SULPHUR SPRINGS PROJECT WASTE ROCK
WASTE ROCK GEOCHEMISTRY OVERVIEW

PREPARED FOR:

VENTUREX RESOURCES LIMITED

MAY 2018

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1. INTRODUCTION

1.1 BACKGROUND

The Sulphur Springs Zinc-Copper Project (the project) is a greenfields deposit located approximately 144 km south east of Port Hedland and 57 km west of Marble Bar (by road) in the Pilbara Region of Western Australia Figure 1. Venturex Resources Limited (Venturex) owns this project having acquired the project tenements from CBH Sulphur Springs Pty Ltd (CBH) in 2011.

In 2013 Venturex submitted a Mining Proposal for a 1.0 Mtpa underground mine, 1.0 Mtpa processing plant and dry stack tailings storage facility (TSF) to the Department of Mines and Petroleum (DMP). The project was approved by the DMP in April 2014 (REG ID 40542). No activities approved under this Mining Proposal (and associated clearing permit CPS 5658/1) have been carried out to date.

During 2015 and 2016 Venturex investigated mining and processing options for the project and identified a number of opportunities that would improve its financial viability. Venturex now wishes to progress Sulphur Springs as follows:

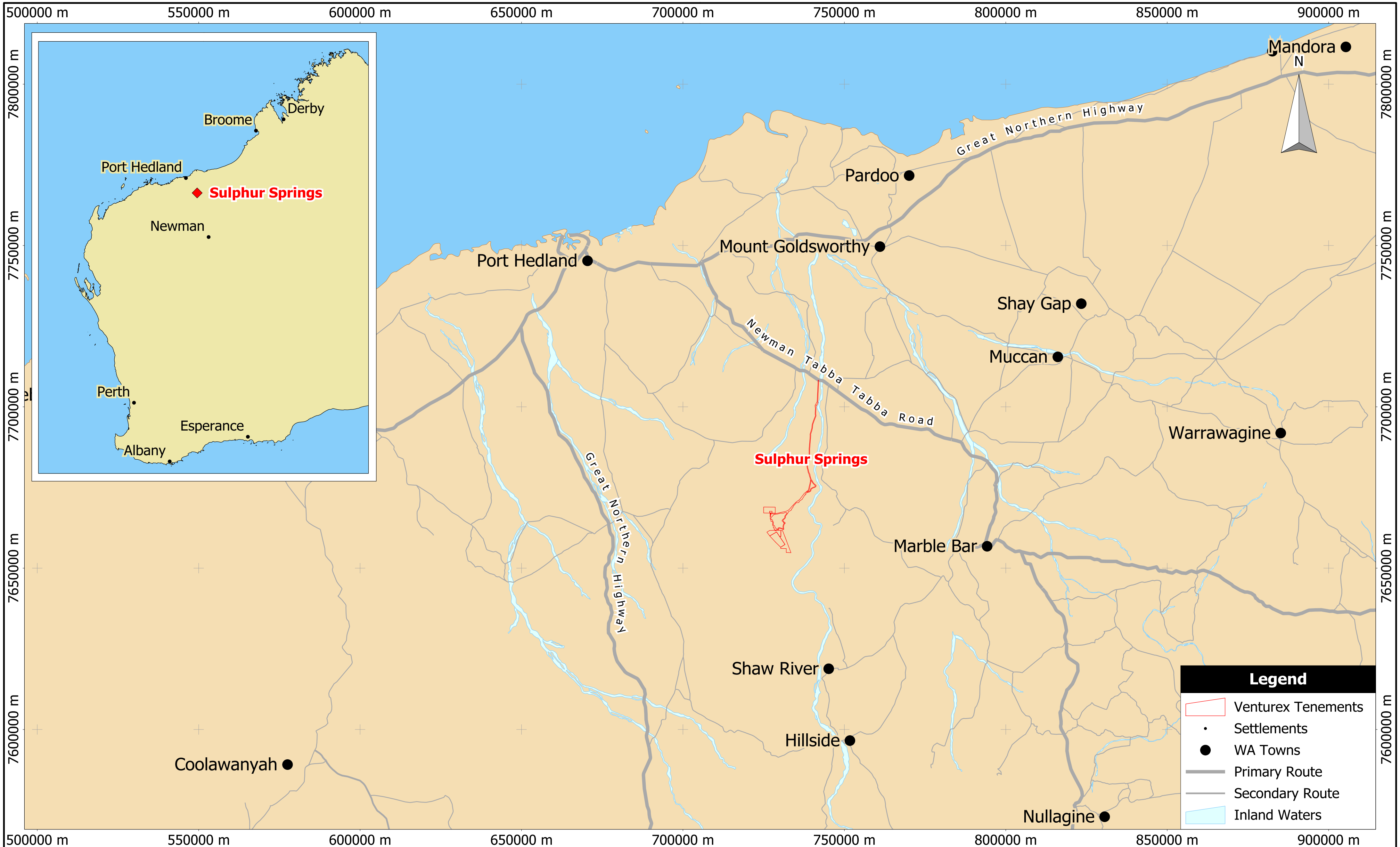
- Develop a 1.5 Mtpa open pit to mine the top portion of the orebody.
- Develop a 1.5 Mtpa underground mine (accessed via a portal within the pit) to mine the remainder of the orebody.
- Construct a 1.5 Mtpa conventional processing plant which will produce separate copper and zinc concentrates for sale.
- Store tailings in a 'valley fill' Tailings Storage Facility (TSF) with a combined High Density Polyethylene (HDPE) and compacted low permeability sub-base liner.
- Construct a copper heap leach facility (HLF) within the same valley storage area as the TSF. The heap leach pad design includes a combined HDPE and compacted low permeability sub-base liner. The HDPE liner will be welded to the TSF liner to form a continuous liner under the entire heap leach / TSF facility area.
- Construct a copper Solvent Extraction and Electrowinning Plant (SX-EW) adjacent to the processing plant.
- Construct a permanent waste rock dump (WRD).
- Construct additional supporting elements such as internal roads, material stockpiles, surface water management, accommodation village and power station.

1.2 OBJECTIVE AND SCOPE OF WORK

The objectives and scope of work for this waste rock geochemistry overview were to:

- Review previous waste rock geochemical characterisation reports prepared for CBH prior to 2011.
- Undertake a knowledge gap assessment to identify aspects requiring further work that may include:
  - More representative waste rock sampling to align with the revised open pit and underground mine designs.
  - Ensuring test methods used are consistent with DMP draft guidelines for waste rock and regolith characterisation (DMP 2016).
  - Ensure that the geochemical characteristics of low-grade ore and highly mineralised waste rock are adequate for managing these materials during life of mine.

- Liaise with Venturex personnel for provision of drill log data including lithology, sulphur assays (percentage sulphur) and depth for any addition samples identified from the knowledge gap assessment.
- Submit samples to a laboratory for determination of the following acid base accounting (ABA) parameters:
  - Total sulphur and sulphate sulphur.
  - Acid Neutralising Capacity (ANC).
  - Net Acid Generation (NAG) test.
- Submit selected samples to a laboratory for the following:
  - Elemental analysis of four acid digest solutions (Ag, Al, As, Ba, Be, Bi, Ca, Cd, Co, Cu, Cr, Fe, Ga, K, La, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Th, Ti, Tl, U, V, W and Zn) and mercury (separate digestion required).
  - Analysis of water and dilute acid leachates of selected samples for pH, EC, alkalinity/acidity, major ions (Ca, Mg, Na, K, Cl, sulphate and F) and soluble metals and metalloids (Ag, Al, As, Ba, Bi, Cd, Co, Cu, Cr, Fe, K, Hg, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Te, Th, U, V, and Zn).
- Preparation of a concise geochemical report outlining the properties of waste rock lithologies generated by open pit mining of the upper portion of the orebody.
- Determine a reliable total sulphur cut-off grade that can be used to identify non-acid forming (NAF) and potentially acid forming (PAF) waste rock, focusing on the hanging wall of the proposed open pit.
- Assessment of the relative risk of neutral and acid drainage potential within waste rock from the project, based on current information and current/intended mine practices.



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Venturex Resources Limited
Sulphur Springs Project

Figure 1

Location Plan

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2. PROJECT GEOLOGY AND HYDROLOGY

2.1 SULPHUR SPRINGS GEOLOGY

Sulphur Springs is a volcanogenic massive sulphide copper-zinc deposit in the mid-eastern area of the Abydos Plain and incorporates a small portion of the Gorge Range. Base metal sulphide mineralisation was first discovered at the site in 1991. Since this time, a number of exploration programs, studies and reviews have been conducted to further define the resource and develop a viable project development concept.

2.1.1 Regional Geology

The Pilbara Craton comprises Archaean and paleo-Proterozoic rocks that outcrop in the Pilbara Region of northwest Western Australia. The Craton consists of a 250,000 km^2 ovoid segment of terranes and basins and most of the southern craton is concealed by the Hamersley Basin (URS 2007b).

The northern Pilbara Craton is divided into several types of tectonic elements, following Van Kranendonk (1998). These include lithotectonic terranes, polyphase granitic complexes, individual granitic intrusions, greenstone belts (East Pilbara Terrane only) and sedimentary basins of the De Grey Supergroup (Van Kranendonk *et al*., 2006 and URS 2007b) subdivided the Pilbara Craton into:

- The 3,650 to 3,200 Maximum Age (Ma) East Pilbara Terrane.
- The 3,270 to 3,060 Ma West Pilbara Superterrane comprising the Karratha, Regal and Sholl Terranes.
- The older than 3,200 Ma Kurrana Terrane.
- The 3,020 to 2,930 Ma De Grey Superbasin, comprising five later, predominantly siliclastic sedimentary basins – the Gorge Creek, Whim Creek, Mallina, Lalla Rookh and Mosquito Creek Basins.

Sulphur Springs is located in the East Pilbara Terrane, the oldest component of the northern Pilbara Craton. The East Pilbara Terrane is a 'dome-and-basin' granite-greenstone domain in which ovoid granites are flanked by arcuate-shaped volcano-sedimentary packages. This Terrane represents the nucleus of the Pilbara Craton, formed through a succession of mantle plumes (3,530 to 3,230 Ma) that produced a dominantly basaltic volcanic succession, known as the Pilbara Supergroup, on an older sialic basement. Granitic complexes in the East Pilbara Terrane are structural domes that are separated from one another by faults or intervening greenstone belts, or both. Each complex contains several different age components, but many of the components are common to several complexes, prompting the division of granitic rocks in the East Pilbara Terrane into suites and supersuites rather than by the complex in which they occur (Van Kranendonk *et al*., 2006).

2.1.2 Project Geology

The proposed Sulphur Springs open pit hosts a copper and zinc orebody linked to volcanogenic massive sulphide deposits. The geology and extent of mineralisation has been interpreted from a number of closely-spaced exploratory drill holes and the geology flanking the orebody and pit has been based on regional mapping, isolated exploration holes and groundwater monitoring bores (Figure 2).

The Sulphur Springs Group of the Pilbara Supergroup in the East Pilbara Terrane hosts the deposit mineralisation. North east portions of the open pit are also expected to intercept the Soanesville Group successions, which dip 50º to 55º to the north east. Footwall rocks are predominantly formed of dacite/rhyodacite volcanics of the Kangaroo Caves Formation (Sulphur Springs Group). Sulphide mineralisation is strongly stratabound on the contact between the footwall successions and overlying marker chert beds. Mineralisation is interpreted to occur in association with stratabound shear zones that are concordant with the shear and foliation fabric of the marker chert. Hanging wall rocks include polymict breccias and upper chert beds of the Kangaroo Caves Formation and the overlying siltstone and quartz arenite of the Corboy Formation (Soanesville Group) (URS 2007b).

Sulphide mineralisation is dominated by massive pyrite, which contains enriched horizons of sphalerite and chalcopyrite and minor amounts of galena. The sphalerite-rich zone lies towards the top of the massive pyrite lenses and the copper-rich zone of the deposit lies towards the base of the influence of the pyrite. The pyrite lenses have a gradational contact with the barren felsic volcanics beneath.

Faults influence the distribution of both the local stratigraphic successions and mineralisation. Most faults are only locally distributed; the Main Fault is different, being a normal fault of northerly strike, 80 m downthrow and mapped strike length of approximately 3,000 m within the Sulphur Springs Group succession. The Main Fault displaces the mineralisation; forming two distinct Western and Eastern lodes. This fault is not interpreted to propagate into the overlying Soanesville Group.

Estimated waste rock tonnages by lithology, most of which is sourced from the hanging wall sediments, are given in Table 1.

Table 1: Sulphur Springs Open Pit Waste Rock (Venturex 2018)

Lithology	Tonnes	Percentage of Total Waste
Dacite (footwall)	2,330,833	14.3
Rhydocite (footwall)	1,982,500	11.4
Chert (footwall)	337,500	1.9
Chert (hanging wall)	1,884,583	10.8
Mineralised Chert	3,022,917	17.4
Breccia, Siltstone and Sandstone (hanging wall)	7,684,583	44.2
Total	17,242,917	100

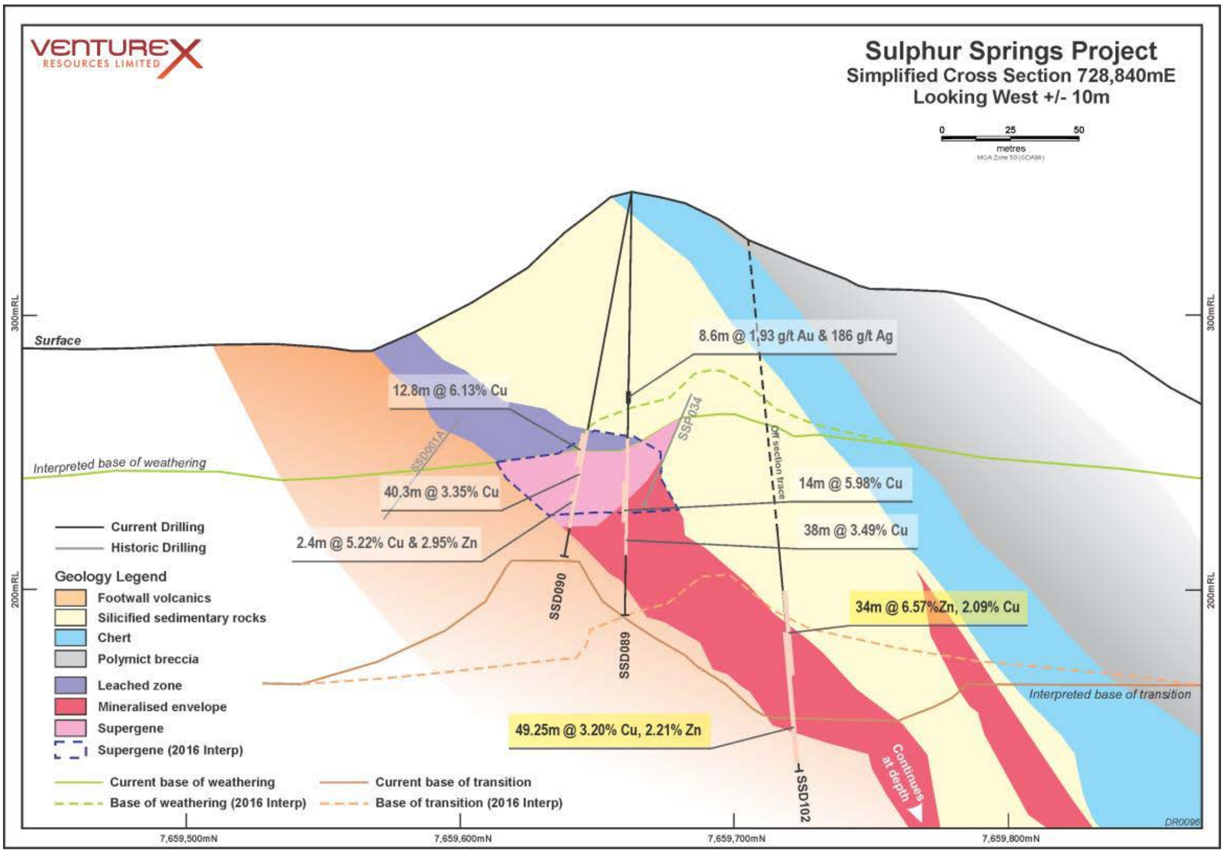

Figure 2: Sulphur Springs Orebody Geological Cross Section

2.2 REGIONAL AND LOCAL HYDROGEOLOGY

The conceptual hydrogeology for Sulphur Springs has been characterised through interpretations of the Archaean geology, catchment distributions, data obtained during exploratory drilling and groundwater sampling programs (URS 2007b) and recent groundwater investigations (AECOM 2018). Groundwater and surface water flow systems in the area are complex, variable and linked. There are strong correlations with topography, geology and structure in both the groundwater and surface water flow systems.

Groundwater type and quality varies across the project area. Groundwater sampling carried out in June 2007 determined that the dominant groundwater type was magnesium bicarbonate ($MgHCO_3$), with minor magnesium – sodium chloride (Mg-NaCl) and magnesium sulphate ($MgSO_4$) groundwaters in upland areas (URS 2007b).

More detail of aquifer systems and groundwater quality in the vicinity of proposed mine components is provided in the following sections.

Local geology, mineralisation and structure are major influences on hydrogeology in the Sulphur Springs open pit area. The proposed pit and immediate hinterland hosts a fractured rock aquifer system that is interpreted to be closely controlled by both mineralisation lodes and occurrence of the marker chert.

2.2.1 Aquifer System

Local geology, mineralisation and structure are major influences on hydrogeology in the Sulphur Springs mining void area. The proposed void and immediate hinterland hosts a fractured rock aquifer system that is interpreted to be closely controlled by both mineralisation lodes and occurrence of the marker chert. The local fractured rock aquifer system is interpreted to be compartmentalised, with groundwater flow strongly linked to transmissive structures.

Groundwater and surface water flow systems in the area are complex, variable and linked (AECOM 2018). There are strong correlations with topography, geology and structure (such as faults and thrusts).

Hydrogeological characteristics at Sulphur Springs include:

- Groundwater flow and groundwater gradients broadly reflect the local topography.
- Recharge occurs in upland areas and groundwater discharges to valley floor domains and associated watercourses.
- Recharge areas dominate the catchment surface area. Recharge mobilises quickly down slope within a weathered bedrock aquifer.
- Discharge occurs in creeklines. The rate and extent of discharge varies seasonally. Base flows discharge perennially, but are more obvious in the dry season. Groundwater discharges in the dry season result in the accumulation of precipitates of iron sulphate and silica within and immediately downstream of the mine area, as well as calcium/magnesium sulphates and carbonates elsewhere.
- Geological units and structures such as faults and thrusts influence groundwater and surface water flow systems. Groundwater flow is predominantly linked to fractures in bedrock and local geology has the potential to compartmentalise fractured rock aquifer systems and associated groundwater flow, which may influence aquifer system limits, drawdown extents and local volumes of stored groundwater that is connected to the mine.
- Most of the known fractured-rock aquifer systems are aligned with valley-floor watercourses and associated shallow water table settings.
- Groundwater levels fluctuate in response to seasonal rainfall patterns. Monitoring over the past ten years indicates the water table fluctuates seasonally by up to 5 m.
- The occurrence of pools on valley floors shows where the water table is shallow and the local aquifer systems are seasonally full.
- Groundwater within the orebody discharges into Sulphur Springs Creek. Groundwater and surface water quality data suggest that this has created acidic conditions and elevated metal concentrations in the creek system within the orebody zone. Groundwater chemistry most likely evolved through chemical equilibration with the more reactive minerals in this zone (AECOM 2017).

2.2.2 Groundwater Quality

Groundwater quality varies widely:

- Within the pit footprint, where solution cavities have formed through extensive oxidation of sulphide materials, resulting in groundwater that is low in pH and contains elevated concentrations of salinity, sulphate and metals/metalloids including cadmium, copper, nickel and zinc.
- Outside the mineralised zone, surface water and groundwater are typically of near-neutral pH, low in salinity and contain lower concentrations of metals and metalloids.

3. GEOCHEMICAL CHARACTERISATION METHODS

3.1 ACID FORMING WASTE CLASSIFICATION METHODOLOGY

There is no simple method to define whether mine waste containing small quantities of sulphur will produce sulphuric acid. Sulphide minerals are variable in their behaviour under oxidising conditions and not all forms will produce sulphuric acid (H_2SO_4). Instead, a combination of approaches is often applied to more accurately classify mine waste. These approaches are listed below in order of increasing data requirements (and therefore increased reliability):

- The "Analysis Concept", which only requires data for total sulphur content. Its adoption is based on long term experience of wastes from Western Australian mine sites in arid and semi-arid conditions. Experience has shown that waste rock containing very low sulphur contents (less than 0.2 to 0.3%) rarely produces significant amounts of acidic seepage.
- The "Ratio Concept", which compares the relative proportions of acid neutralising minerals (measured by the Acid Neutralising Capacity (ANC)) to acid generating minerals (measured by the Maximum Potential Acidity (MPA)). Experience has shown that the risk of generating acidic seepage is generally low when this ratio (the Neutralisation Potential Ratio – NPR) is above a value of two.
- Acid-Base Accounting, in which the calculated value for Nett Acid Producing Potential (NAPP) is used to classify the acid generating potential of mine waste. NAPP is equal to the MPA minus the ANC.
- Procedures recommended by AMIRA (2002), which take into consideration measured values provided by the Nett Acid Generation (NAG) test and calculated NAPP values.
- Kinetic leaching column test data, which provides information for the relative rates of acid generation under controlled laboratory conditions, intended to simulate those within a waste rock dump (WRD) or tailings storage facility (TSF).

A sound knowledge of geological and geochemical processes must also be employed in the application of the above methods.

Classification of wastes in this report uses procedures recommended by AMIRA (2002) based on NAPP and NAG pH results. However, results are also compared to the Analysis Concept (total sulphur) and Ratio Concept models and a modification of the AMIRA procedure by determination of the following:

- Analysis for total sulphur (Tot_S) and sulphate sulphur (SO_4_S), both reported as sulphur, as a measure of oxidisable sulphur. Alternatively, Chromium Reducible Sulphur (CRS) can be used a direct measure of oxidisable sulphur and is potentially a better method for lithologies with significant organic carbon such as shales and slates.
- Analysis for ANC (quoted in kg H_2SO_4/t).
- Calculation of carbonate neutralising potential (CarbNP) (quoted in kg H_2SO_4/t) from measured concentrations of carbon.
- Calculation of Acid Production Potential (AP) = [(Tot_S – SO_4_S) * 30.6] kg H_2SO_4/t. CRS can be used in place of total sulphur minus sulphate sulphur in this calculation of AP.
- Calculation of NAPP = [AP – ANC] kg H_2SO_4/t.
- Calculation of Effective NAPP = [AP – CarbNP] kg H_2SO_4/t.
- Analysis for NAG (quoted in kg H_2SO_4/t).
- Analysis for NAGpH.
- Calculation of NPR = ANC/AP.

This AMIRA approach is more conservative than either the Analysis Concept or the Ratio Concept alone, but assumes the absence of sulphur present as barium sulphate. The AMIRA approach of using NAG testing is particularly useful for PAF-LC materials or where there is very low ANC in the host rock. A combined acid generation classification scheme based on NAPP and NAG determinations is presented in Table 2.

Table 2: Waste Classification Criteria

Primary Geochemical Waste Type Class	NAPP Value kg H_2SO_4/t	NAGpH	Sulphide S Content
Potentially Acid Forming – Low Capacity (PAF-LC)	0 to 10	< 4.5	0.16 to 0.3%
Potentially Acid Forming – High Capacity (PAF-HC)	≥10	< 4.5	≥ 0.3%
Uncertain (UC)	0 to 5	> 4.5	Not important
Uncertain (UC)	-10 to 0	< 4.5	Not important
Non Acid Forming (NAF)	-100 to 0	> 4.5	Not important
Acid Consuming (AC)	< -100	> 4.5	Not important

Table 2 is based on the Australian Government's Guidelines on Managing Acidic and Metalliferous Drainage (DIIS 2016) and is in turn based on an earlier classification system included within the AMIRA ARD Test Handbook (AMIRA 2002), which is advocated by the Global Acid Rock Drainage Guidelines (GARD) published by the International Network for Acid Prevention (INAP 2009). This classification system, based on static acid base accounting procedures and used in conjunction with geological, geochemical and mineralogical analysis can still leave materials classified as 'uncertain' where there is conflicting NAGpH and NAPP results. Uncertain materials demonstrating a NAGpH above 4.5 may be tentatively assigned as potentially NAF and those below pH 4.5 as potentially PAF – however in such cases, further assessment, such as the use of kinetic leaching columns may be required to provide a definitive classification.

3.2 LABORATORY METHODS

Representative samples were identified and selected by Venturex geologists and submitted to ALS laboratories, which holds accreditation with the National Association of Testing Authorities (NATA). Collated results of all analysis are presented in Appendix 1 and original laboratory reports, in Appendix 2.

3.2.1 Acid Base Accounting

All samples were analysed for total sulphur, sulphate-sulphur, total carbon, ANC and NAG test parameters (NA to pH 4.5 and 7.0, NAG pH).

ANC was measured by a modified Sobek procedure (AMIRA 2002), which involves addition of dilute hydrochloric acid to the sample, followed by gentle simmering (two hours) to complete the reaction. The ABA scheme relies on measurement of oxidisable sulphur. The value of this fraction of sulphur in mine waste samples is calculated as the difference between total sulphur and sulphate-sulphur, which is present in a fully oxidised form and therefore not capable of generating additional acidity. Sulphate-sulphur content was determined by a heated hydrochloric acid extraction and Inductively Coupled Plasma – Optical Emission Spectrometry (ICP-OES) finish.

When assessing data for the MPA and NAPP, it must be noted that both parameters are based on the assumption that all sulphur contained in the sample is acid producing (sourced from pyrite (FeS_2) and other iron sulphide minerals). However, this represents a worst case scenario as not all minerals containing sulphur will result in acid production. Conversely, the NAPP calculation also assumes that the acid neutralising material measured in ANC is rapid-acting. In practice, some neutralising capacity is supplied by silicate and aluminosilicate minerals which can be much slower to react. Further still, iron carbonate minerals such as siderite ($FeCO_3$) have limited or no capacity to neutralise acidity due to acid producing reactions resulting from oxidation of the dissolved ferrous iron component. Despite these assumptions, NAPP remains a suitable conservative prediction of potential acid generation when used in conjunction with mineralogical data.

The NAG test involves the addition of hydrogen peroxide, a strong oxidising agent, to a sample of mine waste to oxidise reactive sulphides. After cooling the sample pH is measured (NAGpH) and any acidity generated measured by back titrating with sodium hydroxide solution to a pH of 4.5 (NAG to pH 4.5) and pH 7 (NAG to pH 7). NAG is expressed in units of kg H_2SO_4/t. A significant NAG result (i.e. final NAGpH less than 4.5) generally indicates that the sample is PAF (Table 2) and the test provides a direct measure of the NAG potential. A NAGpH of 4.5 or more generally indicates that the sample is NAF, but may still be capable of generating metalliferous drainage following oxidation of the sulphide minerals. Results for titrations of aliquots of the NAG solution to endpoint pH values of 4.5 and 7.0 allow estimation by the difference between these results of the relative amounts of non-acid producing base metal (such as copper) and iron sulphides in the sample.

3.2.2 Water and Dilute Acid Extractable Leach

Selected samples (composite footwall samples) were subjected to a water extraction (deionised, 1:5 extraction ratio) to assess potentially soluble species from waste rock. The Australian Standard Leaching Procedure (ASLP, 1:20 ratio) was also performed on selected samples using dilute acetic acid (pH 2.9) as the extraction fluid. This test was performed to simulate seepage quality expected under mild acidic conditions which may be achieved by severe oxidation of sulphide minerals.

3.2.3 Elemental Composition

Environmentally significant metals and metalloids were measured following digestion of a finely ground sample with a mixture of four acids (hydrochloric, nitric, perchloric and hydrofluoric acids) which is a near total determination for the elements measured. Mercury was also analysed following a separate, lower temperature digestion.

From this data, the global abundance index (GAI) for each element was calculated by comparison to the average earth crustal abundance (Bowen 1979 and AusIMM 2001). The main purpose of the GAI is to provide an indication of any elemental enrichment that could be of environmental significance. The GAI (based on a log-2 scale) is expressed in integer increments from zero to six (GARD Guide). A GAI of zero indicates that the content of the element is less than or up to three times the average crustal abundance; a GAI of one corresponds to a three to six fold enrichment; a GAI of two corresponds to a six to 12 fold enrichment and so forth, up to a GAI of six which corresponds to a 96-fold, or greater, enrichment above average crustal abundances. A GAI of more than three is considered significant and may warrant further investigation. Results have been truncated to show no more than a GAI of six.

4. PREVIOUS STUDIES

Venturex provided MBS with the following reports relating to geochemical characterisation of waste rock from Sulphur Springs:

- Geochemical characterisation of waste rock and tailings materials, including conceptual WRD design and TSF cover design by URS (Alan Robertson) in 2007 (URS 2007a).
- Sulphur block modelling undertaken for CBH by C.H. Lutherborrow in 2007 (Lutherborrow 2007).
- Detailed waste rock characterisation undertaken for CBH by RGS in 2008, in line with recommendations from URS (2007a) (RGS 2008).
- Further waste rock characterisation coordinated by Graeme Campbell and Associates in 2012 (GCA 2012).

These studies are discussed further in the following sections.

4.1 URS (2007) STUDY

The URS study (URS 2007a) characterised Sulphur Springs waste rock likely to be generated by a large open cut mine approximately 800 m long, 520 m wide and 360 m deep.

4.1.1 Sample Descriptions and Methodology

Only single samples from each of the three major lithologies were assessed in this study:

- Felsic volcanic (footwall, 303 m down hole sample).
- Siltstone/breccia (hanging wall, 298 m down hole sample).
- Chert (hanging wall, 557 m down hole sample).

The samples were analysed by ALS laboratories in Brisbane using static test methods consistent with those described in Section 3. The samples were analysed for:

- ABA parameters; Tot_S, SO_4_S, ANC and NAG test.
- Elemental composition (Al, Sb, As, Fe, Cd, Cr, Co, Cu, Pb, Mn, Hg, Ni, Se and Zn).
- Effective Cation Exchange Capacity (eCEC) and Exchangeable Sodium Percentage (ESP), as indicators of structural stability.

The same three samples were also assessed for sulphur oxidation and acid generation rates using the open kinetic column method described by AMIRA (AMIRA International 2002).

4.1.2 Key Findings

Results indicated all samples exhibited slightly alkaline pH and very low salinity. The footwall volcanics and hanging wall siltstone/breccia samples had elevated total sulphur concentrations of 0.80 and 0.91%, respectively, which was mainly present in the sulphide (oxidisable) form, whereas the hanging wall chert was essentially barren of sulphur (0.01%). All samples had low to negligible ANC and both the volcanics and siltstone/breccia had positive NAPP values. The NAGpH and NAG capacity data indicated that materials could be classified as follows:

- Footwall volcanics: Potentially Acid Forming – Moderate Capacity (PAF-MC).
- Hanging wall siltstone/breccia: Uncertain (UC).
- Hanging wall chert: Non-Acid Forming (NAF).

The reason for the uncertainty surrounding the acid forming nature of the hanging wall siltstone/breccia was a discrepancy between the NAPP and NAGpH results. This discrepancy was further investigated by the kinetic leach column test program. Initial results predicted that leachate from this waste rock would be pH-neutral and contain low concentrations of soluble metals and salts for a period of at least six months.

The results indicated that the eCEC of the waste rock samples ranged from <1 to 14 milliequivalents/100 g and that the ESP of ranges from 0.9 to 6.9 %. These results indicate that waste rock materials are unlikely to be sodic and should have a low risk of dispersion and erosion.

4.2 SULPHUR BLOCK MODELLING (2007)

Sulphur block modelling, undertaken for CBH as per the large open pit project proposed at the time (Lutherborrow 2007), estimated the acid production potential of waste rock based on total sulphur assay data obtained from exploration drilling. A total of 2,248 drill core samples from 118 drill holes covering the extent of the proposed open pit area were analysed for total sulphur content. For block modelling, the sulphur content of the ore (sulphide) domain was interpolated by ordinary kriging into the allocated domain blocks using sulphur concentrations for 1,781 samples from 67 drill holes. For the waste rock domain, the sulphur content was interpolated by ordinary kriging into the allocated domain blocks using sulphur concentrations for 467 samples from 51 drill holes.

Data indicated that the vast majority (approximately 92.3%) of waste rock generated by the large open pit contained less than 0.1% sulphur and this material was classified as NAF. However, the data also indicated that some (approximately 7.7%) PAF material was present, mainly as a "halo" around the ore body.

On the advice of CBH test work, a total sulphur threshold of 0.3% sulphur was adopted for classification of NAF and PAF waste. It was acknowledged that this value may not be the final threshold, but this value was used for the purpose of waste rock mass calculation at the time.

4.3 RGS (2008) STUDY

4.3.1 Mine Description

In 2008, RGS was contracted by CBH to undertake more detailed waste rock characterisation in line with recommendations from the 2007 URS study (URS 2007a). At the time, the mine was proposed as an open pit operation generating about 43 million BCM of waste rock. Details of waste volumes and sample numbers for each lithology are presented in Table 3.

Table 3: Open Pit Waste Rock (RGS 2008)

Lithology	Volume (BCM)	Percentage by Volume	Total Samples	Weathered Samples
Dacite (volcanic)	250,889	1.4%	2	1
Rhyodacite (volcanic)	590,650	3.3%	4	2
Chert	4,732,462	26.4%	14	3
Poly-mict breccia	9,093,185	50.8%	24	5
Siltstone	1,589,065	8.9%	8	2
Sandstone	1,640,957	9.2%	8	2
Total Waste Rock	17,897,208	100%	60	15 (25%)

4.3.2 Sample Descriptions and Methodology

A total of 61 waste rock samples from six lithologies and one sample of contact material from the interface between the footwall volcanics and massive sulphide were selected from eight drill holes. A summary of lithologies represented by the waste rock samples is included in Table 3 and demonstrates sample numbers for each lithology aligned reasonably with their contributions to total waste rock volumes. Unlike the URS (2007a) study, samples were selected from drill core regolith from the surface to a maximum down hole depth of 282.5 m, which provided a better representation of material across the proposed open pit design at that time.

These samples were analysed for ABA parameters and elemental composition by ALS (Brisbane) laboratories by the same test methods used for the URS (2007a) study. In addition, 15 composite samples were prepared and analysed for pH, EC and soluble metals/metalloids in a 1:5 water extract.

An additional set of six composite samples, representing each lithology listed in Table 3, were prepared for kinetic leach column testwork (AMIRA International 2002). The composite samples varied in total sulphur content from <0.01% (sandstone) to 3.2% (chert/volcanic footwall).

4.3.3 Key Findings

Results from the kinetic leach column testwork were published as a letter report dated 24 January 2009 (not provided) and results from the static test program were supplied in spreadsheet format. Key findings from assessment of the data by MBS are summarised below:

- Of the 61 samples assessed:
  - 50 samples (83% of all samples) were classified as NAF.
  - Seven samples were classified as PAF.
  - Four samples were classified as "Uncertain".
- PAF samples, mainly volcanics and footwall chert, were characterised by:
  - Elevated total sulphur concentrations (0.65 to 8.02%), most of which was present in the sulphide form.
  - Very low ANC values (<0.1 to 4 kg H_2SO_4/t).
- NAF samples, mainly hanging wall siltstone/breccias, were characterised by:
  - Low total sulphur concentrations (<0.01 to 0.48%), with variable amounts of sulphate (oxidised) sulphur.
  - Variable, but typically moderate, ANC values (<0.5 to 111 kg H_2SO_4/t).
- Uncertain samples (chert and footwall volcanics) were characterised by low sulphur concentrations (0.11 to 0.17%) and low ANC (<0.5 to 6 kg H_2SO_4/t). NAPP values ranged from -3 to 5 kg H_2SO_4/t, while all NAG pH values were less than 4.5 (3.2 to 4.4), suggesting the materials were more likely to behave as PAF rather than NAF.

Fifteen composite samples were extracted with water (1 to 5 extraction ratio) to assess potential for leaching of soluble salts, metals and metalloids from freshly mined waste rock. Eleven of these samples were classified as NAF (mainly siltstone, chert and breccia), two as PAF (volcanic footwall, and sulphidic sedimentary rock) and two as 'Uncertain (volcanic footwall and chert). Water leachates of the 15 composite samples were typically alkaline (pH 7.3 to 9.6), except for the composite PAF footwall volcanics/chert sample (pH 4.8). Leachate EC values ranged from 11 to 1,040 µS/cm, indicating potential for fresh to brackish salinity in any seepage or runoff from freshly mined waste rock. Oxidation of low concentrations of sulphide minerals in NAF waste rock may slightly increase leachate salinity, but are not expect to produce acidic leachate or elevated concentrations of metals and metalloids.

Concentrations of soluble sodium (<2 to 38 mg/L) were generally low compared to other soluble major cations (calcium, magnesium and potassium), indicating low sodicity materials.

The alkaline leachates of NAF waste rock samples contained very low concentrations of environmentally significant metals and metalloids. However, the acidic leachate of a PAF volcanic footwall sediment sample contained elevated concentrations of iron (41.6 mg/L), manganese (2.16 mg/L), nickel (0.86 mg/L) and zinc (7.3 mg/L), but low concentrations of arsenic (<0.02 mg/L), cadmium (<0.02 mg/L), copper (<0.02 mg/L), selenium (<0.02 mg/L) and lead (<0.02 mg/L).

Key findings from the kinetic leach column program, comprising three samples from the URS (2007a) study (Section 4.1) and six composite samples from the RGS study leached for 11 months, were:

- Initial and ongoing surface runoff and leachate from "low sulphur" (<0.3% total sulphur) waste rock types is likely to be pH neutral and contain low concentrations of soluble metals and salts.
- Initial and ongoing surface runoff and leachate from "high sulphur" (>1% total sulphur) waste rock types may be acidic and contain elevated concentrations of some soluble metals (Al, Cd, Co, Ni and Zn) and sulphate salts.
- Other factors being equal, the sulphur oxidation rates for chert and sandstone lithologies were slower than those for breccia, siltstone and volcanic footwall samples.

NAF hanging wall sedimentary waste rock is considered suitable as a covering material for PAF waste rock in an above ground WRD, but has insufficient ANC to enable blending with PAF waste rock as a means for limiting acid formation potential from these materials.

4.4 CAMPBELL (2012) STUDY

Further waste rock characterisation work was coordinated by Graeme Campbell and Associates (GCA 2012) to inform a revised mine plan based on underground mining only, with no open pit.

4.4.1 Sample Descriptions and Methodology

A total of 17 samples described as 'mullock' were provided for assessment. These samples comprised:

- 13 samples of dacite (volcanics) from the footwall from drill hole material collected at down hole depths between 147 and 285 m.
- One sample of hanging wall dacite.
- Three samples of hanging wall sediments.

Four samples of dacite from the proposed decline path were also assessed. These samples originated from down hole depths ranging from 6 to 152 m.

4.4.2 Key Findings

The testwork results indicated that all 'mullock' derived from footwall dacites, hanging wall dacites and sulphidic hanging wall sediments from the Sulphur Springs deposit should be treated as PAF: the footwall 'mullock' (0.22 to 12% total sulphur) being at much greater risk for acid generation than the hanging wall 'mullock' (0.22 to 0.96% total sulphur).

Enrichments in Cu, Zn, Cd, Pb, and As were generally greater for the footwall samples compared with the hanging wall samples.

The decline path samples were classified as NAF, due to very low sulphur concentrations (0.01 to 0.12%), and lack of appreciable enrichment in a wide range of minor-elements. Mineralogical results were consistent with that expected for dacite volcanics, as indicated by quartz being the major mineral in all samples, and plagioclase and muscovite being the only feldspar and mica minerals, respectively, identified.

5. KNOWLEDGE GAPS

In light of the current proposed project, which has a smaller pit than proposed by CBH, MBS Environmental and Venturex reviewed previous waste rock characterisation testwork data to determine whether the studies discussed in Section 4:

- Were consistent with contemporary methodology (INAP 2009, DIIS 2016, DMP 2016).
- Reflected waste rock volume and lithology for the currently proposed open pit.
- Were suitable for reliably identifying the volume and placement of benign waste rock materials that could be used to encapsulate predicted volumes of PAF waste rock in an above ground WRD.

From this review, the following knowledge gaps were identified:

- Further assessment of shallow, partly weathered hanging wall sedimentary waste rock was required. This material was expected to provide most of the benign NAF waste rock for construction of the run-of-mine (ROM) pad and encapsulating PAF waste rock in an above ground WRD.
- A highly sulphidic (pyrite), but sub-grade material present in the footwall volcanics had not been assessed previously. This material was expected to be stored either underground or encapsulated by benign NAF waste rock in the permanent WRD.
- The potential for mobilisation of metals and metalloids from NAF waste rock by contact with acid solutions, such as seepage from blended PAF waste or mineralised PAF stored on a ROM pad constructed from NAF waste had not been assessed.
- The total sulphur threshold value of 0.3% for differentiating NAF and PAF waste rock used for earlier block modelling (Section 4.2) had not been validated by robust ABA data.

A total of 35 additional waste rock samples, comprising 31 samples of shallow hanging wall sediments and four composite samples of mineralised footwall waste were collected by Venturex and submitted to ALS laboratories (Perth) to address these knowledge gap issues. The results for analysis of these samples are presented in Section 6.

6. ADDITIONAL ANALYSES

6.1 SAMPLE DESCRIPTIONS

Descriptions of the 35 waste rock samples are presented in Table A1-1 of Appendix 1. The samples comprised:

- 16 samples of hanging wall siltstone.
- Eight samples of hanging wall breccia.
- One sample of hanging wall sandstone.
- Four samples of hanging wall chert.
- Two samples of hanging wall sedimentary rock adjacent to a fault structure.
- Four composite samples of footwall volcanic materials:
  - Composite 1: footwall dacite (felsic volcanics).
  - Composite 2: footwall brecciated chert and shale.
  - Composite 3: massive sulphides (low Cu/Zn).
  - Composite 4: dacite and silicified shale.

6.2 ACID BASE ACCOUNTING

Laboratory results for total sulphur, total carbon, SO_4_S, ANC, NAG testing and calculated acid base accounting parameters are collated in Table A1-2 of Appendix 1. The original laboratory reports are included in Appendix 2.

6.2.1 Sulphur Forms

A summary of results for the sulphur forms assessed (total sulphur and sulphate sulphur) is provided in Table 4. Hanging wall siltstone samples contained low to moderate sulphur concentrations (0.02% to 0.55%), with relatively high proportions present in the sulphate (oxidised form). As expected, the footwall composite samples were highly acidic, with total sulphur concentrations ranging from 10.7% to 34.0%, although considerable amounts of sulphate-S were also present. It is likely that some sulphate-S was produced by oxidation of sulphide minerals in drill core material stored at site prior to laboratory analysis. Previous work (RGS 2008) indicated the sulphide minerals in volcanic footwall waste oxidised rapidly in kinetic leach column tests.

Table 4: Sulphur (%) Forms Summary

Lithology	# Samples	SO_4_S Range	SO_4_S Mean	Total S Range	Total S Mean
Siltstone	16	0.01 – 0.47	0.10	0.02 – 0.55	0.15
Breccia	8	0.08 – 0.37	0.19	0.10 – 0.43	0.21
Sandstone	1	0.23	0.23	0.26	0.26
Chert	4	0.06 – 0.34	0.19	0.06 – 0.42	0.22
Fault	2	0.24 – 0.35	0.30	0.26 – 0.43	0.34
Footwall composites	4	2.8 – 14.8	8.4	10.7 – 34.0	17.4

These results generally align with those from earlier studies, notably RGS (2008) and GCA (2012).

6.2.2 Acid Neutralisation Capacity

ANC was measured directly by acid addition, heating and back-titration. Results are provided in Table A1-2 (Appendix 1), with a summary by lithology presented in Table 5.

Table 5: ANC Summary (kg H_2SO_4/t)

Lithology	# Samples	ANC Minimum	ANC Maximum	ANC Mean
Siltstone	16	1.7	18	7
Breccia	8	6.6	39	19
Sandstone	1	18	18	18
Chert	4	<0.5	1.2	0.7
Fault	2	1.5	1.6	1.6
Footwall composites	4	<0.5	20	7

Based on the data in Table 5, and Table A1-2 (Appendix 1), the following are noted as key points:

- ANC levels were low in most samples from all lithologies, but in particular chert and fault zone materials.
- The clastic sedimentary hanging wall samples (sandstone and siltstone lithologies) had low ANC values, with a mean value of 7 kg H_2SO_4/t for siltstone.
- Breccia samples typically had higher ANC values (maximum 39 kg H_2SO_4/t) with a mean value of 19 kg H_2SO_4/t. Overall, the ability of hanging wall waste rock to neutralise sulphide acidity is considered marginal.
- In contrast with earlier investigations, notably RGS (2008), none of the samples analysed contained moderate to high ANC values. The RGS (2008) results (Section 4.3.3) indicated ANC values for hanging wall sediments as high as 111 kg H_2SO_4/t. The typically low ANC values for samples assessed in this current study are considered to reflect the highly weathered state of these particular samples, which were collected specifically to address identified knowledge gaps (Section 5).

Hanging wall samples were also analysed for total carbon, enabling calculation of CarbNP. Chart 1 compares calculated CarbNP values with measured ANC values, and includes a (red) line for the 1:1 relationship (in which measured ANC is only provided by reactive calcium/magnesium carbonate minerals). Only nine siltstone samples indicated good agreement between CarbNP and measured ANC, suggesting the ANC of these particular samples was mainly provided by reactive calcium/magnesium carbonate. For the other seven siltstone samples, and all samples from other hanging wall lithologies, the calculated CarbNP values were significantly higher than ANC. This observation demonstrates that ANC measured in the laboratory is a better indicator than total carbon for characterising acid neutralisation properties of Sulphur Springs waste rock

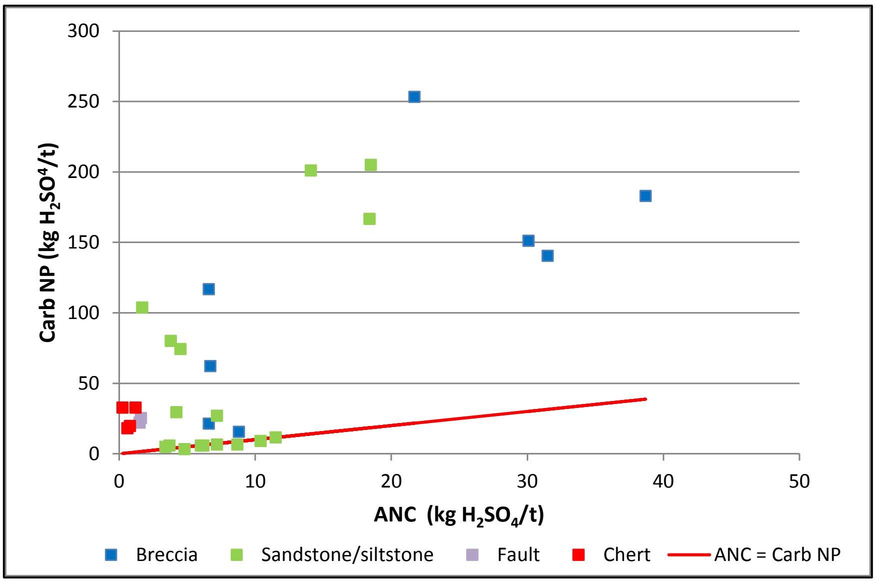

Chart 1: Comparison Between ANC and Carb-NP

6.2.3 Acid Drainage Classification

Acid drainage potential classifications are outlined in Table A1-2 of Appendix 1 and summarised in Table 6. Classifications are represented as a plot of NAPP versus NAGpH (hanging wall samples and footwall composites) in Chart 2, or by lithology for hanging wall sedimentary samples in Chart 3. The four quadrants are labelled as NAF, PAF and UC according to the AMD (acid metalliferous drainage) classification criteria in Table 2.

Table 6: AMD Classification Summary

Lithology	# Samples	NAF	PAF-HC	PAF-LC	Uncertain
Siltstone	16	10	1	1	4
Breccia	8	8	0	0	0
Sandstone	1	1	0	0	0
Chert	4	0	1	2	1
Fault	2	0	1	1	0
Footwall composites	4	0	4	0	0

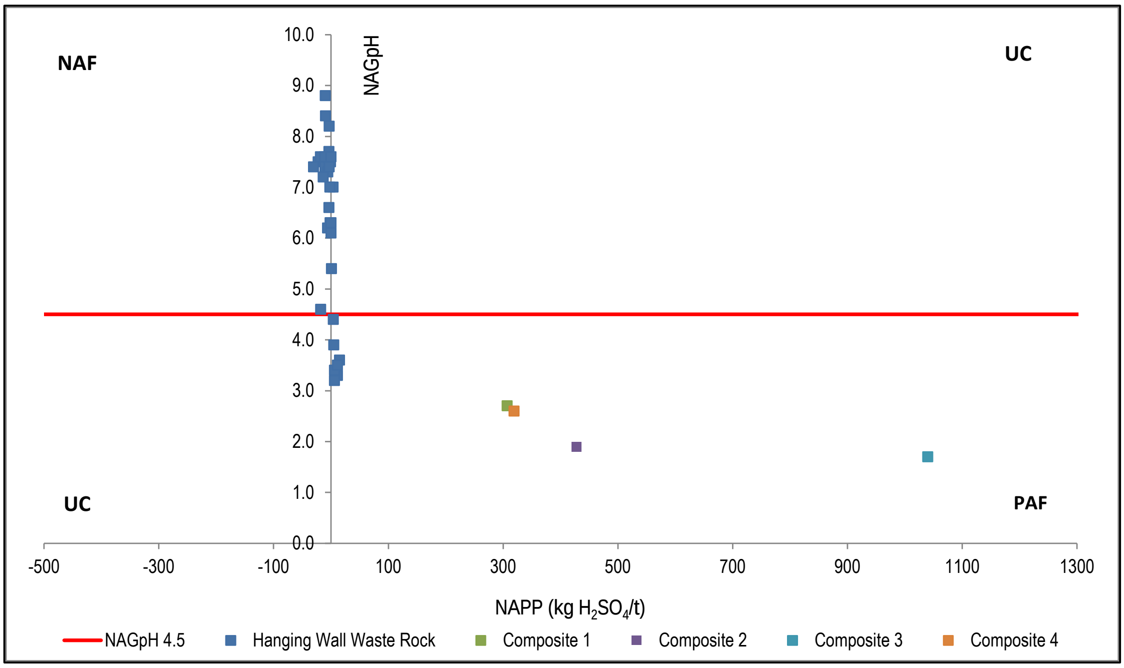

Chart 2: AMD Plot Classifications – All Samples

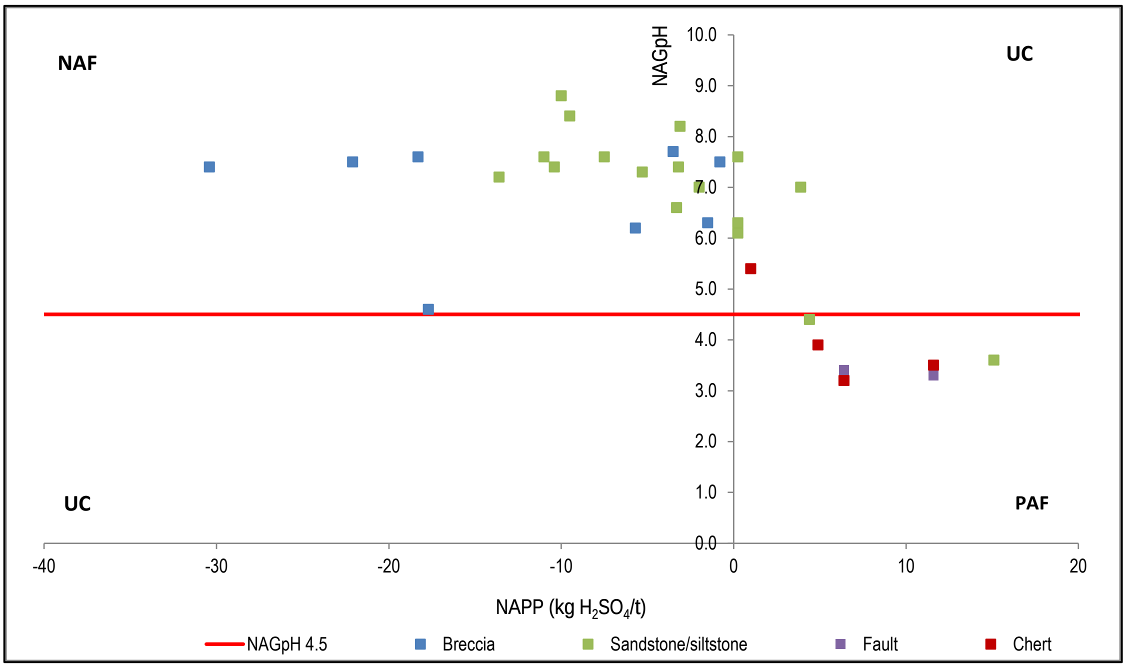

Chart 3: AMD Plot Classifications – Hanging Wall Samples

Based on examination of these results, the following can be noted:

- All breccia samples were classified as NAF.
- Three of the four chert samples were classified as PAF, with the other sample classified as Uncertain as a consequence of conflicting NAG pH (pH 6.3, suggesting NAF classification) and a very low, but positive NAPP value (<0.5 kg H_2SO_4/t, suggesting PAF-LC classification).
- Both "fault" samples were classified as PAF (one PAF-HC, the other PAF-LC).

- All sulphidic composite footwall samples were classified as PAF-HC.
- The single sandstone sample was classified as NAF.
- Siltstone samples were more variable in terms of AMD classification, which aligns with results from earlier studies, notably RGS (2008):
  - One sample was classified as PAF-HC. This sample (P520133) had the highest total sulphur concentration (0.55%).
  - One sample was classified as PAF-LC. This sample (P520134) had the second highest total sulphur concentration (0.28%) and was collected from the following segment in drill hole: SSD061 (42-43 m) to sample P520133.
  - Four samples were classified as Uncertain as a consequence of conflicting NAG pH (greater than pH 4.5, suggesting NAF classification) and very low, but positive NAPP values.
  - Ten samples were classified as NAF on the basis of their low total sulphur content range (0.02 to 0.16%).

The following inferences can be drawn from these results and findings from previous studies:

- All open pit footwall waste, particularly volcanics, are classified as PAF-HC and it is recommended that these materials be segregated from hanging wall waste.
- Mineralised waste is highly sulphidic and therefore classified as PAF-HC. Based on kinetic studies (RGS 2008) of samples containing significant amounts of iron sulphides (>0.3% total S), the highly mineralised materials are expected to be reactive and produce AMD within several weeks to months under optimal weathering conditions.
- Hanging wall sedimentary waste, particularly breccia, siltstone and sandstone within the oxide zone, are expected to be mainly NAF. Total sulphur concentration is expected to provide a suitable tool for segregating NAF and PAF hanging wall wastes (Section 7).

6.3 ELEMENTAL COMPOSITION

Total elemental composition of four composite footwall samples is presented in Table A1-3 of Appendix 1. Tables A1-4 of Appendix 1 presents calculated GAI values for these samples, as outlined in Section 3.2.3, with values greater than or equal to three indicated by yellow shading.

Key points are as follows:

- All samples were geochemically enriched in silver and antimony. Samples were also likely enriched in bismuth and thallium, although it was not appropriate to assign GAI values to samples recording concentrations below the relatively high method reporting limits for these elements.
- Composite 1 (footwall dacite) was also enriched in copper and molybdenum.
- Composite 2 (footwall brecciated chert and shale) was also enriched in arsenic, cadmium, mercury, lead and zinc.
- Composite 3 (massive sulphides – low Cu/Zn) was also enriched in arsenic, mercury and molybdenum.
- Composite 4 (dacite and silicified shale) was also enriched on cadmium, copper, mercury, lead and zinc.

Overall, all footwall waste lithologies were generally highly enriched in several environmentally significant metals and metalloids. As these materials are also classified as PAF-HC (Section 6.2.3) and expected to be reactive in air and water (Section 4.3.3), formation of AMD is expected within a short period, if not managed appropriately.

6.4 WATER LEACHATE CHARACTERISATION

6.4.1 Soluble Salts, Alkalinity and pH

Results for pH, EC, alkalinity and major ions in the 1:5 water extracts of the composite footwall samples are given in Table A1-5 of Appendix 1.

Samples of fresh waste rock from the footwall volcanics were found to have:

- Generally acidic pH values, ranging from 4.1 to 6.6 in 1:5 extracts of fresh rock to deionised water.
- Effectively zero alkalinity. A small amount of bicarbonate alkalinity (3 mg $CaCO_3$/L) was recorded in Composite 1 (footwall dacite).
- Relatively low levels of salinity and soluble salts in fresh rock waste samples, with 1:5 extracts for most samples having EC values below 500 µS/cm. Magnesium was the dominant cation and sulphate the dominant anion in all samples.

6.4.2 Soluble Metals and Metalloids

Results for water-soluble metals and metalloids in the 1:5 extracts of composite footwall samples are presented in Table A1-6 of Appendix 1. ANZECC 2000 Livestock Drinking Water Guidelines (cattle) are provided for comparison, with exceedances highlighted using yellow shading.

Key observations are summarised below.

- Despite geochemical enrichment in a variety of elements, the only elements in the 1:5 extracts of fresh (non-oxidised) waste rock samples to exceed ANZECC 2000 Livestock Drinking Water Guidelines were:
  - Lead (maximum concentration 6.3 mg/L) in Composites 2, 3 and 4.
  - Zinc (32 mg/L) in Composite 4.
  - Cadmium (marginal exceedance of 0.014 vs. 0.01 mg/L) in Composite 2.
- Water leachates for Composites 2, 3 and 4 contained elevated concentrations of iron (maximum 128 mg/L in Composite 2). Although dissolved iron is not considered toxic to livestock, these concentrations are considered environmentally significant. Most of the soluble iron is predicted to be in the reduced (ferrous) form. Mixing of footwall waste rock seepage with oxygenated surface waters or groundwater will result in oxidation of dissolved iron to form ferric hydroxide 'flocs' and acidity.

These results indicate the leachate from freshly mined footwall waste is expected to be slightly acidic and contain environmentally significant concentrations of lead, zinc, iron and other metals. All of this material mined as waste rock will be encapsulated in the WRD and therefore presents no significant environmental risk. Rainwater flowing over exposed footwall rock in the pit walls is expected to be acidic and slightly metalliferous and will require management (such as lime dosing) if it needs to be discharged to the environment during operations. This material will also be a potential source of acid and soluble metals in the post-closure pit lake, although the rate of acid and solute release will decrease rapidly as the level of the pit lake increases and eventually covers these materials in response to recharge by groundwater and incident rainfall.

6.5 DILUTE ACID LEACHATE CHARACTERISATION

Dilute acetic acid leachate tests provide an indication of which acid-neutralising minerals are present, and which metals may be released if sulphide oxidation and acid formation are not controlled through appropriate management measures. Results for the four composite footwall waste rock samples are presented in Table A1-7 of Appendix 1.

Under the acidic conditions of this test (starting pH 2.9, final pH 3.0 to 3.4) the following was noted:

- Almost no calcium (maximum 2 mg/L in Composite 1) and very little magnesium (maximum 16 mg/L in Composite 1) was dissolved by the acid. Also, comparatively elevated concentrations of iron (21 to 53 mg/L) suggest that the low ANC of these materials is mainly provided by magnesium carbonates in association with siderite ($FeCO_3$).
- Interaction of freshly mined volcanic footwall waste in acidic seepage is predicted to release:
  - Elevated copper from Composite 1 (23 mg/L).
  - Elevated zinc from Composites 2 and 4 (5.4 and 13 mg/L, respectively).
  - Elevated lead from Composites 2 and 4 (23 and 15 mg/L, respectively).
  - Slightly elevated concentrations of cadmium from Composites 1, 2 and 3 (0.01 to 0.03 mg/L).
  - Slightly elevated concentrations of arsenic and antimony (but not selenium or tellurium) from Composites 2 and 3. Composite 1 leachate contained 0.01 mg/L tellurium, which is considered elevated for this extremely rare, but highly toxic, metalloid.
- Despite significant geochemical enrichment by silver, bismuth, mercury and molybdenum in several samples (Section 6.3), concentrations of these elements in acidic leachates were relatively low.

It is important to note that the acetic acid leach test is not expected to dissolve metals and metalloids present as insoluble sulphide minerals, such as cinnabar (HgS) and molybdenite (MoS_2). However, oxidation of sulphide minerals, if not managed, is expected to release metals and metalloids present as sulphides, notably Cu, Zn, Cd and Pb.

Management measures required for prevention of release of metals from NAF waste rock by interaction with acidic fluids should include:

- Effective segregation of NAF and PAF waste rock, using the proposed total sulphur cut-off grade (Section 7).
- Effective encapsulation of PAF waste rock cell in the WRD. This will require coverage (top, bottom and sides) by a compacted clay layer with a permeability of less than 10^{-7} m/sec.
- Managing seepage and run-off from temporarily stockpiled sulphidic materials (including low grade ore) to prevent interaction with the surrounding environment.

7. TOTAL SULPHUR CUT-OFF GRADE

Findings from earlier studies and this assessment indicate:

- All open pit footwall waste is expected to be classified as PAF-HC as a consequence of elevated total sulphur concentrations and generally low ANC.
- Hanging wall open pit paste has much lower total sulphur concentrations, of which variable proportions will be in the oxidised (sulphate) form. ANC values were variable, but often low. Although the fully oxidised hanging wall waste is expected to be classified as NAF, acid formation from weathered and fresh hanging wall waste cannot be accurately predicted by lithology.

Where acid formation potential cannot be predicted or managed by waste rock lithology alone, a total sulphur cut-off grade is the preferred and most practical complementary approach for identifying and segregating PAF from NAF waste.

A total sulphur cut-off grade for open pit hanging wall waste rock was estimated using pooled laboratory data from the RGS (2008) study (50 samples) and this assessment (31 samples). Two approaches were adopted:

- Comparison of total sulphur concentration (%S) and NAG pH, using a NAG pH value of 4.5 to identify probable PAF and NAF wastes (presented in Chart 4, with the proposed sulphur cut-off grade of 0.5% as a dashed green line).
- Comparison of total sulphur concentration (%S) and NAG to pH 4.5, using a positive NAG result to identify probable PAF wastes (presented in Chart 5, with the proposed sulphur cut-off grade of 0.5%).

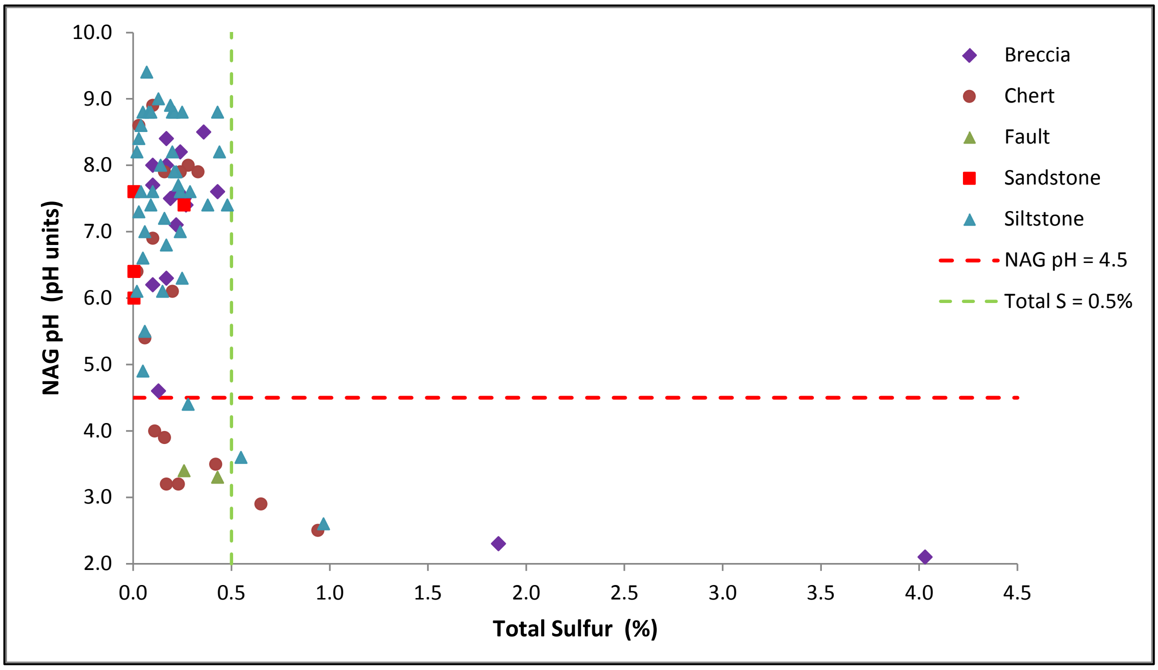

Chart 4: Relationship Between Total S and NAG pH - Hanging Wall Samples

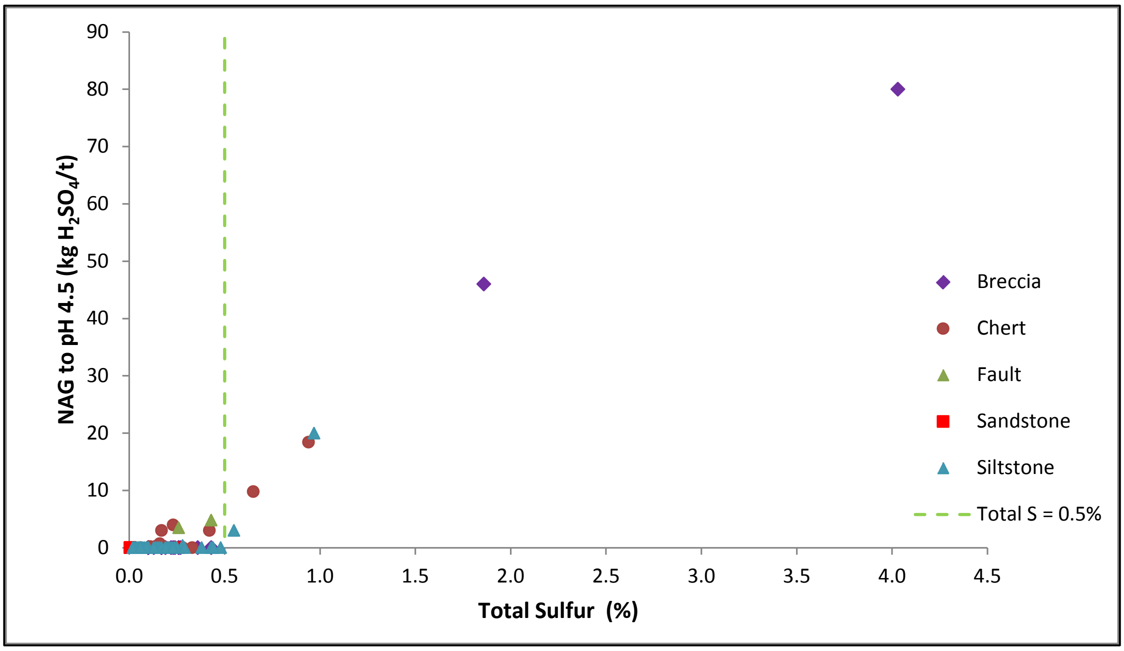

Chart 5: Relationship Between Total S and NAG to pH 4.5 - Hanging Wall Samples

Comparison of total sulphur concentrations (%S) and NAG pH values (Chart 4) shows:

- All samples containing greater than 0.5% total sulphur had NAG pH values below 4.5 pH units and are therefore likely to be classified as PAF.
- All breccia and sandstone samples containing less than 0.5% total sulphur attained NAG pH values exceeding 4.5 pH units, and are therefore likely to be classified as NAF.
- Both "fault" zone materials from this study contained less than 0.5% total sulphur, but had NAG pH values below 4.5 pH units, and are therefore likely to be classified as PAF. These samples were classified as PAF-LC and PAF-HC as a consequence of very low ANC (Section 6.2.3).
- Of the 17 chert samples in the pooled data set, 15 had total sulphur contents below 0.5%. Of these 15 samples, ten (67%) had NAG pH values greater than 4.5 pH units and are therefore likely to be classified as NAF, while five samples (33%) had NAG pH values below 4.5 pH units, indicating their classification as PAF.

Comparison of total sulphur concentrations (%S) and NAG to pH 4.5 values (Chart 5) shows:

- There was a strong correlation between NAG to pH 4.5 values and total sulphur concentrations for samples containing more than 0.5% total sulphur.
- Nearly all breccia, sandstone and siltstone samples containing less than 0.5% total sulphur recorded NAG to pH 4.5 values below the laboratory reporting limit (<0.1 kg H_2SO_4/t) and therefore are likely to be classified as NAF. A single sample of siltstone (P520134) gave a NAG to pH 4.5 value of 0.4 H_2SO_4/t and a NAG pH of 3.9, indicating a classification as PAF-LC.
- Many (more than 40%) "fault" zone material and chert samples containing less than 0.5% total sulphur recorded positive NAG to pH 4.5 values below 10 kg H_2SO_4/t and are therefore likely to be classified as PAF-LC (based on a reasonable comparison between NAG to pH 4.5 and calculated NAPP values, Table A1-2 of Appendix 1.

On the basis of these findings, a total sulphur cut-off grade of 0.5% is proposed for breccia, sandstone and siltstone open pit, hanging wall waste rock. This cut-off grade is not considered to be sufficiently robust for distinguishing NAF and PAF chert and "fault" zone materials.

As chert materials are expected to provide a substantial proportion of open pit waste (Table 1), there are two recommended options for management of chert (and "fault" zone) waste rock to minimise potential for AMD:

- Manage all non-weathered chert (and "fault" zone) waste rock as PAF-LC, which will require encapsulation in the permanent WRD and coverage by a minimum of 5 m of NAF waste rock.
- Adopt a lower (more conservative) cut-off grade for these materials. Based on the current data, an interim value of 0.2% would be a robust total sulphur cut-off grade for these materials.

8. CONCLUSIONS

This report consolidates Sulphur Springs waste rock geochemistry data provided from:

- Previous geochemical characterisation studies conducted on 85 samples and composite samples collected from across the waste rock lithologies for the project between 2007 and 2012 (URS 2007a, RGS 2008 and GCA 2012).
- Sulphur block modelling methodology adopted for earlier open put and underground mine designs. This modelling was based on total sulphur analysis of 1,781 ore samples and 467 waste rock samples collected from exploration drilling programs (Lutherborrow 2007).
- Analysis of 35 additional samples and composite samples collected in 2016 and 2017, as recommended by a knowledge gap assessment of earlier studies relevant to the current open pit operations planned for Sulphur Springs.

Characteristics of the major open pit waste rock types are summarised as follows:

- The footwall is comprised predominantly of dacite/rhyodacite volcanics of the Kangaroo Caves Formation (Sulphur Springs Group). These lithologies contain moderate to very high concentrations of sulphide minerals. In combination with elevated sulphur concentrations and typically low ANC, most of the footwall waste rock is classified as PAF-HC.
- The hanging wall, which is expected to contribute more than 70% of open pit waste rock (based on volumes presented in Table 1), is a sequence of sedimentary lithologies comprising mainly sandstone, siltstone, polymictic breccia and chert. The upper 30+ metres of the hanging wall is highly weathered and expected to provide significant volumes of NAF, non-saline waste rock.
- Partially unweathered and fresh sandstone, siltstone and polymictic breccia typically contain low to moderate total sulphur concentrations and low to moderate ANC. A total sulphur cut-off grade of 0.5% is proposed to identify and segregate NAF and PAF mine waste. Sulphur block modelling (Lutherborrow 2007) using this cut-off value is expected to provide a reliable estimate of the relative proportions and positions of NAF and PAF waste rock.
- As chert materials are expected to provide a substantial proportion of open pit waste (Table 1), there are two recommended options for management of chert waste rock (and "fault" zone material) to minimise potential for AMD:
  - Manage all non-weathered chert (and "fault" zone) waste rock as PAF-LC, which will require encapsulation within the permanent WRD and coverage by a minimum of 5 m of NAF waste rock.
  - Adopt a lower (more conservative) cut-off grade for these materials. An interim value of 0.2% would be a robust total sulphur cut-off grade for these materials.

Highly mineralised footwall wastes contain elevated concentrations of oxidisable sulphur and environmentally significant metal and metalloids including silver, cadmium, copper, lead, mercury and zinc. Leachate from these freshly mined materials is predicted to be moderately acidic and contain slightly elevated concentrations of copper, lead, ferrous iron and zinc, with fresh to slightly brackish salinity. Kinetic leach column studies (RGS 2008) indicate that the sulphide minerals are very reactive when exposed to air and water and are predicted to produce highly acidic, metalliferous and saline seepage within several months of exposure. As a consequence, the following management measures for highly mineralised footwall wastes, ore and low grade ore are recommended:

- Capture of all seepage and runoff from surface stockpiles of these materials.
- Construction of a low-permeability base layer for surface stockpiles of these materials.

Alternatively, PAF waste rock can be stored in the pit and backfilled underground as mine scheduling allows, without the need for implementation of the above measures.

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10. GLOSSARY OF TECHNICAL TERMS

Term	Explanation
AC	Acid consuming material.
ANC	Acid Neutralising Capacity. A process where a sample is reacted with excess 0.5 m HCl at a pH of about 1.5, for 2-3 hours at 80-90ºC followed by back-titration to pH=7 with sodium hydroxide. This determines the acid consumed by soluble materials in the sample.
Ankerite	A calcium, iron, magnesium, manganese carbonate mineral of general formula $Ca(Fe,Mg,Mn)(CO_3)_2$. In composition it is closely related to dolomite, but differs from this in having magnesium replaced by varying amounts of iron(II) (ferroan ankerite) and manganese(II).
AP	Acid Potential. Similar to MPA, but only is based on the amount of sulphide-sulphur (calculated as the difference between total sulphur and sulphate-sulphur (SO_4-S) rather than total sulphur. AP (kg H_2SO_4/t) = (Total S – SO_4-S) x 30.6
Basalt	A dark coloured fine grained mafic extrusive igneous rock composed chiefly of calcium plagioclase and pyroxene. Extrusive equivalent of gabbro, underlies the ocean basins and comprises oceanic crust.
Breccia	A clastic sedimentary rock that is composed of large angular fragments (greater than 2 mm in diameter). The spaces between the large angular fragments are filled with a matrix of smaller particles and a mineral cement that binds the rock together. A polymictic breccia is a clastic sedimentary rock composed of angular clasts from different origin intermixed in a consolidated matrix.
Carb NP	Carbon Neutralising Potential. The amount of ANC provided by carbonate minerals. Carb NP (kg H_2SO_4/t) = TIC (%) x 81.7
Chert	A microcrystalline or cryptocrystalline chemical sedimentary rock material composed of silica (SiO_2).
Circum-neutral pH	pH value near 7.
CRS	Chromium Reducible Sulphur. A measurement of reactive sulphide sulphur normally applied to acid sulphate soils using reaction with metallic chromium and hydrochloric acid to liberate hydrogen sulphide gas which is trapped and then measured by iodometric titration. For certain sample types, it is considered to be a more accurate estimate of oxidisable sulphur for iron sulphides than the difference between total sulphur and sulphate-sulphur (SO_4-S) for calculating Acid Potential (AP).
Dacite	An igneous, volcanic rock. It has an aphanitic to porphyritic texture and is intermediate in composition between andesite and rhyolite
Dolerite	A mafic, holocrystalline, subvolcanic rock equivalent to volcanic basalt or plutonic gabbro
Dolomite	Calcium magnesium carbonate $CaMg(CO_3)_2$.
EC	Electrical conductivity. A measurement of solution salinity. Conversion: 1000 µS/cm = 1 dS/m = 1 mS/cm
felsic	Silicate minerals, magma, and rocks which are enriched in the lighter elements such as silicon, oxygen, aluminium, sodium, and potassium.
mafic	Descriptive of igneous rock containing a high content of ferromagnesian silicate minerals, but less than those present in ultramafic rocks. Common mafic rocks include basalt, dolerite and gabbro.
Magnesite	Magnesium carbonate ($Mg(CO_3)_2$) or magnesium iron carbonate (Mg, $Fe(CO_3)_2$), the latter is termed ferroan magnesite.

Term	Explanation
MPA	Maximum Potential Acidity. A calculation where the total sulphur in the sample is assumed to all be present as pyrite. This value is multiplied by 30.6 to produce a value known as the Maximum Potential Acidity reported in units of kg H_2SO_4/t. MPA should include only the non-sulphate sulphur to avoid over-estimation of acid production in which case it may be referred to as AP.
NAF	Non Acid Forming
NAG	Net Acid Generation. A process where a sample is reacted with 15% hydrogen peroxide solution at pH = 4.5 to oxidise all sulphides and then time allowed for the solution to react with acid soluble materials. This is a direct measure of the acid generating capacity of the sample but can be affected by the presence of organic materials.
NAPP	Net Acid Producing Potential. NAPP (kg H_2SO_4/t) = AP – ANC. NAPP (kg H_2SO_4/t) = AP – ANC
effective NAPP	NAPP calculated using CarbNP rather than traditional ANC. Effective NAPP (kg H_2SO_4/t) = AP – CarbNP
PAF	Potentially Acid Forming. A sample is classified as PAF if the NAG pH is less than 4.5 and NAPP is positive (i.e. AP is greater than ANC).
PAF-LC	Potentially Acid Forming – Low Capacity. Waste rock classification for samples with NAPP values less than or equal to 10 kg H_2SO_4/t.
PAF-HC	Potentially Acid Forming – High Capacity. Waste rock classification for samples with NAPP values greater than 10 kg H_2SO_4/t.
Pyrite	Iron (II) sulphide, FeS_2. Pyrite is the most common sulphide minerals and the major acid forming mineral oxidising to produce sulphuric acid.
Rhyodacite	An extrusive volcanic rock intermediate in composition between dacite and rhyolite. Rhyolites are differentiated from dacites by higher concentrations of plagioclase feldspars and lower concentrations of alkali feldspars (such as orthoclase, microcline and albite).
Siderite	Iron (II) carbonate $FeCO_3$. Siderite reacts with acid to release ferrous ions (pale green) which then oxidise to ferric (brown) and this in turn generates acidity equal to the initial acid consumption by carbonate. It therefore does not overall contribute to ANC.

APPENDICES

APPENDIX 1: COLLATED RESULTS

LIST OF APPENDIX TABLES

Table A1-1: Sample Descriptions

Sample ID	Hole ID	Depth (m)	Lithology Description
P520123	SSD061	1 – 2	Siltstone
P520124	SSD061	2 – 3	Siltstone
P520125	SSD061	3 – 4	Siltstone
P520126	SSD061	4 – 5	Siltstone
P520127	SSD061	5 – 6	Siltstone
P520128	SSD061	6 – 7	Siltstone
P520129	SSD061	7 - 8	Siltstone
P520130	SSD061	8 – 9	Siltstone
P520131	SSD061	9 - 10	Siltstone
P520132	SSD061	40 – 41	Siltstone
P520133	SSD061	41 – 42	Siltstone
P520134	SSD061	42 – 43	Siltstone
P520135	SSD061	43 – 44	Siltstone
P520136	SSD061	44 - 45	Siltstone
P520137	SSD061	70 – 71	Breccia
P520138	SSD061	71 – 72	Breccia
P520139	SSD061	72 - 73	Breccia
P520140	SSD061	73 – 74	Breccia
P520141	SSD061	74 - 75	Breccia
P520142	SSD071	132 – 133	Breccia
P520143	SSD071	133 – 134	Breccia
P520144	SSD071	134 - 135	Breccia
P520145	SSD077	89 – 90	Siltstone
P520146	SSD077	90 – 91	Siltstone
P520147	SSD077	91 - 92	Sandstone
P520148	SSD077	107 – 108	Fault
P520149	SSD077	108 – 109	Fault
P520150	SSD077	114 – 115	Chert
P520151	SSD077	115 – 116	Chert
P520152	SSD077	116 – 117	Chert
P520153	SSD077	117 - 118	Chert
Composite 1	SSD091 108-109, 114-118 m		Dacite (felsic volcanic)
Composite 2	SSD091, 130-131, 134-135, 139-141.5 m		Brecciated chert and shale
Composite 3	SSD092, 118-124 m		Massive sulphide

Sample ID	Hole ID	Depth (m)	Lithology Description
Composite 4	SSD091, 125-126, 133-136 m SSD092, 72-76, 76-80 m		Dacite/silicified shale

Table A1-2: Acid Base Accounting

Sample	Lithology	Total-S	SO_4-S	Total-C	AP	ANC	Carb-NP	NAPP	$NAG_{pH4.5}$	NAG_{pH7}	NAGpH	NPR Ratio	Classification
		%	%		kg H_2SO_4/t						pH units		
P520123	Siltstone	0.25	0.24	0.08	0.3	7.2	7	<0.5	<0.1	1.1	6.3	2.5	Uncertain
P520124	Siltstone	0.05	0.03	0.14	0.8	11.5	11	-10	<0.1	<0.1	8.8	1.6	NAF
P520125	Siltstone	0.02	0.02	0.07	0.1	3.7	6	-3	<0.1	<0.1	8.2	5.9	NAF
P520126	Siltstone	0.03	0.01	0.11	0.6	10.4	9	-10	<0.1	<0.1	8.4	1.9	NAF
P520127	Siltstone	0.03	0.01	0.07	0.6	6.2	6	-5	<0.1	<0.1	7.3	1.0	NAF
P520128	Siltstone	0.05	0.01	0.04	1.2	4.8	3	-3	<0.1	1.5	6.6	0.4	NAF
P520129	Siltstone	0.04	0.01	0.08	0.8	8.7	7	-8	<0.1	<0.1	7.6	1.2	NAF
P520130	Siltstone	0.09	0.01	0.07	2.4	6.0	6	-3	<0.1	<0.1	7.4	0.2	NAF
P520131	Siltstone	0.24	0.01	0.06	7.0	3.4	5	4	<0.1	<0.1	7.0	0	Uncertain
P520132	Siltstone	0.06	0.03	0.98	1.0	3.8	80	-2	<0.1	<0.1	7.0	0.4	NAF
P520133	Siltstone	0.55	0.47	1.27	2.4	1.7	104	15	3.0	10	3.6	0.1	PAF-HC
P520134	Siltstone	0.28	0.23	0.36	1.6	4.2	29	4	0.4	3.9	4.4	0.3	PAF-LC
P520135	Siltstone	0.15	0.15	0.91	0.1	4.5	74	<0.5	<0.1	1.1	6.1	5.6	Uncertain
P520136	Siltstone	0.10	0.09	2.46	0.3	14.1	201	-11	<0.1	<0.1	7.6	5.3	NAF
P520137	Breccia	0.26	0.23	1.85	0.9	30.1	151	-22	<0.1	<0.1	7.5	3.6	NAF
P520138	Breccia	0.43	0.37	1.72	1.9	31.5	140	-18	<0.1	<0.1	7.6	1.7	NAF
P520139	Breccia	0.27	0.27	2.24	0.0	38.7	183	-30	<0.1	<0.1	7.4	382	NAF
P520140	Breccia	0.19	0.18	1.43	0.4	6.6	117	-1	<0.1	<0.1	7.5	1.6	NAF
P520141	Breccia	0.17	0.16	0.76	0.2	6.7	62	-2	<0.1	1.8	6.3	3.1	NAF
P520142	Breccia	0.10	0.10	0.19	0.0	8.8	16	-6	<0.1	1.0	6.2	22	NAF
P520143	Breccia	0.10	0.10	0.26	0.0	6.6	21	-4	<0.1	<0.1	7.7	69	NAF
P520144	Breccia	0.13	0.08	3.10	1.5	21.7	253	-18	<0.1	1.3	4.6	1.4	NAF

Sample	Lithology	Total-S	SO_4-S	Total-C	AP	ANC	Carb-NP	NAPP	$NAG_{pH4.5}$	NAG_{pH7}	NAGpH	NPR Ratio	Classification
		%	%		kg H_2SO_4/t						pH units		
P520145	Siltstone	0.24	0.19	0.33	1.6	7.2	27	<0.5	<0.1	<0.1	7.6	0.4	Uncertain
P520146	Siltstone	0.16	0.11	2.51	1.5	18.5	205	-14	<0.1	<0.1	7.2	1.3	NAF
P520147	Sandstone	0.26	0.23	2.04	0.8	18.4	167	-10	<0.1	<0.1	7.4	2.5	NAF
P520148	Fault	0.43	0.35	0.31	2.4	1.6	25	12	4.8	9.1	3.3	0.1	PAF-HC
P520149	Fault	0.26	0.24	0.27	0.5	1.5	22	6	3.5	5.9	3.4	0.4	PAF-LC
P520150	Chert	0.42	0.34	0.40	2.3	1.2	33	12	3.0	9.0	3.5	0	PAF-HC
P520151	Chert	0.16	0.16	0.40	0	<0.5	33	5	0.7	2.9	3.9	0	PAF-LC
P520152	Chert	0.23	0.22	0.22	0.5	0.6	18	6	4.0	6.3	3.2	0.1	PAF-LC
P520153	Chert	0.06	0.06	0.24	0	0.8	20	1	<0.1	1.3	5.4	4.9	Uncertain
Composite 1	Dacite (felsic volcanic)	10.7	2.82	0.13	241	20.4	11	307	55	118	2.7	0	PAF-HC
Composite 2	Brecciated chert and shale	14.0	8.50	0.49	168	<0.5	40	428	241	291	1.9	0	PAF-HC
Composite 3	Massive sulphide	34.0	14.8	0.06	587	<0.5	5	1,040	530	609	1.7	0	PAF-HC
Composite 4	Dacite/silicified shale	10.7	7.47	0.52	99	8.5	42	319	47	192	2.6	0	PAF-HC

(red)	Denotes PAF classification
(yellow)	Denotes Uncertain classification
(green)	Denotes NAF/AC classification

Table A1-3: Total Metals and Metalloids – Footwall Composite Samples

Sample	Ag	Al	As	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	Ga	Hg	K	La
	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	%	mg/kg	mg/kg	%	mg/kg
Composite 1	0.7	6.82	29	130	0.6	54	0.08	0.5	129	9	8,040	17.35	30	0.093	0.20	30
Composite 2	7.4	1.98	280	100	0.5	<2	0.03	21.5	28	126	121	12.85	10	4.44	0.55	10
Composite 3	4.9	0.15	508	30	<0.5	68	0.03	<0.5	56	52	355	28.7	<10	7.62	0.04	<10
Composite 4	16.3	3.78	114	120	<0.5	12	0.04	240	34	19	1,080	10.15	30	22.3	0.13	20
DER 2010 EIL			20	300				3	50	400	100					
Crustal Average	0.07	8.2	25	425	0.17	0.17	4.1	0.11	20	100	50	4.1	15	0.08	2.1	30

Table A1-3: Total Metals and Metalloids - Footwall Composite Samples, continued

Sample	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Sc	Sr	Ti	Tl	Th	U	V	W	Zn
	%	mg/kg	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Composite 1	5.11	384	22	0.02	9	740	94	9	16	7	0.32	<10	<20	<10	14	<10	467
Composite 2	0.61	173	11	0.02	112	140	2,830	27	5	3	0.04	10	<20	<10	26	<10	1.1%
Composite 3	0.03	243	14	0.01	61	10	290	67	<1	<1	<0.01	20	<20	<10	3	<10	502
Composite 4	2.72	261	6	0.01	11	240	1,190	46	8	2	0.18	<10	<20	<10	6	10	9.8%
DER 2010 EIL	500	40			60		600						50				
Crustal Average	2.3	950	1.5	2.3	75	1,000	14	0.2	16	375	0.57	0.45	10	2.7	135	1.5	70

Table A1-4: Global Abundance Index (GAI)

Sample	Ag	Al	As	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	Ga	Hg	K	La
Composite 1	3	0	0	0	0	6	0	2	2	0	6	1	0	0	0	0
Composite 2	6	0	3	0	0	-	0	6	0	0	1	1	0	5	0	0
Composite 3	6	0	4	0	0	6	0	-	1	0	2	2	0	6	0	0
Composite 4	6	0	2	0	0	6	0	6	0	0	4	1	0	6	0	0

Table A1-4: Global Abundance Index (GAI) continued

Sample	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Sc	Sr	Ti	Tl	Th	U	V	W	Zn
Composite 1	1	0	3	0	0	0	2	5	0	0	0	-	0	-	0	-	2
Composite 2	0	0	2	0	0	0	6	6	0	0	0	4	0	-	0	-	6
Composite 3	0	0	3	0	0	0	4	6	0	0	0	5	0	-	0	-	2
Composite 4	0	0	1	0	0	0	6	6	0	0	0	-	0	-	0	2	6

Table A1-5: Water Leachate (1:5), Major Ions

Sample	pH	EC	Ca	Mg	Na	K	F	Cl	SO_4	Total Alkalinity	HCO_3 Alkalinity	CO_3 Alkalinity
		µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg $CaCO_3$/L		
Composite 1	6.6	106	10	40	<10	<10	2	<10	210	3	3	<1
Composite 2	4.4	222	<10	30	<10	<10	<1	<10	510	<1	<1	<1
Composite 3	4.1	469	<10	10	<10	<10	<1	10	1,430	<1	<1	<1
Composite 4	4.8	283	10	50	<10	<10	<1	10	660	<1	<1	<1

Table A1-6: Water Soluble Metals and Metalloids

Sample	Ag	Al	As	Ba	Bi	Cd	Co	Cr	Cu	Fe	Hg
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Composite 1	0.002	<0.02	<0.002	<0.002	<0.002	<0.002	0.008	<0.002	0.04	<0.2	<0.0001
Composite 2	<0.002	1.4	0.004	0.056	<0.002	0.014	0.34	0.002	<0.002	27	<0.0001
Composite 3	<0.002	2.3	0.030	0.054	<0.002	0.002	0.16	0.026	<0.002	128	<0.0001
Composite 4	<0.002	0.26	0.004	0.076	<0.002	0.030	0.022	<0.002	<0.002	12	<0.0001
Livestock Limit	-	5	0.5	-	-	0.01	1	1	1	-	0.002

Sample	Mn	Mo	Ni	Pb	Sb	Se	Te	Th	U	V	Zn
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Composite 1	0.058	0.004	<0.002	<0.002	<0.002	0.02	<0.01	<0.002	<0.002	<0.02	0.042
Composite 2	0.87	<0.002	0.71	6.3	0.012	<0.02	<0.01	<0.002	<0.002	<0.02	5.1
Composite 3	1.66	<0.002	0.16	0.83	0.010	<0.02	<0.01	<0.002	<0.002	<0.02	1.0
Composite 4	0.22	<0.002	0.028	2.1	0.002	<0.02	<0.01	<0.002	<0.002	<0.02	32
Livestock Limit	-	0.15	1	0.1	-	0.02	-	-	0.2	-	20

Table A1-7: Dilute Acid (1:20 Acetic) Leachate, Major Ions, Metals and Metalloids

Sample	pH	Ag	Al	As	Ba	Bi	Ca	Cd	Co	Cr	Cu	Fe	Hg	K
	pH units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Composite 1	3.4	<0.01	15	<0.005	<0.1	0.02	2	0.01	0.04	0.01	23	27	<0.0010	<1
Composite 2	3.0	<0.01	3.3	0.2	0.1	0.001	<1	0.02	0.1	0.2	<0.01	21	<0.0010	<1
Composite 3	3.0	<0.01	0.9	0.2	<0.1	0.2	<1	0.001	0.1	0.3	<0.01	53	<0.0010	<1
Composite 4	3.3	<0.01	11	0.01	0.1	0.01	1	0.03	0.01	0.1	0.01	29	<0.0010	<1

Sample	Mg	Mn	Mo	Na	Ni	Pb	Sb	Se	Te	Th	U	V	Zn
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Composite 1	16	0.3	<0.01	<1	<0.01	0.01	<0.01	0.01	0.01	0.002	0.002	<0.01	1.3
Composite 2	2	0.7	<0.01	<1	0.3	23	0.02	<0.01	<0.005	<0.001	<0.001	<0.01	5.4
Composite 3	<1	2.4	<0.01	<1	0.1	0.8	0.04	<0.01	<0.005	<0.001	<0.001	<0.01	0.7
Composite 4	11	0.3	<0.01	<1	0.02	15	<0.01	<0.01	<0.005	<0.001	<0.001	<0.01	13

APPENDIX 2: LABORATORY REPORTS

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Finalized Date: 29- DEC- 2017
Account: VENPIL

CERTIFICATE PH17271694

Project: SULPHUR SPRINGS WASTE

This report is for 31 Rock samples submitted to our lab in Perth, WA, Australia on 8- DEC- 2017.

The following have access to data associated with this certificate:

EMMA BAMFORTH		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
SPL- 21X	Addnl Crush Split w No Analysis
SPL- 34X	Pulp Split - For send out
SND- ALS	Send samples to internal laboratory
PUL- QC	Pulverizing QC Test
FND- 03	Find Reject for Addn Analysis
WEI- 21	Received Sample Weight
LEV- 01	Waste Disposal Levy
LOG- 22	Sample login - Rcd w/o BarCode
CRU- 21	Crush entire sample >70% - 6 mm
CRU- 31	Fine crushing - 70% <2mm
SPL- 22Y	Split Sample - Boyd Rotary Splitter
PUL- 31	Pulverize split to 85% <75 um
BAG- 01	Bulk Master for Storage
CRU- QC	Crushing QC Test

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
C- IR07	Total Carbon (Leco)	LECO
S- IR08	Total Sulphur (Leco)	LECO

To: VENTUREX RESOURCES LIMITED
ATTN: EMMA BAMFORTH
PO BOX 585
WEST PERTH WA 6872

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:

Cameron Brosnan, Laboratory Manager, Perth

Australian Laboratory Services Pty. Ltd.
32 Shand Street
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www.alsglobal.com/geochemistry

Finalized Date: 29- DEC- 2017
Account: VENPIL

Project: SULPHUR SPRINGS WASTE

CERTIFICATE OF ANALYSIS PH17271694

Sample Description	Method / Analyte / Units / LOR	PUL- QC Pass75um % 0.01	CRU- QC Pass2mm % 0.01	C- IR07 C % 0.01	S- IR08 S % 0.01	WEI- 21 Recvd Wt. kg 0.02
P520123		96.9	91.8	0.08	0.24	1.23
P520124				0.14	0.05	2.18
P520125				0.07	0.03	1.81
P520126				0.11	0.05	3.31
P520127				0.07	0.04	3.10
P520128				0.04	0.05	4.12
P520129				0.08	0.03	3.33
P520130				0.07	0.10	4.11
P520131				0.06	0.23	4.24
P520132				0.98	0.06	2.29
P520133				1.27	0.46	1.97
P520134				0.36	0.24	2.36
P520135				0.91	0.15	2.16
P520136				2.46	0.11	2.35
P520137				1.85	0.25	2.78
P520138				1.72	0.36	2.57
P520139				2.24	0.25	2.78
P520140				1.43	0.17	2.55
P520141				0.76	0.17	2.76
P520142				0.19	0.11	2.65
P520143				0.26	0.10	2.67
P520144				3.10	0.14	2.62
P520145				0.33	0.20	2.79
P520146				2.51	0.16	2.74
P520147				2.04	0.25	2.87
P520148				0.31	0.36	2.64
P520149				0.27	0.23	2.53
P520150				0.40	0.37	2.46
P520151				0.40	0.17	2.13
P520152				0.22	0.20	2.54
P520153				0.24	0.06	2.72

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Finalized Date: 29- DEC- 2017
Account: VENPIL

Project: SULPHUR SPRINGS WASTE

CERTIFICATE OF ANALYSIS PH17271694

CERTIFICATE COMMENTS

LABORATORY ADDRESSES

Processed at ALS Perth located at 31 Denninup Way, Malaga, Australia. NATA Accreditation does not cover the performance of ALS Perth Sample Preparation which is processed at 79 Distinction Road, Wangara, WA, Australia

Applies to Method:

BAG- 01	C- IR07	CRU- 21	CRU- 31
CRU- QC	FND- 03	LEV- 01	LOG- 22
PUL- 31	PUL- QC	S- IR08	SND- ALS
SPL- 21X	SPL- 22Y	SPL- 34X	WEI- 21

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ALS Perth is a NATA Accredited Testing Laboratory. Corporate Accreditation No: 825, Corporate Site No: 23001.

Finalized Date: 29- DEC- 2017
Account: VENPIL

CERTIFICATE PH17271726

Project: SULPHUR SPRINGS WASTE

This report is for 4 Crushed Rock samples submitted to our lab in Perth, WA, Australia on 8- DEC- 2017.

The following have access to data associated with this certificate:

EMMA BAMFORTH		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI- 21	Received Sample Weight
LEV- 01	Waste Disposal Levy
SND- ALS	Send samples to internal laboratory
SPL- 34X	Pulp Split - For send out
SPL- 21X	Addnl Crush Split w No Analysis
PUL- QC	Pulverizing QC Test
LOG- 22	Sample login - Rcd w/o BarCode
CRU- QC	Crushing QC Test
BAG- 01	Bulk Master for Storage
FND- 03	Find Reject for Addn Analysis
CRU- 31	Fine crushing - 70% <2mm
SPL- 22Y	Split Sample - Boyd Rotary Splitter
PUL- 31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
ME- ICP61	33 element four acid ICP- AES	ICP- AES
ME- OG62	Ore Grade Elements - Four Acid	ICP- AES
Zn- OG62	Ore Grade Zn - Four Acid	ICP- AES
Hg- MS42	Trace Hg by ICPMS	ICP- MS
C- IR07	Total Carbon (Leco)	LECO
S- IR08	Total Sulphur (Leco)	LECO

To: **VENTUREX RESOURCES LIMITED**
ATTN: EMMA BAMFORTH
PO BOX 585
WEST PERTH WA 6872

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:

Cameron Brosnan, Laboratory Manager, Perth

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Finalized Date: 29- DEC- 2017
Account: VENPIL

Project: SULPHUR SPRINGS WASTE

CERTIFICATE OF ANALYSIS PH17271726

Sample Description	Method	WEI- 21	PUL- QC	CRU- QC	C- IR07	S- IR08	ME- ICP61	ME- ICP61	ME- ICP61	ME- ICP61	ME- ICP61	ME- ICP61	ME- ICP61	ME- ICP61	ME- ICP61	ME- ICP61
	Analyte	Recvd Wt.	Pass75um	Pass2mm	C	S	Ag	Al	As	Ba	Be	Bi	Ca	Cd	Co	Cr
	Units	kg	%	%	%	%	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
	LOR	0.02	0.01	0.01	0.01	0.01	0.5	0.01	5	10	0.5	2	0.01	0.5	1	1
Composite 1		1.00	95.2		0.13	10.55	0.7	6.82	29	130	0.6	54	0.08	0.5	129	9
Composite 2		1.00		95.9	0.49	14.20	7.4	1.98	280	100	0.5	<2	0.03	21.5	28	126
Composite 3		1.00			0.06	36.9	4.9	0.15	508	30	<0.5	68	0.03	<0.5	56	52
Composite 4		1.00			0.52	10.65	16.3	3.78	114	120	<0.5	12	0.04	240	34	19

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Finalized Date: 29- DEC- 2017
Account: VENPIL

Project: SULPHUR SPRINGS WASTE

CERTIFICATE OF ANALYSIS PH17271726

Sample Description	Method / Analyte / Units / LOR	ME- ICP61 Cu ppm 1	ME- ICP61 Fe % 0.01	ME- ICP61 Ga ppm 10	ME- ICP61 K % 0.01	ME- ICP61 La ppm 10	ME- ICP61 Mg % 0.01	ME- ICP61 Mn ppm 5	ME- ICP61 Mo ppm 1	ME- ICP61 Na % 0.01	ME- ICP61 Ni ppm 1	ME- ICP61 P ppm 10	ME- ICP61 Pb ppm 2	ME- ICP61 S % 0.01	ME- ICP61 Sb ppm 5	ME- ICP61 Sc ppm 1
Composite 1		8040	17.35	30	0.20	30	5.11	384	22	0.02	9	740	94	>10.0	9	16
Composite 2		121	12.85	10	0.55	10	0.61	173	11	0.02	112	140	2830	>10.0	27	5
Composite 3		355	28.7	<10	0.04	<10	0.03	243	14	0.01	61	10	290	>10.0	67	<1
Composite 4		1080	10.15	30	0.13	20	2.72	261	6	0.01	11	240	1190	9.87	46	8

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Finalized Date: 29- DEC- 2017
Account: VENPIL

Project: SULPHUR SPRINGS WASTE

CERTIFICATE OF ANALYSIS PH17271726

Sample Description	Method / Analyte / Units / LOR	ME- ICP61 Sr ppm 1	ME- ICP61 Th ppm 20	ME- ICP61 Ti % 0.01	ME- ICP61 Tl ppm 10	ME- ICP61 U ppm 10	ME- ICP61 V ppm 1	ME- ICP61 W ppm 10	ME- ICP61 Zn ppm 2	Zn- OG62 Zn % 0.001	Hg- MS42 Hg ppm 0.005
Composite 1		7	<20	0.32	<10	<10	14	<10	467		0.093
Composite 2		3	<20	0.04	10	<10	26	<10	>10000	1.095	4.44
Composite 3		<1	<20	<0.01	20	<10	3	<10	502		7.62
Composite 4		2	<20	0.18	<10	<10	6	10	>10000	9.83	22.3

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Finalized Date: 29- DEC- 2017
Account: VENPIL

Project: SULPHUR SPRINGS WASTE

CERTIFICATE OF ANALYSIS PH17271726

CERTIFICATE COMMENTS

ACCREDITATION COMMENTS

NATA Accredited. Corporate Accreditation No: 825, Corporate Site No: 23001. The Technical Signatory is Wendy Wong, Senior QC Chemist.

Applies to Method: ME- ICP61, ME- OG62

LABORATORY ADDRESSES

Processed at ALS Perth located at 31 Denninup Way, Malaga, Australia. NATA Accreditation does not cover the performance of ALS Perth Sample Preparation which is processed at 79 Distinction Road, Wangara, WA, Australia

Applies to Method:

BAG- 01	C- IR07	CRU- 31	CRU- QC
FND- 03	Hg- MS42	LEV- 01	LOG- 22
ME- ICP61	ME- OG62	PUL- 31	PUL- QC
S- IR08	SND- ALS	SPL- 21X	SPL- 22Y
SPL- 34X	WEI- 21	Zn- OG62	

CERTIFICATE OF ANALYSIS

Work Order	: **EP1714283**	Page	: 1 of 11
Client	: **ALS MINERALS**	Laboratory	: Environmental Division Perth
Contact	: AMY HOPPENBROUWERS	Contact	: Customer Services EP
Address	: ALS PERTH MINERALS 31 DENNINUP WAY MALAGA 6090	Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: 08 9347 3222	Telephone	: +61-8-9209 7655
Project	: Sulphur Springs Waste Characterisation	Date Samples Received	: 15-Dec-2017 16:00
Order number	: ----	Date Analysis Commenced	: 19-Dec-2017
C-O-C number	: ----	Issue Date	: 28-Dec-2017 21:39
Sampler	: ----		
Site	: ----		
Quote number	: EP/1246/17		
No. of samples received	: 35		
No. of samples analysed	: 35		

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		Brisbane Acid Sulphate Soils, Stafford, QLD
Canhuang Ke	Metals Instrument Chemist	Perth Inorganics, Malaga, WA
Indra Astuty	Instrument Chemist	Perth Inorganics, Malaga, WA
Jeremy Truong	Laboratory Manager	Perth Inorganics, Malaga, WA

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/AMD conducted by ALS Brisbane, NATA Site No. 818.
- ED037 (Alkalinity): NATA accreditation does not cover the performance of this service.
- EK040S (Fluoride): Sample 'Composite 2' shows poor spike recovery due to possible sample matrix interference.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.

Analytical Results

Sub-Matrix: ACETIC ACID LEACHATE (Matrix: WATER)			Client sample ID	Composite 1	Composite 2	Composite 3	Composite 4	----
			Client sampling date / time	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	----
Compound	CAS Number	LOR	Unit	EP1714283-032	EP1714283-033	EP1714283-034	EP1714283-035	--------
				Result	Result	Result	Result	----
ED093C: Leachable Major Cations								
Calcium	7440-70-2	1	mg/L	**2**	<1	<1	**1**	----
Magnesium	7439-95-4	1	mg/L	**16**	**2**	<1	**11**	----
Sodium	7440-23-5	1	mg/L	<1	<1	<1	<1	----
Potassium	7440-09-7	1	mg/L	<1	<1	<1	<1	----
EG020C: Leachable Metals by ICPMS								
Aluminium	7429-90-5	0.1	mg/L	**15.1**	**3.3**	**0.9**	**10.6**	----
Arsenic	7440-38-2	0.005	mg/L	<0.005	**0.172**	**0.181**	**0.009**	----
Barium	7440-39-3	0.1	mg/L	<0.1	**0.1**	<0.1	**0.1**	----
Bismuth	7440-69-9	0.001	mg/L	**0.018**	**0.001**	**0.157**	**0.005**	----
Cadmium	7440-43-9	0.001	mg/L	**0.006**	**0.015**	**0.001**	**0.028**	----
Cobalt	7440-48-4	0.01	mg/L	**0.04**	**0.11**	**0.05**	**0.01**	----
Chromium	7440-47-3	0.01	mg/L	**0.01**	**0.22**	**0.28**	**0.09**	----
Copper	7440-50-8	0.01	mg/L	**22.5**	<0.01	<0.01	**0.01**	----
Manganese	7439-96-5	0.01	mg/L	**0.31**	**0.69**	**2.40**	**0.29**	----
Molybdenum	7439-98-7	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
Nickel	7440-02-0	0.01	mg/L	<0.01	**0.26**	**0.08**	**0.02**	----
Lead	7439-92-1	0.01	mg/L	**0.01**	**23.0**	**0.77**	**14.6**	----
Antimony	7440-36-0	0.01	mg/L	<0.01	**0.02**	**0.04**	<0.01	----
Selenium	7782-49-2	0.01	mg/L	**0.01**	<0.01	<0.01	<0.01	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
Zinc	7440-66-6	0.1	mg/L	**1.3**	**5.4**	**0.7**	**13.0**	----
Iron	7439-89-6	0.05	mg/L	**27.0**	**21.1**	**52.8**	**28.6**	----
Silver	7440-22-4	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
Tellurium	22541-49-7	0.005	mg/L	**0.009**	<0.005	<0.005	<0.005	----
Thorium	7440-29-1	0.001	mg/L	**0.002**	<0.001	<0.001	<0.001	----
Uranium	7440-61-1	0.001	mg/L	**0.002**	<0.001	<0.001	<0.001	----
EG035C: Leachable Mercury by FIMS								
Mercury	7439-97-6	0.0010	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	----

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	P520123	P520124	P520125	P520126	P520127
			Client sampling date / time	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00
Compound	CAS Number	LOR	Unit	EP1714283-001	EP1714283-002	EP1714283-003	EP1714283-004	EP1714283-005
				Result	Result	Result	Result	Result
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	<0.5	**-10.0**	**-3.1**	**-9.5**	**-5.3**
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	**6.3**	**8.8**	**8.2**	**8.4**	**7.3**
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	**1.1**	<0.1	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**7.2**	**11.5**	**3.7**	**10.4**	**6.2**
ANC as CaCO3	----	0.1	% CaCO3	**0.7**	**1.2**	**0.4**	**1.1**	**0.6**
Fizz Rating	----	0	Fizz Unit	**0**	**1**	**0**	**1**	**0**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.25**	**0.05**	**0.02**	**0.03**	**0.03**
ED043: Total Oxidised Sulfur as SO4 2-								
Total Oxidised Sulfur as SO4 2-	----	10	mg/kg	**7220**	**755**	**533**	**332**	**294**

Analytical Results

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

Compound	CAS Number	LOR	Unit	P520128	P520129	P520130	P520131	P520132
			Client sampling date / time	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00
				EP1714283-006	EP1714283-007	EP1714283-008	EP1714283-009	EP1714283-010
				Result	Result	Result	Result	Result
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	**-3.3**	**-7.5**	**-3.2**	**3.9**	**-2.0**
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	**6.6**	**7.6**	**7.4**	**7.0**	**7.0**
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	**1.5**	<0.1	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**4.8**	**8.7**	**6.0**	**3.4**	**3.8**
ANC as CaCO3	----	0.1	% CaCO3	**0.5**	**0.9**	**0.6**	**0.3**	**0.4**
Fizz Rating	----	0	Fizz Unit	**0**	**0**	**0**	**0**	**0**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.05**	**0.04**	**0.09**	**0.24**	**0.06**
ED043: Total Oxidised Sulfur as SO4 2-								
Total Oxidised Sulfur as SO4 2-	----	10	mg/kg	**282**	**444**	**317**	**346**	**852**

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	P520133	P520134	P520135	P520136	P520137
			Client sampling date / time	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00
Compound	CAS Number	LOR	Unit	EP1714283-011	EP1714283-012	EP1714283-013	EP1714283-014	EP1714283-015
				Result	Result	Result	Result	Result
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	**15.1**	**4.4**	<0.5	**-11.0**	**-22.1**
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	**3.6**	**4.4**	**6.1**	**7.6**	**7.5**
NAG (pH 4.5)	----	0.1	kg H2SO4/t	**3.0**	**0.4**	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	**9.9**	**3.9**	**1.1**	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**1.7**	**4.2**	**4.5**	**14.1**	**30.1**
ANC as CaCO3	----	0.1	% CaCO3	**0.2**	**0.4**	**0.4**	**1.4**	**3.1**
Fizz Rating	----	0	Fizz Unit	**0**	**0**	**0**	**1**	**2**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.55**	**0.28**	**0.15**	**0.10**	**0.26**
ED043: Total Oxidised Sulfur as SO4 2-								
Total Oxidised Sulfur as SO4 2-	----	10	mg/kg	**14100**	**6840**	**4430**	**2740**	**6960**

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	P520138	P520139	P520140	P520141	P520142
			Client sampling date / time	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00
Compound	CAS Number	LOR	Unit	EP1714283-016	EP1714283-017	EP1714283-018	EP1714283-019	EP1714283-020
				Result	Result	Result	Result	Result
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	**-18.3**	**-30.4**	**-0.8**	**-1.5**	**-5.7**
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	**7.6**	**7.4**	**7.5**	**6.3**	**6.2**
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	**1.8**	**1.0**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**31.5**	**38.7**	**6.6**	**6.7**	**8.8**
ANC as CaCO3	----	0.1	% CaCO3	**3.2**	**3.9**	**0.7**	**0.7**	**0.9**
Fizz Rating	----	0	Fizz Unit	**2**	**2**	**1**	**0**	**1**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.43**	**0.27**	**0.19**	**0.17**	**0.10**
ED043: Total Oxidised Sulfur as SO4 2-								
Total Oxidised Sulfur as SO4 2-	----	10	mg/kg	**11000**	**8090**	**5270**	**4880**	**2960**

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	P520143	P520144	P520145	P520146	P520147
			Client sampling date / time	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00
Compound	CAS Number	LOR	Unit	EP1714283-021	EP1714283-022	EP1714283-023	EP1714283-024	EP1714283-025
				Result	Result	Result	Result	Result
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-3.5	-17.7	<0.5	-13.6	-10.4
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	7.7	4.6	7.6	7.2	7.4
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	1.3	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	6.6	21.7	7.2	18.5	18.4
ANC as CaCO3	----	0.1	% CaCO3	0.7	2.2	0.7	1.9	1.9
Fizz Rating	----	0	Fizz Unit	1	1	0	1	1
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.10	0.13	0.24	0.16	0.26
ED043: Total Oxidised Sulfur as SO4 2-								
Total Oxidised Sulfur as SO4 2-	----	10	mg/kg	2990	2410	5660	3320	7040

Analytical Results

Sub-Matrix: ROCK
(Matrix: SOIL)

Compound	CAS Number	LOR	Unit	P520148	P520149	P520150	P520151	P520152
			Client sampling date / time	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00
				EP1714283-026	EP1714283-027	EP1714283-028	EP1714283-029	EP1714283-030
				Result	Result	Result	Result	Result
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	11.6	6.4	11.6	4.9	6.4
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	3.3	3.4	3.5	3.9	3.2
NAG (pH 4.5)	----	0.1	kg H2SO4/t	4.8	3.5	3.0	0.7	4.0
NAG (pH 7.0)	----	0.1	kg H2SO4/t	9.1	5.9	9.0	2.9	6.3
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	1.6	1.5	1.2	<0.5	0.6
ANC as CaCO3	----	0.1	% CaCO3	0.2	0.2	0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit	0	0	0	0	0
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.43	0.26	0.42	0.16	0.23
ED043: Total Oxidised Sulfur as SO4 2-								
Total Oxidised Sulfur as SO4 2-	----	10	mg/kg	10500	7340	10300	4800	6450

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	P520153	Composite 1	Composite 2	Composite 3	Composite 4
			Client sampling date / time	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00
Compound	CAS Number	LOR	Unit	EP1714283-031	EP1714283-032	EP1714283-033	EP1714283-034	EP1714283-035
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	----	**6.6**	**4.4**	**4.1**	**4.8**
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	**1.0**	**307**	**428**	**1040**	**319**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	----	**106**	**222**	**469**	**283**
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	**5.4**	**2.7**	**1.9**	**1.7**	**2.6**
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	**55.1**	**241**	**530**	**46.8**
NAG (pH 7.0)	----	0.1	kg H2SO4/t	**1.3**	**118**	**291**	**609**	**192**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**0.8**	**20.4**	<0.5	<0.5	**8.5**
ANC as CaCO3	----	0.1	% CaCO3	<0.1	**2.1**	<0.1	<0.1	**0.9**
Fizz Rating	----	0	Fizz Unit	**0**	**1**	**0**	**0**	**0**
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	----	<1.0	<1.0	<1.0	<1.0
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	----	**3**	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	----	**3**	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	----	<1	<1	<1	<1
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	----	**210**	**510**	**1430**	**660**
Sulfur as S	63705-05-5	10	mg/kg	----	**70**	**170**	**480**	**220**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.06**	**10.7**	**14.0**	**34.0**	**10.7**
ED043: Total Oxidised Sulfur as SO4 2-								
Total Oxidised Sulfur as SO4 2-	----	10	mg/kg	**1790**	**84500**	**255000**	**445000**	**224000**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	----	<10	<10	**10**	**10**
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	----	**10**	<10	<10	**10**
Magnesium	7439-95-4	10	mg/kg	----	**40**	**30**	**10**	**50**
Sodium	7440-23-5	10	mg/kg	----	<10	<10	<10	<10

Analytical Results

Sub-Matrix: ROCK (Matrix: SOIL)			Client sample ID	P520153	Composite 1	Composite 2	Composite 3	Composite 4
			Client sampling date / time	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00	18-Dec-2017 00:00
Compound	CAS Number	LOR	Unit	EP1714283-031	EP1714283-032	EP1714283-033	EP1714283-034	EP1714283-035
				Result	Result	Result	Result	Result
ED093S: Soluble Major Cations - Continued								
Potassium	7440-09-7	10	mg/kg	----	<10	<10	<10	<10
EG005S : Soluble Metals by ICPAES								
Iron	7439-89-6	1	mg/kg	----	<1	137	642	62
EG020S: Soluble Metals by ICPMS								
Arsenic	7440-38-2	0.01	mg/kg	----	<0.01	0.02	0.15	0.02
Selenium	7782-49-2	0.1	mg/kg	----	0.1	<0.1	<0.1	<0.1
Silver	7440-22-4	0.01	mg/kg	----	0.01	<0.01	<0.01	<0.01
Barium	7440-39-3	0.01	mg/kg	----	<0.01	0.28	0.27	0.38
Cadmium	7440-43-9	0.01	mg/kg	----	<0.01	0.07	0.01	0.15
Bismuth	7440-69-9	0.01	mg/kg	----	<0.01	<0.01	<0.01	<0.01
Cobalt	7440-48-4	0.01	mg/kg	----	0.04	1.68	0.79	0.11
Chromium	7440-47-3	0.01	mg/kg	----	<0.01	0.01	0.13	<0.01
Thorium	7440-29-1	0.01	mg/kg	----	<0.01	<0.01	<0.01	<0.01
Copper	7440-50-8	0.01	mg/kg	----	0.20	<0.01	<0.01	<0.01
Manganese	7439-96-5	0.01	mg/kg	----	0.29	4.34	8.29	1.12
Molybdenum	7439-98-7	0.01	mg/kg	----	0.02	<0.01	<0.01	<0.01
Nickel	7440-02-0	0.01	mg/kg	----	<0.01	3.56	0.81	0.14
Lead	7439-92-1	0.01	mg/kg	----	<0.01	31.4	4.14	10.5
Antimony	7440-36-0	0.01	mg/kg	----	<0.01	0.06	0.05	0.01
Uranium	7440-61-1	0.01	mg/kg	----	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.05	mg/kg	----	0.21	25.4	5.01	160
Vanadium	7440-62-2	0.1	mg/kg	----	<0.1	<0.1	<0.1	<0.1
Aluminium	7429-90-5	0.1	mg/kg	----	<0.1	7.2	11.5	1.3
Tellurium	22541-49-7	0.05	mg/kg	----	<0.05	<0.05	<0.05	<0.05
EG035S: Soluble Mercury by FIMS								
Mercury	7439-97-6	0.0005	mg/kg	----	<0.0005	<0.0005	<0.0005	<0.0005
EK040S: Fluoride Soluble								
Fluoride	16984-48-8	1	mg/kg	----	2	<1	<1	<1
EN60: ASLP Leaching Procedure								
Initial pH	----	0.1	pH Unit	----	6.7	4.7	4.5	5.1
After HCl pH	----	0.1	pH Unit	----	1.5	----	----	1.5
Extraction Fluid pH	----	0.1	pH Unit	----	2.9	2.9	2.9	2.9
Final pH	----	0.1	pH Unit	----	3.4	3.0	3.0	3.3

Environmental

QUALITY CONTROL REPORT

Work Order	: **EP1714283**		Page	: 1 of 10
Client	: **ALS MINERALS**		Laboratory	: Environmental Division Perth
Contact	: AMY HOPPENBROUWERS		Contact	: Customer Services EP
Address	: ALS PERTH MINERALS 31 DENNINUP WAY MALAGA 6090		Address	: 10 Hod Way Malaga WA Australia 6090
Telephone	: 08 9347 3222		Telephone	: +61-8-9209 7655
Project	: Sulphur Springs Waste Characterisation		Date Samples Received	: 15-Dec-2017
Order number	: ----		Date Analysis Commenced	: 19-Dec-2017
C-O-C number	: ----		Issue Date	: 28-Dec-2017
Sampler	: ----			
Site	: ----			
Quote number	: EP/1246/17			
No. of samples received	: 35			
No. of samples analysed	: 35			

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 Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

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		Brisbane Acid Sulphate Soils, Stafford, QLD
Canhuang Ke	Metals Instrument Chemist	Perth Inorganics, Malaga, WA
Indra Astuty	Instrument Chemist	Perth Inorganics, Malaga, WA
Jeremy Truong	Laboratory Manager	Perth Inorganics, Malaga, WA

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

Key :
- Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
- 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
- RPD = Relative Percentage Difference
- # = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA002 : pH (Soils) (QC Lot: 1329883)									
EP1714283-032	Composite 1	EA002: pH Value	----	0.1	pH Unit	6.6	6.4	2.47	0% - 20%
EA010: Conductivity (QC Lot: 1329882)									
EP1714283-032	Composite 1	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	106	95	11.0	0% - 20%
EA011: Net Acid Generation (QC Lot: 1334741)									
EP1714283-011	P520133	EA011: NAG (pH 4.5)	----	0.1	kg H2SO4/t	3.0	3.0	0.00	0% - 20%
		EA011: NAG (pH 7.0)	----	0.1	kg H2SO4/t	9.9	10.1	2.00	0% - 20%
		EA011: pH (OX)	----	0.1	pH Unit	3.6	3.6	0.00	0% - 20%
EM1717473-007	Anonymous	EA011: NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	0.00	No Limit
		EA011: NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	0.00	No Limit
		EA011: pH (OX)	----	0.1	pH Unit	8.8	8.7	1.14	0% - 20%
EA011: Net Acid Generation (QC Lot: 1334745)									
EP1714283-020	P520142	EA011: NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	0.00	No Limit
		EA011: NAG (pH 7.0)	----	0.1	kg H2SO4/t	1.0	1.0	0.00	0% - 50%
		EA011: pH (OX)	----	0.1	pH Unit	6.2	6.4	3.17	0% - 20%
EP1714283-031	P520153	EA011: NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	0.00	No Limit
		EA011: NAG (pH 7.0)	----	0.1	kg H2SO4/t	1.3	1.2	8.00	0% - 50%
		EA011: pH (OX)	----	0.1	pH Unit	5.4	5.5	1.83	0% - 20%
EA013: Acid Neutralising Capacity (QC Lot: 1334740)									
EP1714283-011	P520133	EA013: ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	1.7	1.3	26.7	No Limit
EM1717473-007	Anonymous	EA013: ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	36.6	36.3	0.823	0% - 20%
EA013: Acid Neutralising Capacity (QC Lot: 1334744)									

Sub-Matrix: **SOIL**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EA013: Acid Neutralising Capacity (QC Lot: 1334744) - continued									
EP1714283-020	P520142	EA013: ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	8.8	8.2	7.06	0% - 50%
EP1714283-031	P520153	EA013: ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	0.8	0.8	0.00	No Limit
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 1329916)									
EP1714211-001	Anonymous	EA055: Moisture Content	----	1	%	10.0	9.2	8.94	0% - 50%
EP1714266-004	Anonymous	EA055: Moisture Content	----	1	%	50.0	48.8	2.32	0% - 20%
ED037: Alkalinity (QC Lot: 1329873)									
EP1714283-032	Composite 1	ED037: Total Alkalinity as CaCO3	----	1	mg/kg	3	2	0.00	No Limit
ED040S: Soluble Major Anions (QC Lot: 1329872)									
EP1714283-032	Composite 1	ED040S: Sulfate as SO4 2-	14808-79-8	10	mg/kg	210	210	0.00	0% - 20%
ED042T: Total Sulfur by LECO (QC Lot: 1334042)									
EM1717473-007	Anonymous	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	0.03	0.03	0.00	No Limit
EP1714283-009	P520131	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	0.24	0.25	0.00	0% - 20%
ED042T: Total Sulfur by LECO (QC Lot: 1334043)									
EP1714283-020	P520142	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	0.10	0.10	0.00	0% - 50%
EP1714283-029	P520151	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	0.16	0.17	6.73	0% - 50%
ED043: Total Oxidised Sulfur as SO4 2- (QC Lot: 1337776)									
EP1714283-001	P520123	ED043: Total Oxidised Sulfur as SO4 2-	----	10	mg/kg	7220	7250	0.429	0% - 20%
EP1714283-011	P520133	ED043: Total Oxidised Sulfur as SO4 2-	----	10	mg/kg	14100	13900	1.24	0% - 20%
ED043: Total Oxidised Sulfur as SO4 2- (QC Lot: 1337777)									
EP1714283-021	P520143	ED043: Total Oxidised Sulfur as SO4 2-	----	10	mg/kg	2990	3090	3.19	0% - 20%
EP1714283-031	P520153	ED043: Total Oxidised Sulfur as SO4 2-	----	10	mg/kg	1790	1860	3.42	0% - 20%
ED045G: Chloride by Discrete Analyser (QC Lot: 1329877)									
EP1714283-032	Composite 1	ED045G: Chloride	16887-00-6	10	mg/kg	<10	10	0.00	No Limit
ED093S: Soluble Major Cations (QC Lot: 1329876)									
EP1714283-032	Composite 1	ED093S: Calcium	7440-70-2	10	mg/kg	10	10	0.00	No Limit
		ED093S: Magnesium	7439-95-4	10	mg/kg	40	40	0.00	No Limit
		ED093S: Sodium	7440-23-5	10	mg/kg	<10	10	0.00	No Limit
		ED093S: Potassium	7440-09-7	10	mg/kg	<10	<10	0.00	No Limit
EG005S : Soluble Metals by ICPAES (QC Lot: 1329874)									
EP1714283-032	Composite 1	EG005S: Iron	7439-89-6	1	mg/kg	<1	<1	0.00	No Limit
EG020S: Soluble Metals by ICPMS (QC Lot: 1329878)									
EP1714283-032	Composite 1	EG020R-S: Tellurium	22541-49-7	0.05	mg/kg	<0.05	<0.05	0.00	No Limit
EG020S: Soluble Metals by ICPMS (QC Lot: 1329879)									
EP1714283-032	Composite 1	EG020X-S: Arsenic	7440-38-2	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
		EG020X-S: Barium	7440-39-3	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
		EG020X-S: Cobalt	7440-48-4	0.01	mg/kg	0.04	0.04	0.00	No Limit

Sub-Matrix: **SOIL**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EG020S: Soluble Metals by ICPMS (QC Lot: 1329879) - continued									
EP1714283-032	Composite 1	EG020X-S: Chromium	7440-47-3	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
		EG020X-S: Copper	7440-50-8	0.01	mg/kg	0.20	0.20	0.00	0% - 20%
		EG020X-S: Manganese	7439-96-5	0.01	mg/kg	0.29	0.28	4.02	0% - 20%
		EG020X-S: Molybdenum	7439-98-7	0.01	mg/kg	0.02	0.01	0.00	No Limit
		EG020X-S: Nickel	7440-02-0	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
		EG020X-S: Lead	7439-92-1	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
		EG020X-S: Antimony	7440-36-0	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
		EG020X-S: Uranium	7440-61-1	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
		EG020X-S: Zinc	7440-66-6	0.05	mg/kg	0.21	0.18	11.2	No Limit
		EG020X-S: Vanadium	7440-62-2	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020X-S: Aluminium	7429-90-5	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
EG020S: Soluble Metals by ICPMS (QC Lot: 1329880)									
EP1714283-032	Composite 1	EG020Y-S: Cadmium	7440-43-9	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
		EG020Y-S: Bismuth	7440-69-9	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
		EG020Y-S: Thorium	7440-29-1	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
		EG020Y-S: Selenium	7782-49-2	0.1	mg/kg	0.1	0.1	0.00	No Limit
EG020S: Soluble Metals by ICPMS (QC Lot: 1329881)									
EP1714283-032	Composite 1	EG020Z-S: Silver	7440-22-4	0.01	mg/kg	0.01	<0.01	0.00	No Limit
EG035S: Soluble Mercury by FIMS (QC Lot: 1329875)									
EP1714283-032	Composite 1	EG035S: Mercury	7439-97-6	0.0005	mg/kg	<0.0005	<0.0005	0.00	No Limit
EK040S: Fluoride Soluble (QC Lot: 1329884)									
EP1714283-032	Composite 1	EK040S: Fluoride	16984-48-8	1	mg/kg	2	2	0.00	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
ED093C: Leachable Major Cations (QC Lot: 1334794)									
EP1714283-032	Composite 1	ED093C: Calcium	7440-70-2	1	mg/L	2	2	0.00	No Limit
		ED093C: Magnesium	7439-95-4	1	mg/L	16	16	0.00	0% - 50%
		ED093C: Sodium	7440-23-5	1	mg/L	<1	<1	0.00	No Limit
		ED093C: Potassium	7440-09-7	1	mg/L	<1	<1	0.00	No Limit
EG020C: Leachable Metals by ICPMS (QC Lot: 1334792)									
EP1714283-032	Composite 1	EG020A-C: Cadmium	7440-43-9	0.001	mg/L	0.006	0.006	0.00	No Limit
		EG020A-C: Arsenic	7440-38-2	0.005	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-C: Cobalt	7440-48-4	0.01	mg/L	0.04	0.04	0.00	No Limit
		EG020A-C: Chromium	7440-47-3	0.01	mg/L	0.01	0.01	0.00	No Limit
		EG020A-C: Copper	7440-50-8	0.01	mg/L	22.5	22.4	0.140	0% - 20%
		EG020A-C: Manganese	7439-96-5	0.01	mg/L	0.31	0.32	0.00	0% - 20%
		EG020A-C: Molybdenum	7439-98-7	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-C: Nickel	7440-02-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-C: Lead	7439-92-1	0.01	mg/L	0.01	0.01	0.00	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EG020C: Leachable Metals by ICPMS (QC Lot: 1334792) - continued									
EP1714283-032	Composite 1	EG020A-C: Antimony	7440-36-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-C: Selenium	7782-49-2	0.01	mg/L	0.01	0.01	0.00	No Limit
		EG020A-C: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-C: Iron	7439-89-6	0.05	mg/L	27.0	27.1	0.509	0% - 20%
		EG020A-C: Aluminium	7429-90-5	0.1	mg/L	15.1	15.0	0.00	0% - 20%
		EG020A-C: Barium	7440-39-3	0.1	mg/L	<0.1	<0.1	0.00	No Limit
		EG020A-C: Zinc	7440-66-6	0.1	mg/L	1.3	1.3	0.00	0% - 50%
EG020C: Leachable Metals by ICPMS (QC Lot: 1334793)									
EP1714283-032	Composite 1	EG020B-C: Bismuth	7440-69-9	0.001	mg/L	0.018	0.019	0.00	0% - 50%
		EG020B-C: Thorium	7440-29-1	0.001	mg/L	0.002	0.001	0.00	No Limit
		EG020B-C: Uranium	7440-61-1	0.001	mg/L	0.002	0.001	0.00	No Limit
		EG020B-C: Tellurium	22541-49-7	0.005	mg/L	0.009	0.008	0.00	No Limit
		EG020B-C: Silver	7440-22-4	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EG035C: Leachable Mercury by FIMS (QC Lot: 1341927)									
EP1714283-032	Composite 1	EG035C: Mercury	7439-97-6	0.0001	mg/L	<0.0010	<0.0010	0.00	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA002 : pH (Soils) (QCLot: 1329883)								
EA002: pH Value	----	----	pH Unit	----	4 pH Unit	100	70	130
				----	7 pH Unit	100	70	130
EA010: Conductivity (QCLot: 1329882)								
EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	24800 µS/cm	97.2	94	106
EA011: Net Acid Generation (QCLot: 1334741)								
EA011: NAG (pH 7.0)	----	----	kg H2SO4/t	----	22.5 kg H2SO4/t	100	70	130
EA011: Net Acid Generation (QCLot: 1334745)								
EA011: NAG (pH 7.0)	----	----	kg H2SO4/t	----	22.5 kg H2SO4/t	100	70	130
EA013: Acid Neutralising Capacity (QCLot: 1334740)								
EA013: ANC as H2SO4	----	----	kg H2SO4 equiv./t	----	9.9 kg H2SO4 equiv./t	90.9	82	120
EA013: Acid Neutralising Capacity (QCLot: 1334744)								
EA013: ANC as H2SO4	----	----	kg H2SO4 equiv./t	----	9.9 kg H2SO4 equiv./t	90.9	82	120
ED037: Alkalinity (QCLot: 1329873)								
ED037: Total Alkalinity as CaCO3	----	----	mg/kg	----	200 mg/kg	98.6	70	130
ED040S: Soluble Major Anions (QCLot: 1329872)								
ED040S: Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	250 mg/kg	115	86	116
ED042T: Total Sulfur by LECO (QCLot: 1334042)								
ED042T: Sulfur - Total as S (LECO)	----	0.01	%	<0.01	0.16 %	106	70	130
ED042T: Total Sulfur by LECO (QCLot: 1334043)								
ED042T: Sulfur - Total as S (LECO)	----	0.01	%	<0.01	0.16 %	107	70	130
ED043: Total Oxidised Sulfur as SO4 2- (QCLot: 1337776)								
ED043: Total Oxidised Sulfur as SO4 2-	----	10	mg/kg	<10	----	----	----	----
ED043: Total Oxidised Sulfur as SO4 2- (QCLot: 1337777)								
ED043: Total Oxidised Sulfur as SO4 2-	----	10	mg/kg	<10	----	----	----	----
ED045G: Chloride by Discrete Analyser (QCLot: 1329877)								
ED045G: Chloride	16887-00-6	10	mg/kg	<10	50 mg/kg	100	82	126
				<10	5000 mg/kg	92.1	82	126
ED093S: Soluble Major Cations (QCLot: 1329876)								
ED093S: Calcium	7440-70-2	10	mg/kg	<10	250 mg/kg	106	92	108
ED093S: Magnesium	7439-95-4	10	mg/kg	<10	250 mg/kg	108	96	108
ED093S: Sodium	7440-23-5	10	mg/kg	<10	250 mg/kg	109	85	109
ED093S: Potassium	7440-09-7	10	mg/kg	<10	250 mg/kg	105	81	111

Sub-Matrix: **SOIL**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report: Result	Laboratory Control Spike (LCS) Report: Spike Concentration	Spike Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High
EG005S : Soluble Metals by ICPAES (QCLot: 1329874)								
EG005S: Iron	7439-89-6	1	mg/kg	<1	5 mg/kg	102	70	130
EG020S: Soluble Metals by ICPMS (QCLot: 1329878)								
EG020R-S: Tellurium	22541-49-7	0.05	mg/kg	<0.05	0.5 mg/kg	96.2	70	120
EG020S: Soluble Metals by ICPMS (QCLot: 1329879)								
EG020X-S: Arsenic	7440-38-2	0.01	mg/kg	<0.01	0.5 mg/kg	102	70	130
EG020X-S: Barium	7440-39-3	0.01	mg/kg	<0.01	0.5 mg/kg	96.6	70	130
EG020X-S: Cobalt	7440-48-4	0.01	mg/kg	<0.01	0.5 mg/kg	98.2	70	130
EG020X-S: Chromium	7440-47-3	0.01	mg/kg	<0.01	0.5 mg/kg	93.6	70	130
EG020X-S: Copper	7440-50-8	0.01	mg/kg	<0.01	0.5 mg/kg	98.2	70	130
EG020X-S: Manganese	7439-96-5	0.01	mg/kg	<0.01	0.5 mg/kg	107	70	130
EG020X-S: Molybdenum	7439-98-7	0.01	mg/kg	<0.01	0.5 mg/kg	100	70	130
EG020X-S: Nickel	7440-02-0	0.01	mg/kg	<0.01	0.5 mg/kg	94.4	70	130
EG020X-S: Lead	7439-92-1	0.01	mg/kg	<0.01	0.5 mg/kg	95.7	70	130
EG020X-S: Antimony	7440-36-0	0.01	mg/kg	<0.01	0.1 mg/kg	80.2	70	130
EG020X-S: Uranium	7440-61-1	0.01	mg/kg	<0.01	----	----	----	----
EG020X-S: Zinc	7440-66-6	0.05	mg/kg	<0.05	0.5 mg/kg	102	70	130
EG020X-S: Vanadium	7440-62-2	0.1	mg/kg	<0.1	0.5 mg/kg	101	70	130
EG020X-S: Aluminium	7429-90-5	0.1	mg/kg	<0.1	2.5 mg/kg	97.6	70	130
EG020S: Soluble Metals by ICPMS (QCLot: 1329880)								
EG020Y-S: Selenium	7782-49-2	0.1	mg/kg	<0.1	0.5 mg/kg	102	70	130
EG020Y-S: Cadmium	7440-43-9	0.01	mg/kg	<0.01	0.5 mg/kg	97.5	70	130
EG020Y-S: Bismuth	7440-69-9	0.01	mg/kg	<0.01	0.5 mg/kg	85.3	70	130
EG020Y-S: Thorium	7440-29-1	0.01	mg/kg	<0.01	----	----	----	----
EG020S: Soluble Metals by ICPMS (QCLot: 1329881)								
EG020Z-S: Silver	7440-22-4	0.01	mg/kg	<0.01	0.1 mg/kg	111	70	130
EG035S: Soluble Mercury by FIMS (QCLot: 1329875)								
EG035S: Mercury	7439-97-6	0.0005	mg/kg	<0.0005	0.05 mg/kg	94.4	70	130
EK040S: Fluoride Soluble (QCLot: 1329884)								
EK040S: Fluoride	16984-48-8	1	mg/kg	<1	25 mg/kg	102	70	130
EN60: ASLP Leaching Procedure (QCLot: 1327294)								
EN60a: Extraction Fluid pH	----	0.1	pH Unit	5.0	----	----	----	----
EN60a: Final pH	----	0.1	pH Unit	5.1	----	----	----	----

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report: Result	Laboratory Control Spike (LCS) Report: Spike Concentration	Spike Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High
ED093C: Leachable Major Cations (QCLot: 1334794)								
ED093C: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
ED093C: Leachable Major Cations (QCLot: 1334794) - continued								
ED093C: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093C: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093C: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020C: Leachable Metals by ICPMS (QCLot: 1334792)								
EG020A-C: Aluminium	7429-90-5	0.1	mg/L	<0.1	0.5 mg/L	93.4	79	120
EG020A-C: Arsenic	7440-38-2	0.005	mg/L	<0.005	0.1 mg/L	93.2	80	120
EG020A-C: Barium	7440-39-3	0.1	mg/L	<0.1	0.1 mg/L	92.8	83	120
EG020A-C: Cadmium	7440-43-9	0.001	mg/L	<0.001	0.1 mg/L	91.4	80	120
EG020A-C: Cobalt	7440-48-4	0.01	mg/L	<0.01	0.1 mg/L	94.3	76	120
EG020A-C: Chromium	7440-47-3	0.01	mg/L	<0.01	0.1 mg/L	86.4	81	120
EG020A-C: Copper	7440-50-8	0.01	mg/L	<0.01	0.1 mg/L	89.1	76	120
EG020A-C: Manganese	7439-96-5	0.01	mg/L	<0.01	0.1 mg/L	93.9	78	120
EG020A-C: Molybdenum	7439-98-7	0.01	mg/L	<0.01	0.1 mg/L	92.8	85	120
EG020A-C: Nickel	7440-02-0	0.01	mg/L	<0.01	0.1 mg/L	91.0	75	120
EG020A-C: Lead	7439-92-1	0.01	mg/L	<0.01	0.1 mg/L	88.6	83	120
EG020A-C: Antimony	7440-36-0	0.01	mg/L	<0.01	0.02 mg/L	82.5	73	120
EG020A-C: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	97.8	78	120
EG020A-C: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	93.5	82	120
EG020A-C: Zinc	7440-66-6	0.1	mg/L	<0.1	0.1 mg/L	95.6	73	120
EG020A-C: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	112	80	120
EG020C: Leachable Metals by ICPMS (QCLot: 1334793)								
EG020B-C: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.1 mg/L	86.6	83	120
EG020B-C: Silver	7440-22-4	0.01	mg/L	<0.01	0.02 mg/L	78.5	70	130
EG020B-C: Tellurium	22541-49-7	0.005	mg/L	<0.005	0.1 mg/L	94.8	79	120
EG020B-C: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-C: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG035C: Leachable Mercury by FIMS (QCLot: 1341927)								
EG035C: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	107	85	117

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
				Concentration	MS	Low	High
ED045G: Chloride by Discrete Analyser (QCLot: 1329877)							
EP1714283-033	Composite 2	ED045G: Chloride	16887-00-6	5000 mg/kg	90.5	70	130

Sub-Matrix: **SOIL**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low	High
EG005S : Soluble Metals by ICPAES (QCLot: 1329874)							
EP1714283-033	Composite 2	EG005S: Iron	7439-89-6	5 mg/kg	# Not Determined	70	130
EG020S: Soluble Metals by ICPMS (QCLot: 1329879)							
EP1714283-033	Composite 2	EG020X-S: Arsenic	7440-38-2	1 mg/kg	121	70	130
		EG020X-S: Barium	7440-39-3	1 mg/kg	108	70	130
		EG020X-S: Cobalt	7440-48-4	1 mg/kg	102	70	130
		EG020X-S: Chromium	7440-47-3	1 mg/kg	121	70	130
		EG020X-S: Copper	7440-50-8	1 mg/kg	125	70	130
		EG020X-S: Manganese	7439-96-5	1 mg/kg	# Not Determined	70	130
		EG020X-S: Nickel	7440-02-0	1 mg/kg	113	70	130
		EG020X-S: Lead	7439-92-1	1 mg/kg	# Not Determined	70	130
		EG020X-S: Zinc	7440-66-6	1 mg/kg	# Not Determined	70	130
		EG020X-S: Vanadium	7440-62-2	1 mg/kg	128	70	130
EG020S: Soluble Metals by ICPMS (QCLot: 1329880)							
EP1714283-033	Composite 2	EG020Y-S: Cadmium	7440-43-9	0.25 mg/kg	90.1	70	130
EG035S: Soluble Mercury by FIMS (QCLot: 1329875)							
EP1714283-033	Composite 2	EG035S: Mercury	7439-97-6	0.05 mg/kg	80.7	70	130
EK040S: Fluoride Soluble (QCLot: 1329884)							
EP1714283-033	Composite 2	EK040S: Fluoride	16984-48-8	24.5 mg/kg	# 62.0	70	130

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low	High
EG020C: Leachable Metals by ICPMS (QCLot: 1334792)							
EP1714283-033	Composite 2	EG020A-C: Arsenic	7440-38-2	1 mg/L	96.0	70	130
		EG020A-C: Barium	7440-39-3	1 mg/L	93.9	70	130
		EG020A-C: Cadmium	7440-43-9	0.25 mg/L	94.4	70	130
		EG020A-C: Cobalt	7440-48-4	1 mg/L	81.8	70	130
		EG020A-C: Chromium	7440-47-3	1 mg/L	75.5	70	130
		EG020A-C: Copper	7440-50-8	1 mg/L	80.9	70	130
		EG020A-C: Manganese	7439-96-5	1 mg/L	93.0	70	130
		EG020A-C: Nickel	7440-02-0	1 mg/L	91.8	70	130
		EG020A-C: Lead	7439-92-1	1 mg/L	# Not Determined	70	130
		EG020A-C: Vanadium	7440-62-2	1 mg/L	95.5	70	130

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report Spike Concentration	SpikeRecovery(%) MS	Recovery Limits (%) Low	High
EG020C: Leachable Metals by ICPMS (QCLot: 1334792) - continued							
EP1714283-033	Composite 2	EG020A-C: Zinc	7440-66-6	1 mg/L	# Not Determined	70	130
EG035C: Leachable Mercury by FIMS (QCLot: 1341927)							
EP1714283-033	Composite 2	EG035C: Mercury	7439-97-6	0.01 mg/L	73.7	70	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EP1714283**	Page	: 1 of 13
Client	: **ALS MINERALS**	Laboratory	: Environmental Division Perth
Contact	: AMY HOPPENBROUWERS	Telephone	: +61-8-9209 7655
Project	: Sulphur Springs Waste Characterisation	Date Samples Received	: 15-Dec-2017
Site	: ----	Issue Date	: 28-Dec-2017
Sampler	: ----	No. of samples received	: 35
Order number	: ----	No. of samples analysed	: 35

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **SOIL**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EG005S : Soluble Metals by ICPAES	EP1714283--033	Composite 2	**Iron**	7439-89-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020S: Soluble Metals by ICPMS	EP1714283--033	Composite 2	**Manganese**	7439-96-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020S: Soluble Metals by ICPMS	EP1714283--033	Composite 2	**Lead**	7439-92-1	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020S: Soluble Metals by ICPMS	EP1714283--033	Composite 2	**Zinc**	7440-66-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EK040S: Fluoride Soluble	EP1714283--033	Composite 2	**Fluoride**	16984-48-8	62.0 %	70-130%	**Recovery less than lower data quality objective**

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EG020C: Leachable Metals by ICPMS	EP1714283--033	Composite 2	**Lead**	7439-92-1	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020C: Leachable Metals by ICPMS	EP1714283--033	Composite 2	**Zinc**	7440-66-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	***Sample Date***	*Extraction / Preparation*			*Analysis*		
Container */ Client Sample ID(s)*		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA002 : pH (Soils)								
80* dried soil (EA002)								
Composite 1,	Composite 2,	**18-Dec-2017**	**21-Dec-2017**	25-Dec-2017	✓	**21-Dec-2017**	21-Dec-2017	✓
Composite 3,	Composite 4							
EA010: Conductivity								
80* dried soil (EA010)								
Composite 1,	Composite 2,	**18-Dec-2017**	**21-Dec-2017**	25-Dec-2017	✓	**21-Dec-2017**	18-Jan-2018	✓
Composite 3,	Composite 4							
EA011: Net Acid Generation								
80* dried soil (EA011)								
P520123,	P520124,	**18-Dec-2017**	**22-Dec-2017**	18-Dec-2018	✓	**22-Dec-2017**	20-Jun-2018	✓
P520125,	P520126,							
P520127,	P520128,							
P520129,	P520130,							
P520131,	P520132,							
P520133,	P520134,							
P520135,	P520136,							
P520137,	P520138,							
P520139,	P520140,							
P520141,	P520142,							
P520143,	P520144,							
P520145,	P520146,							
P520147,	P520148,							
P520149,	P520150,							
P520151,	P520152,							
P520153,	Composite 1,							
Composite 2,	Composite 3,							
Composite 4								

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA013: Acid Neutralising Capacity								
80* dried soil (EA013)								
P520123,	P520124,	**18-Dec-2017**	**22-Dec-2017**	18-Dec-2018	✓	**22-Dec-2017**	20-Jun-2018	✓
P520125,	P520126,							
P520127,	P520128,							
P520129,	P520130,							
P520131,	P520132,							
P520133,	P520134,							
P520135,	P520136,							
P520137,	P520138,							
P520139,	P520140,							
P520141,	P520142,							
P520143,	P520144,							
P520145,	P520146,							
P520147,	P520148,							
P520149,	P520150,							
P520151,	P520152,							
P520153,	Composite 1,							
Composite 2,	Composite 3,							
Composite 4								
EA055: Moisture Content (Dried @ 105-110°C)								
80* dried soil (EA055)								
Composite 1,	Composite 2,	**18-Dec-2017**	**----**	----	----	**20-Dec-2017**	01-Jan-2018	✓
Composite 3,	Composite 4							
ED037: Alkalinity								
80* dried soil (ED037)								
Composite 1,	Composite 2,	**18-Dec-2017**	**21-Dec-2017**	16-Jun-2018	✓	**21-Dec-2017**	16-Jun-2018	✓
Composite 3,	Composite 4							
ED040S : Soluble Sulfate by ICPAES								
80* dried soil (ED040S)								
Composite 1,	Composite 2,	**18-Dec-2017**	**21-Dec-2017**	15-Jan-2018	✓	**21-Dec-2017**	18-Jan-2018	✓
Composite 3,	Composite 4							

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
ED042T: Total Sulfur by LECO								
80* dried soil (ED042T)								
P520123,	P520124,	**18-Dec-2017**	**21-Dec-2017**	15-Jan-2018	✓	**21-Dec-2017**	15-Jan-2018	✓
P520125,	P520126,							
P520127,	P520128,							
P520129,	P520130,							
P520131,	P520132,							
P520133,	P520134,							
P520135,	P520136,							
P520137,	P520138,							
P520139,	P520140,							
P520141,	P520142,							
P520143,	P520144,							
P520145,	P520146,							
P520147,	P520148,							
P520149,	P520150,							
P520151,	P520152,							
P520153,	Composite 1,							
Composite 2,	Composite 3,							
Composite 4								
ED043: Total Oxidised Sulfur as SO4 2-								
80* dried soil (ED043)								
P520123,	P520124,	**18-Dec-2017**	**27-Dec-2017**	16-Jun-2018	✓	**27-Dec-2017**	16-Jun-2018	✓
P520125,	P520126,							
P520127,	P520128,							
P520129,	P520130,							
P520131,	P520132,							
P520133,	P520134,							
P520135,	P520136,							
P520137,	P520138,							
P520139,	P520140,							
P520141,	P520142,							
P520143,	P520144,							
P520145,	P520146,							
P520147,	P520148,							
P520149,	P520150,							
P520151,	P520152,							
P520153,	Composite 1,							
Composite 2,	Composite 3,							
Composite 4								

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
ED045G: Chloride by Discrete Analyser								
80* dried soil (ED045G)								
Composite 1, Composite 3,	Composite 2, Composite 4	**18-Dec-2017**	**21-Dec-2017**	15-Jan-2018	✓	**21-Dec-2017**	18-Jan-2018	✓
ED093S: Soluble Major Cations								
80* dried soil (ED093S)								
Composite 1, Composite 3,	Composite 2, Composite 4	**18-Dec-2017**	**21-Dec-2017**	16-Jun-2018	✓	**21-Dec-2017**	16-Jun-2018	✓
EG005S : Soluble Metals by ICPAES								
80* dried soil (EG005S)								
Composite 1, Composite 3,	Composite 2, Composite 4	**18-Dec-2017**	**21-Dec-2017**	16-Jun-2018	✓	**21-Dec-2017**	16-Jun-2018	✓
EG020S: Soluble Metals by ICPMS								
80* dried soil (EG020Z-S)								
Composite 1, Composite 3,	Composite 2, Composite 4	**18-Dec-2017**	**21-Dec-2017**	16-Jun-2018	✓	**21-Dec-2017**	16-Jun-2018	✓
EG035S: Soluble Mercury by FIMS								
80* dried soil (EG035S)								
Composite 1, Composite 3,	Composite 2, Composite 4	**18-Dec-2017**	**21-Dec-2017**	15-Jan-2018	✓	**27-Dec-2017**	15-Jan-2018	✓
EK040S: Fluoride Soluble								
80* dried soil (EK040S)								
Composite 1, Composite 3,	Composite 2, Composite 4	**18-Dec-2017**	**21-Dec-2017**	25-Dec-2017	✓	**27-Dec-2017**	18-Jan-2018	✓
EN60: ASLP Leaching Procedure								
Non-Volatile Leach: 28 day HT(e.g. Hg, CrVI) (EN60a)								
Composite 1, Composite 3,	Composite 2, Composite 4	**18-Dec-2017**	**19-Dec-2017**	15-Jan-2018	✓	**----**	----	----

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
ED093C: Leachable Major Cations								
Clear Plastic Bottle - Nitric Acid; Unfiltered (ED093C)								
Composite 1, Composite 3,	Composite 2, Composite 4	**19-Dec-2017**	**22-Dec-2017**	16-Jan-2018	✓	**22-Dec-2017**	16-Jan-2018	✓
EG020C: Leachable Metals by ICPMS								
Clear Plastic Bottle - Nitric Acid; Unfiltered (EG020B-C)								
Composite 1, Composite 3,	Composite 2, Composite 4	**19-Dec-2017**	**22-Dec-2017**	17-Jun-2018	✓	**22-Dec-2017**	17-Jun-2018	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG035C: Leachable Mercury by FIMS							
Clear Plastic Bottle - Nitric Acid; Unfiltered (EG035C)							
Composite 1, Composite 2, Composite 3, Composite 4	**19-Dec-2017**	**----**	----	----	**27-Dec-2017**	16-Jan-2018	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type / Analytical Methods	Method	Count QC	Count Regular	Rate (%) Actual	Rate (%) Expected	Evaluation	Quality Control Specification
Laboratory Duplicates (DUP)							
Acid Neutralising Capacity (ANC)	EA013	4	36	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Alkalinity in Soil	ED037	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Cations - soluble by ICP-AES	ED093S	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride - Soluble	EK040S	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Anions - Soluble	ED040S	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Net Acid Generation	EA011	4	36	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Mercury by FIMS	EG035S	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICPAES	EG005S	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICP-MS - Suite R	EG020R-S	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICP-MS - Suite X	EG020X-S	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICP-MS - Suite Y	EG020Y-S	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICP-MS - Suite Z	EG020Z-S	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	4	36	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total Oxidised as SO4 2-	ED043	4	35	**11.43**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Acid Neutralising Capacity (ANC)	EA013	2	36	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Alkalinity in Soil	ED037	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Cations - soluble by ICP-AES	ED093S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	2	4	**50.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride - Soluble	EK040S	3	4	**75.00**	**15.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Anions - Soluble	ED040S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Net Acid Generation	EA011	2	36	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	4	**50.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Mercury by FIMS	EG035S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICPAES	EG005S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICP-MS - Suite R	EG020R-S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICP-MS - Suite X	EG020X-S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICP-MS - Suite Y	EG020Y-S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICP-MS - Suite Z	EG020Z-S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	2	36	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type / Analytical Methods	Method	Count QC	Count Regular	Rate (%) Actual	Rate (%) Expected	Evaluation	Quality Control Specification
Method Blanks (MB) - Continued							
ASLP for Non & Semivolatile Analytes	EN60a	1	8	**12.50**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Cations - soluble by ICP-AES	ED093S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride Soluble By Discrete Analyser	ED045G	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride - Soluble	EK040S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Anions - Soluble	ED040S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Mercury by FIMS	EG035S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICPAES	EG005S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICP-MS - Suite R	EG020R-S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICP-MS - Suite X	EG020X-S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICP-MS - Suite Y	EG020Y-S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICP-MS - Suite Z	EG020Z-S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total as S (LECO)	ED042T	2	36	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfur - Total Oxidised as SO4 2-	ED043	2	35	**5.71**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Chloride Soluble By Discrete Analyser	ED045G	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride - Soluble	EK040S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Mercury by FIMS	EG035S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICPAES	EG005S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICP-MS - Suite X	EG020X-S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Soluble Metals by ICP-MS - Suite Y	EG020Y-S	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type / Analytical Methods	Method	Count QC	Count Regular	Rate (%) Actual	Rate (%) Expected	Evaluation	Quality Control Specification
Laboratory Duplicates (DUP)							
Leachable Major Cations	ED093C	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Leachable Mercury by FIMS	EG035C	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Leachable Metals by ICPMS - Suite A	EG020A-C	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Leachable Metals by ICPMS - Suite B	EG020B-C	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Leachable Mercury by FIMS	EG035C	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Leachable Metals by ICPMS - Suite A	EG020A-C	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Leachable Metals by ICPMS - Suite B	EG020B-C	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Leachable Major Cations	ED093C	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Leachable Mercury by FIMS	EG035C	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Leachable Metals by ICPMS - Suite A	EG020A-C	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Leachable Metals by ICPMS - Suite B	EG020B-C	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Matrix Spikes (MS) - Continued							
Leachable Mercury by FIMS	EG035C	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Leachable Metals by ICPMS - Suite A	EG020A-C	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH (1:5)	EA002	SOIL	In house: Referenced to Rayment and Lyons 4A1 and APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Net Acid Production Potential	EA009	SOIL	In house: Referenced to Coastech Research (Canada)(Mod.). NAPP = Acid Production Potential (APP or MAP-Maximum Acid Potential) minus Neutralising Capacity (ANC). NAPP may be +ve, zero or -ve.
Electrical Conductivity (1:5)	EA010	SOIL	In house: Referenced to Rayment and Lyons 3A1 and APHA 2510. Conductivity is determined on soil samples using a 1:5 soil/water leach. This method is compliant with NEPM (2013) Schedule B(3)
Net Acid Generation	EA011	SOIL	In house: Referenced to Miller (1998) Titremetric procedure determines net acidity in a soil following peroxide oxidation. Titrations to both pH 4.5 and pH 7 are reported.
Acid Neutralising Capacity (ANC)	EA013	SOIL	In house: Referenced to USEPA 600/2-78-054, I. Miller (2000). A fizz test is done to semiquanititatively estimate the likely reactivity. The soil is then reacted with an known excess quanitity of an appropriate acid. Titration determines the acid remaining, and the ANC can be calculated from comparison with a blank titration.
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Alkalinity in Soil	ED037	SOIL	In house: Referenced to APHA 2320 B Alkalinity is determined and reported on a 1:5 soil/water leach.
Major Anions - Soluble	ED040S	SOIL	In house: Soluble Anions are determined off a 1:5 soil / water extract by ICPAES.
Sulfur - Total as S (LECO)	ED042T	SOIL	In house: Dried and pulverised sample is combusted in a high temperature furnace in the presence of strong oxidants / catalysts. The evolved S (as SO2) is measured by infra-red detector
Sulfur - Total Oxidised as SO4 2-	ED043	SOIL	In house: The sample is reacted with Peroxide to oxidise all Sulfur forms to soluble Sulfate. Sulfate is determined by ICPAES and reported TOS as SO4 2-.
Chloride Soluble By Discrete Analyser	ED045G	SOIL	In house: Referenced to APHA 4500-Cl- E. The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm. Analysis is performed on a 1:5 soil / water leachate.
Leachable Major Cations	ED093C	SOIL	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations in leachates are determined by either ICP-AES or ICP-MS techniques.
Cations - soluble by ICP-AES	ED093S	SOIL	In house: Referenced to APHA 3120; USEPA SW 846 - 6010 (ICPAES) Water extracts of the soil are analyzed for major cations by ICPAES. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (2013) Schedule B(3)
Soluble Metals by ICPAES	EG005S	SOIL	In house: Referenced to APHA 3120; USEPA SW 846 - 6010. Soluble metals are determined following an appropriate soil / water extraction of the soil. The ICPAES technique ionises samples in a plasma, emitting characteristic spectrums based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards.
Leachable Metals by ICPMS - Suite A	EG020A-C	SOIL	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020: The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	Method	Matrix	Method Descriptions
Leachable Metals by ICPMS - Suite B	EG020B-C	SOIL	In house: referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Soluble Metals by ICP-MS - Suite R	EG020R-S	SOIL	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Soluble Metals by ICP-MS - Suite X	EG020X-S	SOIL	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Soluble Metals by ICP-MS - Suite Y	EG020Y-S	SOIL	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Soluble Metals by ICP-MS - Suite Z	EG020Z-S	SOIL	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Leachable Mercury by FIMS	EG035C	SOIL	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the TCLP solution. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Soluble Mercury by FIMS	EG035S	SOIL	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. Mercury in solids are determined following an appropriate acid digestion. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the extract. Ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve.
Fluoride - Soluble	EK040S	SOIL	In house: Referenced to APHA 4500 F--C Soluble Fluoride is determined after a 1:5 soil/water extract using an ion selective electrode.

Preparation Methods	Method	Matrix	Method Descriptions
Sulfur - Total Oxidised as Sulfate or Sulfur	ED043PR	SOIL	In house: The sample is reacted with Peroxide to oxidise all Sulfur forms to soluble Sulfate.
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house
Digestion for Total Recoverable Metals in TCLP Leachate	EN25C	SOIL	In house: Referenced to USEPA SW846-3005. Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (2013) Schedule B(3)

Preparation Methods	Method	Matrix	Method Descriptions
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.
ASLP for Non & Semivolatile Analytes	EN60a	SOIL	In house QWI-EN/60 referenced to AS4439.3 Preparation of Leachates
Dry and Pulverise (up to 100g)	GEO30	SOIL	#

CHAIN OF CUSTODY

ALS Laboratory: please tick →

CLIENT: Venturex Resources Limited	TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
OFFICE:	☒ Standard TAT (List due date):
	☐ Non Standard or urgent TAT (List due date):
PROJECT: Sulphur Springs Waste Characterisation	ALS QUOTE NO.: Quotation - 1006979
ORDER NUMBER:	
PROJECT MANAGER: Emma Bamforth	CONTACT PH: 0419 919 196
SAMPLER:	SAMPLER MOBILE:
COC emailed to ALS? (YES / NO)	EDD FORMAT (or default):
Email Reports to (will default to PM if no other addresses are listed): emma.bamforth@venturexresources.com	
Email Invoice to (will default to PM if no other addresses are listed): emma.bamforth@venturexresources.com	

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 4 5 6 7
OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt: 28.0 °C
Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Emma Bamforth	M Uelll		
7th December 2017	DATE/TIME: 18/12/17 1600	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: Samples to be delivered from ALS Geochemistry

ALS USE	SAMPLE DETAILS MATRIX: SOLID (S) WATER (W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL CONTAINERS	Total C & S (ME-IR08)	Acid-Base Accounting (AASS1)	Metals by Multi acid digestion (GEO-4ACID and ME-ICP61)	Mercury (GEO-AR01 and HgMS42)	Soil Analysis (1:5 leach)	ASLP Leach, Acetic Acid pH 2.9			Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	P520123		Rock	None	1	x	x							
2	P520124		Rock	None	1	x	x							
3	P520125		Rock	None	1	x	x							
4	P520126		Rock	None	1	x	x							
5	P520127		Rock	None	1	x	x							
6	P520128		Rock	None	1	x	x							
7	P520129		Rock	None	1	x	x							
8	P520130		Rock	None	1	x	x							
9	P520131		Rock	None	1	x	x							
10	P520132		Rock	None	1	x	x							
11	P520133		Rock	None	1	x	x							
12	P520134		Rock	None	1	x	x							
13	P520135		Rock	None	1	x	x							
14	P520136		Rock	None	1	x	x							
15	P520137		Rock	None	1	x	x							
16	P520138		Rock	None	1	x	x							

Environmental Division
Perth
Work Order Reference
EP1714283

Telephone : + 61-8-9209 7655

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ ADELAIDE 21 Burma Road Pooraka SA 5095 ☐ BRISBANE 32 Shand Street Stafford QLD 4053 ☐ GLADSTONE 46 Callemondah Drive Clinton QLD 4680 ☐ MACKAY 78 Harbour Road Mackay QLD 4740 ☐ MELBOURNE 2-4 Westall Road Springvale VIC 3171 ☐ MUDGEE 27 Sydney Road Mudgee NSW 2850 ☐ NEWCASTLE 5 Rose Gum Road Warabrook NSW 2304 ☐ NOWRA 4/13 Geary Place North Nowra NSW 2541 ☐ PERTH 10 Hod Way Malaga WA 6090 ☐ SYDNEY 277-289 Woodpark Road Smithfield NSW 2164 ☐ TOWNSVILLE 14-15 Desma Court Bohle QLD 4818 ☐ WOLLONGONG 99 Kenny Street Wollongong NSW 2500

CLIENT: Venturex Resources Limited

OFFICE:

PROJECT: Sulphur Springs Waste Characterisation

ORDER NUMBER:

PROJECT MANAGER: Emma Bamforth CONTACT PH: 0419 919 196

SAMPLER: SAMPLER MOBILE:

COC emailed to ALS? (YES / NO) EDD FORMAT (or default):

Email Reports to (will default to PM if no other addresses are listed): emma.bamforth@venturexresources.com

Email Invoice to (will default to PM if no other addresses are listed): emma.bamforth@venturexresources.com

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)

☒ Standard TAT (List due date):

☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.: Quotation - 1006979

COC SEQUENCE NUMBER (Circle)

COC: 1 2 3 4 5 6 7

OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)

Custody Seal Intact? Yes No N/A

Free ice / frozen ice bricks present upon receipt? Yes No N/A

Random Sample Temperature on Receipt: °C

Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Emma Bamforth	mu		
7th December 2017	DATE/TIME:	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: Samples to be delivered from ALS Geochemistry

ALS USE	SAMPLE DETAILS MATRIX: SOLID (S) WATER (W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
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17	P520139		Rock	None	1	x	x							
18	P520140		Rock	None	1	x	x							
19	P520141		Rock	None	1	x	x							
20	P520142		Rock	None	1	x	x							
21	P520143		Rock	None	1	x	x							
22	P520144		Rock	None	1	x	x							
23	P520145		Rock	None	1	x	x							
24	P520146		Rock	None	1	x	x							
25	P520147		Rock	None	1	x	x							
26	P520148		Rock	None	1	x	x							
27	P520149		Rock	None	1	x	x							
28	P520150		Rock	None	1	x	x							
29	P520151		Rock	None	1	x	x							
30	P520152		Rock	None	1	x	x							
31	P520153		Rock	None	1	x	x							
32	Composite 1		Rock	vacuumed sealed	1	x	x	x	x	x	x			

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ ADELAIDE 21 Burma Road Pooraka SA 5095 Ph: 08 8359 0890 E: adelaide@alsglobal.com
☐ BRISBANE 32 Shand Street Stafford QLD 4053 Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com
☐ GLADSTONE 46 Callemondah Drive Clinton QLD 4680 Ph: 07 7471 5600 E: gladstone@alsglobal.com
☐ MACKAY 78 Harbour Road Mackay QLD 4740 Ph: 07 4944 0177 E: mackay@alsglobal.com
☐ MELBOURNE 2-4 Westall Road Springvale VIC 3171 Ph: 03 8549 9600 E: samples.melbourne@alsglobal.com
☐ MUDGEE 27 Sydney Road Mudgee NSW 2850 Ph: 02 6372 6735 E: mudgee.mail@alsglobal.com
☐ NEWCASTLE 5 Rose Gum Road Warabrook NSW 2304 Ph: 02 4968 9433 E: samples.newcastle@alsglobal.com
☐ NOWRA 4/13 Geary Place North Nowra NSW 2541 Ph: 024423 2063 E: nowra@alsglobal.com
☐ PERTH 10 Hod Way Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsglobal.com
☐ SYDNEY 277-289 Woodpark Road Smithfield NSW 2164 Ph: 02 8784 8555 E: samples.sydney@alsglobal.com
☐ TOWNSVILLE 14-15 Desma Court Bohle QLD 4818 Ph: 07 4796 0600 E: townsville.environmental@alsglobal.com
☐ WOLLONGONG 99 Kenny Street Wollongong NSW 2500 Ph: 02 4225 3125 E: portkembla@alsglobal.com

CLIENT: Venturex Resources Limited	TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
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PROJECT: Sulphur Springs Waste Characterisation	☐ Non Standard or urgent TAT (List due date):
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COC:	1	2	3	4	5	6	7
OF:	1	2	3	4	5	6	7

FOR LABORATORY USE ONLY (Circle)

Custody Seal Intact?	Yes	No	N/A
Free ice / frozen ice bricks present upon receipt?	Yes	No	N/A
Random Sample Temperature on Receipt:		°C	
Other comment:			

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Emma Bamforth	m ✓		
7th December 2017	DATE/TIME:	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: **Samples to be delivered from ALS Geochemistry**

ALS USE	SAMPLE DETAILS MATRIX: SOLID (S) WATER (W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
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33	Composite 2		Rock	vacuumed sealed	1	x	x	x	x	x	x			
34	Composite 3		Rock	vacuumed sealed	1	x	x	x	x	x	x			
35	Composite 4		Rock	vacuumed sealed	1	x	x	x	x	x	x			
				TOTAL										

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.