ENVIRONMENTAL ASSESSMENT

Duralie Extension Project

APPENDIX I

GEOCHEMISTRY ASSESSMENT

GLOUCESTER COAL

ResourceStrategies

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Appendix I

Duralie Extension Project

Geochemical Assessment of Overburden and Floor Rock

Contents

List of Plates (within text)

List of Tables (after text)

List of Figures (after text)

List of Attachments (after Tables and Figures)

I1.0 Introduction

Environmental Geochemistry International Pty Ltd (EGi) by were commissioned by Duralie Coal Pty Ltd (DCPL) to conduct geochemical assessment of overburden (waste rock) and floor rock for the Duralie Extension Project (the Project). The Duralie Coal Mine (DCM) is located approximately 10 kilometres (km) north of the village of Stroud and approximately 20km south of Stratford in the Gloucester Valley in New South Wales (NSW) (Figure I-1).

The overall objectives of the geochemical assessment were to assess the acid rock drainage (ARD) potential of overburden and floor rock, identify the main ARD issues, and provide recommendations for materials management. The geochemical assessment utilised data available from the existing DCM operations supplemented with geochemical testing of drillhole samples from the Project area.

I2.0 Previous Geochemical Assessment

A geochemical assessment was prepared by EGi (EGi, 1996) for the existing DCM for inclusion in the *Duralie Coal Project Environmental Impact Statement* (DCPL, 1996). The assessment included:

- geochemical characterisation of overburden and floor rock materials from 17 drill holes located within the original DCM development area; and
- leach column and surface lysimeter testing to evaluate reaction rates, leachate chemistry and limestone treatment effectiveness for overburden and floor rock.

Many of the leaching tests operated beyond 1996, with the last leach column terminated in August 2003.

The findings of this assessment are relevant to the Project since the proposed new development would include the excavation of similar rock types and include an extension of the existing approved open pit in the Weismantel Seam to the north-west (the target seam of the current DCM operations). Findings and results of the geochemical testing for the DCM have been incorporated into this document where appropriate.

I3.0 Background and Geology

The proposed mining activities would involve extension of the existing approved open pit in the Weismantel Seam to the north-west (i.e. Weismantel Extension open pit) and open cut mining operations in the Clareval Seam (i.e. Clareval North West open pit). These seams would be mined as separate parallel pits, although the pits would overlap in places. Both seams strike approximately NNW and dip to the east at 30 to 60 degrees (°). The pit locations and general mine arrangement are shown on Figure I-2.

Open pits would be progressively backfilled with waste rock as mining develops, with most waste rock placed within the pit footprint, and extending the existing DCM in pit waste rock dump. This would minimise the need for dumping in areas outside the open pit footprint and direct most infiltration from the dump into the open pit void.

Figure I-3 is a typical stratigraphic section of the mine sequence[1]. The Project coal resource is located within the Permian-aged Gloucester Basin in NSW, with the DCM in the southern closure of the main synclinal structure of the Gloucester Basin, and the proposed new mining area on the northern part of the western limb of the same syncline. The coal resource occurs within the coal bearing strata of the Dewrang Group, which comprises three main stratigraphic units as follows (from youngest to oldest): Mammy Johnsons Formation; Weismantel Formation; and Durallie Road Formation. The main target seams are the Weismantel and Clareval, hosted by the Weismantel Formation and Durallie Road Formation, respectively.

The coal seams and host sedimentary materials were deposited under a marine influenced environment, resulting in elevated pyrite in the coal seams (particularly the seam tops), and common pyrite in overburden and floor.

Geological descriptions indicate the Clareval Seam overburden is relatively uniform, comprising mainly marine sandstones, with some siltstone and conglomerate, and occasional finer grained units (claystone/siltstone) on the immediate seam roof. Clareval Seam floor materials appear to comprise mainly sandstone and conglomerate.

The Clareval Seam includes an upper split referred to as the Clareval Upper Seam (CLU), which is often separated from the Clareval Main Seam (CLM) by a parting (CLP1) generally ranging in thickness from 0.1 to 0.6 metres (m). It is understood the CLP1 would report to overburden where it is greater than 300 millimetres (mm), otherwise it would be mined with the coal and processed. The combined CLU and CLM is typically 8m to 9m thick, however sequences of 30m and up to 50m thickness are known to exist in the north-west in fault thickened areas. A Clareval Lower Seam (CLL) also occurs in some areas a few meters below CLM, and ranges from 1m to 4m in thickness.

The overburden and floor of the Weismantel Seam is also relatively uniform, comprising massive medium to coarse grained lithic sandstones with varying carbonaceous content, conglomerates and minor siltstones. The Weismantel Seam is generally 10m to 12m thick, however significant reverse faulting causes repetition of the middle and lower sections of the seam resulting in coal thicknesses of up to 20m. The Weismantel Seam is divided into working sections on a coal quality basis. The upper 3m to 4m is generally thermal coal and the lower 7m to 8m is a mixture of coking coal and thermal coal. The immediate roof and floor of the Weismantel Seam have a high pyrite content.

[1] Note that the full sequence shown is not represented in any one part of the proposed pits.

In between the Weismantel and Clareval Seams, there are also two thin coal seam horizons named the Cheer Up 1 (CH1) and Cheer Up 2 (CH2) Seams. The CH1 and CH2 Seams range in thickness from 0.5 to 3.5m, are 10 to 20m apart, and occur approximately 200m below the Weismantel Seam and 50 to 100m above the Clareval Seam. These seams would generally be mined as coal and processed with Weismantel and Clareval Seam coal.

A number of drillholes (DU150C, DU204C, DU205C and WC218C) were examined during an EGi site visit to DCM and Stratford Mine sites in July 2009 to help obtain a better understanding of pyrite occurrence in overburden materials. In general, pyrite appeared to be preferentially associated with carbonaceous mudstone clasts and lenses within the sandstone that dominates the Weismantel and Clareval Seam overburden (examples Plates I-1 to I-3). Pyrite was often difficult to observe directly, but the presence of pyrite was indicated by the presence of typical oxidation products such a jarosite, sulphate salts and iron staining. A number of zones of jarosite and sulphate salts were also observed in sandstone free of visible carbonaceous material, indicating pyrite also occurs as fine disseminations within the sandstone matrix (Plate I-4). Pyrite lenses and nodules within the sandstone were also observed less frequently (Plates I-5 and I-6).

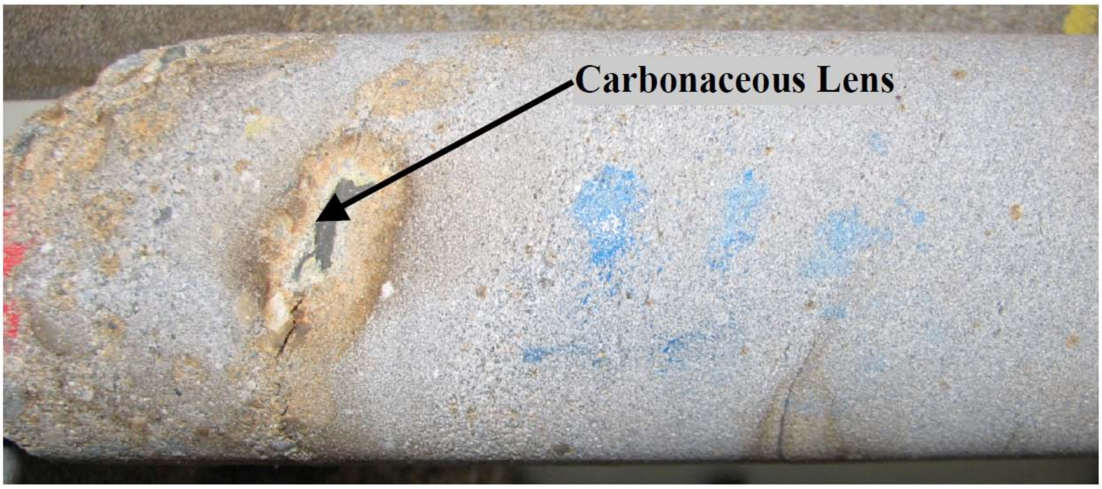

Plate I-1: Jarositic oxidation rim around a carbonaceous lens in sandstone, indicating fine disseminated pyrite. Hole DU150C, 69.15m.

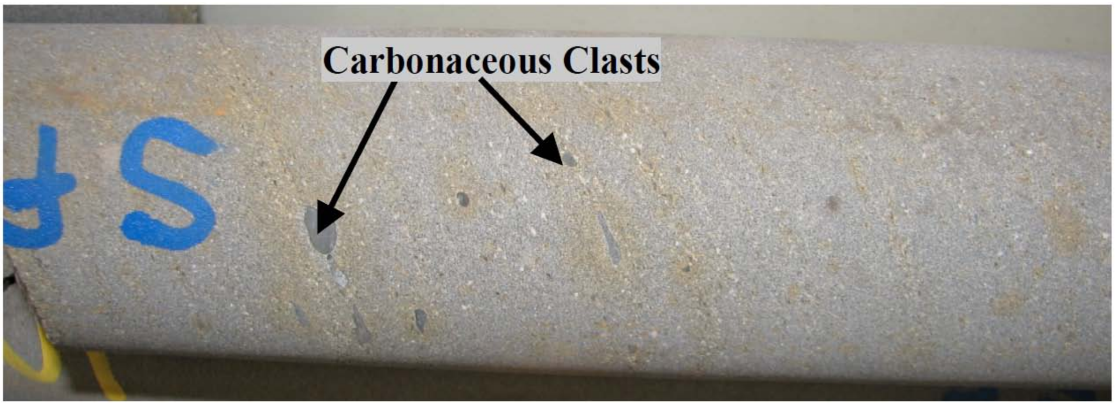

Plate I-2: Jarositic oxidation associated with carbonaceous clasts in sandstone, indicating fine disseminated pyrite. Hole DU150C, 108.90m.

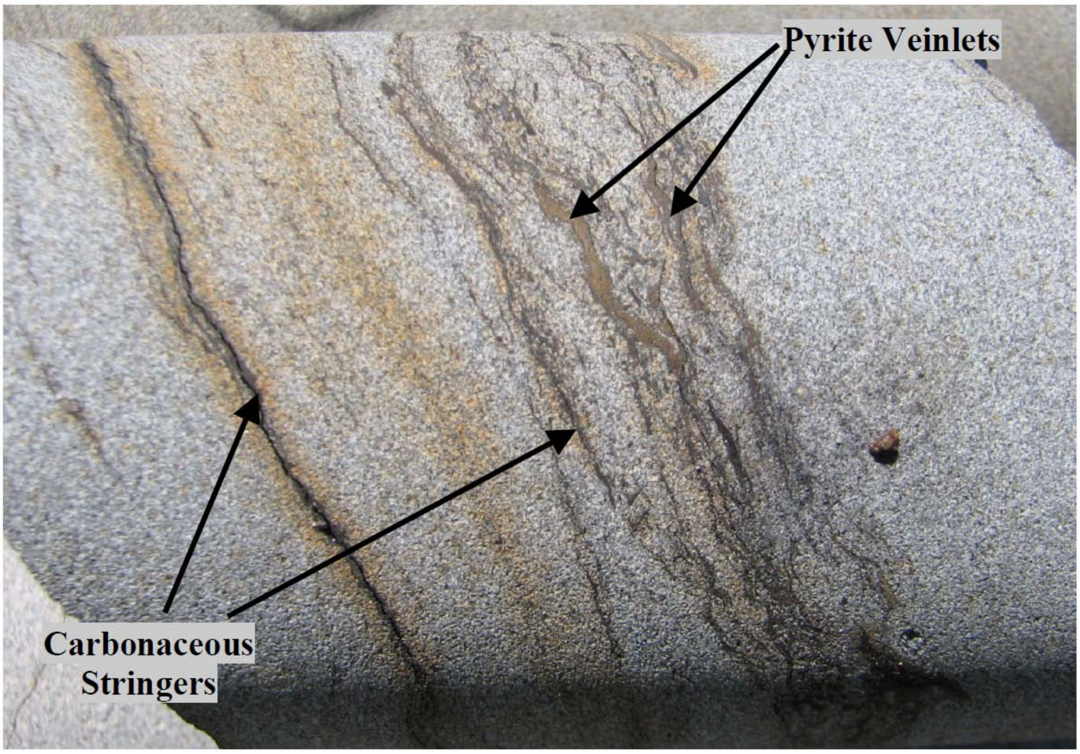

Plate I-3: Pyrite veinlets associated with carbonaceous stringers in sandstone. Fine disseminated pyrite indicated by oxidation rims in other carbonaceous partings. Hole DU204C.

Plate I-4: Jarosite and sulphate salts in sandstone, indicating fine disseminated pyrite. No obvious carbonaceous material or pyrite. Hole WC218C, 17.22m.

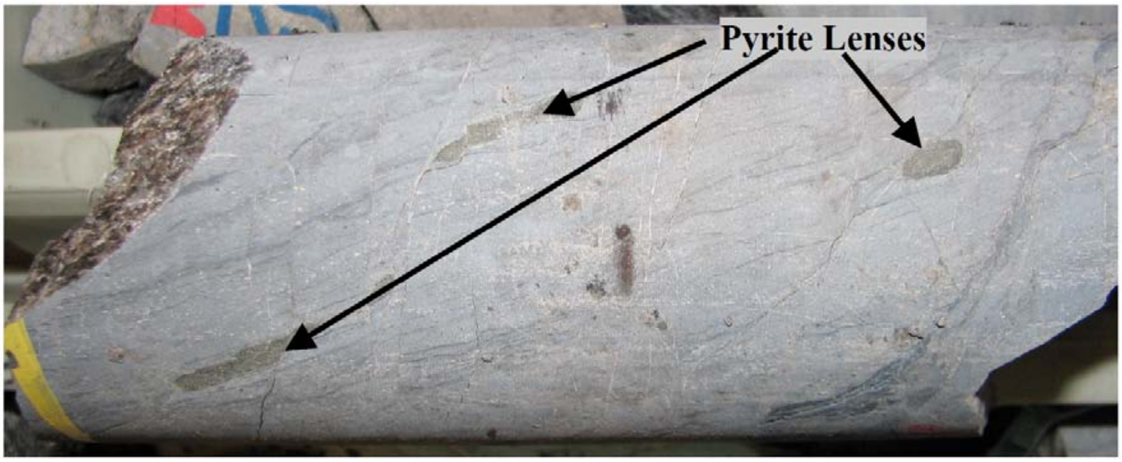

**Plate I-5: Pyrite lenses in fine sandstone just below Clareval Upper Seam.
Hole DU150C, 130.80m.**

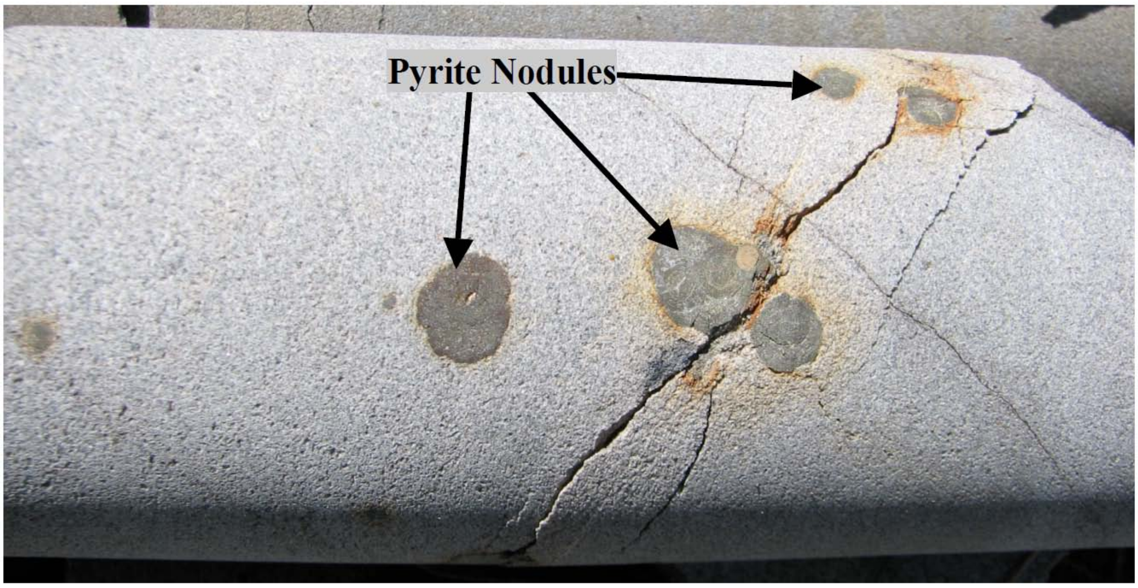

Plate I-6: Pyrite nodules in sandstone. Hole DU204C.

I4.0 Sample Selection and Preparation

Geochemical testing was carried out on samples from 12 diamond and open holes, and 10 blast holes from drilling programmes carried out between 2006 to 2009 as outlined below:

Drill Hole	Target Seam	Open Hole Interval	Core Interval
2006 Drilling Programme			
DU020C	Clareval	0.00m to 35.15m	35.15m to 50.25m
WC216C	Weismantel	Pre-Collar Not Provided	16.78m to 50.60m
2007 Drilling Programme			
DU072C	Clareval	Pre-Collar Not Provided	26.40m to 101.50m
DU083C	Clareval	Pre-Collar Not Provided	17.45m to 19.87m
DU090R	Clareval	4.00m to 71.07m	Open Hole Only
DU092R	Clareval*	0.00m to 48.00m	Open Hole Only
WC217AC	Weismantel	Pre-Collar Not Provided	23.00m to 39.00m
2009 Drilling Programme			
DU109R	Clareval	84.00m to 203.00m	Open Hole Only
DU126R	Clareval	0.00m to 138.00m	Open Hole Only
DU165R	Clareval	0.00m to 92.00m	Open Hole Only
DU150C	Clareval	Pre-Collar Not Provided	65.60m to 153.05m
DU206C	Weismantel	Pre-Collar Not Provided	9.55m to 39.50m
Blast Hole 1to 6 & 8 to10	Weismantel	7.00m to 25.00m	Open Hole Only
Blast Hole 7	Weismantel	0.00m to 5.00m	Open Hole Only

* Later geological interpretation showed that the coal intercepted is likely to represent a thin seam below the Clareval Seam (i.e. would not form part of the Project stratigraphic sequence).

Note that samples were restricted to overburden and floor materials, and no samples of coal intercepts were provided.

Locations of the above core holes, open holes and blast holes are shown in Figure I-4 (northern part of project area) and Figure I-5 (southern part of project area). Locations of the 17 holes geochemically tested for the 1996 EIS are shown in Figure I-5.

2006 Drilling Program

The 2006 drilling program (EGi, 2006) included the collection of 26 samples from two drill holes DU020C [16 samples] and WC216C [10 samples]). Sample collection, interval selection and core sample crushing to -4mm for the 2006 and 2007 holes were arranged and supervised by contract geologists from McElroy Bryan Geological Services (MBGS).

Core samples comprised full core (i.e. not split) combined into selected sample intervals and provided a good representation of the interval drilled. Chip samples were collected with a scoop as small sub-samples during drilling and sometimes composited in the field, and may not be fully representative of the interval drilled. Individual crushed core samples from holes DU020C and WC216C were combined (weighted according to sample interval) by EGi into composite intervals of up to 4m where appropriate. EGi arranged pulverising to -75 microns (µm) of 300 to 500 grams (g) splits of all crushed core and chip samples, which was carried out by Sydney Environmental and Soil Laboratory (SESL).

2007 Drilling Program

The 2007 drilling programme (EGi, 2007) included the collection of 34 samples from 5 drill holes:

- DU072C (12 samples);
- DU083C (1 sample);
- DU090R (6 samples);
- DU092R (10 samples); and
- WC217AC (5 samples).

Sample collection, interval selection and core sample crushing to -4mm were arranged by MBGS. Samples from the 2007 drilling programme were collected and prepared as per the 2006 drilling programme (described above).

2009 Drilling Program

The 2009 drilling program included the collection of 163 samples from 15 drill holes:

- DU109R (20 samples);
- DU126R (18 samples);
- DU165R (56 samples);
- DU150C (39 samples);
- DU206C (20 samples); and
- 10 blast holes (Holes 1 to 10) (10 samples).

Samples from drill holes DU109R, DU126R and DU165R were provided to EGi in 2009 as drill chips. Sample collection was arranged by MBGS supervising the drilling programme. Samples for DU165R were collected at 1m intervals in two containers placed along side the collar to capture a reasonable cross-section of the ejected drill chips, with the hole cleared between each sample. At the end of each sample interval, the two containers were combined and mixed thoroughly, and placed on a 1mm aperture sieve to drain off any excess water. Approximately 600g of chips were collected with a scoop from the bulk material in the sieve.

Samples from drill holes DU109R and DU126R were provided as 6m sample intervals, with samples collected at 1m intervals and combined into 6m composites in the field. A scoop was then used to collect 600g sub-samples from the 6m composites, which were drained on a -1mm sieve. The drill hole was cleared every 3m for the 6m composite drill holes. EGi arranged pulverising to -75µm of 300 to 500g splits of all chip samples, which was carried out by SESL.

Sample intervals for cored drill holes DU150C and DU206C were selected by MBGS geologists in conjunction with EGi. Sample collection was arranged by MBGS, and EGi arranged sample preparation, which was carried out by ACTest in Newcastle. Sample preparation involved crushing each sample to -4mm, and pulverising 300 to 500g splits to -75µm.

The core samples collected provide the best representation of the intervals sampled. The chip samples are less representative and sample quality could be improved through use of splitters for sub-sampling and compositing, and better designed sampling trays, which should be considered for future work. However, the samples collected are expected to be sufficiently representative to provide an overall indication of the relative ARD potential of overburden and floor materials for the Project.

In addition to the above samples, a line of 10 blast holes (Holes 1 to 10) was drilled across the full Weismantel Seam overburden to be mined just north of the DCM operations. The westernmost blast hole (i.e. Hole 7) intercepted the weathered Weismantel Seam close to surface, and was continued to 5m depth. The 0m to 5m interval was collected from the sample cone in a cross-section representing the horizontal and vertical extent of the cone to reduce the chance of sample bias. The remaining 9 blast holes were drilled to 25m, with the interval 0m to 7m cleared from the collar after drilling to remove the weathered portion, and the 7m to 25m interval collected from the sample cone in the same way as Hole 7. The resulting samples represent a series of holes sampling fresh overburden across the full pit extent. Note that the stratigraphy of the blast hole samples do not completely overlap, but testing of these samples provides an indication of whether there are likely to be any significant potentially acid forming (PAF) horizons in the Weismantel Seam overburden apart from that previously identified immediately above the Weismantel Seam (EGi, 1996).

I5.0 Test Methodology

Various analytical programs have been conducted for each of the drilling programs conducted to date (Section I4). A summary of the analytical programs is provided below.

Drill Hole	$pH_{1:2}$	$EC_{1:2}$	Acid-Base Analysis					NAG Test		
			Total S (%)	MPA	ANC	NAPP	ANC/ MPA	NAG_{pH}	NAG (pH 4.5)	NAG (pH 7.0)
2006 Drilling Program										
DU020C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
WC216C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2007 Drilling Program										
DU072C	-	-	✓	✓	-	-	-	✓	✓	✓
DU083C	-	-	✓	✓	-	-	-	✓	✓	✓
DU090R	-	-	✓	✓	-	-	-	✓	✓	✓
DU092R	-	-	✓	✓	-	-	-	✓	✓	✓
WC217AC	-	-	✓	✓	-	-	-	✓	✓	✓
2009 Drilling Program										
DU109R	-	-	✓	✓	✓	✓	✓	✓	✓	✓
DU126R	-	-	✓	✓	✓	✓	✓	✓	✓	✓
DU165R	-	-	✓	✓	✓	✓	✓	✓	✓	✓
DU150C	-	-	✓	✓	✓	✓	✓	✓	✓	✓
DU206C			✓	✓	✓	✓	✓	✓	✓	✓
Blast Holes 1 to 10			✓	✓	✓	✓	✓	✓	✓	✓

Key:

$pH_{1:2}$	pH of 1:2 extract	NAPP	Net Acid Producing Potential
$EC_{1:2}$	Electrical Conductivity of 1:2 extract	$NAG_{(pH\ 4.5)}$	Net Acid Generation capacity to pH 4.5
MPA	Maximum Potential Acidity	$NAG_{(pH\ 7.0)}$	Net Acid Generation capacity to pH 7.0
ANC	Acid Neutralising Capacity	NAG_{pH}	pH of NAG liquor

Selected samples from drill holes DU020C and WC216C were subjected to specialised testing to help resolve uncertainties in classification, including sequential NAG, kinetic NAG, acid buffering characteristic curves (ABCC), and multi-element testing of solids and water extracts.

This specialised testing indicated that total sulphur (S) and single addition NAG testing could be used for routine ARD screening. DU072C, DU083C, DU090R, DU092R and WC217AC were drilled to provide infill data, and hence testing of samples from these drill holes was restricted to total S and single addition NAG.

Total S assays were carried out by SESL. Multi-element analyses were carried out by Genalysis Pty Ltd (Perth). All other analyses were carried out by EGi.

A general description of ARD tests and their use is included in Attachment I-A.

I6.0 Standard Geochemical Characterisation Results

Tables I-1 and I-2 compile the acid forming characteristics of Clareval Seam and Weismantel Seam drill holes, respectively, tested as part of the drilling programmes described in Section I4. Table I-3 compiles results of geochemical characterisation of the Weismantel Seam holes tested for the 1996 EIS geochemical assessment (EGi, 1996).

I6.1 pH and EC

The $pH_{1:2}$ and $EC_{1:2}$ results were determined by equilibrating the sample in deionised water for approximately 16 hours at a solid to water ratio of 1:2 (w/w). This gives an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste rock emplacement area.

The $pH_{1:2}$ values ranged from 3.0 to 9.1, with most samples (approximately 75%) showing no inherent acidity having a pH greater than 6. Six of the samples tested had an acidic pH of less than 4.0.

$EC_{1:2}$ values ranged from 0.08 to 1.41 deci-siemens per metre (dS/m) with most samples (approximately 75%) falling within the non-saline to slightly saline range having an EC of less than 0.8 dS/m[2]. The remaining samples fell within the moderately saline range (0.8 to 1.6 dS/m).

Figure I-6 is a plot of $pH_{1:2}$ and $EC_{1:2}$ versus total S, which shows that the lower $pH_{1:2}$ values and, to a lesser extent, the higher $EC_{1:2}$ values are generally associated with higher S samples. This indicates that lower $pH_{1:2}$ and higher $EC_{1:2}$ values are the result of partial pyrite oxidation occurring between sample collection and sample testing.

Results indicate a general lack of immediately available acidity and salinity in the samples except where due to partial oxidation of pyrite. Pyrite oxidation would therefore be the main source of salinity in overburden materials.

I6.2 Acid Base (NAPP) Results

Total S ranges from 0.01%S to 12.70%S. Figure I-7 is a box plot of the distribution of S split by sample set (i.e. Clareval Seam, Weismantel Seam tested in the 1996 EIS, and proposed Weismantel Seam areas). The plot shows that overburden and floor rock samples for all three data sets show a similar S distribution, with the Clareval Seam samples have slightly lower S overall than the two Weismantel Seam sample sets.

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[2] Salinity criteria adapted from Richards, LA., (ed) (1954), *Diagnosis and Improvement of Saline and Alkaline Soils*, USDA Handbook No. 60, Washington DC.

Results indicate that the overall pyrite distribution in overburden and floor from the Weismantel Extension open pit does not vary significantly from that in the current DCM operations (as represented by the Weismantel Seam drill holes in the 1996 EIS geochemical assessment), and that the Clareval North West open pit may be slightly less pyritic overall.

ANC ranges up to 210 kilograms of sulphuric acid per tonne (kg H_2SO_4/t). Figure I-8 is a box plot of the distribution of ANC split by sample set, which again shows the overall ANC distribution is similar in all three sample sets, with the Clareval Seam set showing a slightly higher median.

The NAPP value is an acid-base account calculation using measured total S and ANC values. It represents the balance between the MPA and ANC. A negative NAPP value indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, a positive NAPP value indicates that the material may be acid generating.

Figure I-9 is an acid-base account plot of ANC verses total S, split by sample set. Figure I-10 is the same acid-base account plot as Figure I-9, but re-scaled to better represent total S below 3%S and ANC below 100kg H_2SO_4/t. The NAPP zero line is shown which defines the NAPP positive and NAPP negative domains.

Figures I-9 and I-10 show a broad scatter of S and ANC values for all three sample sets, with many of the higher S values (>1%S) having moderate to high ANC values (>20kg H_2SO_4/t), and indicate a similar geochemistry in the overburden and floor rock for the existing DCM operations and the Project. The geochemical similarity of the two Weismantel Seam data sets indicates that the findings from 1996 geochemical assessment for the existing DCM operations (EGi, 1996) would apply to the overburden and floor materials in the Weismantel Extension open pit.

I6.3 Single Addition NAG Results

Generally a NAGpH value greater than or equal to 4.5 indicates a sample is unlikely to be net acid generating, and 56% of samples have NAGpH values greater than 4.5.

NAG test results are used in conjunction with NAPP values to classify samples according to acid forming potential. Figure I-11 is an ARD classification plot showing NAGpH versus NAPP value, with results split according to sample set. Figure I-12 is the same ARD classification plot rescaled to better represent the NAPP range from -100 to 100kg H_2SO_4/t. PAF, non-acid forming (NAF) and uncertain (UC) classification domains are indicated. A sample is classified PAF when it has a positive NAPP and NAGpH < 4.5, and NAF when it has a negative NAPP and NAGpH ≥ 4.5. Samples are classified uncertain when there is an apparent conflict between the NAPP and NAG results, i.e. when the NAPP is positive and NAGpH ≥ 4.5, or when the NAPP is negative and NAGpH < 4.5.

Figures I-11 and I-12 show that most samples have consistent NAPP and NAGpH results, plotting in either the PAF or NAF domain, but some samples plot in the upper right and lower left uncertain domains.

A total of 45 samples plot in the upper right uncertain domain. Eighteen of these samples have low total S values of less than or equal to 0.5%S, and in these cases the NAG test would normally account for all pyritic S in the sample, and these samples are expected to be NAF in accordance with the NAG results. The remaining samples have moderate to high ANC and total S greater than 0.5%S, and in these cases pyrite oxidation may not be complete in the single addition NAG test. Sequential NAG and ABCC testing was carried out to help resolve the uncertainty in these samples.

Nine samples plot in the bottom left hand uncertain domain, with slightly acidic NAGpH values of 2.7 to 4.3 and NAPP values of 0 and -20kg H_2SO_4/t. One of these samples has a very low total S of 0.02%S, and is classified NAF since it is unlikely to result in low pH. The remaining samples are expected to be PAF in accordance with NAG results, and it is likely that the ANC is partly poorly available, causing underestimation of the acid potential in the NAPP result.

I7.0 Specialised Geochemical Characterisation Results

I7.1 Acid Buffering Characteristic Curve (ABCC) Testing

An ABCC profile is produced by slow titration of a sample with acid, and provides an indication of the relative reactivity of the ANC measured. The acid buffering of a sample to pH 4 can be used as an estimate of the proportion of readily available ANC. ABCC tests were carried out on 19 selected samples to evaluate the availability of the ANC measured. Results are presented in Figures I-13 to I-19, with calcite, dolomite, ferroan dolomite and siderite standard curves as reference. Calcite and dolomite readily dissolve in acid and exhibit strongly buffered pH curves in the ABCC test, rapidly dropping once the ANC value is reached. The siderite standard provides very poor acid buffering, exhibiting a very steep pH curve in the ABCC test. Ferroan dolomite is between siderite and dolomite in acid buffering availability.

Thirteen of the 19 samples have ABCC curves that plot close to dolomite and calcite standard trends, indicating reactive ANC with 80% or more of the total ANC measured readily available.

The curves for samples 31518 (Figures I-13), 31512 (Figure I-15) and 31511 (Figure I-17) plot close to the ferroan dolomite standard trends, indicating neutralising carbonates are slowly reactive, and that 40 to 70% of the total ANC measured is readily available.

Samples 39008 (Figure I-14), 31525 (Figure I-15) and 37831 (Figure I-17) have ABCC curves that plot between the dolomite and ferroan dolomite standard trends, indicating that the ANC is more reactive and that over 70% of the total ANC measured is readily available.

Overall, ABCC results suggest that the acid buffering minerals within the samples tested are generally reactive, and that the ANC would be mainly effective.

I7.2 Sequential NAG Testing

When testing samples with high sulphide contents it is common for oxidation to be incomplete in the single addition NAG test. Sequential NAG testing overcomes this limitation to an extent through successive additions of peroxide to the same sample. Sequential NAG testing of up to 5 stages was carried out on 16 selected samples with total S greater than 1%S and moderate ANC values of 22 to 59kg H_2SO_4/t to help resolve uncertainties in ARD classification. Results are presented in Table I-4.

Sample 39140 had high S of 3.29%S, moderate ANC of 51kg H_2SO_4/t, a high positive NAPP of 50 H_2SO_4/t and a single addition NAGpH value of 7.5. Sequential NAG testing was carried out to check whether additional stages of NAG testing would result in acid production. Table I-4 shows that although the first stage NAGpH was greater than 4.5, successive stages resulted in acid generation, confirming this sample is likely to be acid forming, consistent with the NAPP results.

Twelve samples have single addition NAGpH values greater than 4.5 and slightly negative or positive NAPP values (-10 to 9kg H_2SO_4/t). None of these samples produced acid in successive sequential NAG stages and these samples are expected to be NAF, consistent with single addition NAG test results.

Sample 38994 had a negative NAPP of -8kg H_2SO_4/t but a marginally acidic single addition NAGpH value of 4.2. Sequential NAG testing confirms only minor acid release from this sample after 5 stages, and this sample is expected to be PAF with low capacity.

Samples 39008 and 37833 had moderate NAPP values of 22 and 18kg H_2SO_4/t, respectively, but only low capacities of less than 5kg H_2SO_4/t in single addition NAG testing. Sequential NAG testing confirmed these samples produced only low acidity after 5 stages, confirming the low capacity classification indicated by the single addition NAG testing.

Results confirm that single addition NAG testing is a reliable indication of acid forming potential. Only one exception occurred (sample 39140) in which the single addition NAGpH was greater than 4.5, but acid was produced after the first stage of the sequential NAG test. Note that this only appears to affect high S samples with greater than 2%S, and in most cases samples with greater than 2%S in the dataset have a consistent NAG and NAPP PAF classification.

I7.3 Kinetic NAG Testing

Kinetic NAG tests provide an indication of the kinetics of sulphide oxidation and acid generation for a sample. Figures I-20 to I-32 present kinetic NAG test results for 13 selected samples with S values greater than 0.8%S, including results for 8 samples from the 1996 EIS geochemical assessment (EGi, 1996).

Samples 4025, 4034, 4041, 4167, 4052, 4053, 31518, 31521, 31512 and 31591 are PAF samples, and the kinetic NAG profiles (Figures I-20 to I-22, I-24 to I-26, I-28, I-29, I-31, and I-32) show a rapid pH decrease with time, reaching pH 4 in 10 minutes or less, indicating short lag times of less than 1 to 2 months before materials would generate acid under atmospheric oxidation conditions. Sample 4168 (Figure I-27) is also classified PAF but takes longer to reach pH 4, indicating a longer lag of 6 to 12 months.

Samples 4050 and 31526 are NAF samples, and the pH profiles (Figures I-23 and I-30) confirm strong buffering of acid for the duration of the test.

Typically, there would be a distinct temperature peak of greater than 50 degrees Celsius (°C) in the kinetic NAG profile for samples with pyritic S greater than 0.7%S. However, the kinetic NAG profiles for PAF samples 4168 (Figure I-27), 31518 (Figure I-28) and 31521 (Figure I-29) do not show any significant temperature peak, despite total S values of up to 1.40%S. This indicates that a proportion of the total S measured in these samples is likely to be in non-pyrite form or as a less reactive sulphide, and hence the NAPP values may overestimate the acid potential.

Overall, results indicate that PAF overburden and floor materials represented by these samples are likely to produce acid in a short time frame (less than 2 months) after exposure to atmospheric oxidation. This was confirmed with leach column testing (see Section I7.5).

I7.4 Multi-Elements of Solids and Water Extracts

A total of 15 waste rock sample solids were analysed for multi-elements, including 10 samples from the 1996 EIS geochemical assessment (EGi, 1996). Samples represent low S and high S overburden and high S floor rock samples. Three of the samples are Clareval Seam overburden and the rest are Weismantel Seam overburden and floor rock samples. Results of multi-element scans were compared to the median soil abundance (from Bowen, 1979) to highlight enriched elements.

The extent of enrichment is reported as the Geochemical Abundance Index (GAI), which relates the actual concentration with an average abundance on a log 2 scale. The GAI is expressed in integer increments where a GAI of 0 indicates the element is present at a concentration similar to, or less than, average abundance; and a GAI of 6 indicates approximately a 100-fold enrichment above average abundance. As a general rule, a GAI of 3 or greater signifies enrichment that warrants further examination.

Results of multi-element analysis are presented in Table I-5 and the corresponding GAI values are presented in Table I-6. Results show that there is no significant enrichment of metals or metaloids in the solids apart from S, which is already discussed above in the context of acid forming potential.

The same 15 samples were subjected to deionised water extraction at a solids:liquor ratio of 1:2, and the resulting liquors were analysed for multi-elements. Due to the highly reactive nature of the pyrite in these types of sedimentary materials, it was expected that partial pyrite oxidation would have occurred between sample collection and testing, generating ARD products. The water extracts would therefore provide some indication of the constituents likely to be immediately liberated if these materials are exposed to atmospheric conditions. The compositions of the 15 water extractions are given in Table I-7. The total S content of the solid for each sample is also provided to assist comparison of water extract results between samples.

Samples 31513, 31591 and 4167 have water extract pH values below 4 and have high S (8.7%, 2.2% and 4.5%S, respectively). The chemistry of the water extracts for these low pH samples show that pyrite oxidation and acid release is likely to be accompanied by release of elevated concentrations of aluminium (Al), cobalt (Co), iron (Fe), manganese (Mn), nickel (Ni) and zinc (Zn). The solubility of these elements is largely determined by pH and therefore control of acid generation would effectively control metal leaching.

The bulk chemistry of most samples is dominated by sulphate (SO_4), indicating that salinity from materials represented by these samples would be controlled by pyrite oxidation and sulphate generation. Hence controlling pyrite oxidation would also control salinity.

Results suggest that materials represented by these samples have no significant elemental enrichment apart from S, but would mobilise elevated concentrations of metals at low pH.

I7.5 Summary of Leach Column Testing on 1996 EIS Samples

Leach column and surface drainage lysimeter investigations were carried out by EGi for the DCM to evaluate the sulphide oxidation kinetics and leachate geochemistry of Weismantel Seam overburden and floor materials. Columns and lysimeters treated with limestone were included in the work to determine appropriate rates of treatment required in the field for operational control of ARD and associated contaminants from exposed floor rock and PAF overburden. In addition, column testing of a low capacity PAF (PAF-LC) overburden blended with NAF overburden was carried out to determine the appropriate mixing ratio required to generate net pH neutral leachate. This work partly contributed to the 1996 EIS geochemical assessment (EGi, 1996), but many of the leaching tests operated beyond 1996 to confirm continuation of geochemical trends and duration of lag times in PAF samples blended with limestone and NAF overburden.

These investigations formed the basis of designing the ARD geochemical controls currently being implemented at the DCM. The tests were initiated in December 1995, and the last column (OB-2) was terminated in August 2003. The results of leach testing for the lysimeters and columns were previously reported by EGi between 1996 and 2004 (EGi, 1996, 1998, 1999, 2000, 2001, 2003 and 2004).

Geochemical testing by EGi identified (EGi, 1996) three main PAF units in the Weismantel Seam sequence as follows:

- High capacity fast reacting PAF materials in overburden within 4 to 6m of the coal seam roof;
- High capacity PAF materials in coal seam floor rock material; and
- Lower capacity discontinuous PAF materials in the upper (5 to 20m) portion of the overburden.

The relative amounts of PAF and NAF overburden based on preliminary modelling for the current DCM operations (DCLP, 2002) was 11% PAF and 89% NAF (including topsoil, clay and fresh rock).

Figure I-33 is a plot of the pH profiles for leach column testing of untreated (as received) samples of NAF overburden and PAF overburden, and surface drainage lysimeter testing of PAF floor rock. The results confirmed that the NAF overburden was non acid producing, and that all PAF samples were acid producing. All of the PAF samples had low ANC (3 kg H_2SO_4/t) and were quick to react, producing acid leachate in the first collection. The rapid reaction times of the PAF materials showed that acid neutralisation would be required during operations to manage mine water quality. Leach column experiments also showed that dissolved sulphate (SO_4), calcium (Ca), magnesium (Mg), Al, Fe, Mn and Zn are likely to be the main contaminants expected from acid producing materials, and that control of metal release is likely to require maintenance of a pH not less than 4 within the waste rock disposal area. Leach column testing also confirmed that salinity from these materials would mainly be related to SO_4 generation through oxidation of pyrite, rather than any inherent salinity stored in the rock materials, consistent with results of water extracts discussed in Section I7.4.

To better assess the operational treatment controls required for PAF samples, duplicate columns and surface drainage lysimeters of PAF materials were treated with varying rates of limestone addition. The objectives of the treatment were to reduce release rates of acid and salinity (mainly as SO_4).

Figure I-34 is a plot of pH and Figure I-35 is a plot of SO_4 concentration for PAF overburden at various treatment rates and size fractions. The plots show that treatment with -4mm crushed limestone did not offer any significant buffering, even at high rates of 100 kilograms of calcium carbonate per tonne (kg $CaCO_3$/t). The pulverised limestone added at 10 and 20kg $CaCO_3$/t shows minor buffering, but did not prevent high rates of SO_4 release. Addition of -1mm limestone at a rate of 40kg $CaCO_3$/t increased the pH by 1 to 2 units compared to the untreated sample, and significantly reduced the SO_4 concentrations, particularly in the first 40 weeks of column operation. Results indicated that treatment of roof rock with -1mm limestone at a rate of 40kg $CaCO_3$/t would be sufficient for short-term control of pH and sulphate release.

Figure I-36 is a plot of pH trends for untreated and limestone treated PAF floor surface drainage lysimeters. The plot shows that addition of -1mm limestone at a rate of 20 tonnes $CaCO_3$ per hectare (t $CaCO_3$/ha) was sufficient to provide control of pH from pyritic floor materials.

Figure I-37 is a plot of the pH trend for column OB-2, made up of 2 parts PAF-LC overburden blended with 1 part NAF overburden. The objective of the column was to confirm that blending at this minimum ratio would be sufficient to control pH into the long term. Results show that the blending ratio was sufficient to maintain near neutral pH values after 7.5 years, and testing of the leached solid showed that the material was expected to be NAF into the long term.

Leach column work indicated the following treatment rates for controlling ARD (pH and contaminant loadings) during operations:

- Roof rock should be treated with -1mm limestone at 20t $CaCO_3$/ha for general use and up to 40kg $CaCO_3$/t incorporated into the exposed surface if required.
- Floor rock should be treated with -1mm limestone at 20t $CaCO_3$/ha.

Testing identified discontinuous PAF-LC material within the overburden. Column testing showed that as long as PAF-LC material was blended at a ratio of not less than 2:1 with NAF overburden, long term ARD control would be achieved. It was expected that this blending would occur during normal mining practice.

I8.0 Sample Classification and Distribution of ARD Rock Types

ARD classification of samples shown in Tables I-1 to I-3 was carried out based on the testing discussed above as follows:

Non-Acid Forming (NAF)

- Total S ≤ 0.05% (due to the very low risk of acid formation from these samples); or
- NAPP ≤ 0kg H_2SO_4/t and NAGpH ≥ 4.5; or
- NAGpH ≥ 4.5 and S ≤ 0.5% (since NAG testing accounts for pyritic S of at least 0.5%S).

Potentially Acid Forming (PAF)

- NAGpH < 4.5.

Potentially Acid Forming - Lower Capacity (PAF-LC)

- PAF samples with NAG acidities to pH 4.5 ≤ 5 kg H_2SO_4/t.

Uncertain expected to be NAF (UC(NAF))

- NAPP > 0kg H_2SO_4/t and NAGpH ≥ 4.5 and total S <2.0%S; or
- No ANC testing and NAGpH ≥ 4.5 and total S > 0.5% and <2.0%S; or
- No S testing and NAGpH ≥ 4.5.

Uncertain expected to be PAF (UC(PAF))

- NAPP > 0kg H_2SO_4/t and NAGpH ≥ 4.5 and total S ≥ 2.0%S.

The following shows the approximate breakdown of geochemical rock types based on sample intervals tested to date (not taking spatial distribution or mining blocks into account):

Material Type	PAF inc. UC(PAF)	PAF-LC	NAF inc. UC(NAF)
Clareval Seam Overburden	28%	19%	53%
Clareval Seam Floor	0%	20%	80%
Weismantel Seam Overburden	12%	9%	79%
Weismantel Seam Floor	71%	8%	21%

The results indicate that:

- Weismantel Seam overburden is likely to be mostly NAF;
- Weismantel Seam floor is likely to be mostly PAF;
- Clareval Seam overburden is likely to include a greater proportion of PAF/PAF-LC than Weismantel Seam overburden; and
- Clareval Seam floor is likely to be mostly NAF.

Figure I-38 is a plot of NAGpH profiles for Weismantel Seam drill holes from the Weismantel Extension open pit and selected deeper 1996 EIS geochemical assessment holes to the south from the existing DCM operations. PAF and PAF-LC samples are shown as red symbols, and approximate zones of NAF and PAF are shown with blue and red shading, respectively. The holes are aligned according to the Weismantel Seam and are ordered approximately north to south from left to right. The distribution of PAF and NAF between holes is consistent, with a distinct PAF zone above and below the Weismantel Seam, a broader NAF zone above, and including a PAF-LC zone in the upper part of some of the holes. The upper untested portion of the 1996 EIS geochemical assessment holes is likely to comprise mainly weathered rock, which is expected to be NAF. Note that earlier geochemical testing showed that normal operational blending of the PAF-LC overburden with NAF overburden should result in long term ARD control (Section I7.5).

Results from the 1996 EIS geochemical assessment holes (Table I-3) provide a good representation of the full Weismantel Seam overburden to be mined, and suggest the PAF zone above the coal seam and overlying thicker NAF zone are continuous and predictable. Results from drilling in the Weismantel Extension Pit (DU206C and WC216C) suggest continuation of these trends, although the full overburden thickness is not represented.

A line of 10 blast holes was drilled into fresh overburden in the northern part of the current DCM to supplement the information from the two drill holes in the proposed Weismantel Extension open pit. The blast holes were drilled from the Weismantel Seam sub-crop (Hole 7) to the east to sample fresh overburden across the full open pit extent to Hole 8 (Figure I-4). Results in Table I-2 show that it is only the overburden sample in Hole 6 that was PAF, with the rest NAF except for a PAF-LC sample in the upper part of the overburden represented by hole 9. Although the blast hole samples do not completely stratigraphically overlap, the trends identified are consistent with those in the 1996 EIS geochemical assessment, and suggest continuity of the PAF, NAF and PAF-LC horizons to the north.

Figure I-39 is a plot of NAGpH profiles for Clareval Seam drill holes. The drill holes are again aligned according to seam and are ordered approximately north to south from left to right. Holes DU109R, DU126R and DU165R overlap to represent most of the overburden stratigraphy likely to be mined above the Clareval Seam.

Results for the Clareval Seam drill holes demonstrate that the upper strongly weathered zone is likely to be a consistent and laterally continuous source of NAF materials, and that there are likely to be broad zones of NAF amenable to selective mining and handling. The Clareval Seam floor also appears to be mainly NAF. The Clareval Seam overburden appears to include a greater thickness of PAF than the Weismantel Seam overburden, with multiple PAF horizons. The distribution and continuity of NAF and PAF horizons in the Clareval Seam overburden is also less clear than for the Weismantel Seam overburden. Some of the drill holes tested (DU109R, DU126R and DU090R) were sampled at 1m intervals and blended into relatively coarse sample intervals of 6m or more in the field, and some of the apparent discontinuities may be the result of the sampling method used. Infill drilling and more detailed sampling may better define the distribution of the NAF and PAF zones. In summary, results indicate the following in regard to the Clareval Seam overburden and floor rock:

- strongly weathered overburden is likely to have low pyrite content and be NAF;
- all overburden below the depth of strong weathering is likely to be pyritic, and about half is expected to be NAF and half PAF/PAF-LC, occurring in multiple horizons;
- the occurrence of NAF is generally due to the presence of moderate to high ANC rather than low pyritic S;
- the immediate roof within a few metres of the Clareval Seam is likely to be PAF and strongly pyritic and reactive; and
- Clareval Seam floor appears to be mainly NAF.

I9.0 Current DCM ARD Management and Performance Monitoring

Management of PAF materials at the DCM is currently conducted in accordance with the *Potentially Acid Forming Material Management Plan* (DCPL, 2003). The main objectives of the ARD management strategies currently implemented at the DCM are to control the release of acid, salinity (as SO_4) and other associated contaminants during operations and into the long term. The main components of ARD management at the DCM are described in the following sub-sections, split into long-term controls and operational controls.

I9.1 Long-Term Controls

Long term control of ARD from overburden and floor rock is focused on reducing the rate of acid generation by inhibiting oxygen diffusion into PAF materials. For in pit dumping, this is achieved by placing PAF materials below the final recovered post-mining water table level. The predicted water table recovery level in the pit is approximately relative level (RL) 55m. PAF materials are currently being conservatively placed below RL40m. These materials would become fully covered by water, providing an effective and secure barrier to oxygen diffusion.

In the initial stages of developing the DCM it was not possible to place PAF materials below the water table until sufficient pit space became available. In the interim an out of pit PAF cell was used to contain PAF materials. The PAF cell construction involved compaction of the in situ clay floor, placement of PAF overburden in 4m lifts (with limestone treatment of each lift surface at a rate of 20t $CaCO_3$/ha), and covering of PAF overburden with a traffic compacted 10m NAF layer comprising mainly clay and around 10% NAF overburden.

The planned permanent in pit inundation of the bulk of the PAF material for the DCM is an established and effective means of reducing pyrite oxidation and acid generation to negligible rates. Since the dumped overburden would not be inundated for many years, operational controls are required to manage ARD in the interim to prevent accumulation of ARD products in the dump and potential mobilisation during inundation.

A key component to the success of these long-term controls is the identification and segregation of PAF and NAF overburden types. Currently, PAF materials in Weismantel Seam overburden are assumed to be within a 5m layer above the coal seam, which is based on geochemical testing of 17 holes as part of the 1996 EIS geochemical assessment (EGi, 1996). Review of the EIS geochemical assessment data for this report (see Section I7) indicates this is a reasonable basis, but confirmatory testing and checks are required to check the continuity of the PAF main horizon and confirm the absence of other PAF horizons in the rest of the overburden. In practice at the current DCM operations, it is understood that the amount of space required for the PAF materials is significantly less than the space available, so that materials below RL40m are generally a mix of PAF and NAF materials. However, only overburden materials classified NAF are placed above RL40m.

I9.2 Operational Controls

Operational ARD controls involve limestone ($CaCO_3$) treatment of waste rock dump lifts/faces, limestone treatment of open pit floors, placement of oxygen consuming NAF covers, and water management to minimise contact time with reactive waste rock materials. The purpose of these measures is for interim control of the release of ARD products until the implementation of the long-term controls described above.

The incorporation of limestone into waste rock dump and open pit surfaces was designed to minimise the release of SO_4, metals and acid in the short term to meet irrigation targets, and to help reduce accumulation of ARD products in dumped materials to minimise long term water quality impacts. Target treatment rates were based on EGi test work (see Section I7.5) as follows:

- Limestone (-1mm crushed) treatment of floor rock at 20t $CaCO_3$/ha; and
- Limestone (-1mm crushed) treatment of PAF overburden at 20t $CaCO_3$/ha on exposed PAF waste rock dump lift surfaces.

Limestone is added to all exposed Weismantel floor, all final PAF surfaces at RL40m, and on an opportunity basis for interim PAF waste rock dump lifts. Interim PAF waste rock dump lifts are only treated if they are likely to be exposed for more than a few weeks. The amount of limestone added during operations has been recorded, and the calculated rate of application from June 2008 to June 2009 for the floor is approximately 50t $CaCO_3$/ha. The rate for the final PAF lift at RL40m over the same period is approximately 25t $CaCO_3$/ha. Treatment of interim waste rock dump lifts is carried out the same way as for RL40m, and similar limestone application rates are expected, although harder to quantify.

Geochemical results from the 1996 EIS geochemical assessment (EGi, 1996) showed that although NAF materials would produce neutral leachate, they still contained significant sulphide and would therefore consume oxygen during oxidation of the pyrite. Modelling of oxygen diffusion and consumption indicated that a NAF layer of 10 to 20m over PAF materials would delay oxidation of the PAF layer for at least 30 years. A minimum 20m thick oxygen consuming NAF layer is placed on the PAF materials in the open pit to help control oxidation of the PAF materials until they became fully flooded as part of long term control. The NAF is placed in an advancing face just behind PAF dumping to minimise the exposure of PAF materials (Plate I-7).

Open pit water is promptly removed to the Main Water Dam under normal operations, and pooling of water is minimised, which minimises contact time between water and waste rock. This limits flushing of ARD products and hence reduces acid and sulphate loads. The consequent armouring by secondary products on particle surfaces also lowers the rates of pyrite oxidation.

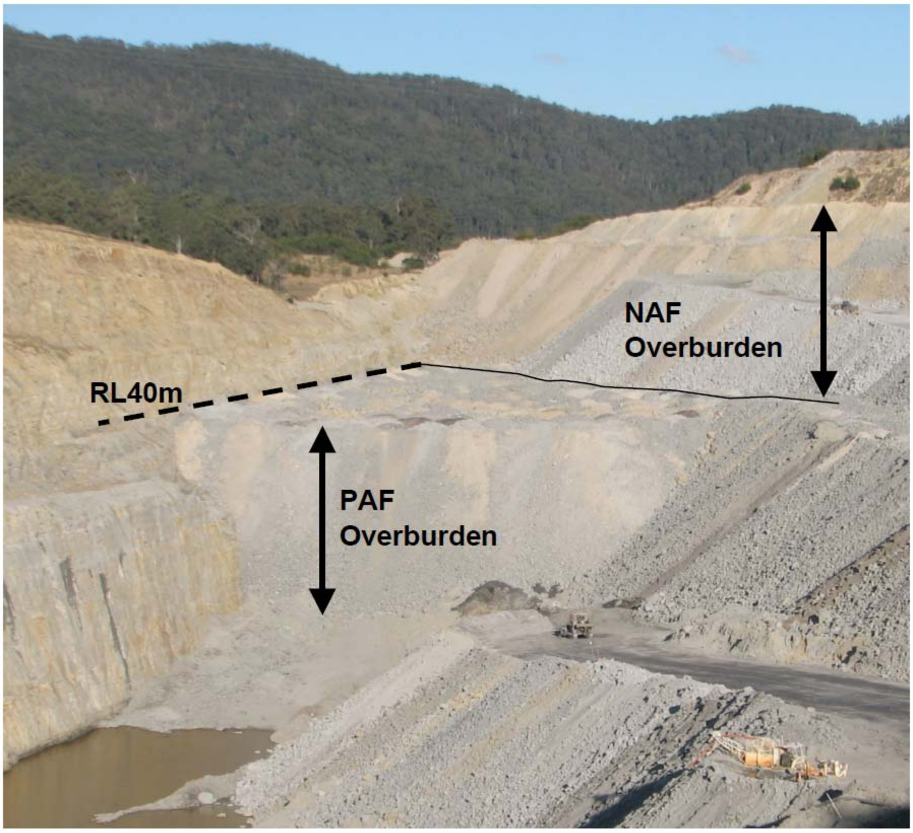

Plate I-7: Overburden management at the existing DCM operations. Shows placement of PAF overburden to RL40 with NAF overburden being dumped over the top.

Open pit sump water quality is monitored on a weekly basis and after rainfall events to check for indications of ARD from the open pit floor and waste rock dumps. Note that the open pit sump is a transient body that moves with open pit development, and does not always contain water.

Figure I-40 is a plot of pH for the open pit sump from the start of mining to date. Results show that in general the pH is circum-neutral at above pH 6, and there are only four values with an acidic pH below 4. Overall results indicate that the operational measures discussed above have been successful in controlling acid release from the open pit floor and waste rock dumps. The few acidic pH values are related to spot sampling of small ponds and shallow pools within PAF rock, which were subsequently treated in situ with limestone.

Figure I-41 is a plot of open pit sump EC monitoring results, which show reasonable consistency, ranging mainly from 2000 to 3000 microSiemens per centimetre (µS/cm). Figure I-42 is a plot of SO_4 and chloride (Cl) concentrations in open pit water, which shows that the EC results are controlled mainly by dissolved sodium chloride (NaCl) and calcium sulphate ($CaSO_4$), with $CaSO_4$ dominant especially from January 2007. These monitoring results support leach column predictions of the importance of pyrite oxidation and sulphate release to salinity (Section I7.5).

The pit water is pumped to the Main Water Dam, and then used for irrigation. To date there has been no need to treat the Main Dam Water. Results of water quality monitoring indicate that the limestone treatment rates, dumping strategies and water management are sufficient for control of pH and salinity during operations.

I10.0 Conclusions and Recommendations

Results of ARD investigations to date indicate that the mine stratigraphic sequence for the Clareval Seam and Weismantel Seam in the Project area would include NAF, PAF and PAF-LC materials. The PAF and PAF-LC materials would have only a short lag before onset of acid generation. The overburden for both seams appears to be pyritic except where it is strongly weathered, and is particularly pyritic within 1 to 2m of the top of both seams. Although pyritic, much of the overburden is NAF due to excess acid buffering. Strongly weathered overburden is likely to be NAF, and partially weathered to fresh overburden may be NAF or PAF depending on the relative abundance of pyrite and acid buffering minerals.

Weismantel Seam overburden appears to be mainly NAF except for a PAF horizon within 5m (perpendicular to bedding) immediately above the coal seam. The Weismantel Seam floor rock is likely to be mainly PAF. Results from the 1996 EIS geochemical assessment (EGi, 1996) suggest the PAF zone above the coal seam, the overlying thicker NAF zone, and the PAF floor rock are continuous and predictable, which is supported by more recent testing and operational experience.

Results for the Clareval Seam holes show that the upper strongly weathered zone is likely to be a consistent and laterally continuous source of NAF materials. Partially weathered to fresh overburden for the Clareval Seam appears to include roughly equal proportions of NAF and PAF/PAF-LC, with some indication of thick NAF horizons that may be amenable to selective mining. Limited testing of the Clareval Seam floor indicates it may be mainly NAF. The continuity and distribution of PAF and NAF horizons for the Clareval overburden is more complex than for the Weismantel Seam, with apparent discontinuities between holes.

Multi-element analysis and leach column testing suggests that materials represented by the samples tested would have no significant elemental enrichment (except for S), but would mobilise significant concentrations of metals and other constituents at low pH. Under neutral pH conditions there would be negligible mobilisation of metals and other constituents. Pyrite oxidation and acid release is likely to be accompanied by release of elevated concentrations of SO_4, Al, Co, Fe, Mn, Ni and Zn.

Results indicate that PAF and NAF materials from Weismantel Seam overburden and Clareval Seam overburden are geochemically similar, and hence the existing management approaches used for Weismantel Seam overburden at the DCM operations (Section I9) are expected to be applicable to Clareval Seam overburden. However, some modifications would be required to account for the greater complexity in the distribution of PAF and NAF in Clareval Seam overburden, and the potential greater volumes of PAF material. A better understanding of the proportion and distribution of PAF and NAF materials is required before management strategies can be finalised, but results to date combined with several years experience of managing ARD at the existing operations is sufficient to outline the overall approach to ARD management. The following are recommended approaches for long term ARD management:

- Placing PAF material below the RL of the water table recovery level should be the first priority for long term ARD management. Currently PAF material is conservatively placed below RL40m, which is below the groundwater table recovery level of RL55m predicted in the 1996 EIS. It is understood that the groundwater table recovery level for the Project would be higher than RL55m (Heritage Computing, 2009). Accordingly, the PAF placement level could be raised to increase the dumping capacity.
- If the amount of PAF overburden exceeds the disposal level RL, long term control for the excess material would need to rely on control of infiltration and oxygen diffusion through placement of PAF materials below a designed cover system. The details of the design would require assessment of the hydraulic and physical properties of the various mine materials in conjunction with local climate controls to determine the type of cover system that is appropriate.
- All PAF overburden should be disposed in pit. If any ex-pit dumping is required only NAF material should be used.

- Reliable segregation of PAF and NAF overburden is key to operational and long term ARD control. Segregation of PAF and NAF overburden for the Weismantel Extension open pit is likely to require continuation of existing procedures, involving selective mining and handling of the PAF horizon immediately above the Weismantel Coal Seam. Segregation of NAF and PAF in the Clareval Seam overburden would be more complex, with multiple PAF horizons and possible lateral discontinuities. Additional testing would be required to define the distribution and continuity of NAF and PAF horizons in the Clareval Seam overburden. Segregation of Clareval Seam overburden should focus on extraction of well defined NAF horizons for placement above the final water table recovery level and for use in construction of surface structures. Mixed PAF and NAF that are not readily separated during mining would need to be managed as PAF.

Performance monitoring of the operational controls currently being carried out at the DCM indicate that these would be suitable for the Project, with some modifications as follows:

- Limestone treatment should be carried out on exposed Weismantel Seam floor rock, all final PAF overburden lift surfaces, and interim PAF waste rock dump surfaces likely to be exposed for more than 3 weeks. Limestone application rates should be at least 20t $CaCO_3$/ha and averaging close to 50t $CaCO_3$/ha using current procedures. Limestone treatment of Clareval Seam floor may not be necessary pending further testing and operational monitoring.
- The immediate 1 to 2m above the Weismantel and Clareval Seams appear to be high capacity PAF and likely to be fast reacting, and hence coal cleanings may require special handling and limestone treatment to prevent ARD during operations.
- Due to the expected larger proportion and production of PAF materials in the Clareval overburden, alternative waste rock handling techniques should be considered, e.g. paddock dump and traffic compact PAF material in lifts of 5m or less to minimise the risk of accelerated oxidation through convection.
- Continue placement of at least 20m of NAF overburden over PAF materials to provide an oxygen consuming barrier to help control oxidation of PAF materials. As per current practice, the NAF cover placement should follow closely behind the advancing PAF waste rock dump face to minimise the exposure time of PAF materials.
- Continue prompt removal of water from pit sump and shape dumped materials to minimise infiltration into PAF, and ensure there is site capability for treatment (i.e. neutralisation with hydrated lime or limestone) of open pit water if acid generation occurs.

In addition to the above, routine monitoring across the site should be carried out to provide checks on materials management and effects of ARD as follows:

- A programme of routine sampling and geochemical testing of overburden materials from both seams is recommended during operations to monitor variation in acid potential and to reconcile the predicted distribution of ARD rock types in overburden.
- Water quality monitoring of seepage and runoff from pit surfaces and waste rock dumps should be continued to check for ARD generation, assess the performance of management strategies, and determine and/or refine limestone treatment requirements.
- Routine site water quality monitoring programmes should be continued and include pH, EC, acidity/alkalinity, SO_4, Al, Co, Fe, Mn, Ni, Zn and storage volumes and flows to monitor the performance of the ARD control programme.

The sampling and testing programme conducted in this assessment together with operational experience at the existing DCM was sufficient to provide an overall indication of the relative ARD potential of overburden and floor materials for the Project. However, a more intensive sampling is required to provide more accurate information for PAF materials management, particularly as results to date for the Clareval Seam overburden show greater complexity than Weismantel Seam overburden. The following work is recommended:

- Additional testing of drillholes in the Project area should be conducted for both Weismantel and Clareval Seam overburden and floor to model the distribution of NAF and PAF materials. Future sampling of open hole chip samples should be modified to better represent the interval drilled, which would improve data quality and assist correlation of NAF and PAF horizons between holes.
- Testing of drillhole samples in the Weismantel Extension Pit should be conducted to check the continuity of PAF and NAF horizons identified in the overburden from the 1996 EIS, and confirm the lack of additional PAF horizons. The samples tested should capture the full potential mine stratigraphy including the weathered zone, which has not been represented to date for Weismantel overburden.
- More comprehensive testing of Clareval Seam overburden should be conducted due to the presence of multiple PAF and NAF horizons. Again, the samples tested should to capture the full potential mine stratigraphy, and be collected from sufficient holes to adequately represent the expected variation in geology and geochemistry. Clareval Seam floor should also be tested in more detail to confirm preliminary findings that indicate it may be mainly NAF.
- Analysis of future samples for total S and NAG should be sufficient to identify the main pyritic and PAF horizons, with possible ANC determinations and more detailed testing if required to resolve any uncertainties in sample classification.

- Leach column testing has been previously carried out on Weismantel Seam overburden and floor, but not Clareval Seam materials. Leach column testing may be required to better define the ARD potential, reaction rates and lag times of a variety of Clareval Seam mine materials once these are better defined.

I11.0 References

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Table I-1: Acid forming characteristics of overburden and seam floor samples from Clareval Seam drill holes.

Drill Hole	Depth (m)			EGi Sample No.	Duralie Sample No.	Sample Type	Geological Description	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
	From	To	Interval							Total %S	MPA	ANC	NAPP	ANC /MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
DU020C	0.00	2.00	2.00	31514	1233	Chip	Soil and clay	5.6	0.88	0.01	0	3	-3	9.8	5.7	0	3	NAF
DU020C	2.00	5.00	3.00	31515	1234	Chip	Siltstone, Weathered	5.9	0.77	0.01	0	2	-2	6.5	6.2	0	2	NAF
DU020C	5.00	10.00	5.00	31516	1235	Chip	Siltstone, Weathered	5.4	0.78	0.10	3	3	0	1.0	5.5	0	1	NAF
DU020C	10.00	13.00	3.00	31517	1236	Chip	Sandstone Fine Grain, Slightly Weathered	4.7	1.02	0.33	10	2	8	0.2	3.3	2	4	PAF-LC
DU020C	13.00	18.00	5.00	31518	1237	Chip	Sandstone, Grey Lithic	7.8	0.11	0.81	25	9	16	0.4	2.8	9	11	PAF
DU020C	18.00	23.00	5.00	31519	1238	Chip	Sandstone, Grey Lithic	7.9	0.13	0.65	20	64	-44	3.2	8.8	0	0	NAF
DU020C	23.00	28.00	5.00	31520	1239	Chip	Sandstone, Grey Lithic	8.1	0.23	0.85	26	36	-10	1.4	8.4	0	0	NAF
DU020C	28.00	33.00	5.00	31521	1240	Chip	Sandstone, Grey Lithic	7.2	0.22	1.26	39	30	9	0.8	3.4	2	4	PAF-LC
DU020C	33.00	35.15	2.15	31522	1241	Chip	Sandstone, Grey Lithic	7.1	0.21	1.21	37	40	-3	1.1	5.3	0	1	NAF
DU020C	35.15	39.00	3.85	31523	1242-1245	Core	Sandstone & Siltstone, Grey Lithic	8.3	0.10	0.36	11	31	-20	2.8	4.3	0.02	2	PAF-LC
DU020C	39.00	43.00	4.00	31524	1246-1249	Core	Sandstone & Siltstone, Grey Lithic	7.9	0.09	1.25	38	54	-16	1.4	7.8	0	0	NAF
DU020C	43.00	46.00	3.00	31525	1250, 1137, 1138	Core	Sandstone & Siltstone, Grey Lithic	8.0	0.09	1.33	41	37	4	0.9	4.6	0	1	UC(NAF)
DU020C	46.00	48.00	2.00	31526	1139-1140	Core	Sandstone & Siltstone, Grey Lithic	8.1	0.08	1.38	42	48	-6	1.1	7.9	0	0	NAF
DU020C	48.00	49.00	1.00	31511	1141	Core	Sandstone & Siltstone, Grey Lithic	8.1	0.22	1.55	47	46	1	1.0	4.8	0	2	UC(NAF)
DU020C	49.00	50.00	1.00	31512	1142	Core	Sandstone & Siltstone, Grey Lithic	7.3	0.18	2.81	86	34	52	0.4	2.5	30	35	PAF
DU020C	50.00	50.25	0.25	31513	1143	Core	Sandstone & Siltstone, Grey Lithic	3.7	1.31	8.71	267	0	267	0.0	1.9	153	168	PAF
DU020C	50.25						Clareval Seam											
DU072C	26.40	28.00	1.60	33837	2255	Core	Sandstone, Minor Carbonaceous Laminae			1.50	46				3.6	2	7	PAF-LC
DU072C	28.00	31.00	3.00	33838	2256	Core	Sandstone, Minor Carbonaceous Laminae			1.31	40				7.5	0	0	UC(NAF)
DU072C	31.00	34.00	3.00	33839	2257	Core	Sandstone, Minor Carbonaceous Laminae			1.35	41				3.2	5	12	PAF-LC
DU072C	34.00	37.00	3.00	33840	2258	Core	Sandstone, Minor Carbonaceous Laminae			1.31	40				7.4	0	0	UC(NAF)
DU072C	37.00	39.00	2.00	33841	2259	Core	Sandstone, Minor Carbonaceous Laminae			1.39	43				7.5	0	0	UC(NAF)
DU072C	39.00	40.00	1.00	33842	2260	Core	Sandstone, Minor Carbonaceous Laminae			1.20	37				7.5	0	0	UC(NAF)
DU072C	40.00	41.00	1.00	33843	2261	Core	Sandstone, Minor Carbonaceous Laminae			1.26	39				5.3	0	1	UC(NAF)
DU072C	41.00	42.00	1.00	33844	2262	Core	Sandstone, Minor Carbonaceous Laminae			1.52	47				2.9	15	22	PAF
DU072C	42.00	43.00	1.00	33845	2263	Core	Sandstone, Minor Carbonaceous Laminae			1.21	37				2.9	11	18	PAF
DU072C	43.00	43.85	0.85	33846	2264	Core	Sandstone, Minor Carbonaceous Laminae			5.07	155				2.2	113	133	PAF
DU072C	43.85	99.77	55.92				Clareval Seam											
DU072C	99.77	100.42	0.65	33847	2265	Core	Siltstone, Carbonaceous Wisps, Py on Bedding Plane			0.71	22				7.1	0	0	UC(NAF)
DU072C	100.42	101.50	1.08	33848	2266	Core	Sandstone			0.50	15				7.4	0	0	NAF
DU083C	17.45	19.87	2.42	33849	3923	Core	Sandstone/Siltstone, Minor Coal & Carb Claystone			5.59	171				2.2	115	137	PAF
DU083C	19.87						Clareval Seam											
DU150C	65.60	66.74	1.14	39135	4101	Core	Sandstone Fine Grain, Carb.Claystone at Base (0.03m)			1.52	47	16	31	0.3	3.6	13	25	PAF
DU150C	66.74	69.22	2.48	39136	4102	Core	Sandstone Fine Grain			1.84	56	15	41	0.3	3.2	15	30	PAF
DU150C	69.22	70.87	1.65	39137	4103	Core	Sandstone Fine Grain			1.92	59	22	37	0.4	3.0	15	28	PAF
DU150C	70.87	72.25	1.38	39138	4104	Core	Sandstone Fine Grain			1.60	49	40	9	0.8	7.3	0	0	UC(NAF)
DU150C	72.25	73.83	1.58	39139	4105	Core	Sandstone Fine/Med Grain, Carb.Claystone with Calcite Veins at Base (0.04m)			1.13	35	33	2	1.0	7.4	0	0	UC(NAF)
DU150C	73.83	75.59	1.76	39140	4106	Core	Cheer Up 2 Seam, Pyritic in Places			3.29	101	51	50	0.5	7.5	0	0	UC(PAF)
DU150C	75.59	76.60	1.01	39141	4107	Core	Sandstone Fine Grain, Minor Carb. Claystone, Pyritic in Places			0.58	18	6	12	0.3	3.0	9	16	PAF
DU150C	76.60	78.25	1.65	39142	4108	Core	Sandstone Fine Grain			0.15	5	12	-7	2.6	6.2	0	1	NAF
DU150C	78.25	79.87	1.62	39143	4109	Core	Sandstone Fine Grain, Rare Calcite			0.35	11	6	5	0.6	4.2	0.4	7	PAF-LC
DU150C	79.87	81.29	1.42	39144	4110	Core	Sandstone Fine Grain, Bioturbation			0.40	12	5	7	0.4	4.1	1	7	PAF-LC
DU150C	81.29	84.30	3.01	39145	4111	Core	Sandstone Fine Grain			0.27	8	11	-3	1.3	5.3	0	2	NAF
DU150C	84.30	85.59	1.29	39146	4112	Core	Sandstone Fine Grain			0.10	3	15	-12	4.9	7.2	0	0	NAF
DU150C	85.59	85.81	0.22	39147	4113	Core	Conglomerate			0.29	9	29	-20	3.3	6.9	0	0	NAF
DU150C	85.81	87.25	1.44	39148	4114	Core	Sandstone Fine Grain			0.31	9	12	-3	1.3	5.4	0	1	NAF
DU150C	87.25	88.98	1.73	39149	4115	Core	Sandstone Fine Grain			0.31	9	20	-11	2.1	6.9	0	0	NAF
DU150C	88.98	89.20	0.22	39150	4116	Core	Sandstone Fine/Med Grain			0.69	21	18	3	0.9	4.6	0	4	UC(NAF)
DU150C	89.20	90.30	1.10	39151	4117	Core	Sandstone Fine Grain			0.50	15	14	1	0.9	4.7	0	2	UC(NAF)
DU150C	90.30	93.29	2.99	39152	4118	Core	Sandstone Fine Grain			0.44	13	15	-2	1.1	5.6	0	1	NAF
DU150C	93.29	96.24	2.95	39153	4119	Core	Sandstone Fine Grain			0.44	13	51	-38	3.8	7.5	0	0	NAF
DU150C	96.24	99.29	3.05	39154	4120	Core	Sandstone Fine Grain			0.61	19	54	-35	2.9	7.4	0	0	NAF
DU150C	99.29	102.27	2.98	39155	4121	Core	Sandstone Fine Grain			0.69	21	23	-2	1.1	7.1	0	0	NAF
DU150C	102.27	105.25	2.98	39156	4122	Core	Sandstone Fine Grain			0.46	14	64	-50	4.5	7.4	0	0	NAF
DU150C	105.25	108.25	3.00	39157	4123	Core	Sandstone Fine Grain			0.82	25	17	8	0.7	4.1	2	9	PAF-LC
DU150C	108.25	111.27	3.02	39158	4124	Core	Sandstone Fine Grain			0.64	20	28	-8	1.4	7.2	0	0	NAF
DU150C	111.27	114.27	3.00	39159	4125	Core	Sandstone Fine Grain			0.75	23	23	0	1.0	7.3	0	0	NAF
DU150C	114.27	117.27	3.00	39160	4126	Core	Sandstone Fine Grain			1.07	33	33	0	1.0	6.9	0	0	NAF
DU150C	117.27	120.27	3.00	39161	4127	Core	Sandstone Fine Grain			0.92	28	40	-12	1.4	7.5	0	0	NAF
DU150C	120.27	123.33	3.06	39162	4128	Core	Sandstone Fine Grain, Common Bioturbation			0.93	28	34	-6	1.2	7.4	0	0	NAF
DU150C	123.33	126.28	2.95	39163	4129	Core	Sandstone Fine Grain, Rare Bioturbation			1.24	38	35	3	0.9	7.3	0	0	UC(NAF)
DU150C	126.28	128.01	1.73	39164	4130	Core	Sandstone Fine Grain, Common Bioturbation, Common Pebbles at Base			1.40	43	53	-10	1.2	7.5	0	0	NAF
DU150C	128.01	129.15	1.14	39165	4131	Core	Sandstone Fine Grain, Rare Boiturbation, Pyritic at Base			3.10	95	32	63	0.3	2.6	49	77	PAF
DU150C	129.15	130.70	1.55				Clareval Upper Seam, Pyrite Nodules Lenses and Disseminated.											
DU150C	130.70	131.47	0.77	39166	4132	Core	Sandstone Very Fine, Common Pyritic Lenses Up to 2cm Thick			0.81	25	12	13	0.5	3.6	8	26	PAF

Table I-1: Acid forming characteristics of overburden and seam floor samples from Clareval Seam drill holes.

Drill Hole	Depth (m) From	Depth (m) To	Depth (m) Interval	EGi Sample No.	Duralie Sample No.	Sample Type	Geological Description	$pH_{1:2}$	$EC_{1:2}$	Acid-Base Analysis Total %S	MPA	ANC	NAPP	ANC /MPA	NAG Test NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	ARD Classification
DU150C	131.47	132.30	0.83	39167	4133	Core	Sandstone Very Fine			0.36	11	15	-4	1.4	4.3	1	13	PAF-LC
DU150C	132.30	133.23	0.93	39168	4134	Core	Sandstone Medium Grain			0.83	25	38	-13	1.5	7.3	0	0	NAF
DU150C	133.23	133.79	0.56	39169	4135	Core	Sandstone Fine Grain, Carb.Claystone & Coal at Top (0.04m)			4.15	127	0	127	0.0	2.3	90	118	PAF
DU150C	133.79	150.24	16.45				Clareval Seam, Variable Pyrite											
DU150C	150.24	150.82	0.58	39170	4136	Core	Sandstone Fine Grain			0.14	4	32	-28	7.5	7.1	0	0	NAF
DU150C	150.82	151.40	0.58	39171	4137	Core	Sandstone Fine Grain			0.08	2	50	-48	20.4	7.4	0	0	NAF
DU150C	151.40	152.25	0.85	39172	4138	Core	Sandstone Fine to Coarse			0.06	2	27	-25	14.7	7.3	0	0	NAF
DU150C	152.25	153.05	0.80	39173	4139	Core	Sandstone Fine to Coarse, Coarse at Base			0.05	2	20	-18	13.1	7.2	0	0	NAF
DU090R	4.00	8.00	4.00	33813	2268	Chips	Sandstone Fine Grain, Highly Weathered			0.05	2				4.9	0	14	NAF
DU090R	8.00	16.00	8.00	33814	2269	Chips	Sandstone Fine Grain, Moderate to Slightly Weathered			1.37	42				2.5	32	42	PAF
DU090R	16.00	24.00	8.00	33815	2270	Chips	Sandstone Fine Grain			2.81	86				2.3	66	78	PAF
DU090R	24.00	29.30	5.30	33816	2271	Chips	Sandstone Fine Grain, D Brown Claystone on Seam Roof			6.60	202				2.2	126	147	PAF
DU090R	29.30	61.07	31.77				Clareval Seam											
DU090R	61.07	63.00	1.93	33817	2279	Chips	Sandstone Fine Grain			0.43	13				3.3	4	9	PAF-LC
DU090R	63.00	71.07	8.07	33818	2280	Chips	Sandstone Fine Grain			0.29	9				3.5	2	8	PAF-LC
DU092R	0.00	5.00	5.00	33819	1638	Chips	Conglomerate/Soil, Lithic, Highly Weathered			0.01	0				5.5	0	15	NAF
DU092R	5.00	10.00	5.00	33820	1639	Chips	Conglomerate, Lithic, Highly Weathered			0.02	1				5.5	0	11	NAF
DU092R	10.00	15.00	5.00	33821	1640	Chips	Conglomerate, Lithic, Slightly Weathered			0.03	1				5.4	0	4	NAF
DU092R	15.00	20.00	5.00	33822	1641	Chips	Conglomerate, Lithic			0.06	2				5.5	0	4	NAF
DU092R	20.00	25.00	5.00	33823	1642	Chips	Conglomerate, Lithic			0.08	2				5.2	0	2	NAF
DU092R	25.00	30.00	5.00	33824	1643	Chips	Siltstone/Conglomerate Lithic			0.12	4				4.9	0	3	NAF
DU092R	30.00	35.00	5.00	33825	1644	Chips	Conglomerate, Lithic			0.07	2				5.2	0	4	NAF
DU092R	35.00	40.00	5.00	33826	1645	Chips	Sandstone/Conglomerate Lithic			0.10	3				5.2	0	3	NAF
DU092R	40.00	44.35	4.35	33827	1646	Chips	Conglomerate Lithic /Claystone			0.70	21				3.2	6	13	PAF
DU092R	44.35	47.10	2.75				Unidentified Seam Below Clareval											
DU092R	47.10	48.00	0.90	33828	1648	Chips	Claystone			0.21	6				5.0	0	4	NAF
DU109R	84.00	90.00	6.00	38977		Chips	Sandstone Fine, Rare Silty Wisps, Grey, Fresh, Rare Calcite			2.04	62	0	62	0.0	2.2	41	48	PAF
DU109R	90.00	96.00	6.00	38978		Chips	Sandstone Fine, Rare Silty Wisps, Grey, Fresh, Rare Calcite			0.86	26	11	15	0.4	2.7	7	11	PAF
DU109R	96.00	102.00	6.00	38979		Chips	Sandstone Fine, Rare Silty Wisps, Grey, Fresh, Rare Calcite			2.19	67	31	36	0.5	2.5	18	24	PAF
DU109R	102.00	108.00	6.00	38980		Chips	Sandstone Very Fine, Rare Silty Wisps, Mottled, Brown Grey, Rare Calcite, Minor Coal & Carb.Claystone			2.94	90	21	69	0.2	2.3	58	68	PAF
DU109R	108.00	114.00	6.00	38981		Chips	Sandstone Fine, Rare Silty Wisps, Grey, Rare Calcite			1.36	42	17	25	0.4	2.6	13	18	PAF
DU109R	114.00	120.00	6.00	38982		Chips	Sandstone Fine, Rare Silty Wisps, Grey, Rare Calcite, Minor Coal & Carb.Claystone			0.40	12	15	-3	1.2	7.1	0	0	NAF
DU109R	120.00	126.00	6.00	38983		Chips	Sandstone Fine, Rare Silty Wisps, Grey, Rare Calcite			0.29	9	9	0	1.0	4.5	0	3	NAF
DU109R	126.00	132.00	6.00	38984		Chips	Sandstone Fine, Rare Silty Wisps, Grey, Rare Calcite			0.35	11	14	-3	1.3	5.2	0	1	NAF
DU109R	132.00	138.00	6.00	38985		Chips	Sandstone Fine, Rare Silty Wisps, Grey, Rare Calcite			0.39	12	16	-4	1.3	6.9	0	0	NAF
DU109R	138.00	144.00	6.00	38986		Chips	Sandstone Fine, Rare Silty Wisps, Grey, Rare Calcite			0.48	15	16	-1	1.1	5.0	0	1	NAF
DU109R	144.00	150.00	6.00	38987		Chips	Sandstone Fine, Rare Silty Wisps, Grey, Rare Calcite			0.31	9	18	-9	1.9	7.4	0	0	NAF
DU109R	150.00	156.00	6.00	38988		Chips	Sandstone Fine, Rare Silty Wisps, Grey, Rare Calcite			0.60	18	27	-9	1.5	7.5	0	0	NAF
DU109R	156.00	162.00	6.00	38989		Chips	Sandstone Fine, Rare Silty Wisps, Grey, Rare Calcite			0.60	18	24	-6	1.3	7.6	0	0	NAF
DU109R	162.00	168.00	6.00	38990		Chips	Sandstone Fine, Rare Silty Wisps, Grey, Rare Calcite			0.54	17	39	-22	2.4	7.8	0	0	NAF
DU109R	168.00	174.00	6.00	38991		Chips	Sandstone Fine, Rare Silty Wisps, Grey, Rare Calcite			0.65	20	35	-15	1.8	7.5	0	0	NAF
DU109R	174.00	180.00	6.00	38992		Chips	Sandstone Very Fine, Rare Silty Wisps, Dark, Grey, Rare Calcite.			1.03	32	61	-29	1.9	7.7	0	0	NAF
DU109R	180.00	186.00	6.00	38993		Chips	Sandstone Very Fine, Rare Silty Wisps, Dark, Grey, Rare Calcite.			1.28	39	26	13	0.7	3.2	5	12	PAF-LC
DU109R	186.00	192.00	6.00	38994		Chips	Sandstone Very Fine, Rare Silty Wisps, Dark, Grey, Rare Calcite.			1.55	47	55	-8	1.2	4.2	0.4	4	PAF-LC
DU109R	192.00	198.00	6.00	38995		Chips	Sandstone Very Fine, Dark Grey, Rare Calcite, Minor Coal (Cheer Up 1 Seam) & Carb.Claystone			2.38	73	43	30	0.6	2.4	24	31	PAF
DU109R	198.00	203.00	5.00	38996		Chips	Sandstone Very Fine, Grey, Rare Calcite, Minor Coal & Carb.Claystone			0.83	25	34	-9	1.3	7.4	0	0	NAF
DU126R	0.00	6.00	6.00	38997		Chips	Clay, Highly To Moderately Weathered			0.02	1	1	0	1.6	3.9	1	21	NAF
DU126R	6.00	12.00	6.00	38998		Chips	Sandstone Very Fine, Light, Brown to Grey, Mod Weathered to Unweathered, Rare Carbonaceous Wisps, Minor Coal (CH2?)			0.69	21	0	21	0.0	2.7	10	17	PAF
DU126R	12.00	18.00	6.00	38999		Chips	Sandstone Fine, Rare Carbonaceous Wisps, Grey.			0.84	26	15	11	0.6	4.1	0.4	3	PAF-LC
DU126R	18.00	24.00	6.00	39000		Chips	Sandstone Fine, Rare Carbonaceous Wisps, Grey.			1.09	33	18	15	0.5	3.4	2	7	PAF-LC
DU126R	24.00	30.00	6.00	39001		Chips	Sandstone Fine, Rare Carbonaceous Wisps, Grey, Carb.Claystone at Base			1.22	37	22	15	0.6	3.4	3	7	PAF-LC
DU126R	30.00	36.00	6.00	39002		Chips	Sandstone Fine, Rare Carbonaceous Wisps, Grey, Minor Carb.Claystone			1.16	35	16	19	0.5	3.4	2	7	PAF-LC
DU126R	36.00	42.00	6.00	39003		Chips	Sandstone Fine, Rare Carbonaceous Wisps, Grey.			1.19	36	13	23	0.4	3.1	4	9	PAF-LC
DU126R	42.00	48.00	6.00	39004		Chips	Sandstone Fine, Common Carbonaceous Wisps, Rare Pebbles, Grey Brown, Minor Carb.Claystone & Siltstone			1.42	43	6	37	0.1	2.7	10	15	PAF
DU126R	48.00	54.00	6.00	39005		Chips	Sandstone Fine, Rare Carbonaceous Wisps, Grey.			1.48	45	10	35	0.2	2.6	12	18	PAF
DU126R	54.00	60.00	6.00	39006		Chips	Sandstone Fine, Rare Carbonaceous Wisps, Rare Calcite, Minor Carb.Claystone			1.01	31	12	19	0.4	3.3	2	6	PAF-LC
DU126R	60.00	66.00	6.00	39007		Chips	Carb.Claystone, Black Brown.			1.23	38	19	19	0.5	2.9	6	11	PAF
DU126R	66.00	72.00	6.00	39008		Chips	Sandstone Fine, Rare Carbonaceous Wisps, Grey.			1.43	44	22	22	0.5	3.0	3	8	PAF-LC
DU126R	72.00	78.00	6.00	39009		Chips	Sandstone Fine, Grey.			0.98	30	28	2	0.9	6.9	0	0	UC(NAF)
DU126R	78.00	84.00	6.00	39010		Chips	Sandstone Fine, Grey.			0.96	29	20	9	0.7	3.5	1	5	PAF-LC
DU126R	84.00	90.00	6.00	39011		Chips	Sandstone Fine, Grey.			1.60	49	19	30	0.4	2.9	6	11	PAF
DU126R	90.00	96.00	6.00	39012		Chips	Sandstone Fine, Grey.			1.48	45	19	26	0.4	2.8	8	13	PAF
DU126R	96.00	101.00	5.00	39013		Chips	Sandstone Fine, Grey.			1.55	47	20	27	0.4	2.8	6	10	PAF
DU126R	101.00	137.00	36.00				Clareval Seam											
DU126R	137.00	138.00	1.00	39014		Chips	Conglomerate Mottled, Grey Brown.			0.29	9	72	-63	8.1	7.5	0	0	NAF

Table I-1: Acid forming characteristics of overburden and seam floor samples from Clareval Seam drill holes.

Drill Hole	Depth (m) From	To	Interval	EGi Sample No.	Duralie Sample No.	Sample Type	Geological Description	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS Total %S	MPA	ANC	NAPP	ANC /MPA	NAG TEST NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	ARD Classification
DU165R	0.00	1.00	1.00	37800		Chips	Clay Sandy Iron Stained, Dark, Red Brown, Completely Weathered.			0.12	4	0	4	0.0	4.8	0	13	NAF
DU165R	1.00	2.00	1.00	37801		Chips	Clay Sandy Iron Stained, Mottled, Red Cream Brown, Completely Weathered.			0.06	2	0	2	0.0	5.6	0	6	NAF
DU165R	2.00	3.00	1.00	37802		Chips	Clay Sandy Iron Stained, Mottled, Red Cream, Extremely Weathered.			0.06	2	0	2	0.0	5.5	0	6	NAF
DU165R	3.00	4.00	1.00	37803		Chips	Sandstone Fine/Med Grain, Clayey Iron Stained, Orange Red, Extremely Weathered.			0.09	3	0	3	0.0	5.4	0	5	NAF
DU165R	4.00	5.00	1.00	37804		Chips	Sandstone Fine/Med Grain, Clayey Iron Stained, Orange Red, Extremely Weathered.			0.09	3	0	3	0.0	4.9	0	8	NAF
DU165R	5.00	6.00	1.00	37805		Chips	Sandstone Fine/Med Grain, Clayey Iron Stained, Orange Red, Extremely Weathered.			0.10	3	0	3	0.0	4.7	0	11	NAF
DU165R	6.00	7.00	1.00	37806		Chips	Sandstone Fine/Med Grain, Clayey Iron Stained, Orange Red, Extremely Weathered.			0.12	4	0	4	0.0	4.9	0	6	NAF
DU165R	7.00	8.00	1.00	37807		Chips	Sandstone Fine/Med Grain, Clayey Iron Stained, Orange Red, Extremely Weathered.			0.10	3	0	3	0.0	4.6	0	9	NAF
DU165R	8.00	9.00	1.00	37808		Chips	Sandstone Fine/Med Grain, Clayey Iron Stained, Orange Red, Extremely Weathered.			0.12	4	0	4	0.0	4.7	0	9	NAF
DU165R	9.00	10.00	1.00	37809		Chips	Sandstone Fine/Med Grain, Clayey Iron Stained, Orange Red, Extremely Weathered.			0.12	4	0	4	0.0	5.0	0	10	NAF
DU165R	10.00	11.00	1.00	37810		Chips	Sandstone Fine/Med Grain, Clayey Iron Stained, Grey Orange, Partially Weathered.			0.08	2	0	2	0.0	5.1	0	5	NAF
DU165R	11.00	12.00	1.00	37811		Chips	Sandstone Fine/Med Grain, Clayey Iron Stained, Grey Orange, Partially Weathered.			1.09	33	0	33	0.0	2.4	27	37	PAF
DU165R	12.00	13.00	1.00	37812		Chips	Sandstone Fine/Med Grain, Clayey Iron Stained, Grey Orange, Partially Weathered.			1.35	41	0	41	0.0	2.4	21	29	PAF
DU165R	13.00	14.00	1.00	37813		Chips	Sandstone Fine/Med Grain, Clayey Iron Stained, Grey Orange, Partially Weathered.			2.08	64	0	64	0.0	2.2	51	61	PAF
DU165R	14.00	15.00	1.00	37814		Chips	Sandstone Fine/Med Grain, Clayey Iron Stained, Grey Orange, Partially Weathered.			1.41	43	27	16	0.6	3.5	1	6	PAF-LC
DU165R	15.00	16.00	1.00	37815		Chips	Sandstone Fine/Med Grain, Clayey Iron Stained, Grey Orange, Partially Weathered.			1.54	47	11	36	0.2	2.6	12	18	PAF
DU165R	16.00	17.00	1.00	37816		Chips	Sandstone Fine/Med Grain, Grey, Fresh. Partially Weathered in Top 20cm.			1.44	44	29	15	0.7	2.9	7	13	PAF
DU165R	17.00	18.00	1.00	37817		Chips	Sandstone 50% Medium Grain, Dark, Grey. Siltstone 50%, Dark, Grey.			1.22	37	36	1	1.0	6.9	0	0	UC(NAF)
DU165R	18.00	19.00	1.00	37818		Chips	Sandstone Fine/Med Grain, Grey. Minor Siltstone			1.19	36	62	-26	1.7	7.8	0	0	NAF
DU165R	19.00	20.00	1.00	37819		Chips	Sandstone Fine/Med Grain, Grey.			0.81	25	52	-27	2.1	8.4	0	0	NAF
DU165R	20.00	21.00	1.00	37820		Chips	Sandstone Fine/Med Grain, Grey.			0.83	25	55	-30	2.2	8.2	0	0	NAF
DU165R	21.00	22.00	1.00	37821		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.27	39	28	11	0.7	3.6	2	7	PAF-LC
DU165R	22.00	23.00	1.00	37822		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.63	50	46	4	0.9	6.6	0	0	UC(NAF)
DU165R	23.00	24.00	1.00	37823		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			2.60	80	23	57	0.3	2.4	33	54	PAF
DU165R	24.00	25.00	1.00	37824		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			2.44	75	25	50	0.3	2.3	28	47	PAF
DU165R	25.00	26.00	1.00	37825		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.31	40	76	-36	1.9	7.5	0	0	NAF
DU165R	26.00	27.00	1.00	37826		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.61	49	59	-10	1.2	7.7	0	0	NAF
DU165R	27.00	28.00	1.00	37827		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.51	46	83	-37	1.8	7.8	0	0	NAF
DU165R	28.00	29.00	1.00	37828		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.71	52	25	27	0.5	3.0	7	18	PAF
DU165R	29.00	30.00	1.00	37829		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			2.35	72	26	46	0.4	2.6	20	37	PAF
DU165R	30.00	31.00	1.00	37830		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			2.57	79	25	54	0.3	2.4	31	47	PAF
DU165R	31.00	32.00	1.00	37831		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.44	44	43	1	1.0	7.2	0	0	UC(NAF)
DU165R	32.00	33.00	1.00	37832		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.48	45	69	-24	1.5	7.7	0	0	NAF
DU165R	33.00	34.00	1.00	37833		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.90	58	40	18	0.7	3.5	2	8	PAF-LC
DU165R	34.00	35.00	1.00	37834		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.43	44	39	5	0.9	7.2	0	0	UC(NAF)
DU165R	35.00	36.00	1.00	37835		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.14	35	56	-21	1.6	7.4	0	0	NAF
DU165R	36.00	37.00	1.00	37836		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.49	46	35	11	0.8	2.9	7	13	PAF
DU165R	37.00	38.00	1.00	37837		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.12	34	37	-3	1.1	7.3	0	0	NAF
DU165R	38.00	39.00	1.00	37838		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.15	35	59	-24	1.7	8.2	0	0	NAF
DU165R	39.00	40.00	1.00	37839		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.26	39	22	17	0.6	3.1	5	11	PAF-LC
DU165R	40.00	41.00	1.00	37840		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.10	34	47	-13	1.4	7.9	0	0	NAF
DU165R	41.00	42.00	1.00	37841		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.12	34	52	-18	1.5	8.1	0	0	NAF
DU165R	42.00	43.00	1.00	37842		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.28	39	34	5	0.9	7.9	0	0	UC(NAF)
DU165R	43.00	44.00	1.00	37843		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.15	35	52	-17	1.5	8.2	0	0	NAF
DU165R	44.00	45.00	1.00	37844		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.08	33	61	-28	1.8	8.4	0	0	NAF
DU165R	45.00	46.00	1.00	37845		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.27	39	36	3	0.9	8.2	0	0	UC(NAF)
DU165R	46.00	47.00	1.00	37846		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.21	37	47	-10	1.3	8.1	0	0	NAF
DU165R	47.00	48.00	1.00	37847		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.30	40	33	7	0.8	8.0	0	0	UC(NAF)
DU165R	48.00	49.00	1.00	37848		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces.			1.30	40	22	18	0.6	3.1	5	10	PAF-LC
DU165R	49.00	50.00	1.00	37849		Chips	Sandstone Fine/Med Grain, Rare Silty Wisps, Dark, Grey, Rare Calcite, Traces. Carb.Claystone at Base			4.88	149	0	149	0.0	2.2	91	101	PAF
DU165R	50.00	86.00	36.00				Clareval Seam											
DU165R	86.00	87.00	1.00	37850		Chips	Sandstone Fine/Med Grain, Rare Pebbles/ Pebbly, Grey Buff.			0.35	11	28	-17	2.6	8.3	0	0	NAF
DU165R	87.00	88.00	1.00	37851		Chips	Sandstone Fine/Med Grain, Rare Pebbles/ Pebbly, Grey Buff.			0.33	10	54	-44	5.3	8.4	0	0	NAF
DU165R	88.00	89.00	1.00	37852		Chips	Sandstone Fine Grain, Rare Silty Wisps, Grey.			0.13	4				8.5	0	0	NAF
DU165R	89.00	90.00	1.00	37853		Chips	Sandstone Fine Grain, Rare Silty Wisps, Grey.			0.90	28				7.9	0	0	UC(NAF)
DU165R	90.00	91.00	1.00	37854		Chips	Sandstone Fine Grain, Rare Silty Wisps, Grey.			0.24	7				7.7	0	0	NAF
DU165R	91.00	92.00	1.00	37855		Chips	Sandstone Fine Grain, Rare Silty Wisps, Grey.			0.04	1				8.2	0	0	NAF

KEY

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

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

MPA = Maximum Potential Acidity (kgH_2SO_4/t)

ANC = Acid Neutralising Capacity (kg H_2SO_4/t)

NAPP = Net Acid Producing Potential (kg H_2SO_4/t)

NAGpH = pH of NAG liquor

$NAG_{(pH4.5)}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)

$NAG_{(pH7.0)}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

NAF = Non-Acid Forming

PAF = Potentially Acid Forming

PAF-LC = PAF - lower capacity

UC(NAF) = Uncertain but Expected to be NAF

UC(PAF) = Uncertain but Expected to be PAF

Table I-2: Acid forming characteristics of overburden and seam floor samples from Weismantel Seam drill holes.

Drill Hole	Depth (m) From	Depth (m) To	Depth (m) Interval	EGi Sample No.	Duralie Sample No.	Sample Type	Geological Description	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS Total %S	MPA	ANC	NAPP	ANC /MPA	NAG TEST NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	ARD Classification
DU206C	16.78	18.00	1.22	39174	4140	Core	Sandstone Fine			1.67	51	45	6	0.9	7.5	0	0	UC(NAF)
DU206C	18.00	19.00	1.00	39175	4141	Core	Sandstone Fine			0.53	16	115	-99	7.1	7.4	0	0	NAF
DU206C	19.00	20.00	1.00	39176	4142	Core	Sandstone Fine			0.35	11	93	-82	8.7	7.6	0	0	NAF
DU206C	20.00	21.00	1.00	39177	4143	Core	Sandstone Fine			0.80	24	92	-68	3.8	7.2	0	0	NAF
DU206C	21.00	22.00	1.00	39178	4144	Core	Sandstone Fine			0.59	18	113	-95	6.3	7.3	0	0	NAF
DU206C	22.00	23.00	1.00	39179	4145	Core	Sandstone Fine			0.78	24	77	-53	3.2	7.2	0	0	NAF
DU206C	23.00	24.00	1.00	39180	4146	Core	Sandstone Fine			0.93	28	210	-182	7.4	7.4	0	0	NAF
DU206C	24.00	25.00	1.00	39181	4147	Core	Sandstone Fine			1.22	37	47	-10	1.3	7.2	0	0	NAF
DU206C	25.00	26.00	1.00	39182	4148	Core	Sandstone Fine			1.26	39	3	36	0.1	2.7	26	40	PAF
DU206C	26.00	27.00	1.00	39183	4149	Core	Sandstone Fine To Coarse			1.98	61	0	61	0.0	2.6	43	61	PAF
DU206C	27.00	28.00	1.00	39184	4150	Core	Sandstone Fine/Conglomerate			1.89	58	7	51	0.1	2.5	42	59	PAF
DU206C	28.00	29.00	1.00	39185	4151	Core	Sandstone Medium Grained			1.59	49	0	49	0.0	2.4	42	58	PAF
DU206C	29.00	30.00	1.00	39186	4152	Core	Sandstone Medium/Conglomerate			1.15	35	0	35	0.0	2.9	17	26	PAF
DU206C	30.00	30.95	0.95	39187	4153	Core	Sandstone Medium/Conglomerate			2.72	83	0	83	0.0	2.3	64	81	PAF
DU206C	30.95	31.18	0.23	39188	4154	Core	Sandstone Fine			6.45	197	0	197	0.0	2.1	114	144	PAF
DU206C	31.18	46.24	15.06				Weismantel Seam											
DU206C	46.24	47.00	0.76	39189	4155	Core	Sandstone Fine			1.55	47	1	46	0.0	2.4	30	44	PAF
DU206C	47.00	48.00	1.00	39190	4156	Core	Sandstone Fine			1.51	46	34	12	0.7	3.7	4	11	PAF-LC
DU206C	48.00	49.00	1.00	39191	4157	Core	Sandstone Fine			0.56	17	10	7	0.6	4.0	1	6	PAF-LC
DU206C	49.00	50.00	1.00	39192	4158	Core	Sandstone Fine			0.18	6	23	-17	4.2	7.2	0	0	NAF
DU206C	50.00	50.60	0.60	39193	4159	Core	Sandstone Fine			0.11	3	26	-23	7.7	7.4	0	0	NAF
WC216C	9.55	11.00	1.45	31586	1123-1125	Core	Sandstone, Grey, Carbonaceous	7.5	0.42	1.22	37	63	-26	1.7	8.2	0	0	NAF
WC216C	11.00	12.50	1.50	31587	1120-1122	Core	Sandstone, Grey, Carbonaceous	5.2	0.71	1.27	39	5	34	0.1	2.4	21	25	PAF
WC216C	12.50	13.50	1.00	31588	1118-1119	Core	Sandstone, Grey	4.4	0.83	1.34	41	0	41	0.0	2.3	29	33	PAF
WC216C	13.50	14.50	1.00	31589	1116-1117	Core	Sandstone, Grey, Silty	3.9	1.04	2.21	68	0	68	0.0	2.1	58	64	PAF
WC216C	14.50	15.50	1.00	31590	1114-1115	Core	Sandstone, Grey	3.6	1.14	1.61	49	0	49	0.0	2.1	50	55	PAF
WC216C	15.50	16.00	0.50	31591	1113	Core	Sandstone, Grey	4.1	0.98	2.21	68	0	68	0.0	2.0	53	59	PAF
WC216C	16.00	16.50	0.50	31592	1112	Core	Sandstone, Grey	3.1	1.01	3.34	102	0	102	0.0	2.0	87	95	PAF
WC216C	16.50	17.38	0.88	31593	1111	Core	Sandstone, Grey with Conglomerate	3.0	1.41	4.44	136	0	136	0.0	1.9	99	110	PAF
WC216C	17.38	38.61	21.23				Weismantel Seam											
WC216C	38.61	39.00	0.39	31594	1126	Core	Sandstone, Grey Brown, Carbonaceous	7.3	0.09	0.11	3	2	1	0.6	5.4	0	3	NAF
WC216C	39.00	39.50	0.50	31595	1127	Core	Sandstone, Grey Brown	7.4	0.09	0.15	5	3	2	0.7	4.1	0.2	3	PAF-LC
WC217AC	23.00	24.00	1.00	33852	1535	Core	Sandstone with Minor Conglomerate			2.97	91				2.2	79	93	PAF
WC217AC	24.00	25.00	1.00	33851	1534	Core	Sandstone			3.73	114				2.2	90	108	PAF
WC217AC	25.00	25.43	0.43	33850	1533	Core	Carbonaceous Siltsone and Claystone			6.90	211				2.1	136	168	PAF
WC217AC	25.43	37.18	11.75				Weismantel Seam											
WC217AC	37.18	38.00	0.82	33853	1536	Core	Sandstone			0.70	21				2.6	17	23	PAF
WC217AC	38.00	39.00	1.00	33854	1537	Core	Sandstone			0.27	8				2.9	6	10	PAF
8	7.00	25.00	18.00	39120	8B	Chips	Fresh Overburden, Approx. 185m from Edge of Weismantel Seam			0.41	13	29	-16	2.3	4.9	0	1	NAF
9	7.00	25.00	18.00	39121	9B	Chips	Fresh Overburden, Approx. 170m from Edge of Weismantel Seam			0.44	13	22	-9	1.6	3.8	1	5	PAF-LC
10	7.00	25.00	18.00	39122	10B	Chips	Fresh Overburden, Approx. 150m from Edge of Weismantel Seam			0.41	13	26	-13	2.1	7.6	0	0	NAF
1	7.00	25.00	18.00	39113	1B	Chips	Fresh Overburden, Approx. 120m from Edge of Weismantel Seam			0.19	6	18	-12	3.1	7.4	0	0	NAF
2	7.00	25.00	18.00	39114	2B	Chips	Fresh Overburden, Approx. 100m from Edge of Weismantel Seam			0.13	4	12	-8	3.0	4.8	0	2	NAF
3	7.00	25.00	18.00	39115	3B	Chips	Fresh Overburden, Approx. 80m from Edge of Weismantel Seam			0.35	11	40	-29	3.7	8.5	0	0	NAF
4	7.00	25.00	18.00	39116	4B	Chips	Fresh Overburden, Approx. 60m from Edge of Weismantel Seam			0.61	19	32	-13	1.7	8.9	0	0	NAF
5	7.00	25.00	18.00	39117	5B	Chips	Fresh Overburden, Approx. 40m from Edge of Weismantel Seam			0.59	18	46	-28	2.5	9.2	0	0	NAF
6	7.00	25.00	18.00	39118	6B	Chips	Fresh Overburden, Approx. 20m from Edge of Weismantel Seam			1.97	60	18	42	0.3	2.2	40	45	PAF
7	0.00	5.00	5.00	39119	7A	Chips	Weismantel Seam (Weathered)			0.07	2	5	-3	2.3	5.5	0	8	NAF

KEY

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

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

MPA = Maximum Potential Acidity (kgH_2SO_4/t)

ANC = Acid Neutralising Capacity (kg H_2SO_4/t)

NAPP = Net Acid Producing Potential (kg H_2SO_4/t)

NAGpH = pH of NAG liquor

$NAG_{(pH4.5)}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)

$NAG_{(pH7.0)}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

NAF = Non-Acid Forming

PAF = Potentially Acid Forming

PAF-LC = PAF - lower capacity

UC(NAF) = Uncertain but Expected to be NAF

UC(PAF) = Uncertain but Expected to be PAF

Table I-3: Compiled acid forming characteristics from the 1996 Duralie EIS for overburden and seam floor samples from Weismantel Seam drill holes.

Drill Hole	Depth (m)			EGi Sample No.	Duralie Sample No.	Sample Type	Sample Description	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
	From	To	Interval							Total %S	MPA	ANC	NAPP	ANC /MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
WC100	6.00	11.00	5.00	4019	4	Core	O/B	8.2	1.21	0.33	10	0	10	0.0	3.8	2	11	PAF-LC
WC100	11.00	18.00	7.00	4020	5	Core	O/B	8.0	1.28	1.20	37	25	12	0.7	8.7	0	0	UC(NAF)
WC100	18.00	19.20	1.20	4021	6	Core	O/B	8.3	0.96	1.00	31	85	-54	2.8	10.0	0	0	NAF
WC100	19.20	26.40	7.20	4022	7	Core	O/B	8.2	0.84	0.66	20	40	-20	2.0	10.3	0	0	NAF
WC100	26.40	34.00	7.60	4023	8	Core	O/B	7.9	1.14	1.40	43	46	-3	1.1	9.7	0	0	NAF
WC100	34.00	35.80	1.80	4024	2	Core	Roof	4.9	1.05	2.50	77	0	77	0.0	1.8	52	59	PAF
WC100	35.80	37.80	2.00	4025	1	Core	Roof	4.7	0.96	3.10	95	0	95	0.0	1.6	75	81	PAF
WC100	37.80	66.00	28.20				Weismantel Seam											
WC100	66.00	67.00	1.00	4026	3	Core	Floor	7.2	0.32	0.39	12	2	10	0.2	2.5	9	16	PAF
WC101	11.00	17.30	6.30	4027	4	Core	O/B	6.5	0.69	0.27	8	0	8	0.0	3.3	1	8	PAF-LC
WC101	17.30	27.00	9.70	4028	5	Core	O/B	8.0	0.83	0.47	14	0	14	0.0	6.6	0	8	NAF
WC101	27.00	37.00	10.00	4029	6	Core	O/B	9.1	0.39	0.44	13	18	-5	1.3	9.7	0	0	NAF
WC101	37.00	47.00	10.00	4030	7	Core	O/B	8.7	0.57	0.74	23	18	5	0.8	8.7	0	0	UC(NAF)
WC101	47.00	57.00	10.00	4031	8	Core	O/B	8.2	0.77	1.40	43	53	-10	1.2	9.6	0	0	NAF
WC101	57.00	66.00	9.00		n/s	Core	O/B - No Sample											
WC101	66.00	68.00	2.00	4032	2	Core	Roof	5.0	0.85	1.90	58	0	58	0.0	1.9	42	47	PAF
WC101	68.00	70.00	2.00	4033	1	Core	Roof	4.5	1.01	4.20	129	0	129	0.0	1.4	89	95	PAF
WC101	70.00	81.00	11.00				Weismantel Seam											
WC101	81.00	81.96	0.96	4034	3	Core	Floor	7.6	0.35	1.10	34	3	31	0.1	2.2	20	25	PAF
WC102	7.50	17.50	10.00	4035	4	Core	O/B	8.0	0.65	0.49	15	5	10	0.3	8.8	0	0	NAF
WC102	17.50	27.00	9.50	4036	5	Core	O/B	8.6	0.42	0.65	20	17	3	0.9	10.0	0	0	UC(NAF)
WC102	27.00	37.00	10.00	4037	6	Core	O/B	8.5	0.55	0.62	19	13	6	0.7	8.6	0	0	UC(NAF)
WC102	37.00	47.00	10.00	4038	7	Core	O/B	8.0	0.88	1.20	37	28	9	0.8	8.9	0	0	UC(NAF)
WC102	47.00	51.37	4.37	4039	8	Core	O/B	7.8	0.94	1.30	40	68	-28	1.7	9.7	0	0	NAF
WC102	51.40	54.68	3.28	4040	3	Core	Roof	8.0	0.76	1.60	49	56	-7	1.1	10.1	0	0	NAF
WC102	54.70	56.88	2.18	4041	1	Core	Roof	5.0	0.69	3.30	101	0	101	0.0	1.8	70	75	PAF
WC102	56.88	68.60	11.72				Weismantel Seam											
WC102	68.60	69.60	1.00	4042	2	Core	Floor	7.6	0.21	0.48	15	0	15	0.0	2.3	11	15	PAF
WC103	5.80	11.90	6.10	4043	4	Core	O/B	7.9	0.67	0.22	7	12	-5	1.8	8.4	0	0	NAF
WC103	11.90	16.80	4.90	4044	5	Core	O/B	8.0	0.71	0.53	16	14	2	0.9	8.8	0	0	UC(NAF)
WC103	16.80	23.51	6.71	4045	6	Core	O/B	8.2	0.51	0.40	12	3	9	0.2	7.8	0	0	NAF
WC103	23.50	26.00	2.50	4046	7	Core	O/B	8.3	0.55	0.57	17	23	-6	1.3	9.7	0	0	NAF
WC103	26.00	36.00	10.00	4047	8	Core	O/B	8.7	0.43	0.70	21	20	1	0.9	9.2	0	0	UC(NAF)
WC103	36.00	44.00	8.00	4048	9	Core	O/B	8.5	0.44	0.62	19	13	6	0.7	7.3	0	0	UC(NAF)
WC103	44.00	52.00	8.00	4049	10	Core	O/B	8.3	0.54	0.78	24	29	-5	1.2	9.6	0	0	NAF
WC103	52.00	57.80	5.80	4050	11	Core	O/B	8.0	0.63	1.40	43	60	-17	1.4	10.2	0	0	NAF
WC103	57.80	60.30	2.50	4051	2	Core	Roof	8.0	0.69	1.60	49	40	9	0.8	9.2	0	0	UC(NAF)
WC103	60.30	61.60	1.30	4052	1	Core	Roof	5.6	0.58	4.30	132	10	122	0.1	1.5	85	89	PAF
WC103	61.60	73.50	11.90				Weismantel Seam											
WC103	73.50	74.50	1.00	4053	3	Core	Floor	7.7	0.25	1.50	46	0	46	0.0	2.0	37	40	PAF
WC104	5.80	8.50	2.70	4161	8	Core	O/B	8.5	1.09	0.72	22	28	-6	1.3	2.5	5	8	PAF-LC
WC104	8.50	14.30	5.80	4162	7	Core	O/B	8.6	0.82	0.83	25	27	-2	1.1	2.2	8	11	PAF
WC104	14.30	24.30	10.00	4163	6	Core	O/B	8.4	0.72	0.52	16	37	-21	2.3	8.5	0	0	NAF
WC104	24.30	34.30	10.00	4164	5	Core	O/B	8.2	0.64	0.93	28	56	-28	2.0	8.7	0	0	NAF
WC104	34.30	36.30	2.00	4165	4	Core	Roof	4.8	0.61	1.60	49	6	43	0.1	1.6	33	37	PAF
WC104	36.30	37.30	1.00	4166	3	Core	Roof	4.6	0.65	1.80	55	2	53	0.0	1.6	41	46	PAF
WC104	37.30	38.30	1.00	4167	2	Core	Roof	3.9	0.94	4.50	138	1	137	0.0	1.3	94	102	PAF
WC104	38.30	49.30	11.00				Weismantel Seam											
WC104	49.30	50.00	0.70	4168	1	Core	Floor	7.5	0.24	1.00	31	4	27	0.1	1.8	20	23	PAF

Table I-3: Compiled acid forming characteristics from the 1996 Duralie EIS for overburden and seam floor samples from Weismantel Seam drill holes.

Drill Hole	Depth (m)			EGi Sample No.	Duralie Sample No.	Sample Type	Sample Description	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
	From	To	Interval							Total %S	MPA	ANC	NAPP	ANC /MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
WC111	12.00	16.00	4.00	4169	7	Core	O/B	8.6	0.56	0.70	21	62	-41	2.9	8.8	0	0	NAF
WC111	16.00	24.20	8.20	4170	6	Core	O/B	8.5	0.72	0.77	24	61	-37	2.6	8.3	0	0	NAF
WC111	24.20	34.20	10.00	4171	5	Core	O/B	8.3	0.60	0.78	24	64	-40	2.7	8.8	0	0	NAF
WC111	34.20	44.20	10.00	4173	4	Core	O/B	8.1	0.69	0.98	30	61	-31	2.0	9.5	0	0	NAF
WC111	44.20	46.20	2.00	4174	3	Core	Roof	5.0	0.57	1.50	46	2	44	0.0	1.6	34	37	PAF
WC111	46.20	48.20	2.00	4175	2	Core	Roof	4.2	0.55	3.20	98	1	97	0.0	1.4	69	76	PAF
WC111	48.20	67.20	19.00				Weismantel Seam											
WC111	67.20	68.20	1.00	4176	1	Core	Floor	7.5	0.19	0.45	14	3	11	0.2	2.1	11	13	PAF
WC113	12.00	17.50	5.50	4212	8	Core	O/B	8.2	0.92	0.62	19	16	3	0.8	3.2	1	4	PAF-LC
WC113	17.50	23.00	5.50	4211	7	Core	O/B	8.7	0.68	0.43	13	29	-16	2.2	9.5	0	0	NAF
WC113	23.00	28.20	5.20	4210	6	Core	O/B	8.6	0.57	0.37	11	39	-28	3.4	10.4	0	0	NAF
WC113	28.20	38.20	10.00	4209	5	Core	O/B	8.5	0.61	0.48	15	29	-14	2.0	5.6	0	0	NAF
WC113	38.20	48.20	10.00	4208	4	Core	O/B	8.1	0.72	0.50	15	41	-26	2.7	10.2	0	0	NAF
WC113	48.20	58.20	10.00	4207	3	Core	O/B	8.0	0.77	1.30	40	64	-24	1.6	10.7	0	0	NAF
WC113	58.20	60.15	1.95	4206	2	Core	Roof	8.0	0.75	1.00	31	42	-11	1.4	9.7	0	0	NAF
WC113	60.20	62.00	1.80	4205	1	Core	Roof	5.3	0.87	4.00	122	1	121	0.0	1.0	77	82	PAF
WC113	62.00	84.00	22.00				Weismantel Seam											
WC113	84.00	84.70	0.70	4213	9	Core	Floor	8.0	0.24	0.42	13	3	10	0.2	1.8	10	13	PAF
WC114	12.00	21.00	9.00	4413	8	Core	O/B	7.7	0.74	0.22	7	8	-1	1.2	3.5	1	9	PAF-LC
WC114	21.00	30.80	9.80	4412	7	Core	O/B	7.8	0.76	0.35	11	11	0	1.0	6.4	0	0	NAF
WC114	30.80	40.80	10.00	4411	6	Core	O/B	8.4	0.54	0.30	9	23	-14	2.5	9.3	0	0	NAF
WC114	40.80	50.80	10.00	4410	5	Core	O/B	8.1	0.55	0.52	16	49	-33	3.1	9.3	0	0	NAF
WC114	50.80	60.80	10.00	4409	4	Core	O/B	7.6	0.82	1.00	31	28	3	0.9	4.9	0	4	UC(NAF)
WC114	60.80	70.80	10.00	4408	3	Core	O/B	7.6	0.89	1.10	34	48	-14	1.4	8.4	0	0	NAF
WC114	70.80	72.80	2.00	4407	2	Core	Roof	5.3	0.62	1.60	49	0	49	0.0	2.1	34	39	PAF
WC114	72.80	74.80	2.00	4406	1	Core	Roof	4.5	0.58	3.90	119	0	119	0.0	1.8	73	81	PAF
WC114	74.80	85.40	10.60				Weismantel Seam											
WC114	85.40	86.10	0.70	4414	9	Core	Floor	7.6	0.23	1.60	49	1	48	0.0	3.1	27	31	PAF
WC116	12.00	16.00	4.00	4419	5	Core	O/B	8.2	0.55	0.71	22	23	-1	1.1	4.8	0	4	NAF
WC116	16.00	19.90	3.90	4418	4	Core	O/B	8.1	0.53	0.71	22	22	0	1.0	3.0	3	9	PAF-LC
WC116	19.90	29.90	10.00	4417	3	Core	O/B	7.8	0.66	1.00	31	56	-25	1.8	8.2	0	0	NAF
WC116	29.90	31.90	2.00	4416	2	Core	Roof	8.0	0.52	1.10	34	80	-46	2.4	9.3	0	0	NAF
WC116	31.90	33.90	2.00	4415	1	Core	Roof	7.9	0.51	2.70	83	80	3	1.0	7.5	0	0	UC(PAF)
WC116	33.90	43.90	10.00				Weismantel Seam											
WC116	43.90	44.90	1.00	4420	6	Core	Floor	7.0	0.30	1.00	31	1	30	0.0	2.3	22	26	PAF
WC117	6.00	12.00	6.00	4421	1	Core	O/B	6.6	0.18	0.01	0	2	-2	6.5	6.2	0	7	NAF
WC117	12.00	19.30	7.30	4422	2	Core	O/B	6.0	0.70	0.47	14	6	8	0.4	3.0	5	11	PAF-LC
WC117	19.30	27.10	7.80	4423	3	Core	O/B	7.4	0.82	0.36	11	10	1	0.9	5.6	0	5	NAF
WC119	7.00	11.67	4.67	4429	6	Core	O/B	8.0	0.68	0.33	10	11	-1	1.1	4.5	0	5	NAF
WC119	11.70	21.70	10.00	4428	5	Core	O/B	7.7	0.75	1.10	34	38	-4	1.1	7.0	0	0	NAF
WC119	21.70	31.70	10.00	4427	4	Core	O/B	7.8	0.65	1.30	40	42	-2	1.1	6.5	0	0	NAF
WC119	31.70	41.70	10.00	4426	3	Core	O/B	7.5	0.62	0.89	27	48	-21	1.8	9.0	0	0	NAF
WC119	41.70	43.70	2.00	4425	2	Core	Roof	4.8	0.65	3.10	95	0	95	0.0	1.9	60	65	PAF
WC119	43.70	45.70	2.00	4424	1	Core	Roof	4.9	0.78	4.90	150	0	150	0.0	1.8	80	91	PAF
WC119	45.70	58.60	12.90				Weismantel Seam											
WC119	58.60	59.10	0.50	4430	7	Core	Floor	4.0	1.18	4.10	125	0	125	0.0	1.8	90	97	PAF

Table I-3: Compiled acid forming characteristics from the 1996 Duralie EIS for overburden and seam floor samples from Weismantel Seam drill holes.

Drill Hole	Depth (m)			EGi Sample No.	Duralie Sample No.	Sample Type	Sample Description	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
	From	To	Interval							Total %S	MPA	ANC	NAPP	ANC /MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
WC128	0.00	5.00	5.00	9131	1	Chips	O/B								5.3	0	1	UC(NAF)
WC128	5.00	10.00	5.00	9132	2	Chips	O/B								8.6	0	0	UC(NAF)
WC128	10.00	15.00	5.00	9133	3	Chips	O/B								8.3	0	0	UC(NAF)
WC128	15.00	20.00	5.00	9134	4	Chips	O/B								8.0	0	0	UC(NAF)
WC128	20.00	25.00	5.00	9135	5	Chips	O/B								8.1	0	0	UC(NAF)
WC128	25.00	30.00	5.00	9136	6	Chips	O/B								8.1	0	0	UC(NAF)
WC128	30.00	35.00	5.00	9137	7	Chips	O/B								8.1	0	0	UC(NAF)
WC128	35.00	40.00	5.00	9138	8	Chips	O/B								8.1	0	0	UC(NAF)
WC128	40.00	41.00	1.00	9139	9	Chips	Roof								2.2	23	26	PAF
WC128	41.00	42.00	1.00	9140	10	Chips	Roof								2.0	40	44	PAF
WC128	42.00	42.80	0.80	9141	11	Core	Roof			2.40	73				1.9	45	51	PAF
WC128	42.80	43.60	0.80	9142	12	Core	Roof			2.90	89				1.9	57	65	PAF
WC128	43.60	44.50	0.90	9143	13	Core	Roof			5.90	181				1.8	104	117	PAF
WC129	0.00	5.00	5.00	9144	1	Chips	O/B								7.7	0	0	UC(NAF)
WC129	5.00	10.00	5.00	9145	2	Chips	O/B								7.6	0	0	UC(NAF)
WC129	10.00	15.00	5.00	9146	3	Chips	O/B								7.7	0	0	UC(NAF)
WC129	15.00	20.00	5.00	9147	4	Chips	O/B								3.2	2	4	PAF-LC
WC129	20.00	25.00	5.00	9148	5	Chips	O/B								3.4	1	3	PAF-LC
WC129	25.00	30.00	5.00	9149	6	Chips	O/B								7.8	0	0	UC(NAF)
WC129	30.00	31.00	1.00	9150	7	Chips	O/B								8.3	0	0	UC(NAF)
WC129	31.00	32.00	1.00	9151	8	Chips	O/B								8.1	0	0	UC(NAF)
WC129	32.00	33.00	1.00	9152	9	Chips	O/B								8.3	0	0	UC(NAF)
WC129	33.00	34.00	1.00	9153	10	Chips	Roof								8.2	0	0	UC(NAF)
WC129	34.00	35.30	1.30	9154	11	Core	Roof			2.50	77				1.8	47	53	PAF
WC129	35.30	36.50	1.20	9155	12	Core	Roof			2.60	80				1.8	50	56	PAF
WC129	36.50	38.20	1.70	9156	13	Core	Roof			4.20	129				1.7	71	79	PAF
WC121	29.00	34.00	5.00	4778		Core	Floor	6.8	0.26	0.65	20	2	18	0.1	2.6	19	21	PAF
WC121	34.00	39.00	5.00	4779		Core	Floor	8.7	0.21	0.35	11	18	-7	1.6	6.7	0	0	NAF
WC122	48.50	49.00	0.50	5786		Chips	Roof			1.40	43	44	-2	1.0	8.4	0	0	NAF
WC122	49.00	49.50	0.50	5787		Chips	Roof			1.30	40	58	-19	1.5	8.2	0	0	NAF
WC122	49.50	50.00	0.50	5788		Chips	Roof			0.90	28	57	-29	2.1	8.7	0	0	NAF
WC122	50.00	50.50	0.50	5789		Chips	Roof			0.78	24	55	-31	2.3	8.7	0	0	NAF
WC122	50.50	51.00	0.50	5790		Chips	Roof			0.94	29	53	-24	1.8	8.5	0	0	NAF
WC122	51.00	51.50	0.50	5791		Chips	Roof			0.71	22	86	-65	4.0	8.4	0	0	NAF
WC122	51.50	52.00	0.50	5792		Chips	Roof			0.94	29	90	-61	3.1	8.1	0	0	NAF
WC122	52.00	52.50	0.50	5793		Chips	Roof			0.80	24	76	-52	3.1	8.5	0	0	NAF
WC122	52.50	53.00	0.50	5794		Chips	Roof			1.40	43	30	13	0.7	2.9	4	6	PAF-LC
WC122	53.00	53.50	0.50	5795		Chips	Roof			1.10	34	8	26	0.2	2.3	17	20	PAF
WC122	53.50	54.00	0.50	5796		Chips	Roof			1.60	49	3	46	0.1	2.1	29	33	PAF
WC122	54.00	54.50	0.50	5797		Chips	Roof			3.10	95	0	95	0.0	2.0	51	56	PAF
WC122	54.50	55.00	0.50	5798		Chips	Roof			2.60	80	0	80	0.0	2.0	51	56	PAF
WC122	55.00	55.50	0.50	5799		Chips	Roof			4.40	135	0	135	0.0	1.9	87	96	PAF
WC122	55.50	56.00	0.50	5800		Chips	Roof			5.60	171	0	171	0.0	1.8	99	109	PAF
WC122	56.00	56.50	0.50	5801		Chips	Roof			8.40	257	0	257	0.0	1.6	133	146	PAF
WC122	56.50	70.30	13.80				Weismantel Seam											
WC122	70.30	70.95	0.65	5802		Core	Floor			0.40	12	5	7	0.4	3.0	5	7	PAF-LC

Table I-3: Compiled acid forming characteristics from the 1996 Duralie EIS for overburden and seam floor samples from Weismantel Seam drill holes.

Drill Hole	Depth (m)			EGi Sample No.	Duralie Sample No.	Sample Type	Sample Description	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
	From	To	Interval							Total %S	MPA	ANC	NAPP	ANC /MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
WC123	48.50	49.00	0.50	5803		Chips	Roof			0.82	25	66	-41	2.6	8.9	0	0	NAF
WC123	49.00	49.50	0.50	5804		Chips	Roof			1.20	37	55	-18	1.5	9.2	0	0	NAF
WC123	49.50	50.00	0.50	5805		Chips	Roof			1.70	52	62	-10	1.2	8.2	0	0	NAF
WC123	50.00	50.50	0.50	5806		Chips	Roof			1.30	40	74	-34	1.9	8.3	0	0	NAF
WC123	50.50	51.00	0.50	5807		Chips	Roof			1.30	40	40	0	1.0	8.3	0	0	NAF
WC123	51.00	51.50	0.50	5808		Chips	Roof			0.99	30	118	-88	3.9	8.5	0	0	NAF
WC123	51.50	52.00	0.50	5809		Chips	Roof			1.50	46	103	-57	2.2	8.3	0	0	NAF
WC123	52.00	52.50	0.50	5810		Chips	Roof			1.40	43	114	-71	2.6	8.9	0	0	NAF
WC123	52.50	53.00	0.50	5811		Chips	Roof			1.00	31	75	-44	2.4	8.7	0	0	NAF
WC123	53.00	53.50	0.50	5812		Chips	Roof			1.20	37	95	-58	2.6	8.8	0	0	NAF
WC123	53.50	54.00	0.50	5813		Chips	Roof			1.20	37	66	-29	1.8	8.3	0	0	NAF
WC123	54.00	54.50	0.50	5814		Chips	Roof			1.30	40	17	22	0.4	2.6	12	15	PAF
WC123	54.50	55.00	0.50	5815		Chips	Roof			2.20	67	4	63	0.1	2.1	35	40	PAF
WC123	55.00	55.50	0.50	5816		Chips	Roof			2.50	77	3	73	0.0	1.9	46	50	PAF
WC123	55.50	56.00	0.50	5817		Chips	Roof			1.70	52	3	49	0.0	2.0	34	38	PAF
WC123	56.00	56.50	0.50	5818		Chips	Roof			2.30	70	1	69	0.0	1.9	42	47	PAF
WC123	56.50	57.00	0.50	5819		Chips	Roof			2.70	83	2	80	0.0	1.9	52	58	PAF
WC123	57.00	57.50	0.50	5820		Chips	Roof			8.50	260	1	259	0.0	1.6	139	154	PAF
WC123	57.50	69.79	12.29				Weismantel Seam											
WC123	69.79	70.47	0.68	5821		Core	Floor			1.00	31	3	28	0.1	2.2	19	22	PAF
WC124	17.00	17.50	0.50	5822		Chips	Roof			1.60	49	150	-101	3.1	9.7	0	0	NAF
WC124	17.50	18.00	0.50	5823		Chips	Roof			1.20	37	105	-69	2.9	10.3	0	0	NAF
WC124	18.00	18.50	0.50	5824		Chips	Roof			1.20	37	75	-39	2.1	10.1	0	0	NAF
WC124	18.50	19.00	0.50	5825		Chips	Roof			0.93	28	19	9	0.7	3.2	2	3	PAF-LC
WC124	19.00	19.50	0.50	5826		Chips	Roof			1.00	31	8	23	0.3	2.4	13	15	PAF
WC124	19.50	20.00	0.50	5827		Chips	Roof			1.00	31	8	23	0.2	2.3	16	19	PAF
WC124	20.00	20.50	0.50	5828		Chips	Roof			1.20	37	5	32	0.1	2.2	21	24	PAF
WC124	20.50	21.00	0.50	5829		Chips	Roof			1.30	40	4	36	0.1	2.2	24	28	PAF
WC124	21.00	21.50	0.50	5830		Chips	Roof			2.60	80	5	75	0.1	1.9	49	54	PAF
WC124	21.50	22.00	0.50	5831		Chips	Roof			2.10	64	4	61	0.1	2.0	37	41	PAF
WC124	22.00	22.50	0.50	5832		Chips	Roof			1.80	55	3	52	0.1	2.0	35	39	PAF
WC124	22.50	23.00	0.50	5833		Chips	Roof			2.20	67	8	60	0.1	1.9	37	42	PAF
WC124	23.00	23.50	0.50	5834		Chips	Roof			1.70	52	13	39	0.3	2.1	26	30	PAF
WC124	23.50	24.00	0.50	5835		Chips	Roof			1.60	49	15	34	0.3	2.2	20	24	PAF
WC124	24.00	24.50	0.50	5836		Chips	Roof			3.30	101	9	92	0.1	1.8	59	66	PAF
WC124	24.50	25.00	0.50	5837		Chips	Roof			12.70	389	2	386	0.0	1.7	165	192	PAF
WC124	25.00	39.40	14.40				Weismantel Seam											
WC124	39.40	39.90	0.50	5838		Core	Floor			0.97	30	2	27	0.1	2.1	22	25	PAF
WC124	39.90	40.40	0.50	5839		Core	Floor			0.76	23	2	21	0.1	2.2	17	20	PAF
WC124	40.40	40.90	0.50	5840		Core	Floor			0.77	24	3	21	0.1	2.3	14	17	PAF

KEY

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

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

MPA = Maximum Potential Acidity (kgH_2SO_4/t)

ANC = Acid Neutralising Capacity (kg H_2SO_4/t)

NAPP = Net Acid Producing Potential (kg H_2SO_4/t)

NAGpH = pH of NAG liquor

$NAG_{(pH4.5)}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)

$NAG_{(pH7.0)}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

NAF = Non-Acid Forming

PAF = Potentially Acid Forming

PAF-LC = PAF - lower capacity

UC(NAF) = Uncertain but Expected to be NAF

UC(PAF) = Uncertain but Expected to be PAF

Table I-4: Sequential NAG test results for selected samples.

EGi Sample No	Drill Hole	Total S (%)	ANC	NAPP	Seq. NAG test Stage 1			Seq. NAG test Stage 2			Seq. NAG test Stage 3			Seq. NAG test Stage 4			Seq. NAG test Stage 5			Total Sequential NAG	
					NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	to pH 4.5	to pH 7.0
			(kg H_2SO_4/t)	(kg H_2SO_4/t)		(kg H_2SO_4/t)			(kg H_2SO_4/t)			(kg H_2SO_4/t)			(kg H_2SO_4/t)			(kg H_2SO_4/t)		(kg H_2SO_4/t)	
31522	DU020C	1.21	40	-3	5.3	0	1	7.2	0	0	7.8	0	0	7.8	0	0				0	1
31525	DU020C	1.33	37	4	4.5	0	1	6.9	0	0	7.7	0	0	7.9	0	0				0	1
31511	DU020C	1.55	46	1	4.8	0	1	7.4	0	0	7.9	0	0	7.8	0	0				0	1
39138	DU150C	1.60	40	9	7.0	0	0	4.6	0	2	5.2	0	0	6.1	0	0	6.9	0	0	0	2
39140	DU150C	3.29	51	50	7.4	0	0	2.6	16	30	2.5	27	47	2.5	23	40	2.6	17	34	83	151
39163	DU150C	1.24	35	3	7.2	0	0	5.8	0	1	6.9	0	0							0	1
39164	DU150C	1.40	53	-10	7.2	0	0	6.9	0	0	7.2	0	0							0	0
38994	DU109R	1.55	55	-8	4.7	0	1	4.0	0.2	2	5.7	0	1	6.0	0	0	6.9	0	0	0.2	4
39008	DU126R	1.43	22	22	3.0	3	5	3.3	1	6	4.2	0.1	4	5.0	0	2	5.4	0	3	4	20
37826	DU165R	1.61	59	-10	7.6	0	0	7.3	0	0	7.9	0	0	8.4	0	0	8.3	0	0	0	0
37831	DU165R	1.44	43	1	7.4	0	0	7.3	0	0	7.8	0	0							0	0
37833	DU165R	1.90	40	18	3.4	2	3	3.5	1	3	4.3	0.2	2	5.5	0	0	6.9	0	0	3	8
37842	DU165R	1.28	34	5	7.6	0	0	6.0	0	0	6.9	0	0							0	0
37847	DU165R	1.30	33	7	7.9	0	0	6.2	0	0	7.1	0	0							0	0
39174	DU206C	1.67	45	6	7.3	0	0	4.6	0	2	5.2	0	1	6.0	0	1				0	4
39181	DU206C	1.22	47	-10	7.5	0	0	6.9	0	0	6.9	0	0	7.1	0	0				0	0

KEY

NAGpH = pH of NAG liquor

$NAG_{(pH4.5)}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)

$NAG_{(pH7.0)}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

Table I-5: Multi-element composition (mg/kg except where shown) of selected sample solids.

Element	Detection Limit	Material Type and Sample Number														
		Clareval Seam Samples			Weismantel Seam Samples											
		Overburden	Overburden	Overburden	Overburden	Overburden	Overburden	Overburden	Overburden	Floor	Overburden	Overburden	Overburden	Floor	Overburden	Floor
		31513	31515	31518	31591	31594	4019	4025	4027	4033	4034	4041	4052	4053	4167	4168
Ag	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Al	0.002%	7.86%	7.37%	7.71%	7.43%	9.36%	7.40%	7.40%	7.60%	7.20%	9.20%	7.80%	7.60%	8.00%	7.80%	8.60%
As	1	10	5	4	3	1	7	7	5	13	1	4	8	2	9	5
Ba	0.1	142	510	629	64	576	580	64	920	78	100	58	60	185	62	195
Be	0.1	1.7	1.7	1.7	1.1	1.1	1.8	1.2	1.8	1.0	0.9	1.2	1.2	0.7	1.3	1.0
Ca	0.001%	0.32%	0.31%	0.69%	0.07%	0.08%	0.47%	0.09%	0.30%	0.08%	0.20%	0.15%	0.18%	0.13%	0.13%	0.17%
Cd	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.6	<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2
Co	0.1	8.3	1.9	9.0	6.4	2.8	7.0	9.0	8.0	11.0	2.0	5.0	7.0	1.0	7.0	3.0
Cr	2.0	41	45	42	27	23	32	42	34	44	40	34	38	32	28	26
Cu	1.0	14	11	6	3	3	15	18	13	12	16	8	12	8	8	6
F	50	401	320	342	222	248	250	100	200	150	150	150	150	150	150	150
Fe	0.01%	7.40%	1.99%	2.05%	1.84%	0.28%	0.17%	2.25%	1.70%	2.75%	0.90%	2.30%	2.85%	1.30%	3.10%	0.98%
Hg	0.01	0.12	<0.01	<0.01	<0.01	<0.01	<0.04	<0.20	<0.06	<0.09	<0.02	<0.04	<0.02	<0.01	<0.03	<0.01
K	0.002%	1.20%	1.91%	2.27%	0.46%	1.61%	2.40%	0.46%	2.75%	0.58%	0.98%	0.64%	0.70%	1.16%	0.58%	0.98%
Mg	0.002%	0.15%	0.26%	0.53%	0.08%	0.06%	0.92%	0.09%	0.66%	0.10%	0.10%	0.10%	0.10%	0.09%	0.09%	0.10%
Mn	1.0	122	18	284	119	17	255	118	230	108	36	94	118	26	135	39
Mo	0.1	4.0	3.8	1.9	0.5	0.4	0.5	1.5	0.5	2.5	0.5	0.5	1.0	0.5	2.0	0.5
Na	0.002%	0.75%	2.21%	2.24%	0.04%	0.11%	0.92%	0.04%	2.15%	0.03%	0.03%	0.03%	0.03%	0.17%	0.03%	0.18%
Ni	1.0	19	6	26	10	7	14	22	20	28	15	12	16	13	7	8
P	20	232	134	217	96	87	240	60	180	60	60	160	200	40	160	60
Pb	2.0	14	14	13	12	14	34	20	22	26	18	22	22	24	20	22
S	0.001%	8.71%	0.01%	0.81%	2.21%	0.11%	0.33%	3.10%	0.27%	4.20%	1.10%	3.30%	4.30%	1.50%	4.50%	1.00%
Sb	0.05	0.68	0.58	0.56	0.49	0.45	1.60	0.80	0.80	0.80	0.60	0.60	0.60	0.80	0.60	0.80
Se	0.01	0.56	0.37	0.29	0.04	0.11	0.14	0.28	0.12	0.33	0.15	0.10	0.17	0.19	0.18	0.17
Si	0.1%	26.5%	35.7%	34.4%	36.5%	34.7%	31.0%	31.0%	31.0%	33.0%	34.0%	33.0%	32.0%	33.0%	33.0%	33.0%
Sn	0.1	2.6	1.5	1.6	1.3	1.4	1.0	2.0	2.0	2.0	2.0	1.0	1.0	1.0	2.0	1.0
Sr	0.05	126	153	173	15	57	64	14	195	15	39	16	17	40	16	42
Th	0.01	8.38	7.33	7.41	7.29	6.57										
U	0.01	2.79	2.46	2.35	1.57	1.64										
Zn	1.0	73	35	59	41	55	65	78	82	78	64	88	54	52	60	56

< element at or below analytical detection limit.

Table I-6: Geochemical abundance indices (GAI) of selected sample solids.

Element	Median Soil Abundance*	Material Type and Sample Number														
		Clareval Seam Samples			Weismantel Seam Samples											
		Overburden	Overburden	Overburden	Overburden	Overburden	Overburden	Overburden	Overburden	Floor	Overburden	Overburden	Overburden	Floor	Overburden	Floor
		31513	31515	31518	31591	31594	4019	4025	4027	4033	4034	4041	4052	4053	4167	4168
Ag	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Al	7.1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ba	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Be	0.3	2	2	2	1	1	2	1	2	1	1	1	1	1	2	1
Ca	1.5%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cd	0.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Co	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cr	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cu	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fe	4.0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hg	0.06	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
K	1.4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mg	0.5%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mn	1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mo	1.2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Na	0.5%	-	2	2	-	-	-	-	2	-	-	-	-	-	-	-
Ni	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pb	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S	0.07%	6	-	3	4	-	2	5	1	5	3	5	5	4	5	3
Sb	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Se	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Si	33.0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sn	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sr	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Th	9	-	-	-	-	-										
U	2	-	-	-	-	-										
Zn	90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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

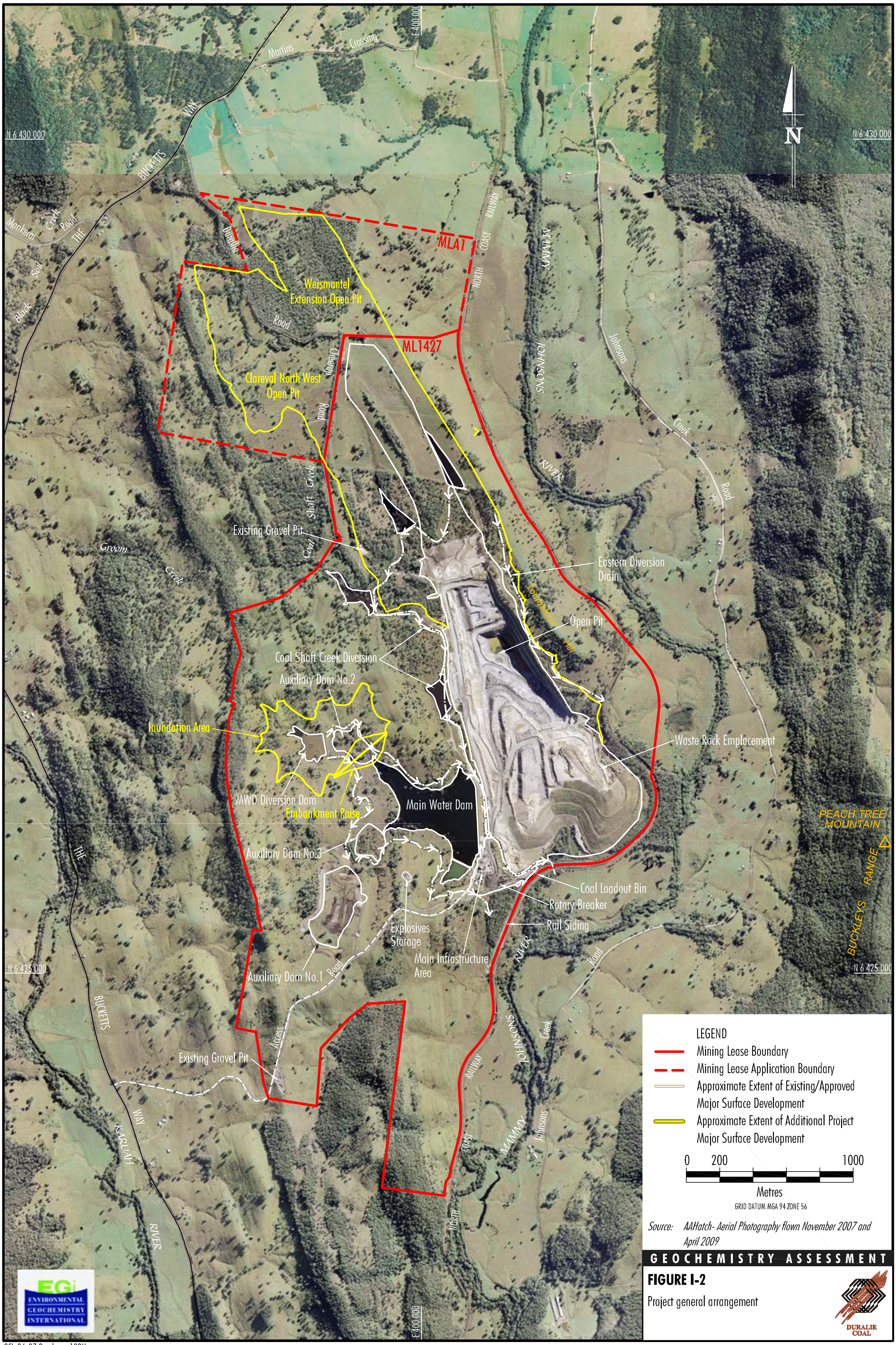
Table I-7: Multi-element composition of water extracts from selected sample solids.

Parameter		Detection Limit	Material Type, Sample Number and %S in Solid														
			Clareval Seam Samples			Weismantel Seam Samples											
			Overburden	Overburden	Overburden	Overburden	Overburden	Overburden	Overburden	Overburden	Floor	Overburden	Overburden	Overburden	Floor	Overburden	Floor
			31513	31515	31518	31591	31594	4019	4025	4027	4033	4034	4041	4052	4053	4167	4168
			8.71%	0.01%	0.81%	2.21%	0.11%	0.33%	3.10%	0.27%	4.20%	1.10%	3.30%	4.30%	1.50%	4.50%	1.00%
pH		0.01	3.4	5.4	6.8	3.7	6.4	8.2	4.7	6.5	4.5	7.6	5.0	5.6	7.7	3.9	7.5
EC	dS/m	0.01	1.67	0.81	0.21	1.47	0.10	1.21	0.96	0.69	1.01	0.35	0.69	0.58	0.25	0.94	0.24
Ag	mg/l	0.00001	0.00003	<0.00001	<0.00001	0.00002	<0.00001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Al	mg/l	0.01	29.60	2.85	1.95	40.00	3.28	0.03	6.60	0.22	7.20	0.13	2.75	2.50	0.05	1.80	0.14
As	mg/l	0.0001	0.018	0.002	0.002	0.021	0.002	<0.005	0.005	<0.005	0.010	<0.005	0.005	0.005	<0.005	0.005	<0.005
B	mg/l	0.01	<0.01	0.03	0.02	<0.01	0.02	0.01	0.01	0.02	0.01	0.02	0.02	0.01	0.01	0.02	0.02
Ba	mg/l	0.00005	0.030	0.025	0.044	0.027	0.106	0.002	0.032	0.026	0.028	0.004	0.036	0.044	0.006	0.048	0.022
Be	mg/l	0.0001	0.0712	0.0001	0.0075	0.0454	0.0003	<0.0002	0.0980	0.0022	0.0260	0.0004	0.0540	0.0540	0.0008	0.0600	0.0008
Ca	mg/l	0.01	287	1	175	110	3	25	165	18	140	32	190	225	22	145	8
Cd	mg/l	0.00002	0.00521	0.00002	0.00212	0.00219	0.00002	<0.001	0.004	<0.001	0.005	<0.001	0.002	0.002	<0.001	0.001	<0.001
Cl	mg/l	2	7	18	16	6	4	140	15	20	10	5	20	20	10	20	10
Co	mg/l	0.0001	0.418	0.001	0.579	0.832	0.005	0.002	1.400	0.084	1.350	0.024	0.145	0.185	0.004	0.140	0.002
Cr	mg/l	0.01	0.30	<0.01	<0.01	0.19	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
Cu	mg/l	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01
F	mg/l	0.1	0.5	<0.1	0.2	<0.1	0.4	2.1	2.0	0.3	2.0	1.0	1.3	1.1	0.7	1.0	1.4
Fe	mg/l	0.01	540.38	1.03	16.00	399.30	2.18	0.01	220.00	2.75	205.00	3.30	135.00	106.00	1.30	68.00	0.80
Hg	mg/l	0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
K	mg/l	0.1	2.6	2.9	17.2	1.1	2.2	3.8	4.8	4.4	5.2	5.2	7.6	8.0	3.1	7.2	1.8
Mg	mg/l	0.01	72	1	82	37	1	22	50	25	52	5	30	29	4	26	2
Mn	mg/l	0.01	6.54	<0.01	7.50	4.09	0.02	0.18	4.60	0.60	3.20	0.11	2.65	2.50	0.13	3.60	0.07
Mo	mg/l	0.00005	0.0014	0.0002	0.0003	0.0016	0.0006	0.0170	<0.001	<0.001	<0.001	0.0230	<0.001	<0.001	0.0200	<0.001	0.0060
Na	mg/l	0.1	66	31	33	20	11	310	52	165	46	54	41	49	41	43	34
Ni	mg/l	0.01	0.85	<0.01	1.38	1.11	<0.01	<0.01	1.06	0.05	0.96	0.03	0.23	0.22	<0.01	0.24	0.01
P	mg/l	0.1	0.2	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pb	mg/l	0.0005	0.009	0.001	0.004	0.100	0.002	<0.005	0.090	<0.005	0.110	<0.005	0.100	0.060	<0.005	0.020	<0.005
SO_4	mg/l	0.3	2295	39	832	1516	29	500	1100	450	1040	135	960	980	116	660	56
Sb	mg/l	0.00001	0.0002	0.0001	0.0003	0.0008	0.0003	0.0010	<0.001	<0.001	<0.001	0.0010	<0.001	<0.001	0.0010	<0.001	<0.001
Se	mg/l	0.0005	0.009	0.001	0.011	0.013	0.008	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Si	mg/l	0.05	6.30	9.50	5.71	2.77	7.39	3.40	11.40	12.50	10.60	4.50	12.50	13.50	7.00	13.50	6.60
Sn	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.002	<0.002	<0.002	<0.002	<0.002	0.0020	<0.002	<0.002	<0.002	<0.002
Sr	mg/l	0.00002	4.79	0.01	1.13	0.50	0.06	0.07	0.80	0.11	0.68	0.52	1.16	1.25	0.29	0.94	0.10
Th	mg/l	0.00001	0.0423	0.0002	0.0001	0.0459	0.0004										
U	mg/l	0.00001	0.0346	0.0001	0.0019	0.0162	0.0002										
Zn	mg/l	0.01	3.50	0.03	0.66	3.26	0.02	0.05	4.30	0.19	6.80	0.11	4.30	1.45	0.05	0.92	0.02

< element at or below analytical detection limit.

FIGURE I-1
Regional location

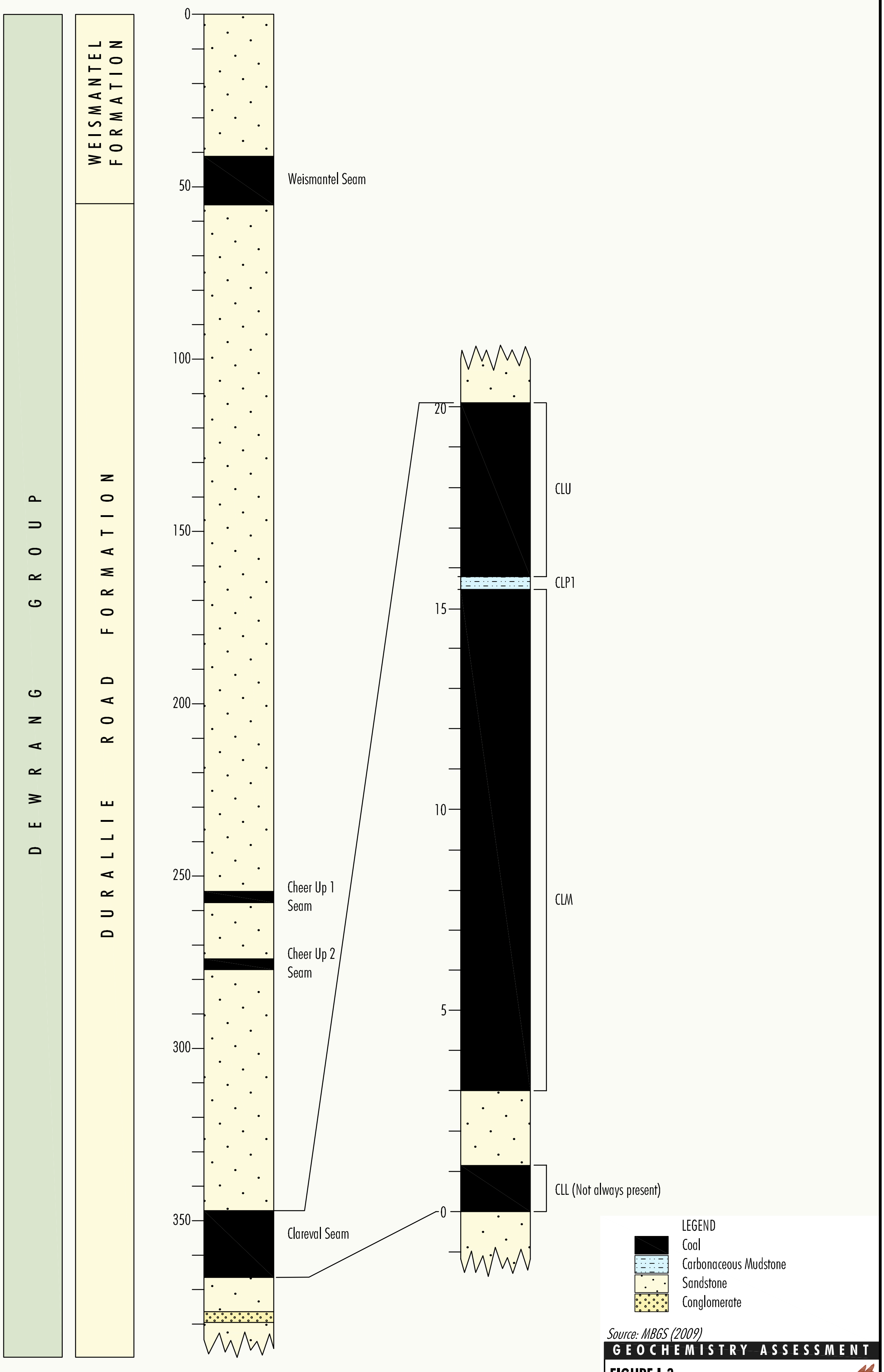
GCL-06-07 Geochem_101C



GEOCHEMISTRY ASSESSMENT

FIGURE I-2

Project general arrangement



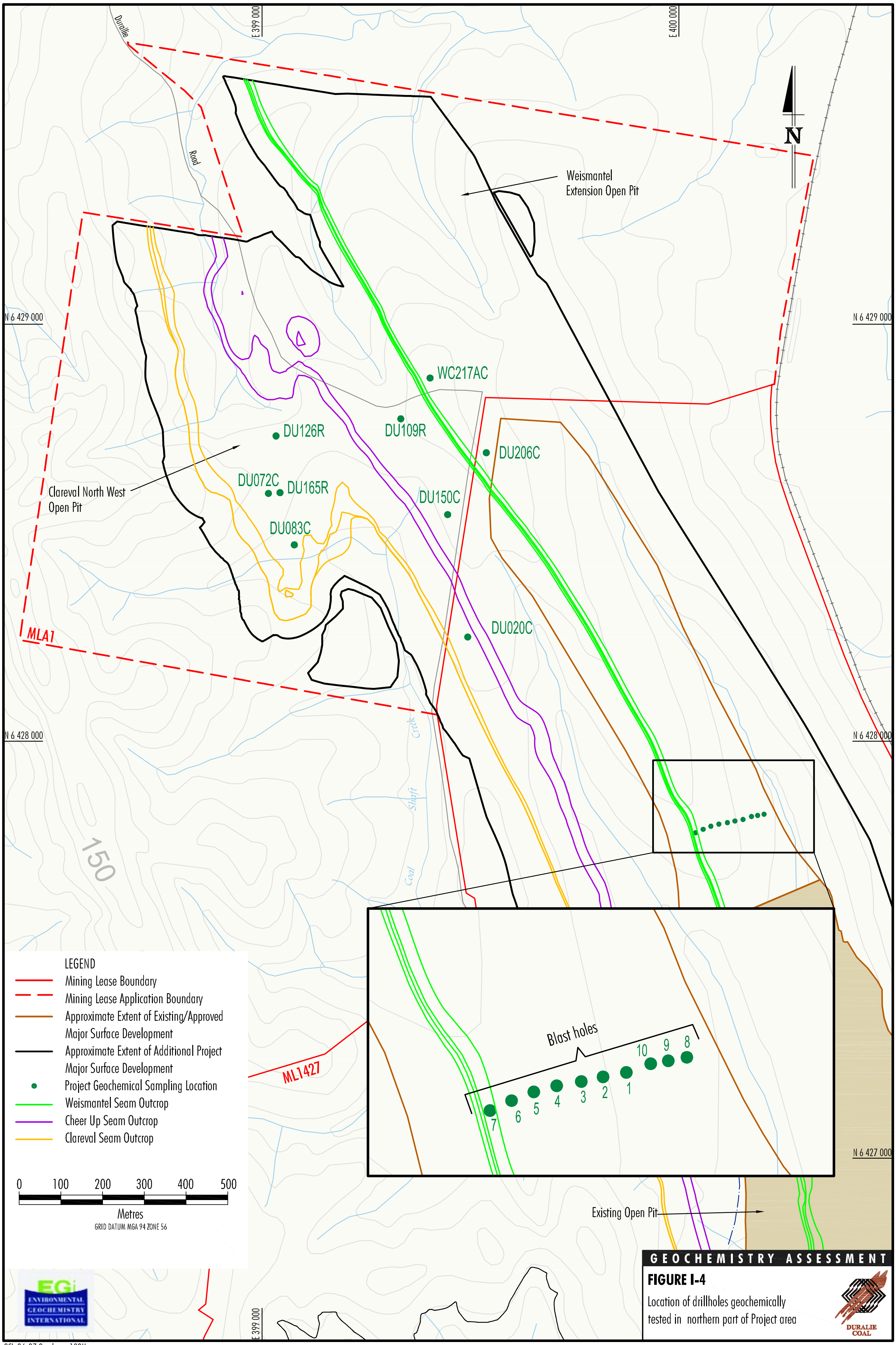
Source: MBGS (2009)

GEOCHEMISTRY ASSESSMENT

FIGURE I-3

Typical stratigraphic section for the Project

GCL-06-07 Geochem_104D

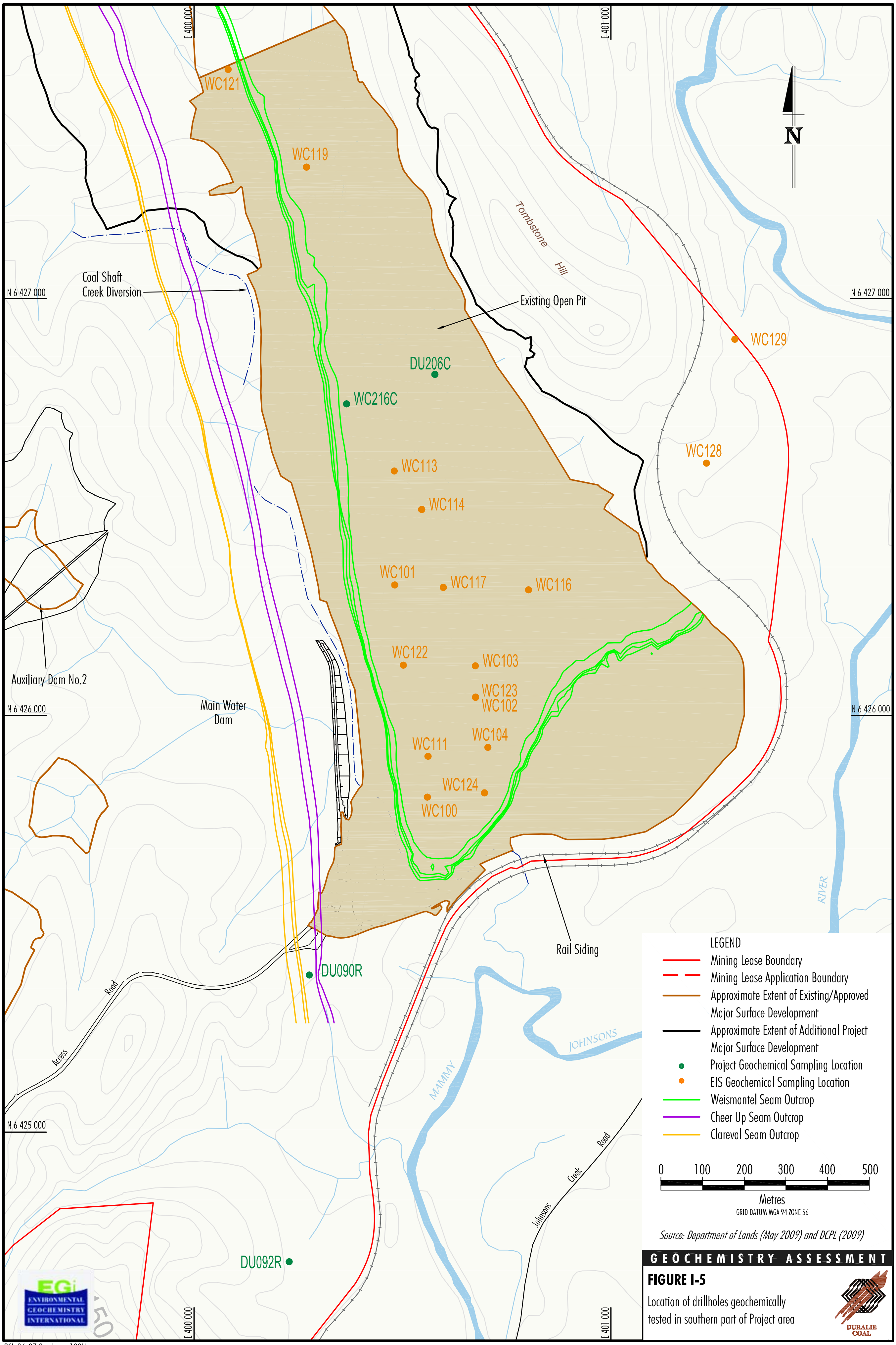


GEOCHEMISTRY ASSESSMENT

FIGURE I-4

Location of drillholes geochemically tested in northern part of Project area

GCL-06-07 Geochem_103H



GEOCHEMISTRY ASSESSMENT

FIGURE I-5

Location of drillholes geochemically tested in southern part of Project area

GCL-06-07 Geochem_103H

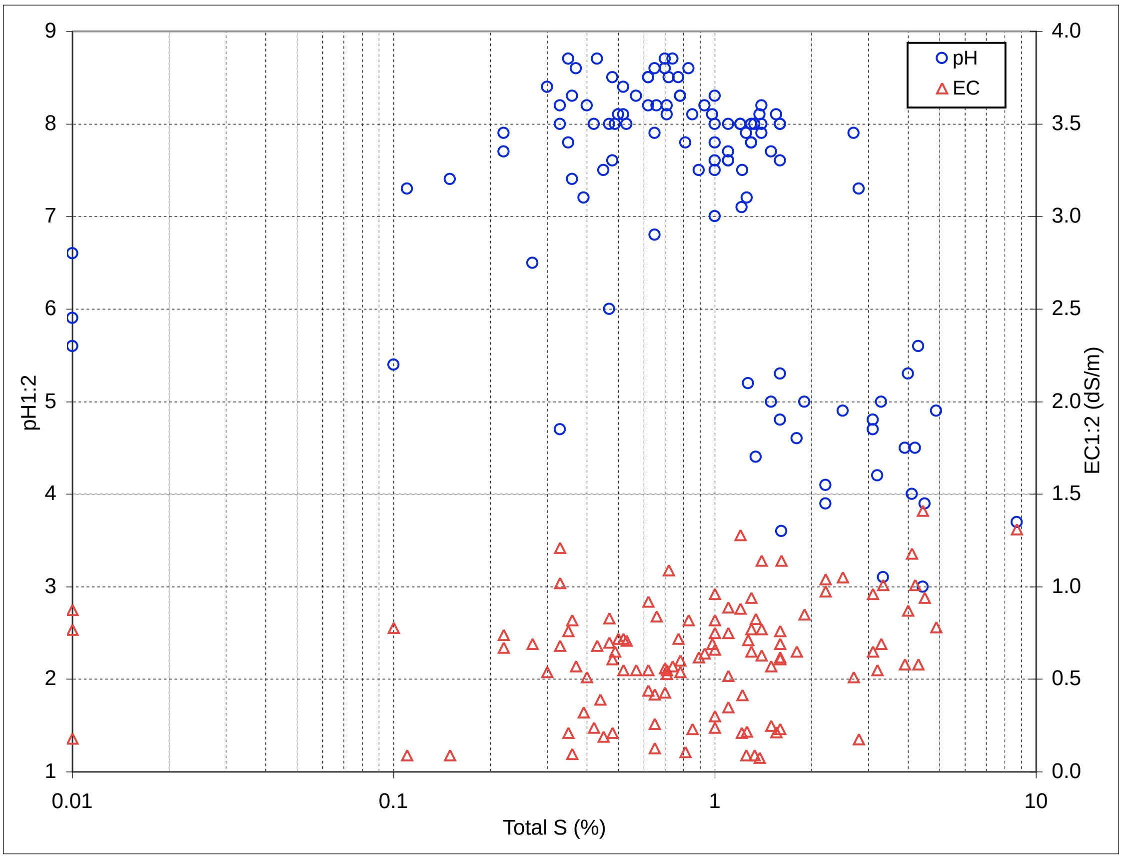


Figure I-6: Plot showing pH1:2 and EC1:2 versus total S.

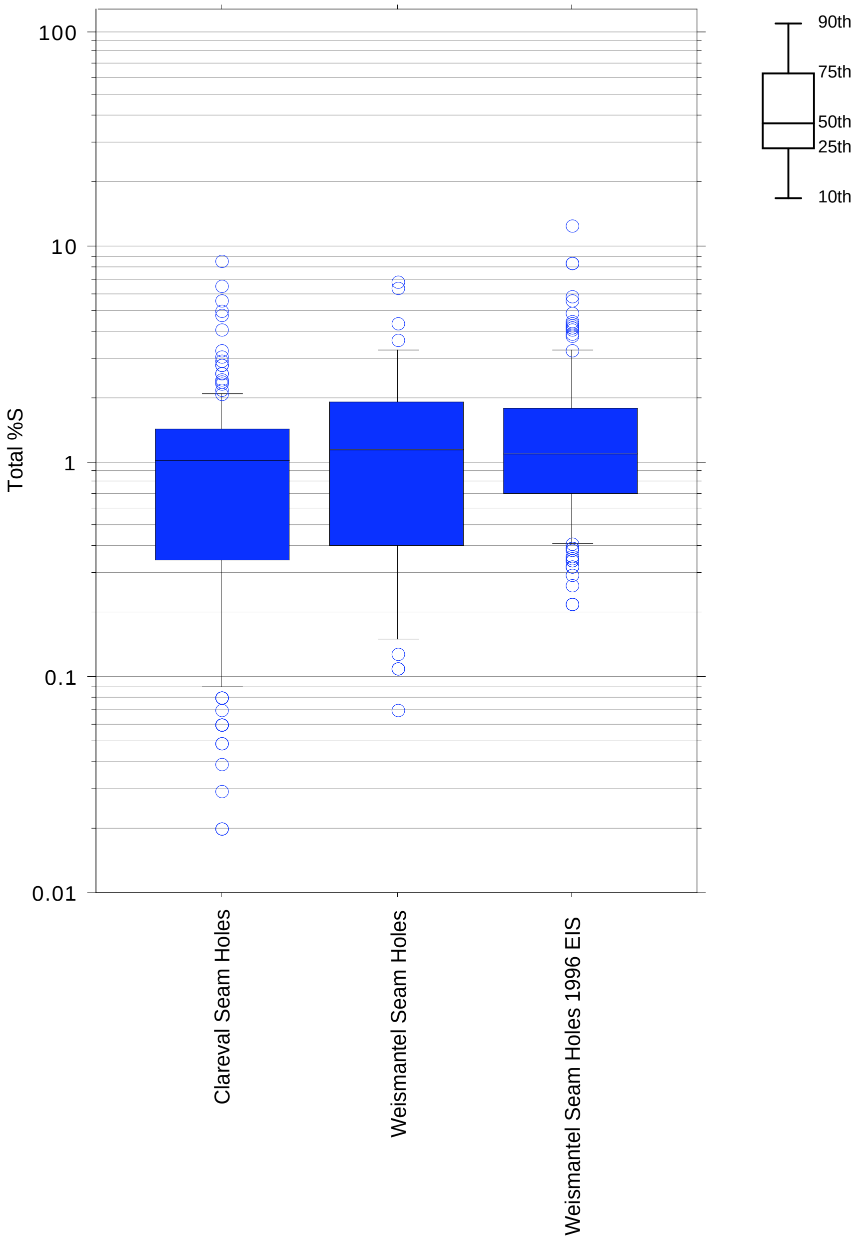


Figure I-7: Box plot showing the distribution of S split by sample set. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

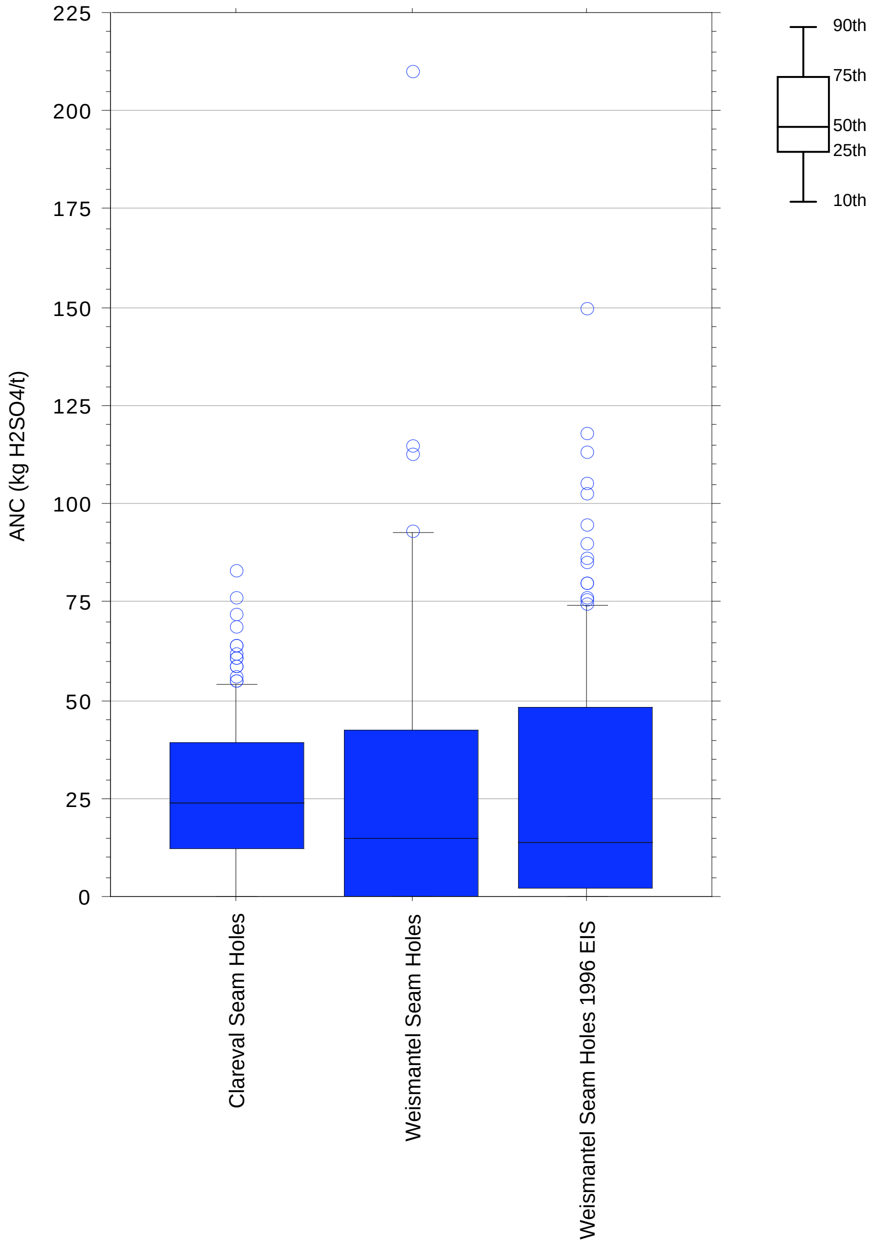


Figure I-8: Box plot showing the distribution of ANC split by sample set. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

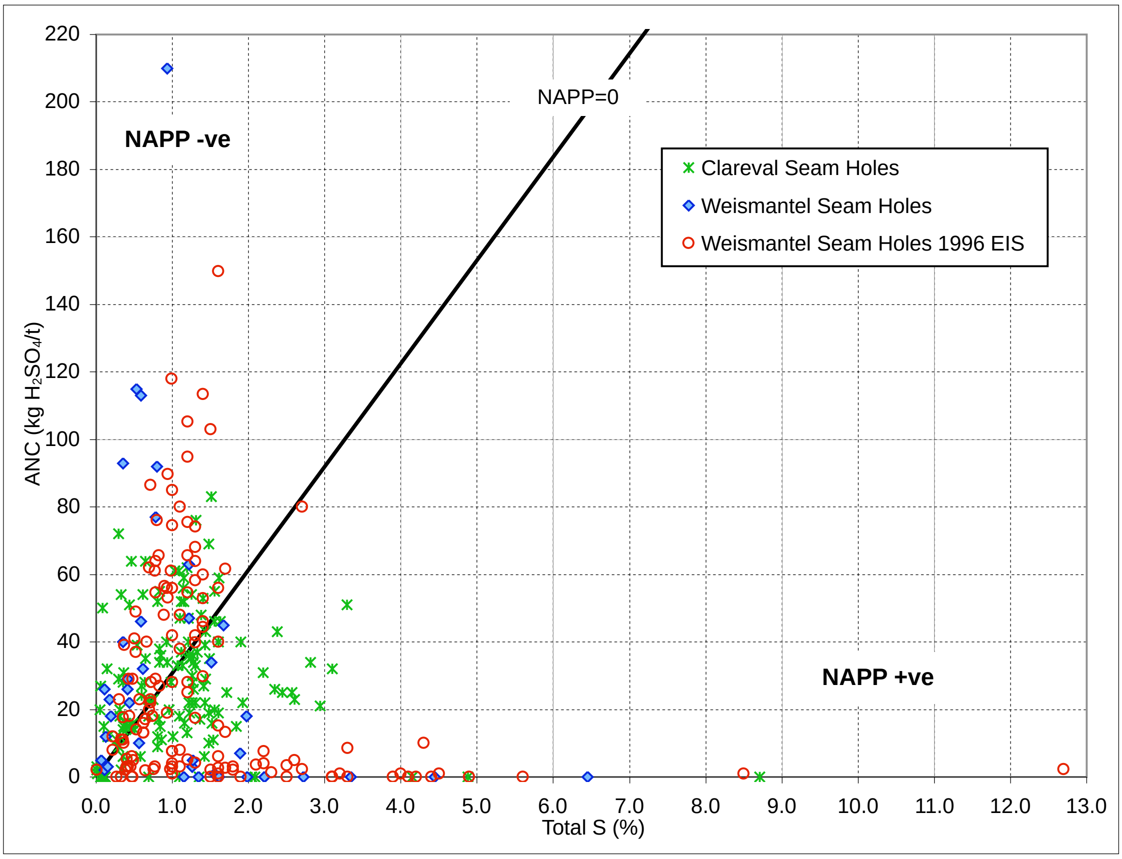


Figure I-9: Acid-base account (ABA) plot showing ANC versus total S split by lithology.

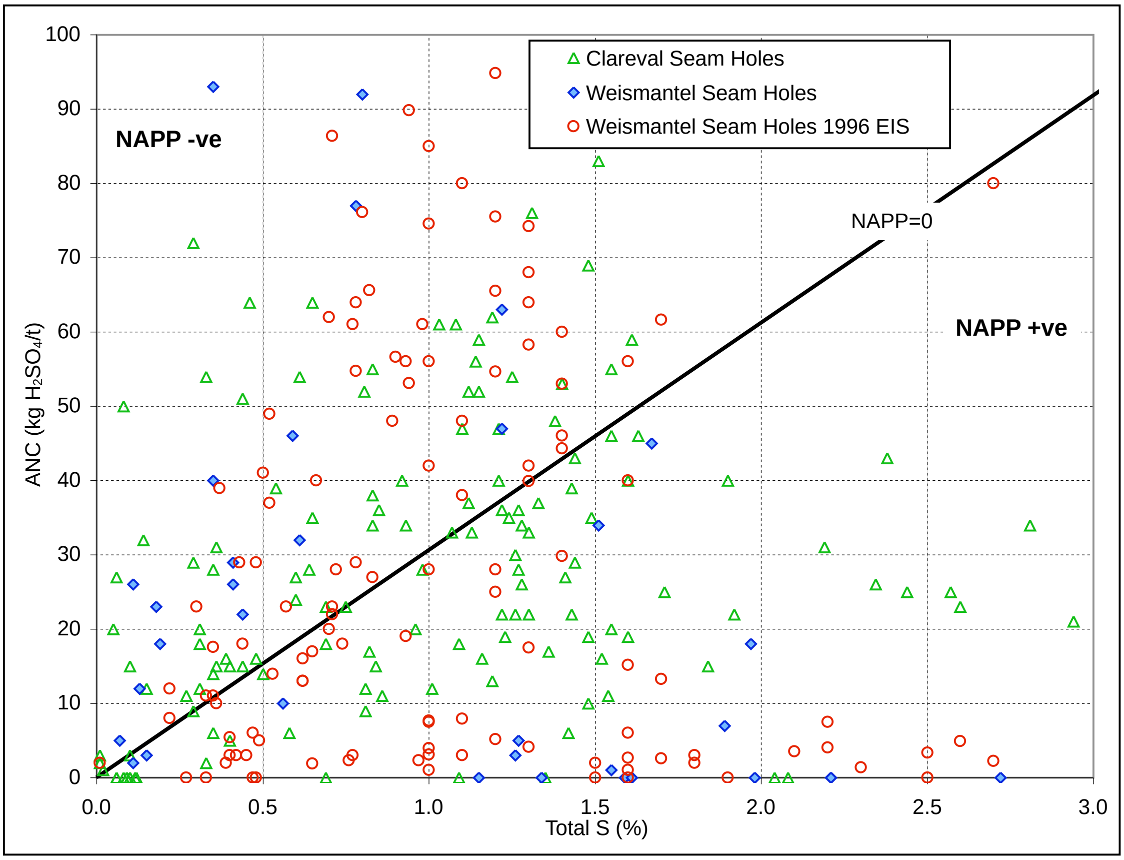


Figure I-10: Acid-base account (ABA) plot showing ANC versus total S split by lithology.

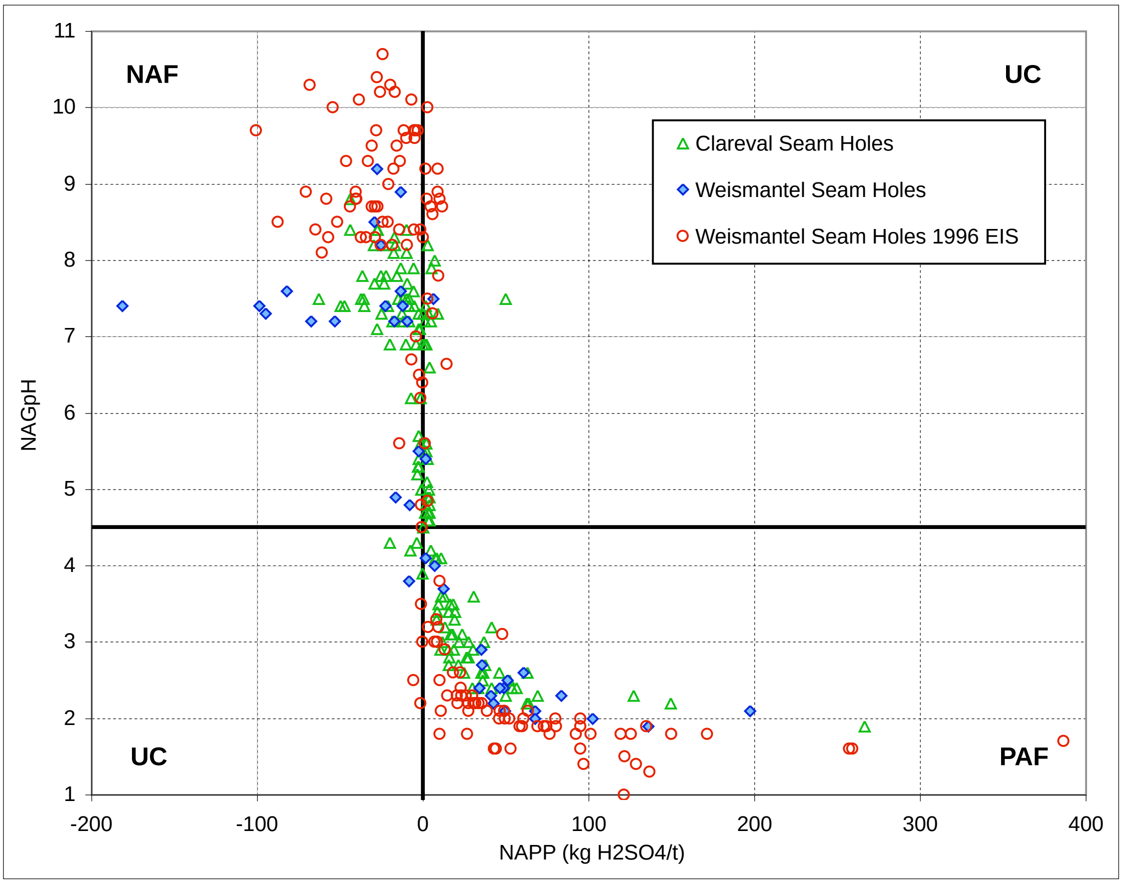


Figure I-11: ARD classification plot showing NAGpH versus NAPP split by lithology, with ARD classification domains indicated.

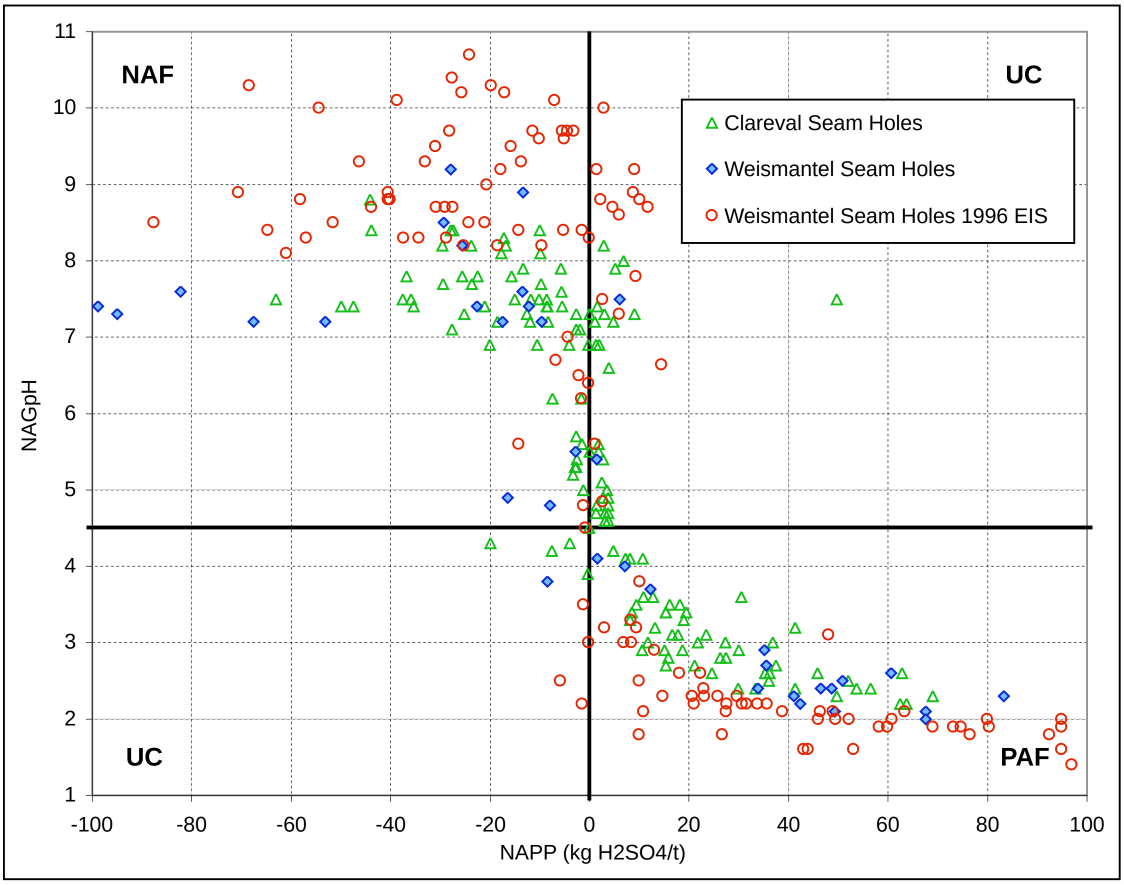


Figure I-12: ARD classification plot showing NAGpH versus NAPP split by lithology, with ARD classification domains indicated.

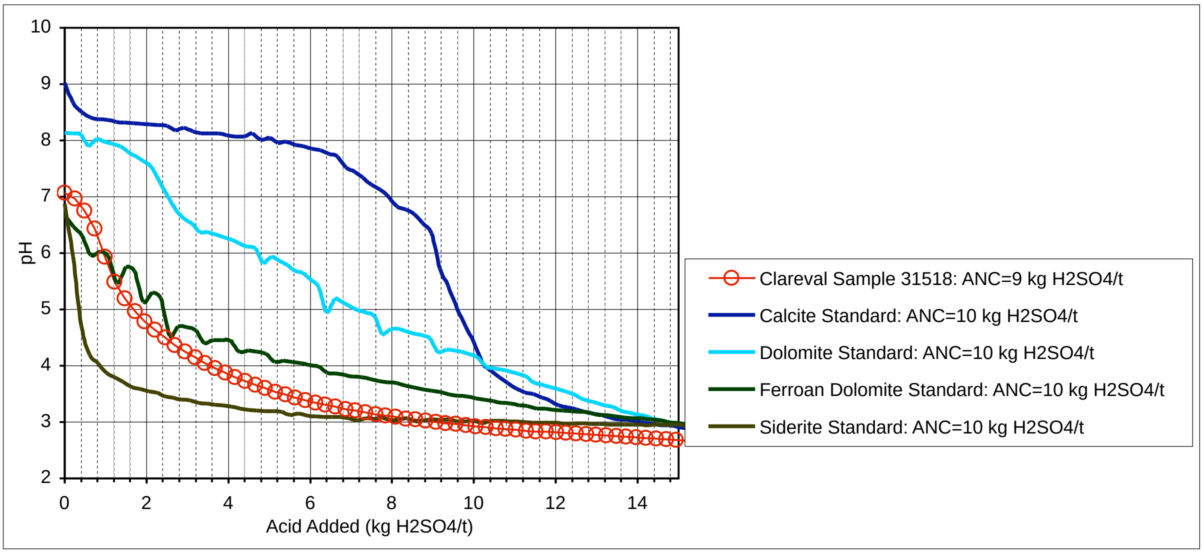


Figure I-13: ABCC profile for sample 31518 with an ANC value close to 10 kg H_2SO_4/t. Carbonate standard curves are included for reference.

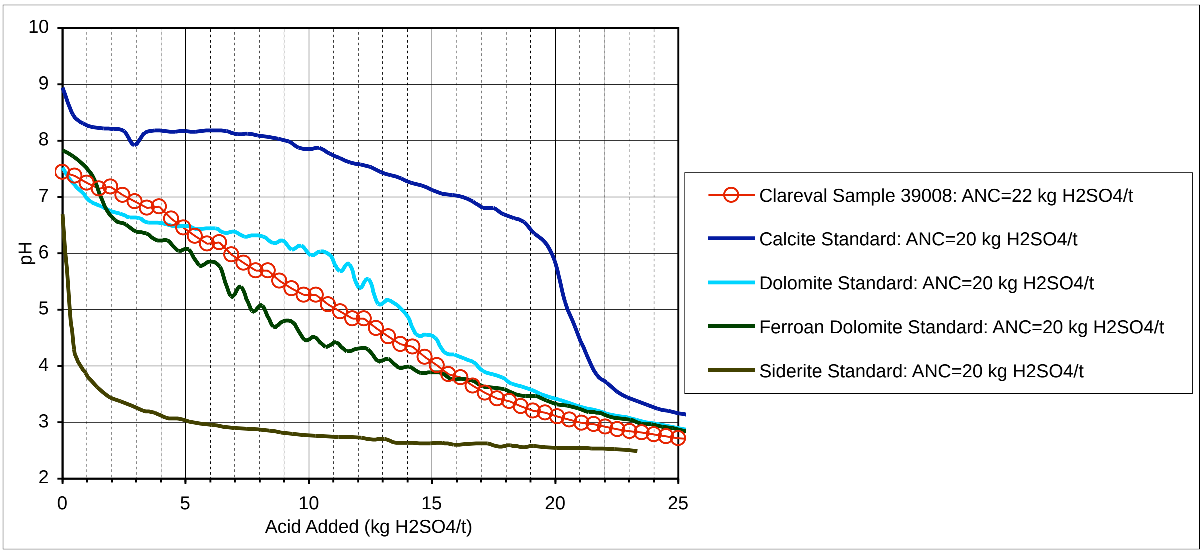


Figure I-14: ABCC profile for sample 39008 with an ANC value close to 20 kg H_2SO_4/t. Carbonate standard curves are included for reference.

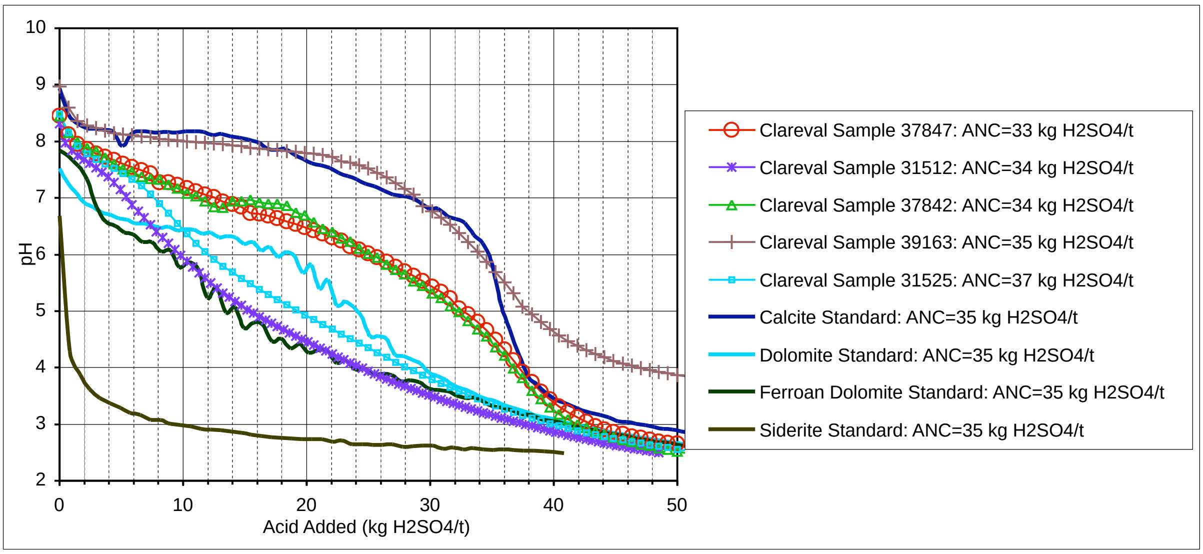


Figure I-15: ABCC profile for samples with an ANC value close to 35 kg H_2SO_4/t. Carbonate standard curves are included for reference.

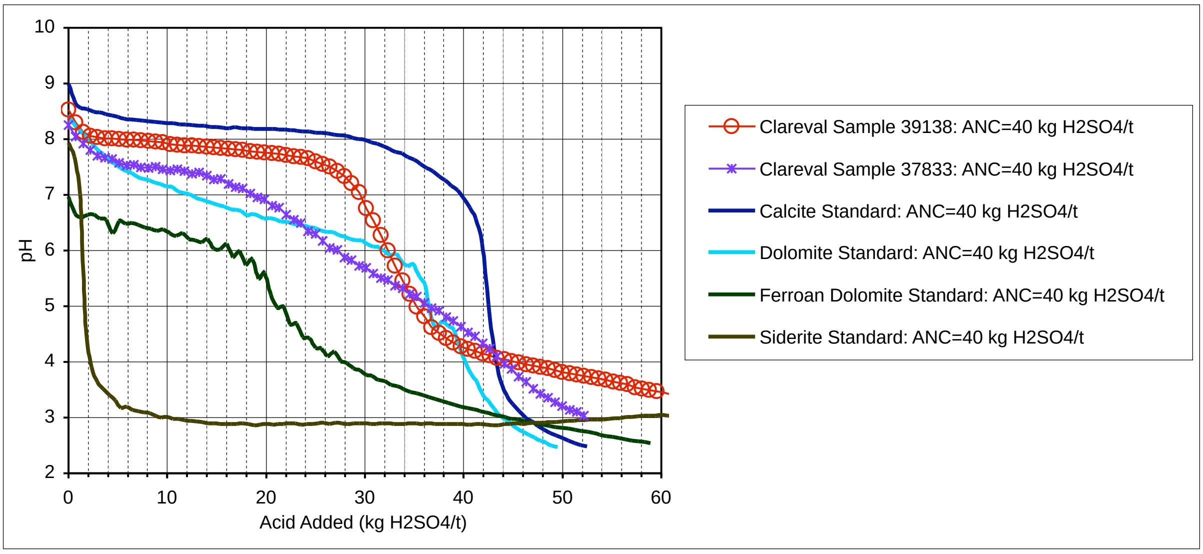


Figure I-16: ABCC profile for samples with an ANC value close to 40 kg H2SO4/t. Carbonate standard curves are included for reference.

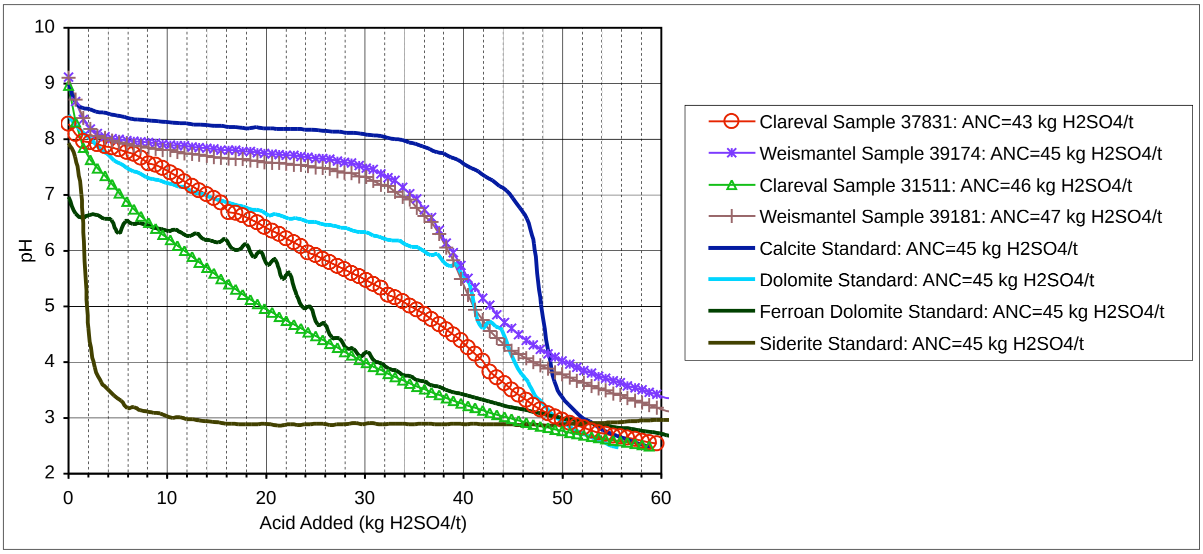


Figure I-17: ABCC profile for samples with an ANC value close to 45 kg H2SO4/t. Carbonate standard curves are included for reference.

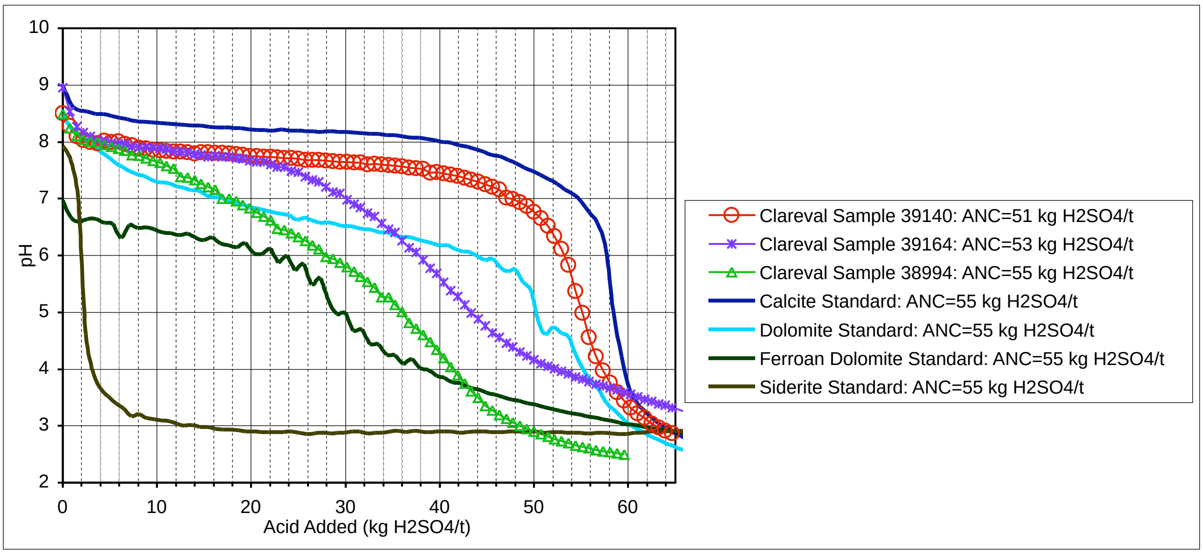


Figure I-18: ABCC profile for samples with an ANC value close to 55 kg H2SO4/t. Carbonate standard curves are included for reference.

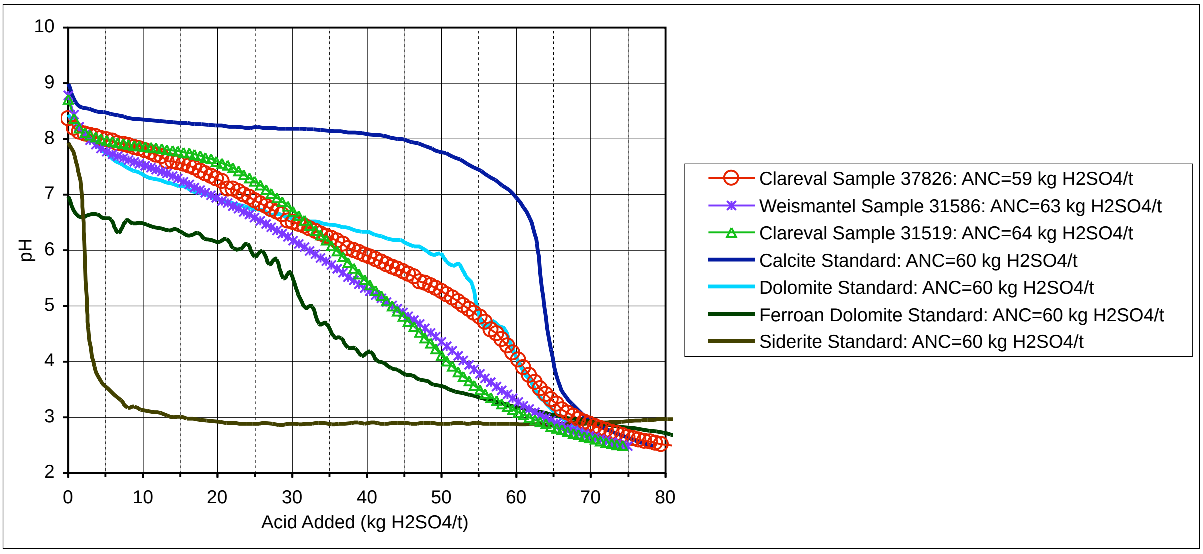
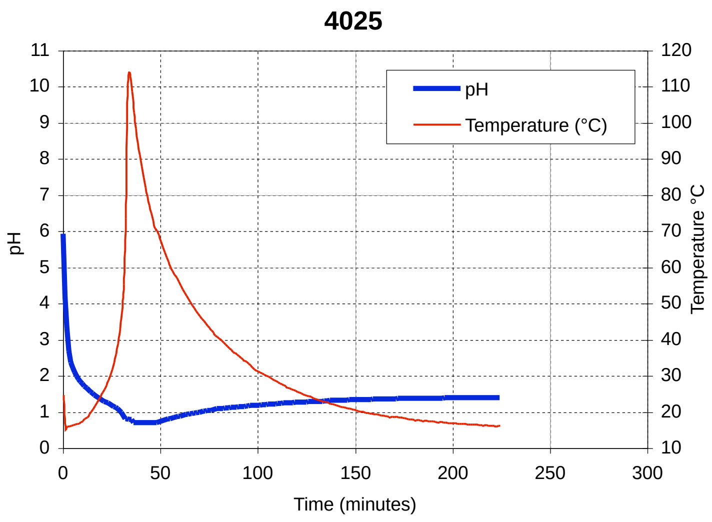
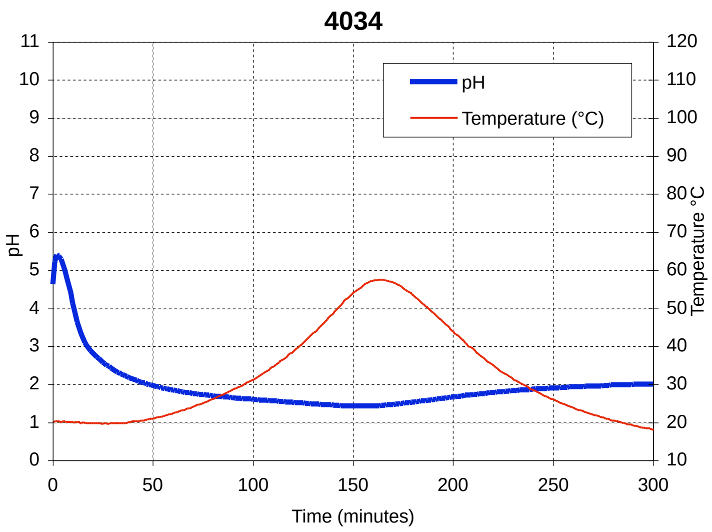


Figure I-19: ABCC profile for samples with an ANC value close to 60 kg H2SO4/t. Carbonate standard curves are included for reference.



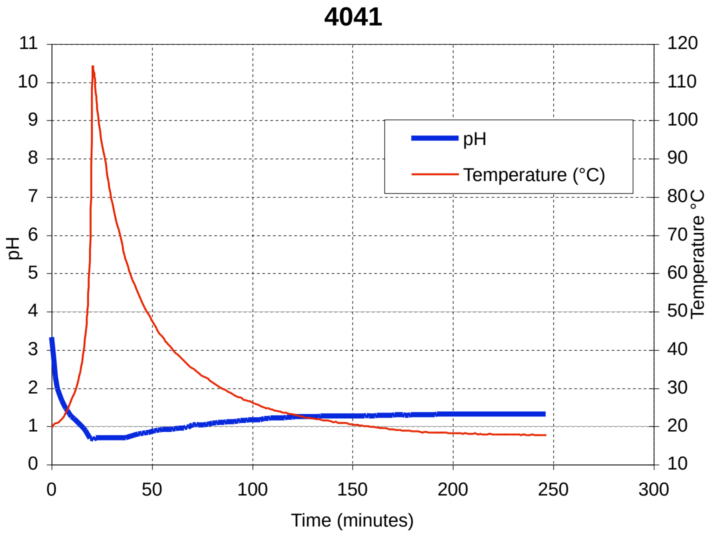
Sample Characteristics
%S = 3.10
ANC = 0 kg H2SO4/t
NAPP = 95 kg H2SO4/t
NAGpH = 1.6

Figure I-20: Kinetic NAG graph for sample 4025.



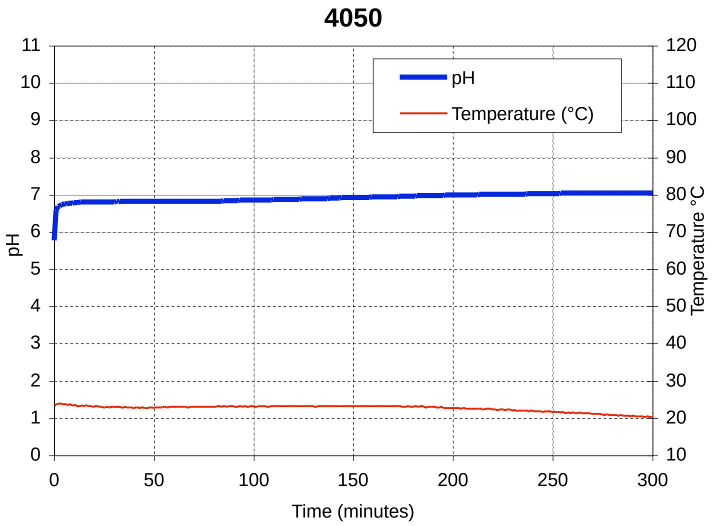
Sample Characteristics
%S = 1.10
ANC = 3 kg H2SO4/t
NAPP = 31 kg H2SO4/t
NAGpH = 2.2

Figure I-21: Kinetic NAG graph for sample 4034.



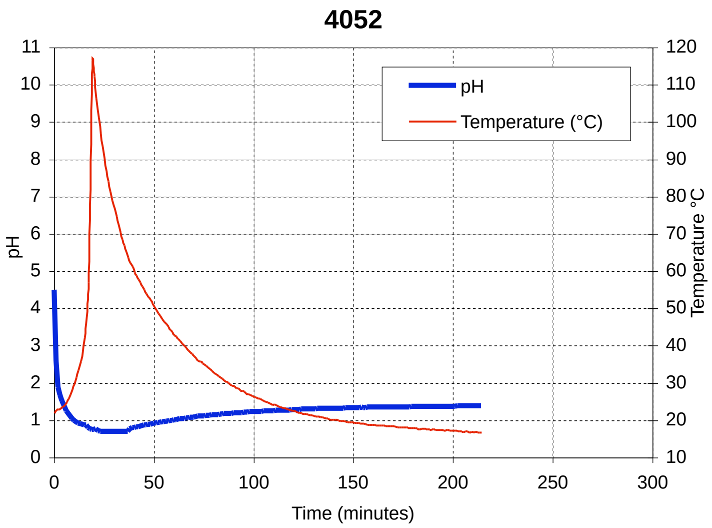
Sample Characteristics
%S = 3.30
ANC = 0 kg H2SO4/t
NAPP = 101 kg H2SO4/t
NAGpH = 1.8

Figure I-22: Kinetic NAG graph for sample 4041.



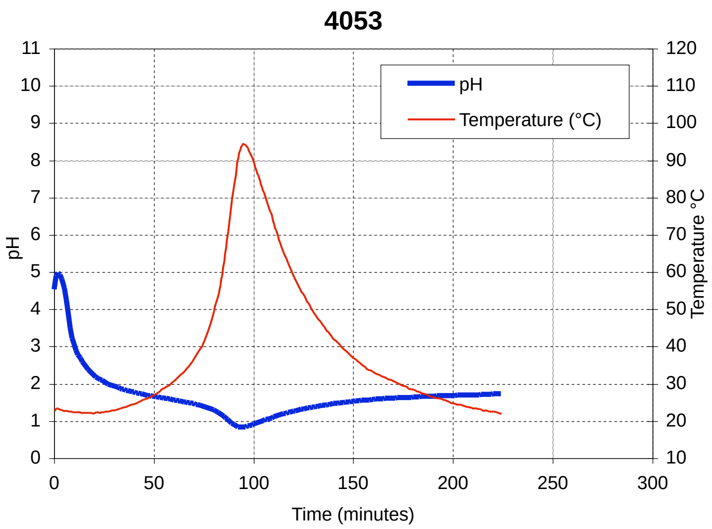
Sample Characteristics
%S = 1.40
ANC = 60 kg H2SO4/t
NAPP = -17 kg H2SO4/t
NAGpH = 10.2

Figure I-23: Kinetic NAG graph for sample 4050.



Sample Characteristics
%S = 4.30
ANC = 10 kg H2SO4/t
NAPP = 122 kg H2SO4/t
NAGpH = 1.5

Figure I-24: Kinetic NAG graph for sample 4052.



Sample Characteristics
%S = 1.50
ANC = 0 kg H2SO4/t
NAPP = 46 kg H2SO4/t
NAGpH = 2.0

Figure I-25: Kinetic NAG graph for sample 4053.

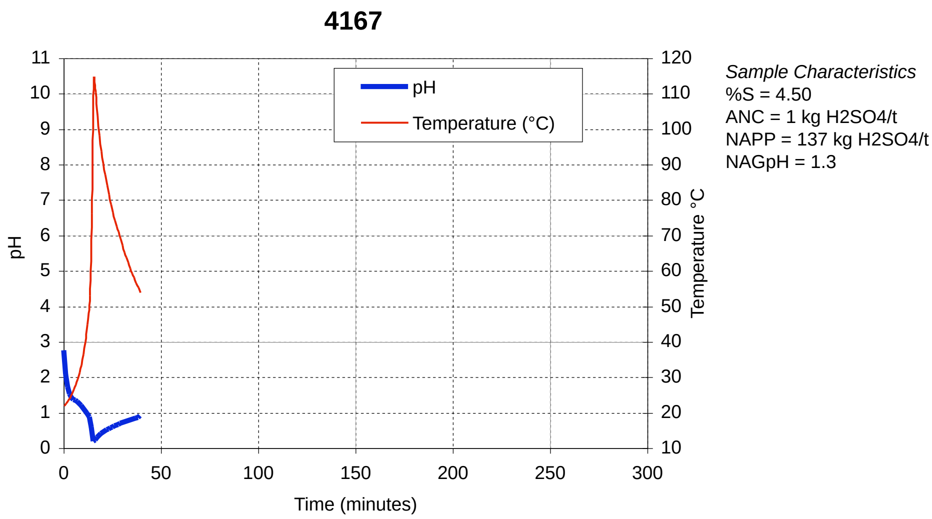


Figure I-26: Kinetic NAG graph for sample 4167.

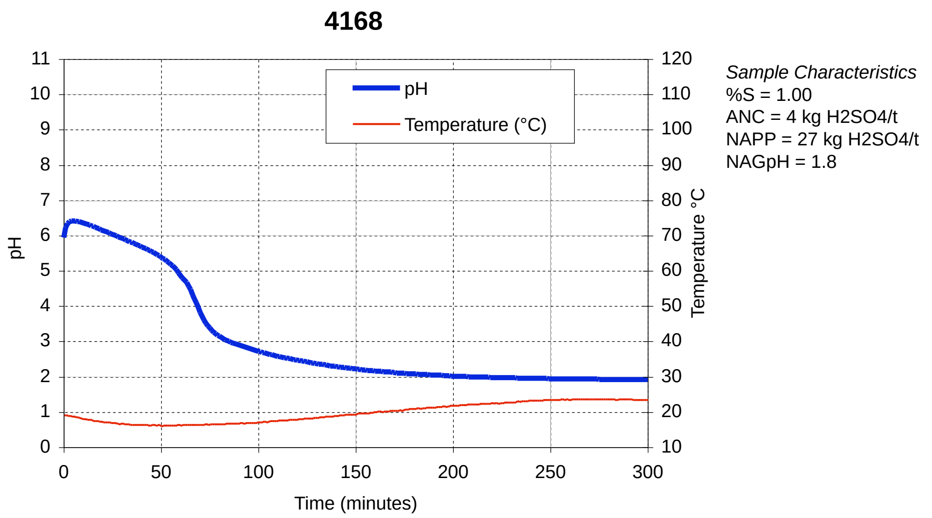


Figure I-27: Kinetic NAG graph for sample 4168.

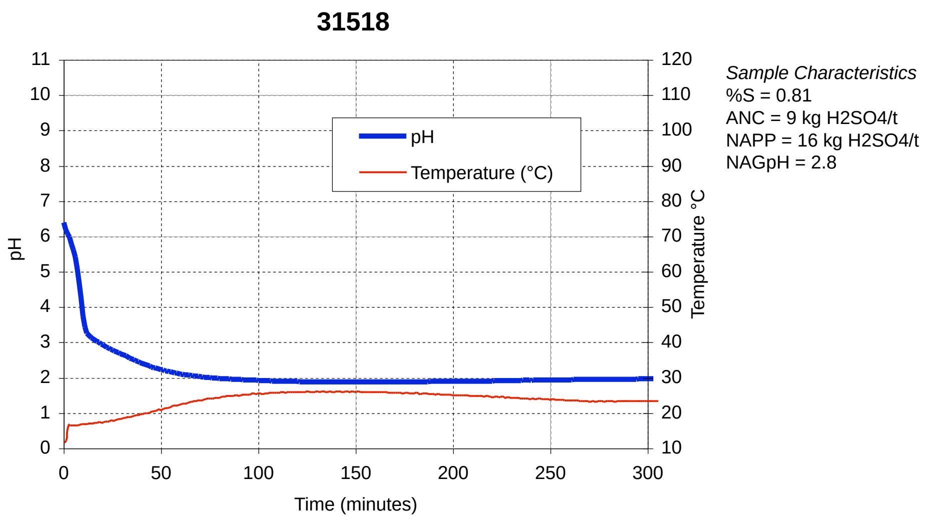
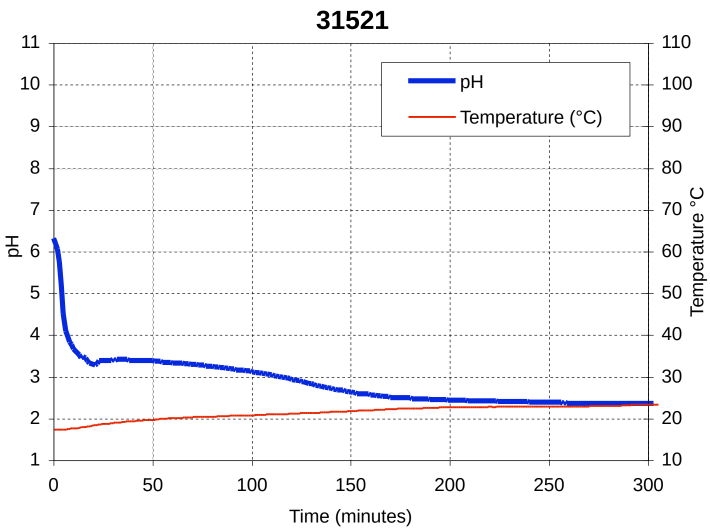
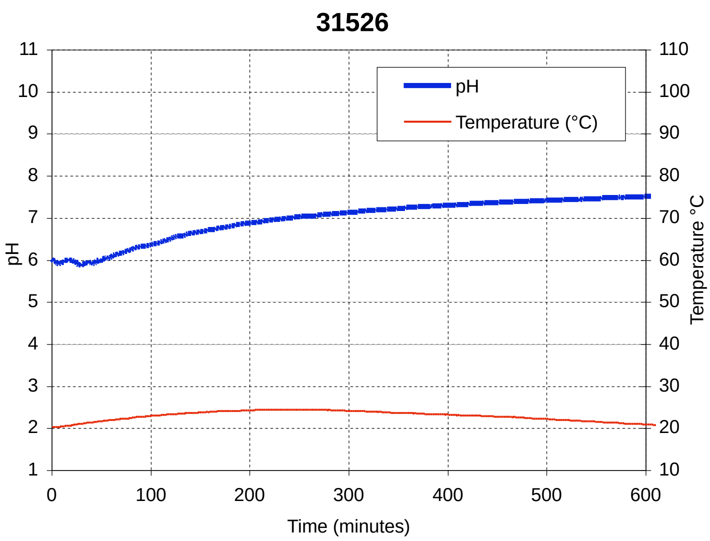


Figure I-28: Kinetic NAG graph for sample 31518.



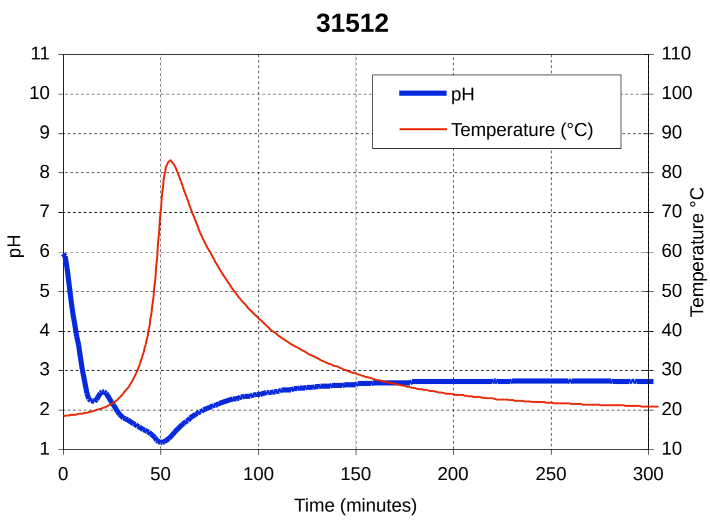
Sample Characteristics
%S = 1.26
ANC = 30 kg H2SO4/t
NAPP = 9 kg H2SO4/t
NAGpH = 3.4

Figure I-29: Kinetic NAG graph for sample 31521.



Sample Characteristics
%S = 1.38
ANC = 48 kg H2SO4/t
NAPP = -6 kg H2SO4/t
NAGpH = 7.9

Figure I-30: Kinetic NAG graph for sample 31526.



Sample Characteristics
%S = 2.81
ANC = 34 kg H2SO4/t
NAPP = 52 kg H2SO4/t
NAGpH = 2.5

Figure I-31: Kinetic NAG graph for sample 31512.

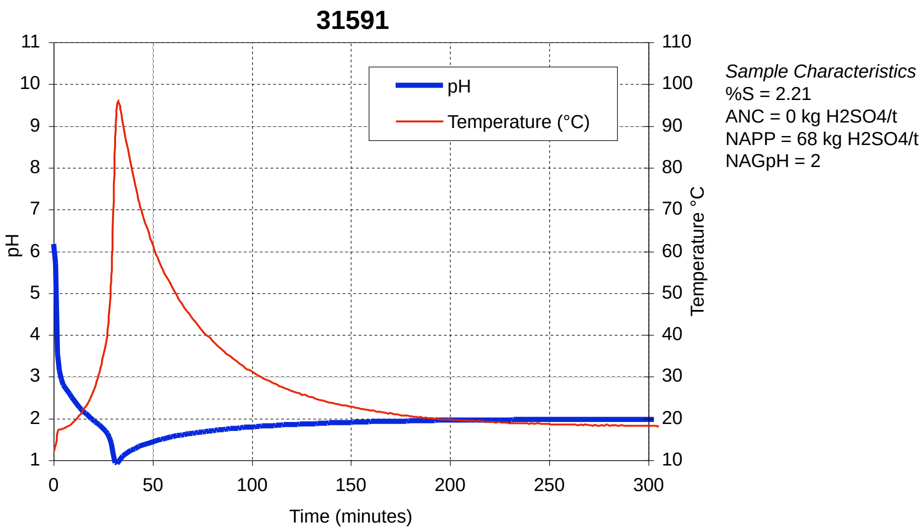


Figure I-32: Kinetic NAG graph for sample 31591.

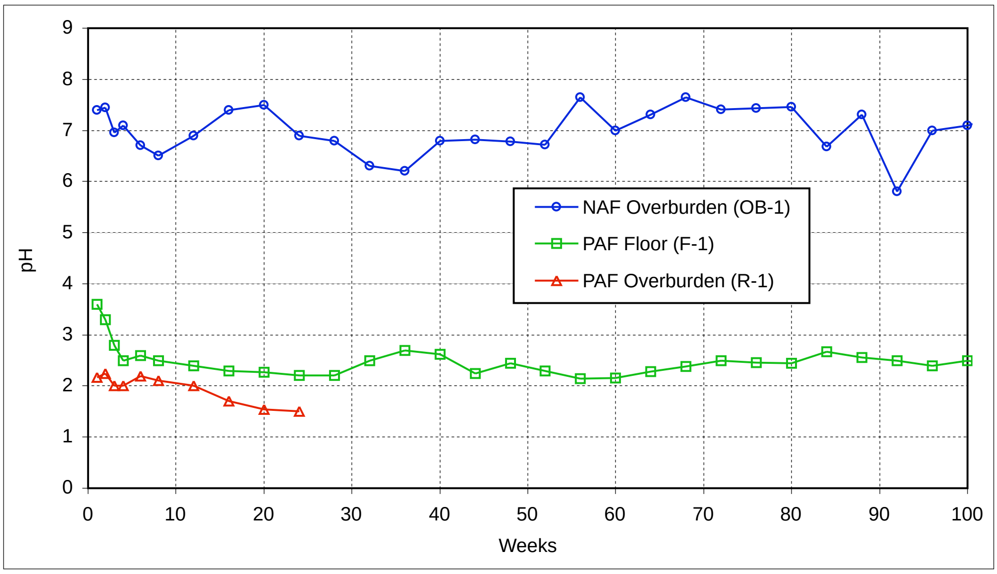


Figure I-33: pH trends of leachates from NAF overburden column OB-1, PAF overburden column R-1 and PAF floor lysimeter F-1.

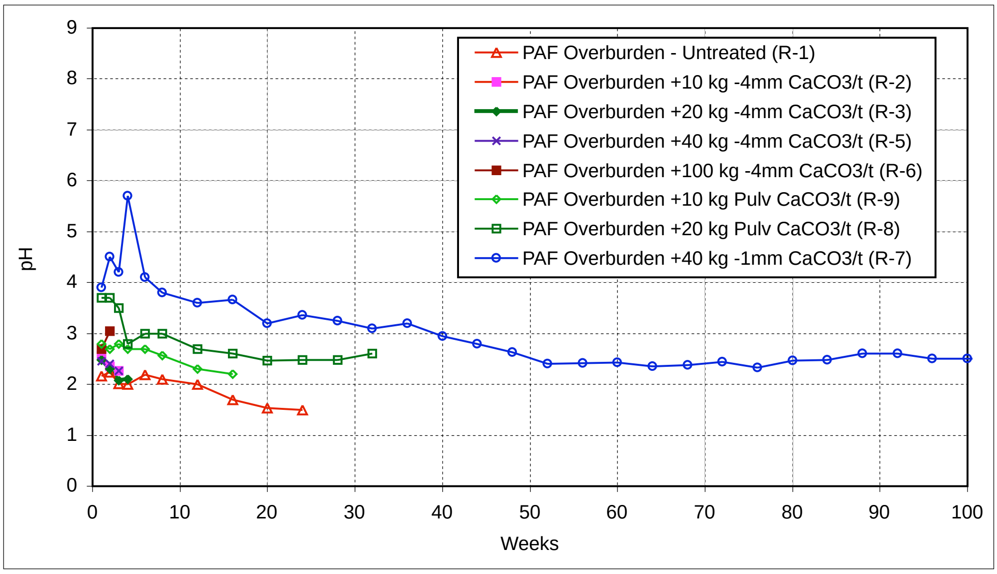


Figure I-34: pH trends of leachates from PAF overburden columns at varying limestone addition rates and size fractions.

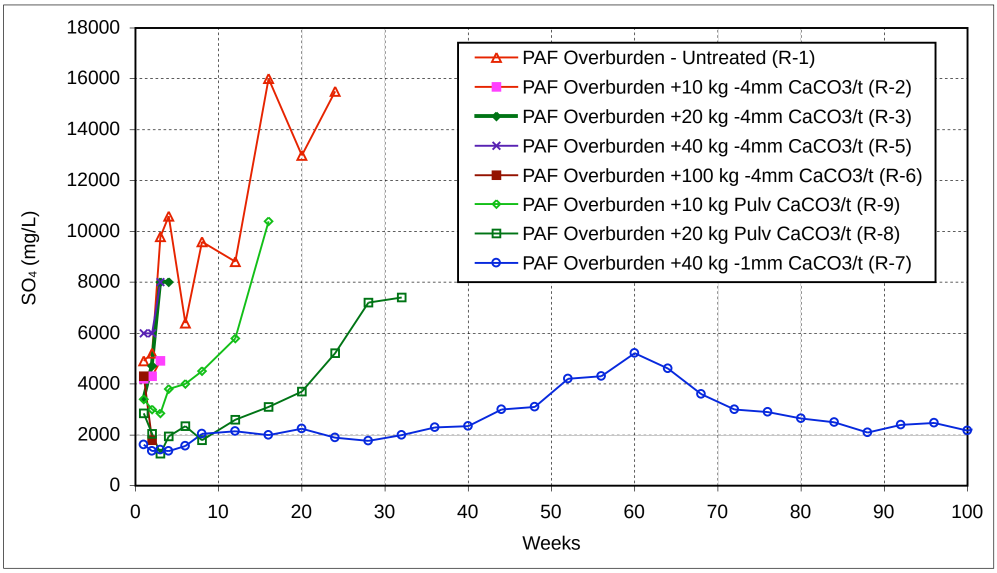


Figure I-35: SO4 trends of leachates from PAF overburden columns at varying limestone addition rates and size fractions.

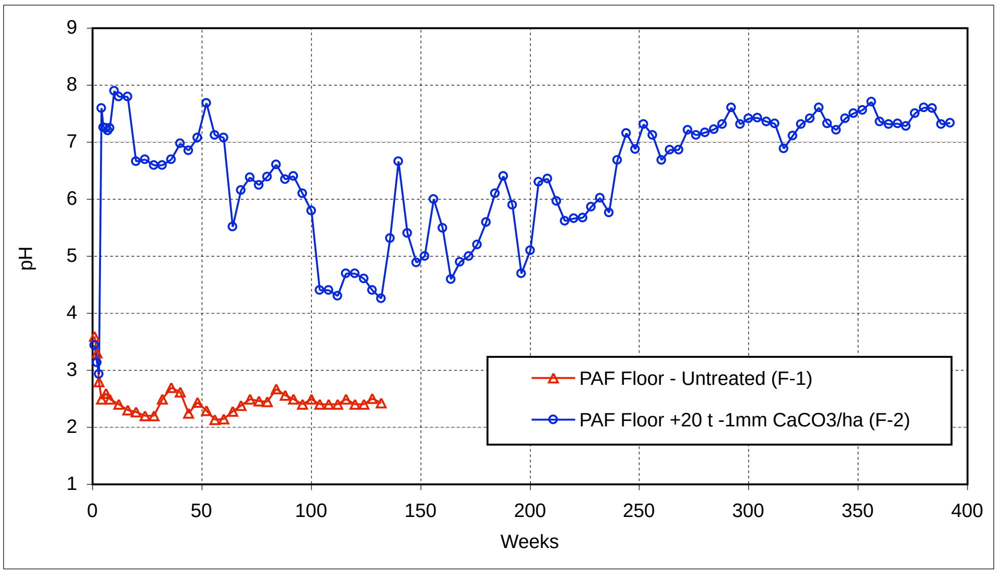


Figure I-36: pH trends of leachates from untreated and limestone treated PAF floor surface drainage lysimeters.

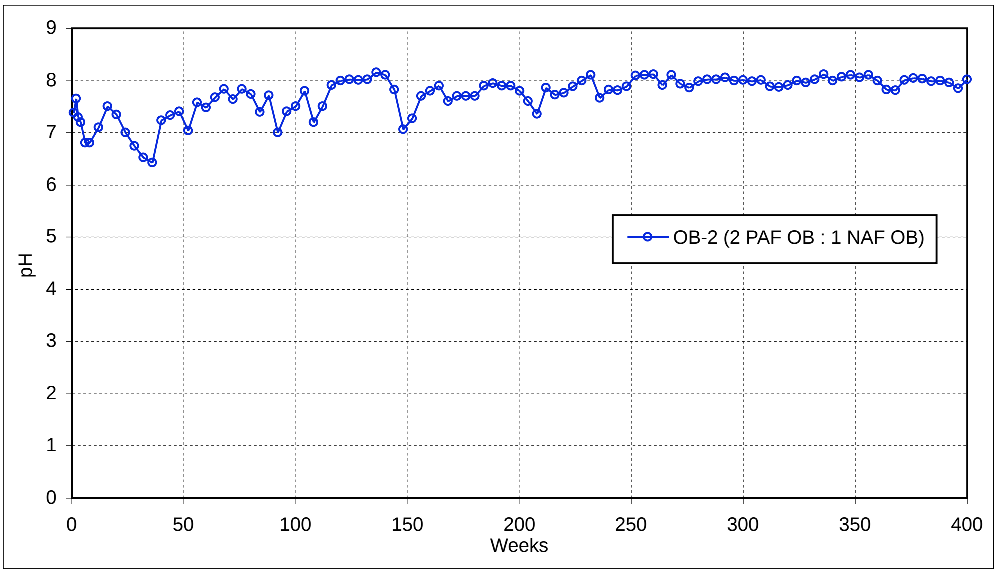


Figure I-37: pH trend of leachates from column OB-2 made up of 2 parts PAF low capacity overburden blended with 1 part NAF overburden.

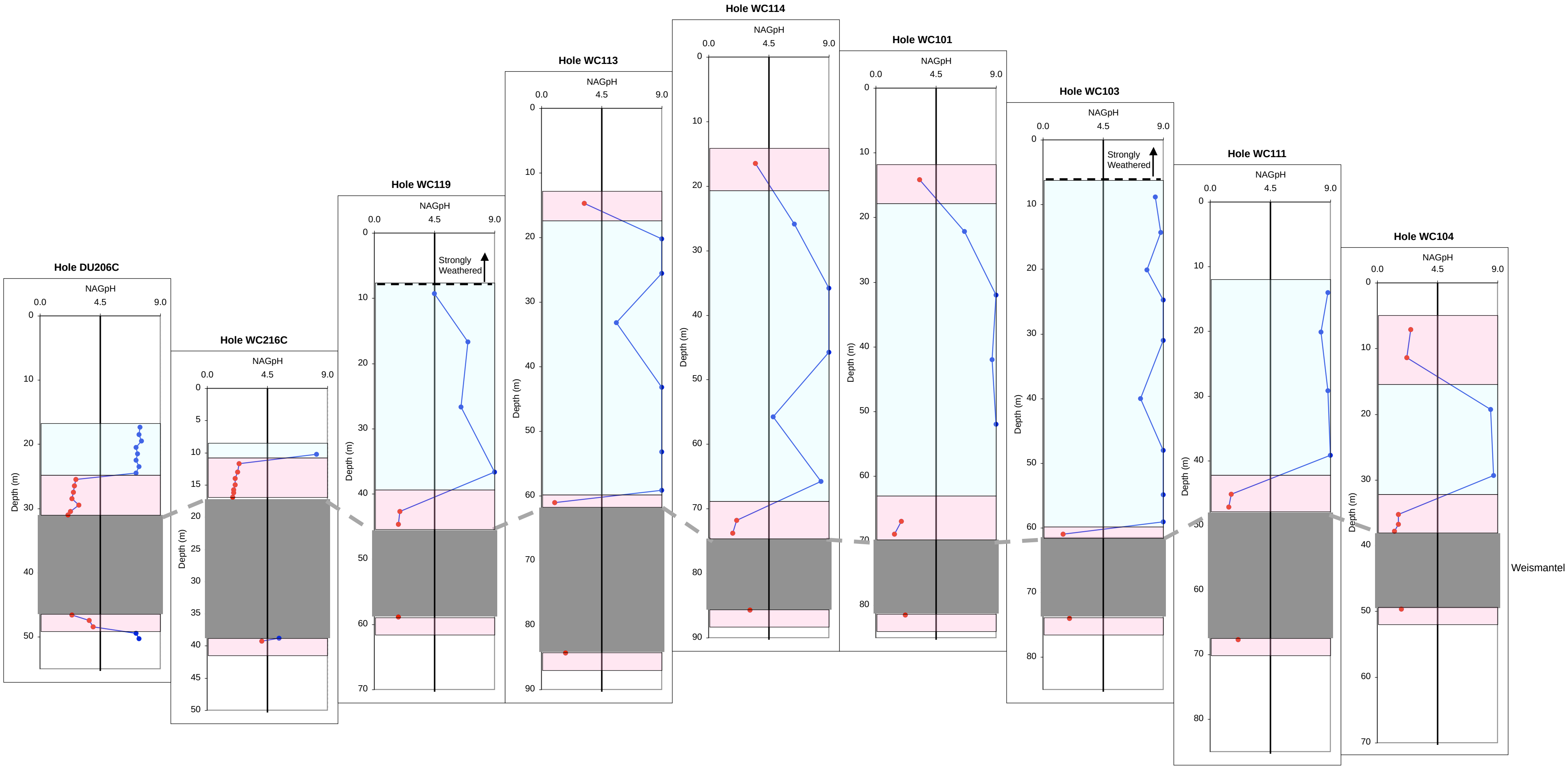


Figure I-38: Plot of total NAGpH profiles for Weismantel Seam drillholes. PAF and PAF-LC samples are shown as red symbols, and approximate zones of NAF are shown as blue shading and PAF as pink shading.

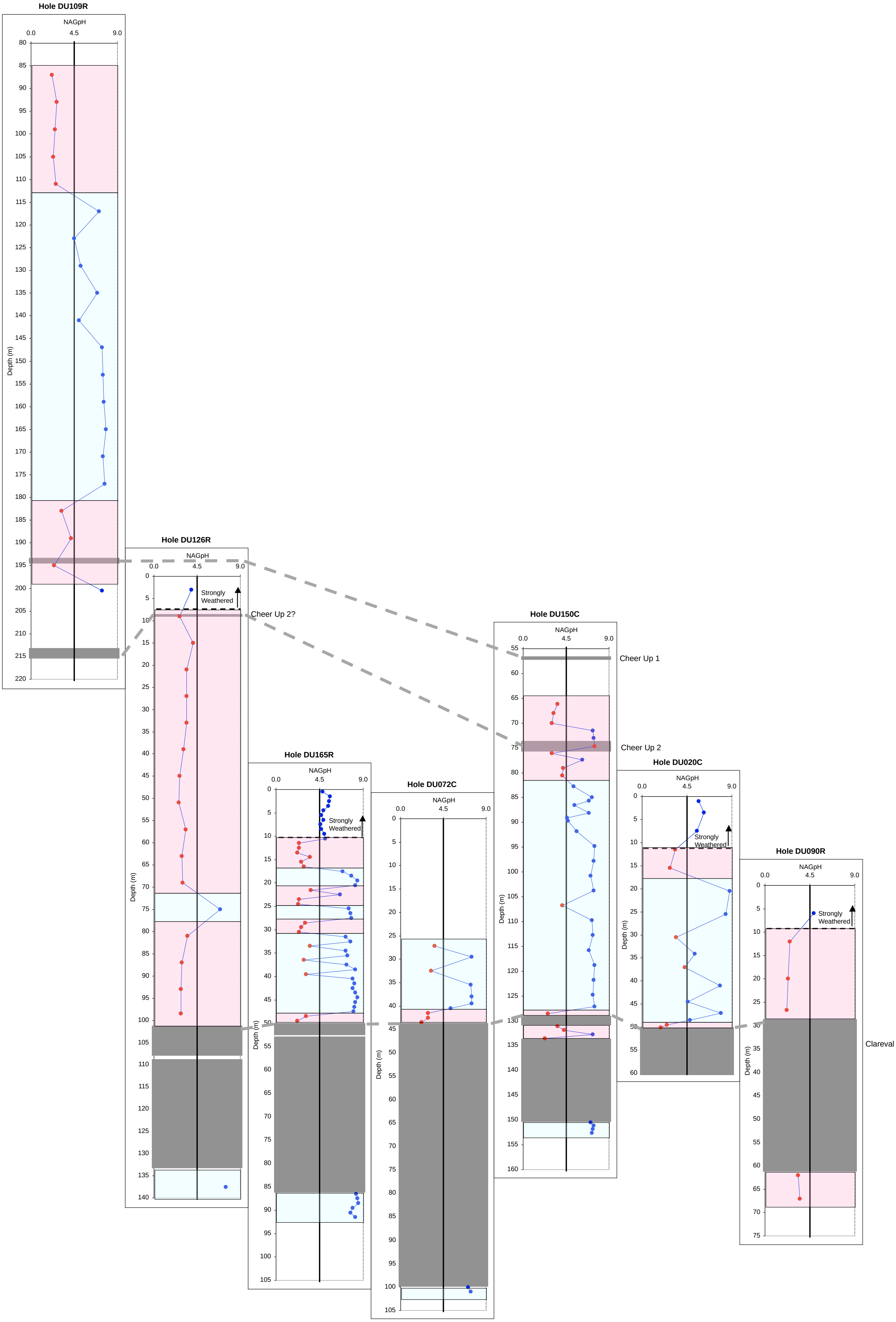


Figure I-39: Plot of total NAGpH profiles for Clareval Seam drillholes. PAF and PAF-LC samples are shown as red symbols, and approximate zones of NAF are shown as blue shading and PAF as pink shading.

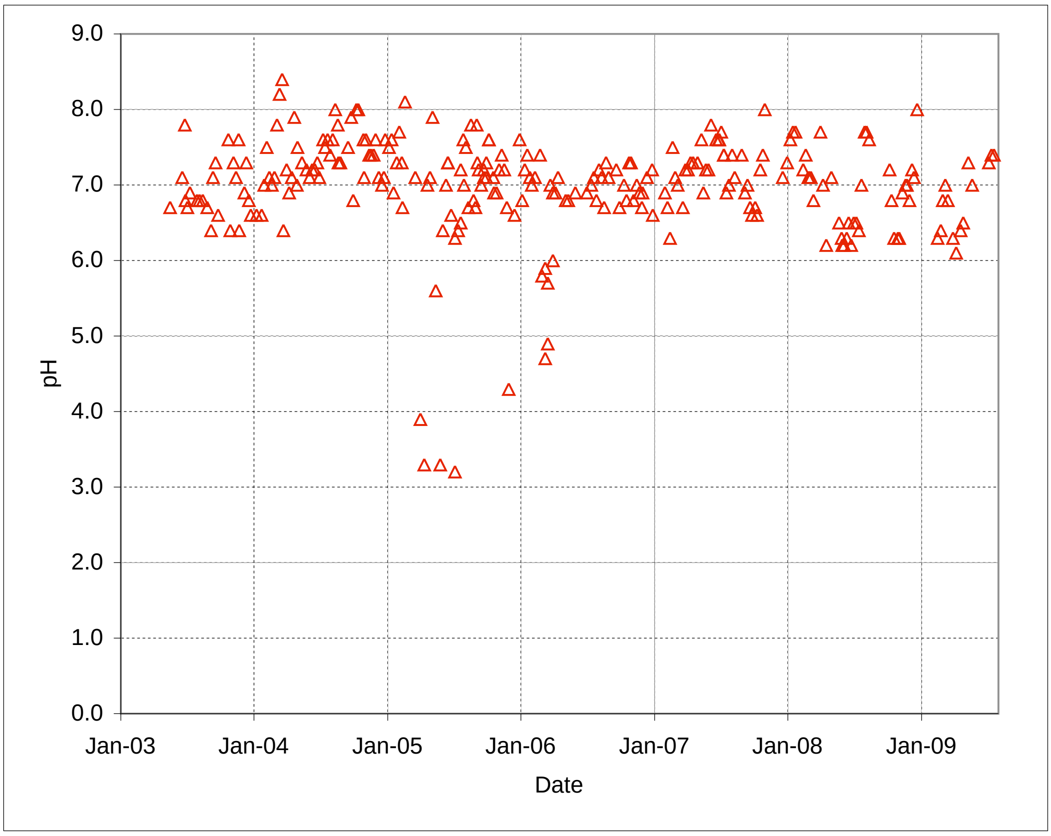


Figure I-40: Results of pH monitoring of the Duralie Coal Mine pit sump (SW4).

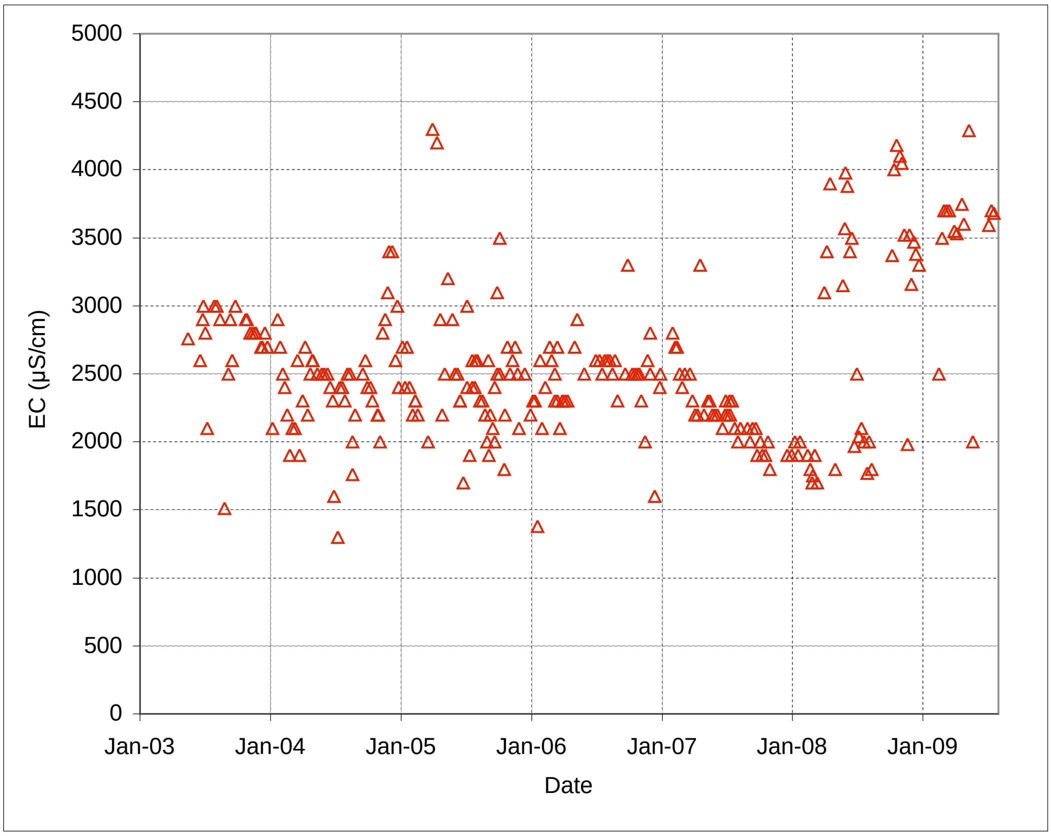


Figure I-41: Results of EC monitoring of the Duralie Coal Mine pit sump (SW4).

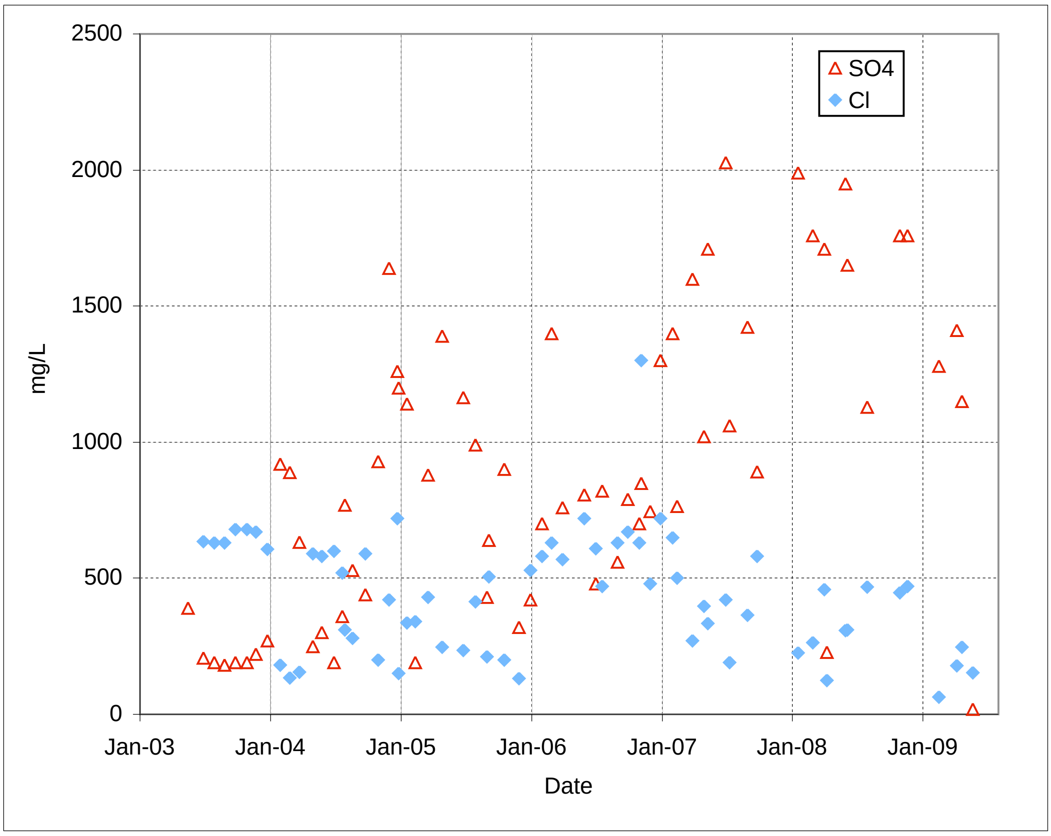


Figure I-42: Results of SO_4 and Cl monitoring of the Duralie Coal Mine pit sump (SW4).

ATTACHMENT I-A

Assessment of Acid Forming Characteristics

Assessment of Acid Forming Characteristics

Introduction

Acid rock drainage (ARD) is produced by the exposure of sulphide minerals such as pyrite to atmospheric oxygen and water. The ability to identify in advance any mine materials that could potentially produce ARD is essential for timely implementation of mine waste management strategies.

A number of procedures have been developed to assess the acid forming characteristics of mine waste materials. The most widely used methods are the Acid-Base Account (ABA) and the Net Acid Generation (NAG) test. These methods are referred to as static procedures because each involves a single measurement in time.

Acid-Base Account

The acid-base account involves static laboratory procedures that evaluate the balance between acid generation processes (oxidation of sulphide minerals) and acid neutralising processes (dissolution of alkaline carbonates, displacement of exchangeable bases, and weathering of silicates).

The values arising from the acid-base account are referred to as the potential acidity and the acid neutralising capacity, respectively. The difference between the potential acidity and the acid neutralising capacity value is referred to as the net acid producing potential (NAPP).

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

Potential Acidity

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

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \Rightarrow Fe(OH)_3 + 2\ H_2SO_4$$

Based on the above reaction, the potential acidity of a sample containing 1 %S as pyrite would be 30.6 kilograms of H_2SO_4 per tonne of material (i.e. kg H_2SO_4/t). The pyrite content estimate can be based on total S and the potential acidity determined from total S is referred to as the maximum potential acidity (MPA), and is calculated as follows:

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

The use of an MPA calculated from total sulphur is a conservative approach because some sulphur may occur in forms other than pyrite. Sulphate-sulphur, organic sulphur and native sulphur, for example, are non-acid generating sulphur forms. Also, some sulphur may occur as other metal sulphides (e.g. covellite, chalcocite, sphalerite, galena) which yield less acidity than pyrite when oxidised or, in some cases, may be non-acid generating. The total sulphur content is commonly used to assess potential acidity because of the difficulty, costs and uncertainty involved in routinely determining the speciation of sulphur forms within samples, and determining reactive sulphide-sulphur contents. However, if the sulphide mineral forms are known then allowance can be made for non- and lesser acid generating forms to provide a better estimate of the potential acidity.

Acid Neutralising Capacity (ANC)

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

The ANC is commonly determined by the Modified Sobek method. This method involves the addition of a known amount of standardised hydrochloric acid (HCl) to an accurately weighed sample, allowing the sample time to react (with heating), then back-titrating the mixture with standardised sodium hydroxide (NaOH) to determine the amount of unreacted HCl. The amount of acid consumed by reaction with the sample is then calculated and expressed in the same units as the MPA (kg H_2SO_4/t).

Net Acid Producing Potential (NAPP)

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

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

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

ANC/MPA Ratio

The ANC/MPA ratio is frequently used as a means of assessing the risk of acid generation from mine waste materials. The ANC/MPA ratio is another way of looking at the acid base account. A positive NAPP is equivalent to an ANC/MPA ratio less than 1, and a negative NAPP is equivalent to an ANC/MPA ratio greater than 1. A NAPP of zero is equivalent to an ANC/MPA ratio of 1.

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

Acid-Base Account Plot

Sulphur and ANC data are often presented graphically in a format similar to that shown in Figure A-1. This figure includes a line indicating the division between NAPP positive samples from NAPP negative samples. Also shown are lines corresponding to ANC/MPA ratios of 2 and 3.

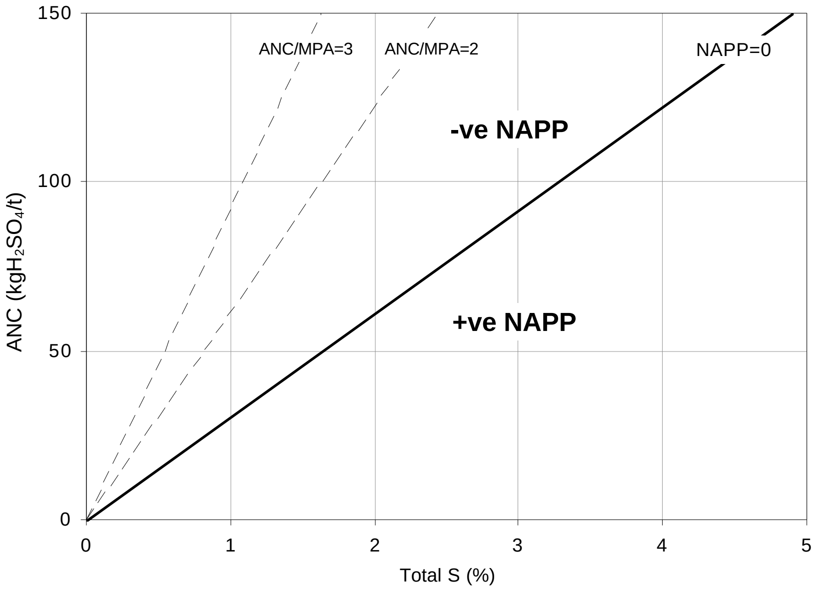


Figure A-1: Acid-base account (ABA) plot

Net Acid Generation (NAG) Test

The NAG test is used in association with the NAPP to classify the acid generating potential of a sample. The NAG test involves reaction of a sample with hydrogen peroxide to rapidly oxidise any sulphide minerals contained within a sample. During the NAG test both acid generation and acid neutralisation reactions can occur simultaneously. The end result represents a direct measurement of the net amount of acid generated by the sample. The final pH is referred to as the NAGpH and the amount of acid produced is commonly referred to as the NAG capacity, and is expressed in the same units as the NAPP (kg H_2SO_4/t).

Several variations of the NAG test have been developed to accommodate the wide geochemical variability of mine waste materials. The four main NAG test procedures currently used by EGi are the single addition NAG test, the sequential NAG test, the kinetic NAG test, and the extended boil and calculated NAG test.

Single Addition NAG Test

The single addition NAG test involves the addition of 250 ml of 15% hydrogen peroxide to 2.5 g of sample. The peroxide is allowed to react with the sample overnight and the following day the sample is gently heated to accelerate the oxidation of any remaining sulphides, then vigorously boiled for several minutes to decompose residual peroxide. When cool, the NAGpH and NAG capacity are measured.

An indication of the form of the acidity is provided by initially titrating the NAG liquor to pH 4.5, then continuing the titration up to pH 7. The titration value at pH 4.5 includes acidity due to free acid (i.e. H_2SO_4) as well as soluble iron and aluminium. The titration value at pH 7 also includes metallic ions that precipitate as hydroxides at between pH 4.5 and 7.

Sequential NAG Test

When testing samples with high sulphide contents it is not uncommon for oxidation to be incomplete in the single addition NAG test. This can sometimes occur when there is catalytic breakdown of the hydrogen peroxide before it has had a chance to oxidise all of the sulphides in a sample. To overcome this limitation, a sequential NAG test is often carried out. This test may also be used to assess the relative geochemical lag of PAF samples with high ANC.

The sequential NAG test is a multi-stage procedure involving a series of single addition NAG tests on the one sample (i.e. 2.5 g of sample is reacted two or more times with 250 ml aliquots of 15% hydrogen peroxide). At the end of each stage, the sample is filtered and the solution is used for measurement of NAGpH and NAG capacity. The NAG test is then repeated on the solid residue. The cycle is repeated until such time that there is no further catalytic decomposition of the peroxide, or when the NAGpH is greater than pH 4.5. The overall NAG capacity of the sample is then determined by summing the individual acid capacities from each stage.

Kinetic NAG Test

The kinetic NAG test is the same as the single addition NAG test except that the temperature and pH of the liquor are recorded. Variations in these parameters during the test provide an indication of the kinetics of sulphide oxidation and acid generation. This, in turn, can provide an insight into the behaviour of the material under field conditions. For example, the pH trend gives an estimate of relative reactivity and may be related to prediction of lag times and oxidation rates similar to those measured in leach columns. Also, sulphidic samples commonly produce a temperature excursion during the NAG test due to the decomposition of the peroxide solution, catalysed by sulphide surfaces and/or oxidation products.

Extended Boil and Calculated NAG Test

Organic acids may be generated in NAG tests due to partial oxidation of carbonaceous materials[1] such as coal washery wastes. This can lead to low NAGpH values and high acidities in standard single addition NAG tests unrelated to acid generation from sulphides. Organic acid effects can therefore result in misleading NAG values and misclassification of the acid forming potential of a sample.

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

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

The extended boiling test is carried out on the filtered liquor of a standard NAG test, and involves vigorous boiling of the solution on a hot plate for 3-4 hours. After the boiling step the solution is cooled and the pH measured. An extended boil NAGpH less than 4.5 confirms the sample is potentially acid forming (PAF), but a pH value greater than 4.5 does not necessarily mean that the sample is non acid forming (NAF), due to some loss of free acid during the extended boiling procedure. To address this issue, a split of the same filtered NAG solution is assayed for concentrations of S, Ca, Mg, Na, K and Cl, from which a calculated NAG value is determined[2].

The concentration of dissolved S is used to calculate the amount of acid (as H_2SO_4) generated by the sample and the concentrations of Ca, Mg, Na and K are used to estimate the amount of acid neutralised (as H_2SO_4). The concentration of Cl is used to correct for soluble cations associated with Cl salts, which may be present in the sample and unrelated to acid generating and acid neutralising reactions.

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

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[1] Stewart, W., Miller, S., Thomas, J.E., and Smart R. (2003), 'Evaluation of the Effects of Organic Matter on the Net Acid Generation (NAG) Test', in *Proceedings of the Sixth International Conference on Acid Rock drainage (ICARD), Cairns, 12-18th July 2003*, 211-222.

[2] Environmental Geochemistry International, Levay and Co. and ACeSSS, 2008. *ACARP Project C15034: Development of ARD Assessment for Coal Process Wastes*, EGi Document No. 3207/817, July 2008.

Sample Classification

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

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

Barren

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

Non-acid forming (NAF)

A sample classified as NAF may, or may not, have a significant sulphur content but the availability of ANC within the sample is more than adequate to neutralise all the acid that theoretically could be produced by any contained sulphide minerals. As such, material classified as NAF is considered unlikely to be a source of acidic drainage. A sample is usually defined as NAF when it has a negative NAPP and the final NAG pH ≥ 4.5.

Potentially acid forming (PAF)

A sample classified as PAF always has a significant sulphur content, the acid generating potential of which exceeds the inherent acid neutralising capacity of the material. This means there is a high risk that such a material, even if pH circum-neutral when freshly mined or processed, could oxidise and generate acidic drainage if exposed to atmospheric conditions. A sample is usually defined as PAF when it has a positive NAPP and a final NAGpH < 4.5.

Uncertain (UC)

An uncertain classification is used when there is an apparent conflict between the NAPP and NAG results (i.e. when the NAPP is positive and NAGpH > 4.5, or when the NAPP is negative and NAGpH ≤ 4.5). Uncertain samples are generally given a tentative classification that is shown in brackets e.g. UC(NAF).

Figure A-2 shows the format of the classification plot that is typically used for presentation of NAPP and NAG data. Marked on this plot are the quadrats representing the NAF, PAF and UC classifications.

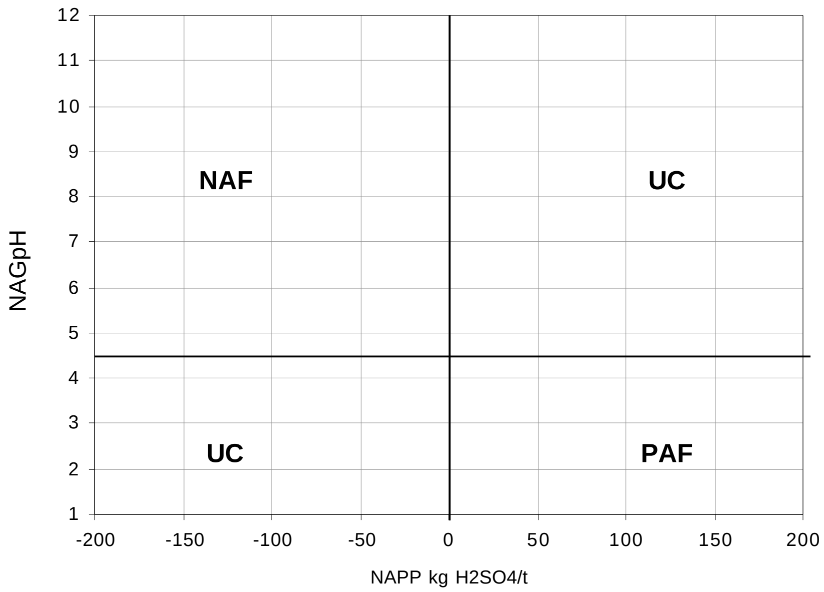

Figure A-2 ARD classification plot

Other Methods

Other test procedures may be used to define the acid forming characteristics of a sample.

pH and Electrical Conductivity

The pH and electrical conductivity (EC) of a sample is determined by equilibrating the sample in deionised water for a minimum of 12 hours (or overnight), typically at a solid to water ratio of 1:2 (w/w). This gives an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area.

Acid Buffering Characteristic Curve (ABCC) Test

The ABCC test involves slow titration of a sample with acid while continuously monitoring pH. These data provides an indication of the portion of ANC within a sample that is readily available for acid neutralisation.