APPENDIX W

Appendix W - REA Acid & Metalliferous Drainage and Spontaneous Combustion Assessment

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GeoTerra

TAHMOOR COAL PTY LIMITED

TAHMOOR SOUTH PROJECT REJECT EMPLACEMENT AREA ACID & METALLIFEROUS DRAINAGE AND SPONTANEOUS COMBUSTION ASSESSMENT

Tahmoor, NSW

BAR4-R1B
10 DECEMBER, 2013

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GeoTerra

BAR4-R1B (10 December 2013)

Tahmoor Coal Pty Ltd
Tahmoor Mine
Remembrance Driveway
TAHMOOR NSW 2573

Attention: Ron Bush

Ron,

RE: Tahmoor South Project Reject Emplacement Area Acid & Metalliferous Drainage and Spontaneous Combustion Assessment

Please find enclosed a copy of the above mentioned report.

Yours faithfully

GeoTerra Pty Ltd

Andrew Dawkins (AuSIMM CP-Env)

Managing Geoscientist

Distribution:	Original	GeoTerra Pty Ltd
	1 electronic copy	Tahmoor Coal Pty Ltd

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Authorised on behalf of Geoterra Pty Ltd:	
Name:	Andrew Dawkins
Signature:	
Position:	Managing Geoscientist

Date	Rev	Comments
07.08.2013		Initial Draft
20.11.2013	A	Incorporate Reviewers Comments
10.12.2013	B	Correct labelling in Figure 5

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GLOSSARY OF TERMS

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.
AMD	Acid and metalliferous drainage caused by exposure of sulfide minerals in mine waste materials to oxygen and water. Typically characterised by low pH and elevated concentrations of salts, sulfate and metals.
ANC	Acid neutralising capacity of a sample 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.
CHPP	Coal handling and preparation plant.
EC	Electrical conductivity, expressed as µS/cm.
CEC	Cation exchange capacity provides a measure of the amount of exchangeable cations (Ca, Mg, Na and K) in a sample.
ESP	Exchangeable sodium percentage provides a measure of the sodicity of a materials and propensity to erode.
Interburden	Waste rock material that lies within a coal seam.
KLC test	Kinetic leach column tests are procedures used to measure the geochemical/ weathering behaviour of a sample of mine material overtime.
MPA	Maximum potential acidity calculated by multiplying the total sulfur 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.
Spontaneous Combustion	an increase in temperature due to exothermic oxidation, followed by self heating which rapidly accelerates to high temperatures and finally, ignition of coal or carboniferous stockpiles
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 Sulfur	Total sulfur content of a sample generally measured using a 'Leco' analyser expressed as % sulfur.
Uncertain	Geochemical classification criterion for a sample where the potential to generate acid conditions remains uncertain and may require further analysis.
Underburden	Waste rock material that lies beneath a coal seam.

1. INTRODUCTION

Tahmoor Mine (Tahmoor Mine) is an underground coal mine operated by Tahmoor Coal Pty Ltd (Tahmoor Coal). Tahmoor Coal is an operating entity within Glencore's coal business (Glencore Xstrata plc).

The Tahmoor South Project is located three kilometres south of the town of Tahmoor and thirty five kilometres north west of Wollongong in the Southern Coalfield of New South Wales.

Tahmoor Mine currently uses Continuous Mining Development and Long Wall Extraction methods to produce a current Run of Tahmoor Mine (ROM) output of approximately 2.5Mtpa.

Tahmoor Coal is seeking approval for the Tahmoor South Project (Project), which is for continuation of mining at Tahmoor Mine, extending underground operations and associated infrastructure south, within the Bargo area, and to the east within the Pheasants Nest area. The proposed development seeks to extend the life of underground mining at Tahmoor Mine until approximately 2040, depending upon geological and mining parameters.

The proposed project is a State Significant Development (SSD) as defined under the *State Environmental Planning Policy (State and Regional Development) 2011* and requires development consent under Division 4.1, Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

1.1 Acid Mine Drainage and Spontaneous Combustion Assessment

Geoterra Pty Ltd (Geoterra) were commissioned by Tahmoor Coal to conduct an assessment of the existing and potential acid and metalliferous drainage (AMD) and spontaneous combustion nature of the Reject Emplacement Area (REA) at Tahmoor Mine for the Tahmoor South Project.

The potential sources of AMD and spontaneous combustion from the operation include the Bulli Seam, as well as roof and floor rejects from the Coal Handling and Preparation Plant (CHPP).

The existing Tahmoor Mine REA is proposed to be expanded to accommodate the additional reject material that is proposed to be generated by the Tahmoor South Project.

This investigation incorporated sampling, laboratory assessment and interpretation of;

- selected laboratory washery recovery test core intervals from the Bulli Seam within the Tahmoor South Project Area, and;
- leachate and runoff samples from the current Tahmoor Mine REA that contains in excess of 10 million tonnesof reject material from the existing Tahmoor Mine Bulli Seam, roof and floor material.
- In addition, two upslope and downslope piezometers were installed and used to measure the standing water level as well as water chemistry of groundwater contained within the Hawkesbury Sandstone that underlies the existing and proposed extension to the REA.

The AMD and spontaneous combustion laboratory analyses were conducted on four (post washery laboratory testing) drill core intervals of the Bulli Seam, roof and floor from exploration bores TBC25, TBC26, TBC34 and TBC36.

Leachate and runoff from the existing REA was sampled in a culvert and settling dams S7, S7A and S9.

Standing water level and field / laboratory water chemistry was assessed in the REA upgradient and down gradient piezometers TGW4 and TGW5.

The location of sampling points in the vicinity of the existing REA is shown in **Figure 1**.

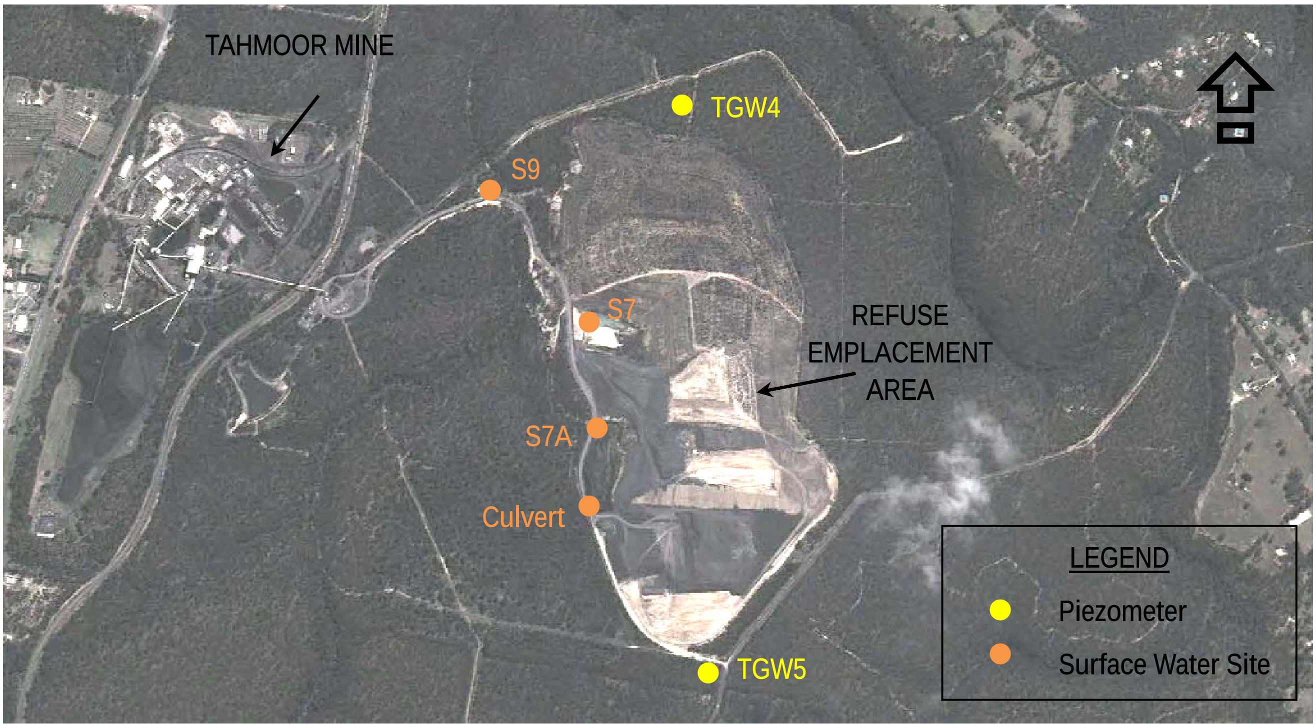

Figure 1 **Existing REA and Sampling Locations**

1.2 Objectives

The objective of the study is to understand the potential AMD and spontaneous combustion characteristics of the proposed REA waste materials and the existing physical and chemical baseline status of the shallow regional groundwater up and down gradient of the current REA.

1.3 Authority Requirements

As part of the preparation of the AMD and Spontaneous Combustion Assessment for the Project consideration was given to the requirements of the Director General of the Department of Planning and Infrastructure (DoPI) and correspondance from the NSW Environment Protection Authority (EPA) including any key issues identified by these authorities.

The Director General's Requirements include:

Land Resources – including a detailed assessment of the potential impacts on:

- soils and land capability (including contamination);

The EPA matters for consideration include:

> *3.4 Groundwater Assessment of the Coal Wash Emplacement Area*
>
> *The EPA recommends that a ground water impact assessment should be undertaken in relation to the existing and any expansion of the Coal Wash Emplacement Area. Such an assessment will examine any impacts from existing emplacement methods to ensure any identified values of the groundwater are protected. This should include information on the hydrogeological conditions of the area, any existing groundwater quality data, groundwater monitoring data undertaken at the emplacement area and the proximity of any sensitive groundwater resources. The outcomes of this assessment will inform any need to change future emplacement methods.*

2. GEOLOGY AND HYDROGEOLOGY

Tahmoor Mine is situated at the southern end of the Permo-Triassic Sydney Basin in the Illawarra Coal Measures, which have four workable seams, with the uppermost being the currently mined Bulli Seam.

The REA contains reject material from the Tahmoor Mine CHPP and comprises washed rejects from the product Bulli Coal seam, as well as roof and floor material that was extracted with the coal.

The material that will be placed at the REA from the proposed Tahmoor South Bulli seam extraction will have the same geological, lithological and geochemical characteristics as the material from the current Tahmoor Mine operations.

In the vicinity of the REA, the underlying Hawkesbury Sandstone is exposed at surface. It, in turn, is underlain by a generic sequence of;

- Newport and Garie Formations;
- Bald Hill Claystone;
- Bulgo Sandstone;
- Stanwell Park Claystone;
- Scarborough Sandstone;
- Wombarra Claystone, and;
- the roof of the Bulli Seam which lies at approximately 364 - 440mbgl for the sampled bores.

The Hawkesbury Sandstone consists of fine to medium grain flat bedded sands, medium to coarse sands and minor shale that are highly localised and variable across the area. Finer grained siltstone and shale facies are likely to be present within the sandstone that would form vertical flow barriers under the plateau.

The Hawkesbury Sandstone in the vicinity of the REA extends to approximately 175m below surface.

There are no known mapped or inferred regional scale geological structures in the REA vicinity.

Groundwater flows from the REA toward the Bargo River gorge in the north under a regional hydraulic gradient with dominantly horizontal confined flow along discrete discontinuities and fractures within bedding planes, and / or above fine grained, relatively impermeable strata within the Hawkesbury Sandstone.

2.1 REA Piezometer Construction

Drilling and installation of two open standpipe piezometers, as well as groundwater level and water chemistry monitoring were conducted in the vicinity of the REA during June and July 2013.

The work was conducted to enable assessment of the hydrogeological characteristics of the Hawkesbury Sandstone and its upper phreatic groundwater surface upstream and downstream of the REA as shown in **Figure 2**.

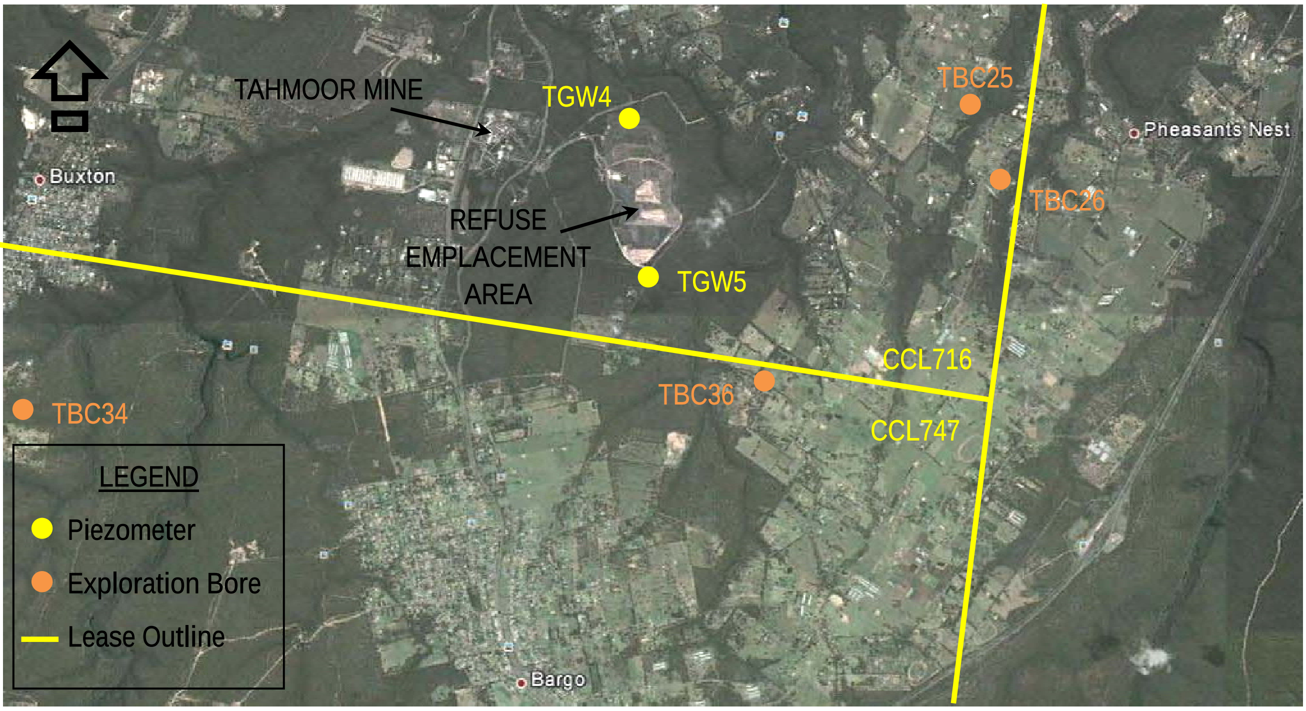

Figure 2 **Exploration and Piezometer Bore Locations**

Test monitoring bore licences supplied by the NSW Office of Water (NOW) are shown in **Table 1**, whilst geological logs and piezometer construction details are shown in **Appendix A**.

Table 1 **Piezometer Licencing**

Piezometer	Bore Licence No.	Issued
TGW4	10BL605341	27/02/2013
TGW5	10BL605341	27/02/2013

2.1.1 Standing Water levels

Standing water levels in the REA piezometers TGW4 and TGW5 have been measured in the vicinity of the REA since July 2013 as shown in **Table 2**, as well as other available open private bores and Tahmoor Coal installed piezometers across the Tahmoor South Project Area since April 2013 as shown in **Figure 3**.

Table 2 **Piezometer Details**

Piezometer	East (MGA)	North (MGA)	Total Depth (mbgl)	Piezometer Intake (mbgl)	Standing Water Level (mbgl)
TGW4	278362	6207827	54.85	50.85 – 54.85	39.89
TGW5	278446	6206332	54.45	50.45 – 54.45	31.15

Monitoring of open standpipe bores and Tahmoor Coal piezometers in the Tahmoor South Project Area in July 2013 indicates a generic flow to the north east at a gradient of 0.017.

A suite of vibrating wire piezometers have also been installed by Tahmoor Coal within the Tahmoor South Project and Tahmoor North mining areas, however details and results from them are not discussed further here.

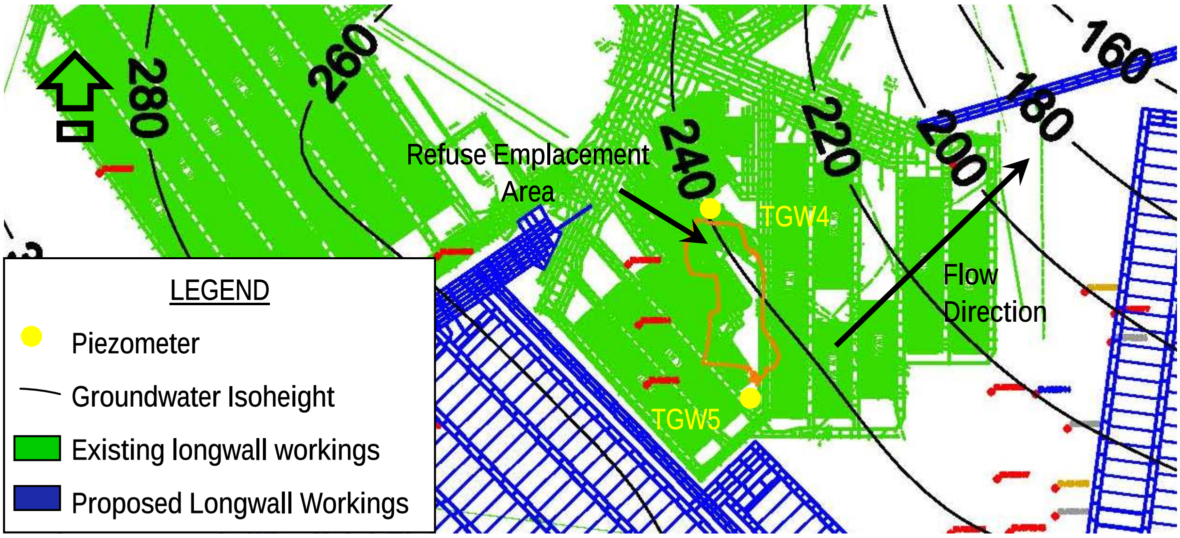

Figure 3 REA Groundwater Phreatic Surface

3. SAMPLE SELECTION, PREPARATION AND ANALYSIS

3.1 AMD

Four laboratory generated / simulated washery reject samples were sourced from the Tahmoor South Project Area exploration drillholes, TBC25, TBC26, TBC34 and TBC36, as shown in **Table 3** and outlined on Figure 2.

Cores of the product coal from the Bulli Seam and the immediate roof and floor had been removed for metallurgical / washability analysis prior to the AMD / spontaneous combustion sampling process. As such, the presence or absence of pyrite in the seam and adjoining lithologies could not be assessed.

The samples were used to represent material that could be reject material from the CHPP.

Table 3 Tahmoor South Exploration Bore Locations

Hole	Easting	Northing	Bulli Seam Roof Depth (mbgl)
TBC25	281343	6208003	440
TBC26	281603	6207068	431.66
TBC34	272956	6205076	363.90
TBC36	279622	6205307	418.96

A split of the drill core based REA samples were tested for $pH_{1:2}$ and electrical conductivity ($EC_{1:2}$) with de-ionised water extracts using a one solid to two part water ratio (volume / volume) at the Geoterra Pty Ltd laboratory. The $pH_{1:2}$ and $EC_{1:2}$ tests were conducted by equilibrating the sample in deionised water for a minimum of 1 month to provide an indication of the potential leachate acidity and salinity.

A split of the simulated REA reject samples were despatched to Sydney Analytical Laboratories Pty Ltd and the Environmental Analysis Laboratory (EAL) at Southern Cross University for laboratory analysis of;

- total sulfur (TS) by the Leco method;
- chromium reducible sulfur (CrS) where total sulfur >0.05%, to differentiate between pyritic acid forming sulfur and non-acid forming sulfate species, and;
- acid neutralising capacity (ANC).

The net acid production potential (NAPP) was then calculated using the ANC / TS and the ANC / CrS.

Based on the non acid generating results from the NAPP assessment, there was no further requirement for testing via the extended boil Net Acid Generation (NAG) or the calculated NAG analysis using the sulfur, calcium, magnesium, sodium, potassium and chloride concentrations in the NAG leachate.

A flow chart of the AMD assessment process is shown in **Figure 4**.

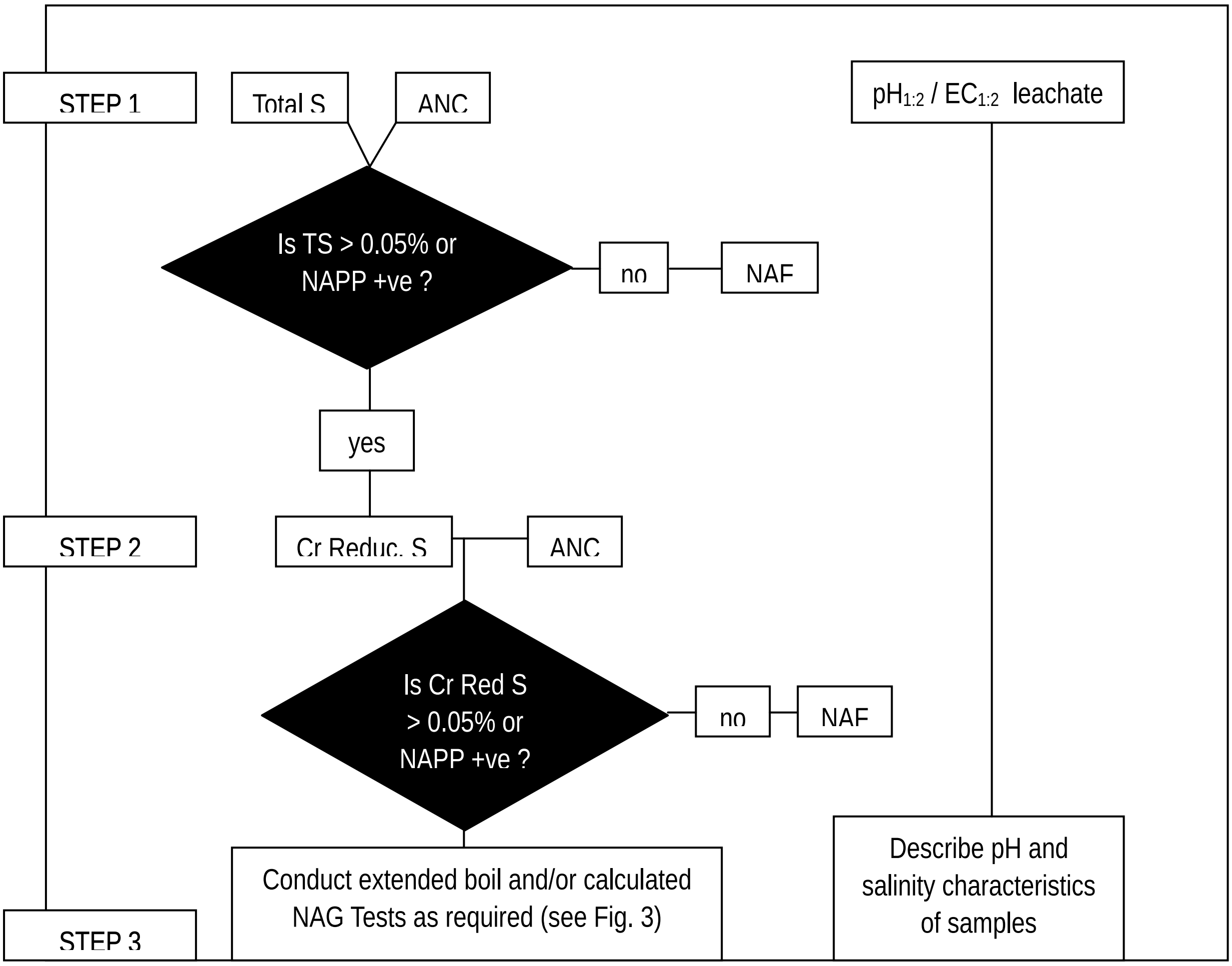

Figure 4 Initial Screening Test Protocol

The Geoterra generated REA leachate samples were analysed for pH, total dissolved solids (TDS), sulfate and selected metals.

Sydney Analytical Laboratories conducted the Leco total sulfur on the simulated reject solids, along with the dissolved solids (TDS), sulfate, total / filtered iron and manganese and filtered selected metals on the 1:2 ratio leachates.

The chromium reducible sulfur analyses were conducted by MPL Laboratories.

Chromium reducible sulfur analysis was conducted by EAL Pty Ltd.

All laboratory work and data analysis was conducted according to procedures outlined in the Australian Coal Association Research Project C15034 (Environmental Geochemistry International et al, 2008) as well as (AMIRA, 2002) and (Price, W.A, 2009).

The laboratory and data interpretation procedures used in this assessment are outlined in **Appendix B**.

3.2 REA Piezometer and Surface Runoff

Two groundwater (up / down gradient) samples were sourced from piezometers installed adjacent to the REA as shown in **Table 4**, whilst four REA surface leachate sample sites were used to monitor runoff originating from the existing REA as shown in **Table 5**.

Table 4 Refuse Emplacement Area Piezometers

Hole	Easting	Northing	SWL (mbgl)	Intake (mbgl)	Lithology
TGW4	278362	6207827	39.92	50.75 – 54.75	Hawkesbury Sandstone
TGW5	278446	6206332	31.08	50.5 – 54.5	Hawkesbury Sandstone

Table 5 Refuse Area Emplacement Leachate Monitoring Locations

Hole	Description
Culvert	Drainage culvert east of REA
S7A	Settling dam east of REA (upstream of S7)
S7	Settling dam east of REA
S9	Tea Tree Creek discharge dam from REA

The piezometer and surface runoff samples were used to represent leachate that is being generated from the existing REA.

The groundwater and REA leachate samples were monitored for pH and EC by calibrated, hand held meters in the Geoterra laboratory, whilst total dissolved solids (TDS), sulfate, nutrients and selected metals were analysed by Sydney Analytical Laboratories as summarised in **Appendix C**.

3.1 Spontaneous Combustion

A split of the four laboratory generated / simulated washery reject samples sourced from the Tahmoor South Project exploration drillholes were composited to form a 500g sample and analysed for its Adiabatic Self Heating Test potential at the ALS – Coal Division laboratory.

The laboratory and data interpretation procedures used in this assessment are outlined in **Appendix B**.

4. ACID AND METALLIFEROUS DRAINAGE RESULTS

4.1 Acid Neutralisation Capacity

The acid neutralisation capacity (ANC) of the three tested samples indicate a relatively low to moderate value of 1.04 – 3.61% $CaCO_3$ (which is equivalent to 10.4 – 36.1kg H_2SO_4/t).

4.2 Sulfur

Total sulfur (TS) in the samples ranged from 0.017 - 0.022%, with no samples exceeding 0.05% total sulfur.

For the sulfide sulfur tests, as represented by chromium reducible sulfur (S_{Cr}) analysis, the sulfur content of all samples was 0.01%.

A plot of total and sulfide sulfur against ANC indicates the samples have a non – acid forming characteristic as shown in **Figure 5**.

The sulfide sulfur assessment is a better representative of what sulfuric acid based runoff could occur from the tailings, as the total sulfur based values also include the oxidised sulfate and organic forms of sulfur, which do not form sulfuric acid.

The NAPPusing total sulfur ranged from -10 to -35kg H_2SO_4/t, and for chromium reducible sulfide sulfur it ranged from -36 to -11kg H_2SO_4/t, which are both acid consuming results.

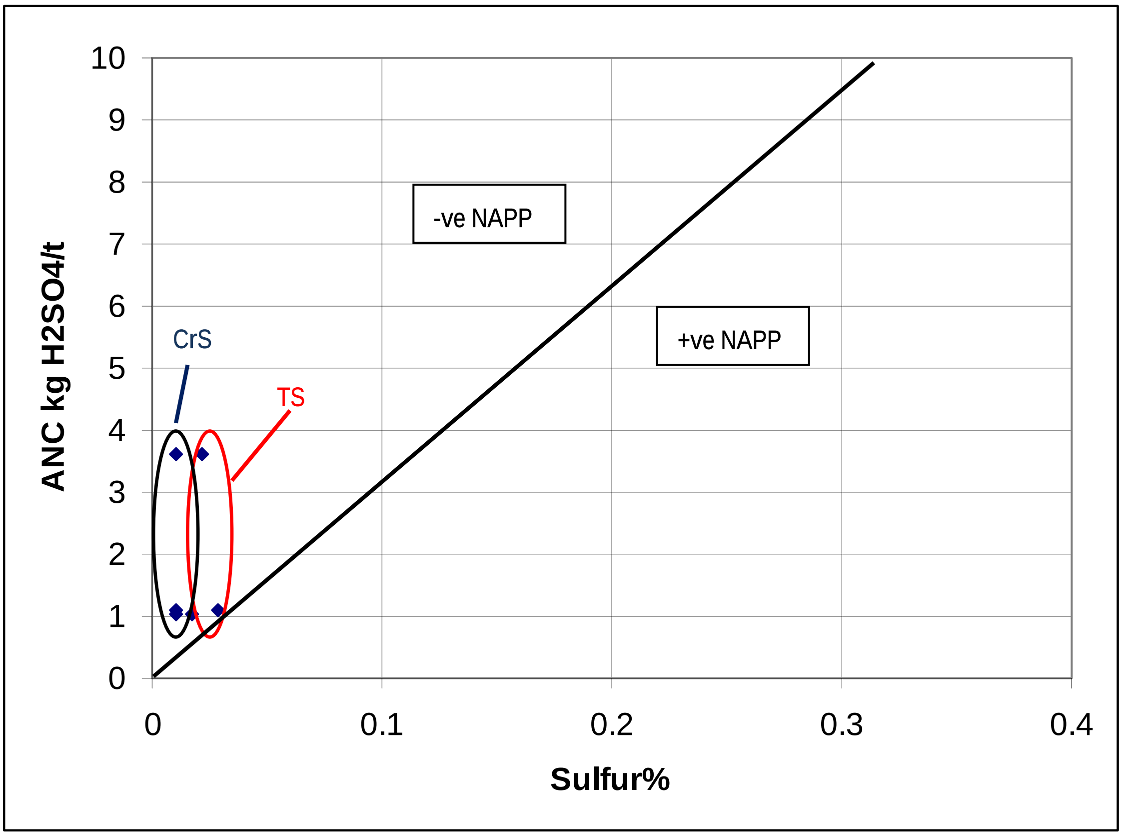

Figure 5 Total Sulfur and Sulfide Sulfur Acid Base Account

As a result of the non-acid forming characteristics of the samples, no further analytical work was warranted, such as extended boil NAG or calculated NAG testwork.

Due to the low acid neutralisation capacity (ANC) values, and, as a result, their low buffering potential, acid buffering characteristic curve (ABCC) testing was not conducted on the samples.

4.3 AMD Classification

Analysis of the potential rejects from the CHPP after extraction of the Bulli Seam at Tahmoor South indicate that the REA should be non-acid forming due to the very low chromium reducible sulfur levels (ie low pyrite), with sulfur not exceeding 0.01% chromium reducible S in all samples.

The ANC of the material is also low to moderate.

It is not anticipated that these materials will result in AMD.

5. WATER CHEMISTRY ANALYSIS RESULTS

5.1 Batch Leachate (1:2)

5.1.1 pH and Salinity

After five weeks of leaching with the 1:2 solid:water batch leach sample preparations, the pH ranged from 7.49 – 7.97 for the prepared CHPP reject samples.

The batch leach conductivities ranged from 592 – 676 µS/cm.

The four combined CHPP reject batch leach samples indicated a pH of 8.40 and salinity of 721µS/cm, as shown in **Table 6**.

These results indicates there is no potential acid generation and a low potential salinity for the proposed Tahmoor South CHPP rejects

Table 6 (1:2) Batch Leachate pH and Salinity

Sample	Test Start	Test Finish	pH	EC (µS/cm)
TBC25 / 26	10/5/2013	18/6/2013	7.97	632
TBC34	10/5/2013	18/6/2013	7.79	676
TBC36	10/5/2013	18/6/2013	7.49	592
TBC25/26/34/36	18/6/2013	5/7/2013	8.40	721

5.1.1 Major Ions and Metals

The four representative CHPP reject 1:2 batch leachate samples were combined into one composite sample that was analysed as shown in **Table 7** and compared against the ANZECC/ARMCANZ (2000) trigger values for freshwater upland streams and protection of 95% of aquatic species.

The composite leachate had results generally below the threshold ANZECC/ARMCANZ (2000) trigger values for freshwater upland streams and protection of 95% of aquatic species as summarised in **Table 7**, with the exception of exceedances for pH, TDS, Cu and total nitrogen.

Table 7 (1:2) Batch Leachate (Major Metals and Nutrients)

ANALYTE	ANZECC / ARMCANZ 2000	Units	TBC25 / 26 / 34 / 36
pH	6.5 – 7.5	_	**8.40**
TDS	350	mg/L	**440**
SO4	_	mg/L	30
Al (filt)	0.055 (for pH>6.5)	mg/L	0.04
As (filt)	0.024 (As III)	mg/L	<0.01
Cu (filt)	0.0014	mg/L	**0.004**
Fe (total)	_	mg/L	0.11
Fe (filt)	_	mg/L	0.01
Pb (filt)	0.0034	mg/L	<0.001
Mn (total)	1.9	mg/L	<0.01
Mn (filt)	1.9	mg/L	<0.01
Ni (filt)	0.001	mg/L	<0.01
Zn (filt)	0.008	mg/L	0.007
Total Phosphorous	0.02	mg/L	0.01
Total Nitrogen	0.25	mg/L	**6.6**

NOTE: ANZECC/ARMCANZ (2000) trigger values For Protection of 95% of Aquatic Freshwater Species and Trigger Values For Physical and Chemical Stressors for SE Australian Upland Streams

5.2 REA Surface Runoff

5.2.1 pH and Salinity

The REA surface runoff leachate pH ranged from 7.56 – 8.51, whilst the conductivities ranged from 1420 - 2820µS/cm as shown in **Table 8**.

The sample sites from upstream to downstream of the REA are sequentially, the culvert, followed by S7A, S7 then S9.

These results indicates the batch leach tests for the proposed Tahmoor South Bulli seam CHPP rejects are relatively equivalent to the current REA leachate pH whilst the proposed Tahmoor South salinity (EC) is under-estimated in comparison to the current REA leachate.

The results from the existing REA indicate an alkaline runoff with low to moderate salinty from the current Tahmoor Mine CHPP rejects.

Table 8 Reject Emplacement Area Surface Runoff (pH and Salinity)

Sample	Sample Date	pH	EC (µS/cm)
Culvert	20/3 & 17/7/2013	7.67 / 8.51	2270 / 2820
S7A	20/3/2013	7.56	1495
S7	20/3/2013	8.43	1706
S9	20/3/2013	8.29	1420

5.2.1 Major Ions and Metals

The four REA runoff were compared to the ANZECC/ARMCANZ (2000) trigger values for freshwater upland streams and protection of 95% of aquatic species as summarised in **Table 9**, which found exceedances for pH, salinity (as measured by TDS) Cu, Pb, Zn, Ni and total nitrogen.

It is noted that the REA runoff water, including water reporting to the culvert, S7A, S7 and S9, is discharged from the existing LDP1 EPA licenced discharge point, with runoff water pumped via the existing water management system to LDP1. It is also noted that Tahmoor Mine is implementing a new water treatment plant designed to remove heavy metals from the mine water discharge at LDP1, as required by the existing PRP22 conditioned in Tahmoor Mine's EPA Licence EPL1389.

Table 9 Reject Emplacement Area Surface Runoff (Major Metals)

ANALYTE	ANZECC / ARMCANZ 2000	Units	Culvert 20/3/13	Culvert 17/7/13	S7A	S7	S9
pH	6.5 – 7.5	_	**7.67**	**8.51**	**7.56**	**8.43**	**8.29**
Total Dissolved Solids	350	mg/L	**2250**	**1910**	**1310**	**1030**	**940**
SO4	_	mg/L	12	10	9	9	43
Al (filt)	0.055 (for pH>6.5)	mg/L	0.02	0.04	0.02	0.03	0.03
As (filt)	0.024 (As III)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Cu (filt)	0.0014	mg/L	**0.003**	**0.006**	<0.001	**0.002**	<0.001
Fe (total)	_	mg/L	0.06	0.26	0.18	0.08	0.06
Fe (filt)	_	mg/L	0.03	0.17	0.04	0.05	0.04
Pb (filt)	0.0034	mg/L	0.002	**0.004**	<0.001	<0.001	<0.001
Mn (total)	1.9	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Mn (filt)	1.9	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Ni (filt)	0.001	mg/L	**0.03**	<0.01	**0.03**	**0.02**	**0.01**
Zn (filt)	0.008	mg/L	**0.022**	**0.015**	0.006	0.007	0.006
Total Phosphorous	0.02	mg/L	0.01	<0.01	**0.03**	**0.03**	**0.04**
Total Nitrogen	0.25	mg/L	**190**	**120**	**2.6**	**19**	**6.1**

NOTE: ANZECC/ARMCANZ (2000) trigger values For Protection of 95% of Aquatic Freshwater Species and Trigger Values For Physical and Chemical Stressors for SE Australian Upland Streams

5.3 REA Piezometers

5.3.1 pH and Salinity

Groundwater in the vicinity of the REA from piezometers completed within the Hawkesbury Sandstone indicate a pH range from 6.45 (up gradient) to 6.59 (down gradient), whilst the conductivities range from 2350µS/cm (upgradient) to 612µS/cm (downgradient) as shown in **Table 10**.

Table 10 Refuse Emplacement Area Piezometer pH and Salinity

Piezometer	Location	Sample Date	pH	EC (µS/cm)
TGW4	Down gradient of REA	17/7/2013	6.59	612
TGW5	Up gradient of REA	17/7/2013	6.45	2350

The results do not indicate any trend or definitive influence from the current Tahmoor Mine CHPP rejects within the REA with groundwater flow down gradient, as they have circum – neutral pH and low to moderate salinities.

The observations indicate that the pH remains similar, whilst the salinity is actually lower in the down gradient piezometer, which is in line with the natural variation seen within the Tahmoor / Thirlmere area in the Hawkesbury Sandstone (Geoterra, in prep).

5.3.1 Major Ions and Metals

The groundwater were compared to the ANZECC/ARMCANZ (2000) trigger values for freshwater upland streams and protection of 95% of aquatic species as summarised in **Table 11**, which showed that the results had exceedances including pH, TDS, Cu, Mn, Ni, Zn, total phosphorous and total nitrogen.

It should be noted that the above exceedances are also observed in groundwater within the Bargo / Pheasants Nest / Thirlmere / Tahmoor area (Geoterra 2013, 2013A) and do not represent a specific influence from REA leachate.

Table 11 Reject Emplacement Area Piezoemeters (Major Ions and Metals)

Seam	ANZECC / ARMCANZ 2000	Units	TGW5 (Upstm)	TGW4 (Dwnstm)
pH	6.5 – 7.5	_	**6.45**	**6.59**
TDS	350	mg/L	**1250**	**340**
SO4	_	mg/L	49	18
Al (filt)	0.055 (for pH>6.5)	mg/L	0.03	0.03
As (filt)	0.024 (As III)	mg/L	<0.01	<0.01
Cu (filt)	0.0014	mg/L	**0.003**	**0.003**
Fe (total)	_	mg/L	12.0	7.8
Fe (filt)	_	mg/L	7.7	0.35
Pb (filt)	0.0034	mg/L	<0.001	<0.001
Mn (total)	1.9	mg/L	**2.5**	**2.0**
Mn (filt)	1.9	mg/L	**2.4**	**2.0**
Ni (filt)	0.001	mg/L	**0.07**	**0.07**
Zn (filt)	0.008	mg/L	**0.62**	**0.30**
Total Phosphorous	0.02	mg/L	**0.24**	**0.19**
Total Nitrogen	0.25	mg/L	**1.6**	**1.3**

NOTE: ANZECC/ARMCANZ (2000) trigger values For Protection of 95% of Aquatic Freshwater Species and Trigger Values For Physical and Chemical Stressors for SE Australian Upland Streams

6. SPONTANEOUS COMBUSTION ANALYSIS RESULTS

The Adiabatic Self-Heating Test conducted on the TBC25 / 26 / 34 / 36 composite sample of the Proposed Tahmoor South Bulli seam rejects indicates that the rate of self-heating from 40 - 70°C (R70) was 0.003°C/hr.

The data indicates that spontaneous combustion of the carbonaceous material is unlikely as shown in **Appendix C**.

7. DISCUSSION

7.1 Acid and Metalliferous Drainage

Economic coal from the Bulli Seam and its associated carbonaceous lithologies will be mined, washed in the CHPP and sold as product coal, with the waste material placed in the REA.

As the pH and salinity results are derived from pulverised samples, where the surface area in contact with water is potentially greater than at a typical reject emplacement area, and anticipating that further dilution from rainfall infiltration is likely in the field, the laboratory based results are likely to represent a “worst case” scenario.

The final field seepage water quality will be affected by an as yet undefined and ongoing rainwater runoff and seepage dilution rate.

On this basis, and in view of the circum neutral to alkaline pH and the low to moderate salinity results obatained in the field and laboratory testwork, the risk of acidic or saline runoff and seepage from placement of Tahmoor South CHPP rejects at the REA is anticipated to be low.

Results to date indicate the Bulli Seam and its associated roof and floor lithologies have a median (sulfide) sulfur level of 0.01%, and low to moderate acid neutralising capacity of 1.04 – 3.61 % CaCO3, with an overall low risk of AMD generation.

The AMD test results indicate that all of the utilised Tahmoor South samples are NON ACID FORMING, which is supported by the observations of no acidic leachate in the surface runoff or groundwater in the vicinity of the current REA.

The pH was alkaline for the batch leach (1:2) tested samples (7.49 – 8.40), whilst the current REA site runoff was similarly alkaline (7.56 – 8.51).

The REA groundwater became slightly more alkaline with downgradient flow from 6.45 – 6.59 with passgae under the REA.

Salinity is low for the batch leach (1:2) tested samples (632 - 721µS/cm), whilst the current REA site runoff was low to moderate, and reduced with flow downstream, from 2820 - 1420µS/cm.

The REA groundwater salinity reduced with downgradient flow from 2350 - 612µS/cm, and showed no trend of increased salinity with passage under the REA.

The (1:2) batch leach tests indicated that pH, as well as TDS, Cu and total nitrogen may exceed the ANZECC/ARMCANZ (2000) upland stream or 95% protection of aquatic species trigger values. However, the current REA runoff exceeds the same criteria for pH, total dissolved solids (TDS) as well as Cu, Ni, Zn and total nitrogen.

This indicates the 1:2 leachate test may under estimate the potential REA leachate quality as the laboratory test uses a representative core drilling based sample, whilst the actual

REA emplacement incorporates a larger range of lithologies and may involve less dilution than used in the batch leach test.

The laboratory tests represent pore water chemistry from pulverised samples, whilst the coarse rock waste emplacement will contain grain sizes up to large rocks, with a resultant lesser interaction with leachate passing through the material.

On this basis, leachate discharging from the overburden is likely to contain low concentrations of dissolved metals with a slightly alkaline pH.

Past experience with similar waste emplacements and similar AMD characteristics indicates that dilution from rainfall infiltration and surface runoff mixing are likely to occur in the field, and as a result, the "field" dissolved metal concentration (as opposed to laboratory test results) in discharge from the overburden are unlikely to present significant bulk discharge surface water quality environmental issues.

7.2 Spontaneous Combustion

Spontaneous combustion is the process of self-heating coal and carboniferous reject material stockpiles by oxidation. On exposure to air, coal undergoes a continuous oxidizing reaction. A hazard exists when the rate of heat production by this exothermic reaction exceeds the rate of cooling, produced mainly by the convective effects of air. The coal can then increase in temperature until combustion takes place.

The actual spontaneous combustion process is complex and subject to a number of influencing factors, including gas and water content, particle size, secondary mineralisation and attendant leakage paths, oxygen supply and the rate of exposure of the coal to oxygen and convection cooling.

It is generally observed that;

- reshaping batters allows the movement of air over the surface rather than penetrating through the unshaped steep batters into rock voids and lowers the likelihood of spontaneous combustion outbreaks.
- compaction can assist in controlling and managing spontaneous combustion as areas that experience higher compaction, such as roads, exhibit less spontaneous combustion than batter areas.

Monitoring of the existing REA, as it has been sequentially constructed, shaped and revegetated since the early 1980's, indicates there has been no observed occurrence of spontaneous combustion.

This observation supports the laboratory test results that the occurrence of spontaneous combustion from CHPP rejects from the proposed Bulli Seam extraction at Tahmoor South is unlikely.

8. CONCLUSIONS

Based on field and laboratory data from studies of both the potential and existing REA materials, it is not anticipated that there will be any significant observable;

- Acid mine drainage;
- Metalliferous discharge;
- Elevated salinity, or;
- Spontaneous combustion;

associated with the proposed placement of Tahmoor South Bulli Seam waste material on the proposed extension to the REA.

All tested samples were classified as Non Acid Forming and had a low spontaneous combustion potential.

The REA is not anticipated to generate AMD assuming typical residence times and reaction rates, and therefore, provision for capture of runoff/leachate, monitoring and lime treatment associated with the REA is not anticipated.

9. RECOMMENDATIONS

9.1 Acid Mine Drainage

No specific waste management handling, storage or testing procedures are considered to be required in regard to AMD management, although additional ongoing AMD testing during the REA construction process could be used, if required.

A program of routine water quality sampling and testing of runoff (as is currently conducted by Tahmoor Mine) should be continued during active placement at the REA to monitor any variation in AMD.

Routine site water quality monitoring programmes should include pH, EC, acidity/alkalinity, sulfate, Al, As, Co, Cu, Fe, Mn, Ni and Zn to monitor for any effects of pyrite oxidation and AMD generation.

9.2 Spontaneous Combustion

No specific waste management handling, storage or testing procedures are considered to be required in regard to spontaneous combustion management, although Adiabatic Self Heating test work could be conducted, if required, during the REA construction process.

The REA should undergo regular visual inspections for the presence of spontaneous combustion, with the inspections observing the stockpiles for any visible signs of smoke or any other obvious signs of heat production.

10. REFERENCES

AMIRA International, 2002. AMD Test Handbook, Project P387A. Prediction & Kinetic Control of Acid and Metalliferous Drainage.

ANZECC/ARMCANZ, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand. Canberra, ACT.

Environmental Geochemistry International, Levay and Co. Environmental Services & ACeSSS – University of South Australia, 2008 Australian Coal Association Research Program Project C15034, Development of AMD Assessment for Coal Process Wastes.

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Price, W. A., 2009. Prediction Manual for Drainage Chemistry From Sulfidic Geologic Materials, MEND Report 1.20.1, CANMET Mining and Mineral Sciences Laboratories.

LIMITATIONS

This report was prepared in accordance with the scope of services set out in the contract between Geoterra Pty Ltd (Geoterra) and the client, or where no contract has been finalised, the proposal agreed to by the client. To the best of our knowledge the report presented herein accurately reflects the client’s requirements when it was printed. However, the application of conditions of approval or impacts of unanticipated future events could modify the outcomes described in this document.

In preparing this report, Geoterra has relied upon information and documentation provided by the client and / or third parties. Geoterra did not attempt to independently verify the accuracy or completeness of that information. To the extent that the conclusions and recommendations in this report are based in whole or in part on such information, they are contingent on its validity. Geoterra assume the client will make their own enquiries in regard to conclusions and recommendations made in this document. Geoterra accept no responsibility for any consequences arising from any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to Geoterra.

The findings contained in this report are the result of discrete / specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site in question. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points.

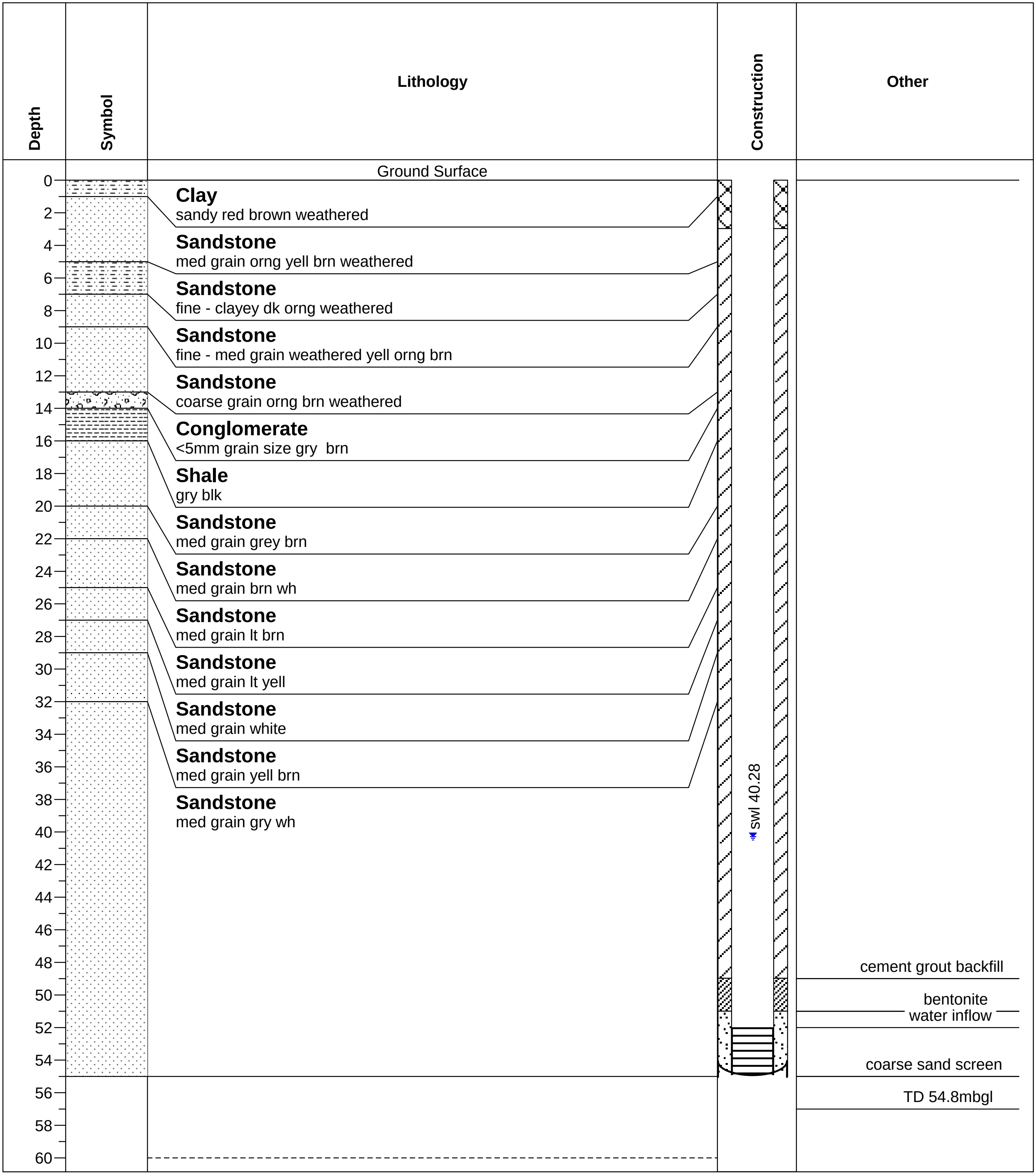
Interpretations and recommendations provided in this report are opinions provided for our Client’s sole use in accordance with the specified brief. As such they do not necessarily address all aspects of water, soil or rock conditions on the subject site. The responsibility of Geoterra is solely to its client and it is not intended that this report be relied upon by any third party. This report shall not be reproduced either wholly or in part without the prior written consent of Geoterra.

APPENDIX A

REA PIEZOMETER DRILL LOGS

GeoTerra

Bore / Piezo: TGW4 **Page 1 of 1**
Project: Tahmoor South
Location: REA (downgradient)
Coordinates: E 278363 **N 6207827**
Project Number: BAR3
Datum: **Elevation: 276.7**
Logged By: A Dawkins



Clay
sandy red brown weathered

Sandstone
med grain orng yell brn weathered

Sandstone
fine - clayey dk orng weathered

Sandstone
fine - med grain weathered yell orng brn

Sandstone
coarse grain orng brn weathered

Conglomerate
<5mm grain size gry brn

Shale
gry blk

Sandstone
med grain grey brn

Sandstone
med grain brn wh

Sandstone
med grain lt brn

Sandstone
med grain lt yell

Sandstone
med grain white

Sandstone
med grain yell brn

Sandstone
med grain gry wh

Driller: Macquarie Drilling
Drilling Method: Open hole hammer
Drilling Equipment:
Drilling Start: July 2013
Drilling Finish: July 2013

Bore / Piezo: TGW5 **Page 1 of 1**

Project: Tahmoor South

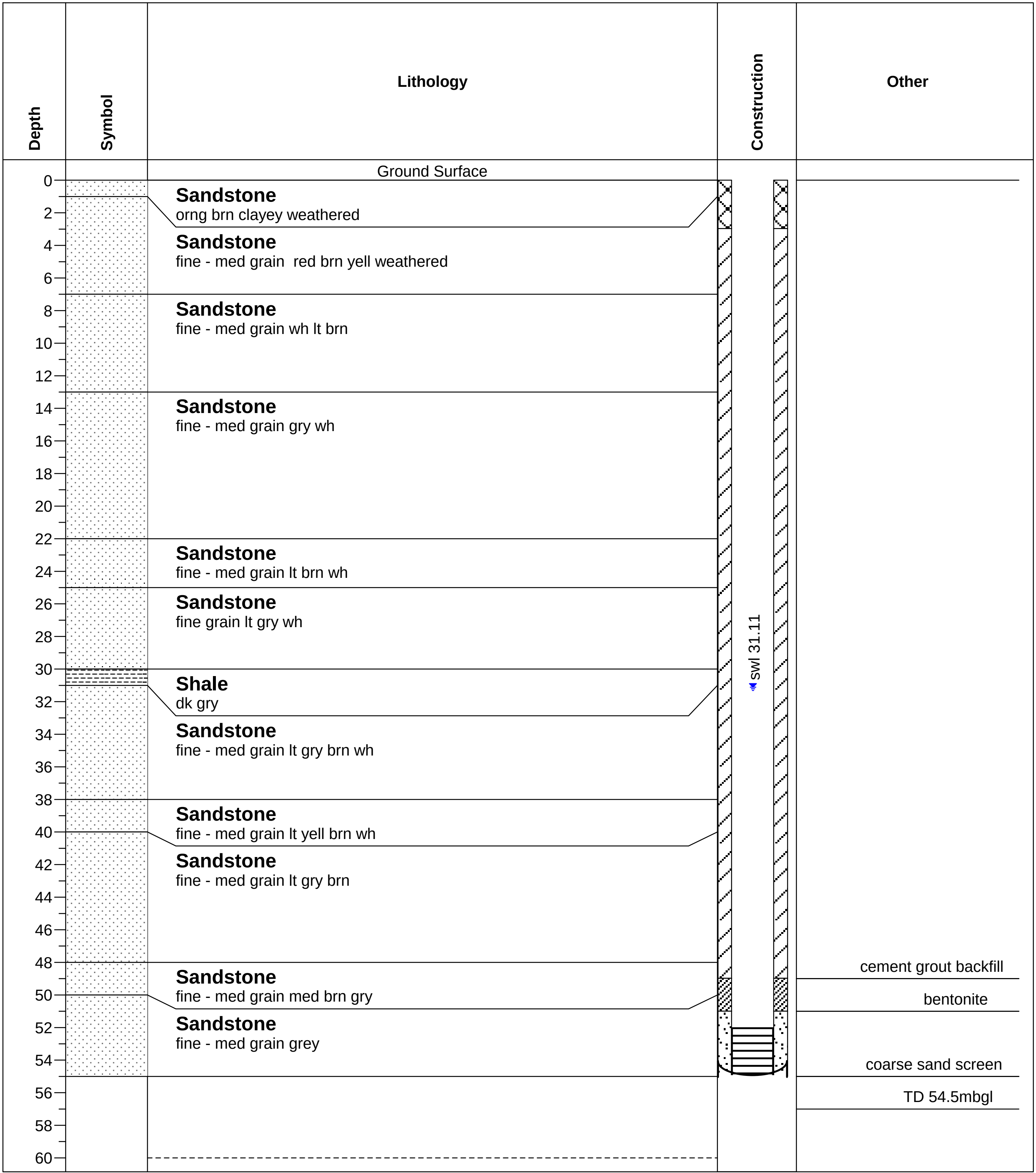
Location: REA (upgradient)

Coordinates: **E 278446** **N 6206332**

Project Number: BAR3

Datum: **Elevation: 285.6**

Logged By: A Dawkins



Sandstone
orng brn clayey weathered

Sandstone
fine - med grain red brn yell weathered

Sandstone
fine - med grain wh lt brn

Sandstone
fine - med grain gry wh

Sandstone
fine - med grain lt brn wh

Sandstone
fine grain lt gry wh

Shale
dk gry

Sandstone
fine - med grain lt gry brn wh

Sandstone
fine - med grain lt yell brn wh

Sandstone
fine - med grain lt gry brn

Sandstone
fine - med grain med brn gry

Sandstone
fine - med grain grey

cement grout backfill

bentonite

coarse sand screen

TD 54.5mbgl

Driller: Macquarie Drilling

Drilling Method: Open hole hammer

Drilling Equipment:

Drilling Start: July 2013

Drilling Finish: July 2013

APPENDIX B

AMD AND SPONTANEOUS COMBUSTION LABORATORY PROCEDURES

ACID AND METALLIFEROUS DRAINAGE (AMD)

DESCRIPTION OF TEST AND ANALYSIS METHODS

Acid and metalliferous drainage (AMD) is produced by the exposure of sulfide minerals, such as pyrite, to atmospheric oxygen and water.

The ability to identify waste rock, tailings, as well as pit wall and floor materials that could potentially produce AMD is essential to effectively implement mine waste management strategies.

An outline of methods used to assess and classify mine waste materials is described below.

ACID BASE ACCOUNT

The acid-base account involves static laboratory procedures that evaluate the balance between acid generation processes from oxidation of sulfide minerals, and acid neutralising processes, such as dissolution of alkaline carbonates', displacement of exchangeable bases and weathering of silicates.

The results from an acid-base account are referred to as the potential acidity and the acid neutralising capacity.

The difference between the potential acidity and the acid neutralising capacity is referred to as the net acid producing potential (NAPP).

The chemical and theoretical basis of the ABA are discussed below.

Maximum Potential Acidity

The potential acidity that can be generated by a sample is calculated from an estimate of the pyrite (FeS_2) content and assumes that the pyrite reacts under oxidising conditions to generate acid according to the following reaction:

$FeS_2 + 15/40^{2+}\ 7/2\ H_20 \Rightarrow Fe(OH)_3 + 2H_2SO_4$

Based on the above reaction, the potential acidity of a sample containing 1 %S (as pyrite) would generaste 30.6 kilograms of H2SO4 per tonne of material (i.e. kg H_2SO_4/t)

The pyrite content estimate can be based on total S and the potential.acidity determined from total S is referred to as the maximum potential acidity (MPA), and is calculated as follows:

MPA (kg H_2SO_4/t) = (Total %S) x 30.6

The use of an MPA calculated from total sulphur is a conservative approach because some sulphur may occur in forms other than pyrite. .

Sulfate-sulphur, organic sulphur and native sulphur, for example, are non-acid generating sulphur forms.

Also, some sulphur may occur as other metal sulfides (e.g. covellite, chalcocite, sphalerite, galena) which yield less acidity than pyrite when oxidised or, in some cases, may be non-acid generating.

The total sulphur content is commonly used to assess potential acidity because of the difficulty, costs and uncertainty involved in routinely determining the speciation of sulphur forms within samples, and determining reactive sulfide-sulphur contents.

However, if the sulfide mineral forms are known then allowance can be made for non- and lesser acid generating forms to provide a better estimate of the potential acidity.

To better define the potential for sulfide minerals to generate AMD, once Total S "screening" has been done, and to exclude the measurement of oxidised sulfur species (sulfates) which generally do not generate acid on dissolution, (except for jarosite) an assessment of the total sulfide S can also be conducted via the Chromium Reducible Sulfur analytical method..

Acid Neutralising Capacity (ANC)

The, acid formed from pyrite oxidation will to some extent react with acid neutralising minerals contained within the sample. This inherent acid buffering is quantified in terms of the ANC.

The ANC is commonly determined by the Modified Sobek method. This method involves the addition of a known amount of standardised hydrochloric acid (HCl) to an accurately weighed sample, allowing the sample time to react (with heating), then back-titrating the mixture with standardised sodium hydroxide (NaOH) to determine the amount of unreacted HCL

The amount of acid consumed by reaction with the sample is then calculated and expressed in the same units as the MPA (kg H_2SO_4/t).

Net Acid Producing Potential (NAPP)

The NAPP is a theoretical calculation commonly used to indicate if a material has potential to produce acidic drainage. It represents the balance between the capacity of a sample to generate acid (MPA) and its capacity to neutralise acid (ANC). The NAPP is also expressed in units of kg H_2SO_4/t and is calculated as follows:

NAPP = MPA - ANC

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

ANC / MPA Ratio

The ANC/MPA ratio is frequently used as a means of assessing the risk of acid generation from mine waste materials. The ANC/MPA ratio is another way of looking at the acid base account.

A positive NAPP is equivalent to an ANC/MPA ratio less than 1, and a negative NAPP is equivalent to an ANC/MPA ratio greater than 1. A NAPP of zero is equivalent to an ANC/MPA ratio of 1.

The purpose of the ANC/MPA ratio is to provide an indication of the relative margin of safety (or lack thereof) within a material. Various ANC/MPA values are reported in the literature for indicating safe values for prevention of acid generation. These values typically range from 1 to 3. As a general rule, an ANC/MPA ratio of 2 or more signifies there is a high probability that the material will remain circum-neutral in pH and should not be problematic with respect to acid and metalliferous drainage.

NET ACID GENERATION (NAG) TEST

The NAG test is used in association with the NAPP to classify the acid generating potential of a sample. The NAG test involves reaction of a sample with hydrogen peroxide to rapidly oxidise any sulfide minerals contained within a sample. During the NAG test both acid generation and acid neutralisation reactions can occur simultaneously.

The end result represents a direct measurement of the net amount of acid generated by the sample.

The final pH is referred to as the NAGpH and the amount of acid produced is commonly referred to as the NAG capacity, and is expressed in the same units as the NAPP (kg H_2SO_4/t).

Extended Boil and Calculated NAG Test

Organic acids may be generated in NAG tests due to partial oxidation of carbonaceous materials such as coal washery wastes. This can lead to low NAGpH values and high acidities in standard single addition NAG tests unrelated to acid generation from sulfides.

Organic acid effects can therefore result in misleading NAG values and misclassification of the acid forming potential of a sample.

The extended boil and calculated NAG tests can be used to account for the relative proportions of pyrite derived acidity and organic acidity in a given NAG solution, thus providing a more reliable measure of the acid forming potential of a sample.

The procedure involves two steps to differentiating pyritic acid from organic derived acid:

- **Extended Boil NAG** decomposes the organic acids and hence removes the influence of non-pyritic acidity on the NAG solution.
- **Calculated NAG** calculates the net acid potential based on the balance of cations and anions in the NAG solution, which will not be affected by organic acid.

The extended boiling test is carried out on the filtered liquor of a standard NAG test, and involves vigorous boiling of the solution on a hot plate for 34 hours. After the boiling step the solution is cooled and the pH measured.

An extended boil NAGpH less than 4.5 confirms the sample is potentially acid forming (PAF), but a pH value greater than 4.5 does not necessarily mean that the sample is non acid forming (NAF), due to some loss of free acid during the extended boiling procedure.

To address this issue, a split of the same filtered NAG solution is assayed for concentrations of S, Ca, Mg, Na, K and C1, from which a calculated NAG value is determined.

The concentration of dissolved S is used to calculate the amount of acid (as H_2SO_4) generated by the sample and the concentrations of Ca, Mg, Na and K are used to estimate the amount of acid neutralised (as H_2SO_4).

The concentration of Cl is used to correct for soluble cations associated with Cl salts, which may be present in the sample and unrelated to acid generating and acid neutralising reactions.

The calculated NAG value is the amount of neutralised acid subtracted from the amount of acid generated. A positive value indicates that the sample has excess acid generation and is likely to be PAF, and a zero or negative value indicates that the sample has excess neutralising capacity and is likely to be NAF.

ELEMENT ENRICHMENT AND SOLUBILITY

In mineralised areas, enriched elements may be present that have resulted from natural geological mineralisation processes.

Multi-element scans are carried out to identify elements in, or readily leachable, from a material at concentrations that may be of environmental concern with respect to surface water quality, revegetation and public health.

The samples are generally analysed for:

Major elements	Al, Ca, Fe, K, Mg, Na and S (in mg//L).
Minor elements	As, B, Cd, Co, Cr, Cu, F, Hg, Mn, Mo, Ni, Pb, Sb, Se, Zn (in mg/L)

The concentration of these elements can be directly compared with relevant state or national environmental and health based concentration guideline criteria to determine the level of significance.

Water extracts can be used to determine the element solubilities under specific pH conditions, where the following tests can be conducted:

WATER EXTRACTS

Multi-element composition of water extracts from solid samples can be determined using a combination of ICP-mass spectroscopy (ICP-MS), ICP-optical emission spectroscopy (OES) and atomic absorption spectrometry (AAS).

Under some conditions (e.g. low pH) the solubility and mobility of common environmentally important elements can increase significantly.

If element mobility under initial pH conditions is deemed likely and/or subsequent low pH conditions may occur, kinetic leach column test work may be completed on representative samples.

The pH (no specific units) and electrical conductivity (EC in µS/cm) of a sample can also be determined by equilibrating the sample in deionised water for a minimum of 12 hours (or overnight), typically at a solid to water ratio of 1:2 or 1:5 (w/w) to provide an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area.

SAMPLE CLASSIFICATION

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

- Non-acid forming (NAF);
- Potentially acid forming (PAF); and
- Uncertain (UC).

Non-acid forming (NAF)

A sample classified as NAF may, or may not, have a significant sulphur content but the availability of ANC within the sample is more than adequate to neutralise all the acid that theoretically could be produced by any contained sulfide minerals. As such, material classified as NAF is considered unlikely to be a source of acidic drainage.

A sample is defined as NAF when it has a negative NAPP and the final NAG pH > 4.5.

Potentially acid forming (PAF)

A sample classified as PAF always has a significant sulphur content, the acid generating potential of which exceeds the inherent acid neutralising capacity of the material. This means there is a high risk that such a material, even if pH circum-neutral when freshly mined or processed, could oxidise and generate acidic drainage if exposed to atmospheric conditions.

A sample is usually defined as PAF when it has a positive NAPP and a final NAGpH < 4.5.

Uncertain (UC)

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

Uncertain samples are generally given a tentative classification that is shown in brackets e.g. UC(NAF).

SPONTANEOUS COMBUSTION

DESCRIPTION OF TEST AND ANALYSIS METHODS

Spontaneous combustion is the process of self-heating of coal by oxidation.

On exposure to air, coal undergoes a continuous oxidizing reaction. A hazard exists when the rate of heat production by this exothermic reaction exceeds the rate of cooling, produced mainly by the convective effects of air. The coal can then increase in temperature until combustion takes place.

The actual spontaneous combustion process is complex and subject to a number of influencing factors, including gas content, water content, particle size, secondary mineralisation, geological structures and attendant leakage paths, oxygen supply and the rate of exposure of the coal to oxygen and convection cooling.

ADIABATIC SELF-HEATING TEST

The coal sample to be tested is prepared by crushing to 200 microns and drying in nitrogen at about 105^{o}C. The coal sample is allowed to cool after drying before being loaded into the vacuum flask reaction vessel.

Once loaded, the reaction vessel is sealed with a push fit stopper through which pass a gas inlet, an exhaust, and a double platinum bulb resistance thermometer.

As soon as practical, a flow of nitrogen is established through the coal sample in order to prevent pre-oxidation.

The reaction vessel is then placed into a fan forced oven. The temperature of the-oven is maintained constant by an electronic controller until the sample temperature stabilises at 40^{o}C. The gas supply which passes through a copper coil housed in the oven to pre-heat it, is then changed from nitrogen to oxygen. The function of the electronic controller is also changed to adiabatic mode in which it holds the oven temperature as close to the coal temperature as possible. The temperature of the coal is recorded during the self heating period until 70°C is exceeded or until 72 hours have expired since admission of oxygen.

The rate of temperature rise gives a relative measure of the oxidation rate of the coal.

To quantify the propensity of the coal to spontaneous combustion, the average rate of self-heating from 40^{o}C to 70^{o}C(R_{70}) is used as an index. As R_{70} increases, reactivity of .the coal, and hance its propensity to spontaneous combustion increases.

For a range of Australian bituminous coals previously tested (Humphreys, 1979 and Humphreys et al, 1981), the range of R_{7}0 self-heating rates observed was from 0^{o}C/hour to 1.45^{o}C/hour. R_{70} values greater than 0.5°C/h were obtained with coals having some history of spontaneous combustion problems in practice.

HUMPRREYS, D.R. 1979 A study of Propensity of Queensland Coal to Spontaneous Combustion, M.Sc. Thesis, University of Queensland

HUMPREYS, D.R., ROWLANDS, D. and CUDMORE, J.F. 1981 Proceedings of AusIMM Symposium on Ignition, Explosion and Fires in Coal Mines

APPENDIX C

AMD, WATER CHEMISTRY AND SPONTANEOUS COMBUSTION LABORATORY RESULTS

SYDNEY
ANALYTICAL
LABORATORIES

Office:
PO BOX 48
ERMINGTON NSW 2115

Laboratory:
1/4 ABBOTT ROAD
SEVEN HILLS NSW 2147
Telephone: (02) 9838 8903
Fax: (02) 9838 8919
A.C.N. 003 614 695
A.B.N. 81 829 182 852
NATA No: 1884

ANALYTICAL REPORT for:

GEOTERRA

77 ABERGELDIE STREET
DULWICH HILL 2203

ATTN: ANDREW DAWKINS

JOB NO:	SAL24584D
CLIENT ORDER:	BAR4
DATE RECEIVED:	06/05/13
DATE COMPLETED:	28/05/13
TYPE OF SAMPLES:	SOILS
NO OF SAMPLES:	2

....
Issued on 29/05/13
Lance Smith
(Chief Chemist)

ANALYTICAL REPORT

JOB NO: SAL24584D
CLIENT ORDER: BAR4

	SAMPLES	Tot.S %	ANC %CaCO3	NAPP kgH2SO4/T
1	TBC34	0.22	1.6	-9.1
2	TBC36	0.10	1.7	-13.9
MDL		0.002	0.01	0.1
Method Code		HT3	C15	CAL
Preparation		P1	P1	P1

RESULTS ON DRY BASIS

ANALYTICAL REPORT

JOB NO: SAL24584D
CLIENT ORDER: BAR4

METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory.

P1	Analysis performed on sample as received
HT3	Total Sulphur - Determined by High Temperature Furnace
C15	Acid Neutralising Capacity - USEPA 600/2-78-054 SOBECK
CAL	Nett Acid Producing Potential - S.D.Miller 1986 Determined by Calculation

RESULTS OF ACID SULFATE ROCK ANALYSIS (Page 1 of 1)

3 samples supplied by GeoTerra on the 12th June, 2013 - Lab. Job No.C6873

Analysis requested by Andrew Dawkins. **Your Project: Coal**

(PO Box 220, Canterbury, NSW, 2193)

Sample Site	EAL lab code	Texture (note 6)	MOISTURE CONTENT (% moisture of total wet weight)	MOISTURE CONTENT (g moisture / g of oven dry soil)	REDUCED INORGANIC SULFUR (% chromium reducible S) (%Scr)	REDUCED INORGANIC SULFUR (% chromium reducible S) (mole H^+/tonne)	TOTAL SULFUR %S	TOTAL SULFUR (mole H^+/tonne)	ACID NEUTRALISING CAPACITY (ANC_{BT}) (% $CaCO_3$)	ACID NEUTRALISING CAPACITY (ANC_{BT}) (mole H^+/tonne)	NAPP (Net Acid Producing Potential) Kg H_2SO_4/tonne	CLASSIFICATION (based on NAPP) *(ie. 1- ACM; 2- NAF, 3- PAF-LC, 4- PAF)*	NAPP (Net Acid Producing Potential) Kg H_2SO_4/tonne	CLASSIFICATION (based on NAPP) *(ie. 1- ACM; 2- NAF, 3- PAF-LC, 4- PAF)*
											(Based on total sulfur: does not include actual acidity)		(Based on Scr: does not include actual acidity)	
Method No.					*22B*	*a- 22B*	*1:1 HCL:Nitric Acid Digest: ICPOES*		*19A2*	*a-19A2*	***note 12***	***note 12***	***note 12***	***note 12***
TBC25/26	*C6873/1*	Coal	1.1	0.01	0.01	6	0.022	14	3.61	721	-35	1-ACM	-36	1-ACM
TBC34	*C6873/2*	Coal	1.6	0.02	0.01	6	0.029	18	1.09	218	-10	1-ACM	-11	1-ACM
TBC36	*C6873/3*	Coal	1.5	0.01	0.01	6	0.017	11	1.04	208	-10	1-ACM	-10	1-ACM

NOTE:

1 - All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)

2 - Samples analysed by SPOCAS method 23 (ie Suspension Peroxide Oxidation Combined Acidity & sulfate) and 'Chromium Reducible Sulfur' technique (Scr - Method 22B)

3 - Methods from Ahern, CR, McElnea AE , Sullivan LA (2004). ***Acid Sulfate Soils Laboratory Methods Guidelines.*** QLD DNRME.

4 - Bulk Density is required for liming rate calculations per soil volume. Lab. Bulk Density is no longer applicable - field bulk density rings can be used and dried/ weighed in the laboratory.

5 - **ABA Equation: Net Acidity = Potential Sulfidic Acidity (ie. Scrs or Sox) + Actual Acidity + Retained Acidity - measured ANC/FF (with FF currently defaulted to 1.5)**

6 - The neutralising requirement, lime calculation, includes a 1.5 safety margin for acid neutralisation (an increased safety factor may be required in some cases)

7 - For Texture: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays

8 - .. denotes not requested or required

9 - SCREENING, CRS, TAA and ANC are NATA accredited but other SPOCAS segments are currently not NATA accredited

10- Results at or below detection limits are replaced with '0' for calculation purposes.

11 - Projects that disturb >1000 tonnes of soil, the ≥0.03% S classification guideline would apply (refer to acid sulfate management guidelines).

12 - ROCK CLASSIFICATION = 1-ACM: acid consuming potential; 2-NAF: non-acid forming; 3-PAF-LC: potentially acid forming, low capacity (<5kg H2SO4/tonne); 4-PAF: potentially acid forming); UC = Uncertain.

13 - ROCK METHODS and classification from AMIRA international, May 2002. ARD Test Handbook, Project P387A Prediction and Kinetic Control of Acid Mine Drainage. Ian Walk Institute, Melbourne.

NATA
WORLD RECOGNISED ACCREDITATION
Accreditation No. 14960.
Accredited for compliance
with ISO/IEC 17025.

(Classification of potential acid sulfate material if: coarse Scr≥0.03%S or 19mole H+/t; medium Scr≥0.06%S or 37mole H+/t; fine Scr≥0.1%S or 62mole H+/t) - as per QUASSIT Laboratory Methods Guidelines

checked: ....
Graham Lancaster
Laboratory Manager

SYDNEY
ANALYTICAL
LABORATORIES

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A.C.N. 003 614 695
A.B.N. 81 829 182 852
NATA No: 1884

ANALYTICAL REPORT for:

GEOTERRA

77 ABERGELDIE STREET
DULWICH HILL 2203

ATTN: ANDREW DAWKINS

JOB NO: SAL24584B

CLIENT ORDER: BAR4

DATE RECEIVED: 27/03/13

DATE COMPLETED: 24/04/13

TYPE OF SAMPLES: WATERS

NO OF SAMPLES: 4

NATA
This document is issued in accordance with NATA's accreditation requirements
Accredited for compliance with ISO/IEC 17025

....
Issued on 26/04/13
Lance Smith
(Chief Chemist)

ANALYTICAL REPORT

JOB NO: SAL24584B
CLIENT ORDER: BAR4

DATE OF COLLECTION SAMPLES		22/03/13 CULVERT	22/03/13 S7
Total Dissolved Solids	mg/L	2250	1030
Total Phosphorus	mg/L	0.01	0.03
Total Nitrogen	mg/L	190	19
Iron (Total)	mg/L	0.06	0.08
Iron (Dissolved)	mg/L	0.03	0.05
Manganese (Total)	mg/L	<0.01	<0.01
Manganese (Dissolved)	mg/L	<0.01	<0.01
Copper	mg/L	0.003	0.002
Lead	mg/L	0.002	<0.001
Zinc	mg/L	0.022	0.007
Nickel	mg/L	0.03	0.02
Aluminium	mg/L	0.02	0.03
Arsenic	mg/L	<0.01	<0.01
Lithium	mg/L	3.6	1.5
Barium	mg/L	5.4	2.2
Strontium	mg/L	0.66	0.70

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	720	31.320	350	15.225
Calcium Ca++	13	0.649	17	0.848
Potassium K+	31	0.794	28	0.717
Magnesium Mg++	11	0.905	23	1.893
TOTAL CATIONS		33.668		18.683
Chloride Cl-	39	1.100	16	0.451
Fluoride F-	0.37	0.019	0.23	0.012
Bicarbonate HCO3-	1120	18.368	1010	16.564
Sulphate SO4--	12	0.250	9	0.187
Nitrate NO3-	825	13.283	80	1.288
TOTAL ANIONS		33.020		18.502

ANALYTICAL REPORT

JOB NO: SAL24584B
CLIENT ORDER: BAR4

DATE OF COLLECTION SAMPLES		22/03/13 S7A	22/03/13 S9
Total Dissolved Solids	mg/L	1310	940
Total Phosphorus	mg/L	0.03	0.04
Total Nitrogen	mg/L	2.6	6.1
Iron (Total)	mg/L	0.18	0.06
Iron (Dissolved)	mg/L	0.04	0.04
Manganese (Total)	mg/L	<0.01	<0.01
Manganese (Dissolved)	mg/L	<0.01	<0.01
Copper	mg/L	0.002	<0.001
Lead	mg/L	<0.001	<0.001
Zinc	mg/L	0.006	0.006
Nickel	mg/L	0.03	0.01
Aluminium	mg/L	0.02	0.03
Arsenic	mg/L	<0.01	<0.01
Lithium	mg/L	1.7	1.4
Barium	mg/L	2.1	0.56
Strontium	mg/L	0.81	0.62

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	465	20.228	295	12.833
Calcium Ca++	14	0.699	13	0.649
Potassium K+	36	0.922	25	0.640
Magnesium Mg++	27	2.222	36	2.963
TOTAL CATIONS		24.071		17.085
Chloride Cl-	12	0.338	12	0.338
Fluoride F-	0.21	0.011	0.20	0.011
Bicarbonate HCO3-	1470	24.108	970	15.908
Sulphate SO4--	9	0.187	43	0.894
Nitrate NO3-	7.5	0.121	22	0.354
TOTAL ANIONS		24.765		17.505

ANALYTICAL REPORT

JOB NO: SAL24584B
CLIENT ORDER: BAR4

DATE OF COLLECTION		22/03/13
SAMPLES		BLANK
Total Dissolved Solids	mg/L	<1
Total Phosphorus	mg/L	<0.01
Total Nitrogen	mg/L	<0.1
Iron (Total)	mg/L	<0.01
Iron (Dissolved)	mg/L	<0.01
Manganese (Total)	mg/L	<0.01
Manganese (Dissolved)	mg/L	<0.01
Copper	mg/L	<0.001
Lead	mg/L	<0.001
Zinc	mg/L	<0.001
Nickel	mg/L	<0.01
Aluminium	mg/L	<0.01
Arsenic	mg/L	<0.01
Lithium	mg/L	<0.001
Barium	mg/L	<0.001
Strontium	mg/L	<0.001

	mg/L	meq/L
Sodium Na+	<0.1	
Calcium Ca++	<0.1	
Potassium K+	<0.1	
Magnesium Mg++	<0.1	
TOTAL CATIONS		
Chloride Cl-	<1	
Fluoride F-	<0.1	
Bicarbonate HCO3-	<1	
Sulphate SO4--	<2	
Nitrate NO3-	<0.1	
TOTAL ANIONS		

ANALYTICAL REPORT

JOB NO: SAL24584B
CLIENT ORDER: BAR4

METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory, in accordance with APHA Standard Methods of Water and Wastewater 21st Edition, or other approved methods listed below:

2540C	Total Dissolved Solids
3500B	Sodium Na+
3111B	Calcium Ca++
3500B	Potassium K+
3111B	Magnesium Mg++
4500D	Chloride Cl-
4500C	Fluoride F-
2320B	Bicarbonate HCO3-
4110B	Sulphate SO4--
4500BF	Total Phosphorus
4500B	Total Nitrogen
3111B	Iron (Total)
3111B	Iron (Dissolved)
3111B	Manganese (Total)
3111B	Manganese (Dissolved)
3111C	Copper
3111C	Lead
3111C	Zinc
3111B	Nickel
3111D	Aluminium
3114B	Arsenic
3500B	Lithium
3111D	Barium
3500B	Strontium
4500F	Nitrate NO3-

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A.B.N. 81 829 182 852
NATA No: 1884

ANALYTICAL REPORT for:

GEOTERRA

77 ABERGELDIE STREET
DULWICH HILL 2203

ATTN: ANDREW DAWKINS

JOB NO:	SAL24685C
CLIENT ORDER:	BAR4
DATE RECEIVED:	22/07/13
DATE COMPLETED:	05/08/13
TYPE OF SAMPLES:	WATERS
NO OF SAMPLES:	2

NATA Accredited for compliance with ISO/IEC 17025

....
Issued on 06/08/13
Lance Smith
(Chief Chemist)

ANALYTICAL REPORT

JOB NO: SAL24685C
CLIENT ORDER: BAR4

DATE OF COLLECTION		17/07/13	18/07/13
SAMPLES		REA DRAIN	25/26/34 /36
Dissolved Organic Carbon	mg/L	7	8
Total Dissolved Solids	mg/L	1910	440
Total Phosphorus	mg/L	<0.01	0.01
Total Nitrogen	mg/L	120	6.6
Iron (Total)	mg/L	0.26	0.11
Iron (Dissolved)	mg/L	0.17	0.01
Manganese (Total)	mg/L	<0.01	<0.01
Manganese (Dissolved)	mg/L	<0.01	<0.01
Copper	mg/L	0.006	0.004
Lead	mg/L	0.004	<0.001
Zinc	mg/L	0.015	0.007
Nickel	mg/L	<0.01	<0.01
Aluminium	mg/L	0.04	0.04
Arsenic	mg/L	<0.01	<0.01
Lithium	mg/L	2.6	0.19
Barium	mg/L	4.1	1.4
Strontium	mg/L	0.81	0.52

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	650	28.275	78	3.393
Calcium Ca++	20	0.998	43	2.146
Potassium K+	32	0.819	18	0.461
Magnesium Mg++	11	0.905	13	1.070
TOTAL CATIONS		30.997		7.070
Chloride Cl-	45	1.269	97	2.735
Fluoride F-	0.47	0.025	0.87	0.046
Bicarbonate HCO3-	1220	20.008	200	3.280
Sulphate SO4--	10	0.208	30	0.624
Nitrate NO3-	520	8.372	28	0.451
TOTAL ANIONS		29.882		7.136

ANALYTICAL REPORT

JOB NO: SAL24685C
CLIENT ORDER: BAR4

DATE OF COLLECTION SAMPLES		18/07/13 BLANK
Dissolved Organic Carbon	mg/L	<1
Total Dissolved Solids	mg/L	<1
Total Phosphorus	mg/L	<0.01
Total Nitrogen	mg/L	<0.1
Iron (Total)	mg/L	<0.01
Iron (Dissolved)	mg/L	<0.01
Manganese (Total)	mg/L	<0.01
Manganese (Dissolved)	mg/L	<0.01
Copper	mg/L	<0.001
Lead	mg/L	<0.001
Zinc	mg/L	<0.001
Nickel	mg/L	<0.01
Aluminium	mg/L	<0.01
Arsenic	mg/L	<0.01
Lithium	mg/L	<0.001
Barium	mg/L	<0.001
Strontium	mg/L	<0.001

	mg/L	meq/L
Sodium Na+	<0.1	
Calcium Ca++	<0.1	
Potassium K+	<0.1	
Magnesium Mg++	<0.1	
TOTAL CATIONS		
Chloride Cl-	<1	
Fluoride F-	<0.1	
Bicarbonate HCO3-	<1	
Sulphate SO4--	<2	
Nitrate NO3-	<0.1	
TOTAL ANIONS		

ANALYTICAL REPORT

JOB NO: SAL24685C
CLIENT ORDER: BAR4

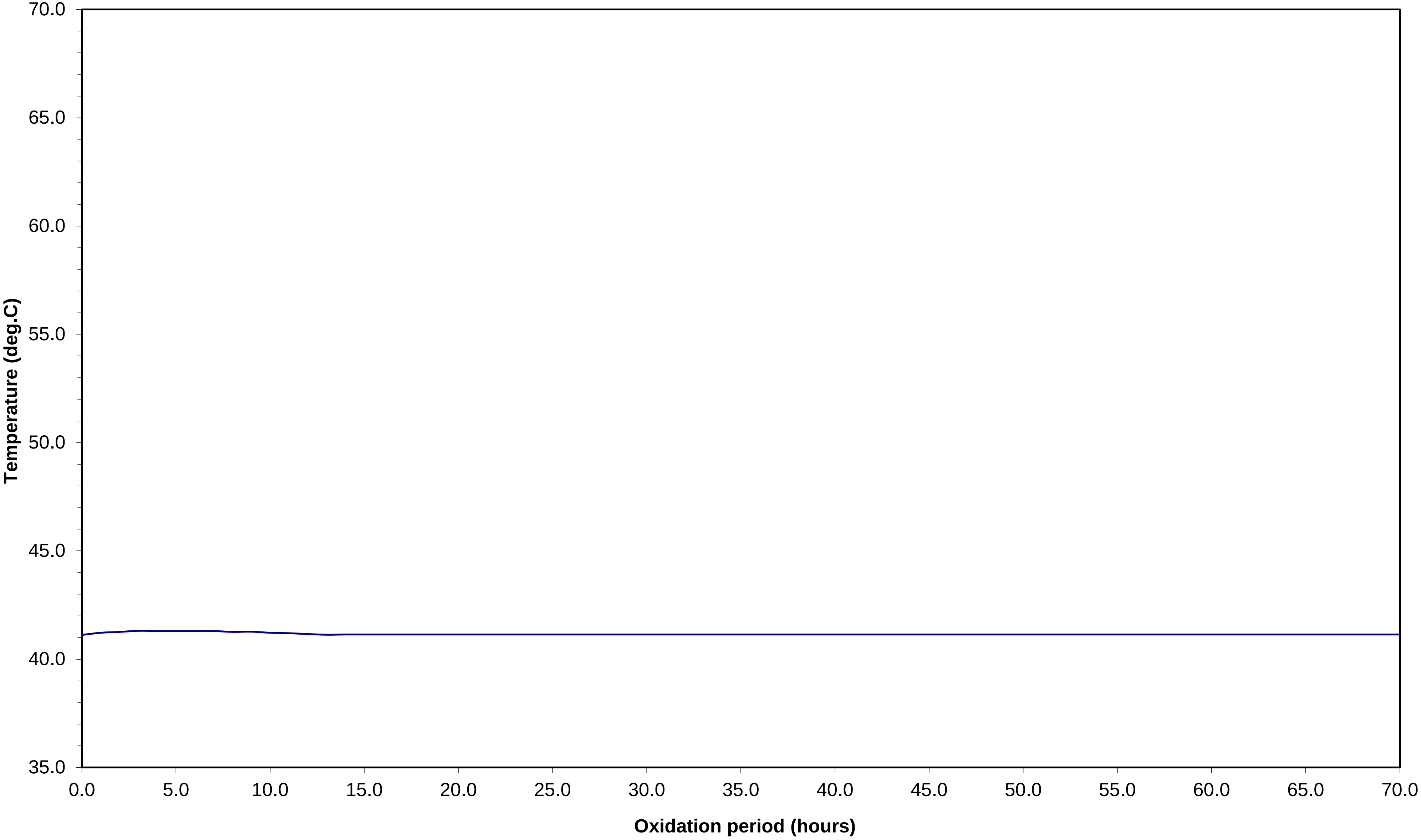
METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory, in accordance with APHA Standard Methods of Water and Wastewater 21st Edition, or other approved methods listed below:

5310C	Dissolved Organic Carbon
2540C	Total Dissolved Solids
3500B	Sodium Na+
3111B	Calcium Ca++
3500B	Potassium K+
3111B	Magnesium Mg++
4500D	Chloride Cl-
4500C	Fluoride F-
2320B	Bicarbonate HCO3-
4110B	Sulphate SO4--
4500BF	Total Phosphorus
4500B	Total Nitrogen
3111B	Iron (Total)
3111B	Iron (Dissolved)
3111B	Manganese (Total)
3111B	Manganese (Dissolved)
3111C	Copper
3111C	Lead
3111C	Zinc
3111B	Nickel
3111D	Aluminium
3114B	Arsenic
3500B	Lithium
3111D	Barium
3500B	Strontium
4500F	Nitrate NO3-

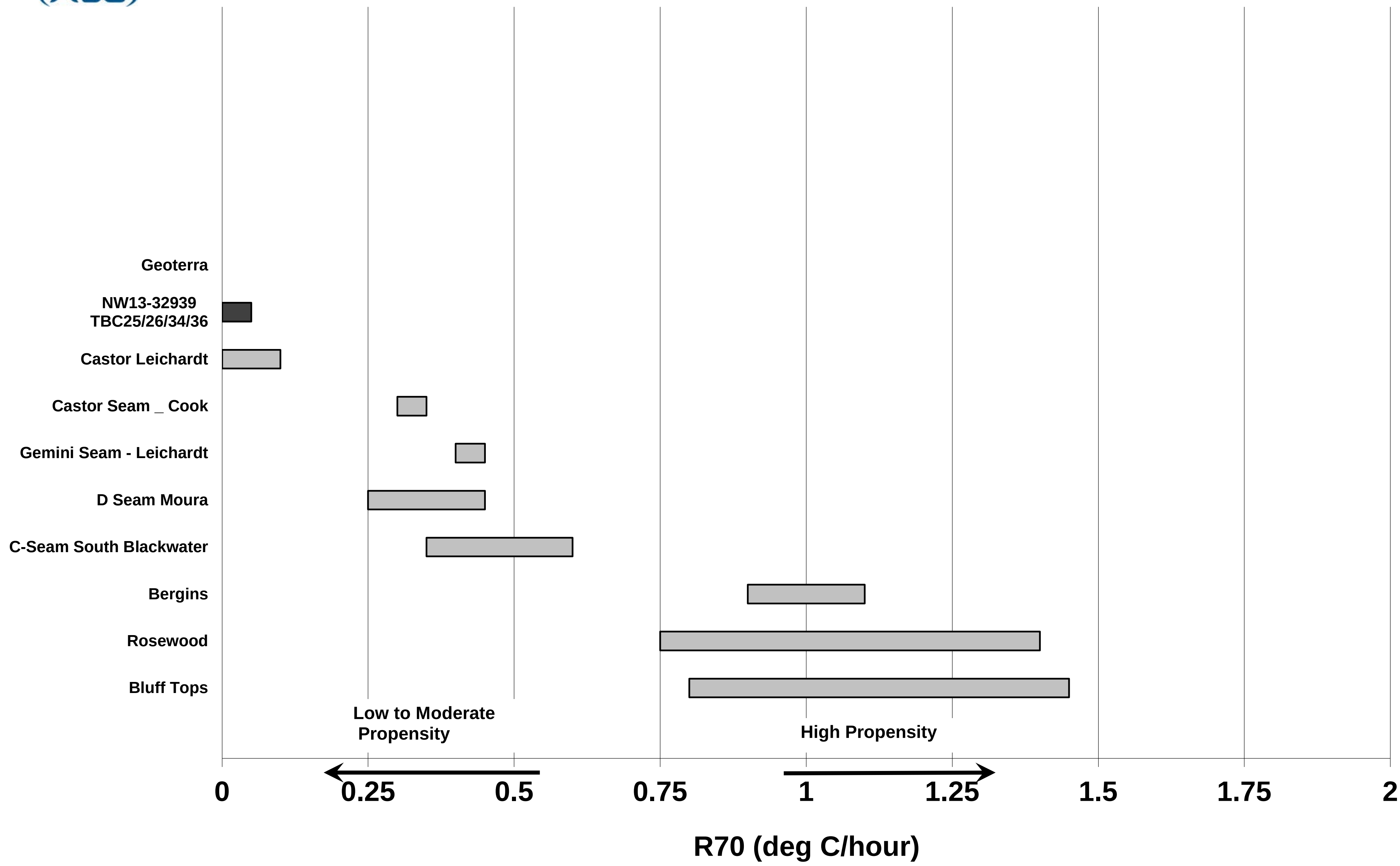
Company: **Geoterra**
Sample: **NW13-32939 TBC25/26/34/36**
ALS Richlands Job No & Sample No: **21013043 RH238814**

R70 = 0.003 deg.C/Hour



Adiabatic Self Heating Test

Comparison With Other Coals



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