Appendix

P

Geochemical Assessment

RGS

Continuation of Boggabri Coal Mine
Geochemical Assessment

Final report prepared for:

Hansen Bailey Pty Ltd
PO Box 473
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EXECUTIVE SUMMARY

ES1 Background

RGS Environmental Pty Ltd (RGS) has completed a geochemical assessment of overburden and potential coal rejects materials for Hansen Bailey Pty Ltd (Hansen Bailey) as part of the Continuation of Boggabri Coal Mine Project ("the Project").

Boggabri Coal Pty Limited (Boggabri Coal) is seeking approval to continue open cut coal mining and associated activities largely consistent with the existing approval for a further 21 years. Project approval is sought under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) which is being supported by an Environmental Assessment (EA) which this study will form an Appendix to.

The work was designed to update and enhance preliminary geochemical assessment work completed on these materials as part of the original Environmental Impact Statement (Boggabri EIS, 1987), as well as more recent geochemical assessment work (EGi, 2006). The Project is located 15 km north-east of the township of Boggabri, NSW within the Narrabri Local Government Area.

The Project is located within a major regional geological feature known as the Gunnedah Basin, one of the main coal basins in NSW. The Maules Creek Formation Sub-basin is the principal coal bearing sequence and contains 16 identifiable coal seams. Overburden (and interburden) consists predominantly of sandy conglomerate with minor amounts of interbedded sandstone, siltstone and mudstone separating the coal seams. **Figure 1** provides a schematic of the typical site stratigraphy, showing the main coal seams and overburden (and interburden) rock types.

ES2 Scope of Work

The overall objective of the RGS scope of work was to complete an EA Geochemical Impact Assessment for the Project suitable to support a Project Approval Application under Part 3A of the EP&A Act. The study addresses the Environmental Assessment Requirements (EARs).

RGS has conducted a targeted geochemical characterisation of overburden material and potential coal reject material from the four coal seams (Braymont, Bollol Creek, Jeralong and Merriown) mined at the Project. The results of the characterisation have been used to confirm and update the results of previous investigations and develop any necessary environmental management measures related to overburden and potential coal reject emplacement and rehabilitation.

The RGS scope of work completed for the Project has included:

- A review of existing geological data and prior geochemical assessments within the Project Boundary;
- A site visit;
- Coordination of a geochemical sampling and laboratory testing program;
- A geochemical assessment of representative overburden and potential reject materials; and
- Preparation of a Geochemical Assessment Report (this report) detailing any acid generating potential or other salinity / dispersivity issues related to overburden characteristics within the EA Boundary.

ES3 Methodology

RGS has completed a review of available geochemical and geological data associated with the Project, supplied by Hansen Bailey and Boggabri Coal personnel. Supplied information was used in the development of an overburden and potential coal reject sampling and testing program.

A site visit by RGS personnel was completed in April 2009 and available drill core material was selected from two drill holes at locations with sufficient spread to enhance the lateral coverage of areas of the Project site not specifically covered by three drill holes sampled during previous geochemical assessment programs (Boggabri EIS, 1987; EGi, 2006). There are no specific regulatory requirements regarding the number of samples required to be obtained and tested for overburden and potential coal reject materials at mines in NSW. As such, existing technical guidelines for geochemical assessment of mine waste in Australia (AMIRA, 2002; DITR, 2007) and worldwide (INAP, 2009) were used as a framework for developing the sampling (and geochemical testing) program at the Project.

The location of all of the drill holes used for geochemical sampling (five drill holes) is provided at **Figure 2**. The sampling strategy was based on the expected geological variability and complexity in rock types; potential for significant environmental or health impacts; size of operation; statistical sample representation requirements; material volumes; level of confidence in predictive ability; and cost.

A total of 69 samples were collected by Boggabri Coal personnel from two drill holes at various depth intervals. The samples represented the range of overburden (and interburden) lithologies (47 samples) found at the mine and also potential coal rejects materials taken from the roof and floor material at the target coal seams (22 samples). Samples were subjected to a series of geochemical tests at a commercial laboratory in Brisbane. The geochemical test program was designed to assess the degree of risk from Acid Rock Drainage (ARD), oxidation of pyrite, leachability of metals, and characterisation of standard soil parameters including salinity, sodicity, cation exchange capacity, potential nutrients and major metal compositions.

ES4 Conclusions

The results of the geochemical assessment of representative overburden and potential coal reject materials from the Project indicate that:

Overburden

- Most overburden is likely to have negligible (<0.1%) total sulphur content and is therefore classified as Non Acid Forming (NAF) barren. Overburden also appears to have excess acid buffering capacity typical of a moderate Acid Neutralising Capacity (ANC) value, which should more than compensate for any acid that could potentially be generated from the small amount of overburden materials with uncertain acid generating classification.
- Most overburden materials generated at the Project are likely to be NAF and have a high factor of safety with respect to potential acid generation. The overburden can therefore be regarded as a NAF unit.
- The concentration of total metals in overburden solids is well below applied guideline criteria for soils and is unlikely to present any environmental issues associated with revegetation and rehabilitation.
- Most overburden materials will generate slightly alkaline and relatively low-salinity run-off and seepage following surface exposure. The major ion chemistry of initial surface run-off and seepage from overburden materials is likely to be dominated by sodium, bicarbonate, chloride and sulphate.
- The concentration of dissolved metals in initial run-off and seepage from overburden materials is unlikely to present any significant environmental issues associated with surface and ground water quality as a result of the Project.
- Most overburden materials are sodic and likely to have structural stability problems related to potential dispersion. Some near surface and conglomerate overburden materials are likely to be less sodic and may be the most suitable materials for revegetation and rehabilitation activities (as a growth medium). For all other sodic overburden materials, it is likely that

treatment would be required if these were to be considered for use as vegetation growth medium.

- These findings correlate well with previous geochemical assessment findings for overburden described in **Section 3** of this report.

Potential Coal Reject

- Most potential coal reject materials are likely to have negligible (< 0.1 %) total sulphur content and are therefore classified as NAF-barren. These materials have a high factor of safety with respect to potential acid generation.
- A small proportion of the potential coal reject materials located near the Braymont Seam (roof samples) have a relatively high total sulphur content and negligible buffering capacity (and hence a low factor of safety) and are classified as Potentially Acid Forming - High Capacity (PAF-HC). This finding correlates well with the findings of previous geochemical assessment work described in **Section 3** of this report, however the previous work also indicated the existence of some PAF materials associated with immediate roof and floor materials at both the Braymont and Jeralong seams.
- The concentration of total metals in potential coal reject solids is well below applied guideline criteria for soils and is unlikely to present any environmental issues associated with revegetation and rehabilitation.
- Most potential coal reject materials will generate slightly alkaline and relatively low-salinity run-off and seepage following surface exposure. The exception is potential coal reject material from the Braymont seam (and potentially the Jeralong seam) where PAF materials may generate acidic and more saline run-off and seepage.
- The major ion chemistry of initial surface run-off and seepage from potential coal reject materials is likely to be dominated by sodium, bicarbonate, chloride and sulphate, although for PAF materials, calcium and sulphate may become more dominant. For PAF materials, the initial concentration of soluble sulphate in run-off and seepage is expected to remain within the applied water quality guideline criterion, although further exposure to oxidising conditions could lead to increased soluble sulphate concentrations.
- The concentration of dissolved metals in initial run-off and seepage from potential coal reject materials is unlikely to present any significant environmental issues associated with surface and ground water quality as a result of the Project.
- Most potential coal reject materials are sodic and likely to have structural stability problems related to potential dispersion. These materials are unlikely to be suitable for use as a vegetation growth medium.
- These findings correlate well with previous geochemical assessment findings for potential coal reject materials described in **Section 3** of this report.

ES5 Recommendations

Overburden

The ongoing management of overburden should consider the geochemistry of these materials with respect to their potential risk to cause harm to the environment and their suitability for use in construction and revegetation. It is therefore recommended that Boggabri Coal undertakes:

- Pre-stripping topsoil from areas to be mined for use in final rehabilitation activities (surface cover or vegetation growth medium); and
- Placement of overburden at the emplacement area in a manner that limits the risk of surface exposure of highly sodic material and subsequent run-off and erosion.

Surface water and seepage from overburden material, should be monitored to ensure that key water quality parameters remain within appropriate criteria. It is therefore recommended that Boggabri Coal:

- Continues to monitor run-off/seepage from overburden emplacement areas for pH, electrical conductivity (EC), total suspended solids (TSS) and dissolved metals, as required.

Potential Coal Reject

The ongoing management of potential coal rejects material should consider the geochemistry of materials with respect to their potential risk to cause harm to the environment and their suitability for use in construction and revegetation. It is therefore recommended that Boggabri Coal considers:

- Placement of reject materials in the open pit and/or co-disposal with overburden;
- Deep (in-pit) burial of PAF potential coal reject materials from the Braymont and Jeralong seams;
- For the co-disposal option, placement of NAF potential coal reject material in a manner that limits the risk of surface exposure of highly sodic materials and subsequent run-off and erosion;
- Confirmation of the geochemical and physical characteristics of coal rejects material in future (post approval) when bulk samples become available from the CHPP.

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ABCC	Acid buffering characteristic curve measures the readily available portion of the inherent acid neutralising capacity (ANC) of a sample by slow acid titration to a set end-point and then calculation of the amount of acid consumed and evaluation of the resultant titration curve.
Acid	A measure of hydrogen ion (H+) concentration; generally expressed as pH.
Acid Base Account	Evaluation of the balance between acid generation and acid neutralisation processes. Generally determines the maximum potential acidity (MPA) and the inherent acid neutralising capacity (ANC), as defined below.
ANC	Acid neutralising capacity, expressed as kg H_2SO_4 per tonne of sample.
ANC/MPA Ratio	Ratio of the acid neutralising capacity and maximum potential acidity of a sample. Used to assess the risk of a sample generating acid conditions.
ARD	Acid Rock Drainage from mine waste materials characterised by low pH, elevated metal concentrations, high sulphate concentrations and high salinity.
CHPP	Coal Handling and Preparation Plant.
EC	Electrical Conductivity, expressed as µS/cm.
Kinetic test	Procedure used to measure the geochemical/weathering behaviour of a sample of mine material over time.
MPA	Maximum Potential Acidity calculated by multiplying the total sulphur content of a sample by 30.6 (stoichiometric factor) and expressed as kg H_2SO_4 per tonne.
NAF	Non acid forming. Geochemical classification criterion for a sample that will not generate acid conditions.
NAG test	Net acid generation test. Hydrogen peroxide solution is used to oxidise sulfides in a sample, then any acid generated through oxidation may be consumed by neutralising components in the sample. Any remaining acidity is expressed as kg H_2SO_4 per tonne.
NAPP	Net acid producing potential expressed as kg H_2SO_4 per tonne. Calculated by subtracting the ANC from the MPA.
Overburden	Material that overlies a coal resource and must be removed to mine the coal.
PAF	Potentially acid forming. Geochemical classification criterion for a sample that has the potential to generate acid conditions.
(Coal) Reject	Mixture of coarse and finely ground materials from which the desired mineral (coal) values have been largely extracted.
Static test	Procedure for characterising the geochemical nature of a sample at one point in time. Static tests may include measurements of mineral and chemical composition of a sample and the Acid Base Account.
(Coal) Tailing	Finely ground materials from which the desired mineral (coal) values have been largely extracted.
TSF	Tailing storage facility designed for the storage of tailing (fine reject) materials produced during coal processing at the CHPP. Supernatant water may be recycled back to the CHPP from a decant pond.
Total Sulphur	Total sulphur content of a sample generally measured using a 'Leco' analyser expressed as % S.
Uncertain	Geochemical classification criterion for a sample where the potential to generate acid conditions remains uncertain and may require further analysis.

1.0 INTRODUCTION

1.1 Background

RGS Environmental Pty Ltd (RGS) was commissioned by Hansen Bailey Pty Ltd (Hansen Bailey) to complete a geochemical assessment of overburden and potential coal reject materials as part of the Continuation of Boggabri Coal Mine Project ("the Project") as per RGS Proposal Number 890022 dated 20 March 2009. The work was designed to complement geochemical assessment work completed on these materials as part of the original Environmental Impact Statement (Boggabri EIS, 1987), as well as more recent geochemical assessment work (EGi, 2006).

The Project area is located 15 km north-east of the township of Boggabri, NSW within the Narrabri Local Government Area. Boggabri Coal Pty Limited (Boggabri Coal), which is a wholly owned subsidiary of Idemitsu Australia Resources Pty Ltd, operates Boggabri Coal Mine. Boggabri Coal operates under Departmental File Number DA79/1443(z)2 (Development Consent), that allows for open cut mining of up to 5 Million tonnes per annum (Mtpa) product coal for a period of 21 years from the date of granting of mining lease CL368.

Boggabri Coal is seeking approval to continue open cut coal mining and associated activities largely consistent with the existing operation for a further 21 years. Project approval is being sought under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act), which is being supported by an Environmental Assessment (EA), which this study will form an Appendix to.

1.2 Geology

The Project area is located within a major regional geological feature known as the Gunnedah Basin, one of the main coal basins in NSW. Two sub-basins separated by the Bobbabri Volcanics (Boggabri Ridge) have been identified. The Maules Creek sub basin is located to the east and Mulalley to the west of Boggabri Ridge.

There are two coal-bearing sequences within Gunnedah Basin, the Early Permian Bellata Group and Late Permian Black Jack Group. The majority of the Bellata Group coal seams are found within the Maules Creek Formation where the coal bearing strata can reach thicknesses of greater than 800 m.

The Maules Creek Formation is the principal coal bearing sequence in the EA boundary containing 16 identifiable coal seams. Overburden (and interburden) consists predominantly of sandy conglomerate with minor amounts of interbedded sandstone, siltstone and mudstone separating the coal seams. **Figure 1** provides a schematic of the typical Boggabri site stratigraphy, showing the main coal seams and overburden (and interburden) rock types. The underlying Leard Formation is highly variable and consists of lithic conglomerate, sandstone and mudstone, with finer sediments generally associated with interbedded coal seams (Hansen Bailey, 2009).

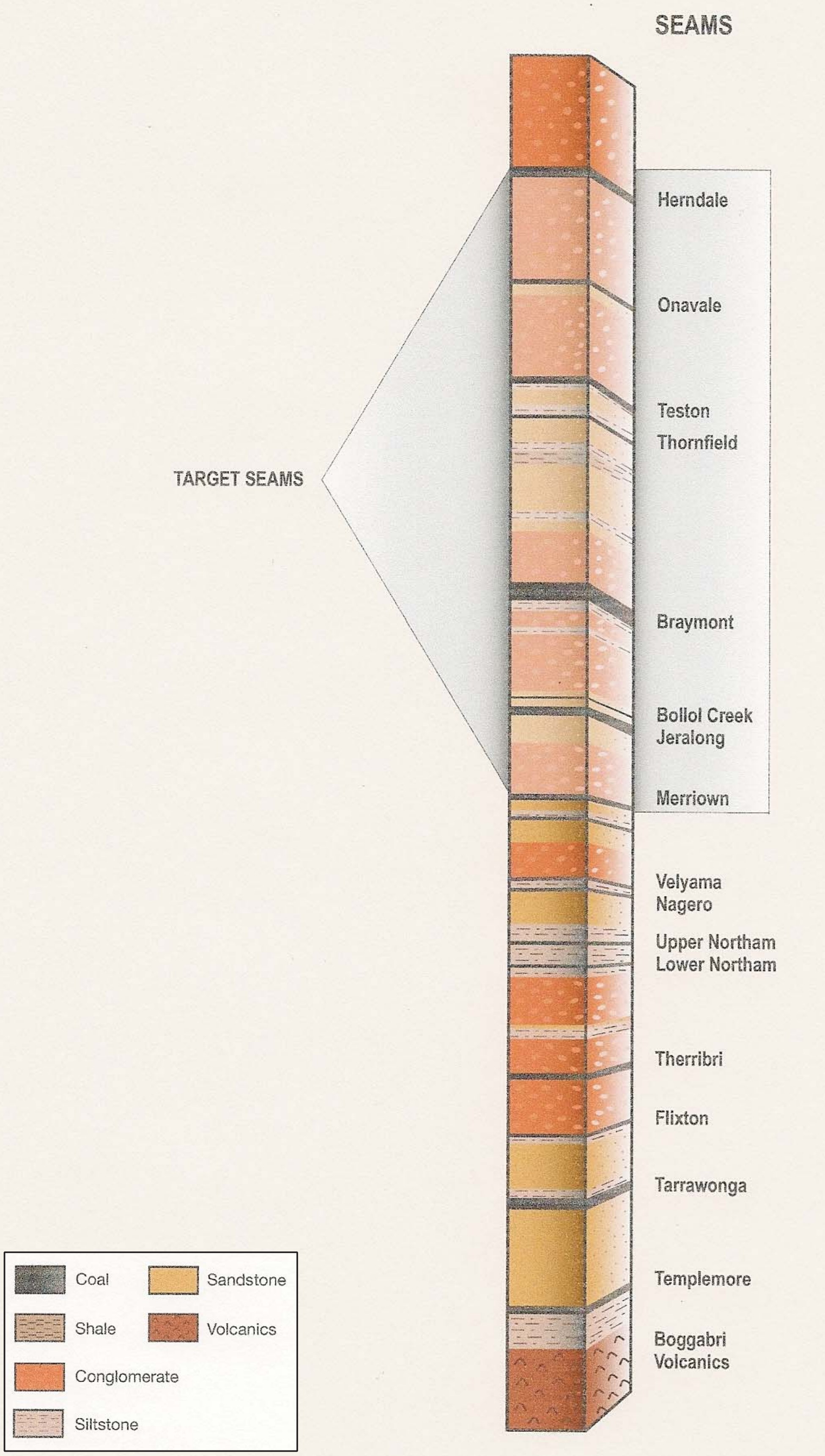
1.3 Scope of Work

The RGS scope of work was to complete an EA Geochemical Impact Assessment for the Project suitable to support a Project Approval Application under Part 3A of the EP&A Act. The study was to specifically address the Environmental Assessment Requirements (EARs).

RGS has conducted a targeted geochemical characterisation of overburden material and potential coal reject material from the four coal seams currently being mined (Braymont, Bollol Creek, Jeralong and Merriown) at Boggabri Coal Mine. The results of the characterisation have been used to confirm and update the results of previous investigations and develop any necessary environmental management measures related to overburden and potential coal reject emplacement and rehabilitation.

The RGS scope of work completed for the Project has included:

- A review of existing geological data and any prior geochemical assessments undertaken in the vicinity of the Project;
- The design of a limited geochemical assessment including a sampling and testing program/protocol for representative overburden and potential reject materials within the Project Boundary. This program has utilised exploration drill core and also some drill chip samples from recent drilling programs;
- A site visit to the Project completed on 29 April 2009 in the company of John Rogis (Boggabri Coal Exploration Manager) and Joe Rennick (Boggabri Coal Environmental Coordinator). This allowed RGS personnel (Alan Robertson) to gain an understanding of the proposed layout of the Project and ensure that any material sampling program was understood and completed according to RGS guidelines. The site visit provided additional rigour to the geochemical assessment process and ensured that results interpretation and final conclusions were robust and that any geochemical testing was based on a sound sampling and testing methodology;
- Coordination of the sampling program (sample collection was completed by Boggabri Coal Exploration personnel);
- Coordination of the geochemical analysis program for samples by ALS Brisbane laboratory; and
- Preparation of a Geochemical Assessment Report (this report) specific to the Project based on existing information, sample analyses and discussion regarding any acid rock generating potential or other salinity / dispersivity issues related to the Project.



Data Source: Hansen Bailey Pty Ltd, File: 914_BOGGABRIGEOLOGY1.INDD, 29/07/2009.

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BOGGABRI COAL PROJECT:
GEOCHEMICAL ASSESSMENT OF OVERBURDEN AND
POTENTIAL COAL REJECT MATERIALS

Figure: **1**

SITE STRATIGRAPHY

2.0 METHODOLOGY

2.1 Desktop Review

RGS has completed a review of available geochemical and geological data, groundwater quality data, and existing drillhole database (including plans, drillhole logs and drill core photographs) associated with the Project. Relevant Project information was supplied to RGS by Hansen Bailey and Boggabri Coal[1] personnel. Supplied information was used in the development of the overburden and potential coal reject sampling and testing program.

2.2 Site Visit

RGS personnel completed a site visit on 29 April 2009 and met with key Boggabri Coal site exploration and environmental personnel. Available drill core material from two selected drill holes was identified for sampling by RSG personnel and site exploration personnel were briefed on completion of the sampling program. RGS personnel completed a site tour of the Boggabri Coal Mine during the site visit in the company of the Boggabri Coal Environmental Coordinator (Joe Rennick). This process enabled RGS to make efficient use of existing data and exploration drilling programs to develop an effective sampling and testing program for overburden and potential coal reject materials for the Project.

2.3 Sampling and Testing Program

2.3.1 Sampling Program

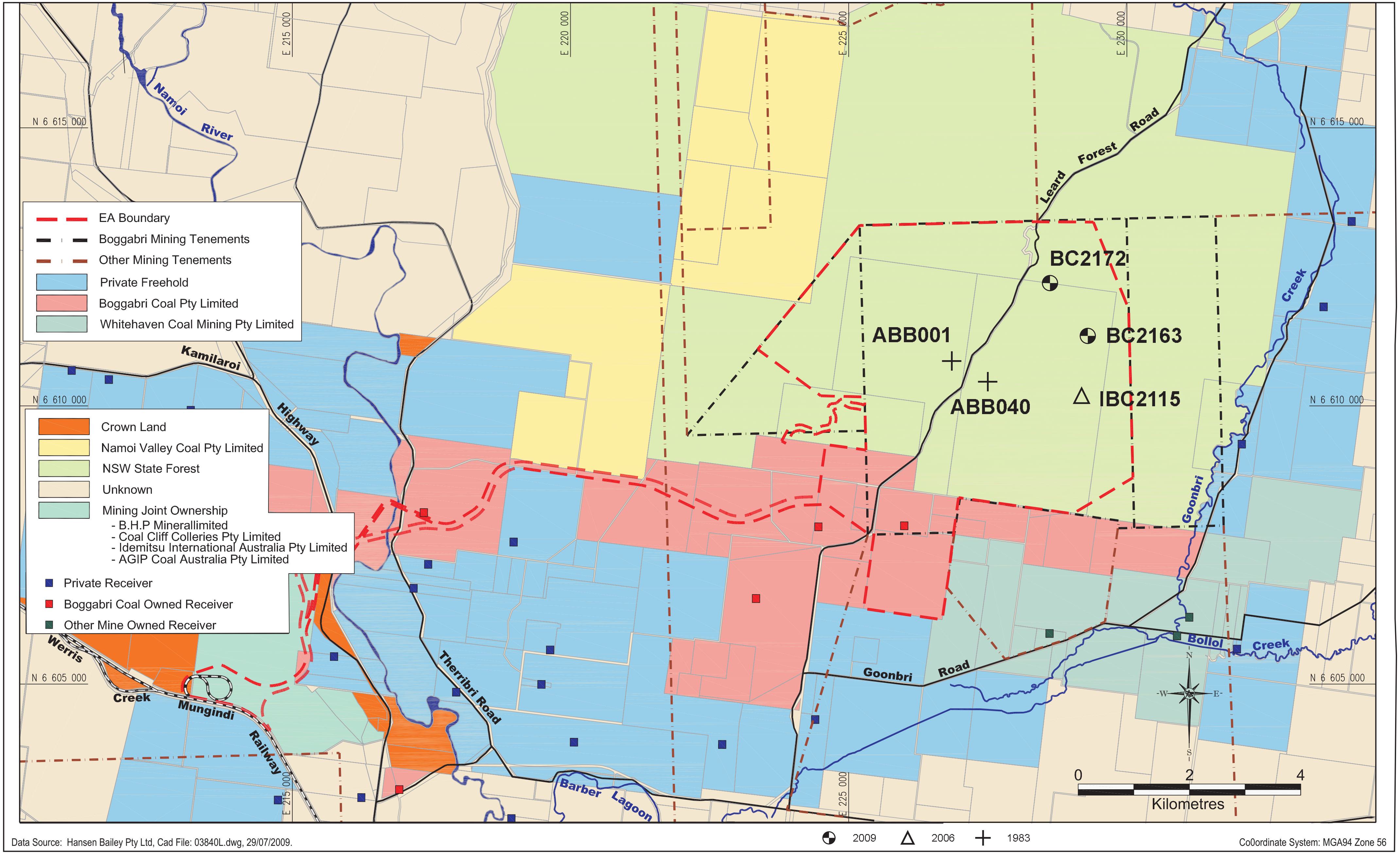
There are no specific regulatory requirements regarding the number of samples required to be obtained and tested for overburden and potential coal reject materials at mines in NSW. As such, existing technical guidelines for geochemical assessment of mine waste in Australia (AMIRA, 2002; DITR, 2007) and worldwide (INAP, 2009) have been used by RGS as a framework for developing the sampling (and testing) program at the Project.

Samples were selected from two drill holes at locations with sufficient spread to enhance the lateral coverage of areas of the EA Boundary not specifically covered by three drill holes sampled during previous geochemical assessment programs (Boggabri EIS, 1987; EGi, 2006). The location of all of the drill holes used for geochemical sampling (five drill holes) is shown in **Figure 2**. The sampling strategy was based on the expected geological variability and complexity in rock types; potential for significant environmental or health impacts; size of operation; statistical sample representation requirements; material volumes; level of confidence in predictive ability; and cost.

As part of the site visit on 29 April 2009, Boggabri Coal provided a suitably qualified person (Exploration Geologist) to assist/supervise the collection of representative samples of the required range of overburden and potential coal reject materials. The site Exploration Geologist was provided with instructions to allow collection and dispatch of the relevant drill core (and some drill chip) samples to ALS Brisbane (via ALS Gunnedah) for assay. RGS also provided the relevant ALS chain of custody documentation to the site Exploration Geologist.

A total of up to 69 samples were collected by Boggabri Coal personnel from two drill holes at various depth intervals (**Table 1**). The samples represented the range of overburden (and interburden) lithologies (47 samples) found at the mine and also potential coal reject materials taken from the roof and floor material at the target coal seams (22 samples).

[1] Information supplied to RGS by John Rogis (Exploration Manager) and Joe Rennick (Environmental Coordinator) of Boggabri Coal, Site Visit 29 April 2009.



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BOGGABRI COAL PROJECT:
GEOCHEMICAL ASSESSMENT OF OVERBURDEN AND
POTENTIAL COAL REJECT MATERIALS

Figure: 2

LOCATION OF
GEOCHEMICAL ASSESSMENT
DRILL HOLES

Table 1: Number of Samples Selected for Geochemical Testing

Sample Type	Sample Number
Overburden (and Interburden) Materials	47 samples
Roof and Floor Potential Coal Reject Materials	22 samples

Drill core (and some drill chip) samples were transferred to ALS Gunnedah laboratory (by Boggabri Coal personnel) for initial sample preparation (crushing, splitting and sub-sampling) before being shipped to ALS Brisbane to undergo a series of geochemical tests. The geochemical test program was designed to assess the degree of risk from Acid Rock Drainage (ARD), oxidation of pyrite, leachability of metals, and characterisation of standard soil parameters including salinity, sodicity, cation exchange capacity, potential nutrients and major metal compositions.

For drill core samples, approximately 1-2 kg of crushed, riffle split and sub-sampled drill core material was used in this study. Full core taken from specific drill core depth intervals ranging from approximately 0.5 m to 5 m was taken depending on lithology and stratigraphy. Eight of the 69 samples collected were obtained from composite drill chip samples covering a range of depth intervals associated with near surface materials. Individual samples comprised single lithologies, where possible, to facilitate interpretation of geochemical results. Relevant drillhole logs and core photos for these samples were utilised for sample selection and this information is provided at **Attachment A**.

2.3.2 Geochemical Testing Program

The crushed drill core samples received by ALS Brisbane were subjected to a series of geochemical tests as described below. A description of laboratory tests typically used in geochemical assessment programs for mine waste materials is provided at **Attachment B**. The geochemical test program was designed to assess the degree of risk from oxidation of pyrite, acid generation, and leaching of soluble metals and salts. The assessment also included characterisation of standard soil parameters including salinity, cation exchange capacity, potential nutrients and major metal compositions.

All of the 69 samples collected were subjected to initial Acid Base Account (ABA) geochemical testing as part of an initial screening process. Specifically, each sample was tested for:

- pH and Electrical Conductivity (EC) (1:5);
- Total sulfur;
- Acid neutralising capacity (ANC); and
- Net acid producing potential (NAPP).

After the results of the ABA tests were received and reviewed, a further 10 composite samples were prepared from 40 of the 69 original samples collected with sample selection based on lithology, drill hole, depth interval and geochemical characteristics. Multi-element testing was then completed on solid and soluble fractions of these composite samples. Composite samples were tested for:

- pH and EC (1:5);
- Alkalinity or acidity (pH dependent) (1:5);
- Total metals (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Mn, Mo, N, Ni, Sb, Se, Zn) in solids;
- Total cations (Ca, Mg, Na, K) and Exchangeable cations (Ca, Mg, Na, K);
- Soluble metals (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Mn, Mo, Ni, Sb, Se, Zn) in 1:5 water extracts;
- Soluble cations (Ca, Mg, Na, K) and soluble anions (Cl, SO_4);
- Cation Exchange Capacity (eCEC); and
- Exchangeable Sodium Percentage (ESP).

3.0 SUMMARY OF PREVIOUS GEOCHEMICAL STUDIES

Historical geochemical assessment work on overburden and potential coal reject materials from the Boggabri Coal Mine was completed as part of a previous Environmental Impact Statement completed in 1983 (Boggabri EIS, 1987). More recently, geochemical assessment work was completed in 2006 (EGi, 2006). The two studies provided information on the geochemical characteristics of samples obtained from a total of three drill holes within the Project Boundary (see **Figure 2**). Groundwater quality investigations have also been completed at Boggabri Coal Mine (Parsons Brinckerhoff, 2005), which provides useful information regarding background water quality at the site.

3.1 Boggabri Environmental Impact Statement (1987)

Geochemical assessment studies completed on 32 soil probe samples and 31 rock samples from two drill holes at Boggabri Coal Mine were completed as part of the Environmental Impact Statement (EIS) for Boggabri Coal Mine (Boggabri EIS, 1987) which found that:

- A-horizons of the soil profile were the best plant growth medium available for use in revegetation efforts following mining;
- Sub-soil (B-C horizons) materials, weathered unconsolidated and bedrock materials were saline and sodic;
- Sandy conglomerate associated with the Braymont and Jeralong seams was sodic;
- Roof and floor material from the Braymont Seam was potentially acid forming;
- Most overburden (and interburden) materials were likely to be non-saline, non-sodic and slightly alkaline to slightly acidic; and
- Potential sodic, saline and acid producing strata relative to the four main coal seams considered for extraction, made up a relatively small proportion of the total thickness of overburden (and interburden).

The EIS recommended that all potentially sodic, saline or acidic overburden (and interburden) materials were to be buried during the mining process in order to significantly reduce the risk of environmental impacts from the proposed mining activities.

3.2 ARD Assessment of Overburden (2006)

A geochemical Acid Rock Drainage (ARD) assessment study completed on 49 composite drill core samples (prepared from 106 individual drill core samples) from a single drill hole (IBC2115) at Boggabri Coal mine was completed in 2006 (EGi, 2006). The location of drill hole IBC2115 is shown in **Figure 2**. The study found that:

- The bulk of the overburden materials were NAF;
- Material close to the Braymont and Jeralong seams (roof and floor material) may be PAF;
- Standard net acid generation (NAG) test results overestimated the acid potential of some materials due to organic acid effects[2];
- There was no significant elemental enrichment in the overburden materials and no significant risk of leaching of metals or metalloids at neutral pH; and
- Segregation and selective handling of PAF materials would be necessary and could involve deep burial of PAF material.

The EGi report went on to recommend further sampling and geochemical (ARD) characterisation of overburden materials ahead of pit development.

[2] It is well documented that the standard NAG test is not appropriate for materials with high organic carbon content and may generate false positive results (Stewart *et. al*., 2003; Stewart, 2005 and ACARP, 2008). Hence, the NAG test was not used in the current geochemical assessment reported herein.

3.3 Groundwater Quality Investigations (2005)

Groundwater quality investigations were completed at Boggabri Coal Mine in 2005 (Parsons Brinckerhoff, 2005) using monitoring data from nine boreholes drilled to depths ranging from 36 m to 157 m below ground level. The borehole screened intervals typically corresponded to the four coal seams currently being mined (Braymont, Bollol Creek, Jeralong and Merriown) at Boggabri Coal Mine.

The groundwater quality investigations included analysis of pH, conductivity, major metals, major cations and anions, and trace metals. The results indicated that groundwater was approximately pH 8.1, of low to medium salinity, and was dominated by sodium and bicarbonate. All water quality parameters, apart from iron, were within guideline threshold levels for livestock and irrigation (ANZECC, 2000).

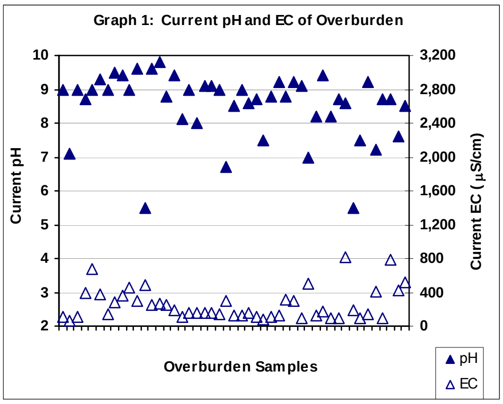
4.0 GEOCHEMICAL TEST RESULTS

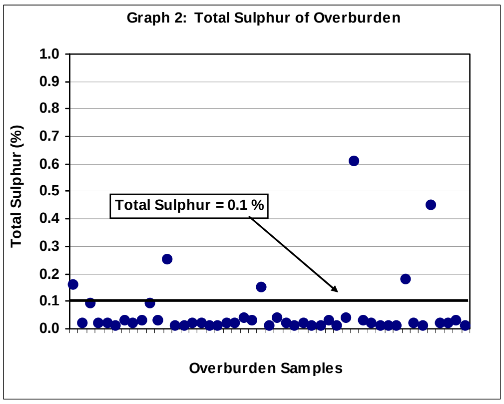
4.1 Acid Base Account Results

4.1.1 Overburden

ABA test results for the 47 overburden samples are summarised below and presented in **Table 2** and **Graphs 1, 2, 3** and **4**.

- pH: The current pH1:5 of the overburden samples ranges from 5.5 to 9.8 and is typically alkaline (median pH 8.8) (**Graph 1**).
- EC: The current EC1:5 of the overburden samples ranges from 55 to 815 µS/cm and is typically low (median 160 µS/cm) (**Graph 1**).
- Total sulphur: The total sulphur content of the overburden samples is typically low and ranges from 0.01 to 0.61 % (median 0.02 %). Forty-two (42) of the 47 overburden samples tested have total sulphur values less than 0.1 % (**Graph 2**).
- Maximum potential acidity (MPA): Based on the total sulphur content, the MPA that could be generated by the overburden samples is typically low and ranges from 0.3 to 19 kg H_2SO_4/t (median 0.6 kg H_2SO_4/t) (**Graph 3**).
- ANC: The ANC value for the samples ranges from 4 to 55 kg H_2SO_4/t and is typically moderate (median 17 kg H_2SO_4/t) (**Graph 3**).
- NAPP: The calculated NAPP value for the samples ranges from -55 to +6 kg H_2SO_4/t and is typically negative (median -17 kg H_2SO_4/t).





Graph 3 illustrates that the ANC value exceeds the MPA value in most overburden samples and, consequently, most of the overburden samples (42 out of 47 samples) have negative NAPP values.

Graph 4 shows a plot of ANC versus MPA for the overburden samples. The ANC/MPA ratio of the samples ranges from 0.7 to 180 and is typically high (median 26). ANC/MPA ratio lines have been plotted on the graph to illustrate the factor of safety associated with the samples. Generally those samples with an ANC/MPA ratio of greater than 2 are considered to have a negligible risk of acid generation and a high factor of safety in terms of potential for ARD (DITR, 2007; INAP, 2009[3]). The results indicate that approximately 87% of the overburden samples have negligible risk of acid generation and a high factor of safety. Of the remaining six samples with an ANC/MPA ratio less than 2, all had a very low capacity to generate acid value (≤ 6 kg H_2SO_4/t).

[3] INAP considers that mine materials with an ANC/MPA ratio greater than 2 are likely to be NAF unless significant preferential exposure of sulphides along fracture planes occurs in combination with insufficiently reactive ANC.

Table 2: Acid-base Results for Overburden and Potential Coal Reject Materials

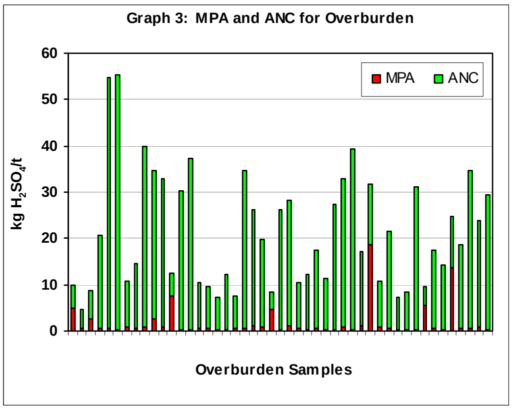
ALS Laboratory Sample ID		Date	Drill Hole ID	Sample Interval (m)			Client Sample No.	Sample Type	Sample Lithology	pH[1]	EC[1]	Total Sulfur	MPA[2]	ANC[2]	NAPP[2]	ANC/MPA ratio	Sample Classification[3]
				From	To	Depth					(µS/cm)	(%)	(kg H_2SO_4/t)				
Overburden																	
EB0908778	004	01-Jun-09	BC2163	26.06	26.69	0.63	7318	Overburden	Carbonaceous Siltstone	9.0	116	0.16	4.9	5.0	0	1.0	Uncertain (PAF-LC)
EB0908778	046	01-Jun-09	BC2172	64.89	65.22	0.33	7360	Overburden	Carnonaceous Siltstone	7.1	55	0.02	0.6	4.0	-3	6.5	NAF (barren)
EB0908778	027	01-Jun-09	BC2163	134.91	135.16	0.25	7341	Overburden	Clayey Shale	9.0	109	0.09	2.8	6.0	-3	2.2	NAF (barren)
EB0909240	002	01-Jun-09	BC2163	2.00	5.00	3.00	Comp 2	Overburden	Conglomerate	8.7	385	0.02	0.6	20.0	-19	32.7	NAF (barren)
EB0909240	003	01-Jun-09	BC2163	6.00	10.00	4.00	Comp 3	Overburden	Conglomerate/Shaley Coal	9.0	678	0.02	0.6	54.0	-53	88.2	NAF (barren)
EB0909240	004	01-Jun-09	BC2163	11.00	20.00	9.00	Comp 4	Overburden	Conglomerate/Sandstone	9.3	380	0.01	0.3	55.0	-55	179.7	NAF (barren)
EB0908778	007	01-Jun-09	BC2163	30.05	33.27	3.22	7321	Overburden	Conglomerate	9.0	142	0.03	0.9	10.0	-9	10.9	NAF (barren)
EB0908778	008	01-Jun-09	BC2163	40.00	45.00	5.00	7322	Overburden	Conglomerate	9.5	285	0.02	0.6	14.0	-13	22.9	NAF (barren)
EB0908778	009	01-Jun-09	BC2163	50.60	55.60	5.00	7323	Overburden	Conglomerate	9.4	368	0.03	0.9	39.0	-38	42.5	NAF (barren)
EB0908778	010	01-Jun-09	BC2163	60.60	65.60	5.00	7324	Overburden	Conglomerate	9.0	451	0.09	2.8	32.0	-29	11.6	NAF (barren)
EB0908778	011	01-Jun-09	BC2163	70.60	75.60	5.00	7325	Overburden	Conglomerate	9.6	291	0.03	0.9	32.0	-31	34.9	NAF (barren)
EB0908778	015	01-Jun-09	BC2163	82.60	85.60	3.00	7329	Overburden	Conglomerate	5.5	481	0.25	7.7	5.0	3	0.7	Uncertain (PAF-LC)
EB0908778	019	01-Jun-09	BC2163	94.40	99.40	5.00	7333	Overburden	Conglomerate	9.6	256	0.01	0.3	30.0	-30	98.0	NAF (barren)
EB0908778	020	01-Jun-09	BC2163	104.50	109.50	5.00	7334	Overburden	Conglomerate	9.8	269	0.01	0.3	37.0	-37	120.9	NAF (barren)
EB0908778	021	01-Jun-09	BC2163	114.50	119.50	5.00	7335	Overburden	Conglomerate	8.8	249	0.02	0.6	10.0	-9	16.3	NAF (barren)
EB0908778	024	01-Jun-09	BC2163	122.70	127.70	5.00	7338	Overburden	Conglomerate	9.4	195	0.02	0.6	9.0	-8	14.7	NAF (barren)
EB0908778	033	01-Jun-09	BC2163	142.45	147.45	5.00	7347	Overburden	Conglomerate	8.1	105	0.01	0.3	7.0	-7	22.9	NAF (barren)
EB0908778	034	01-Jun-09	BC2163	152.80	157.80	5.00	7348	Overburden	Conglomerate	9.0	160	0.01	0.3	12.0	-12	39.2	NAF (barren)
EB0908778	035	01-Jun-09	BC2163	158.56	159.06	0.50	7349	Overburden	Conglomerate	8.0	150	0.02	0.6	7.0	-6	11.4	NAF (barren)
EB0908778	039	01-Jun-09	BC2172	24.00	29.00	5.00	7353	Overburden	Conglomerate	9.1	154	0.02	0.6	34.0	-33	55.6	NAF (barren)
EB0908778	040	01-Jun-09	BC2172	34.00	39.00	5.00	7354	Overburden	Conglomerate	9.1	152	0.04	1.2	25.0	-24	20.4	NAF (barren)
EB0908778	041	01-Jun-09	BC2172	44.00	49.00	5.00	7355	Overburden	Conglomerate	9.0	135	0.03	0.9	19.0	-18	20.7	NAF (barren)
EB0908778	042	01-Jun-09	BC2172	53.81	56.42	2.61	7356	Overburden	Conglomerate	6.7	297	0.15	4.6	4.0	1	0.9	Uncertain (PAF-LC)
EB0908778	047	01-Jun-09	BC2172	68.25	73.25	5.00	7361	Overburden	Conglomerate	8.5	130	0.01	0.3	26.0	-26	85.0	NAF (barren)
EB0908778	048	01-Jun-09	BC2172	79.50	84.50	5.00	7362	Overburden	Conglomerate	9.0	118	0.04	1.2	27.0	-26	22.1	NAF (barren)
EB0908778	049	01-Jun-09	BC2172	89.80	90.89	1.09	7363	Overburden	Conglomerate	8.6	156	0.02	0.6	10.0	-9	16.3	NAF (barren)
EB0908778	052	01-Jun-09	BC2172	93.35	97.93	4.58	7366	Overburden	Conglomerate	8.7	107	0.01	0.3	12.0	-12	39.2	NAF (barren)
EB0908778	054	01-Jun-09	BC2172	99.17	100.17	1.00	7368	Overburden	Conglomerate	7.5	79	0.02	0.6	17.0	-16	27.8	NAF (barren)
EB0908778	057	01-Jun-09	BC2172	107.14	112.14	5.00	7371	Overburden	Conglomerate	8.8	104	0.01	0.3	11.0	-11	35.9	NAF (barren)
EB0908778	058	01-Jun-09	BC2172	117.14	122.14	5.00	7372	Overburden	Conglomerate	9.2	132	0.01	0.3	27.0	-27	88.2	NAF (barren)
EB0908778	059	01-Jun-09	BC2172	126.50	131.50	5.00	7373	Overburden	Conglomerate	8.8	321	0.03	0.9	32.0	-31	34.9	NAF (barren)
EB0909240	008	01-Jun-09	BC2172	11.00	20.00	9.00	Comp 8	Overburden	Conglomerate/Siltstone	9.2	295	0.01	0.3	39.0	-39	127.5	NAF (barren)
EB0908778	028	01-Jun-09	BC2163	135.16	136.00	0.84	7342	Overburden	Mudstone	9.1	93	0.04	1.2	16.0	-15	13.1	NAF (barren)
EB0908778	001	01-Jun-09	BC2163	21.75	22.39	0.64	7315	Overburden	Sandstone	7.0	501	0.61	18.7	13.0	6	0.7	Uncertain (PAF-LC)
EB0908778	018	01-Jun-09	BC2163	92.25	92.61	0.36	7332	Overburden	Sandstone	8.2	120	0.03	0.9	10.0	-9	10.9	NAF (barren)
EB0908778	025	01-Jun-09	BC2163	128.83	131.13	2.30	7339	Overburden	Sandstone	9.4	179	0.02	0.6	21.0	-20	34.3	NAF (barren)
EB0908778	032	01-Jun-09	BC2163	140.77	141.97	1.20	7346	Overburden	Sandstone	8.2	90	0.01	0.3	7.0	-7	22.9	NAF (barren)
EB0908778	038	01-Jun-09	BC2163	163.95	167.97	4.02	7352	Overburden	Sandstone	8.7	94	0.01	0.3	8.0	-8	26.1	NAF (barren)
EB0909240	006	01-Jun-09	BC2172	2.00	5.00	3.00	Comp 6	Overburden	Sandstone	8.6	815	0.01	0.3	31.0	-31	101.3	NAF (barren)
EB0908778	043	01-Jun-09	BC2172	57.06	57.78	0.72	7357	Overburden	Sandstone	5.5	196	0.18	5.5	4.0	2	0.7	Uncertain (PAF-LC)
EB0908778	053	01-Jun-09	BC2172	98.01	99.17	1.16	7367	Overburden	Sandstone	7.5	87	0.02	0.6	17.0	-16	27.8	NAF (barren)

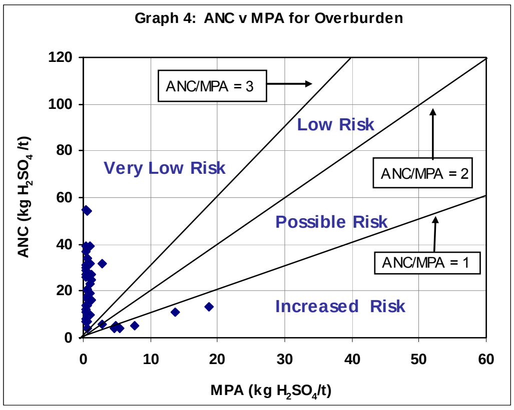
Table 2: Acid-base Results for Overburden and Potential Coal Reject Materials

ALS Laboratory Sample ID		Date	Drill Hole ID	Sample Interval (m)			Client Sample No.	Sample Type	Sample Lithology	pH[1]	EC[1]	Total Sulfur	MPA[2]	ANC[2]	NAPP[2]	ANC/MPA ratio	Sample Classification[3]
				From	To	Depth					(µS/cm)	(%)	(kg H_2SO_4/t)				
EB0908778	026	01-Jun-09	BC2163	131.23	134.73	3.50	7340	Overburden	Sandstone/Siltstone	9.2	143	0.01	0.3	14.0	-14	45.8	NAF (barren)
EB0908778	012	01-Jun-09	BC2163	78.53	79.33	0.80	7326	Overburden	Siltstone	7.2	414	0.45	13.8	11.0	3	0.8	Uncertain (PAF-LC)
EB0908778	029	01-Jun-09	BC2163	136.00	136.70	0.70	7343	Overburden	Siltstone	8.7	98	0.02	0.6	18.0	-17	29.4	NAF (barren)
EB0909240	007	01-Jun-09	BC2172	6.00	10.00	4.00	Comp 7	Overburden	Siltstone/ Conglomerate	8.7	783	0.02	0.6	34.0	-33	55.6	NAF (barren)
EB0909240	001	01-Jun-09	BC2163	0.00	1.00	1.00	Comp 1	Overburden	Soil	7.6	430	0.03	0.9	23.0	-22	25.1	NAF (barren)
EB0909240	005	01-Jun-09	BC2172	0.00	1.00	1.00	Comp 5	Overburden	Soil	8.5	513	0.01	0.3	29.0	-29	94.8	NAF (barren)
Potential Coal Rejects																	
EB0908778	005	01-Jun-09	BC2163	28.00	28.54	0.54	7319	Braymont Upper Roof	Siltstone	9.0	122	0.02	0.6	5.0	-4	8.2	NAF (barren)
EB0908778	044	01-Jun-09	BC2172	57.82	58.17	0.35	7358	Braymont Roof	Sandstone	3.0	2,510	5.77	176.6	0.5	176	0.003	PAF-HC
EB0908778	013	01-Jun-09	BC2163	79.33	80.11	0.78	7327	Braymont 11/12 Roof	Siltstone	7.1	356	0.06	1.8	5.0	-3	2.7	NAF (barren)
EB0908778	016	01-Jun-09	BC2163	85.89	86.19	0.30	7330	Braymont 13 Roof	Conglomerate	3.6	1570	1.54	47.1	0.5	47	0.01	PAF-HC
EB0908778	050	01-Jun-09	BC2172	90.89	91.21	0.32	7364	Bollol Creek Roof	Carbonaceous Claystone	8.5	49	0.06	1.8	4.0	-2	2.2	NAF (barren)
EB0908778	022	01-Jun-09	BC2163	120.81	121.31	0.50	7336	Bollol Creek Roof	Conglomerate	8.0	141	0.04	1.2	5.0	-4	4.1	NAF (barren)
EB0908778	055	01-Jun-09	BC2172	100.27	101.30	1.03	7369	Jeralong Roof	Conglomerate	7.7	69	0.01	0.3	7.0	-7	22.9	NAF (barren)
EB0908778	030	01-Jun-09	BC2163	136.70	137.16	0.46	7344	Jeralong Roof	Mudstone	9.0	73	0.03	0.9	9.0	-8	9.8	NAF (barren)
EB0908778	060	01-Jun-09	BC2172	134.68	135.18	0.50	7374	Merriowan Roof	Conglomerate	5.5	357	0.06	1.8	3.0	-1	1.6	NAF (barren)
EB0908778	036	01-Jun-09	BC2163	159.20	159.70	0.50	7350	Merriowan Roof	Mudstone	8.7	78	0.02	0.6	11.0	-10	18.0	NAF (barren)
EB0908778	002	01-Jun-09	BC2163	22.50	23.16	0.66	7316	Thornfield Roof	Siltstone	9.5	251	0.05	1.5	8.0	-6	5.2	NAF (barren)
EB0908778	006	01-Jun-09	BC2163	29.88	30.05	0.43	7320	Braymont Upper Floor	Siltstone	9.1	179	0.06	1.8	2.0	0	1.1	NAF (barren)
EB0908778	045	01-Jun-09	BC2172	64.42	64.67	0.25	7359	Braymont Floor	Carbonaceous Siltstone	6.5	47	0.03	0.9	4.0	-3	4.4	NAF (barren)
EB0908778	014	01-Jun-09	BC2163	82.14	82.34	0.20	7328	Braymont 11/12 Floor	Claystone	6.9	207	0.16	4.9	7.0	-2	1.4	Uncertain (NAF)
EB0908778	017	01-Jun-09	BC2163	91.75	92.71	0.96	7331	Braymont 13 Floor	Siltstone	8.0	119	0.08	2.4	3.0	-1	1.2	NAF (barren)
EB0908778	051	01-Jun-09	BC2172	92.75	93.35	0.60	7365	Bollol Creek Floor	Sandstone	8.5	60	0.01	0.3	7.0	-7	22.9	NAF (barren)
EB0908778	023	01-Jun-09	BC2163	122.29	122.60	0.31	7337	Bollol Creek Floor	Siltsone/Sandstone	9.1	100	0.06	1.8	8.0	-6	4.4	NAF (barren)
EB0908778	056	01-Jun-09	BC2172	104.56	104.85	0.29	7370	Jeralong Floor	Carbonaceous Claystone	8.5	52	0.04	1.2	15.0	-14	12.3	NAF (barren)
EB0908778	031	01-Jun-09	BC2163	140.35	140.77	0.42	7345	Jeralong Floor	Mudstone	8.2	86	0.05	1.5	6.0	-4	3.9	NAF (barren)
EB0908778	061	01-Jun-09	BC2172	137.77	138.27	0.50	7375	Merriowan Floor	Conglomerate	8.2	36	0.03	0.9	3.0	-2	3.3	NAF (barren)
EB0908778	037	01-Jun-09	BC2163	163.36	163.76	0.40	7351	Merriowan Floor	Mudstone/Siltstone	8.3	43	0.03	0.9	3.0	-2	3.3	NAF (barren)
EB0908778	003	01-Jun-09	BC2163	23.76	24.70	0.94	7317	Thornfield Floor	Siltstone	8.5	185	0.06	1.8	9.0	-7	4.9	NAF (barren)

Notes

1. Current pH and EC provided for 1:5 sample:water extracts
2. MPA = Maximum potential acidity; ANC = Acid neutralising capacity; NAPP = Net acid producing potential; and NAG = Net acid generation.
3. Sample classification detail provided in report text.





The ABA results presented in this section have been used to classify the acid forming nature of the 47 overburden samples as shown in **Table 2**. The geochemical criteria used by RGS to classify the acid forming nature of the overburden samples are provided in **Table 3**.

Table 3

Geochemical Classification Criteria for Overburden Materials

Geochemical Classification	Total Sulfur (%)	NAPP (kg H_2SO_4/t)	ANC/MPA Ratio	Number of samples	% of total samples
NAF - Barren	≤ 0.1	≤ 0	≥ 2	41	87
Uncertain (PAF-LC or NAF)	≥ 0.1	within +/- 20	< 2	6	13
PAF-HC	≥ 0.1	> 20	< 2	0	0

Notes: NAF = Non-Acid Forming, PAF = Potentially Acid Forming, LC = Low Capacity; HC = High Capacity

The results in **Table 3** indicate that most of the overburden samples (41 out of 47) tested fall in the NAF-Barren category. Only six samples were classified as Uncertain (PAF-LC).

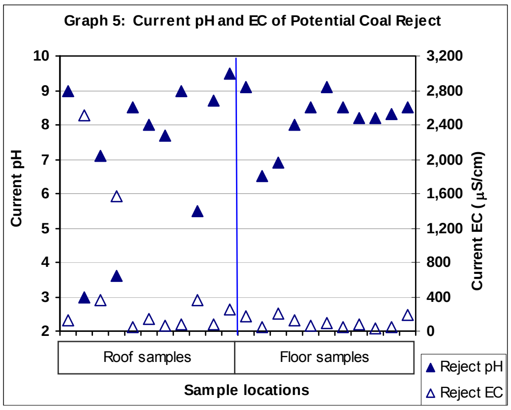
Overall, from an acid-base perspective, the overburden material can be generally regarded as a NAF unit. A very small proportion of overburden materials samples may have a very low capacity to generate acid, but most of these materials (and other materials sampled) have significant excess buffering capacity that should be available to more than adequately buffer any acid production.

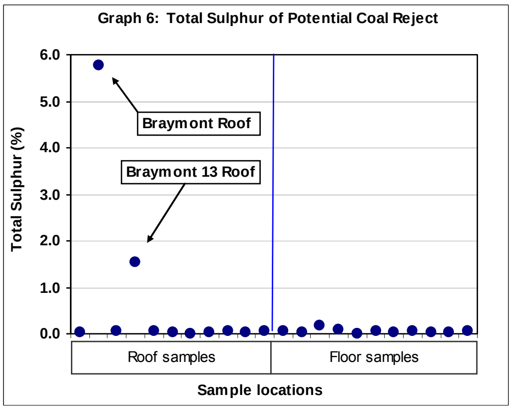
4.1.2 Potential Coal Reject

ABA test results for the 22 potential coal reject samples are presented in **Table 2**, summarised below, and presented in **Graphs 5**, **6**, **7** and **8**.

- **pH**: The current $pH_{1:5}$ of the potential coal reject samples ranges from 3.0 to 9.5 and is typically slightly alkaline (median pH 8.3) (**Graph 5**).
- **EC**: The current $EC_{1:5}$ of the potential coal reject samples ranges from 36 to 2,510 µS/cm and is typically low (median 110 µS/cm) (**Graph 5**).
- **Total sulphur**: The total sulphur content of the potential coal reject samples is typically low and ranges from 0.01 to 5.77 % (median 0.05 %). 19 of the 22 potential coal reject samples tested have total sulphur values less than 0.1 % (**Graph 6**).

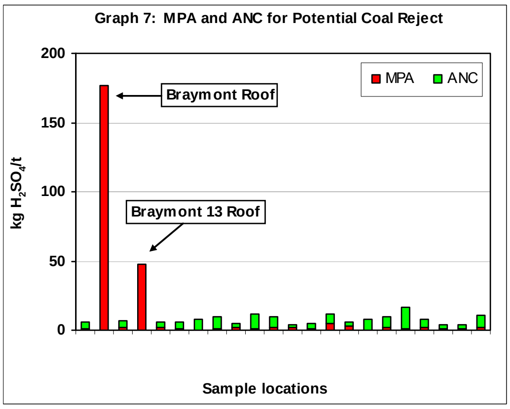
- **MPA**: Based on the total sulphur content, the MPA that could be generated by the potential coal reject samples is typically low and ranges from 0.3 to 177 kg H_2SO_4/t (median 1.5 kg H_2SO_4/t) (**Graph 7**).
- **ANC**: The ANC value for the samples ranges from 0.5 to 15 kg H_2SO_4/t and is typically low (median 5 kg H_2SO_4/t) (**Graph 7**).
- **NAPP**: The calculated NAPP value for the samples ranges from -14 to +176 kg H_2SO_4/t and is typically negative (median -3 kg H_2SO_4/t).
- **ANC/MPA ratio**: The ANC/MPA ratio of the samples ranges from 0.003 to 23 and is typically greater than 3 (median 4).

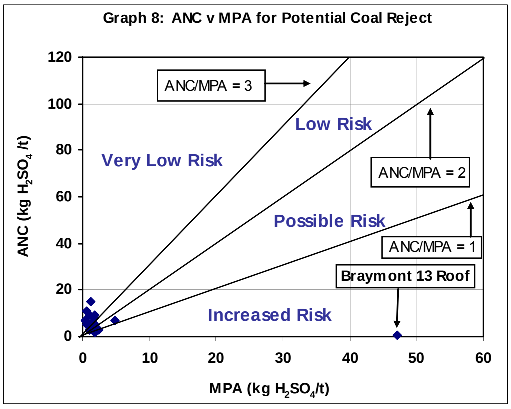




Graph 7 illustrates that the ANC value exceeds the MPA value in most potential coal reject samples and, consequently, most of these samples (20 out of 22 samples) have negative or zero NAPP. The samples with a positive NAPP are from the roof of the Braymont seam.

Graph 8 shows a plot of ANC versus MPA for the potential coal reject samples. The ANC/MPA ratio of the samples ranges from 0.003 to 23 and is typically greater than 3 (median 4). ANC/MPA ratio lines have been plotted on the graph to illustrate the factor of safety associated with the samples. Generally those samples with an ANC/MPA ratio of greater than 2 (or with a total sulphur content of less than 0.1 %) are considered to have a low risk of acid generation and a high factor of safety in terms of potential for ARD (DITR, 2007; INAP, 2009).





The results indicate that approximately 86 % of potential coal reject samples have a low risk of acid generation and a high factor of safety. The remaining two samples are from the Braymont Seam roof and have an ANC/MPA ratio less than 2, and significantly positive NAPP value (> 20 kg H_2SO_4/t)[4].

The ABA results presented in this section have been used to classify the acid forming nature of the 22 potential coal reject samples as shown in **Table 2**. The geochemical criteria used to classify the acid forming nature of the potential coal reject samples are shown at **Table 4**.

Table 4

Geochemical Classification Criteria for Potential Coal Reject Materials

Geochemical Classification	Total Sulfur (%)	NAPP (kg H_2SO_4/t)	ANC/MPA Ratio	Number of samples	% of total samples
NAF - Barren	≤ 0.1	≤ 0	≥ 2	20	86
Uncertain (PAF-LC or NAF)	≥ 0.1	within +/- 20	< 2	1	5
PAF-HC	≥ 0.1	> 20	< 2	2	9

Notes: NAF = Non-Acid Forming, PAF = Potentially Acid Forming, LC = Low Capacity; HC = High Capacity

The results in **Table 4** indicate that most of the potential coal reject samples tested (20 out of 22) fall in the NAF-Barren or Uncertain (NAF) categories. Only two samples were classified as (PAF-HC), and these are from the roof of the Braymont Seam.

Overall, from an acid-base perspective, most of the potential coal reject materials are likely to be NAF and essentially barren of sulfur. A very small proportion of potential coal reject materials have a significant capacity to generate acid, although the results of the current sampling program indicate that these are limited to the roof of the Braymont Seam.

The results of the ABA tests on overburden and potential coal reject samples and any potential implications for mine waste management at the Project are discussed further in **Section 5**.

4.2 Multi-Element Concentration in Solids

Multi-element scans are completed to identify any elements (particularly metals) present in a mine waste material at concentrations that may be of environmental concern with respect to revegetation (and surface water/seepage quality). The results are then compared to potentially relevant guideline criteria to determine any concerns related to mine operation and final rehabilitation. For total metal concentrations in overburden or potential coal reject materials in NSW, there are no specific guidelines and/or regulatory criteria. In the absence of these and to provide relevant context, RGS has compared the total metal concentration in overburden and potential coal reject materials (solids) to health-based investigation levels (HILs) that apply to soils in parks, recreational open spaces and playing fields (NEPC, 1999a). The applicability of this guideline stems from the potential final land use of the mine following closure (*e.g.* forestry, ecological values and agricultural activities).

Four (4) composite overburden samples were made up from 26 of the 47 individual overburden samples and five (5) composite samples of potential coal reject materials were made up from 14 of the 22 individual roof and floor samples. These nine (9) composite samples were then subjected to multi-element test work. The composition of the composite samples is provided in **Table 5**. The near surface composite samples (ME004 and ME005) had to be combined into a single sample due to the small sample volume available.

[4] One of the results for the potential coal reject samples (Braymont Roof sample) is not shown on **Graph 8** as it has a much larger MPA value (180 kg H_2SO_4/t) than the rest of the samples.

The results from multi-element testing (total metals) of the composite overburden and potential coal reject samples are presented in **Table 6**. The acquired data indicates that the overburden and potential coal reject materials have total metal concentrations in solids well within the applied NEPC guideline criteria for soils.

The results of the multi-element tests on composite mine waste samples and any potential implications for waste management are discussed further in **Section 5**.

4.3 Effective Cation Exchange Capacity and Sodicity

The effective cation exchange capacity (eCEC) results presented in **Table 6** indicate that the eCEC of composite overburden and potential coal reject samples is moderate and ranges from 10.1 to 30.3 meq/100g (median = 12.6 meq/100g). There is no significant difference between the eCEC results obtained for the overburden and potential coal reject materials.

The exchangeable sodium percentage (ESP) results presented in **Table 6** indicate that the sodicity of composite overburden and coal reject samples is moderate to high, ranging from 8.1 to 24.2 % (median = 13.9 %). ESP values obtained for the near surface and conglomerate overburden samples are significantly less than the other overburden and potential coal reject samples tested.

The results of the cation exchange capacity and sodicity tests on composite mine waste samples and any potential implications for waste management at the Project are discussed further in **Section 5**.

Table 5: Composite Drill Core Sample Details for Overburden and Coal Reject Materials

ALS Laboratory Sample ID		RGS Sample Number	Sample Interval (m)			Drill Hole ID	Sample Description	Sample Lithology	Preliminary Sample Classification
			From	To	Depth				
EB0908778	012	ME001	78.53	79.33	0.80	BC2163	Overburden	Siltstone	Uncertain (PAF-LC)
EB0908778	029		136.00	136.70	0.70	BC2163	Overburden	Siltstone	NAF (barren)
EB0908778	026		131.23	134.73	3.50	BC2163	Overburden	Sandstone/Siltstone	NAF (barren)
EB0908778	001	ME002	21.75	22.39	0.64	BC2163	Overburden	Sandstone	Uncertain (PAF-LC)
EB0908778	018		92.25	92.61	0.36	BC2163	Overburden	Sandstone	NAF (barren)
EB0908778	025		128.83	131.13	2.30	BC2163	Overburden	Sandstone	NAF (barren)
EB0908778	032		140.77	141.97	1.20	BC2163	Overburden	Sandstone	NAF (barren)
EB0908778	038		163.95	167.97	4.02	BC2163	Overburden	Sandstone	NAF (barren)
EB0908778	008	ME003	40.00	45.00	5.00	BC2163	Overburden	Conglomerate	NAF (barren)
EB0908778	010		60.60	65.60	5.00	BC2163	Overburden	Conglomerate	NAF (barren)
EB0908778	019		94.40	99.40	5.00	BC2163	Overburden	Conglomerate	NAF (barren)
EB0908778	021		114.50	119.50	5.00	BC2163	Overburden	Conglomerate	NAF (barren)
EB0908778	033		142.45	147.45	5.00	BC2163	Overburden	Conglomerate	NAF (barren)
EB0908778	039		24.00	29.00	5.00	BC2172	Overburden	Conglomerate	NAF (barren)
EB0908778	041		44.00	49.00	5.00	BC2172	Overburden	Conglomerate	NAF (barren)
EB0908778	047		68.25	73.25	5.00	BC2172	Overburden	Conglomerate	NAF (barren)
EB0908778	057		107.14	112.14	5.00	BC2172	Overburden	Conglomerate	NAF (barren)
EB0908778	059		126.50	131.50	5.00	BC2172	Overburden	Conglomerate	NAF (barren)
EB0909240	001	ME004	0.00	1.00	1.00	BC2163	Overburden	Soil	NAF (barren)
EB0909240	005		0.00	1.00	1.00	BC2172	Overburden	Soil	NAF (barren)
EB0909240	002	ME005	2.00	5.00	3.00	BC2163	Overburden	Conglomerate	NAF (barren)
EB0909240	006		2.00	5.00	3.00	BC2172	Overburden	Sandstone	NAF (barren)
EB0909240	003		6.00	10.00	4.00	BC2163	Overburden	Conglomerate/Shaley Coal	NAF (barren)
EB0909240	007		6.00	10.00	4.00	BC2172	Overburden	Siltstone/ Conglomerate	NAF (barren)
EB0909240	004		11.00	20.00	9.00	BC2163	Overburden	Conglomerate/Sandstone	NAF (barren)
EB0909240	008		11.00	20.00	9.00	BC2172	Overburden	Conglomerate/Siltstone	NAF (barren)
EB0908778	030	ME006	136.70	137.16	0.46	BC2163	Jeralong Roof	Mudstone	NAF (barren)
EB0908778	055		100.27	101.30	1.03	BC2172	Jeralong Roof	Conglomerate	NAF (barren)
EB0908778	005	ME007	28.00	28.54	0.54	BC2163	Braymont Upper Roof	Siltstone	NAF (barren)
EB0908778	044		57.82	58.17	0.35	BC2172	Braymont Roof	Sandstone	PAF-HC
EB0908778	013		79.33	80.11	0.78	BC2163	Braymont 11/12 Roof	Siltstone	NAF (barren)
EB0908778	016		85.89	86.19	0.30	BC2163	Braymont 13 Roof	Conglomerate	PAF-HC
EB0908778	022	ME008	120.81	121.31	0.50	BC2163	Bollol Creek Roof	Conglomerate	NAF (barren)
EB0908778	050		90.89	91.21	0.32	BC2172	Bollol Creek Roof	Carbonaceous Claystone	NAF (barren)
EB0908778	006	ME009	29.88	30.05	0.43	BC2163	Braymont Upper Floor	Siltstone	NAF (barren)
EB0908778	045		64.42	64.67	0.25	BC2172	Braymont Floor	Carbonaceous Siltstone	NAF (barren)
EB0908778	017		91.75	92.71	0.96	BC2163	Braymont 13 Floor	Siltstone	NAF (barren)
EB0908778	014		82.14	82.34	0.20	BC2163	Braymont 11/12 Floor	Claystone	Uncertain (NAF)
EB0908778	023	ME010	122.29	122.60	0.31	BC2163	Bollol Creek Floor	Siltsone/Sandstone	NAF (barren)
EB0908778	051		92.75	93.35	0.60	BC2172	Bollol Creek Floor	Sandstone	NAF (barren)

Table 6 : Multi-Element Results for Overburden and Potential Coal Reject Materials

Parameters	Detection Limit	NEPC[1] Health-Based Investigation Level	Overburden				Potential Coal Reject Materials				
	RGS composite number -->		ME001	ME002	ME003	ME004/005	ME006	ME007	ME008	ME009	ME010
	Material description (refer to report text for details)		Silttone/Sandstone	Siltstone	Conglomerate	Near Surface Materials	Mudstone/Conglomerate	Siltstone/Sandtone/ Conglomerate	Conglomerate/ Carbonaceous Claystone	Carbonaceous Siltstone/ Claystone	Sandstone/Siltstone
Elements	mg/kg		All units mg/kg								
Aluminium (Al)	50	-	2,860	2,700	2,950	6,680	2,880	2,800	2,620	2,670	2,920
Antimony (Sb)	5	-	<5	<5	<5	<5	<5	<5	<5	<5	<5
Arsenic (As)	5	200	10	7	<5	6	7	32	<5	<5	<5
Boron (B)	50	6,000	<50	<50	<50	<50	<50	<50	<50	<50	<50
Cadmium (Cd)	1	40	<1	<1	<1	<1	<1	<1	<1	<1	<1
Calcium (Ca)	10	-	1,620	1,920	4,990	8,820	1,150	1,050	1,120	1,850	1,340
Chromium (Cr) total	2	-**	4	12	18	46	9	7	10	4	7
Cobalt (Co)	2	200	5	5	3	5	3	3	<2	<2	3
Copper (Cu)	5	2,000	14	10	<5	7	16	14	13	21	16
Iron (Fe)	50	-	22,500	25,000	11,900	18,200	1,700	23,800	1,210	70,000	8,280
Lead (Pb)	5	600	16	14	11	11	20	15	16	13	17
Magnesium (Mg)	10	-	2,000	2,160	1,620	2,520	690	980	530	1,820	1,210
Manganese (Mn)	5	3,000	322	372	225	206	23	110	6	2,310	86
Molybdenum (Mo)	2	-	<2	<2	<2	<2	<2	<2	<2	<2	<2
Nickel (Ni)	2	600	17	15	8	10	10	14	10	6	9
Potassium (K)	10	-	1,180	1,150	1,140	1,590	1,180	1,170	1,220	1,070	1,250
Selenium (Se)	5	-	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sodium (Na)	10	-	730	900	910	900	630	420	480	490	630
Zinc (Zn)	5	14,000	95	65	32	32	54	68	60	44	90
Exchangeable Cations	meq/100g (except ESP)		All units meq/100g (except Exchangeable Sodium Percentage (%))								
Exch. Calcium	0.1	-	5.1	4.3	11.0	20.1	4.9	4.4	4.5	3.9	5.4
Exch. Magnesium	0.1	-	5.7	4.3	2.9	5.7	4.0	5.7	3.2	4.2	4.1
Exch. Potassium	0.1	-	1.1	1.0	0.9	1.5	1.0	0.8	0.9	0.9	1.1
Exch. Sodium	0.1	-	2.4	3.0	1.3	2.9	2.0	1.4	1.4	1.4	2.0
Cation Exchange Capacity	0.1	-	14.3	12.6	16.1	30.3	12.0	12.4	10.1	10.4	12.6
Exchangeable Sodium Percentage	0.1 %	-	16.9	24.2	8.1	9.7	17.2	11.2	13.9	13.8	16.1

Notes < indicates less than the analytical detection limit.

1. NEPC (1999)a. National Environmental Protection Council (NEPC). National Environmental Protection (Assessment of Site Contamination) Measure (NEPM). Guideline on investigation levels for soil and groundwater. HIL(E); parks, recreation open space and playing fields.

** Guideline level for Cr(VI) = 200 mg/kg. Guideine level for Cr(III) = 24% of total Cr.

4.4 Multi-Element Concentration in Water Extracts

It is important to note that there are no specific regulatory criteria for metal concentrations in leachate derived from overburden and potential coal reject materials on mine sites in NSW. As such, RGS has compared the multi-element concentrations in water extracts from overburden and potential coal reject samples with Australian guidelines to provide some context for discussion of test results (ANZECC, 2000 and NEPC, 1999b).

The results from multi-element testing of soluble metals concentrations in water extracts (1:5 solid:water) from the nine composite overburden and potential coal reject samples are presented in **Table 7**. The extracts are slightly alkaline except for potential coal reject sample ME007, which has an acidic pH of 4.3 and negligible alkalinity. The extracts typically have low EC values (8 of the 9 composite samples tested have EC values ranging from 96 to 405 µS/cm). The highest EC value was recorded for Sample ME007 (1,060 µS/cm).

The dominant major soluble cation is typically sodium in most samples with the exception of Sample ME007, where calcium has a similar concentration to sodium. The dominant major soluble anions are typically bicarbonate, chloride and sulphate, although the sulphate concentration is elevated by an order of magnitude in potential coal reject sample ME007. The concentration of soluble sulphate is elevated, but is within the applied water quality guideline criteria of 1,000 mg/L (ANZECC, 2000).

Similarly, the concentration of trace metals tested in the water extracts is typically very low, predominantly below the analytical detection limit, and well within the applied water quality guideline criteria (ANZECC, 2000; and NEPC, 1999b). Minor exceptions are the concentration of molybdenum in one composite overburden sample and molybdenum and selenium in three and one potential reject samples, respectively.

The soluble metals concentration results for water extracts from the composite overburden and potential coal reject samples and any potential implications for waste management for the Project are discussed further in **Section 5**.

4.5 Geochemical Test Data

A copy of all the geochemical test results received from ALS Brisbane for the Project is provided as **Attachment C**.

Table 7: Multi-Element Results for Water Extracts from Overburden and Potential Coal Reject Materials

			Overburden				Potential Coal Reject Materials				
	RGS composite number -->		ME001	ME002	ME003	ME004/005	ME006	ME007	ME008	ME009	ME010
	Material description (refer to report text for details)		Silttone/Sandstone	Siltstone	Conglomerate	Near Surface Materials	Mudstone/Conglomerate	Siltstone/Sandstone/ Conglomerate	Conglomerate/ Carbonaceous Claystone	Carbonaceous Siltstone/ Claystone	Sandstone/Siltstone
Parameters	Detection Limit	Guideline Levels[1]									
pH	0.1 pH unit	-	8.0	8.2	9.2	8.8	8.5	4.3	8.1	7.6	8.1
Electrical Conductivity	1 µS/cm	-	207	244	233	405	96	1,060	107	167	120
Total Alkalinity (mg $CaCO_3$/L)	0.2		302	308	1,254	-	240	<0.2	194	152	204
Bicarbonate Alkalinity (mg $CaCO_3$/L)	0.2	-	302	308	1,192	-	230	<0.2	192	152	204
Carbonate Alkalinity (mg $CaCO_3$/L)	0.2	-	<0.2	<0.2	61	-	9	<0.2	2	<0.2	<0.2
Major Ions	All element concentrations in mg/L										
Calcium (Ca)	2	1,000	<2	<2	2	4	<2	58	<2	<2	<2
Magnesium (Mg)	2	-	<2	<2	<2	2	<2	52	<2	<2	<2
Sodium (Na)	2	-	38	44	36	60	16	52	20	30	24
Potassium (K)	2	-	4	4	10	12	4	24	4	6	4
Chloride (Cl)	2	-	62	40	16	42	28	14	24	48	40
Sulphate (SO_4)	2	1,000	52	62	32	22	16	544	20	34	14
Metals	All element concentrations in mg/L										
Aluminium (Al)	0.2	5	2.0	1.0	0.8	0.2	3.8	0.8	3.4	2.0	3.6
Antimony (Sb)	0.02	-	<0.02	<0.02	<0.02	0.2	<0.02	<0.02	<0.02	0.1	<0.02
Arsenic (As)	0.02	0.5	0.020	<0.02	<0.02	<0.02	0.160	0.020	<0.02	<0.02	0.100
Boron (B)	0.2	5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cadmium (Cd)	0.02	0.01	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chromium (Cr)	0.02	1 / -	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cobalt (Co)	0.02	1	<0.02	<0.02	<0.02	<0.02	<0.02	0.1	<0.02	<0.02	<0.02
Copper (Cu)	0.02	1 / 0.5	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Iron (Fe)	0.2	-	<0.2	<0.2	<0.2	<0.2	0.2	33.6	0.2	<0.2	0.2
Lead (Pb)	0.02	0.1	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Manganese (Mn)	0.02	-	<0.02	<0.02	<0.02	<0.02	<0.02	0.500	<0.02	<0.02	<0.02
Molybdenum (Mo)	0.02	0.015 / 0.01	0.02	<0.02	<0.02	<0.02	0.02	<0.02	0.04	<0.02	0.02
Nickel (Ni)	0.02	1	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Selenium (Se)	0.02	0.02	<0.02	<0.02	<0.02	<0.02	0.02	0.42	<0.02	<0.02	<0.02
Zinc (Zn)	0.02	20	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

Notes: < Indicates concentration less than the detection limit. Shaded cells indicate values which exceed recommended maximum ANZECC/NEPC guideline values.

1. The first guideline level shown refers to ANZECC (2000) and the second to NEPC (1999) e.g. 0.015 / 0.01. Where the two guidelines limits for a given element are in agreement, only one value is shown. A 'dash' represents no trigger value provided for this element.

a. ANZECC and ARMCANZ, Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, ACT (2000). Livestock drinking water (cattle).

b. NEPC (1999b). National Environment Protection Council (NEPC). National Environmental Protection (Assessment of Site Contamination) Measure (NEPM) Guideline on investigation levels for soil and groundwater. Groundwater Investigations Levels (Agricultural: Livestock).

5.0 DISCUSSION

5.1 Acid Base Account Test Results

The results of the ABA tests presented in **Section 4.1**, indicate that most (87%) overburden (and interburden[5]) materials tested are likely to be NAF and have a high factor of safety with respect to potential acid generation. Most overburden samples have negligible (< 0.1 %) total sulphur content and are therefore classified as NAF-barren. These materials also appear to have a large acid buffering capacity (moderate ANC value), which should more than compensate for any acid that could potentially be generated from the small amount of materials with uncertain acid generating classification.

Overall, from an acid-base perspective, the overburden material can be generally regarded as a NAF unit. This finding correlates well with the findings of previous geochemical assessment work completed at Boggabri Coal Mine described in **Section 3**.

The results of the ABA tests presented in **Section 4.1**, indicate that most (86 %) of potential coal reject samples tested have a low risk of acid generation and a high factor of safety. Most potential coal reject samples have negligible (< 0.1 %) total sulphur content and are therefore classified as NAF-barren.

However, some samples obtained from near the Braymont Seam (roof samples) have a relatively high total sulphur content and negligible buffering capacity (and hence a low factor of safety) and are classified as PAF (High Capacity).

Overall, from an acid-base perspective, most of the potential coal reject materials are likely to be NAF and essentially barren of sulfur. A small proportion of potential coal reject materials have a significant capacity to generate acid, although these appear to be limited to the roof of the Braymont seam for the drill holes tested. This finding correlates well with the findings of previous geochemical assessment work at Boggabri Coal Mine (**Section 3**), however the previous work also indicated the existence of some PAF materials associated with immediate roof and floor materials at both the Braymont and Jeralong seams. As a conservative management measure, RGS recommends deep (in pit) burial for coal reject material sourced from both the Braymont and Jeralong seams.

5.2 Multi-Element Composition and Water Quality

5.2.1 Multi-element composition

The multi-element composition of composite overburden and potential coal reject samples are presented at **Section 4.2**, along with a comparison of any enriched metal concentrations with those described in NEPC (1999a) health-based guidelines (HIL(E)) for soils in ‘parks and recreational open spaces’. Additionally, the multi-element composition of water extracts from these materials is provided in **Section 4.4**, along with a comparison of soluble metal concentrations with applied (ANZECC, 2000; and NEPC, 1999b) livestock drinking water guidelines.

It is important to note that there are no specific regulatory criteria for metal concentrations in overburden and potential coal reject materials, nor in leachate derived from such materials on mine sites in NSW. In the absence of these, RGS has compared the multi-element concentrations in overburden and potential coal reject samples, and in water extracts derived from these materials, with the above guidelines to provide some context for discussion of test results.

[5] For the purpose of this discussion, overburden (and interburden) materials are collectively termed overburden.

The acquired data indicate that all total metal concentrations in overburden and potential coal reject samples are well below the NEPC (1999a) HIL(E) guideline values, where such guideline levels exist. Hence, overburden and potential coal reject materials are unlikely to present a significant risk to the environment with respect to total metal concentrations in solids. This finding correlates well with the findings of previous geochemical assessment work completed at Boggabri Coal Mine described in **Section 3**.

5.2.2 Water Quality

Water extract results from leachate samples described in **Section 4.4** indicate that surface run-off and seepage from most overburden and potential coal reject materials is likely to be slightly alkaline. The exception is potential coal reject material from the Braymont seam (and potentially the Jeralong seam) where PAF materials may generate acidic surface run-off and seepage.

Water extracts from most overburden and potential coal reject samples typically have low EC values, although the EC is higher for PAF materials. Based on these results, the salinity of surface run-off and seepage from most overburden and potential coal reject materials is expected to be low. Given that the EC values are derived from pulverised samples, where the surface area in contact with water is much greater than at a typical overburden or coal rejects emplacement area, and that further dilution is likely in the field, this laboratory salinity result is likely to represent a potential 'worst case' scenario.

Hence, the risk of any saline run-off and seepage from most overburden and potential coal reject materials significantly impacting the quality of surface and groundwater from the Project is expected to be low. In contrast, the risk of saline run-off and seepage from exposed PAF materials is expected to be high.

Based on the water extract results and existing groundwater data (Parsons Brinckerhoff, 2005), the major ion chemistry of initial surface run-off and seepage from overburden and potential coal reject materials will be dominated by sodium, bicarbonate, chloride and sulphate, although for PAF materials, calcium and sulphate may become more dominant. For PAF materials, the initial concentration of soluble sulphate in run-off and seepage is expected to remain within the applied water quality guideline criteria of 1,000 mg/L (ANZECC, 2000), although further exposure of PAF materials to oxidising conditions may lead to increased soluble sulphate concentrations.

5.2.3 Soluble Metals

Leachate from most overburden and potential coal reject materials is likely to contain dissolved metal concentrations well below maximum recommended levels for livestock drinking water (ANZECC, 2000; NEPC, 1999b), with some minor exceptions (molybdenum and selenium) in a few materials. Given that water extract data represents pore water chemistry for pulverised samples and that further dilution effects from rainfall and natural attenuation are likely to occur in the field, it is expected that the marginally elevated soluble concentrations of some elements in any run-off and seepage from a few overburden and coal reject materials will be further attenuated in the field.

Hence, multi-element results indicated that the concentration of dissolved metals in any run-off and seepage from overburden and potential coal reject materials is unlikely to present any significant environmental issues associated with on-site or downstream water quality from the Project.

5.3 Material Suitability for use in Revegetation and Rehabilitation

The following discussion provides some context to the soil chemistry of overburden and potential coal reject materials, should these materials report to final surfaces. However, it is recognised that most overburden and potential coal rejects are unlikely to be specifically used in revegetation and rehabilitation activities (in final surfaces or as a growth medium).

From a soil chemistry viewpoint, all of the overburden and potential coal reject materials (excluding PAF reject materials from the Braymont seam and potentially the Jeralong seam) are likely to be slightly alkaline (approximate pH 8.3). The materials will generally have low EC/salinity, and display moderate eCEC values.

All of the overburden and potential coal reject samples tested had ESP values that exceed 8%. Where the EC is relatively low, such as in the tested samples, soils are considered sodic if the ESP value is greater than 6% and less than 14% and strongly sodic if the ESP is 15 or more (Isbell, 2002; and Northcote and Skene, 1972). Materials classified as sodic may be prone to dispersion and erosion. Hence, most overburden and potential coal reject materials are likely to have structural stability problems related to potential dispersion. The ESP values obtained for the near surface and conglomerate overburden materials are significantly less than the other overburden and potential coal reject materials. Hence, near surface and conglomerate overburden materials may be the most suitable for revegetation and rehabilitation activities (in final landform surfaces or as a growth medium) for the Project. For all other overburden materials, it is likely that treatment of all sodic materials would be required if these were to be considered for use as vegetation growth medium.

In addition to potential dispersion problems, sodic soils often have unbalanced nutrient ratios that can lead to macro-nutrient deficiencies (Hazelton and Murphy, 2007). The table below (**Table 8**) shows the proportions of each exchangeable cation relative to eCEC. The 'desirable' proportions of each major cation are also shown (Abbott, 1989, in Hazelton and Murphy, 2007).

Table 8

CEC proportions for major exchangeable cations

Exchangeable Cation	Desirable ranges	Overburden	Near Surface and Conglomerate Overburden	Potential Coal Rejects
	% CEC			
Calcium (Ca)	65 – 80	34 – 66 (median 51)	66 – 68 (median 67)	35 – 45 (median 41)
Magnesium (Mg)	10 – 15	18 – 40 (median 26)	18 – 19 (median 19)	32 – 46 (median 33)
Potassium (K)	1 – 5	5 – 8 (median 7)	5 – 6 (median 6)	6 – 9 (median 9)
Sodium (Na)	0 – 1	8 - 24 (median 13)	8 - 10 (median 9)	11 - 17 (median 14)

When compared to the desirable ranges for exchangeable cations in soil (**Table 8**), exchangeable Ca proportions in most overburden and potential coal reject materials are slightly low, exchangeable Mg and K proportions are slightly high, and exchangeable Na proportions are very high. In comparison, near surface and conglomerate overburden materials appear to have more favourable exchangeable cation % eCEC proportions and may be more amenable for revegetation and rehabilitation activities (in final surfaces or as a growth medium)

It should be noted that in soil chemistry a pH1:5 (solid:water) greater than 8.5 is regarded as 'strongly' alkaline. Most of the overburden and potential coal reject samples tested exhibited a pH greater than 8.0, therefore some degree of nutrient imbalance is likely to already exist in these materials, as shown in **Table 8** above.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

RGS has completed a geochemical assessment of representative overburden and potential coal reject materials from the Project. From the results of this work it is concluded that:

6.1.1 Overburden

- Most overburden is likely to have negligible (<0.1%) total sulphur content and is therefore classified as NAF-barren. Overburden also appear to have excess acid buffering capacity (moderate ANC value), which should more than compensate for any acid that could potentially be generated from the small amount of overburden materials with uncertain acid generating classification;
- Most overburden materials generated at the Project are likely to be NAF and have a high factor of safety with respect to potential acid generation. The overburden can therefore be regarded as a NAF unit;
- The concentration of total metals in overburden solids is well below applied guideline criteria for soils and is unlikely to present any environmental issues associated with revegetation and rehabilitation;
- Most overburden materials will generate slightly alkaline and relatively low-salinity run-off and seepage following surface exposure. The major ion chemistry of initial surface run-off and seepage from overburden materials is likely to be dominated by sodium, bicarbonate, chloride and sulphate;
- The concentration of dissolved metals in initial run-off and seepage from overburden materials is unlikely to present any significant environmental issues associated with surface and ground water quality as a result of the Project;
- Most overburden materials are sodic and likely to have structural stability problems related to potential dispersion. Some near surface and conglomerate overburden materials are likely to be less sodic and may be the most suitable materials for revegetation and rehabilitation activities (as a growth medium). For all other sodic overburden materials, it is likely that treatment would be required if these were to be considered for use as vegetation growth medium; and
- These findings correlate well with previous geochemical assessment findings for overburden described in **Section 3** of this report.

6.1.2 Potential Coal Reject

- Most potential coal reject materials are likely to have negligible (< 0.1 %) total sulphur content and are therefore classified as NAF-barren. These materials have a high factor of safety with respect to potential acid generation;
- A small proportion of the potential coal reject materials located near the Braymont Seam (roof samples) have a relatively high total sulphur content and negligible buffering capacity (and hence a low factor of safety) and are classified as PAF (High Capacity). This finding correlates well with the findings of previous geochemical assessment work described in **Section 3** of this report, however the previous work also indicated the existence of some PAF materials associated with immediate roof and floor materials at both the Braymont and Jeralong seams;
- The concentration of total metals in potential coal reject solids is well below applied guideline criteria for soils and is unlikely to present any environmental issues associated with revegetation and rehabilitation;

- Most potential coal reject materials will generate slightly alkaline and relatively low-salinity run-off and seepage following surface exposure. The exception is potential coal reject material from the Braymont seam (and potentially the Jeralong seam) where PAF materials may generate acidic and more saline run-off and seepage;
- The major ion chemistry of initial surface run-off and seepage from potential coal reject materials is likely to be dominated by sodium, bicarbonate, chloride and sulphate, although for PAF materials, calcium and sulphate may become more dominant. For PAF materials, the initial concentration of soluble sulphate in run-off and seepage is expected to remain within the applied water quality guideline criterion, although further exposure to oxidising conditions could lead to increased soluble sulphate concentrations;
- The concentration of dissolved metals in initial run-off and seepage from potential coal reject materials is unlikely to present any significant environmental issues associated with surface and ground water quality as a result of the Project;
- Most potential coal reject materials are sodic and likely to have structural stability problems related to potential dispersion. These materials are unlikely to be suitable for use as a vegetation growth medium; and
- These findings correlate well with previous geochemical assessment findings for potential coal reject materials described in **Section 3** of this report.

6.2 Recommendations

6.2.1 Overburden

The ongoing management of overburden should consider the geochemistry of these materials with respect to their potential risk to cause harm to the environment and their suitability for use in construction and revegetation. It is therefore recommended that the Boggabri Coal undertakes:

- Pre-stripping topsoil from areas to be mined for use in final rehabilitation activities (surface cover or vegetation growth medium); and
- Placement of overburden at the emplacement area in a manner that limits the risk of surface exposure of highly sodic material and subsequent run-off and erosion.

Surface water and seepage from overburden material, should be monitored to ensure that key water quality parameters remain within appropriate criteria. It is therefore recommended that Boggabri Coal:

- Continues to monitor of run-off/seepage from overburden emplacement areas for pH, electrical conductivity (EC), total suspended solids (TSS) and dissolved metals as required.

6.2.2 Potential Coal Reject

The ongoing management of potential coal rejects material should consider the geochemistry of materials with respect to their potential risk to cause harm to the environment and their suitability for use in construction and revegetation. It is therefore recommended that Boggabri Coal considers:

- Placement of NAF coal reject materials in the open pit and/or co-disposal with overburden;
- Deep (in-pit) burial of PAF potential coal reject materials from the Braymont and Jeralong seams;
- For the co-disposal option, placement of NAF coal reject material in a manner that limits the risk of surface exposure of highly sodic materials and subsequent run-off and erosion; and
- Confirmation of the geochemical and physical characteristics of coal rejects material in future (post approval) when bulk samples become available from the CHPP.

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7.0 LIMITATIONS

RGS Environmental Pty Ltd (RGS) has prepared this report for the use of Hansen Bailey Pty Ltd and Boggabri Coal Pty Ltd. It is based on accepted consulting practices and standards and no other warranty is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in Proposal P001-A (890022) dated 20 March 2009.

This report was prepared from April to November 2009 and is based on the information provided by Hansen Bailey Pty Ltd and Boggabri Coal Mine at the time of preparation. RGS disclaims responsibility for any changes that may have occurred after this time.

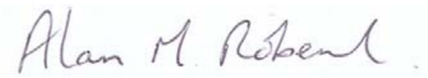
The sources of information and methodology used by RGS are outlined in this report and no independent verification of this information has been made. RGS assumes no responsibility for any inaccuracies or omissions, although no indication was found that any information contained in this report as provided to RGS was incorrect.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice, which can only be given by qualified legal practitioners.

If you have any questions regarding the information presented in this report, please contact the undersigned on (+617) 3856 5591 or (+61) 431 620 623.

Yours sincerely,

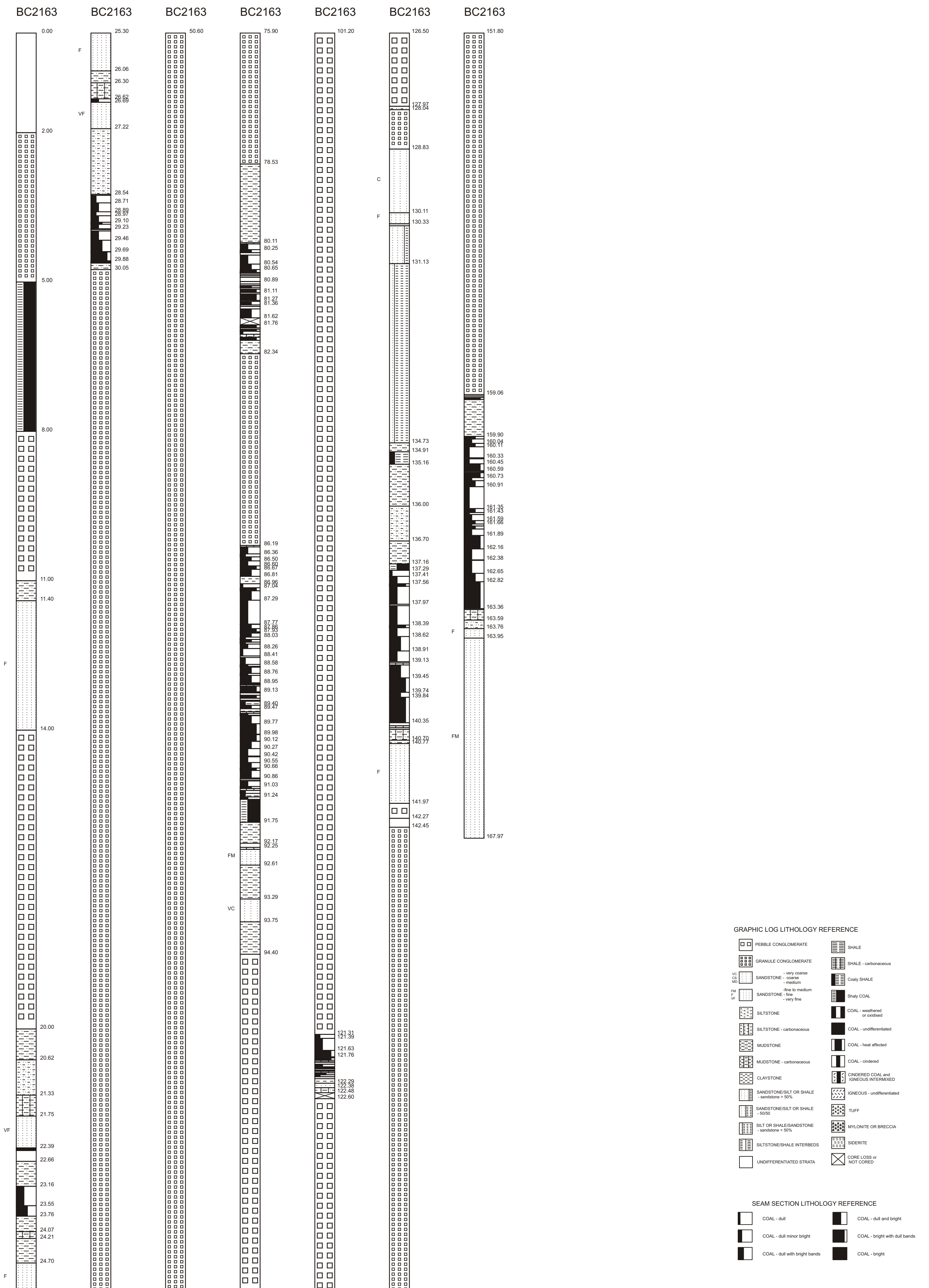
RGS ENVIRONMENTAL PTY LTD



Dr. Alan Robertson
Principal Geochemist/Director

ATTACHMENT A

Drillhole Logs and Core Photos for BC2163 and BC2172



BOGGABRI COAL PTY LIMITED
BOGGABRI PROJECT

Date 29/4/2009
Scale 1: 50
Approved: JR

Bc2163
Drillhole Graphics


BC 2163
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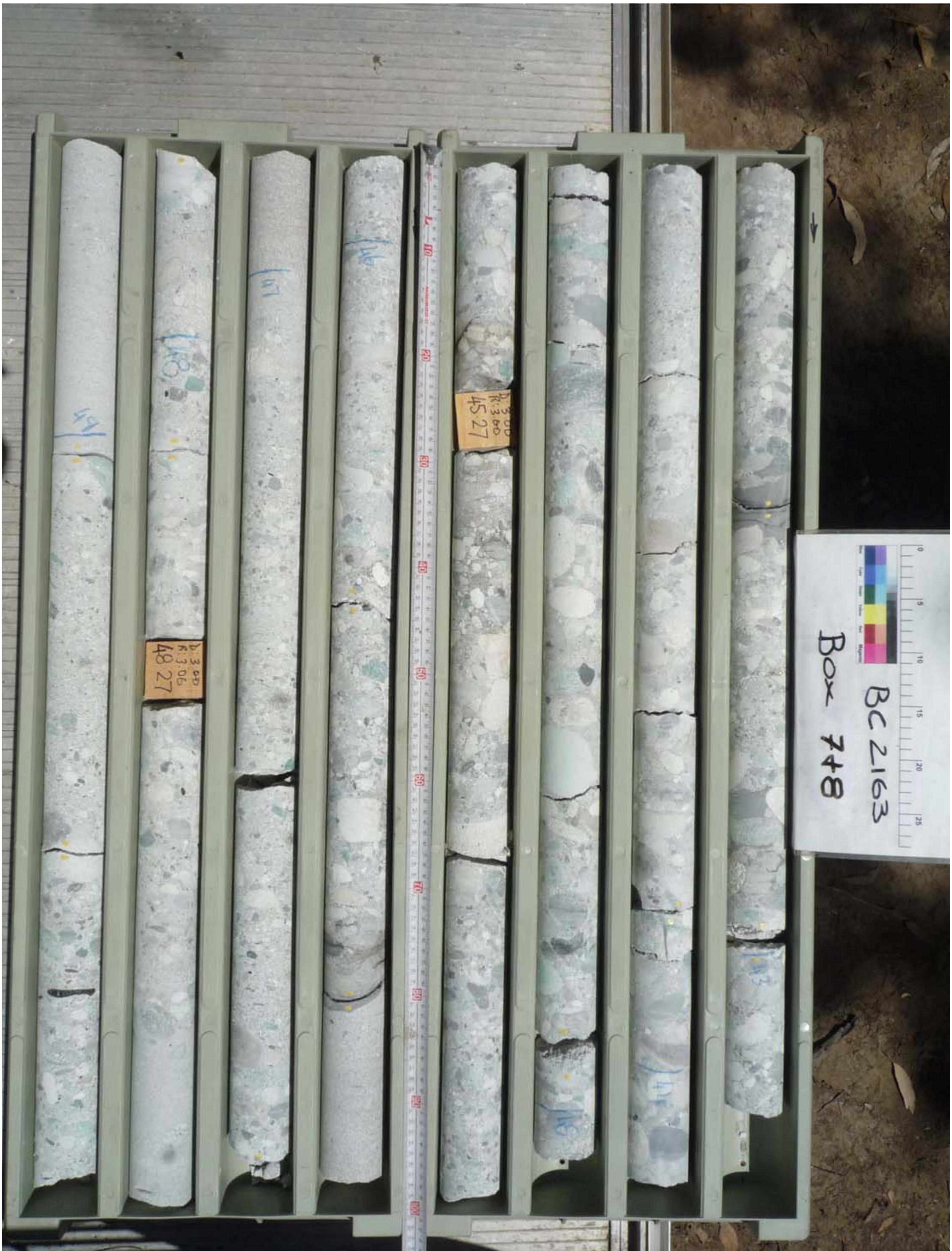
Bogabri Coal Project
BC2163
Box 1 + 2


BC2163
Box 3+4


BC2163
Box 5+6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Box 9+10


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Box 11+12


BC 2163
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BC 2163
Box 15+16


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Box 17+18


BC 2163
Box 19+20


BC 2163
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BC 2163
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BC 2163
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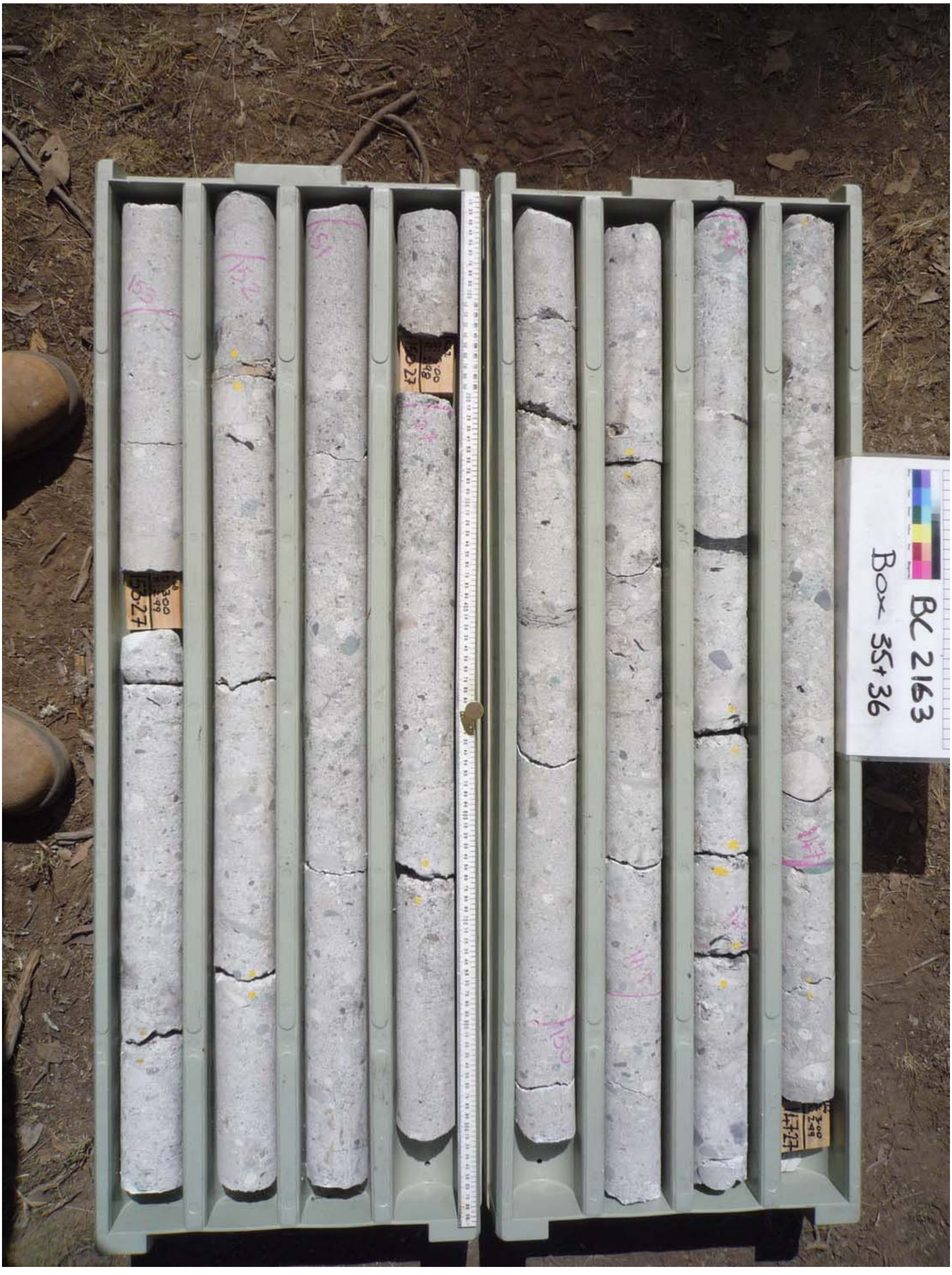
BC 2163
Box 35+36


BC 2163
Box 37+38