Appendix 3

Geochemical Assessment and Groundwater Impact Assessment

MEMORANDUM

To:	Mick Callan - Vitrinite
From:	Christine Jones
CC:	Dave Moss
Date:	30 November 2021
Subject:	**Groundwater and Geochemical Impact Assessment Vulcan Coal Mine EA0002912 Amendment**

1 INTRODUCTION

Queensland Coking Coal Pty Ltd (QCC) and Queensland Coal Aust. No. 1 (QCA1) hold the coal tenure associated with the Vulcan Coal Mine (the VCM). Both companies are fully owned by Vitrinite Pty Ltd (Vitrinite) and as such, Vitrinite is the proponent of the VCM.

The VCM is located north of Dysart and approximately 35 km south of Moranbah in Queensland's Bowen Basin (**Figure 1**). The VCM lies to the immediate west of several established mining operations, including Peak Downs Mine and Saraji Mine.

Mining Lease (ML) ML700060 and environmental authority (EA) EA0002912 have been granted to Vitrinite to develop the Jupiter hard coking coal target into an open cut mine via a single open cut pit. The VCM will operate for approximately four years and will extract approximately six million tonne of Run of Mine (ROM) hard coking coal at a rate of up to 1.95 million tonnes per annum (Mtpa). The VCM will target the Alex and multiple Dysart Lower coal seams. Truck and shovel mining operations will be employed to develop the pit.

A small out of pit waste rock dump will be established prior to commencing in-pit dumping activities that will continue for the life of the operation. In-pit dumping will fill the majority of the open cut pit during operations, with the remaining final void to be backfilled upon cessation of mining. The out of pit waste rock dump will be rehabilitated in-situ.

2 PROPOSED ENVIRONMENTAL AUTHORITY AMENDMENT

This memo is provided as supporting technical information for a proposed amendment to the VCM EA. The purpose of the EA amendment is to include the establishment and operation of a Coal Handling and Preparation Plant (CHPP), Trail Load-out Facility (TLF) and a dedicated rail loop on Mining Lease ML700060.

Figure 2 provides the revised site layout proposed for the environmental authority (EA) amendment application.

3 RATIONALE

Whilst the proposed EA amendment does not change the mine pit extent, nor any other sub-surface infrastructure that may impact on groundwater resources, it does include co-disposal of dry tailings (coarse and fine reject material) produced by the CHPP, with waste rock that will be backfilled in the in-pit dump (to backfill the void).

The current approval, based on assessment of the project in 2020, includes backfilling of the pit void with waste rock during operations and in closure. The only change to the previous groundwater assessment outcomes and current approval, is the inclusion of dry tailings in the backfilled material.

This memo has been prepared to provide an assessment of that change, in reference to previously prepared groundwater and geochemical assessments of the project. Specifically, this memo summarises information from the following two technical reports:

1. Groundwater Impact Assessments for the Vulcan Complex Project (hydrogeologist.com.au, 2020), and
2. Geochemical Assessment of Waste Rock and Coal Reject for the Vulcan Complex Project (RGS, 2020).

Figure 1: Vulcan Coal Mine - Regional Location

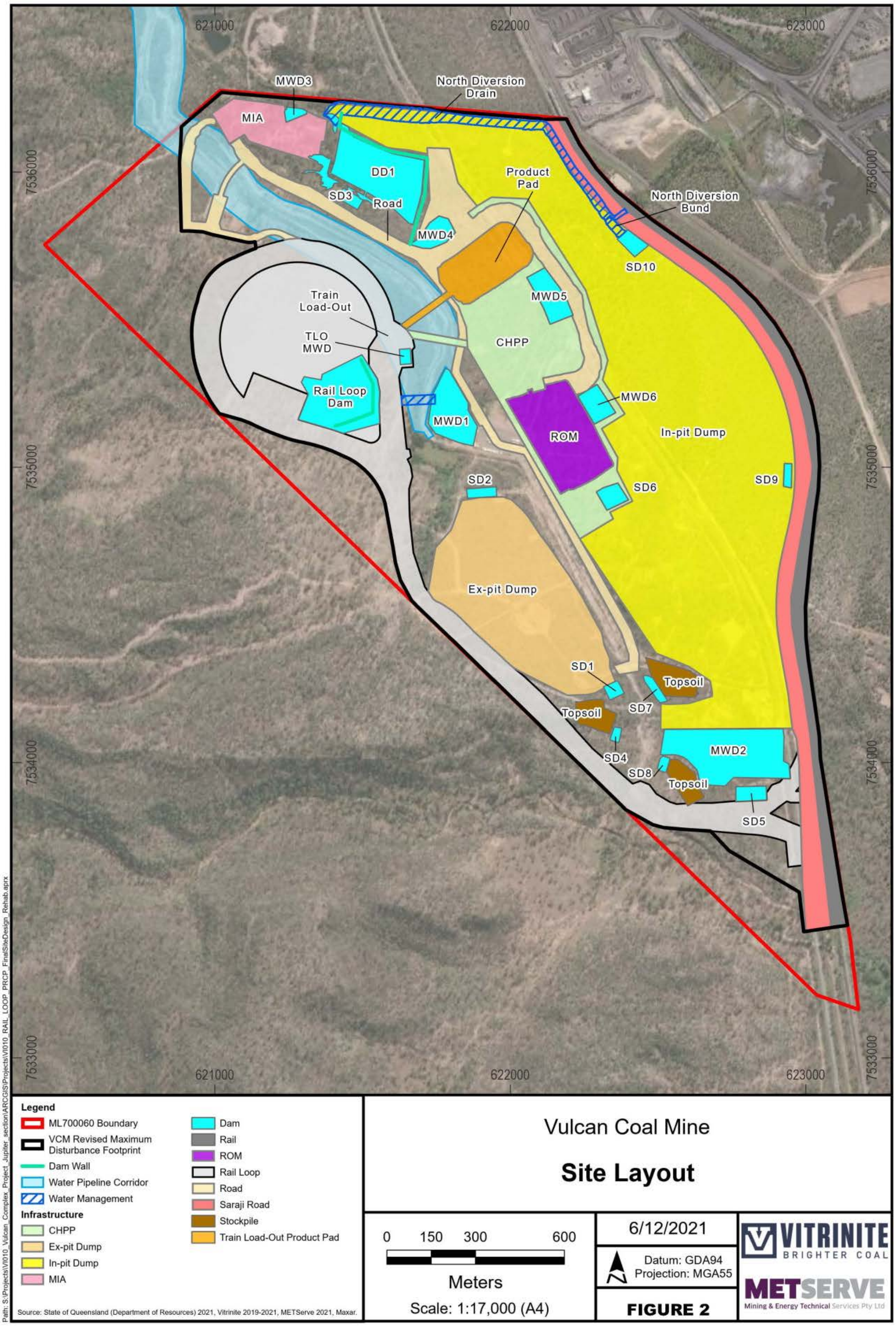

Figure 2: Updated Site Layout Plan

4 GROUNDWATER

In the vicinity of the VCM, all geological formations yield low volumes of groundwater and therefore would not typically be classified as aquifers in most hydrogeological settings. Based on the limited extent of groundwater at the VCM and the lack of change to the pit extents, little change to the outcomes of the previous groundwater impact assessment is anticipated. That is:

- groundwater driven pit dewatering is not anticipated to be required (due to negligible groundwater inflows to the pit);
- the extent of groundwater drawdown is limited;
- impacts on Groundwater Dependent Ecosystems (GDEs) as a result of groundwater drawdown are not anticipated;
- impacts on the existing poor quality groundwater are not anticipated; and
- impacts on other groundwater users are not anticipated.

The potential impacts on groundwater will continue to be monitored in accordance with the EA.

4.1. Summary of Groundwater Impact Assessment Report

hydrogeologist.com.au was engaged to prepare a groundwater impact assessment of the Vulcan Coal Mine (26 August 2020).

These groundwater impact assessment addressed the following aspects:

- Reviewed the existing geological and hydrogeological information in the public domain and from private investigations.
- Described the following components of the groundwater regime:
  - geology and stratigraphy, locally and regionally, including faulting;
  - aquifer types (confined / unconfined), hydraulic characteristics and connectivity;
  - depth to, and thickness of aquifers and their transmissivity;
  - relationship between local and regional groundwater flows;
  - groundwater flow directions and discharge;
  - groundwater quality and chemistry;
  - sources of recharge and recharge rates for each aquifer; and
  - surface water interactions and potential groundwater dependent ecosystems (GDEs).
- Determined the local environmental values and water quality objectives of the groundwater resource in accordance with the Environmental Protection (Water) Policy 2009 (Qld), the Queensland Water Quality Guidelines (Department of Environment and Heritage Protection, 2011) and the ANZECC Water Quality Guidelines (AWQG, 2018).
- Developed a calibrated numerical groundwater model to predict potential drawdown of all relevant aquifers. The groundwater impact assessment:
  - presented the conceptualisation of the hydrogeological system, including assumptions and limitations;
  - defined each hydrogeological or hydro-stratigraphic unit including storage, flow, connectivity, recharge / discharge pathways and the predicted changes likely to occur as a result of the VCM;
  - simulated the VCM and predicts groundwater level drawdown or depressurisation in each hydro-stratigraphic unit during the life of the VCM and post closure;
  - predicted the volumes of groundwater reporting to the pit as seepage or inflow including proportions from each hydro-stratigraphic unit;

    predicted residual groundwater levels and recovery rates in each hydro-stratigraphic unit during post closure; and
  - included an assessment of the quality of, and risks inherent in the data used and modelling, which may require sensitivity analysis.

- Predicted and presented impacts on environmental values, including identified third party landholder bores and potential GDEs.
- Predicted and presented impacts on potential interactions and connectivity between surface waters and groundwaters.
- Predicted and presented drawdown impact during operations and post mining resulting from the VCM.
- Predicted and presented cumulative drawdown impacts with other existing, known or reasonably foreseeable projects in the region during mine operation and post mining.
- Proposes an ongoing groundwater management strategy including monitoring of the established bore network, any measures to manage or mitigate potential impacts and a program for the review and update of the numerical model.
- Describes potential impacts on groundwater quality from the VCM (e.g. spills, contaminants).

The following geological formations may contain groundwater (hydrogeologist.com.au, 2020):

Quaternary alluvium: Confined to discrete channels in the beds of existing waterways. Alluvial sediments are unsaturated and disconnected laterally.

Tertiary sediments and weathered regolith: Silts and clays, which comprise of the bulk of the regolith overlaying the coals measures, are densely compacted, hard and generally dry. Sand and gravel lenses embedded within the regolith are permeable but have low hydraulic conductivity and limited lateral and vertical extent. These have a potential to represent unconfined to confined aquifers, depending on location.

Permian coal measures: The ALEX and DLL coal seams are poor aquifers of low hydraulic conductivity. They are confined above and below by low-permeability regolith and sedimentary rocks. Nevertheless, these represent the largest and uppermost aquifers across most of the region surrounding the VCM.

Back Creek Group: This formation of sandstones, siltstones and shale forms a largely impervious layer beneath the DLL coal seam aquifer. However, the Back Creek Group also contains narrow coal seams that can act as poor aquifers.

4.2. Depth to Groundwater

Groundwater is between 2m and 30m deep within the region surrounding the VCM, but generally is between 5m and 30m deep in the area of the open cut pit as shown in **Figure 3** below. There are areas on the northern and southern mining lease boundaries with a depth to groundwater less than 5m. Due to the depth of groundwater, aquatic GDEs are absent from most of the local land surface. A small extent of possible groundwater dependent terrestrial vegetation occurs where the groundwater is 5m to 20m deep, which is out of reach of most plant's roots, but within reach of some species.

4.3. Groundwater Drawdown

hydrogeologist.com.au (2020) has developed a numerical groundwater flow model of the survey area and broader region to predict the effects of the Vulcan Coal Mine on local groundwater levels. The drawdown predicted from the VCM is limited in geographic extent (up to 3,000m to the northeast toward existing mining operations) and magnitude (up to 10m) (**Figure 4**). This limited drawdown propagation is mainly due to the limited extent of saturation in the regions surrounding the VCM, the low hydraulic conductivities and low storage coefficients. The predicted drawdown extends towards the east, toward Saraji Mine.

Fault zones can influence groundwater transmission rates and flow directions; however there are no known fault zones in or near the VCM. Within the coal measures, groundwater largely flows along the bedding planes of the coal seams. In general, groundwater flows from the west to the east, mimicking the surface water drainage pattern. The low hydraulic conductivity and small storage of local aquifers means that their levels have remained largely unaffected by 40 years of dewatering at adjacent mining operations located approximately 600 m away.

The zone of drawdown contains some potential GDEs, but only within the clearing footprint. No remnant vegetation outside the clearing footprint is found within the zone of drawdown. In summary, negligible impacts to GDEs are predicted to result from the Vulcan Coal Mine, beyond that which will occur due to vegetation clearing.

There are no third party groundwater users within the predicted extent of drawdown, hence impacts on existing users are considered unlikely. The nearest third party groundwater bore to the open cut mine pit is 700m from the 1m predicted drawdown contour line. An uncertainty analysis has been undertaken and shows that the maximum probable drawdown does not extend to the nearest third party bore, and that impact to the bore is very unlikely.

This is a substantial buffer, and together with the proposed monitoring program, will ensure that third party bores are not put at undue risk by operations at the VCM.

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4.5. Open Cut Pit Inflow

Due to the limited presence of groundwater in the region surrounding the VCM, groundwater fed pit inflows are anticipated to be negligible with limited flows likely to express as pit wall moisture and coal moisture. Due to evaporation, groundwater driven pit dewatering is not anticipated to be required.

Any effects of drawdown will cease soon after the cessation of operations at the VCM and no surface expression of groundwater will occur once the final landform is constructed. Due to the negligible risk, no measures are required or proposed to limit groundwater discharge to the surface. Following recharge, minor groundwater interaction with placed waste material within the former pit is expected, however based on assessment of the waste material characterisation (**Section 5**) and the current quality of groundwater, this is anticipated to be of limited consequence.

4.6. Surface-Groundwater Interaction

An assessment of the mechanism of recharge from surface water systems in the region surrounding the VCM was undertaken. It was concluded that there was no significant surface-groundwater interaction in the region surrounding the VCM. It was also determined that impacts on surface waters from groundwater interaction are extremely unlikely.

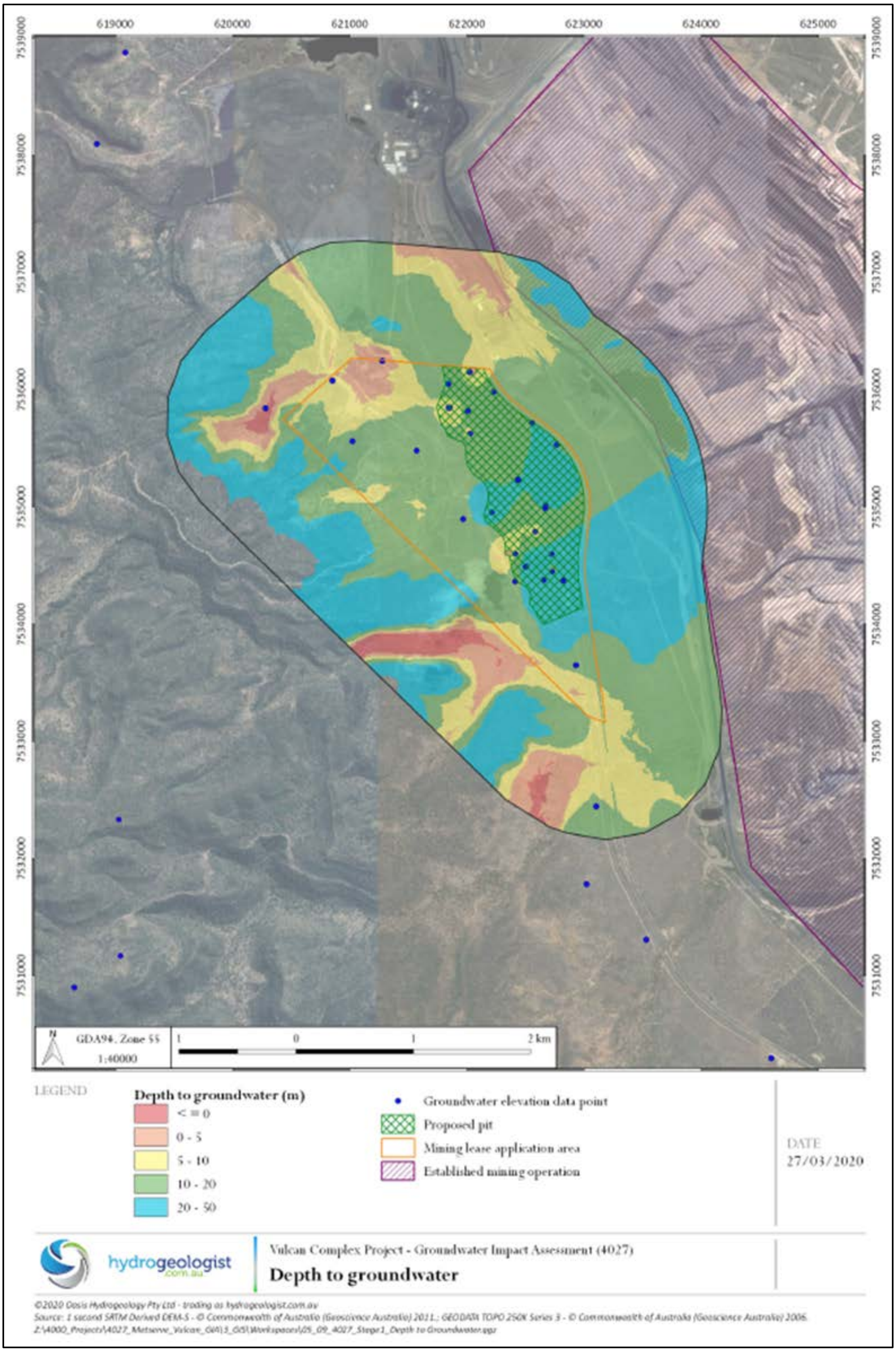

Figure 3: Depth to Groundwater

4.7. Groundwater Quality

The pH of local groundwater is neutral to slightly acidic. Salinity levels are relatively high, and are brackish to saline with electrical conductivity of between 2,700 and 11,700 µS/cm. This conductivity is driven mostly by high concentrations of sodium and chloride (with moderate bicarbonate in some samples), consistent with it being sodic water of marine origin. This groundwater is generally unsuitable for irrigation, but it may be used in limited quantities as water for livestock. Conductivity above 7,463 µS/cm is associated with declines in animal health if consumed for prolonged periods (ANZG 2018).

All groundwater on site fails to meet guidelines for drinking water suitability for humans. Overall, groundwater on site has no or limited value for most uses, with the exception of limited stock watering and potential industrial purposes.

5 GEOCHEMISTRY

RGS Environmental Pty. Ltd. (RGS) was engaged to prepare a geochemical assessment of waste rock and coal reject material at the Vulcan Complex Project (the VCM).

The geochemical assessment addressed the following aspects:

- Review of available geochemical and geological data and existing drill hole database (including plans, drill hole logs and drill core photographs) associated with the VCM.
- Design of a geochemical assessment program, including sampling for, and testing of, representative overburden, interburden and coal reject material within the VCM boundary.
- Coordination of the material sampling and geochemical analysis programs.
- Geochemical characterisation of waste rock material (overburden and interburden) from the open cut pit area and coal reject material from processing of the target coal seams, through static and kinetic testing programs.
- Development of any necessary environmental management measures related to waste rock and coal reject emplacement and rehabilitation.
- Preparation of a Geochemical Assessment Report based on existing information, sample analysis and discussion regarding any Acid and Metalliferous Drainage (AMD) potential or other salinity/erosion/dispersion issues related to the VCM.

The geochemical test program was designed to assess the degree of risk from AMD, oxidation of pyrite, leachability of metals/metalloids, and characterisation of standard soil parameters including salinity, cation exchange capacity and major metal/metalloid compositions.

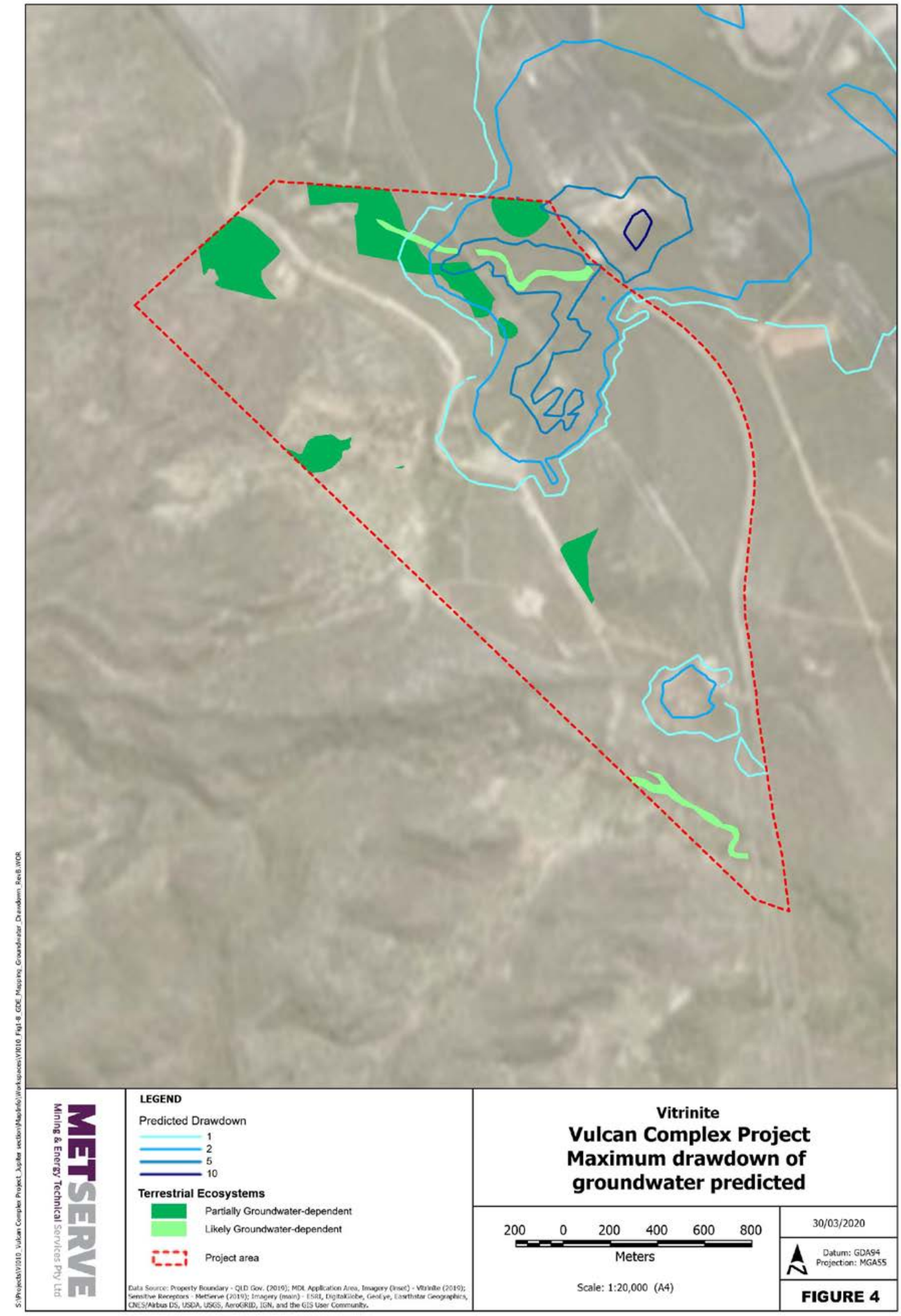

Figure 4: Groundwater to Drawdown Model

5.1. Waste Rock (Overburden and Interburden)

Acid Base Account

Acid Base Account results for the waste rock samples from the VCM are summarised below. Please refer to the Geochemical Assessment Report (RGS, 2020) for the full data set.

pH: The $pH_{(1:5)}$ of the 23 samples collected from the Jupiter target ranges from 5.1 to 9.0, with a median value of 7.0 as shown below in **Figure 5**. The pH results indicate that the waste rock material will add some alkalinity to any contact water as the pH of deionized water used in the pH tests is typically in the range of 5.0 to 6.5.

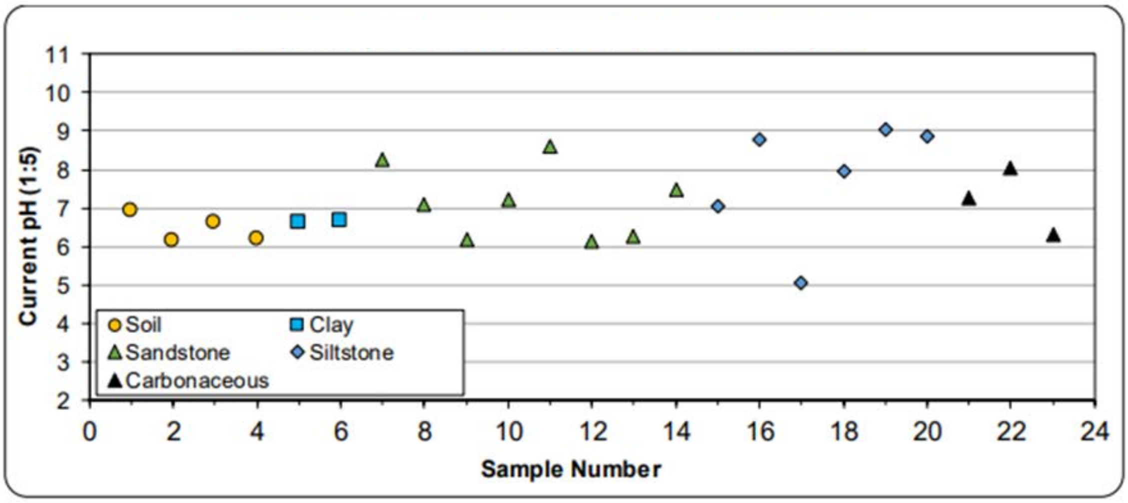

Figure 5: pH Values for Jupiter Waste Rock Samples

EC: The current EC (1:5) of the Jupiter target ranges from 43 to 331 µS/cm, with a median value of 152 µS/cm as shown below in **Figure 6.**

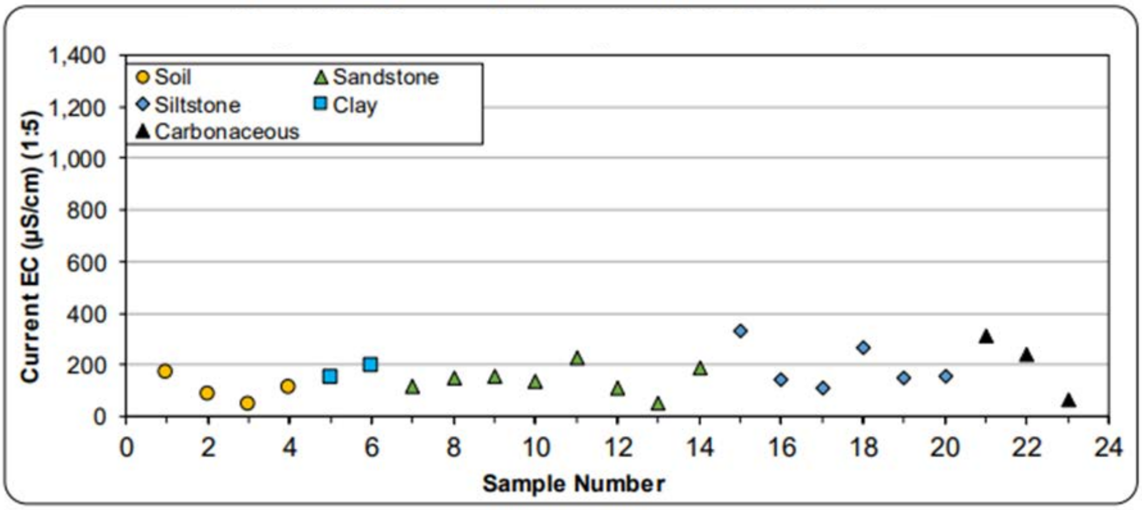

Figure 6: EC Values for Jupiter Waste Rock Samples

To provide additional context, the $EC_{(1:5)}$ and $pH_{(1:5)}$ results for waste rock (overburden and interburden) are classified against pH and salinity criteria for mine waste material, as defined by Queensland Department of Mines and Energy (1995) technical guidelines for the environmental management of exploration and mining in Queensland (**Table 1** below).

Based on the median pH and EC values, the waste rock (overburden/interburden) samples tested are regarded as having a 'medium' soil pH and 'low' salinity characteristics, as indicated by the distribution of samples corresponding to each pH and salinity class.

Table 1: Salinity and pH Criteria for Assessment of Waste Rock Samples

Jupiter Target	Very Low	Low	Medium	High	Very High
$pH_{(1:5)}$	<4.5	4.5 – 5.5	5.5 – 7.0 Median – 7.0)	7.0 – 9.0	>9.0
$EC_{(1:5)}$	<150	150 – 450 (Median – 152)	450 – 900	900 – 2,000	>2,000

NOTE: Adapted from DME, 1995. Highlighted cells show the category corresponding to the median pH and EC values (orange shading) for the waste rock (overburden/interburden) samples.

The pH and EC tests were completed on pulverized samples (≤ 75 µm) with a large surface area in contact with the leaching solution, thereby providing greater potential for dissolution and reaction, and represent a 'worst case scenario'. It is also expected that the salinity of leachate from low sulfur mining waste material will diminish with time as salts are flushed from the rock matrix and a state of equilibrium develops. At that point, the salinity of seepage/runoff is predicted to stabilize at a lower asymptotic concentration relative to the weathering/erosion of the material.

Sulfur: The total sulfur content of the samples ranges from below the laboratory limit of reporting (LoR) to 0.30 %S and has a very low median value of 0.02 %S, compared with the median crustal abundance value of 0.07 %S in unmineralised soils (Bowen, 1979; INAP, 2009). Material with a total sulfur content less than or equal to 0.1 %S are essentially barren of sulfur, generally representing background concentrations and have a negligible capacity to generate acidity. The sample analysis shown below in **Figure 7** demonstrates that most samples have a total sulfur concentration well below the median crustal abundance of 0.07 %S

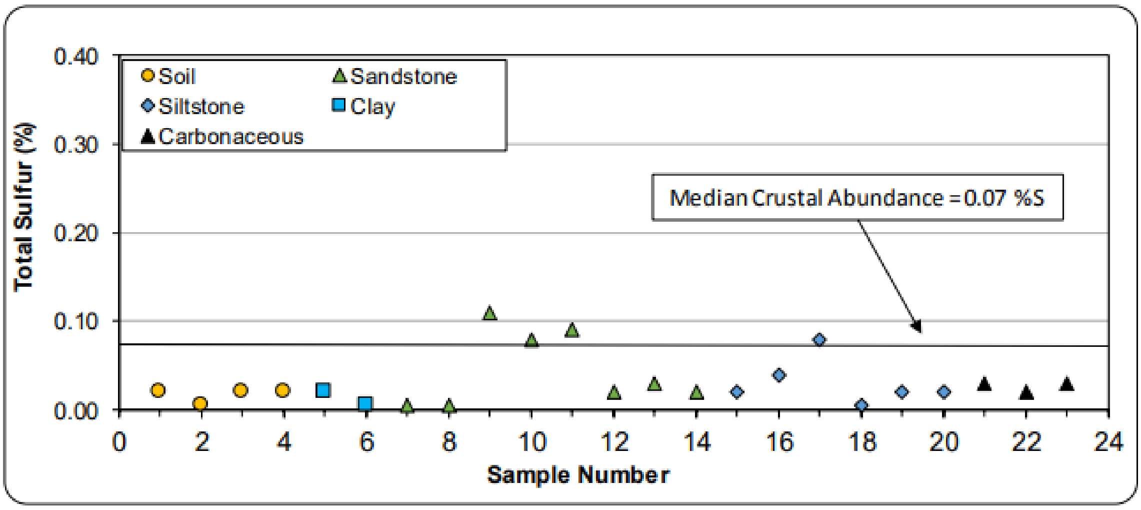

Figure 7: Total Sulfur Values for Jupiter Waste Rock Samples

Sulfide Sulfur: Due to the very low sulfur content of most of the waste rock (overburden/interburden) samples, only one sample from the Jupiter target was tested for sulfide sulfur using the Scr method. The test result returned that there was no appreciable sulfide sulfur contained within the sample.

Maximum Potential Acidity (MPA): Based on the total sulfur content, the MPA that could be generated by the waste rock samples ranges from 0.2 (below the laboratory LoR) to 2.8 kg H_2SO_4/t, and has a very low median value of 0.6 kg H_2SO_4/t.

Acid Neutralising Capacity (ANC): The ANC for the samples ranges from 0.25 to 15.4 kg H_2SO_4/t and had a median value of 6.0 kg H_2SO_4/t which is 10 times the median MPA.

ANC:MPA Ratio: The ANC:MPA ratio of the samples ranges from 0.4 to 50.9, with a median value of 7.8. In simplistic terms, this means that the waste rock (overburden/interburden) has more capability to neutralize acid rather than the potential to form acid.

Net Acid Producing Potential (NAPP): The NAPP values of the samples ranges from -14.8 to 0.4 kg H2SO4/t, with a negative median value of -5.3 kg H2SO4/t as shown below in **Figure 8.**

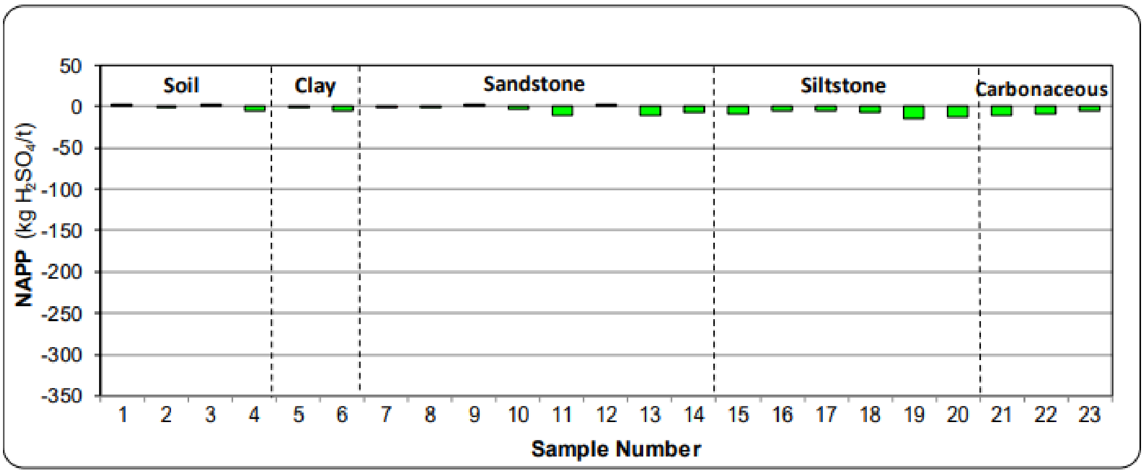

Figure 8: NAPP Values for Jupiter Waste Rock Samples

Given the very low sulfur content of the waste rock tested and the generally negative NAPP values, the risk of generating any significant amounts of acidity from these material is considered to be negligible.

Figure 9 below plots the ANC against the MPA for the waste rock samples tested by material type. ANC:MPA ratio lines have been plotted on the figures to illustrate the factor of safety associated with the samples in terms of potential for generation of acidity. Generally, those samples with an ANC:MPA ratio of greater than 2 and sulfide content of <0.1 %S are considered to represent material with a high factor of safety and a very low risk of generating acidity (COA, 106; INAP, 2009).

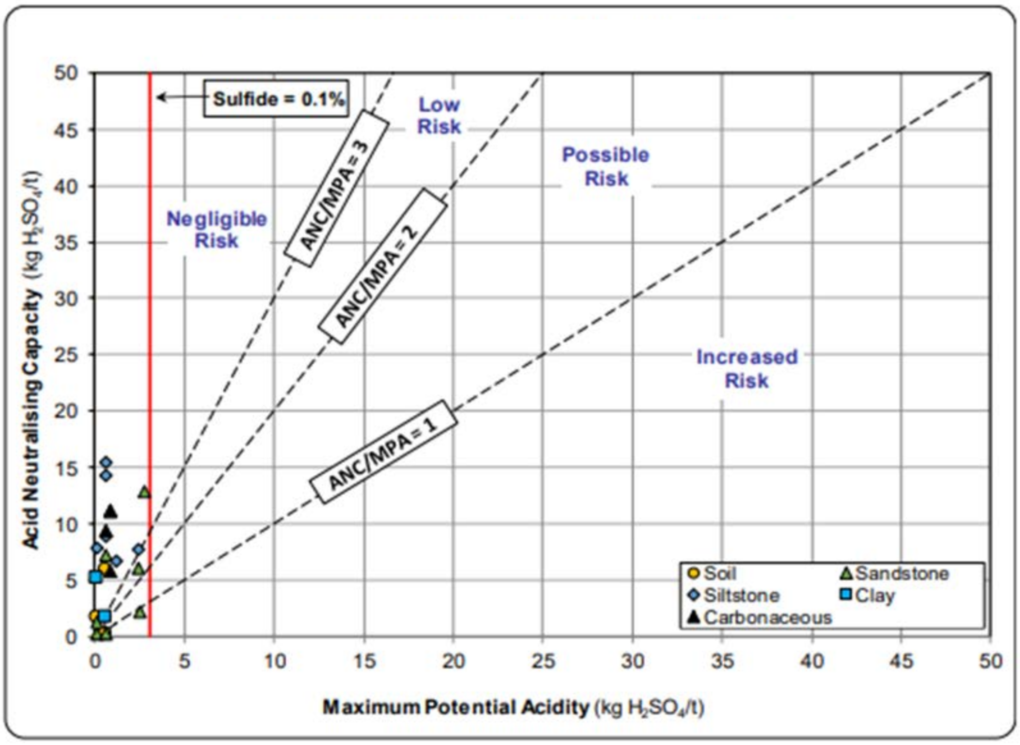

Figure 9: ANC v MPA for Jupiter Waste Rock Samples

5.2. Coal Reject

Acid Base Account results for the coal reject samples from the VCM are summarised below. Please refer to the Geochemical Assessment Report (RGS, 2020) for the full data set.

pH: The $pH_{(1:5)}$ of the 11 samples collected from the Jupiter target ranges from 4.5 to 8.4 and has a median pH value of 7.4 as shown below in **Figure 10.** The pH results indicate that the bulk reject material generated at the VCM will most likely add alkalinity to any contact water as the pH of deionized water used in the pH tests is typically in the pH range of 5.0 to 6.5. The lowest pH value was obtained from one of the course reject samples; however the remaining four course reject samples have a neutral to slightly alkaline pH value. On the basis of these results, it is expected that the leachate from bulk coal reject material will be pH neutral.

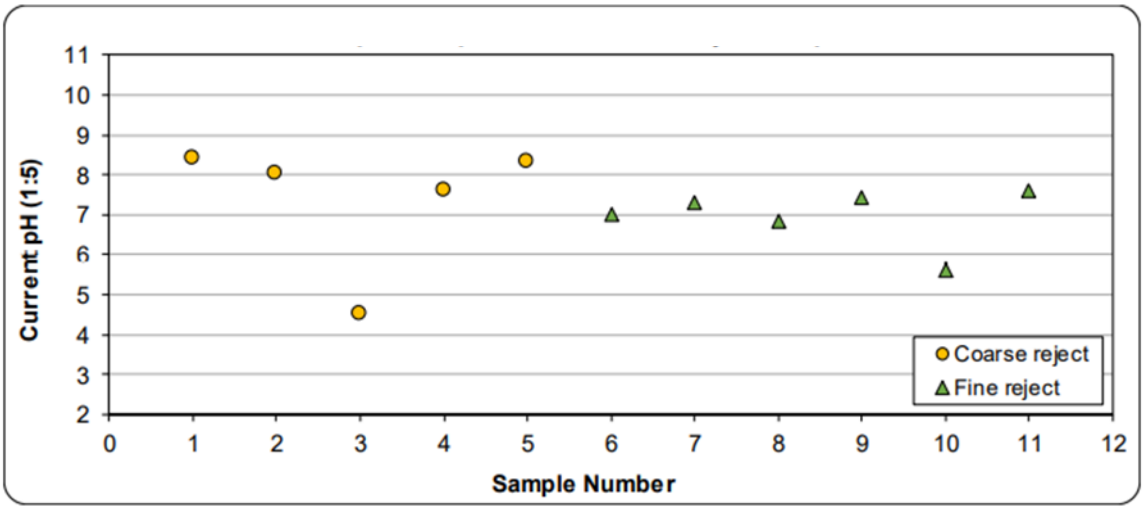

Figure 10: pH Values for Coal Reject Samples

EC: The current EC(1:5) of the coal reject samples ranges from 116 to 595 µS/cm and has a median value of 401 µS/cm as shown in **Figure 11** below. The highest EC is measured in a sample of fine reject material.

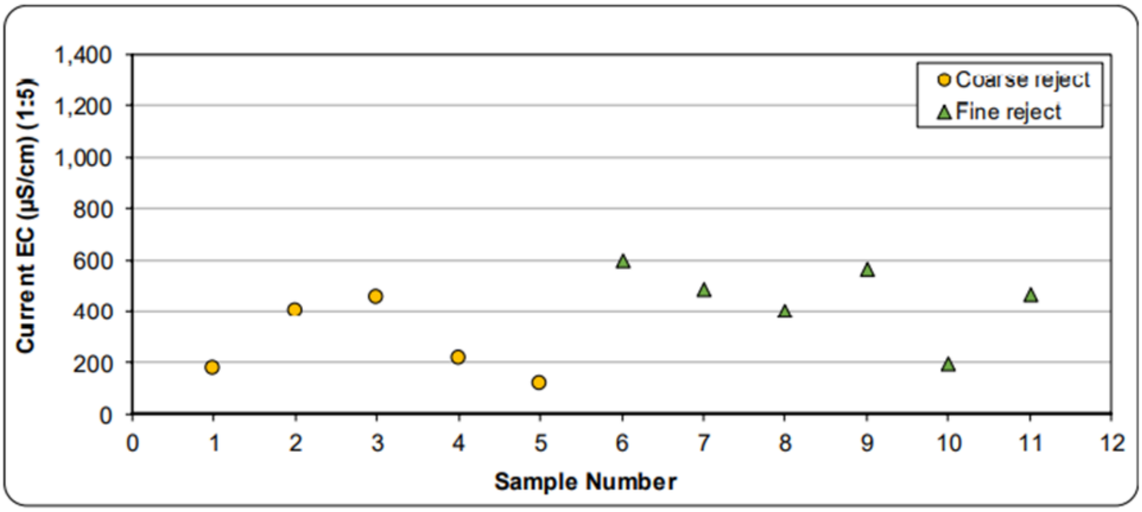

Figure 11: EC Values for Coal Reject Samples

To provide additional context, the EC(1:5) and pH(1:5) results for coal reject are classified against pH and salinity criteria for mine waste material, as defined by Queensland Department of Mines and Energy (1995) technical guidelines for the environmental management of exploration and mining in Queensland (**see Table 2** below).

Table 2: Salinity and pH Criteria for Assessment of Coal Reject Samples

Jupiter Target	Very Low	Low	Medium	High	Very High
$pH_{(1:5)}$	<4.5	4.5 – 5.5	5.5 – 7.0	7.0 – 9.0 (Median – 7.4)	>9.0
$EC_{(1:5)}$	<150	150 – 450 (Median – 401)	450 – 900	900 – 2,000	>2,000

NOTE: Adapted from DME, 1995. Highlighted cells show the category corresponding to the median pH and EC values (orange shading) for the coal samples.

Based on the median pH and EC values, the coal reject samples tested are generally regarded as having a slightly 'high' pH, and 'low' salinity characteristics, as indicated by the distribution of samples corresponding to each pH and salinity class.

The pH and EC tests were completed on pulverized samples (≤ 75 µm) with a large surface area in contact with the leaching solution, thereby providing greater potential for dissolution and reaction, and represent a 'worst case scenario'. While sulfide oxidation in some coal reject material may contribute to increases in the salinity of leachate in the short term, it is expected that in the longer term the salinity from bulk coal reject material will stabilize and potentially diminish over time at a concentration relative to the weathering/erosion of the material as salts are flushed from the material matrix and a state of equilibrium develops.

Sulfur: The total sulfur content of the coal reject samples ranges from 0.12 to 0.82 %S and has an elevated median value of 0.38 %S, compared with the median crustal abundance value of 0.07 %S in unmineralised soils (Bowen, 1979; INAP, 2009). The total sulfur content for coal reject samples is shown below in **Figure 12.** The results demonstrate that all samples have a total sulfur concentration above the median crustal abundance of 0.07 %S.

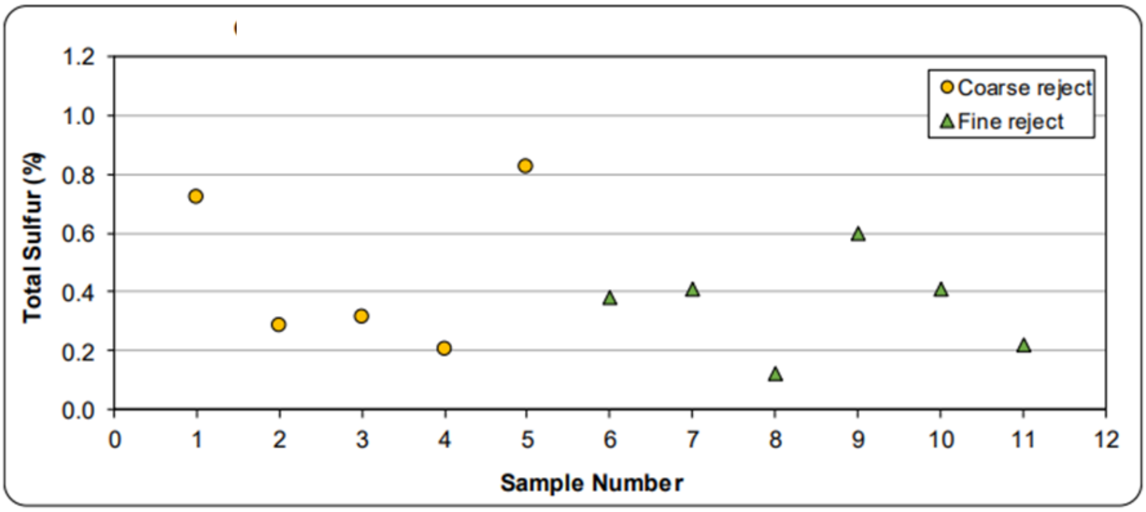

Figure 12: Total Sulfur for Coal Reject Samples

Sulfide Sulfur: Due to the elevated total sulfur content of most of the coal reject samples, all of the samples were tested for sulfide using the Scr method. The test results show that on average, approximately 40 % of the total sulfur is present as sulfide and the remainder of the total sulfur is likely to be present as organic sulfur or sulfate.

Maximum Potential Acidity (MPA): Based on the sulfide content, the MPA that could be generated by the coal samples ranges from 0.6 to 17.4kg H_2SO_4/t, and has a moderate median value of 4.7kg H_2SO_4/t.

Acid Neutralising Capacity (ANC): The ANC for the coal reject samples ranges from 1.8 to 36kg H_2SO_4/t and has a median value of 11.kg H_2SO_4/t, which is over twice the median MPA value.

ANC:MPA Ratio: the ANC:MPA ratio for the coal reject samples ranges from 0.6 to 65.3kg H_2SO_4/t, with a median value of 1.5kg H_2SO_4/t. In simplistic terms, this means that the waste rock (overburden/interburden) has more capability to neutralize acid rather than the potential to form acid.

Net Acid Producing Potential (NAPP): The calculated NAPP values range from -35.4 to 6.1kg H_2SO_4/t, with a negative median value of -2.7kg H_2SO_4/t. The NAPP date is presented below in **Figure 13** and shows that while most of the coal reject samples have a negative NAPP value or a value that is close to zero, two course coal reject samples have a slightly positive NAPP value.

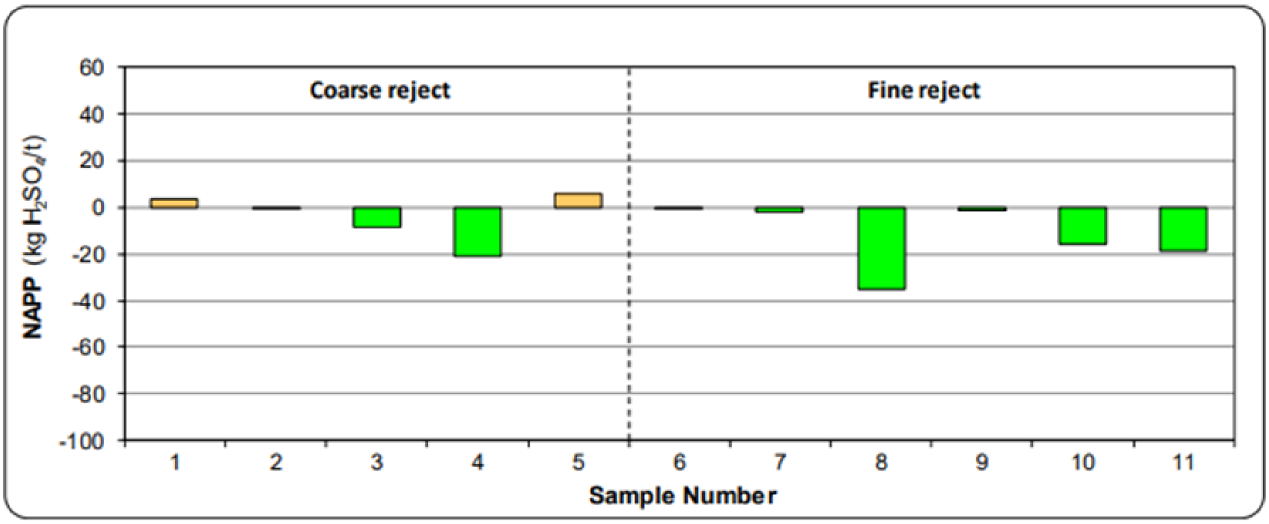

Figure 13: NAPP Values for Coal Reject Samples

hydrogeologist.com.au consider that overall, as a bulk mixed material, the risk of generating any significant amount of acidity from these material is considered to be low.

Figure 14 below plots the ANC against the MPA for the coal reject samples for both course and fine samples. ANC:MPA ratio lines have been plotted on the figures to illustrate the factor of safety associated with the samples in terms of potential for generation of acidity. Generally, those samples with an ANC:MPA ratio of greater than 2 and sulfide content of <0.1 %S are considered to represent material with a high factor of safety and a very low risk of generating acidity (COA, 106; INAP, 2009).

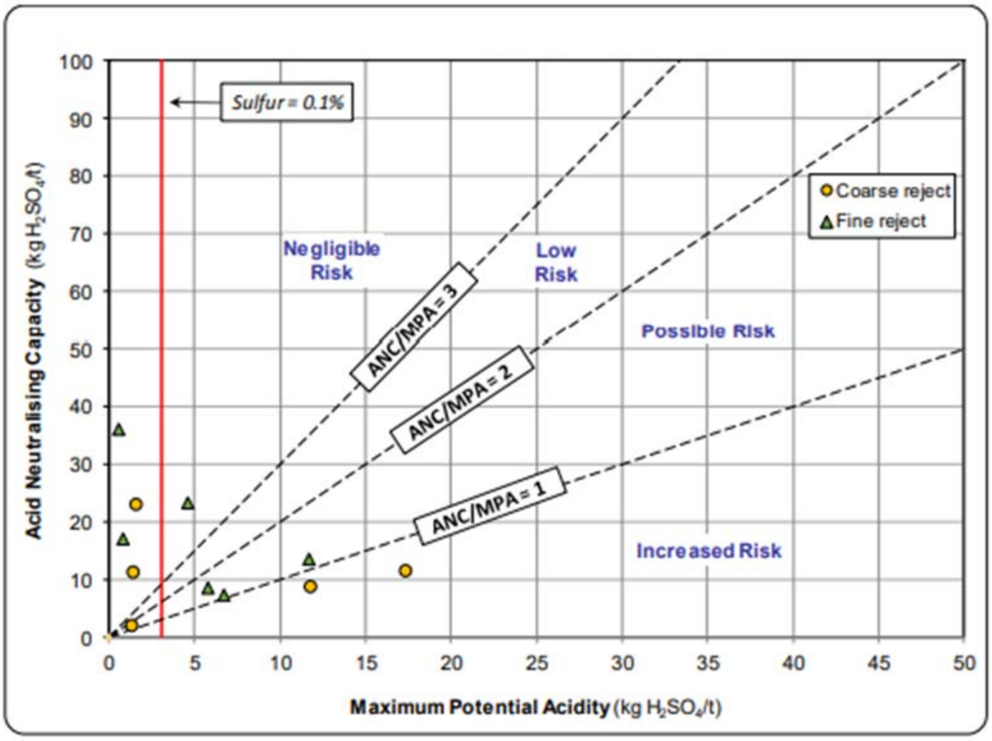

Figure 14: ANC v MPA Values for Coal Reject Samples

The Acid Base Account result shows that six coal reject samples plot in the negligible to low risk domains, three samples plot in the possible risk domain (ANC:MPA ratio is between 1.0 and 2.0) and two course samples plot in the increased risk domain (ANC:MPA ration <1.0). Overall, as a bulk mixed material the coal reject material has relatively low sulfide content, excess of ANC and is classified as non-acid forming. Co-disposal of coal reject material within the in-pit waste rock dump is likely to be beneficial and eliminate any residual risk of acid generation.

6 CONCLUSIONS

The proposed EA Amendment to establish infrastructure, including a CHPP, TLF, a dedicated rail loop, and the co-disposal of coal reject material within the in-pit waste rock dump is not predicted to cause any adverse impact to groundwater levels or quality, impact on third party users or groundwater dependent ecosystems.

C0-disposal of mixed course and fine coal reject material within waste rock dumps will be beneficial as waste rock typically has a very low sulfur content and excess acid neutralising capacity. This approach to coal reject management has been successfully used at a number of existing coal mining operations in Queensland.

The geochemical test results indicate that the surface water runoff and seepage from mine waste material and co-disposed coal rejects is likely to be pH neutral to slightly alkaline and have a low to moderate EC value indicating low to moderate salinity levels.