

TECHNICAL REPORT

Geochemical investigation of overburden, footwall units, ore and tailings

Ardmore Phosphate Mine

Prepared for: Centrex Metals



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Executive summary

The purpose of the geochemical investigation was to evaluate the potential of the material that will be mined and processed, or utilised for progressive rehabilitation to produce acid, neutral or alkaline drainage with associated saline or metalliferous drainage potential.

Fresh samples of overburden (n=36) and footwall (n=5) samples were collected from drill core and reverse circulation chips drilled from August 2017. Representative samples, ore (n=1) and tailings (n=1) from bulk metallurgical were also provided by Centrex.

The overburden samples were found to be acid consuming (AC (n=6)), non-acid forming – barren (NAF-Barren (n=20) or non-acid forming (NAF (n=10)). The footwall samples were found to be non-acid forming – barren (NAF-Barren (n=1), potentially non-acid forming (PAF (n=3)) or acid forming (AF (n=1)). The ore and tailings samples were both NAF.

Based on the total elemental concentrations and soluble leachate analyses the potential for acid and metalliferous is considered to be low. However, the overburden does have elevated salinity. The ore may also be processed using a combination of fresh water and saline groundwater with a total dissolved solids concentration of 17,000 mg/L. Because of this the tailings produced at the site are likely to have a higher salinity than the samples analysed in this study.

The development and implementation of a sampling and static and kinetic analytical program should be developed as part of a site management plan to enable the geochemical properties of the overburden, ore, tailings and footwall samples to be tracked over subsequent stages of the project to verify the findings of this study.

When there is sufficient kinetic leach cell data the outputs from these tests can be used as geochemical source terms with the site water balance model to evaluate if water quality objectives for the project will be met to minimise the potential for environmental harm.

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Glossary of terms and acronyms

AC	Acid consuming mine waste that has the potential to consume substantial acidity.
AF	Acid forming mine waste typified as having an existing pH < 5.
bgl	Below ground level.
Acid Base Account	Evaluation of the balance between acid generation and acid neutralisation processes. Determines the maximum potential acidity (MPA) and the inherent acid neutralising capacity (ANC), as defined below.
AMD	Acid and metalliferous drainage from mine waste materials characterised by low pH, elevated metal concentrations, high sulfate concentrations and high salinity. See also "NMD".
ANC	Acid Neutralising Capacity, expressed as kg H ₂ SO ₄ per tonne of sample. A measure of a sample's maximum potential ability to neutralise acid.
ANC: MPA Ratio	The ratio of the acid neutralising capacity to the maximum potential acidity of a sample. Used to assess the risk of a sample generating acid conditions.
CRS	Chromium reducible sulfur. Analytical procedure to determine the sulfide sulfur concentration in a sample.
EA	Environmental authority.
EC	Electrical Conductivity, expressed as µS/cm.
eCEC	Effective cation exchange capacity provides a measure of the amount of exchangeable cations (Ca, Mg, Na and K) in a sample.
eH	A measure of the redox (oxidation-reduction) state of a solute. eH is a measurement of electrical potential and thus commonly expressed in volts.
DES	Department of Environment and Science (Queensland).
ESP	Exchangeable sodium percentage provides a measure of the sodicity of a material and propensity to erode.
LoM	Life of Mine.
IOR	Intrinsic oxidation rate.
Kinetic Test	Procedure used to measure the geochemical/weathering behaviour of a sample of mine material over time.
KLC	Kinetic leach column.
KLC test	Kinetic leach column tests are procedures used to measure the geochemical/weathering behaviour of a sample of mine material over time.
LoR	Limit of Reporting. Laboratory detection limit for the reporting of results for a particular geochemical test.
MPA	Maximum Potential Acidity. Calculated by multiplying the total sulfur or sulfide-sulfur (CRS) content of a sample by 30.6 (stoichiometric factor) and expressed as kg H ₂ SO ₄ per tonne.
NAF	Non-Acid Forming. Geochemical classification criterion for a sample that will not generate acid conditions.

NAPP	Net Acid Producing Potential, expressed as kg H ₂ SO ₄ per tonne. Calculated by subtracting the ANC from the MPA.
NMD	Neutral and metalliferous drainage typically caused by exposure of sulfide minerals in mine waste materials to oxygen and water and then neutralisation by gangue minerals. Typically characterised by neutral pH and elevated concentrations of salts, sulfate and metals.
PAF	Potentially Acid Forming. Geochemical classification criterion for a sample that has the potential to generate acid conditions.
pH	A measure of hydrogen ion (H ⁺) concentration; generally expressed as pH.
pH_{ox}	Hydrogen ion concentration of the oxidised NAG solution.
ROM	Run-of-Mine. Ore as it comes from the mine prior to screening or processing.
S	Sulfur.
SS	Sulfide sulfur.
S_{PYR}	Sulfur as Pyrite.
S_{SO4}	Sulfur as Sulfate.
SO₄²⁻	Sulfate.
Static test	Procedure for characterising the geochemical nature of a sample at a single point in time. Static tests may include measurements of mineral and chemical composition of a sample and the Acid Base Account.
Tailings	Fine-grained mineral waste materials produced from the processing of coal or ore.
TS	Total sulfur content of a sample generally measured using a 'LECO' analyser expressed as total sulfur%.
TDS	Total dissolved solids is a measurement of the dissolved solids (major ions or salts) concentration in a water sample.
TSS	Total suspended solids is a measurement of the suspended solids concentration in a water sample.

1 Introduction

RGS Environmental Pty Ltd (RGS) was engaged by Golder Associates Pty Ltd (Golder) to undertake a geochemical assessment of overburden, tailings and ore associated with the Ardmore Phosphate Project.

The Ardmore deposit was discovered in the 1960s with comprehensive exploration conducted through the 1970s. The deposit was acquired by Centrex Metals Ltd (Centrex) from Southern Cross Fertilisers Pty Ltd, a subsidiary of Incitec Pivot Limited in 2017. The Ardmore Phosphate Project (Ardmore) is a high-grade phosphate rock deposit located 128 km south of the City of Mount Isa and 25 km west of Dajarra. It is understood that the deposit outcrops and is very shallow with the target phosphorate unit hanging wall and footwall average contact depths being 8.3 m and 12.0 m respectively. It is proposed that the phosphate ore will be mined from a shallow 25 m deep pit and will have a waste:ore stripping ratio of 3:1. The life of mine is approximately 10 years.

Ardmore's deposits are covered by Mining Lease ML5542, held by Centrex. As part of the Feasibility Study, reverse circulation and diamond drilling was undertaken. Samples from 10 diamond drill and 4 reverse circulation holes were submitted to ALS Environmental Pty Ltd (ALS) for testing. The results of this analysis are presented and discussed in this report.

1.1 Purpose of the investigation

The purpose of the geochemical investigation discussed in this report was to evaluate the potential of the material that will be mined and processed, or utilised for progressive rehabilitation to produce:

- acid, neutral or alkaline drainage;
- saline drainage; and,
- metalliferous drainage.

The data from this work will lead to mined material from the soil to the footwall units being classified into deleterious and beneficial material classes. The geochemical data can be combined with the geological model and mine plan to produce a life of mine material balance and material placement schedule to ensure that all practicable measures are considered during development of the project to minimise the potential for environmental harm.

The approach to geochemical characterisation in this report is consistent with Australian and International guidelines (AMIRA, 2002 and COA, 2016, INAP, 2017) to confirm that the sampling and analytical process was appropriate, risk based and focused on obtaining representative samples of regolith units in the overburden above the ore, footwall units below the ore and representative samples of ore and tailings. RGS adopted a phased approach to geochemical characterisation, allowing for the baseline program to develop at a level and pace that complements the development of the Project.

The Stage 1 testing discussed in this report includes static geochemical characterisation of 43 samples to ensure appropriate spatial and compositional assessment of the deposit. Stage 2 would be commenced when the next stage of the project development is approved and is likely to require long-term kinetic leach tests conducted on a limited sample set to quantify sulfide oxidation rates and the rate that major, minor and trace elements may be released from the samples over time under the influence of chemical and physical weathering processes. Stage 2 testing may also include supplemental static test work on fresh rock samples to validate the results of Stage 1 testing.

The results of Stage 1 and Stage 2 are likely to be required to be incorporated into robust conceptual site models and then into numerical models to quantify potential site water quality during mining and through the progressive phase of site rehabilitation through to site closure and relinquishment.

2 Geology

2.1 Regional geology

The Georgina Basin, which stretches across Queensland and the Northern Territory is host to Australia's significant phosphate rock deposits. The basin is a northwest-southeast trending extensional basin which covers an area of 325,000 km² across the Northern Territory and western Queensland. Middle Cambrian marine sediments (505 - 515 million years ago) around the edge of the basin are the host to sedimentary phosphorite deposits such as Ardmore (Centrex Metals Limited, 2018).

The Ardmore deposit is located approximately 120 km SSW of Mt Isa within the Ardmore Outlier. It is block bounded to the east by the large regional north-south orientated Rufus fault zone. A lesser fault bounds the deposit to the west (**Figure 2-1**).

2.2 Local geology

The geological setting of the project area is a well-defined stratigraphic sequence that includes a Pre-Cambrian Footwall. The Eastern Creek Volcanics and the Sybella Granite form a basement of crystalline Pre-Cambrian rocks around the Ardmore Outlier. The stratigraphy from youngest to oldest is as follows (Golder Associates, 2017):

- Alluvium (Quaternary): clay, silt, sand gravel; flood-plain alluvium
- Blazan Shale (middle Cambrian): siliceous shale, chert, siltstone, fine arenite, conglomerate, dolomitic and bituminous limestone, phosphorite
- Beetle Creek Formation (middle Cambrian): chert, siliceous shale with trilobite fossils, basal conglomerate
- Thornton Limestone (middle Cambrian): Grey crystalline limestone
- Riversdale Formation (early Cambrian): Conglomerate, arenite sandstone, arkose sandstone, shale, mudstone, dolomite
- Sulieman Gneiss (Palaeo Proterozoic): Felsic gneiss, augen gneiss, hornblende schist, amphibolite, quartzite

Phosphate mineralisation is located within the Beetle Creek Formation, as succession of cherts, phosphatic siltstones, phosphate rock and minor shales that outcrops in some areas within the project area (**Figure 2-1**). Within the Beetle Creek Formation, the upper Simpson Creek Phosphorite Member hosts high-grade mineralisation while the underlying Lower Siltstone or Chert Member sub-units have lower grade phosphatic siltstones and shales. The Thornton Limestone underlies the Beetle Creek Formation, while the Blazan Shale overlies it (Centrex Metals Limited, 2018).

The Simpson Creek Phosphorite Member is an average of 4.3 m thick across the project. The unit dips shallowly across most of the deposit, although the dip becomes steeper along the eastern bounding fault (Centrex Metals Limited, 2018).

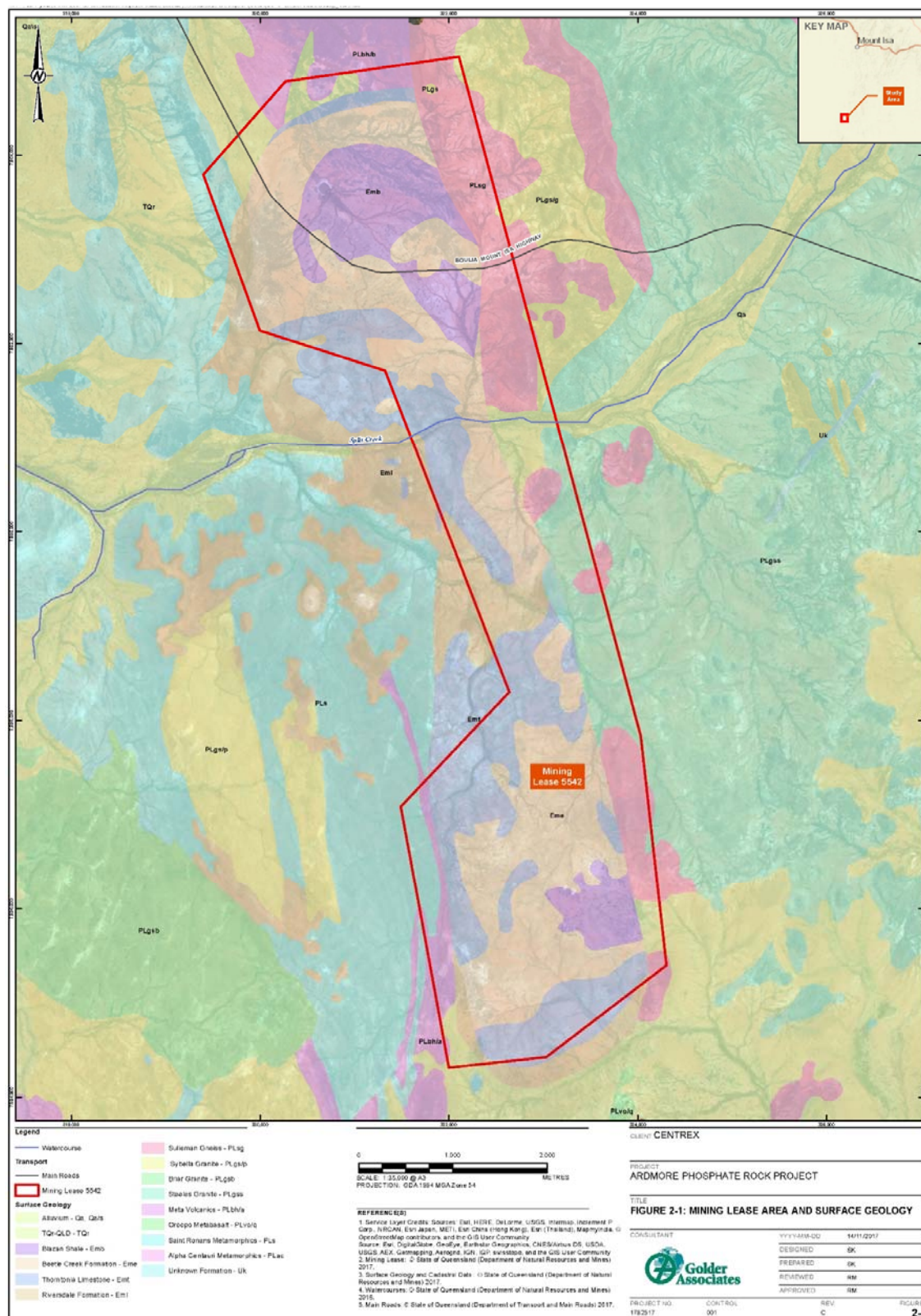


Figure 2-1: Mining lease area and geology of Ardmore Phosphate Mine

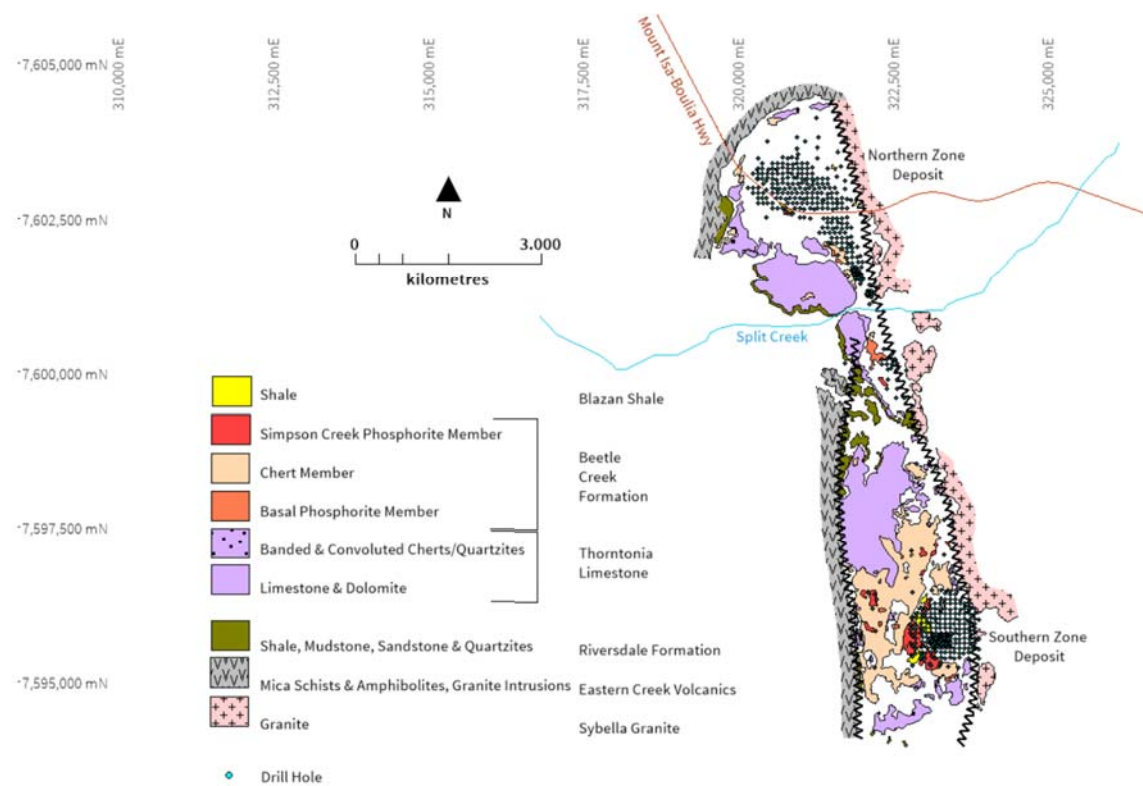


Figure 2-2: Ardmore local geology

3 Geochemical assessment

The most reliable method to characterise the acid producing potential of a sample would be to undertake a range of analyses that include total sulfur (TS), sulfide sulfur (SS) measured using the chromium reducible sulfur method (CRS), sulfate (that can be measured in a range of fractions and species using various methods), the hydrogen ion concentration (pH), electrical conductivity (EC), total acid neutralising capacity (ANC_T), reactive ANC using the acid buffering characteristic curve (ABCC) method, mineralogy, and the single peroxide addition net acid generation (NAG) method (MEND, 2009). However, it is often cost prohibitive and unnecessary to undertake all these analyses on every sample.

RGS undertake pH, EC, TS and ANC_T on all samples to screen them and undertake supplementary analyses on specific samples to understand anomalies or to verify assumptions. This approach results in a balance between sample coverage and cost and is an appropriate strategy for a project at this level.

3.1 Maximum potential acidity (MPA)

3.2 Actual acidity

Actual acidity can be divided into soluble acidity and retained acidity. Soluble acidity is defined here as acidity measured using a 1:5 (soil:water) extract whereas retained acidity is defined as the acidity that is not recorded in such an extraction. However, there is no clear-cut distinction between soluble acidity and retained acidity because part of the retained forms of acidity can be released during successive extractions with water. Soluble acidity can be subdivided into active soluble acidity and buffered acidity. Active soluble acidity accounts for the activity of hydrogen ion (H⁺) whereas buffered soluble acidity accounts for other soluble acidic cations (mainly Fe²⁺, AlSO₄⁺ and Al³⁺) that can produce hydrogen ion when they hydrolyse (Lin et al, 2002). Retained acidity can be sub-divided into (a) exchangeable acidity, (b) acidity carried by protonated variably charged particles, such as clays, and (c) acidity carried by basic sulfate minerals. These retained forms of acidity are temporarily immobilised by soils and are subject to re-mobilisation if geochemical conditions change, such as occur in liming or re-flooding with brackish tidal water. Exchangeable acidity is acidity that is retained through cation exchange reactions (Lin et al, 2002). Jarosite is the most common basic sulfate mineral in ASS. One mole of jarosite carries three moles of acidity that can be released by hydrolysis: $\text{KFe}_3(\text{OH})_6(\text{SO}_4)_2 + 3\text{OH}^- \rightarrow 3\text{Fe}(\text{OH})_3 + 2\text{SO}_4^{2-} + \text{K}^+$. Acidity that is buffered through protonation of variably charged particles can be released through their deprotonation, e.g. $[\text{Al}(\text{OH})]^{2+} - \text{SO}_4^{2-} + 2\text{OH}^- \rightarrow \text{Al}(\text{OH})_3 + \text{SO}_4^{2-}$.

3.3 Potential acidity

TS is measured by combustion of the sample in a furnace at 1,350°C in the presence of strong oxidants/catalysts. This method measures the total concentration of sulfur, including elemental sulfur, sulfur present in sulfide and sulfate minerals as well as organic sulfur. The most environmentally conservative approach to calculate maximum potential acidity (MPA) is to assume that all sulfur in a sample is potentially reactive sulfide and therefore capable of generating acid. By convention in acid base accounting studies, it is assumed that the sulfide sulfur is present as pyrite (FeS₂). Therefore, the stoichiometry of pyrite oxidation is used to calculate a theoretical maximum amount of sulfuric acid that could be generated. However, this ignores the fact that not all sulfur will contribute to the generation of acidity (e.g. sulfate sulfur in gypsum and barite). As a result, the TS concentration may overestimate the acid generation potential of a sample which is expressed in kg H₂SO₄ / tonne.

Sulfur can be present within acid producing primary minerals such as Pyrite (FeS₂), Chalcopyrite (CuFeS₂) and Bornite (Cu₅FeS₄) and non-acid producing primary minerals such as Galena (PbS) and Sphalerite (ZnS). TS can also be present as a large number of non-acid producing secondary minerals such as Alunite (KAl₃(SO₄)₂(OH)₆), Gypsum (CaSO₄·2H₂O) through to minerals such as Jarosite (KFe³⁺3(OH)₆(SO₄)₂) that can store and release acid and trace, minor and major elements.

To differentiate between total sulfur and sulfide sulfur the CRS method was used to measure the sulfide sulfur. The CRS method provides a direct measure of reduced inorganic sulfur over the wide range of values encountered in acid sulfate soils and mineral waste in geological materials. The selectivity of the CRS test in samples containing residual organic sulfur makes it an ideal choice analytically to measure sulfide within primary sulfide minerals. While this method excludes sulfur present as sulfate, or organic

sulfur it does not differentiate between acid producing (e.g. Pyrite) and non-acid producing (e.g. Sphalerite) minerals.

Acid generation is caused by the exposure of sulfide minerals, most commonly pyrite (FeS_2), to atmospheric oxygen and water. Sulfur assay results are used to calculate the maximum acid that could be generated by the sample by either directly determining the pyritic sulfur content or assuming that all sulfur not present as sulfate occurs as pyrite. Pyrite reacts under oxidising conditions to generate acid according to the following overall reaction: $4\text{FeS}_2 + 15\text{O}_2 + 14\text{H}_2\text{O} \rightarrow 4\text{Fe}(\text{OH})_3 + 8\text{H}_2\text{SO}_4$.

According to this reaction, the maximum potential acidity (MPA) of a sample containing 1% S as pyrite would be 30.6 kg H_2SO_4 /t. The chemical components of the acid generation process consist of the above sulfide oxidation reaction and acid neutralization, which is mainly provided by inherent carbonates and, to a lesser extent, silicate materials. The amount and rate of acid generation is determined by the interaction and overall balance of the acid generation and neutralisation components.

3.4 Total acid neutralising capacity

The total acid neutralising capacity (ANC_T) can be measured by the peroxide siderite correction for the Sobek method that utilises digestion of a pulp sample with 0.5 M HCl, boiling and addition of 5mL of 30% H_2O_2 . The sample is then back titrated with NaOH to measure the amount of acid consumed by reaction with the sample and provides the ANC_T in kg H_2SO_4 /t. Acid neutralising capacity is expressed in kg H_2SO_4 /t of material representing the capacity of the solids to neutralise acid but not necessarily implying that calcite (CaCO_3) is present. This is the method used for this work.

The primary minerals in geological materials that are readily able to neutralise acidity are calcium and magnesium carbonates. Secondary neutralising minerals accounted for in the measurement of total acid neutralising capacity include basic silicates such as calcic feldspars, olivine, amphiboles, and biotite. However, due to their slower dissolution rates, their contribution to the overall ANC is generally considered to be small under ambient conditions. Felsic silicates such as sodic and potassic feldspars, muscovite, most clay minerals, and quartz do not contribute significantly to the ANC. In addition, carbonate minerals that contain iron and/or manganese do not report to the ANC measurement. The relative reactivity of acid consuming minerals at pH 5 is provided in **Table 3-1**.

Table 3-1: Relative Mineral Reactivity

Mineral Group	Typical Minerals	Relative Reactivity at pH 5
Dissolving	Calcite, aragonite, dolomite, magnesite, brucite	1.0
Fast weathering	Anorthite, nepheline, olivine, jadeite, leucite, spodumene, diopside, wollastonite	0.6
Intermediate weathering	Epidote, zoisite, enstatite, hypersthene, augite, hedenbergite, hornblende, glaucophane, tremolite, actinolite, anthophyllite, serpentine, chrysotile, talc, chlorite,	0.4
Slow weathering	Albite, oligoclase, labradorite, montmorillonite, vermiculite, gibbsite, kaolinite	0.02
Very slow weathering	K-feldspars, muscovite	0.01
Inert	Quartz, rutile, zircon	0.004

(Source <http://technology.infomine.com/enviromine/ard/acid-base%20accounting/ABAdiscussion.htm>)

3.5 Reactive acid neutralising capacity

The reactive (available) ANC is determined using the ABCC (AMIRA, 2002) method that was derived from the British Columbia Research Incorporated Initial Neutralisation Potential method (Duncan and Bruynesteyn, 1979). The measurements of reactive (available) acid neutralising capacity (ABCC_{ANC}) involves slow titration of a sample with the addition of hydrochloric or sulfuric acid over set time intervals

while continuously measuring the pH. The method is used to estimate the ANC of the material and the buffering capacity available at a pre-determined pH value. When acid is added to finely ground particles or aggregates the material will react with the acid neutralising components and reduce the pH of the solution. The amount of acid required to reach each pH interval is dependent on the amount of neutralisation present. 'Buffering' occurs where a significant amount of acid is added before the pH drops, thereby producing a 'step-like' curve in a plot of pH versus volume of acid added. RGS has not included reactive ANC testing in this assessment.

3.6 Net acid producing potential and neutralisation potential ratio

Geochemical classification is achieved using the net acid producing potential (NAPP) of a sample, which is calculated from acid base accounting (ABA) procedures (DITR, 2007). The NAPP value is derived as the difference between the maximum potential acidity (MPA) and total acid neutralising capacity (ANC_T) of a sample.

The ANC_T/MPA ratio (or Neutralising Potential Ratio (NPR)) is also used as a means of assessing the risk of acid generation from mine waste materials. The purpose of the ANC_T/MPA ratio is to provide an indication of the relative margin of safety within a material. As a general rule, an ANC_T/MPA ratio of 2 or more signifies that there is a high probability that the material will remain circum-neutral in pH (AMIRA, 2002; INAP, 2009).

3.7 Net acid generation

The single addition NAG test involves a single addition of 250 ml of 15% H₂O₂ to a 2.5 g of pulverised (less than 75 µm) sample. The sample is then allowed to react overnight. The entire sample is heated until gently bubbling for approximately 1-2 h to remove excess H₂O₂ and encourage release of inherent neutralising capacity. Once the sample has cooled to room temperature, the pH and titrated acidity to pH 4.5 and 7.0 (in kg H₂SO₄/t of sample) of the solution are measured. A NAG_{pHox} less than 4.5 generally indicates the sample is acid producing.

A NAG_{pHox} value can be used in combination with NAPP values to classify the geochemical nature of samples. The Australian Government Leading Practice Handbook on Acid and Metalliferous Drainage COA, 2016 now states that, "the risks of misclassifying Non-Acid Forming (NAF) material as Potentially Acid Forming (PAF) and PAF material as NAF, are substantially reduced by conducting both NAPP and NAG tests."

The NAG method is also known to have a number of limitations that should be considered in the interpretation of data (MEND, 2009). RGS has not included NAG testing in this assessment.

3.8 Metalliferous drainage potential

The potential of a geological material to leach trace, minor or major elements (salts, metals and metalloids) is a function of the fractionation and speciation of the elements and the way the mine waste materials will be managed. The static methods used in this assessment have measured the "total" and "water soluble" fractions of these elements.

The geochemical abundance index (GAI) quantifies a "total" assay result for a particular element in terms of the average crustal abundance for that element. The index, based on a log (2) scale, is expressed in seven integer increments (0 to 6), which correspond to enrichment factors from 0 to over 96 times average crustal abundance, as shown in **Table 3-2**.

Table 3-2 Geochemical Abundance Index (GAI) values and Enrichment Factor

GAI	Enrichment factor	GAI	Enrichment factor
0	Less than 3-fold enrichment	4	24 – 48 fold enrichment
1	3 – 6 fold enrichment	5	48 – 96 fold enrichment
2	6 – 12 fold enrichment	6	Greater than 96 fold enrichment
3	12 – 24 fold enrichment		

As a general rule, a GAI greater than or equal to three indicates element enrichment to a level that may warrant further investigation (INAP, 2009). This is the case with some environmentally important 'trace' elements, such as As, Cd, Cu and Zn, rather than with major rock-forming elements, such as Ca, Mg, K and Na. Elements identified as enriched may not necessarily be a concern for revegetation, drainage water quality or public health, but their significance should still be evaluated. Similarly, because an element is not enriched does not mean it will never be a concern, because under some conditions (e.g. low pH) the solubility of common environmentally important elements such as Al, Cu, Cd, Fe and Zn increases significantly.

A 1:3 (solid:solute) leach can be used to measure the pH, EC, and the concentration of major ions and trace metals/metalloids in water extracts. It should be recognised that direct comparison of geochemical data from 1:3 water extracts with guideline values can be misleading.

RGS has a preference to evaluate the solubility of metals and major ions from mine waste and tailings using kinetic leach cell testing that provides the rate of weathering and associated concentration of elements in the leachate.

3.9 Saline drainage potential

Saline drainage is of concern to regulators in Queensland and other states and territories. Saline drainage can come from the release of major cations and anions from geological units due to weathering of the host rock, or from the accumulation of elements over time e.g. accumulation of NaCl in soil from rain.

Saline drainage can also be attributed to sulfide oxidation process that release sulfate and or the weathering of sulfate minerals such as gypsum. Sulfate and other major ions such as NaCl can be present under both acid and neutral pH conditions.

3.10 AMD classification

Terms used to classify mined materials can include the following.

- **AF** (Acid Forming) – sample is producing acidity (< pH 5), contains no ANC and has additional sulfide content that will oxidise and produce additional acid
- **PAF** (Potentially Acid Forming) – has a pH > 5 and has the potential to produce acid when all ANC is consumed
- **PAF-LC** (Low Capacity – Potentially Acid Forming) - has the potential to produce minor acidity
- **NAF-Barren** (Non-Acid Forming - Barren) - is geochemically inert in respect to total sulfur and will produce circum-neutral drainage in the range of 7 to 9 with low sulfate concentrations
- **NAF** (Non-Acid Forming) - will not produce acid but may leach salts and some metals/metalloids due to the presence of low sulfide bearing material
- **AC** (Acid Consuming) - has some ANC that will contribute to ongoing acid neutralisation e.g. calcite

Other terminology used to classify geological materials include the following.

- Saline - material may leach salts dominated by NaCl and or sulfate
- Sodic – this material has a proportionally high concentration of exchangeable Na and has the potential to disperse and tunnel

General industry terms that can be used to describe water quality at mines include the following.

- Acid Mine Drainage
- Acid Rock Drainage
- Acid and Metalliferous Drainage
- Neutral Drainage
- Saline Drainage
- Mine Impacted Water

In this report we use the term mine impacted water (MIW) as a general term to describe water that comes into contact with disturbed ground. Mine impacted water (MIW) can be classified as having:

- acid, neutral or alkaline pH
- variable concentrations of major ions (salts e.g. calcium, magnesium, potassium, sodium, chloride, sulfate, boron or fluoride, or in the instance of this project - phosphate)
- variable concentrations of metals (e.g. Al, Fe, Mn and Zn) or metalloids (e.g. Be, Mo, Se and V) with the concentrations often linked to pH.

Potential sources of acid in MIW at mine sites can include:

- oxidation of sulfide minerals such as pyrite that produce sulfuric acid (INAP, 2009)
- oxidation of coal that can produce humic acid like materials and organic acid
- rainfall and leaching of cations such as Ca, Mg, K and Na that reduce soil acidification by atmospheric carbonic, nitric or sulfuric acid
- organic matter decay
- use of ammonium-based nitrogen fertilisers.

Potential sources of salts in MIW at mine sites can include:

- oxidation of sulfide minerals, the production of sulfuric acid and subsequent neutralisation reactions that mobilise major ions such as sulfate (SO_4^{2-}) and calcium (Ca^{2+})
- chemical weathering of adjacent soil and rock by sulfuric acid that releases major ions such as sodium (Na^+), potassium (K^+), magnesium (Mg^{2+}) and chloride (Cl^-)
- the mobilisation of sodium chloride (NaCl) or sodium bi-carbonate (NaHCO_3) that are present within geological units and groundwater and then released in fluxes as mined materials are extracted (blasted), processed (crushed) and placed into mine landforms

Potential sources of metals (e.g. Al, Fe, Mn and Zn) and oxyanions (e.g. Mo, Se and V) in water at mine sites that can include elements present:

- as ancillary minerals within primary sulfide minerals like pyrite or marcasite that weather very slowly;
- in the solid phase of geological units in a range of minerals with increasing environmental mobility that include immobile oxide <<< carbonate << exchangeable < water soluble.
- in pore water.

4 Sampling and analytical program

Representative samples of ore and tailings samples were provided by Centrex. In addition, RGS reviewed the geological database and identified 41 samples of overburden from 10 diamond drill cores and 4 samples of footwall material from reverse circulation drill holes that were drilled in 2017. The diamond drill hole locations are shown in **Figure 4-1** and drill holes sampled and sampled intervals are detailed in **Table 4-1**. The analytical program was designed to identify the potential for acidic, saline, and metalliferous drainage (herein referred to as AMD) from the overburden and footwall material below the ore deposit (**Table 4-2**).

Table 4-1: Drill hole samples

Client ID	Area Hole ID	GDA94z54 X Coordinate	GDA94z54 Y Coordinate	Depth From	Depth To	Area Hole Interval	Lithology
RDS001	AMDD023	321684	7602514	1	1.9	Northern	CL
RGS002	AMDD023	321684	7602514	2	2.6	Northern	SH
				2.6	2.95	Northern	SH
				2.95	3.35	Northern	SH
				3.35	4.15	Northern	SH
RGS003	AMDD023	321684	7602514	4.15	4.7	Northern	ST
				4.7	4.75	Northern	CH
				4.75	5.1	Northern	SH
				5.1	5.2	Northern	SH
RGS004	AMDD024	320922	7603153	0.9	1.1	Northern	SH
				1.1	1.9	Northern	SH
				1.9	3	Northern	SH
RGS005	AMDD024	320922	7603153	3	3.1	Northern	EV
				3.1	5.05	Northern	SH
RGS006	AMDD024	320922	7603153	7.9	10.85	Northern	SH
RGS007	AMDD024	320922	7603153	14	14.35	Northern	CH
				14.35	14.45	Northern	ST
				14.45	14.75	Northern	ST
				14.75	14.85	Northern	MS
RGS008	AMDD026	322064	7601844	1.8	4.1	Northern	SH
RGS009	AMDD026	322064	7601844	4.2	5	Northern	SH
				5	5.4	Northern	SH
				5.4	5.9	Northern	SH
RGS010	AMDD026	322064	7601844	6.5	7.25	Northern	SH
				7.25	7.3	Northern	CH
				7.3	7.4	Northern	SH
				7.4	7.5	Northern	FC
				7.5	7.65	Northern	SH
RGS011	AMDD026	322064	7601844	12.5	12.6	Northern	CH
				12.6	12.7	Northern	FP
				12.7	13.1	Northern	CH
				13.1	13.2	Northern	CH
				13.2	13.5	Northern	FP
				13.5	14.9	Northern	ST
RGS012	AMDD005	322064	7601844	1.65	1.9	Southern	SH
				1.9	2.7	Southern	SH
RGS013	AMDD005	323431	7595556	8.04	8.06	Southern	CH
				8.06	8.2	Southern	ST
				8.2	8.35	Southern	IP
				8.35	8.65	Southern	ST
				8.65	8.75	Southern	CH
RGS014	AMDD006	323733	7595704	1.4	2.7	Southern	SH
RGS015	AMDD006	323733	7595704	2.73	4.4	Southern	SH
RGS016	AMDD006	323733	7595704	4.4	8.6	Southern	SH
RGS017	AMDD006	323733	7595704	8.6	12.7	Southern	SH

Client ID	Area Hole ID	GDA94z54 X Coordinate	GDA94z54 Y Coordinate	Depth From	Depth To	Area Hole Interval	Lithology
RGS018	AMDD006	323733	7595704	17.53	17.55	Southern	CH
				17.55	17.7	Southern	FP
				17.7	17.72	Southern	CH
				17.72	17.88	Southern	FP
				17.88	17.9	Southern	CH
RGS019	AMDD006	323733	7595704	17.9	19.23	Southern	ST
RGS020	AMDD008	323131	7595728	1.5	3.1	Southern	SH
RGS021	AMDD008	323131	7595728	3.1	3.13	Southern	SH
				3.13	3.15	Southern	CH
				3.15	3.27	Southern	SH
				3.27	3.32	Southern	CH
				3.32	3.71	Southern	SH
RGS022	AMDD008	323131	7595728	7.9	9.1	Southern	ST
RGS023	AMDD010	323475	7595790	1	2.4	Southern	SU
RGS024	AMDD010	323475	7595790	2.4	3.2	Southern	CL
				3.2	3.8	Southern	SC
				3.8	4.94	Southern	SH
RGS025	AMDD010	323475	7595790	4.94	4.96	Southern	CH
				4.96	5.45	Southern	SH
				5.45	5.55	Southern	SH
RGS026	AMDD010	323475	7595790	9.9	10.05	Southern	SH
				10.05	10.1	Southern	CH
				10.1	10.3	Southern	SH
				10.3	10.9	Southern	ST
				10.9	12	Southern	CH
RGS027	AMDD017	323118	7596031	2	3.2	Southern	SH
RGS028	AMDD017	323118	7596031	9	9.02	Southern	CH
				9.02	10	Southern	ST
RGS029	AMDD018	323574	7596175	0.6	2	Southern	SH
RGS030	AMDD018	323574	7596175	2	3	Southern	SH
				3	3.4	Southern	SH
				3.4	3.65	Southern	SH
RGS031	AMDD018	323574	7596175	6.25	6.35	Southern	FP
				6.35	6.55	Southern	ST
				6.55	6.65	Southern	SH
				6.65	6.75	Southern	FP
				6.75	8.5	Southern	CH
RGS032	AMDD021	323742	7596321	1.7	2	Southern	SH
RGS033	AMDD021	323742	7596321	2	4.3	Southern	SH
RGS034	AMDD021	323742	7596321	4.3	5.9	Southern	SH
RGS035	AMDD021	323742	7596321	5.9	7.2	Southern	SH
RGS036	AMDD021	323742	7596321	10.7	11	Southern	ST
				11	12.7	Southern	CH
				12.7	12.8	Southern	FP
RGS037	AMRC718	321761	7603238	51	52	Northern	ST
RGS038	AMRC728	321683	7603402	51	52	Northern	ST
RGS039	AMRC808	320756	7603619	21	22	Northern	SH
RGS040	AMRC815	321804	7603166	47	48	Northern	ST
RGS041	AMDD024	320922	7603153	17.35	18.35	Northern	ST

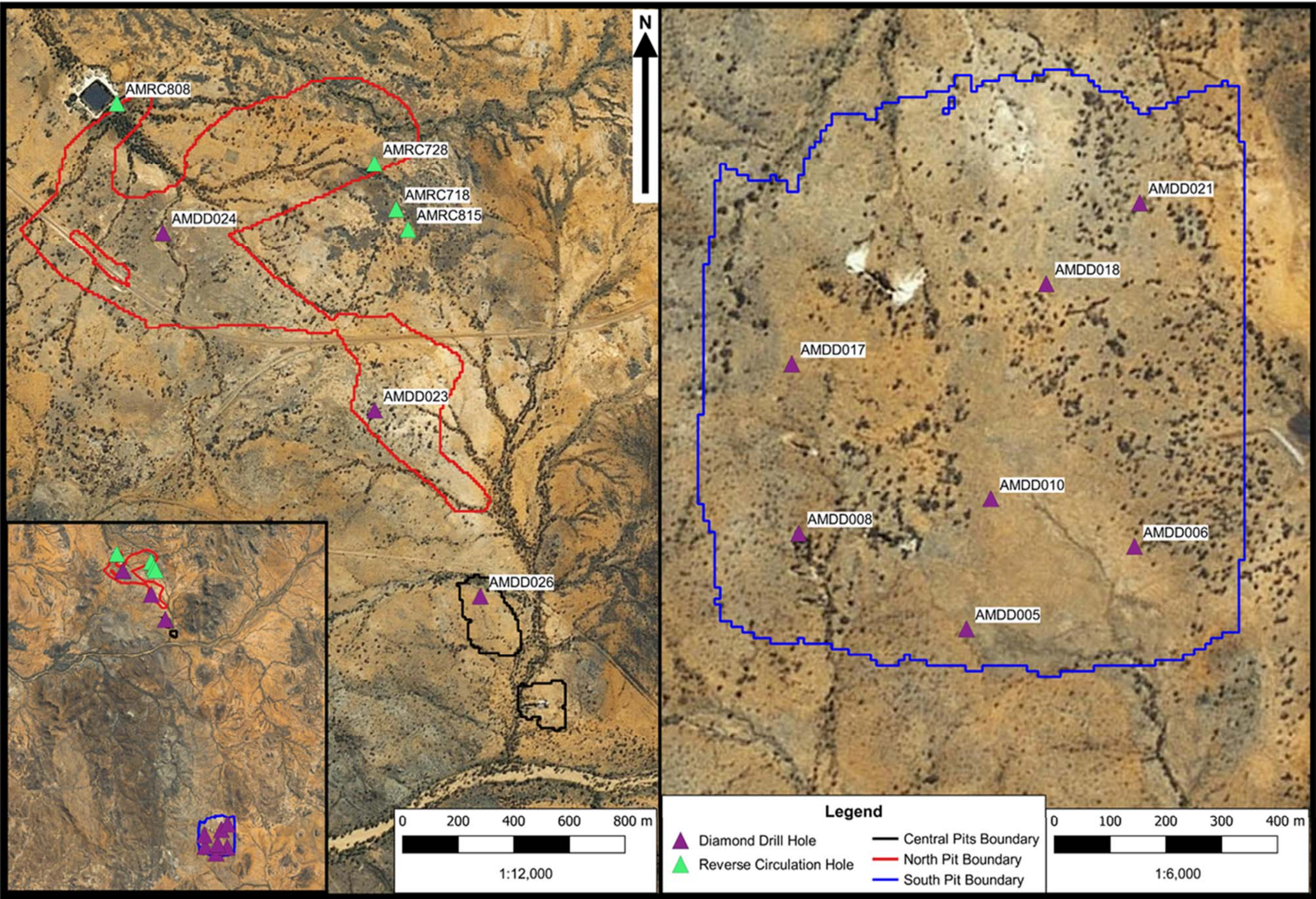


Figure 4-1: Sampled drill hole locations

Table 4-2: Analytical Program

					EA002: pH (Soils)	EA010: Conductivity (Soils)	EA009: Nett Acid Production Potential	EA013: Acid Neutralising Capacity	EA026: Chromium Reducible Sulfur	ED042T: Total Sulfur by LECO	MPA	NPR	ED006/ED008: Exchangeable Cations	EK067G: Total Phosphorus as P by Discrete Analyser	EK074: Fluoride Extractable Phosphorus (Bray)	EP003: Total Organic Carbon (TOC) in Soil	EP080/071: Total Petroleum Hydrocarbons	EP080/071: Total Recoverable Hydrocarbons -	EP080: Benzene, Toluene, Ethylbenzene, Xylene and Naphthalene	ME-MS41: Total Metals by ICP- MS
Sample ID	Area Hole ID	Depth From	Depth To	Lithology	pH Unit	µS/cm	kg H2SO4/t	kg H2SO4 equiv./t	%	%	kg H2SO4 equiv./t		meq/100g	mg/L	mg/kg	%	mg/kg	mg/kg	mg/kg	ppm
Baltimore				Final Attrition Test work (Baltimore)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Tailings - 38µm fraction				Tailings - 38µm fraction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S012	AMDD005	1.65	2.7	SH	✓	✓	✓	✓	✓	✓	✓	✓	✓							
S013	AMDD005	8.04	8.75	CH	✓	✓	✓	✓		✓	✓	✓								
S014	AMDD006	1.4	2.7	SH	✓	✓	✓	✓	✓	✓	✓	✓	✓							
S015	AMDD006	2.73	4.4	SH	✓	✓	✓	✓		✓	✓	✓								
S016	AMDD006	4.4	8.6	SH	✓	✓	✓	✓		✓	✓	✓								
S017	AMDD006	8.6	12.7	SH	✓	✓	✓	✓		✓	✓	✓								
S018	AMDD006	17.53	17.9	CH	✓	✓	✓	✓	✓	✓	✓	✓	✓							
S019	AMDD006	17.9	19.23	ST	✓	✓	✓	✓		✓	✓	✓								
S020	AMDD008	1.5	3.1	SH	✓	✓	✓	✓		✓	✓	✓								
S021	AMDD008	3.1	3.71	SH	✓	✓	✓	✓		✓	✓	✓								
S022	AMDD008	7.9	9.1	ST	✓	✓	✓	✓		✓	✓	✓								
S023	AMDD010	1	2.4	SU	✓	✓	✓	✓	✓	✓	✓	✓	✓							
S024	AMDD010	2.4	4.94	CL	✓	✓	✓	✓		✓	✓	✓								
S025	AMDD010	4.94	5.55	CH	✓	✓	✓	✓	✓	✓	✓	✓	✓							
S026	AMDD010	9.9	12	SH	✓	✓	✓	✓		✓	✓	✓								
S027	AMDD017	2	3.2	SH	✓	✓	✓	✓		✓	✓	✓								
S028	AMDD017	9	10	CH	✓	✓	✓	✓		✓	✓	✓								
S029	AMDD018	0.6	2	SH	✓	✓	✓	✓	✓	✓	✓	✓	✓							
S030	AMDD018	2	3.65	SH	✓	✓	✓	✓	✓	✓	✓	✓	✓							
S031	AMDD018	6.25	8.5	FP	✓	✓	✓	✓	✓	✓	✓	✓	✓							
S032	AMDD021	1.7	2	SH	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓
S033	AMDD021	2	4.3	SH	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓
S034	AMDD021	4.3	5.9	SH	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓
S035	AMDD021	5.9	7.2	SH	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓
S036	AMDD021	10.7	12.8	ST	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓
S001	AMDD023	1	1.9	CL	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓
S002	AMDD023	2	4.15	SH	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓
S003	AMDD023	4.15	5.2	ST	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓
S004	AMDD024	0.9	3	SH	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓
S005	AMDD024	3	5.05	EV	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓
S006	AMDD024	7.9	10.85	SH	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓
S007	AMDD024	14	14.85	CH	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓
S041	AMDD024	17.35	18.35	ST	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓
S008	AMDD026	1.8	4.1	SH	✓	✓	✓	✓	✓	✓	✓	✓	✓							
S009	AMDD026	4.2	5.9	SH	✓	✓	✓	✓	✓	✓	✓	✓	✓							
S010	AMDD026	6.5	7.65	SH	✓	✓	✓	✓	✓	✓	✓	✓	✓							
S011	AMDD026	12.5	14.9	CH	✓	✓	✓	✓	✓	✓	✓	✓	✓							
S037	AMRC718	51	52	ST	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓
S038	AMRC728	51	52	ST	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓
S039	AMRC808	21	22	SH	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓
S040	AMRC815	47	48	ST	✓	✓	✓	✓	✓	✓	✓	✓	✓							✓

5 Interpretation

5.1 Ore and tailings samples

5.1.1 Net acid producing potential

The ore (Ardmore Ore) and tailings (Pilot plant test work) samples provided by Centrex have mildly alkaline pH measured using a 1:5 solid:water ratio 1 hour leach test. The percentage of the total sulfur (TS%) of 0.29% to 0.5% indicated there is some potential for the presence of sulfide minerals. Supplementary analysis undertaken using the chromium reducible sulfur (CRS) method verified that the actual sulfide concentration is < 0.02%. Based on these results the acid producing potential is therefore very low. Coupled with the presence of minor acid neutralising capacity (ANC) in the range of 36 to 66 kg H₂SO₄/t, the maximum potential acidity (MPA) of the samples using the CRS method was < 1 kg H₂SO₄/t.

The net acid producing potential (NAPP) and neutralisation potential ratio (NPR) of the samples using CRS was:

- -66 kg H₂SO₄/t (NAPP) with an NPR of 148 for the -38 µm geotechnical tailings sample; and,
- -36 kg H₂SO₄/t (NAPP) with an NPR of 63 for the Balmore ore sample.

This analysis verifies that both the ore tailings samples are non-acid forming (NAF) and therefore, there is negligible potential for the samples to produce acidic drainage (**Table 5-1**).

Table 5-1: Static geochemical properties of the Ardmore tailings and ore samples

	Sample ID	Ardmore Phosphate Attrition (50Hx) Tailings -38µm fraction (Pilot plant test work)	Centrex Ardmore Phosphate Final Attrition Test work (Ardmore Ore)
	ALS 1st ID	EB1807385	EB1807385
Parameter	ALS 2nd ID	EB1807385001	EB1807385002
pH _{1:5} (EA002)	pH Unit	8.1	7.9
TS	%	0.29	0.5
MPA _{TS}	kg H ₂ SO ₄ /t	8.87	15.29
CRS	%	0.015	0.019
MPA _{CRS}	kg H ₂ SO ₄ /t	0.45	0.58
ANC	kg H ₂ SO ₄ equiv./t	66.9	36.8
NAPP _{TS}	kg H ₂ SO ₄ /t	-58.03	-21.51
NPR _{TS}		7.5	2.4
NAPP _{CRS}	kg H ₂ SO ₄ /t	-66.45	-36.22
NPR _{CRS}		148	63
Moisture Content	%	60.4	1.1

5.1.2 Saline drainage potential

The NAPP data coupled with (1) the EC measured using a 1:5 solid:water ratio 1 hour leach test (2) soluble major ion concentrations measured using a 1:3 solid:water 16 hour leach test and (3) the CEC of the samples suggests there is a low potential for saline drainage from the ore and tailings samples.

However, the exchangeable sodium percentage (ESP) of the Balmore sample verifies some potential for sodic conditions (slaking) to occur in this sample. The low saline drainage potential of the samples does not exclude the potential for saline drainage to become a management issue in an ore stockpile or tailings impoundment as the effects of evapoconcentration in the project environment will increase the salinity in surface water and seepage within the impoundments.

It is noted that the ore may be processed with saline groundwater, dam water or a combination of both for processing i.e. Centrex will not be processing only with non-saline (dam or reverse osmosis) water and will also be processing with saline water (17,000mg/L TDS) and rinsing with non-saline water (from site water dam or reverse osmosis plant). Either way, the TSF will end up holding a substantial salt load through water use.

Table 5-2: Soluble and exchangeable saline properties of the Ardmore ore and tailings samples

	Sample ID	Ardmore Phosphate Attrition (50Hx) Tailings -38µm fraction (Pilot plant test work)	Centrex Ardmore Phosphate Final Attrition Test work (Ardmore Ore)
	ALS 1st ID	EB1807385	EB1807385
Parameter	ALS 2nd ID	EB1807385001	EB1807385002
EC _{1:5} (EA010)	µS/cm	167	1030
1:3 soluble Calcium	mg/L	14	71
1:3 soluble Magnesium	mg/L	6	24
1:3 soluble Sodium	mg/L	23	228
1:3 soluble Potassium	mg/L	2	3
1:3 soluble Chloride	mg/L	25	417
1:3 soluble Sulfate	mg/L	38	167
Exchangeable Calcium	meq/100g	6.4	2.3
Exchangeable Magnesium	meq/100g	2.9	0.8
Exchangeable Potassium	meq/100g	0.2	0.1
Exchangeable Sodium	meq/100g	0.4	0.8
Cation Exchange Capacity	meq/100g	10	3.8
Exchangeable Sodium Percent	%	4.5	20.5

The total concentration of major cations and phosphorous is in **Table 5-3**. The elevated concentration of the Ca and P in the tailings could present issues with these elements in seepage from stockpiles and impounded tailings.

Table 5-3: Total major cation and phosphorous concentrations in tailings samples

	Sample ID	Ardmore Phosphate Attrition (50Hx) Tailings -38µm fraction (Pilot plant test work)	Centrex Ardmore Phosphate Final Attrition Test work (Ardmore Ore)
	ALS 1st ID	EB1807385	EB1807385
Parameter	ALS 2nd ID	EB1807385001	EB1807385002
Sodium	mg/kg	1960	3210
Potassium	mg/kg	3540	1820
Calcium	mg/kg	198000	374000
Magnesium	mg/kg	3610	1630
Total Phosphorus as P	mg/kg	97100	111000
Fluoride Extractable P (Bray)	mg/kg	152	388

5.1.3 Metalliferous drainage potential

The geochemical abundance index (GAI) provides a comparison of total metal/metalloid concentrations compared to median soil values (Bowen, 1979). This can be useful in identifying samples with the potential to elevate metal/metalloid concentrations in the surrounding regolith. GAI values alone are not diagnostic but can be used to highlight metals/metalloids that require further investigation. The solubility of these elements over time is typically assessed using kinetic leach column tests. Total metal/metalloid analysis has been undertaken for the ore and tailings samples and the GAI values are presented in **Table 5-3**.

Nearly all metals and metalloids analysed were within median soil concentrations. While silver, beryllium and tellurium are elevated in comparison to soil concentrations in non-mineralised areas, they are still within the range of background concentrations found in soils. Elevated calcium is likely to be due to the presence of calcium orthophosphate ($\text{Ca}_3(\text{PO}_4)_2$) and apatite ($\text{Ca}_5(\text{PO}_4)_3(\text{F}, \text{Cl}, \text{OH})$).

Uranium was present in the ore and tailings samples at 99 and 93 mg/kg and is often elevated in association with phosphatic sediments in sedimentary rocks and may also be present as an accessory

element in detrital grains (Salminen, et al., 2005) possibly derived from the granites surrounding the outlier. Detrital minerals may contain yttrium (Salminen, et al., 2005) and the formation of xenotime (YPO₄) through diagenesis in phosphatic sediments has been observed (Vallini, Rasmussen, Krapež, Fletcher, & McNaughton, 2002).

Table 5-4: Geochemical Abundance Index of metals and metalloids in the ore and tailings samples

	EB1807385-001	EB1807385-002		EB1807385-001	EB1807385-002
Ag	3	3	Mo	3	2
Al	0	0	Na	0	0
As	3	2	Nb	0	0
Ba	0	0	Ni	0	0
Be	5	5	P	4	4
Bi	1	1	Pb	0	0
Ca	3	0	Rb	0	0
Cd	2	2	S	1	2
Ce	2	2	Sb	2	1
Co	1	1	Sc	2	1
Cr	0	0	Se	0	0
Cs	0	0	Sn	0	0
Cu	2	1	Sr	2	2
Fe	0	0	Ta	0	0
Ga	0	0	Te	5	3
Ge	0	0	Th	0	0
Hf	0	0	Ti	0	0
Hg	0	0	Tl	2	2
In	0	0	U	5	5
K	0	0	V	2	1
La	2	2	W	0	0
Li	0	0	Y	3	3
Mg	0	0	Zn	1	1
Mn	0	0	Zr	0	0

Values of 3 not highlighted are due to rounding.

Because of the GAI values and the fine-grained nature of the samples, the potential for metalliferous drainage was evaluated on these materials by subjecting the two samples to a 1:3 solid:water 16 hour leach test. The pH of the samples using this method was 7.7 and 7.46 and the EC was 263 and 1,650 µS/cm. The water-soluble analyses obtained minor concentrations of the metals/metalloids below:

- < 1.0 > 0.1 mg/L for B, Ba, Sr and Zn
- < 0.1 > 0.01 mg/L for Al, Mo and V
- < 0.01 > 0.001 mg/L for Cr, Li, Mn, Rb
- < 0.0001 mg/L for Cd

All other water soluble leachable elements were less than the laboratory limit of reporting (LoR): this included uranium. The low TS and CRS concentrations coupled with the NAPP and NPR values; and the soluble metal/metalloid concentrations measured on 48 major, minor, trace and rare earth elements using a 1:3 solid:water 16 hour leach test; verify there is a low potential for metalliferous drainage from the samples. However, as discussed above, this does not exclude the potential for metalliferous drainage issues to occur in a tailings impoundment due to evapoconcentration.

5.2 Organic geochemistry

The two tailings samples were analysed for total petroleum hydrocarbons, total recoverable hydrocarbons, BTEXN. All concentrations were less than the laboratory LoR. RGS included these analyses as they were requested by Centrex in the initial scope of work developed with Golder.

5.3 Radioactivity

Radioactive materials, like uranium and radium, are normal constituents of the earth's crust. The radioactivity of phosphate rock is enhanced by geological processes. Phosphate rocks of sedimentary origin contain Uranium (238), Thorium (232) and its decay products in addition to phosphate minerals.

Considerable variations are found in the chemical composition of rock phosphate from different mining areas (Roessler, 1990 in Sahu *et al.*, 2014). In general, sedimentary phosphate rocks, or phosphorites, that originated in a marine environment, are characterised by activity concentrations of uranium much higher than those of volcanic and biological rocks. These phosphates are largely used for the production of phosphoric acid, fertilizers and hence phosphate fertilizer industries are considered to be a potential source of natural radionuclide contamination.

This investigation has not evaluated the potential for radioactive emissions and this should be addressed in a subsequent stage of work, on the overburden, footwall units, ore, and tailings streams.

Radioactive emissions are considered unlikely but should be addressed to verify this assumption.

5.4 Overburden and footwall samples

5.4.1 Net acid producing potential

The majority of the 41 samples ($n = 37$) are circum-neutral or basic with a pH between 6 and 9. The pH of the deionised water used in the analysis of samples was 5.6. Only three samples have pH values below this, 2 at a pH of 5 and 1 with a pH of 3.7, and these are all within the footwall units below the overburden and ore.

Total sulfur concentrations range from 0.02% to 3.15% with a median of 0.12%. Of the 41 samples 16 have total sulfur concentrations below 0.1%. A further 22 samples with a total sulfur concentration of greater than 0.1% were subsequently determined to have sulfide sulfur concentrations measured using CRS of less than 0.1%. The median CRS concentration is notably lower at 0.007%. Only 4 samples had CRS results greater than 0.1%, these were all samples taken from below the maximum proposed pit depth in reverse circulation drill holes (AMRC718, AMRC728, AMRC808 and AMRC815).

In some cases where the samples utilised in the static acid base accounting analyses are older weathered samples there is a need to determine if the measured CRS results accurately reflect in-situ sulfide sulfur content. RGS consider it is probable that the CRS results reflect in-situ conditions. This is because if the samples did initially contain sulfide minerals and they oxidised they would have produced acid that would have resulted in acidic pH measured in the pH analysis, and this was not observed. The samples from this study were drilled in August 2017.

Verification of sulfide content in overburden can be undertaken with the collection and analysis of fresh samples from ongoing drilling that would be collected directly after drilling to ensure that any effects of sulfide oxidation can be accounted for.

Drill hole sample ANC ranges from below the laboratory LoR to the equivalent of 173 kg $\text{H}_2\text{SO}_4/\text{t}$. The median value is 19 kg $\text{H}_2\text{SO}_4/\text{t}$. There is no clear correlation between lithology or depth and ANC (at this stage), although this may become apparent with additional analyses over the life of the project.

When the CRS analyses were combined with the ANC results the NAPP and NPR results verified all overburden samples are NAF or AC (**Table 5-6**). These results indicate that the potential environmental risk associated with the mining, temporary stockpiling and ultimate placement of the overburden that would occur during progressive rehabilitation at the site is relatively low. These NAPP results (do not on their own) discount the potential for environmental issues associated with salinity (refer to **Section 5.3.2**).

Conversely the geochemical analyses of the footwall samples verify that the footwall material below the deposit may be PAF (**Table 5-6**). This suggests that the exposure of PAF waste rock below the ore may result in sulfide oxidation, and care must be taken to prevent acid production in the underlying strata exposed by mining. As all the deeper samples have been obtained from the area around the northern pit, further sampling is recommended in the area of the proposed southern and central pits to determine if potentially acid generating sulfide underlie these pits also. RGS note that the overburden / ore and footwall sequence in the southern deposit which will be exposed through mining is totally oxidised and the potential for PAF material in the footwall in this area is much lower (negligible).

The presence of PAF footwall units below the ore may have the following adverse impacts on water and mine waste management and rehabilitation.

- The removal of ore from the pits will result in (relatively) shallow pits that may nevertheless have exposed PAF material on the pit floor.
- Progressive backfilling of NAF overburden into the mined pits to pre-mine topography will enable parts of the pits to be rehabilitated through replacement of the NAF overburden and soil, reinstating the initial regolith profile. Under this style of progressive rehabilitation management, the potential for PAF footwall material to produce AMD may be substantially reduced.
- However, there will inevitably be residual shallow voids (pits) in the landscape and if these areas contain PAF footwall material the seasonal inundation of the pits with water during the wet season will produce acidic drainage. If the AMD in the pits is not contained in the voids it could seep laterally into the adjoining backfilled rehabilitated areas of the pits and this could have an adverse effect on these areas by introducing acid, salts and metals into backfilled NAF overburden.
- The presence of AMD in the residual pits may also affect surface or groundwater resources in the receiving environment.
- It would be advantageous during development of the project to drill, sample and analyse the footwall materials to ascertain if there are NAF footwall units. If there are, the NAF footwall units would be ideal as the residual voids.

Drill hole sample Acid Base Accounting analysis results are shown in **Table 5-6**. Total sulfur is typically used to calculate the MPA and used with ANC results to calculate the NAPP and the NPR. In this study the CRS% (and TS% in the absence of measured CRS) were used with the NAPP. NPR and pH were used to classify the samples for their acid producing or consuming potential (**Table 5-5**). The bulk of the samples contain insufficient sulfide sulfur to have acid forming potential. The samples classified as PAF are hosted within siltstones and shales at a minimum depth of 21 m below ground level.

Table 5-5: AMD classification

Classification	1:5 pH	Total Sulfur %	Total Sulfide %	NAPP (kg H ₂ SO ₄ /t)	NPR	No. of Samples (n=41)
Acid Consuming (AC)	> 5	< 1.0		> -100	> 10	6
Non-Acid Forming - Barren	> 5	< 0.2	< 0.05	-ve		21
Non-Acid Forming	> 5		< 0.1	-ve	≥ 3	10
Potentially Acid Forming – Low Capacity (PAF-LC)	> 5	> 0.2			< 3 > 2	
Potentially Acid Forming (PAF)	> 5	> 0.2			< 2	3
Acid Forming (AF)	< 5	> 0.2	> 0.2	+ve	< 1	1

Figure 5-1 categorises the risk of acidic drainage and sulfate / saline from the drill hole samples. The data points have been coloured to match the classification colouring in **Table 5-5**. The ratio of ANC to MPA for the samples is used to help assess the level of risk of acidic drainage.

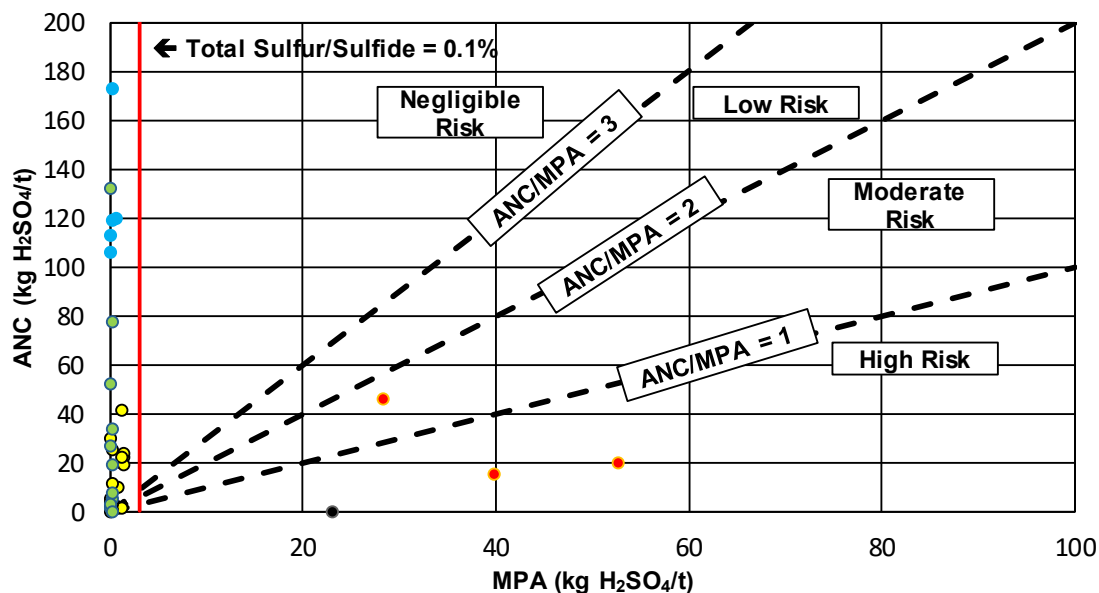


Figure 5-1: Drill hole samples ANC vs MPA plot

Figure 5-2 demonstrates the relationship between TS and CRS in the drill hole samples. All samples contain more sulfur than is present as sulfide sulfur. Lithology logging describes the presence of evaporite minerals thought to be gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) suggesting sulfur is potentially present as sulfate, and or other secondary sulfate minerals.

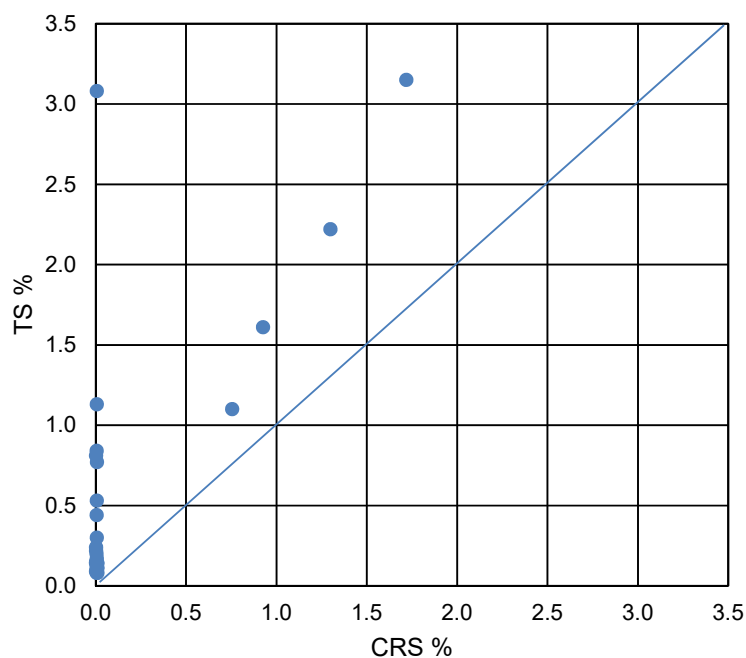


Figure 5-2: A comparison of TS vs. CRS in the drill hole samples

5.4.2 Saline drainage potential

Soil salinity refers to the presence of water soluble salts in a sample that are mainly of sodium, but also of potassium, calcium and magnesium chloride, sulfate or carbonate minerals (Hazelton & Murphy, 2007).

The electrical conductivity was measured using a 1:5 solid to water ratio ($EC_{1:5}$) that determines the salinity level in the samples at the time they were sampled. The $EC_{1:5}$ results are converted to E_{Ce} values based on the estimated water holding capacity of the soils that is based on textural classification. For determining EC it was assumed that the predominant texture of the finer graded mined material would be a silty clay.

Of the 41 samples the E_{Ce} results determined there are:

- (n=0) < 2,000 $\mu\text{S}/\text{cm}$ are non-saline
- (n=5) 2,000 to 4,000 $\mu\text{S}/\text{cm}$ are slightly-saline
- (n=6) 4,000 to 8,000 $\mu\text{S}/\text{cm}$ are moderately saline
- (n=13) 8,000 to 16,000 $\mu\text{S}/\text{cm}$ are highly saline
- (n=17) >16,000 $\mu\text{S}/\text{cm}$ are extremely saline

Most samples (n = 30) have an EC result that is categorised as highly saline, i.e. greater than 8,000 $\mu\text{S}/\text{cm}$ (Hazelton & Murphy, 2007).

The presence of elevated concentrations of salts in the overburden samples indicates that saline drainage could be a significant aspect for site water management. As there is no obvious correlation between major exchangeable cations and salinity it is hypothesised that salinity is predominately present in the form of sodium chloride and sulfate bearing minerals. The concentrations of total phosphorus suggest phosphate may also contribute to the elevated EC measured on the overburden and footwall samples.

The mining process applied to the soil and overburden will increase the particle size distribution of the samples and lead to an increased potential for elevated EC and saline drainage. If the overburden is not mined, stored and used effectively there could be adverse effects on vegetation from salts (and or excessive phosphorous) and compounding adverse effects on the ability of rehabilitated surfaces to develop resilient vegetative cover and resist erosion.

The risk associated with saline drainage and rehabilitation will be largely overcome through adoption of a strip mining and progressive rehabilitation mine plan that is being proposed by Centrix.

5.4.3 Metalliferous drainage potential

Total elemental analyses were undertaken on selected overburden and footwall samples to evaluate the level of mineralisation in these materials. The total elemental concentrations were compared with average soil concentrations to develop an understanding of potential metalliferous issues. The GAI results (**Table 5-7**) coupled with the elevated sulfide concentrations in footwall geological units verify that there may be some metalliferous issues associated with operational water management. However, the issues are likely to be driven by the presence of elements that are prone to be present at circum-neutral pH in the overburden such as Be, Mo and P. In the footwall materials the oxidation of sulfide minerals may produce acidic drainage that could be elevated in a broader range of elements including Al, Fe, Co, Cu, Fe, Mn and Zn.

The GAI values on their own do not infer these elements will be environmentally mobile. As discussed previously the potential for saline and metalliferous drainage should be evaluated using fresh drill core samples and kinetic leach cell testing.

Table 5-6: Drill hole sample Acid/Base Accounting and material classification

Area Hole ID	Depth From	Depth To	Lithology	pH	EC	ECe	Sulfur - Total as S (LECO)	MPA _{TS}	CRS	MPA _{CRS}	ANC as H ₂ SO ₄	NAPP _{TS}	NAPP _{CRS or TS}	NPR _{CRS}	Classification
	m bgl	m bgl		pH Unit	µS/cm	µS/cm	%	kg H ₂ SO ₄ /t	%	kg H ₂ SO ₄ /t	kg H ₂ SO ₄ /t	kg H ₂ SO ₄ /t	kg H ₂ SO ₄ /t		
AMDD005	1.7	2.7	SH	8.4	1270	10922	0.17	5.2	0.0070	0.2	119.0	-113.80	-118.79	555.7	Acid Consuming
AMDD005	8.0	8.8	CH	7.8	492	4231	0.04	1.2	0.0400	1.2	20.0	-18.78	-18.78	16.3	Non-Acid Forming (Barren)
AMDD006	1.4	2.7	SH	7.2	3950	33970	0.81	24.8	0.0025	0.1	1.7	23.08	-1.62	22.2	Non-Acid Forming
AMDD006	2.7	4.4	SH	6.2	1670	14362	0.03	0.9	0.0300	0.9	1.7	-0.78	-0.78	1.9	Non-Acid Forming (Barren)
AMDD006	4.4	8.6	SH	7.3	1420	12212	0.02	0.6	0.0200	0.6	2.6	-1.99	-1.99	4.2	Non-Acid Forming (Barren)
AMDD006	8.6	12.7	SH	7.7	1570	13502	0.02	0.6	0.0200	0.6	1.5	-0.89	-0.89	2.5	Non-Acid Forming (Barren)
AMDD006	17.5	17.9	CH	8.5	513	4412	0.08	2.4	0.0060	0.2	30.2	-27.75	-30.02	164.5	Non-Acid Forming (Barren)
AMDD006	17.9	19.2	ST	8.1	314	2700	0.05	1.5	0.0500	1.5	22.6	-21.07	-21.07	14.8	Non-Acid Forming (Barren)
AMDD008	1.5	3.1	SH	8.6	1000	8600	0.02	0.6	0.0200	0.6	120.0	-119.39	-119.39	196.1	Acid Consuming
AMDD008	3.1	3.7	SH	8.6	1050	9030	0.04	1.2	0.0400	1.2	41.2	-39.98	-39.98	33.7	Non-Acid Forming (Barren)
AMDD008	7.9	9.1	ST	8.6	627	5392	0.05	1.5	0.0500	1.5	19.3	-17.77	-17.77	12.6	Non-Acid Forming (Barren)
AMDD010	1.0	2.4	SU	6.3	3640	31304	0.77	23.6	0.0080	0.2	0.3	23.30	-0.01	1.0	Non-Acid Forming
AMDD010	2.4	4.9	CL	5.8	1880	16168	0.04	1.2	0.0400	1.2	1.6	-0.38	-0.38	1.3	Non-Acid Forming (Barren)
AMDD010	4.9	5.6	CH	6.1	2030	17458	0.1	3.1	0.0070	0.2	0.9	2.16	-0.69	4.2	Non-Acid Forming (Barren)
AMDD010	9.9	12.0	SH	7.9	379	3259	0.05	1.5	0.0500	1.5	23.6	-22.07	-22.07	15.4	Non-Acid Forming (Barren)
AMDD017	2.0	3.2	SH	8.4	768	6605	0.03	0.9	0.0300	0.9	10.1	-9.18	-9.18	11.0	Non-Acid Forming (Barren)
AMDD017	9.0	10.0	CH	8.6	638	5487	0.04	1.2	0.0400	1.2	22.5	-21.28	-21.28	18.4	Non-Acid Forming (Barren)
AMDD018	0.6	2.0	SH	8.1	3310	28466	0.44	13.5	0.0060	0.2	52.3	-38.84	-52.12	285.0	Non-Acid Forming
AMDD018	2.0	3.7	SH	7.6	1680	14448	0.14	4.3	0.0090	0.3	3.4	0.88	-3.12	12.4	Non-Acid Forming (Barren)
AMDD018	6.3	8.5	FP	8.1	1170	10062	0.11	3.4	0.0090	0.3	11.8	-8.44	-11.52	42.9	Non-Acid Forming (Barren)
AMDD021	1.7	2.0	SH	8.3	2540	21844	0.08	2.4	0.0100	0.3	34.1	-31.65	-33.79	111.5	Non-Acid Forming
AMDD021	2.0	4.3	SH	8.0	4130	35518	0.3	9.2	0.0070	0.2	19.3	-10.12	-19.09	90.1	Non-Acid Forming
AMDD021	4.3	5.9	SH	8.1	1960	16856	0.12	3.7	0.0060	0.2	3.7	-0.03	-3.52	20.2	Non-Acid Forming (Barren)
AMDD021	5.9	7.2	SH	7.3	1540	13244	0.14	4.3	0.0025	0.1	0.3	4.03	-0.17	3.3	Non-Acid Forming (Barren)
AMDD021	10.7	12.8	ST	7.5	387	3328	0.1	3.1	0.0060	0.2	3.1	-0.04	-2.92	16.9	Non-Acid Forming (Barren)
AMDD023	1.0	1.9	CL	7.7	4710	40506	0.84	25.7	0.0060	0.2	26.5	-0.80	-26.32	144.4	Non-Acid Forming
AMDD023	2.0	4.2	SH	6.3	2450	21070	0.09	2.8	0.0025	0.1	5.1	-2.35	-5.02	66.7	Non-Acid Forming (Barren)
AMDD023	4.2	5.2	ST	8.6	1790	15394	0.09	2.8	0.0060	0.2	113.0	-110.25	-112.82	615.7	Acid Consuming
AMDD024	0.9	3.0	SH	6.5	5540	47644	1.13	34.6	0.0070	0.2	5.4	29.17	-5.19	25.2	Non-Acid Forming
AMDD024	3.0	5.1	EV	7.6	4520	38872	3.08	94.2	0.0070	0.2	7.6	86.62	-7.39	35.5	Non-Acid Forming
AMDD024	7.9	10.9	SH	7.5	2060	17716	0.2	6.1	0.0050	0.2	2.6	3.52	-2.45	17.0	Non-Acid Forming (Barren)
AMDD024	14.0	14.9	CH	7.5	415	3569	0.24	7.3	0.0025	0.1	2.8	4.54	-2.72	36.6	Non-Acid Forming
AMDD024	17.4	18.4	ST	7.4	359	3087	0.11	3.4	0.0100	0.3	25.0	-21.64	-24.69	81.7	Non-Acid Forming (Barren)
AMDD026	1.8	4.1	SH	8.4	4610	39646	0.53	16.2	0.0070	0.2	173.0	-156.79	-172.79	807.9	Acid Consuming
AMDD026	4.2	5.9	SH	8.8	2100	18060	0.15	4.6	0.0025	0.1	106.0	-101.41	-105.92	1386.1	Acid Consuming
AMDD026	6.5	7.7	SH	8.5	3380	29068	0.22	6.7	0.0025	0.1	132.0	-125.27	-131.92	1726.1	Acid Consuming
AMDD026	12.5	14.9	CH	8.8	542	4661	0.14	4.3	0.0100	0.3	77.4	-73.12	-77.09	253.0	Non-Acid Forming
AMRC718	51.0	52.0	ST	5.0	1770	15222	2.22	67.9	1.3000	39.8	15.3	52.61	24.47	0.4	Potentially Acid Forming
AMRC728	51.0	52.0	ST	5.0	1930	16598	3.15	96.4	1.7200	52.6	19.9	76.46	32.71	0.4	Potentially Acid Forming
AMRC808	21.0	22.0	SH	3.7	1640	14104	1.1	33.6	0.7560	23.1	0.3	33.40	22.88	0.0	Acid Forming
AMRC815	47.0	48.0	ST	6.2	1050	9030	1.61	49.2	0.9270	28.4	46.4	2.85	-18.04	1.6	Potentially Acid Forming
<p>Red values Concentration is below detection limit</p> <p>Blue values TS value used in place of measured CRS value</p>															

Table 5-7: Geochemical abundance index of total metals and metalloids in the drill hole samples

Sample ID	S032	S033	S034	S035	S036	S001	S002	S003	S004	S005	S006	S007	S041	S037	S038	S039	S040
Drill Hole ID	AMDD021	AMDD021	AMDD021	AMDD021	AMDD021	AMDD023	AMDD023	AMDD023	AMDD024	AMDD024	AMDD024	AMDD024	AMDD024	AMRC718	AMRC728	AMRC808	AMRC815
From	1.7	2	4.3	5.9	10.7	1	2	4.15	0.9	3	7.9	14	17.35	51	51	21	47
To	2	4.3	5.9	7.2	11	1.9	2.6	4.7	1.1	3.1	10.85	14.35	18.35	52	52	22	48
Element																	
Al	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
As	0	0	2	0	1	0	0	0	2	1	0	1	0	1	2	1	2
Ba	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Be	1	0	0	0	3	2	2	3	1	0	2	4	3	3	3	1	6
Bi	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0
Ca	0	0	0	0	0	0	0	2	0	0	0	0	1	0	1	0	4
Cd	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Ce	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Co	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Fe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ga	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hf	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	1	0	0	0	0	0	0	0	2	1	1	1	1
In	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
La	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Li	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo	0	0	4	2	2	0	0	0	4	3	3	2	1	3	2	3	2
Nb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P	0	0	0	0	2	0	0	4	1	1	2	3	4	3	4	0	5
Pb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S	0	1	0	0	0	3	0	0	3	4	1	1	0	4	5	3	4
Sb	0	0	3	3	0	0	0	0	1	1	1	1	0	0	0	1	0
Sc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Se	0	0	2	0	0	0	0	0	2	1	0	1	1	2	3	2	2
Sn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sr	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Ta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Te	2	2	3	3	3	2	3	3	2	2	3	2	2	2	2	3	2
Th	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Ti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tl	0	0	0	0	2	0	0	0	0	0	0	2	0	1	1	2	3
U	0	0	2	1	3	0	0	2	1	1	2	3	3	3	3	2	5
V	0	0	1	0	0	0	0	1	1	1	0	1	0	0	0	0	0
W	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Y	0	0	0	0	0	0	0	2	0	0	0	1	1	0	1	0	3
Zn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Values of 3 not highlighted are due to rounding

6 Conclusion and recommendations

Ore and tailings streams

Results suggest that the provided ore and tailings samples are NAF and geochemically benign, with a relatively low risk of generating acidic or saline drainage. It is noted that during production on site the ore may be processed with saline groundwater. Under this approach the tailings may have a higher salt load. The presence of elevated calcium and phosphorous in the samples suggests that management of these elements will be a concern in any ore or tailings streams.

Overburden

The overburden samples (n=36) utilised in the study were fresh samples (< 12 months old). All overburden samples had circum-neutral to mildly alkaline pH verifying the samples had not oxidised and produced acid between the time they were drilled and assayed. The sulfide sulfur analyses using CRS are therefore considered to reflect actual in-situ sulfide content.

The geochemical analyses of the overburden using measured sulfide sulfur to calculate the maximum potential acidity and resultant net acid producing potential verify that the samples are NAF-Barren, NAF or AC.

Of concern from an environmental perspective are the elevated electrical conductivity (EC) measurements in some samples that could also manifest as elevated salinity. The source of the elevated EC has not been determined but could be associated with NaCl or sulfate minerals and/or phosphate.

Footwall units

The footwall units evaluated have determined this material has a high potential to oxidise rapidly and produce acid, saline and metalliferous drainage. Management of footwall materials is likely to be required to minimise the potential for AMD during mining and post closure in the northern area, but in the southern area the overburden, ore and footwall sequence is completely oxidised and the likelihood of PAF material in this area is lower (negligible).

Associated geological units

Limestone and dolomite are present in the project area. The mining and use of these materials will enable adequate management of acid drainage issues either by crushing and adding fine ground limestone to PAF mine waste or using it to treat and manage acid water.

Forward works

Static testing

Static testing including radioactive testing is recommended on ore and tailings materials during project development to ensure that the geochemical characteristics of site produced material is quantified and tracked to measure any changes in these materials over time. The geochemical analysis should include measurement of pH, EC, TS, CRS and ANC. Selected samples should be analysed for soluble, exchangeable and total elemental concentrations.

Supplementary static testing should be undertaken on freshly drilled samples during resource drilling or the collection of representative samples from the proposed test to verify the outcomes of this study. The geochemical analysis should include measurement of pH, EC, TS, CRS and ANC. Selected samples should be analysed for soluble, exchangeable and total elemental concentrations.

Kinetic leach cell testing

Kinetic leach cells testing is required to be undertaken on mined materials that have the potential to produce acid, saline or metalliferous drainage.

RGS recommend that KLC testing should be done all major mine waste types and or beneficiation (ore and tailings) products and should be done for a minimum of 12 months using monthly leach cycles. This

test work should be commenced during subsequent stages of the project to verify the long-term performance of the materials that are removed during mining or that are produced on site from processing streams.

Management plans

A suitable management plan (e.g. AMD Management, Mine Waste Management or Progressive Rehabilitation and Closure Plan) should be developed for the project and include a sampling and analytical program to address the static and kinetic testing programs.

These data would be utilised in site water quality modelling that is utilised to evaluate the ability to meet water quality objectives for the project during operations and then into the closure phase.

7 References

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Appendix

Ore and tailings samples

CERTIFICATE OF ANALYSIS

Work Order : **EB1807385**
Client : **RGS ENVIRONMENTAL PTY LTD**
Contact : **MR ALAN ROBERTSON**
Address : **PO Box 3091**
SUNNYBANK SOUTH QLD, AUSTRALIA 4109
Telephone : **+61 07 3344 1222**
Project : **2018002 - Ardmore Project**
Order number :
C-O-C number : **----**
Sampler : **SITE**
Site : **----**
Quote number : **BN/058/18 V3**
No. of samples received : **3**
No. of samples analysed : **3**

Page : 1 of 9
Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 16-Mar-2018 09:40
Date Analysis Commenced : 22-Mar-2018
Issue Date : 06-Apr-2018 18:32



Accreditation No. 825
 Accredited for compliance with
 ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Andrew Epps	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Diana Mesa	2IC Organic Chemist	Brisbane Organics, Stafford, QLD
Greg Vogel	Laboratory Manager	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.



Analytical Results

Sub-Matrix: LEACHATE
 (Matrix: WATER)

Client sample ID

				Ardmore Phosphate Attrition (50Hx) -38µm Tailing Product (Geotech Test Work)	Centrex Ardmore Phosphate Final Attrition Test work (Balmore)	----	----	----
Client sampling date / time				13-Feb-2018 00:00	07-Mar-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1807385-001	EB1807385-002	-----	-----	-----
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.70	7.46	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	263	1650	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	36	29	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	36	29	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	38	167	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	25	417	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	14	71	----	----	----
Magnesium	7439-95-4	1	mg/L	6	24	----	----	----
Sodium	7440-23-5	1	mg/L	23	228	----	----	----
Potassium	7440-09-7	1	mg/L	2	3	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.01	0.01	----	----	----
Dysprosium	7429-91-6	0.001	mg/L	<0.001	<0.001	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	0.001	<0.001	----	----	----
Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	----	----	----
Erbium	7440-52-0	0.001	mg/L	<0.001	<0.001	----	----	----
Boron	7440-42-8	0.05	mg/L	0.14	0.24	----	----	----
Europium	7440-53-1	0.001	mg/L	<0.001	<0.001	----	----	----
Strontium	7440-24-6	0.001	mg/L	0.078	0.322	----	----	----
Barium	7440-39-3	0.001	mg/L	0.764	0.887	----	----	----
Gadolinium	7440-54-2	0.001	mg/L	<0.001	<0.001	----	----	----
Titanium	7440-32-6	0.01	mg/L	<0.01	<0.01	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	----	----	----
Gallium	7440-55-3	0.001	mg/L	<0.001	<0.001	----	----	----



Analytical Results

Sub-Matrix: LEACHATE
 (Matrix: WATER)

Client sample ID

				Ardmore Phosphate Attrition (50Hx) -38µm Tailing Product (Geotech Test Work)	Centrex Ardmore Phosphate Final Attrition Test work (Balmore)	----	----	----
Client sampling date / time				13-Feb-2018 00:00	07-Mar-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1807385-001	EB1807385-002	-----	-----	-----
				Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Cadmium	7440-43-9	0.0001	mg/L	0.0001	0.0004	----	----	----
Hafnium	7440-58-6	0.01	mg/L	<0.01	<0.01	----	----	----
Tellurium	22541-49-7	0.005	mg/L	<0.005	<0.005	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	----	----	----
Holmium	7440-60-0	0.001	mg/L	<0.001	<0.001	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	----	----	----
Caesium	7440-46-2	0.001	mg/L	<0.001	<0.001	----	----	----
Chromium	7440-47-3	0.001	mg/L	0.001	0.001	----	----	----
Indium	7440-74-6	0.001	mg/L	<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L	0.001	<0.001	----	----	----
Lanthanum	7439-91-0	0.001	mg/L	<0.001	<0.001	----	----	----
Rubidium	7440-17-7	0.001	mg/L	0.001	0.003	----	----	----
Lithium	7439-93-2	0.001	mg/L	0.001	0.004	----	----	----
Lutetium	7439-94-3	0.001	mg/L	<0.001	<0.001	----	----	----
Thorium	7440-29-1	0.001	mg/L	<0.001	<0.001	----	----	----
Cerium	7440-45-1	0.001	mg/L	<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L	0.004	0.005	----	----	----
Neodymium	7440-00-8	0.001	mg/L	<0.001	<0.001	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	0.005	0.011	----	----	----
Praseodymium	7440-10-0	0.001	mg/L	<0.001	<0.001	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	----	----	----
Samarium	7440-19-9	0.001	mg/L	<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Terbium	7440-27-9	0.001	mg/L	<0.001	<0.001	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	----	----
Thulium	7440-30-4	0.001	mg/L	<0.001	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	----	----	----
Ytterbium	7440-64-4	0.001	mg/L	<0.001	<0.001	----	----	----
Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	----	----	----
Yttrium	7440-65-5	0.001	mg/L	<0.001	<0.001	----	----	----
Thallium	7440-28-0	0.001	mg/L	<0.001	<0.001	----	----	----
Zirconium	7440-67-7	0.005	mg/L	<0.005	<0.005	----	----	----
Vanadium	7440-62-2	0.01	mg/L	0.01	0.01	----	----	----



Analytical Results

Sub-Matrix: **LEACHATE**
 (Matrix: **WATER**)

Client sample ID

				Ardmore Phosphate Attrition (50Hx) -38µm Tailing Product (Geotech Test Work)	Centrex Ardmore Phosphate Final Attrition Test work (Balmore)	----	----	----
Client sampling date / time				13-Feb-2018 00:00	07-Mar-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1807385-001	EB1807385-002	-----	-----	-----
				Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Zinc	7440-66-6	0.005	mg/L	0.040	0.141	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.01	<0.01	----	----	----



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				Ardmore Phosphate Attrition (50Hx) -38µm Tailing Product (Geotech Test Work)	Centrex Ardmore Phosphate Final Attrition Test work (Balmore)	DI Water - pH & EC	----	----
Client sampling date / time				13-Feb-2018 00:00	07-Mar-2018 00:00	22-Mar-2018 00:00	----	----
Compound	CAS Number	LOR	Unit	EB1807385-001	EB1807385-002	EB1807385-003	-----	-----
				Result	Result	Result	----	----
EK074: Fluoride Extractable Phosphorus (Bray) - Continued								
Fluoride Extractable P (Bray)	----	1.0	mg/kg	152	388	----	----	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.10	0.07	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	10	mg/kg	<10	<10	----	----	----
C10 - C14 Fraction	----	50	mg/kg	<50	<50	----	----	----
C15 - C28 Fraction	----	100	mg/kg	<100	<100	----	----	----
C29 - C36 Fraction	----	100	mg/kg	<100	<100	----	----	----
^ C10 - C36 Fraction (sum)	----	50	mg/kg	<50	<50	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	10	mg/kg	<10	<10	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	10	mg/kg	<10	<10	----	----	----
>C10 - C16 Fraction	----	50	mg/kg	<50	<50	----	----	----
>C16 - C34 Fraction	----	100	mg/kg	<100	<100	----	----	----
>C34 - C40 Fraction	----	100	mg/kg	<100	<100	----	----	----
^ >C10 - C40 Fraction (sum)	----	50	mg/kg	<50	<50	----	----	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	50	mg/kg	<50	<50	----	----	----
EP080: BTEXN								
Benzene	71-43-2	0.2	mg/kg	<0.2	<0.2	----	----	----
Toluene	108-88-3	0.5	mg/kg	<0.5	<0.5	----	----	----
Ethylbenzene	100-41-4	0.5	mg/kg	<0.5	<0.5	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	0.5	mg/kg	<0.5	<0.5	----	----	----
ortho-Xylene	95-47-6	0.5	mg/kg	<0.5	<0.5	----	----	----
^ Sum of BTEX	----	0.2	mg/kg	<0.2	<0.2	----	----	----
^ Total Xylenes	----	0.5	mg/kg	<0.5	<0.5	----	----	----
Naphthalene	91-20-3	1	mg/kg	<1	<1	----	----	----
Sample Preparation Method								
Amount	----	0.1	g	1.0	1.0	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	0.2	%	58.1	89.3	----	----	----



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				Ardmore Phosphate Attrition (50Hx) -38µm Tailing Product (Geotech Test Work)	Centrex Ardmore Phosphate Final Attrition Test work (Balmore)	DI Water - pH & EC	----	----
Client sampling date / time				13-Feb-2018 00:00	07-Mar-2018 00:00	22-Mar-2018 00:00	----	----
Compound	CAS Number	LOR	Unit	EB1807385-001	EB1807385-002	EB1807385-003	-----	-----
				Result	Result	Result	----	----
EP080S: TPH(V)/BTEX Surrogates - Continued								
Toluene-D8	2037-26-5	0.2	%	60.3	87.2	----	----	----
4-Bromofluorobenzene	460-00-4	0.2	%	60.6	87.4	----	----	----



Surrogate Control Limits

Sub-Matrix: **SOIL**

		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP080S: TPH(V)/BTEX Surrogates			
1,2-Dichloroethane-D4	17060-07-0	53	134
Toluene-D8	2037-26-5	60	131
4-Bromofluorobenzene	460-00-4	59	127

Page: 1
Total # Pages: 2 (A - D)
Plus Appendix Pages
Finalized Date: 29- MAR- 2018
Account: ALSNV

SAMPLE PREPARATION	
ALS CODE	DESCRIPTION
LOG- 22	Sample login - Rcd w/o BarCode
ANALYTICAL PROCEDURES	
ALS CODE	DESCRIPTION
ME- MS41	Ultra Trace Aqua Regia ICP- MS

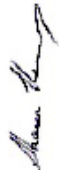
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CERTIFICATE BR18063906	
Project: EB1807385 P.O. No.: ME- MS41 This report is for 2 Pulp samples submitted to our lab in Brisbane, QLD, Australia on 23-MAR- 2018. The following have access to data associated with this certificate: SUB RESULTS - BRIS	

To: ALS ENVIRONMENTAL
ATTN: SUB RESULTS - BRIS
32 SHAND STREET
STAFFORD QLD 4053

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.
***** See Appendix Page for comments regarding this certificate *****

Signature: 
Shaun Kenny, Brisbane Laboratory Manager

Page: 2 - A
Total # Pages: 2 (A - D)
Plus Appendix Pages
Finalized Date: 29- MAR- 2018
Account: ALSENV

Project: EB1807385

CERTIFICATE OF ANALYSIS BR18063906

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Sample Description	Method Analyte Units LOR	ME-M541 Ag ppm 0.01	ME-M541 Al %	ME-M541 As ppm 0.1	ME-M541 Au ppm 0.02	ME-M541 B ppm 10	ME-M541 Ba ppm 10	ME-M541 Be ppm 0.05	ME-M541 Bi ppm 0.01	ME-M541 Ca %	ME-M541 Cd ppm 0.01	ME-M541 Ce ppm 0.02	ME-M541 Co ppm 0.1	ME-M541 Cr ppm 1	ME-M541 Cs ppm 0.05	ME-M541 Cu ppm 0.2
EB1807385-001		0.70	4.10	44.5	<0.02	40	800	13.40	0.59	19.90	1.83	371	20.9	113	2.89	140.5
EB1807385-002		0.57	2.01	36.2	<0.02	30	700	13.05	0.43	>25.0	2.26	417	17.2	62	1.16	91.8

***** See Appendix Page for comments regarding this certificate *****

Method	Analyte	Units	LOR	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41	ME-MS41
Sample Description				Fe	Ca	Ce	Hf	Hg	In	K	La	Li	Mg	Mn	Mo	Na	Ni	
				%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	
EB1807385-001				2.69	9.25	0.84	0.29	0.04	0.090	0.51	207	19.2	0.36	333	12.25	0.19	0.60	72.6
EB1807385-002				1.92	5.56	0.68	0.72	0.04	0.047	0.23	250	8.2	0.16	315	10.05	0.34	0.33	41.6

***** See Appendix Page for comments regarding this certificate *****

Page: 2 - C
Total # Pages: 2 (A - D)
Plus Appendix Pages
Finalized Date: 29- MAR- 2018
Account: ALSENV

Project: EB1807385

CERTIFICATE OF ANALYSIS **BRI8063906**

Australian Laboratory Services Pty. Ltd.
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Sample Description	Method Analyte Units LOR	ME-M541 P ppm 10	ME-M541 Pb ppm 0.2	ME-M541 Rb ppm 0.1	ME-M541 Re ppm 0.001	ME-M541 S %	ME-M541 Sb ppm 0.05	ME-M541 Sc ppm 0.1	ME-M541 Se ppm 0.2	ME-M541 Sn ppm 0.2	ME-M541 Sr ppm 0.2	ME-M541 Ta ppm 0.01	ME-M541 Te ppm 0.01	ME-M541 Th ppm 0.2	ME-M541 Ti %	ME-M541 Tl ppm 0.02
EB1807385-001		>25000	496	27.8	<0.001	0.23	5.44	29.8	0.5	1.4	1175	0.01	0.26	18.2	0.018	0.95
EB1807385-002		>25000	34.5	12.9	0.001	0.39	3.75	27.4	0.2	0.6	1090	0.01	0.10	14.7	0.009	0.94

***** See Appendix Page for comments regarding this certificate *****

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Finalized Date: 29- MAR- 2018
Account: ALSENV

Project: EB1807385

CERTIFICATE OF ANALYSIS BR18063906

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Accreditation No: 825, Corporate Site No: 818.



Sample Description	Method	Analyte	Units	LOR	ME-M641	ME-M641	ME-M641	ME-M641	ME-M641	ME-M641	ME-M641
EB1807385-001		U	ppm	0.05	99.3	508	1.02	600	338	5.2	
EB1807385-002					93.4	346	0.58	670	246	24.2	

***** See Appendix Page for comments regarding this certificate *****

Page: Appendix 1
Total # Appendix Pages: 1
Finalized Date: 29- MAR- 2018
Account: ALSENV

Project: EB1807385

CERTIFICATE OF ANALYSIS **BRI8063906**

Australian Laboratory Services Pty. Ltd.
32 Shand Street
Stafford
Brisbane QLD 4053
Phone: +61 (7) 3243 7222 Fax: +61 (7) 3243 7218
www.alsglobal.com/geochemistry
ALS Brisbane is a NATA Accredited Testing Laboratory. Corporate
Accreditation No: 825, Corporate Site No: 818.



CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g).
ME- MS41

ACCREDITATION COMMENTS

NATA Accreditation covers the performance of this service but does not cover the performance of ALS Brisbane Sample Preparation. Corporate
Accreditation No: 825, Corporate Site No: 818. The Technical Signatory is David Jones, ICPMS Supervising Chemist
ME- MS41

LABORATORY ADDRESSES

Processed at ALS Brisbane located at 32 Shand Street, Stafford, Brisbane, QLD, Australia. Processed at ALS Brisbane Sample Preparation at 116
Delta Street, Geebung, QLD 4034, Australia
LOG- 22
ME- MS41

Applies to Method:

Applies to Method:

Applies to Method:

Overburden and footwall samples

CERTIFICATE OF ANALYSIS

Work Order : **EB1808528**
Client : **RGS ENVIRONMENTAL PTY LTD**
Contact : **MR ALAN ROBERTSON**
Address : **PO Box 3091**
SUNNYBANK SOUTH QLD, AUSTRALIA 4109
Telephone : **+61 07 3344 1222**
Project : **2018002 - Ardmore Project**
Order number :
C-O-C number : **----**
Sampler : **SITE**
Site : **----**
Quote number : **BN/058/18 V3**
No. of samples received : **42**
No. of samples analysed : **42**

Page : 1 of 11
Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 14-Mar-2018 09:30
Date Analysis Commenced : 17-Apr-2018
Issue Date : 19-Apr-2018 15:31



Accreditation No. 825
 Accredited for compliance with
 ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD



General Comments

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Where moisture determination has been performed, results are reported on a dry weight basis.

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Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S001	S002	S003	S004	S005
Client sampling date / time					14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00
Compound	CAS Number	LOR	Unit		EB1808528-001	EB1808528-002	EB1808528-003	EB1808528-004	EB1808528-005
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		7.7	6.3	8.6	6.5	7.6
EA009: Nett Acid Production Potential									
Net Acid Production Potential	----	0.5	kg H2SO4/t		-0.8	-2.3	-110	29.2	86.6
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		4710	2450	1790	5540	4520
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		26.5	5.1	113	5.4	7.6
ANC as CaCO3	----	0.1	% CaCO3		2.7	0.5	11.6	0.6	0.8
Fizz Rating	----	0	Fizz Unit		1	0	2	0	1
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.84	0.09	0.09	1.13	3.08



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S006	S007	S008	S009	S010
Client sampling date / time					14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00
Compound	CAS Number	LOR	Unit		EB1808528-006	EB1808528-007	EB1808528-008	EB1808528-009	EB1808528-010
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		7.5	7.5	8.4	8.8	8.5
EA009: Nett Acid Production Potential									
Net Acid Production Potential	----	0.5	kg H2SO4/t		3.5	4.5	-157	-101	-125
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		2060	415	4610	2100	3380
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		2.6	2.8	173	106	132
ANC as CaCO3	----	0.1	% CaCO3		0.3	0.3	17.6	10.8	13.4
Fizz Rating	----	0	Fizz Unit		0	0	3	2	2
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.20	0.24	0.53	0.15	0.22



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S011	S012	S013	S014	S015
Client sampling date / time					14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00
Compound	CAS Number	LOR	Unit		EB1808528-011	EB1808528-012	EB1808528-013	EB1808528-014	EB1808528-015
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		8.8	8.4	7.8	7.2	6.2
EA009: Nett Acid Production Potential									
Net Acid Production Potential	----	0.5	kg H2SO4/t		-73.1	-114	-18.8	23.1	-0.8
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		542	1270	492	3950	1670
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		77.4	119	20.0	1.7	1.7
ANC as CaCO3	----	0.1	% CaCO3		7.9	12.1	2.0	0.2	0.2
Fizz Rating	----	0	Fizz Unit		2	2	1	0	0
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.14	0.17	0.04	0.81	0.03



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S016	S017	S018	S019	S020
Client sampling date / time					14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00
Compound	CAS Number	LOR	Unit		EB1808528-016	EB1808528-017	EB1808528-018	EB1808528-019	EB1808528-020
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		7.3	7.7	8.5	8.1	8.6
EA009: Nett Acid Production Potential									
Net Acid Production Potential	----	0.5	kg H2SO4/t		-2.0	-0.9	-27.8	-21.1	-119
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		1420	1570	513	314	1000
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		2.6	1.5	30.2	22.6	120
ANC as CaCO3	----	0.1	% CaCO3		0.3	0.2	3.1	2.3	12.2
Fizz Rating	----	0	Fizz Unit		0	0	1	1	2
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.02	0.02	0.08	0.05	0.02



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S021	S022	S023	S024	S025
Client sampling date / time					14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00
Compound	CAS Number	LOR	Unit		EB1808528-021	EB1808528-022	EB1808528-023	EB1808528-024	EB1808528-025
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		8.6	8.6	6.3	5.8	6.1
EA009: Nett Acid Production Potential									
Net Acid Production Potential	----	0.5	kg H2SO4/t		-40.0	-17.8	23.6	-0.4	2.2
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		1050	627	3640	1880	2030
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		41.2	19.3	<0.5	1.6	0.9
ANC as CaCO3	----	0.1	% CaCO3		4.2	2.0	<0.1	0.2	<0.1
Fizz Rating	----	0	Fizz Unit		2	1	0	0	0
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.04	0.05	0.77	0.04	0.10



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S026	S027	S028	S029	S030
Client sampling date / time					14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00
Compound	CAS Number	LOR	Unit		EB1808528-026	EB1808528-027	EB1808528-028	EB1808528-029	EB1808528-030
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		7.9	8.4	8.6	8.1	7.6
EA009: Nett Acid Production Potential									
Net Acid Production Potential	----	0.5	kg H2SO4/t		-22.1	-9.2	-21.3	-38.8	0.9
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		379	768	638	3310	1680
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		23.6	10.1	22.5	52.3	3.4
ANC as CaCO3	----	0.1	% CaCO3		2.4	1.0	2.3	5.3	0.3
Fizz Rating	----	0	Fizz Unit		1	1	1	2	0
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.05	0.03	0.04	0.44	0.14



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S031	S032	S033	S034	S035
Client sampling date / time					14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00
Compound	CAS Number	LOR	Unit		EB1808528-031	EB1808528-032	EB1808528-033	EB1808528-034	EB1808528-035
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		8.1	8.3	8.0	8.1	7.3
EA009: Nett Acid Production Potential									
Net Acid Production Potential	----	0.5	kg H2SO4/t		-8.4	-31.6	-10.1	-0.03	4.3
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		1170	2540	4130	1960	1540
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		11.8	34.1	19.3	3.7	<0.5
ANC as CaCO3	----	0.1	% CaCO3		1.2	3.5	2.0	0.4	<0.1
Fizz Rating	----	0	Fizz Unit		1	2	1	0	0
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.11	0.08	0.30	0.12	0.14



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S036	S037	S038	S039	S040
Client sampling date / time					14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00
Compound	CAS Number	LOR	Unit		EB1808528-036	EB1808528-037	EB1808528-038	EB1808528-039	EB1808528-040
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		7.5	5.0	5.0	3.7	6.2
EA009: Nett Acid Production Potential									
Net Acid Production Potential	----	0.5	kg H2SO4/t		-0.04	52.6	76.5	33.7	2.9
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		387	1770	1930	1640	1050
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		3.1	15.3	19.9	<0.5	46.4
ANC as CaCO3	----	0.1	% CaCO3		0.3	1.6	2.0	<0.1	4.7
Fizz Rating	----	0	Fizz Unit		0	1	1	0	2
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.10	2.22	3.15	1.10	1.61



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	S041	DI water	----	----	----
Client sampling date / time					14-Mar-2018 00:00	14-Mar-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit		EB1808528-041	EB1808528-042	-----	-----	-----
				Result	Result		----	----	----
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		7.4	5.6	----	----	----
EA009: Nett Acid Production Potential									
Net Acid Production Potential	----	0.5	kg H2SO4/t		-21.6	----	----	----	----
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		359	<1	----	----	----
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		25.0	----	----	----	----
ANC as CaCO3	----	0.1	% CaCO3		2.6	----	----	----	----
Fizz Rating	----	0	Fizz Unit		1	----	----	----	----
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.11	----	----	----	----

CERTIFICATE OF ANALYSIS

Work Order : **EB1810208**
Client : **RGS ENVIRONMENTAL PTY LTD**
Contact : MR ALAN ROBERTSON
Address : PO Box 3091
 SUNNYBANK SOUTH QLD, AUSTRALIA 4109
Telephone : +61 07 3344 1222
Project : 2018002 - Ardmore Project
Order number :
C-O-C number : ----
Sampler : , MARY MACELROY
Site : ----
Quote number : BN/058/18 V3
No. of samples received : 29
No. of samples analysed : 29

Page : 1 of 8
Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053

Telephone : +61-7-3243 7222
Date Samples Received : 23-Apr-2018 10:32
Date Analysis Commenced : 01-May-2018
Issue Date : 03-May-2018 09:45



Accreditation No. 825
 Accredited for compliance with
 ISO/IEC 17025 - Testing

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- General Comments
- Analytical Results

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Signatories

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<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Greg Vogel	Laboratory Manager	Brisbane Acid Sulphate Soils, Stafford, QLD



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^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- ED006 (Exchangeable Cations on Alkaline Soils): Magnesium/Potassium ratio could not be determined as both the Magnesium and Potassium results were less than reportable limits for some samples.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity ($H^+ + Al^{3+}$).



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				S001 EB1808528_001	S002 EB1808528_002	S003 EB1808528_003	S004 EB1808528_004	S005 EB1808528_005
Client sampling date / time				14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1810208-001	EB1810208-002	EB1810208-003	EB1810208-004	EB1810208-005
				Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	0.006	<0.005	0.006	0.007	0.007
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	14.7	----	----	----	4.0
Exchangeable Magnesium	----	0.2	meq/100g	6.6	----	----	----	2.4
Exchangeable Potassium	----	0.2	meq/100g	0.4	----	----	----	0.3
Exchangeable Sodium	----	0.2	meq/100g	4.0	----	----	----	1.4
Cation Exchange Capacity	----	0.2	meq/100g	25.8	----	----	----	8.1
Exchangeable Calcium Percent	----	0.2	%	57.1	----	----	----	49.3
Exchangeable Magnesium Percent	----	0.2	%	25.8	----	----	----	29.2
Exchangeable Potassium Percent	----	0.2	%	1.5	----	----	----	3.8
Exchangeable Sodium Percent	----	0.2	%	15.6	----	----	----	17.6
Calcium/Magnesium Ratio	----	0.2	-	2.2	----	----	----	1.7
Magnesium/Potassium Ratio	----	0.2	-	17.4	----	----	----	7.6
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	9.7	----	31.2	----
Exchangeable Magnesium	----	0.1	meq/100g	----	4.3	----	1.7	----
Exchangeable Potassium	----	0.1	meq/100g	----	0.4	----	0.3	----
Exchangeable Sodium	----	0.1	meq/100g	----	0.8	----	0.5	----
Exchangeable Aluminium	----	0.1	meq/100g	----	0.1	----	0.1	----
Cation Exchange Capacity	----	0.1	meq/100g	----	15.2	----	33.8	----
Exchangeable Calcium Percent	----	0.1	%	----	63.6	----	92.3	----
Exchangeable Magnesium Percent	----	0.1	%	----	28.0	----	5.0	----
Exchangeable Potassium Percent	----	0.1	%	----	2.6	----	1.0	----
Exchangeable Sodium Percent	----	0.1	%	----	5.1	----	1.4	----
Exchangeable Aluminium Percent	----	0.1	%	----	0.7	----	0.3	----
Calcium/Magnesium Ratio	----	0.1	-	----	2.2	----	18.4	----
Magnesium/Potassium Ratio	----	0.1	-	----	10.8	----	5.2	----



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				S006 EB1808528_006	S007 EB1808528_007	S008 EB1808528_008	S009 EB1808528_009	S010 EB1808528_010
Client sampling date / time				14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1810208-006	EB1810208-007	EB1810208-008	EB1810208-009	EB1810208-010
				Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	0.005	<0.005	0.007	<0.005	<0.005
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	1.7	----	4.8	1.9	4.4
Exchangeable Magnesium	----	0.2	meq/100g	1.7	----	4.9	3.6	4.3
Exchangeable Potassium	----	0.2	meq/100g	0.4	----	<0.2	0.2	<0.2
Exchangeable Sodium	----	0.2	meq/100g	1.5	----	2.9	2.9	3.0
Cation Exchange Capacity	----	0.2	meq/100g	5.3	----	12.9	8.5	11.9
Exchangeable Calcium Percent	----	0.2	%	32.6	----	37.4	21.8	36.8
Exchangeable Magnesium Percent	----	0.2	%	31.7	----	38.4	41.9	36.0
Exchangeable Potassium Percent	----	0.2	%	7.0	----	1.4	2.5	1.5
Exchangeable Sodium Percent	----	0.2	%	28.6	----	22.8	33.7	25.6
Calcium/Magnesium Ratio	----	0.2	-	1.0	----	1.0	0.5	1.0
Magnesium/Potassium Ratio	----	0.2	-	4.5	----	----	16.6	----



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				S011 EB1808528_011	S012 EB1808528_012	S014 EB1808528_014	S018 EB1808528_018	S023 EB1808528_023
Client sampling date / time				14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1810208-011	EB1810208-012	EB1810208-013	EB1810208-014	EB1810208-015
				Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	0.010	0.007	<0.005	0.006	0.008
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	44.0	----	43.3
Exchangeable Magnesium	----	0.1	meq/100g	----	----	1.4	----	1.1
Exchangeable Potassium	----	0.1	meq/100g	----	----	0.2	----	0.2
Exchangeable Sodium	----	0.1	meq/100g	----	----	0.4	----	0.3
Exchangeable Aluminium	----	0.1	meq/100g	----	----	<0.1	----	0.1
Cation Exchange Capacity	----	0.1	meq/100g	----	----	46.1	----	45.0
Exchangeable Calcium Percent	----	0.1	%	----	----	95.5	----	96.2
Exchangeable Magnesium Percent	----	0.1	%	----	----	3.1	----	2.5
Exchangeable Potassium Percent	----	0.1	%	----	----	0.5	----	0.4
Exchangeable Sodium Percent	----	0.1	%	----	----	0.8	----	0.6
Exchangeable Aluminium Percent	----	0.1	%	----	----	0.2	----	0.3
Calcium/Magnesium Ratio	----	0.1	-	----	----	31.4	----	39.4
Magnesium/Potassium Ratio	----	0.1	-	----	----	6.7	----	5.9



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				S025 EB1808528_025	S029 EB1808528_029	S030 EB1808528_030	S031 EB1808528_031	S032 EB1808528_032
Client sampling date / time				14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1810208-016	EB1810208-017	EB1810208-018	EB1810208-019	EB1810208-020
				Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	0.007	0.006	0.009	0.009	0.010
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	6.6	----	----	3.9
Exchangeable Magnesium	----	0.2	meq/100g	----	2.7	----	----	3.2
Exchangeable Potassium	----	0.2	meq/100g	----	0.2	----	----	0.2
Exchangeable Sodium	----	0.2	meq/100g	----	0.9	----	----	1.3
Cation Exchange Capacity	----	0.2	meq/100g	----	10.5	----	----	8.6
Exchangeable Calcium Percent	----	0.2	%	----	63.2	----	----	45.4
Exchangeable Magnesium Percent	----	0.2	%	----	25.5	----	----	36.7
Exchangeable Potassium Percent	----	0.2	%	----	2.3	----	----	2.5
Exchangeable Sodium Percent	----	0.2	%	----	8.9	----	----	15.4
Calcium/Magnesium Ratio	----	0.2	-	----	2.5	----	----	1.2
Magnesium/Potassium Ratio	----	0.2	-	----	10.9	----	----	14.9
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	6.2	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	1.2	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	0.4	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	0.4	----	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	0.2	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	8.3	----	----	----	----
Exchangeable Calcium Percent	----	0.1	%	74.8	----	----	----	----
Exchangeable Magnesium Percent	----	0.1	%	13.9	----	----	----	----
Exchangeable Potassium Percent	----	0.1	%	4.9	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	4.3	----	----	----	----
Exchangeable Aluminium Percent	----	0.1	%	2.0	----	----	----	----
Calcium/Magnesium Ratio	----	0.1	-	5.2	----	----	----	----
Magnesium/Potassium Ratio	----	0.1	-	2.8	----	----	----	----



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				S033 EB1808528_033	S034 EB1808528_034	S035 EB1808528_035	S036 EB1808528_036	S037 EB1808528_037
Client sampling date / time				14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1810208-021	EB1810208-022	EB1810208-023	EB1810208-024	EB1810208-025
				Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	0.007	0.006	<0.005	0.006	1.30
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	4.9	----	----	----	----
Exchangeable Magnesium	----	0.2	meq/100g	1.6	----	----	----	----
Exchangeable Potassium	----	0.2	meq/100g	<0.2	----	----	----	----
Exchangeable Sodium	----	0.2	meq/100g	1.0	----	----	----	----
Cation Exchange Capacity	----	0.2	meq/100g	7.7	----	----	----	----
Exchangeable Calcium Percent	----	0.2	%	63.9	----	----	----	----
Exchangeable Magnesium Percent	----	0.2	%	21.1	----	----	----	----
Exchangeable Potassium Percent	----	0.2	%	2.3	----	----	----	----
Exchangeable Sodium Percent	----	0.2	%	12.7	----	----	----	----
Calcium/Magnesium Ratio	----	0.2	-	3.0	----	----	----	----



Analytical Results

Sub-Matrix: **SOIL**
 (Matrix: **SOIL**)

Client sample ID

				S038 EB1808528_038	S039 EB1808528_039	S040 EB1808528_040	S041 EB1808528_041	----
Client sampling date / time				14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	14-Mar-2018 00:00	----
Compound	CAS Number	LOR	Unit	EB1810208-026	EB1810208-027	EB1810208-028	EB1810208-029	-----
				Result	Result	Result	Result	----
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	1.72	0.756	0.927	0.010	----



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CERTIFICATE BR18094590

Project: EB1810208

P.O. No.: MS41

This report is for 17 Pulp samples submitted to our lab in Brisbane, QLD, Australia on
26- APR- 2018.

The following have access to data associated with this certificate:

SUB RESULTS - BRIS

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SAMPLE PREPARATION	
ALS CODE	DESCRIPTION
LOG- 22	Sample login - Rcd w/o BarCode
ANALYTICAL PROCEDURES	
ALS CODE	DESCRIPTION
ME- MS41	Ultra Trace Aqua Regia ICP- MS

To: ALS ENVIRONMENTAL
ATTN: SUB RESULTS - BRIS
32 SHAND STREET
STAFFORD QLD 4053

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.
***** See Appendix Page for comments regarding this certificate *****

Signature:

Shaun Kenny, Brisbane Laboratory Manager

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Sample Description	Method Analyte Units LOR	ME-M541 Ag ppm 0.01	ME-M541 Al % 0.01	ME-M541 As ppm 0.1	ME-M541 Au ppm 0.02	ME-M541 Ba ppm 10	ME-M541 Be ppm 0.05	ME-M541 Bi ppm 0.01	ME-M541 Ca % 0.01	ME-M541 Cd ppm 0.01	ME-M541 Ce ppm 0.02	ME-M541 Co ppm 0.1	ME-M541 Cr ppm 1	ME-M541 Cs ppm 0.05	ME-M541 Cu ppm 0.2	ME-M541 Fe % 0.01
S001		0.10	2.32	3.3	<0.02	250	1.31	0.15	1.99	0.03	43.2	8.3	31	1.71	15.4	2.25
S002		0.02	1.02	2.7	<0.02	380	1.30	0.37	0.25	0.09	61.4	4.6	21	1.18	39.9	2.51
S003		0.15	1.35	1.7	<0.02	120	4.17	0.41	6.98	0.67	94.2	11.4	43	3.02	35.0	0.56
S004		0.09	1.50	25.1	<0.02	110	0.71	0.37	1.25	0.04	45.1	1.1	37	0.71	13.4	2.17
S005		0.17	1.01	17.0	<0.02	30	0.63	0.25	2.73	0.03	31.4	0.6	22	0.70	20.7	1.83
S006		0.11	1.06	8.9	<0.02	70	2.52	0.57	0.32	0.14	57.7	2.0	31	1.32	28.7	1.56
S007		0.07	1.87	11.9	<0.02	200	7.22	0.36	0.76	0.19	48.7	5.0	50	1.10	27.4	1.27
S032		0.33	1.25	3.8	<0.02	380	0.89	0.32	1.46	0.06	43.2	5.0	23	0.80	15.1	0.76
S033		0.17	0.64	2.2	<0.02	180	0.47	0.24	1.10	0.03	26.0	0.9	19	0.31	9.0	0.16
S034		0.15	0.47	27.3	<0.02	80	0.46	0.28	0.17	0.17	32.7	3.0	27	0.27	86.1	2.02
S035		0.13	0.52	4.6	<0.02	230	0.62	0.58	0.07	0.07	87.9	2.3	25	0.33	58.9	0.53
S036		0.21	1.14	10.8	0.04	710	4.35	0.37	0.47	0.46	58.4	21.7	94	0.62	49.1	1.48
S037		0.30	0.50	18.2	<0.02	60	3.10	0.37	2.20	1.34	33.5	12.6	59	1.74	36.3	1.60
S038		0.28	0.78	22.2	<0.02	50	3.96	0.30	5.23	1.02	53.2	10.3	78	2.51	53.3	2.14
S039		0.64	0.42	15.5	<0.02	240	1.19	0.52	0.09	0.09	103.5	10.7	23	0.65	69.2	1.45
S040		0.25	0.45	24.6	<0.02	220	27.5	0.10	>25.0	0.18	140.0	2.7	39	1.39	21.4	1.17
S041		0.55	0.58	6.8	<0.02	390	4.64	0.15	4.98	0.73	39.5	2.5	72	1.01	48.7	0.73

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Sample Description	Method Analyte Units LOR	ME-M541 Ga ppm 0.05	ME-M541 Ce ppm 0.05	ME-M541 Hf ppm 0.02	ME-M541 Hg ppm 0.01	ME-M541 In ppm 0.005	ME-M541 La ppm 0.2	ME-M541 Li ppm 0.1	ME-M541 Mg % 0.01	ME-M541 Mn ppm 5	ME-M541 Mo ppm 0.05	ME-M541 Nb ppm 0.05	ME-M541 Ni ppm 0.2	ME-M541 P ppm 10	ME-M541 Pb ppm 0.2	ME-M541 Rb ppm 0.1
S001		6.85	0.06	0.39	0.01	0.029	22.5	10.1	0.56	230	0.70	0.12	17.3	550	9.0	15.8
S002		3.67	0.06	0.41	0.01	0.022	31.2	9.3	0.29	57	0.75	0.11	25.5	320	15.0	7.6
S003		4.60	0.16	0.11	0.02	0.034	75.4	25.1	0.52	204	0.43	0.18	57.7	19900	14.3	15.2
S004		5.26	0.09	0.16	0.01	0.027	24.1	6.8	0.25	24	21.0	0.11	4.2	3030	14.9	7.8
S005		3.83	0.05	0.28	0.04	0.029	16.5	5.6	0.13	12	14.55	0.15	2.7	1880	10.7	4.8
S006		5.22	0.06	0.10	0.05	0.021	28.9	2.8	0.08	22	10.40	0.13	11.6	3780	26.9	6.4
S007		2.78	0.08	0.04	0.07	0.017	31.8	4.2	0.06	82	8.07	0.10	6.3	10600	12.5	6.9
S032		4.36	0.06	0.27	0.01	0.029	23.5	5.5	0.42	130	1.88	0.09	8.2	1640	24.9	7.9
S033		2.69	<0.05	0.32	0.01	0.034	13.2	3.1	0.20	19	1.20	0.05	3.1	720	13.6	4.2
S034		4.76	0.05	0.40	0.03	0.085	17.1	1.5	0.07	20	21.7	0.11	14.3	390	10.4	3.7
S035		3.15	0.08	0.30	0.04	0.041	51.5	1.8	0.06	19	7.79	0.08	11.6	820	27.4	4.0
S036		3.08	0.07	0.03	0.25	0.032	38.4	5.1	0.04	290	5.49	0.13	53.9	5600	20.6	4.2
S037		2.02	0.10	0.21	0.014	0.014	22.0	4.7	0.06	40	14.70	0.12	53.4	10600	20.0	6.4
S038		2.40	0.21	0.22	0.23	0.019	40.4	8.8	0.09	39	8.83	0.15	50.5	24600	13.7	10.3
S039		3.66	0.12	0.48	0.24	0.020	45.4	2.0	0.05	29	19.55	0.12	31.8	990	24.2	5.2
S040		2.77	0.39	0.30	0.15	0.010	138.0	7.6	0.10	152	7.40	0.13	25.6	>25000	37.0	10.4
S041		1.92	0.11	0.21	0.33	0.014	31.9	2.7	0.05	43	3.19	0.10	16.0	22500	6.5	6.3

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Sample Description	Method Analyte Units LOR	ME-M641 S %	ME-M641 Sb ppm	ME-M641 Sc ppm	ME-M641 Se ppm	ME-M641 Sn ppm	ME-M641 Sr ppm	ME-M641 Ta ppm	ME-M641 Te ppm	ME-M641 Th ppm	ME-M641 Ti %	ME-M641 Ti ppm	ME-M641 U ppm	ME-M641 V ppm	ME-M641 W ppm	ME-M641 Y ppm
S001		0.90	0.24	5.0	0.4	1.1	80.0	<0.01	0.04	6.6	0.013	0.24	2.36	70	0.23	23.5
S002		0.08	1.15	3.6	0.7	0.8	38.8	<0.01	0.07	11.1	0.005	0.17	3.63	63	0.18	18.40
S003		0.08	1.10	6.2	0.5	1.0	185.0	0.01	0.10	9.8	0.008	0.31	12.95	224	0.48	184.0
S004		1.03	3.31	5.7	1.7	0.8	368	<0.01	0.04	8.6	0.006	0.24	8.39	212	0.33	15.45
S005		2.23	3.64	4.9	1.4	0.7	152.5	<0.01	0.03	6.8	0.005	0.34	8.21	216	0.26	8.93
S006		0.19	2.62	4.6	0.4	0.9	158.0	<0.01	0.09	10.1	0.005	0.35	11.65	152	0.25	21.6
S007		0.21	3.56	5.1	1.2	0.5	606	<0.01	0.05	6.1	<0.005	1.59	21.9	257	0.19	108.0
S032		0.05	0.68	3.2	0.8	1.0	131.5	<0.01	0.03	7.2	0.007	0.11	4.15	51	0.03	22.9
S033		0.27	0.74	1.8	0.2	0.6	74.1	<0.01	0.04	6.0	<0.005	0.07	2.70	34	0.32	8.88
S034		0.03	10.70	5.9	1.7	0.8	90.9	<0.01	0.06	15.0	0.008	0.10	10.10	230	0.20	50.2
S035		0.04	9.03	7.4	<0.2	0.9	255	<0.01	0.09	21.7	<0.005	0.13	8.42	169	0.23	46.5
S036		0.08	1.21	5.9	0.3	0.5	454	<0.01	0.08	11.9	<0.005	0.99	20.2	161	1.10	31.4
S037		1.92	1.81	2.9	2.7	0.4	130.0	<0.01	0.05	3.9	<0.005	0.76	22.0	102	0.89	46.5
S038		2.71	1.48	3.9	3.5	0.5	188.5	<0.01	0.04	5.2	0.005	0.84	30.5	134	0.77	105.5
S039		1.08	3.07	6.9	2.5	0.7	225	<0.01	0.08	10.6	<0.005	1.22	11.25	138	0.18	49.2
S040		1.55	1.77	5.0	2.3	0.3	686	0.02	0.04	5.2	<0.005	2.09	98.1	85	0.32	375
S041		0.10	0.98	5.3	1.3	0.4	344	0.01	0.03	4.0	<0.005	0.26	26.9	151	2.61	101.5

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Sample Description	Method Analyte Units LOR	ME-M641 Zn ppm 2	ME-M641 Zr ppm 0.5	ME-M641 B ppm 10
S001		30	13.1	10
S002		77	12.2	10
S003		122	4.9	20
S004		11	4.9	10
S005		7	7.9	10
S006		40	3.8	10
S007		88	1.0	20
S032		17	8.5	10
S033		6	8.7	10
S034		32	15.9	<10
S035		30	9.9	<10
S036		176	1.1	10
S037		152	7.7	10
S038		161	8.4	10
S039		26	14.3	<10
S040		21	11.9	20
S041		100	8.3	10

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CERTIFICATE COMMENTS	
Applies to Method:	<p>ANALYTICAL COMMENTS</p> <p>Gold determinations by this method are semi-quantitative due to the small sample weight used (0.5g). ME- MS41</p> <p>ACCREDITATION COMMENTS</p> <p>NATA Accreditation covers the performance of this service but does not cover the performance of ALS Brisbane Sample Preparation. Corporate Accreditation No: 825, Corporate Site No: 818. The Technical Signatory is David Jones, ICPMS Supervising Chemist ME- MS41</p> <p>LABORATORY ADDRESSES</p> <p>Processed at ALS Brisbane located at 32 Shand Street, Stafford, Brisbane, QLD, Australia. Processed at ALS Brisbane Sample Preparation at 116 Delta Street, Geebung, QLD 4034, Australia LOG- 22 ME- MS41</p>
Applies to Method:	
Applies to Method:	

RGSG



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