Carmichael Project:

Mine Waste Acid and Metalliferous Drainage and Dispersive Materials Assessment

Prepared for

GHD Pty Ltd

Report Prepared by

srk consulting

SRK Consulting (Australasia) Pty Ltd

GHD001

November 2012

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Executive Summary

Adani Mining Pty Ltd is proposing to develop the Carmichael thermal coal project (the Project). The Project is located approximately 150 km north west of Clermont in the Galilee Basin in Queensland.

The project would produce 60 million tonnes of coal per annum and has a potential life of 90 years and the total quantity of waste that would be mined is expected to be about 24 billion tonnes.

One hundred samples of potential mine wastes and coal materials were taken from drill core and assessed for their potential to produce acid and metalliferous drainage (AMD). Eighty eight samples were of overburden and interburden, 12 samples were roof, floor or coal materials. No coal reject samples were available for characterisation. Standard static geochemical tests were conducted to characterise the samples. Net potential ratio (NPR) and AMIRA (2002) methods were used to classify the materials into acid generating or non-acid forming categories.

Twenty four samples were tested to determine their potential to be dispersive.

In addition to the geochemical characterisation, a statistical assessment was undertaken to assess the representation of the whole mass of waste by the one hundred samples and determine the need for additional samples.

Typically only a small number of samples were from each lithological unit. To increase the robustness of statistical assessment of the various rock types, samples from lithological units expected to have similar geochemical behaviour were considered to be members of a lithological group.

Conclusions

Representativeness of samples

Statistical analysis showed that the selection of samples was large enough to draw conclusions about average values of the total sulfur content, acid neutralising capacity (ANC) and net acid producing potential (NAPP) across the site for several lithological units. The average NAPP and the upper 95% confidence interval for the average NAPP was less than 0 kg(H_2SO_4/t) for carbonaceous mudstone, clay, claystone, sandstone and siltstone. The upper 95% confidence limit was above 0 kg(H_2SO_4/t) for mudstone. The average NAPP could not be determined for coal or incidental samples (primarily clay and containing calcite and unusually large total sulfur contents of 2 and 10 wt%) because there were too few samples of these types.

The fraction of samples representing each lithological group was proportional to the fraction of the waste in that lithological group with the exception of the carbonaceous group which was intentionally oversampled.

The number of samples was insufficient to make assessments about the spatial variability of the total S content, ANC and NAPP.

Potential for Acid and Metalliferous Drainage

Chromium reducible sulfur (CRS) tests indicated that not all acid generating capacity determined from total sulfur may be available to generate acid. Similarly, acid buffering characteristic curve (ABCC) testing indicated that not all acid neutralising capacity determined from ANC testing may be available to neutralise acid. Thus, there is expected to be some uncertainty on the accuracy of the NPR and AMIRA classifications of the samples.

Based on the available results the majority of the overburden and interburden materials (not immediately adjacent to the coal seams) and roof and floor wastes are not likely to be a source of acid immediately after mining. Nor would most of these materials be expected to an immediate source of salinity; however, some portion could be a source of salinity. The clay materials of the overburden and interburden could have a markedly higher potential to release salts and metals to contact water even though the pH may remain alkaline. Typically however, the concentrations of metals in water contacting the waste would be expected to be low while waters remain circumneutral.

A portion of the carbonaceous mudstone, claystone and sandstone roof and floor and coal materials could be expected to be potentially acid forming in the longer term. The majority of the overburden and interburden waste from all lithological groups is likely to be non-acid forming in the longer term. Some clay, claystone, mudstone and sandstone may be acid forming in the long term and there may be a requirement to manage these materials prevent or limit the longer-term development of AMD.

All siltstone overburden and interburden samples were classed non-acid forming (NAF).

Dispersivity and Breakdown

There was variability in dispersion results within each lithological group. The fresh rocks were typically non-dispersive, however, there was a very low potential for dispersion for some lithological groups.

The clays, weathered mudstone, claystone, carbonaceous mudstone and siltstone generally may exhibit dispersive behaviour. Slightly weathered siltstone and fresh mudstones may show a very slight potential for dispersivity. The weathered sandstone did not show any indication of dispersive behaviour.

Weathered rock (all lithological units), siltstone and sandstone showed potential for deterioration and breakdown after exposure to water. The siltstone showed a moderate rate of deterioration, and the sandstone showed slow deterioration. This may indicate that although the fresh rock units are not dispersive, they are not durable, and with time may degrade to sand, silt or clay. The degraded material may be more prone to physical erosion than the original fresh rock.

Recommendations

Further sampling and testing is required to i) estimate average values of AMD parameters for the significant lithological units, and ii) characterise the spatial variability of AMD related parameters for all lithological units. Further sampling from drillholes spaced between 1000 m and 3000 m apart is recommended in the first instance. This would require twenty additional holes. Assuming six lithological units of interest and three samples per group per hole and additional samples for the coal and calcite bearing clay then about 370 additional samples would be selected for testing.

Precautions should be taken to prevent runoff water contacting the more dispersive lithological units. Storage of the soil and clays and weathered mudstone, claystone and siltstones which showed a high potential for dispersion within the core of the mine waste storage areas is recommended.

Testing of additional samples should be undertaken to identify trends in the dispersive and weathering behaviour of the various rock types.

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Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (Australasia) Pty Ltd (SRK) by GHD Pty Ltd (GHD). The opinions in this Report are provided in response to a specific request from GHD to do so. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them. Opinions presented in this Report apply to the site conditions and features as they existed at the time of SRK's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report, about which SRK had no prior knowledge nor had the opportunity to evaluate.

List of Abbreviations

Term	Definition
ABA	Acid base account
ABCC	Acid buffering capacity curve
ALS	Australian Laboratory Services
AMD	Acid and metalliferous drainage
ANC	Acid neutralising capacity
AP	Acid potential calculated based on all non-sulfate sulfur present as pyrite (kgH_2SO_4/tonne)
ARD	Acid rock drainage
CarbNP	Carbonate neutralisation potential estimated from the measured inorganic carbon concentration and assuming all carbon is present as carbonate (CO_3) (kgH_2SO_4/tonne)
CEC	Cation exchange capacity
CHPP	Coal handling and preparation plant
CRS	Chromium reducible sulfur
DD	Diamond drilling
EC	Electrical conductivity
EIS	Environmental impact statement
EPC	Exploration permit coal
ESP	Exchangeable sodium percent
GAI	Global abundance index
ha	Hectares
ICP-MS	Inductively coupled plasma mass spectrometry
ICP-OES	Inductively coupled optical emission spectroscopy
kg	Kilogram
LOM	Life of mine
M	Million
m	Metre
MDL	Mineral development lease
ML	Mining lease
MLA	Mining lease application
MPA	Maximum potential acidity calculated assuming that all sulfur is present as pyrite (kgH_2SO_4/tonne)
NAF	Non-acid forming - a classification in regard to potential for rock to be acid forming
NAG	Net acid generation (kgH_2SO_4/tonne)
NAPP	Net acid producing potential (kgH_2SO_4/tonne)
NMD	Neutral mine drainage
NP	Acid neutralising capacity (kgH_2SO_4/tonne)
NPR	Net Potential Ratio
PAF	Potentially acid forming - a classification in regard to potential for rock to be acid forming
PAF-LC	Potentially acid forming and of low capacity to produce acid

Term	Definition
pH	Negative logarithm of the concentration of hydrogen ions
RC	Reverse circulation drilling
RL	Relative levels
ROM	Run of mine
SD	Saline drainage
SRK	SRK Consulting (Australasia) Pty Ltd
t	tonnes
TC	Total carbon
TDS	Total dissolved salts
TIC	Total inorganic carbon
TOC	Total organic carbon
tpa	Tonnes per annum
TOTS/Stot	Total sulfur
UC	Uncertain – a classification in regard to potential for rock to be acid forming

1 Introduction

Adani Mining Pty Ltd is proposing to develop the Carmichael thermal coal project (the Project). The Project is located approximately 150 km north west of Clermont in the Galilee Basin in Queensland and would produce 60 million tonnes of coal product per annum. Both open cut and underground mining methods are planned for the site. Large quantities of mine waste (overburden and rock) and tailings would be produced as a result of mining.

SRK was contracted to undertake a preliminary assessment of the potential for contaminant release from, and dispersivity of, the waste materials (including overburden and rejects) that will be mined at the Project. This included selecting and characterising an initial 100 samples from the drill core that was available in December 2011. The characterisation of these samples is an initial phase in a larger programme to assess the properties of materials to be mined at the Project.

The current phase of work was undertaken in five stages:

1. Review of the geology of the region to determine the lithology types at the Project and the potential abundance and distribution of each lithology across the Project area.
2. Development of a sampling strategy.
3. Site visit for selection of samples.
4. Geochemical characterisation of samples.
5. An assessment of adequacy of the samples collected to represent the AMD potential of the various lithologies.

2 Geology

2.1 Structural Setting

The Galilee Basin, located in central Queensland, is a Late Carboniferous to Mid-Triassic extensional intracratonic terrestrial basin of predominantly fluvial sediment infill. The basin covers an area of some 247,000 km^2.

2.2 Stratigraphy and structure

The Carmichael Project is located to eastern edge of the Koburra trough (Figure 2-1). Figure 2-2 shows a cross section of the Koburra Trough in the region of the Carmichael Project. The entire stratigraphic sequence present in the Koburra Trough in the northern Galilee Basin is summarized in Table 2-1 along with paleogeography and structural/basin event history. Along the north-east margin of the basin all sequences are consistently present and laterally persistent.

The stratigraphic units of relevance to the Carmichael Project are the conformable interval between the coal-bearing Colinlea Sandstone-Bandanna Formation and the overlying Rewan Formation with an unconformable and variable veneer of Tertiary sediments which cover the deposit.

The Colinlea Sandstone

The Colinlea sandstone sequence overlies and onlaps the Joe Joe Group and the distribution of the sequence within the Galilee Basin is shown in Figure 2-1. The sequence comprises dominantly quartz sandstone and conglomerate with minor shale and a number of low rank sub-bituminous and sub-hydrous coal seams. This sequence represents fluvial deposition with sandy braided channel and flood plain deposits associated with mire and coal seam development. Three coal seams (D-F Seams) are laterally persistent and correlated regionally.

The Bandanna Formation

The conformably overlying Bandanna Formation comprises calcareous, lithic sandstone, siltstone and a number of low rank sub-bituminous and sub-hydrous coal seams. This sequence represents fluvial deposition with sandy braided channel and flood plain deposits associated with mire and coal seam development. Three coal seams (A-C Seams) are laterally persistent and correlated regionally.

The distribution of the sequence within the Galilee Basin is shown in Figure 2-1 and is similar in distribution to the Colinlea Sandstone unit. In the southern part of the Galilee Basin the marine Black Alley Shale (Figure 2-1) of the southern Bowen Basin interfingers with the lower Bandanna Formation and effectively separates this unit form the underlying Colinlea Sandstone.

The Betts Creek Beds equivalent

Along the far northern margin of the Galilee Basin the conformable contact between the Bandanna Formation and Colinlea Sandstone units are difficult to distinguish which has led to the naming of this combined sequence as the Betts Creek Beds (Figure 2-1 and Figure 2-2).

The Rewan Formation

The stratigraphy of the Triassic units in the Galilee is broadly continuous across the northern and southern regions of the Galilee Basin with little lithofacies or paleaogeographic variance. The Rewan Formation conformably overlies the Bandanna Formation and comprises are monotonous sequence labile sandstones and multi-coloured argillaceous sediments.

Importantly, along the eastern margin of the northern Galilee Basin this conformable sequence of stratigraphic units has a consistent regional expression, i.e., they are consistent in their paleaogeographic characteristics over broad areas.

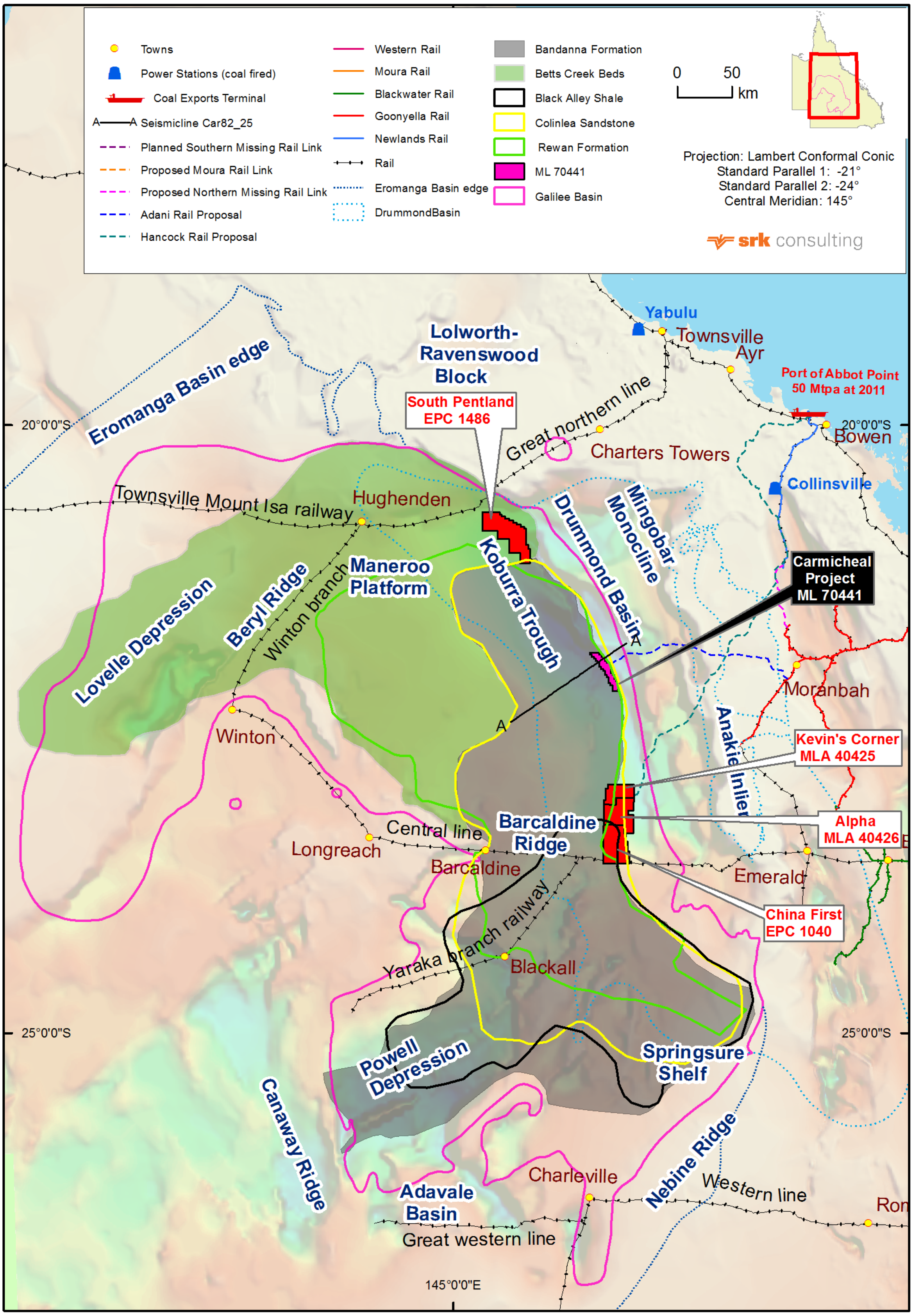
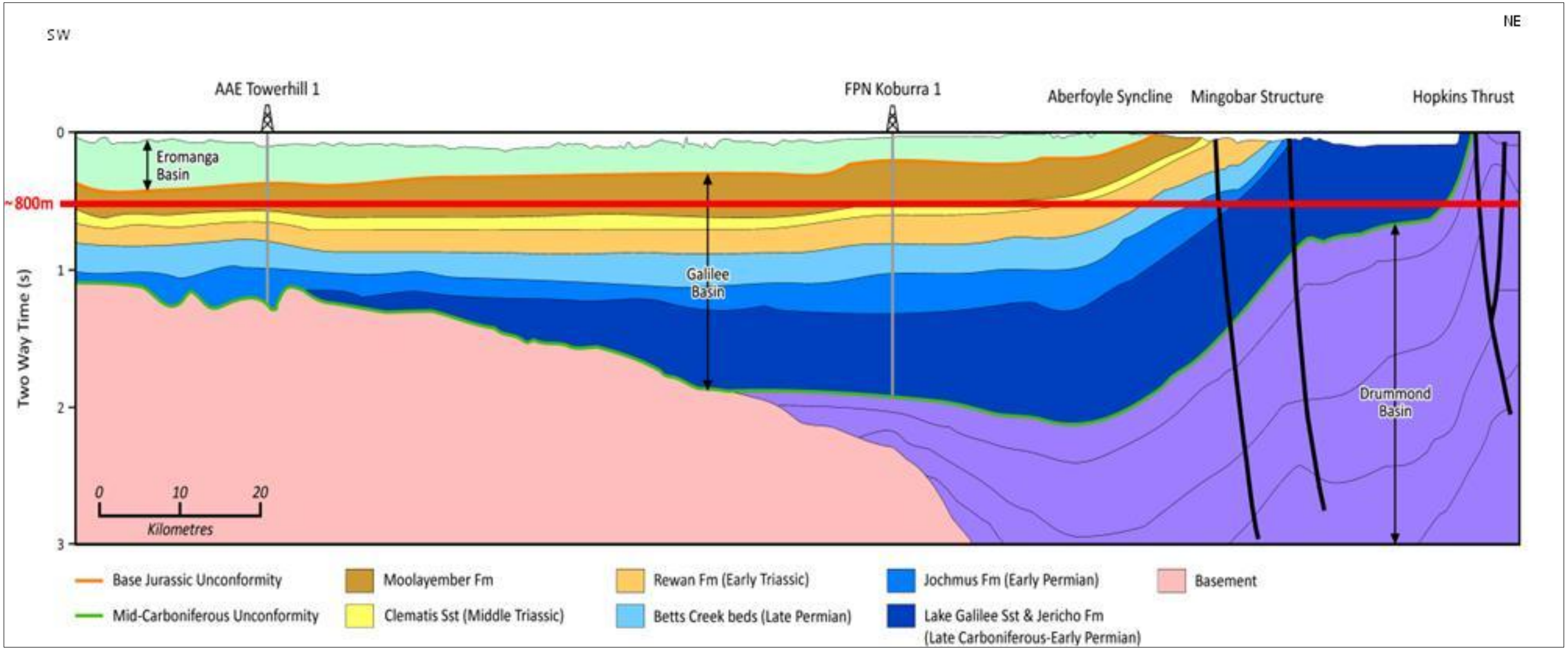


Figure 2-1: Palaeoenvironment - Areal extent of the stratigraphic formations of the Galilee



(Source: Queensland Carbon Dioxide Geological Storage Atlas, 2009).

Figure 2-2: Schematic of the north eastern margin of the Galilee basin

Based on interpretations from seismic line CAR82-25 (note vertical exaggeration).

Table 2-1: Stratigraphy, palaeoenvironment and tectonic event history for the northern Galilee Basin

Age		Northern Region	Lithological unit	Palaeogeographic Environment	Tectonic Unit	Tectonic Event
Tertiary		Undifferentiated	Argillaceous sandstones and clays	Colluvium, alluvium and lacustrine.		
Unconformity						
Triassic	**Middle**	Clematis Sandstone	Quartz sandstone, minor siltstone and mudstone.	Fluvial braided river system.	Galilee Basin	Foreland Basin Development
		Dunda Beds	Labile sandstone, siltstone and mudstone.	Fluvial and channel and floodplain.		Foreland Basin Development
	Early	Rewan Fm	Green-grey mudstone, siltstone and labile sandstones.	Fluvial and channel and floodplain.		Foreland Basin Development
Permian	**Late**	Bandanna Fm	Labile sandstones, siltstones and mudstone and coal seams (3 correlate: A-C).	Braided channel and floodplain.		Thermal Subsidence
		Colinlea Sandstone	Labile quartz sandstone and coal seams (3 correlate: D-F), minor conglomerate and shale.	Sandy braided channel and floodplain with peat swamp development.		Thermal Subsidence
	Unconformity					
	Early	Upper Jochmus Fm	Volcanic-lithic labile sandstones.	Cold-climate fluvioglacial-lacustrine.	Galilee Basin	Thermal Subsidence
		Edie Tuff	Pelite and tuff.	Cold-climate fluvioglacial-lacustrine.		Thermal Subsidence
Carboniferous	**Late**	Lower Jochmus Fm	Volcanic-lithic labile sandstones.	Cold-climate fluvioglacial-lacustrine.		Thermal Subsidence
		Upper Jericho Fm	Mudstones, siltstones and sandstones, minor mudstone and siltstone	Braided Channel and floodplain.		Thermal Subsidence
		Oakleigh Siltstone Mbr	Varved argillaceous siltstone.	Lacustrine and minor fluvial sedimentation		Thermal Subsidence
		Lower Jericho Fm	Pebbly mudstones, volcaniclastic sandstones and conglomerate.	Low-energy fluviatile environment.		Thermal Subsidence
		Lake Galilee Sandstone	Quartzose sandstone, with minor conglomeritic bands, and minor argillaceous dark-grey to black mudstone bands in upper part.	High-energy fluviatile environment.		Thermal Subsidence
	Early	Unconformity				
		Drummond Basin Basement				

3 Local Geology

The Carmichael deposit is located on the eastern margin of the Koburra Trough. The targeted coal seams (A to E Seams) are hosted within the Late Permian Colinlea Sandstone and overlying Bandanna Formation which subcrop beneath a thin cover of Triassic Rewan Formation. The Rewan Formation is in turn, obscured beneath a variable cover of unconsolidated to poorly consolidated Tertiary sediments.

3.1 Local Stratigraphy

At surface, the stratigraphy is dominated by a sequence of undifferentiated Tertiary Sediments up to 100 m thick, although typically about 50 m thick. The Tertiary unit is principally composed of clayey mudstones and soft sandstones and unconformably overly the Triassic sediments of the Rewan Formation and intermittently, where present, the Dunda Beds.

The Dunda Beds are described as an ‘outcrop facies variant of the uppermost Rewan Group characterised by a greater quartzose content and subordinate lutites’ (Heeswijk, 2006). The lower half is dominated by sandstone and the upper half mudstone.

The Rewan Formation is described at Carmichael as an interbedded grey-green fine- to medium-grained lithic sandstone and grey-green mudstone, suggesting that sediment was sourced from the west and indicating an extensive floodplain or fluvial environment of deposition. Thicknesses are variable from 20 to greater than 200 m as a result of the unconformable contact with the overlying Tertiary sequences and general westward dip of stratigraphy approximately (Xenith, 2009).

The Bandanna Coal Measures and Colinlea Sandstone conformably underlie the Triassic sequences and consist of interbedded coal, sandstones, siltstones and mudstones. The combined sequence is up to 150 m thick. Sandstones are dominant with generally thin mudstone bands, often carbonaceous, usually found both above, below and as partings within coal seams. The larger interburden units are predominantly interbedded sandstone and siltstone. Sediment sources were defined as being generally from the west, whilst limited palaeocurrent evidence indicates a south-southeast transport direction (Heeswijk, 2006).

3.2 Igneous and Metamorphic Alteration

The Carmichael project is located within a relatively benign area both for igneous intrusives and structure. To date, no igneous intrusive material has been encountered during drilling, and magnetics do not indicate any dykes or igneous plugs within the project area. This suggests the potential for pyrite formation from igneous sources is likely to be limited.

3.3 Palaeoenvironment and Sulfur Implications

The percentage of pyrite in sedimentary rocks is limited principally by available sulfur during diagenesis, which is generally a function of the available sulfate in water under favourable (anoxic, reducing) conditions. Sedimentary pyrite mineralization occurs, when Fe^{2+} and H_2S formed by sulfate reduction in the presence of decomposing organic material and water react to form FeS and S^0, which subsequently form FeS_2 (pyrite).

The availability of sulfur in a freshwater environment is much less than that of sea water due to the much lower concentrations of dissolved sulfates. As a result, during diagenesis net formation of pyrite within a freshwater or fluvial environment is often much less than that of marine environments.

Furthermore, a greater percentage of sulfur in freshwater environments has a tendency to be bound up organically within coal, reducing the potential for AMD in the waste.

The Galilee Basin has been extensively shown to be predominantly fluvial, and as such, the in-situ sulfur content of the coal can be expected to be low to medium or approximately less than 1% (air dried basis, adb) based solely upon palaeoenvironment. The only unit determined to have a partial marine influence, the Black Alley Shale, does not extend north into the Carmichael project area, nor is it present in some of the key mining developments within equivalent stratigraphy to the south. This is supported the similarity of sulfur contents determined as part of the coal quality assessment at nearby mines (Table 3-1).

A study by Hunt and Hobday (1984) on Permian age coals in Australia showed a clear correlation between palaeoenvironment and sulfur content and supports the influence of marine environments on elevated seam sulfur contents. Coal seams deposited in lower delta plain facies typically showed average raw sulfur contents >0.55%; coal seams associated with braided fluvial facies more distal from marine palaeoenvironments typically contained average raw sulfur contents <0.55%; and upper delta plain palaeoenvironments typically displayed intermediate sulfur contents.

The coal seams present at the Carmichael deposit fit into this broad characterization of typically displaying raw sulfur contents of ~0.4-0.5% for a braided fluvial facies.

Total sulfur contents from coal quality assessments at five project sites in the northern Galilee Basin indicate that the sulfur contents of the coal are similar (Table 4-1).

Table 3-1: Total raw sulfur content of coal at five project sites in the northern Galilee Basin

		Total Sulfur % (adb)		
Project	**Samples**	**Min**	**Max**	**Mean**
Carmichael Coal Project	185	0.03	1.15	0.42
Alpha Coal Project	170	0.31	1.67	0.57
Kevin's Corner Project	296	0.12	1.82	0.51
China First Project	-	-	-	0.45
Pentland South Project	-	0.25	0.31	-

4 Drillholes and Sampling

For the purposes of assessing the potential for acid and metalliferous drainage and dispersivity of the materials, the existing drill logs were reviewed and a sampling plan was developed. The plan was based on the lithological units present, available drill core, distribution of drillholes across the project and need to obtain a set of samples that would be used in a geostatistical assessment of the distribution of geochemical characteristics.

At that time 19 holes had been drilled by Adani Mining across the deposit. Seven of the holes had been partially cored while the other holes were fully cored. Core had been stored in a core library and had been previously sampled for coal quality and geotechnical testing. Consequently some core was not available for geochemical characterisation. Waste materials and coal samples were collected from the 16 drillholes shown in Figure 4-1. A total of 100 samples were collected for testing. Sample descriptions are provided in Appendix A.

The sampled drillholes are distributed over the north western half and lower portion of the south eastern half of the project area. Some sampled drillholes were located in the underground operations area to the west of the pit boundary and east of the lease boundary.

The number of samples from each drillhole that were submitted for geochemical testing is listed in Table 4-1. The lithological unit representation of these samples is discussed in section 4.1.1.

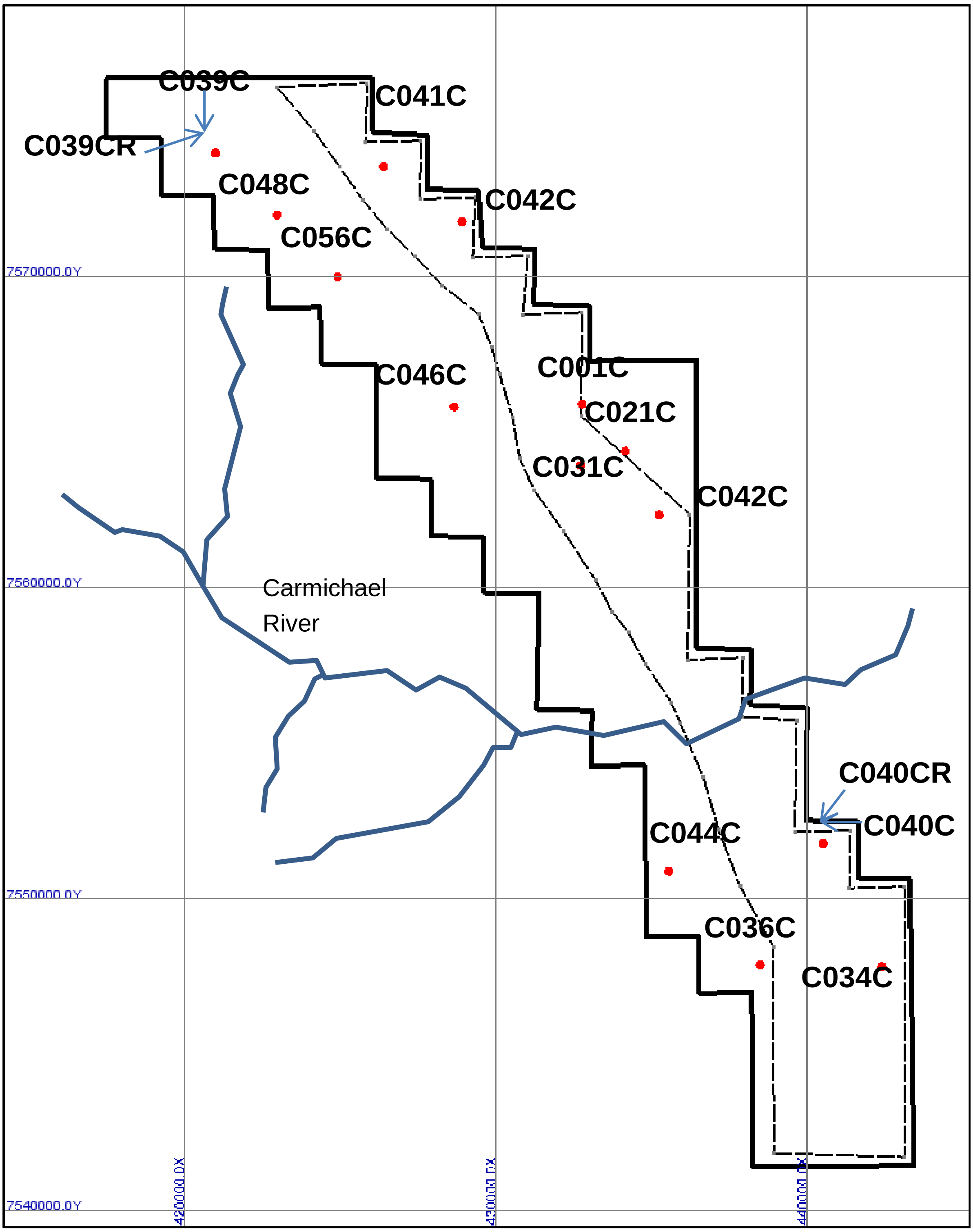


Figure 4-1: Lease boundary (solid), approximate pit boundary (dashed) and drillholes sampled (labelled) for geochemical characterisation

Table 4-1: Samples collected for geochemical characterisation from each drillhole

Drillhole	No. of samples	Drillhole	No. of samples	Drillhole	No. of samples
C001C	5	C039C	3	C044C	2
C0021C	4	C039CR	4	C046C	6
C024C	5	C040C	3	C048C	29
C031C	9	C040CR	2	C056C	7
C034C	5	C041C	6	-	-
C036C	7	C042C	3	Total	100

4.1 Rock Types

4.1.1 Lithological units and lithological groups

Fifty eight different lithological units and sub categories were logged for the core from the Project. Since some of the lithological units were expected to have similar geochemical behaviour they were grouped together for the purposes of statistical and geochemical assessment. A comprehensive listing of the lithological groupings is given in Appendix B.

Estimates of the volume of material that would be produced from each lithological group were not available at time of sample collection. Consequently, the length of drill core of each lithological group was used as a measure of the quantity of material within each lithological group and to guide sample selection.

Table 4-2 presents the lithological groups, the length of drill core logged and the number of samples selected for each group. Carbonaceous materials are highly represented in the collected samples because the experience at other coal sites is that these materials can have relatively high sulfide content (particularly adjacent to coal seams). Coal is under represented in the sampling because most of the coal core had been taken for coal quality analysis.

Table 4-2: Distribution of lithological groups and samples

Lithological group	Sum of length (m)	% of drillhole length	No. of samples
Carbonaceous	190	3.5	15
Clay and soil	442	8.2	12
Coal	403	7.5	2
Potential AN[a]	12	0.2	0
Rem[b]	4259	79.0	71
Sand and gravel	82	1.5	0
Total	5388	100.0	100

Notes:
[a] Potential AN = (acid neutralising) lithological units that thought to contain excess carbonate minerals.

[b] Rem is a group of remaining lithological units not expected to have significant acid forming potential, or would be considered barren with respect to acid neutralisation capacity. Sandstone and siltstone made up the majority of this group.

Sulfide minerals can form as a result of sulfate reduction during the formation of coal (Berner et al., 1985), therefore, there is potential for material in and adjacent to coal seams to have sulfide contents significantly greater than the overlying bedrock and regolith.

Mining methods used immediately adjacent to the coal seams may handle material at smaller unit rates (blocks) than methods used for the overburden and interburden (e.g. truck and shovel vs face shovel). Thus, there is potential to handle waste rock originating from near the coal seam with greater selectivity. The raw coal would potentially be stockpiled and while stockpiled could be a potential source of AMD. The coarse and fine wastes from coal wash plants could also be a potential source of AMD and generally are handled and disposed of separately.

Samples from immediately above or below the coal seams are identified as roof and floor materials. Ten samples were collected from the roof and floor of coal seams. Two samples were taken from within coal seams and the remaining 88 samples were collected from overburden and interburden not immediately adjacent to coal seams. At the time of sample collection, material representing the coal washery wastes (for example from pilot plants) was not available.

4.1.2 Degree of weathering

Oxidation consumes sulfides and produces sulfates, thus lithological units that originally contained sulfides may have significantly lower sulfide contents after oxidation. Oxygen supporting the oxidation (an aspect of weathering) originates in the atmosphere and therefore the oxidised zone over geologic time generally forms above the regional water table.

The distribution of fresh and weathered samples (as identified by visual logging) over depth is presented in Figure 4-2. Table 4-3 shows that collected samples were selected from materials with various degrees of weathering.

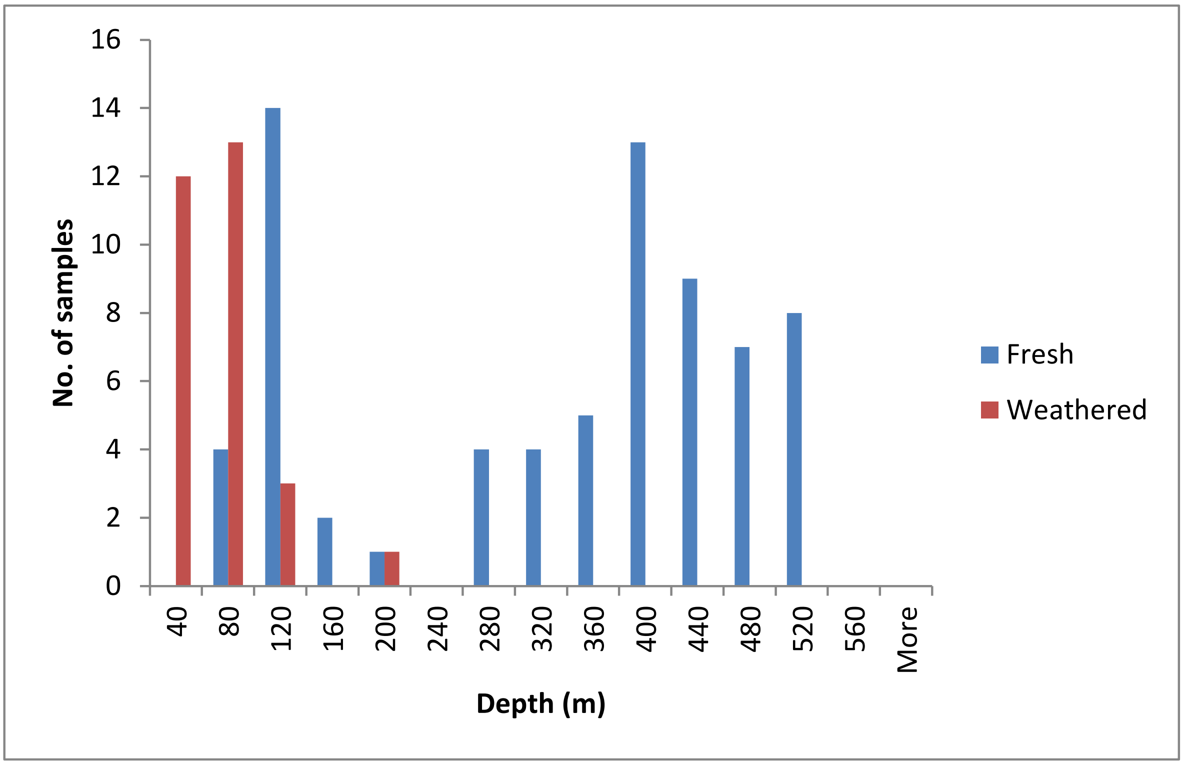


Figure 4-2: Frequency of weathered and fresh samples as a function of depth

Table 4-3: Distribution of samples amongst lithological units and weathering states

Lithological Group & lithological unit	Degree of weathering					
	FR	EW	HW	MW	SW	Grand Total
Carbonaceous	14	-	-	-	1	15
Carb mudstone	12	-	-	-	1	13
Interbedded carb mudstone and tuff	1	-	-	-	-	1
Interbedded carb mudstone and siltstone	1	-	-	-	-	1
Clay and soil	-	4	6	1	1	12
Clay	-	4	6	1	1	12
Coal	2	-	-	-	-	2
Coal	2	-	-	-	-	2
Rem	55	1	7	3	5	71
Claystone	3	1	4		2	10
Interbedded sandstone and siltstone	1	-	-	-	-	1
Mudstone	3	-	-	-	-	3
Sandstone	34	-	3	2	2	41
Siltstone	14	-	-	1	1	16
Grand Total	71	5	13	4	7	100

Notes:
FR – fresh (unweathered)
EW – extremely weathered
HW – highly weathered
MW – moderately weathered
SW – slightly weathered.
‘-‘ – indicates zero samples

5 Testing and Analytical Methods

The following geochemical analyses and tests were undertaken on all 100 samples collected and are reported herein:

- Paste pH and electrical conductivity (AMIRA, 2002)
- Total sulfur content (Leco)
- Carbon speciation: total inorganic carbon (TIC), total organic carbon (TOC), total carbon (TC)
- Acid neutralising capacity (ANC) (AMIRA, 2002)
- Multi-element analysis (four acid digest and/or aqua regia digest followed by ICPAES/ICPMS)
- Dispersivity testing:
  - Cation exchange capacity (CEC) and exchangeable sodium percentage (ESP)
  - Emerson aggregate test
  - Electrical conductivity (s:w ratio 1:5).

Subsequently, subsets of samples were selected for further testing including:

- Single addition net acid generation (NAG) test (AMIRA, 2002)
- Modified NAG test with extended boil (EGi, 2008)
- Sulfur speciation (sulfate sulfur and chromium reducible sulfur content)
- Simple leach tests on solid (solid to de-ionised water (s:w) at a ratio of 1:3) and multi element scan of the extract (Price, 1997)
- Acid buffering characteristics curve (AMIRA, 2002).

ALS Environmental, Brisbane, conducted and coordinated all testing.

6 Results and Discussion

6.1 Paste pH and Electrical Conductivity

Paste parameters provide an indication of the acidity and salinity of a sample at the time of testing. The degree of weathering the material has experienced as well as the availability of readily soluble salts can be inferred from these parameters.

Generally, paste pH ($pH_{1:2}$) values less than pH 5 indicate the presence of stored acidity (i.e. stored oxidation products) and net acid generating conditions, whereas alkaline paste pH values suggest the presence of reactive neutralising minerals.

Paste electrical conductivity ($EC_{1:2}$) provides an indication of the soluble salt loading associated with the sample. Where the sample originates from a naturally saline environment, an elevated paste $EC_{1:2}$ may simply indicate salinity. However, where natural salinity is low, a high paste EC would indicate salt loading from the oxidation of sulfide minerals which can then be used to infer the degree of weathering of the material.

Low paste pH or elevated paste EC values may be indicative of the immediate potential of a sample to impact the quality of water contacting the waste Such potential may exist whether the sample is classified as non-acid forming (NAF), potentially acid forming (PAF) or uncertain (UC) with respect to acid potential.

6.1.1 Roof, Floor and Coal

As the non-coal roof and floor samples are from materials immediately adjacent to the coal seams they originate from members of the non-coal lithological groups in Table 4-2. The 10 roof and floor samples selected are from the Carbonaceous group and the Rem group. In this case the samples are carbonaceous mudstone, claystone, sandstone or siltstone (Appendix A).

Paste $pH_{1:2}$ and $EC_{1:2}$ data are presented in Figure 6-1, Figure 6-2 and Figure 6-3 for the roof and floor and coal samples. A total of 12 roof and floor and coal samples were tested and the summary statistics for $EC_{1:2}$ of the samples are summarised in Table 6-1.

Table 6-1: Roof and floor material $EC_{1:2}$ summary statistics

Statistic	$EC_{1:2}$
	µS/cm
no. of samples	12
minimum	37
mean	578
median	515
maximum	1620

The paste EC values ranged between 37 and 1620 µS/cm with the results for all but one sample the being less than 1000 µS/cm, and only one sample falling below 300 µS/cm (i.e. most samples were within the EC range of 300 to 1000 uS/cm).

The results further suggest that most of roof, floor and coal would not be expected to be an immediate source of salinity; however, some portion could be a source of salinity.

The paste pH of the samples ranged from circumneutral to alkaline (5.5 to 9.3) and the majority (88%) of samples had a paste pH greater than 7. The absence of samples with a paste pH less than 5 indicates none of the samples that may be potentially acid forming had progressed to acidic conditions at the time of testing. Since the majority of samples had a paste pH > 7, the results suggest the presence of reactive neutralising minerals and that the roof, floor and coal materials should not be a source of acid immediately after mining.

There was no apparent correlation between the paste EC and paste pH (Figure 6-3).

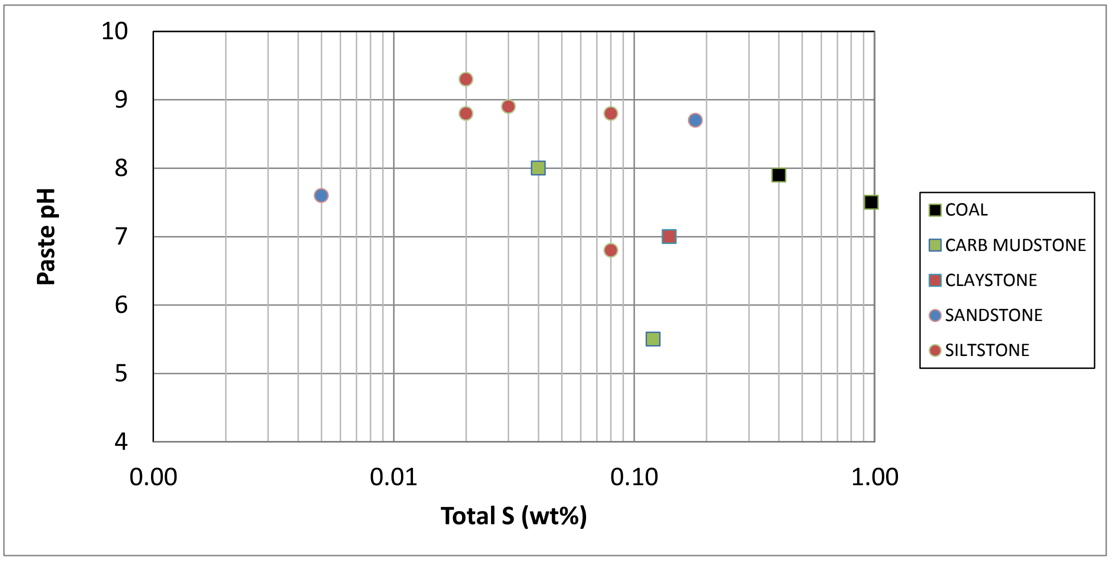


Figure 6-1: Paste pH as a function of total sulfur content (roof, floor and coal)

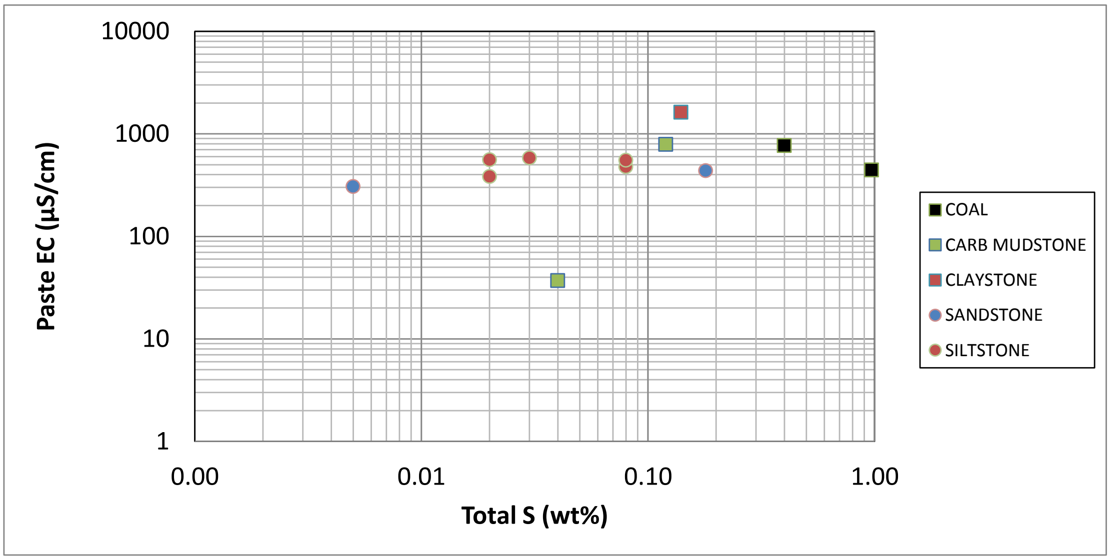


Figure 6-2: Paste EC as a function of total sulfur content (roof, floor and coal)

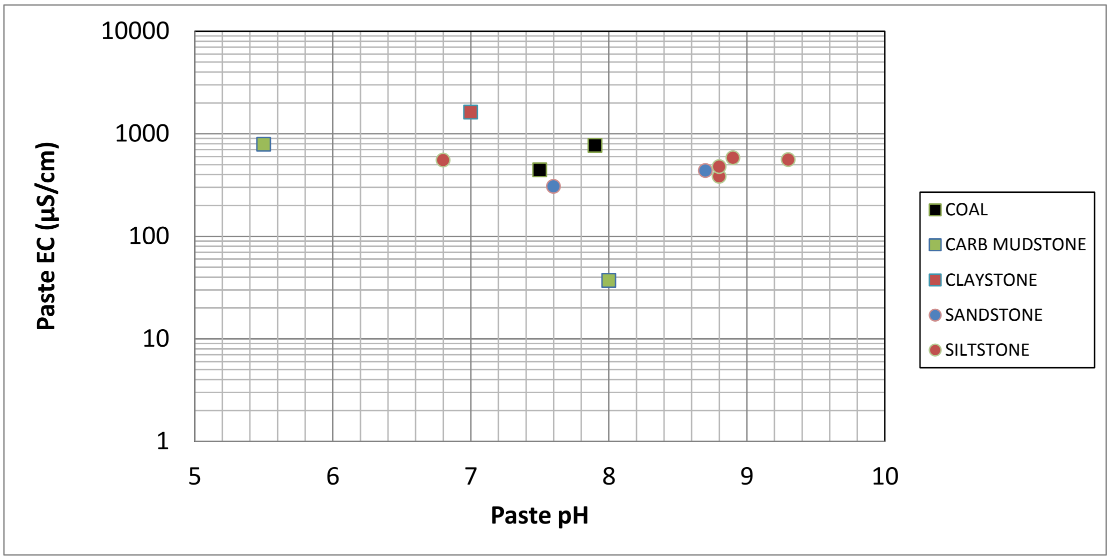


Figure 6-3: Paste EC as a function of paste pH (roof, floor and coal)

6.1.2 Overburden and Interburden

Paste pH and EC data are presented in Figure 6-4, Figure 6-5 and Figure 6-6 for the overburden and interburden samples. A total of 88 overburden and interburden samples were tested and the summary statistics of the samples are provided in Table 6-2.

Table 6-2: Overburden and interburden material $pH_{1:2}$ and $EC_{1:2}$ summary statistics

Statistic	$pH_{1:2}$	$EC_{1:2}$
		µS/cm
no. of samples	88	88
minimum	5.3	68
mean	8.2	697
median	8.3	383
maximum	9.7	6200

The paste pH characteristics of the overburden and interburden were similar to those of the roof, floor and coal samples. That is, the paste pH of the samples ranged from circumneutral to alkaline (5.3 to 9.7). The majority of samples (91%) had a paste pH greater than 7.

The absence of samples with a paste pH less than 5 indicates that no stored oxidation products were present in the samples characterised. Whilst the majority of samples having a paste pH > 7 suggest the presence of reactive neutralising minerals and that the overburden and interburden would not be a source of acid immediately after mining. As for the roof and floor materials, this does not exclude the potential for acid release if sulfides are present and oxidise after mining.

The median of the paste EC of the overburden and interburden (383 µS/cm) was less than that of the roof, floor and coal samples, whilst the average was larger. The average value was strongly influence by the clay materials, which had an average paste $EC_{1:2}$ for the twelve clay samples of 2490 µS/cm compared with the average of 415 µS/cm for all other overburden and interburden samples.

The vast majority of overburden and interburden not immediately adjacent to the coal seams is not likely to be a significant source of salinity. However, the clay materials could have a markedly higher potential to release salts and metals to water contacting them than all other tested materials from overburden, interburden, roof, floor and coal (Figure 6-6).

Like the roof, floor and coal materials there were generally no significant correlations between the paste EC and paste pH. Clay, however, produced paste EC values greater than 1000 µS/cm with corresponding paste pH values between 7.4 and 8.4 and paste EC values. For paste pH values outside this range the paste EC was less than 1000 µS/cm. Only four clay samples lay outside of this paste pH range, so testing of additional samples would be required to confirm this observation.

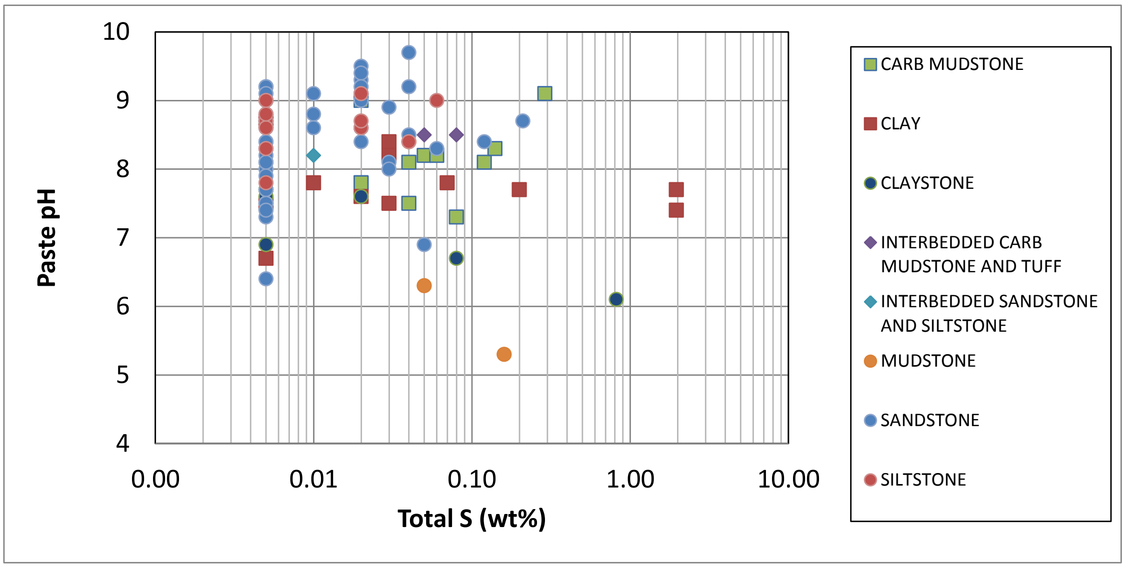


Figure 6-4: Paste pH as a function of total sulfur content (overburden and interburden)

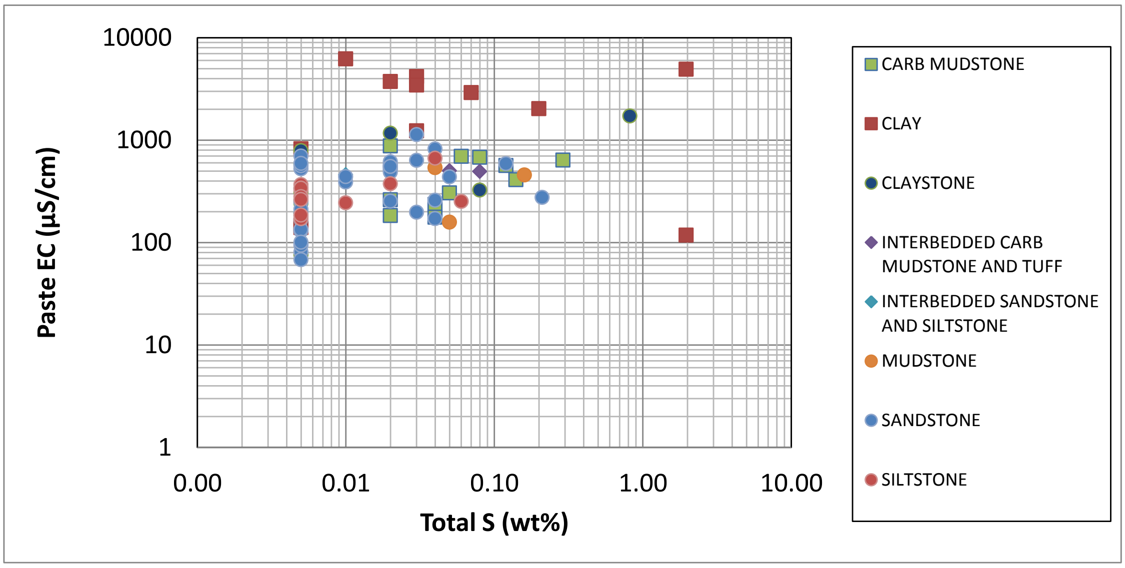


Figure 6-5: Paste EC as a function of total sulfur content (overburden and interburden)

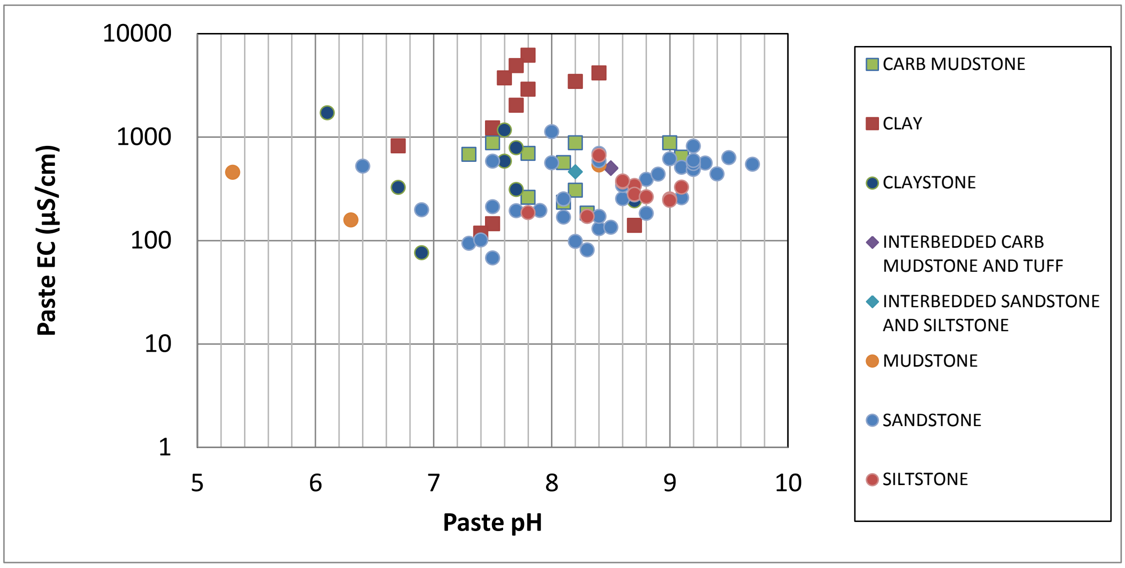


Figure 6-6: Paste EC as a function of paste pH (overburden and interburden)

6.2 Acid Base Account

The net acid producing potential (NAPP) is the theoretical balance between the capacity of the sample to generate acid due to the oxidation of sulfides and its capacity to neutralise any acid formed, i.e. its acid neutralising capacity (ANC) determined by the ANC test (AMIRA, 2002). The maximum potential acidity (MPA) of the sample is calculated from the total sulfur content, assuming that all sulfur is present as pyrite. This assumption generally overestimates the amount of acid potential since sulfur may exist in other forms that are not acid generating (e.g. as sulfate). It is therefore viewed as a conservative approach.

The ANC of a sample may be sourced from both carbonate and silicate minerals. The endpoint pH after the addition of hydrochloric acid (HCl) in the ANC measurement is very low (typically between pH values of 1 and 2) and leads to reactions that will occur only at a low pH (i.e. neutralisation due to dissolution of the silicate minerals). The ANC measurement may therefore overestimate the neutralisation capacity that is available to maintain a near neutral pH. Other analytical methods are available to improve the accuracy of the measurement of acid neutralising capacity. For example, the acid buffering characteristics curve (ABCC) test that will be used in Phase 2 of the characterisation.

The NAPP is calculated as follows:

NAPP = MPA – ANC (kg H_2SO_4/t)

Where MPA = 30.6 x S% and the sulfur content is expressed as weight per cent (wt%).

The MPA, ANC and NAPP are reported in Appendix C.

6.2.1 Acid Potential

The MPA summary statistics for a) the roof, floor and coal, and, b) the overburden and interburden are presented in Table 6-3. The median values of the MPA for: a) the roof, floor and coal, and, b) the overburden and interburden materials, are 2.4 and 0.6 kgH_2SO_4/t respectively. The maximum values are significantly different. For the roof, floor and coal samples the maximum MPA was 18.7 kgH_2SO_4/t, compared with the larger value of 324.4 kgH_2SO_4/t for the overburden and interburden samples.

These results suggest that, overall, the roof, floor and coal waste may have less potential to produce acid and that there may a small fraction of overburden and interburden with a larger potential to produce acid.

Table 6-3: MPA summary statistics

Statistic	**Roof, floor & coal**	**Overburden and interburden**
	kg(H_2SO_4)/t	
no. of samples	12	88
minimum	0.15	0.15
mean	5.3	5.7
median	2.4	0.6
maximum	18.7	324.4
no. MPA>3	5	11
% MPA>3	41.7	12.5

Note: minimum values correspond to half the limit of detection for total sulfur (0.01 wt%).

The MPA values reported in Table 6-3 may be an overestimate of the actual potential acidity. This is because, as described above, the MPA is determined from the total sulfur content. Where a significant portion of sulfur is present as sulfate, a more appropriate measure of the potential for acid generation is the acid potential (AP) of the material. The AP is calculated based on the sulfide content. The sulfide content may be estimated by subtracting the sulfate-sulfur content from the total sulfur content. Alternatively, the chromium reducible sulfur (CRS) test is a supplemental test applicable to coal material developed to differentiate between oxidisable sulfides and other forms of sulfur, which may not be acid forming.

A subset of 35 samples was submitted for sulfate sulfur measurement. Twenty seven samples were overburden and interburden samples and 8 were coal, roof and floor samples. As there was potential for samples to contain organic sulfur the samples were also subjected to the chromium reducible sulfur (CRS) analysis.

Roof, floor and coal

Sulfide S and Total sulfur are presented in Figure 6-7. CRS and sulfide S are presented in Figure 6-8 and CRS and total S are presented in Figure 6-9. The last figure shows that for more than 50% of the samples about 50% or less of the sulfur is present as oxidisable S. However, it must be noted that the number of samples (eight) is small and more samples from across the site would need to be characterised to confirm this finding.

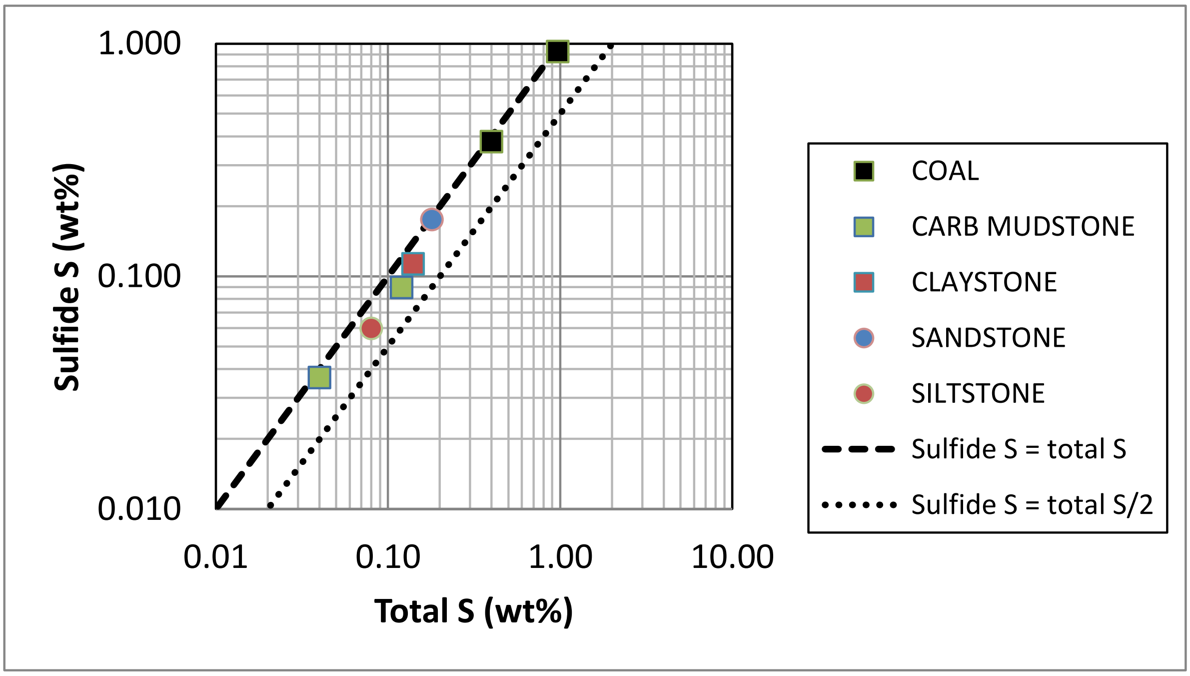


Figure 6-7: Sulfide sulfur (non sulfate sulfur) as a function of total sulfur content for roof, floor and coal samples

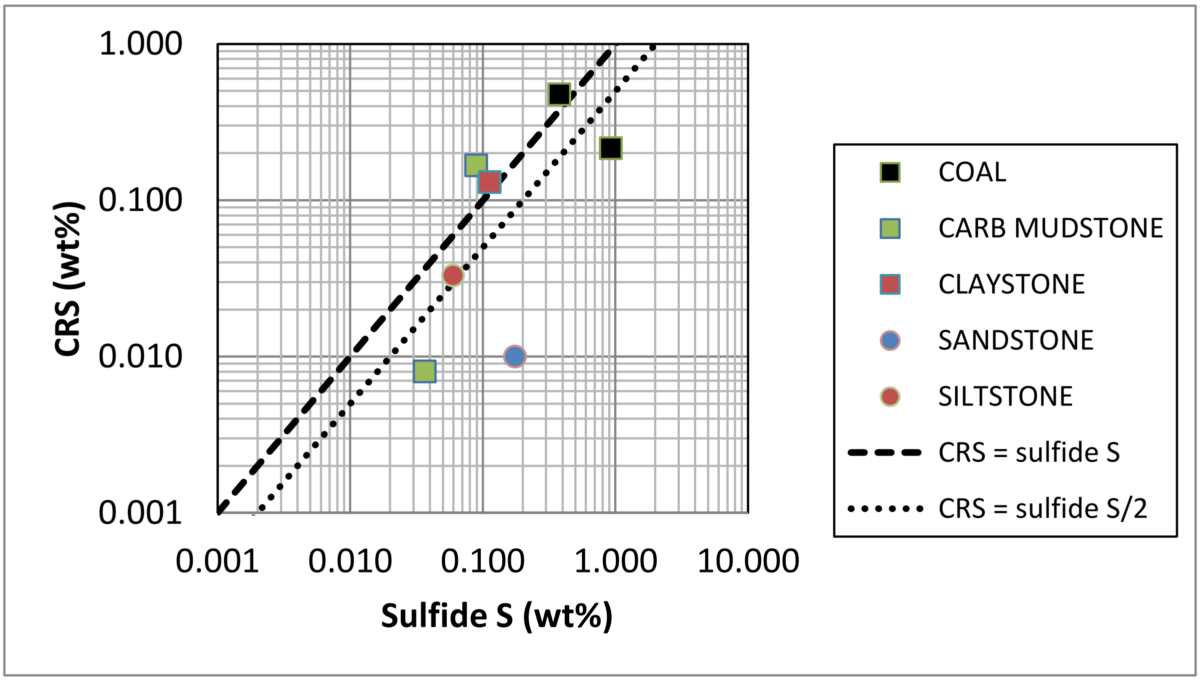


Figure 6-8: Chromium reducible sulfur as a function of sulfide sulfur content for roof, floor and coal samples

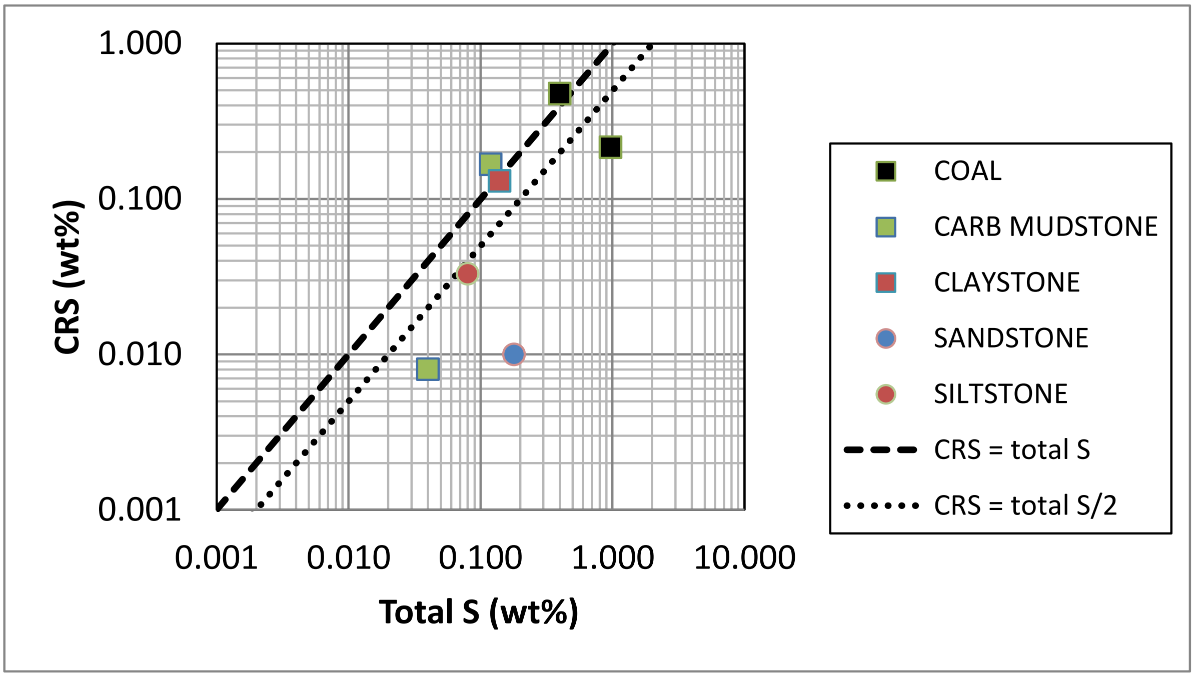


Figure 6-9: Chromium reducible sulfur as a function of total sulfur content for roof, floor and coal samples

Overburden and interburden

A plot of total sulfur minus sulfate sulfur (i.e. sulfide sulfur by convention) as a function of total sulfur for the overburden and interburden is presented in Figure 6-10. The dashed line represents a line of equivalence, where the sulfide sulfate sulfur and total sulfur are equal. The dotted line is where the sulfide sulfur content is half the total sulfur content.

The maximum sulfate sulfur content of 33 of the samples is 0.13 wt%. However, two samples were reported to have sulfate sulfur contents of 6.3 and 6.87 percent. One of the samples had a total S content of 10.6 wt%, whilst for the other sample it was 1.9 wt%. Generally, the sulfate sulfur content was a small fraction of the total S content. However, there were a few samples where the sulfate S content was about 50% of the total S.

For 16 samples the chromium reducible S was less than 50% of the sulfide sulfur (Figure 6-11) suggesting that some of the sulfide sulfur may not be in oxidisable form. This indicates that alunite, barite or other insoluble sulfate minerals (compounds not soluble in HCl) may be present.

A plot of the CRS is shown as a function of the total sulfur in Figure 6-12. The CRS was less than 50% of the total sulfur for 20 of the 35 samples (74%). For the clay and claystone samples the CRS contents approached zero indicating that these lithological units may not contain sulfide minerals. Oxidisable sulfur was the largest fraction of the total S for the sandstone and mudstone samples.

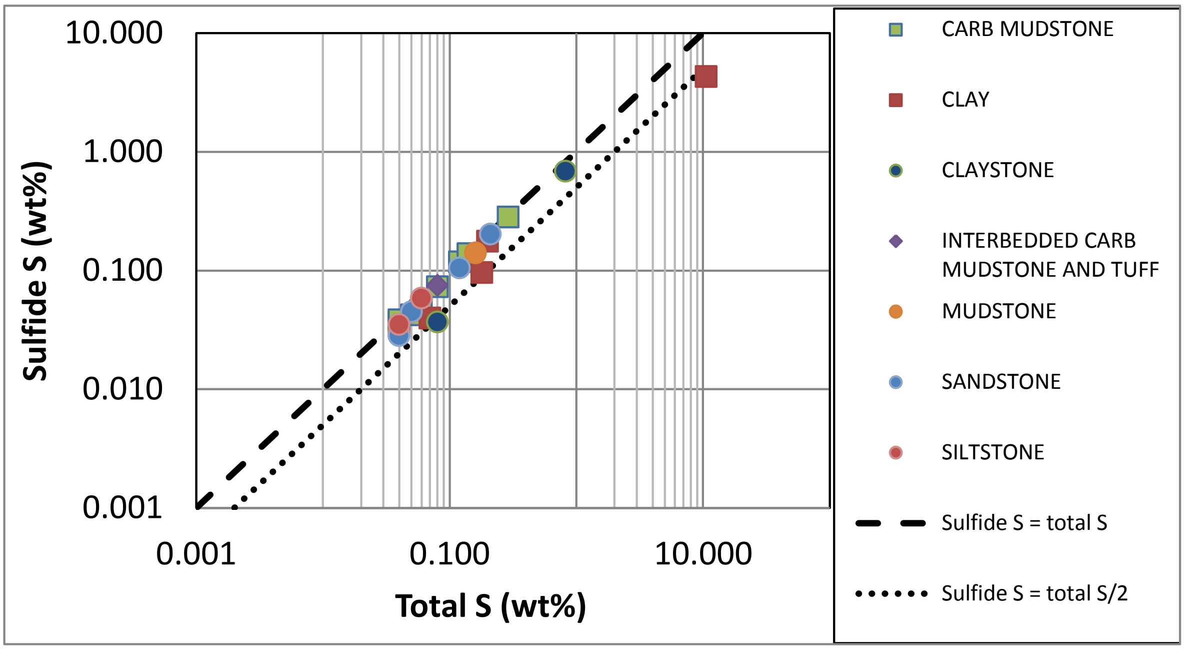


Figure 6-10: Sulfide sulfur (non sulfate sulfur) as a function of total sulfur content for overburden and interburden

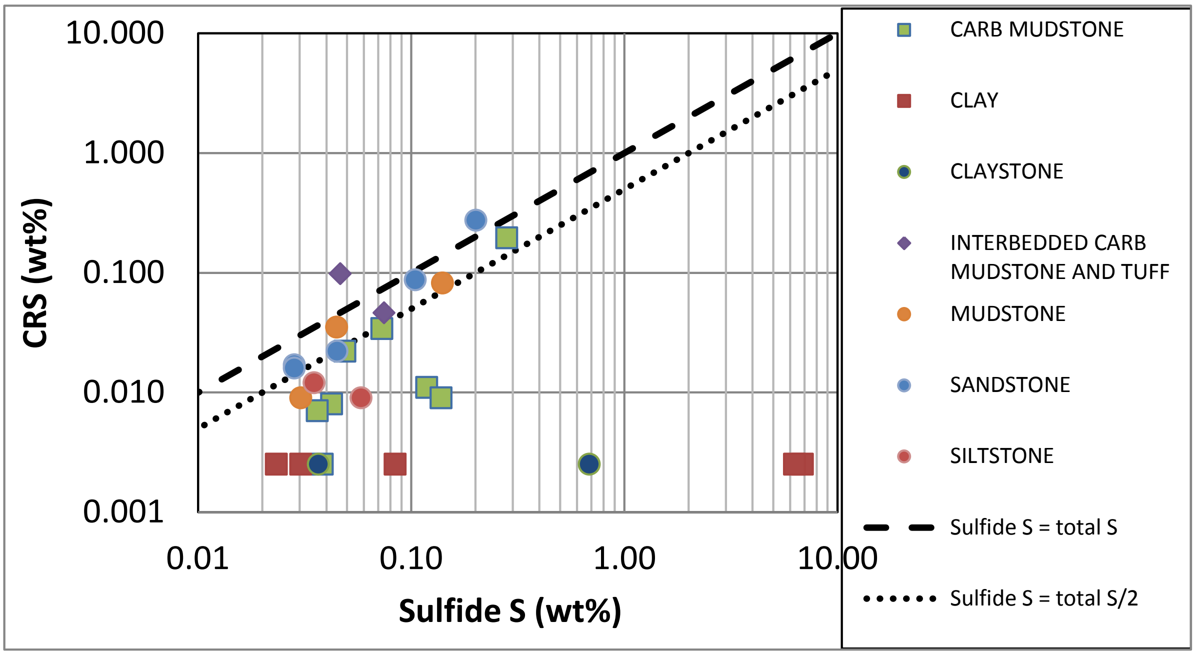


Figure 6-11: Chromium reducible sulfur as a function of sulfide sulfur content for overburden and interburden

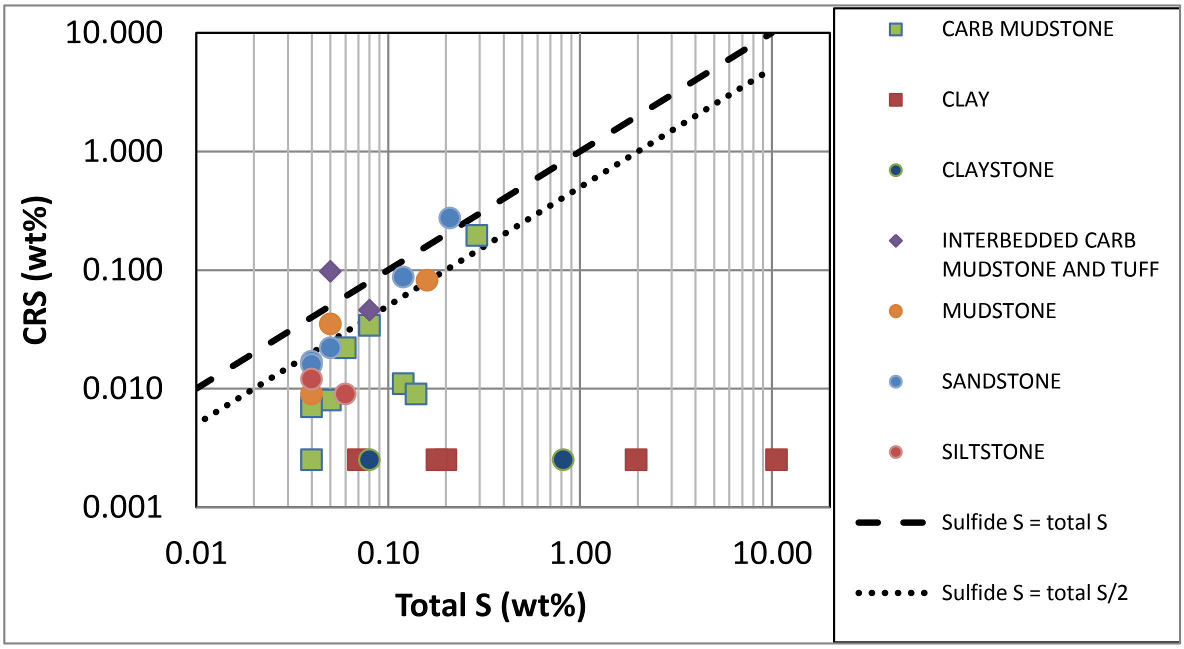


Figure 6-12: Chromium reducible sulfur as a function of total sulfur content for overburden and interburden

6.2.2 Neutralisation Capacity

The ANC summary statistics for a) the roof, floor and coal and b) the overburden and interburden are presented in Table 6-4. The median values of the ANC for a) the roof, floor and coal b) the overburden and interburden materials are 6.8 and 14.2 kgH_2SO_4/t respectively. However, in each case, there are samples with ANC greater than 300 kgH_2SO_4/t.

Table 6-4: ANC summary statistics

Statistic	Roof, floor & coal	Overburden and interburden
	ANC	
	kg(H_2SO_4)/t	
no. of samples	12	88
minimum	0.7	0.3
mean	72.0	26.9
median	6.8	14.2
maximum	381.0	315.0

Carbonate Neutralising Capacity

The Ca and Mg carbonate minerals are of greatest importance in terms of neutralising acidity generated, as they react rapidly and buffer in the near neutral pH range. The total inorganic carbon content can be used to infer the carbonate mineral content and estimate the carbonate neutralization potential (CarbNP). The CarbNP of a subset of samples was measured and the summary statistics are presented in Table 6-5.

Table 6-5: Carbonate neutralising potential summary statistics

Statistic	Roof, floor & coal	Overburden and interburden
	CarbNP	
	kg(H_2SO_4)/t	
no. of samples	6	26
minimum	0.001	0.001
mean	98.1	10.8
median	12.7	4.1
maximum	359.2	44.1

The ANC is plotted as a function of CarbNP in Figure 6-13 and Figure 6-14. A line of equivalence is also shown on each plot (dotted diagonal line), which indicates where the ANC equals the CarbNP. Where the CarbNP equals or exceeds the ANC (below the line of equivalence) it may be assumed that a portion of the carbonate minerals present, do not contribute to acid neutralisation (e.g. siderite ($FeCO_3$)). Where the ANC exceeds the CarbNP (above the line) it may be assumed that slow reacting silicate minerals contribute to the ANC.

Roof, Floor and Coal

Of the roof, floor and coal samples 3 of the 6 samples had an ANC/CarbNP ratio that is less than 1.0, suggesting some carbonate present does not contribute to ANC.

For the other three samples with the ANC/CarNP great than 1.0 a portion of ANC is attributed to slow reacting silicate minerals. It is therefore expected that the ANC readily available to neutralise acidity for these samples is less than that indicated by the ANC test.

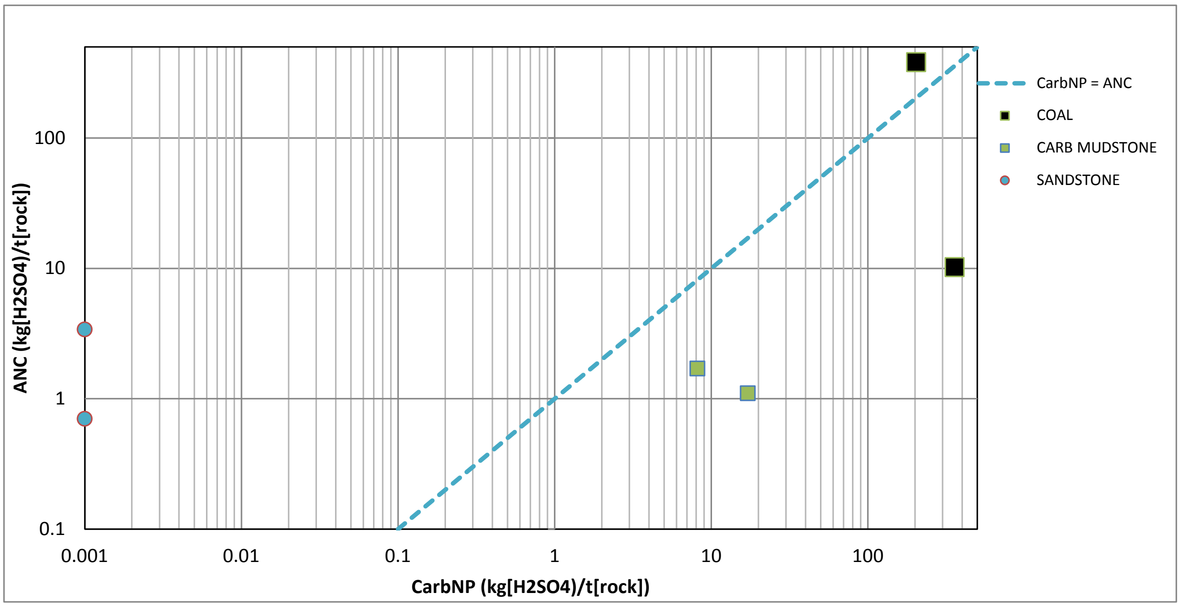


Figure 6-13: ANC plotted as a function of CarbNP (roof, floor and coal)

Overburden and interburden

For 65% of the overburden and interburden samples at least 30% of the ANC is not present as carbonate and therefore could be expected to be available as slow reacting aluminosilicates. About one quarter of the samples had ANC/CarbNP values that indicated the presence of non-neutralising carbonates. The presence of non-neutralising carbonates in the waste is consistent with the records of siderite in the drill logs.

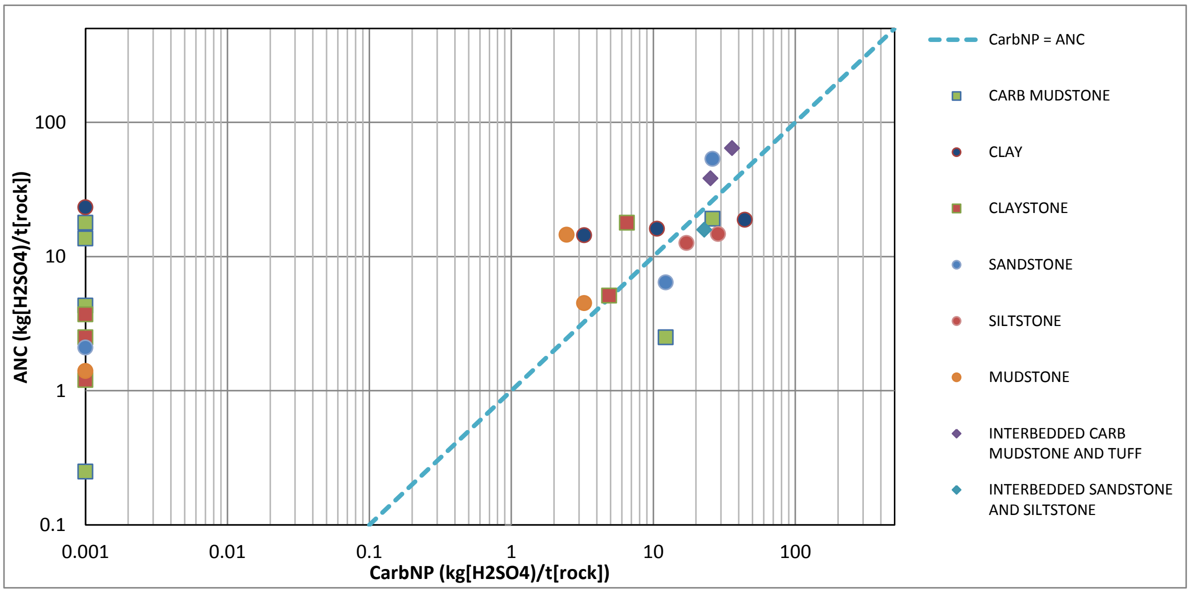


Figure 6-14: ANC plotted as a function of CarbNP (overburden and interburden)

Acid Buffering Characteristic Curves

The determination of the acid base characteristic curve (ABCC) is a method of inferring the availability of the neutralisation potential for carbonates (such as calcite and dolomite) and non-carbonates separately. The test involves the slow titration of the sample with hydrochloric acid, whilst continuously monitoring pH. The ABCC results may be used to infer the availability of the neutralisation potential by calculating the equivalent ANC to pH 6. The ANC measured above pH 6 is indicative of buffering by calcium and magnesium carbonate minerals, such as calcite and dolomite.

Samples with a broad range of ANC values were selected for acid buffering characteristics curve (ABCC) testing.

The results of the ABCC tests are compared with the ANC and CarbNP in Table 6-6. Figure 6-15 presents a plot of ANC versus available ANC determined from the ABCC test results. The results show that the ABCC neutralisation potentials to pH 6 are significantly lower than those indicated by the CarbNP and ANC methods. As a group the sandstone samples tend to have the largest portion of available ANC, however, again the number of samples characterised is small and more samples should be tested to confirm this result.

The neutralising capacity available to buffer above pH 6.0 ranges between <1 to 127 kgH_2SO_4/t and the fraction of ANC available ranges between 4 and 90% of the ANC, suggesting the balance of neutralising capacity as measured by the ANC method may be due to reactions with aluminosilicates at low pH values. Hence, the ANC and the CarbNP may overestimate the neutralisation potential that is available immediately to buffer the pH to above 6 (i.e. to prevent the onset of acid generating conditions).

Table 6-6: Summary of neutralising capacity derived from ANC, CarbNP and ABCC test work

Client sample ID	Lithological unit	ANC	CarbNP	ABCC (to pH 6)	ABCC (to pH 4.5)	Available ANC (to pH 6)
		kgH_2SO_4/t				%
81381	CARB MUDSTONE	19.1	26.12	2.1	3.7	11
81392	CARB MUDSTONE	11.2	-	0.5	1.1	4
81415	CARB MUDSTONE	9.9	-	2.1	2.8	21
81445	CARB MUDSTONE	2.5	12.24	0.3	0.9	13
81356	CLAY	14.4	3.27	2.5	4.8	18
81374	CLAY	167	-	127.2	136.9	76
81376	CLAY	13.9	-	2.5	4.5	18
81394	CLAY	16.1	10.61	4.5	6.8	28
81362	CLAYSTONE	3.7	0.82	0.4	1.0	10
81382	COAL	10.2	359.17	1.2	2.2	11
81439	INTERBEDDED CARB MUDSTONE AND TUFF	38.3	25.31	5.6	13.3	15
81403	MUDSTONE	14.5	2.45	1.9	3.1	13
81368	SANDSTONE	27.2	-	1.4	2.8	5
81380	SANDSTONE	65.9	-	59.6	78.0	90
81384	SANDSTONE	3.7	-	1.6	5.3	42
81391	SANDSTONE	212	-	67.8	134.4	32
81405	SANDSTONE	3.4	0.82	0.5	1.0	14
81371	SILTSTONE	59.3	-	19.4	23.4	33

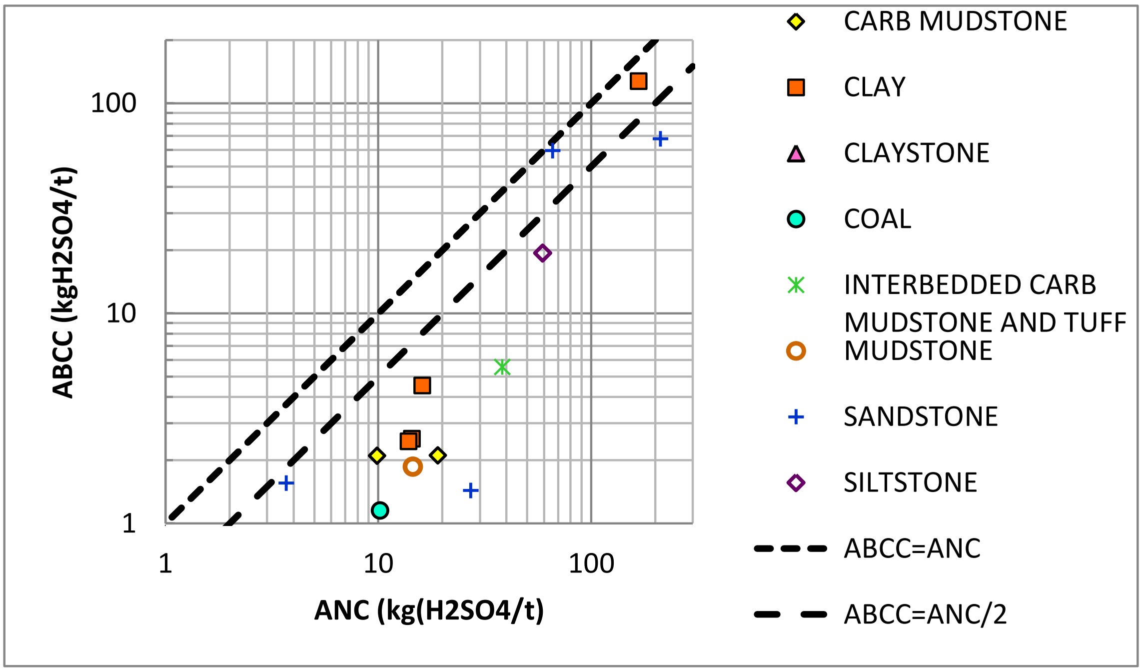


Figure 6-15: ANC and ABCC to pH6

6.3 Sample Classification Schemes

6.3.1 Neutralisation Potential Ratio

Sample classification is based on the acid generating and acid neutralisation potentials of a material. Whilst the net potential may be assessed using the NAPP, an alternative method is based on the neutralisation potential ratio (NPR). The NPR is defined as the ratio of ANC to MPA (Price, 1997). For waste rock, a sample may be classified using the NPR as follows:

- NPR < 1 – potentially acid forming (PAF)
- 1 < NPR < 3 – uncertain (UC) (materials may or may not be net acid forming)
- NPR > 3 – non-acid forming (NAF)
- Total S < 0.1 wt% – non-acid forming (net acid production is low (< 3 kg(H_2SO_4)/t)

Note the last criterion is not a part of the standard NPR method. It is adopted here because samples with acid potential values of less than 3 kg($H_2SO_{4)}$/t are considered of low risk.

The NPR classification scheme can be refined by replacing the MPA with the AP based on estimates of the sulfide sulfur content rather than the total sulfur and the estimates of the neutralising capacity based on ABCC results. However, as these were not available for all samples the above scheme was used.

6.3.2 Roof and floor and coal

Figure 6-16 provides a plot of the total sulfur (S_{tot}) against the ANC results for the 2 samples of coal and 10 samples of roof and floor material. The green dashed line in the plot differentiates samples with characteristics that are NAF (NPR>3) from those that are UC. The solid pink line differentiates the samples with PAF (NPR<1) characteristics from those that are UC. The samples below the solid pink line also have a positive NAPP. The calculated NAPP and NPR values and the sample classifications based on the NPR are shown in the ABA table in Appendix C.

The raw coal samples would potentially be representative of coal stockpile material or uneconomic coal that would be left in the pit. A portion of the roof and floor material, which may comprise non-coal material immediately above and below the coal seams, would also remain in the pit.

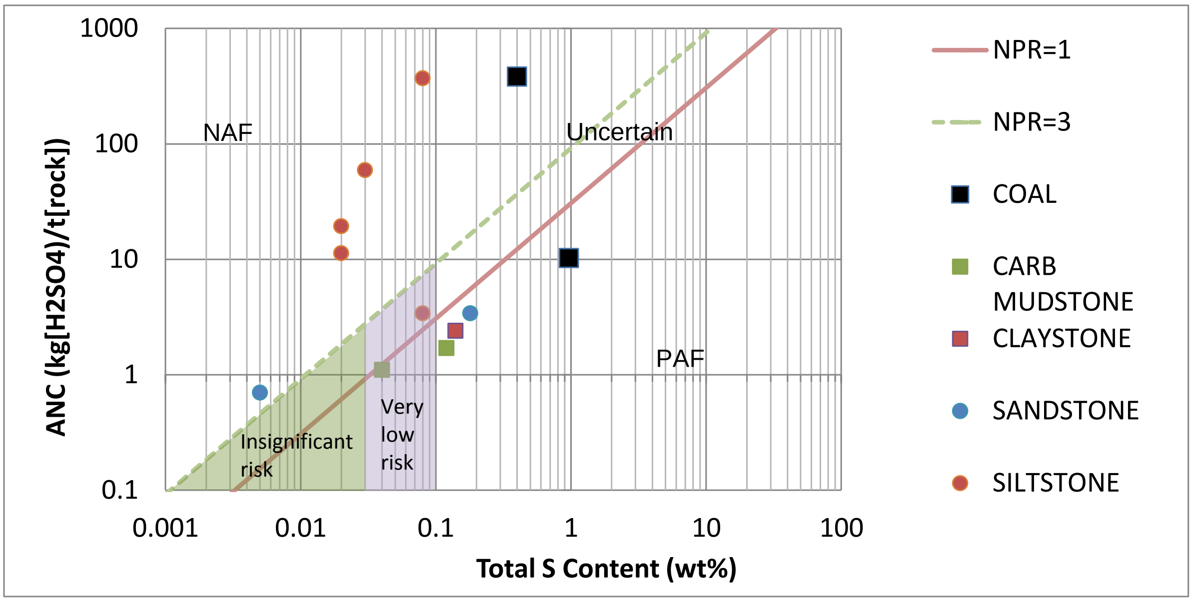


Figure 6-16: ABA plot of coal and roof and floor samples

Table 6-7: Roof, floor and coal sample classification (NPR method)

	No. of samples				Percentage of samples		
	NAF	**UC**	**PAF**	**Totals**	**NAF**	**UC**	**PAF**
Coal	1	0	1	2	50.0	0.0	50.0
Roof & Floor	7	0	3	10	70.0	0.0	30.0
Totals	8	0	4	12	66.7	0.0	33.3

The results in Figure 6-16 indicate that a proportion of the coal would be expected to be acid generating. As much of this coal is saleable product (not waste), it is expected that it would only be stored on site for a short period of time, thus reducing the risk for generation of AMD on site.

A portion of the roof and floor material would be expected to also be potentially acid forming.

Waste reject from the coal handling and processing plant (CHPP) may pose a greater risk of AMD as this would be disposed of on site. Testing of coal washery wastes would be required to assess the potential AMD risks associated with these materials.

As the number of samples that have been tested at this stage is small the inferences drawn from the measurement results must be considered as interim results. These inferences would be reviewed subsequent to the planned testing of additional samples.

6.3.3 Overburden and Interburden

Acid base accounting was conducted for all overburden and interburden samples.

Figure 6-17 shows the results for the 88 samples of overburden and interburden. As for the roof and floor and coal plot the green dashed line in the plot differentiates samples with characteristics that are NAF (NPR>3) from those that are UC. The solid pink line differentiates the samples with PAF

(NPR<1) characteristics from those that are UC. The samples below the solid pink line also have a positive NAPP. The calculated NAPP and NPR values and the sample classifications based on the NPR are shown in the ABA table in Appendix C.

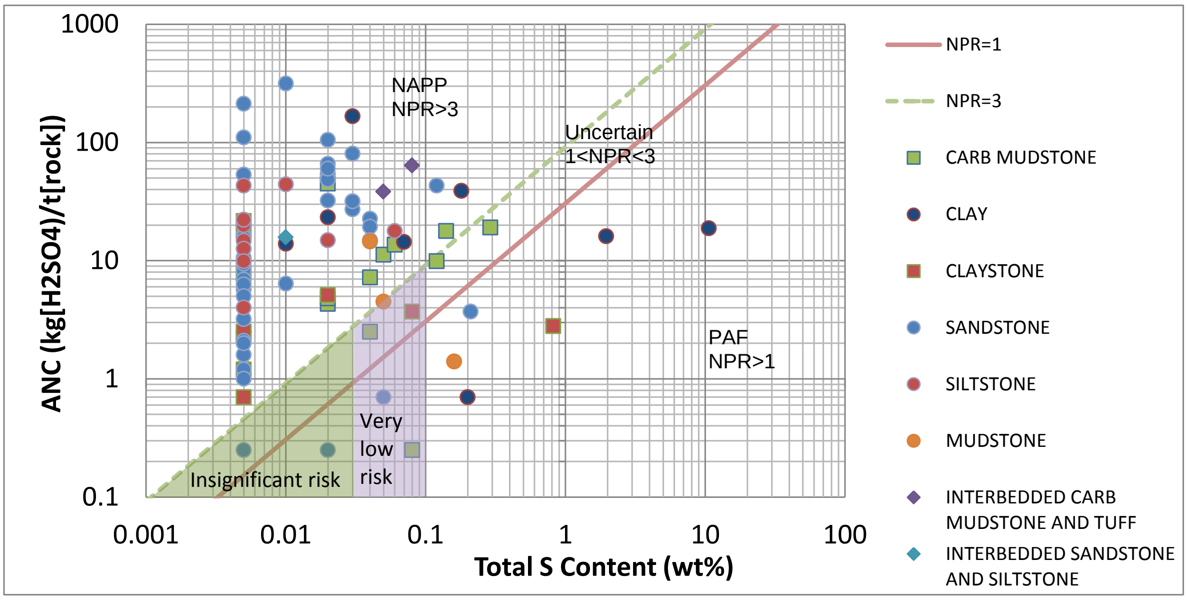


Figure 6-17: ABA plot for overburden and interburden samples

A summary of the overburden and interburden sample classification by group using the NPR classification system is shown in Table 6-8.

Table 6-8: Overburden and interburden sample classification (NPR method)

Lithological unit	No. of samples				Percentage of samples		
	NAF	UC	PAF	Total	NAF	UC	PAF
Carbonaceous mudstone	9	2	0	11	81.8	18.2	0.0
Clay	9	0	3	12	75.0	0.0	25.0
Claystone	8	0	1	9	88.9	0.0	11.1
Interbedded mudstone and tuff	2	0	0	2	100.0	0.0	0.0
Interbedded sandstone and siltstone	1	0	0	1	100.0	0.0	0.0
Mudstone	2	0	1	3	33.3	33.3	33.3
Sandstone	38	0	1	39	97.4	0.0	2.6
Siltstone	11	0	0	11	100.0	0.0	0.0
Totals	80	2	6	88			

The results in Table 6-8 indicate that:

- The majority of the samples (91 to 100%) from all lithological units were classed as NAF.
- The lithological units with the largest percentage classed as PAF or UC were carbonaceous mudstone, clay and claystone. Materials from these lithological units may require active management to prevent or limit the development of AMD.
- All siltstone and the large majority of sandstone samples were classed as NAF.

The number of overburden and interburden samples that have been tested at this stage is small for a project the size of Carmichael. Thus, as for the roof, floor and coal samples, inferences drawn from the measurement results must be considered as interim results. These inferences would be reviewed subsequent to the planned testing of additional samples.

6.3.4 Net Acid Generation Results

The single addition net acid generation (NAG) test measures how a sample could behave under highly oxidising conditions. The sample is contacted with the strong oxidant hydrogen peroxide, which oxidises the sulfides contained in the sample to generate acid. Concurrently, neutralising minerals that may be present react to consume all or part of the acid generated. Following a predetermined contact time, the solution pH (NAGpH) is recorded and the NAG acidity of the sample is quantified by titration with a base (sodium hydroxide).

Titration to pH 4.5 generally accounts for acidity attributable to free acid (H_2SO_4) and ferric iron generated during the oxidation of sulfide minerals (that has not been neutralised by the contained ANC). Titration from pH 4.5 to pH 7 generally accounts for acidity associated with some metals, such as copper, that are mostly soluble at pH 4.5 but practically insoluble at pH 7. Acidity attributed to unoxidised ferrous iron will also be accounted for in the titration up to pH 7 (ferrous iron remains soluble at pH 4.5; however, oxidation to ferric by atmospheric oxygen accelerates as the pH increases).

There is a potential for generation of organic acids in the single addition NAG tests due to partial oxidation of carbonaceous materials (an effect that does not occur naturally in the environment). This may lead to erroneous low NAGpH values and high acidities in the test, which are unrelated to acid generation from sulfide oxidation and can lead to misclassification of the samples. This effect is most likely to occur in samples where the organic carbon content is greater than 7% and the pyrite content is less than 0.7% (e.g. coal washery wastes (ACARP, 2008)).

AMIRA (2002) described the single addition NAG test method used to classify the rock samples according to their potential to be acid forming for samples with low organic carbon contents. The scheme takes account of both the NAGpH and the NAPP of the sample.

The extended boil NAG test may provide a more reliable measure of the acid forming potential of a carbonaceous sample. This test is carried out if the NAGpH of the single addition NAG test is less than 4.5. Additional hydrogen peroxide is added to a split of the NAG solution, which is boiled vigorously for several hours followed by a further measurement of the pH. A sample is classified as acid producing if the solution pH is still less than 4.5.

The acid potential of the sample is uncertain if the pH is greater than 4.5. A solution assay step is then carried out on the other split of the NAG solution for the main cations generated from acid generating (S) and acid neutralising (Ca, Mg, Na, K) processes. The net acid potential is calculated from the solution composition.

The samples were classified according to the scheme shown in Table 6-9. The scheme is that of AMIRA (2002) with a minor change to the definition of UC(PAF) as used by EGi (2005) for higher sulfur content samples. The NAG results and the sample classifications are presented in Appendix C.

Table 6-9: Acid-base accounting classification

Class	Sub-class	Description
NAF	NAF	Samples with a negative NAPP value and a NAG pH of ≥4.5
	NAF-Barren	As above, and also a low ANC (≤5 kgH_2SO_4/t). Such samples have little value with respect to mitigating the effects of acid production in other mine waste materials
PAF	PAF	Samples with a positive NAPP value and a NAG pH of <4.5
	PAF-LC	PAF materials associated with low NAG acidities (NAGpH4.5 < 5 kgH_2SO_4/t)
Uncertain	UC(PAF)	Samples with negative NAPP but giving NAG pH values <4.5 or NAPP ≥0 but giving NAG pH values ≥4.5 and total S > 1%S.
	UC(NAF)	Samples with NAPP ≥0 but giving NAG pH values ≥4.5 and total S ≤ 1%S. Possibly in these samples some of the sulfur present is in non-pyritic forms

Notes: ANC=acid neutralisation capacity; NAPP=net acid producing potential; NAG pH=pH measured during net acid generation test.

The single addition net acid generation (NAG) test measures how a sample could behave under highly oxidising conditions. The sample is contacted with the strong oxidant hydrogen peroxide. The peroxide oxidises the sulfides contained in the sample and thereby generates acid. Concurrently, neutralising minerals that may be present consume all or part of the acid generated. Following a predetermined contact time, the solution pH (NAG pH) is recorded and the NAG acidity of the sample is quantified by titration with a base (sodium hydroxide).

Coal, roof and floor materials

The classifications of 6 coal, roof and floor samples by the standard AMIRA method are presented in Figure 6-18. One sample of coal (Carmichael sample identification number 81382) and one of carbonaceous mudstone (81400) were subjected to the extended boil NAG test in which the sample is classified based on a determined net acid generation capacity rather than the NAGpH and NAPP. The classifications of the various samples are shown in Table 6-10.

The number of samples from any lithological unit is very small and the geochemical characteristics of the set therefore may not accurately represent the distribution of characteristics present in the waste at the site.

Results for one coal and one carbonaceous mudstone sample indicate that some coal and carbonaceous mudstone may be PAF. Other samples were classed either uncertain or non-acid forming. Further testing of roof, floor and coal material will need to be undertaken as part of the planned infill drilling and geochemical sampling/testing programme to ensure that the distribution of geochemical characteristics for the various roof and floor and coal wastes is adequately understood.

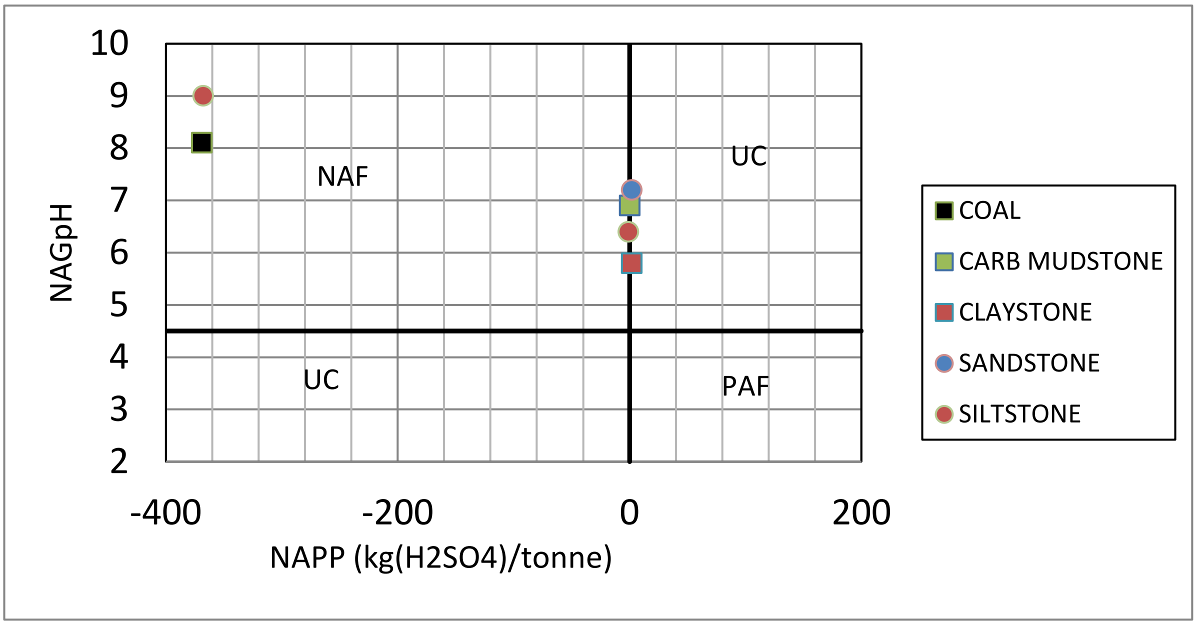


Figure 6-18: **Geochemical classification plot for the coal, roof and floor samples**

Table 6-10: Combined AMIRA and extended boil NAG test classification of roof floor and coal samples

Carmichael Sample ID	Lithological Unit	AMIRA/NAG Classification
81355	CARB MUDSTONE	UC(NAF)
81400	CARB MUDSTONE	PAF
81358	CLAYSTONE	UC(NAF)
81370	COAL	NAF
81382	COAL	PAF
81405	SANDSTONE	UC(NAF)
81372	SILTSTONE	NAF
81373	SILTSTONE	NAF-Barren

Overburden and Interburden

Twenty seven of the overburden and interburden samples characterised using the NPR method were also subjected to either standard or extended boil NAG tests. Results for samples subjected to the standard NAG test are shown in Figure 6-19. The full results are presented in Appendix C. Two carbonaceous mudstone and one sandstone sample were subjected to extended boil NAG tests. These carbonaceous mudstone samples were classed as NAF and the sandstone as PAF.

The standard NAG classification (NAF, UC, PAF) is indicated in each quadrant of the plot of Figure 6-19.

Table 6-11 provides the breakdown of samples by rock type and classification. Seventy percent of samples were classed as either NAF or NAF-Barren and 26% were classed as uncertain. Four percent of samples were classed as PAF. The number of samples is again small; however, the results indicate that some PAF material may be present in the overburden and interburden waste rock. Characterisation of additional samples should be undertaken to determine the distribution of PAF material across the site. Note that 11% of the waste samples were NAF-Barren and therefore had little capacity to neutralise acidity.

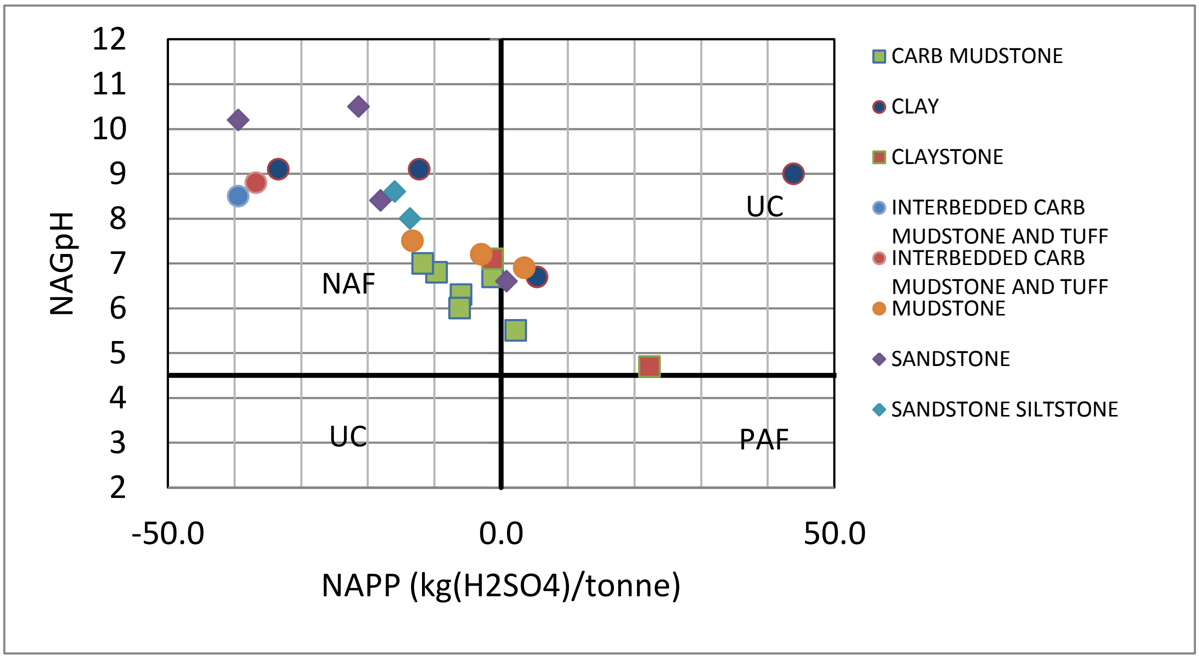


Figure 6-19: Geochemical classification plot for overburden and interburden samples

Table 6-11: Number of samples in each classification

	NAF-Barren	NAF	UC(NAF)	UC(PAF)	PAF	Total
CARB MUDSTONE	1	6	1	0	0	8
CLAY	0	2	1	2	0	5
CLAYSTONE	1	0	1	0	0	2
INTERBEDDED CARB MUDSTONE AND TUFF	0	1	0	0	0	1
INTERBEDDED SANDSTONE AND SILTSTONE	0	1	0	0	0	1
MUDSTONE	1	1	1	0	0	3
SANDSTONE	0	3	1	0	1	5
SILTSTONE	0	2	0	0	0	2
Subtotal	3	16	5	2	1	27
Percent	11	59	19	7	4	100

6.4 Elemental Abundance and Solubility

6.4.1 Elemental Abundance

Quantitative elemental analysis of solid samples was undertaken to determine the abundance of elements in the samples. Dissolution of the samples was either by four acid digest or aqua regia digest. The four acid digest was preferred, however, samples containing greater than 3% organic carbon are incompatible with this digest and sample dissolution was by aqua regia digest instead. The aqua regia digest is less aggressive and will not dissolve silicates that make up the sample matrix.

A direct comparison of the measured abundances of the elements was made with the average abundance of elements in the sediment documented by Bowen (1979). As the abundance of elements varies many-fold, a log base 2 index was developed to simplify comparison of measured abundances with average abundances. The index, called the global abundance index (GAI), was reported by Förstner (1993).

The GAI indicates which elements are ‘enriched’ in the sample with respect to a reference average abundance. The GAI is calculated using the following formula:

$$\text{GAI} = \mathit{Int}\left(\log_2\left(\frac{\text{Measured Concentration}}{1.5\times\text{Average Abundance}}\right)\right)$$

An example of GAI values is provided in Table 6-12. In the table *n* is the ratio of the measured abundance in the sample to the reference material abundance.

Table 6-12: Ranges of the Ratio of the Measured Concentration to Average Abundance (n) and the Corresponding Global Abundance Index

n range	GAI
$1.5 < n < 3$	0
$3 \leq n < 6$	1
$6 \leq n < 12$	2
$12 \leq n < 24$	3
$24 \leq n < 48$	4
$48 \leq n < 96$	5
$96 \leq n < 192$	6

Zero or positive GAI values indicate enrichment of the element in the sample when compared to average-crustal abundances. As a general rule, a GAI of 3 or higher signifies enrichment that warrants further evaluation. GAI values are presented in Appendix C.

All 100 samples were submitted for whole rock assay analysis. Elements that were identified as enriched in a number of samples were S (2 samples), Ag (18), Re (1) and Te (35).

Whilst these elements are enriched, further evaluation of their leachability is required (see Section 6.4.2).

6.4.2 Solute Release

Simple leach tests (Price, 2009) were carried out on 29 samples at a solid:water ratio 1:3 over a period of 24 hours. Selected parameter values are presented in Table 6-13 and full results are presented in Appendix D. The tests provide an indication of the soluble elements and salts that are already present in the samples and form a basis for an initial assessment of the potential for changes to water quality as a result of contact with the waste. Since the physical and chemical conditions of the leach test will not be the same as those expected in the ‘as placed’ environment (e.g. solubility constraints, liquid to solid ratio, particle size, etc.), the leach composition is not expected to be representative of that which may develop in the field. The results cannot be directly extrapolated to predict the leachate quality expected to seep from a dump of the material, but are useful to provide an indication of the leachable elements that may be present. The results have therefore been compared to Stock Water Quality Guidelines (AGWQMR, 2000) only to identify solutes that potentially may be of significance. Note however, that water quality predictions need to consider actual site conditions and are not part of the current scope/report.

The pH values of all leachates were circumneutral. The electrical conductivities, alkalinity, acidity and sulfate concentration were generally low. The largest EC value (2120 µS/cm) was more than 4 times the next largest value and was observed for a clay sample (81394). The clay sample also exhibited the largest SO_4 concentration. Electrical conductivity testing conducted when assessing the potential for samples to be dispersive (section 7.4) also identified clays with high electrical conductivities. These results indicate that the quality of water contacting some clay materials could be adversely impacted.

Concentrations of metals were generally low and did not exceed guideline values for livestock drinking water. However, this may not be the case for the conditions in the waste dumps.

Table 6-13: Selected parameters for static leach test water quality

Sample ID		pH Value	Electrical Conductivity @ 25°C	SO_4	Aluminium	Arsenic	Cadmium	Chloride	Calcium	Iron
	Units	**pH Unit**	**µS/cm**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
	AGWQMR (2000) Stock water guideline value					**0.5**	**0.01**		**1000**	
	LOR	**0.01**	**1**	**1**	**0.01**	**0.001**	**0.0001**	**1**	**1**	**0.05**
	Lithological Unit									
81351	SANDSTONE	7.44	113	4	1.72	0.006	<0.0001	5	2	0.75
81355	CARB MUDSTONE	6.51	103	2	2.06	0.004	0.0001	<1	1	0.5
81356	CLAY	6.64	274	8	2.27	0.002	0.0002	48	2	1.13
81370	COAL	7.48	176	22	0.23	0.002	<0.0001	4	5	0.09
81382	COAL	7.46	363	169	0.28	0.003	0.0006	10	112	0.28
81388	SANDSTONE	6.41	26	26	0.2	0.002	<0.0001	<1	1	0.08
81394	CLAY	6.59	2120	995	0.02	0.001	0.0004	101	269	0.06
81397	CLAYSTONE	6.54	240	15	1.4	0.002	<0.0001	43	2	0.32
81400	CARB MUDSTONE	6.21	82	20	0.55	0.023	<0.0001	2	2	<0.05
81403	MUDSTONE	7.05	95	10	1.31	0.003	<0.0001	2	2	0.68
81406	CARB MUDSTONE	6.89	207	6	0.65	0.001	<0.0001	34	3	0.13
81417	SILTSTONE	7.41	104	5	1.8	0.003	<0.0001	1	1	1.18
81420	CARB MUDSTONE	6.82	57	7	0.59	0.007	<0.0001	<1	1	0.16
81426	SANDSTONE	6.68	30	2	0.74	0.009	<0.0001	<1	<1	0.46
81433	INTERBEDDED SANDSTONE AND SILTSTONE	7.36	97	4	1.16	0.014	<0.0001	<1	2	0.66
81438	INTERBEDDED CARB MUDSTONE AND TUFF	6.62	48	6	0.99	0.011	<0.0001	2	1	0.36
81439	INTERBEDDED SANDSTONE AND SILTSTONE	6.4	20	2	1.14	0.003	<0.0001	<1	<1	0.32
81445	CARB MUDSTONE	6.81	70	8	1.46	0.001	0.0001	1	2	0.11
81450	CLAYSTONE	6.35	36	<1	0.06	<0.001	<0.0001	3	1	<0.05
81455	CARB MUDSTONE	6.71	40	<1	1.51	0.002	0.0001	<1	1	0.74

6.5 Representativeness of samples

The representation of overall waste material characteristics by the characteristics of a limited number of samples needs to be assessed at a number of levels. These include the capacity of the available samples to:

1 Provide an estimate of the average value of a parameter of interest that can be compared with a specified value at a desired level of (statistical) confidence. For example, can it be concluded that the average of all sulfur contents of a lithological unit is below a trigger value for classifying the material as non-acid forming at the 95% confidence level?

2 Characterise the spatial variability of the parameters of interest to ensure that the density of sampling is sufficient to cover the full range of local fluctuations that may occur.

3 Correctly represent the overall proportions of each lithological units within the waste volume of interest.

6.5.1 Samples logged as containing calcite

Two samples that were primarily clay and from near the surface in hole C040C, also contained calcite. The total sulfur contents of these two samples were 2% and 10%, far in excess of any other of the total sulfur values. For the analyses in this section (6.5) these two samples were removed from the clay lithological unit classification and the clay and soil group and assigned to a new lithological unit and group.

Calcite was also observed in form of calcrete (cemented calcite or gypsum) and there was a 20 m interval of interbedded calcrete and ferricrete (cemented ferruginous material) from 30 m to 50 m in drillhole C042. Hole C041 also had one interval of 0.5 m of ferricrete.

There was an additional high total sulfur content sample (0.8%) in hole C040CR, at 61.5 to 62.5 m logged as claystone. CO40CR was a redrill of C040C. The sample was not reallocated and remains in the claystone lithological unit and in the ‘remaining’ weathered group. It is a significant outlier in both sets, with the next largest total sulfur value being 0.14% in the claystone lithological unit and 0.08% in ‘remaining’ weathered group.

The source of the sulfur in these samples is not clear. One possibility is that the gypsum ($CaSO_4.2H_2O$) was mistaken for calcite ($CaCO_3$) during field logging of drillholes. Calcite is sometimes associated with pyrite and the presence of ferricrete in hole C042 suggests that some sources of iron, albeit now in an oxidised form, were present at one time. The other possibility is that holes C040C and C040CR may have been contaminated in some way.

These holes and the immediately adjacent materials require further examination to determine the source of the sulfur and whether it is likely to be widespread or restricted to those holes only.

6.5.2 Proportions of lithological groups and approximate volumes

To assess the approximate proportions of waste in each lithology group in the proposed open cut pit, all of the holes that were logged for lithological unit in the overall resource drilling database within the open cut pit were examined.

All 68 drillholes within the pit that were logged within the resource database were examined to determine the approximate proportions of waste in each lithological group. Of these 68 holes 36 lie within the proposed open pit. The locations of the holes are shown in Figure 6-20.

The blue outline is the lease boundary and the black outline is the approximate outline of the proposed pits. Holes sampled for geochemical testing are shown as red and additional holes with lithological unit logs are black.

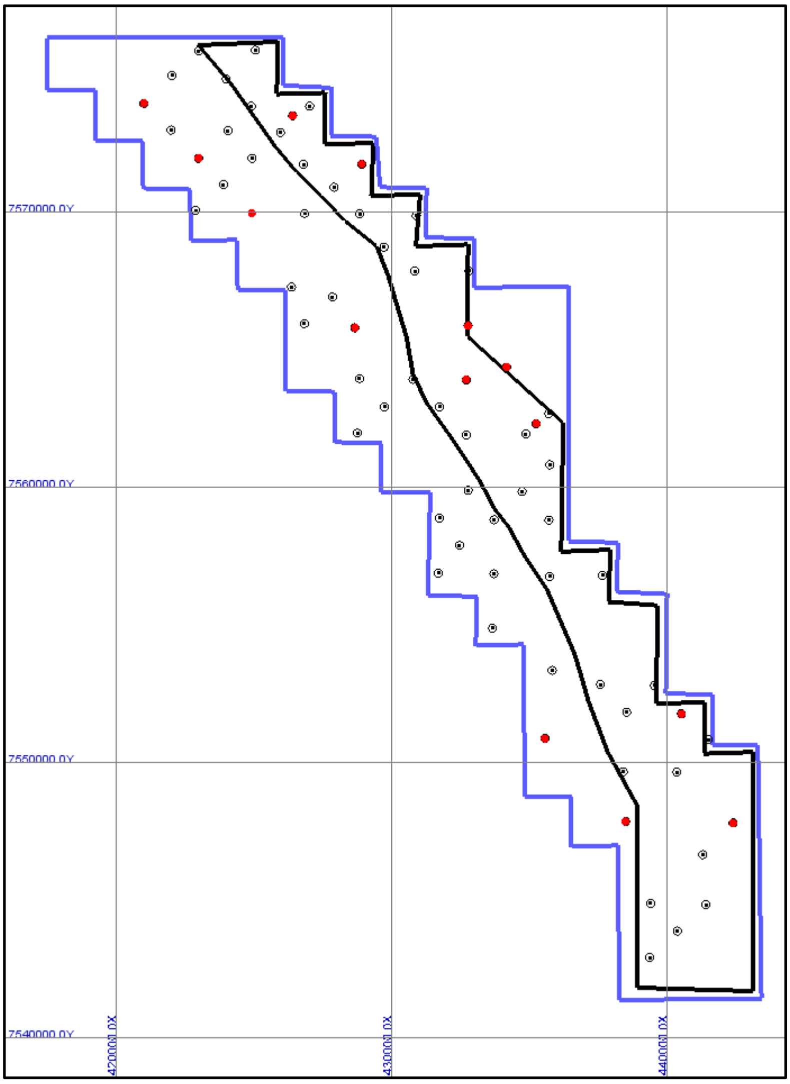


Figure 6-20: Lease and pit outlines with drill collars

The drillholes are reasonably evenly distributed across the open pit. Equal area of influence weighting was assumed for each hole when calculating the proportion of waste in each lithological group. The downhole lengths of each logged lithological unit were aggregated to calculate the overall lithological unit and group proportions.

The number of individual waste lithological unit codes recorded (42) in the resource database for the in-pit holes is far greater than the number of waste lithological unit codes (8) in the holes sampled for geochemical characterisation. Therefore only the lithological group proportions were calculated and not the proportions for individual lithological units.

Two additional breakdowns of the lithology groups are provided. The weathered material is split into weathered tertiary and weathered (weathered Triassic / Permian - Figure 6-21). The base of weathering surface model provided by Adani Mining Pty Ltd (Adani) is always below the tertiary contact surface model. The fresh burden material is split into fresh overburden and fresh inter-burden based on the AB roof or first coal surface model generated by SRK from the Adani coal seam surface models.

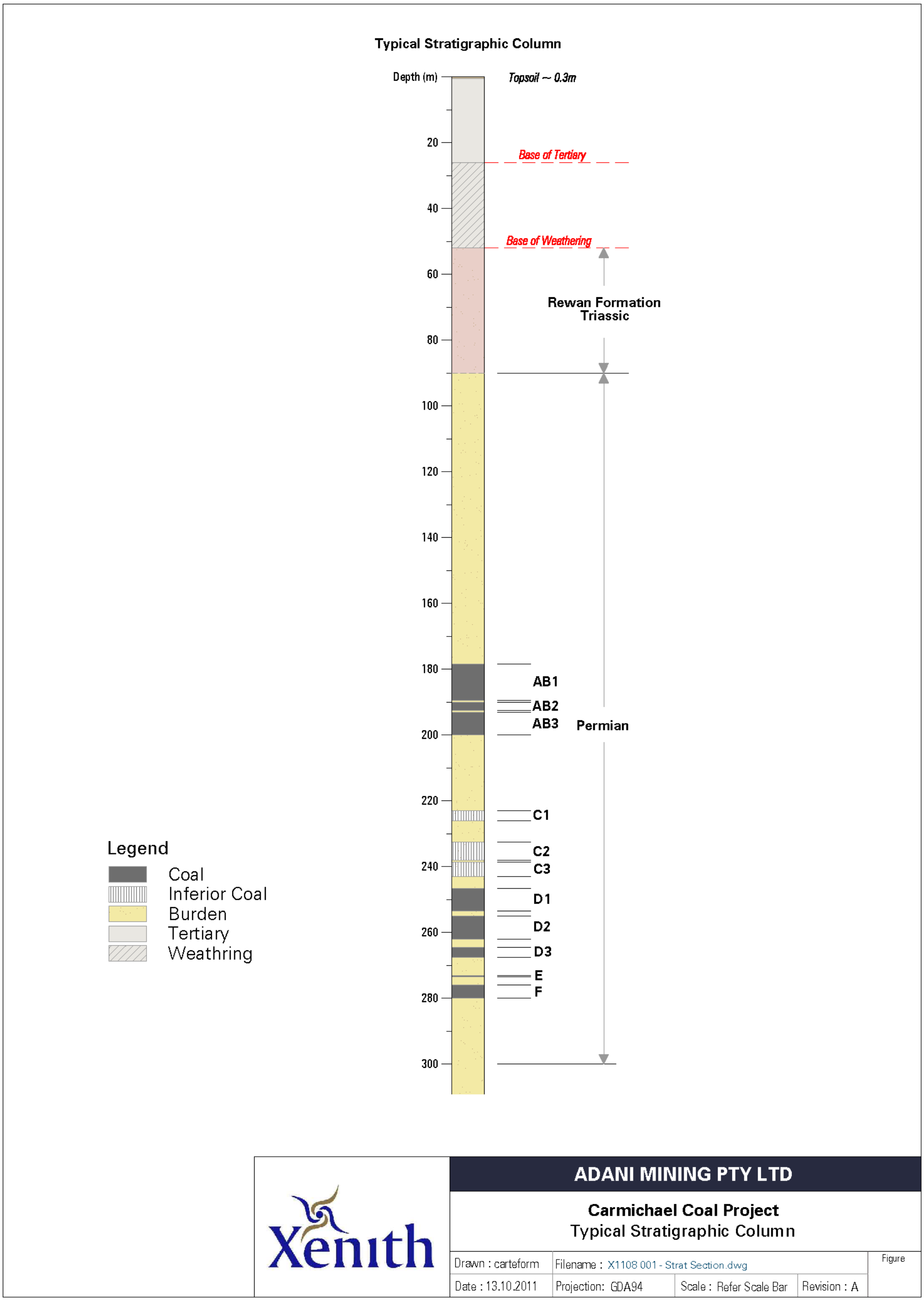


Figure 6-21: Typical stratigraphic column

The total pit waste volumes were taken from the Runge Carmichael Macro-Conceptual Mining Study report (Runge 2011) and the volumes for each group were allocated from the proportions derived from the lithological logging.

Table 6-14: Lithologcal group proportions (%) within the proposed open cut

Proportions (%)	ALL	Weathered Tertiary	Weathered Triassic / Permian	Fresh Overburden	Fresh Inter-burden
C seam inferior coal	3.5	0.0	2.6	0.0	8.4
Carbonaceous	5.5	0.0	0.2	5.3 [1]	11.1
Clay and Soil	17.7	48.7	16.2	0.2	0.0
Coal unknown seam	0.9	0.1	0.0	0.0	2.2
Core loss	1.1	2.4	2.4	0.1	0.2
Remaining	69.4	44.5	72.3	94.4	77.9
Sand and gravel	1.7	3.7	4.9	0.0	0.3
Calcrete and Ferricrete	0.3	0.5	1.4 [2]	0.0	0.0
Total (columns)	100.0	100.0	100.0	100.0	100.0
Total (breakdown)	100.0	34.2	6.0	20.0	39.8

1. Heavily biased by a single hole C074 which has an unusually long run of carbonaceous shale logged between 70 and 121 m downhole above the top of the AB seam. This may be a logging or data entry error.
2. Majority from hole C042C.

Table 6-15: Lithological group volumes within the open cut

Volumes (Mbcm)	ALL	Weathered Tertiary	Weathered Triassic / Permian	Fresh Overburden	Fresh Inter-burden
C seam inferior coal	840	0	36	0	805
Carbonaceous	1318	0	3	259	1056
Clay and Soil	4240	3996	234	7	2
Coal unknown seam	224	11	0	0	213
Core loss	252	198	35	5	15
Remaining	16661	3645	1046	4535	7436
Sand and gravel	401	306	71	0	24
Calcrete and Ferricrete	63	43	20	0	0
Total	24000	8198	1446	4806	9550

Table 6-16: Sampled group proportions

Proportions (%)	All	Weath	Fresh
Calcrete and Ferricrete	0.8	3.1	0.0
Carbonaceous	21.2	6.8	26.1
Clay and Soil	10.4	40.8	0.0
Coal unknown seam	0.8	0.0	1.1
Remaining	66.8	49.3	72.8
Total (column)	100.0	100.0	100.0
Total (breakdown)	100.0	25.6	74.4

The group proportions are reasonable similar between the geochemical sampling and the in-pit waste. The exception is the carbonaceous group which was deliberately oversampled.

6.5.3 Global confidence on the means

A 95% confidence interval has been used in all cases and the confidence intervals were calculated using a nonparametric procedure to allow for skewed and multimodal distributions. A nonparametric procedure does not assume any distribution shape and calculates the confidence intervals based on simulating thousands of possible distributions via random subsampling. This is also known as ‘bootstrapping’. Calculating confidence intervals in software packages such as Excel that use parametric methods usually assume a Gaussian symmetrical distribution which is rarely correct for variables such as total sulfur. For example, use of parametric methods on skewed distributions can lead to negative lower bounds which in the case of total sulfur, is impossible.

The confidence interval alone is not enough information to decide if there are sufficient samples to represent the mean of a lithological unit. A threshold of interest is also required. For the purpose of PAF classification two criteria were considered, a total sulfur threshold of 0.1% and a NAPP of zero.

Where the threshold of 0.1% total sulfur falls within the 95% confidence interval we consider that we do not have confidence in the mean being either above or below the threshold and further sampling may be required to tighten the confidence interval for that lithology (for example the claystone confidence interval in Figure 6-22).

In general the relationship between the mean and threshold would be examined for each lithology individually; however, this is not always necessary. Lithologies may be grouped if they display similar properties and confidence intervals. They can then be re-assessed by group. Grouping will change the confidence interval because more samples are available and will usually, but not always, tighten the confidence interval range.

By lithological unit

The 95% confidence intervals on the means of each lithology with three or greater samples are presented in Figure 6-22, Figure 6-23 and Figure 6-24. The ‘All’ category represents all of the lithologies with more than 2 samples. Lithologies sampled with only one or two samples are:

- Coal (unknown seams)
- Clay – Calcite containing (Calcrete)
- Interbedded carbonaceous mudstone and tuff
- Interbedded sandstone and siltstone.

These lithologies are therefore insufficiently sampled to the extent that no confidence interval can be calculated.

The 0.1% total sulfur threshold lies within the 95% confidence interval of:

- Carbonaceous mudstone
- Clay
- Claystone (sensitive to outlier); and
- Mudstone.

The zero NAPP threshold lies within the 95% confidence interval of:

- Claystone (sensitive to outlier); and
- Mudstone.

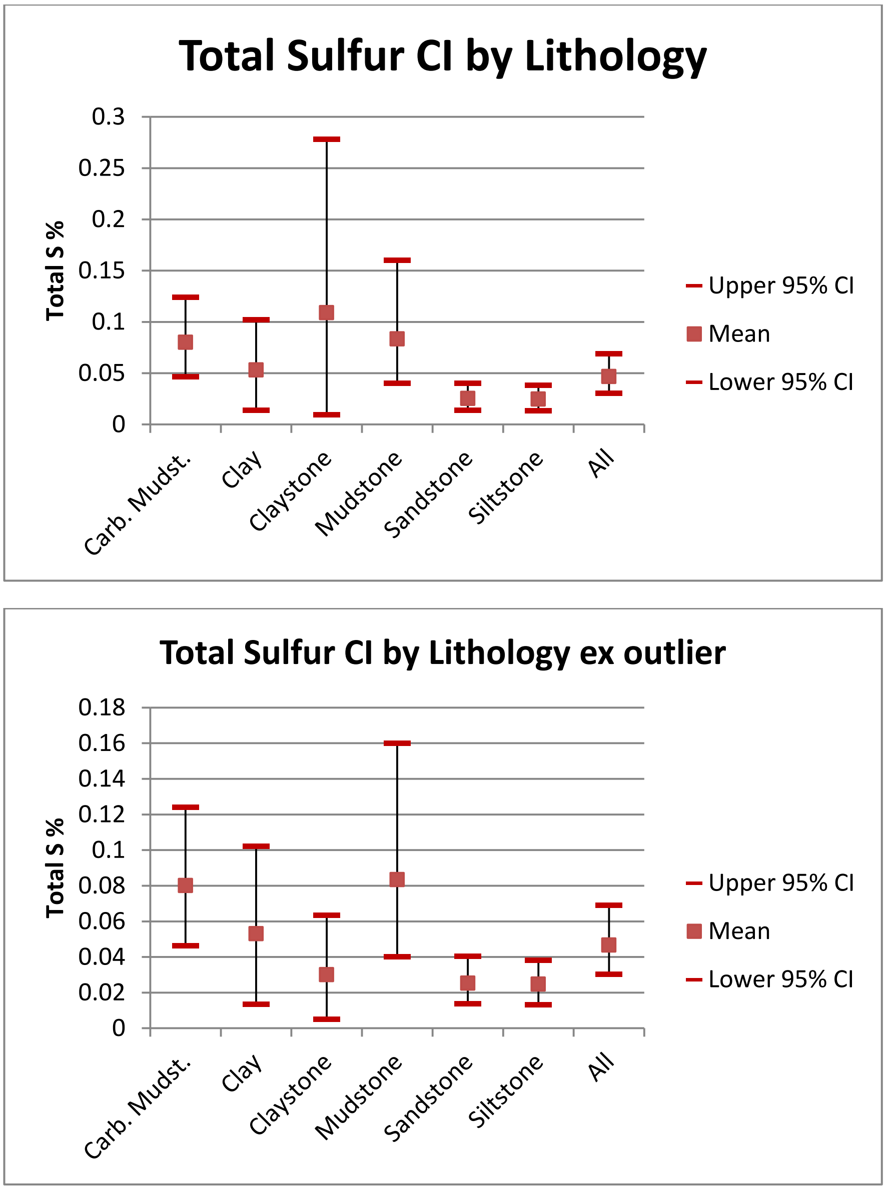


Figure 6-22: Mean and the 95% confidence interval of the mean of the total sulfur by lithology

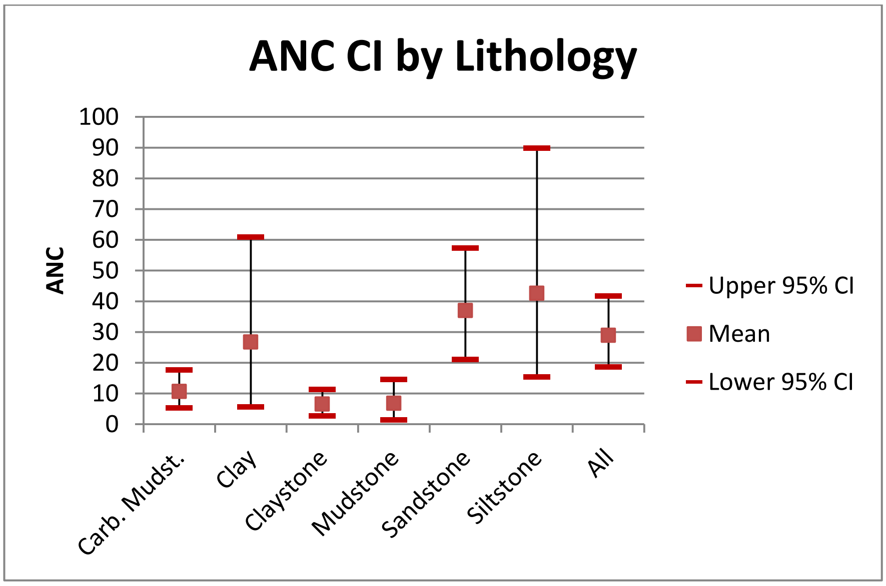


Figure 6-23: Mean and the 95% confidence interval of the mean of the ANC by lithology

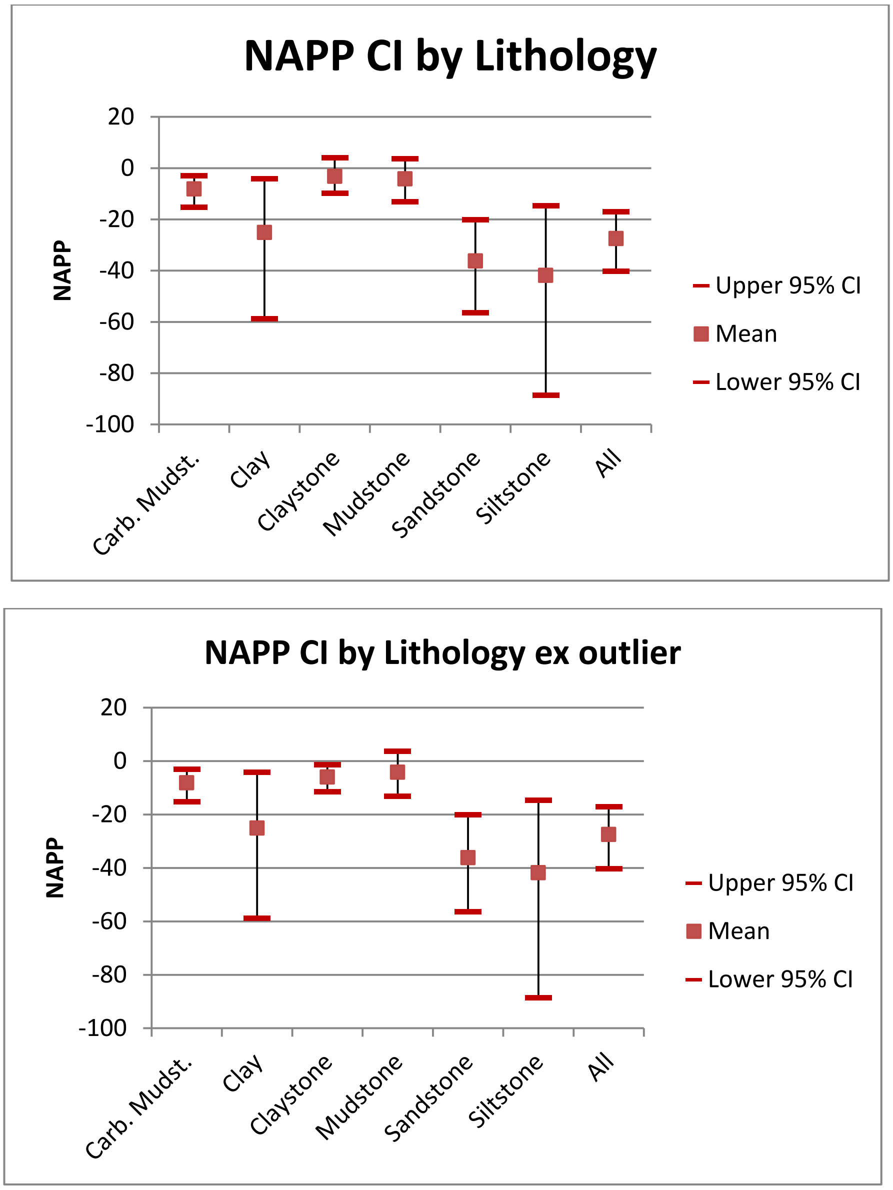


Figure 6-24: Mean and the 95% confidence interval of the mean of the NAPP by lithology

By lithological group

The lithological units were grouped as described in Appendix B. The grouping is designed to aggregate lithological units that are likely to have similar properties with respect to acid and metalliferous drainage characteristics. For this analysis the groups are also split into weathered and fresh where weathered is defined as any of the logged weathering states from extremely weathered to slightly weathered.

Groups that were present in the samples analysed but had only one or two samples are:

- Clay – containing calcite – weathered
- Carbonaceous – weathered
- Coal (unknown seams).

These groups are therefore insufficiently sampled to the extent that no confidence interval can be calculated.

Groups that were present in the samples analysed containing more than two samples are:

- Carbonaceous – fresh (C F) (majority lithological unit was carbonaceous mudstone)
- Clay and Soil – weathered (C&S W) (majority lithological unit was clay)
- Remaining – fresh (R F) (majority lithological unit was sandstone)
- Remaining – weathered (R W) (majority lithological units were claystone and sandstone).

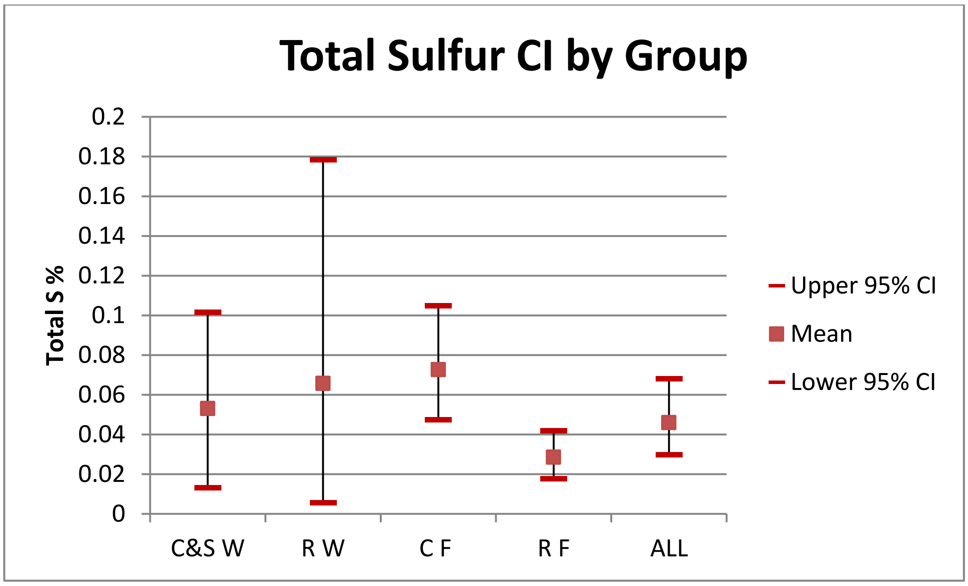
The 95% confidence intervals by group for total sulfur, ANC and NAPP are shown in Figure 6-25, Figure 6-26 and Figure 6-27. The all category represents all of the groups with greater than two samples.

The 0.1% sulfur threshold lies within the 95% confidence interval of:

- Clay and Soil – weathered
- Remaining – weathered (sensitive to outlier)
- Carbonaceous – fresh.

The zero NAPP threshold lies within the 95% confidence interval of:

- Remaining – weathered (sensitive to outlier).



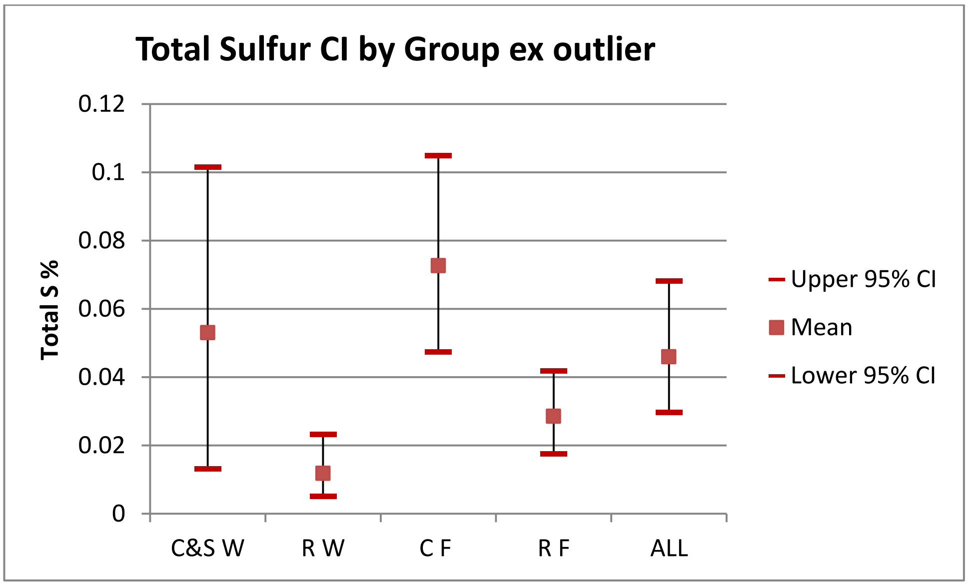


Figure 6-25: Mean and the 95% confidence interval of the mean of the total sulfur by group

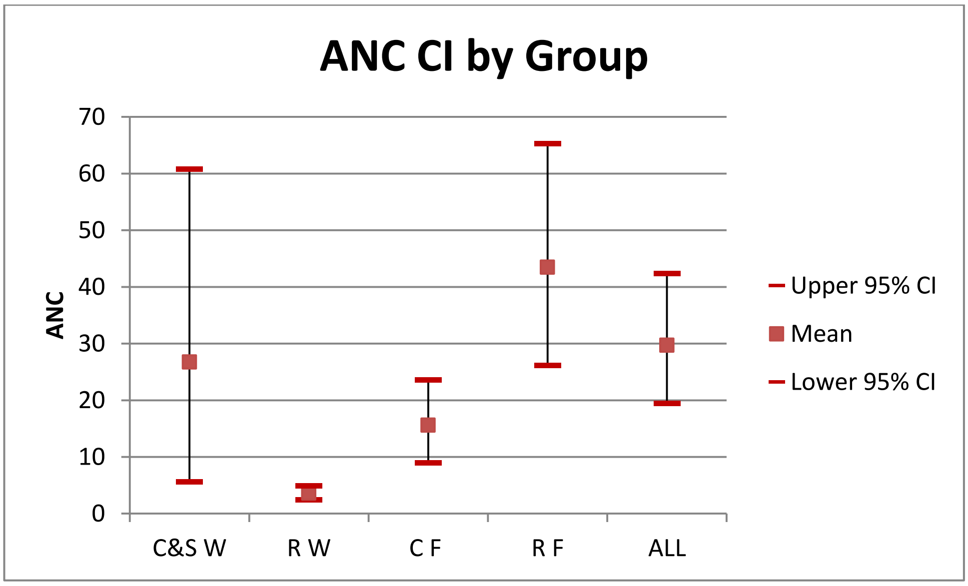


Figure 6-26: Mean and the 95% confidence interval of the mean of the ANC by group

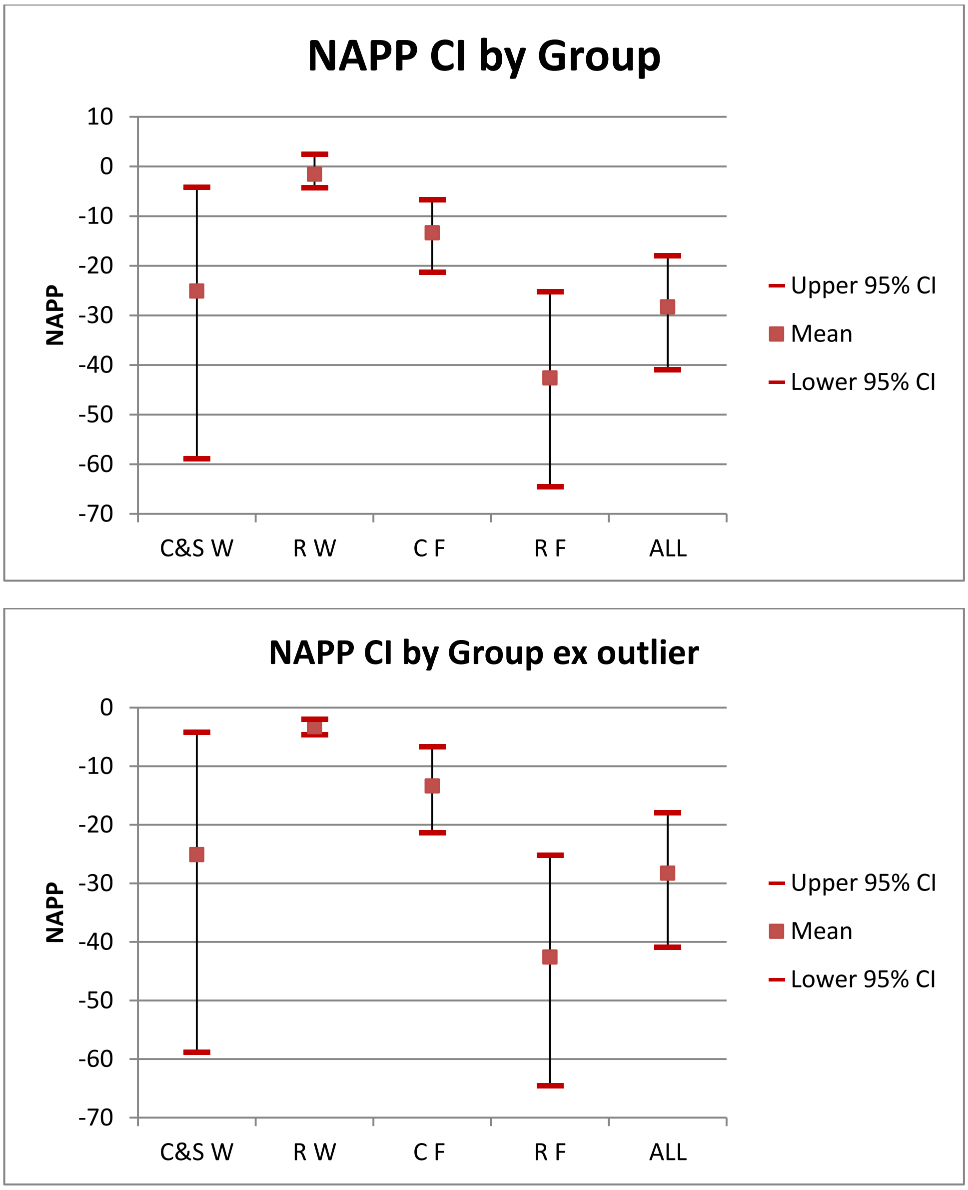


Figure 6-27: **Mean and the 95% confidence interval of the mean of the NAPP by group**

6.5.4 Population Variance and Spatial Variability

Even if the mean of a lithological unit or group is confidently below a threshold of interest it is still likely that some significant proportion of the lithological unit or group may be above the threshold. Estimating the proportion that lies above a threshold of interest at sample volume scale can easily be done by considering the sample distribution assuming sufficient samples are available. Results obtained for small samples collected for laboratory analysis, however, do not directly apply to larger samples collected by truck and shovel during mining. Scaling statistical results obtained using samples of volume suitable for laboratory analysis to mining selectivity scale requires some knowledge of the spatial variability of the parameter of interest. Standard geostatistical techniques that are routinely used for resource estimation can be used to do this and the process is referred to as making a change of support.

Variographic modelling was conducted on each of the lithological unit and lithological groups separately and showed no structure for total sulfur, ANC or NAPP. This indicates that insufficient samples were analysed to characterise the spatial distribution of material properties. Variographic modelling was attempted on the combined data from all lithological groups so as to increase the numbers of samples available in an attempt to obtain better structure resolution for the experimental variogram. This showed possible ranges in the order of 3000 m, however, these were not conclusive. Grouping all lithological groups makes the assumption that all groups have similar properties in terms of spatial variability which is not necessarily correct.

Further sampling is required to characterise the spatial variability of AMD related parameters and enable change of support calculations.

6.5.5 Conclusions and recommendations on the representativeness of samples

The proportion of samples from each lithological group and the proportion of rock to be mined in the pit were similar with the exception of the carbonaceous group which was deliberately oversampled.

The samples logged as interbedded during sampling are special cases. The interbedded sandstone and siltstone was originally logged, pre sampling, as sandstone only and should either be included in the sandstone lithological unit or excluded altogether. The interbedded carbonaceous mudstone and tuff should probably not have been sampled at all as it is a mixed lithological unit.

The high total sulfur values found in hole C040C and C040CR may relate to a very localised geological formation associated with calcite / calcrete or the samples may somehow have been contaminated. Further investigation of the association of calcrete and ferricrete with elevated total sulfur values is required. Further investigation of the spatial distribution of calcrete may be required if it is shown to be associated with high total sulfur values.

Of the lithological units with more than two samples, only the carbonaceous mudstone and mudstone lithological units require better definition with regard to their global mean values based on total S. The carbonaceous mudstone and mudstone lithological units belong to the fresh carbonaceous grouping which is typically contained in the fresh interburden.

The C-seam inferior coal that will not be processed, and therefore will be mined as waste, requires sampling as it has not been sampled.

The spatial density of sampling was inadequate to characterise the spatial distribution of total S, ANC and NAPP. Further sampling from drillholes spaced between 1000 m and 3000 m apart (Figure 6-28) would be required to further investigate the spatial variability. The variable spacing is required to capture the short and long range variability. Samples of each significant lithological unit would be required from these holes.

Assuming no additional core is available for waste sampling SRK recommends that an initial drilling programme of a further twenty holes be completed to meet the required spacing. At least the carbonaceous mudstone, clay, clay containing calcrete, claystone, mudstone, and coal material types should be sampled. Typically at least three samples per material type per hole should be collected; several coal (including C seam) and clay containing calcrete samples should also be collected as only one or two samples were analysed in the first round of testing. Based on this approach about 370 samples would be selected and tested in the next round of static testing. Similar to the method of resource evaluation, subsequent rounds of sampling may be required for defining the spatial variation of the waste characteristics. This sampling could be incorporated in future resource and / or geotechnical drilling programmes so as to maximise efficiency of information collection and minimise costs.

The distribution of calcite in and near hole C042 should be investigated. Initially this could take the form of a geologist inspecting the drill core from C042 and nearby holes. Characterisation of samples could be undertaken where calcite is visually identified. These holes and the immediately adjacent materials require further examination to determine the source of the sulfur and whether it is likely to be widespread or restricted to these holes only.

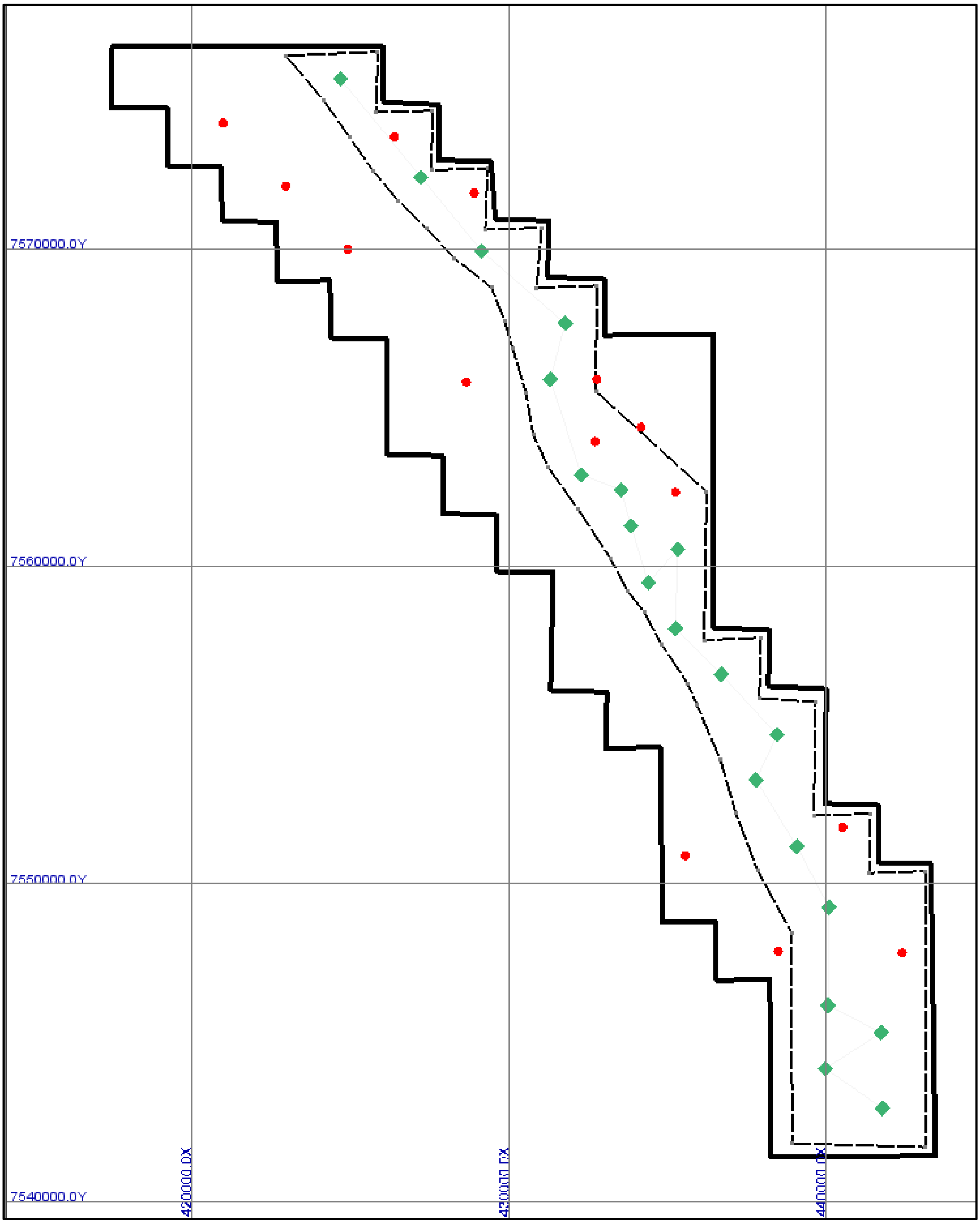


Figure 6-28: Approximate spacing of additional sampling – new samples in green – existing samples in red

6.6 Potential AMD and Waste Management Strategy

The limited testing conducted indicates that some carbonaceous mudstone, claystone and sandstone from the roof and floor and clay, claystone and sandstone from the overburden and interburden may be PAF. In addition some materials have been classed as uncertain in regard to their potential to be net acid forming. These samples were from a range of lithological units; carbonaceous mudstone, clay, claystone, mudstone and sandstone.

Static testing of more samples and kinetic testing is required to better ascertain the potential of various rock types to produce acidic and metalliferous drainage. In addition, a water quality assessment is required to estimate the potential water quality based on the geochemical characterisation results.

In the event that a water quality assessment determines that it is necessary to manage PAF material several options could be available, including:

i) Covering or isolating the PAF waste with NAF materials to reduce the quantity of water contacting the PAF waste (conceptual arrangement shown in Figure 6-29).

ii) Co-mingling or blending the PAF waste with acid consuming waste that has excess neutralisation capacity (however, there are currently no indications that such NAF materials will be available in large quantities).

iii) A variation of option ii) is the addition of limestone ($CaCO_3$) during deposition of PAF waste. This has been demonstrated at some sites to extend the lag time to acidification. The benefits include improvements in surface and pore water quality prior to implementing other longer term management strategies.

iv) Segregating and placing the PAF waste where acid generation can easily be controlled or prevented through reduction in the rate of oxygen supply (e.g. covering the waste, Figure 6-29, or backfilling the open pit below the long term water table, Figure 6-30).

For option i) NAF material would be placed at the base of the dump to reduce contact between PAF waste and the water that flows at the interface of the waste (base of the dump) and the original ground surface. PAF material would then be covered with NAF material, graded to enhance runoff and compacted to limit infiltration, thus reducing the contact between infiltrating rainwater and PAF waste. Depending on the properties of the NAF material (e.g. thickness of layer, sulfide mineral content, particle size distribution, weathering properties etc.), it may also serve to reduce the availability of oxygen to the PAF material thus reducing the rate of oxidation. This management strategy may be used during mining when the pit is being constructed and PAF material must be removed from the pit for efficient mining.

For option ii) PAF material would be blended with material containing excess neutralisation capacity and would require tight controls on blending ratios. This process is operationally complex to implement. Success has been limited in the past due to the fact that it is not always possible to achieve well mixed conditions during placement and maintain contact between the acid produced and neutralising materials in the longer term. It is further constrained by the simultaneous availability of the neutralising materials during mining, and may require rehandling of materials. Based on current information this option would not be recommended.

For option iv), reducing the rate oxygen transport to PAF waste would reduce the rate of sulfide oxidation and thus acid and sulfate production.

A reduction in oxygen transport rates can potentially be achieved by covering the PAF wastes within NAF material (low sulfate production rate) that has low intrinsic permeability and low oxygen diffusion coefficient. Some materials, such as clay, can be suitable for reducing oxygen transport if compacted and maintained at a high degree of saturation (say, greater than 0.85). The success of this approach would depend on the characteristics of the materials available and the amount and frequency of rainfall at the site. The suitability of dispersive materials for use as a cover would need to be investigated.

Alternatively, the in-pit disposal could limit oxygen and oxidation rates of sulfides to very low levels if the PAF waste is placed below the long term steady water level in the pit. To ensure that solute release is limited when the PAF waste is inundated, the material can either be amended with limestone or covered to limit oxygen entry. Amendment with limestone will not prevent oxidation of sulfides and the production of sulfates. Thus, sulfates may be mobilised when the waste is inundated.

The long term benefit of in-pit disposal is that once the wastes are inundated, oxidation is effectively controlled and no further maintenance or control is required. Waste placed at the base of the pit would be inundated after the recovery of the water table, reducing the diffusive supply of oxygen to the waste by about four orders of magnitude or more and would slow the rate of oxidation greatly. Because of the demonstrated performance on controlling oxidation and acid generation, placement of PAF materials below the water table within the open pit is believed to be the most effective long term option for managing PAF waste materials. (Land based disposal requires ongoing water and cover management and maintenance to ensure long term performance).

A conceptual arrangement of the waste in the pit is shown in the schematic provided in Figure 6-30. Benign or NAF material placed over the PAF material would reduce the evaporative loss of rain water and rising groundwater prior to flooding of the pit as a result of the recovery of the groundwater levels. The importance of the NAF layer in reducing evaporation increases in the event that the balance of recharge and evaporation is such that the water level in the pit does not rise far above the pit floor.

A limiting factor of the effectiveness of in-pit disposal method could be the time taken for the groundwater table to recover and saturate the waste. If the time for the groundwater table to recover is determined to be too long, disposal of the saturated tailings with PAF overburden and interburden in a low permeability section of the pit may maintain a high degree of saturation of the PAF waste and reduce the rate of oxidation until the groundwater table recovers.

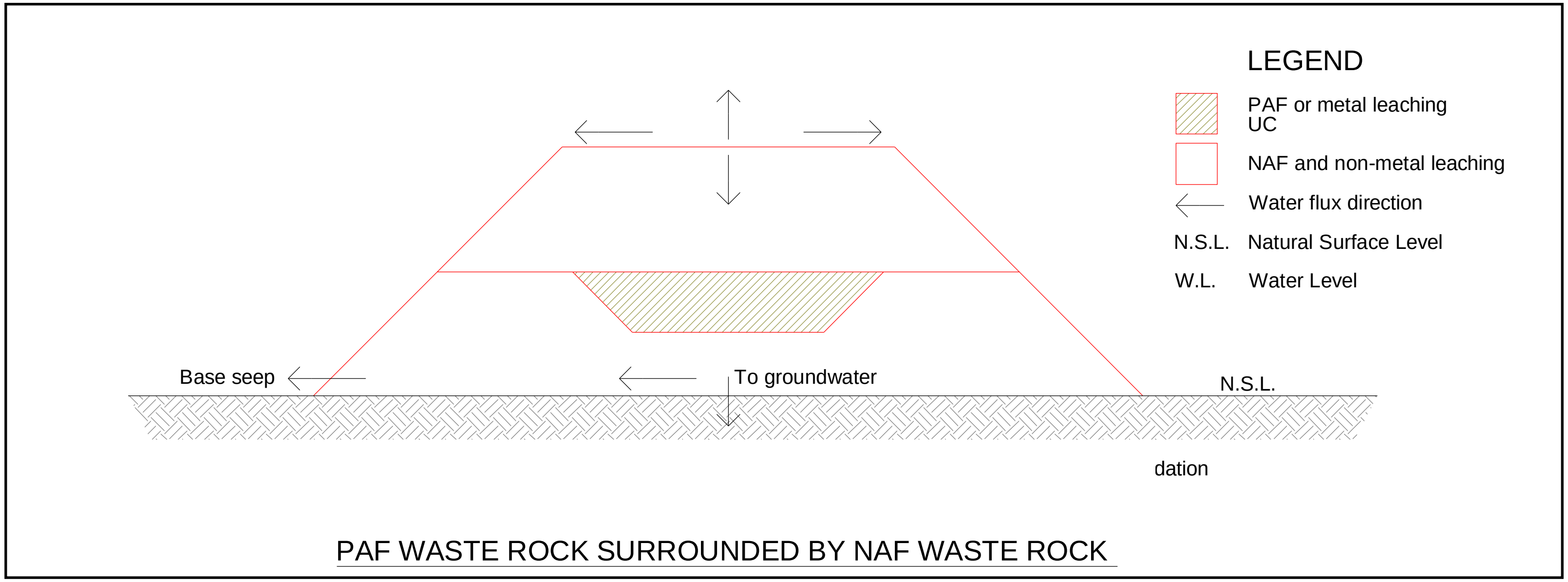


Figure 6-29: PAF waste rock surrounded by NAF waste rock

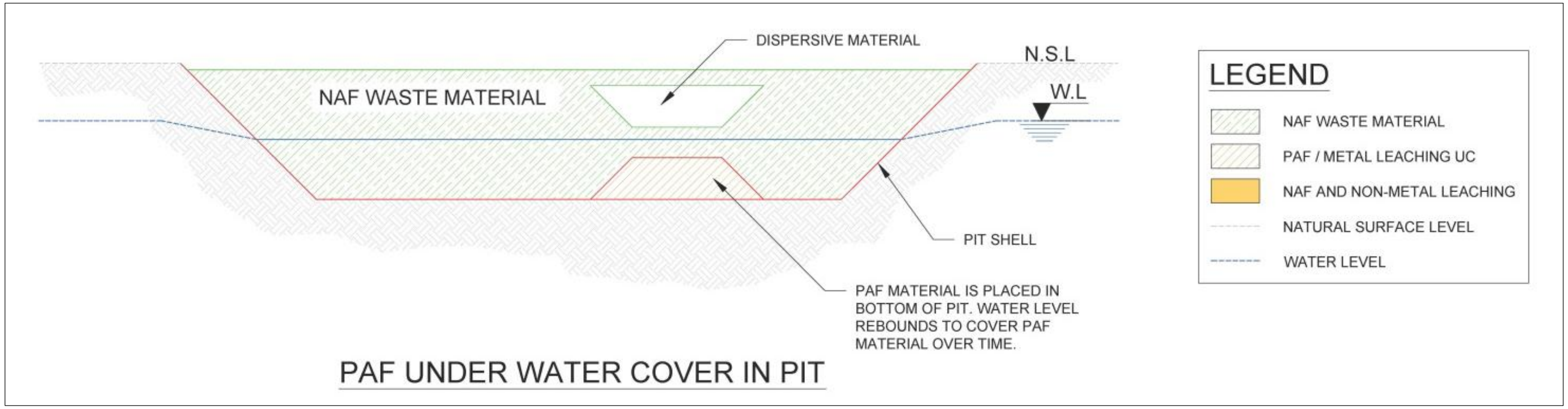


Figure 6-30: PAF waste rock under water cover in pit with water table rebound

7 Dispersivity Assessment

7.1 Introduction

Sodic soils can be dispersive when wet. In non-dispersive soils, the clay fraction remains flocculated in still water, and the water needs to be flowing above a threshold velocity to cause erosion. By contrast, there is no threshold velocity for dispersive soil, the clay particles go into suspension even in still water, and, therefore are highly susceptible to erosion and piping.

The potential for dispersivity is determined primarily by the mineralogy and chemistry of the clay fraction of the material, and by the dissolved salts in the pore and eroding fluids. The presence of exchangeable sodium is the principal chemical factor contributing to the soil dispersion. The exchangeable sodium percentage (ESP) is determined by measuring the concentration of all the exchangeable cations (Cation Exchange Capacity or CEC) in the soil and expressing the amount of exchangeable sodium as a percentage of the CEC.

Another property that governs the susceptibility of clayey soils to dispersion is the total content of dissolved salts (TDS, also assessed indirectly as electrical conductivity, EC) in the soil pore or eroding water. Generally, the lower the TDS or EC, the greater the susceptibility of sodium saturated soils to dispersion. Soils with high content of dissolved salts may remain flocculated even if the ESP is high.

Thus, for a given eroding fluid, the boundary between the flocculated and deflocculated (when dispersion can occur) states depends on the mineralogy and sodium content of the clay, the salt concentration of pore water and the eroding water.

Dispersion is assessed for mine waste materials as the rapid erosion of these materials can cause tunnel erosion and gullying in the waste dumps, which can affect their long term stability and sustainability. In addition to having a high susceptibility to gully erosion, sodic materials can also show severe surface crusting, low infiltration and hydraulic conductivity and hard, dense subsoils.

7.2 Testing for Dispersivity

Dispersivity can be assessed by means of chemical tests to ascertain potential causes of dispersion, or by physical tests to observe the effect of dispersion. Dispersivity can be affected by a range of factors as listed in the previous section. For this reason, it is recommended that a variety of tests be conducted to assess the potential of a material to disperse. Some variability between the results of the different test results is common.

For this project, four tests were conducted to determine the dispersion potential for the materials.

- Exchangeable sodium percentage (ESP) and cation exchange capacity (CEC)
- Electrical conductivity (EC)
- Emerson aggregate test
- Simple accelerated weathering testing on four rock samples.

For the ESP and CEC a sub-sample of material was dried and pulverised to better than 85% passing 75 microns as pulp. The EC (1:5) was also performed on the pulp. The Emerson aggregate test was tested “as received” with no further sample preparation.

For soil materials, an ESP greater than 6% may indicate dispersive properties, and greater than 15% indicates highly dispersive properties (Gerber and von Maltitz Harmse, 1987). However, in SRK’s experience of testing on crushed rock material the threshold values appear to be higher, with an ESP less than 15% indicating non-dispersive properties and an ESP of greater than 30% indicating highly dispersive properties. Factors such as clay type (determined indirectly from the CEC) and total dissolved salts (assessed using the EC) govern the overall behaviour of the material. Materials with a CEC less than 10 meq/100g are generally classified as non-dispersive (Gerber and von Maltitz Harmse, 1987). A high dissolved salt content may mask the effect of the high sodium content, which can cause soils with a high ESP to behave as a non-dispersive material.

The Emerson aggregate test (also called the crumb test) is a simple test in which a block of soil (about 2cm in diameter) is placed in still water and the reaction between soil and water (slaking or dispersion) noted. If no reaction occurs, the sample is remoulded, then shaken and the reaction observed, and also tested for gypsum. Appendix F shows a flow chart for the testing and classification of soils in the Emerson aggregate test and also shows examples of highly dispersive, slightly dispersive and non-dispersive samples in the Emerson aggregate test. The Emerson Test gives a good indication of the expected behaviour of the materials.

7.3 Sample Selection

Dispersivity testing was conducted on samples from the Carmichael project. Twenty eight samples were selected for the Emerson aggregate test and 14 samples for chemical testing. The samples were selected to cover all major material types and weathering grades, but with emphasis on materials more likely to show dispersive behaviour. In addition, four samples were selected for accelerated weathering testing (AWT) in which the deterioration of submerged samples was visually observed. The number of tests completed for each rock type is given in Table 7-1.

Table 7-1: Sample selection

Lithological Group	Rock type	Number of Samples		
		Emerson Testing	Chemical Testing	AWT
Coal	Coal	2	1	
Clay and Soil	Clay (weathered layers)	2	1	1
Sand and Gravel	Sandstone	2	1	
Carbonaceous	Carb. Mudstone	7	2	1
Remaining	Claystone	4	3	
	Siltstone	4	3	1
	Sandstone	4	1	1
	Clay (potentially AN)	3	2	

7.4 Test Results

Test results are summarised in Appendix F, and an interpretation of the dispersivity of each sample given in Table 7-2. An overall classification of dispersive, marginally dispersive and non-dispersive was assessed for each lithological group, according to results of the individual tests.

Paste testing, and results from leach testing, suggest that the rock samples contained little salinity; paste electroconductivity (EC) ranged from 37 to 584 µS/cm for fresh rock and 525 to 1170 µS/cm for weathered rock. The clay samples showed high salinity, with EC ranging from 2030 to 3740 µS/cm. The exchangeable sodium percentage (ESP) values ranged from 3.8 to 56.7%. While these values classify the samples as sodic to strongly sodic the results should be viewed in the context of low cation exchange capacity (less than 10 meq/100g), and also the fact that the common ranges for milled rock may be different from published values for soil classification.

Table 7-2: Interpretation of Results

Sample ID	Lithology Group	Rock Type	Weathering	Emerson Test	CEC and ESP	Assessed Dispersivity for Group
81356	Clay And Soil	Clay	EW	D	D	Dispersive
81362	Clay And Soil	Claystone	HW	D		
81394	Potential An	Clay	EW	N	N	Dispersive
81450	Remaining	Claystone	EW	N		
81365	Remaining	Clay	HW	D	D	
81396	Potential An	Clay	HW	N		
81357	Remaining	Claystone	HW	D	D	
81400	Carbonaceous	Carb Mudstone	SW	D		
81367	Remaining	Siltstone	SW	N	M	Marginally dispersive
81351	Sand And Gravel	Sandstone	MW	N		Non-dispersive
81363	Remaining	Sandstone	MW	N	N	
81382	Coal Group	C5 Coal	FR	N	N	Non-dispersive
81370	Coal Group	Coal	FR	N		
81355	Carbonaceous	Carb Mudstone	FR	N	N	Non-dispersive, very occasionally marginal
81406	Carbonaceous	Carb Mudstone	FR	N		
81455	Carbonaceous	Carb Mudstone	FR	N		
81453	Remaining	Claystone	FR	N	M	
81438	Carbonaceous	Interbedded Carb Mst And Tuff	FR	N		
81401	Carbonaceous	Mudstone	FR	N	N	
81403	Carbonaceous	Mudstone	FR	N		Non-dispersive
81404	Remaining	Sandstone	FR	N		
81405	Sand And Gravel	Sandstone	FR	N	ND	
81410	Remaining	Sandstone	FR	N		
81436	Remaining	Sandstone	FR	N		
81371	Remaining	Siltstone	FR	M	M	Marginal or nondispersive
81379	Remaining	Siltstone	FR	M		
81418	Remaining	Siltstone	FR	N	N	

Where: D = dispersive, M = marginally dispersive and N = nondispersive

7.5 Visual assessment

Simple accelerated weathering testing (AWT) was conducted by SRK on samples of weathered claystone, and unweathered sandstone, siltstone and mudstone. These rock types showed non-dispersive behaviour under laboratory test conditions. AWT testing was conducted to determine the potential for time dependant deterioration or slaking, which may affect long term stability of waste dumps. The testing involved two parts: i) submerging rock fragments in water, and ii) subjecting a second set of samples to daily wetting and drying, and observing changes to the samples over a 20 day period. Results are shown in Appendix G.

As with other test results, none of the samples showed dispersive results: the water remained clear, with clay particles settling out with time, and no clay particles remaining in suspension in the water. The samples did, however, show different degrees of durability/ physical slaking. The extremely weathered claystone showed very rapid slaking, the siltstone moderate slaking and the sandstone minor slaking. The mudstone did not show signs of slaking.

This testing may indicate that although the fresh rock units are not dispersive, they are not durable, and with time may degrade. The degraded material may be more prone to physical erosion than the original fresh rock. It is recommended that additional laboratory testing be conducted to qualify the slake potential of the fresh rock and to understand the effect of this on long term dump behaviour.

7.6 Discussion and Conclusion

The clay and soil group and weathered mudstone, claystone, carbonaceous mudstone and siltstone generally showed dispersive behaviour. Slightly weathered siltstone and fresh mudstones may show very slight potential for dispersivity. The weathered sandstone did not show any indication of dispersive behaviour. The fresh rocks generally tested non-dispersive, although some claystones and siltstones showing a very low potential for dispersion. There was variability in dispersion results within each group. This indicates that not all materials within a group show the same degree of dispersivity.

The accelerated weathering testing showed that the weathered rock, siltstone and sandstone showed potential for deterioration and breakdown after exposure to water. The siltstone showed moderate deterioration, and sandstone slow deterioration. This may indicate that although the fresh rock units are not dispersive, they are not durable, and with time may degrade. The degraded material may be more prone to physical erosion than the original fresh rock.

As a general recommendation, suitable precautions should be taken to prevent water contact with dispersive materials. Storage of the soil and clays and weathered mudstone, claystone and siltstones which show a high potential for dispersion within the core of the overburden storage areas is recommended (Figure 6-30). Further testing on both dispersivity of soil-like and weathered rock, and time dependant slake potential of the unweathered units is recommended.

8 Conclusions and Recommendations

8.1 Representativeness of samples

The drillholes from which samples were obtained are distributed over the north western half and lower portion of the south east half of the project area. The total number of samples tested was 100. Twelve samples were roof, floor and coal samples. Eighty eight samples were overburden or interburden.

The number of samples tested was large enough to draw conclusions about the mean values of AMD related parameters across the site for most of the lithological groups, but was insufficient to make assessments about the spatial variability of parameter values.

Estimates of the mean and the 95% confidence intervals of the mean for total S, ANC and NAPP were obtained for the carbonaceous mudstone, clay, claystone, mudstone, sandstone and siltstone. The NAPP values of all except the mudstone were less than 0 kg(H_2SO_4/t). Only three mudstone samples were characterised. The number of samples should be increased to improve the best estimate of the mean and narrow the 95% confidence interval of the mean for mudstone.

The number of coal samples characterised is too small (2) to allow estimation of mean values. More coal samples should be collected and characterised. The sampling should include the C-seam which has not been sampled to date.

Two samples containing calcrete and ferricrete had unusually high total sulfur contents. These high sulfur contents may be present due to a localised geological formation and further investigation is required to determine whether this is the case.

Further sampling is required to characterise the spatial variability of AMD related parameters. A drilling programme comprising holes spaced between 1000 m and 3000 m apart (Figure 6-28) would be required to support an assessment of the spatial variability. This will require twenty additional holes to be drilled and sampled. On the basis of six lithological units of interest and three samples per lithological unit per hole, and additional samples for the coal and calcite bearing clay, about 370 additional samples will need to be tested in the next phase of the characterisation programme.

In addition, coal washery wastes were not available for testing in the initial programme. Consequently samples representative of coal washery wastes should also be obtained and characterised.

8.2 Geochemical Properties

8.2.1 Acid generation and neutralisation

Acid generation capacities were estimated from the total sulfur, total sulfur minus sulfate sulfur (sulfide sulfur) and chromium reducible sulfur (CRS) contents of the individual samples. The acid generating capacity determined from the CRS measurements was typically less than that determined from the other two parameters. CRS analysis was however, not conducted on all samples thus the use of total sulfur to calculate the acid generating potential likely has resulted in over-estimation of the acid generation potential.

Similarly acid neutralisation capacities were estimated using three approaches: acid neutralising capacity (ANC), carbonate neutralising capacity (CarbNP) and acid buffering characteristic curve (ABCC). The test results indicated that the readily available neutralising capacity may be significantly less than that determined by the more frequently used ANC test. The fraction of ANC available tends to be larger for samples with larger ANC values.

Additional testing utilising CRS measurements to determine the presence of oxidisable sulfur and ABCC tests to determine the availability of ANC are recommended to improve the understanding of the overall potential for acid generation in the waste materials.

Kinetic testing should be conducted to determine the rates of oxidation, acid generation, acid neutralisation and metal leaching rates. The measured rates can then be used to complete water quality predictions and infer potential impacts on receiving water quality. These estimates would also be used to identify suitable mitigation and environmental management measures that would address any issues that may be of significance.

Mineralogical analysis should be undertaken to identify the mineral phases that could contribute to acid generation and acid neutralisation. The results would support the interpretation of kinetic test results.

8.2.2 Roof, floor and coal

Acidity

The majority of roof and floor wastes and coal are not likely to be a source of acid immediately after mining.

Salinity

Most of roof, floor and coal would not be expected to be an immediate source of salinity; however, some portion could be a source of salinity.

Potential for AMD

A portion of the carbonaceous mudstone and claystone roof and floor and coal materials could be expected to be potentially acid forming. The NAPP for the PAF coal sample was 3.4 kg(H_2SO_4)/t and the median for the roof and floor samples was -2.7 kg(H_2SO_4)/t.

Concentrations of metals in water contacting the waste would be expected to be low while waters remain circumneutral.

8.2.3 Overburden and interburden

Acidity

The large majority of overburden and interburden not immediately adjacent to coal seams is not likely to be a source of acid immediately after mining.

Salinity

The large majority of overburden and interburden not immediately adjacent to the coal seams is not likely to be a significant source of salinity. However, the clay materials could have a markedly higher potential to release salts and metals to water contacting them whilst the pH may remain alkaline (7.4 to 8.4).

Potential for AMD

The majority of the waste from all lithological units is likely to be non-acid forming in the longer term.

Although the majority of carbonaceous mudstone and claystone would be expected to be non-acid forming a significant fraction of these lithological units may be potentially acid forming and could require active management strategies to prevent or limit the development of AMD.

All siltstone samples were classed NAF.

Concentrations of metals in water contacting the waste would be expected to be low while waters remain circumneutral.

8.3 Dispersivity

Test results for 24 samples indicate that the clays, weathered mudstone, claystone, carbonaceous mudstone and siltstone generally may have dispersive behaviour. Slightly weathered siltstone and fresh mudstones may show very slight potential for dispersivity. The weathered sandstone did not show any indication of dispersive behaviour.

The fresh rocks were generally non-dispersive, although some claystones and siltstones may have a very low potential for dispersion. There was variability in dispersion results within each group.

Weathered rock, siltstone and sandstone showed potential for deterioration and breakdown after exposure to water. The siltstone showed moderate rate deterioration, and sandstone slow deterioration. This may indicate that although the fresh rock units are not dispersive, they are not durable, and with time may degrade to sand, silt or clay. The degraded material may be more prone to physical erosion than the original fresh rock.

Testing of additional samples should be undertaken to identify trends in the dispersive and weathering behaviour of the various rock types.

Precautions should be taken to prevent surface runoff water contacting materials with dispersive properties. Placement of these materials within the core of the storage areas is recommended.

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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Appendices

Appendix A: Sample characteristics

Client Sample ID	Batch #	Site no.	Sample Type	Lithology	Weathering	Roof, floor, coal	Lithology Group	Drill hole ID	From	To
									m	m
				Limit of detection ->						
81351	1	C001C	HQ core 63mm	SANDSTONE	MW		Rem	C001C	50.48	50.71
81352	1	C001C	HQ core 63mm	CLAY	HW		Clay and soil	C001C	51.55	51.83
81353	1	C001C	HQ core 63mm	SILTSTONE	MW		Rem	C001C	57.86	58.23
81354	1	C001C	HQ core 63mm	SANDSTONE	FR		Rem	C001C	86.47	86.80
81355	1	C001C	HQ core 63mm	CARB MUDSTONE	FR	f	Carbonaceous	C001C	105.80	106.34
81356	1	C0021C	HQ core 63mm	CLAY	EW		Clay and soil	C0021C	5.58	6.51
81357	1	C0021C	HQ core 63mm	CLAYSTONE	HW		Rem	C0021C	34.27	34.90
81358	1	C0021C	HQ core 63mm	CLAYSTONE	FR	r	Rem	C0021C	48.55	48.88
81359	1	C0021C	HQ core 63mm	SANDSTONE	FR	f	Rem	C0021C	54.55	55.35
81360	1	C024C	HQ core 63mm	CLAY	EW		Clay and soil	C024C	5.08	5.80
81361	1	C024C	HQ core 63mm	CLAY	HW		Clay and soil	C024C	12.55	13.55
81362	1	C024C	HQ core 63mm	CLAYSTONE	HW		Rem	C024C	30.00	30.42
81363	1	C024C	HQ core 63mm	SANDSTONE	MW		Rem	C024C	43.31	44.26
81364	1	C024C	HQ core 63mm	SANDSTONE	FR		Rem	C024C	89.67	90.44
81365	1	C031C	HQ core 63mm	CLAY	HW		Clay and soil	C031C	14.22	15.08
81366	1	C031C	HQ core 63mm	SANDSTONE	SW		Rem	C031C	45.75	46.71
81367	1	C031C	HQ core 63mm	SILTSTONE	SW		Rem	C031C	54.96	55.36
81368	1	C031C	HQ core 63mm	SANDSTONE	FR		Rem	C031C	85.41	86.04
81369	1	C031C	HQ core 63mm	SILTSTONE	FR	r	Rem	C031C	92.17	92.42
81370	1	C031C	HQ core 63mm	COAL	FR	c	Coal	C031C	92.42	92.89
81371	1	C031C	HQ core 63mm	SILTSTONE	FR	r	Rem	C031C	96.83	97.88
81372	1	C031C	HQ core 63mm	SILTSTONE	FR	i	Rem	C031C	104.13	104.30
81373	1	C031C	HQ core 63mm	SILTSTONE	FR	r	Rem	C031C	157.76	158.18
81374	1	C034C	HQ core 63mm	CLAY	HW		Clay and soil	C034C	20.71	20.99
81375	1	C034C	HQ core 63mm	CLAY	MW		Clay and soil	C034C	29.80	30.69
81376	1	C034C	HQ core 63mm	CLAY	SW		Clay and soil	C034C	44.24	45.22
81377	1	C034C	HQ core 63mm	CLAYSTONE	HW		Rem	C034C	83.03	83.60
81378	1	C034C	HQ core 63mm	SANDSTONE	FR		Rem	C034C	103.46	103.87
81379	1	C036C	HQ core 63mm	SILTSTONE	FR		Rem	C036C	253.43	253.77
81380	1	C036C	HQ core 63mm	SANDSTONE	FR		Rem	C036C	255.90	256.28
81381	1	C036C	HQ core 63mm	CARB MUDSTONE	FR		Carbonaceous	C036C	295.82	296.21
81382	1	C036C	HQ core 63mm	COAL	FR	c	Coal	C036C	298.14	298.27
81383	1	C036C	HQ core 63mm	SANDSTONE	FR		Rem	C036C	334.80	335.17
81384	1	C036C	HQ core 63mm	SANDSTONE	FR		Rem	C036C	372.53	373.10
81386	1	C036C	HQ core 63mm	SANDSTONE	FR		Rem	C036C	384.72	385.97
81387	1	C039C	HQ core 63mm	SANDSTONE	HW		Rem	C039C	61.00	61.77
81388	1	C039C	HQ core 63mm	SANDSTONE	HW		Rem	C039C	83.82	84.63
81389	1	C039C	HQ core 63mm	SANDSTONE	SW		Rem	C039C	178.70	179.02
81390	1	C039CR	HQ core 63mm	SANDSTONE	FR		Rem	C039CR	410.71	411.24
81391	1	C039CR	HQ core 63mm	SANDSTONE	FR		Rem	C039CR	427.08	427.51
81392	1	C039CR	HQ core 63mm	CARB MUDSTONE	FR		Carbonaceous	C039CR	461.55	462.00
81393	1	C039CR	HQ core 63mm	CARB MUDSTONE	FR		Carbonaceous	C039CR	478.36	478.77
81394	1	C040C	HQ core 63mm	CLAY	EW		Clay and soil	C040C	4.36	4.55
81395	1	C040C	HQ core 63mm	CLAY	HW		Clay and soil	C040C	4.55	5.10
81396	1	C040C	HQ core 63mm	CLAY	HW		Clay and soil	C040C	5.43	5.81
81397	1	C040CR	HQ core 63mm	CLAYSTONE	HW		Rem	C040CR	46.63	47.00
81398	1	C040CR	HQ core 63mm	CLAYSTONE	SW		Rem	C040CR	61.51	62.46
81399	1	C041C	HQ core 63mm	CLAYSTONE	SW		Rem	C041C	60.95	61.23
81400	1	C041C	HQ core 63mm	CARB MUDSTONE	SW	r	Carbonaceous	C041C	64.38	65.23
81401	1	C041C	HQ core 63mm	MUDSTONE	FR		Rem	C041C	67.70	68.21
81402	1	C041C	HQ core 63mm	MUDSTONE	FR		Rem	C041C	76.35	76.90
81403	1	C041C	HQ core 63mm	MUDSTONE	FR		Rem	C041C	98.70	99.45
81404	1	C041C	HQ core 63mm	SANDSTONE	FR		Rem	C041C	107.00	107.57
81405	1	C042C	HQ core 63mm	SANDSTONE	FR	r	Rem	C042C	85.97	86.88
81406	1	C042C	HQ core 63mm	CARB MUDSTONE	FR		Carbonaceous	C042C	96.55	97.14
81407	1	C042C	HQ core 63mm	SANDSTONE	FR		Rem	C042C	103.39	103.66
81408	1	C044C	HQ core 63mm	CARB MUDSTONE	FR		Carbonaceous	C044C	342.00	342.86
81409	1	C044C	HQ core 63mm	SANDSTONE	FR		Rem	C044C	364.66	365.17
81410	1	C046C	HQ core 63mm	SANDSTONE	FR		Rem	C046C	258.26	259.19
81411	1	C046C	HQ core 63mm	SILTSTONE	FR		Rem	C046C	261.40	262.22
81413	1	C046C	HQ core 63mm	SANDSTONE	FR		Rem	C046C	318.50	319.24

Client Sample ID	Batch #	Site no.	Sample Type	Lithology	Weathering	Roof, floor, coal	Lithology Group	Drill hole ID	From	To
									m	m
				Limit of detection ->						
81414	1	C046C	HQ core 63mm	SILTSTONE	FR	r	Rem	C046C	321.42	322.27
81415	1	C046C	HQ core 63mm	CARB MUDSTONE	FR		Carbonaceous	C046C	390.06	390.34
81416	1	C046C	HQ core 63mm	SILTSTONE	FR		Rem	C046C	424.87	425.80
81417	1	C048C	HQ core 63mm	SILTSTONE	FR		Rem	C048C	351.92	352.78
81418	1	C048C	HQ core 63mm	SILTSTONE	FR		Rem	C048C	356.16	356.93
81419	1	C048C	HQ core 63mm	SANDSTONE	FR		Rem	C048C	360.20	360.79
81420	1	C048C	HQ core 63mm	CARB MUDSTONE	FR		Carbonaceous	C048C	373.28	373.83
81421	1	C048C	HQ core 63mm	SANDSTONE	FR		Rem	C048C	375.08	375.98
81423	1	C048C	HQ core 63mm	SANDSTONE	FR		Rem	C048C	382.12	382.94
81424	1	C048C	HQ core 63mm	SANDSTONE	FR		Rem	C048C	386.73	387.69
81425	1	C048C	HQ core 63mm	SANDSTONE	FR		Rem	C048C	391.30	392.30
81426	1	C048C	HQ core 63mm	SANDSTONE	FR		Rem	C048C	395.10	396.00
81427	1	C048C	HQ core 63mm	SANDSTONE	FR		Rem	C048C	398.90	399.90
81428	1	C048C	HQ core 63mm	SANDSTONE	FR		Rem	C048C	402.86	403.84
81430	1	C048C	HQ core 63mm	SANDSTONE	FR		Rem	C048C	410.46	411.40
81431	1	C048C	HQ core 63mm	SANDSTONE	FR		Rem	C048C	414.56	415.46
81432	1	C048C	HQ core 63mm	CARB MUDSTONE	FR		Carbonaceous	C048C	419.25	419.86
81433	1	C048C	HQ core 63mm	INTERBEDDED SANDSTONE AND SILTSTONE	FR		Rem	C048C	428.06	429.13
81434	1	C048C	HQ core 63mm	SILTSTONE	FR		Rem	C048C	437.13	437.87
81435	1	C048C	HQ core 63mm	SANDSTONE	FR		Rem	C048C	440.38	441.29
81436	1	C048C	HQ core 63mm	SANDSTONE	FR		Rem	C048C	444.40	445.79
81437	1	C048C	HQ core 63mm	SANDSTONE	FR		Rem	C048C	447.77	448.65
81438	1	C048C	HQ core 63mm	INTERBEDDED CARB MUDSTONE AND TUFF	FR		Carbonaceous	C048C	463.00	465.26
81439	1	C048C	HQ core 63mm	INTERBEDDED SANDSTONE AND SILTSTONE	FR		Carbonaceous	C048C	465.26	466.45
81440	1	C048C	HQ core 63mm	CARB MUDSTONE	FR		Carbonaceous	C048C	484.43	485.29
81441	1	C048C	HQ core 63mm	SANDSTONE	FR		Rem	C048C	488.53	489.43
81443	1	C048C	HQ core 63mm	SANDSTONE	FR		Rem	C048C	497.48	498.36
81444	1	C048C	HQ core 63mm	SANDSTONE	FR		Rem	C048C	500.63	501.55
81445	1	C048C	HQ core 63mm	CARB MUDSTONE	FR		Carbonaceous	C048C	504.20	505.18
81446	1	C048C	HQ core 63mm	SILTSTONE	FR		Rem	C048C	510.76	511.70
81447	1	C048C	HQ core 63mm	SILTSTONE	FR		Rem	C048C	513.54	514.53
81448	1	C048C	HQ core 63mm	SILTSTONE	FR		Rem	C048C	518.37	519.34
81449	1	C056C	HQ core 63mm	CLAY	EW		Clay and soil	C056C	4.14	5.12
81450	1	C056C	HQ core 63mm	CLAYSTONE	EW		Rem	C056C	75.20	75.99
81451	1	C056C	HQ core 63mm	SANDSTONE	HW		Rem	C056C	85.20	85.80
81452	1	C056C	HQ core 63mm	CLAYSTONE	FR		Rem	C056C	148.07	149.04
81453	1	C056C	HQ core 63mm	CLAYSTONE	FR		Rem	C056C	169.96	171.24
81454	1	C056C	HQ core 63mm	SANDSTONE	FR		Rem	C056C	315.89	316.88
81455	1	C056C	HQ core 63mm	CARB MUDSTONE	FR		Carbonaceous	C056C	366.80	367.73

Appendix B: Lithological units and groups

CARBONACEOUS GROUP	
Lithological Units	Count of LITH CODE
CARBONACEOUS CLAYSTONE	3
CARBONACEOUS MUDSTONE	148
CARBONACEOUS SHALE	4
CARBONACEOUS SILTSTONE	13
Grand Total	**168**

CLAY AND SOIL GROUP	
Lithological Units	Count of LITH CODE
CLAY	94
CLAYEY SAND	6
SOIL	18
Grand Total	**118**

REMAINING GROUP	
Lithological Units	Count of LITH CODE
CHERT	1
CLAYSTONE	77
CONGLOMERATE	1
FAULT ZONE	1
GRANULE CONGLOMERATE	1
IRONSTONE	4
MUD	1
MUDSTONE	71
PEBBLE CONGLOMERATE	2
SANDSTONE	176
SANDSTONEcoarse grained	1
SANDSTONEfine grained	6
SANDSTONEfine to medium grained	10
SANDSTONEmedium grained	1
SANDSTONEmedium to coarse grained	5
SANDSTONEvery fine grained	5
SANDY CLAY	19
SANDY GRAVEL	1
SILT	32
SILTSTONE	212
TUFF	56
Grand Total	**683**

SAND AND GRAVEL GROUP	
Lithological Units	Count of LITH CODE
GRAVEL	9
SAND	15
Grand Total	**24**

CALCRETE AND FERRICRETE GROUP	
Lithological Units	Count of LITH CODE
ALLUVIUM	1
CALCRETE	7
FERRICRETE	7
SILCRETE	1
Grand Total	**16**

LITHOLOGY CODE	LITHOLOGICAL UNIT NAME	LITHOLOGICAL GROUP
AL	ALLUVIUM	NON REACTIVE
AK	ARKOSE	NON REACTIVE
AA	AS ABOVE	NON-ROCK GROUP
BA	BASALT	NON REACTIVE
BT	BENTONITE	CLAY AND SOIL GROUP
BY	BILLY	NON REACTIVE
CA	CALCITE	POTENTIAL AN GROUP
CK	CALCRETE	POTENTIAL AN GROUP
XY	CARBONACEOUS CLAY	CARBONACEOUS GROUP
XC	CARBONACEOUS CLAYSTONE	CARBONACEOUS GROUP
XE	CARBONACEOUS LAMELLE	CARBONACEOUS GROUP
CM	CARBONACEOUS MUDSTONE	CARBONACEOUS GROUP
XM	CARBONACEOUS MUDSTONE	CARBONACEOUS GROUP
XA	CARBONACEOUS SAND	CARBONACEOUS GROUP
XS	CARBONACEOUS SANDSTONE	CARBONACEOUS GROUP
XH	CARBONACEOUS SHALE	CARBONACEOUS GROUP
XT	CARBONACEOUS SILTSTONE	CARBONACEOUS GROUP
XX	CARBONACEOUS SILTSTONE	CARBONACEOUS GROUP
CB	CARBONATE	POTENTIAL AN GROUP
CH	CHERT	NON REACTIVE
CL	CLAY	CLAY AND SOIL GROUP
CS	CLAYSTONE	NON REACTIVE
C4	COAL 10-40% bright	COAL GROUP
CR	COAL FIBROUS	COAL GROUP
CP	COAL SAPROPELIC	COAL GROUP
CU	COAL UNDIFFERENTIATED	COAL GROUP
CW	COAL WEATHERED	COAL GROUP
C5	COAL, <10% bright	COAL GROUP
C1	COAL, >90% bright	COAL GROUP
C3	COAL, 40-60% bright	COAL GROUP
C2	COAL, 60-90% bright	COAL GROUP
C6	COAL, dull <1% bright	COAL GROUP
C7	COAL, dull, conchoidal	COAL GROUP
CO	COAL, undifferentiated	COAL GROUP
C9	COAL, weathered	COAL GROUP
ZC	COALY CLAYSTONE	COAL GROUP
ZM	COALY MUDSTONE	COAL GROUP
CZ	COALY SHALE	COAL GROUP
ZH	COALY SHALE	COAL GROUP
ZS	COALY SILTSTONE	COAL GROUP
CC	COBBLE CONGLOMERATE	NON REACTIVE
CG	CONGLOMERATE	NON REACTIVE
KL	CORE LOSS	NON-ROCK GROUP
LC	CORE LOST	NON-ROCK GROUP
DC	DIRTY COAL	COAL GROUP
FK	FERRICRETE	NON REACTIVE
CF	FUSAINOUS COAL	COAL GROUP
GC	GRANULE CONGLOMERATE	NON REACTIVE
GR	GRANULES	NON REACTIVE

LITHOLOGY CODE	LITHOLOGICAL UNIT NAME	LITHOLOGICAL GROUP
GV	GRAVEL	SAND AND GRAVEL GROUP
GW	GREYWACKE	NON REACTIVE
GY	GYPSUM	NON REACTIVE
IG	IGNEOUS ROCK	NON REACTIVE
IC	INFERIOR COAL	COAL GROUP
IS	IRONSTONE	NON REACTIVE
JA	JASPERLITE	NON REACTIVE
LT	LATERITE	NON REACTIVE
LS	LIMESTONE	POTENTIAL AN GROUP
LM	LIMONITE	NON REACTIVE
MU	MUD	CLAY AND SOIL GROUP
MS	MUDSTONE	NON REACTIVE
NS	NO SAMPLE	NON-ROCK GROUP
NL	NOT LOGGED	NON-ROCK GROUP
PC	PEBBLE CONGLOMERATE	NON REACTIVE
PB	PEBBLES	NON REACTIVE
PY	PYRITE	SULPHIDE GROUP
QZ	QUARTZ	NON REACTIVE
SA	SAND	SAND AND GRAVEL GROUP
SS	SANDSTONE	NON REACTIVE
S1	SANDSTONE VERY FINE GRAINED	NON REACTIVE
SC	SCHIST	NON REACTIVE
SH	SHALE	NON REACTIVE
SD	SIDERITE	NON REACTIVE
SK	SILCRETE	NON REACTIVE
SI	SILT	NON REACTIVE
SL	SILTSTONE	NON REACTIVE
SO	SOIL	CLAY AND SOIL GROUP
SU	SOOT	COAL GROUP
CX	SOOTY CLAY	NON REACTIVE
CY	SOOTY COAL	COAL GROUP
CN	STONY COAL	COAL GROUP
TO	TONSTEIN	NON REACTIVE
TF	TUFF	NON REACTIVE
UD	UNDIFFERENTIATED ROCK TYPE	NON REACTIVE

Appendix C: Static test results

Client Sample ID	Lithology	$pH_{1:2}$	$EC_{1:2}$	Total S	ANC	ABCC	Sulfate as SO4 2-	Chromium reducible S	Total C	TIC	TOC	NAGpH	NAG [pH 4.5]	NAG [pH 7.0]	pH (OX)	pH -2 (ext)	MPA	ANC/MPA (NPR)	NAPP	CarbNP	ass NPR	Class AMIRA (ANC & MPA)	Class Extended boil NAG classific-ation	Class NAG AMIRA with Ext. Boil NAG
		pH Unit	µS/cm	%	kg H_2SO_4/t	kg H_2SO_4/t	mg/kg	%	%	%	%		kg H_2SO_4/t	kg H_2SO_4/t	pH Unit	pH Unit	kg H_2SO_4/t		kg H_2SO_4/t	kg H_2SO_4/t	Price, 2009	Standard NAG tested	Ext. boil NAG result	
	Limit of detection ->	0.1	1.00	0.01	0.5		100	0.005	0.02	0.02	0.02	0.1	0.1	0.1	0.1	0.1	0.306			1.63				
81351	SANDSTONE	8.8	390	0.01	6.4				0.23	0.15	0.08						0.31	20.92	-6.1	12.24	NAF			
81352	CLAY	8.7	140	<0.01	2.1												0.15	13.73	-1.9		NAF			
81353	SILTSTONE	8.3	171	<0.01	4.0												0.15	26.14	-3.8		NAF			
81354	SANDSTONE	8.3	81	<0.01	1.2												0.15	7.84	-1.0		NAF			
81355	CARB MUDSTONE	8.0	37	0.04	1.1		100	0.008	4.14	0.21	3.93	6.9	<0.1	0.10			1.22	0.90	0.1	17.14	NAF	UC(NAF)		UC(NAF)
81356	CLAY	7.8	2910	0.07	14.4	2.5	910	<0.005	0.06	0.04	0.02	9.1	<0.1	<0.1			2.14	6.72	-12.3	3.27	NAF	NAF		NAF
81357	CLAYSTONE	7.7	790	<0.01	1.2				0.15	<0.02	0.14						0.15	7.84	-1.0	0.82	NAF			
81358	CLAYSTONE	7.0	1620	0.14	2.4		810	0.13				5.8	<0.1	0.30	5.8		4.28	0.56	1.9		PAF	UC(NAF)		UC(NAF)
81359	SANDSTONE	7.6	306	<0.01	0.7				0.14	<0.02	0.13						0.15	4.58	-0.5	0.82	NAF			
81360	CLAY	7.5	145	<0.01	2.5												0.15	16.34	-2.3		NAF			
81361	CLAY	6.7	825	<0.01	2.2												0.15	14.38	-2.0		NAF			
81362	CLAYSTONE	6.7	326	0.08	3.7	0.4	1300	<0.005	0.09	<0.02	0.08	7.1	<0.1	<0.1			2.45	1.51	-1.3	0.82	NAF	NAF-Barren		NAF-Barren
81363	SANDSTONE	6.4	525	<0.01	1.6												0.15	10.46	-1.4		NAF			
81364	SANDSTONE	8.4	591	0.12	43.1		460	0.087				10.2	<0.1	<0.1	10.2		3.67	11.74	-39.4		NAF	NAF		NAF
81365	CLAY	7.7	2030	0.2	0.7		700	<0.005				6.7	<0.1	<0.1	6.7		6.12	0.11	5.4		PAF	UC(NAF)		UC(NAF)
81366	SANDSTONE	8.0	563	<0.01	8.2												0.15	53.59	-8.0		NAF			
81367	SILTSTONE	8.4	668	0.04	14.9		150	0.012				8	<0.1	<0.1	8		1.22	12.17	-13.7		NAF	NAF		NAF
81368	SANDSTONE	8.9	438	0.03	27.2	1.4											0.92	29.63	-26.3		NAF			
81369	SILTSTONE	8.8	384	0.02	11.3												0.61	18.46	-10.7		NAF			
81370	COAL	7.9	770	0.4	381.0		620	0.476	18.1	2.5	15.6	8.1	<0.1	<0.1	8.1		12.24	31.13	-368.8	204.08	NAF	NAF		NAF
81371	SILTSTONE	8.9	584	0.03	59.3	19.4											0.92	64.60	-58.4		NAF			
81372	SILTSTONE	8.8	478	0.08	370.0		210	0.057				9	<0.1	<0.1	9		2.45	151.14	-367.6		NAF	NAF		NAF
81373	SILTSTONE	6.8	552	0.08	3.4		610	0.033				6.4	<0.1	0.20	6.4		2.45	1.39	-1.0		NAF	NAF-Barren		NAF-Barren
81374	CLAY	8.4	4180	0.03	167.0	127.2											0.92	181.92	-166.1		NAF			
81375	CLAY	7.5	3450	0.02	23.3				0.11	<0.02	0.11						0.61	38.07	-22.7	0.82	NAF			
81376	CLAY	8.2	1230	0.01	13.9	2.5											0.31	45.42	-13.6		NAF			
81377	CLAYSTONE	7.6	585	<0.01	0.7												0.15	4.58	-0.5		NAF			
81378	SANDSTONE	6.9	198	0.05	0.7		150	0.022				6.6	<0.1	0.20	6.6		1.53	0.46	0.8		NAF	UC(NAF)		UC(NAF)
81379	SILTSTONE	9.0	253	0.06	17.8		<100	0.009				8.6	<0.1	<0.1	8.6		1.84	9.69	-16.0		NAF	NAF		NAF
81380	SANDSTONE	8.6	254	0.02	65.9	59.6											0.61	107.68	-65.3		NAF			
81381	CARB MUDSTONE	9.1	640	0.29	19.1	2.1	250	0.195	9.92	0.32	9.6				4.4	7.4	8.87	2.15	-10.2	26.12	UC		NAF	NAF
81382	COAL	7.5	443	0.97	10.2	1.2	1370	0.215	57.9	4.4	53.5				2.3	4.4	29.68	0.34	19.5	359.17	PAF		PAF	PAF
81383	SANDSTONE	8.7	251	<0.01	6.9												0.15	45.10	-6.7		NAF			
81384	SANDSTONE	8.1	276	0.21	3.7	1.6	250	0.275							2.9	3.1	6.43	0.58	2.7		PAF		PAF	PAF
81386	SANDSTONE	8.2	98	<0.01	1.0												0.15	6.54	-0.8		NAF			
81387	SANDSTONE	7.3	94	<0.01	<0.5												0.15	1.63	-0.1		NAF			
81388	SANDSTONE	7.5	68	<0.01	2.1				<0.02	<0.02	<0.02						0.15	13.73	-1.9	0.82	NAF			
81389	SANDSTONE	8.4	130	<0.01	5.7												0.15	37.25	-5.5		NAF			
81390	SANDSTONE	8.1	253	<0.01	9.4												0.15	61.44	-9.2		NAF			
81391	SANDSTONE	9.1	260	<0.01	212.0	67.8											0.15	1385.62	-211.8		NAF			
81392	CARB MUDSTONE	8.2	306	0.05	11.2	0.5	230	0.008				6.8	<0.1	<0.1	6.8		1.53	7.32	-9.7		NAF	NAF		NAF
81393	CARB MUDSTONE	8.1	235	0.04	7.2		110	0.007				6.3	<0.1	2.50	6.3		1.22	5.88	-6.0		NAF	NAF		NAF
81394	CLAY	7.6	3740	1.96	16.1	4.5	206000	<0.005	0.19	0.13	0.06	9	<0.1	<0.1			59.98	0.27	43.9	10.61	PAF	UC(PAF)		UC(PAF)
81395	CLAY	7.8	6200	0.18	38.9		2530	<0.005				9.1	<0.1	<0.1	9.1		5.51	7.06	-33.4		NAF	NAF		NAF
81396	CLAY	7.7	4910	10.6	18.8		189000	<0.005	0.54	0.54	<0.02	9.3	<0.1	<0.1			324.36	0.06	305.6	44.08	PAF	UC(PAF)		UC(PAF)
81397	CLAYSTONE	7.6	1170	0.02	5.1				0.19	0.06	0.13						0.61	8.33	-4.5	4.90	NAF			
81398	CLAYSTONE	6.1	1720	0.82	2.8		4010	<0.005				4.7	<0.1	2.60	4.7		25.09	0.11	22.3		PAF	UC(NAF)		UC(NAF)
81399	CLAYSTONE	7.7	311	<0.01	7.7												0.15	50.33	-7.5		NAF			
81400	CARB MUDSTONE	5.5	789	0.12	1.7		920	0.167	10.8	0.1	10.7				4.2	4.7	3.67	0.46	2.0	8.16	PAF		PAF	PAF
81401	MUDSTONE	6.3	158	0.05	4.5		160	0.035	2.7	0.04	2.66	7.2	<0.1	<0.1			1.53	2.94	-3.0	3.27	NAF	NAF-Barren		NAF-Barren
81402	MUDSTONE	5.3	457	0.16	1.4		580	0.082	5.03	<0.02	5.03	6.9	<0.1	0.20			4.90	0.29	3.5	0.82	PAF	UC(NAF)		UC(NAF)

Client Sample ID	Lithology	pH$_{1:2}$	EC$_{1:2}$	Total S	ANC	ABCC	Sulfate as SO4 2-	Chromium reducible S	Total C	TIC	TOC	NAGpH	NAG [pH 4.5]	NAG [pH 7.0]	pH (OX)	pH -2 (ext)	MPA	ANC/MPA (NPR)	NAPP	CarbNP	ass NPR	Class AMIRA (ANC & MPA)	Class Extended boil NAG classific-ation	Class NAG AMIRA with Ext. Boil NAG
		pH Unit	µS/cm	%	kg H_2SO_4/t	kg H_2SO_4/t	mg/kg	%	%	%	%		kg H_2SO_4/t	kg H_2SO_4/t	pH Unit	pH Unit	kg H_2SO_4/t		kg H_2SO_4/t	kg H_2SO_4/t	Price, 2009	Standard NAG tested	Ext. boil NAG result	
	Limit of detection ->	0.1	1.00	0.01	0.5		100	0.005	0.02	0.02	0.02	0.1	0.1	0.1	0.1	0.1	0.306			1.63				
81403	MUDSTONE	8.4	539	0.04	14.5	1.9	290	0.009	0.65	0.03	0.62	7.5	<0.1	<0.1			1.22	11.85	-13.3	2.45	NAF	NAF		NAF
81404	SANDSTONE	8.0	1130	0.03	31.8												0.92	34.64	-30.9		NAF			
81405	SANDSTONE	8.7	437	0.18	3.4	0.5	140	0.01	0.26	<0.02	0.25	7.2	<0.1	<0.1			5.51	0.62	2.1	0.82	PAF	UC(NAF)		UC(NAF)
81406	CARB MUDSTONE	7.3	680	0.08	<0.5		210	0.034	9.19	<0.02	9.18	5.5	<0.1	2.90	5.5		2.45	0.10	2.2	0.82	NAF	UC(NAF)		UC(NAF)
81407	SANDSTONE	7.5	584	0.02	<0.5												0.61	0.41	0.4		NAF			
81408	CARB MUDSTONE	7.8	262	0.02	4.3				4.05	<0.02	4.05						0.61	7.03	-3.7	0.82	NAF			
81409	SANDSTONE	9.5	634	0.03	80.3												0.92	87.47	-79.4		NAF			
81410	SANDSTONE	8.6	340	<0.01	16.5												0.15	107.84	-16.3		NAF			
81411	SILTSTONE	9.1	328	<0.01	14.7				0.45	0.35	0.1						0.15	96.08	-14.5	28.57	NAF			
81413	SANDSTONE	9.7	547	0.02	105.0												0.61	171.57	-104.4		NAF			
81414	SILTSTONE	9.3	559	0.02	19.4												0.61	31.70	-18.8		NAF			
81415	CARB MUDSTONE	8.1	566	0.12	9.9	2.1	<100	0.011				6	<0.1	1.90	6		3.67	2.70	-6.2		UC	NAF		NAF
81416	SILTSTONE	8.6	368	<0.01	19.9												0.15	130.07	-19.7		NAF			
81417	SILTSTONE	8.7	340	<0.01	12.6				0.41	0.21	0.2						0.15	82.35	-12.4	17.14	NAF			
81418	SILTSTONE	8.6	376	0.02	14.9												0.61	24.35	-14.3		NAF			
81419	SANDSTONE	8.4	259	<0.01	22.2												0.15	145.10	-22.0		NAF			
81420	CARB MUDSTONE	8.2	694	0.06	13.6		330	0.022	4.07	<0.02	4.06	7	<0.1	<0.1			1.84	7.41	-11.8	0.82	NAF	NAF		NAF
81421	SANDSTONE	9.1	697	0.04	22.6		350	0.017				10.5	<0.1	<0.1	10.5		1.22	18.46	-21.4		NAF	NAF		NAF
81423	SANDSTONE	9.3	561	0.02	32.2												0.61	52.61	-31.6		NAF			
81424	SANDSTONE	9.4	441	0.01	315.0												0.31	1029.41	-314.7		NAF			
81425	SANDSTONE	9.2	531	0.02	50.3												0.61	82.19	-49.7		NAF			
81426	SANDSTONE	9.0	615	0.02	53.3				0.6	0.32	0.28						0.61	87.09	-52.7	26.12	NAF			
81427	SANDSTONE	9.1	510	0.02	54.5												0.61	89.05	-53.9		NAF			
81428	SANDSTONE	9.2	487	0.02	48.5												0.61	79.25	-47.9		NAF			
81430	SANDSTONE	9.2	554	0.02	59.9												0.61	97.88	-59.3		NAF			
81431	SANDSTONE	9.2	594	<0.01	53.3												0.15	348.37	-53.1		NAF			
81432	CARB MUDSTONE	9.0	880	0.02	44.9												0.61	73.37	-44.3		NAF			
81433	INTERBEDDED SANDSTONE AND SILTSTONE	8.2	459	0.01	15.8				2.2	0.28	1.92						0.31	51.63	-15.5	22.86	NAF			
81434	SILTSTONE	7.8	186	<0.01	9.9												0.15	64.71	-9.7		NAF			
81435	SANDSTONE	7.9	195	<0.01	3.2												0.15	20.92	-3.0		NAF			
81436	SANDSTONE	8.8	183	<0.01	110.0												0.15	718.95	-109.8		NAF			
81437	SANDSTONE	8.1	168	<0.01	10.6												0.15	69.28	-10.4		NAF			
81438	INTERBEDDED CARB MUDSTONE AND TUFF	8.5	494	0.08	64.1		150	0.046	3.62	0.44	3.18	8.5	<0.1	<0.1			2.45	26.18	-61.7	35.92	NAF	NAF		NAF
81439	INTERBEDDED SANDSTONE AND SILTSTONE	8.5	502	0.05	38.3	5.6	100	0.097	2.14	0.31	1.83	8.8	<0.1	<0.1			1.53	25.03	-36.8	25.31	NAF	NAF		NAF
81440	CARB MUDSTONE	7.8	184	0.02	4.8												0.61	7.84	-4.2		NAF			
81441	SANDSTONE	7.7	194	<0.01	6.3												0.15	41.18	-6.1		NAF			
81443	SANDSTONE	7.5	134	<0.01	5.0												0.15	32.68	-4.8		NAF			
81444	SANDSTONE	8.5	212	<0.01	15.7												0.15	102.61	-15.5		NAF			
81445	CARB MUDSTONE	7.5	177	0.04	2.5	0.3	<100	<0.005	7.37	0.15	7.22	6.7	<0.1	0.30	6.7		1.22	2.04	-1.3	12.24	NAF	NAF-Barren		NAF-Barren
81446	SILTSTONE	8.7	280	<0.01	22.2												0.15	145.10	-22.0		NAF			
81447	SILTSTONE	8.8	264	<0.01	43.1												0.15	281.70	-42.9		NAF			
81448	SILTSTONE	9.0	245	0.01	44.3												0.31	144.77	-44.0		NAF			
81449	CLAY	7.4	118	<0.01	2.5												0.15	16.34	-2.3		NAF			
81450	CLAYSTONE	6.9	76	<0.01	2.5				<0.02	<0.02	<0.02						0.15	16.34	-2.3	0.82	NAF			
81451	SANDSTONE	7.4	101	<0.01	2.0												0.15	13.07	-1.8		NAF			
81452	CLAYSTONE	8.7	242	<0.01	17.8				0.08	0.08	<0.02						0.15	116.34	-17.6	6.53	NAF			
81453	CLAYSTONE	9.0	195	<0.01	21.6												0.15	141.18	-21.4		NAF			
81454	SANDSTONE	9.2	820	0.04	19.3		350	0.016				8.4	<0.1	<0.1	8.4		1.22	15.77	-18.1		NAF	NAF		NAF

Client Sample ID	Lithology	$pH_{1:2}$	$EC_{1:2}$	Total S	ANC	ABCC	Sulfate as SO4 2-	Chromium reducible S	Total C	TIC	TOC	NAGpH	NAG [pH 4.5]	NAG [pH 7.0]	pH (OX)	pH -2 (ext)	MPA	ANC/MPA (NPR)	NAPP	CarbNP	ass NPR	Class AMIRA (ANC & MPA)	Class Extended boil NAG classific-ation	Class NAG AMIRA with Ext. Boil NAG
		pH Unit	µS/cm	%	kg H_2SO_4/t	kg H_2SO_4/t	mg/kg	%	%	%	%		kg H_2SO_4/t	kg H_2SO_4/t	pH Unit	pH Unit	kg H_2SO_4/t		kg H_2SO_4/t	kg H_2SO_4/t	Price, 2009	Standard NAG tested	Ext. boil NAG result	
	Limit of detection ->	0.1	1.00	0.01	0.5		100	0.005	0.02	0.02	0.02	0.1	0.1	0.1	0.1	0.1	0.306			1.63				
81455	CARB MUDSTONE	8.3	412	0.14	17.8		<100	0.009	18.7	<0.02	18.7				4.4	6.1	4.28	4.15	-13.5	0.82	NAF		NAF	NAF

Appendix D: Metal concentrations and Abundance Indices

Major Element Concentrations **Minor Element Concentrations**

	Site no.	Analyte	Al	Ca	Fe	K	Mg	Mn	Na	P	S	Ag	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr	Cs	Cu	Ga	Ge	Hf
		Units	ppm	ppm	%	ppm	ppm	ppm	%	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Mean Sediment		Comparative Abundance	72000	66000	4.1	20000	14000	770	0.57	670	0.22	0.057	7.7	100	460	2	0.4	0.17	83	14	72	72	33	18	1.7	2.5
Sample ID		Lithology code/LOR >>	0.01	0.01	0.01		0.01	5	0.01	10	0.01	0.01	0.02	10	10	0.05	0.01	0.02	0.01	0.1	1	0.05	0.2	0.05	0.05	0.1
81351	C001C	SANDSTONE	24100	2200	0.92	4200	900	239	0.04	80	0.03	0.1	2.4	10	180	0.63	0.11	0.01	33.2	3.6	55	1.45	33.4	6.23	0.03	1.6
81352	C001C	CLAY	75100	700	1.74	11200	1500	50	0.08	140	0.005	0.08	3.1	20	260	2.75	0.32	0.01	69.7	6.6	44	5.52	27.5	24.1	0.10	5.1
81353	C001C	SILTSTONE	90200	1500	2.03	18100	1900	39	0.1	290	0.01	0.06	2.3	20	360	2.09	0.41	0.06	55.5	9.8	64	7.74	32.2	25.6	0.09	4.9
81354	C001C	SANDSTONE	62700	500	0.93	20500	1500	140	0.07	120	0.01	0.02	3.8	10	480	1.04	0.43	0.05	49.9	3.2	22	4.71	6.8	17.75	0.06	2.7
81355	C001C	CARB MUDSTONE	81300	700	0.45	4700	400	17	0.04	100	0.02	3.06	3.2	10	110	1.77	0.29	0.17	51.1	1.9	13	4.06	7.6	23.1	0.07	4.7
81356	C0021C	CLAY	85600	2800	4.36	11700	5000	629	0.49	490	0.09	0.11	6.6	60	250	1.44	0.42	0.02	53.6	15.1	70	5.61	38.4	25.8	0.15	4.2
81357	C0021C	CLAYSTONE	73500	200	0.82	600	200	34	0.08	220	0.005	0.01	6.6	20	120	0.66	0.76	0.01	36	1.3	15	0.59	46.1	25.9	0.05	6.9
81358	C0021C	CLAYSTONE	139000	800	0.25	600	500	12	0.11	190	0.11	0.06	3.8	20	60	3.26	0.8	0.01	97.6	1.1	17	0.75	36.8	36.1	0.15	9.4
81359	C0021C	SANDSTONE	73200	300	0.27	2000	300	19	0.04	120	0.02	0.03	1.3	20	80	0.98	0.14	0.01	29.7	1.7	14	1.74	6.2	17.75	0.03	3.7
81360	C024C	CLAY	61000	600	2.83	3300	1400	45	0.04	70	0.01	0.06	5.4	30	220	1.27	0.31	0.01	33.9	7.3	49	4.95	17	15.9	0.05	2.7
81361	C024C	CLAY	59900	200	0.76	1000	1000	15	0.08	90	0.01	0.03	2.6	20	160	0.46	0.36	0.01	21.2	1.1	27	1.55	11.8	16.05	0.03	3.7
81362	C024C	CLAYSTONE	76600	1700	0.74	1000	1400	2.5	0.06	5480	0.06	0.09	14.2	30	1410	5.43	0.39	0.02	780	1	9	0.81	31.7	35.4	1.94	6
81363	C024C	SANDSTONE	45500	300	0.4	2200	200	13	0.02	110	0.02	0.05	4.5	10	110	0.66	0.12	0.01	41.4	0.7	21	1.11	5.6	10.4	0.03	2.3
81364	C024C	SANDSTONE	80900	21400	3.52	17300	2800	410	0.14	520	0.13	0.07	16.6	20	330	1.38	0.21	0.09	50.9	12.8	15	4.11	14.7	19.6	0.12	3.6
81365	C031C	CLAY	70600	300	3.89	6300	800	206	0.14	360	0.2	0.03	4.7	30	200	0.96	0.4	0.01	29.8	5.4	51	2.34	29.9	22.1	0.07	3.8
81366	C031C	SANDSTONE	77700	5000	1.8	15700	8200	81	0.44	690	0.02	0.06	3.6	20	290	2.07	0.12	0.04	35.9	20.3	30	6.58	38.2	21.4	0.07	2.5
81367	C031C	SILTSTONE	77200	4700	1.64	21500	5500	121	0.19	400	0.04	0.07	5	20	360	1.92	0.35	0.11	43.5	13	42	6.85	44.3	23.3	0.11	4
81368	C031C	SANDSTONE	72500	8000	7.61	21700	7100	1410	0.3	810	0.05	0.08	8.3	10	320	1.66	0.21	0.09	50	17	45	4.91	31	18.2	0.19	3.1
81369	C031C	SILTSTONE	77800	3500	1.78	23300	4700	184	0.14	610	0.03	0.1	4.2	20	410	1.4	0.48	0.13	52.8	7.9	31	8.49	48.1	20.9	0.10	3.8
81370	C031C	COAL	34400	134500	1.48	1600	3000	2110	0.08	120	0.23	14.8	6.6	10	90	1.17	0.31	0.17	25.2	6.2	3	1.6	20	8.24	0.07	2.1
81371	C031C	SILTSTONE	60600	25300	1.6	11700	5100	323	0.29	320	0.04	0.07	3.6	10	320	1.27	0.36	0.1	54	9.7	31	5.74	20.7	15.65	0.11	3.4
81372	C031C	SILTSTONE	62800	88400	14.55	5600	5300	5810	0.11	3760	0.09	0.12	4.8	5	200	0.71	0.11	0.08	33.8	5.3	3	2.18	137.5	12.65	0.20	1.7
81373	C031C	SILTSTONE	106500	1000	0.31	1200	300	34	0.03	150	0.04	0.22	12.3	10	90	2.74	0.6	0.23	35	6.4	14	1.52	138.5	31.9	0.06	9
81374	C034C	CLAY	84300	65000	5.6	13900	10100	1430	0.54	590	0.06	0.08	6.2	60	270	1.16	0.17	0.1	41.5	42.8	117	4.81	35.2	22.8	0.13	3.2
81375	C034C	CLAY	91300	3500	4.99	5500	8000	254	0.67	260	0.05	0.1	4.2	60	210	1.66	0.36	0.01	41.6	19.9	97	6.54	42	27.7	0.16	3.9
81376	C034C	CLAY	78500	3000	3.71	5400	5600	86	0.41	140	0.03	0.12	3.8	60	180	1.33	0.36	0.02	23.7	18.3	77	9.76	37.1	23	0.07	3.5
81377	C034C	CLAYSTONE	76800	200	0.29	400	200	5	0.06	80	0.01	0.01	0.8	10	90	0.8	0.66	0.01	4.39	0.7	9	0.4	5.6	24.6	0.03	6.9
81378	C034C	SANDSTONE	86800	500	0.43	9600	1000	39	0.05	110	0.05	0.11	5.7	20	230	3.28	0.73	0.23	98.2	3.2	48	9.01	40.1	28.5	0.10	4.3
81379	C036C	SILTSTONE	67600	3600	3.61	14500	4600	519	0.18	440	0.01	0.12	3.1	30	250	2.24	0.47	0.05	29.4	13	45	7.64	48.1	24.9	0.16	3.7
81380	C036C	SANDSTONE	61800	48900	4.78	9000	4000	1130	0.14	700	0.04	0.07	61.8	10	240	1.01	0.18	0.16	57.9	20.2	94	3.05	19.8	15.7	0.14	3.1
81381	C036C	CARB MUDSTONE	52200	5600	3.14	9400	5400	901	0.35	260	0.19	14.2	9.7	10	220	2.38	0.68	0.5	20.9	46.1	16	7.26	41.4	17.2	0.09	4.2
81382	C036C	COAL	14300	1600	1.54	1300	700	394	0.08	70	0.16	1.83	3.7	30	40	7.04	0.48	0.27	8.32	5.9	11	0.61	21.8	11.4	8.89	2.5
81383	C036C	SANDSTONE	78000	1600	1.48	24000	2600	191	0.37	330	0.01	0.07	9.3	10	450	2.07	0.32	0.1	64.1	6.4	44	6.71	29.2	22.5	0.11	4.3
81384	C036C	SANDSTONE	61500	1700	0.45	12900	600	75	0.05	100	0.21	0.03	5.9	10	350	1.18	0.12	0.08	35.9	2.2	35	3.52	6.6	17.7	0.03	2.8
81386	C036C	SANDSTONE	49700	300	0.64	14600	700	89	0.06	80	0.01	0.02	3.5	5	370	1.05	0.07	0.03	33.8	3	32	2.75	4.2	13.7	0.03	2.1
81387	C039C	SANDSTONE	43900	200	0.36	5000	600	26	0.03	110	0.02	0.03	2.6	10	470	0.77	0.46	0.01	70.2	0.8	51	3.35	7.3	16.75	0.03	3.4
81388	C039C	SANDSTONE	66300	1600	2.5	18500	8200	202	0.09	280	0.005	0.06	3.1	10	480	2.21	0.25	0.06	96.2	7.5	53	8.9	37	16.6	0.22	2.9
81389	C039C	SANDSTONE	76000	2500	4.12	17900	4000	420	0.1	210	0.01	0.11	2.4	10	370	2.95	0.6	0.02	74.6	10.8	41	11.75	28.1	20.7	0.15	4
81390	C039CR	SANDSTONE	44400	1100	3.12	15400	3200	407	0.42	180	0.02	0.06	5.5	5	360	1.15	0.19	0.06	44.4	13.9	41	4.08	9.3	10.6	0.09	2.4
81391	C039CR	SANDSTONE	58400	67600	2.43	17900	3400	2330	0.49	360	0.01	0.07	9.6	10	320	1.17	0.87	0.05	48.5	10.1	40	4.56	16	13.15	0.11	2.7
81392	C039CR	CARB MUDSTONE	58000	2100	0.67	4200	500	14	0.07	250	0.02	17.55	4.2	10	190	2.45	0.73	0.23	17	2.7	14	1.92	54.2	26.5	0.08	6.1
81393	C039CR	CARB MUDSTONE	67800	1200	1.17	17900	1700	75	0.07	160	0.02	46.3	3.7	20	360	3.26	0.61	0.33	42.9	9.3	39	9.35	38.6	25.3	0.10	3.6
81394	C040C	CLAY	34800	119000	1.98	4600	3000	506	0.26	140	10.35	0.03	0.1	20	160	0.66	0.14	0.01	27.8	10.8	36	2.32	16	9.35	0.07	2
81395	C040C	CLAY	70000	17900	4.43	10800	7200	644	0.51	290	0.24	0.15	5.8	50	450	1.4	0.29	0.07	57.3	17.8	110	4.88	30.7	19.65	0.14	4
81396	C040C	CLAY	33800	130000	2.12	5300	3100	383	0.23	110	11	0.02	0.1	20	90	0.65	0.12	0.02	23.3	8.6	38	2.03	15.3	9.65	0.03	1.6
81397	C040CR	CLAYSTONE	76200	2000	1.78	1400	1700	58	0.27	70	0.03	0.06	2.5	40	390	1.27	0.46	0.01	8.83	5.6	69	2.1	82.2	38.5	0.14	3.6
81398	C040CR	CLAYSTONE	97000	1000	0.77	6300	600	21	0.21	300	0.88	0.09	3.3	20	600	1.33	0.77	0.01	68.3	1.7	43	6.3	38.9	35	0.06	4.4
81399	C041C	CLAYSTONE	92200	2500	0.37	5700	900	61	0.06	220	0.01	0.03	2.4	20	250	1.51	0.59	<0.02	72.8	1.1	55	4.84	21.2	25.9	0.11	5.6
81400	C041C	CARB MUDSTONE	63500	900	0.34	7200	1000	17	0.06	140	0.09	17.5	7.2	5	220	6.13	0.59	0.56	69.9	15	39	6.32	85.9	22.1	0.11	3.3
81401	C041C	MUDSTONE	86200	300	0.38	9900	1100	24	0.05	90	0.01	10.2	2	20	240	2.42	0.66	0.58	47.5	6.3	44	9.24	33.7	26.9	0.08	3.5
81402	C041C	MUDSTONE	86600	500	0.58	9800	1100	32	0.05	140	0.03	14.9	4.4	20	210	4.8	0.86	0.36	80.7	5.4	38	10.85	48.6	29.1	0.13	3.7
81403	C041C	MUDSTONE	61200	4500	3.35	13700	2200	76	0.12	160	0.07	125	4.7	20	260	2.21	0.72	0.17	45.9	5	21	16.05	29.8	21.8	0.12	3.6

Minor Element Concentrations (continued)

	Site no.	Analyte	In	La	Li	Mo	Nb	Ni	Pb	Rb	Re	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y	Zn	Zr	Hg
		Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Mean Sediment		Comparative Abundance	0.044	41	56	2	13	52.0	19	135	0.000	1.2	10	0.42	4.6	320	1.5	0.005	9.6	0.38	0.95	3.1	105	1.7	40	95	150	0.19
Sample ID		Lithology code/LOR >>	0.005	0.5	0.2	0.05	0.1	0.2	0.5	0.1	0.002	0.05	0.1	1	0.2	0.2	0.05	0.05	0.2	0.005	0.02	0.1	1	0.1	0.1	2	0.5	0.005
81351	C001C	SANDSTONE	0.021	14.4	11.2	0.88	3.7	8.1	9.4	24.9	0.001	0.47	4.7	1	1.8	34.2	0.34	0.025	5.1	0.111	0.18	1.1	23	7.5	16.6	17	57.3	0.016
81352	C001C	CLAY	0.078	29.4	25.5	0.87	11.6	17	20.9	76.9	0.001	0.56	15.9	2	3.2	37.5	0.99	0.025	12	0.477	0.4	3.2	90	2.7	29.3	59	176	0.008
81353	C001C	SILTSTONE	0.082	24.7	26.5	0.29	11.8	17.5	25.5	116.5	0.001	0.72	20.4	2	3.7	50.7	1.01	0.025	13	0.537	0.58	3.2	115	3.1	24.1	86	172.5	0.02
81354	C001C	SANDSTONE	0.048	23.7	18.4	0.41	12.2	7.1	23	121	0.001	0.34	7.5	1	2.8	42.7	1.02	0.025	10.7	0.247	0.69	2.5	32	1.8	12.3	71	93.2	0.048
81355	C001C	CARB MUDSTONE	0.08	23.6	27.1	0.8	12.7	4.4	36.9	28.5	0.002	0.55	9.2	1	4.6	18.9	1.12	0.05	16.1	0.316	0.24	3.8	38	2.7	14.8	47	137.5	0.196
81356	C0021C	CLAY	0.085	23.8	25.3	0.74	15.4	48.5	25.1	74	0.001	0.78	18.1	2	3.3	119.5	1.23	0.05	11.2	0.604	0.55	2.5	107	2.3	19.4	67	154.5	0.007
81357	C0021C	CLAYSTONE	0.085	8.4	31.5	2.48	12	3.2	25.5	4	0.001	0.68	24.7	2	4.6	43.1	1.01	0.2	10.4	0.533	0.04	2.8	85	3	18.1	13	236	0.01
81358	C0021C	CLAYSTONE	0.128	41.2	22.7	2.72	13.6	4	32.9	4.2	0.002	1.42	23.4	3	4.3	38	1.26	0.15	17.4	0.603	0.04	5.9	124	2.4	60.6	9	315	0.045
81359	C0021C	SANDSTONE	0.056	19.8	14.4	0.41	6.9	4	14.5	13.6	0.001	0.58	11.1	1	2	46.4	0.57	0.025	9.4	0.381	0.17	2.2	73	1.6	8.8	26	133.5	0.019
81360	C024C	CLAY	0.057	18.3	24.7	0.56	9.5	17.7	19.4	46.5	0.001	0.78	11.4	1	2.5	26.7	0.82	0.025	12.4	0.356	0.31	1.8	69	3.1	11.2	17	93.8	0.007
81361	C024C	CLAY	0.027	12.4	13.7	1.3	6.6	4.9	8.8	11	0.001	0.69	7.5	1	1.9	47.4	0.49	0.06	5.5	0.293	0.08	1	50	1.8	9.7	8	126.5	0.003
81362	C024C	CLAYSTONE	0.064	280	13.2	0.95	8	4.9	62.8	5.3	0.003	0.45	12.9	5	2.2	2590	0.67	0.07	13.2	0.368	0.06	6.5	84	2.1	46.1	10	222	0.012
81363	C024C	SANDSTONE	0.026	18	10.5	0.7	4.9	2.9	12.9	17.5	0.001	0.63	5.6	1	1.7	19	0.47	0.025	7.4	0.186	0.11	2.1	37	1.3	11.9	4	80.2	0.003
81364	C024C	SANDSTONE	0.064	21.2	25.4	2.49	6.9	8.5	16.3	59.6	0.003	0.82	16.7	2	1.9	118	0.54	0.025	7.9	0.456	1.09	2.3	83	2.4	25.6	82	130.5	0.044
81365	C031C	CLAY	0.065	14.9	9.4	0.39	9.5	16	19.9	32.4	0.001	0.96	12.4	2	2.7	359	0.79	0.06	8.3	0.477	0.23	2.4	119	2	9.7	28	137.5	0.003
81366	C031C	SANDSTONE	0.055	15.7	8.4	0.49	5.4	39	12	67.4	0.001	0.4	12.2	1	1.4	172.5	0.43	0.025	4.6	0.431	0.74	1.4	103	0.9	11.2	215	89.3	0.023
81367	C031C	SILTSTONE	0.07	17.5	29	0.59	8.7	29.1	19.7	96.1	0.002	0.47	13.6	2	2.7	106	0.74	0.06	7.5	0.487	0.59	2.7	105	1.8	17	139	139.5	0.054
81368	C031C	SANDSTONE	0.054	22.2	13.7	0.66	6.7	23	14.8	103.5	0.002	0.5	16.4	1	1.9	136	0.53	0.025	7.9	0.371	0.52	2.1	107	1.3	21.2	75	114	0.036
81369	C031C	SILTSTONE	0.073	22.1	28.4	0.99	8.3	16.4	23.2	113.5	0.001	0.51	15.9	2	2.9	112	0.72	0.09	9.9	0.391	0.57	2.7	99	1.9	19.6	72	132.5	0.07
81370	C031C	COAL	0.046	13.2	8.7	1.03	3.2	8.4	9.4	12.5	0.003	0.36	7.9	1	1.1	226	0.26	0.12	4.1	0.139	0.51	1	28	0.6	16.5	41	80.2	0.083
81371	C031C	SILTSTONE	0.053	24.5	17	1.64	7.1	11.3	17.5	71	0.001	0.58	11.8	1	2.3	183	0.59	0.025	9.3	0.29	0.41	2.4	54	1.8	26	57	126	0.039
81372	C031C	SILTSTONE	0.038	17.9	15.7	1.06	3.1	0.9	9.8	25.9	0.001	0.11	5.2	1	0.9	214	0.25	0.05	2.8	0.32	0.47	1.1	42	0.7	27.2	26	55.4	0.046
81373	C031C	SILTSTONE	0.17	13.8	50.6	0.78	15.3	42.1	30.7	8.3	0.001	0.57	19.1	3	4.4	20.6	1.04	0.22	9.1	0.946	0.58	4.5	192	2.6	24.6	146	314	0.159
81374	C034C	CLAY	0.069	19.5	25.1	1.01	13	89.6	10.1	59.2	0.001	0.4	19.2	1	2.1	160.5	0.9	0.025	7.5	0.521	0.31	2.8	92	1.1	18.7	75	126.5	0.005
81375	C034C	CLAY	0.091	17.9	24.8	0.96	16.7	64.9	18.2	41.9	0.001	0.63	20.4	2	3.3	118	1.27	0.025	12.1	0.6	0.38	3.4	106	2	20.1	79	149	0.003
81376	C034C	CLAY	0.078	14.7	21.9	0.9	14.6	61.1	18.2	61.5	0.001	0.73	17.3	1	3.1	113.5	1.18	0.025	10.1	0.503	0.64	2.9	81	2.1	17.7	102	130	0.003
81377	C034C	CLAYSTONE	0.09	1.9	33	0.61	13	3.2	5.6	2.2	0.001	0.52	13.7	1	4	16.4	1.07	0.7	8.2	0.415	0.02	3.1	81	2.6	12.2	3	239	0.032
81378	C034C	SANDSTONE	0.1	43.5	31.5	0.68	15.8	10.2	42.7	80	0.001	0.64	14.5	2	4.4	25.6	1.4	0.06	19.8	0.39	0.46	6.3	81	3.6	27.3	105	143.5	0.058
81379	C036C	SILTSTONE	0.076	12.8	49.3	0.29	9.8	36.4	22.8	68.4	0.001	0.8	14	1	3	92.7	0.83	0.07	7	0.432	0.62	2.5	105	2	14.2	67	133	0.029
81380	C036C	SANDSTONE	0.061	26.7	14.5	0.56	9.2	50.7	15.2	53.5	0.001	0.78	16.2	2	2.1	92	0.68	0.025	9.9	0.664	0.29	2.3	166	1.4	21.5	127	113.5	0.058
81381	C036C	CARB MUDSTONE	0.082	9.6	13	3.97	6.7	68.9	25.7	30.5	0.004	1.19	9.1	2	2.5	443	0.59	0.21	6.4	0.288	0.92	2.7	82	1.4	13.1	59	167	0.083
81382	C036C	COAL	0.043	3.3	8.8	3.41	7.5	11.6	10.8	2.8	0.003	5.05	4.7	0.5	1.1	78	0.24	0.18	1.9	0.1	1.2	1.3	35	0.7	12.1	26	183.5	0.088
81383	C036C	SANDSTONE	0.077	27.1	24.6	0.54	10.1	15.8	22.2	134.5	0.001	0.58	15.6	2	3.2	75.2	0.88	0.025	11.7	0.428	0.72	3.3	91	2.1	23.9	86	151	0.019
81384	C036C	SANDSTONE	0.045	17.6	19.9	0.67	10.7	7.6	24.9	74.3	0.001	0.39	6.2	1	2.7	45.9	0.95	0.025	10	0.227	0.52	2.9	30	1.9	8	89	89.8	0.035
81386	C036C	SANDSTONE	0.034	15.7	14.6	0.5	8.5	6.7	19.6	81.2	0.001	0.35	4.7	0.5	2.2	41.7	0.77	0.025	7.7	0.174	0.52	1.9	24	1.5	6.7	42	69.2	0.011
81387	C039C	SANDSTONE	0.037	32.5	13.6	0.25	9.6	3.8	23.1	36.5	0.001	1.14	9.4	1	3.1	45.2	0.87	0.025	13.8	0.352	0.23	2.1	32	2.4	12.7	9	111.5	0.007
81388	C039C	SANDSTONE	0.053	32.7	14.3	0.17	7.7	23.4	17	149.5	0.001	0.64	13.7	2	2.1	131	0.68	0.06	11.6	0.368	0.73	2.8	72	1.5	43.6	84	97.8	0.01
81389	C039C	SANDSTONE	0.074	33.7	49.3	0.2	11	22.9	29.4	143.5	0.001	1	15.3	2	3.6	90.4	0.97	0.025	14.5	0.395	0.82	2.6	62	2	29.1	57	144.5	0.029
81390	C039CR	SANDSTONE	0.038	21.8	14.4	0.51	4.8	13	13.7	88.2	0.001	0.57	7.3	1	1.9	49.8	0.48	0.025	8.6	0.152	0.56	1.9	46	1.3	17.5	33	75.9	0.017
81391	C039CR	SANDSTONE	0.044	25.3	16.3	0.58	6.4	15.4	14.8	102.5	0.001	0.5	11.6	1	2	157.5	0.55	0.025	8.4	0.273	0.54	2	60	1.4	24.6	54	93.7	0.016
81392	C039CR	CARB MUDSTONE	0.137	7.8	35.5	1.62	11.4	6	33.3	16.9	0.002	0.76	8.7	2	4.3	39.4	0.87	0.3	5.6	0.695	0.43	3.7	151	3.1	10.3	71	205	0.139
81393	C039CR	CARB MUDSTONE	0.097	18.8	50.6	0.41	15.5	23.8	39.1	91.8	0.002	0.67	10.7	2	5	31.4	1.39	0.12	11.6	0.374	0.88	6	68	2.9	14.9	103	109.5	0.093
81394	C040C	CLAY	0.031	17	9.9	0.64	10.2	26.6	7.5	37.4	0.001	0.31	8.8	1	1.2	170	0.72	0.025	5.8	0.388	0.2	1.5	40	1.1	16.8	26	76.9	0.008
81395	C040C	CLAY	0.067	33.5	20.9	0.55	20.8	52.9	17.1	77.3	0.001	0.63	18.1	2	2.5	1330	1.55	0.025	12	0.833	0.41	2.9	91	2.1	32	59	155	0.003
81396	C040C	CLAY	0.031	11.6	10.8	0.38	8.2	30	6	35.2	0.001	0.3	8.7	1	1.1	222	0.57	0.025	4.6	0.297	0.17	1.4	41	1.2	9.6	24	64.6	0.003
81397	C040CR	CLAYSTONE	0.074	5.4	18.1	1.28	17	28.1	11	12.5	0.001	0.88	13.6	1	4.6	51.4	1.42	0.025	7.6	0.575	0.14	2.2	64	2.6	7.4	40	132	0.012
81398	C040CR	CLAYSTONE	0.091	39.3	28	0.68	19.6	8.4	41	33.5	0.001	1.74	20.1	2	5.6	225	1.86	0.025	12.8	0.653	0.31	6.1	88	5.3	14.5	11	151.5	0.203
81399	C041C	CLAYSTONE	0.124	31.6	13.2	0.46	13.2	3.2	21	44.2	0.001	0.8	22.9	2	4.4	57.1	1.2	0.025	14.6	0.566	0.28	5	103	3.5	35.4	7	187.5	0.01
81400	C041C	CARB MUDSTONE	0.094	29.5	23.3	0.68	13.9	35.9	41	53.3	0.006	0.63	12.1	2	4.6	34.8	1.26	0.13	13.6	0.371	0.58	8.1	81	2.9	39.9	269	99.6	0.251
81401	C041C	MUDSTONE	0.103	23.4	28.2	0.48	18.4	22.1	44.2	74.4	0.002	0.67	11.5	1	5.5	22	1.77	0.13	19.8	0.422	0.57	5.7	59	3.3	15	222	104.5	0.095
81402	C041C	MUDSTONE	0.116	34.2	39.1	0.39	16.7	23	45.7	77.8	0.002	1.23	15.6	2	5.7	22.6	1.56	0.33	17.8	0.421	0.85	6.2	79	3.6	29.9	93	110	0.131
81403	C041C	MUDSTONE	0.092	22.5	17	0.39	9.5	5.9	24.1	84.4	<0.002	0.73	10.3	1	2.8	96.6	0.79	0.16	8.4	0.355	0.77	4.2	84	2.3	15.5	73	120	0.158

Major Element Concentrations **Minor Element Concentrations**

	Site no.	Analyte	Al	Ca	Fe	K	Mg	Mn	Na	P	S	Ag	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr	Cs	Cu	Ga	Ge	Hf
		Units	ppm	ppm	%	ppm	ppm	ppm	%	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Mean Sediment		Comparative Abundance	72000	66000	4.1	20000	14000	770	0.57	670	0.22	0.057	7.7	100	460	2	0.4	0.17	83	14	72	72	33	18	1.7	2.5
Sample ID		Lithology code/LOR >>	0.01	0.01	0.01		0.01	5	0.01	10	0.01	0.01	0.02	10	10	0.05	0.01	0.02	0.01	0.1	1	0.05	0.2	0.05	0.05	0.1
81404	C041C	SANDSTONE	58800	35900	3.07	20600	2000	927	0.21	340	0.05	0.07	8.3	10	370	1.32	0.22	0.12	27.7	5	20	4.03	13.2	16.8	0.11	3
81405	C042C	SANDSTONE	57600	1000	0.66	7200	1200	31	0.16	60	0.2	0.16	5.2	10	180	1.03	0.22	0.03	34.3	11	32	3.82	22.9	14.55	<0.05	3.1
81406	C042C	CARB MUDSTONE	89200	600	0.22	1500	400	13	0.09	90	0.03	29.1	1.4	10	60	2.51	0.86	0.13	47.5	1.1	13	2.65	12.3	24.4	0.07	6
81407	C042C	SANDSTONE	47600	500	0.69	8100	1000	47	0.06	90	0.03	0.01	2.2	20	190	1.31	0.16	<0.02	72.2	4.5	23	4.01	5.5	11.75	0.07	3.2
81408	C044C	CARB MUDSTONE	74500	700	0.36	1700	300	11	0.11	240	0.02	26.7	4.3	20	120	2.78	1.02	0.09	21.1	4.5	30	2.57	51.3	32.4	0.07	6.1
81409	C044C	SANDSTONE	77200	93700	2.82	13800	4600	1160	0.54	990	0.05	0.05	22.3	10	710	1.39	0.11	0.06	37.8	11.4	26	3.45	21.3	18.45	0.11	2.2
81410	C046C	SANDSTONE	74800	4100	3.21	14700	3900	465	0.55	480	0.02	0.12	20.8	20	300	1.75	0.29	0.17	56.5	19.9	49	5.03	27.2	19.3	0.12	3.3
81411	C046C	SILTSTONE	77900	4000	3.97	15800	4900	366	0.35	640	0.01	0.12	1.8	30	290	2.13	0.45	0.05	43.9	14.5	52	8.14	46	23	0.10	3.9
81413	C046C	SANDSTONE	67400	104000	2.76	13900	8000	1480	0.93	760	0.04	0.05	7	5	310	1.29	0.1	0.05	37.5	14.5	26	3.49	16.5	16.2	0.08	2.1
81414	C046C	SILTSTONE	80000	5100	3.38	23200	7500	582	0.61	610	0.03	0.1	6.1	20	390	1.88	0.47	0.16	45.1	12.5	38	10.2	52.6	22.5	0.11	3.7
81415	C046C	CARB MUDSTONE	45000	2700	1.01	11100	1600	100	0.07	50	0.04	4.3	1.4	20	210	2.11	0.49	0.12	21.5	4.5	20	13.05	28.5	16	0.05	2.6
81416	C046C	SILTSTONE	73000	5900	4.03	8200	2500	107	0.07	110	0.02	0.09	5	10	160	2.38	0.47	0.08	69.7	12.3	22	10.6	14.2	17.85	0.12	4.4
81417	C048C	SILTSTONE	77100	5900	5.23	14500	7400	1310	0.24	1280	0.01	0.12	2.9	20	310	2.23	0.45	0.07	36.6	20.4	55	6.68	52	23.7	0.14	3.7
81418	C048C	SILTSTONE	79600	4900	3.19	13500	5300	424	0.33	650	0.03	0.12	4.9	10	310	1.94	0.46	0.17	38.9	15.4	45	7.49	51.7	23.7	0.09	3.8
81419	C048C	SANDSTONE	64500	7900	2.41	9800	3300	510	0.49	550	0.01	0.05	9.5	5	210	0.92	0.21	0.06	38.2	12.6	48	2.82	18.1	17.35	0.07	2.8
81420	C048C	CARB MUDSTONE	60200	3000	1.14	15800	2800	57	0.44	90	0.07	21.4	4.3	10	370	1.84	0.44	0.17	17.4	12.4	28	10.4	77.3	22.9	0.06	2.9
81421	C048C	SANDSTONE	72200	9300	1.3	17200	6100	160	0.84	120	0.06	0.05	12.1	5	630	1.19	0.15	0.1	29.5	25.7	36	3.69	28.8	20.5	0.05	3
81423	C048C	SANDSTONE	76300	15400	2.28	16300	9700	276	1.07	670	0.03	0.04	5.8	5	540	1.5	0.14	0.07	42.1	16.1	49	4.49	25	19.25	0.08	2.7
81424	C048C	SANDSTONE	62600	118500	1.43	13300	5000	1400	1.43	590	0.02	0.04	5	5	380	1.29	0.08	0.05	36	14.3	29	2.78	16.6	15.6	0.08	2
81425	C048C	SANDSTONE	70100	10000	3.32	16300	11200	194	1.12	720	0.03	0.05	7	5	590	1.35	0.13	0.07	33	21.4	42	3.25	22.6	19.8	0.10	2.6
81426	C048C	SANDSTONE	64500	14500	2.94	18700	8200	325	1.09	710	0.03	0.05	6.8	5	630	1.31	0.11	0.08	30.4	18.6	44	2.86	21.7	17.6	0.10	2.5
81427	C048C	SANDSTONE	73600	17500	2.7	19100	7500	221	1.09	680	0.04	0.05	6.2	5	690	1.34	0.11	0.07	42.9	14.6	39	3.29	20	17.45	0.10	2.6
81428	C048C	SANDSTONE	71500	9900	4.14	20500	8700	307	1.04	710	0.03	0.05	5.3	5	590	1.44	0.11	0.04	42.9	16.3	31	3.38	27.3	16.85	0.13	2.6
81430	C048C	SANDSTONE	72600	18400	2.76	21000	8300	726	1.01	730	0.03	0.05	5.1	10	470	1.16	0.11	0.06	41	14.6	33	3.36	18.5	16.8	0.10	2.5
81431	C048C	SANDSTONE	75000	15600	2.51	18600	9200	679	0.92	750	0.02	0.05	5.2	10	410	1.1	0.1	0.06	41.2	13.6	37	3.19	19.9	17.9	0.10	2.5
81432	C048C	CARB MUDSTONE	57500	9100	1.7	5800	7400	64	0.53	440	0.04	10.35	5.9	10	280	1.49	0.25	0.14	27.6	23.2	13	2.73	19	21.4	0.09	4.2
81433	C048C	INTERBEDDED SA	67100	2900	2.94	20800	4300	428	0.45	410	0.02	0.06	8.7	20	420	1.77	0.31	0.12	40.4	8.3	56	6.29	29.8	18.9	0.10	4.1
81434	C048C	SILTSTONE	93600	1500	2.02	23000	3900	114	0.28	180	0.02	0.1	4.2	20	520	3.48	0.64	0.2	76.6	6.8	38	9.52	39.7	27.1	0.12	5.1
81435	C048C	SANDSTONE	51300	800	0.96	18500	1400	110	0.08	190	0.01	0.03	6.4	10	490	0.94	0.16	0.04	34.5	7.5	31	3.06	6.4	11.25	0.05	2.1
81436	C048C	SANDSTONE	43100	43100	0.53	17700	900	218	0.08	90	0.01	0.03	4	10	480	0.69	0.08	0.02	25.7	4.1	15	2.02	3.3	8.29	0.11	1.5
81437	C048C	SANDSTONE	53700	800	1.25	17500	1500	380	0.07	190	0.01	0.04	5.2	10	460	1.09	0.16	0.04	43.3	13.3	23	3.45	7.6	13.15	0.07	2.6
81438	C048C	INTERBEDDED CA	81400	17200	2.67	4700	5000	198	0.13	640	0.1	0.08	7.4	10	310	1.73	0.35	0.11	50.9	6.6	4	2.49	37.8	22.4	0.11	6.1
81439	C048C	INTERBEDDED CA	70500	13700	2.05	4700	3500	110	0.13	450	0.06	0.12	8.3	10	280	1.59	0.46	0.11	51	5.2	4	1.86	20.7	23.6	0.13	7.1
81440	C048C	CARB MUDSTONE	70300	1000	1.2	17900	2400	55	0.08	100	0.02	5.45	3	30	400	3.46	0.69	0.18	58.6	4.4	45	14.85	29.9	28.5	0.09	3.5
81441	C048C	SANDSTONE	40600	500	0.62	13600	900	46	0.05	120	0.01	0.02	8.2	10	330	0.97	0.09	0.03	30.8	5.6	23	2.49	4.7	11.9	0.07	2
81443	C048C	SANDSTONE	43500	400	0.67	12900	900	120	0.05	90	0.01	0.05	5.2	10	310	1.1	0.11	0.02	64.8	14.2	25	2.35	5.2	12.95	0.11	2.3
81444	C048C	SANDSTONE	39900	3100	0.45	12500	600	71	0.05	70	0.01	0.02	3.7	10	280	0.76	0.07	<0.02	28.1	5.7	25	1.77	3.1	10.5	0.08	1.7
81445	C048C	CARB MUDSTONE	69100	1100	0.2	1700	200	13	0.03	100	0.02	23.8	1.9	10	60	2.53	0.92	0.28	37.8	2	23	2.7	21.3	27.9	0.06	6.8
81446	C048C	SILTSTONE	74900	8000	4.93	18800	2400	115	0.06	110	0.01	0.07	1.7	20	220	2.18	0.29	0.04	48.9	3.7	17	16.7	16.8	19.55	0.19	4.1
81447	C048C	SILTSTONE	78600	9700	2.74	20200	2400	109	0.08	280	0.01	0.08	4.2	20	250	2.66	0.48	0.13	119	5.9	19	10.95	22.3	22.2	0.28	5.4
81448	C048C	SILTSTONE	55700	9400	4.24	12100	3100	153	0.43	60	0.02	0.08	5.6	20	280	1.9	0.28	0.05	74.6	11.9	22	10.75	9.9	15.2	0.17	4.2
81449	C056C	CLAY	42400	200	2.01	2000	900	57	0.06	100	0.01	0.06	3.4	10	210	1.12	0.23	<0.02	36.8	2.9	46	3.38	13.2	12.15	0.11	2.6
81450	C056C	CLAYSTONE	83700	100	4.22	8000	900	32	0.05	350	0.01	0.05	5.8	20	240	1.76	0.57	<0.02	38.4	4.2	68	4.1	25.1	26.8	0.15	4.5
81451	C056C	SANDSTONE	32900	200	0.29	2700	400	26	0.02	140	0.01	0.27	0.9	10	270	0.71	0.2	<0.02	110.5	1	32	1.89	6.2	9.07	0.19	2.8
81452	C056C	CLAYSTONE	84700	4000	4.96	17400	7000	708	0.12	500	<0.01	0.15	23.4	20	390	2.35	0.59	<0.02	48.7	16.2	58	11.1	66.9	24.5	0.19	4.1
81453	C056C	CLAYSTONE	76700	5100	4.72	17400	8100	514	0.23	510	<0.01	0.12	7.2	30	360	1.9	0.37	<0.02	50.6	19.5	59	10.15	35.5	23.2	0.18	3.9
81454	C056C	SANDSTONE	83100	5900	1.28	16100	6400	85	0.69	450	0.06	0.04	6.9	10	1390	1.32	0.14	0.08	41	20.5	31	3.06	42	24.6	0.12	3.7
81455	C056C	CARB MUDSTONE	47200	2700	1.39	9200	1800	41	0.16	120	0.07	21.7	2.2	20	270	2.43	0.57	0.16	26.9	6.8	11	4.97	37.7	19.05	0.07	4

Minor Element Concentrations (continued)

	Site no.	Analyte	In	La	Li	Mo	Nb	Ni	Pb	Rb	Re	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y	Zn	Zr	Hg
		Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Mean Sediment		Comparative Abundance	0.044	41	56	2	13	52.0	19	135	0.000	1.2	10	0.42	4.6	320	1.5	0.005	9.6	0.38	0.95	3.1	105	1.7	40	95	150	0.19
Sample ID		Lithology code/LOR >>	0.005	0.5	0.2	0.05	0.1	0.2	0.5	0.1	0.002	0.05	0.1	1	0.2	0.2	0.05	0.05	0.2	0.005	0.02	0.1	1	0.1	0.1	2	0.5	0.005
81404	C041C	SANDSTONE	0.062	13	17.2	0.63	6.7	6.9	14.2	62.1	<0.002	0.58	11.1	1	1.8	81.2	0.52	0.05	5.4	0.436	0.55	2.4	77	2	20.3	87	109.5	0.023
81405	C042C	SANDSTONE	0.043	16.9	15.4	1.86	6.6	11.3	18.6	47.8	<0.002	0.62	8.1	1	1.9	87.5	0.62	0.025	9	0.206	0.79	2	43	2.2	15.3	27	94.5	0.069
81406	C042C	CARB MUDSTONE	0.128	20.4	25.1	0.98	16.5	3.1	47.2	12.7	<0.002	0.75	10.6	2	5.7	16.1	1.52	0.13	18.6	0.45	0.17	5.4	40	3.5	16.5	18	180	0.121
81407	C042C	SANDSTONE	0.029	38.3	11.8	0.23	7.6	3.3	11.8	60.4	<0.002	0.49	7.4	1	2.1	23.6	0.72	0.025	10	0.236	0.34	1.7	47	1.5	36.9	5	104	0.029
81408	C044C	CARB MUDSTONE	0.135	9.2	127	1.7	17.2	16.1	49.8	10.5	<0.002	1.05	8.4	1	7.7	51.8	1.73	0.19	10.2	0.623	0.21	5.9	98	5.2	8.9	27	184	0.122
81409	C044C	SANDSTONE	0.047	18.2	12	0.82	4.8	19.4	13.3	62.6	<0.002	0.38	14.3	1	1.3	402	0.37	0.025	5.1	0.362	0.41	1.3	104	0.8	22.4	82	78.1	0.045
81410	C046C	SANDSTONE	0.058	25.9	24	0.37	9	32.7	20.5	82.6	<0.002	1.29	14.7	1	2.4	78.3	0.77	0.025	11	0.414	0.49	2.7	100	1.7	19.7	82	117.5	0.016
81411	C046C	SILTSTONE	0.074	20.3	32.2	0.26	10.3	37.9	21.5	79.4	<0.002	0.75	15.7	1	2.9	126.5	0.89	0.06	8.7	0.492	0.59	2.5	117	2.2	18.7	81	136.5	0.014
81413	C046C	SANDSTONE	0.036	18.4	9	0.49	4.4	18.3	10.1	70.1	<0.002	0.32	12.7	1	1.1	486	0.35	0.025	5.6	0.278	0.35	1.3	85	0.7	19.5	64	74.6	0.021
81414	C046C	SILTSTONE	0.075	20.3	22.4	1.15	8.5	27.9	22	110.5	<0.002	0.59	15.5	1	2.8	297	0.73	0.08	9.1	0.406	0.69	2.7	107	1.9	19.2	87	126	0.056
81415	C046C	CARB MUDSTONE	0.064	11.1	21.3	1.05	6.5	11.3	18.2	66	<0.002	0.97	9.3	1	2.9	41.6	0.59	0.05	6.1	0.28	0.68	2.2	82	1.7	13.3	29	90.8	0.063
81416	C046C	SILTSTONE	0.054	34.9	26.9	0.25	12	14.2	22	81.7	<0.002	0.59	10.3	1	3	52.4	1.09	0.05	16.6	0.284	0.51	4.5	47	2.2	26.1	56	151	0.054
81417	C048C	SILTSTONE	0.077	16.7	39	0.25	9.4	47.4	23.2	51.1	<0.002	0.84	15.9	1	2.7	129.5	0.8	0.09	7.1	0.44	0.55	2.5	120	1.9	19.8	95	129	0.042
81418	C048C	SILTSTONE	0.078	16.8	39.1	0.3	9.2	31.6	24	61.8	<0.002	0.94	16.5	1	2.7	115.5	0.78	0.09	8	0.458	0.6	3.1	119	2	17.5	89	132.5	0.082
81419	C048C	SANDSTONE	0.058	17.6	18.5	1.86	7.5	21.1	16.1	46.9	<0.002	0.74	10.2	1	2	51.7	0.61	0.025	11.8	0.429	0.38	2.5	101	1.8	15.7	57	94.8	0.035
81420	C048C	CARB MUDSTONE	0.065	10.7	25.5	1.54	7.2	34.7	22.3	66.9	0.004	0.84	7	1	2.7	248	0.67	0.14	5	0.386	1.04	2.4	66	1.7	5.9	100	91.4	0.114
81421	C048C	SANDSTONE	0.065	14.3	11.8	1.77	6.8	31.7	14.4	61.3	<0.002	0.53	11.1	1	1.9	410	0.52	0.025	5.9	0.49	0.71	1.8	95	1.1	8.9	96	102.5	0.052
81423	C048C	SANDSTONE	0.055	19.8	14.6	0.75	5.7	25.2	12.5	76.7	<0.002	0.36	17	1	1.6	514	0.45	0.025	6.4	0.434	0.47	1.6	167	1	16.1	89	90.1	0.022
81424	C048C	SANDSTONE	0.04	17.2	10.2	0.58	4.6	18.9	9	65.9	<0.002	0.27	13	1	1.1	550	0.33	0.025	5.1	0.31	0.35	1.2	96	0.7	18.7	54	70.6	0.017
81425	C048C	SANDSTONE	0.051	15	16.4	1.03	5.5	29.1	13.1	56.5	<0.002	0.44	15.3	1	1.5	453	0.42	0.025	5.2	0.399	0.47	1.5	128	1	13.4	80	90.7	0.017
81426	C048C	SANDSTONE	0.045	13.7	15.1	0.91	5.7	23.1	12.9	58.5	<0.002	0.49	12.8	1	1.4	400	0.46	0.025	4.8	0.391	0.47	1.4	119	0.9	13.3	71	87.7	0.017
81427	C048C	SANDSTONE	0.043	20.1	15.7	0.56	5.1	19.3	13	85.7	<0.002	0.47	12.8	1	1.4	334	0.42	0.025	6.5	0.343	0.48	1.6	112	0.8	15.5	68	87.9	0.013
81428	C048C	SANDSTONE	0.041	20.4	18.7	0.59	5.1	20.2	12.1	93.2	<0.002	0.45	11.7	1	1.4	331	0.41	0.025	6.4	0.328	0.46	1.6	105	0.9	17	63	88.6	0.013
81430	C048C	SANDSTONE	0.043	19.4	9.4	0.5	5.1	18.6	14.1	96.1	<0.002	0.49	12.8	1	1.4	500	0.41	0.025	6.3	0.364	0.45	1.5	109	0.8	16	69	86.8	0.017
81431	C048C	SANDSTONE	0.048	19.2	9.2	0.57	5	18.6	11.7	87.7	<0.002	0.42	16.9	1	1.4	559	0.41	0.025	6	0.374	0.43	1.4	118	0.8	15.2	69	84.5	0.021
81432	C048C	CARB MUDSTONE	0.078	13.1	10.1	2.54	7	30.4	20.9	7.9	0.003	0.47	7.6	2	2.5	642	0.55	0.05	3.7	0.514	0.56	2.5	98	1.4	13.5	86	146	0.105
81433	C048C	INTERBEDDED SA	0.073	18.2	23	0.61	9.2	18.4	20.3	96.9	<0.002	0.59	13.6	1	3.2	116.5	0.83	0.025	8.8	0.424	0.65	2.9	102	2.2	19.5	78	137.5	0.02
81434	C048C	SILTSTONE	0.103	34.7	44.3	0.45	13.8	16	35	130.5	<0.002	0.58	16.8	2	4.6	91.3	1.22	0.07	16.4	0.456	0.84	5	94	2.8	28.7	116	170	0.047
81435	C048C	SANDSTONE	0.033	18.6	12.6	0.56	5.5	9.6	18.3	94.4	<0.002	0.43	6.2	1	1.8	48.3	0.52	0.025	7.7	0.16	0.59	1.7	35	1.1	13.4	35	65	0.011
81436	C048C	SANDSTONE	0.02	13.8	8.6	0.3	3.3	4.9	16.1	83.1	<0.002	0.31	3.6	1	1.1	187.5	0.33	0.025	5.1	0.077	0.5	1.1	19	0.7	14.3	19	46	0.008
81437	C048C	SANDSTONE	0.04	21.6	13.5	1.37	7.4	12.5	20	96.7	<0.002	0.46	6.7	1	2.2	45.2	0.65	0.025	9	0.222	0.64	2.1	39	1.5	15.4	37	81.8	0.01
81438	C048C	INTERBEDDED CA	0.086	22.3	12.3	3.93	8.3	4	24.1	12.4	0.002	0.71	13.3	2	2.6	214	0.71	0.07	8.6	0.456	0.58	3	70	2.7	26.3	77	207	0.147
81439	C048C	INTERBEDDED CA	0.084	21.7	13.4	2.49	9.5	2.8	30.6	12.2	0.002	0.59	10.1	2	3	179	0.9	0.05	10	0.335	0.39	3.9	43	1.9	22.2	71	225	0.146
81440	C048C	CARB MUDSTONE	0.094	28	49.8	0.49	19.3	15.1	40.4	105.5	<0.002	0.46	10.9	1	6.1	30.7	1.81	0.07	16.9	0.423	0.95	6.6	90	3.6	14.1	92	115	0.052
81441	C048C	SANDSTONE	0.029	16.5	13.2	1.3	6.9	9.5	19.7	82.1	<0.002	0.29	3.7	0.5	1.6	31.7	0.57	0.025	7.1	0.117	0.53	1.7	15	0.7	8.4	34	63.9	0.021
81443	C048C	SANDSTONE	0.034	32.6	14.6	0.99	9.2	8.6	19.5	76.9	<0.002	0.35	4.9	1	2.3	31.6	0.85	0.025	15.4	0.201	0.63	2.2	26	1.2	12.7	33	67.9	0.02
81444	C048C	SANDSTONE	0.022	14.9	11.4	1.19	5.2	5	17.5	72.8	<0.002	0.32	3.4	0.5	1.4	30.5	0.46	0.025	6	0.085	0.44	1.3	18	0.6	7.3	24	50.3	0.013
81445	C048C	CARB MUDSTONE	0.14	15.8	41.6	0.8	20.9	5.8	49.2	13	<0.002	0.66	10.3	2	6.5	15.2	1.95	0.2	14.4	0.542	0.17	6	62	3.6	15	20	233	0.069
81446	C048C	SILTSTONE	0.062	37.4	24.7	0.28	8.3	6.9	10.9	140	0.002	0.63	12.4	2	2.3	83.4	0.68	0.05	11.1	0.346	0.69	3.2	68	1.5	38.8	40	140	0.056
81447	C048C	SILTSTONE	0.07	70.8	25.5	0.34	10.9	8.9	22.7	122	0.002	0.68	13.3	2	3	89	0.92	0.05	16.5	0.336	0.71	4	59	1.6	56.2	87	174.5	0.031
81448	C048C	SILTSTONE	0.041	37.7	19.8	0.18	10.3	11.9	18.9	122	<0.002	0.94	6.9	1	2.4	85.1	0.85	0.025	14.1	0.229	0.61	3.1	35	1.5	27.2	42	140.5	0.025
81449	C056C	CLAY	0.039	18.6	17.5	0.85	8.6	13	14.5	31	<0.002	0.55	9.3	1	1.9	21.5	0.7	0.025	9.3	0.305	0.25	1.4	50	3.9	12.7	11	86.4	0.003
81450	C056C	CLAYSTONE	0.11	21.2	10.8	0.55	16.3	18.5	27.1	59	<0.002	1.44	17.8	1	4.7	63.3	1.47	0.025	16.2	0.465	0.36	3.7	125	3.6	10.6	33	144	0.003
81451	C056C	SANDSTONE	0.045	43.9	16.3	0.26	6.4	3.6	16.5	23.9	<0.002	0.62	13.5	1	1.4	56.7	0.56	0.025	10.7	0.221	0.16	1.7	23	3.4	10.6	10	88.1	0.013
81452	C056C	CLAYSTONE	0.077	22.5	54.1	0.23	10.5	44.5	22.9	106.5	<0.002	1.08	17.9	1	3	137.5	0.87	0.07	10.3	0.437	0.74	3.3	95	1.9	21.8	82	137.5	0.003
81453	C056C	CLAYSTONE	0.075	23.5	34.9	0.2	10.1	44.2	21.3	92.4	<0.002	1.06	16.1	1	2.9	163.5	0.82	0.06	9.3	0.436	0.67	2.5	95	1.9	22	98	133	0.006
81454	C056C	SANDSTONE	0.06	18.4	14.7	1.49	7.1	19.3	13.5	59.5	0.002	0.4	12.4	1	1.8	507	0.51	0.025	6	0.586	0.7	1.9	139	0.8	9.8	87	128	0.048
81455	C056C	CARB MUDSTONE	0.088	12.2	25.1	0.79	7.6	10.2	28.3	40.9	<0.002	0.77	8.4	1	3.1	156.5	0.65	0.13	5.9	0.327	0.48	2.8	71	1.8	14.2	59	134	0.1

Major Element Global Abundance Indices **Minor Element Global Abundance Indices**

	Site no.	Analyte	Al	Ca	Fe	K	Mg	Mn	Na	P	S	Ag	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr	Cs	Cu	Ga	Ge
		Units	ppm	ppm	%	ppm	ppm	ppm	%	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Mean Sediment		Comparative Abundance	72000	66000	4.1	20000	14000	770	0.57	670	0.2	0.057	7.7	100	460	2	0.4	0.17	83	14	72	72	33	18	1.7
Sample ID		Lithology code/LOR >>	0.01	0.01	0.01	0	0.01	5	0.01	10	0	0.05	0.1	10	0.2	0.5	0.1	0.002	0.05	0.1	1	0.2	0.2	0.05	0.05
81351	C001C	SANDSTONE																							
81352	C001C	CLAY																							
81353	C001C	SILTSTONE																							
81354	C001C	SANDSTONE																							
81355	C001C	CARB MUDSTONE										5													
81356	C0021C	CLAY																							
81357	C0021C	CLAYSTONE																							
81358	C0021C	CLAYSTONE																							
81359	C0021C	SANDSTONE																							
81360	C024C	CLAY																							
81361	C024C	CLAY																							
81362	C024C	CLAYSTONE								2					1				2						
81363	C024C	SANDSTONE																							
81364	C024C	SANDSTONE																							
81365	C031C	CLAY																							
81366	C031C	SANDSTONE																							
81367	C031C	SILTSTONE																							
81368	C031C	SANDSTONE																							
81369	C031C	SILTSTONE																							
81370	C031C	COAL										7													
81371	C031C	SILTSTONE																							
81372	C031C	SILTSTONE			1			2		1													1		
81373	C031C	SILTSTONE										1											1		
81374	C034C	CLAY																		1					
81375	C034C	CLAY																							
81376	C034C	CLAY																							
81377	C034C	CLAYSTONE																							
81378	C034C	SANDSTONE																							
81379	C036C	SILTSTONE																							
81380	C036C	SANDSTONE											2												
81381	C036C	CARB MUDSTONE										7								1					
81382	C036C	COAL										4				1									1
81383	C036C	SANDSTONE																							
81384	C036C	SANDSTONE																							
81386	C036C	SANDSTONE																							
81387	C039C	SANDSTONE																							
81388	C039C	SANDSTONE																							
81389	C039C	SANDSTONE																							
81390	C039CR	SANDSTONE																							
81391	C039CR	SANDSTONE						1																	
81392	C039CR	CARB MUDSTONE										7													
81393	C039CR	CARB MUDSTONE										9													
81394	C040C	CLAY									4														
81395	C040C	CLAY																							
81396	C040C	CLAY									5														
81397	C040CR	CLAYSTONE																							
81398	C040CR	CLAYSTONE									1														
81399	C041C	CLAYSTONE																							
81400	C041C	CARB MUDSTONE										7				1		1							
81401	C041C	MUDSTONE										6						1							
81402	C041C	MUDSTONE										7													
81403	C041C	MUDSTONE										10													

Minor Element Global Abundance Indices (continued)

	Site no.	Analyte	Hf	In	La	Li	Mo	Nb	Ni	Pb	Rb	Re	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y	Zn	Zr	Hg
		Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Mean Sediment		Comparative Abundance	2.5	0.044	41	56	2	13	52	19	135	0.0004	1.2	10	0.42	4.6	320	1.5	0.005	9.6	0.38	0.95	3.1	105	1.7	40	95	150	0.19
Sample ID		Lithology code/LOR >>	0.2	0.005	0.02	0.1	0.05	0.1	0.2	0.5	0.1	0.002	0.05	0.1	1	0.2	0.2	0.05	0.05	0.2	0.005	0.02	0.1	1	0.1	0.1	2	0.5	0.01
81351	C001C	SANDSTONE																	1						1				
81352	C001C	CLAY													1				1										
81353	C001C	SILTSTONE													1				1										
81354	C001C	SANDSTONE																	1										
81355	C001C	CARB MUDSTONE										1							2										
81356	C0021C	CLAY													1				2										
81357	C0021C	CLAYSTONE													1				4										
81358	C0021C	CLAYSTONE	1									1			2				4										
81359	C0021C	SANDSTONE																	1										
81360	C024C	CLAY																	1										
81361	C024C	CLAY																	3										
81362	C024C	CLAYSTONE			2					1		2			2		2		3										
81363	C024C	SANDSTONE																	1										
81364	C024C	SANDSTONE										2			1				1										
81365	C031C	CLAY													1				3										
81366	C031C	SANDSTONE																	1										
81367	C031C	SILTSTONE										1			1				3										
81368	C031C	SANDSTONE										1							1										
81369	C031C	SILTSTONE													1				3										
81370	C031C	COAL										2							4										
81371	C031C	SILTSTONE																	1										
81372	C031C	SILTSTONE																	2										
81373	C031C	SILTSTONE	1	1											2				4										
81374	C034C	CLAY																	1										
81375	C034C	CLAY													1				1										
81376	C034C	CLAY																	1										
81377	C034C	CLAYSTONE																	6										
81378	C034C	SANDSTONE													1				3										
81379	C036C	SILTSTONE																	3										
81380	C036C	SANDSTONE													1				1										
81381	C036C	CARB MUDSTONE										2			1				4										
81382	C036C	COAL										2	1						4										
81383	C036C	SANDSTONE													1				1										
81384	C036C	SANDSTONE																	1										
81386	C036C	SANDSTONE																	1										
81387	C039C	SANDSTONE																	1										
81388	C039C	SANDSTONE													1				3										
81389	C039C	SANDSTONE													1				1										
81390	C039CR	SANDSTONE																	1										
81391	C039CR	SANDSTONE																	1										
81392	C039CR	CARB MUDSTONE		1								1			1				5										
81393	C039CR	CARB MUDSTONE										1			1				4										
81394	C040C	CLAY																	1										
81395	C040C	CLAY													1		1		1										
81396	C040C	CLAY																	1										
81397	C040CR	CLAYSTONE																	1										
81398	C040CR	CLAYSTONE													1				1						1				
81399	C041C	CLAYSTONE													1				1										
81400	C041C	CARB MUDSTONE										3			1				4										
81401	C041C	MUDSTONE										1							4										
81402	C041C	MUDSTONE										1			1				5										
81403	C041C	MUDSTONE																	4										

Major Element Global Abundance Indices **Minor Element Global Abundance Indices**

	Site no.	Analyte	Al	Ca	Fe	K	Mg	Mn	Na	P	S	Ag	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr	Cs	Cu	Ga	Ge
		Units	ppm	ppm	%	ppm	ppm	ppm	%	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Mean Sediment		Comparative Abundance	72000	66000	4.1	20000	14000	770	0.57	670	0.2	0.057	7.7	100	460	2	0.4	0.17	83	14	72	72	33	18	1.7
Sample ID		Lithology code/LOR >>	0.01	0.01	0.01	0	0.01	5	0.01	10	0	0.05	0.1	10	0.2	0.5	0.1	0.002	0.05	0.1	1	0.2	0.2	0.05	0.05
81404	C041C	SANDSTONE																							
81405	C042C	SANDSTONE																							
81406	C042C	CARB MUDSTONE										8													
81407	C042C	SANDSTONE																							
81408	C044C	CARB MUDSTONE										8													
81409	C044C	SANDSTONE																							
81410	C046C	SANDSTONE																							
81411	C046C	SILTSTONE																							
81413	C046C	SANDSTONE																							
81414	C046C	SILTSTONE																							
81415	C046C	CARB MUDSTONE										5													
81416	C046C	SILTSTONE																							
81417	C048C	SILTSTONE																							
81418	C048C	SILTSTONE																							
81419	C048C	SANDSTONE																							
81420	C048C	CARB MUDSTONE										7													
81421	C048C	SANDSTONE																							
81423	C048C	SANDSTONE																							
81424	C048C	SANDSTONE																							
81425	C048C	SANDSTONE																							
81426	C048C	SANDSTONE																							
81427	C048C	SANDSTONE																							
81428	C048C	SANDSTONE																							
81430	C048C	SANDSTONE																							
81431	C048C	SANDSTONE																							
81432	C048C	CARB MUDSTONE										6													
81433	C048C	INTERBEDDED S																							
81434	C048C	SILTSTONE																							
81435	C048C	SANDSTONE																							
81436	C048C	SANDSTONE																							
81437	C048C	SANDSTONE																							
81438	C048C	INTERBEDDED C																							
81439	C048C	INTERBEDDED C																							
81440	C048C	CARB MUDSTONE										5													
81441	C048C	SANDSTONE																							
81443	C048C	SANDSTONE																							
81444	C048C	SANDSTONE																							
81445	C048C	CARB MUDSTONE										8													
81446	C048C	SILTSTONE																							
81447	C048C	SILTSTONE																							
81448	C048C	SILTSTONE																							
81449	C056C	CLAY																							
81450	C056C	CLAYSTONE																							
81451	C056C	SANDSTONE										1													
81452	C056C	CLAYSTONE											1												
81453	C056C	CLAYSTONE																							
81454	C056C	SANDSTONE													1										
81455	C056C	CARB MUDSTONE										7													

Minor Element Global Abundance Indices (continued)

	Site no.	Analyte	Hf	In	La	Li	Mo	Nb	Ni	Pb	Rb	Re	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y	Zn	Zr	Hg
		Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Mean Sediment		Comparative Abundance	2.5	0.044	41	56	2	13	52	19	135	0.0004	1.2	10	0.42	4.6	320	1.5	0.005	9.6	0.38	0.95	3.1	105	1.7	40	95	150	0.19
Sample ID		Lithology code/LOR >>	0.2	0.005	0.02	0.1	0.05	0.1	0.2	0.5	0.1	0.002	0.05	0.1	1	0.2	0.2	0.05	0.05	0.2	0.005	0.02	0.1	1	0.1	0.1	2	0.5	0.01
81404	C041C	SANDSTONE																	2										
81405	C042C	SANDSTONE																	1										
81406	C042C	CARB MUDSTONE													1				4										
81407	C042C	SANDSTONE																	1										
81408	C044C	CARB MUDSTONE		1															4						1				
81409	C044C	SANDSTONE																	1										
81410	C046C	SANDSTONE																	1										
81411	C046C	SILTSTONE																	3										
81413	C046C	SANDSTONE																	1										
81414	C046C	SILTSTONE																	3										
81415	C046C	CARB MUDSTONE																	2										
81416	C046C	SILTSTONE																	2										
81417	C048C	SILTSTONE																	3										
81418	C048C	SILTSTONE																	3										
81419	C048C	SANDSTONE																	1										
81420	C048C	CARB MUDSTONE										2							4										
81421	C048C	SANDSTONE																	1										
81423	C048C	SANDSTONE																	1										
81424	C048C	SANDSTONE																	1										
81425	C048C	SANDSTONE																	1										
81426	C048C	SANDSTONE																	1										
81427	C048C	SANDSTONE																	1										
81428	C048C	SANDSTONE																	1										
81430	C048C	SANDSTONE																	1										
81431	C048C	SANDSTONE																	1										
81432	C048C	CARB MUDSTONE										2			1				2										
81433	C048C	INTERBEDDED S																	1										
81434	C048C	SILTSTONE													1				3										
81435	C048C	SANDSTONE																	1										
81436	C048C	SANDSTONE																	1										
81437	C048C	SANDSTONE																	1										
81438	C048C	INTERBEDDED C										1			1				3										
81439	C048C	INTERBEDDED C										1			1				2										
81440	C048C	CARB MUDSTONE																	3										
81441	C048C	SANDSTONE																	1										
81443	C048C	SANDSTONE																	1										
81444	C048C	SANDSTONE																	1										
81445	C048C	CARB MUDSTONE		1											1				4										
81446	C048C	SILTSTONE										1			1				2										
81447	C048C	SILTSTONE										1			1				2										
81448	C048C	SILTSTONE																	1										
81449	C056C	CLAY																	1										
81450	C056C	CLAYSTONE																	1										
81451	C056C	SANDSTONE																	1										
81452	C056C	CLAYSTONE																	3										
81453	C056C	CLAYSTONE																	3										
81454	C056C	SANDSTONE										1							1										
81455	C056C	CARB MUDSTONE																	4										

Appendix E: Static leach results

		Analyte grouping/Analyte	pH Value	Electrical Conductivity @ 25°C	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity as CaCO3	Acidity as CaCO3	Sulfur as S	Sulfate as SO4 - Turbidimetric	Aluminium	Arsenic
		Units	pH Unit	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		LOR	0.01	1	1	1	1	1	1	1	1	0.01	0.001
Client sample ID (Primary):	Lithology												
81351	SANDSTONE		7.44	113	<1	<1	37	37	<1	2	4	1.72	0.006
81355	CARB MUDSTONE		6.51	103	<1	<1	11	11	4	<1	2	2.06	0.004
81356	CLAY		6.64	274	<1	<1	13	13	5	2	8	2.27	0.002
81370	COAL		7.48	176	<1	<1	53	53	5	8	22	0.23	0.002
81382	COAL		7.46	363	<1	<1	59	59		105	169	0.28	0.003
81388	SANDSTONE		6.41	26	<1	<1	7	7	5	<1	26	0.2	0.002
81394	CLAY		6.59	2120	<1	<1	10	10	5	343	995	0.02	0.001
81397	CLAYSTONE		6.54	240	<1	<1	11	11	5	5	15	1.4	0.002
81400	CARB MUDSTONE		6.21	82	<1	<1	6	6	5	7	20	0.55	0.023
81403	MUDSTONE		7.05	95	<1	<1	31	31	5	4	10	1.31	0.003
81406	CARB MUDSTONE		6.89	207	<1	<1	22	22	5	2	6	0.65	0.001
81417	SILTSTONE		7.41	104	<1	<1	46	46	5	2	5	1.8	0.003
81420	CARB MUDSTONE		6.82	57	<1	<1	11	11	5	3	7	0.59	0.007
81426	SANDSTONE		6.68	30	<1	<1	13	13	5	<1	2	0.74	0.009
81433	INTERBEDDED SANDSTONE AND SILTSTONE		7.36	97	<1	<1	43	43	5	1	4	1.16	0.014
81438	INTERBEDDED CARB MUDSTONE AND TUFF		6.62	48	<1	<1	9	9	5	7	6	0.99	0.011
81439	INTERBEDDED SANDSTONE AND SILTSTONE		6.4	20	<1	<1	7	7	5	2	2	1.14	0.003
81445	CARB MUDSTONE		6.81	70	<1	<1	16	16	5	3	8	1.46	0.001
81450	CLAYSTONE		6.35	36	<1	<1	7	7	5	<1	<1	0.06	<0.001
81455	CARB MUDSTONE		6.71	40	<1	<1	14	14	5	<1	<1	1.51	0.002

		Boron	Cadmium	Chlorine	Calcium	Iron	Magnesium	Sodium	Potassium	Aluminium	Dysprosium	Silver	Arsenic
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		0.05	0.0001	1	1	0.05	1	1	1	0.01	0.001	0.001	0.001
Client sample ID (Primary):	Lithology												
81351	SANDSTONE	0.92	<0.0001	5	2	0.75	<1	20	<1	1.72	<0.001	<0.001	0.006
81355	CARB MUDSTONE	0.79	0.0001	<1	1	0.5	<1	7	<1	2.06	<0.001	<0.001	0.004
81356	CLAY	1.54	0.0002	48	2	1.13	1	45	<1	2.27	<0.001	<0.001	0.002
81370	COAL	0.68	<0.0001	4	5	0.09	2	28	2	0.23	<0.001	<0.001	0.002
81382	COAL	3.96	0.0006	10	112	0.28	18	83	4	0.28	<0.001	<0.001	0.003
81388	SANDSTONE	0.8	<0.0001	<1	1	0.08	<1	5	<1	0.2	<0.001	<0.001	0.002
81394	CLAY	1	0.0004	101	269	0.06	41	186	2	0.02	<0.001	<0.001	0.001
81397	CLAYSTONE	0.96	<0.0001	43	2	0.32	<1	38	<1	1.4	<0.001	<0.001	0.002
81400	CARB MUDSTONE	0.8	<0.0001	2	2	<0.05	1	13	<1	0.55	<0.001	<0.001	0.023
81403	MUDSTONE	0.85	<0.0001	2	2	0.68	<1	17	<1	1.31	<0.001	<0.001	0.003
81406	CARB MUDSTONE	0.86	<0.0001	34	3	0.13	<1	34	<1	0.65	<0.001	<0.001	0.001
81417	SILTSTONE	0.87	<0.0001	1	1	1.18	<1	21	<1	1.8	<0.001	<0.001	0.003
81420	CARB MUDSTONE	0.63	<0.0001	<1	1	0.16	<1	12	<1	0.59	<0.001	<0.001	0.007
81426	SANDSTONE	0.48	<0.0001	<1	<1	0.46	<1	7	<1	0.74	<0.001	<0.001	0.009
81433	INTERBEDDED SANDSTONE AND SILTSTONE	0.78	<0.0001	<1	2	0.66	<1	20	<1	1.16	<0.001	<0.001	0.014
81438	INTERBEDDED CARB MUDSTONE AND TUFF	0.7	<0.0001	2	1	0.36	<1	10	<1	0.99	<0.001	<0.001	0.011
81439	INTERBEDDED SANDSTONE AND SILTSTONE	0.44	<0.0001	<1	<1	0.32	<1	4	<1	1.14	<0.001	<0.001	0.003
81445	CARB MUDSTONE	0.85	0.0001	1	2	0.11	<1	12	<1	1.46	<0.001	<0.001	0.001
81450	CLAYSTONE	0.81	<0.0001	3	1	<0.05	<1	7	<1	0.06	<0.001	<0.001	<0.001
81455	CARB MUDSTONE	0.75	0.0001	<1	1	0.74	<1	9	<1	1.51	<0.001	<0.001	0.002

		Bismuth	Erbium	Boron	Europium	Strontium	Barium	Gadolinium	Titanium	Beryllium	Gallium	Cadmium	Hafnium
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		0.001	0.001	0.05	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.0001	0.01
Client sample ID (Primary):	Lithology												
81351	SANDSTONE	<0.001	<0.001	0.92	<0.001	0.024	0.949	<0.001	0.04	<0.001	<0.001	<0.0001	<0.01
81355	CARB MUDSTONE	<0.001	<0.001	0.79	<0.001	0.013	0.718	<0.001	0.07	<0.001	<0.001	0.0001	<0.01
81356	CLAY	<0.001	<0.001	1.54	<0.001	0.036	1.78	<0.001	0.06	<0.001	<0.001	0.0002	<0.01
81370	COAL	<0.001	<0.001	0.68	<0.001	0.119	1.11	<0.001	<0.01	<0.001	<0.001	<0.0001	<0.01
81382	COAL	<0.001	<0.001	3.96	<0.001	2.38	0.822	<0.001	0.01	<0.001	<0.001	0.0006	<0.01
81388	SANDSTONE	<0.001	<0.001	0.8	<0.001	0.028	0.615	<0.001	<0.01	<0.001	<0.001	<0.0001	<0.01
81394	CLAY	<0.001	<0.001	1	<0.001	0.831	0.078	<0.001	<0.01	<0.001	<0.001	0.0004	<0.01
81397	CLAYSTONE	<0.001	<0.001	0.96	<0.001	0.02	0.591	<0.001	0.05	<0.001	<0.001	<0.0001	<0.01
81400	CARB MUDSTONE	<0.001	<0.001	0.8	<0.001	0.018	0.714	<0.001	0.08	<0.001	<0.001	<0.0001	<0.01
81403	MUDSTONE	<0.001	<0.001	0.85	<0.001	0.025	0.956	<0.001	0.06	<0.001	<0.001	<0.0001	<0.01
81406	CARB MUDSTONE	<0.001	<0.001	0.86	<0.001	0.034	1.15	<0.001	0.07	<0.001	<0.001	<0.0001	<0.01
81417	SILTSTONE	<0.001	<0.001	0.87	<0.001	0.022	0.787	<0.001	0.08	<0.001	<0.001	<0.0001	<0.01
81420	CARB MUDSTONE	<0.001	<0.001	0.63	<0.001	0.016	0.549	<0.001	0.03	<0.001	<0.001	<0.0001	<0.01
81426	SANDSTONE	<0.001	<0.001	0.48	<0.001	0.024	0.513	<0.001	0.02	<0.001	<0.001	<0.0001	<0.01
81433	INTERBEDDED SANDSTONE AND SILTSTONE	<0.001	<0.001	0.78	<0.001	0.036	0.999	<0.001	0.08	<0.001	<0.001	<0.0001	<0.01
81438	INTERBEDDED CARB MUDSTONE AND TUFF	<0.001	<0.001	0.7	<0.001	0.027	0.789	<0.001	0.03	<0.001	<0.001	<0.0001	<0.01
81439	INTERBEDDED SANDSTONE AND SILTSTONE	<0.001	<0.001	0.44	<0.001	0.016	0.488	<0.001	0.03	<0.001	<0.001	<0.0001	<0.01
81445	CARB MUDSTONE	<0.001	<0.001	0.85	<0.001	0.025	1.06	<0.001	0.2	<0.001	<0.001	0.0001	<0.01
81450	CLAYSTONE	<0.001	<0.001	0.81	<0.001	0.012	0.787	<0.001	<0.01	<0.001	<0.001	<0.0001	<0.01
81455	CARB MUDSTONE	<0.001	<0.001	0.75	<0.001	0.024	0.919	<0.001	0.06	<0.001	<0.001	0.0001	<0.01

		Tellurium	Cobalt	Holmium	Uranium	Caesium	Chromium	Indium	Copper	Lanthanum	Rubidium	Lithium	Lutetium
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		0.005	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Client sample ID (Primary):	Lithology												
81351	SANDSTONE	<0.005	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.006	<0.001	0.003	0.016	<0.001
81355	CARB MUDSTONE	<0.005	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	0.004	0.007	<0.001	0.002	<0.001
81356	CLAY	<0.005	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	0.004	0.001	0.004	0.001	<0.001
81370	COAL	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.003	0.002	<0.001
81382	COAL	<0.005	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	<0.001	0.004	0.007	<0.001
81388	SANDSTONE	<0.005	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
81394	CLAY	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.004	0.001	<0.001
81397	CLAYSTONE	<0.005	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.004	<0.001	0.001	<0.001	<0.001
81400	CARB MUDSTONE	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.004	<0.001	0.001	<0.001
81403	MUDSTONE	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	0.003	<0.001	<0.001
81406	CARB MUDSTONE	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	0.002	0.003	<0.001
81417	SILTSTONE	<0.005	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.004	0.001	0.003	0.002	<0.001
81420	CARB MUDSTONE	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
81426	SANDSTONE	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
81433	INTERBEDDED SANDSTONE AND SILTSTONE	<0.005	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	0.003	<0.001	0.003	<0.001	<0.001
81438	INTERBEDDED CARB MUDSTONE AND TUFF	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.001	<0.001	<0.001
81439	INTERBEDDED SANDSTONE AND SILTSTONE	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	<0.001	<0.001	<0.001	<0.001
81445	CARB MUDSTONE	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	0.001	<0.001	0.004	<0.001
81450	CLAYSTONE	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
81455	CARB MUDSTONE	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.003	0.001	<0.001	<0.001

		Thorium	Cerium	Manganese	Neodymium	Molybdenum	Praseodymium	Nickel	Samarium	Lead	Terbium	Antimony	Thulium
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Client sample ID (Primary):	Lithology												
81351	SANDSTONE	<0.001	0.002	0.01	0.002	0.003	<0.001	0.002	<0.001	0.001	<0.001	<0.001	<0.001
81355	CARB MUDSTONE	0.003	0.014	0.004	0.005	<0.001	0.001	<0.001	<0.001	0.005	<0.001	0.001	<0.001
81356	CLAY	<0.001	0.003	0.016	0.002	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
81370	COAL	<0.001	0.001	0.004	<0.001	0.014	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
81382	COAL	<0.001	<0.001	0.114	<0.001	0.008	<0.001	0.006	<0.001	<0.001	<0.001	<0.001	<0.001
81388	SANDSTONE	<0.001	<0.001	0.004	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
81394	CLAY	<0.001	<0.001	0.008	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
81397	CLAYSTONE	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
81400	CARB MUDSTONE	0.002	0.009	0.002	0.004	0.002	0.001	0.002	<0.001	<0.001	<0.001	0.001	<0.001
81403	MUDSTONE	<0.001	0.002	0.003	0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
81406	CARB MUDSTONE	<0.001	<0.001	0.003	<0.001	0.003	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
81417	SILTSTONE	<0.001	0.002	0.018	0.001	0.001	<0.001	0.002	<0.001	0.001	<0.001	0.001	<0.001
81420	CARB MUDSTONE	<0.001	<0.001	0.003	<0.001	0.014	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
81426	SANDSTONE	<0.001	<0.001	0.003	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
81433	INTERBEDDED SANDSTONE AND SILTSTONE	<0.001	0.002	0.011	0.001	0.006	<0.001	0.001	<0.001	0.002	<0.001	0.001	<0.001
81438	INTERBEDDED CARB MUDSTONE AND TUFF	<0.001	0.001	0.003	<0.001	0.121	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
81439	INTERBEDDED SANDSTONE AND SILTSTONE	<0.001	<0.001	0.001	<0.001	0.024	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
81445	CARB MUDSTONE	<0.001	0.003	0.003	0.001	0.004	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001
81450	CLAYSTONE	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
81455	CARB MUDSTONE	<0.001	0.007	0.003	0.003	0.004	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001

		Selenium	Ytterbium	Tin	Yttrium	Thallium	Zirconium	Vanadium	Zinc
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		0.01	0.001	0.001	0.001	0.001	0.005	0.01	0.005
Client sample ID (Primary):	Lithology								
81351	SANDSTONE	<0.01	<0.001	<0.001	<0.001	<0.001	<0.005	0.02	0.102
81355	CARB MUDSTONE	<0.01	<0.001	<0.001	0.001	<0.001	<0.005	0.01	0.184
81356	CLAY	<0.01	<0.001	<0.001	0.002	<0.001	<0.005	<0.01	0.226
81370	COAL	0.02	<0.001	<0.001	<0.001	<0.001	<0.005	<0.01	0.076
81382	COAL	0.02	<0.001	<0.001	<0.001	<0.001	<0.005	<0.01	0.518
81388	SANDSTONE	<0.01	<0.001	<0.001	<0.001	<0.001	<0.005	<0.01	0.041
81394	CLAY	<0.01	<0.001	<0.001	<0.001	<0.001	<0.005	<0.01	0.348
81397	CLAYSTONE	<0.01	<0.001	<0.001	<0.001	<0.001	<0.005	<0.01	0.128
81400	CARB MUDSTONE	0.02	<0.001	<0.001	0.002	<0.001	<0.005	0.02	0.178
81403	MUDSTONE	<0.01	<0.001	<0.001	<0.001	<0.001	<0.005	<0.01	0.097
81406	CARB MUDSTONE	0.02	<0.001	<0.001	<0.001	<0.001	<0.005	<0.01	0.097
81417	SILTSTONE	<0.01	<0.001	<0.001	<0.001	<0.001	<0.005	<0.01	0.075
81420	CARB MUDSTONE	<0.01	<0.001	<0.001	<0.001	<0.001	<0.005	<0.01	0.032
81426	SANDSTONE	<0.01	<0.001	<0.001	<0.001	<0.001	<0.005	<0.01	0.036
81433	INTERBEDDED SANDSTONE AND SILTSTONE	<0.01	<0.001	<0.001	<0.001	<0.001	<0.005	<0.01	0.058
81438	INTERBEDDED CARB MUDSTONE AND TUFF	<0.01	<0.001	<0.001	<0.001	<0.001	<0.005	0.02	0.092
81439	INTERBEDDED SANDSTONE AND SILTSTONE	<0.01	<0.001	<0.001	<0.001	<0.001	<0.005	<0.01	0.068
81445	CARB MUDSTONE	0.01	<0.001	<0.001	<0.001	<0.001	0.007	<0.01	0.097
81450	CLAYSTONE	<0.01	<0.001	<0.001	<0.001	<0.001	<0.005	<0.01	0.063
81455	CARB MUDSTONE	<0.01	<0.001	<0.001	0.001	<0.001	<0.005	<0.01	0.109

Appendix F: Dispersivity data

Appendices

Table 1: Dispersivity Testing: Laboratory Testing Results

Sample Number	BHID	From	To	Lithology	Weathering	Lithology Group	Emerson Class	pH Value	Electrical Conductivity (µS/cm)	EC (dS/m)	Exchangeable Calcium	Exchangeable Magnesium	Exchangeable Potassium	Exchangeable Sodium	Cation Exchange Capacity	Exchangeable Sodium Percent
81351	C001C	50.48	50.71	SANDSTONE	MW	SAND AND GRAVEL GROUP	5									
81355	C001C	105.80	106.34	CARB MUDSTONE	FR	CARBONACEOUS GROUP	5	8	37	0.037	2.3	0.8	<0.1	0.7	3.9	17.2
81356	C0021C	5.58	6.51	CLAY	EW	CLAY AND SOIL GROUP	1	7.8	2910	2.91	13.1	10.9	0.6	19.6	44.2	44.4
81357	C0021C	34.27	34.90	CLAYSTONE	HW	REMAINING	2	7.7	790	0.79	0.8	1.6	0.1	2.8	5.2	53
81362	C024C	30.00	30.42	CLAYSTONE	HW	CLAY AND SOIL GROUP	1									
81363	C024C	43.31	44.26	SANDSTONE	MW	REMAINING	6	6.4	525	0.525	1.5	0.3	<0.1	0.3	2.2	12.3
81365	C031C	14.22	15.08	CLAY	HW	REMAINING	2	7.7	2030	2.03	1.4	2.8	<0.1	5.6	9.8	56.7
81367	C031C	54.96	55.36	SILTSTONE	SW	REMAINING	5	8.4	668	0.668	14.8	8	0.6	3.4	26.8	12.7
81370	C031C	92.42	92.89	COAL	FR	COAL GROUP	5									
81371	C031C	96.83	97.88	SILTSTONE	FR	REMAINING	3	8.9	584	0.584	26.5	6	0.8	3.8	37.2	10.2
81379	C036C	253.43	253.77	SILTSTONE	FR	REMAINING	3									
81382	C036C	298.14	298.27	C5 COAL	FR	COAL GROUP	5	7.5	443	0.443	3	1.3	<0.1	1.4	5.9	24.8
81394	C040C	4.36	4.55	CLAY	EW	POTENTIAL AN GROUP	6	7.6	3740	3.74	192	6	0.3	7.8	206	3.8
81396	C040C	5.43	5.81	CLAY	HW	POTENTIAL AN GROUP	5									
81397	C040CR	46.63	47.00	CLAYSTONE	HW	REMAINING	5	7.6	1170	1.17	8.8	7.1	0.5	10.3	26.7	38.7
81400	C041C	64.38	65.23	CARB MUDSTONE	SW	CARBONACEOUS GROUP	2									
81401	C041C	67.70	68.21	MUDSTONE	FR	CARBONACEOUS GROUP	5	6.3	158	0.158	1.2	2.4	0.2	0.5	4.3	12.1
81403	C041C	98.70	99.45	MUDSTONE	FR	CARBONACEOUS GROUP	5									
81404	C041C	107.00	107.57	SANDSTONE	FR	REMAINING	5	8.7	437	0.437	1.5	0.4	<0.1	1.1	3.2	35
81405	C042C	85.97	86.88	SANDSTONE	FR	SAND AND GRAVEL GROUP	5									
81406	C042C	96.55	97.14	CARB MUDSTONE	FR	CARBONACEOUS GROUP	5									
81410	C046C	258.26	259.19	SANDSTONE	FR	REMAINING	5									
81418	C048C	356.16	356.93	SILTSTONE	FR	REMAINING	5	8.6	376	0.376	12.6	0.9	0.3	1.8	15.7	11.6
81436	C048C	444.40	445.79	SANDSTONE	FR	REMAINING	4									
81438	C048C	463.00	465.26	CARB MUDSTN AND TUFF	FR	CARBONACEOUS GROUP	5									
81450	C056C	75.20	75.99	CLAYSTONE	EW	REMAINING	5									
81453	C056C	169.96	171.24	CLAYSTONE	FR	REMAINING	5	9	195	0.195	17.5	4.2	0.6	3.2	25.5	12.5
81455	C056C	366.80	367.73	CARB MUDSTONE	FR	CARBONACEOUS GROUP	5									

Table 2: Dispersivity Testing: Result Interpretation

SAMPLE NUMBER	BHID	From	To	LITHOLOGY	Lithology Group	Veatherin	EMERSON	EC (dM/s)	CEC	ESP	Interpretation
81356	C0021C	5.58	6.51	CLAY	CLAY AND SOIL GROUP	EW	1	2.91	44.2	44.4	Dispersive
81362	C024C	30.00	30.42	CLAYSTONE	CLAY AND SOIL GROUP	HW	1				Dispersive
81394	C040C	4.36	4.55	CLAY	POTENTIAL AN GROUP	EW	6	3.74	206	3.80	Nondispersive
81450	C056C	75.20	75.99	CLAYSTONE	REMAINING	EW	5				Nondispersive
81365	C031C	14.22	15.08	CLAY	REMAINING	HW	2	2.03	9.80	56.7	Dispersive
81396	C040C	5.43	5.81	CLAY	POTENTIAL AN GROUP	HW	5				Nondispersive
81357	C0021C	34.27	34.90	CLAYSTONE	REMAINING	HW	2	0.79	5.20	53.0	Dispersive
81397	C040CR	46.63	47.00	CLAYSTONE	REMAINING	HW	5	1.17	26.7	38.7	Dispersive
81400	C041C	64.38	65.23	CARB MUDSTONE	CARBONACEOUS GROUP	SW	2				Dispersive
81367	C031C	54.96	55.36	SILTSTONE	REMAINING	SW	5	0.67	26.8	12.70	Marginal
81351	C001C	50.48	50.71	SANDSTONE	SAND AND GRAVEL GROUP	MW	5				Nondispersive
81363	C024C	43.31	44.26	SANDSTONE	REMAINING	MW	6	0.53	2.20	12.30	Nondispersive
81382	C036C	298.14	298.27	C5 COAL	COAL GROUP	FR	5	0.44	5.90	24.80	Nondispersive
81355	C001C	105.80	106.34	CARB MUDSTONE	CARBONACEOUS GROUP	FR	5	0.04	3.90	17.20	Nondispersive
81406	C042C	96.55	97.14	CARB MUDSTONE	CARBONACEOUS GROUP	FR	5				Nondispersive
81455	C056C	366.80	367.73	CARB MUDSTONE	CARBONACEOUS GROUP	FR	5				Nondispersive
81453	C056C	169.96	171.24	CLAYSTONE	REMAINING	FR	5	0.20	25.5	12.50	Nondispersive
81370	C031C	92.42	92.89	COAL	COAL GROUP	FR	5				Nondispersive
81438	C048C	463.00	465.26	CARB MUDSTONE &	CARBONACEOUS GROUP	FR	5				Nondispersive
81401	C041C	67.70	68.21	MUDSTONE	CARBONACEOUS GROUP	FR	5	0.16	4.30	12.10	Nondispersive
81403	C041C	98.70	99.45	MUDSTONE	CARBONACEOUS GROUP	FR	5				Nondispersive
81404	C041C	107.00	107.57	SANDSTONE	REMAINING	FR	5				Nondispersive
81405	C042C	85.97	86.88	SANDSTONE	SAND AND GRAVEL GROUP	FR	5	0.44	3.20	35.0	Nondispersive
81410	C046C	258.26	259.19	SANDSTONE	REMAINING	FR	5				Nondispersive
81436	C048C	444.40	445.79	SANDSTONE	REMAINING	FR	4				Nondispersive
81371	C031C	96.83	97.88	SILTSTONE	REMAINING	FR	3	0.58	37.2	10.20	Marginal
81379	C036C	253.43	253.77	SILTSTONE	REMAINING	FR	3				Marginal
81418	C048C	356.16	356.93	SILTSTONE	REMAINING	FR	5	0.38	15.7	11.60	Nondispersive

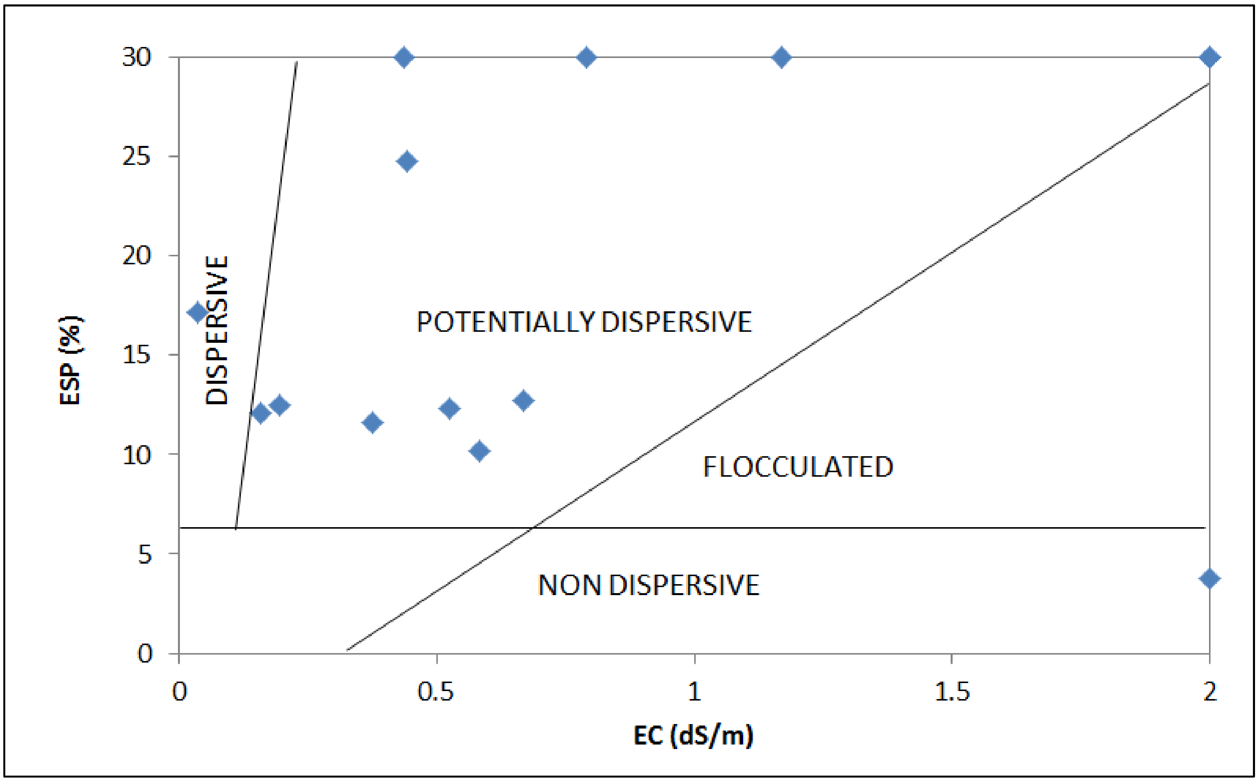


Figure 1: Assessment of dispersivity based on ESP and EC

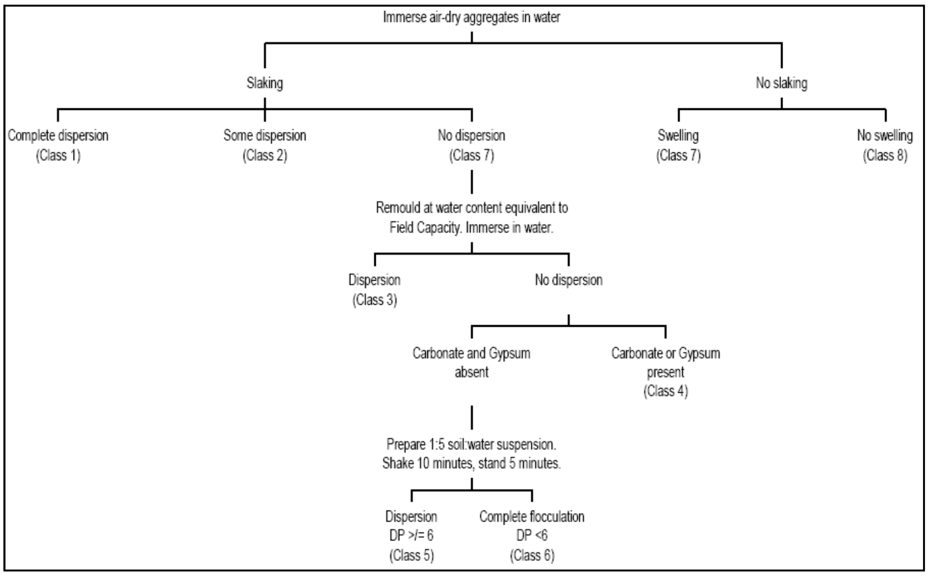


Figure 2: Diagram for Determining the Emerson Class Number

Figure 3: Example of Emerson Tests showing Highly Dispersive (Class 1), Slightly Dispersive (Class 2 or 3) and Non-dispersive (Class 4, 5 or 6) Results .

Accelerated Weathering Testing

Figure 4: Accelerated weathering test samples at beginning of test

Figure 5: **Static durability tests after 19 days**

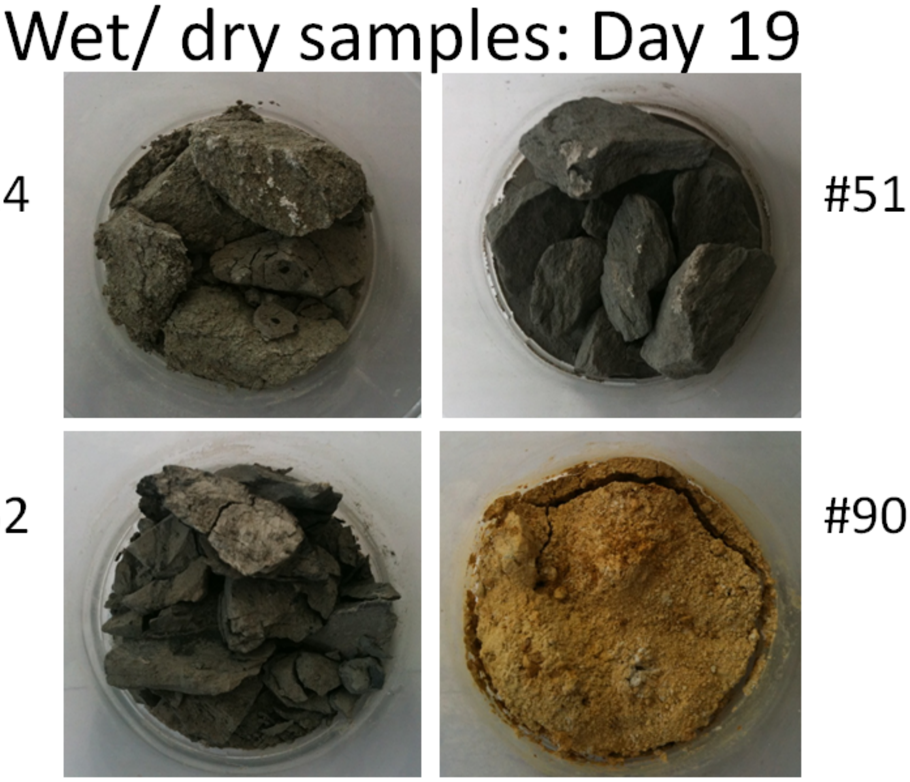


Figure 6: **Wet/dry tests after 19 days**

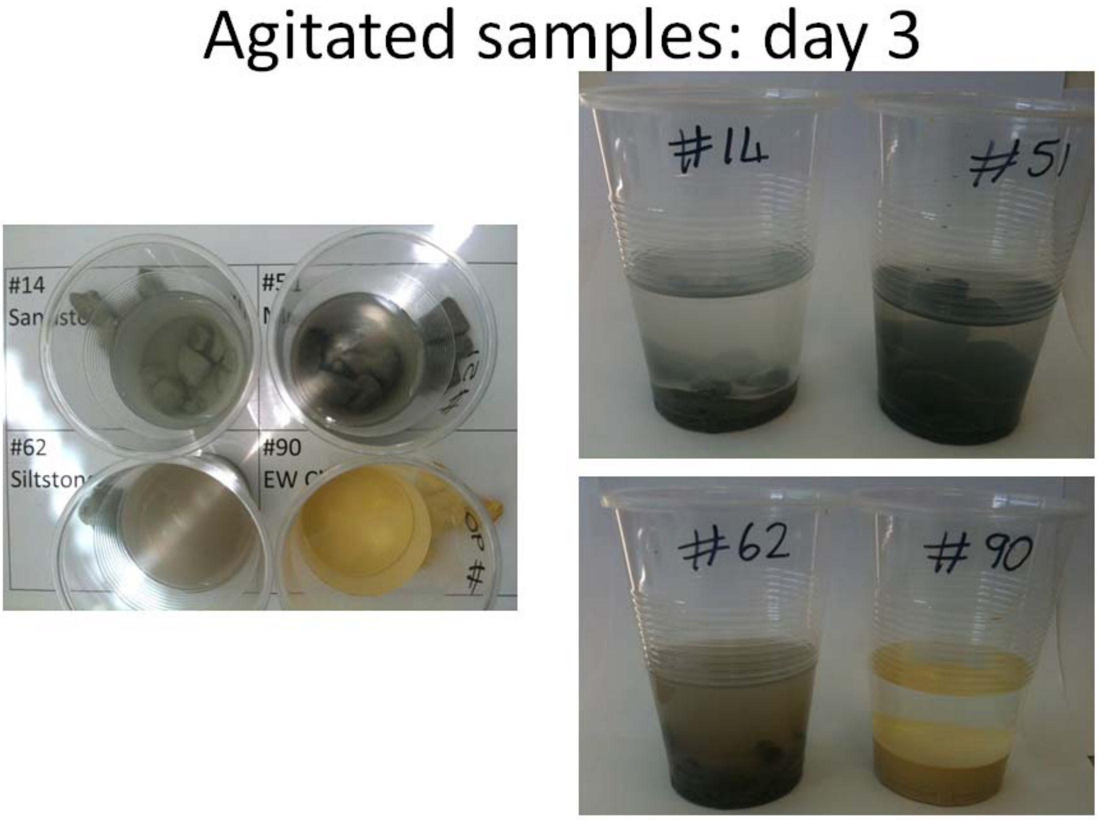


Figure 7: Dynamic test after 3 days

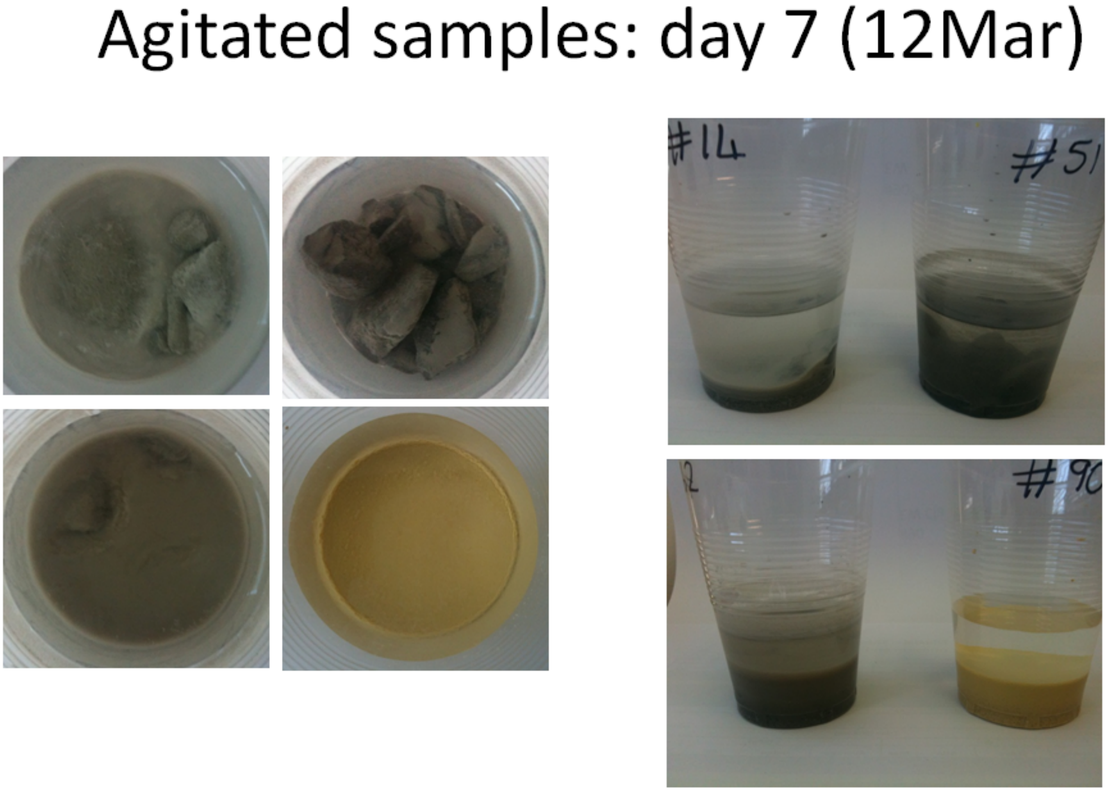


Figure 8: Dynamic test after 7 days

Appendix G: Accelerated weathering test

Accelerated Weathering Test

Sample Number	Lab #	Borehole	Depth From	Depth To	Lithology	Weathering	Emerson	CEC, ESP & EC
81364	#14	C024C	89.67	90.44	Sandstone	FR	Nondispersive	Nondispersive
81402	#51	C041C	76.35	76.9	Mudstone	FR	Nondispersive	Marginal/ nondispersive
81414	#62	C046C	321.42	322.27	Siltstone	FR	Marginal	Marginal?
81450	#90	C056C	75.2	75.99	Claystone	EW	Dispersive	Dispersive

Three tests performed:

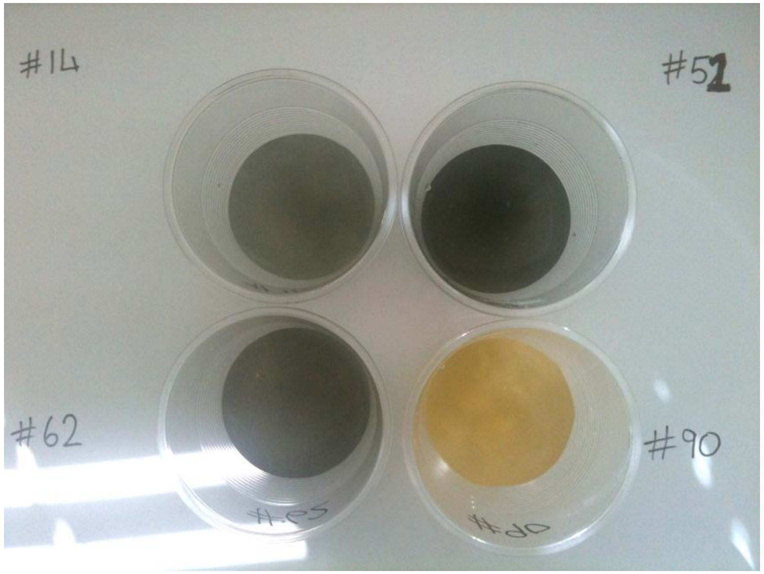
- Static durability test
- Wet/dry test
- Dynamic durability test

Static durability samples

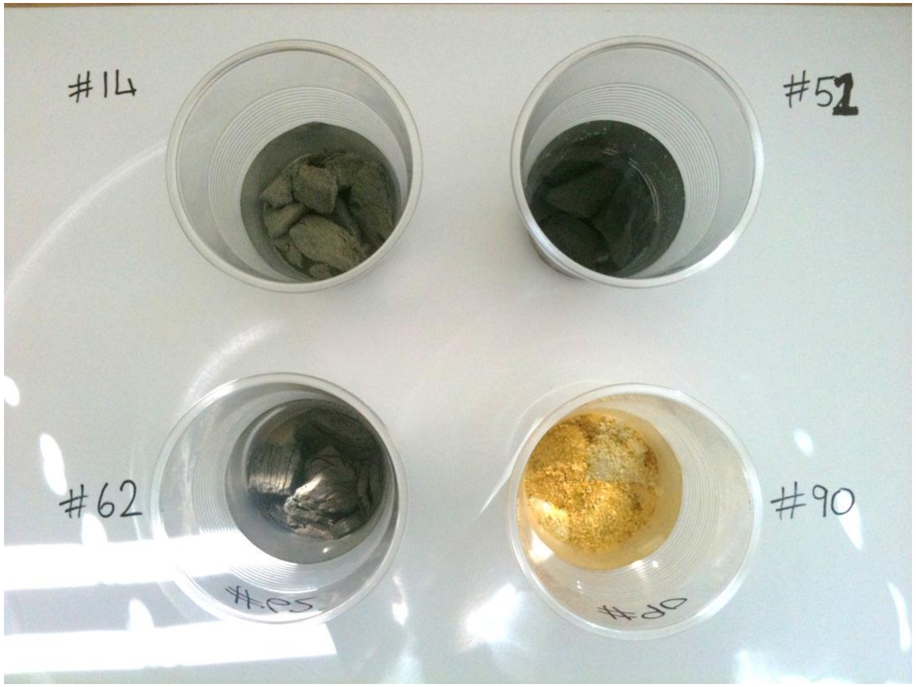
Time	Date	#14- Sandstone	#51 - Mudstone	#62 - Siltstone	#90- HW Claystone
5 minutes	1 March	Solution very cloudy	Solution very cloudy	Solution very cloudy	Solution very cloudy
1 hour	1 March	Cloudiness settling.	Cloudiness settling.	Cloudiness settling.	Cloudiness settling. Sample slaking.
1 day	2 March	Solution clear. Cracks appearing in fragments.	Solution clear No change in fragments.	Hint of cloudiness in solution. Fragments starting to cleave along bedding planes	Solution clear. All fragments have slaked completely.
5 days	5 March	Solution clear. Fragments show minor cracking, especially on edges.	Solution clear No change in fragments. Very minor slaking (thin layer of clay on bottom of container)	Bare hint of cloudiness in solution. Fragments starting to cleave and separate along bedding planes	Solution clear. All fragments have slaked completely.
10 days	12 March	No change	No change	No change	No change – colours of different fragments blending together
19 days	19 March	No change	No change	No change	Colours of different fragments blending together

Samples submerged in water, thereafter not disturbed. Water was gently topped up when required.

Static durability: 1 hour



Static durability : Day 1



Static durability samples – Day 7

#14

#51

#62

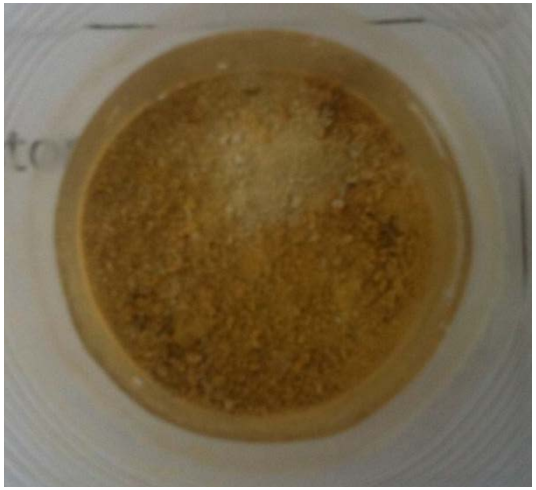
#90

Static durability samples – Day 12

#14

#51

#62



#90

Static durability samples: Day 19

#14

#51

#62

#90

Daily wet/ dry samples

Time	Date	#14- Sandstone	#51 - Mudstone	#62 - Siltstone	#90- HW Claystone
1 hour	1 March	No change	No change	No change	Fragments starting to slake
1 day	2 March	Minor slaking of fragments	No change	Cracks forming in fragments	Fragments starting to slake, but fragment shape still visible.
5 days	7 March	Fragments looking pitted as particles flake off. Minor cracks appearing in some fragments	Minor clay fraction present at base of cup, no noticeable change to fragments	Fragments are breaking into smaller fragments, small clay/silt fraction at base of cup	Fragments completely slaked, but fragment shape still visible.
10 days	12 March	Fragments looking more pitted, some cracks appear larger.	No noticeable change	As above, but showing more deterioration of fragments	Fragments completely slaked, fragment shape becoming indistinct
19 days	19 March	Fragments looking more pitted, some cracks appear larger.	No noticeable change	As above, but showing more deterioration of fragments	Fragments completely slaked, fragment shape lost

Samples just covered in water, allowed to dry out before covered in water again. Process repeated as required.

Wet/ dry samples: Day 1

Wet/ dry samples: Day 7

#14

#51

#62

#90

Wet/ dry samples: Day 12

#14

#51

#62

#90

Wet/ dry samples: Day 19

#14

#51

#62

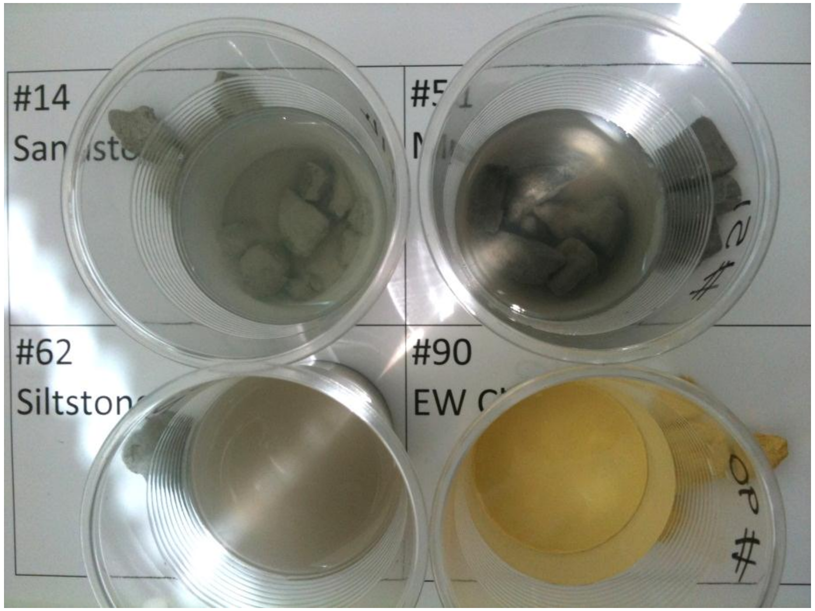
#90

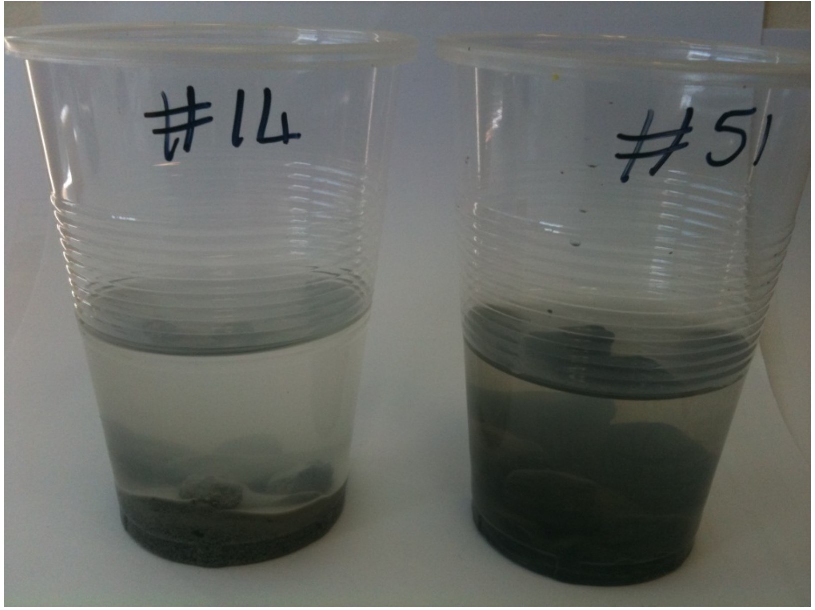
Agitated samples

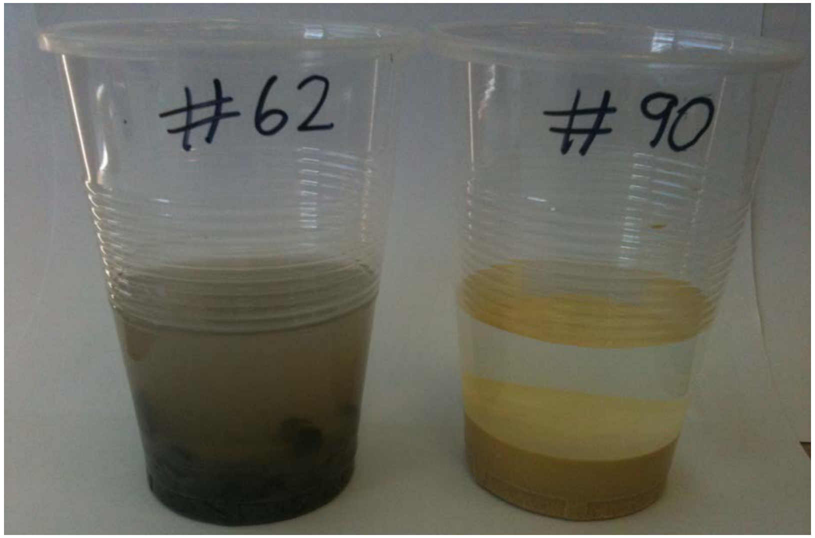
Time	Date	#14- Sandstone	#51 - Mudstone	#62 - Siltstone	#90- HW Claystone
5 Minutes	5 March	Fragments start to break down (30% breaks to sand) on first stirring	Some fragments break off	Fragments start to break down (50% breaks to silt, sand, clay) on first stirring	Fragments break down almost entirely on first agitation
1 day	6 March	Fragments start to break down (40% breaks to sand) on first stirring	Small fragments break off		
3 days	7 March	Fragments start to break down (50% breaks to sand)	Small fragments break off (5-10%) and slake to form clay. Water shows slight cloudiness overnight	Fragments start to break down (60% breaks to silt, sand, clay). Water still distinctly cloudy after samples has stood overnight.	Material completely broken to silt/ clay. Water almost clear overnight.
7 days	12 March	Fragments start to break down (60% breaks to sand/ silt)	Small fragments break off (10%) and break down to clay. Water shows slight cloudiness three days after last stir	Fragments start to break down (60% breaks to silt, sand, clay). Clay fraction slowly starting to settle (top half of water has hint of cloudiness, bottom half of water contains heavy colloidal contact.	As previous
15 days	19 March	~70% broken to sand/silt. Water completely clear	Surface of rock fragments appears overed in clay. Water with bear hint of cloudiness	~90% broken down to silt, clay, sand.	Silt /clay. Water completely clear.

Agitation by gentle stirring of the fragments submerged in water. Care was taken not to crush the fragments in the stirring process.

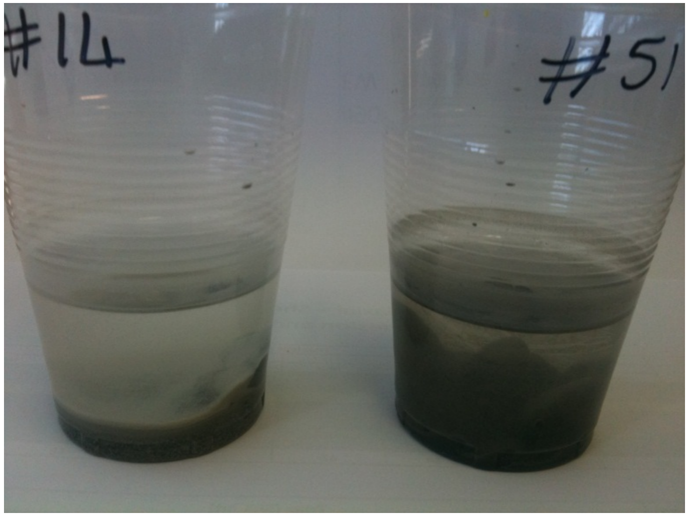
Agitated samples: day 3

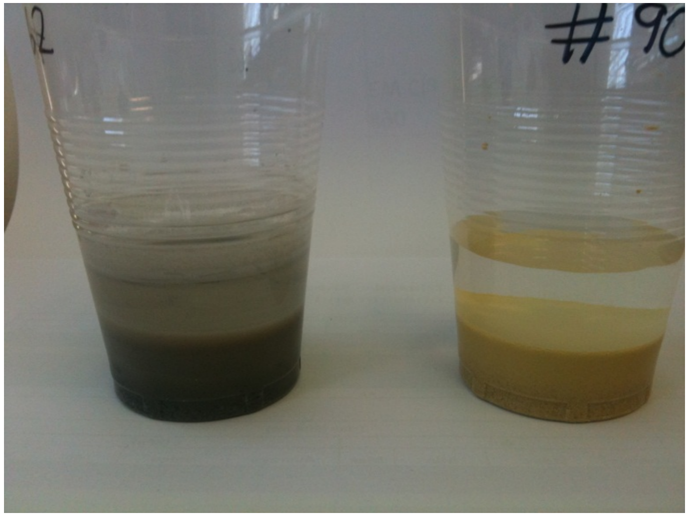






Agitated samples: day 7 (12Mar)





Agitated samples: day 15 (19Mar)

#14 Sandstone	#51 Mudstone
#62 Siltstone	#90 EW Claystone

SRK Report Client Distribution Record

Project Number: GHD001

Date Issued: 16 November 2012

Name/Title	Company
Stuart Winchester (Environment Business Leader – Mining, NSW / Qld)	GHD Pty Ltd

Rev No.	Date	Revised By	Revision Details
0	25 June 2012	A Garvie	Draft Report presented to client (pdf and MS Word doc)
1	10 July 2012	A Garvie	Final Report presented to client (pdf and MS Word doc)
2	15 November 2012	A Garvie	Final Report presented to client (pdf and MS Word doc)
3	16 November 2012	A Garvie	Amended Final Report presented to client (pdf and MS Word doc)