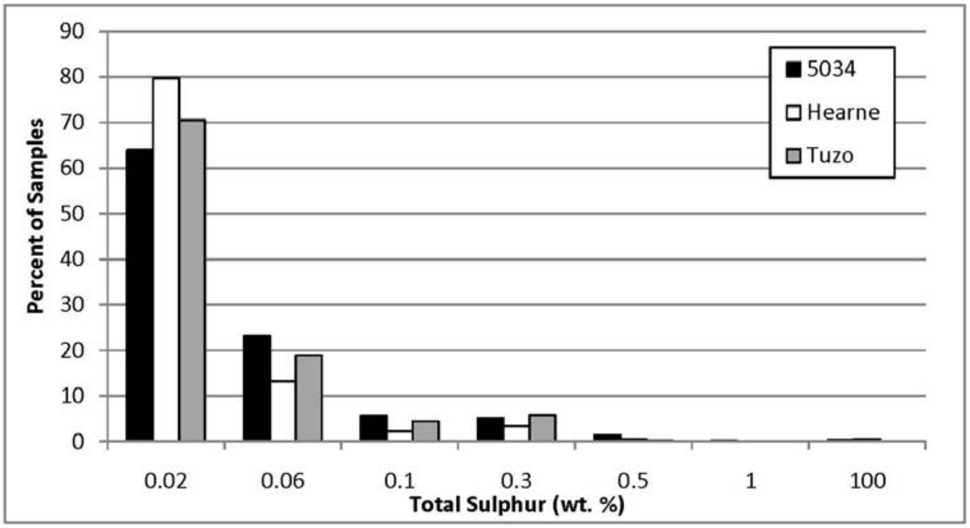


Table 8.II-35 Percent of Samples by Sulphur Concentration for Mine Rock Lithologies

Rock Type	0.1% Sulphur		0.3% Sulphur	
	n	Percent	n	Percent
Granite	73	6%	12	1%
Altered granite	7	70%	3	30%
Diabase	3	43%	0	0%
Diorite	1	100%	0	0%
Gneissic granite	2	22%	0	0%
Granodiorite	1	17%	1	17%
Altered granodiorite	16	100%	2	13%

% = percent

Assuming the AMEC (2008) geochemistry dataset is spatially representative of the Project mine rock, a small quantity of mine rock will be classified as PAG based on the proposed sulphur cutoff criterion of 0.1%. Any volume of the granite or granodiorite that has a total sulphur concentration greater than 0.1 wt% should not be used for site development. A mine rock management plan should be developed for the Project.

8.II.5.2 PROCESSED KIMBERLITE MANAGEMENT

According to the Project Description, all PK waste streams will be contained within the disturbed Kennady Lake footprint. Site development plans for PK management are as follows:

- All PK will be contained within the controlled area of Kennady Lake.
- Fine PK will be stored in the Fine PKC Facility between Years 1 to 8. The Fine PKC Facility will be progressively reclaimed during operations with a one meter layer of coarse PK overlain by one meter of non-AG mine rock.
- Starting in Year 8, fine PK will be deposited in the mined-out Hearne Pit.
- Coarse PK will be placed on the Coarse PK Pile. In later years, coarse PK will be used for reclamation of the Fine PKC Facility, and co-disposed with mine rock in the 5034 Pit.
- At closure, Kennady Lake will be allowed to recharge to its natural lake elevation, effectively flooding all of the materials (i.e., mine rock and fine PK) stored in the mined out open pits. It is expected that all surface mine waste storage facilities will freeze, minimizing the amount of seepage reporting to Kennady Lake.

The results of geochemical testing of PK, and PK process water analyses can be used to infer the potential range of composition of water in contact with the various PK management areas during operations and at closure. Table 8.II-23 compares the range of composition of the various results of geochemical testing that were evaluate the composition of PK contact water.

The composition of seepage from the Fine PKC Facility will be geochemically similar to the process water discharged with the fine PK slurry. Process water is water that is recycled through the process plant, which gain a mass load from the PK as water is cycled through the Process Plant. Table 8.II-19 presents the detailed range of composition of process water.

Fine PK and coarse PK exposed in the Fine PKC Facility and Coarse PK Pile, respectively, will undergo seasonal wet and dry cycles during the summer months. The results of humidity cell testing were used to simulate the effects of accelerated chemical weathering. Recently deposited PK will contain residuals from the Process Plant and soluble minerals that are gradually flushed from the PK over the course of time. The range of first flush water quality presented in Table 8.11-20a is presented to demonstrate the range of water in contact with freshly deposited fine and coarse PK. As weathering progresses, soluble mineral phases will deplete and mineral reaction rates will stabilize, generating a steady state water quality, as presented in Table 8.II-20b. A comparison of range of concentrations measured in the humidity cell test results will be completed after stable concentration trends have been achieved in the recently initiated fine and coarse PK humidity cell tests. As presented in Table 8.II-21, PK has a low long-term acid generation potential, owing to the negligible sulphur content of this material.

Submerged column tests were initiated to evaluate the effect of submerging fine and coarse PK as Kennady Lake is allowed to re-flood during the closure period. Submerged column tests were initiated in July 2010. Sufficient data was not available at the time of preparation of this report to make definitive statements with respect to the effects of submerging fine and coarse PK. The initial results of submerged column tests suggest a negligible difference in the composition of Fine PK pore water ("bottom" submerged column test leachates) and the standing column of water overlying the Fine PK. Metal concentrations in Coarse PK pore water, however, were greater than concentrations measured in the overlying column of water (Table 8.II-22). Concentration trends will continue to be monitored in the submerged column tests to identify concentration trends over time that could signify diffusion of mobile parameters through the PK to the overlying column of water.

8.II.6 LIMITATIONS

Due to the nature of the Project there are several limitations inherent in the data provided in this report. The results of baseline geochemical characterization presented in this report were provided to Golder Associates Limited (Golder) by De Beers. Golder collected a limited number of samples for this project, as outlined in Golder (2002). The remainder of the samples were collected by Canamara (1996); and AMEC (2008). The geochemical dataset presented in this report has been interpreted based on the understanding (as of the project description) of the Project, for the purpose of evaluating the geochemical characteristics of kimberlite, PK and mine rock. The accuracy of any reporting is reflective of the availability and accuracy of the information presented in Canamara (1996); and AMEC (2008), and laboratory data provided by the analytical facilities.

8.II.7 SUMMARY OF KEY RESULTS

The following is a summary of key results from the geochemical program as of August 2010:

Kimberlite

- Kimberlite generally contains very little sulphide mineralization (represented by total sulphur concentrations). Most samples in the geochemical dataset has NP:AP ratios greater than three, and are therefore classified as non-AG according to the DIAND criteria.
- Average concentrations of nickel, cobalt, chromium, magnesium, selenium and strontium were greater in kimberlite samples than average concentrations in continental rock.
- The results of short-term and kinetic testing suggest that kimberlite has a low potential for metal leaching. Chloride, sulphate, and nickel concentrations are elevated relative to the mine rock leachates.

Processed Kimberlite

- The AGP of PK is negligible according to the DIAND classification criteria.
- In general, metal concentrations were higher in fine PK than coarse PK samples. Metals that occurred at elevated concentrations (relative to crustal abundances) in coarse PK samples included nickel, cobalt, chromium, boron and bismuth. Arsenic, boron, bismuth, cobalt, chromium, copper, magnesium, molybdenum, nickel, antimony and selenium were elevated in fine PK samples.
- The results of SFE and humidity cell tests confirmed that fine PK and coarse PK will not generate acidity in the long-term. SFE and HCT leachates reported low sulphate and metal concentrations. Fine PK leachate concentrations were slightly higher than coarse PK leachate concentrations of select metals.
- Process water samples had a similar composition to PK SFE leachates.
- Submerged column testing is underway to evaluate the effect of submerging fine PK and coarse PK under a water cover at closure.

Mine Rock

- The AGP of mine rock is generally low. Most samples of mine rock contained very little sulphide mineralization; however, mine rock also has very little buffering capacity. Based on ABA results, 1.1% of mine rock samples are PAG, with NP/AP ratios below three and sulphide-sulphur concentrations exceeding 0.3%. The results of humidity cell testing confirm that samples containing less than 0.1% sulphide-sulphur are unlikely to generate acidity in the long-term.
- The results of SFE and HCT confirm that non-AG samples have a low potential for metal leaching.

- One HC with a sulphur concentration of 0.1 wt% and NP of 4.3 kg $CaCO_3$/t was acid generating and leached metals at higher concentrations than the neutral pH HC.

8.II.8 CONCLUSIONS

The following is a summary of key results from the geochemical program as of August 2010:

- In comparison to other diamond mining projects in Northern Canada, kimberlite collected at the Project is geochemically similar to the kimberlite samples that underwent geochemical characterization in support of the Snap Lake Mine. The Project mine rock is most similar to the Ekati Diamond Mine and the low sulphur granite at the Snap Lake Mine.
- Kimberlite samples and most mine rock is non-acid generating. A small fraction (less than 1.5%) of the mine rock has some limited potential to generate acidity, however the likelihood of significant amounts of acidic water to be released from the project is low and will depend on the final site configuration.
- Mine rock with visible sulphides and/or a sulphur concentration greater than 0.1 wt% should not be used for site construction unless additional testing suggests otherwise. A mine rock management plan is required to classify rock for use in site developments during operations.

It is expected that monitoring programs and adaptive management will be implemented on-site to minimize the potential for impact.

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8.II.10 ACRONYMS AND GLOSSARY

8.II.10.1 ACRONYMS

A/ARD	Acid/alkaline rock drainage
ABA	Acid Base Accounting
AGP	Acid generation potential
ANP	Acid Neutralization Potential
AP	Acid Potential
ARD/ML	Acid rock drainage and metal leaching
Coarse PK	Coarse Processed Kimberlite
DIAND	Department of Indian Affairs and Northern Development
DMS	Dense-medium separation
Fine PK	Fine Processed Kimberlite
Golder	Golder Associates Ltd.
HC	Humidity cell
HCT	Humidity Cell Tests
HPRC	High pressure roller crusher
ID	Identification
MDL	Method detection limit
ML	Metal leaching
NAG	Net Acid Generation
Non-AG	Non-acid generating
NP	neutralization potential
NWT	Northwest Territories
PAG	Potentially acid generating
PK	Processed Kimberlite
Project	Gahcho Kué Project
QA/QC	Quality assurance/quality control
RPD	Relative percent differences
SD	Standard deviation
SFE	Shake Flask Extraction
TDS	Total dissolved solids
XRD	X-ray diffraction

8.II.10.2 UNITS OF MEASURE

%	percent
>	greater than
<	less than
kg	kilogram
kg/t	kilogram per tonne
mm	kilometre
m	metre
m^2	square metres
mg/kg	milligrams per kilogram
mg/g	milligrams per gram
mg/L	milligrams per litre
mg/L/wk	milligrams per litre per week
mm	millimetre
Mt	million tonnes
ppm	parts per million
s.u.	standard unit
t	tonnes
µs/cm	microSiemens per centimetre
µg/L	micrograms per litre
wt. %	percent by weight

8.II.10.3 GLOSSARY

Acid Base Accounting (ABA)	Acid base accounting; a static test that defines the amounts, and relative balance, of potentially acid-generating and acid-neutralizing (or base) minerals in a sample.
Acidic drainage	A general term applied to any drainage with an acidic pH; an acidic pH is defined as a value less than 6.0.
Acid mine drainage	A variation on acid rock drainage, mine site drainage with an acidic pH due to the oxidation of sulphide minerals exposed by mining activity
Acid rock drainage (ARD)	Acidic pH rock drainage due to the oxidation of sulphide minerals that includes natural acidic drainage from rock not related to mining activity; an acidic pH is defined as a value less than 6.0.
Alkaline mine drainage	Mine site drainage with an alkaline pH; an alkaline pH is defined as a value greater than 8.5.
Basalt	A dark-coloured igneous rock, commonly extrusive, composed primarily of calcic plagioclase and pyroxene; the fine-grained equivalent of gabbro.

CCME guidelines	Canadian Council of Ministers of the Environment; body of Environment Canada that sets ambient guidelines for air, water, soil, and contaminants.
Drainage chemistry	Concentrations of elements and other aqueous parameters in mine site drainage from mine site components through surface or subsurface pathways.
Gneiss	A coarse crystalline metamorphic rock in which there are bands of light and dark minerals of widely varying origin and mineralogy.
Granite	A coarsely crystalline igneous intrusive rock composed of quartz, potassium feldspar, mica, and/or hornblende.
Granitoid	Rocks with a composition the same as, or similar to granite.
Humidity cell	A type of kinetic test in which a small sample (about 1 kg) is placed in an enclosed chamber in a laboratory, alternating cycles of moist and dry air is constantly pumped through the chamber, and once a week the sample is rinsed with water; chemical analysis of rinse water yields concentrations of elements and other parameters used to calculate reaction rates;
Kinetic test	A geochemical procedure for characterizing the chemical status of a sample through time during continued exposure to a known set of environmental conditions, such as a humidity cell; see also static test.
Loading	Concentration multiplied by a flow, providing a mass per unit time flowing through or from a mine site component.
Metasediments	Sedimentary rocks that have been modified by metamorphic processes.
Metavolcanics	Volcanic rocks that have been modified by metamorphic processes.
Mined-rock piles	A general term referring to any accumulation of rock at a mine, including mine rock piles, ore and low grade ore stockpiles, roads, heap leach piles, and building foundations.
Mine site drainage	Water that runs off or flows through a mine site component, including surface and subsurface (groundwater) flow; see also acid mine drainage, neutral mine drainage, alkaline mine drainage, and drainage chemistry.
Mine rock	Excavated bed rock surrounding the kimberlite deposits.
Metal leaching (ML)	The release of a metal from its solid-phase mineral into mine site drainage; described by concentrations in static tests and by metal release rates obtained from kinetic tests.
Overburden	A general term referring to soil and broken rock, lying above ore and mine rock, that can usually be removed without blasting; at mines in soft sedimentary rock like coal, overburden can be synonymous with mine rock.
Potentially acid generating (PAG)	Rock with an NP/AP ratio less than 3 as determined by static tests.

Processed Kimberlite Containment
On-site storage facility for storing processed kimberlite.

Primary minerals
Minerals that existed in the rock prior to disturbance by human activity, often occurring as (but not limited to) sulphide, aluminosilicate, and oxide minerals; see also secondary minerals.

Retention
Amount of oxidized primary minerals not released to mine drainage, but held within mine rock and tailings; reflects physical processes such as incomplete rinsing of mine site components and geochemical processes such as the formation of secondary minerals.

Secondary minerals
Minerals that formed in or on a mine site component after disturbance by human activity, often occurring as (but not limited to) sulphate, carbonate, and hydroxide minerals; see also kinetic test, primary minerals, and retention.

Static test
A procedure for characterizing the physical and/or chemical status of a sample at one point in time, such as acid base accounting.

Sulphide oxidation
Oxidation of chemically reduced sulphur, such as sulphide (S22-) and elemental sulphur to a partially or fully oxidized form, such as sulphate (SO42-). Generally used to refer to the oxidation of pyrite (FeS2).

Sulphide sulphur
A part of acid base accounting that provides the sulphide content of a sample, expressed as %S.

Sulphate sulphur
A part of acid base accounting that provides the sulphate content of a sample, expressed as %S.

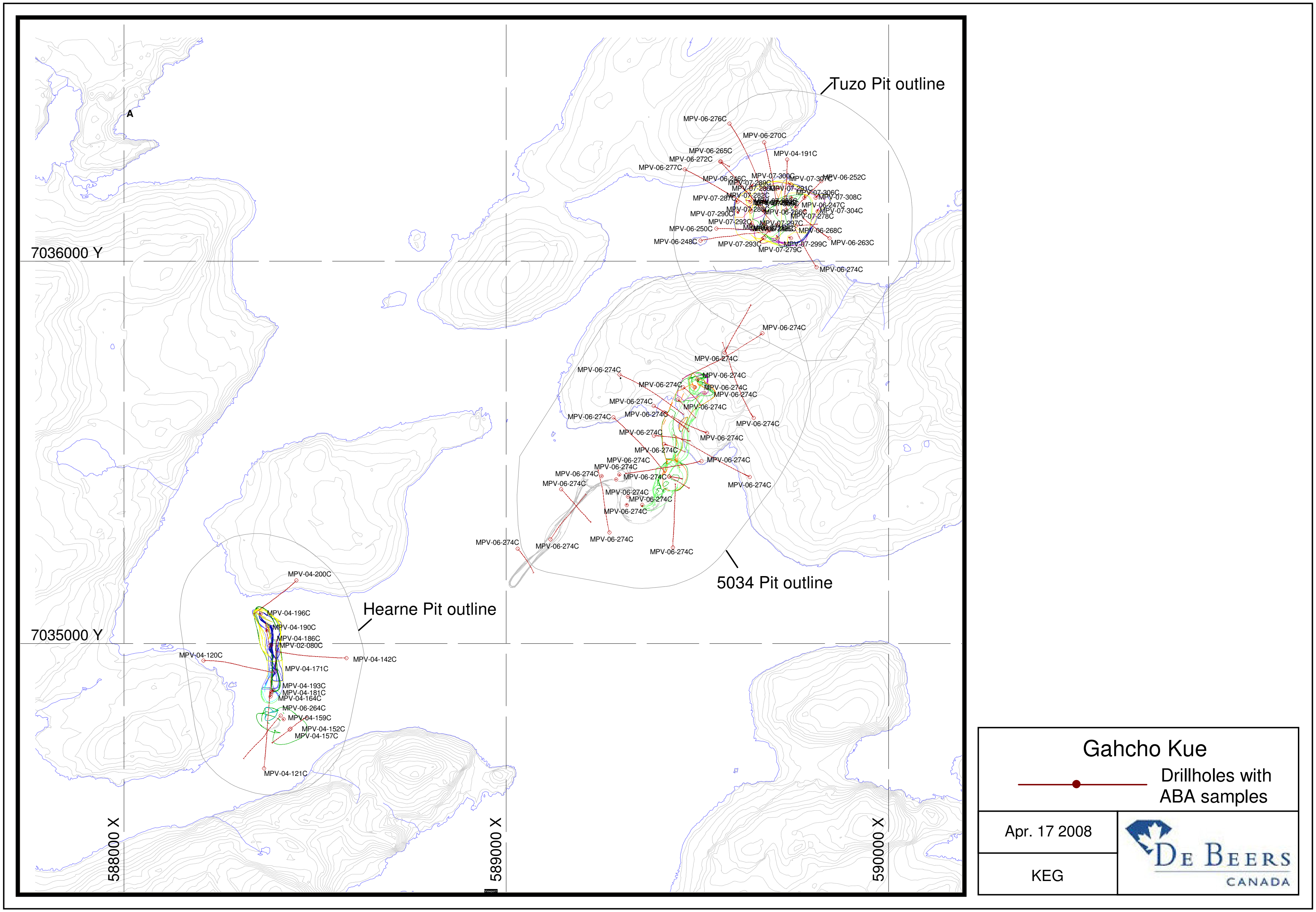
Total sulphur
A part of acid base accounting that provides the total sulphur content of a sample, expressed as %S; see also sulphide sulphur, total sulphate sulphur.

Mine rock pile
A mined rock pile containing mine rock.

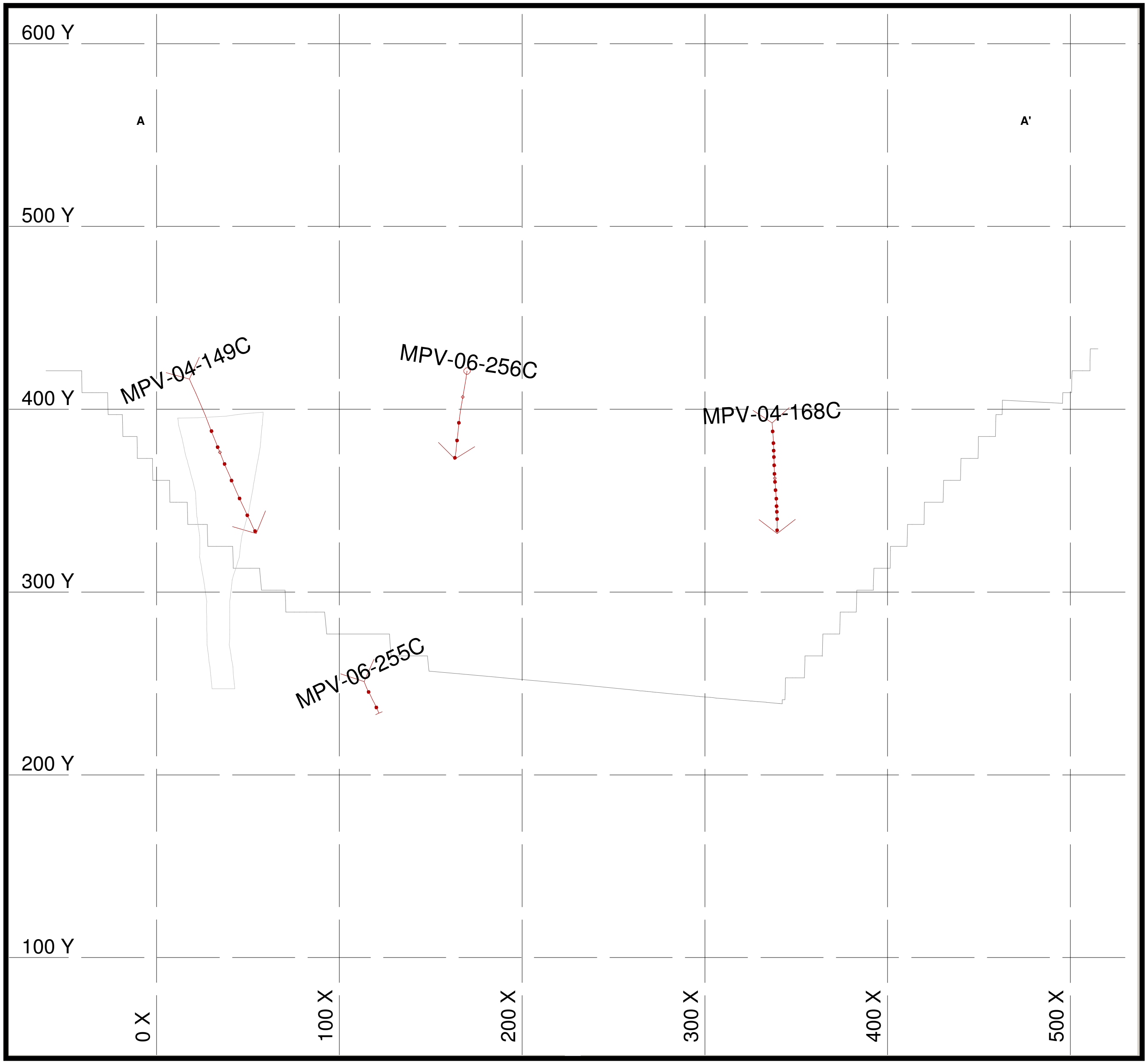
ATTACHMENT 8.II.1

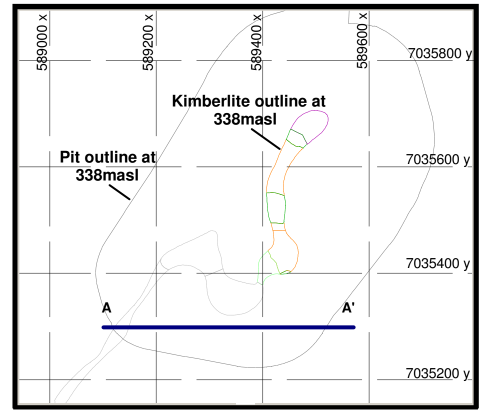
DRILLHOLE LOCATIONS

Note: the figures included in this attachment show the pit outlines from a previous iteration of the Project Description. Please consult Figure 8.4-3 for the iteration being assessed in this Environmental Impact Statement (EIS).

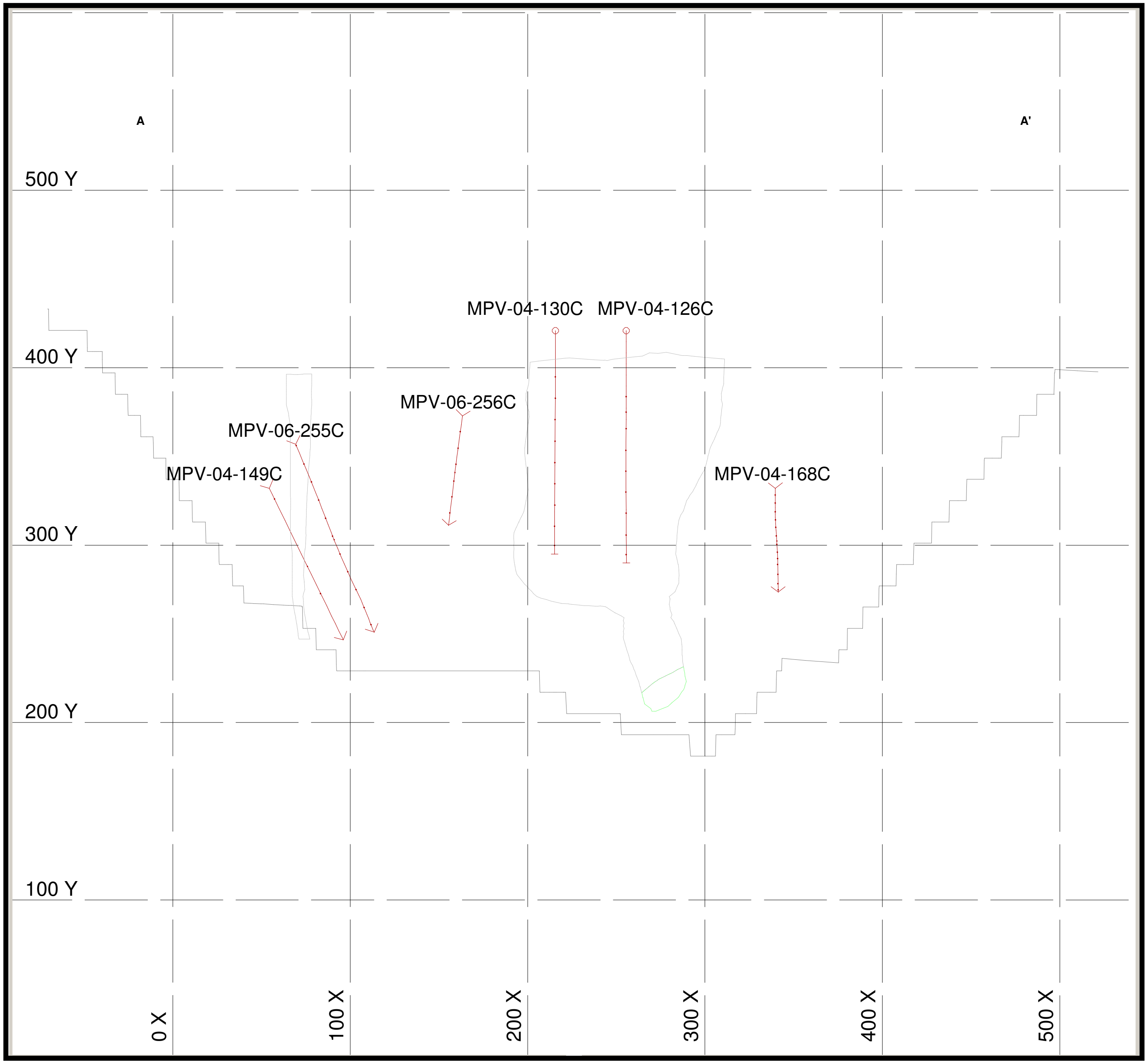


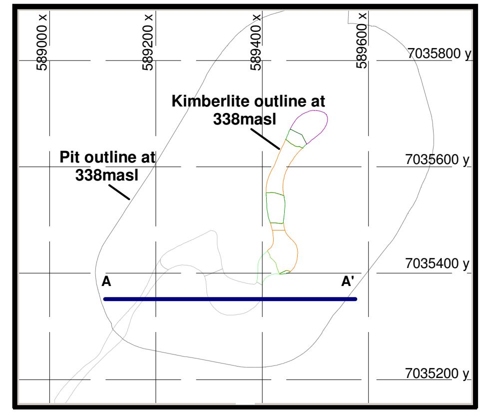
Tuzo Pit outline
5034 Pit outline
Hearne Pit outline
7036000 Y
7035000 Y
588000 X
589000 X
590000 X
Gahcho Kue
Drillholes with ABA samples
Apr. 17 2008
KEG
DE BEERS CANADA





5034 Section 7035300	
ABA sample location	
Apr. 17 2008	De Beers Canada
KEG	

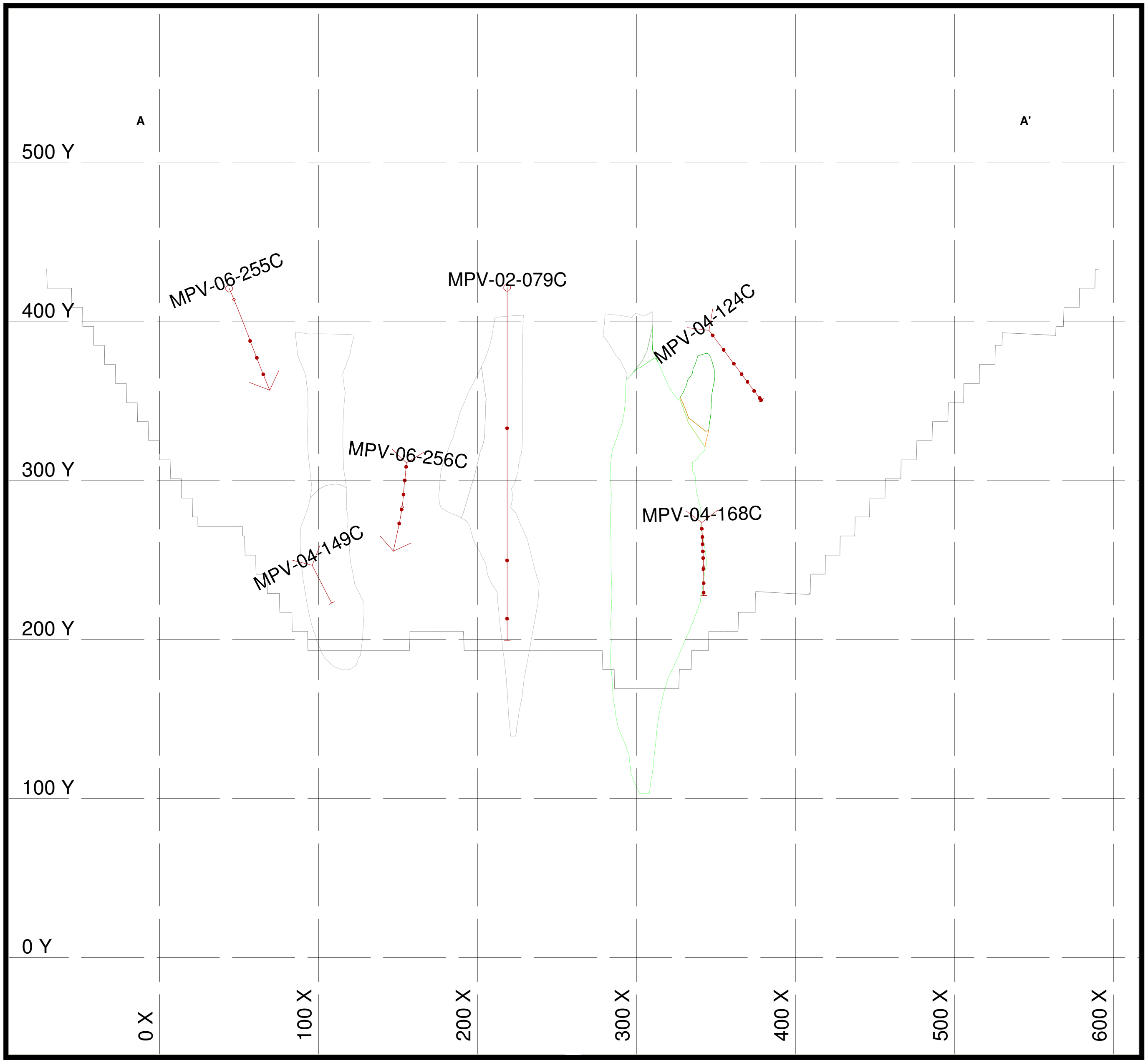


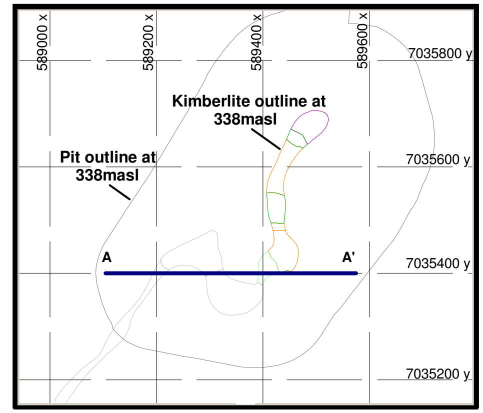


5034 Section 7035350

ABA sample location

Apr. 17 2008	DE BEERS CANADA
KEG	





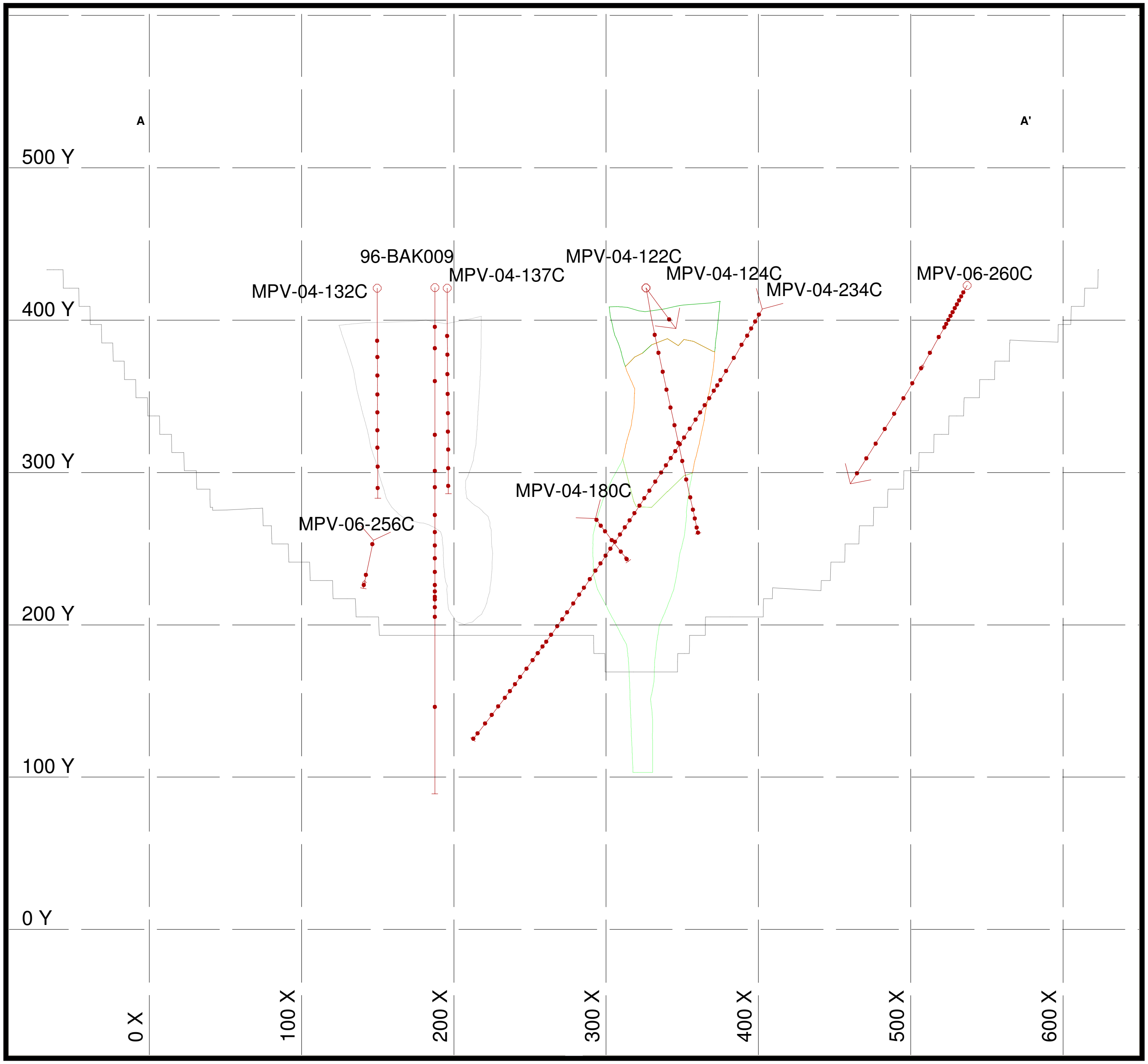
5034 Section 7035400

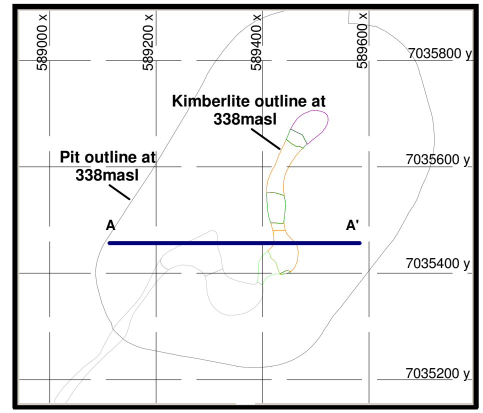
ABA sample location

Apr. 17 2008

KEG

DE BEERS CANADA





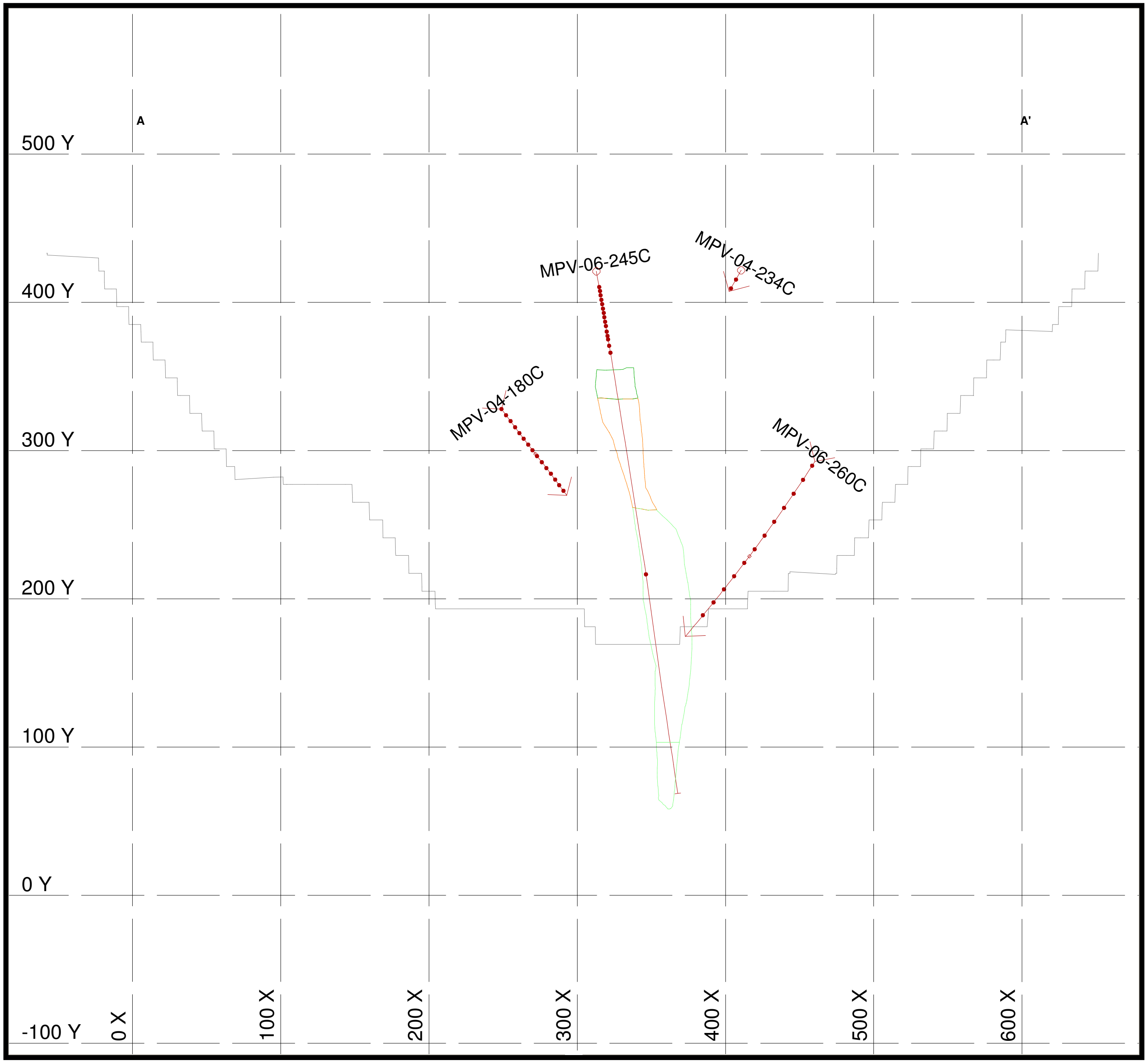
5034 Section 7035450

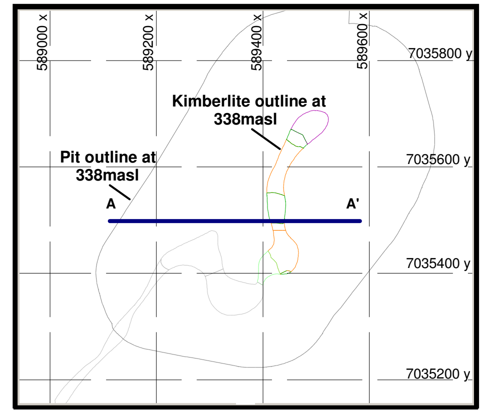
ABA sample location

Apr. 17 2008

KEG

DE BEERS CANADA

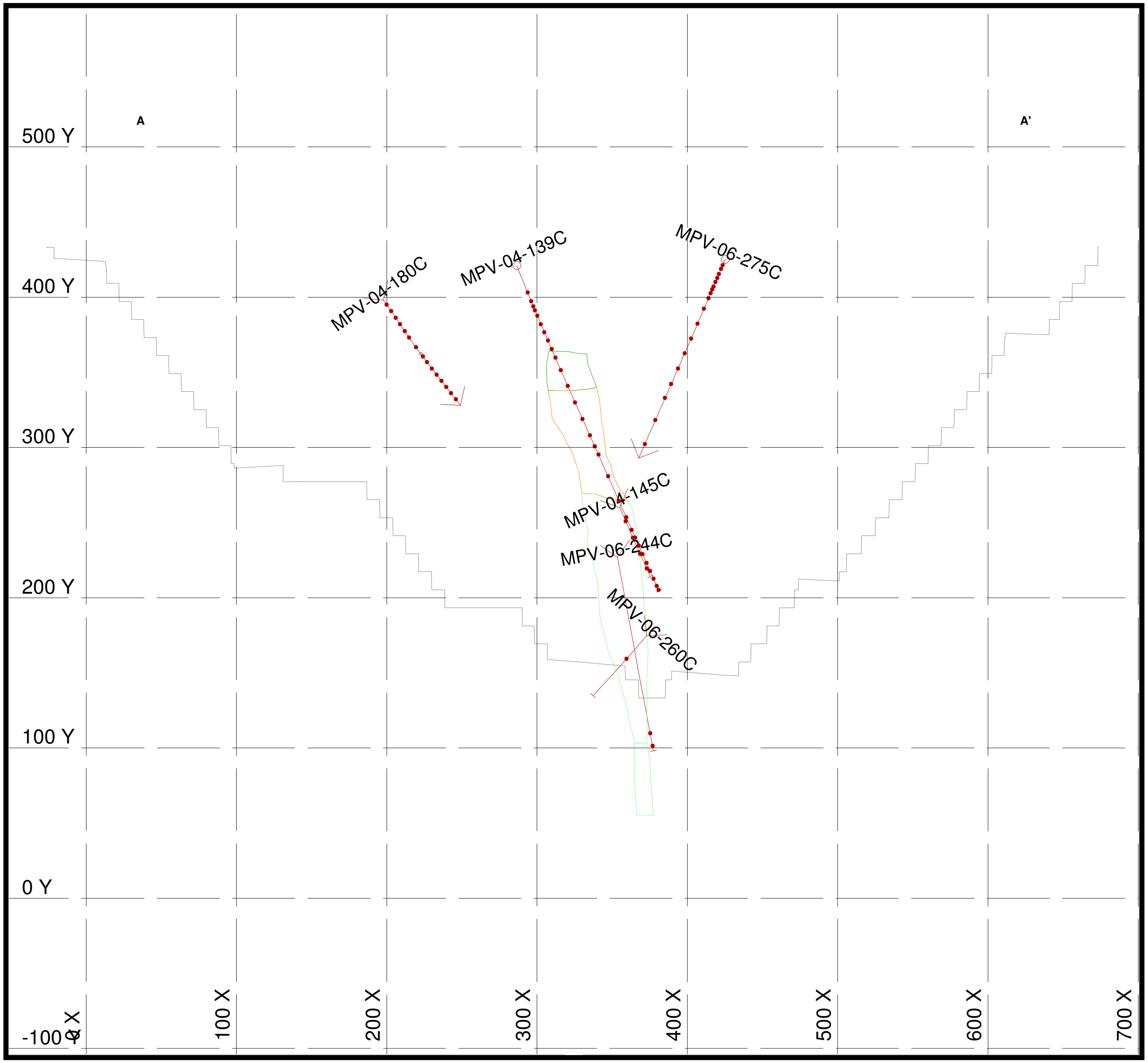


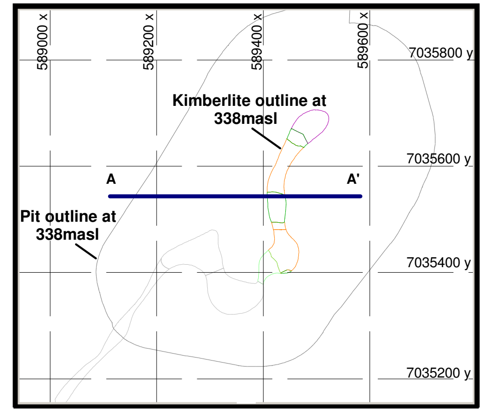


5034 Section 7035500

ABA sample location

Apr. 17 2008	DE BEERS CANADA
KEG	





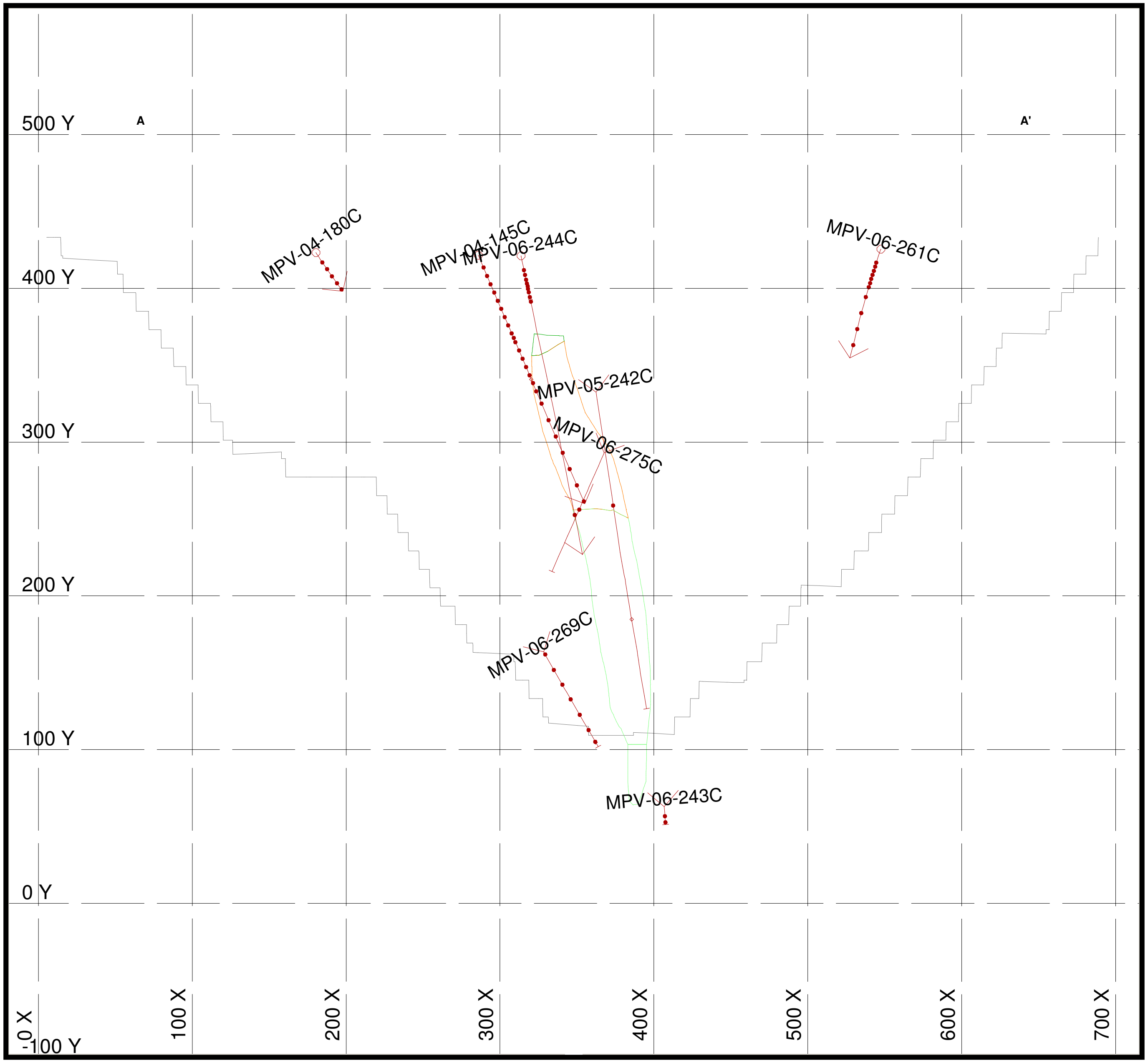
5034 Section 7035550

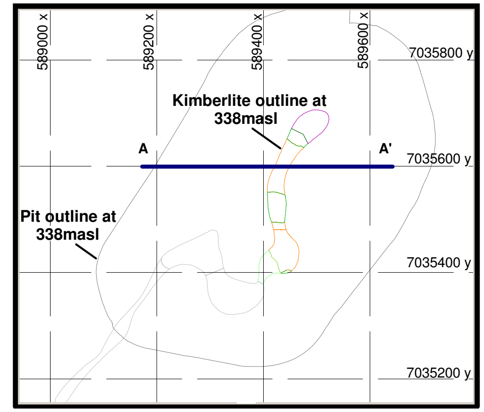
ABA sample location

Apr. 17 2008

KEG

DE BEERS CANADA





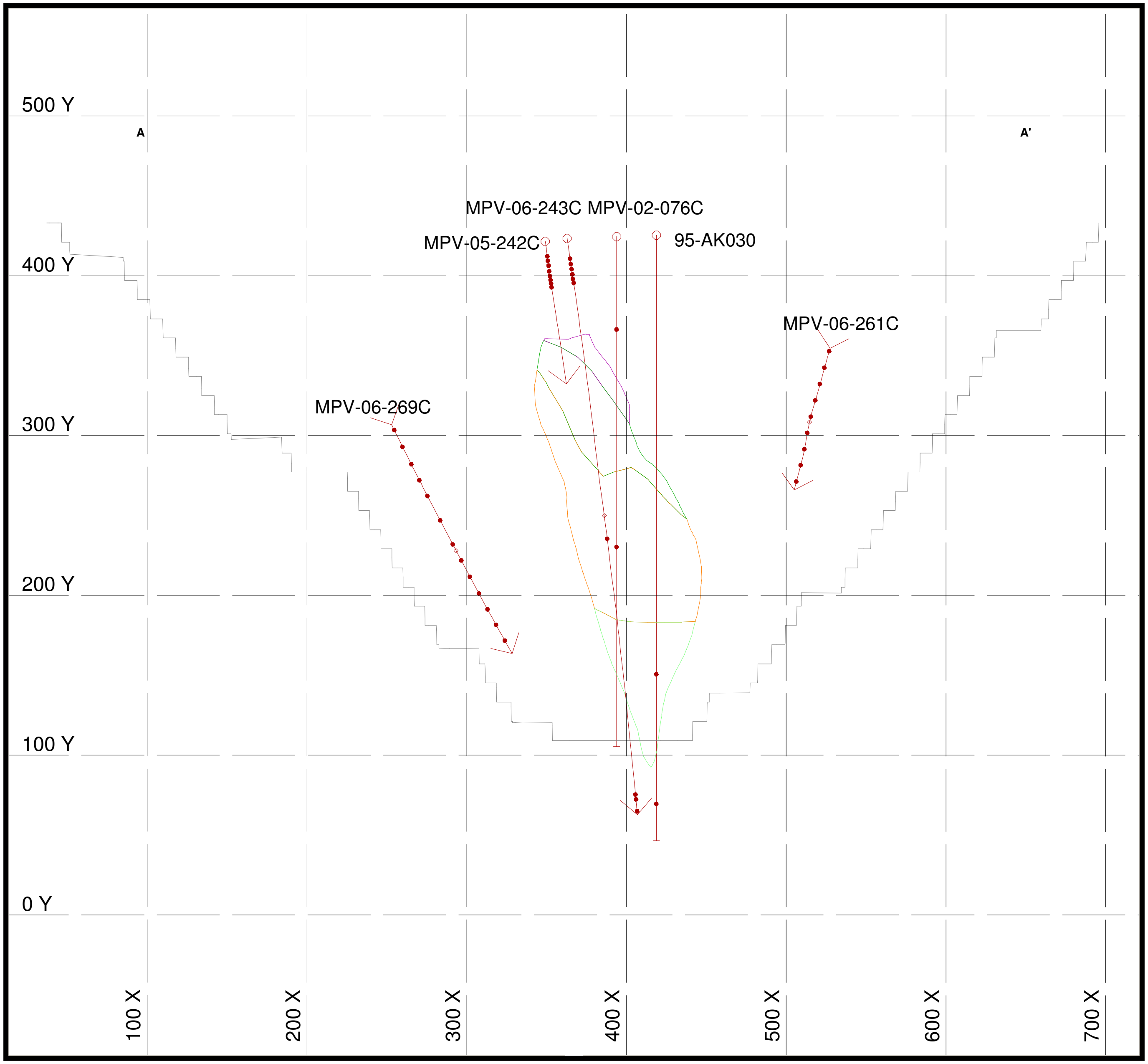
5034 Section 7035600

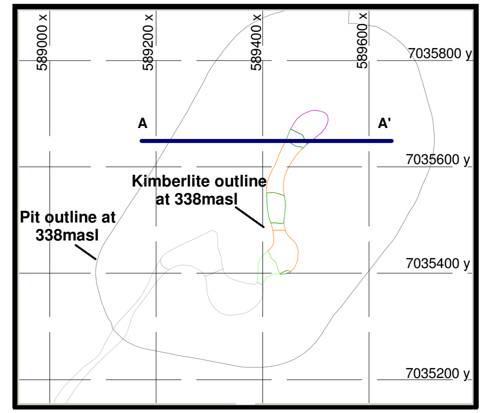
ABA sample location

Apr. 17 2008

KEG

De Beers Canada





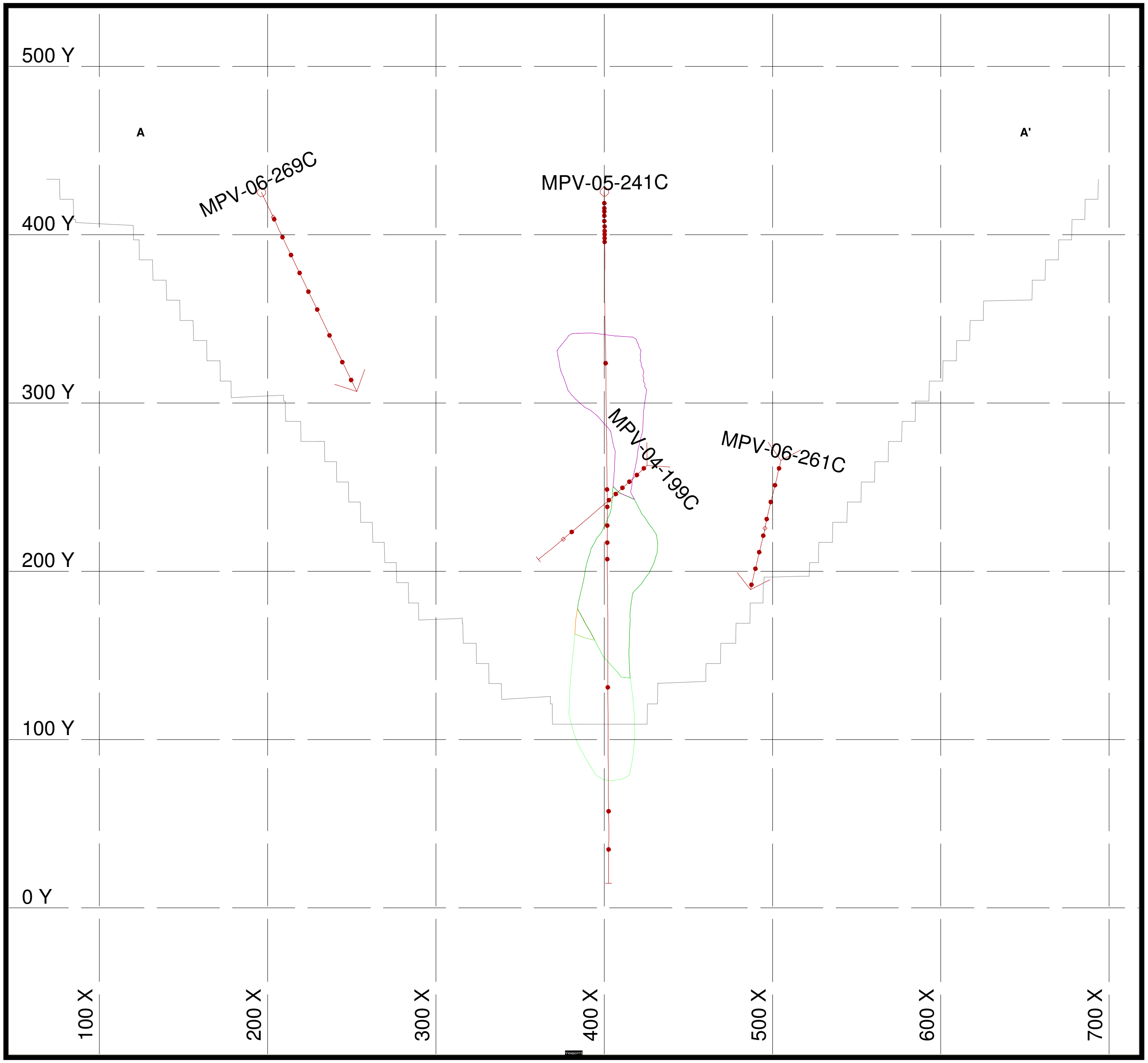
5034 Section 7035650

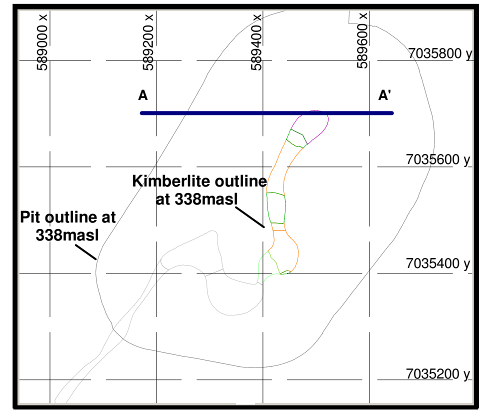
ABA sample location

Apr. 17 2008

KEG

De Beers Canada

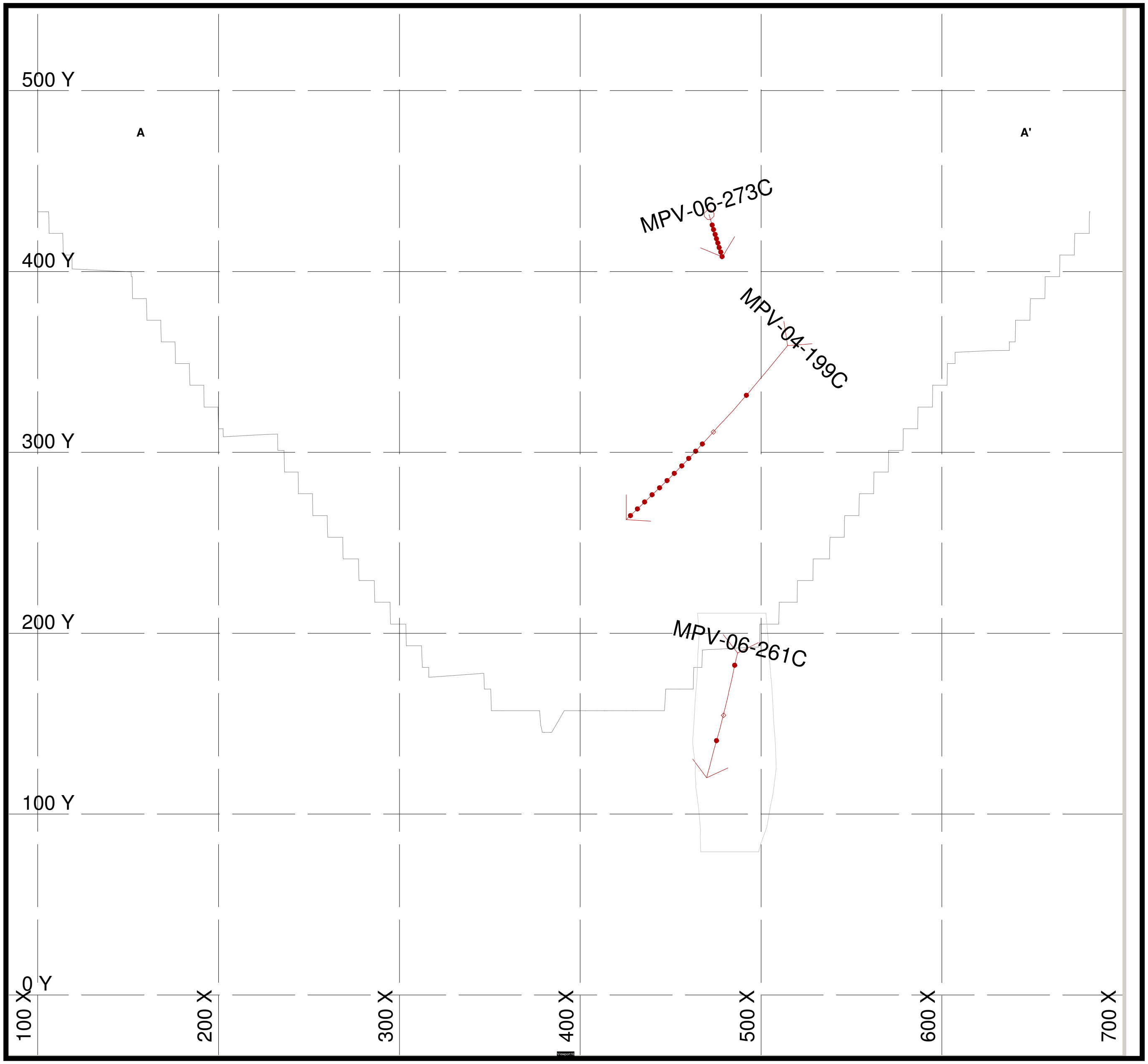


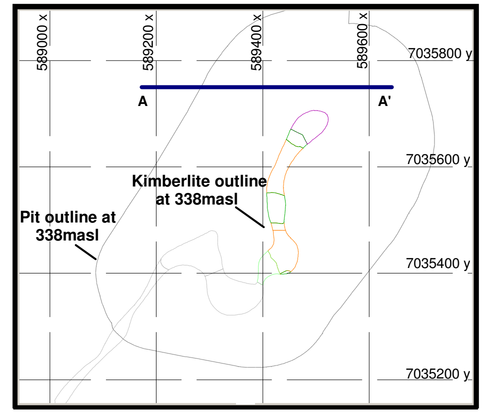


5034 Section 7035700

ABA sample location

Apr. 17 2008	De Beers Canada
KEG	





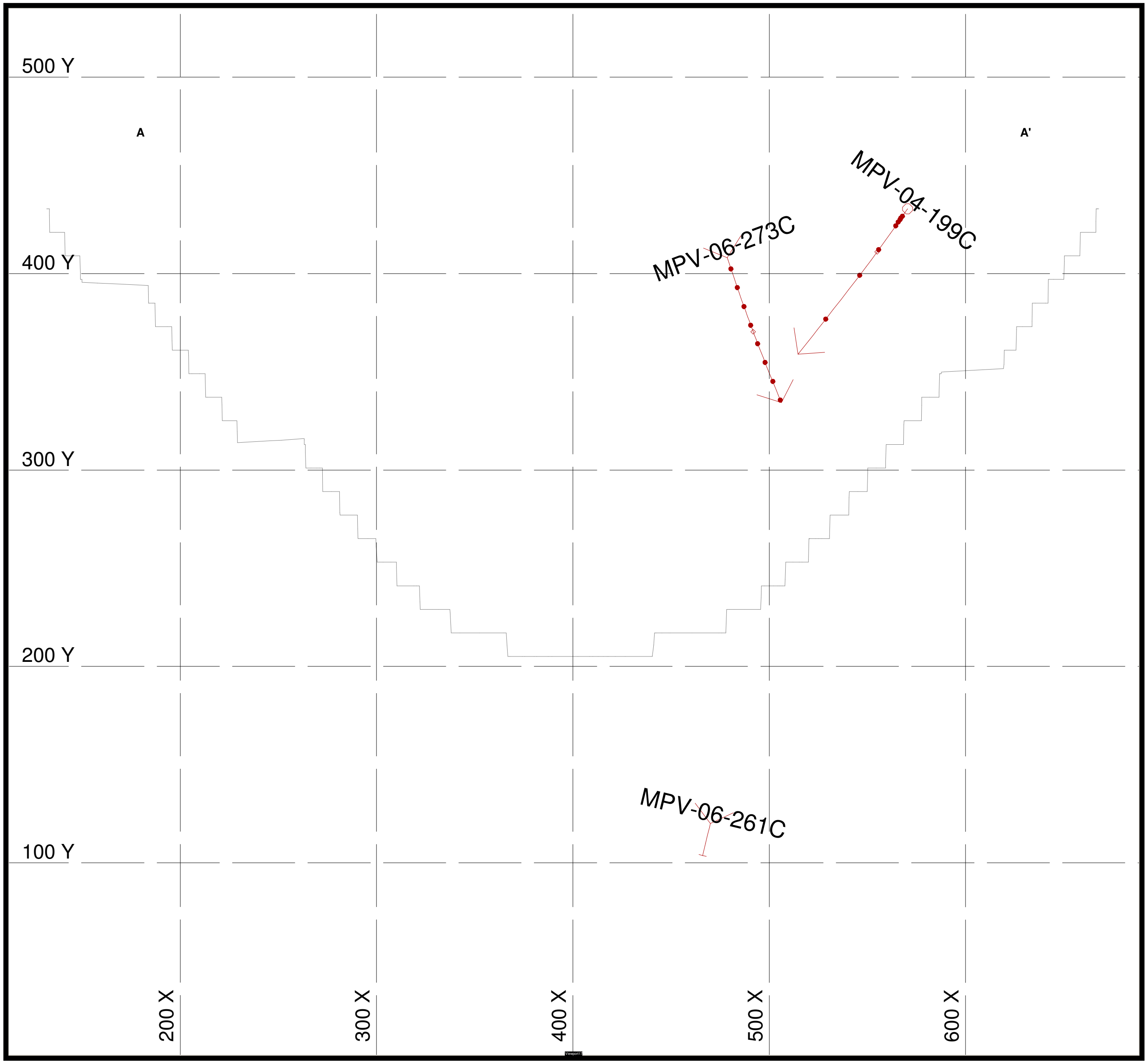
5034 Section 7035750

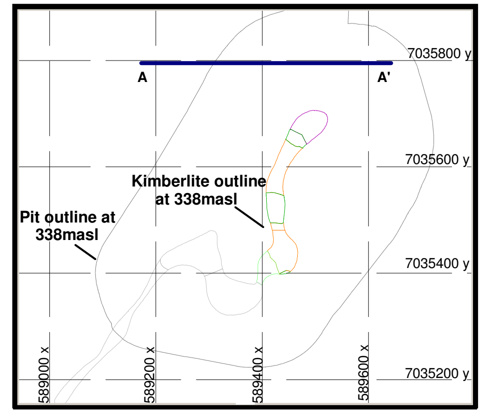
ABA sample location

Apr. 17 2008

KEG

De Beers Canada





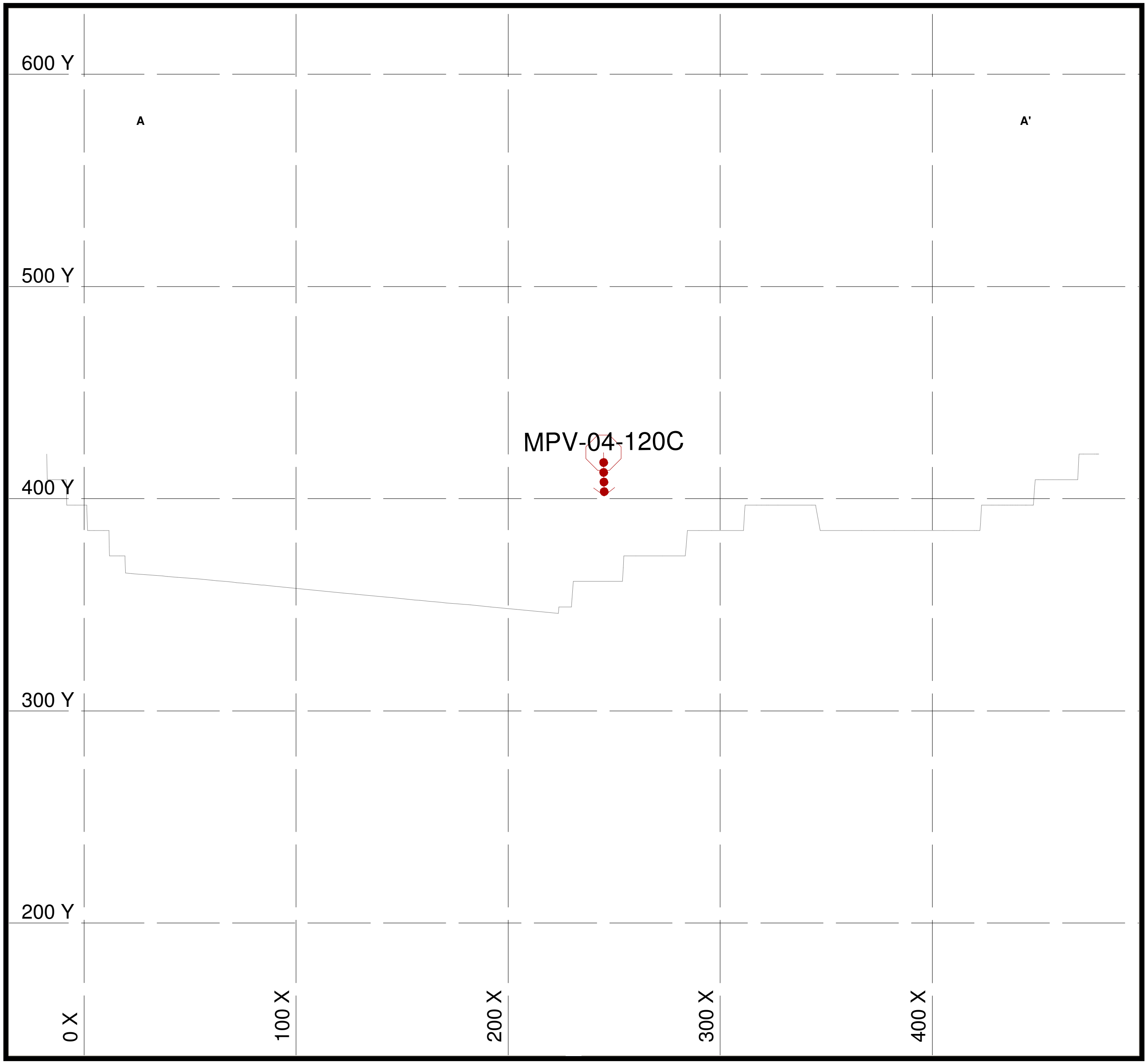
5034 Section 7035800

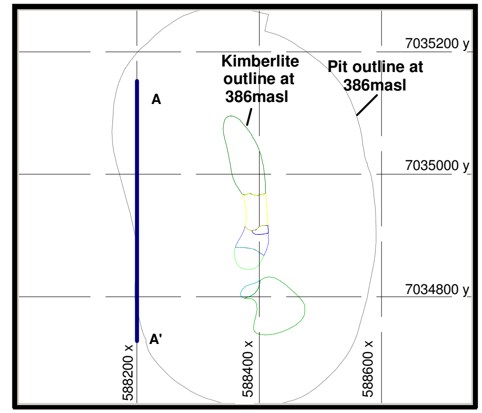
ABA sample location

Apr. 17 2008

KEG

DE BEERS CANADA

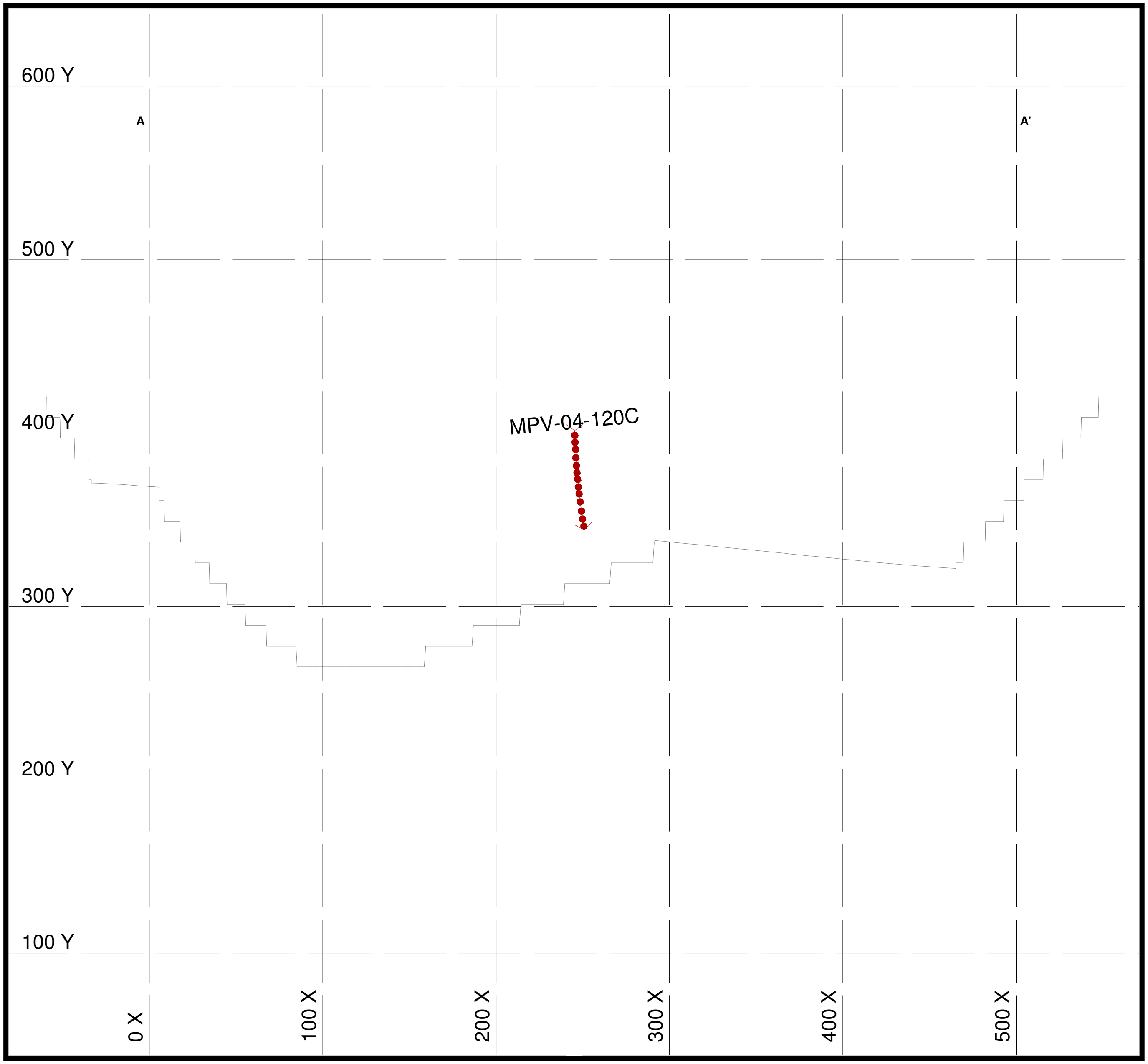


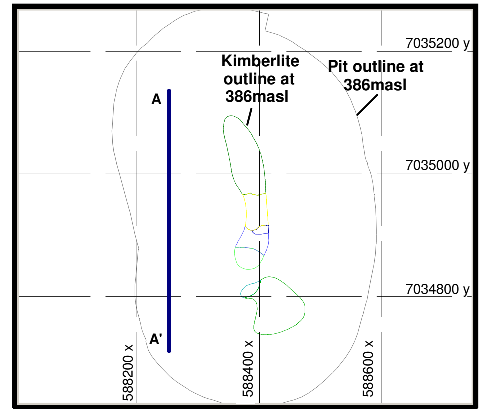


Hearne Section 588200

ABA sample location

Apr. 17 2008	De Beers Canada
KEG	

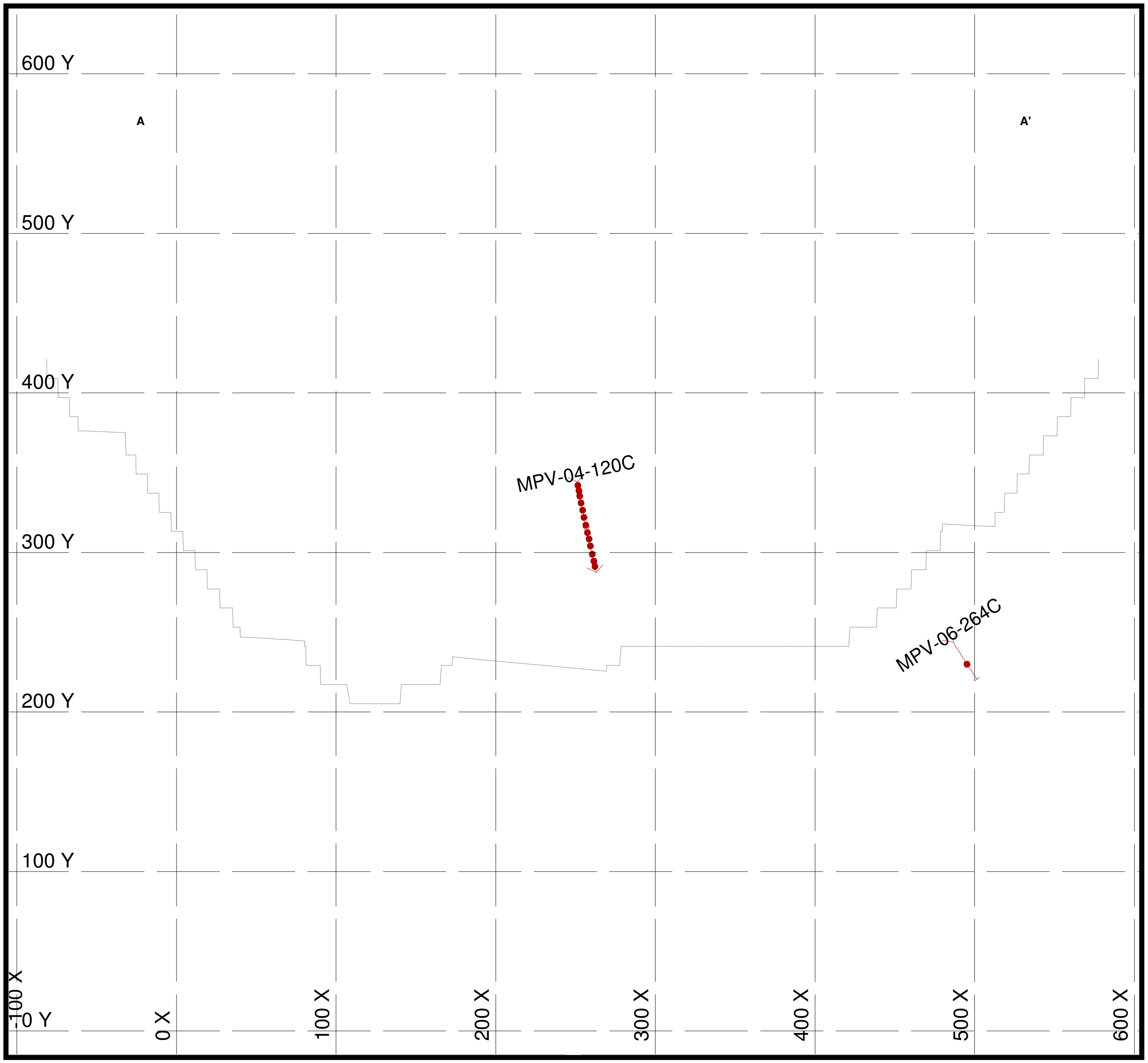


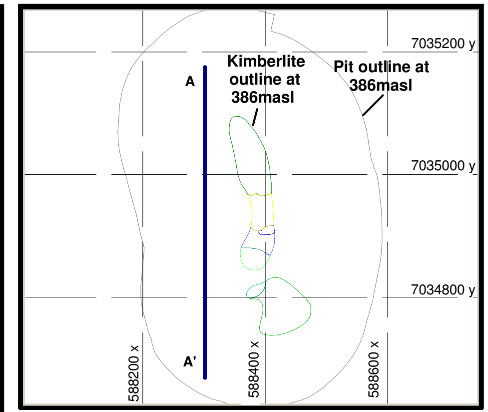


Hearne Section 588250

ABA sample location

Apr. 17 2008	De Beers Canada
KEG	

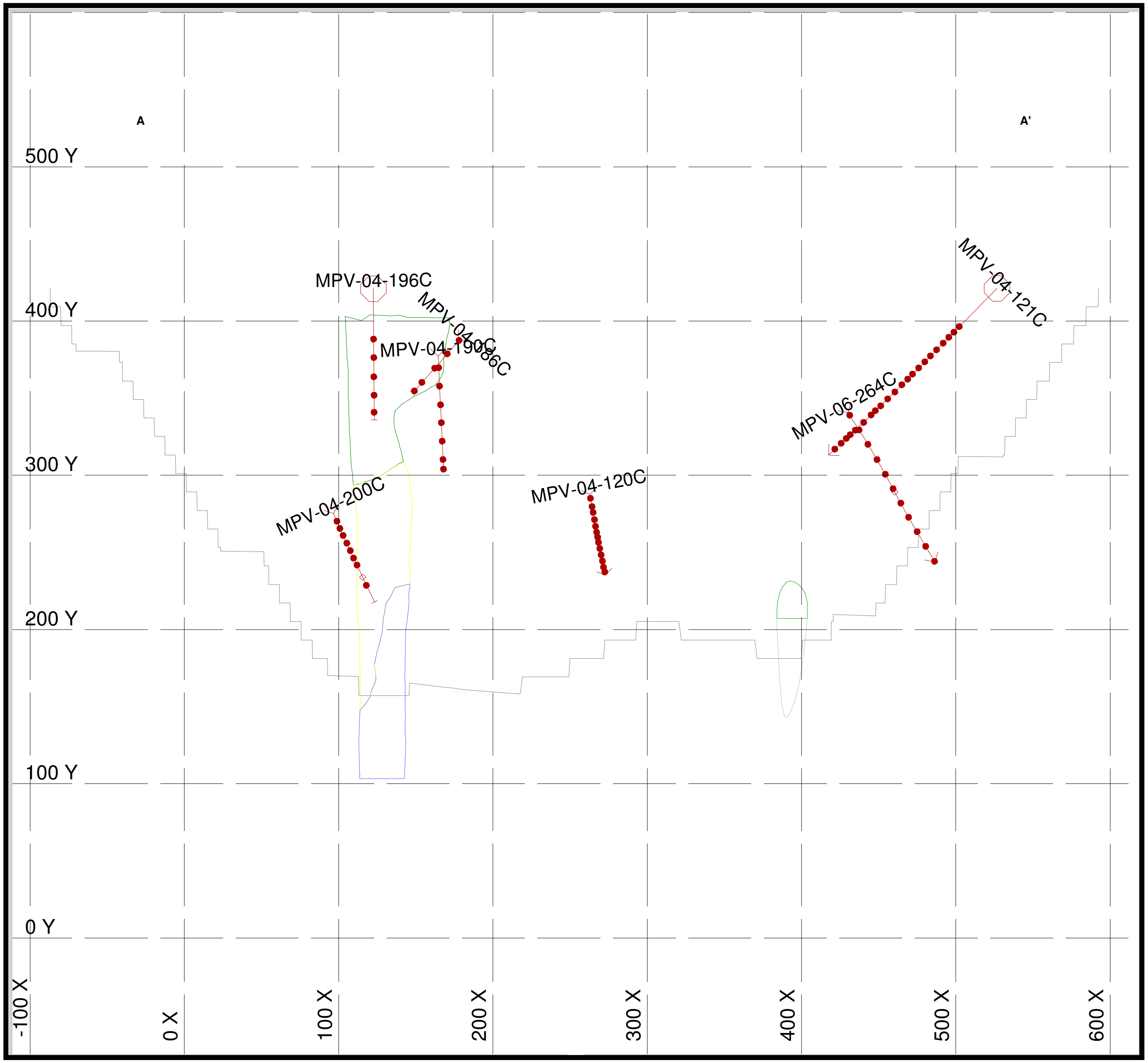


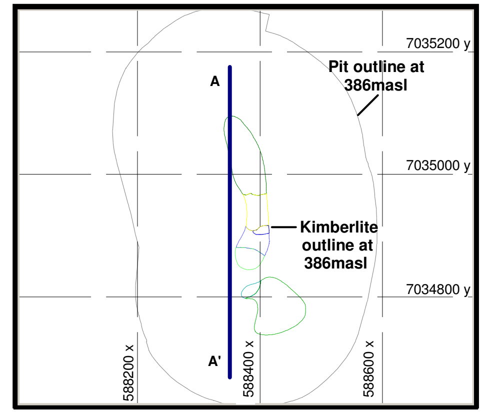


Hearne Section 588300

ABA sample location

Apr. 17 2008	De Beers Canada
KEG	

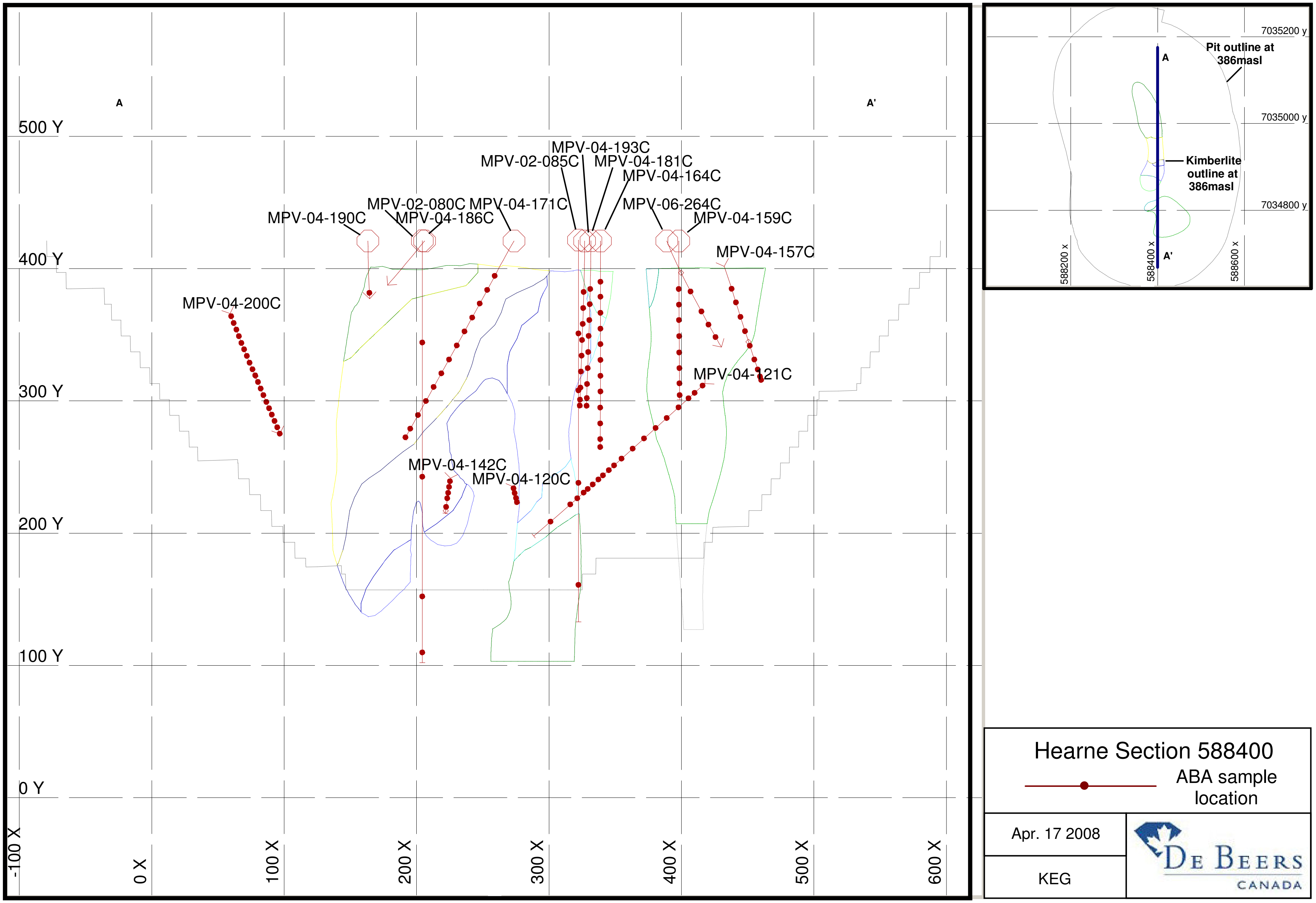




Hearne Section 588350

ABA sample location

Apr. 17 2008	De Beers Canada
KEG	



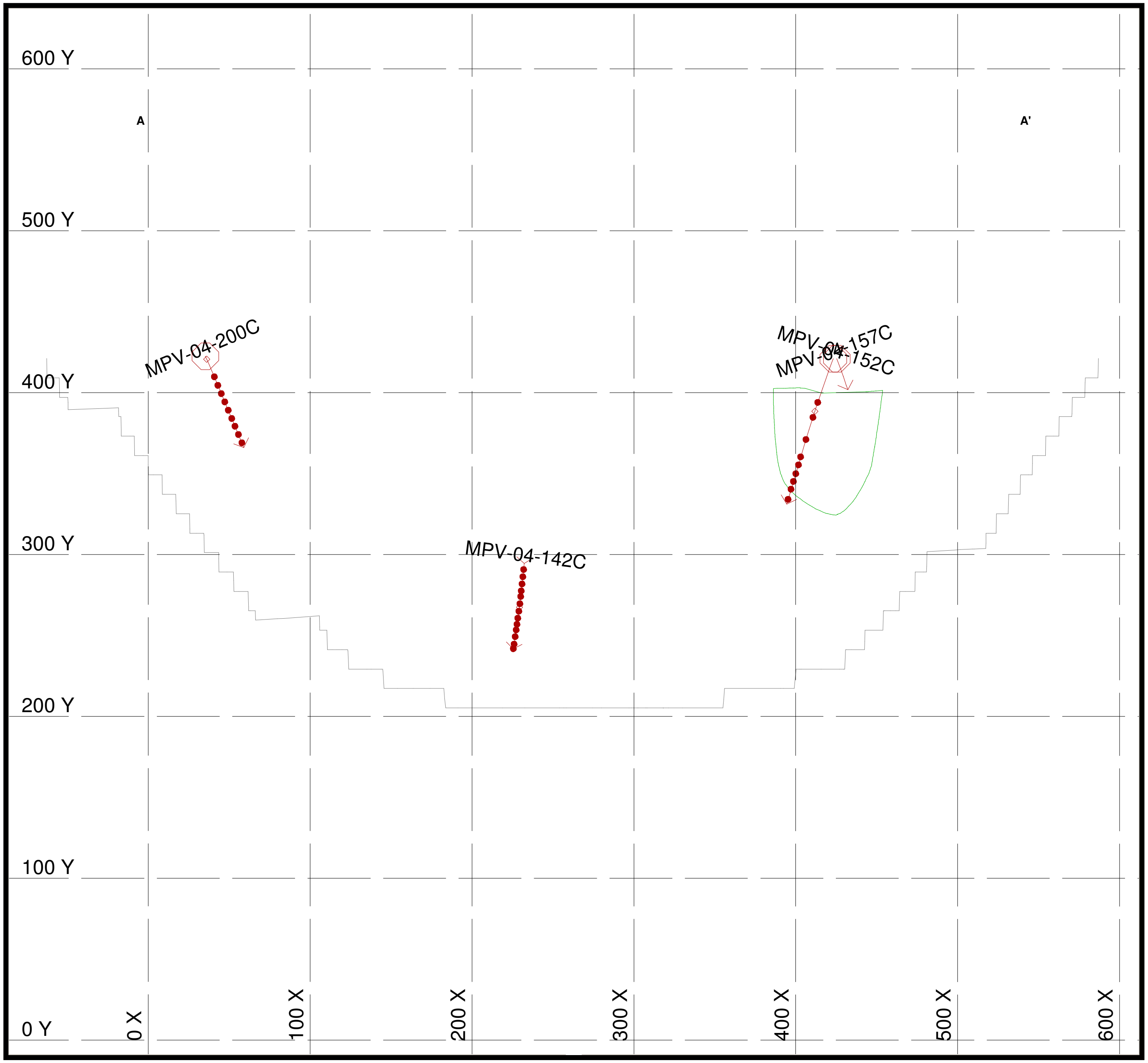
Hearne Section 588400

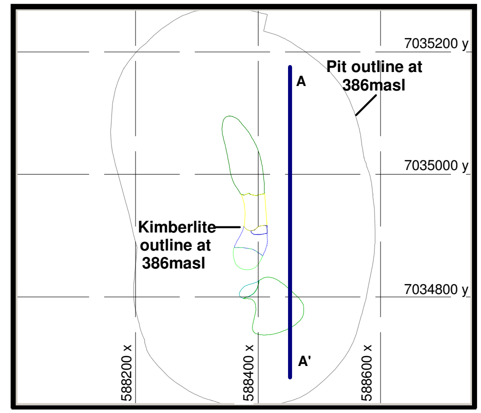
ABA sample location

Apr. 17 2008

KEG

De Beers Canada

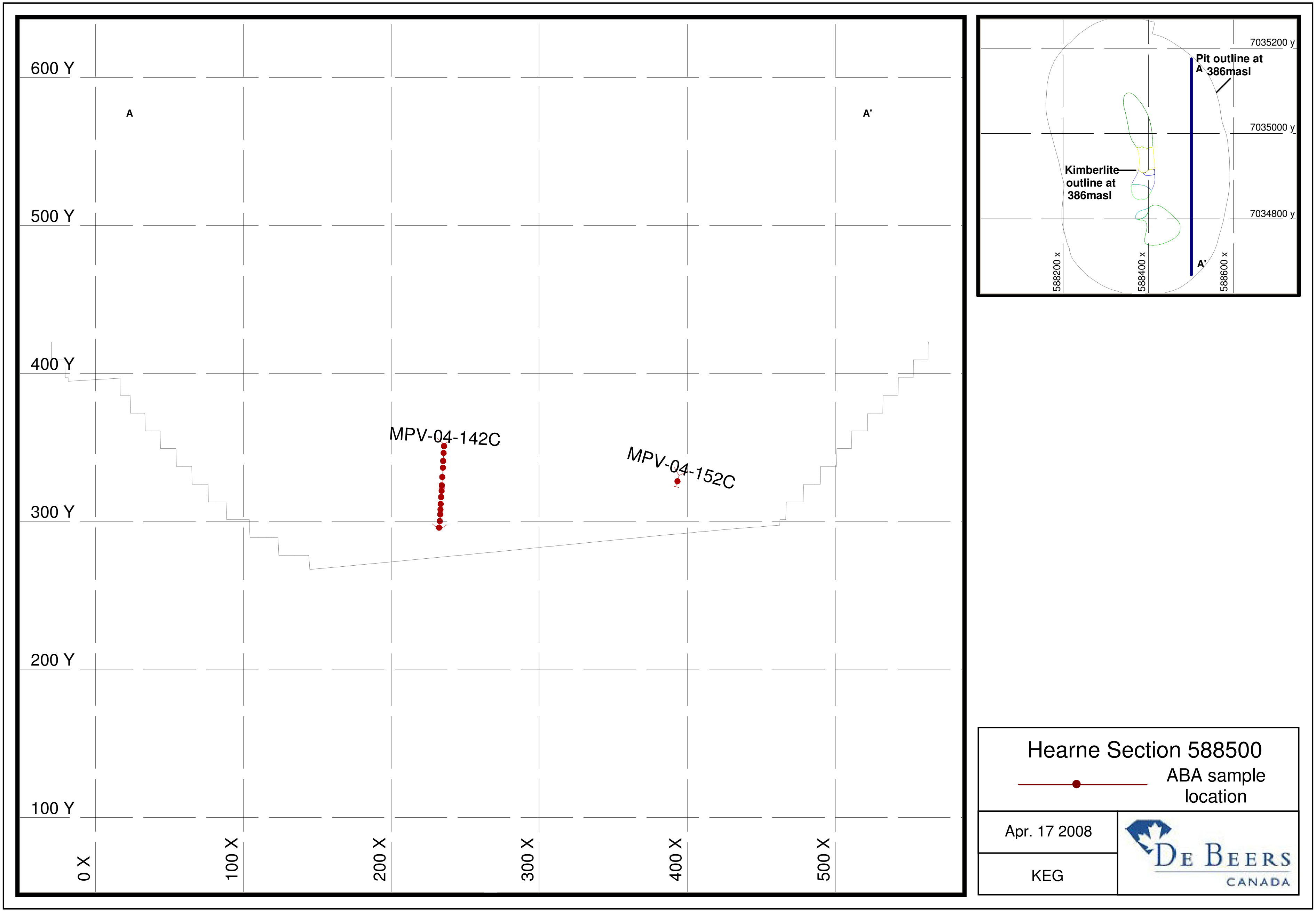




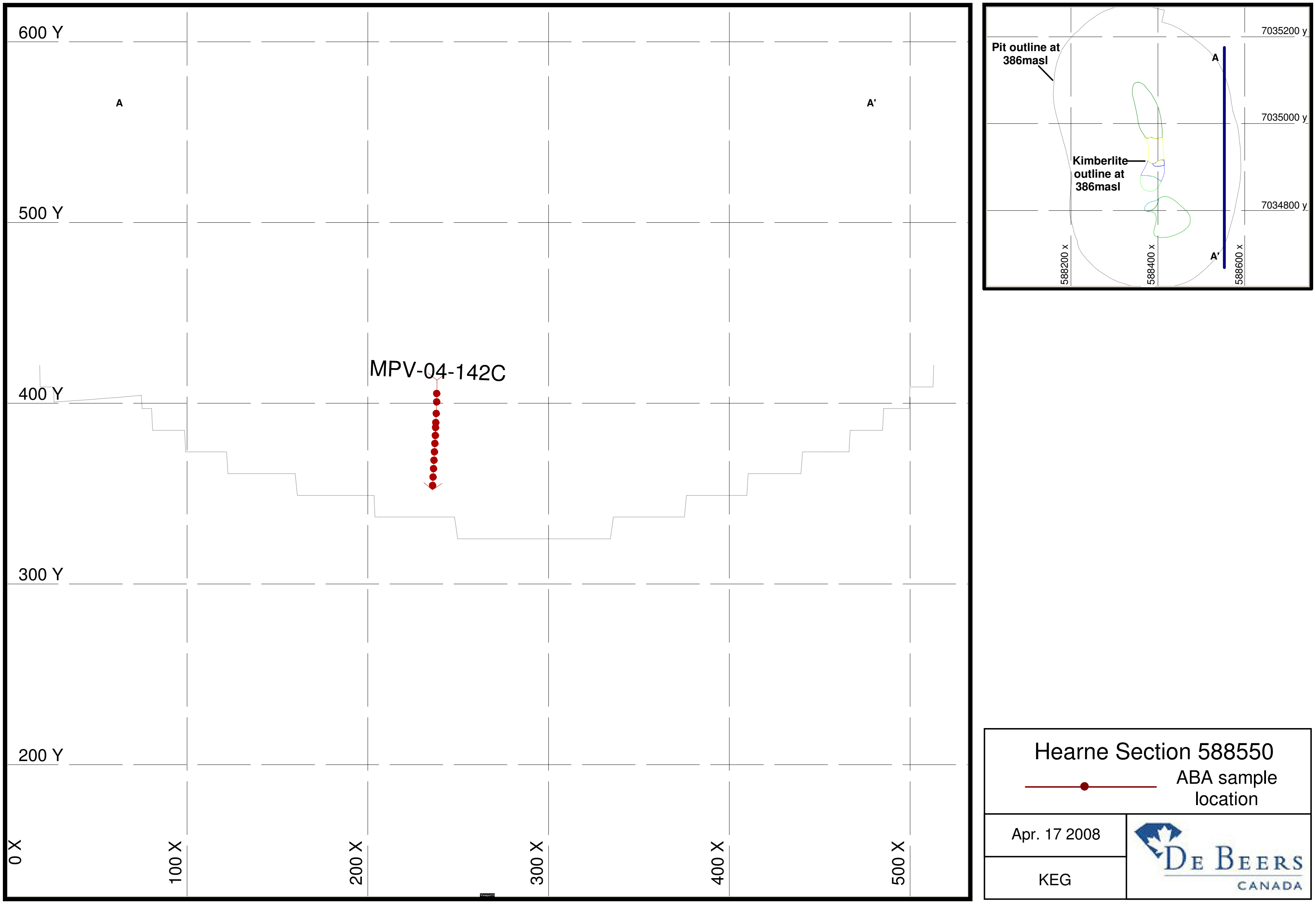
Hearne Section 588450

ABA sample location

Apr. 17 2008	De Beers Canada
KEG	



600 Y
500 Y
400 Y
300 Y
200 Y
100 Y
A
A'
MPV-04-142C
MPV-04-152C
0 X
100 X
200 X
300 X
400 X
500 X
7035200 y
7035000 y
7034800 y
Pit outline at 386masl
Kimberlite outline at 386masl
588200 x
588400 x
588600 x
Hearne Section 588500
ABA sample location
Apr. 17 2008
KEG



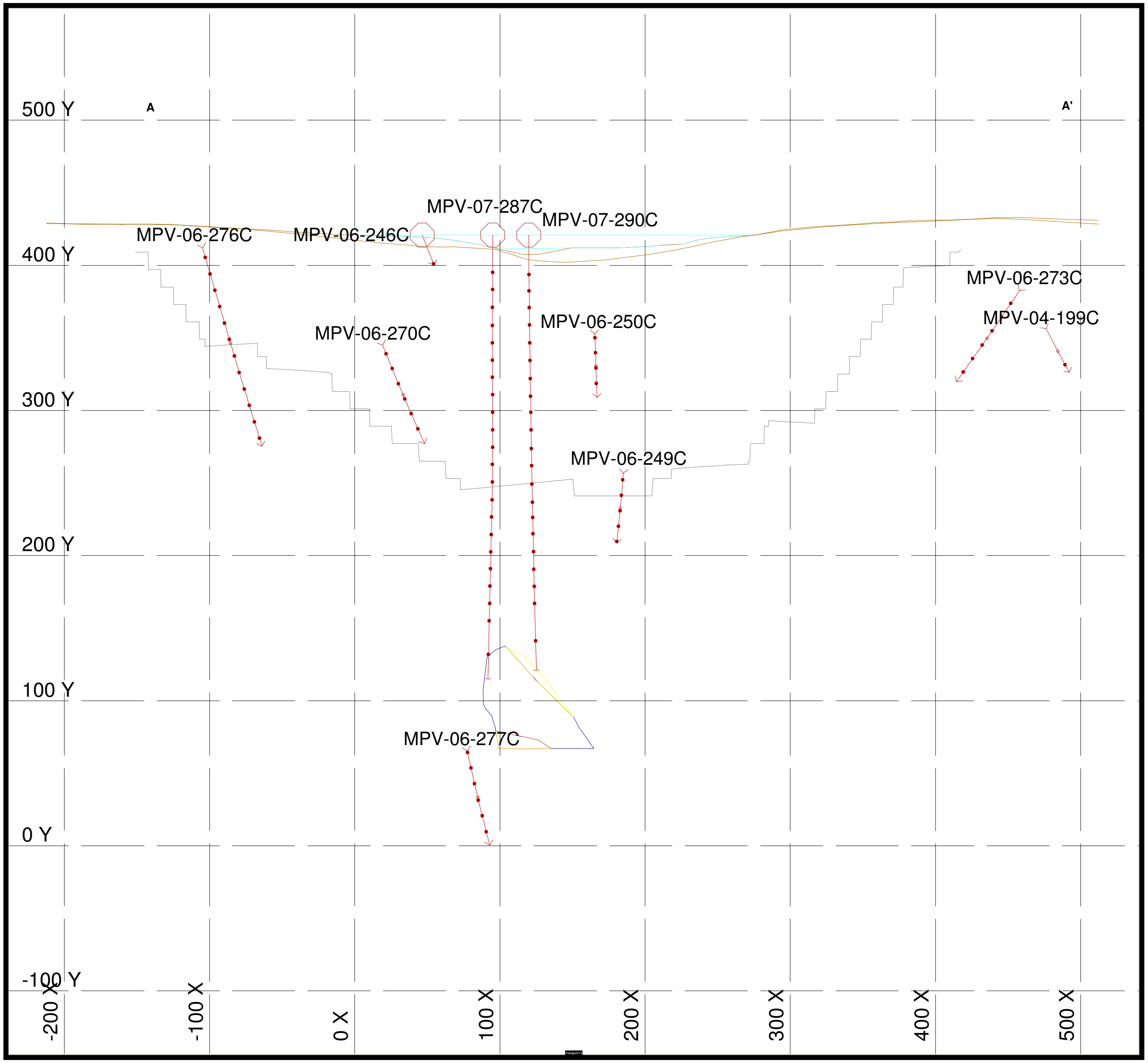
Hearne Section 588550

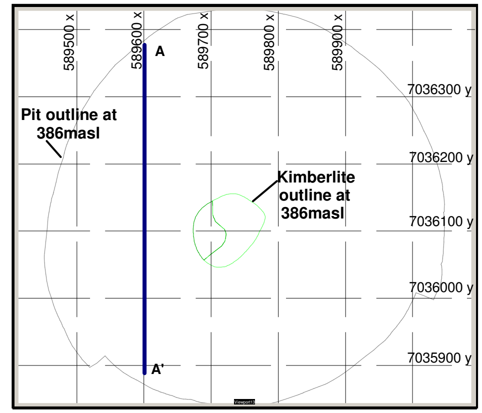
ABA sample location

Apr. 17 2008

KEG

De Beers Canada





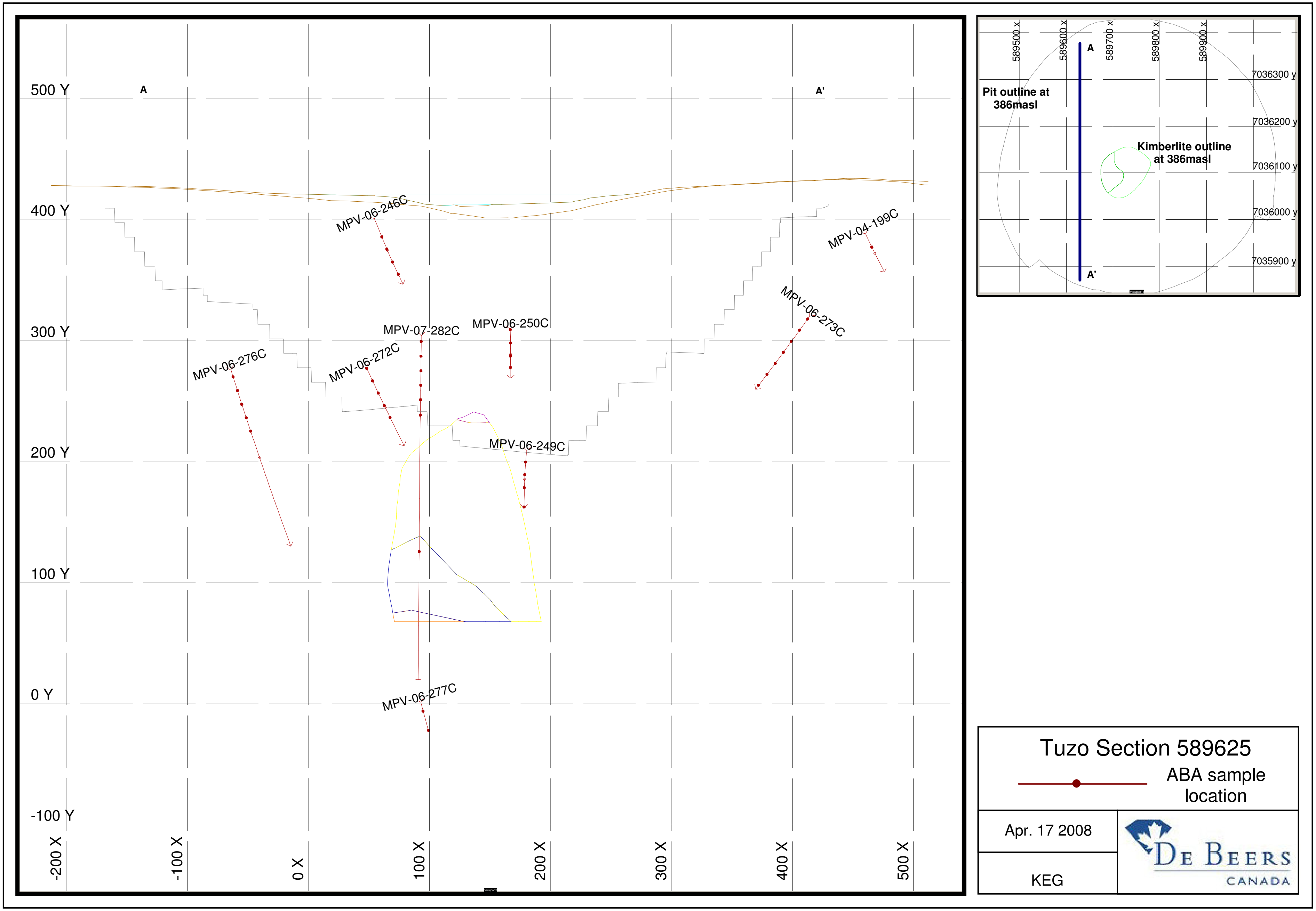
Tuzo Section 589600

ABA sample location

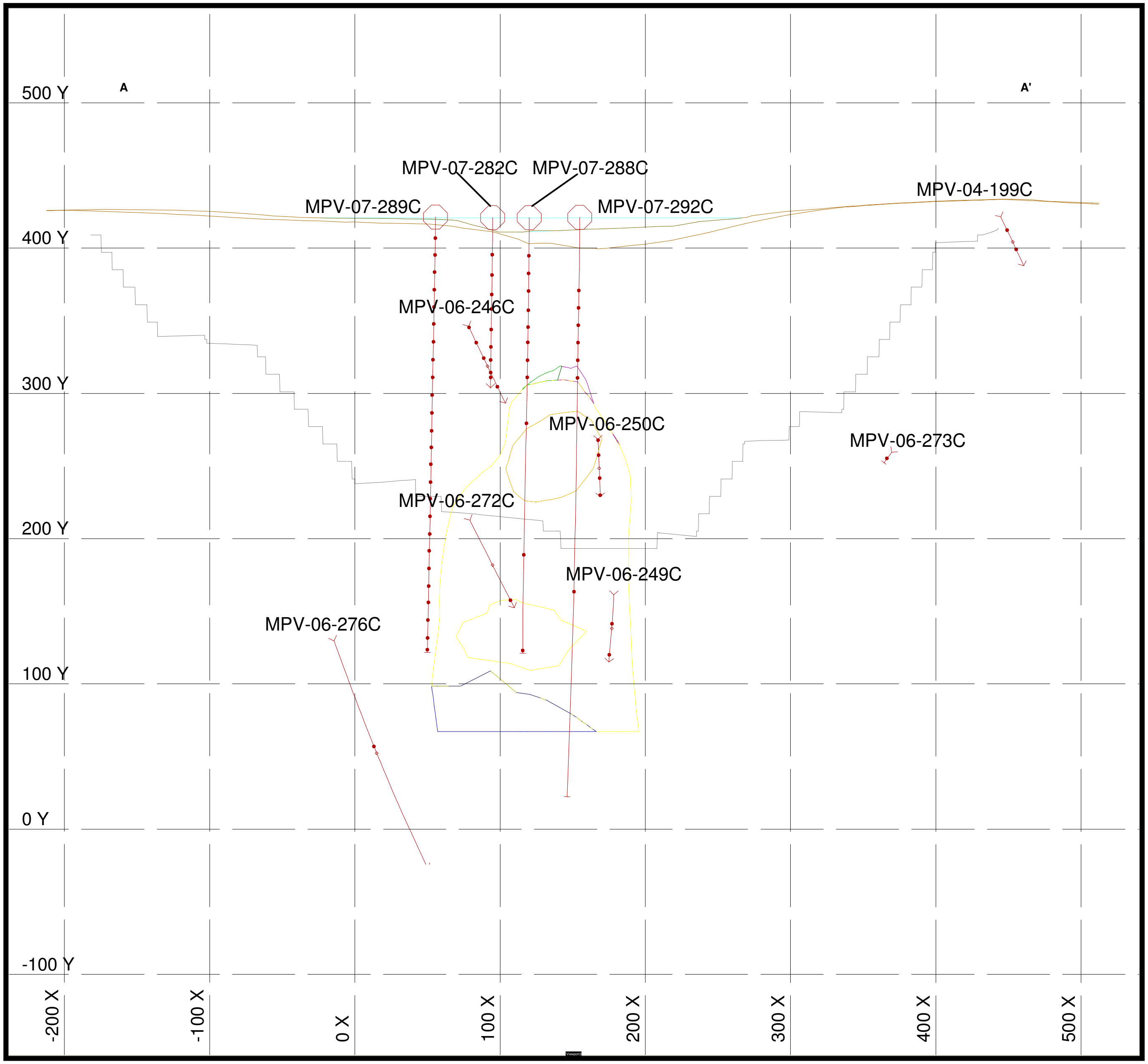
Apr. 17 2008

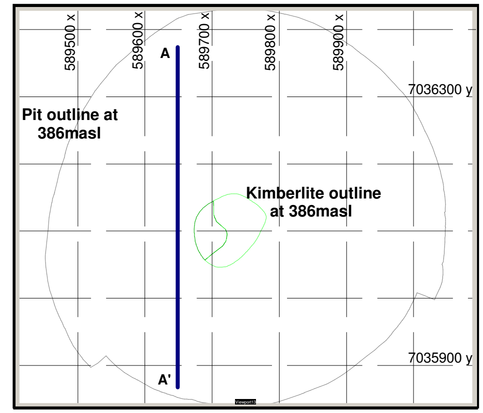
KEG

De Beers Canada



500 Y
400 Y
300 Y
200 Y
100 Y
0 Y
-100 Y
-200 X
-100 X
0 X
100 X
200 X
300 X
400 X
500 X
A
A'
MPV-06-246C
MPV-04-199C
MPV-06-273C
MPV-07-282C
MPV-06-250C
MPV-06-276C
MPV-06-272C
MPV-06-249C
MPV-06-277C
589500 x
589600 x
589700 x
589800 x
589900 x
7036300 y
7036200 y
7036100 y
7036000 y
7035900 y
Pit outline at 386masl
Kimberlite outline at 386masl
Tuzo Section 589625
ABA sample location
Apr. 17 2008
KEG
DE BEERS CANADA

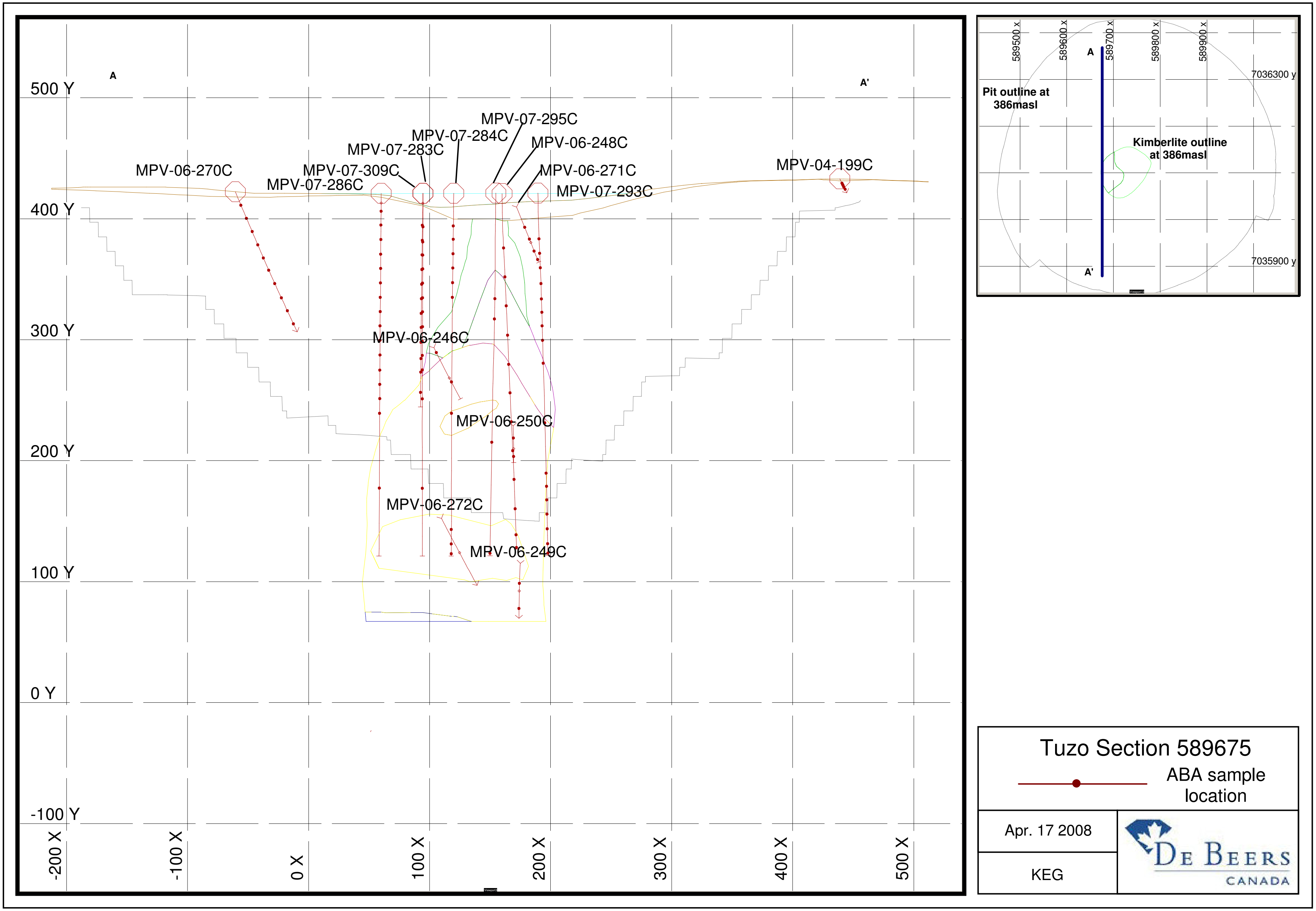




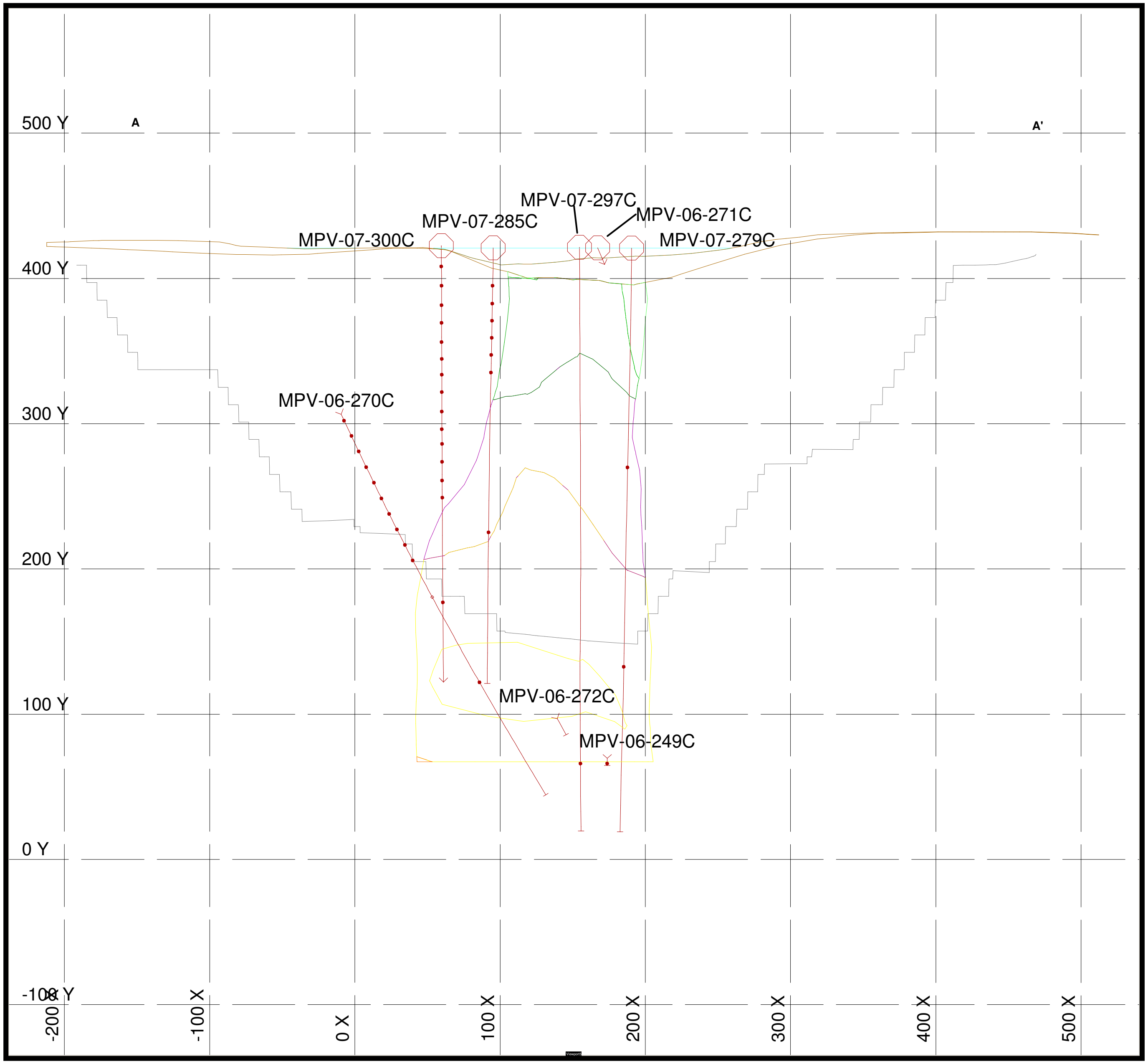
Tuzo Section 589650

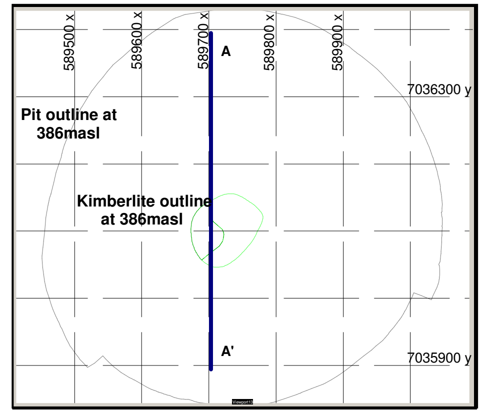
ABA sample location

Apr. 17 2008	De Beers Canada
KEG	



A
A'
500 Y
400 Y
300 Y
200 Y
100 Y
0 Y
-100 Y
-200 X
-100 X
0 X
100 X
200 X
300 X
400 X
500 X
MPV-07-295C
MPV-07-284C
MPV-07-283C
MPV-06-248C
MPV-06-270C
MPV-07-309C
MPV-07-286C
MPV-06-271C
MPV-07-293C
MPV-04-199C
MPV-06-246C
MPV-06-250C
MPV-06-272C
MPV-06-249C
589500 x
589600 x
589700 x
589800 x
589900 x
7036300 y
7035900 y
Pit outline at 386masl
Kimberlite outline at 386masl
Tuzo Section 589675
ABA sample location
Apr. 17 2008
KEG
De Beers Canada





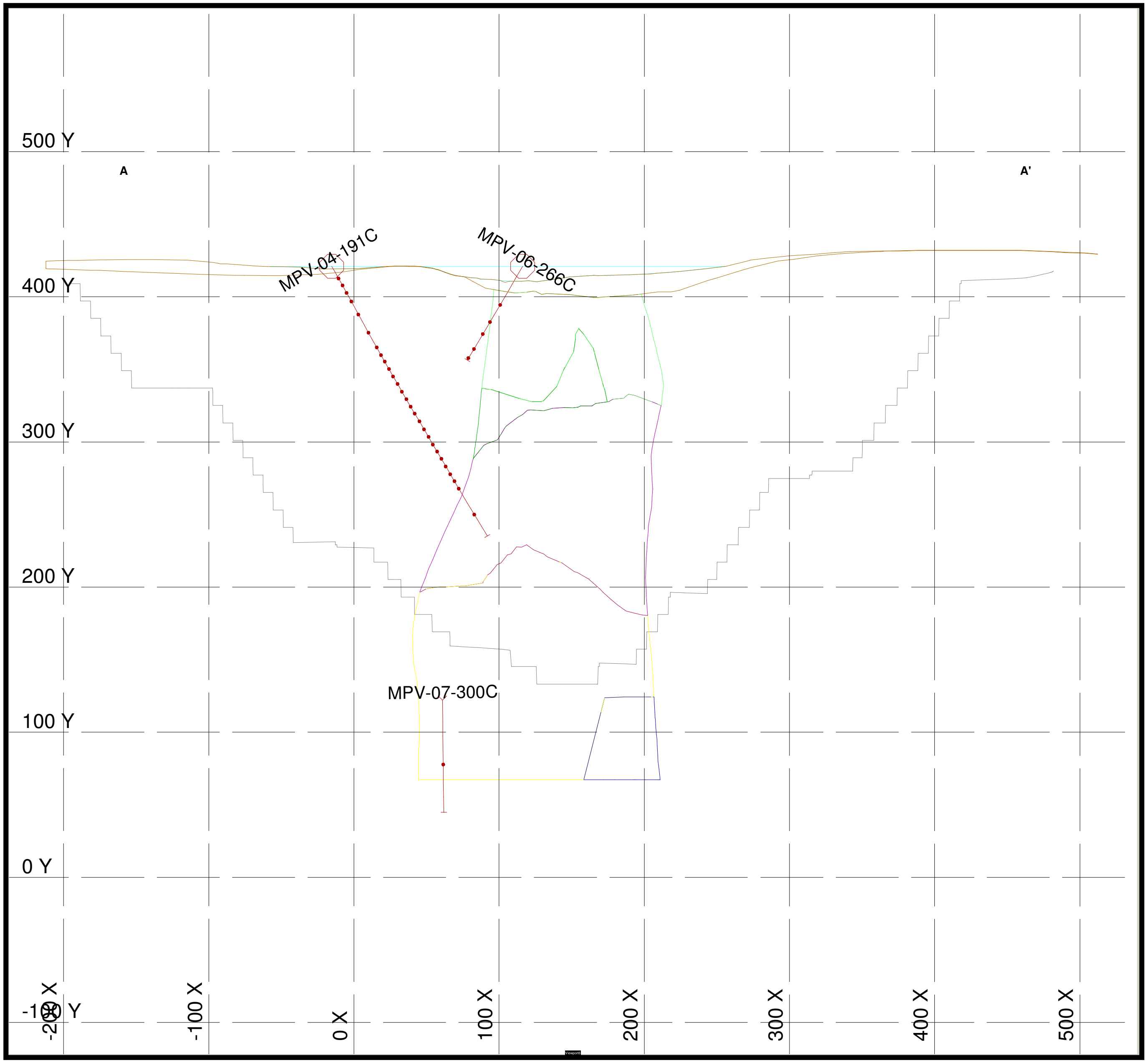
Tuzo Section 589700

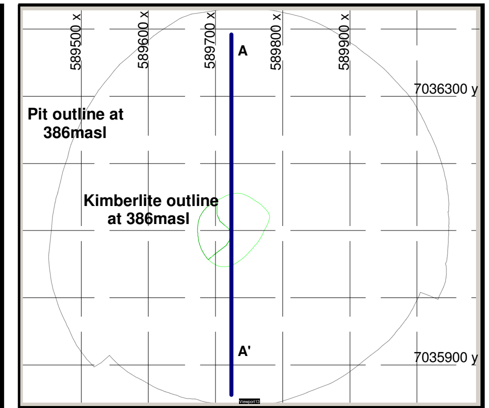
ABA sample location

Apr. 17 2008

KEG

DE BEERS CANADA





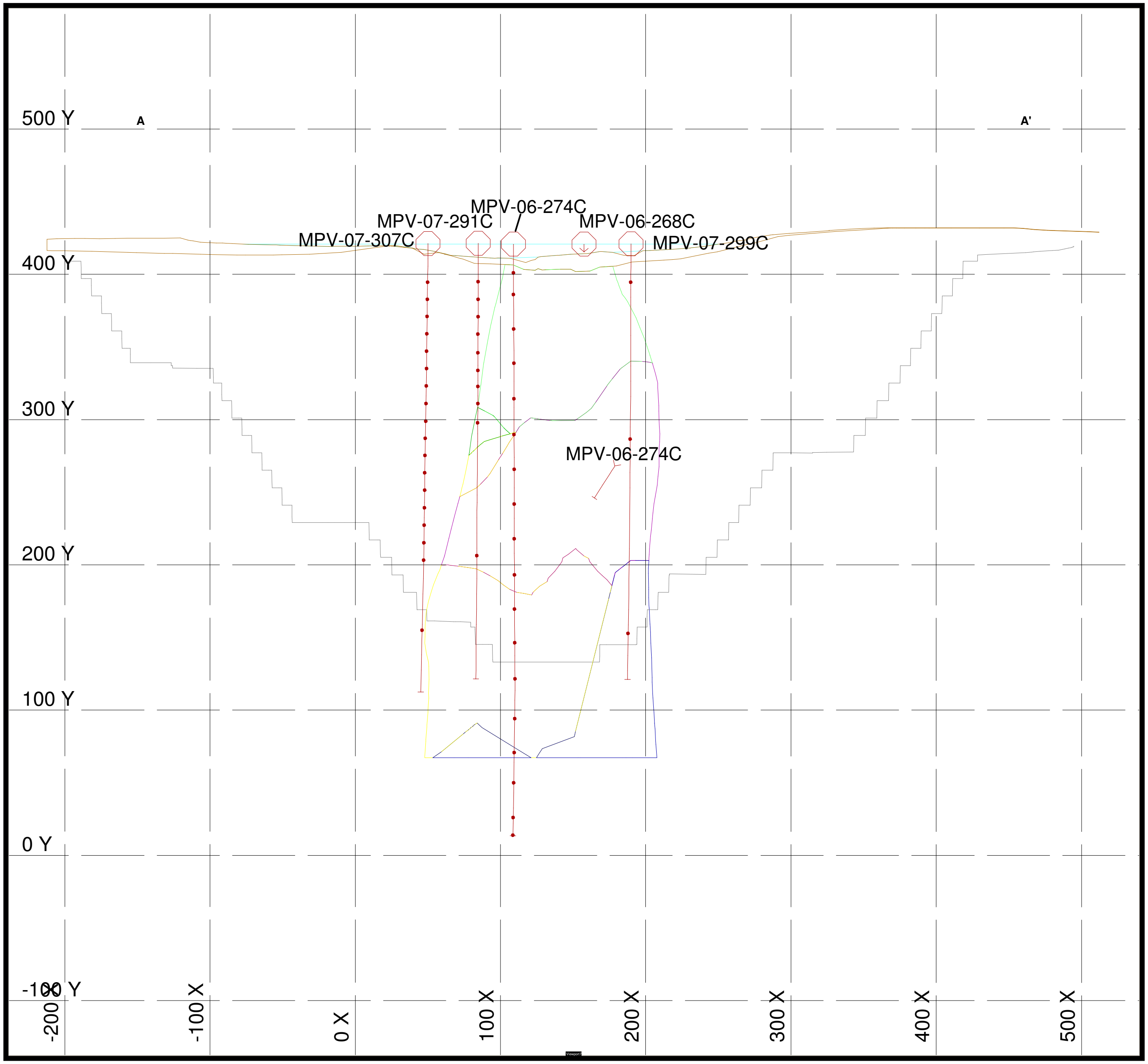
Tuzo Section 589725

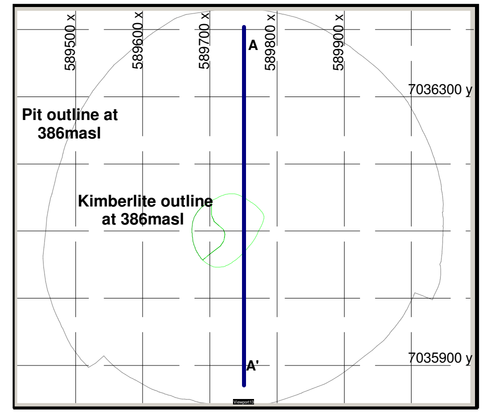
ABA sample location

Apr. 17 2008

KEG

DE BEERS CANADA





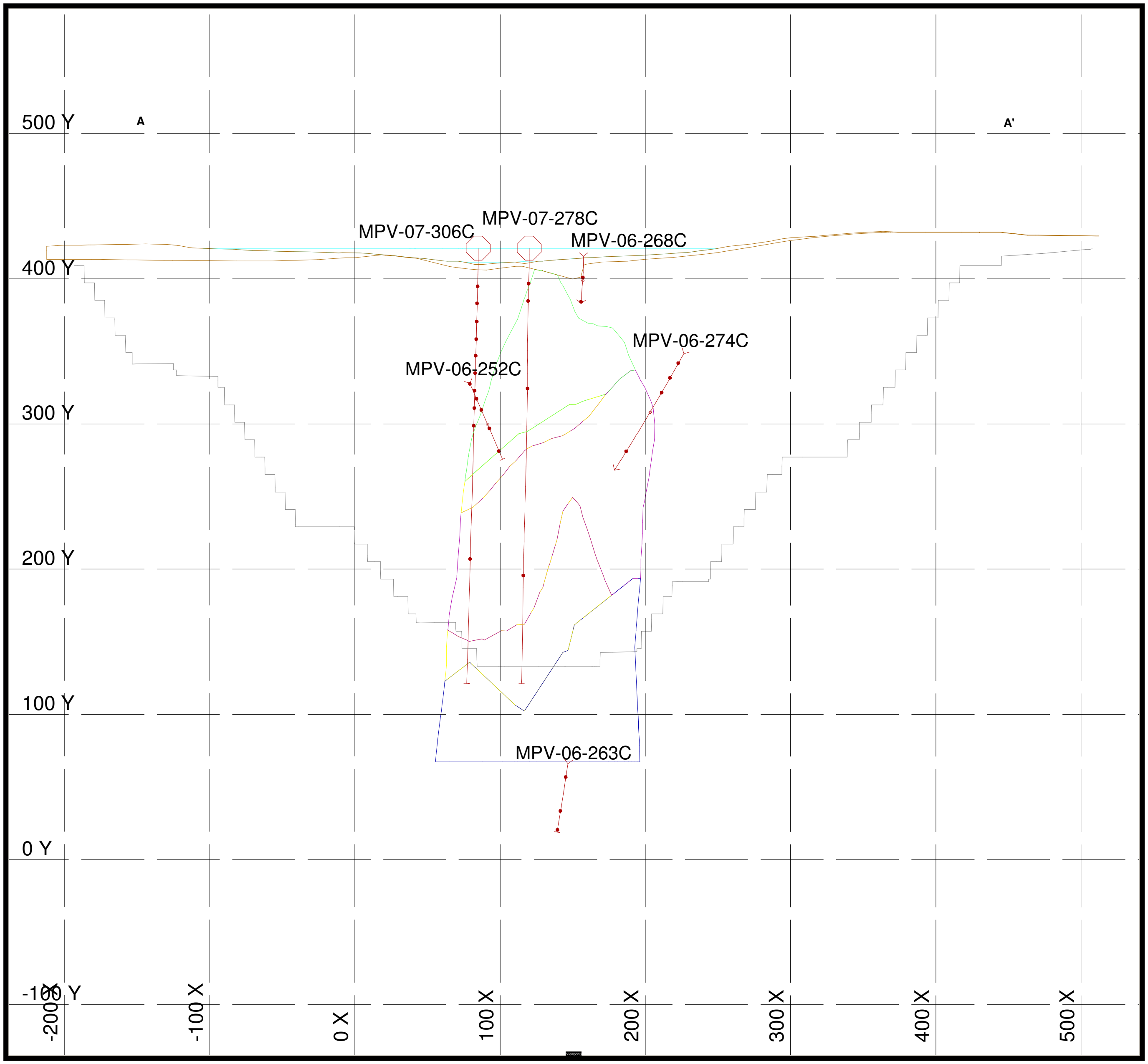
Tuzo Section 589750

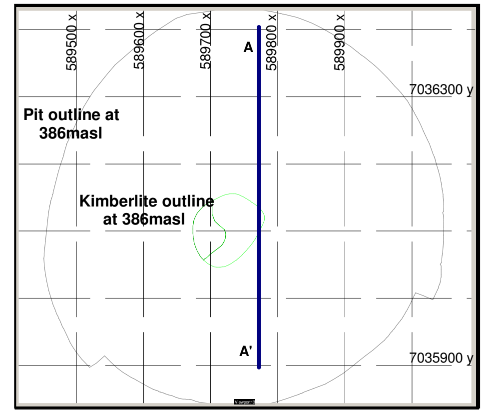
ABA sample location

Apr. 17 2008

KEG

De Beers Canada

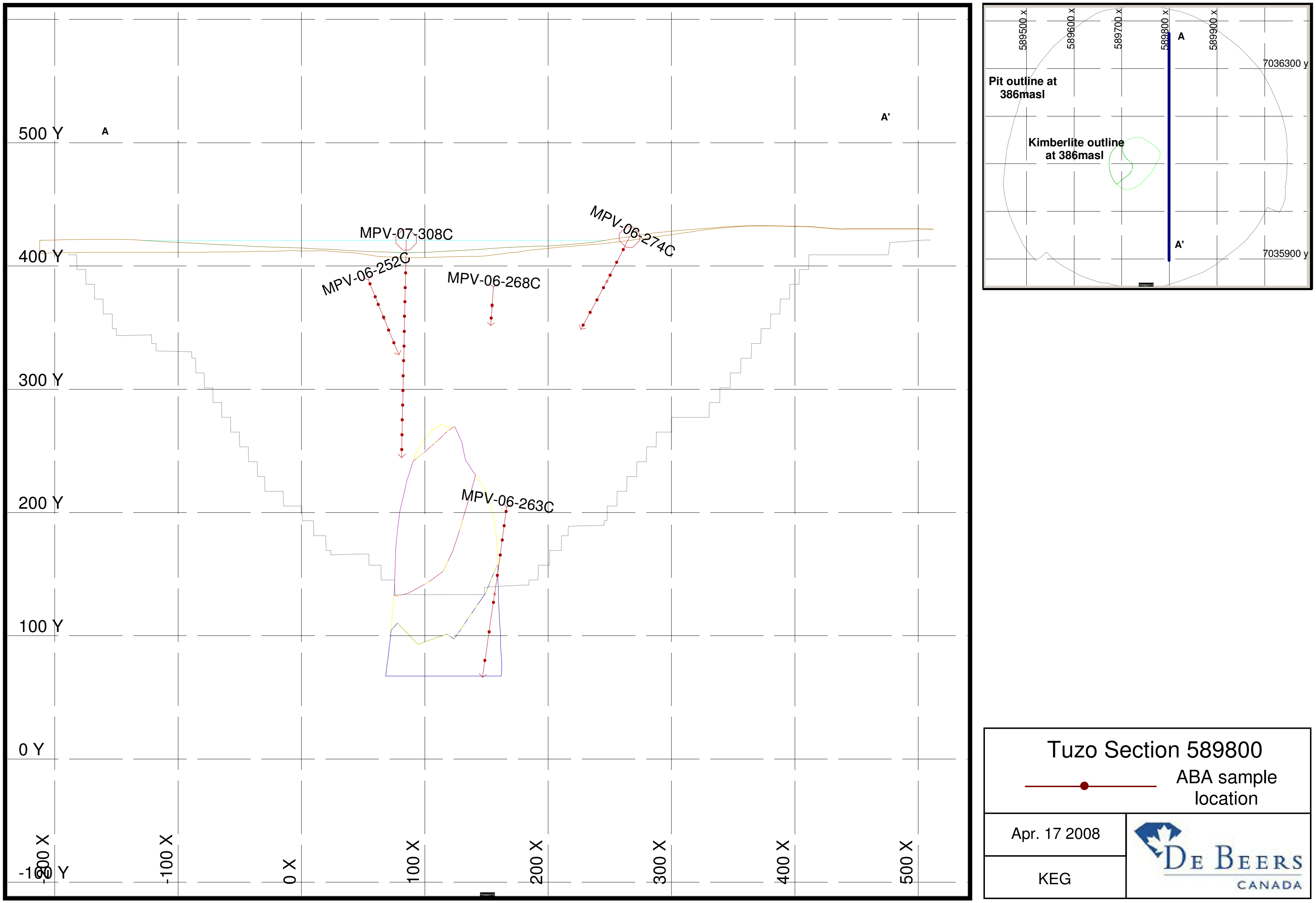




Tuzo Section 589775

ABA sample location

Apr. 17 2008	De Beers Canada
KEG	



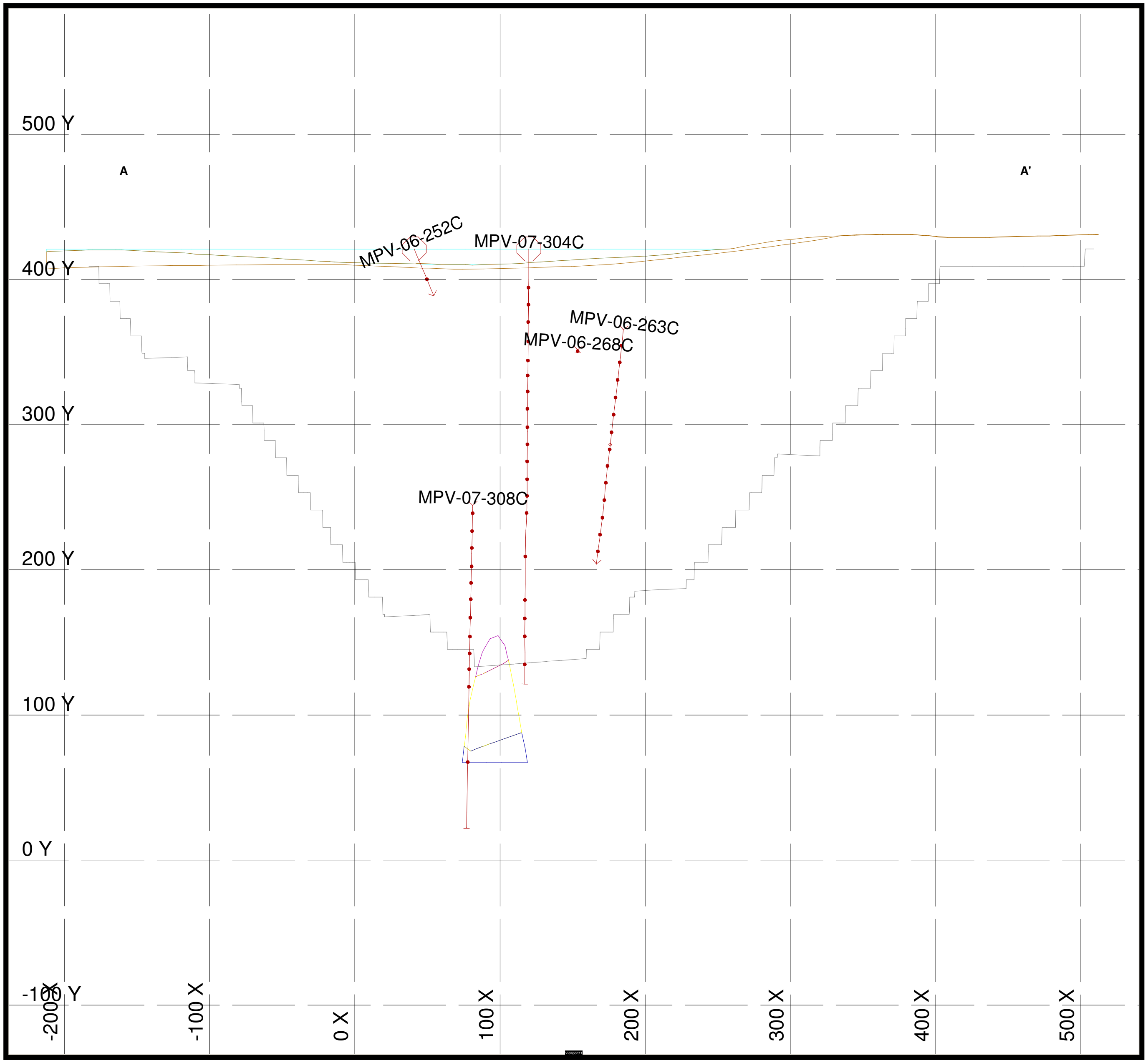
Tuzo Section 589800

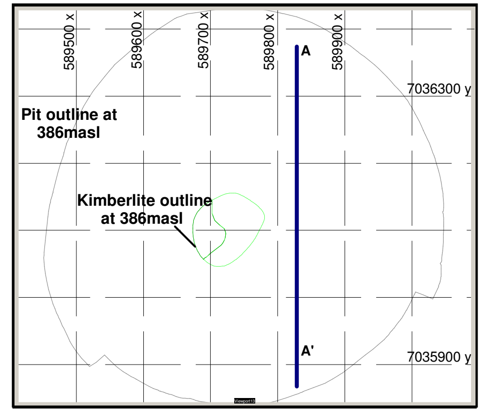
ABA sample location

Apr. 17 2008

KEG

De Beers Canada





Tuzo Section 589825

ABA sample location

Apr. 17 2008	DE BEERS CANADA
KEG	

ATTACHMENT 8.II.2

TESTING PROCEDURE

Mineralogical Analysis

Two mineralogical analyses were conducted to identify the major, minor and trace mineralogical assemblages. The 2004 mineralogy report by Petrascience and the 2010 mineralogy report by CEMI are attached in Attachment II. In 2004, the methodology completed to determine the mineralogical composition of the tailings included qualitative X-ray diffraction (XRD) and optical microscopy of polished thin sections of kimberlite, country rock and processed kimberlite samples. Two processed kimberlite composite samples were analyzed in 2010 using semi-quantitative XRD.

Note that the mineralogical quantities that are reported in Appendix II are largely based on results of XRD and may not fully represent the mineralogical compositions of the samples. XRD cannot identify amorphous phases, and therefore semi-crystalline precipitate minerals may not be fully represented by the results of XRD. In addition, trace concentrations of minerals are difficult to identify due to the limitations of the analytical method: generally, the minimum detection limit for XRD is approximately 1%.

Whole Rock and Trace Metal Chemistry

Major oxide and trace metal composition of a sample are determined using whole rock chemical analysis. Whole rock analysis (WRA) was assessed by a combination of X-ray fluorescence (XRF) and trace metal analysis using aqua regia digest followed by inductively coupled plasma (ICP) atomic emission instrumental analysis. Global Discovery Labs of Vancouver, British Columbia conducted the whole rock and trace metals analysis under sub-contract to Vizon SciTech (now Maxaam Analytics) of Vancouver, British Columbia. Processed kimberlite studies in 2010 were conducted by SGS laboratories in Vancouver.

Acid Base Accounting and Net Acid Generation Tests

The acid base accounting (ABA) analysis determines and balances the amount of acid potential (AP) with the amount of acid neutralizing potential (NP) that may be generated by a sample. ABA testing was conducted by Vizon SciTech (now Maxaam Analytics) (Vancouver, British Columbia) prior to 2010, and SGS laboratories (Vancouver, British Columbia) in 2010 using the modified Sobek methods (Sobek et al., 1978) as recommended by Price (1997). Specific analyses included for ABA determination are paste pH , sulphur species, acid potential (AP), neutralization potential (NP) and carbon species (total carbon, carbonate content and organic carbon content).

Acid Potential

The acid potential (AP) represents the bulk amount of acidity that can be produced, if all the sulphide minerals in the sample were oxidized. In the evaluation in this report, AP is calculated from total sulphur content. This was a conservative assumption carried forward from AMEC (2008). Total sulphur concentrations include but sulphur from sulphide minerals and often includes amounts of oxidized, non-reactive forms of sulphur, such as sulphate. Although the dissolution of sulphate minerals can contribute some AP in the short-term, sulphate minerals do not generally contribute to the long-term acid generation potential of a material.

Neutralization Potential

The neutralization potential (NP) represents the bulk amount of acidity that the sample can potentially consume or neutralize. The NP was determined by acidifying the sample with sulphuric acid. Following the acidification of the sample, the amount of acid that is consumed during the test period is determined by a reverse titration. Negative NP values indicate that samples contained stored acidity in the form of soluble phases that contribute acidity on dissolution.

The carbonate neutralization potential (CaNP) is a calculated value that represents the bulk amount of acidity that the sample can potentially consume through the dissolution of carbonate minerals. Carbonate NP was calculated using carbon dioxide concentrations for all samples analyzed prior to 2010. Carbon dioxide concentrations were not reported in 2010 processed kimberlite samples, therefore total inorganic carbon concentrations were used to calculate the carbonate NP.

Calculated CaNP values assume that all of the measured carbon in the sample is contained in carbonate minerals that contribute fully to acid neutralization. General limitations of using total carbon include the presence of organic carbon (coal, peat, etc.) and the presence of carbonate minerals that release net acidity on dissolution, such as siderite. These general limitations were not an issue for the lithologies evaluated as part of this project since appreciable amounts of siderite or organic carbon were not observed.

NP and CaNP are typically compared for the purpose of evaluating the mineralogical source of neutralization potential in a sample. In addition to the consumption of acid by readily soluble carbonate minerals, the ‘bulk’ NP could include neutralization potential released by the dissolution of aluminosilicate, silicate and/or other minerals that do not typically dissolve until / unless acid generating conditions are achieved. If the NP is approximately equal to the

CaNP, the NP is likely attributable to the dissolution of carbonate minerals. In cases where the NP is significantly greater than CaNP, the NP could be overestimated due to the partial dissolution of silicate minerals. The rate of aluminosilicate or silicate mineral dissolution is kinetically limited and generally too slow to provide effective neutralizing capacity under ambient field conditions; silicate minerals predominantly provide NP if (and when) acidic conditions are achieved, or where water-rock interaction times are very long.

Interpretation of Acid Base Accounting Results

Acid Base Accounting results for some samples were below analytical method detection limits. For calculation of summary statistics, results at or below the method detection limit were replaced with one half the value of the lower detection limit for calculation purposes The acid rock drainage (ARD) classification of samples was based on Department of Indian Affairs and Northern Development (now INAC) (DIAND 1992) criteria presented in "Guidelines for ARD Prediction in the North." The guide was developed to "assist the Department of Indian Affairs and Northern Development in predicting the potential in active and inactive hardrock mines in the Yukon and Northwest Territories." The acid generation potential guide is summarized in the Table 8.II.2-1 below:

Table 8.II.2-1 Interpretation of Acid Base Accounting Results

Acid Generation Potential	Criteria	Comments
Potentially Acid Generating (PAG)	NP/AP < 1	Potentially acid generating unless sulphide minerals are non-reactive.
Uncertain	1 < NP/AP < 3	Possibly acid generating if NP is insufficiently reactive or is depleted at a rate faster than sulphides.
Non-Acid Generating (Non-AG)	3 < NP/AP	Not expected to generate acidity.

Source: INAP 2009.

Note: For tailings material (i.e., processed kimberlite) a lower NP/AP ratio may be acceptable as the material is more homogenious and reactive due to communition, and should be evaluated within the context of material placement and processing.

The criteria listed in Table 8.II.2-1 are consistent with the recommendations in MEND (2009) and INAP (2009). However, it should be noted that for several reasons, no single NP/AP ratio or sulphur concentration is universally applicable with respect to acid generation prediction. The actual threshold values for a particular test sample are material specific, and could depend on several factors, including chemical and mineralogical composition (i.e., presence and amounts of acid generation and neutralization minerals), morphology (i.e., grain size, texture and crystallinity) and site-specific exposure conditions.

Net Acid Generation Testing

Processed kimberlite samples collected in 2010 were submitted for Net Acid Generation (NAG) testing, conducted according to the protocols in AMIRA (2002) and Miller et al. (1997). The purpose of the NAG test is to evaluate potential for acid generation following complete oxidation of all sulphide minerals within the sample. During the NAG test, hydrogen peroxide is added to a sample in quantities sufficient to completely oxidize all sulphide minerals. The pH of the oxidized solution was measured after the completion of the reaction to determine the NAG-pH, followed by titration of the solution to a pH of 4.5 with sodium hydroxide. Back-titration to a pH of 7 was completed to provide added information on buffering capacity.

The results of the NAG test were used to provide an initial indication of the propensity of a material to produce acidity after a period of exposure and weathering. The NAG pH is a useful indicator of whether a sample contains sufficient internal buffering capacity to neutralize the acidity produced through sulphide oxidation. A NAG-pH value of less than 4.5 is indicative that insufficient NP exists in the tailings to buffer the acidity generated by the complete oxidation of sulphide minerals, however rates of mineral dissolution are not evaluated by the NAG testing.

Shake Flask Extraction Testing

Short-term static leachate extraction tests are used to determine the readily-soluble component of a sample. These tests, commonly known as shake flask extractions (SFE), are useful for indicating the short-term leaching characteristics and potential for metal release from a sample. SFE tests do not assess long-term processes, such as dissolution of refractory minerals and sulphide oxidation. A modified version of the British Columbia solid waste extraction procedure (SWEP) using distilled water as the leaching agent and a 3:1 mass ratio (750 millilitres [mL] of water with 250 grams [g] of rock) was conducted by Vizon SciTech (Vancouver, British Columbia) in 2004 and SGS (Vancouver, British Columbia) in 2010.

SFEs results represent metal release due to the dissolution of readily soluble minerals such as carbonates and salts. The SFE tests do not simulate site drainage chemistry. Results at or below the analytical detection limits were replaced with one half the value of the lower detection limit for calculating summary statistics.

Chemical Analysis of Process Water

Process water represents the water used in the process plant during the recovery of diamonds. This water is in contact with PK, and ultimately is discharged as a component of the PK fines slurry. Samples of process water were collected by De Beers during metallurgical testing conducted in 2010; samples were collected after each sample had gone through the process plant. A total of 9 samples of process water were provided to SGS (Vancouver, British Columbia) for chemical analysis.

Kinetic Testing

Kinetic tests are repetitive leaching tests designed to simulate enhanced weathering and provide rates for acid generation, acid neutralization, and metal and major element leaching under laboratory conditions. Kinetic tests were conducted using several methodologies, to evaluate the variability in sample reactivity in different exposure conditions, including:

- Humidity cell tests (HCT) carried out using the standard humidity cell test (HCT) approach described in ASTM D 5744-96, 1996.
- Column cell testing, as described by Price (1997).
- Submerged column tests as described in the following section.

The results of HC testing are particularly suited for the development of reaction rates, and can also be used to make inferences with respect to long-term water chemistry. The column cell data can provide an understanding of the secondary geochemistry and may simulate of potential drainage chemistry characteristics. Submerged column tests were initiated to provide an indication of leachate concentrations that could be produced by PK submerged under a column of water over time.

In scaling up kinetic test results to field conditions a number of factors including the greater particle size of country rock compared to kinetic tests, potential for preferential exposure of acid producing or acid neutralizing minerals during mining, climate conditions, and limitations in the scale of laboratory based tests need to be considered. However, as discussed in Price (1997), results from kinetic tests can be used as “analogue” inputs for contact water in the absence of site specific data.

Humidity Cell (HC) Testing

Laboratory humidity cell testing (HCT) of kimberlite, country rock and processed kimberlite samples was conducted in 2004, and additional humidity cell testing on processed kimberlites is currently underway. The kinetic tests are being performed according to the ASTM D5744-96 Standard Test Method for Accelerated Weathering of Solid Materials Using a Modified Humidity Cell (ASTM, 2001). A humidity cell is a weathering chamber designed to provide simple control over air, temperature and moisture, while allowing for the removal of weathering products (principally oxidation products) in solution. Country rock and PK HCTs initiated in 2004 consist of a 1-kg sample (dry equivalent) of sample which was pre-leached (Cycle 0) with 1 L of de-ionized water, after which weekly leaching cycles were initiated. The weekly cycles include a 3-day period where dry air is circulated in the cell followed by a 3-day period where humid air is circulated in the cell and a final leach day when the cell is flooded with 1 L of distilled water (1:1 liquid to solid ratio by weight). After 1 hour of retention, the leach water is drained from the bottom of the cell, filtered (0.45 µm filter) and collected for analysis. The same testing methodology was applied to the PK HCTs initiated in 2010, only the sample charge was limited to 0.5 kg owing to sample availability.

Humidity cell leachate compositions were used in conjunction with ABA data to calculate sulphide and neutralization potential (NP) depletion. Depletion calculations, based on the relative rate of production of sulphate and alkalinity, are a useful method of predicting the time to onset of acid generation. Sulphide and NP depletion calculations were conducted to evaluate the rate of depletion of acid producing (i.e., sulphide) and acid neutralizing (i.e., carbonate) minerals in the tailings. Empirical rates of NP depletion were calculated according to the recommendations in Price (1997), which assume that the NP depletion is equivalent to the rate of sulphate production (i.e. acid production) and the rate of alkalinity production / acidity consumption. If acid producing minerals are depleted from the tailings prior to soluble, neutralizing minerals, it is unlikely that acid generating conditions will be realized. However, if the rate of dissolution of carbonate minerals exceeds the rate of oxidation of sulphide minerals, acid generation could occur.

Humidity Cell Testing of Pre-Leached Samples

Four samples of granite were submitted for “pre-leached” HCT to evaluate the long-term geochemical characteristics of granite after the complete reaction of NP (HC-28, HC-29, HC-30, HC-31). Samples were “pre-leached” using hydrogen chloride. The effectiveness of removing NP using hydrogen chloride was confirmed by ABA. Samples were pre-treated with a 6 normal hydrochloric acid solution, which removed both the carbonate NP and bulk NP, leaving the AP in the sample intact. After the pre-leaching of the samples, HCT was carried out according to the method outlined in the previous section.

Column Testing

Ten columns were set up in January 2005 at Vizon SciTech (Vancouver, BC, Canada), with the week 0 flush commencing on 31 January 2005, and leachates were analyzed for metals and pH.

Submerged Column Tests

Supplemental testing of PK was initiated in May 2010 to address the possible influence of submerging PK in post-closure mine waste facilities. Composite samples of fine PK and coarse PK, respectively, were used as charges for the column tests. Sample charges with a weight of 3 kg were placed in a PVC column, which was inundated with an initial volume of distilled water (de-oxygenated by bubbling with nitrogen gas) of approximately 2.5 L. The water columns are kept under a nitrogen gas head to limit exposure to the atmosphere.

Each week, samples of water are collected from the base ("bottom") of the column and the water overlying the top of the column ("top"). Additional distilled water is added to the top of the column to replace the volume of water collected each week.

ATTACHMENT 8.II.3

MINERALOGICAL ANALYSIS

CHARACTERIZATION OF RAW AND HUMIDITY CELL SAMPLES

PETROGRAPHY AND RIETVELD XRD ANALYSES

GAHCHO KUE PROJECT

(AMEC DEBEERS 2-21-914)

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Background

19 samples from the Gahcho Kue Diamond Project are characterized in this report. They were received October 5, 2005 from Sierra Raines of AMEC Corp.

The purpose of the study was to characterize the mineralogy with particular emphasis on the carbonates and sulfur-bearing minerals present.

Characterization consists of descriptions based on optical microscopy (19 samples) and on XRD Rietveld analysis (16 samples). Alexandra Mauler and Anne Thompson analyzed the sections using an optical microscope in the PetraScience office, Vancouver. XRD analysis was carried out by Elisabetta Pani and Mati Raudsepp at the University of British Columbia.

Sample descriptions with representative photomicrographs follow this summary. All percentages in the descriptions are approximate. The summary of the Rietveld analysis is included below and with the plots at the end of this report. Due to the large amount of clay material present in the samples, the Rietveld analysis should only be viewed as semi-quantitative.

Sample Characterization

Gangue minerals

Most samples are dominated by kimberlitic material, typically pervasively altered to a very fine-grained assemblage of clay ± chlorite ± talc ± biotite, only identified by Rietveld XRD. Olivine is preserved in some samples, typically partly to totally pseudomorphosed by serpentine, itself variously replaced by the clay ± chlorite ± talc ± biotite assemblage. Quartz, amphibole and K-feldspar commonly occur in small amounts.

Samples 04-ARD 139-004 and 04-ARD 199-002 are made of granitic fragments, dominated by K-feldspar, quartz and biotite. Sample 04-ARD 191-06/07/08/09 consists of altered ?doleritic fragments consisting mostly of clay, plagioclase, olivine and clinopyroxene.

Carbonate amount is low, typically below 3% and consists of calcite and dolomite (identified by Rietveld XRD).

The presence of disordered clay minerals, serpentine and chlorite yields to broad Rietveld XRD peaks and contributes to the poor fit of the refined plots. Therefore the results must be considered as **semi-quantitative,** also explaining why no sulfides were recognized.

Sulfides/Oxides

Sulfides are extremely rare in the samples (less than 2%) and mostly consist of pyrite with lesser chalcopyrite and trace ?pyrrhotite.

Very fine grains of Ti-oxides and Fe-oxides including rutile, perovskite, ilmenite, magnetite and hematite also locally occur in most samples.