Tarrawonga Coal Project

Environmental Assessment

APPENDIX N

GEOCHEMISTRY ASSESSMENT

Resource Strategies

Tarrawonga Coal Pty Ltd

TARRAWONGA COAL PROJECT –

GEOCHEMISTRY ASSESSMENT OF OVERBURDEN, INTERBURDEN AND COARSE REJECTS

September 2011

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1.0 Introduction

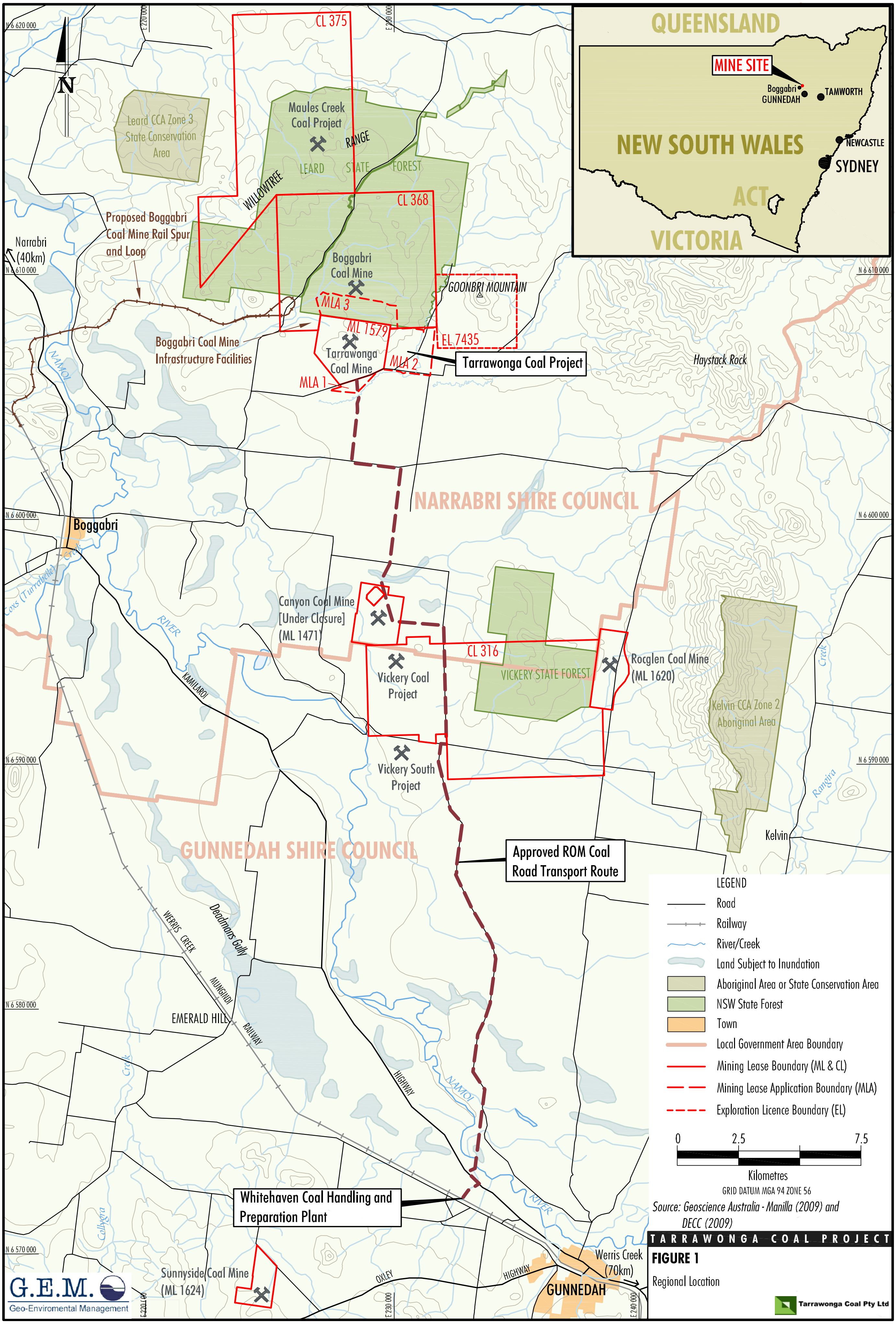
Geo-Environmental Management Pty Ltd (GEM) was commissioned by Tarrawonga Coal Pty Ltd (TCPL) to carry out an environmental geochemistry assessment for the life-of-mine expansion project proposed for the Tarrawonga Coal Mine (referred to herein as the Project). The Tarrawonga Coal Mine, as shown on Figure 1, is situated in central northern New South Wales (NSW), approximately 42 kilometres (km) north north-west of Gunnedah. Resource Strategies Pty Ltd is assisting Whitehaven with the preparation of an Environmental Assessment (EA) for the Project, and this environmental geochemistry assessment is required for, and will be provided as an appendix to, the Project EA.

This report presents the results and findings of the geochemical assessment program and the identified geochemical implications for the Project, and provides any recommendations for environmental management and any future geochemical testing requirements for the Project.

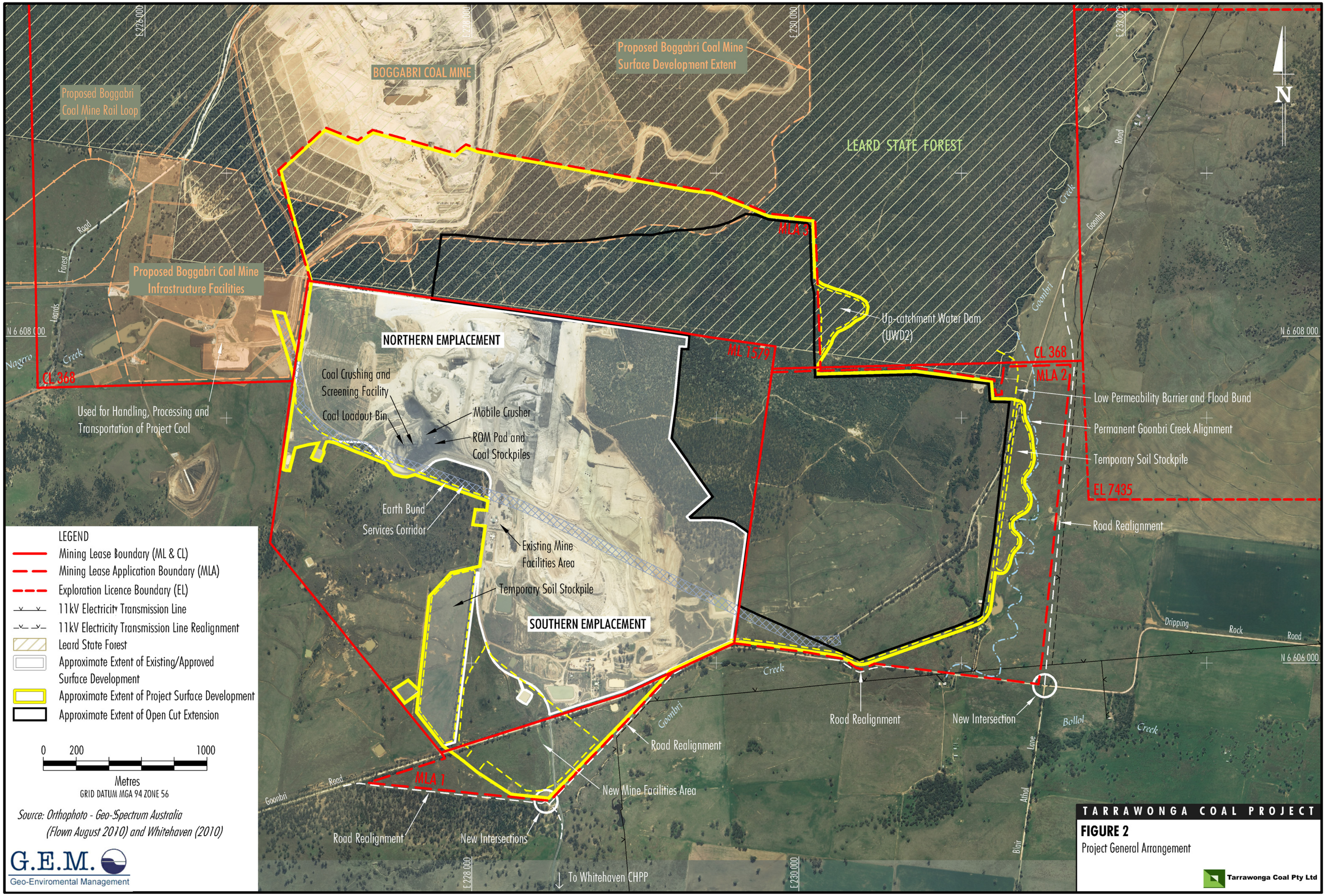
1.1 Background

The Tarrawonga Coal Mine is an open-cut mining operation using conventional truck and excavator mining methods to produce up to 2 million tonnes (Mt) of coal annually. The coal is crushed and screened on-site and trucked to Whitehaven's Coal Handling and Preparation Plant (CHPP) located in Gunnedah. At the CHPP the coal is either washed to achieve required coal quality or bypassed as product coal for direct rail load-out. The overburden and interburden are disposed in the mined-out sections of the open pit and in two out-of-pit overburden emplacements located to the north-west (Northern Emplacement) and to the south (Southern Emplacement) of the open-cut pit. Figure 2 shows the general arrangement of the mine and the changes proposed for this Project.

The Tarrawonga Coal Mine is located within the Maules Creek sub-basin comprising numerous coal seams with interbedded sedimentary rocks of Early Permian age (Maules Creek Formation) which are overlain in places by recent alluvial deposits. The Maules Creek Formation directly overlies the Boggabri Ridge Volcanics and contains approximately 15 coal seams with an average thickness of 1.5 metres (m). The approved open-cut mining operations at Tarrawonga target the upper 8 coal seams from the sequence and these are separated from the lower seams by a thick (approximately 40 m) interburden unit. The lower seams within the sequence are a future potential underground resource, however are not considered for the purposes of this assessment. Figure 3 provides the typical stratigraphy of the project area.

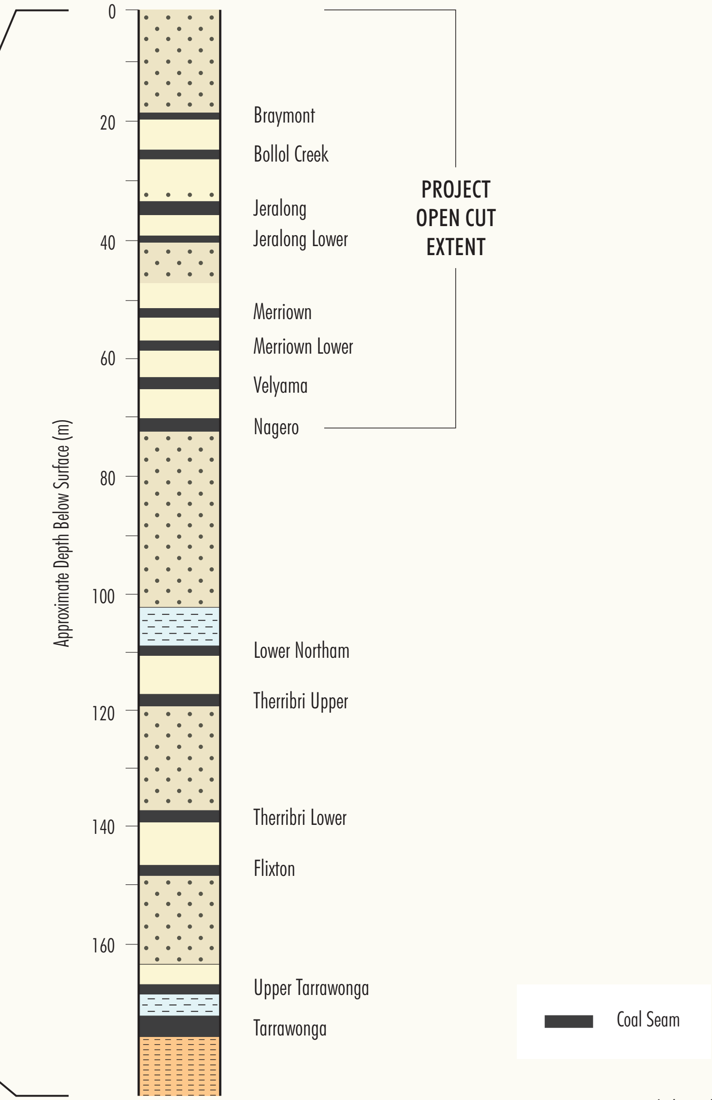


QUEENSLAND
MINE SITE
Boggabri
GUNNEDAH
TAMWORTH
NEW SOUTH WALES
NEWCASTLE
SYDNEY
ACT
VICTORIA
N
CL 375
Maules Creek Coal Project
RANGE
LEARD STATE FOREST
WILLOWTREE
Leard CCA Zone 3 State Conservation Area
CL 368
Proposed Boggabri Coal Mine Rail Spur and Loop
Narrabri (40km)
Boggabri Coal Mine
GOONBRI MOUNTAIN
MLA 3
ML 1579
EL 7435
Boggabri Coal Mine Infrastructure Facilities
Tarrawonga Coal Mine
MLA 2
MLA 1
Tarrawonga Coal Project
Haystack Rock
NAMOI
NARRABRI SHIRE COUNCIL
Boggabri
Canyon Coal Mine [Under Closure] (ML 1471)
RIVER
CL 316
Vickery Coal Project
VICKERY STATE FOREST
Rocglen Coal Mine (ML 1620)
KAMILAROI
Kelvin CCA Zone 2 Aboriginal Area
Vickery South Project
Kelvin
GUNNEDAH SHIRE COUNCIL
Approved ROM Coal Road Transport Route
WERRIS CREEK
Deadmans Gully
MUNGINDI
RAILWAY
EMERALD HILL
HIGHWAY
NAMOI
RIVER
Whitehaven Coal Handling and Preparation Plant
Sunnyside Coal Mine (ML 1624)
OXLEY
HIGHWAY
GUNNEDAH
Werris Creek (70km)
LEGEND
Road
Railway
River/Creek
Land Subject to Inundation
Aboriginal Area or State Conservation Area
NSW State Forest
Town
Local Government Area Boundary
Mining Lease Boundary (ML & CL)
Mining Lease Application Boundary (MLA)
Exploration Licence Boundary (EL)
0 2.5 7.5
Kilometres
GRID DATUM MGA 94 ZONE 56
Source: Geoscience Australia - Manilla (2009) and DECC (2009)
TARRAWONGA COAL PROJECT
FIGURE 1
Regional Location
Tarrawonga Coal Pty Ltd
G.E.M. Geo-Enviromental Management



BOGGABRI COAL MINE
Proposed Boggabri Coal Mine Surface Development Extent
Proposed Boggabri Coal Mine Rail Loop
LEARD STATE FOREST
N
Proposed Boggabri Coal Mine Infrastructure Facilities
MLA 3
Up-catchment Water Dam (UWD2)
NORTHERN EMPLACEMENT
ML 1579
CL 368
MLA 2
Low Permeability Barrier and Flood Bund
Permanent Goonbri Creek Alignment
Temporary Soil Stockpile
EL 7435
Road Realignment
Used for Handling, Processing and Transportation of Project Coal
Coal Crushing and Screening Facility
Coal Loadout Bin
Mobile Crusher
ROM Pad and Coal Stockpiles
Earth Bund
Services Corridor
Existing Mine Facilities Area
Temporary Soil Stockpile
SOUTHERN EMPLACEMENT
Dripping Rock Road
Road Realignment
New Intersection
Road Realignment
New Mine Facilities Area
MLA 1
Road Realignment
New Intersections
To Whitehaven CHPP
E 226 000
E 228 000
E 230 000
E 232 000
N 6 608 000
N 6 606 000
LEGEND
Mining Lease Boundary (ML & CL)
Mining Lease Application Boundary (MLA)
Exploration Licence Boundary (EL)
11kV Electricity Transmission Line
11kV Electricity Transmission Line Realignment
Leard State Forest
Approximate Extent of Existing/Approved Surface Development
Approximate Extent of Project Surface Development
Approximate Extent of Open Cut Extension
0 200 1000
Metres
GRID DATUM MGA 94 ZONE 56
Source: Orthophoto - Geo-Spectrum Australia (Flown August 2010) and Whitehaven (2010)
G.E.M.
Geo-Enviromental Management
TARRAWONGA COAL PROJECT
FIGURE 2
Project General Arrangement
Tarrawonga Coal Pty Ltd

BASIN	PERIOD		GROUP/FORMATION	
GUNNEDAH	TRIASSIC	MIDDLE	Napperby Formation	
		EARLY	Digby Formation	
	PERMIAN	LATE	Black Jack Group	
		EARLY	Millie Group	
			Bellata Group	Maules Creek Formation
				Goonbri Formation
				Leard Formation
			Boggabri Volcanics	



Source: Minarco-Mineconsult (2011) and NSW Industry and Investment (2011)

TARRAWONGA COAL PROJECT

FIGURE 3
Stratigraphy of the Project Area

Tarrawonga Coal Pty Ltd

G.E.M. Geo-Enviromental Management

The main activities associated with the development of the Project would include:

- continued development of mining operations in the Maules Creek Formation to facilitate a Project run-of-mine (ROM) coal production rate of up to 3 million tonnes per annum (Mtpa), including open cut extensions:
  - to the east within Mining Lease (ML) 1579 and Mining Lease Application (MLA) 2; and
  - to the north within Coal Lease (CL) 368 (MLA 3) which adjoins ML 1579;
- ongoing exploration activities;
- construction and use of a services corridor (including haul road link) directly from the Project open cut mining operation to the upgraded Boggabri Coal Mine Infrastructure Facilities[1];
- use of upgraded Boggabri Coal Mine Infrastructure Facilities for the handling and processing of Project coal and the loading of Project product coal to trains for transport on the Boggabri Coal Mine private rail spur to the Werris Creek Mungindi Railway[1];
- construction and use of a new mine facilities area including relocation of existing mine facilities infrastructure and service facilities;
- use of an existing on-site mobile crusher for coal crushing and screening of up to 150,000 tonnes (t) of domestic specification coal per annum for direct collection by customers at the mine site;
- use an existing on-site mobile crusher to produce up to approximately 90,000 cubic metres of gravel materials per annum for direct collection by customers at the mine site;
- progressive backfilling of the mine void behind the advancing open cut mining operation with waste rock and minor quantities of coarse reject material;
- continued and expanded placement of waste rock in the Northern Emplacement (including integration with the Boggabri Coal Mine emplacement) and Southern Emplacement, as mining develops;
- progressive development of new haul roads and internal roads, as mining develops;
- realignment of sections of Goonbri Road and construction of new intersections;
- construction of an engineered low permeability barrier to the east and south-east of the open cut to reduce the potential for local drainage of alluvial groundwater into the open cut;

[1] Subject to approvals and upgrades being in place for the transfer of Project ROM coal to the Boggabri Coal Mine Infrastructure Facilities.

- removal of a section of Goonbri Creek within the Project open cut and the establishment of a permanent Goonbri Creek alignment and associated flood bund to the east and south-east of the open cut;
- progressive development of sediment basins and storage dams, pumps, pipelines and other water management equipment and structures;
- continued development of soil stockpiles, laydown areas and gravel/borrow areas;
- ongoing monitoring and rehabilitation; and
- other associated minor infrastructure, plant, equipment and activities.

The proposed life of the Project is 17 years, commencing 1 January 2013.

1.2 Study Objectives

The Tarrawonga Coal Mine was approved via Development Consent (DA-88-4-2005) by the NSW Minister for Planning in November 2005 under Part 4 of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act). This environmental geochemistry assessment report has been compiled in support of an EA for the proposed life-of-mine expansion to the Tarrawonga Coal Mine under the EP&A Act.

The objectives of this study included:

- Review the relevant available information including previous geochemical test work, and geological maps and drill-hole logs for the proposed pit extension areas.
- Select and sample drill-holes that are representative of the major rock units to be mined as overburden or interburden from the proposed extended pit area.
- Select test work parameters and suitable analytical laboratories to assess the salinity, sodicity, acid forming potential and elemental composition (solids and water extracts) of the selected samples.
- Prepare a geochemical assessment report which summarises the results and findings of the previous geochemical investigations conducted at the Tarrawonga Coal Mine, describes in detail the current sampling and test work programs and discusses the salinity, sodicity, acid forming potential, and metal enrichment and solubility of the overburden and interburden, and the acid forming potential and metal enrichment for the coarse reject materials from the proposed extended pit area.

2.0 Previous Geochemical Investigations

Previous geochemical characterisation of overburden and interburden samples from the Tarrawonga Coal Mine was carried out by URS Australia Pty Ltd in May 2005 (URS, 2005). This geochemical assessment program was required for the *East Boggabri Joint Venture Environmental Impact Statement* (2005 EIS) (R.W Corkery & Co Pty Limited, 2005). For this program, five sample composites were prepared from one drill-hole located within the proposed open pit area. It is understood that the sample composites comprised mixed lithologies from within the major overburden units and that the depth intervals represented ranged from 8 to 20 m.

The results from the geochemical characterisation program indicated that the materials represented had relatively low sulfur (S) contents (0.04 to 0.31 %S) and a range in acid neutralising capacities (ANC) from 8 to 64 kilograms of sulfuric acid per tonne of material (i.e. kg H_2SO_4/t). The corresponding net acid producing potential (NAPP) values were all negative, indicating an excess in acid neutralisation over acid potential. The net acid generation (NAG) test results derived pH of NAG liquor (NAGpH) values all greater than pH 4.5 (NAGpH range 6.2 to 9.0). Based on these results, the materials represented by the samples tested were all classified as non-acid forming (NAF). This program also indentified a low potential for soluble salt generation, indicating a low salinity risk. The sodicity ratings of the overburden materials were not determined at the time.

In 2010 a detailed geochemical characterisation of a further 29 drill-hole samples was undertaken by GEM. The samples were collected from one drill-hole and represented the discrete lithologies occurring within the overburden of the modification area (GEM, 2010). The results from this program indicated that the overburden was likely to be NAF with low S contents (<0.01 to 0.11 %S) and a relatively large range in ANC values from 5 to 185 kg H_2SO_4/t. Nine samples were selected for NAG testing and all of these samples had NAGpH values greater than 4.5 (NAGpH range 5.2 to 10.4) confirming that the materials represented by these samples were NAF.

The test work conducted by URS in 2005 indicated that the overburden was only likely to have a low salinity risk and this was confirmed by the test work conducted by GEM in 2010 (URS, 2005; GEM 2010). However, the test work conducted by GEM indicated that some of the overburden materials are likely to be moderately sodic (i.e. highly dispersive). Additionally GEM reported that, although the overburden represented by the samples tested was not likely to contain any significantly enriched or readily soluble metals, a number of elements were indentified of potential environmental concern, including arsenic (As), molybdenum (Mo), antimony (Sb) and selenium (Se), and it was recommended that these be included in the site water quality monitoring program.

3.0 Geochemical Assessment Program

3.1 Testing Methodology and Program

The laboratory program for the Project included the following tests and procedures:

- pH and Electrical Conductivity (EC) determination (all samples);
- acid-base analysis (total S, ANC, NAPP) (all samples);
- exchangeable cation analysis (selected samples);
- sulfide sulfur analysis (selected samples);
- single addition NAG testing (selected samples); and
- multi-element scans on solids and water extracts (selected samples).

The pH and EC determinations, and deionised water extracts for multi-element analyses were conducted in-house. The sample preparation, exchangeable cation analysis, acid-base analysis, and NAG testing were performed by Australian Laboratory Services Pty Ltd in Brisbane and the multi-element analyses on solids and water extracts were performed by Genalysis Laboratories in Perth.

An overview of the test procedures used for this program is presented below.

pH and Electrical Conductivity Determination

The pH and EC of a sample is determined by equilibrating the sample in deionised water for a minimum of 2 hours at a solid to water ratio of 1:2 weight by weight (w/w). This gives an indication of the inherent acidity and salinity of the material when it is initially exposed. The general salinity ranking based on $EC_{1:2}$ is provided below:

$EC_{1:2}$ (dS/m)	Salinity
< 0.5	Non-Saline
0.5 to 1.5	Slightly Saline
1.5 to 2.5	Moderately Saline
> 2.5	Highly Saline

dS/m = deciSiemens per metre.

Exchangeable Cation Analysis

Exchangeable cation analyses are carried out to determine the sodicity of a sample. Sodicity occurs in materials that have high concentrations of exchangeable sodium (Na) relative to the other major cations (i.e. Calcium [Ca] and Magnesium [Mg]), causing the material to be highly dispersive. The Exchangeable Sodium Percent (ESP) is used to determine the sodicity of a sample by comparing the amount of exchangeable Na to Ca and Mg concentrations. The ESP is used to rank materials according to sodicity and likely dispersion characteristics as shown below:

ESP	Sodicity	Dispersion
< 6	Non-Sodic	Not Dispersive
6 to 15	Slightly Sodic	Slightly Dispersive
15 to 30	Moderately Sodic	Moderately Dispersive
> 30	Highly Sodic	Highly Dispersive

Acid Forming Characteristic Evaluation

A number of test procedures are used to assess the acid forming characteristics of mine waste materials. The most widely used assessment methods are the acid-base account and the NAG test. These methods are referred to as static procedures because each involves a single measurement in time.

Acid-Base Account

The acid-base account involves laboratory procedures that evaluate the balance between acid generation processes (oxidation of sulfide minerals) and acid neutralising processes (dissolution of alkaline carbonates, displacement of exchangeable bases, and weathering of silicates). The values arising from the acid-base account are referred to as the maximum potential acidity (MPA) and the ANC, respectively. The difference between the MPA and ANC value is referred to as the NAPP.

The MPA is calculated using the total sulfur content of the sample. This calculation assumes that all of the sulfur measured in the sample occurs as pyrite (FeS_2) and that the pyrite reacts under oxidising conditions to generate acid according to the following reaction:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \Rightarrow Fe(OH)^3 + 2\ H_2SO_4$$

According to this reaction, the MPA of a sample containing 1 %S as pyrite would be 30.6 kg H_2SO_4/t. Hence the MPA of a sample is calculated from the total sulfur content using the following formula:

$$\text{MPA (kg } H_2SO_4\text{/t)} = \text{(Total \%S)} \times 30.6$$

The use of the total sulfur assay to estimate the MPA is a conservative approach because some sulfur may occur in forms other than pyrite. Sulfate-sulfur and native sulfur, for example, are non-acid generating sulfur forms. Also, some sulfur may occur as other metal sulfides (e.g. covellite, chalcocite, sphalerite, galena) that yield less acidity than pyrite when oxidised.

The acid formed from pyrite oxidation would, to some extent, react with acid neutralising minerals contained within the sample. This inherent acid neutralisation is quantified in terms of the ANC and is commonly determined using 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).

The NAPP is a theoretical calculation commonly used to indicate if a material has the potential to produce acid. 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:

$$\text{NAPP} = \text{MPA} - \text{ANC}$$

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.

The ANC/MPA ratio is used as a means of assessing the risk of acid generation from mine waste materials. 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. Generally, an ANC/MPA ratio of 3 or more signifies that there is a high probability that the material is not acid generating.

<u>Net Acid Generation Test</u>

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. Therefore, the end result represents a direct measurement of the net amount of acid generated by the sample. This value is commonly referred to as the NAG capacity and is expressed in the same units as NAPP, that is kg H_2SO_4/t.

The standard NAG test involves the addition of 250 millilitres (mL) of 15% hydrogen peroxide to 2.5 grams (g) of sample. The peroxide is allowed to react with the sample overnight and the following day the sample is gently heated to accelerate the oxidation of any remaining sulfides, then vigorously boiled for several minutes to decompose residual peroxide. When cool, the pH and acidity of the NAG liquor are measured. The acidity of the liquor is then used to estimate the net amount of acidity produced per unit weight of sample.

Metal Enrichment and Solubility

Multi-element scans are carried out to identify any elements that are present in a material at concentrations that may be of environmental concern with respect to water quality and revegetation. The assay results from the solid samples are compared to the average crustal abundance for each element to provide a measure of the extent of element enrichment. The extent of enrichment is reported as the Geochemical Abundance Index (GAI). However, identified element enrichment does not necessarily mean that an element would be a concern for revegetation, water quality, or public health and this technique is used to identify any significant element enrichments that warrant further examination.

Multi-element scans are also performed on water extracts from the solid samples (1:2 sample/deionised water) to determine the immediate element solubilities under the existing sample pH conditions of the sample. However, common environmentally important elements that are not identified as significantly enriched or immediately soluble may still present an environmental risk under low pH conditions and where acid forming materials are identified, additional (kinetic) testing is required to develop an understanding of the geochemical behaviour of these materials.

3.2 Geochemical Classification

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

- barren;
- NAF;
- potentially acid forming (PAF);
- acid forming; and
- uncertain.

Barren
A sample classified as barren essentially has no acid generating capacity and no acid buffering capacity. This category is most likely to apply to highly weathered materials. In essence, it represents an ‘inert’ material with respect to acid generation. The criteria used to classify a sample as barren may vary between sites, but it generally applies to materials with a total sulfur content 0.1 %S and an ANC 5 kg H_2SO_4/t.

Non-Acid Forming
A sample classified as NAF may, or may not, have a significant sulfur 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 usually defined as NAF when it has a negative NAPP and a final NAGpH 4.5.

Potentially Acid Forming
A sample classified as PAF always has a significant sulfur content, the acid generating potential of which exceeds the inherent ANC 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.

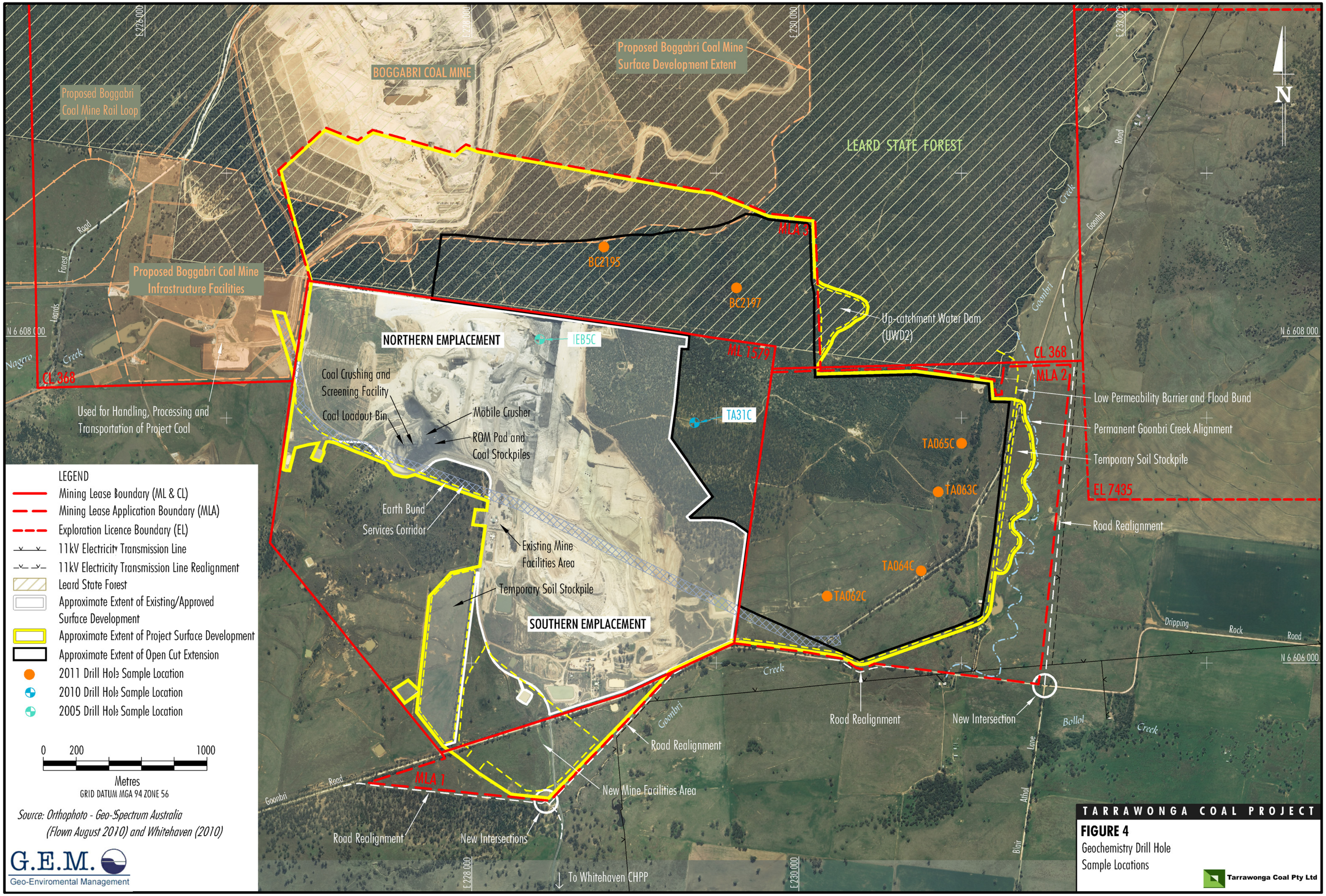
Acid Forming
A sample classified as acid forming has the same characteristics as the PAF samples, however, these samples also have an existing pH of less than 4.5. This indicates that acid conditions have already been developed, confirming the acid forming nature of the sample.

Uncertain
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).

3.3 Sample Selection and Preparation

A total of 119 drill-hole samples, comprising 79 samples from the proposed eastern pit extension and 40 samples from the proposed northern pit extension, were collected by on-site Tarrawonga Coal Mine personnel for inclusion in the geochemical testing program. These samples were collected from 4 drill-holes spatially distributed across the eastern extension area (eastern pit boundary into MLA 2) and from 2 drill-holes spatially distributed across the northern extension area (northern pit boundary into CL368). Figure 4 shows the area limits for the proposed pit extensions and the location of the selected drill-holes within each of these areas. This figure also shows the drill-holes sampled in previous geochemistry test work programs in 2005 by URS, and in 2010 by GEM.

The intervals selected for sampling through each drill-hole were based on the lithology and proximity to the coal seams using the stratigraphic logs for the selected drill-holes. Strata that occur as finely interbedded materials of different lithology have been logged as discrete units of mixed lithology (e.g. carbonaceous mudstone and siltstone). The sample intervals selected comprise either discrete lithologies or discrete units of mixed lithology and the samples were collected continuously through each selected interval. The selected sample sets are therefore considered to be representative of the major overburden rock types within the proposed pit extension areas. The sample details, including drill-hole, depth interval, lithology and degree of weathering, are provided in Attachment A. Table 1 provides the proportion of the major lithologies sampled and the number of samples collected for each lithology. The mixed lithology samples are grouped according to the dominant lithology within the sample.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2010 Drill Hole Sample Location
2005 Drill Hole Sample Location
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GRID DATUM MGA 94 ZONE 56
Source: Orthophoto - Geo-Spectrum Australia (Flown August 2010) and Whitehaven (2010)
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TARRAWONGA COAL PROJECT
FIGURE 4
Geochemistry Drill Hole Sample Locations
Tarrawonga Coal Pty Ltd

Table 1: Sample count and proportion of the total sample interval for the major overburden and interburden lithologies within the stratigraphic sequence of the eastern and northern pit extension areas.

Lithology	Weathering	Sample Count	Interval Sampled (m)	Prop of Total Sample Interval (%)
EASTERN EXTENSION				
Clay	Weathered	3	16.80	4.0%
Sandstone	Weathered	4	27.10	6.5%
Siltstone	Weathered	2	4.00	1.0%
Mudstone	Weathered	1	1.10	0.3%
Conglomerate	Weathered	6	44.30	10.6%
Gravel	Weathered	3	31.50	7.5%
Sandstone	Fresh	26	114.81	27.4%
Siltstone	Fresh	5	6.01	1.4%
Mudstone	Fresh	13	28.81	6.9%
Conglomerate	Fresh	12	139.18	33.3%
Carbonaceous Mudstone	Fresh	3	3.86	0.9%
Stony Coal, Mudstone	Fresh	1	0.96	0.2%
TOTAL		**79**	**418.43**	**100%**
NORTHERN EXTENSION				
Sandstone	Weathered	3	5.28	2.9%
Claystone	Weathered	2	2.90	1.6%
Conglomerate	Weathered	3	36.50	20.0%
Carb. Claystone	Weathered	1	1.00	0.5%
Sandstone	Fresh	4	6.31	3.5%
Siltstone	Fresh	1	5.29	2.9%
Claystone	Fresh	12	20.89	11.5%
Conglomerate	Fresh	2	34.17	18.8%
Pebble Conglomerate	Fresh	4	58.99	32.4%
Carb. Claystone	Fresh	8	10.86	6.0%
TOTAL		**40**	**182.19**	**100%**

The samples were sent to Australian Laboratory Services Pty Ltd in Brisbane for preparation where all of the sample was crushed to minus 4 mm and a 200 g split was then pulverised to minus 75 micrometres (µm) prior to testing.

4.0 Overburden and Interburden Geochemistry

The geochemical test results for the 119 overburden samples, including the $pH_{(1:2)}$ and $EC_{(1:2)}$, acid forming characteristics, sodicity assessment and element enrichment and solubility, are provided in Attachment B and summaries of the $pH_{(1:2)}$ and $EC_{(1:2)}$, and acid-base characteristics of the different overburden and interburden material types from the proposed eastern and northern extension areas are provided on Tables 2 and 3, respectively.

Table 2: Summary of the pH, EC and acid-base characteristics of the different overburden and interburden material types from the proposed eastern pit extension area.

Material Type		$pH_{1:2}$	$EC_{1:2}$ (dS/m)	Total S (%S)	MPA	ANC	NAPP
					(kg H_2SO_4/t)		
Weathered Material	min	7.2	0.084	<0.01	0	2	-210
	max	9.2	0.755	0.04	1	210	-1
(19 samples)	mean	7.9	0.296	0.01	0	22	-22
Sandstone	min	6.9	0.081	<0.01	0	2	-66
	max	9.3	0.596	0.14	4	67	-1
(26 samples)	mean	8.6	0.366	0.03	1	19	-19
Siltstone	min	8.2	0.261	0.02	1	7	-13
	max	9.0	0.404	0.07	2	15	-6
(5 samples)	mean	8.8	0.316	0.03	1	10	-9
Mudstone	min	5.5	0.160	<0.01	0	4	-9
	max	9.3	0.674	0.09	3	11	-2
(13 samples)	mean	8.3	0.297	0.04	1	6	-5
Conglomerate	min	6.7	0.205	<0.01	0	0	-79
	max	9.4	0.659	0.21	6	80	6
(12 samples)	mean	8.2	0.429	0.03	1	30	-29
Carb. Mudstone/ Stony Coal	min	7.6	0.097	0.03	1	6	-8
	max	8.2	0.221	0.12	4	10	-2
(4 samples)	mean	7.9	0.136	0.07	2	8	-6
Eastern Extension All Materials	min	5.5	0.081	0.01	0	0	-210
	max	9.4	0.755	0.21	6	210	6
(79 samples)	mean	8.3	0.334	0.03	1	18	-17

* The median value is used for the average pH rather than the mean due the the pH being a log-scale.

Table 3: Summary of the pH, EC and acid-base characteristics of the different overburden and interburden material types from the proposed northern pit extension area.

Material Type		*$pH_{1:2}$	$EC_{1:2}$ (dS/m)	Total S (%S)	MPA	ANC	NAPP
					(kg H_2SO_4/t)		
Weathered Material	min	5.5	0.103	<0.01	0	3	-16
	max	8.7	0.296	0.09	3	17	-2
(9 samples)	mean	8.5	0.162	0.02	1	8	-8
Sandstone	min	8.5	0.157	<0.01	0	8	-99
	max	8.9	0.238	0.01	0	99	-8
(4 samples)	mean	8.7	0.195	0.01	0	36	-36
Siltstone (1 sample)		8.7	0.174	0.02	1	18	-18
Claystone	min	7.1	0.135	0.02	1	5	-13
	max	9.5	0.295	0.06	2	15	-4
(12 samples)	mean	8.8	0.192	0.04	1	9	-8
Conglomerate	min	8.8	0.220	0.01	0	14	-32
	max	9.1	0.299	0.03	1	32	-13
(2 samples)	mean	9.0	0.260	0.02	1	23	-23
Pebble Conglomerate	min	8.6	0.167	0.01	0	16	-35
	max	9.3	0.402	0.05	2	35	-16
(4 samples)	mean	9.1	0.288	0.02	1	23	-22
Carb. Claystone	min	8.2	0.115	0.01	0	5	-10
	max	9.3	0.261	0.11	3	12	-3
(8 samples)	mean	8.7	0.189	0.05	2	8	-7
Northern Extension All Materials	min	5.5	0.103	0.01	0	3	-99
	max	9.5	0.402	0.11	3	99	-2
(40 samples)	mean	8.7	0.202	0.03	1	14	-13

* The median value is used for the average pH rather than the mean due the the pH being a log-scale.

4.1 pH, Salinity and Sodicity

The $pH_{1:2}$ values for the overburden and interburden samples range widely from 5.5 to 9.4, with an average (median) of 8.3 for the eastern extension samples and 8.7 for the northern extension samples. Tables 2 and 3 show that the large range in $pH_{1:2}$ values, from slightly acid to moderately alkaline, is typical for all of the different overburden and interburden material types and that the median $pH_{1:2}$ of the different material types is typically alkaline, ranging from 7.9 to 8.8 for the eastern extension area samples and 8.5 to 9.1 for the northern extension area samples.

The $EC_{1:2}$ values range from 0.081 to 0.755 dS/m in the eastern area samples and from 0.103 to 0.402 dS/m in the northern area samples indicating that the overburden and interburden represented by these samples is only expected to be non- to slightly saline. Tables 2 and 3 show that the range in $EC_{1:2}$ values is relatively consistent for the different overburden material types and the average values for the different material types range from 0.136 to 0.429 dS/m for the eastern extension area samples and

0.162 to 0.288 dS/m for the northern extension area samples. These results indicate that the different overburden and interburden material types are typically expected to be non-saline but some of these materials are likely to be slightly saline.

A total of 45 overburden and interburden samples, including 28 samples from the eastern extension and 17 samples from the northern extension, were selected for exchangeable cation analysis and determination of the ESP in order to assess the sodicity risk presented by the different overburden material types. The samples that were selected provided a sample set with the expected range of $EC_{1:2}$ values (salinities) for each of the different lithology units within the stratigraphic sequence of each pit extension area. The results from these analyses are provided in Attachment B.

Figures 5 and 6 are plots of the ESP values compared to the $EC_{1:2}$ for the different overburden and interburden material types from the eastern and northern extension areas, respectively. These plots provide the salinity and sodicity ranking for the different materials types and show that, although the samples are non- to slightly saline, the eastern extension samples range from slightly to highly sodic (8.2 to 46.6 %) and the northern extension samples range from non- to highly sodic (1.6 to 37.8 %). The moderate to highly sodic samples from the eastern extension area include the Weathered Materials, Sandstone, Siltstone, Conglomerate, Mudstone, Carbonaceous Mudstone and the Stony Coal, and from the northern extension area include only the Claystone and Carbonaceous Claystone. The materials represented by these moderately and highly sodic samples may be highly dispersive and erodible.

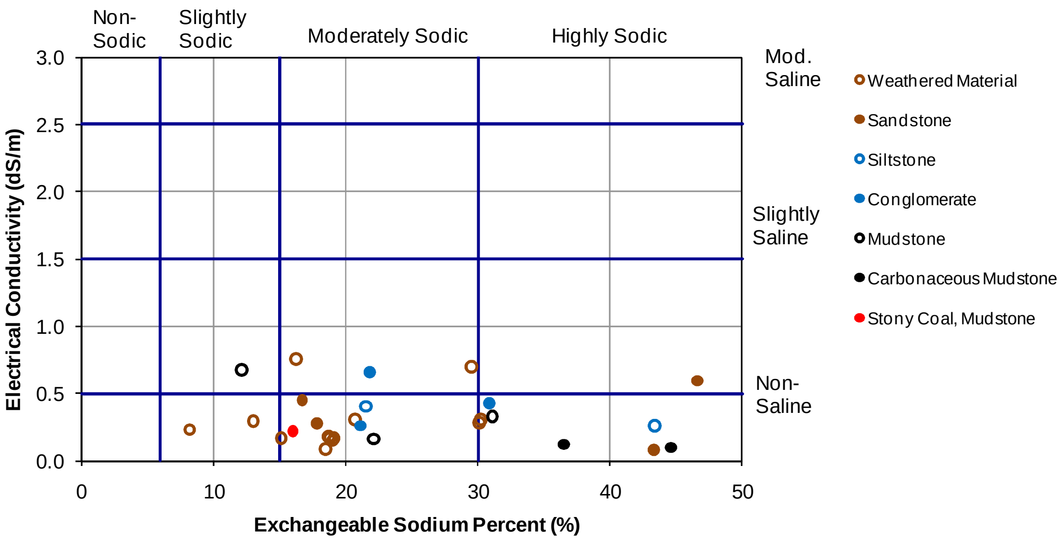

Figure 5: Salinity and sodicity ranking for selected overburden and interburden samples from the proposed eastern pit extension area.

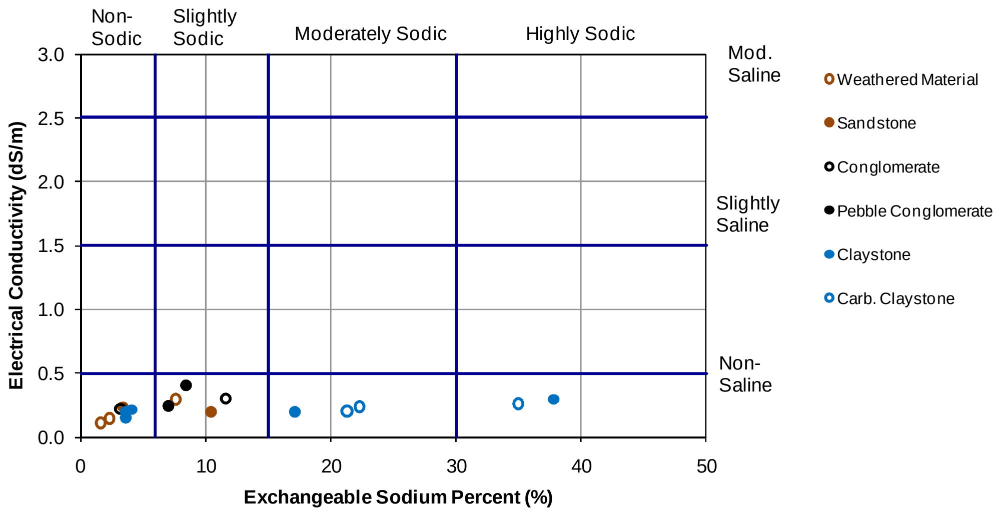

Figure 6: Salinity and sodicity ranking for selected overburden and interburden samples from the proposed northern pit extension area.

4.2 Acid Forming Characteristics

The total sulfur (S) content of the overburden and interburden samples is low ranging from <0.01 to 0.21 %S in the eastern extension samples and from <0.01 to 0.11 %S in the northern extension. The average total S content for both sample sets is 0.03 %S and only 13% of the samples from the eastern extension and 20% of the samples from the northern extension have total S contents greater than 0.05 %S.

A total of 15 samples from the proposed eastern and northern pit extension areas were selected for sulfide S analysis. The selected samples included a number of samples with higher total S contents (0.06 to 0.21 %S) from the different lithologies. The results from these analyses are provided in Attachment B and indicate a range of sulfide S contents from 0.006 to 0.145 %S. These results indicate that not all of the S in these materials occurs as reactive S (sulfide S) with from 20 to 94 % of the total S in the selected samples occuring in a non-reactive form such as sulfate or organic S. For these samples the proportion of the total S that occurs as sulfide ranges from 6 to 80 %.

The ANC of the overburden and interburden samples varies widely, but is generally relatively low for both pit extension areas. The ANC of the eastern pit extension samples ranges from 0 to 210 kg H_2SO_4/t with an average of 18 kg H_2SO_4/t and the ANC of the northern pit extension samples ranges from 3 to 99 kg H_2SO_4/t with an average of 14 kg H_2SO_4/t.

Figures 7 and 8 are plots of the total sulfur content compared to the ANC for the different material types of the eastern and northern extensions, respectively. Samples that plot above the NAPP = 0 (ANC/MPA = 1) line are NAPP negative, indicating an excess in acid buffering capacity over potential acidity. Samples that plot above the

ANC/MPA=2 line have at least a two-fold excess in acid buffering over acid potential and those that plot above the ANC/MPA=3 line have a three-fold excess. These plots show that generally these samples are relatively inert with low total S and low ANC and that the majority of the samples are NAPP negative with ANC/MPA ratios greater than 3 and therefore have a significant excess in acid buffering over the acid potential. However, a number of the higher total S samples have low ANC and subsequently one of these samples, a conglomerate (sample TA063C/14), is NAPP positive and the others are NAPP negative with ANC/MPA ratios of less than 3. These samples were selected for NAG testing to confirm their acid forming characteristics and geochemical classification.

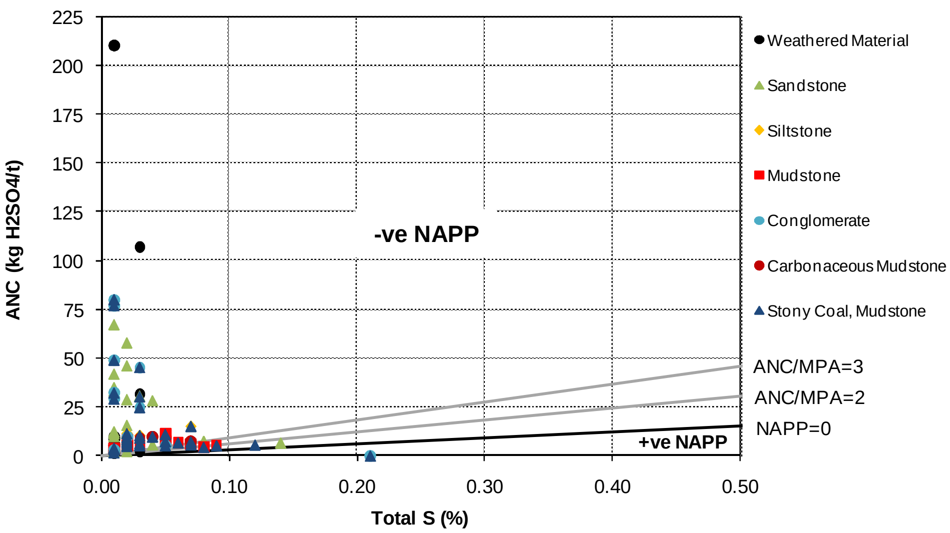

Figure 7: Acid-base account plot for the overburden and interburden samples from the proposed eastern pit extension area.

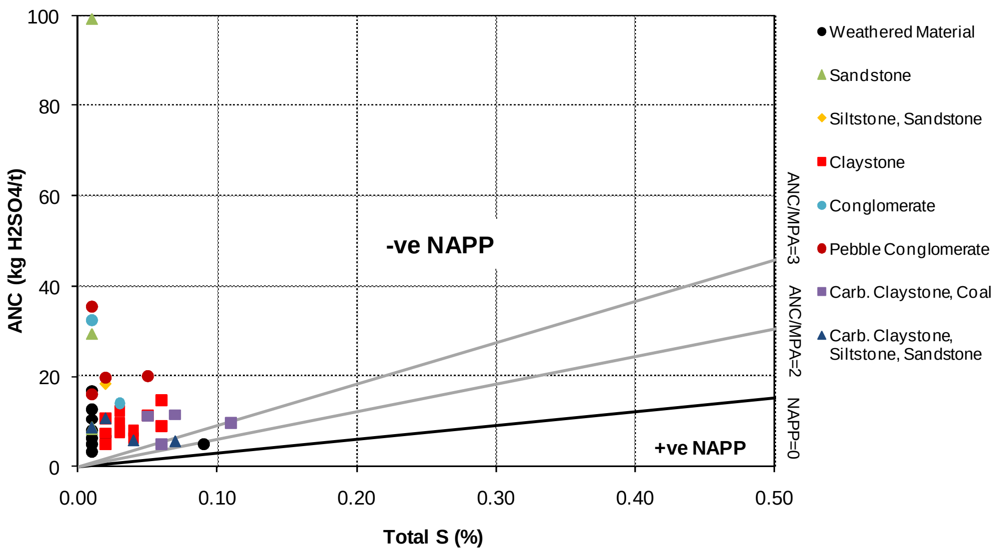

Figure 8: Acid-base account plot for the overburden and interburden samples from the proposed northern pit extension area.

A total of 15 samples, including 10 samples from the eastern pit extension and 5 from the northern pit extension, were selected for NAG testing and the results from these tests are provided in Attachment B. Figure 9 is a plot of the NAPP values compared to the NAGpH for the selected samples. Samples that plot in the upper left quadrate are NAPP negative with NAGpH values greater than 4.5, and these samples are confirmed as NAF. Samples that plot in the lower right quadrate are NAPP positive with NAGpH values less than 4.5, and these samples are confirmed as PAF. However, samples that plot in the lower left or upper right quadrates have an uncertain geochemical classification. This plot shows that the majority of the NAPP negative samples have a NAGpH greater than 4.5 and these samples are confirmed as NAF. This plot also shows that the NAPP positive sample of conglomerate (TA063C/14) has a NAGpH of 3.2 and is confirmed as PAF. However, 3 of the samples are NAPP negative with NAGpH's less than 4.5 and the classification of these samples is therefore uncertain (UC).

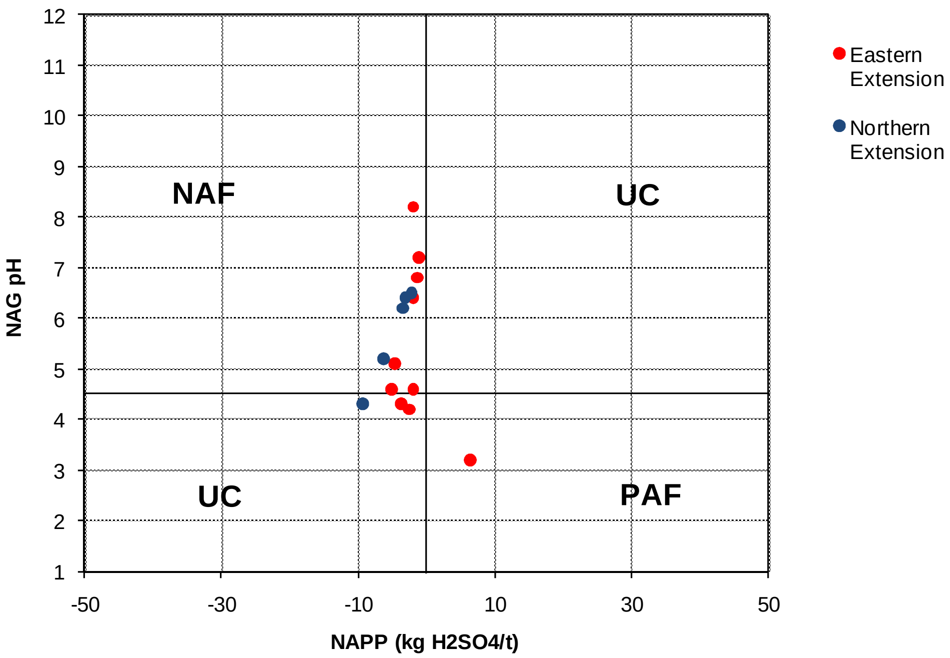

Figure 9: Geochemical classification plot for selected overburden and interburden samples from the proposed eastern and northern pit extension areas.

The 3 samples with an UC geochemical classification include 2 mudstone samples from the eastern extension and 1 carbonaceous claystone sample from the northern extension. These samples all have sulfide S contents of 0.01 %S or less indicating that the slightly lowered NAGpH's of 4.2 to 4.3 for these samples is most likely attributed to the presence of carbonaceous material rather than acid generation through sulfide oxidation. Carbonaceous materials have the potential to interfere with the NAG test reaction causing a premature breakdown of the hydrogen peroxide.

Based on this it is expected that these samples with an UC geochemical classification are most likely to be NAF (i.e. UC[NAF] as shown in Tables B-1 and B-2).

The identified PAF sample represents a relatively thin unit (1.85 m) of the conglomerate which is located immediately above the Bollol Creek coal seam from the eastern pit extension area (Drill-Hole TA063C). This sample has a NAPP of 6 kg H_2SO_4/t and a NAG capacity of only 2 kg H_2SO_4/t when titrated to pH 4.5 and therefore it is considered that the material represented by this sample only has a low capacity to generate acid (i.e. PAF/LC as shown in Table B-1).

Based on the samples tested, it is expected that the majority of the overburden and interburden materials from the proposed extension areas will be NAF. However, due to the occurrence of slightly increased S concentrations, some materials that have low ANC may be PAF. Due to the relatively low S contents it is expected that these materials will only have a low capacity to generate acid (< 10 kg H_2SO_4/t).

4.3 Metal Enrichment and Solubility

A total of 25 samples, including 15 samples from the eastern extension and 10 samples from the northern extension, were selected for multi-element analysis based on their stratigraphic location, lithology and geochemical characteristics. The results from these analyses and the geochemical abundances indices for the selected samples are provided in Attachment B.

These results are consistent with the results from the previous geochemical investigations at Tarrawonga (GEM, 2010) and indicate that As and Sb are slightly enriched in all samples and significantly enriched in a number of samples, and that Se is slightly enriched in a number of samples compared to the average crustal abundances. The enrichment of As, Sb and Se is a relatively common characteristic of coal deposits of this region. The concentration ranges and average crustal abundance of these elements are summarised in Table 4.

Table 4: Concentration ranges and average crustal abundances for enriched elements in selected overburden and interburden samples from the proposed eastern and northern pit extensions.

Element	*Average Crustal Abundance (mg/kg)	Concentration Range (mg/kg)	
		Eastern Extension	Northern Extension
As	1.5	1.0 to 15.2	4.6 to 12.6
Sb	0.2	0.50 to 2.68	0.58 to 1.87
Se	0.05	0.02 to 0.15	0.01 to 0.27

mg/kg = milligrams per kilogram
*Bowen H.J.M. (1979) Environmental Chemistry of the Elements.

The results also show that boron (B) is significantly enriched in a number of the Weathered Material samples and that cadmium (Cd) and zinc (Zn) are significantly enriched in one of the Weathered Material samples. The enriched B concentrations range from 98 to 266 mg/kg and occur in samples that are all highly weathered and collected from the upper zone (0 to 30m) of the stratigraphy. The sample containing enriched concentrations of Cd (1.42 mg/kg) and Zn (786 mg.kg) represents a relatively small interval (1.1 m) of partially weathered mudstone from the eastern extension area. The average crustal abundances of B, Cd and Zn are 10 mg/kg, 0.11 mg/kg and 75 mg/kg, respectively.

Multi-element scans were also performed on the water extracts (1 part sample/2 parts deionised water) from the selected overburden and interburden samples in order to provide an indication of relative element solubility in these materials. The results from these scans are presented in Attachment B and, consistent with the results from the previous investigations (GEM, 2010), indicate that As, Mo and Se are likely to be relatively soluble in the overburden and interburden materials. Although slightly enriched in some of the overburden samples, Sb was not found to be readily soluble in the samples tested. The concentration ranges of As, Mo and Se are compared to Australian and New Zealand Environment Conservation Council (ANZECC) irrigation water quality guidelines (ANZECC, 2000) in Table 5 in order to provide an indication of the relative solubility of these elements.

Table 5: Concentration ranges and the ANZECC (2000) Irrigation Water Quality Guideline values for readily soluble elements in the overburden and interburden samples from Tarrawonga Expansion Project.

Element	**Concentration Range (µg/L)**	**Irrigation Water Quality Guideline (ANZECC, 2000)**	
		Short-Term Exposure (µg/L)	**Long-Term Exposure (µg/L)**
As	1.3 - 406	2000	100
Mo	0.27 - 195.9	50	10
Se	1.1 - 111.7	50	10

These results indicate that As, Mo and Se are typically less soluble in the Weathered Material samples and this is most likely due to leaching of the readily soluble constituents in these materials over time.

5.0 Coarse Reject Geochemistry

For the current TCM operations a proportion of the coarse rejects produced at Whitehaven's CHPP in Gunnedah is trucked to the TCM for in-pit disposal and it is understood that this practice will continue for the proposed Project. Two grab samples of the coarse reject (chitter) representing the mixed and Tarrawonga washery waste were submitted to ACIRL Ltd (Upper Hunter) for whole-rock geochemical analysis in October 2009 (Report No. 26001092). The whole-rock analyses were performed on the ash component of these materials and the major oxides concentrations were converted to element concentrations in order to identify any significant element enrichments.

The multi-element composition and geo-chemical abundance indices for the mixed and Tarrawonga coarse rejects are provided in Attachment B (Table B-11). It is understood that the mixed coarse reject sample is considered to be the most representative of the coarse reject materials that are disposed at the TCM. These results indicate that Se is significantly enriched and As is slightly enriched in both samples, and that S is significantly enriched in the mixed reject sample. Mo was not included in the analytical suite of elements and therefore it is not known whether or not this element is enriched in these samples. The concentrations of the enriched elements and the respective average crustal abundances are provided on Table 6.

Table 6: Element concentrations and average crustal abundances for enriched elements in the coarse reject (chitter) samples from the Whitehaven CHPP.

Element	*Average Crustal Abundance	Element Concentration	
		Tarrawonga Chitter	Mixed Chitter
As	1.5 mg/kg	6.4 mg/kg	6.1 mg/kg
S	0.03 %	0.01 %	0.40 %
Se	0.05 mg/kg	0.5 mg/kg	0.5 mg/kg

*Bowen H.J.M. (1979) Environmental Chemistry of the Elements.

The enrichment of As and Se is consistent with the findings from the multi-element scans performed on the overburden and interburden samples from this study. However, the concentration of S in the mixed reject sample is significantly higher than those of the overburden and interburden samples. A sulfur concentration of 0.4% equates to an MPA of 12 kg H_2SO_4/t. Although further analysis of this material is required, including ANC determination and NAG testing, to determine the acid-base balance and geochemical classification, the S concentration reported indicates that this material has a risk of being acid forming.

6.0 Conclusions and Recommendations

6.1 Overburden and Interburden

Previous geochemical investigations, including those conducted by URS Australia Pty Ltd as part of the 2005 EIS for the current operations (R.W Corkery & Co Pty Limited, 2005) and those conducted by GEM in 2010 for the proposed pit expansion as part of the Tarrawonga Modification Project (GEM, 2010), indicated that the overburden was likely to be NAF and to only have a low salinity risk. Due to the relatively inert nature of the overburden, it was recommended that no specific constraints relating to the handling and storage of the overburden would be required for geochemically secure disposal of the overburden. However, GEM reported the occurrence of moderately sodic materials within the overburden which may become highly dispersive and cause stability and erosion problems if left exposed on the outer dump surfaces (GEM, 2010).

The results of the current geochemical investigations indicate that the overburden and interburden from the proposed eastern and northern pit extension areas, as shown on Figure 2, is generally expected to be NAF with a low salinity risk consistent with the previous investigations. Although the overburden and interburden from these areas is expected to be relatively barren, a small quantity of the overburden, most likely strata immediately adjacent to some of the coal seams, may contain slightly increased S concentrations with low or no ANC and these materials present a risk of being PAF. However, due to the low S content, these materials are only expected to have a low capacity to generate acid (< 10 kg H_2SO_4/t).

These investigations have also confirmed that a relatively high proportion of the overburden and interburden from the proposed extension areas is likely to the moderately or highly sodic. If these materials are left exposed on the dump surfaces (or final pit walls) they may become highly dispersive causing problems with dump (and pit wall) stability, increased erosion potential and impacting water quality due to increased Total Suspended Solids (TSS).

Consistent with the previous geochemical investigations conducted by GEM (GEM, 2010) and typical of the coal deposits in this region, the overburden and interburden materials from the proposed pit extension areas are likely to contain significantly enriched concentrations of As and Se and slightly enriched concentrations of Sb compared to the average crustal abundance. The analysis of water extracts from selected overburden and interburden samples indicates that As, Mo and Se are likely to be slightly soluble under the prevailing near-neutral pH conditions.

Based on these findings the following recommendations are made:

1. Because of the identified risk of a small quantity of the overburden and interburden from immediately above or below the coal seams being PAF low capacity (<10 kg H_2SO_4/t), it is recommended that the appropriate mine personnel be briefed in Acid Rock Drainage (ARD) awareness in order for them to be able to identify if any PAF materials (or ARD) are exposed within the dump surfaces or pit walls or floor. The presented results indicate that if any PAF materials do occur within the strata they are likely to be located immediately above or below the coal seams.

   Although ROM blending of overburden and interburden from the current pit and proposed pit extensions will be sufficient to produce an overall NAF material, if localised zones of PAF material are identified within the final dump surface they will need to be either excavated and buried within the dump or covered with sufficient NAF material to reduce the risk of developing low pH conditions or ARD.

2. In order to ensure long-term dump stability and erosion control, and to help with maintaining the quality (TSS) of the site water, the final dump surfaces (top and batter slopes) will need to be treated with gypsum and/or constructed of material that is known to be non-sodic or to only have low sodicity. It is therefore recommended that a sufficient quantity of suitable material be identified prior to completion of the dumps which can either make-up the final lift of each dump or can be placed as a cover over the completed dumps.

3. It is recommended that the water quality monitoring program for the potentially impacted areas include the following parameters:

   - pH, EC, TSS, total alkalinity/acidity, SO_4, As, Se, and Mo.

   It is assumed that sample collection for the water quality monitoring program will be performed quarterly. The data generated should be periodically reviewed and it is recommended that this be carried out 12-monthly. The reviews should be able to identify if exposure of sodic or PAF materials within the dumps or pit walls is impacting water quality and will also indicate if the release of any of the enriched or soluble elements is adversely impacting the quality of water in the receiving environment. The recommended parameter list for this program should also be reviewed 12-monthly.

4. It is recommended that additional detailed geochemical investigations be conducted on overburden and interburden in the future if the mining operations expand or move into new areas not covered by the previous or current investigations.

6.2 Coal Rejects

A proportion of the coarse reject (chitter) from the Whitehaven CHPP in Gunnedah is disposed in dedicated emplacements within the mined out pits at the TCM and this practice will continue for the proposed Project. Whole rock geochemical analysis of a blended sample of this material indicates that it is likely to be significantly enriched with S and Se and slightly enriched with As. Due to the relatively high S content, this material has a risk of being acid generating and it is recommended that additional geochemical testing be conducted on a larger sample set to confirm the acid forming characteristics of this material in order to identify any specific requirements for geochemically secure emplacement within the in-pit disposal facility.

The enrichment of Se and As in the coarse reject is consistent with the overburden and interburden from the TCM and therefore the water quality monitoring program recommended for the overburden and interburden emplacements should be extended to cover the proposed coarse reject emplacement. The recommended water quality monitoring program is designed to monitor ongoing acid generation reactions within the proposed emplacement along with the release of any identified elements of potential concern to the receiving environment.

7.0 References

Australian and New Zealand Environment Conservation Council (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Canberra, October.

Bowen H.J.M. (1979) Environmental Chemistry of the Elements. Academic Press, London.

Geo-Environmental Management Pty Ltd (2010) Environmental Geochemistry Assessment of the Tarrawonga Coal Mine Modification, NSW.

R.W. Corkery and Co. Pty Ltd (2005) East Boggabri Joint Venture Environmental Impact Statement.

URS Australia Pty Ltd (2005) Acid Mine Drainage and Salinity Potential Assessment for the proposed Boggabri Coal Mine. Prepared on behalf of the East Boggabri Joint Venture.

Attachment A

Drill-Hole Sample Detail

Table A-1: Drill-hole sample detail for the Eastern Extension, Tarrawonga Expansion Project.

Table A-2: Drill-hole sample detail for the Northern Extension, Tarrawonga Expansion Project.

Table A-1: Drill-hole sample detail for the Eastern Extension, Tarrawonga Expansion Project.

Drill-Hole	Sample Code	Depth (m)			Lithology	Weathering
		from	to	Interval		
TA062C	TA062C/6	30.50	31.50	1.00	Sandstone	Highly Weathered
TA062C	TA062C/7	32.50	36.50	4.00	Conglomerate	Highly Weathered
TA062C	TA062C/8	37.20	42.00	4.80	Conglomerate	Weathered
TA062C		44.75	47.14	2.39	SEAM 1	
TA062C	TA062C/9	47.14	47.82	0.68	Sandstone	Fresh
TA062C		48.18	50.80	2.62	SEAM 1 Lower	
TA062C	TA062C/10	51.05	57.05	6.00	Sandstone	Fresh
TA062C	TA062C/11	57.05	65.93	8.88	Conglomerate	Fresh
TA062C	TA062C/12	66.50	74.70	8.20	Sandstone	Fresh
TA062C		74.70	76.34	1.64	SEAM 2	
TA062C	TA062C/13	76.34	77.30	0.96	Mudstone	Fresh
TA062C	TA062C/14	77.30	81.14	3.84	Sandstone	Fresh
TA062C	TA062C/15	82.45	84.05	1.60	Mudstone	Fresh
TA062C	TA062C/16	84.15	98.90	14.75	Conglomerate	Fresh
TA062C	TA062C/17	99.03	102.07	3.04	Mudstone	Fresh
TA062C	TA062C/18	103.50	110.20	6.70	Conglomerate	Fresh
TA062C	TA062C/19	112.60	114.94	2.34	Sandstone	Fresh
TA062C		114.94	116.95	2.01	SEAM 3	
TA062C	TA062C/20	123.75	152.75	29.00	Conglomerate	Fresh
TA062C	TA062C/21	153.09	159.26	6.17	Sandstone	Fresh
TA062C	TA062C/22	159.26	159.70	0.44	Mudstone	Fresh
TA062C		159.70	161.73	2.03	SEAM 4	
TA062C	TA062C/23	161.87	163.40	1.53	Carbonaceous Mudstone	Fresh
TA062C		163.40	165.46	2.06	SEAM 5	
TA062C	TA062C/24	165.46	166.04	0.58	Carbonaceous Mudstone	Fresh
TA062C	TA062C/25	167.25	169.20	1.95	Sandstone	Fresh
TA062C		169.20	169.92	0.72	SEAM 6	
TA062C	TA062C/26	169.92	170.50	0.58	Sandstone	Fresh
TA062C	TA062C/27	170.50	172.25	1.75	Carbonaceous Mudstone	Fresh
TA062C	TA062C/28	177.00	185.40	8.40	Sandstone	Fresh
TA062C	TA062C/29	185.40	187.40	2.00	Sandstone	Fresh
TA062C		187.40	188.94	1.54	SEAM 7	
TA063C	TA063C/1	0.00	7.00	7.00	Conglomerate	Highly Weathered
TA063C	TA063C/2	7.00	30.20	23.20	Sandstone	Highly Weathered
TA063C	TA063C/3	30.20	33.00	2.80	Clay	Highly Weathered
TA063C	TA063C/4	33.00	34.10	1.10	Mudstone	Partially Weathered
TA063C	TA063C/5	34.10	35.00	0.90	Sandstone	Weathered
TA063C	TA063C/6	35.00	37.50	2.50	Conglomerate	Weathered
TA063C	TA063C/7	40.90	53.50	12.60	Conglomerate	Fresh
TA063C	TA063C/8	53.50	54.50	1.00	Sandstone	Fresh
TA063C	TA063C/9	54.50	56.25	1.75	Mudstone	Fresh
TA063C		56.25	58.10	1.85	SEAM 1	
TA063C	TA063C/10	58.10	58.60	0.50	Mudstone	Fresh
TA063C	TA063C/11	58.60	59.56	0.96	Stony Coal, Mudstone	Fresh
TA063C	TA063C/12	61.00	64.85	3.85	Sandstone	Fresh
TA063C	TA063C/13	64.85	88.50	23.65	Conglomerate	Fresh
TA063C	TA063C/14	88.50	90.35	1.85	Conglomerate	Fresh
TA063C		90.35	91.37	1.02	SEAM 2	
TA063C	TA063C/15	91.50	92.70	1.20	Sandstone	Fresh
TA063C	TA063C/16	92.70	98.60	5.90	Conglomerate	Fresh
TA063C	TA063C/17	101.80	104.10	2.30	Siltstone	Fresh

Table A1: Drill-hole sample detail for the Eastern Extension, Tarrawonga Expansion Project.

Drill-Hole	Sample Code	Depth (m)			Lithology	Weathering
		from	to	Interval		
TA063C	TA063C/18	104.10	106.80	2.70	Sandstone	Fresh
TA063C	TA063C/19	107.00	114.70	7.70	Sandstone	Fresh
TA063C	TA063C/20	114.70	115.67	0.97	Siltstone	Fresh
TA063C		115.67	119.40	3.73	SEAM 3	
TA063C	TA063C/21	119.40	122.35	2.95	Sandstone	Fresh
TA063C		122.35	122.67	0.32	SEAM 4	
TA063C		122.95	123.95	1.00	SEAM 5	
TA063C	TA063C/22	123.95	125.70	1.75	Sandstone	Fresh
TA063C	TA063C/23	125.70	141.85	16.15	Conglomerate	Fresh
TA063C	TA063C/24	146.40	147.37	0.97	Mudstone	Fresh
TA063C		147.37	147.72	0.35	SEAM 6	
TA063C	TA063C/25	147.72	150.04	2.32	Mudstone	Fresh
TA063C		150.04	151.16	1.12	SEAM 7	
TA063C	TA063C/26	151.16	151.70	0.54	Mudstone	Fresh
TA063C	TA063C/27	151.70	153.50	1.80	Sandstone	Fresh
TA063C	TA063C/28	153.50	160.00	6.50	Conglomerate	Fresh
TA063C	TA063C/29	160.00	162.70	2.70	Sandstone	Fresh
TA063C		162.70	165.35	2.65	SEAM 8	
TA064C	TA064C/1	3.00	29.00	26.00	Gravel	Highly Weathered
TA064CR	TA064C/2	29.00	40.00	11.00	Clay	Weathered
TA064CR	TA064C/3	40.00	55.00	15.00	Conglomerate	Partially Weathered
TA064CR	TA064C/4	55.00	60.00	5.00	Conglomerate	Fresh
TA064CR	TA064C/5	60.00	72.50	12.50	Mudstone	Fresh
TA064CR		72.50	75.40	2.90	SEAM 1	
TA064CR	TA064C/6	75.40	79.80	4.40	Sandstone	Fresh
TA064CR		79.80	81.85	2.05	SEAM 2	
TA064CR	TA064C/7	81.85	82.80	0.95	Mudstone	Fresh
TA064CR	TA064C/8	84.00	103.50	19.50	Sandstone, Siltstone, Mudstone	Fresh
TA064CR	TA064C/9	103.50	106.10	2.60	Mudstone	Fresh
TA064CR		106.10	108.00	1.90	SEAM 3	
TA064CR	TA064C/10	108.00	110.10	2.10	Sandstone	Fresh
TA064CR	TA064C/11	112.90	119.90	7.00	Sandstone	Fresh
TA064CR	TA064C/12	119.90	120.37	0.47	Siltstone	Fresh
TA064CR		120.37	120.74	0.37	SEAM 4	
TA064CR		120.78	121.86	1.08	SEAM 5	
TA064CR	TA064C/13	121.86	122.50	0.64	Mudstone	Fresh
TA064CR	TA064C/14	122.50	129.60	7.10	Sandstone	Fresh
TA064CR	TA064C/15	129.60	130.65	1.05	Siltstone	Fresh
TA064CR		130.65	130.94	0.29	SEAM 6 Upper	
TA064CR		131.36	131.98	0.62	SEAM 6 Lower	
TA064CR	TA064C/16	132.00	133.22	1.22	Siltstone	Fresh
TA064CR		133.22	134.46	1.24	SEAM 7	
TA064CR	TA064C/17	134.65	138.31	3.66	Sandstone	Fresh
TA064CR	TA064C/18	138.31	143.55	5.24	Sandstone	Fresh
TA064CR		143.55	149.10	5.55	SEAM 8	
TA064CR	TA064C/19	149.10	157.30	8.20	Conglomerate	Fresh
TA065C	TA065C/1	0.5	4.0	3.5	Gravel	Highly Weathered
TA065C	TA065C/2	4.0	7.0	3.0	Clay	Highly Weathered
TA065C	TA065C/3	7.0	9.0	2.0	Gravel	Highly Weathered
TA065C	TA065C/4	9.0	20.0	11.0	Conglomerate	Weathered
TA065C	TA065C/5	20.0	22.0	2.0	Siltstone	Weathered
TA065C	TA065C/6	22.0	24.0	2.0	Sandstone	Partially Weathered
TA065C	TA065C/7	24.0	26.0	2.0	Siltstone	Partially Weathered

Table A-2: Drill-hole sample detail for the Northern Extension, Tarrawonga Expansion Project.

Drill-Hole	Sample Code	Depth (m)			Lithology	Weathering
		from	to	Interval		
BC2195	BC2195/1	0.50	24.00	23.50	Conglomerate	Weathered
BC2195	BC2195/2	24.00	26.00	2.00	Sandstone	Highly Weathered
BC2195	BC2195/3	26.00	27.00	1.00	Carb. Claystone	Highly Weathered
BC2195	BC2195/4	31.00	35.00	4.00	Conglomerate	Weathered
BC2195	BC2195/5	35.05	35.52	0.47	Sandstone	Weathered
BC2195	BC2195/6	35.52	36.27	0.75	Claystone	Fresh
		36.27	37.55	1.28	SEAM BC	
BC2195	BC2195/7	37.55	38.95	1.40	Claystone, Siltstone, Sandstone	Fresh
BC2195	BC2195/8	38.95	40.88	1.93	Sandstone	Fresh
BC2195	BC2195/9	46.81	52.10	5.29	Siltstone, Sandstone	Fresh
BC2195	BC2195/10	52.10	53.45	1.35	Claystone	Fresh
BC2195	BC2195/11	54.76	55.88	1.12	Sandstone	Fresh
BC2195	BC2195/12	55.88	79.58	23.70	Conglomerate	Fresh
		79.58	81.50	1.92	SEAM JE1	
BC2195	BC2195/13	81.50	83.23	1.73	Sandstone	Fresh
		83.23	83.50	0.27	SEAM JE2	
BC2195	BC2195/14	83.50	85.18	1.68	Carb. Claystone, Claystone, Siltstone,	Fresh
		85.18	85.66	0.48	SEAM MN11	
		85.74	86.08	0.34	SEAM MN12	
BC2195	BC2195/15	86.08	88.40	2.32	Carb. Claystone, Claystone, Siltstone,	Fresh
		88.40	90.84	2.44	SEAM MN2	
BC2195	BC2195/16	90.84	91.46	0.62	Claystone	Fresh
BC2195	BC2195/17	92.24	93.40	1.16	Carb. Claystone, Coal	Fresh
BC2195	BC2195/18	93.40	109.36	15.96	Pebble Conglomerate	Fresh
		109.36	110.43	1.07	SEAM VY	
BC2195	BC2195/19	110.43	111.80	1.37	Claystone, Sandstone	Fresh
BC2195	BC2195/20	116.99	117.56	0.57	Carb. Claystone, Coal	Fresh
		117.56	119.10	1.54	SEAM NG	
BC2195	BC2195/21	119.10	123.05	3.95	Claystone, Siltstone, Sandstone	Fresh
		123.05	123.24	0.19	SEAM UN1	
BC2197	BC2197/1	1.00	10.00	9.00	Conglomerate	Weathered
BC2197	BC2197/2	19.00	19.80	0.80	Claystone	Weathered
		19.80	19.90	0.10	SEAM BR3	
BC2197	BC2197/3	19.90	22.00	2.10	Claystone	Weathered
BC2197	BC2197/4	24.34	27.15	2.81	Sandstone	Partially Weathered
BC2197	BC2197/5	28.30	29.20	0.90	Claystone	Fresh
		29.20	30.67	1.47	SEAM BC	
BC2197	BC2197/6	30.67	32.06	1.40	Claystone, Sandstone	Fresh
BC2197	BC2197/7	44.64	58.57	13.93	Pebble Conglomerate	Fresh
BC2197	BC2197/8	58.57	60.10	1.53	Sandstone	Fresh
BC2197	BC2197/9	69.99	79.73	9.74	Pebble Conglomerate	Fresh
BC2197	BC2197/10	79.85	80.84	0.99	Claystone, Siltstone, Sandstone	Fresh
		80.84	83.33	2.49	SEAM JE	
		83.53	83.93	0.40	SEAM MN12	
BC2197	BC2197/11	83.93	85.30	1.37	Carb. Claystone, Siltstone, Sandstone	Fresh
BC2197	BC2197/12	85.30	95.77	10.47	Conglomerate	Fresh
BC2197	BC2197/13	95.77	97.39	1.62	Claystone, Sandstone	Fresh
		97.39	99.71	2.32	SEAM MN2	
BC2197	BC2197/14	99.71	100.66	0.95	Carb. Claystone, Coal	Fresh
BC2197	BC2197/15	101.68	102.67	0.99	Carb. Claystone, Coal	Fresh
BC2197	BC2197/16	105.47	124.83	19.36	Pebble Conglomerate	Fresh
		124.83	125.94	1.11	SEAM VY	
BC2197	BC2197/17	125.94	127.76	1.82	Carb. Claystone, Siltstone, Sandstone	Fresh
BC2197	BC2197/18	134.45	138.10	3.65	Claystone, Sandstone	Fresh
		138.10	139.91	1.81	SEAM NG	
BC2197	BC2197/19	139.91	142.80	2.89	Claystone, Sandstone	Fresh

Attachment B

Geochemical Test Results

Table B-1: Acid forming characteristics of drill-hole samples from the Eastern Extension, Tarrawonga Expansion Project.

Sample Code	Sample Description	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS Total %S	Sulfide %S	MPA	ANC	NAPP	ANC/ MPA	NAG TEST NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	ARD Classification
TA062C/6	Sandstone (Highly Weathered)	7.9	0.167	<0.01		0	2	-1	4.9				NAF
TA062C/7	Conglomerate (Highly Weathered)	7.7	0.149	<0.01		0	2	-1	5.2				NAF
TA062C/8	Conglomerate (Weathered)	7.3	0.084	<0.01		0	2	-1	4.9				NAF
	SEAM 1												
TA062C/9	Sandstone	7.3	0.278	0.04		1	5	-4	4.3				NAF
	SEAM 1 Lower												
TA062C/10	Sandstone	7.7	0.183	0.02		1	2	-1	3.1	6.8	0	0	NAF
TA062C/11	Conglomerate	8.7	0.408	0.01		0	77	-76	250				NAF
TA062C/12	Sandstone	9.0	0.279	0.02		1	10	-9	16				NAF
	SEAM 2												
TA062C/13	Mudstone	8.2	0.160	0.07	0.010	2	6	-4	2.7	4.3	1	13	UC(NAF)
TA062C/14	Sandstone	8.9	0.252	0.02		1	11	-10	18				NAF
TA062C/15	Mudstone	8.3	0.257	0.02		1	5	-5	8.7				NAF
TA062C/16	Conglomerate	9.2	0.439	0.03		1	25	-24	27				NAF
TA062C/17	Mudstone	8.7	0.163	0.05		2	11	-9	7.2				NAF
TA062C/18	Conglomerate	7.7	0.424	0.05		2	5	-4	3.4				NAF
TA062C/19	Sandstone	8.7	0.464	0.02		1	46	-45	75				NAF
	SEAM 3												
TA062C/20	Conglomerate	9.4	0.530	0.01		0	32	-32	105				NAF
TA062C/21	Sandstone	8.6	0.406	0.04		1	28	-27	23				NAF
TA062C/22	Mudstone	8.3	0.209	<0.01		0	4	-3	12				NAF
	SEAM 4												
TA062C/23	Carbonaceous Mudstone	8.2	0.102	0.03		1	9	-8	9.9				NAF
	SEAM 5												
TA062C/24	Carbonaceous Mudstone	7.8	0.123	0.07	0.006	2	7	-5	3.4	4.6	0	5	NAF
TA062C/25	Sandstone	7.6	0.383	0.02		1	12	-11	19				NAF
	SEAM 6												
TA062C/26	Sandstone	8.3	0.081	<0.01		0	11	-11	36				NAF
TA062C/27	Carbonaceous Mudstone	8.0	0.097	0.04		1	10	-8	7.9				NAF
TA062C/28	Sandstone	7.6	0.349	0.01		0	41	-41	135				NAF
TA062C/29	Sandstone	8.5	0.104	0.01		0	12	-12	39				NAF
	SEAM 7												

KEY

$pH_{1:2}$ = pH of 1:2 extract
$EC_{1:2}$ = Electrical Conductivity of 1:2 extract (dS/m)
MPA = Maximum Potential Acidity (kgH_2SO_4/t)
ANC = Acid Neutralising Capacity (kgH_2SO_4/t)
NAPP = Net Acid Producing Potential (kgH_2SO_4/t)

NAGpH = pH of NAG liquor
$NAG_{(pH4.5)}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)
$NAG_{(pH7.0)}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

ARD Classification Key

NAF = Non-Acid Forming
PAF = Potentially Acid Forming
UC = Uncertain (with expected classification shown in brackets)

Table B-1: Acid forming characteristics of drill-hole samples from the Eastern Extension, Tarrawonga Expansion Project.

Sample Code	Sample Description	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS						NAG TEST			ARD Classification
				Total %S	Sulfide %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
TA063C/1	Conglomerate (Highly Weathered)	9.0	0.755	0.03		1	32	-31	34				NAF
TA063C/2	Sandstone (Highly Weathered)	8.3	0.303	<0.01		0	3	-2	8.5				NAF
TA063C/3	Clay (Highly Weathered)	7.9	0.170	<0.01		0	9	-9	31				NAF
TA063C/4	Mudstone (Partially Weathered)	7.4	0.293	0.04		1	10	-8	7.8				NAF
TA063C/5	Sandstone (Weathered)	7.5	0.177	<0.01		0	3	-2	8.2				NAF
TA063C/6	Conglomerate (Weathered)	8.3	0.175	<0.01		0	2	-2	6.2				NAF
TA063C/7	Conglomerate	7.6	0.260	0.01		0	2	-1	5.2				NAF
TA063C/8	Sandstone	7.3	0.245	0.14	0.112	4	6	-2	1.4	8.2	0	0	NAF
TA063C/9	Mudstone	7.2	0.416	0.08	0.045	2	4	-2	1.8	6.4	0	1	NAF
	SEAM 1												
TA063C/10	Mudstone	8.4	0.252	0.03		1	5	-4	5.8				NAF
TA063C/11	Stony Coal, Mudstone	7.6	0.221	0.12	0.007	4	6	-2	1.5	4.6	0	8	NAF
TA063C/12	Sandstone	7.2	0.470	0.02		1	5	-4	8.3				NAF
TA063C/13	Conglomerate	7.0	0.330	0.02		1	10	-9	16				NAF
TA063C/14	Conglomerate	6.7	0.323	0.21	0.145	6	0	6	0.0	3.2	2	5	PAF/LC
	SEAM 2												
TA063C/15	Sandstone	7.1	0.207	<0.01		0	2	-1	5.9				NAF
TA063C/16	Conglomerate	7.6	0.334	0.03		1	45	-44	49				NAF
TA063C/17	Siltstone	9.0	0.325	0.02		1	7	-6	11				NAF
TA063C/18	Sandstone	9.1	0.474	0.02		1	57	-57	94				NAF
TA063C/19	Sandstone	9.3	0.481	<0.01		0	67	-66	218				NAF
TA063C/20	Siltstone	9.0	0.404	0.07	0.026	2	15	-13	7.0				NAF
	SEAM 3												
TA063C/21	Sandstone	8.8	0.409	0.02		1	5	-5	8.7				NAF
	SEAM 4												
	SEAM 5												
TA063C/22	Sandstone	9.1	0.491	<0.01		0	10	-9	31				NAF
TA063C/23	Conglomerate	8.5	0.659	0.01		0	49	-48	159				NAF
TA063C/24	Mudstone	9.3	0.263	0.05		2	7	-6	4.8				NAF
	SEAM 6												
TA063C/25	Mudstone	8.9	0.226	0.09	0.007	3	5	-2	1.9	4.2	1	15	UC(NAF)
	SEAM 7												
TA063C/26	Mudstone	9.0	0.307	0.03		1	6	-5	6.9				NAF
TA063C/27	Sandstone	9.3	0.470	<0.01		0	35	-34	113				NAF
TA063C/28	Conglomerate	8.9	0.578	<0.01		0	29	-29	95				NAF
TA063C/29	Sandstone	8.9	0.456	0.02		1	15	-15	25				NAF
	SEAM 8												

KEY

$pH_{1:2}$ = pH of 1:2 extract
$EC_{1:2}$ = Electrical Conductivity of 1:2 extract (dS/m)
MPA = Maximum Potential Acidity (kgH_2SO_4/t)
ANC = Acid Neutralising Capacity (kgH_2SO_4/t)
NAPP = Net Acid Producing Potential (kgH_2SO_4/t)

NAGpH = pH of NAG liquor
$NAG_{(pH4.5)}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)
$NAG_{(pH7.0)}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

ARD Classification Key

NAF = Non-Acid Forming
PAF = Potentially Acid Forming
UC = Uncertain (with expected classification shown in brackets)

Table B-1: Acid forming characteristics of drill-hole samples from the Eastern Extension, Tarrawonga Expansion Project.

Sample Code	Sample Description	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS Total %S	Sulfide %S	MPA	ANC	NAPP	ANC/ MPA	NAG TEST NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	ARD Classification
TA064C/1	Gravel (Highly Weathered)	8.3	0.230	<0.01		0	8	-8	27				NAF
TA064C/2	Clay (Weathered)	7.2	0.485	0.03		1	2	-1	2.2	7.2	0	0	NAF
TA064C/3	Conglomerate (Partially Weathered)	7.9	0.164	<0.01		0	2	-2	6.5				NAF
TA064C/4	Conglomerate	8.0	0.205	<0.01		0	3	-3	10				NAF
TA064C/5	Mudstone	5.5	0.674	0.02		1	9	-8	14				NAF
	SEAM 1												
TA064C/6	Sandstone	6.9	0.216	0.08	0.010	2	7	-5	2.9	5.1	0	1	NAF
	SEAM 2												
TA064C/7	Mudstone	7.6	0.357	0.02		1	5	-4	8.0				NAF
TA064C/8	Sandstone, Siltstone, Mudstone	7.9	0.450	0.03		1	30	-29	33				NAF
TA064C/9	Mudstone	8.7	0.326	0.01		0	4	-4	13				NAF
	SEAM 3												
TA064C/10	Sandstone	8.6	0.294	0.02		1	9	-8	14				NAF
TA064C/11	Sandstone	9.1	0.436	<0.01		0	33	-32	107				NAF
TA064C/12	Siltstone	8.7	0.292	0.02		1	8	-7	12				NAF
	SEAM 4												
	SEAM 5												
TA064C/13	Mudstone	8.2	0.254	0.06	0.010	2	7	-5	3.6				NAF
TA064C/14	Sandstone	8.9	0.442	0.02		1	11	-11	19				NAF
TA064C/15	Siltstone	8.8	0.298	0.02		1	11	-11	19				NAF
	SEAM 6 Upper												
	SEAM 6 Lower												
TA064C/16	Siltstone	8.2	0.261	0.03		1	10	-9	11				NAF
	SEAM 7												
TA064C/17	Sandstone	8.2	0.596	0.02		1	8	-7	13				NAF
TA064C/18	Sandstone	8.7	0.592	0.02		1	28	-28	46				NAF
	SEAM 8												
TA064C/19	Conglomerate	8.4	0.652	0.01		0	80	-79	260				NAF
TA065C/1	Gravel (Highly Weathered)	8.2	0.281	<0.01		0	5	-5	16				NAF
TA065C/2	Clay (Highly Weathered)	9.2	0.698	0.03		1	107	-106	117				NAF
TA065C/3	Gravel (Highly Weathered)			<0.01		0	210	-210	686				NAF
TA065C/4	Conglomerate (Weathered)	9.1	0.303	<0.01		0	9	-8	28				NAF
TA065C/5	Siltstone (Weathered)			<0.01		0	6	-5	18				NAF
TA065C/6	Sandstone (Partially Weathered)			<0.01		0	5	-5	16				NAF
TA065C/7	Siltstone (Partially Weathered)			<0.01		0	5	-5	17				NAF

KEY

$pH_{1:2}$ = pH of 1:2 extract
$EC_{1:2}$ = Electrical Conductivity of 1:2 extract (dS/m)
MPA = Maximum Potential Acidity (kgH_2SO_4/t)
ANC = Acid Neutralising Capacity (kgH_2SO_4/t)
NAPP = Net Acid Producing Potential (kgH_2SO_4/t)

NAGpH = pH of NAG liquor
$NAG_{(pH4.5)}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)
$NAG_{(pH7.0)}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

ARD Classification Key

NAF = Non-Acid Forming
PAF = Potentially Acid Forming
UC = Uncertain (with expected classification shown in brackets)

Table B-2: Acid forming characteristics of drill-hole samples from the Northern Extension, Tarrawonga Expansion Project.

Sample Code	Sample Description	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS Total %S	Sulfide %S	MPA	ANC	NAPP	ANC/ MPA	NAG TEST NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	ARD Classification
BC2195/1	Conglomerate (Weathered)	8.7	0.103	<0.01		0	13	-12	41				NAF
BC2195/2	Sandstone (Highly Weathered)			<0.01		0	3	-3	11				NAF
BC2195/3	Carb. Claystone (Highly Weathered)			<0.01		0	11	-10	34				NAF
BC2195/4	Conglomerate (Weathered)	8.7	0.106	<0.01		0	17	-16	55				NAF
BC2195/5	Sandstone (Weathered)	8.2	0.141	<0.01		0	8	-8	26				NAF
BC2195/6	Claystone	8.1	0.208	0.05		2	11	-10	7.3				NAF
	SEAM BC												
BC2195/7	Claystone, Siltstone, Sandstone	8.1	0.215	0.04		1	6	-5	5.1				NAF
BC2195/8	Sandstone	8.5	0.190	0.01		0	29	-29	96				NAF
BC2195/9	Siltstone, Sandstone	8.7	0.174	0.02		1	18	-18	30				NAF
BC2195/10	Claystone	8.7	0.193	0.03		1	12	-11	14				NAF
BC2195/11	Sandstone	8.8	0.157	0.01		0	9	-8	29				NAF
BC2195/12	Conglomerate	8.8	0.220	0.01		0	32	-32	106				NAF
	SEAM JE1												
BC2195/13	Sandstone	8.6	0.196	<0.01		0	8	-8	27				NAF
	SEAM JE2												
BC2195/14	Carb. Claystone, Siltstone, Sandstone	8.2	0.174	0.02		1	11	-10	17				NAF
	SEAM MN11												
	SEAM MN12												
BC2195/15	Carb. Claystone, Siltstone, Sandstone	8.3	0.192	0.04		1	6	-5	4.7				NAF
	SEAM MN2												
BC2195/16	Claystone	8.4	0.135	0.02		1	5	-4	8.0				NAF
BC2195/17	Carb. Claystone, Coal	8.2	0.148	0.07	0.009	2	12	-9	5.4	4.3	1	9	UC(NAF)
BC2195/18	Pebble Conglomerate	9.0	0.240	0.01		0	16	-16	52				NAF
	SEAM VY												
BC2195/19	Claystone, Sandstone	9.1	0.194	0.02		1	7	-7	12				NAF
BC2195/20	Carb. Claystone, Coal	9.0	0.238	0.11	0.031	3	10	-6	2.9	5.2	0	6	NAF
	SEAM NG												
BC2195/21	Claystone, Siltstone, Sandstone	8.9	0.159	0.03		1	7	-6	8.1				NAF
	SEAM UN1												

KEY
$pH_{1:2}$ = pH of 1:2 extract
$EC_{1:2}$ = Electrical Conductivity of 1:2 extract (dS/m)
MPA = Maximum Potential Acidity (kgH_2SO_4/t)
ANC = Acid Neutralising Capacity (kgH_2SO_4/t)
NAPP = Net Acid Producing Potential (kgH_2SO_4/t)

NAGpH = pH of NAG liquor
$NAG_{(pH4.5)}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)
$NAG_{(pH7.0)}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

ARD Classification Key
NAF = Non-Acid Forming
PAF = Potentially Acid Forming
UC = Uncertain (with expected classification shown in brackets)

Table B-2: Acid forming characteristics of drill-hole samples from the Northern Extension, Tarrawonga Expansion Project.

Sample Code	Sample Description	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS						NAG TEST			ARD Classification
				Total %S	Sulfide %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
BC2197/1	Conglomerate (Weathered)			<0.01		0	5	-5	16				NAF
BC2197/2	Claystone (Weathered)			0.01		0	6	-6	21				NAF
	SEAM BR3												
BC2197/3	Claystone (Weathered)			0.02		1	7	-6	11				NAF
BC2197/4	Sandstone (Partially Weathered)	5.5	0.296	0.09	0.010	3	5	-2	1.8	6.5	0	0	NAF
BC2197/5	Claystone	7.1	0.148	0.06		2	9	-7	4.8				NAF
	SEAM BC												
BC2197/6	Claystone, Sandstone	7.6	0.150	0.04		1	8	-7	6.5				NAF
BC2197/7	Pebble Conglomerate	8.6	0.167	0.01		0	35	-35	115				NAF
BC2197/8	Sandstone	8.9	0.238	0.01		0	99	-99	324				NAF
BC2197/9	Pebble Conglomerate	9.2	0.342	0.02		1	20	-19	32				NAF
BC2197/10	Claystone, Siltstone, Sandstone	9.0	0.147	0.06		2	15	-13	8.0				NAF
	SEAM JE												
	SEAM MN12												
BC2197/11	Carb. Claystone,Siltstone, Sandstone	8.5	0.115	0.07	0.010	2	6	-3	2.6	6.2	0	1	NAF
BC2197/12	Conglomerate	9.1	0.299	0.03		1	14	-13	15				NAF
BC2197/13	Claystone, Sandstone	8.9	0.231	0.02		1	11	-10	17				NAF
	SEAM MN2												
BC2197/14	Carb. Claystone, Coal	8.9	0.200	0.06	0.008	2	5	-3	2.7	6.4	0	2	NAF
BC2197/15	Carb. Claystone, Coal	8.8	0.187	0.05		2	11	-10	7.3				NAF
BC2197/16	Pebble Conglomerate	9.3	0.402	0.05		2	20	-18	13				NAF
	SEAM VY												
BC2197/17	Carb. Claystone, Siltstone, Sandstone	9.3	0.261	0.01		0	9	-8	28				NAF
BC2197/18	Claystone, Sandstone	9.5	0.295	0.03		1	10	-9	10				NAF
	SEAM NG												
BC2197/19	Claystone, Sandstone	9.2	0.223	0.03		1	8	-7	8.7				NAF

KEY

$pH_{1:2}$ = pH of 1:2 extract
$EC_{1:2}$ = Electrical Conductivity of 1:2 extract (dS/m)
MPA = Maximum Potential Acidity (kgH_2SO_4/t)
ANC = Acid Neutralising Capacity (kgH_2SO_4/t)
NAPP = Net Acid Producing Potential (kgH_2SO_4/t)

NAGpH = pH of NAG liquor
$NAG_{(pH4.5)}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)
$NAG_{(pH7.0)}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

ARD Classification Key
NAF = Non-Acid Forming
PAF = Potentially Acid Forming
UC = Uncertain (with expected classification shown in brackets)

Table B-3: pH and EC, exchangeable cations, cation exchange capacity and exchangeable sodium percent for the selected drill-hole samples from the Eastern Extension of the Tarrawonga Coal Mine Expansion.

Sample Code	Sample Description	$pH_{1:2}$	$EC_{1:2}$	Exch. Cations (meq/100g)				CEC	ESP
				Ca	Mg	K	Na		
TA062C/6	Sandstone (Highly Weathered)	7.9	0.167	3.0	3.5	0.8	1.7	9.0	19.1
TA062C/7	Conglomerate (Highly Weathered)	7.7	0.149	2.5	2.8	0.9	1.4	7.7	19.0
TA062C/8	Conglomerate (Weathered)	7.3	0.084	2.0	2.2	0.7	1.1	6.0	18.5
TA062C/12	Sandstone	9.0	0.279	5.1	4.4	0.9	2.2	12.6	17.8
TA062C/13	Mudstone	8.2	0.160	3.3	3.3	1.0	2.1	9.7	22.1
TA062C/18	Conglomerate	7.7	0.424	4.4	3.7	0.7	3.9	12.7	30.9
TA062C/24	Carbonaceous Mudstone	7.8	0.123	2.6	4.5	0.8	4.6	12.6	36.5
TA062C/26	Sandstone	8.3	0.081	2.6	5.5	1.2	7.0	16.3	43.3
TA062C/27	Carbonaceous Mudstone	8.0	0.097	2.3	4.9	1.4	6.8	15.4	44.6
TA063C/1	Conglomerate (Highly Weathered)	9.0	0.755	21.2	5.4	0.8	5.3	32.7	16.2
TA063C/2	Sandstone (Highly Weathered)	8.3	0.303	2.0	3.1	0.6	2.4	8.1	30.2
TA063C/3	Clay (Highly Weathered)	7.9	0.170	9.2	7.5	0.6	3.1	20.3	15.1
TA063C/4	Mudstone (Partially Weathered)	7.4	0.293	10.6	9.5	0.6	3.1	23.8	13.0
TA063C/5	Sandstone (Weathered)	7.5	0.177	2.9	3.4	0.5	1.6	8.4	18.7
TA063C/6	Conglomerate (Weathered)	8.3	0.175	2.5	3.0	0.6	1.4	7.5	18.8
TA063C/7	Conglomerate	7.6	0.260	2.0	2.2	0.5	1.3	6.0	21.1
TA063C/11	Stony Coal, Mudstone	7.6	0.221	2.4	2.6	0.3	1.0	6.3	16.0
TA063C/20	Siltstone	9.0	0.404	8.5	4.7	0.7	3.8	17.8	21.5
TA063C/23	Conglomerate	8.5	0.659	9.8	1.0	0.4	3.1	14.4	21.8
TA064C/1	Gravel (Highly Weathered)	8.3	0.230	14.3	2.7	0.5	1.6	19.2	8.2
TA064C/5	Mudstone	5.5	0.674	5.8	3.3	0.6	1.3	11.0	12.1
TA064C/8	Sandstone, Siltstone, Mudstone	7.9	0.450	11.8	4.7	0.8	3.5	20.9	16.7
TA064C/9	Mudstone	8.7	0.326	4.0	4.7	0.8	4.3	13.8	31.1
TA064C/16	Siltstone	8.2	0.261	2.8	2.2	0.7	4.4	10.1	43.4
TA064C/17	Sandstone	8.2	0.596	4.9	2.3	0.9	7.1	15.4	46.6
TA065C/1	Gravel (Highly Weathered)	8.2	0.281	30.1	1.8	2.7	0.9	2.3	7.6
TA065C/2	Clay (Highly Weathered)	9.2	0.698	29.5	8.3	11.3	1.4	8.8	29.8
TA065C/4	Conglomerate (Weathered)	9.1	0.303	20.7	2.9	3.0	0.5	1.7	8.1

KEY

$pH_{1:2}$ = pH of 1:2 extract

$EC_{1:2}$ = Electrical Conductivity of 1:2 extract (dS/m)

CEC = Cation Exchange Capacity (meq/100g)

ESP = Exchangeable Sodium Percent (%)

Table B-4: pH and EC, exchangeable cations, cation exchange capacity and exchangeable sodium percent for the selected drill-hole samples from the Northern Extension of the Tarrawonga Coal Mine Expansion.

Sample Code	Sample Description	$pH_{1:2}$	$EC_{1:2}$	Exch. Cations (meq/100g)				CEC	ESP
				Ca	Mg	K	Na		
BC2195/4	Conglomerate (Weathered)	8.7	0.106	1.6	19.4	3.0	0.5	0.4	23.4
BC2195/5	Sandstone (Weathered)	8.2	0.141	2.3	11.0	2.4	0.6	0.3	14.4
BC2195/7	Claystone, Siltstone, Sandstone	8.1	0.215	4.1	6.3	4.3	1.0	0.5	12.0
BC2195/10	Claystone	8.7	0.193	3.6	13.1	7.5	1.5	0.8	22.9
BC2195/12	Conglomerate	8.8	0.220	3.2	18.0	3.1	1.0	0.7	22.9
BC2195/13	Sandstone	8.6	0.196	10.4	3.7	3.9	1.0	1.0	9.5
BC2195/18	Pebble Conglomerate	9.0	0.240	7.0	11.4	2.5	1.2	1.1	16.3
BC2195/19	Claystone, Sandstone	9.1	0.194	17.1	4.6	4.7	1.3	2.2	12.9
BC2195/20	Carb. Claystone, Coal	9.0	0.238	22.3	3.0	3.5	1.0	2.2	9.8
BC2197/4	Sandstone (Partially Weathered)	5.5	0.296	7.6	2.5	1.8	0.7	0.4	5.4
BC2197/5	Claystone	7.1	0.148	3.6	5.9	4.1	1.4	0.4	11.7
BC2197/8	Sandstone	8.9	0.238	3.4	21.1	2.7	0.9	0.9	25.6
BC2197/12	Conglomerate	9.1	0.299	11.6	4.7	4.1	1.1	1.3	11.3
BC2197/14	Carb. Claystone, Coal	8.9	0.200	21.3	3.0	5.0	0.6	2.3	10.8
BC2197/16	Pebble Conglomerate	9.3	0.402	8.4	16.1	2.0	1.0	1.8	20.8
BC2197/17	Carb.Claystone,Siltstone,Sandstone	9.3	0.261	35.0	2.3	3.7	1.2	3.9	11.1
BC2197/18	Claystone, Sandstone	9.5	0.295	37.8	3.7	5.3	1.8	6.5	17.3

KEY

$pH_{1:2}$ = pH of 1:2 extract

$EC_{1:2}$ = Electrical Conductivity of 1:2 extract (dS/m)

CEC = Cation Exchange Capacity (meq/100g)

ESP = Exchangeable Sodium Percent (%)

Table B-5: Multi-element composition of selected drill-hole samples from the Eastern Extension of the Tarrawonga Expansion Project.

Element	Unit	Detection Limit	Sample Description/Code														
			Weathered Material					Sandstone		Siltstone		Conglomerate		Mudstone		Carb. Mudstone	
			TA063C/1	TA063C/2	TA063C/3	TA063C/4	TA064C/1	TA062C/26	TA063C/8	TA063C/20	TA064C/16	TA062C/16	TA063C/14	TA062C/13	TA063C/25	TA062C/24	TA062C/27
Ag	mg/kg	0.01	0.04	0.1	0.08	0.04	0.04	0.08	0.1	0.06	0.07	0.06	0.06	<	0.06	0.07	0.09
Al	%	0.005%	5.222%	6.413%	10.001%	10.776%	5.135%	9.040%	6.182%	7.551%	9.030%	6.404%	6.948%	8.338%	6.972%	7.941%	8.621%
As	mg/kg	0.5	5	8	7.6	1	11.9	5.3	8.7	4.5	8	5.8	8.5	3.9	4.6	15.2	6.8
B	mg/kg	50	98	266	<	<	103	<	<	<	<	<	<	<	<	<	<
Ba	mg/kg	0.1	1493.6	959.8	781.2	239.9	679.8	617.9	446.2	367.3	394.4	537.5	1556.1	529	395.7	327.1	541.9
Be	mg/kg	0.05	1.62	2.01	3.95	3.18	1.63	2.51	2.71	2.64	1.76	1.58	2.36	2.52	2.11	2.4	3.19
Ca	%	0.005%	1.673%	0.077%	0.379%	0.343%	0.531%	0.102%	0.515%	0.547%	0.160%	0.643%	0.103%	0.117%	0.070%	0.082%	0.106%
Cd	mg/kg	0.02	0.05	0.09	0.15	1.42	0.03	0.11	0.05	0.07	0.23	0.09	0.07	0.16	0.14	0.09	0.13
Co	mg/kg	0.1	8.1	5.2	9.6	2	5.2	5.7	8.2	13.2	7.1	5	4.1	4.7	10	7.3	6.1
Cr	mg/kg	5	35	35	52	51	44	43	23	38	48	28	62	46	48	39	47
Cu	mg/kg	1	10	13	37	36	9	32	10	21	31	9	5	33	32	27	31
Fe	%	0.01%	1.69%	4.40%	1.29%	0.63%	2.55%	1.71%	18.01%	2.48%	3.37%	2.16%	0.61%	1.64%	1.20%	1.13%	2.08%
Hg	mg/kg	0.01	0.02	0.03	0.02	0.14	0.01	0.04	0.02	0.07	0.07	0.17	0.07	0.08	0.04	0.05	0.04
K	%	0.002%	1.819%	2.490%	2.191%	1.498%	2.424%	3.659%	1.874%	2.306%	1.679%	2.089%	3.202%	2.395%	1.420%	1.861%	3.541%
Mg	%	0.002%	0.495%	0.193%	0.327%	0.338%	0.239%	0.428%	0.725%	0.413%	0.559%	0.259%	0.064%	0.302%	0.301%	0.291%	0.441%
Mn	mg/kg	1	83	610	412	21	204	113	2687	136	129	314	67	96	53	54	112
Mo	mg/kg	0.1	1.6	0.9	0.9	0.9	0.9	0.5	0.7	1.1	0.7	1.3	1	1.2	1.4	2	0.7
Na	%	0.002%	0.500%	0.358%	0.183%	0.109%	0.886%	0.235%	0.532%	0.248%	0.161%	0.133%	2.503%	0.142%	0.246%	0.148%	0.240%
Ni	mg/kg	1	10	13	21	22	8	19	25	38	28	18	13	20	37	23	21
P	mg/kg	50	127	157	591	210	209	265	319	146	267	261	67	229	222	190	183
Pb	mg/kg	0.5	18.3	15.5	30.5	37.6	17.3	20.8	11.7	21.1	24	14.7	20.4	23.6	19.3	27.1	24.5
Sb	mg/kg	0.05	0.84	1.32	0.82	2.68	1.08	0.79	0.5	2.38	1.04	1.37	0.45	2.67	1.04	1.22	1.47
Se	mg/kg	0.01	0.07	0.02	0.02	0.08	0.04	0.15	0.02	0.07	0.13	0.02	0.04	0.06	0.13	0.14	0.1
Si	%	0.1%	34.3%	34.1%	30.3%	27.3%	36.3%	30.6%	19.6%	22.8%	25.7%	33.5%	35.3%	25.7%	19.7%	24.4%	28.2%
Sn	mg/kg	0.1	2.1	2.8	3.7	4.4	2.1	3.4	1.5	3.2	3.7	2.2	2.3	3.2	2.7	3.2	3.4
Th	mg/kg	0.01	8.97	13.17	17.32	16.59	10.96	12.98	7.83	13.13	15.25	12.28	9.74	12.66	11.5	11.44	12.65
U	mg/kg	0.01	2.18	2.63	2.51	7.9	2.13	2.39	2.1	2.89	3.8	2.38	2.37	3.26	2.81	3.53	2.77
V	mg/kg	1	51	55	102	137	69	110	57	119	146	37	18	142	128	97	150
Zn	mg/kg	1	25	44	67	786	31	57	73	81	150	59	59	119	63	57	91

< element at or below analytical detection limit.

Table B-6: Geochemical abundance indices for selected drill-hole samples from the Eastern Extension of the Tarrawonga Expansion Project.

Element	***Mean Crustal Abundance**	**Sample Description/Code**														
		Weathered Material					Sandstone		Siltstone		Conglomerate		Mudstone		Carb. Mudstone	
		TA063C/1	TA063C/2	TA063C/3	TA063C/4	TA064C/1	TA062C/26	TA063C/8	TA063C/20	TA064C/16	TA062C/16	TA063C/14	TA062C/13	TA063C/25	TA062C/24	TA062C/27
Ag	0.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Al	8.2%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As	1.5	1	2	2	-	2	1	2	1	2	1	2	1	1	**3**	2
B	10	**3**	**4**	<2	<2	**3**	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Ba	500	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Be	2.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ca	4.0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cd	0.11	-	-	-	**3**	-	-	-	-	-	-	-	-	-	-	-
Co	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cr	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cu	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fe	4.1%	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
Hg	0.05	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-
K	2.1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mg	2.3%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mn	950	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Mo	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Na	2.3%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ni	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pb	14	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-
Sb	0.2	1	2	1	**3**	2	1	1	**3**	2	2	1	**3**	2	2	2
Se	0.05	-	-	-	-	-	1	-	-	1	-	-	-	1	1	-
Si	27.7%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sn	2.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Th	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
U	2.4	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
V	160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zn	75	-	-	-	**3**	-	-	-	-	-	-	-	-	-	-	-

*Bowen H.J.M.(1979) Environmental Chemistry of the Elements.

Table B-7: Chemical composition of water extracts from selected drill-hole samples from the Eastern Extension of the Tarrawonga Expansion Project.

Parameter		Detection Limit	Sample Description/Code														
			Weathered Material					Sandstone		Siltstone		Conglomerate		Mudstone		Carb. Mudstone	
			TA063C/1	TA063C/2	TA063C/3	TA063C/4	TA064C/1	TA062C/26	TA063C/8	TA063C/20	TA064C/16	TA062C/16	TA063C/14	TA062C/13	TA063C/25	TA062C/24	TA062C/27
pH		0.1	9.0	8.3	7.9	7.4	8.3	8.3	7.3	9.0	8.2	9.2	6.7	8.2	8.9	7.8	8.0
EC	dS/m	0.001	0.755	0.303	0.170	0.293	0.230	0.081	0.245	0.404	0.261	0.439	0.323	0.160	0.226	0.123	0.097
SO4	mg/l	0.3	78.5	20.1	6.9	62.9	6.1	19.6	55.3	38.7	36.8	75.0	161.3	32.1	32.5	30.7	18.2
Cl	mg/l	5.0	100	43	22	39	27	<	11	14	<	11	5	7	<	<	<
Al	mg/l	0.01	0.39	0.25	0.45	0.51	0.72	0.78	0.05	0.54	0.79	0.73	<	0.48	1.46	1.05	0.56
B	mg/l	0.01	<	<	<	0.08	<	<	<	<	0.01	<	<	<	0.02	<	<
Ca	mg/l	0.01	1.12	0.51	1.26	3.42	1.88	0.22	4.09	1.13	1.15	1.16	8.08	1.22	1.22	0.64	0.15
Cr	mg/l	0.01	<	<	<	<	<	<	<	<	<	<	<	<	0.01	<	<
Cu	mg/l	0.01	<	0.01	<	0.03	<	0.02	<	0.01	<	0.02	<	0.04	0.03	0.04	0.01
Fe	mg/l	0.01	0.20	0.04	0.04	0.12	0.15	0.07	<	0.04	0.13	0.04	0.16	0.14	0.32	0.17	0.04
K	mg/l	0.1	2.6	1.5	0.9	2.2	1.7	1.0	2.6	2.3	1.8	2.6	2.7	1.7	1.6	1.5	0.8
Mg	mg/l	0.01	1.44	0.50	0.75	2.39	1.29	0.24	3.66	0.95	0.77	0.65	6.42	0.36	0.94	0.68	0.18
Mn	mg/l	0.01	<	0.0	0.0	<	<	<	<	<	<	<	0.3	<	<	<	<
Na	mg/l	0.1	176.2	63.0	37.7	76.0	58.3	34.9	66.0	105.6	115.4	93.9	64.3	41.8	84.2	44.7	41.9
Ni	mg/l	0.01	<	<	0.02	0.02	<	0.01	<	<	<	0.01	0.18	<	<	<	<
P	mg/l	0.1	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Si	mg/l	0.05	10.18	3.10	4.13	4.84	8.91	2.45	1.21	2.54	2.68	2.20	4.34	1.94	5.03	2.63	2.26
V	mg/l	0.01	0.04	<	<	0.33	<	<	<	0.02	<	<	<	<	0.03	<	0.01
Zn	mg/l	0.01	<	<	0.01	0.21	<	0.01	<	0.01	0.05	<	0.09	0.05	0.06	0.03	0.02
Ag	ug/l	0.01	<	<	0.02	0.02	<	<	<	<	<	<	<	<	<	<	<
As	ug/l	0.1	19.4	1.3	2.0	7.0	7.0	97.2	0.6	237.3	81.3	36.4	1.5	22.3	205.5	406.0	113.4
Ba	ug/l	0.05	10.35	13.98	21.47	26.28	23.11	68.81	8.40	20.83	62.44	44.11	14.55	49.00	93.21	110.54	48.84
Be	ug/l	0.1	<	0.2	1.0	1.5	0.2	0.3	<	0.3	0.8	<	0.4	0.2	1.6	0.6	0.2
Cd	ug/l	0.02	<	0.05	0.04	0.74	0.04	0.04	<	0.03	0.02	0.06	0.24	0.20	0.28	0.16	0.16
Co	ug/l	0.1	0.4	0.2	0.9	0.9	0.3	1.4	0.3	2.7	1.3	1.1	61.0	0.7	3.1	4.1	0.7
Hg	ug/l	0.1	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Mo	ug/l	0.05	3.45	3.96	2.86	53.83	3.98	25.30	18.48	195.93	85.99	154.45	0.27	43.89	133.93	157.06	22.75
Pb	ug/l	0.5	<	1.9	1.6	7.2	1.5	3.0	<	2.3	3.1	2.1	1.5	13.5	6.4	8.5	2.6
Sb	ug/l	0.01	0.24	0.08	0.16	40.74	0.16	1.84	0.13	7.48	0.93	1.93	0.05	1.84	1.56	1.49	2.25
Se	ug/l	0.5	4.4	1.1	1.5	40.4	1.4	31.9	2.8	66.7	90.9	9.4	5.9	42.5	111.7	72.4	47.4
Sn	ug/l	0.1	<	<	<	0.5	<	<	<	<	<	<	<	0.1	0.2	0.2	<
Th	ug/l	0.005	0.110	0.278	0.092	0.057	0.273	0.023	0.008	0.143	0.124	0.061	<	0.046	0.307	0.099	0.028
U	ug/l	0.005	3.571	0.028	0.010	0.552	0.559	0.094	0.872	5.507	5.056	1.206	0.600	0.229	1.473	0.552	0.272

< element at or below analytical detection limit.

Table B-8: Multi-element composition of selected drill-hole samples from the Northern Extension of the Tarrawonga Expansion Project.

Element	Unit	Detection Limit	Sample Description/Code									
			Weathered Material	Sandstone	Siltstone	Conglom.	Pebble Conglom.	Claystone			Carb. Claystone	
			BC2197/4	BC2197/8	BC2195/9	BC2197/12	BC2197/16	BC2195/7	BC2197/5	BC2197/18	BC2195/20	BC2197/11
Ag	mg/kg	0.01	0.07	0.07	0.07	0.03	0.03	0.08	0.04	0.03	0.04	0.05
Al	%	0.005%	7.121%	6.197%	8.719%	8.091%	6.325%	9.041%	8.044%	8.830%	7.106%	9.032%
As	mg/kg	0.5	12.8	5.3	5.4	5.6	9.3	5.3	10.4	4.6	5	1.6
B	mg/kg	50	<	<	<	<	<	<	<	<	<	<
Ba	mg/kg	0.1	748.5	666.6	664.5	667.9	1773.9	516.3	502.2	662.1	443.9	297.5
Be	mg/kg	0.05	1.28	2.05	2.46	2.23	1.72	2.44	2.13	3	2.58	2.69
Ca	%	0.005%	0.105%	1.590%	0.569%	0.307%	0.748%	0.168%	0.161%	0.128%	0.199%	0.076%
Cd	mg/kg	0.02	0.07	0.08	0.14	0.13	0.04	0.14	0.11	0.11	0.13	0.21
Co	mg/kg	0.1	5.3	6.2	6.7	7.9	4.9	4.8	5.7	7.7	8.3	4.6
Cr	mg/kg	5	15	18	37	17	15	30	35	47	46	40
Cu	mg/kg	1	4	6	20	12	10	19	21	29	20	27
Fe	%	0.01%	0.95%	8.07%	1.91%	0.89%	1.33%	0.75%	1.31%	1.26%	3.10%	0.52%
Hg	mg/kg	0.01	0.01	0.01	0.03	0.03	0.06	0.05	0.03	0.04	0.05	0.13
K	%	0.002%	2.175%	2.395%	2.984%	2.760%	3.076%	2.572%	2.397%	3.264%	2.625%	1.821%
Mg	%	0.002%	0.118%	0.447%	0.439%	0.265%	0.230%	0.263%	0.309%	0.448%	0.335%	0.237%
Mn	mg/kg	1	104	1268	295	85	208	32	77	46	385	19
Mo	mg/kg	0.1	1.8	1.3	1	1.1	1.4	1.6	0.9	0.9	0.7	0.9
Na	%	0.002%	0.620%	0.794%	0.351%	0.276%	1.182%	0.229%	0.169%	0.333%	0.364%	0.102%
Ni	mg/kg	1	12	17	16	10	13	10	19	20	25	11
P	mg/kg	50	173	158	260	145	205	174	151	340	199	113
Pb	mg/kg	0.5	17.5	12.2	19.7	21.2	14.9	21.5	17.4	15.9	19.1	30
Sb	mg/kg	0.05	0.58	0.78	0.92	1.38	0.92	1.03	0.95	1.1	1.43	1.87
Se	mg/kg	0.01	0.18	0.01	0.09	0.04	0.02	0.27	0.14	0.1	0.07	0.14
Si	%	0.1%	36.8%	28.1%	30.2%	32.9%	35.1%	31.0%	31.1%	29.9%	24.8%	26.3%
Sn	mg/kg	0.1	1.6	1.9	3.1	3.3	2	2.9	3.4	3.7	2.9	3.5
Th	mg/kg	0.01	10.63	7.63	12.99	12.94	12.06	11.45	12.79	14.24	12.74	14.33
U	mg/kg	0.01	2.89	2.38	2.95	2.89	2.5	3.51	3.12	3.45	2.83	3.29
V	mg/kg	1	28	46	98	48	30	77	83	134	118	126
Zn	mg/kg	1	31	84	73	74	39	91	59	75	92	103

< element at or below analytical detection limit.

Table B-9: Geochemical abundance indices for selected drill-hole samples from the Northern Extension of the Tarrawonga Expansion Project.

Element	*Mean Crustal Abundance	Sample Description/Code									
		Weathered Material	Sandstone	Siltstone	Conglom.	Pebble Conglom.	Claystone			Carb. Claystone	
		BC2197/4	BC2197/8	BC2195/9	BC2197/12	BC2197/16	BC2195/7	BC2197/5	BC2197/18	BC2195/20	BC2197/11
Ag	0.07	-	-	-	-	-	-	-	-	-	-
Al	8.2%	-	-	-	-	-	-	-	-	-	-
As	1.5	**3**	1	1	1	2	1	2	1	1	-
B	10	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Ba	500	-	-	-	-	1	-	-	-	-	-
Be	2.6	-	-	-	-	-	-	-	-	-	-
Ca	4.0%	-	-	-	-	-	-	-	-	-	-
Cd	0.11	-	-	-	-	-	-	-	-	-	-
Co	20	-	-	-	-	-	-	-	-	-	-
Cr	100	-	-	-	-	-	-	-	-	-	-
Cu	50	-	-	-	-	-	-	-	-	-	-
Fe	4.1%	-	-	-	-	-	-	-	-	-	-
Hg	0.05	-	-	-	-	-	-	-	-	-	1
K	2.1%	-	-	-	-	-	-	-	-	-	-
Mg	2.3%	-	-	-	-	-	-	-	-	-	-
Mn	950	-	-	-	-	-	-	-	-	-	-
Mo	1.5	-	-	-	-	-	-	-	-	-	-
Na	2.3%	-	-	-	-	-	-	-	-	-	-
Ni	80	-	-	-	-	-	-	-	-	-	-
P	1000	-	-	-	-	-	-	-	-	-	-
Pb	14	-	-	-	-	-	-	-	-	-	1
Sb	0.2	1	1	2	2	2	2	2	2	2	**3**
Se	0.05	1	-	-	-	-	2	1	-	-	1
Si	27.7%	-	-	-	-	-	-	-	-	-	-
Sn	2.2	-	-	-	-	-	-	-	-	-	-
Th	12	-	-	-	-	-	-	-	-	-	-
U	2.4	-	-	-	-	-	-	-	-	-	-
V	160	-	-	-	-	-	-	-	-	-	-
Zn	75	-	-	-	-	-	-	-	-	-	-

*Bowen H.J.M.(1979) Environmental Chemistry of the Elements.

Table B-10: Chemical composition of water extracts from selected drill-hole samples from the Northern Extension of the Tarrawonga Expansion Project.

Parameter		**Detection Limit**	**Sample Description/Code**									
			Weathered Material	Sandstone	Siltstone	Conglom.	Pebble Conglom.	Claystone			Carb. Claystone	
			BC2197/4	BC2197/8	BC2195/9	BC2197/12	BC2197/16	BC2195/7	BC2197/5	BC2197/18	BC2195/20	BC2197/11
pH		0.1	5.5	8.9	8.7	9.1	9.3	8.1	7.1	9.5	9.0	8.5
EC	dS/m	0.001	0.296	0.238	0.174	0.299	0.402	0.215	0.148	0.295	0.238	0.115
SO4	mg/l	0.3	113.4	72.6	25.2	66.9	119.8	47.8	33.5	29.4	28.6	18.9
Cl	mg/l	5.0	12	<	<	9	11	9	<	6	6	<
Al	mg/l	0.01	<	0.07	0.04	0.15	0.55	0.10	0.18	0.65	0.24	0.07
B	mg/l	0.01	0.02	0.01	<	0.04	0.02	0.02	<	0.02	0.04	0.02
Ca	mg/l	0.01	16.88	8.92	4.87	2.25	1.88	11.00	5.91	0.41	0.78	0.47
Cr	mg/l	0.01	<	<	<	<	0.01	<	<	<	<	<
Cu	mg/l	0.01	<	<	<	<	<	0.02	0.03	0.01	0.02	<
Fe	mg/l	0.01	<	<	<	<	0.01	<	0.01	0.06	0.22	<
K	mg/l	0.1	6.7	2.7	3.5	2.8	2.1	4.5	5.4	1.5	1.8	1.1
Mg	mg/l	0.01	8.79	4.50	3.85	1.95	1.54	5.70	2.86	0.37	0.53	0.34
Mn	mg/l	0.01	0.3	0.0	<	<	<	<	0.0	<	<	<
Na	mg/l	0.1	26.9	46.3	30.0	69.0	95.6	28.0	19.5	76.9	54.3	29.6
Ni	mg/l	0.01	0.09	<	<	<	<	<	0.04	<	<	0.01
P	mg/l	0.1	<	<	<	<	<	<	<	<	<	<
Si	mg/l	0.05	3.32	1.75	2.23	1.97	2.48	2.04	2.53	3.17	2.15	1.40
V	mg/l	0.01	<	<	<	<	<	<	<	0.02	<	<
Zn	mg/l	0.01	0.03	<	<	<	<	0.03	0.02	0.01	0.02	0.01
Ag	ug/l	0.01	<	<	<	<	<	<	<	<	<	<
As	ug/l	0.1	3.3	18.6	68.7	75.9	44.6	59.9	54.0	190.7	42.3	14.5
Ba	ug/l	0.05	59.83	31.80	31.64	8.50	32.27	25.08	69.94	35.27	12.64	4.17
Be	ug/l	0.1	<	<	<	<	<	<	<	0.2	0.3	<
Cd	ug/l	0.02	0.16	0.04	0.06	0.02	0.03	0.26	0.45	0.16	0.15	0.05
Co	ug/l	0.1	41.1	0.8	0.4	0.5	0.5	3.2	3.4	1.2	1.6	1.8
Hg	ug/l	0.1	<	<	<	<	<	<	<	<	<	<
Mo	ug/l	0.05	4.35	135.41	76.37	108.23	78.35	180.43	52.25	96.57	30.54	66.20
Pb	ug/l	0.5	<	<	0.7	<	<	3.9	1.9	1.5	1.0	1.5
Sb	ug/l	0.01	0.17	1.69	2.04	2.26	1.29	1.78	0.51	4.19	1.16	1.05
Se	ug/l	0.5	28.8	1.6	33.6	13.5	4.5	65.0	21.8	52.9	37.7	37.2
Sn	ug/l	0.1	<	<	<	<	<	<	0.2	0.7	0.1	<
Th	ug/l	0.005	0.010	<	<	0.006	0.031	0.017	0.047	0.032	0.009	<
U	ug/l	0.005	0.118	0.373	0.805	0.625	0.293	2.628	0.290	1.392	0.626	0.036

< element at or below analytical detection limit.

Table B-11: Multi-element composition and geochemical abundance indices for the coarse reject (chitter) samples from the Whitehaven CHPP.

Element	**Unit**	Element Concentration		*Average Crustal Abundance	Geochemical Abundance Index	
		Tarrawonga Chitter	Mixed Chitter		Tarrawonga Chitter	Mixed Chitter
Al	%	11.1%	10.6%	8.2%	-	-
As	mg/kg	6.4	6.1	1.5	2	1
B	mg/kg	20	22	10	-	1
Ba	mg/kg	465	432	500	-	-
Be	mg/kg	1.4	1.4	2.6	-	-
Ca	%	0.13%	0.28%	4.0%	-	-
Cd	mg/kg	0.12	0.1	0.11	-	-
Co	mg/kg	12	13	20	-	-
Cr	mg/kg	101	116	100	-	-
Cu	mg/kg	42	56	50	-	-
Fe	%	0.91%	3.36%	4.1%	-	-
Hg	mg/kg	0.06	0.09	0.05	-	-
Mg	%	0.22%	0.36%	2.3%	-	-
Mn	mg/kg	95	613	950	-	-
Mo	mg/kg	na	na	1.5	na	na
Na	%	0.15%	0.16%	2.3%	-	-
Ni	mg/kg	53	67	80	-	-
P	mg/kg	349.19	480.14	1000	-	-
Pb	mg/kg	18.1	17.6	14	-	-
S	%	0.01%	0.40%	0.03%	-	**3**
Sb	mg/kg	<0.2	0.2	0.2	-	-
Se	mg/kg	0.5	0.5	0.05	**3**	**3**
Si	%	34.5%	33.1%	27.7%	-	-
V	mg/kg	56	58	160	-	-
Zn	mg/kg	60	72	75	-	-

*Bowen H.J.M.(1979) Environmental Chemistry of the Elements.