



Appendix J

Environmental geochemistry assessment





COWAL GOLD OPERATIONS UNDERGROUND DEVELOPMENT ENVIRONMENTAL GEOCHEMISTRY ASSESSMENT

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Executive Summary

Evolution Mining Limited is seeking approval to develop an underground mining operation adjacent to the Cowal Gold Operations (CGO) and GEM was commissioned to conduct a geochemical assessment, as a requirement of the development approval. This assessment was undertaken for the development's EIS and addresses the requirements set out in the SEARs and submissions provided by the respective regulatory agencies.

Previous geochemical investigations undertaken for the CGO have identified that:

- the waste rock, low-grade ore and tailings have high concentrations of arsenic and reactive sulfides, but due to their high acid buffering potential, these materials are non-acid forming (NAF).
- The un-oxidised waste rock and tailings have low salinity and sodicity. However, when oxidised, these materials are expected to be highly saline and sodic.

For this assessment 34 development waste rock samples collected from the mine access area, 18 mine rock samples representing the underground workings, 21 ore and low grade ore samples were characterised to assess the risk of these materials developing saline or sodic conditions, or producing acid and metalliferous drainage.

Development Waste Rock

The development waste rock is expected to have similar geochemical characteristics to the waste rock from the previous, open-pit investigations and, based on these findings, the following recommendations are provided:

- Due to the expected NAF nature, no special management would be required for AMD control.
- Due to the salinity and sodicity risks, excessive release of sulfate salts and the development of sodic conditions, leading to increased sediment dispersion and surface erosion, may occur if these materials are left exposed to surficial weathering processes.

Mine Rock and Underground Workings

The mine rock is expected to have similar geochemical characteristics to that of the un-oxidised waste rock from the previous, open-pit operations and, based on these findings, the following recommendations are provided:

- Due to the expected NAF nature, no special management would be required for AMD control within the underground workings.
- Although increased salinity may occur during mine dewatering, due to the high salinity of the groundwater system, any increase in the salinity from these materials would be negligible.

Ore and Low Grade Ore Stockpiles

The majority of the ore and low grade ore is expected to be NAF, however, a small amount of PAF and PAF-LC material was identified within the ore material. Based on these findings and the expectation that the ore would only be stockpiled on the surface

for relatively short periods, the following recommendations are provided:

- No special management practices for AMD control would be required for the stockpiled low grade ore. However, an increase in the salinity of the stockpile runoff may occur if it is left exposed for extended periods.
- If any PAF or PAF-LC material is exposed on the surface of the ore stockpiles, low pH conditions may develop leading to an increase in salinity and metal release within the stockpile runoff. Due to this, it is recommended that further geochemical characterisation of the ore be undertaken to better understand the quantity and distribution of PAF material within the orebody.

Tailings

Due to the risk that a small amount of the ore will be PAF or PAF-LC, there is an increased risk that some of the tailings will be PAF or PAF-LC. Based on this, it is recommended that:

- A detailed geochemical characterisation program is conducted on any pilot plant tailings if and when available, and a routine characterisation program is undertaken when the process discharge tailings are available in order to monitor the occurrence of PAF tailings and to provide information required for closure planning.
- As previously recommended, the TSF will need to be capped as soon as practical in order to reduce the risk of developing saline (salt-pan) conditions.

Water Quality Monitoring

The parameters for the current site water quality program include pH, EC, turbidity, dissolved oxygen, temperature, biological oxygen demand, faecal indicators, total hardness, total suspended solids, Ca, Mg, K, Na, Cl, SO₄, Ag, As, Cd, Mo, Pb, Sb, Se and Zn. Based on the findings of this assessment, including the acid forming and the metal enrichment and solubility characteristics, it is recommended that the alkalinity is included in this suite in order to provide an indication of the ongoing processes acid generation and neutralisation with the potential of developing low pH or acid conditions. It is also recommended that the mine water from the proposed underground workings is included in the water quality program.

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1.0 Introduction

Evolution Mining Limited (Evolution), owner and operator of Cowal Gold Operations (CGO), located north-east of West Wyalong in New South Wales (Figure 1), is seeking approval to develop an underground (UG) mining operation adjacent to the existing CGO open pit. EMM Consulting Pty Limited (EMM) has been commissioned by CGO to prepare an Environmental Impact Statement (EIS) as part of the approval process for this development. As a requirement of the EIS, Geo-Environmental Management Pty Ltd (GEM) has conducted a geochemistry assessment of the proposed UG development in accordance with the requirements set out in the Secretary's Environmental Assessment Requirements (SEARs) and addressing the relevant submissions made by the Environmental Protection Authority (EPA) and Division of Resources & Geoscience (DRG).

This report provides the results and findings of the detailed geochemical assessment of the proposed UG development and incorporates the results and findings from previous geochemical investigations in order to identify any potential environmental impacts as a consequence of the proposed development. Based on these findings the report provides recommendations for managing the ore and low-grade ore stockpiles, placement of the development waste rock and tailings, and the underground activities.

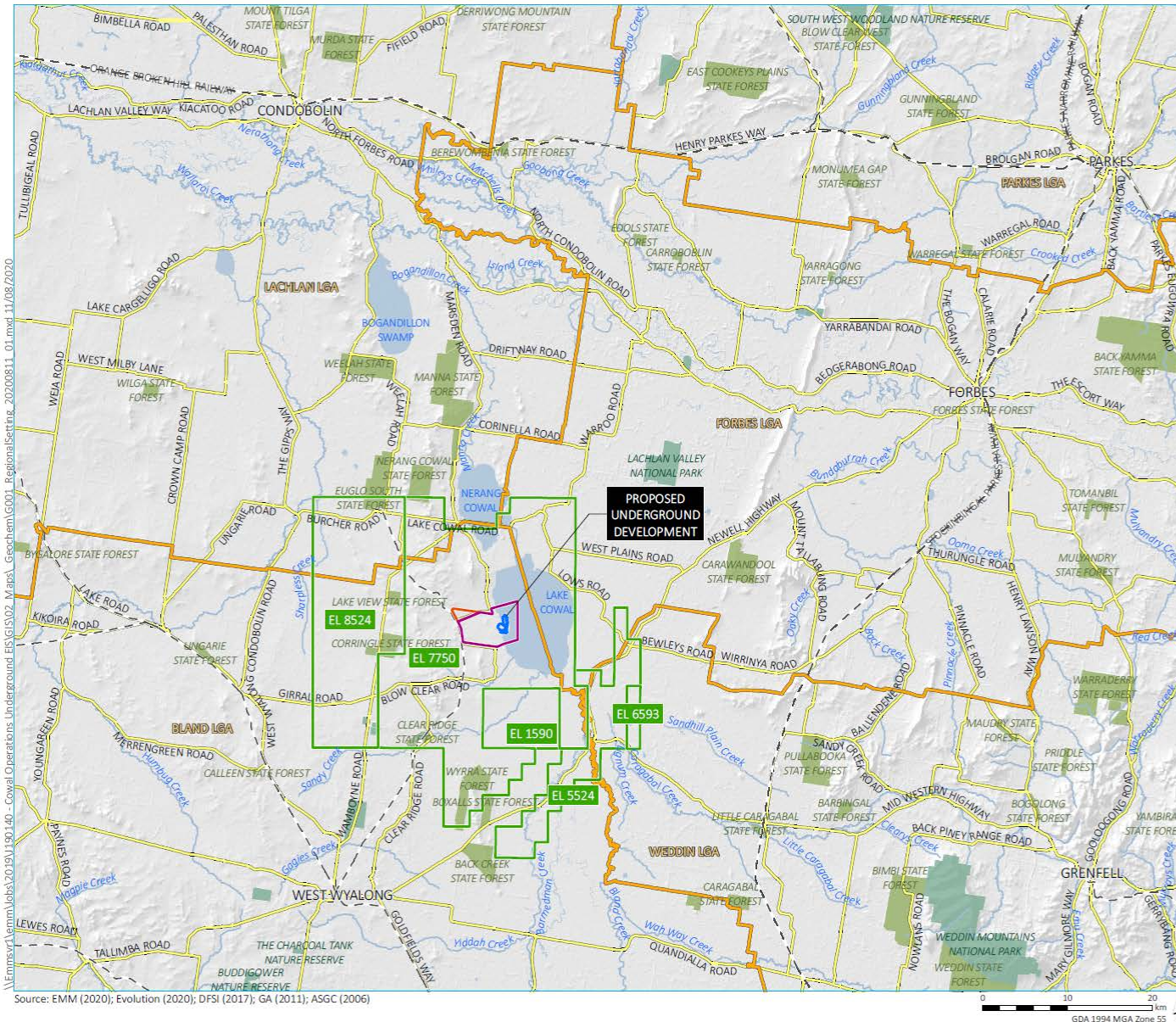
1.1 Background

Evolution recently obtained approval for the development of an exploration decline in order to further explore the UG resource immediately adjacent to the existing open pit. The mine design for the proposed UG mining operation is in progress pending findings from the ongoing resource drilling program and the proposed mine layout is provided in Figure 2. From the information available to-date, the ore will be extracted using conventional stope methods and the available facilities will be used to process the ore. The run-of-mine (ROM) ore will be stockpiled adjacent to the process plant prior to processing, and it is expected that the mineralised waste (low-grade ore) will be stockpiled on-site, that the tailings generated will be pumped to the existing tailings storage facilities, and that any waste rock excavated will be placed within the existing waste rock emplacements.

The key components of the UG EIS in relation to the proposed geochemistry assessment program include:

- Development of an UG mining operation beneath Lake Cowal via underground stope mining methods.
- A 1 m increase in the final rehabilitated height of the Integrated Waste Landform (IWL).
- Extension of the life of mine to 2040.

COWAL GOLD OPERATIONS UNDERGROUND DEVELOPMENT
Environmental Geochemistry Assessment



- KEY**
- Proposed underground development
 - Mining lease (ML1535)
 - Mining lease (ML1791)
 - Exploration licence (EL)
 - Rail line
 - Main road
 - Named watercourse
 - Waterbody
 - Local government area
 - NPWS reserve
 - State forest

Regional setting

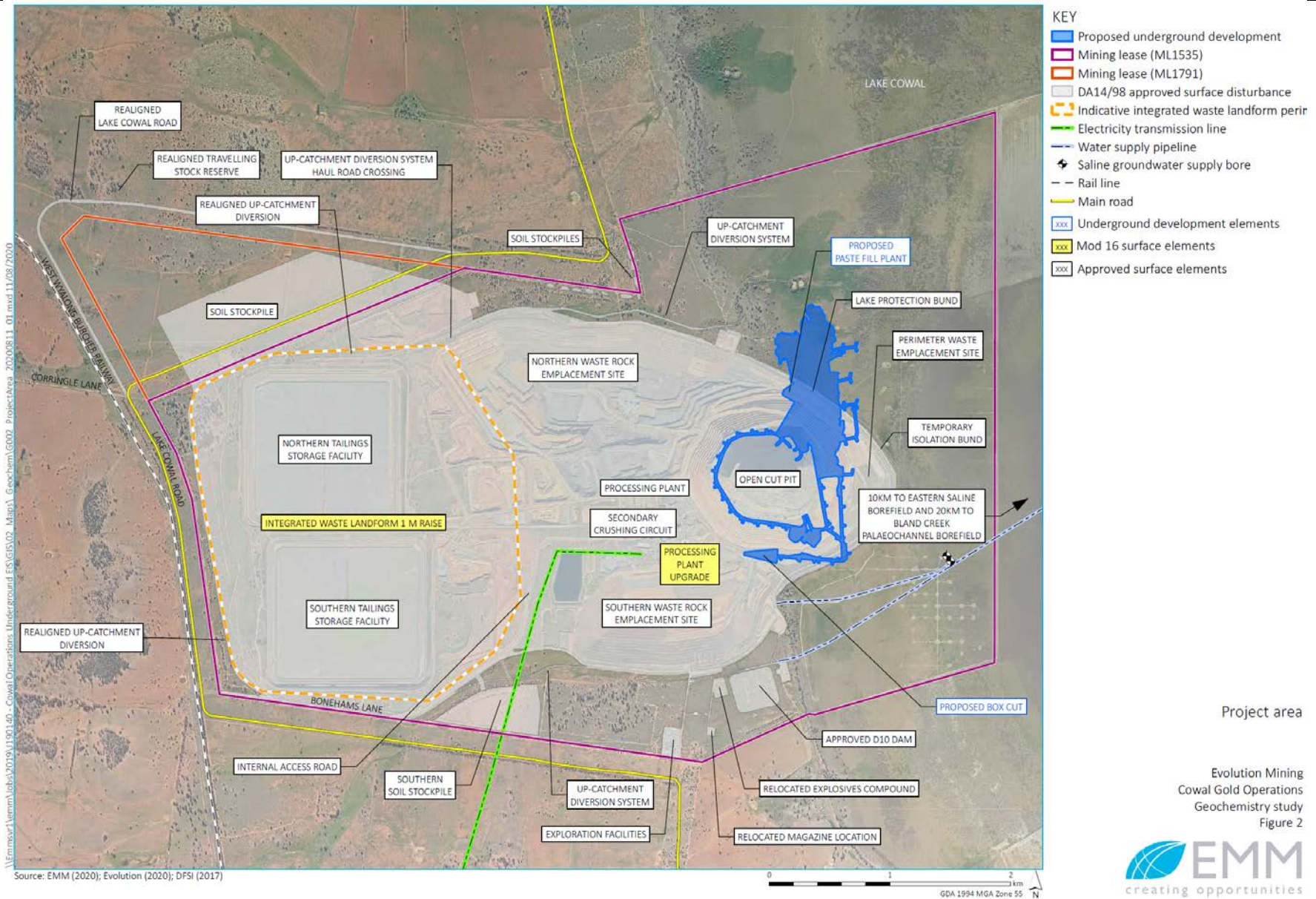
Evolution Mining
 Cowal Gold Operations
 Geochemistry study
 Figure 1



Source: EMM (2020); Evolution (2020); DFSI (2017); GA (2011); ASGC (2006)

COWAL GOLD OPERATIONS UNDERGROUND DEVELOPMENT

Environmental Geochemistry Assessment



Project area

Evolution Mining
Cowal Gold Operations
Geochemistry study
Figure 2



1.2 Study Objectives

The objectives of this study include, but are not limited to, the following components:

1. Review the available information and previous geochemical investigations for the E42, Gateway/Regal and E46 Deposits, in order to identify any additional information that may aid the UG geochemical assessment program. Review the SEARs, and the EPA and DRG submissions to guide the development of the assessment program.
2. Review the logs for the drill-holes intersecting the proposed UG mine workings and select the drill-hole intervals to be sampled in order to provide representative samples of the main lithological and geochemical rock types present within the ore, low-grade ore and waste rock that will be excavated and within the mine workings (mine rock).
3. Provide Evolution with clear instructions to enable site personnel to collect, bag and dispatch the selected samples for analysis.
4. Design the required testing program to assess the acid forming potential, salinity, sodicity, and element enrichment and solubility of the materials sampled, and coordinate the sample preparation and testing programs.
5. Receive and tabulate the test results and evaluate the results in conjunction with any existing geochemical data.
6. Prepare a report on the geochemistry assessment which describes the sampling and testing program in detail and provides the results and findings of this assessment and any related assessment programs that may be available. Using this information, the report will provide an evaluation of the salinity, sodicity, and acid and metalliferous drainage (AMD) risks for the ore, low-grade ore, mine rock and excavated waste rock; identify any implications for management of these materials; and provide recommendations for the geochemical security of the waste rock emplacement, ore and low-grade ore stockpiles, tailings storage facility and UG operations.

2.0 Previous Geochemical Investigations

Initial geochemical investigations were conducted by Environmental Geochemistry International Pty Ltd (EGi) prior to commencing mining operations at the approved CGO. These investigations were commissioned by North Limited and reported in the Cowal Gold Project Environmental Impact Statement (EIS) (North Limited, 1998). Subsequent geochemical investigations were commissioned by Barrick (Cowal) Limited (Barrick) to confirm the initial findings and expand the waste rock and tailings geochemical databases for mining operations, environmental management and closure planning (EGi, 2004). Since these investigations a number of targeted geochemical investigations were conducted by GEM to address specific planning and approvals requirements for Barrick. These investigations included the E42 Modification (GEM, 2008), the Augmentation Project (GEM, 2011a), the Extension Project Pre-Feasibility Study (GEM, 2011b), and the Extension Modification Project (GEM, 2013). Subsequently, GEM conducted a geochemical investigation for Evolution to assist with the Mine Life Modification approval (GEM, 2016).

Table 1 provides an historical summary of the geochemical investigations carried out for CGO to-date. Following is a review of the geochemical characteristics of the waste rock, ore, low grade ore and tailings, and the implications for environmental management and closure planning at CGO.

2.1 Salinity and Sodicity

The initial geochemical investigations (EGi, 1997) indicated that the primary (fresh) waste rock and tailings were expected to only have low salinity. However, due to the presence of reactive sulfides, the salinity of these materials was expected to increase with weathering. It was also reported that the oxide waste rock and tailings were expected to be moderately to highly saline and highly sodic. Subsequent investigations conducted by EGi and GEM (EGi, 2004; GEM, 2011a; GEM, 2011b; GEM, 2013; GEM, 2016) confirmed that the waste rock, ore, low grade ore and tailing were expected to have low salinity and to be non-sodic, and that the oxide materials (i.e. saprock, saprolite, alluvium and transported material) were expected to have a moderate to high salinity and high sodicity.

Table 1: Geochemical investigations conducted for CGO to-date

Geochemical Investigations	Samples Analysed	Test Work Conducted
Environmental Geochemical Assessment of Process Tailings, Mine Rock and Surface Zone Materials (EGi, 1995)	87 Mine Rock, Ore and Surface Materials	Salinity, ABA, NAG, Multi-Elements
	2 Tailings	Salinity, ABA, NAG, Multi-Elements, Leach Columns, CN Atten.
Environmental Geochemical Assessment of Simulated Tailings (EGi, 1996)	1 Oxide Tailings	ABA, NAG, Multi-Elements, CN Speciation and Decay
Environmental Geochemistry Assessment of Proposed Mining Activities (EGi, 1997) - Appendix C in the Cowal Gold Project EIS (North Limited, 1998)	4 Tailings	ABA, NAG, Multi-Elements, CN Decay, Leach Columns
	2 TSF Sub-Soils	ABA, Soil Chemistry, Attenuation Characteristics
	3 Construction Materials	ABA, Soil Chemistry
	2 Waste Rock Composites	Salinity, ABA, Sequential Batch Extraction
Final Void Water Chemistry (EGi, 1998)	1 Groundwater	Pit Water Chemistry Modelling
Geochemical Assessment of Waste Rock and Process Tailings (EGi, 2004)	100 Mine Rock and Ore	Salinity, ABA, NAG, Multi-Elements
	8 Tailings	ABA, NAG, Multi-Elements
Cowal Gold Mine E42 Modification, Tailings and Waste Rock Geochemical Assessment (GEM, 2008)	-	Review of existing data
Review of Cowal Gold Mine Cyanide Destruction (CSIRO Minerals, 2010)	5 Tailings	CN Speciation and Decay
Cowal Gold Mine Augmentation Project, Environmental Geochemistry Assessment of Waste Rock and Tailings (GEM, 2011a)	30 Mine Rock and Ore	Salinity, ABA, NAG, Multi-Elements
	5 Tailings (ex-mill)	Salinity, ABA, NAG, ABCC, Multi-Elements
	5 Tailings (discharge & deposited)	Salinity, ABA, NAG, Multi-Elements
	2 Tailings Decant	pH, Salinity, Multi-Element Composition
Cowal Gold Mine Extension Project Pre-Feasibility, Environmental Geochemistry Assessment of Waste Rock, Low Grade Ore and Tailings (GEM, 2011b)	135 Waste Rock	Salinity, ABA, NAG, ABCC, Multi-Elements
	16 Low Grade Ore	Salinity, ABA, NAG, ABCC, Multi-Elements
	30 Ore	Salinity, ABA, NAG, Multi-Elements
Cowal Gold Mine Extension Modification, Environmental Geochemistry Assessment of Waste Rock and Tailings (GEM, 2013)	54 Waste Rock	Salinity, ABA, NAG, Multi-Elements
	11 Low Grade Ore	Salinity, ABA, NAG, Multi-Elements
	5 Ore	ABA, NAG, Multi-Elements
Cowal Gold Operations Mine Life Modification, Environmental Geochemistry Assessment of Waste Rock and Tailings (GEM, 2016)	10 Waste Rock	Salinity, ABA, NAG, Multi-Elements
	8 Ore	Salinity, ABA, NAG, Multi-Elements

ABA = Acid-Base Account, NAG = Net Acid Generation, ABCC = Acid Buffering Characteristic Curve

2.2 Acid Forming Characteristics

The initial geochemical investigations carried out for the EIS (EGi, 1995; EGi, 1996; EGi, 1997) indicated that the primary (fresh) waste rock and tailings were expected to contain reactive sulfides, but due to a high acid neutralising capacity (ANC), these materials were expected to be non acid forming (NAF). It was also reported that the oxide waste rock and tailings were expected to be NAF due to the relatively low reactive sulfide content. The later investigations conducted by EGi and GEM (EGi, 2004; GEM, 2011a; GEM, 2011b; GEM, 2013; GEM, 2016) confirmed that the waste rock, ore, low grade ore and tailings all contained reactive sulfides, but due to their high ANC, these materials were expected to be NAF. The oxide materials which were also confirmed to be NAF, were expected to have lower reactivity, due to the relatively low reactive sulfide and ANC.

2.3 Metal Enrichment and Solubility

Elemental analyses carried out for the EIS on selected waste rock, ore, low grade ore and tailings samples (EGi, 1995; EGi, 1996; EGi, 1997) and subsequent analyses (EGi, 2004; GEM, 2011a; GEM, 2011b; GEM, 2013; GEM, 2016) indicated that the majority of the waste rock and low grade ore was expected to have high concentrations of arsenic (As) and that some of these materials were also expected to have high concentrations of silver (Ag), cadmium (Cd), lead (Pb), selenium (Se), antimony (Sb) and zinc (Zn). These investigations also predicted high concentrations of As, Cd, Pb, molybdenum (Mo), Sb and Zn in the oxide and primary tailings.

Early investigations included the potential release of environmentally significant elements from waste rock and tailings (EGi, 1995 and 1997). Sequential batch water extractions indicated that leaching of environmentally important elements from waste rock at the CGO was unlikely to be of concern provided near neutral pH values were maintained, and column leach tests carried out on the tailings identified an initial flush of soluble copper (Cu) and Zn from the primary tailings could be expected. However, it was concluded that this release was most likely associated with the residual CN in the tailings liquor from the CIL processing procedure and did not represent a long-term concern for water quality.

3.0 Geochemical Assessment Program

The geochemical assessment program for these investigations was designed to identify the presence and distribution of any acid generating materials within the waste rock (mine access), mine rock, and the ore and low-grade ore from the proposed UG development, and to assess the salinity, and metal enrichment and solubility risks associated with the proposed underground mining project. Additional to this, an assessment of the sodicity of the waste rock was undertaken. At the time of this assessment no tailings samples were available for the proposed UG development and the characteristics of the ore samples were used to determine the expected characteristics of the tailings that would be produced.

3.1 Testing Methodology

The analytical program for this assessment included the following standard static geochemical tests and procedures:

- pH and electrical conductivity (EC) determination (all samples);
- total sulfur (S) assay (all samples);
- sulfide S analysis (selected samples);
- ANC determination (all samples);
- single addition net acid generation (NAG) test (all samples);
- extended boil NAG test (selected samples);
- acid buffering characteristic curve (ABCC) determination (selected samples);
- exchangeable cation analysis (selected samples); and
- multi-element scans on solids and water extracts (selected samples).

The analytical laboratories used for these analyses included:

- Indicium Labs Pty Ltd
- Australian Laboratory Services Pty Ltd (Brisbane Laboratory)
- Environmental Geochemistry International Pty Ltd,
- Genalysis Laboratories Pty Ltd.

Following is an overview of the tests and procedures used for this assessment is presented below.

3.1.1 pH, Salinity and Sodicity Determination

pH and Electrical Conductivity Determination

The pH and EC of a sample is determined by equilibrating a solid sample in deionised water for a minimum of two hours. Variations to this test include mixing the solids with water at a ratio of 1:2 or 1:5 by weight (w/w), or as a saturated paste. Typically,

a ratio of 1:2 is used for providing an indication of the inherent acidity and salinity of a material when it is initially exposed. The salinity rankings based on EC values from 1:5 extracts ($EC_{1:5}$), 1:2 extracts ($EC_{1:2}$) and saturation extracts (EC_{sat}) are provided below in Table 2.

Table 2: Electrical conductivity and corresponding salinity rankings for solid samples equilibrated in deionised water.

EC_{1:5} (dS/m)	EC_{1:2} (dS/m)	EC_{sat} (dS/m)	Salinity
< 0.2	< 0.5	< 2.0	Non-Saline
0.2 to 0.3	0.5 to 1.5	2 to 4.0	Slightly Saline
0.3 to 0.4	1.5 to 2.5	4 to 8.0	Moderately Saline
> 0.4	> 2.5	> 8.0	Highly Saline

Source: Rhoades *et al.* (1999)

Exchangeable Cation Analysis

Exchangeable cation analyses are carried out to determine the sodicity of a sample. Sodicity occurs in materials that have high concentrations of exchangeable Sodium (Na) relative to the other major cations Calcium (Ca) and Magnesium (Mg), causing the material to be highly dispersive. The Exchangeable Sodium Percent (ESP) is used to determine the sodicity of a sample by comparing the amount of exchangeable Na to Ca and Mg concentrations. The ESP is used to rank materials according to sodicity and likely dispersion characteristics (Table 3).

Table 3: ESP ranking criteria, and the respective sodicity and dispersion characteristics.

ESP	Sodicity	Dispersion
< 6	Non-Sodic	Not Dispersive
6 to 15	Slightly Sodic	Slightly Dispersive
15 to 30	Moderately Sodic	Moderately Dispersive
> 30	Highly Sodic	Highly Dispersive

3.1.2 Acid Forming Characteristic Evaluation

A number of test procedures are used to assess the acid forming characteristics of mine waste materials. The most widely used assessment methods are the ABA and the NAG test. These methods are referred to as static procedures because each involves a single measurement in time.

Acid-Base Account

The ABA involves laboratory procedures that evaluate the balance between acid generation processes (oxidation of sulfide minerals) and acid neutralising processes

(dissolution of alkaline carbonates, displacement of exchangeable bases, and weathering of silicates). The values arising from the ABA are referred to as the maximum potential acidity (MPA) and the ANC, respectively. The difference between the MPA and ANC value is referred to as the NAPP.

The MPA is calculated using the total sulfur content of the sample. This calculation assumes that all of the sulfur measured in the sample occurs as pyrite (FeS₂) and that the pyrite reacts under oxidising conditions to generate acid according to the following reaction:



According to this reaction, the MPA of a sample containing 1 %S as pyrite would be 30.6 kilograms of H₂SO₄ per tonne of material (i.e. kg H₂SO₄/t). Hence the MPA of a sample is calculated from the total sulfur content using the following formula:

$$\text{MPA (kg H}_2\text{SO}_4\text{/t)} = (\text{Total \%S}) \times 30.6$$

The use of the total sulfur assay to estimate the MPA is a conservative approach because some sulfur may occur in forms other than pyrite. Sulfate sulfur and native sulfur, for example, are non-acid generating sulfur forms. Also, some sulfur may occur as other metal sulfides (e.g. covellite, chalcocite, sphalerite and galena) that yield less acidity than pyrite when oxidised.

The acid formed from pyrite oxidation would to some extent react with acid neutralising minerals contained within the sample. This inherent acid neutralisation is quantified in terms of the ANC and is determined using the Modified Sobek method. This method involves the addition of a known amount of standardised hydrochloric acid (HCl) to an accurately weighed sample, allowing the sample time to react (with heating), then back titrating the mixture with standardised sodium hydroxide to determine the amount of unreacted HCl. The amount of acid consumed by reaction with the sample is then calculated giving the ANC expressed in the same units as the MPA, which is kg H₂SO₄/t.

Determination of the ANC using the Modified Sobek provides an indication of the total neutralisation capacity of a material. However, in some materials not all mineral phases would be readily available to neutralise sulfide generated acidity. For these material types ABCCs can be used to determine the amount of ANC that is available to neutralise any sulfide generated acidity under more natural weathering conditions. The ABCCs are obtained by slow titration of a sample with acid while continuously monitoring pH and plotting the amount of acid added against pH. Careful evaluation of the plot provides an indication of the portion of ANC within a sample that is readily available for acid neutralisation.

The NAPP is a theoretical calculation commonly used to indicate if a material has the potential to produce acid. It represents the balance between the capacity of a sample to generate acid (MPA) and its capacity to neutralise acid (ANC). The NAPP is also expressed in units of kg H₂SO₄/t and is calculated as follows:

$$\text{NAPP} = \text{MPA} - \text{ANC}$$

If the MPA is less than the ANC then the NAPP is negative, which indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, if the MPA exceeds the ANC then the NAPP is positive, which indicates that the material may be acid generating.

The ANC/MPA ratio is used as a means of assessing the risk of acid generation from mine waste materials. A positive NAPP is equivalent to an ANC/MPA ratio less than 1, and a negative NAPP is equivalent to an ANC/MPA ratio greater than 1. Generally, an ANC/MPA ratio of 3 or more signifies that there is a high probability that the material is not acid generating.

Figure 3 is an ABA plot which is commonly used to provide a graphical representation of the distribution of sulfur and ANC in a sample set. The plotted line shows where the NAPP = 0 (i.e. ANC = MPA or ANC/MPA=1). Samples that plot to the lower-right of this line have a positive NAPP and samples that plot to the upper left of it have a negative NAPP. Figure 3 also shows the plotted lines corresponding to ANC/MPA ratios of 2 and 3.

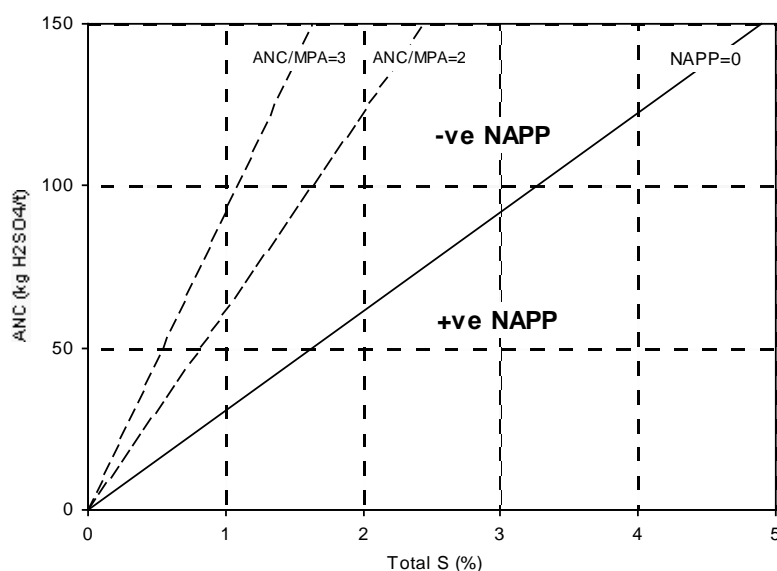


Figure 3: Acid-base account plot

Net Acid Generation Test

The single addition NAG test is used in association with the NAPP to classify the acid generating potential of a sample. The standard (single addition) NAG test involves reaction of a sample with hydrogen peroxide to oxidise any sulfide minerals contained within a sample. During the NAG test, acid generation and neutralisation reactions occur simultaneously and the end result represents a direct measurement of the net amount of acid generated by the oxidised sample. The pH of the NAG solution on completion of the oxidation reaction is referred to as the NAGpH. A NAGpH < 4.5 indicates that acid conditions remain after all acid generating and acid neutralising reactions have taken place and a NAGpH > 4.5 indicates that any generated acidity has been neutralised. An indication of the capacity of the sample to generate acid is provided by titrating the NAG solution to the pH end-points of 4.5 and 7.0. This value is commonly referred to as the NAG capacity and is expressed in the same units as the NAPP (i.e. kg H₂SO₄/t). The titration value at pH 4.5 includes the acidity produced due to free acid (i.e. H₂SO₄) as well as soluble iron and aluminium. The titration value at pH 7 also includes metallic ions that precipitate as hydroxides.

The kinetic NAG test uses the same procedure as the single addition NAG test except that the temperature and pH of the solution are recorded. Variations in these parameters during the test provide an indication of the kinetics of sulfide oxidation and acid generation during the test. This, in turn, can provide an insight into the behaviour of the material under field conditions. For example, the pH trend gives an estimate of relative reactivity and may be related to prediction of lag times and oxidation rates similar to those measured in leach columns. Also, sulfidic samples commonly produce a temperature excursion during the NAG test due to the decomposition of the peroxide solution, catalysed by sulfide surfaces and/or oxidation products.

When subjected to the NAG test, samples containing carbonaceous material may generate organic acids potentially producing misleading low NAGpH values and acidities. To overcome this effect an extended boil NAG test has been developed by Environmental Geochemistry International Pty Ltd (EGi), where the organic acids are fully decomposed with boiling in order to ensure that the measured NAGpH and acidity of the NAG solution are due solely to sulfide oxidation.

3.1.3 Multi-Element Analysis

Multi-element scans are primarily carried out on solid samples to identify any elements that are present at concentrations that may be of environmental concern with respect to water quality and revegetation. The assay results from the solid samples are compared to the average crustal abundance for each element to provide a measure of the extent of element enrichment. The extent of enrichment is reported as the Geochemical Abundance Index. However, identified element enrichment does not necessarily mean that an element would be a concern for revegetation, water quality,

or public health and this technique is used to identify any significant element enrichments that warrant further examination.

Multi-element scans are also performed on liquor samples to determine the chemical composition of the solution and identify any elemental concerns for water quality.

3.2 Geochemical Classification

The acid forming potential of a sample is classified on the basis of the ABA and NAG test results into one of the following categories:

- Barren;
- Non-Acid Forming (NAF);
- Potentially Acid Forming (PAF);
- Acid Forming (AF); and
- Uncertain (UC).

Barren

A sample classified as barren essentially has no acid generating capacity and no acid buffering capacity. This category is most likely to apply to highly weathered materials. In essence, it represents an 'inert' material with respect to acid generation. The criteria used to classify a sample as barren may vary between sites, but it generally applies to materials with a total S content $\leq 0.1\%S$ and an ANC $\leq 10 \text{ kg H}_2\text{SO}_4/\text{t}$.

Non-Acid Forming

A sample classified as NAF may or may not have a significant S content but the availability of ANC within the sample is more than adequate to neutralise all the acid that theoretically could be produced by any contained sulfide minerals. As such, material classified as NAF is considered unlikely to be a source of acidic drainage. A sample is usually defined as NAF when it has a negative NAPP and a final NAGpH ≥ 4.5 .

Potentially Acid Forming

A sample classified as PAF always has a significant S content, the acid generating potential of which exceeds the inherent acid neutralising capacity of the material. This means there is a high risk that such a material, even if pH circum-neutral when freshly mined or processed, could oxidise and generate acidic drainage if exposed to atmospheric conditions. A sample is usually defined as PAF when it has a positive NAPP and a final NAGpH < 4.5 . Typically, if a PAF sample has a NAPP and or NAG capacity, when titrated to pH 4.5, of $\leq 5 \text{ kg H}_2\text{SO}_4/\text{t}$, it is considered to only have a low capacity to generate acid and is classified as PAF-LC.

Acid Forming

A sample classified as AF has the same characteristics as the PAF samples however these samples also have an existing pH of less than 4.5. This indicates that acid conditions have already been developed, confirming the acid forming nature of the sample.

Uncertain

An uncertain classification is used when there is an apparent conflict between the NAPP and NAG results (i.e. when the NAPP is positive and NAGpH > 4.5, or when the NAPP is negative and NAGpH ≤ 4.5).

Figure 4 shows a typical geochemical classification plot for mine waste materials where the NAPP values are plotted against the NAGpH values. Samples that plot in the upper left quadrante, with negative NAPP values and NAGpH values greater than 4.5, are classified as NAF. Those that plot on the lower right quadrante, with positive NAPP values and NAGpH values of 4.5 or less, are classified as PAF. Samples that plot in the upper right or lower left quadrantes of this plot have an uncertain geochemical classification (UC) due to a contradiction in the acid-base and NAG test results, and further testing is required to determine the geochemical classification of these material types.

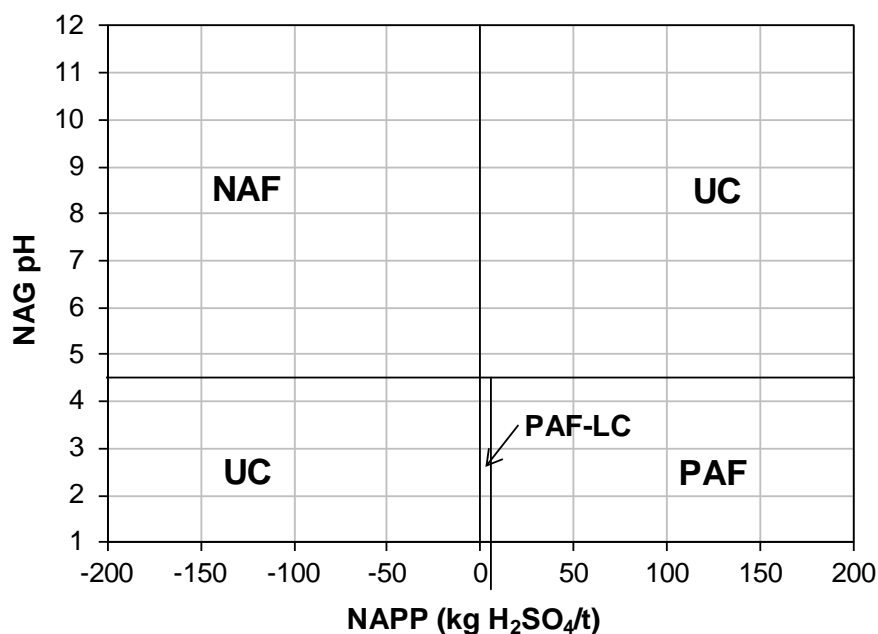


Figure 4: Geochemical classification plot.

3.3 Sample Selection and Preparation

A total of 73 drill-core samples, including 34 samples representing the mine development waste rock (mine access), 18 samples representing the underground mine rock, 12 samples representing the ore and 9 samples representing the low grade ore, were provided by Evolution personnel under instruction from GEM. The details for these samples are provided in Attachment A, including Tables A1 and A2 providing the selected drill-holes and intervals sampled, and the sample lithology and lithology codes for the waste rock (Table A1), and the mine rock, ore and low-grade ore (Table A2), and Figure A1 providing the drill hole locations. The sample intervals were selected in order to provide representative samples of the major lithologies that will be excavated during UG development (waste rock) and that will be encountered during UG mining, including the mine rock (non-ore), ore and low grade ore.

Depending on the selected interval thickness, the sample weights typically ranged from 1 to 5 kilograms (kg). Each sample was crushed to <4 millimetres (mm) and a 500 gram (g) sub-sample pulverised to minus 75 micrometres (μm) for analysis.

4.0 Waste and Mine Rock Geochemistry

The geochemical test results for the mine development waste rock and mine rock samples are provided in Attachment B, for the pH, EC and acid forming characteristics, and in Attachment C, for the multi-element scans. A summary of the pH, EC and acid forming characteristics is provided in Table 4. The majority of the waste rock samples were collected from below the oxidised zone and are therefore classified as fresh, however two samples were collected from the oxidised zone and these samples, representing the Saprock Diorite, are classified as oxide.

Table 4: Summary of the pH and EC, and acid forming characteristics for the waste rock and mine rock samples.

Material Type	pH _{1:2}	EC _{1:2} (dS/m)	Total S (%S)	MPA	ANC	NAPP	NAGpH	
				(kg H ₂ SO ₄ /t)				
Waste Rock (Saprock) (2 samples)	min.	7.2	1.285	0.02	1	1	-4	5.6
	max.	7.4	1.884	0.03	1	4	0	8.7
	aver.	7.3	1.585	0.03	1	3	-2	7.2
Waste Rock (32 samples)	min.	7.5	0.110	0.01	0	30	-180	8.3
	max.	9.3	0.478	1.06	32	187	-30	10.0
	aver.	7.9	0.184	0.38	12	87	-75	8.8
Mine Rock (18 samples)	min.	7.7	0.138	0.02	1	60	-179	7.6
	max.	8.7	0.632	2.45	75	194	10	9.2
	aver.	8.1	0.211	0.96	29	117	-88	8.3

4.1 pH, Salinity and Sodicity

The pH of these samples is slightly to moderately alkaline with pH_{1:2} values ranging from 7.2 to 7.4 for the saprock, from 7.5 to 9.3 for the general waste rock, and 7.7 to 8.7 for the mine rock.

The EC_{1:2} values for the general waste rock range from 0.110 to 0.478 dS/m, and for the mine rock range from 0.138 to 0.632 dS/m. All of the general waste rock samples and all but one of the mine rock samples has an EC_{1:2} value <0.5 dS/m and are considered to be non-saline. One of the mine rock samples (322A/1), representing the mudstone, has an EC_{1:2} value of 0.632 dS/m and this sample is considered to be slightly saline. The EC_{1:2} values for the saprock samples are 1.285 and 1.884 dS/m and these samples are considered to be slightly to moderately saline.

The exchangeable cations, CEC and ESP for selected waste rock samples are provided in Table 5 and the EC_{1:2} values are plotted against the ESP for these samples in Figure 5. These results indicate that the samples range from non- to highly sodic with an ESP ranging from 4.4 to 57.3 %. However, the majority of the samples are non- to slightly

sodic. As well as being slightly to moderately saline, the two saprock samples, with an ESP of 33.4 and 46.9 %, are highly sodic. Additional to these samples, although non-saline, two of the general waste rock samples representing the diorite (Sample 323/3) and dyke (Sample 323/4) are highly sodic with an ESP of 57.3 and 48.1 %, respectively.

Table 5: pH and EC, exchangeable cations and ESP for selected waste rock samples.

Sample ID	Material Type	pH _{1:2}	EC _{1:2}	Exch. Cations (meq/100g)				CEC	ESP
				Ca	Mg	K	Na		
323/1	Saprock Diorite	7.2	1.285	1.5	3.9	0.2	2.8	8.5	33.4
323/2	Saprock Diorite	7.4	1.884	3.7	9.2	0.4	11.7	24.9	46.9
323/3	Diorite	9.3	0.478	2.4	2.2	0.4	6.8	11.8	57.3
353C/5	Diorite	7.7	0.140	3.0	0.4	0.4	0.3	4.1	6.7
323/4	Dyke	9.1	0.380	2.6	1.3	0.2	3.8	8.0	48.1
323/8	Sandstone	8.4	0.150	2.0	<0.2	0.5	0.5	3.0	15.6
323/11	Fault/Shear Zone	8.1	0.213	4.3	0.4	0.4	<0.2	5.2	<0.2
323/14	Conglomerate	7.8	0.179	2.0	0.4	0.6	<0.2	3.1	<0.2
353C/12	Andesite Sill	7.5	0.170	1.4	<0.2	<0.2	0.3	1.8	14.4
353C/15	Breccia	7.7	0.157	1.8	<0.2	0.9	0.4	3.1	12.5
322A/1	Mudstone (mine rock)	7.7	0.632	4.5	0.6	1.2	0.3	6.5	4.4

KEY
 pH_{1:2} = pH of 1:2 extract
 EC_{1:2} = Electrical Conductivity of 1:2 extract (dS/m)
 CEC = Cation Exchange Capacity (meq/100g)
 ESP = Exchangeable Sodium Percent (%)

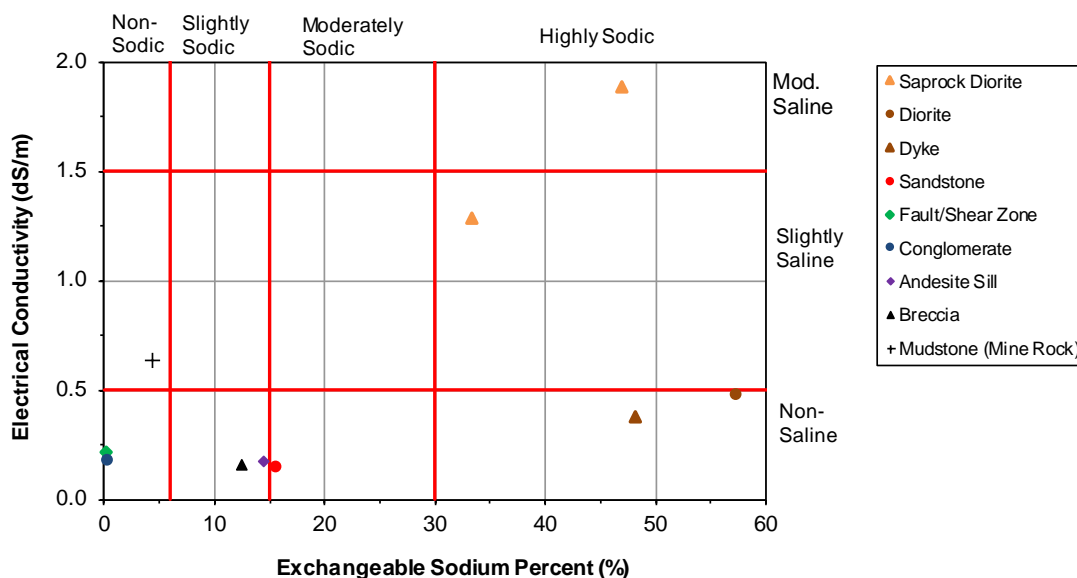


Figure 5: Salinity and sodicity ranking for selected waste rock samples.

4.2 Acid Forming Characteristics

The acid forming characteristics for the general and saprock waste rock and the mine rock samples are provided in Attachment B (Tables B1 and B2), and a summary of the characteristics is provided in Table 4. The total S content and ANC of the two saprock samples are low with a total S of 0.02 and 0.03 %S and an ANC of 1 and 4 kg H₂SO₄/t. These samples have NAPP values of minus 4 and 0 kg H₂SO₄/t, and are considered to be barren in terms of acid generation and neutralisation.

The 32 general waste rock samples have a variable total S content from 0.01 to 1.06 %S and a typically moderate ANC ranging from 30 to 107 kg H₂SO₄/t. All of these samples are NAPP negative with values ranging from minus 180 to minus 30 kg H₂SO₄/t. The 18 mine rock samples also have a variable total S content ranging from 0.02 to 2.45 %S and a typically moderate ANC ranging from 60 to 194 kg H₂SO₄/t. Although the majority of these samples is NAPP negative, ranging from minus 179 to minus 28 kg H₂SO₄/t, one sample is NAPP positive with a value of 10 kg H₂SO₄/t.

Figure 6 is an acid base account plot using the total S contents. This plot shows that, although the majority of the NAPP negative samples have an ANC/MPA ratio > 3, a number of the waste rock and mine rock samples have an ANC/MPA ratio < 3 and some of the mine rock samples have a ratio < 2.

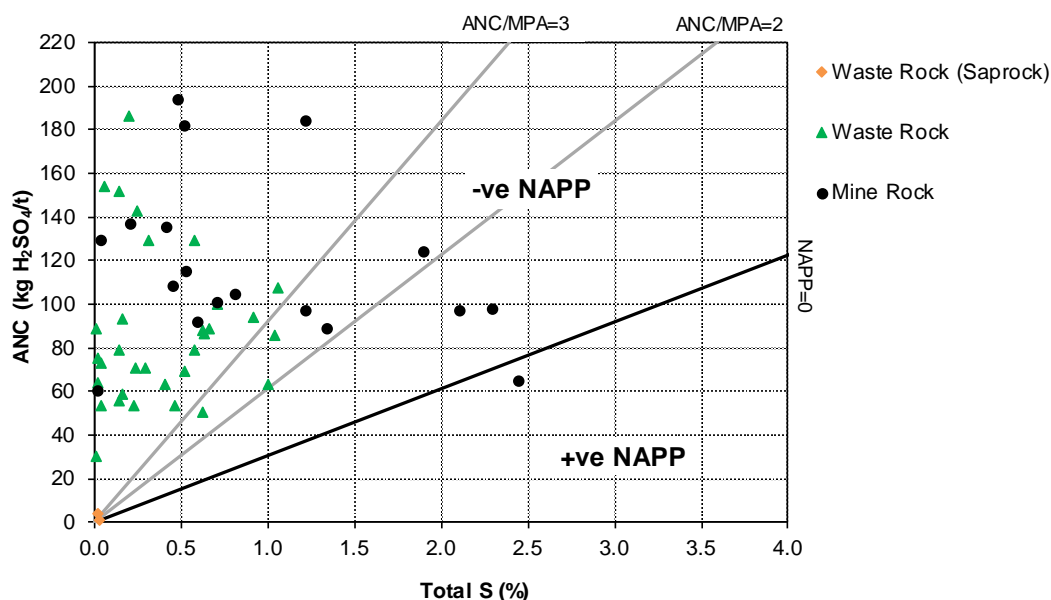


Figure 6: Acid-base account plot for the waste rock and mine rock samples.

The NAGpH values for all of the waste rock and mine rock samples are > 4.5 and range from 5.6 to 10.0. Figure 7 is the geochemical classification plot for these samples where the NAPP values are plotted against the NAGpH. This plot shows that

all but one of the samples plot on the upper left quadrate of the plot, with a negative NAPP and a NAGpH > 4.5, and these samples are classified as NAF. One of the mine rock samples (331A/7) representing the sandstone, plots on the upper right quadrate of the plot, with a positive NAPP and a NAGpH > 4.5, and this sample has a UC classification.

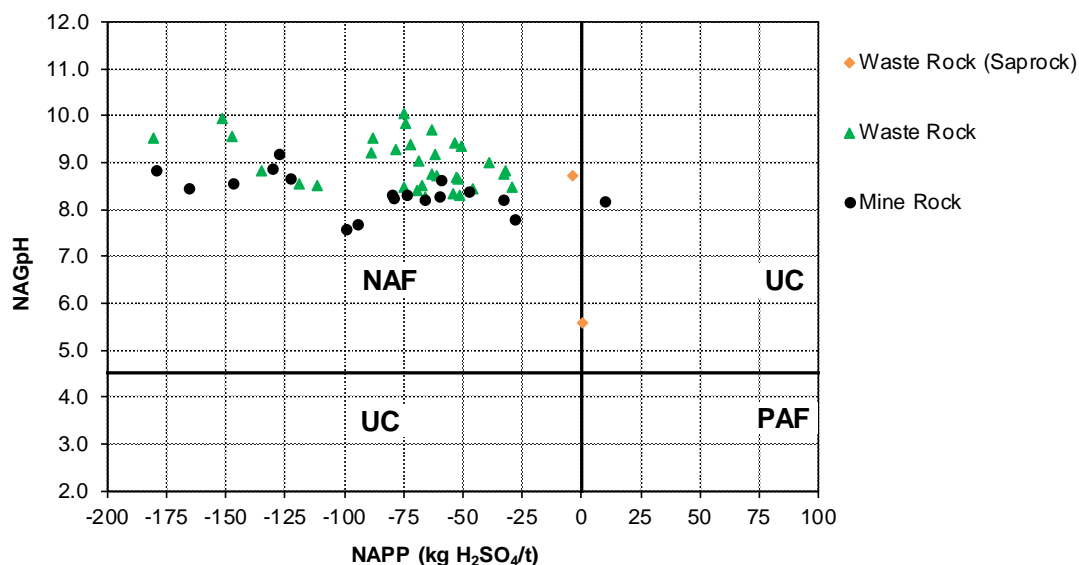


Figure 7: Geochemical classification plot for the waste rock and mine rock samples.

Sulfide S analysis indicates that, as expected, only approximately 50% of the contained (total) S within the selected saprock sample occurs as reactive S (sulfide). For the majority of the general waste rock and mine rock samples, approximately 80 to 100% of the contained S occurs as reactive S. However, only a small proportion (24%) of the contained S occurs as reactive S in one of the samples, sample 331A/7 which has a UC classified. When the sulfide S content of this sample is used to calculate the NAPP it is decreased from 10 kg H₂SO₄/t to minus 47 kg H₂SO₄/t, and is therefore classified as NAF.

These results indicate that all of the characterised samples are classified as NAF. The saprock samples have a low S content and ANC, and the materials represented by these samples are considered to be barren in terms of acid generation and neutralisation. Although all of the general waste rock and mine rock samples are classified as NAF, due to their relatively high S content and ANC, the materials represented by these samples are expected to be relatively reactive in terms of acid generation and neutralisation.

4.3 Metal Enrichment and Solubility

Multi-element scans were performed on 9 of the waste rock samples and 3 of the mine rock samples. The results from these analyses and the geochemical abundance indices are provided in Attachment C (Tables C1 and C2). These results indicate that, similar to previous investigations (EGi, 1995; EGi, 2004; GEM, 2011a; GEM, 2011b; GEM, 2013 and GEM, 2016), all of the waste rock and mine rock samples are enriched in As and Sb.

The results of multi-element scans performed on the water extracts from these samples indicate that, although Cl and SO₄ salts occur in roughly equal proportions in these samples, with an EC_{1:2} of 1.884 dS/m, Cl salts are the dominate salt in the saprock (oxide) sample (323/2). These results also indicate that these samples generally have low element solubility apart from As, which is found to be relatively soluble. As a guide, the dissolved As concentrations are compared to the ANZECC irrigation water quality guidelines (ANZECC, 2000) in Table 6. This comparison indicates that the dissolved As concentrations do not exceed the short term or long term exposure guidelines. Recommendations for water quality monitoring and management of the underground workings and development waste in regard to these findings are provided in Section 7.0.

Table 6: The range in dissolved As concentrations in the waste rock and mine rock extracts, compared to the ANZECC (2000) irrigation water quality guidelines.

Element	Units	Concentration Range	Irrigation Water Quality Guideline (ANZECC, 2000)	
			Short-Term Exposure (up to 20 years)	Long-Term Exposure (up to 100 years)
As	µg/L	1.1 - 70.8	2000	100

µg/L = micrograms per litre.

5.0 Ore and Low Grade Ore Geochemistry

The geochemical test results for the ore and low grade ore samples are provided in Attachment B, for the pH, EC and acid forming characteristics, and in Attachment C, for the multi-element scans. A summary of the pH, EC and acid forming characteristics is provided in Table 7.

Table 7: Summary of the pH and EC, and acid forming characteristics for the ore and low grade ore samples.

Material Type	pH _{1:2}	EC _{1:2} (dS/m)	Total S (%S)	MPA	ANC	NAPP	NAGpH
				(kg H ₂ SO ₄ /t)			
Low Grade <i>min.</i>	7.7	0.141	0.04	1	43	-93	8.0
Ore <i>max.</i>	8.8	0.222	3.01	92	105	31	9.0
<i>(9 samples)</i> <i>aver.</i>	8.1	0.170	0.96	30	85	-55	8.3
Ore <i>min.</i>	7.6	0.115	0.32	10	40	-185	3.1
<i>max.</i>	8.5	0.400	3.92	120	212	40	9.3
<i>(12 samples)</i> <i>aver.</i>	8.0	0.185	1.67	51	89	-38	8.3

5.1 pH and Salinity

The ore and low-grade ore samples are slightly alkaline with pH_{1:2} values ranging from 7.6 to 8.1, and non-saline with EC_{1:2} values ranging from 0.115 to 0.400 dS/m.

5.2 Acid Forming Characteristics

The acid forming characteristics results for the ore and low grade ore samples are provided in Attachment B (Table B3). The total sulfur contents range widely from 0.04 %S for the ore samples, and from 0.32 to 3.92 %S for the low grade ore samples. The ANC values are typically moderate to high, with values ranging 43 to 105 kg H₂SO₄/t for the ore and 40 to 212 kg H₂SO₄/t. Four of the ore samples with a range of ANC values, including 322A/4, 322A/12, 351/8 and 354/8, were selected for ABCC determination and the plots for these analyses are provided in Attachment B (Figure B-1). These plots indicate that a high proportion, ranging from 70 to 90% of the total ANC is readily available to neutralise the sulfide generate acidity.

Figure 8 is an acid-base account plot for these samples and it shows that the majority of the samples plot above the NAPP=0 line and are NAPP negative, indicating an excess in acid buffering capacity over potential acidity. However, a number of the samples plot below the NAPP=0, being NAPP positive, and a number plot below the ANC/MPA=2 line, indicating only a 2-fold excess in acid neutralisation of over acid generation.

The NAGpH values from the standard static NAG test performed on all samples range from 3.1 to 8.5. Apart from two samples with a NAGpH of 3.1 and 3.2 for ore samples 322A/4 and 331A/11, respectively, all of the samples have a NAG pH >4.5. Figure 9 is the geochemical classification plot for these samples and it shows that most of the samples plot in the upper left quadrant and are classified as NAF. One of the samples with a NAGpH <4.5 (331A/8) has a positive NAPP and this sample is classified as PAF. However, the other sample with a NAGpH <4.5 (322A/4) has a negative NAPP and this sample has a UC classification. Additional to these samples, one low grade ore sample (354/7) and two ore samples (354/8 and 322A/12) have a positive NAPP, but a NAGpH >4.5 and these samples also have a UC classification.

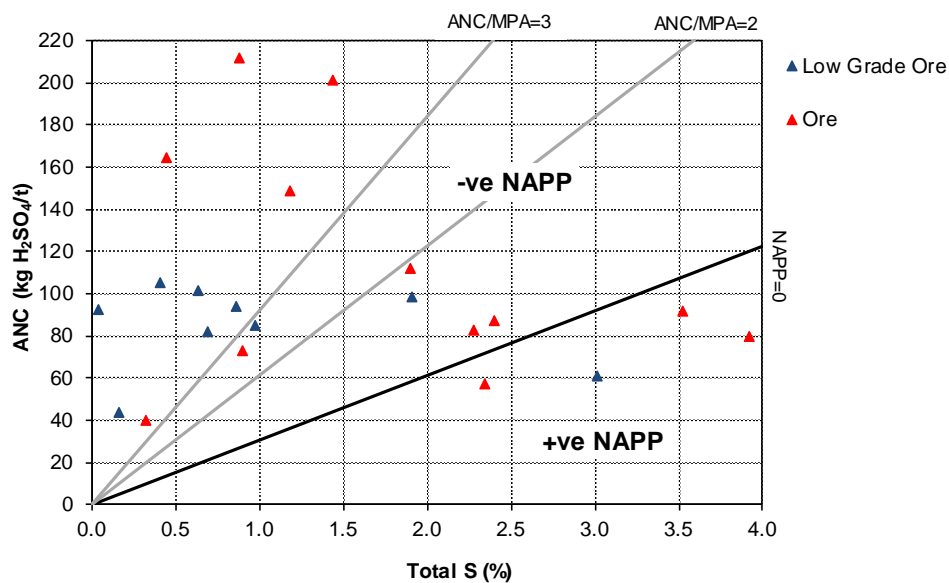


Figure 8: Acid-base account plot for the ore and low grade ore samples.

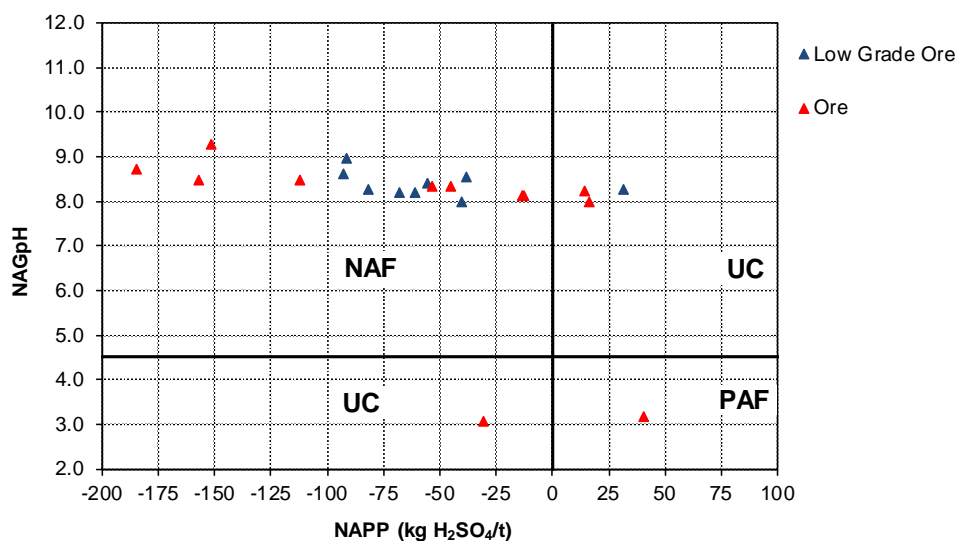


Figure 9: Geochemical classification plot for the ore and low grade ore samples.

Sulfide S analyses, performed on three low grade ore samples and 8 ore samples, indicate that 80% to 100%, and typically 90%, of the contained S is present as sulfide. Extended boil NAG testing was performed on two of the UC samples (32A/4 and 322A/12) and these results confirmed the NAGpH values derived from the standard NAG test. Therefore, the results from these two analyses were not able to clarify the classification any of the UC samples. Based on these findings it is expected that the three UC samples with a NAGpH >4.5 would be NAF and that the UC sample with a NAGpH <4.5 would be PAF/LC.

5.3 Metal Enrichment and Solubility

Multi-element scans were performed three low grade ore samples and five ore samples. The results from these analyses and the geochemical abundance indices are provided in Attachment C (Tables C1 and C2). These results indicate that, similar to previous investigations on the ore and low grade ore (GEM, 2011b; GEM, 2013 and GEM, 2016), these materials are typically significantly enriched in Ag and As. Additional to these metals, some of the samples are significantly in Cd, Cu, Pb, Se and Zn.

The results of multi-element scans performed on the water extracts from these samples indicate that, similar to the waste rock and mine rock samples, the low grade ore and ore generally have low element solubility apart from As, which is found to be relatively soluble. As a guide, the dissolved As concentrations are compared to the ANZECC irrigation water quality guidelines (ANZECC, 2000) in Table 8. This comparison indicates that the dissolved As concentrations do not exceed the short term or long term exposure guidelines. Recommendations for water quality monitoring and management of the underground workings and development waste in regard to these findings are provided in Section 7.0.

Table 8: The range in dissolved As concentrations in the low grade ore and ore extracts, compared to the ANZECC (2000) irrigation water quality guidelines.

Element	Units	Concentration Range	Irrigation Water Quality Guideline (ANZECC, 2000)	
			Short-Term Exposure (up to 20 years)	Long-Term Exposure (up to 100 years)
As	µg/L	1.7 - 87.2	2000	100

6.0 Conclusions and Recommendations

For this assessment 73 drill-core samples were collected from five drill-holes located across the proposed mine area. This included 34 samples representing the waste rock that will be excavated during mine development, 18 samples representing the underground mine rock that will be exposed within the underground workings, 12 samples representing the ore material and 9 samples representing the low grade ore material. These samples were assessed to determine the salinity, sodicity, and acid and metalliferous drainage (AMD) risks associated with the proposed underground mining operations. The drill-hole codes and locations, and the interval and lithology details for these samples are provided in Attachment A.

Following are the findings from this assessment, which are compared to those from the previous investigations, and based on these findings, recommendations for the environmental management of the different materials associated with the proposed underground mining activities are provided below.

6.1 Development Waste Rock

The samples collected from the two drill holes intersecting the proposed mine access area were included in this program in order to characterise the material that would be excavated during mine development and placed within a surface waste rock emplacements. The findings from this assessment are consistent with the findings from the characterisation of the waste rock from previous investigations for the open-pit operations.

Following is a summary of the findings from the development waste rock assessment:

- The oxide waste rock is expected to be saline and sodic. Due to the low reactive sulfide content and low ANC, this material is expected to be NAF and barren in terms acid generation and neutralisation, and the development of increased salinity.
- The general (primary) waste rock is expected to be non-saline, non- to slightly sodic and NAF. However, some moderately and highly sodic materials are likely to be encountered. Although the general waste rock is expected to be non-saline, due to a relatively high reactive sulfide content, it has a risk of becoming saline when oxidised.
- The waste rock is expected to be significantly enriched with As and Sb, and As may be moderately soluble under the prevailing quasi neutral pH conditions.

Recommendations for Waste Rock:

These results confirm that the proposed underground development waste rock is geochemically similar to the waste rock from the current open pit operations, indicating that the management strategies currently employed for the waste rock

emplacements would not need to be modified to accommodate the development waste.

Based on these findings the following recommendations are provided:

- Due to the low AMD risk no special management requirements would be required for AMD control within the waste rock.
- Due to the salinity of the oxide waste rock and the potential of the primary waste rock to become saline, release of sulfate salts, such as gypsum, may occur if these materials are left exposed to surficial weathering processes. Additionally, due to the expected sodicity of the oxide waste rock and some of the primary waste rock, sodic conditions may develop, leading to increased sediment dispersion and surface erosion if these materials are left exposed on the surface of the emplacement.
- Due to the predicted enrichment of As and Sb, it is recommended that the development waste rock be included in the waste rock emplacement's water quality monitoring program as outlined in Section 6.5.

6.2 Mine Rock and Underground Workings

The samples collected from the three drill holes intersecting the proposed mine workings were included in this program in order to characterise the material that would be exposed during underground mining. The findings from this assessment indicate the mine rock samples are geochemically similar the waste rock characterised during this and previous investigations.

Following is a summary of the findings from the mine rock assessment:

- The mine rock is expected to be non-saline and NAF. However, due to the relatively high reactive sulfide content, this material has a risk of becoming saline if it is allowed to oxidise following dewatering of the underground workings.
- As with the waste rock, the mine rock is expected to be significantly enriched with As and Sb, and As may be moderately soluble under the prevailing quasi neutral pH conditions.

Recommendations for Mine Rock and Underground Workings:

The mine rock is expected to be geochemically similar to the general (not oxide) waste rock assessed within the current and previous investigations, and therefore the following recommendations are provided:

- Due to the low AMD risk no special management requirements would be required for AMD control within the underground workings.
- If the mine rock is allowed to oxidise an increase in salinity may occur. However, considering the regional groundwater has a TDS of around 40,000 to

45,000 mg/L, the contribution of sulfate salts from the underground workings is expected to be negligible.

- Due to the predicted enrichment of As and Sb in the mine rock, it is recommended that these metals are included in the mine water quality monitoring program as outlined in Section 6.5.

6.3 Ore and Low Grade Ore Stockpiles

The findings from this assessment are generally consistent with the previous investigations for the ore and low grade ore, except that a small amount of PAF material was identified within the ore to be won from the proposed underground mining operation. Following is a summary of the findings from the ore and low grade ore assessment:

- The ore and the low grade ore are expected to be non-saline, however, due to the presence of reactive sulfides, an increase in salinity may occur if these materials are left exposed on the surface of their respective stockpiles.
- The low grade ore is expected to be NAF. However, one sample of PAF material and one sample expected to be PAF-LC were identified within the 12 ore samples that were assessed.
- All of the ore and low grade ore materials are expected to be enriched in Ag and As, and some of these materials are expected to be enriched with Cd, Cu, Pb, Se and Zn. As with the other materials associated with the proposed underground mine, As is expected to be slightly soluble under the prevailing slightly alkaline pH conditions.

Recommendations for Ore and Low Grade Ore Stockpiles:

It is expected that the stockpiled ROM ore would only be exposed to surface oxidation conditions within the ore stockpile for short periods. However, it is expected that the low grade ore could be stockpiled and exposed to surface oxidation and leaching conditions over long periods and this presents a greater risk to impacting the quality of any release water if it is not managed correctly. On this basis, the following recommendations are provided for the ore and the low grade ore stockpiles.

- Because of the predicted NAF nature and low AMD risk for the low grade ore, no special management would be required for AMD control of the stockpile. However, if the low grade ore is left exposed for extended periods, an increase in salinity may occur and this would need to be taken into account for water management of the stockpile pads.
- A small amount of the ore may be PAF. Due to the expected short time period of exposure and the expected low quantity of PAF material, development of acidic drainage is not expected to be a concern for the ore stockpiles. However, if any PAF or PAF-LC material is exposed on the surface of the stockpiles for even a relatively short time period, low pH conditions may develop leading to an increase in salinity and metal solubility and release. Because of this, it is

recommended that a geochemical assessment of the ROM ore be undertaken over a time period to develop a better understanding of the quantity and distribution of the PAF and PAF-LC material within the underground ore.

- Because of the potential enrichment of Ag, As, Cd, Cu, Pb, Se and Zn in the ore and low grade ore it is recommended that these metals are included in the water quality monitoring as discussed in Section 6.5.

6.4 Tailings

Although the ore from the current investigations is generally considered to be geochemically similar to that from the previous investigations, the current investigations have identified the possible occurrence of a small quantity of PAF and/or PAF-LC material within the ore. Because of this, there will be an increased risk of some of the tailings being PAF or PAF-LC.

Recommendations for Tailings:

- Because of the risk that some of the tailings from the proposed underground operations would be PAF or PAF-LC, it is recommended that a program be undertaken to geochemically characterise any pilot plant tailings that may be available and the process tailings when they are available. The characterisation program for the process tailings would most likely involve the routine collection of the discharge tailings over a period of time.
- Previous investigations have identified the risk of the tailings from the open-pit operations being saline and developing saline conditions within the tailings storage facility (TSF). It was therefore recommended that the TSF design include a cover in order to avoid development of a salt-pan.
- Based on the similar geochemical characteristics of the ore between the previous and current investigations, it is predicted that the tailings would be enriched in Ag, As, Cd, Pb, Sb, Se and Zn, and it is recommended that these metals be included in the TSF water quality monitoring program as discussed in Section 6.5.

6.5 Water Quality Monitoring

The findings of the previous geochemical investigations at the CGO have been used to help develop the site water quality monitoring programs, including waste rock emplacements, ROM ore stockpile, low grade ore stockpile, and the TSF. The parameters include pH, EC, turbidity, dissolved oxygen, temperature, biological oxygen demand, faecal indicators, total hardness, total suspended solids, Ca, Mg, K, Na, Cl, SO₄, Ag, As, Cd, Mo, Pb, Sb, Se and Zn.

- The findings from these investigations are consistent with the current water quality monitoring program and it is recommended that this program also be adopted for the water from the proposed underground operations.
- It is also recommended, if it has not already been done so, include total alkalinity in the suite of parameters for the site water quality monitoring programs.

7.0 References

Bowen H.J.M. (1979) *Environmental Chemistry of the Elements*. Academic Press, London.

Environmental Geochemistry International Pty Ltd (1995) *Cowal Gold Project Environmental Geochemical Assessment of Process Tailings, Mine Rock and Surface Zone Materials*. Report prepared for North Limited.

Environmental Geochemistry International Pty Ltd (1996) *Cowal Gold Project Environmental Geochemical Assessment of Simulated Tailings*. Report prepared for North Limited.

Environmental Geochemistry International Pty Ltd (1997) *Cowal Gold Project Environmental Geochemistry Assessment of Proposed Mining Activities for Cowal Gold Project*. Report prepared for North Limited.

Environmental Geochemistry International Pty Ltd (1998) *Cowal Gold Project Final Void Water Chemistry*. Report prepared for North Limited.

Environmental Geochemistry International Pty Ltd (2004) *Geochemical Assessment of Waste Rock and Process Tailings*. Report prepared for Barrick Australia Limited.

Geo-Environmental Management Pty Ltd (2008) *Cowal Gold Mine E42 Modification, Tailings and Waste Rock Geochemical Assessment*. Report prepared for Barrick Australia Limited.

Geo-Environmental Management Pty Ltd (2011a) *Cowal Gold Mine Augmentation Project, Environmental Geochemistry Assessment of Waste Rock and Tailings*. Report prepared for Barrick Australia Limited.

Geo-Environmental Management Pty Ltd (2011b) *Cowal Gold Mine Extension Project Pre-Feasibility, Environmental Geochemistry Assessment of Waste Rock, Low Grade Ore and Tailings*. Report prepared for Barrick Australia Limited.

Geo-Environmental Management Pty Ltd (2013) *Cowal Gold Mine Extension Modification, Environmental Geochemistry Assessment of Waste Rock and Tailings*. Report prepared for Barrick Australia Limited.

Geo-Environmental Management Pty Ltd (2016) *Cowal Gold Operations Mine Life Modification, Environmental Geochemistry Assessment of Waste Rock and Tailings*. Report prepared for Evolution Mining (Cowal) Pty Limited.

Rhoades J.D., Chanduvi F. and Lesch S.M. (1999) *Soil Salinity Assessment: Methods and Interpretation of Electrical Conductivity Measurements*. FAO Irrigation and Drainage Paper No. 57, Food and Agriculture Organisation of the United Nations, Rome, Italy.

Attachment A

Multi-Element Analysis Results

Table A-1: Drill hole intervals, lithology and lithology codes for the waste rock (mine access) samples, CGO Underground Mine Development.

Table A-2: Drill hole intervals, lithology and lithology codes for the mine rock, ore and low grade ore samples, CGO Underground Mine Development.

Figure A-1: Drill hole locations.

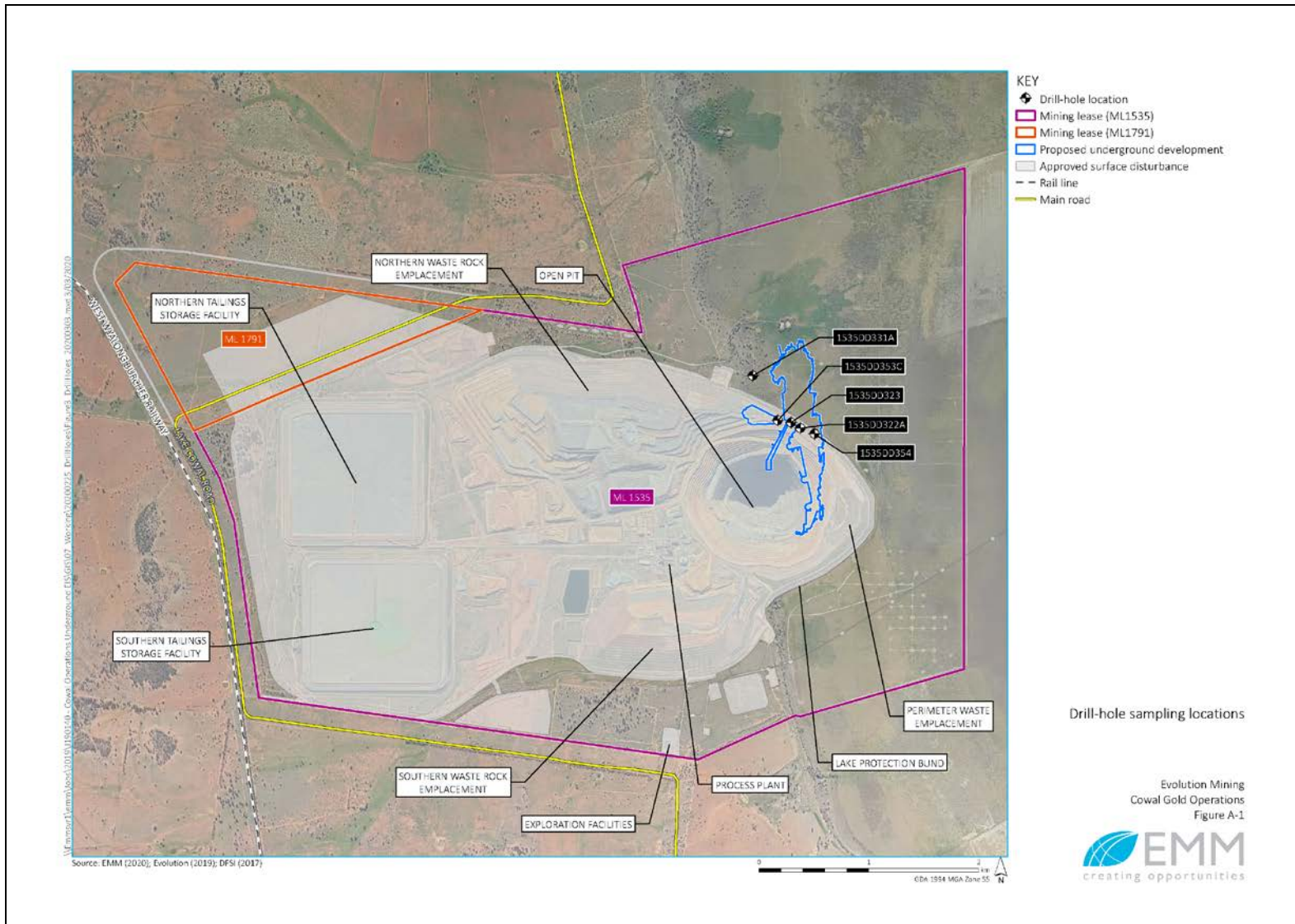


Table A-1: Drill hole intervals, lithology and lithology codes for the waste rock (mine access) samples, CGO Underground Mine Development.

Sample ID	Drill-Hole ID	Depth (m)			Lithology	Lithology Code
		from	to	interval		
323/1	1535DD323	27.10	43.00	15.90	Saprock Diorite	SRDI
323/2	1535DD323	43.00	56.40	13.40	Saprock Diorite	SRDI
323/3	1535DD323	56.40	76.90	20.50	Diorite	DI
323/4	1535DD323	76.90	88.90	12.00	Dyke	DY
323/5	1535DD323	97.95	120.52	22.57	Diorite	DI
323/6	1535DD323	120.52	130.51	9.99	Sandstone	VS
323/7	1535DD323	135.50	145.80	10.30	Mudstone	VM
323/8	1535DD323	159.20	182.95	23.75	Sandstone	VS
323/9	1535DD323	205.00	225.55	20.55	Mudstone	VM
323/10	1535DD323	225.55	229.00	3.45	Dyke	DY
323/11	1535DD323	247.01	254.80	7.79	Fault/Shear Zone	FZ/SZ
323/12	1535DD323	260.00	282.25	22.25	Diorite	DI
323/13	1535DD323	282.25	299.78	17.53	Lava	LA
323/14	1535DD323	315.10	329.00	13.90	Conglomerate	VC
323/15	1535DD323	374.32	388.00	13.68	Mudstone	VM
323/16	1535DD323	388.00	397.23	9.23	Conglomerate	VC
323/17	1535DD323	397.23	400.00	2.77	Andesite Sill	AN
353C/1	1535DD353C	225.00	245.00	20.00	Diorite	DI
353C/2	1535DD353C	284.00	304.00	20.00	Diorite	DI
353C/3	1535DD353C	340.30	341.45	1.15	Dyke	DY
353C/4	1535DD353C	341.45	347.75	6.30	Fault/Shear Zone	FZ/SZ
353C/5	1535DD353C	425.00	445.00	20.00	Diorite	DI
353C/6	1535DD353C	471.80	476.85	5.05	Fault/Shear Zone	FZ/SZ
353C/7	1535DD353C	486.00	506.00	20.00	Diorite	DI
353C/8	1535DD353C	567.25	587.00	19.75	Diorite	DI
353C/9	1535DD353C	609.33	616.27	6.94	Diorite Dyke	DY
353C/10	1535DD353C	637.00	645.00	8.00	Conglomerate	VC
353C/11	1535DD353C	685.74	691.00	5.26	Andesite Sill	AN
353C/12	1535DD353C	704.00	712.00	8.00	Andesite Sill	AN
353C/13	1535DD353C	713.90	725.55	11.65	Mudstone	VM
353C/14	1535DD353C	725.55	727.65	2.10	Breccia	VX
353C/15	1535DD353C	765.85	767.00	1.15	Breccia	VX
353C/16	1535DD353C	779.74	789.00	9.26	Dyke	DY
353C/17	1535DD353C	802.54	812.73	10.19	Sandstone	VS

Table A-2: Drill hole intervals, lithology and lithology codes for the mine rock, ore and low grade ore samples, CGO Underground Mine Development.

Sample ID	Drill-Hole ID	Depth (m)			Lithology	Lithology Code
		from	to	interval		
MINE ROCK						
322A/1	1535DD322A	281.00	281.73	0.73	Mudstone	VM
322A/2	1535DD322A	374.00	374.94	0.94	Diorite	DI
322A/3	1535DD322A	413.00	414.00	1.00	Lava	LA
322A/7	1535DD322A	458.22	459.00	0.78	Sandstone	VS
322A/8	1535DD322A	477.00	478.00	1.00	Sandstone	VS
322A/11	1535DD322A	493.00	494.00	1.00	Conglomerate	VC
322A/13	1535DD322A	495.00	495.80	0.80	Dyke	DY
331A/1	1535DD331A	574.00	575.00	1.00	Diorite	DI
331A/3	1535DD331A	580.00	581.00	1.00	Fault/Shear Zone	FZ/SZ
331A/5	1535DD331A	721.00	722.00	1.00	Diorite	DI
331A/7	1535DD331A	730.00	731.00	1.00	Sandstone	VS
331A/9	1535DD331A	799.00	800.00	1.00	Lava	LA
331A/13	1535DD331A	835.35	836.40	1.05	Dyke	DY
331A/14	1535DD331A	859.00	860.00	1.00	Conglomerate	VC
354/3	1535DD354	155.00	156.00	1.00	Diorite	DI
354/6	1535DD354	261.00	262.00	1.00	Diorite	DI
354/9	1535DD354	285.07	286.00	0.93	Sandstone	VS
354/11	1535DD354	317.00	318.00	1.00	Andesite Sill	AN
ORE						
322A/4	1535DD322A	377.00	379.00	2.00	Lava	LA
322A/6	1535DD322A	433.00	435.33	2.33	Dyke	DY
322A/10	1535DD322A	480.00	483.00	3.00	Sandstone	VS
322A/12	1535DD322A	494.00	494.56	0.56	Conglomerate	VC
331A/2	1535DD331A	575.00	576.00	1.00	Diorite	DI
331A/4	1535DD331A	583.00	584.00	1.00	Fault/Shear Zone	FZ/SZ
331A/8	1535DD331A	791.00	794.00	3.00	Lava	LA
331A/11	1535DD331A	819.00	820.00	1.00	Sandstone	VS
354/2	1535DD354	144.00	146.10	2.10	Diorite	DI
354/4	1535DD354	248.00	249.00	1.00	Diorite	DI
354/8	1535DD354	284.00	285.07	1.07	Sandstone	VS
354/10	1535DD354	288.00	290.00	2.00	Conglomerate	VC
LOW GRADE ORE						
322A/5	1535DD322A	417.00	419.00	2.00	Lava	LA
322A/9	1535DD322A	479.00	480.00	1.00	Sandstone	VS
331A/6	1535DD331A	725.00	726.00	1.00	Sandstone	VS
331A/10	1535DD331A	802.00	804.00	2.00	Lava	LA
331A/12	1535DD331A	820.00	822.00	2.00	Conglomerate	VC
354/1	1535DD354	141.00	142.00	1.00	Diorite	DI
354/5	1535DD354	249.00	250.00	1.00	Diorite	DI
354/7	1535DD354	283.00	284.00	1.00	Sandstone	VS
354/12	1535DD354	343.00	344.00	1.00	Andesite Sill	AN

Attachment B

Acid Forming Characteristic Test Results

Table B-1: Acid forming characteristics of the waste rock (mine access) samples, CGO Underground Mine Development.

Table B-2: Acid forming characteristics of the mine rock samples, CGO Underground Mine Development.

Table B-3: Acid forming characteristics of the low grade ore and ore samples, CGO Underground Mine Development.

Figure B-1: Acid buffering characteristic curves for selected ore samples.

Table B-1: Acid forming characteristics of the waste rock (mine access) samples, CGO Underground Mine Development.

Sample ID	Lithology	pH _{1:2}	EC _{1:2}	ACID-BASE ANALYSIS							NAG TEST			Geochem. Class.
				Total %S	Sulfide %S	MPA	ANC	NAPP	NAPP _{sulf.}	ANC/MPA	NAGpH	NAG _{pH4.5}	NAG _{pH7.0}	
323/1	Saprock Diorite	7.2	1.285	0.03	0.015	1	1	0	0	0.9	5.6	0	2	NAF
323/2	Saprock Diorite	7.4	1.884	0.02		1	4	-4		6.9	8.7	0	0	NAF
323/3	Diorite	9.3	0.478	0.01		0	30	-30		97.5	8.5	0	0	NAF
323/4	Dyke	9.1	0.380	0.16		5	93	-88		19.0	9.5	0	0	NAF
323/5	Diorite	8.6	0.204	0.24		7	70	-63		9.6	9.7	0	0	NAF
323/6	Sandstone	8.7	0.229	0.71		22	100	-78		4.6	9.3	0	0	NAF
323/7	Mudstone	8.3	0.141	0.16		5	59	-54		12.0	9.4	0	0	NAF
323/8	Sandstone	8.4	0.150	0.41		13	63	-51		5.1	9.4	0	0	NAF
323/9	Mudstone	8.1	0.160	0.62	0.576	19	51	-32	-33	2.7	8.8	0	0	NAF
323/10	Dyke	8.0	0.174	1.00	0.878	31	64	-33	-37	2.1	8.8	0	0	NAF
323/11	Fault/Shear Zone	8.1	0.213	0.20		6	187	-180		30.5	9.5	0	0	NAF
323/12	Diorite	8.0	0.156	0.04		1	73	-72		59.7	9.4	0	0	NAF
323/13	Lava	7.7	0.157	0.29		9	70	-62		7.9	9.2	0	0	NAF
323/14	Conglomerate	7.8	0.179	0.58		18	79	-61		4.5	8.7	0	0	NAF
323/15	Mudstone	7.9	0.184	0.58	0.869	18	130	-112	-103	7.3	8.5	0	0	NAF
323/16	Conglomerate	7.9	0.195	0.25		8	143	-135		18.7	8.8	0	0	NAF
323/17	Andesite Sill	7.8	0.190	1.06		32	107	-75		3.3	8.5	0	0	NAF
353C/1	Diorite	7.6	0.110	0.14		4	55	-51		12.9	8.3	0	0	NAF
353C/2	Diorite	7.8	0.163	0.02		1	64	-63		104.2	8.7	0	0	NAF
353C/3	Dyke	8.1	0.216	0.06		2	154	-152		83.7	10.0	0	0	NAF
353C/4	Fault/Shear Zone	7.5	0.128	0.46		14	53	-39		3.8	9.0	0	0	NAF
353C/5	Diorite	7.7	0.140	0.66		20	89	-68		4.4	9.1	0	0	NAF
353C/6	Fault/Shear Zone	7.8	0.172	0.04		1	53	-52		43.6	8.7	0	0	NAF
353C/7	Diorite	7.8	0.188	0.23		7	53	-46		7.5	8.5	0	0	NAF
353C/8	Diorite	8.0	0.185	0.02		1	75	-75		122.8	10.0	0	0	NAF
353C/9	Diorite Dyke	8.0	0.153	0.01		0	89	-89		290.6	9.2	0	0	NAF
353C/10	Conglomerate	7.7	0.167	0.52		16	69	-53		4.3	8.7	0	0	NAF
353C/11	Andesite Sill	7.6	0.166	0.62		19	88	-69		4.6	8.4	0	0	NAF
353C/12	Andesite Sill	7.5	0.170	0.92		28	94	-66		3.3	8.3	0	0	NAF
353C/13	Mudstone	7.7	0.125	0.63		19	87	-67		4.5	8.5	0	0	NAF
353C/14	Breccia	8.0	0.169	0.31		9	129	-119		13.6	8.5	0	0	NAF
353C/15	Breccia	7.7	0.157	1.04		32	86	-54		2.7	8.3	0	0	NAF
353C/16	Dyke	7.8	0.142	0.14		4	151	-147		35.4	9.6	0	0	NAF
353C/17	Sandstone	7.6	0.136	0.14		4	79	-74		18.4	9.8	0	0	NAF
KEY											Classification Key			
pH _{1:2} = pH of 1:2 extract				NAPP = Net Acid Producing Potential (kgH ₂ SO ₄ /t)							NAF = Non-Acid Forming			
EC _{1:2} = Electrical Conductivity of 1:2 extract (dS/m)				NAGpH = pH of NAG liquor							PAF = Potentially Acid Forming			
MPA = Maximum Potential Acidity (kgH ₂ SO ₄ /t)				NAG _{pH4.5} = Net Acid Generation capacity to pH 4.5 (kgH ₂ SO ₄ /t)							PAF-LC = PAF Low Capacity			
ANC = Acid Neutralising Capacity (kgH ₂ SO ₄ /t)				NAG _{pH7.0} = Net Acid Generation capacity to pH 7.0 (kgH ₂ SO ₄ /t)							UC = Uncertain (expected classification)			

Table B-2: Acid forming characteristics of the mine rock samples, CGO Underground Mine Development.


Sample ID	Lithology	pH _{1:2}	EC _{1:2}	ACID-BASE ANALYSIS							NAG TEST			Geochem. Class.
				Total %S	Sulfide %S	MPA	ANC	NAPP	NAPP _{sulf.}	ANC/MPA	NAGpH	NAG _{pH4.5}	NAG _{pH7.0}	
322A/1	Mudstone	7.7	0.632	0.53		16	115	-99		7.1	7.6	0	0	NAF
322A/2	Diorite	8.1	0.224	1.90	1.81	58	124	-66	-68	2.1	8.2	0	0	NAF
322A/3	Lava	7.9	0.157	2.30		70	98	-28		1.4	7.8	0	0	NAF
322A/7	Sandstone	8.0	0.160	0.60		18	92	-74		5.0	8.3	0	0	NAF
322A/8	Sandstone	8.2	0.140	0.81		25	105	-80		4.2	8.3	0	0	NAF
322A/11	Conglomerate	8.1	0.160	1.22	1.28	37	97	-59	-58	2.6	8.3	0	0	NAF
322A/13	Dyke	8.3	0.191	0.21		6	137	-130		21.3	8.9	0	0	NAF
331A/1	Diorite	8.2	0.150	0.48		15	194	-179		13.2	8.8	0	0	NAF
331A/3	Fault/Shear Zone	8.4	0.166	0.52		16	182	-166		11.4	8.4	0	0	NAF
331A/5	Diorite	8.2	0.251	1.22		37	184	-146		4.9	8.6	0	0	NAF
331A/7	Sandstone	7.7	0.356	2.45	0.595	75	65	10	-47	0.9	8.2	0	0	NAF
331A/9	Lava	8.2	0.158	0.45		14	108	-94		7.8	7.7	0	0	NAF
331A/13	Dyke	8.6	0.272	0.71		22	101	-79		4.6	8.2	0	0	NAF
331A/14	Conglomerate	7.9	0.154	2.11	1.87	65	97	-33	-40	1.5	8.2	0	0	NAF
354/3	Diorite	8.7	0.192	0.02		1	60	-59		97.9	8.6	0	0	NAF
354/6	Diorite	8.1	0.155	0.04		1	129	-128		105.3	9.2	0	0	NAF
354/9	Sandstone	7.8	0.138	1.34	1.25	41	88	-47	-50	2.2	8.4	0	0	NAF
354/11	Andesite Sill	7.9	0.150	0.42		13	135	-122		10.5	8.6	0	0	NAF
KEY											Classification Key			
pH _{1:2} = pH of 1:2 extract				NAPP = Net Acid Producing Potential (kgH ₂ SO ₄ /t)							NAF = Non-Acid Forming			
EC _{1:2} = Electrical Conductivity of 1:2 extract (dS/m)				NAGpH = pH of NAG liquor							PAF = Potentially Acid Forming			
MPA = Maximum Potential Acidity (kgH ₂ SO ₄ /t)				NAG _{pH4.5} = Net Acid Generation capacity to pH 4.5 (kgH ₂ SO ₄ /t)							PAF-LC = PAF Low Capacity			
ANC = Acid Neutralising Capacity (kgH ₂ SO ₄ /t)				NAG _{pH7.0} = Net Acid Generation capacity to pH 7.0 (kgH ₂ SO ₄ /t)							UC = Uncertain (expected classification)			

Table B-3: Acid forming characteristics of the low grade ore and ore samples, CGO Underground Mine Development.

Sample ID	Lithology	pH _{1:2}	EC _{1:2}	ACID-BASE ANALYSIS							NAG TEST			NAG TEST (Extended Boil)			Geochem. Class.
				Total %S	Sulfide %S	MPA	ANC	NAPP	NAPP _{sulf.}	ANC/MPA	NAGpH	NAG _{pH4.5}	NAG _{pH7.0}	NAGpH	NAG _{pH4.5}	NAG _{pH7.0}	
LOW GRADE ORE																	
322A/5	Lava	8.0	0.152	1.91	1.720	58	99	-40	-46	1.7	8.0	0	0				NAF
322A/9	Sandstone	8.1	0.149	0.86		26	94	-68		3.6	8.2	0	0				NAF
331A/6	Sandstone	8.2	0.222	0.97	0.881	30	85	-55	-58	2.9	8.4	0	0				NAF
331A/10	Lava	8.1	0.141	0.69		21	82	-61		3.9	8.2	0	0				NAF
331A/12	Conglomerate	8.2	0.182	0.63		19	101	-82		5.2	8.3	0	0				NAF
354/1	Diorite	8.8	0.205	0.16		5	43	-39		8.9	8.5	0	0				NAF
354/5	Diorite	8.1	0.149	0.41		13	105	-93		8.4	8.6	0	0				NAF
354/7	Sandstone	7.7	0.176	3.01	2.810	92	61	31	25	0.7	8.3	0	0				NAF
354/12	Andesite Sill	7.9	0.157	0.04		1	93	-91		75.6	9.0	0	0				NAF
ORE																	
322A/4	Lava	8.0	0.115	0.32	0.325	10	40	-30	-30	4.1	3.1	8	16	3.7	0	2	UC(PAF-LC)
322A/6	Dyke	8.0	0.203	2.40	1.940	73	87	-14	-28	1.2	8.1	0	0				NAF
322A/10	Sandstone	7.9	0.136	2.28	1.820	70	82	-13	-27	1.2	8.1	0	0				NAF
322A/12	Conglomerate	7.8	0.233	3.52	3.360	108	91	16	11	0.8	8.0	0	0	7.5	0	0	UC(NAF)
331A/2	Diorite	8.1	0.140	0.88		27	212	-185		7.9	8.7	0	0				NAF
331A/4	Fault/Shear Zone	8.1	0.127	1.44		44	201	-157		4.6	8.5	0	0				NAF
331A/8	Lava	7.6	0.400	3.92	3.710	120	80	40	34	0.7	3.2	8	15				PAF
331A/11	Sandstone	8.2	0.217	0.90	0.816	28	73	-45	-48	2.6	8.3	0	0				NAF
354/2	Diorite	8.5	0.392	0.44		13	165	-151		12.2	9.3	0	0				NAF
354/4	Diorite	8.1	0.167	1.90	1.580	58	112	-54	-64	1.9	8.3	0	0				NAF
354/8	Sandstone	7.6	0.155	2.34	2.290	72	57	14	13	0.8	8.2	0	0				UC(NAF)
354/10	Conglomerate	7.7	0.322	1.18		36	149	-112		4.1	8.5	0	0				NAF
KEY												Classification Key					
pH _{1:2} = pH of 1:2 extract				NAPP = Net Acid Producing Potential (kgH ₂ SO ₄ /t)				NAGpH = pH of NAG liquor				NAF = Non-Acid Forming					
EC _{1:2} = Electrical Conductivity of 1:2 extract (dS/m)				NAGpH _{4.5} = Net Acid Generation capacity to pH 4.5 (kgH ₂ SO ₄ /t)				NAGpH _{7.0} = Net Acid Generation capacity to pH 7.0 (kgH ₂ SO ₄ /t)				PAF = Potentially Acid Forming					
MPA = Maximum Potential Acidity (kgH ₂ SO ₄ /t)												PAF-LC = PAF Low Capacity					
ANC = Acid Neutralising Capacity (kgH ₂ SO ₄ /t)												UC = Uncertain (expected classification)					

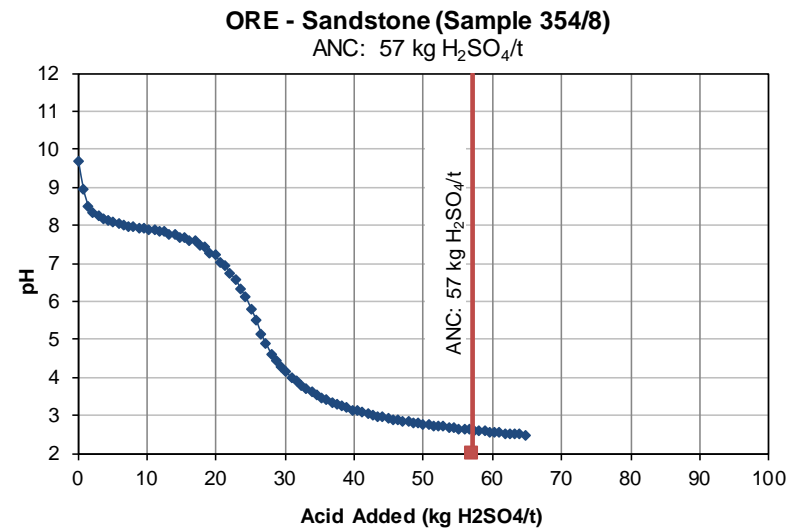
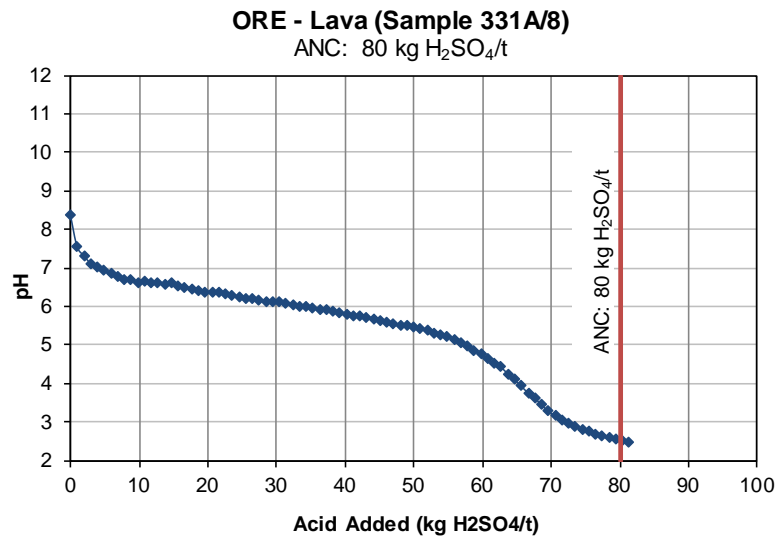
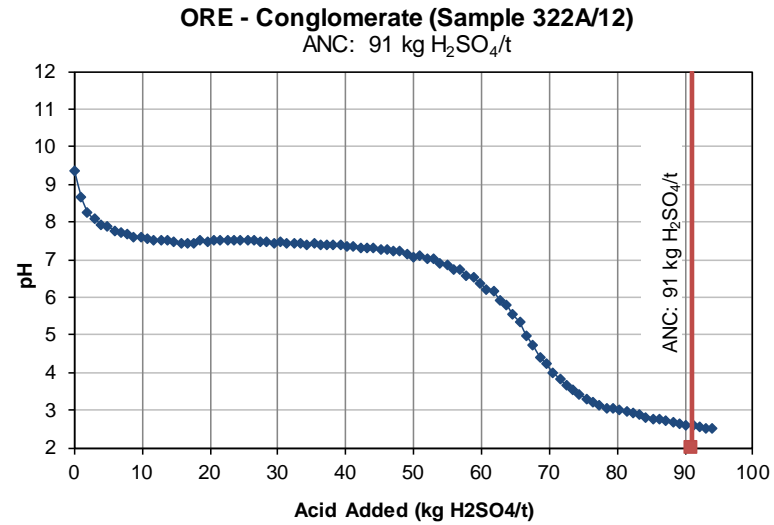
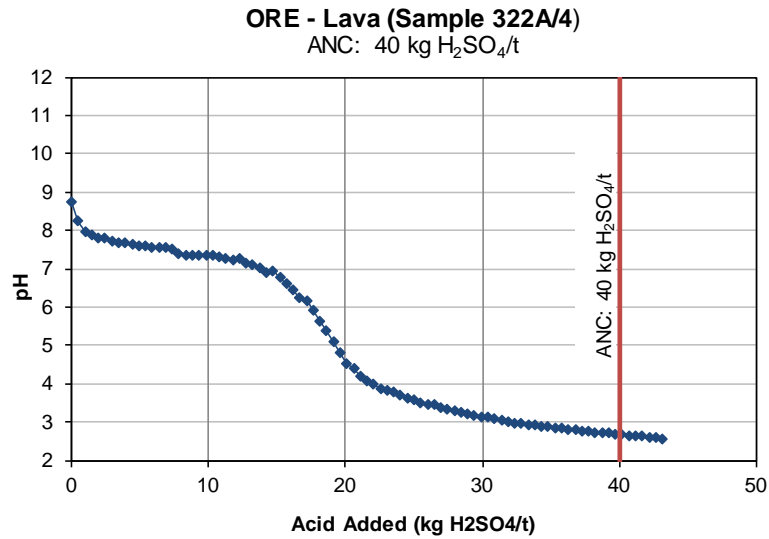


Figure B-1: Acid buffering characteristic curves for selected ore samples.

Attachment C

Multi-Element Test Results

Table C-1: Multi-element composition of selected waste rock, mine rock, low grade ore and ore samples, CGO Underground Mine Development.

Table C-2: Geochemical abundance indices for selected waste rock, mine rock, low grade ore and ore samples, CGO Underground Mine Development.

Table C-3: Chemical composition of water extracts from selected waste rock, mine rock, low grade ore and ore samples, CGO Underground Mine Development.

Table C-1: Multi-element composition of selected waste rock, mine rock, low grade ore and ore samples, CGO Underground Mine Development.

Element	Unit	Detect. Limit	Element Concentration																			
			Waste Rock									Mine Rock			Low Grade Ore			Ore				
			SR/DI	AN	VX	VC	DI	DY	FZ/SZ	VM	VS	DI	DY	LA	VC	DI	VS	VC	DI	DY	LA	VS
			323/2	353C/11	353C/14	353C/10	353C/2	353C/16	353C/6	353C/13	353C/17	354/6	331A/13	331A/9	331A/12	354/1	354/7	322A/12	354/2	322A/6	331A/8	322A/10
Ag	mg/kg	0.05	0.11	0.23	0.05	0.54	0.19	0.17	0.22	0.28	0.25	0.25	0.24	0.58	0.61	0.87	2.76	4.76	2.85	1.53	3.61	9.76
Al	%	0.005%	11.6%	8.21%	8.07%	8.49%	8.66%	7.64%	8.88%	8.16%	7.65%	8.37%	10.42%	7.11%	7.59%	7.80%	8.68%	8.13%	7.38%	7.04%	7.42%	7.81%
As	mg/kg	0.5	49.4	18.5	11.1	22.0	69.3	17.3	89.8	10.1	15.2	5.7	24.7	16.8	36.1	30.7	50.0	87.7	45.8	84.7	187.6	83.3
B	mg/kg	50	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Ba	mg/kg	0.1	340.3	345.0	175.7	304.3	281.9	685.8	219.4	537.7	584.5	385.1	216.9	791.3	669.6	366.3	64.6	918.1	174.6	1209.8	726.8	833.9
Be	mg/kg	0.05	1.03	0.82	1.15	1.00	0.84	1.13	0.56	1.05	1.07	0.73	1.10	1.14	1.17	0.58	0.59	0.85	0.57	0.69	0.63	0.90
Ca	%	0.005%	1.34%	3.04%	3.43%	2.55%	5.65%	5.35%	6.81%	2.72%	3.17%	4.59%	2.92%	1.76%	2.54%	4.96%	1.99%	3.04%	6.21%	2.75%	2.18%	2.54%
Cd	mg/kg	0.02	0.38	0.07	0.20	0.12	0.12	0.07	0.17	0.04	0.04	0.12	0.21	0.06	0.16	6.03	0.94	0.15	4.02	1.19	0.31	0.46
Co	mg/kg	0.1	105.2	20.4	9.6	23.1	31.6	26.2	36.1	14.6	23.0	29.2	32.6	10.2	12.8	41.4	11.3	28.9	41.5	11.0	22.6	15.6
Cr	mg/kg	5	50	26	35	23	36	170	58	39	163	109	21	61	32	162	81	44	202	80	59	24
Cu	mg/kg	1	283	101	31	106	254	154	158	63	66	150	174	28	1	227	337	80	173	117	621	378
Fe	%	0.01%	10.9%	6.13%	3.88%	5.98%	7.19%	5.23%	6.99%	5.28%	5.49%	6.35%	7.64%	4.39%	5.21%	7.95%	5.91%	7.96%	6.97%	3.62%	5.83%	6.20%
Hg	mg/kg	0.001	0.021	0.011	0.011	0.012	0.011	0.013	0.018	0.026	0.017	0.005	0.009	0.002	0.018	0.081	0.040	0.173	0.079	0.030	0.063	0.128
K	%	0.002%	0.41%	1.38%	3.93%	0.87%	1.02%	1.05%	1.14%	2.12%	1.59%	0.89%	3.77%	3.83%	2.98%	1.65%	0.34%	3.62%	1.05%	1.65%	1.71%	3.64%
Mg	%	0.002%	1.06%	1.75%	1.50%	2.74%	2.48%	2.79%	3.01%	1.78%	3.52%	3.29%	2.21%	1.35%	1.82%	4.36%	1.08%	1.93%	3.22%	0.71%	0.65%	1.49%
Mn	mg/kg	1	3155	1679	1019	1667	1458	1530	1481	1223	1281	1594	1837	1272	1543	1723	911	1295	1560	868	891	1464
Mo	mg/kg	0.1	0.5	1.4	0.2	0.6	1.0	1.3	0.6	1.1	0.6	0.5	0.8	1.0	1.3	0.6	1.2	1.7	4.3	1.2	2.7	0.8
Na	%	0.002%	1.03%	3.39%	0.12%	3.67%	2.29%	2.46%	2.02%	1.95%	1.92%	2.91%	0.67%	0.46%	1.41%	1.97%	5.32%	1.67%	2.23%	3.59%	3.93%	1.82%
Ni	mg/kg	1	47	5	5	6	15	46	19	7	45	32	12	2	2	51	14	13	48	3	4	2
P	mg/kg	50	440	1602	1192	1526	1132	1451	798	1415	1404	1016	869	1550	1685	844	1338	1292	841	1676	1694	1861
Pb	mg/kg	0.5	4.0	5.1	3.5	5.8	5.6	5.5	3.9	3.8	6.3	4.1	5.9	4.6	5.3	116.9	6.7	22.0	157.7	13.1	10.1	15.4
Sb	mg/kg	0.05	1.97	1.98	3.20	2.99	2.70	2.06	1.83	2.34	2.01	1.43	4.31	2.70	2.55	2.00	1.53	2.30	2.05	1.94	2.25	2.64
Se	mg/kg	0.01	0.02	0.11	0.05	0.16	0.07	0.07	0.11	0.11	0.06	0.08	0.16	0.20	0.14	0.22	0.26	0.34	0.22	0.19	0.75	0.30
Si	%	0.001	0.22	0.27	0.28	0.25	0.23	0.24	0.21	0.28	0.27	0.23	0.21	0.29	0.28	0.23	0.27	0.23	0.22	0.29	0.27	0.26
Sn	mg/kg	0.1	0.5	0.8	1.1	0.9	1.0	1.0	0.6	1.0	1.2	0.7	0.6	1.3	1.1	0.6	1.1	0.9	0.5	1.1	1.0	1.1
Th	mg/kg	0.01	0.77	2.02	2.91	2.42	2.21	4.42	1.01	2.68	5.41	1.52	0.98	3.60	3.05	1.35	2.83	3.04	1.10	3.26	3.62	3.46
U	mg/kg	0.01	0.66	1.38	1.82	1.59	1.45	3.34	0.65	1.84	4.45	0.84	0.65	2.57	2.05	0.84	1.85	1.95	1.08	2.30	2.51	2.26
V	mg/kg	1	337	199	99	207	265	204	272	146	210	259	205	82	107	294	167	154	260	66	74	87
Zn	mg/kg	1	349	93	69	154	98	88	92	79	119	132	118	65	83	1012	229	149	697	151	73	146

< element at or below analytical detection limit.

Table C-2: Geochemical abundance indices for selected waste rock, mine rock, low grade ore and ore samples, CGO Underground Mine Development.

Element	*Mean Crustal Abund.	Geochemical Abundance Indices																				
		Waste Rock										Mine Rock			Low Grade Ore			Ore				
		SR/DI	AN	VX	VC	DI	DY	FZ/SZ	VM	VS	DI	DY	LA	VC	DI	VS	VC	DI	DY	LA	VS	
		323/2	353C/11	353C/14	353C/10	353C/2	353C/16	353C/6	353C/13	353C/17	354/6	331A/13	331A/9	331A/12	354/1	354/7	322A/12	354/2	322A/6	331A/8	322A/10	
Ag	0.07	-	1	-	2	1	1	1	1	1	1	2	3	3	5	6	5	4	5	6		
Al	8.2%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
As	1.5	4	3	2	3	5	3	5	2	3	1	3	3	4	4	4	5	4	5	6	5	
B	10	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2		
Ba	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-		
Be	2.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Ca	4.0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Cd	0.11	1	-	-	-	-	-	-	-	-	-	-	-	5	3	-	5	3	1	1		
Co	20	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Cr	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Cu	50	2	-	-	-	2	1	1	-	-	1	1	-	-	2	2	-	1	1	3	2	
Fe	4.1%	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Hg	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
K	2.1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Mg	2.3%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Mn	950	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Mo	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-		
Na	2.3%	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-		
Ni	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
P	1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Pb	14	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	3	-	-	-		
Sb	0.2	3	3	3	3	3	3	3	3	3	2	4	3	3	3	2	3	3	3	3		
Se	0.05	-	1	-	1	-	-	1	1	-	-	1	1	1	2	2	2	2	1	3	2	
Si	27.7%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Sn	2.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Th	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
U	2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
V	160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Zn	75	2	-	-	-	-	-	-	-	-	-	-	-	3	1	-	3	-	-	-		

*Bow en H.J.M.(1979) Environmental Chemistry of the Elements.

Table C-3: Chemical composition of water extracts from selected waste rock, mine rock, low grade ore and ore samples, CGO Underground Mine Development.

Parameter	Unit	Det. Limit	Chemical Composition																			
			Waste Rock									Mine Rock			Low Grade Ore			Ore				
			SR/DI	AN	VX	VC	DI	DY	FZ/SZ	VM	VS	DI	DY	LA	VC	DI	VS	VC	DI	DY	LA	VS
323/2	353C/11	353C/14	353C/10	353C/2	353C/16	353C/6	353C/13	353C/17	354/6	331A/13	331A/9	331A/12	354/1	354/7	322A/12	354/2	322A/6	331A/8	322A/10			
pH		0.1	7.4	7.6	8.0	7.7	7.8	7.8	7.8	7.7	7.6	8.1	8.6	8.2	8.2	8.8	7.7	7.8	8.5	8.0	7.6	7.9
EC	dS/m	0.001	1.884	0.166	0.169	0.167	0.163	0.142	0.172	0.125	0.136	0.155	0.272	0.158	0.182	0.205	0.176	0.233	0.392	0.203	0.400	0.136
SO4	mg/l	0.3	295.2	35	21.2	26.6	11.3	17.3	14.2	12.5	7.4	10.8	41.3	21.2	35.5	6.1	58.9	88.4	99.8	57.2	216.6	32.6
Cl	mg/l	2.0	696	10	5	16	29	9	23	9	8	18	9	6	7	4	17	11	36	15	12	8
<i>Major Constituents</i>																						
Al	mg/l	0.01	<	0.17	0.14	0.18	0.17	0.22	0.21	0.17	0.16	0.17	0.27	0.12	0.15	0.22	0.12	0.08	0.12	0.08	0.03	0.12
B	mg/l	0.01	0.06	0.02	0.03	0.01	0.02	0.02	0.02	<	0.02	<	0.07	0.03	0.03	0.01	<	0.01	<	<	0.01	0.01
Ca	mg/l	0.01	5.57	14.58	9.86	14.26	11.96	8.98	10.52	10.96	9.89	12.53	2.91	5.48	8.98	2.29	27.79	32.47	6.83	21.38	58.31	19.51
Cr	mg/l	0.01	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Cu	mg/l	0.01	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Fe	mg/l	0.01	0.01	<	<	<	0.02	<	0.02	0.01	0.01	<	0.02	0.01	<	0.06	<	<	0.02	<	<	<
K	mg/l	0.1	3	4.9	4.7	1.6	0.8	1.8	1.2	2.4	1.5	1.9	3.9	5.3	6	1.1	1.1	4.1	1.8	4.8	4.7	3.2
Mg	mg/l	0.01	12.17	1.4	1.74	1.32	0.57	1.02	1.06	1.25	1.31	1.5	0.56	1.41	2.1	0.55	3.28	2.64	1.75	2.34	16.05	1.5
Mn	mg/l	0.01	0.01	0.03	0.02	0.02	<	<	<	0.02	<	0.01	<	0.03	0.03	<	0.12	0.06	<	0.06	0.56	0.06
Na	mg/l	0.1	566.8	37	47.5	41.2	43.4	39.5	44.4	34.6	39.5	33.4	86.2	41.2	41.9	68.7	19.4	28	110.6	32	30	16.8
Ni	mg/l	0.01	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	0.01	<	<
P	mg/l	0.1	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Si	mg/l	0.05	7.57	2.55	1.91	2.36	2.79	2.02	2.82	1.57	2.26	1.76	1.81	1.42	2.01	3.48	1.65	1.88	2.91	1.62	1.02	1.67
V	mg/l	0.01	<	<	<	<	<	<	<	<	<	<	0.02	<	<	0.03	<	<	0.03	<	<	<
Zn	mg/l	0.01	<	<	<	0.01	<	<	<	<	<	0.01	<	<	<	<	<	<	<	<	<	<
<i>Minor Constituents</i>																						
Ag	ug/l	0.01	0.01	<	<	<	<	<	<	<	<	<	<	<	<	<	0.15	<	<	0.01	<	<
As	ug/l	0.1	1.1	4.3	2.1	4.8	37.2	31.8	70.8	5.4	25	2.6	4.4	3.6	7.7	23.7	5	87.2	84	2.8	1.7	4.7
Ba	ug/l	0.05	6.69	105.28	29.29	42.66	3.26	98.9	3.42	107.62	42.17	63.32	8.86	47.2	59.07	2.02	16.48	35.36	2.62	68.86	47.14	59.51
Be	ug/l	0.1	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Cd	ug/l	0.50	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Co	ug/l	0.1	0.2	<	<	<	<	<	<	<	<	<	<	0.2	0.1	<	0.2	0.1	<	0.2	3	0.1
Hg	ug/l	0.1	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Mo	ug/l	0.05	1.22	12.48	3.35	2.95	3.23	18.12	2.02	6.24	19.63	1.6	10.51	11.88	10.06	1.14	9.15	6.16	45.67	39.63	22.21	7.29
Pb	ug/l	2.0	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Sb	ug/l	0.01	0.07	2.25	3.06	1.79	0.51	1.61	0.66	3.04	1.63	0.88	2.91	2.16	2.49	0.67	1.77	2.26	1.4	1.57	0.9	1.2
Se	ug/l	0.5	1.1	<	<	<	0.6	<	<	<	<	<	<	<	<	0.7	<	0.5	2.1	<	0.9	<
Sn	ug/l	0.1	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Th	ug/l	0.005	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
U	ug/l	0.005	<	0.16	0.237	0.108	0.167	0.051	0.146	0.078	0.064	0.02	0.169	0.274	0.156	0.11	0.146	0.293	0.395	0.46	0.196	0.14

< element at or below analytical detection limit.