Whitehaven

Blackwater North Extension Project

Appendix I
Geochemistry Assessment



TERRENUS
EARTH SCIENCES

Geochemical Assessment of Potential Spoil and Coal Reject Materials

BLACKWATER NORTH EXTENSION PROJECT

Prepared for:

Whitehaven Blackwater Pty Ltd

Geochemical Assessment of Potential Spoil and Coal Reject Materials

BLACKWATER NORTH EXTENSION PROJECT

Prepared for:

Whitehaven Blackwater Pty Ltd

DOCUMENT CONTROL

Report Title	Environmental Geochemical Assessment of Potential Spoil and Coal Reject Materials		
Project Name	Blackwater North Extension Project		
Job Number	25-063-201	**Client**	Whitehaven Blackwater Pty Ltd
Report Number	25-063-201 / R001		
Author	Dr. Ian P. Swane (Terrenus Earth Sciences)		

DOCUMENT ISSUE

Document Status	Issued To	Date Issued
DRAFT v0	Whitehaven Blackwater Pty Ltd and Resource Strategies	2 August 2025
FINAL DRAFT	Whitehaven Blackwater Pty Ltd and Resource Strategies	14 October 2025
FINAL	Whitehaven Blackwater Pty Ltd and Resource Strategies	23 January 2026

© Terrenus Earth Sciences, 2026
www.terrenus.com.au

PO Box 132, Wilston QLD 4051
Ph. 0414 924 233

Limitations and disclaimer:

This report documents the work undertaken by Terrenus Earth Sciences (Terrenus). Terrenus Earth Sciences is the registered trading name of Terrenus Pty Ltd as trustee for the Swane Family Trust.

This document has been produced by Terrenus as supporting information for environmental and mine planning aspects of the Blackwater North Extension Project (the Project). This document may contain confidential information. The document is intended for specific use by Whitehaven Blackwater Pty Ltd [a subsidiary of Whitehaven Coal Limited (WHC)] and their appointed advisors (Resource Strategies [RS], on behalf of WHC and Whitehaven Blackwater Pty Ltd) – herein called 'the Client'. The concepts and information contained in this document are the property of Terrenus. Use or copying of this document in whole or in part without the written permission of Terrenus constitutes an infringement of copyright.

This report should be read in full. While the findings presented in this report are based on information that Terrenus considers reliable unless stated otherwise, the accuracy and completeness of source information cannot be guaranteed, although Terrenus has taken reasonable steps to verify the accuracy of such source data. Terrenus has made no independent verification of this information beyond the agreed scope of works and Terrenus assumes no responsibility for any inaccuracies or omissions outside of Terrenus' direct control. Furthermore, the information compiled in this report addresses the specific needs of the Client, so may not address the needs of third parties using this report for their own purposes. Thus, Terrenus and its employees accept no liability for any losses or damage for any action taken or not taken on the basis of any part of the contents of this report. Those acting on information provided in this report do so entirely at their own risk.

This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

No AI Training: Without in any way limiting Terrenus' exclusive rights under copyright, any use of this document to 'train' generative AI technologies to generate text, images, figures, graphs or tables is expressly prohibited. Terrenus reserves all rights to license uses of this work for generative AI training and development of machine learning language models.

EXECUTIVE SUMMARY

This report serves to document and discuss the environmental geochemical characteristics of mineral waste materials associated with the Blackwater North Extension Project (the Project), being developed by Whitehaven Blackwater Pty Ltd, a subsidiary of Whitehaven Coal Limited (WHC). The Project proposes an eastern extension of WHC's existing Blackwater Mine (BWM), as a continuation of BWM operations. The geochemical assessment was completed to assist with mine planning and as part of the environmental regulatory documentation for the Project.

The objective of the assessment is to evaluate the geochemical nature of mineral waste currently at BWM and mineral waste likely to be generated by the Project, and identify relevant environmental issues/opportunities that may be associated with mining, handling and storing mineral waste to inform appropriate rehabilitation and management strategies.

BWM mines spoil (overburden/interburden) and run-of-mine (ROM) coal from the Rangal Coal Measures (RCM) and the Project proposes to mine the same geologic materials as are currently mined at BWM. Therefore, drill-hole, tailings and rejects samples from, or associated with, the current approved mining area at BWM are representative of these same materials to be mined from the Project – hence geochemical data from BWM is representative of materials expected to be mined at the Project.

Material Types

BWM has three main types of mineral waste, and the geochemical characteristics and potential hazards associated with mineral waste materials at BWM and the Project are discussed by type:

- Spoil (overburden and interburden) comprises approximately 99% per cent (%) of all mineral waste at BWM (WHC, 2025) and includes Tertiary- and Permian-age weathered waste and Permian-age fresh (unweathered) waste. The Project is expected to produce spoil as a similar proportion of mineral waste to that currently produced at BWM. In the northern mining area, which includes the Project, approximately 15% of the spoil is weathered and the remaining 85% (approximately) of spoil is fresh.
- Tailings are (and would continue to be) generated at the BWM North Coal Preparation Plant (NCPP) from processing ROM coal and typically represent the clay, silt and fine sand fractions of ROM waste. Since late 2023, tailings from the NCPP have been disposed as a slurry into Bonnie Doon in-pit tailings storage facility (TSF). Prior to this, tailings from NCPP were disposed as a slurry into the above-ground NCPP TSF (the NCPP TSF is currently inactive). Tailings comprise approximately 0.5% of all mineral waste at BWM – with this approximate proportion expected for the remaining life of asset mine plan at BWM, including tailings generated by processing ROM coal from the Project. The Project would not contain any disposed tailings as all tailings from the NCPP would remain at BWM.
- Rejects are (and would continue to be) generated at the NCPP, and potentially a negligible amount from the Thermal Coal Plant (TCP), from processing ROM coal. Rejects typically represents coarser and rockier seam roof, partings and floor material. Rejects are trucked to several locations for disposal into spoil. Historically, rejects were also disposed onto out-of-pit rejects dumps – the main historic rejects dump being Ramp 36 rejects dump. Some rejects have been used in construction of the NCPP TSF embankments and infrastructure pads. Rejects comprise approximately 0.5% of all mineral waste at BWM – with this approximated proportion expected for the remaining life of asset mine plan. The Project would not contain any rejects as all rejects from the NCPP (and TCP) would remain at BWM.

Coal is also included in the assessment; however, coal is generally not considered mineral waste, with the exception of small quantities of sub-economic seams that may report to the spoil dumps, and remnant coal exposed on pit highwalls (such as in residual voids).

Sample Collection

Sampling and laboratory test-work has been undertaken by previous site owners (BM Alliance Coal Operations Pty Ltd [BMA]), WHC and consultants throughout the development and operation of BWM. The BWM geochemical database contains all available geochemical data for mineral waste samples at BWM, including data from drill-holes located within the Project footprint. The geochemical database was provided to Terrenus for this assessment. The assessment is based on detailed geochemical results for 3182 samples.

Drill-hole sampling was used to collect spoil and coal samples for geochemical assessment. Geochemical data is available for 2260 spoil samples and 214 coal samples collected between 2020 and 2025 from 22 drill-holes located throughout the northern mining area at BWM and in the vicinity of the Project.

Geochemical data is available for 471 tailings samples comprising 305 fresh tailings samples collected from the NCPP and 166 aged tailings samples collected from shallow grab samples and geotechnical investigation drill-holes within the NCPP TSF.

Geochemical data is available for 237 rejects samples comprising 48 fresh rejects samples collected from the NCPP, 45 aged rejects samples collected from geotechnical investigation drill-holes within the NCPP TSF, and 144 aged rejects samples collected from drill-holes and test-pit excavations within Ramp 36 rejects dump.

Acid and Metalliferous Drainage Potential of Mineral Waste and Coal Material Types

Mineral waste samples have undergone environmental geochemical characterisation and assessment with regard to their potential to generate acid and metalliferous drainage (AMD), which comprises acid drainage (AD), neutral and metalliferous drainage (NMD) and/or saline drainage (SD) (salinity due to sulfate derived from sulfide oxidation). Additionally, samples have been assessed with regard to their potential to generate salinity (non-oxidative) and, for spoil materials, their sodicity and dispersion potential.

Acid and Metalliferous Drainage Potential of Spoil – Non-Carbonaceous

Non-carbonaceous spoil, which comprises about 92% of spoil at BWM (WHC, 2025), is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage), which is typical for mine spoil in the Bowen Basin.

Based on the results, non-carbonaceous spoil from the Project has a negligible potential to generate AMD as either AD and/or NMD and/or SD.

The total sulfur (S) concentration of non-carbonaceous spoil is very low, with a 95th percentile total S concentration of 0.09%. As such, and combined with moderate to high acid neutralising capacity (ANC) values (median 45 kilograms of sulfuric acid per tonne of rock [kg H_2SO_4/t]), which is significantly higher than the maximum potential acidity (MPA) (median 0.9 kg H_2SO_4/t), greater than 99% of non-carbonaceous spoil samples tested were classified as non-acid forming (NAF), with one sample classified as UC(NAF) (uncertain, but expected to be NAF). Less than 0.4% of non-carbonaceous spoil

samples were classified as potentially acid forming (PAF), PAF-LC (PAF, low capacity) or UC(PAF) (uncertain, but expected to be PAF or PAF-LC) or NAF-S (NAF, but with total S greater than 1%).

The test-work undertaken has demonstrated that the ANC for the non-carbonaceous spoil is generally expected to be about 40-70% available under field conditions (based on 25th and 75th percentile values). Mineralogical analysis indicates that iron-dolomite and calcite are the main carbonate minerals contributing to the acid buffering potential of non-carbonaceous spoil. Overall, non-carbonaceous spoil has excess acid neutralising capacity and is expected to be bulk acid consuming.

Total metal and metalloid concentrations from 264 non-carbonaceous spoil samples tested are very low compared to the average elemental abundance in soil in the Earth's crust. Six samples (out of 264) were significantly enriched with regard to one or more of arsenic (As), barium (Ba), mercury (Hg) and/or S. The enrichment in these elements in a very small number of samples is not cause for concern. In summary, non-carbonaceous spoil (as a bulk material) has low enrichment in total metals and metalloids compared to un-mineralised rocks.

Soluble multi-element results (from 264 non-carbonaceous samples) indicate that leachate from this material is expected to contain low concentrations of soluble metals and metalloids. Approximately 11% of these samples (almost all NAF) produced leachate with low-moderate soluble metal and metalloid concentrations under near-neutral to alkaline pH, largely driven by higher concentrations of soluble aluminium (Al) and/or As. Peroxide leaching undertaken on a single non-carbonaceous spoil sample classified as UC(PAF), showed that 'PAF' material, when oxidised, has the potential to generate low pH leachate (AD) with elevated sulfate and soluble metal and metalloid concentrations.

For the key aspects assessed, including acid-base accounting (ABA) components (total S, sulfide [Scr], ANC), total metals and metalloids, and soluble metals and metalloids, the assessment has demonstrated that non-carbonaceous spoil from the Project can be expected to have AMD characteristics that are comparable to non-carbonaceous spoil currently mined at BWM.

Acid and Metalliferous Drainage Potential of Spoil – Carbonaceous

Carbonaceous spoil represents approximately 8% of spoil material at BWM (WHC, 2025) and, as a bulk material, is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage) similar to non-carbonaceous spoil. Essentially all carbonaceous spoil is fresh (unweathered).

Based on the results from 160 samples, most carbonaceous spoil has a generally low to moderate potential to generate AD and/or NMD and/or SD. Some carbonaceous spoil – mostly associated with coal seams – has a greater potential to generate low-level AD and/or NMD and/or SD.

The total S concentration of carbonaceous spoil is very low to low, with a 95th percentile total S concentration of 0.52%.

Approximately 92% (147 out of 160 samples) of carbonaceous spoil samples were classified as NAF, which includes two samples classified as UC(NAF). The remaining 8% of carbonaceous spoil samples were classified as PAF-LC or UC(PAF), including two samples classified as NAF-S. Three samples had moderate to high total S concentrations (S greater than 1%). Of the 13 samples classified as 'PAF' (of any type), all except two were closely associated with coal seams and could potentially end up as coarse reject if mined with ROM coal.

The test-work undertaken has demonstrated that the ANC for the carbonaceous spoil is generally expected to be about 20-35% available under field conditions (based on 25th and 75th percentile values),

which is only about half that of non-carbonaceous spoil. Mineralogical analysis indicates that iron-dolomite is expected to be the main carbonate mineral contributing to the acid buffering potential of carbonaceous spoil. ANC is only slightly lower, overall, compared to non-carbonaceous spoil, however the much lower availability of the ANC under field conditions in carbonaceous spoil (compared to non-carbonaceous spoil) is likely due to carbonaceous spoil having less calcite than non-carbonaceous spoil coupled with a much higher amorphous (non-crystalline) content and lower overall carbonate content.

Total metal and metalloid concentrations from 39 carbonaceous spoil samples tested are generally very low compared to the average elemental abundance in soil in the Earth's crust, and very similar to the assay concentrations from non-carbonaceous spoil. Seven out of 39 carbonaceous spoil samples – all classified as 'PAF' of some type – were significantly enriched with regard to one or more of As, Hg and/or S – and all seven samples were closely associated with coal seams. The enrichment in these elements in a small proportion of spoil is not cause for concern. In summary, carbonaceous spoil (as a bulk material) has low enrichment in total metals and metalloids compared to un-mineralised rocks.

Soluble multi-element results (from 39 samples) indicate that leachate from carbonaceous spoil is expected to contain generally low concentrations of soluble metals and metalloids – similar to the non-carbonaceous spoil samples. Of the 39 samples, all except three had low soluble metal and metalloid concentrations under pH-neutral to alkaline conditions. Three samples (two NAF and one UC[PAF]) had moderate soluble metal and metalloid concentrations under pH-neutral to alkaline conditions. Two fresh carbonaceous spoil samples, both classified as UC(NAF), underwent peroxide leaching and both were confirmed as NAF, however one of the samples produced leachate with moderate metal and metalloid concentrations.

For the key aspects assessed, including ABA components (total S, Scr, ANC), total metals and metalloids, and soluble metals and metalloids, the assessment has demonstrated that carbonaceous spoil from the Project can be expected to have AMD characteristics that are comparable to non-carbonaceous spoil currently mined at BWM.

Acid and Metalliferous Drainage Potential of Tailings

The geochemical characteristics differed slightly between fresh tailings from the NCPP versus aged tailings from NCPP TSF for different parameters. However, the overall AMD hazard posed by tailings from the two sources (fresh vs aged) was generally similar. As such, the discussion that follows only differentiates between the two tailings sources where the differences between the two sources was significant for some parameters and worthy of discussion. Else, the AMD potential of tailings is discussed as a bulk material.

Based on the results, approximately half of BWM tailings have a moderate to high potential to generate AMD as either AD and/or NMD and/or SD, and the remaining half (approximately) have a relatively low potential to generate AMD as either AD and/or NMD and/or SD. ROM coal from the Project is expected to produce tailings with AMD potential similar to fresh tailings currently produced at BWM NCPP.

Fresh tailings from the NCPP are expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage). Overall, aged tailings have lower pH compared to fresh tailings, however the pH in aged tailings was generally pH-neutral to alkaline. The difference in pH observed between fresh and aged tailings (and the differences within the aged tailings) may be due to a number of factors, however the most likely cause is oxidation processes consuming readily available neutralising minerals, leading to aged tailings generally having a low(er) acid neutralising potential.

The total S concentration of tailings ranges from low to high, but is generally low-moderate to moderate, with a 75th percentile total S concentration of 1.04%; with total S in fresh NCPP tailings being only marginally higher than aged tailings. Based on median values, Scr accounts for approximately 69% of total S in fresh NCPP tailings and 50% of total S in aged tailings – the lower proportion of Scr in aged tailings (compared to fresh tailings) is likely due to some sulfide in aged tailings being oxidised to sulfate.

As a bulk material, tailings have generally moderate ANC (median 28 kg H_2SO_4/t); with ANC in fresh NCPP tailings being higher than aged tailings. Combined with low-moderate MPA values (median 21 kg H_2SO_4/t) reflective of the range of total S values, approximately 52% of the tailings samples were classified as NAF or UC(NAF). The remaining 48% of samples were classified as PAF, PAF-LC or UC(PAF), including 4% of tailings samples classified as NAF-S.

The test-work undertaken has demonstrated that the ANC for both fresh and aged tailings (combined) is generally expected to be about 45-68% available under field conditions. However, the 'field availability' of ANC generally ranged from about 20 to 85%. Iron-dolomite and calcite are expected to be the main carbonate minerals contributing to the acid buffering potential of tailings. All tailings have appreciable concentrations of siderite (an iron carbonate mineral), however, siderite provides no net acid neutralising capacity. Overall, carbonate concentrations were similar between fresh and aged tailings.

Total metal and metalloid concentrations from 42 fresh and 14 aged tailings samples tested are very low compared to the average elemental abundance in soil in the Earth's crust. However, about one-quarter of fresh NCPP tailings samples and about half of the aged tailings samples were significantly enriched with S, including two aged tailings samples with significant enrichment in Ag. All of the tailings samples that were significantly enriched in S were classified as 'PAF' of some type.

Solubility data indicate that fresh NCPP tailings samples under freshwater (deionised water) leaching conditions are expected to have low soluble metal and metalloid concentrations and have near-neutral to alkaline pH. For the aged tailings, five of the 20 samples had moderate soluble metal and metalloid concentrations under pH-neutral to alkaline conditions. A further two aged tailings samples (both classified as PAF) produced acidic leachate with highly elevated metal and metalloid concentrations – confirming their PAF classification. These results suggests that, overtime, some tailings can generate AD as field ANC is consumed. Under saline leaching conditions tailings produced low concentrations of soluble metals and metalloids.

Peroxide leaching undertaken on 41 tailings samples (fresh and aged, and about half of the samples classified as 'PAF') showed that when exposed to highly oxidising conditions 'PAF' tailings can produce weakly to highly acidic leachate with moderate to elevated soluble metal and metalloid concentrations. It must be noted that samples with potentially high organic carbon (C-org) concentrations, such as some tailings samples, may be influenced by organic acids producing acidity and correspondingly elevated soluble metal and metalloid concentrations unrelated to AMD. As such, the results for such coaly/carbonaceous samples should be interpreted with this in mind. Nevertheless, 'PAF' tailings have typically produced moderate to elevated soluble metal and metalloid concentrations from the freshwater and peroxide leaching tests. These results indicate that 'PAF' tailings have the potential to generate low pH leachate (AD); however, the salinity (sulfate) loads are not expected to be high – due to generally low total S concentrations (with minor exceptions).

Acid and Metalliferous Drainage Potential of Rejects

The geochemical characteristics differed markedly between fresh and aged rejects for several geochemical parameters – unlike tailings, where the geochemical differences were minor between fresh

and aged tailings. For context, some of the aged rejects sampled from deep within Ramp 36 rejects dump are from the early 1970s, and are 40-50 years older than the fresh NCPP rejects.

Based on the results, fresh NCPP rejects have a low potential to generate AMD as either AD and/or NMD and/or SD. Comparatively, about one-third of aged rejects – more from Ramp 36 rejects dump than NCPP TSF – have a moderate to high potential to generate AMD as either AD and/or NMD and/or SD. The remaining two-thirds of aged rejects have a relatively low to low-moderate potential to generate AMD as either AD and/or NMD and/or SD. ROM coal from the Project is expected to produce rejects with AMD potential similar to fresh rejects currently produced at BWM NCPP.

Fresh rejects from the NCPP are expected to generate highly pH-alkaline contact water (run-off and seepage). Aged rejects have much lower pH compared to fresh rejects and are expected to generate pH-neutral to alkaline contact water (run-off and seepage). The difference in pH observed between fresh and aged rejects may be due to a number of factors, however the most likely cause is oxidation processes in aged rejects consuming readily available neutralising minerals, leading to aged rejects having a low(er) remnant acid neutralising potential.

The total S concentration of fresh rejects is generally low, with a median value of 0.28%. Aged rejects from NCPP TSF generally had low to low-moderate total S values (median 0.46%). Aged rejects from Ramp 36 rejects dump generally had low-moderate total S values (median 0.68%). The reason(s) for differences in total S between the three sources of rejects (NCPP, NCPP TSF and Ramp 36 rejects dump) is unclear. However, the most likely reason is due to changes in geochemistry of ROM coal being processed. That is, ROM coal becoming less S-rich over time due to a change in the relative proportions of the various coal seams/plys being mined and processed.

Based on median values, Scr accounts for approximately 74% of total S in fresh NCPP rejects and 61% of total S in aged rejects – the difference between fresh and aged likely due to sulfide oxidation from the aged samples.

Rejects have generally moderate to high ANC (median 30 kg H_2SO_4/t); with ANC in fresh rejects being generally higher (median 40 kg H_2SO_4/t) compared to aged rejects (median 27 kg H_2SO_4/t). Combined with low to moderate MPA values (median 16 kg H_2SO_4/t), resulted in all of the fresh rejects and about two-thirds of the aged rejects being classified as NAF or UC(NAF). Approximately one-third of aged rejects – predominantly from Ramp 36 rejects dump – were classified as PAF, PAF-LC or UC(PAF), including 11% of aged dump rejects classified as NAF-S.

Test-work indicated that about 50-78% of the ANC in fresh rejects (based on 25th and 75th percentile values) is expected to be available under field conditions; and about 45-56% available for the aged rejects (also based on 25th and 75th percentile values).

Total metal and metalloid concentrations from 13 fresh and 17 aged rejects samples tested are very low compared to the average elemental abundance in soil in the Earth's crust. No fresh NCPP rejects showed significant enrichment in any elements, and four of the aged rejects samples were significantly enriched with S, which is consistent with ABA data for these samples – and all four were classified as 'PAF' of some type.

Solubility data from 32 rejects samples tested (fresh and aged, and most of the samples classified as NAF or UC[NAF]) indicate that leachate from rejects under freshwater (deionised water) leaching conditions is generally expected to have low soluble metal and metalloid concentrations and have near-neutral to alkaline pH, with minor exceptions.

Peroxide leaching undertaken on six aged rejects samples (four classified as 'PAF' and two as UC[NAF]) showed that when exposed to highly oxidising conditions 'PAF' rejects can produce weakly to highly acidic leachate with moderate soluble metal and metalloid concentrations. The results suggest that under acid/acidic conditions, some rejects are capable of generating moderate metal and metalloid loads, however the salinity (sulfate) loads are not expected to be high – due to the generally low total S concentration (with some exceptions).

Acid and Metalliferous Drainage Potential of Coal

Coal is not regarded as waste and ROM coal remains on-site for a relatively short period of time. However, some minor coal seams/plys would report directly as waste, and remnant coal (seams) would be exposed on the highwalls of residual voids at closure.

Coal represents about 7% (on average) of all lithological material at BWM in the vicinity of the Project and about 5-7% of the highwall meterage along the approximate line of the geological long-section. Assuming the large majority of this will report as ROM coal, we can conservatively assume that coal would represent a very small proportion of mineral waste (i.e. nominally 1-2% at the most). Most ROM coal from the Project would be from the same seams as are currently mined at BWM in the vicinity of the Project.

Based on the results, and as a bulk material, ROM coal is conservatively assessed as having a low-moderate to moderate potential to generate AMD as either AD, NMD and/or SD. A small proportion of coal would have a moderate to moderate-high potential to generate AMD. ROM coal, as a bulk material, is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage).

The total S concentration of coal is generally low; with a median value of 0.22%. Approximately 13% (median value) of the total S is present as sulfide (Scr), with the bulk of the total S likely present as organic S (S-org), which does not contribute to AMD. Coal samples have a wide range of ANC values; however, the median ANC, overall, is low (median 12 kg H_2SO_4/t). As such, 72% of coal samples were classified as NAF or UC(NAF). Of the remaining 28% (approximately) of coal samples, almost all were classified as PAF-LC. Two samples were classified as PAF and one sample classified as NAF-S – noting that the AMD classification is based on total S, which for coal samples likely leads to a highly conservative classification.

Of the 59 coal samples classified as 'PAF' (including NAF-S), all except two samples were from the P and L seam group; with two samples from the T seam group.

These results suggest that coal stored on the ROM pad, coal located within pit walls and un-economic coal seam material reporting as spoil (mixed with non-coal spoil) would likely be bulk NAF. The exception is predominantly coal from the P and L seam group, where it is expected that a small proportion of coal may pose a higher AMD hazard due to the higher S grade. However, it is expected that the bulk AMD source hazard for all coal is low.

Assay data for 37 coal samples show that the total metal and metalloid concentrations are low compared to the average elemental abundance in soil in the Earth's crust. One coal sample was significantly enriched with regard to As and S.

Soluble multi-element results from 37 coal samples tested, with a range of NAF to PAF classifications, indicate that contact water (run-off and seepage) from coal is generally expected to contain low

concentrations of soluble metals and metalloids. One coal sample classified as PAF-LC produced weakly acidic leachate with low soluble metal and metalloid concentrations.

Salinity, Sodicity and Dispersion Potential of Mineral Wastes and Coal

Salinity, Sodicity and Dispersion Potential of Spoil – Non-Carbonaceous

Non-carbonaceous spoil has low median and 95th percentile electrical conductivity (EC)$_{1:5}$ values of 390 and 549 microSiemens per centimetre (μS/cm), respectively, and has very low total S concentrations. On this basis, contact water (run-off and seepage) is expected to be generally non-saline to slightly saline, as a result of dissolution of geogenic salts more so than from sulfide oxidation (sulfate salinity). Weathered non-carbonaceous spoil generally has slightly higher EC$_{1:5}$ values, overall, compared to fresh non-carbonaceous spoil.

Non-carbonaceous spoil has modest cation exchange capacity (CEC) values and high exchangeable sodium percentage (ESP) values, resulting in all samples being classified as 'sodic' to 'strongly sodic' based on CEC and ESP data alone and, therefore, has potential for dispersion. Based on Emerson aggregate class testing to directly measure dispersion, about 56% of the 262 non-carbonaceous samples tested displayed some degree of dispersion. Therefore, based on the CEC, ESP and Emerson aggregate class test results, a significant proportion of non-carbonaceous spoil at BWM and the Project is expected to be sodic and dispersive to varying degrees.

Salinity, Sodicity and Dispersion Potential of Spoil – Carbonaceous

Carbonaceous spoil has low median and 95th percentile EC$_{1:5}$ values of 362 and 547 μS/cm, respectively, and has very low to low total S concentrations. On this basis, contact water (run-off and seepage) is expected to be similar to non-carbonaceous spoil. That is, generally non-saline to slightly saline, primarily as a result of dissolution of geogenic salts more so than from sulfide oxidation (sulfate salinity).

Carbonaceous spoil samples (all fresh) had similar CEC values compared to fresh non-carbonaceous spoil, but generally higher ESP values compared to non-carbonaceous spoil – resulting in all carbonaceous samples being classified as 'strongly sodic', with potential for dispersion. Based on Emerson aggregate class testing to directly measure dispersion, about 52% of the 33 carbonaceous samples tested displayed some degree of dispersion. Therefore, based on the CEC, ESP and Emerson aggregate class test results, a significant proportion of carbonaceous spoil at BWM and the Project is expected to be sodic and dispersive to varying degrees.

Salinity Potential of Tailings

Tailings samples have EC$_{1:5}$ values ranging from 97 to 8900 μS/cm, with median and 95th percentile EC$_{1:5}$ values of 711 and 2070 μS/cm, respectively. Fresh and aged tailings are generally slightly to moderately saline – and both tailings types have generally low-moderate to moderate total S concentrations. Therefore, tailings are generally slightly to moderately saline with a low to low-moderate potential for SD (from sulfide oxidation).

Salinity Potential of Rejects

Rejects samples have EC$_{1:5}$ values ranging from 229 to 2830 μS/cm, with median and 95th percentile EC$_{1:5}$ values of 761 and 2404 μS/cm, respectively. Fresh NCPP rejects were generally non-saline, whereas aged rejects were generally slightly to moderately saline. Overall, as a bulk material, rejects are

assessed as being slightly to moderately saline. Most fresh rejects have low total S concentrations, whereas most aged rejects have low to low-moderate total S concentrations. Therefore, based on the total S concentrations, the potential for SD (from sulfide oxidation) from rejects is low to low-moderate.

Salinity Potential of Coal

Coal has low median and 95th percentile $EC_{1:5}$ values of 103 and 309 μS/cm, respectively; and has generally low total S concentrations. On this basis, contact water (run-off and seepage) from coal, as a bulk material, is expected to be non-saline, either as a result of dissolution of geogenic salts and/or from sulfide oxidation (sulfate salinity).

Management and Mitigation Measures

Spoil Management Strategy

The management of spoil (overburden and interburden) generated by the Project would be consistent with the current approved BWM waste management strategy – comprising the disposal of spoil from the Project into in-pit dumps behind the active mining face, then progressively rehabilitated – with run-off and seepage captured by the mine water management system.

Spoil comprises approximately 99% of the mineral waste at BWM, of which about 92% of spoil is non-carbonaceous. These approximate proportions are expected to continue as mining progresses eastwards into the Project. The assessment has found no difference between the geochemical characteristics of spoil from current BWM compared to the spoil expected to be mined from the Project.

Spoil is overwhelmingly NAF with excess ANC and has a negligible risk of developing AMD, including AD, NMD and/or SD. Furthermore, surface water run-off and seepage from bulk spoil is expected to be non-saline to slightly saline with low soluble metal and metalloid concentrations. However, spoil is expected to be sodic to strongly sodic with potential for dispersion and erosion.

Where highly sodic and/or dispersive spoil is identified it should, wherever practicable, not report to final landform surfaces and should not be used in construction activities. Tertiary spoil has generally been found to be unsuitable for construction use or on final landform surfaces (Australian Coal Association Research Program [ACARP], 2004 and 2019).

It is unlikely that sodic and potentially dispersive spoil would be able to be selectively handled and emplaced during operation of the Project, as is the case at BWM. Therefore, in the absence of such selective handling, spoil landforms would need to be constructed and progressively rehabilitated to minimise erosion.

Surface water run-off and seepage from spoil, including any rehabilitated areas, should be monitored for 'standard' water quality parameters including, but not limited to, pH, EC, major ions and a broad suite of soluble metals and metalloids at high resolution analysis.

With the implementation of the proposed management and mitigation measures spoil is regarded as posing a low risk of environmental harm.

Validation of Spoil Characteristics

The AMD hazard posed by existing spoil at BWM is well understood, and the geochemical characteristics (AMD hazard) of future spoil generated by BWM and the Project are expected to be similar to the current

spoil being produced at BWM. Nevertheless, WHC would continue to undertake geochemical test-work of overburden and interburden throughout development of the Project. Test-work would, at minimum, comprise a broad suite of environmental geochemical parameters, such as pH, EC (salinity), ABA parameters, S speciation, and total and soluble metals and metalloids analysis at high resolution.

Tailings and Rejects Management Strategy

Fresh tailings and rejects samples from the NCPP are those types regarded as being most representative of current tailings and rejects at BWM and are likely to represent short- to medium-term tailings and rejects expected to be generated in the early years of the Project. Tailings and rejects each comprise approximately 0.5% of mineral waste at BWM; and these approximate proportions are expected to be similar from the Project.

Approximately half of BWM tailings has a moderate to high potential to generate AMD as either AD and/or NMD and/or SD, and the remaining half (approximately) has a relatively low potential to generate AMD as either AD and/or NMD and/or SD. ROM coal from the Project is expected to produce tailings with AMD potential similar to fresh tailings currently produced at BWM NCPP.

Fresh NCPP rejects have a low potential to generate AMD as either AD and/or NMD and/or SD. Comparatively, about one-third of aged rejects have a moderate to high potential to generate AMD as either AD and/or NMD and/or SD, with the remaining two-thirds of aged rejects having a relatively low to low-moderate potential to generate AMD. ROM coal from the Project is expected to produce rejects with AMD potential similar to fresh rejects currently produced at BWM NCPP.

At BWM, tailings are currently being disposed into Bonnie Doon in-pit TSF and rejects are currently primarily disposed into in-pit spoil disposal areas within Besgrove and Deep Creek pits. The management of tailings and rejects generated by the Project would be consistent with the current approved strategies for managing tailings and rejects at BWM, including potential future dewatering of tailings and subsequent co-disposal of coal rejects (mixed fine and coarse rejects) into spoil dumps, subject to the conditions of the BWM Environmental Authority.

Validation of Tailings and Rejects Characteristics

The AMD hazard posed by existing tailings and rejects at BWM is well understood, and the geochemical characteristics (AMD hazard) of future tailings and rejects generated by the Project are expected to be similar to the current tailings and rejects being produced at BWM. Nevertheless, WHC would continue to undertake geochemical test-work of tailings and rejects samples during operations at BWM and throughout development of the Project. Test-work would, at a minimum, comprise a broad suite of environmental geochemical parameters, such as pH, EC (salinity), ABA parameters, S speciation, and total and soluble metals and metalloids analysis at high resolution.

Run-of-Mine Coal

ROM coal is not mining waste, and surface water run-off and seepage from ROM pads would be managed as part of the mine water management system.

ROM coal from BWM is conservatively assessed as having a low-moderate to moderate potential to generate AMD as either AD, NMD and/or SD. A small proportion of coal – mostly from the P and L seam group – would have a moderate to moderate-high potential to generate AMD. ROM coal, as a bulk material, is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage).

ROM coal is stored for a very short period of time (typically days to weeks) compared to mineral waste materials, which are stored in perpetuity. Management practices are therefore different for ROM coal (compared to mineral wastes) and are largely based around the operational (day-to-day) management of surface water run-off from ROM pads.

Surface water run-off from ROM pads would be monitored for 'standard' water quality parameters including, but not limited to, pH, EC, major ions, and a broad suite of soluble metals and metalloids at high resolution analysis.

Blackwater North Extension Project

Geochemical Assessment of Potential Spoil and Coal Reject Materials

Executive Summary iii
Glossary of Terms xvii

TABLE of CONTENTS

1 Introduction and Context 21
1.1 Objective 21
1.2 Material Types and Quantities 23
1.3 Geological Background 23

2 Potential Environmental Geochemical Hazards 27
2.1 Acid and Metalliferous Drainage 27
2.2 Salinity, Sodicity and Dispersion 27

3 Assessment Methodology 28
3.1 Information Review 28
3.2 Sample Collection 28
3.3 Sample Characterisation 30
3.4 Geochemical Source Hazard Assessment 33

4 Results 39
4.1 Mineralogy 39
4.2 Acid-Base Accounting (Potential for Acid Generation) 41
4.3 Total Metals and Metalloids 56
4.4 Initial Solubility in Deionised Water 57
4.5 'Saline' Water Solubility of Tailings and Rejects 61
4.6 Characteristics of Tailings Liquor (Water) 62
4.7 Peroxide Leachate Solutions 62
4.8 Cation Exchange Capacity, Sodicity and Dispersion of Spoil 64
4.9 Kinetic Column Leaching of Tailings 65
4.10 OxCon Test-work of Tailings 66

5 Summary of Geochemical Characteristics 68
5.1 AMD Potential of Mineral Waste and Coal 68
5.2 Salinity, Sodicity and Dispersion Potential of Mineral Waste and Coal 73

6 Management and Mitigation Measures 75
6.1 Spoil Management Strategy 75
6.2 Validation of Spoil Characteristics 75
6.3 Tailings and Rejects Management Strategy 75
6.4 Validation of Tailings and Rejects Characteristics 76
6.5 ROM Coal 76

7 References 77

APPENDICES

Appendix A. Drill-hole Information for Spoil and Coal Samples

TABLES and FIGURES

Tables

Table 3-1. Preliminary acid and metalliferous drainage classification criteria
Table 3-2. Sulfur category
Table 3-3. ANC category
Table 3-4. Soil salinity classification
Table 3-5. Soil pH type
Table 3-6. Geochemical abundance index
Table 3-7. Soluble trace element concentration category and associated cut-off values
Table 3-8. Sodicity classification
Table 3-9. Emerson classification
Table 4-1. Acid-base accounting results statistics for spoil samples
Table 4-2. Acid-base accounting results statistics for tailings and rejects samples
Table 4-3. Acid-base accounting results statistics for coal samples
Table 4-4. Geochemical classification of samples
Table 4-5. Samples subjected to deionised water solubility tests
Table 4-6. Summary of OxCon results for the tailings samples

Figures

Figure 1-1. Geochemical sampling locations
Figure 1-2. Geological long-section – Sagittarius Pit to Stewarton Pit
Figure 1-3. Geological cross-sections – Burngrove Pit and Deep Creek Pit
Figure 3-1. Classification of soluble metals and metalloids as a function of pH
Figure 4-1. Mineral distribution within spoil samples
Figure 4-2. Mineral distribution within tailings and rejects samples

Figure 4-3. Distribution of total sulfur in spoil and coal
Figure 4-4. Distribution of total sulfur in tailings and rejects
Figure 4-5. Distribution of total sulfur and chromium reducible sulfur (sulfide) in spoil and coal
Figure 4-6. Distribution of total sulfur and chromium reducible sulfur (sulfide) in tailings and rejects
Figure 4-7. Distribution of acid neutralising capacity in spoil and coal
Figure 4-8. Distribution of acid neutralising capacity in tailings and rejects
Figure 4-9. Distribution of acid neutralising capacity as total, acid neutralising capacity at pH 4.5 and proportion (%) of acid neutralising capacity expected to be readily available
Figure 4-10. Distribution of the ratio of acid neutralising capacity to maximum potential acidity in spoil and coal
Figure 4-11. Distribution of the ratio of acid neutralising capacity to maximum potential acidity in tailings and rejects
Figure 4-12. Distribution of net acid producing potential in spoil and coal
Figure 4-13. Distribution of net acid producing potential in tailings and rejects
Figure 4-14. Distribution of net acid generation pH
Figure 4-15. Geochemical classification of samples
Figure 4-16. Frequency distribution of geochemical abundance indices of selected elements
Figure 4-17. Electrical conductivity distribution
Figure 4-18. pH distribution
Figure 4-19. Sum of key environmental metals versus pH in deionised water extracts in spoil
Figure 4-20. Sum of key environmental metals versus pH in deionised water extracts in tailings, rejects and coal
Figure 4-21. Sum of key environmental metals versus pH in saline water extracts and tailings liquor
Figure 4-22. Sum of key environmental metals versus pH in peroxide (NAG) leachate solution
Figure 4-23. Cation exchange capacity and exchangeable sodium percentage of spoil
Figure 4-24. Sum of key environmental metals versus pH in kinetic column leachate solution
Figure 4-25. Sum of key environmental metals versus pH in OxCon leachate solution

GLOSSARY of TERMS

Acid	A measure of hydrogen ion (H^+) concentration in water; generally expressed as pH.
Acidity	A measure of hydrogen concentration and latent acidity generated by metal hydroxylation, expressed as mg/L.
ABA	Acid-Base Account. Evaluation of the balance between acid generation and acid neutralisation processes. Generally determined by the maximum potential acidity (MPA) and the inherent acid neutralising capacity (ANC), as defined below. See also MPA and ANC.
AD	Acid drainage. A component of AMD, AD occurs where drainage is acidic as a result of sulfide oxidation reactions, and contains elevated trace metals and metalloids in solution.
AMD	Acid and metalliferous drainage. AMD has three components: acid drainage (AD), pH-neutral and metalliferous drainage (NMD) and/or sulfide-derived saline drainage (SD) – and/or any combination of these, all generated by sulfide oxidation processes +/- neutralisation reactions.
ANC	Acid neutralising capacity, expressed as kg H_2SO_4 per tonne of rock/material. A measure of a sample's maximum potential ability to neutralise acid.
ANC/MPA	Ratio of the acid neutralising capacity (ANC) to the maximum potential acidity (MPA) of a sample. Used to assess the risk of a sample generating acid conditions. See also ANC and MPA.
BWM	Blackwater Mine.
C-org	Organic carbon.
CHPP	Coal handling and preparation plant. BWM has two CHPPs associated with the northern mining area: the current (operational) CHPP, called NCPP, which is located near the BWM industrial area; and a small thermal coal plant called TCP.
Co-Disposal	The practice of disposing different waste types together. For example, disposing coarse reject amongst spoil.
EA	Environmental Authority. A permit issued by the Queensland Department of the Environment, Tourism, Science and Innovation (DETSI) to allow the EA holder (in this case, Whitehaven Blackwater Pty Ltd and South Blackwater Coal Ltd) to undertake an 'environmentally relevant activity'. Mining is an example of an environmentally relevant activity.
EC	Electrical conductivity, expressed as μS/cm.
Interburden	Potential spoil material located between mined coal seams. See also Overburden, Mineral waste and Spoil.
Kinetic test	Procedure used to measure the geochemical/weathering behaviour of a sample of mine material over time.
Mineral waste	Material comprising mine spoil, ± coarse/fine reject, ± waste coal. Sometimes called 'mine waste' or 'mining waste'.

MPA	Maximum potential acidity. Calculated by multiplying the total sulfur (S) content of a sample by 30.6 (stoichiometric factor) and expressed as kg H_2SO_4 per tonne of rock/material (kg H_2SO_4/t). Assumes all sulfur is present as sulfide and will oxidise to generate acid.
NAG	Net acid generating test. A pulp sample is reacted with hydrogen peroxide to encourage rapid oxidation. Any acid generated through oxidation may be consumed by neutralising components in the sample. Any remaining acidity (after neutralising material is consumed) is measured and expressed as kg H_2SO_4/t. At the conclusion of the NAG test the resulting liquor is called peroxide (NAG) leachate, and can be analysed for various parameters, such as soluble metals.
NAPP	Net acid producing potential, expressed as kg H_2SO_4 per tonne of rock/material (kg H_2SO_4/t). Calculated by subtracting the ANC from the MPA.
NCPP	North coal handling and preparation plant; the current (operational) CHPP located near the BWM industrial area.
NMD	Neutral and metalliferous drainage. A component of AMD, NMD occurs where drainage is pH-neutral or higher yet contains elevated trace metals and metalloids in solution.
S-org	Organic sulfur.
Overburden	Mineral (mining) waste located above (overburden proper) or between (interburden) coal seams and reports to spoil dumps. Typically comprises non-coaly and non-carbonaceous material, such as sandstone, siltstone and claystone/mudstone, but also includes a small percentage of carbonaceous material (e.g. carbonaceous siltstone) and sub-economic waste coal.
OxCon	Oxygen consumption test. A type of kinetic (dynamic) test for estimating the sulfide oxidation rates, acidity generation rates and carbonate neutralisation rates for sulfidic geological materials.
PAF	Potentially acid forming. Geochemical classification criterion for a sample that has the potential to generate acid conditions. A sample classified as PAF has an acid generating potential (MPA) that exceeds the inherent acid neutralising capacity (ANC) of the material. This means that such a material is likely to generate acidic drainage (AD) if exposed to atmospheric conditions. See also PAF-LC.
PAF-LC	Potentially acid forming (low capacity). Geochemical classification criterion for a sample that has the potential to generate relatively low-level AD.
Ply(s)	The individual coal seams within a seam group and separated by interburden. A seam group is typically comprised of several plys.
Product coal	Coal produced from a CHPP after being washed/processed. Coal that is ready for sale.
Rejects	Coarse sand to cobble-sized rock material produced during coal processing. Rejects are typically associated with the roof, floor and partings of coal seams and are separated from ROM coal in the CHPP. Current rejects produced at BWM are disposed within in-pit spoil dumps in the general vicinity of the NCPP. Historic rejects from NCPP have been disposed into rejects dumps (stockpiles) and within disused pits. Rejects have also been used in construction activities, such as NCPP TSF embankments and used for capping/construction of pads.

Rejects dump	In-pit or out-of-pit landform containing rejects.
Residual void	The term given to an open-pit after mining has ceased and any rehabilitation of the pit has been undertaken (i.e. post-closure).
ROM	Run-of-Mine. The term given to mined coal before being processed at the CHPP.
ROM pad	Location where ROM coal is temporarily stored pending processing at the CHPP.
S	Sulfur.
Scr	Chromium reducible sulfur. Analytical procedure to determine the sulfide-sulfur concentration in a sample. This typically represents the proportion of sulfur associated with sulfide (reactive) minerals.
SD	Saline drainage. A component of AMD, SD occurs where drainage is saline due to elevated sulfate as a result of sulfide oxidation and neutralisation reactions.
SO_4	Sulfate.
Spoil	Rock material overlying and between 'target' coal seams, which reports as waste. Waste rock overlying a coal seam is called overburden. Waste rock between mined coal seams is called interburden. See also Overburden and Interburden.
Spoil dump	In-pit or out-of-pit spoil disposal location.
Static test	Procedure for characterising the geochemical nature of a sample at one point in time. Static tests may include measurements of mineral and chemical composition of a sample and the Acid-Base Account.
Tailings	Very fine to medium grained sand, silt and clay-sized material, which is commonly coaly and carbonaceous, produced during coal washing. Tailings are associated with coal seams and are separated from ROM coal in the NCPP. Tailings produced at BWM are disposed within Tailings Storage Facilities (TSFs – also called tailings dams).
TSF	Tailings storage facility. A dam or pit used to dispose tailings, which are delivered to the TSF as a slurry. The tailings solid forms a 'beach' and the water drains to one end of the TSF in an area referred to as the decant pond. The decant water is recycled back into the mine water management system. The current (operational) TSF is Bonnie Doon in-pit TSF [active since late 2023]. Prior tailings were disposed into the above-ground NCPP TSF.
Uncertain	In the context of classifying a material or sample as NAF or PAF. An 'Uncertain' (UC) classification applies when there is an apparent conflict in results such that neither NAF nor PAF classification can be given, or there is insufficient information to unequivocally classify as NAF or PAF. UC samples are given a tentative sub-classification as UC(NAF) or UC(PAF) where preliminary data suggests the sample is expected to be NAF or PAF, respectively.
UC(NAF)	In the context of classifying a material or sample as NAF or PAF. A material or sample has an uncertain geochemical classification, but the available data suggests the sample is expected to be NAF.
UC(PAF)	In the context of classifying a material or sample as NAF or PAF. A material or sample has an uncertain geochemical classification, but the available data suggests the sample is expected to be PAF.

Waste coal	Sub-economical coal that reports directly to the spoil dumps as waste (i.e. not ROM coal). Waste coal can be fresh or weathered (oxidised). All weathered/oxidised and coked (cindered) coal is waste.
Water extract	A method to determine the water-soluble parameters in soil. Solid samples undergo a bottle leach method where 10 g of pulped solid (100% passing 212 μm) is combined with 50 grams of water (leaching fluid) into a glass bottle. Depending on the type of leaching undertaken the leaching fluid may be deionised water (DI water extract) or saline water (saline water extract). The 1:5 solution (1 part solid to 5 parts water) is tumbled end-over-end for at least one hour. Solutes are leached from the pulp by the continuous suspension and agitation. The water extract solution is measured for pH and electrical conductivity (EC) prior to filtering for solute analysis (e.g. metals and metalloids, and major ions).

1 Introduction and Context

Terrenus Earth Sciences (Terrenus) has completed a geochemical assessment of potential mineral waste (sub-soil and rock) from the Blackwater North Extension Project (the Project), being developed by Whitehaven Blackwater Pty Ltd, a subsidiary of Whitehaven Coal Limited (WHC). The Project proposes an eastern extension of WHC's existing Blackwater Mine (BWM), as a continuation of BWM operations. The geochemical assessment was completed to assist with mine planning and as part of the environmental regulatory documentation for the Project. The Project setting is shown at Figure 1-1.

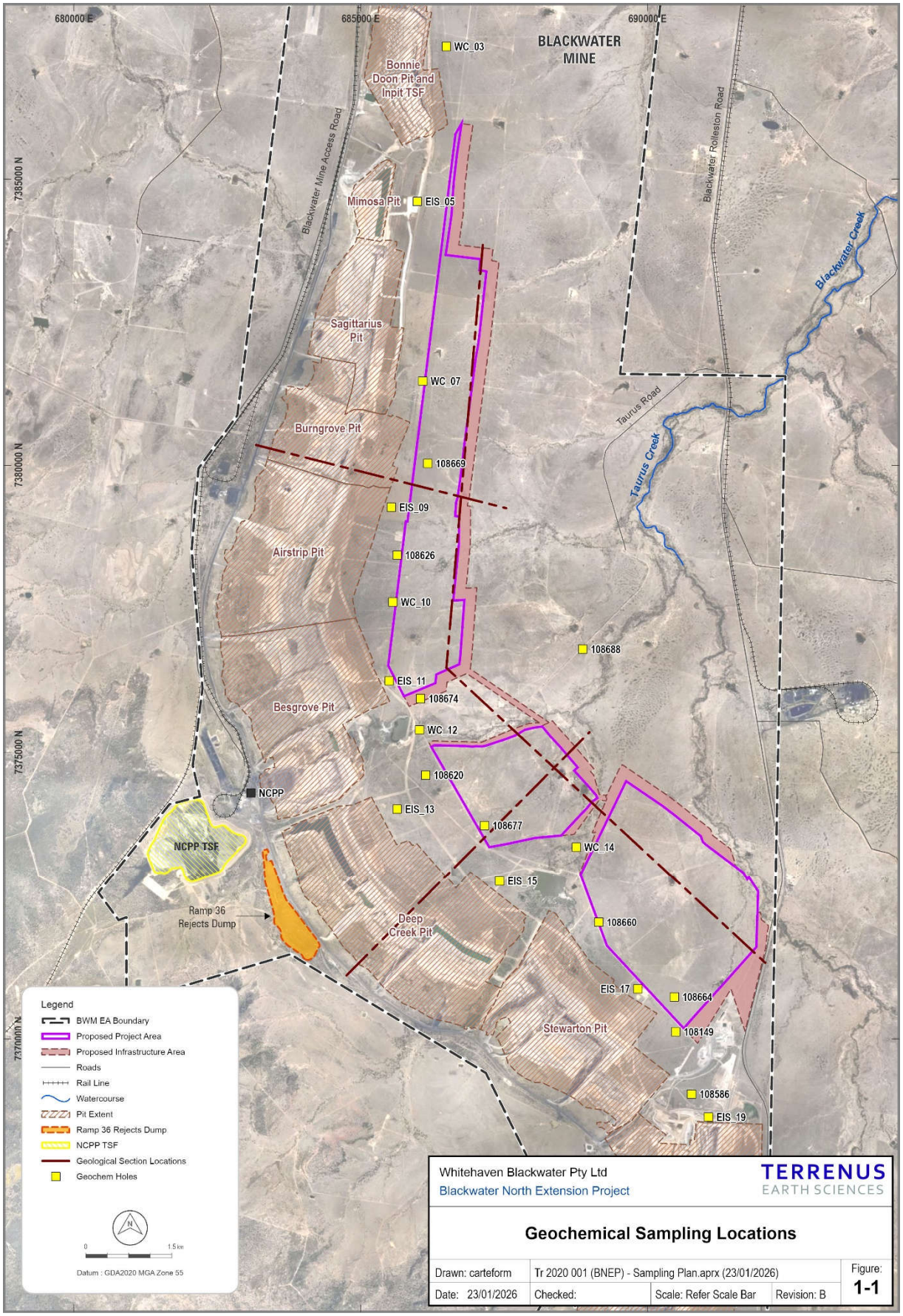
Coal would be mined by conventional open cut methods and spoil (waste rock) would be disposed into in-pit dumps behind the active mining face – as is currently undertaken at BWM. Run-of-mine (ROM) coal would be trucked to the BWM North Coal Preparation Plant (NCPP) for processing – consistent with existing ROM coal processing at BWM. Coal rejects from the NCPP comprising tailings (fine rejects) and coarse rejects would be disposed at BWM under BWM's approved management measures for such materials; including potential future dewatering of tailings and subsequent co-disposal of rejects and dewatered tailings into spoil dumps.

BWM is a very large mine with a strike length of approximately 65 kilometres (km) and is informally divided into two mining areas: north and south, based on historical ownership. The northern area of BWM is the current mining area – from Bonnie Doon Pit at the northern end through to Blackdown Pit at the southern end. Only those facilities associated with the northern mining area are relevant to the Project, as shown in Figure 1-1. The southern mining area and associated facilities are not relevant to this geochemical assessment or the Project.

1.1 Objective

The objective of the assessment (consistent with Condition E14 of Environmental Authority EPML00717813) is to evaluate the geochemical nature of mineral waste currently at BWM and mineral waste likely to be generated by the Project, and identify relevant environmental issues/opportunities that may be associated with mining, handling and storing mineral waste to inform appropriate rehabilitation and management strategies.

Figure 1-1. Geochemical sampling locations



1.2 Material Types and Quantities

BWM has three main types of mineral waste, and the geochemical characteristics and potential hazards associated with mineral waste materials at BWM and the Project are discussed by type:

- Spoil (overburden and interburden) currently comprises approximately 99% of all mineral waste at BWM (WHC, 2025) and includes Tertiary- and Permian-age weathered waste and Permian-age fresh (unweathered) waste. The Project is expected to produce spoil as a similar proportion of mineral waste to that currently produced at BWM. In the northern mining area, which includes the Project, approximately 15% of the spoil is weathered and the remaining 85% (approximately) of spoil is fresh.
- Tailings are (and will continue to be) generated at the NCPP from processing ROM coal; and typically represent the clay, silt and fine sand fractions of ROM waste. Since late 2023, tailings from the NCPP have been disposed as a slurry into Bonnie Doon in-pit tailings storage facility (TSF). Prior to this, tailings from NCPP were disposed as a slurry into the above-ground NCPP TSF (the NCPP TSF is currently inactive). Tailings comprise approximately 0.5% of all mineral waste at BWM – with this approximate proportion expected for the remaining life of asset mine plan at BWM, including tailings generated by processing ROM coal from the Project. The Project would not contain any tailings as all mineral waste from the NCPP would remain at BWM.
- Rejects are (and would continue to be) generated at the NCPP, and potentially a negligible amount from the Thermal Coal Plant (TCP), from processing ROM coal. Rejects typically represents coarser and rockier seam roof, partings and floor material. Rejects are trucked to several locations for disposal into spoil. Historically, rejects were also disposed onto out-of-pit rejects dumps – the main historic rejects dump being Ramp 36 rejects dump. Some rejects have been used in construction of the NCPP TSF embankments and infrastructure pads. Rejects comprise approximately 0.5% of all mineral waste at BWM – with this approximated proportion expected for the remaining life of asset mine plan. The Project would not contain any rejects as all mineral waste from the NCPP (and TCP) would remain at BWM.

Coal is also included in the assessment; however, coal is generally not considered mineral waste, with the exception of small quantities of sub-economic seams that may report to the spoil dumps, and remnant coal exposed on pit highwalls (such as in residual voids).

1.3 Geological Background

The lithology at the Project is consistent with the lithology of the current and future northing mining areas at BWM.

BWM sits on the eastern flanks of the Comet Ridge, a major regional anticline. Throughout most of the northern mining area at BWM the sediments strike north-south and dip gently towards the east with average bedding dips of 3-5 degrees (although there are steeper areas associated with faulting). The lithology at BWM is characterised by typical basin-fill sediments, comprising mudstone, claystone, siltstone, sandstone (typically fine- to medium-grained), carbonaceous sediments and coal seams.

Minor basalt is encountered within Tertiary-age material. At the Project, the depth to base of weathering averages about 17 metres (m) below the natural surface throughout, but ranges from about 10 to 30 m below the natural surface, depending on the local topography.

In coal environments (i.e. at coal mines) fresh carbonaceous materials typically have higher sulfide concentrations compared to fresh non-carbonaceous materials and, as such, typically pose a greater environmental geochemical hazard compared with fresh non-carbonaceous material. Comparatively, non-carbonaceous lithologies are essentially void of (or have a negligible amount of) carbonaceous material and thus have low or nil sulfide mineral concentration. The key exception is that non-carbonaceous materials located within coal seams or immediately above and below (within approximately 0.5 to 1 m of) coal seams tend to have a higher sulfide concentration compared to bulk overburden/interburden located away from seams.

The economic coal seams in the Blackwater area are contained within the late Permian-age Rangal Coal Measures (RCM). BWM currently exposes three principal seam groups from the RCM – called the tops, middles and lowers. The northern mining area predominately mines the lower seam groups (P and L seams) and lesser proportion of the middle (MR) and top (T) seam groups. The seams split and re-join through the mine often creating upper and lower sub-sections of itself, typically called riders (e.g. Top Rider [TR] and Middle Rider [MR]). This splitting is especially evident with the P & L seam group, which splits into upper and lower seams.

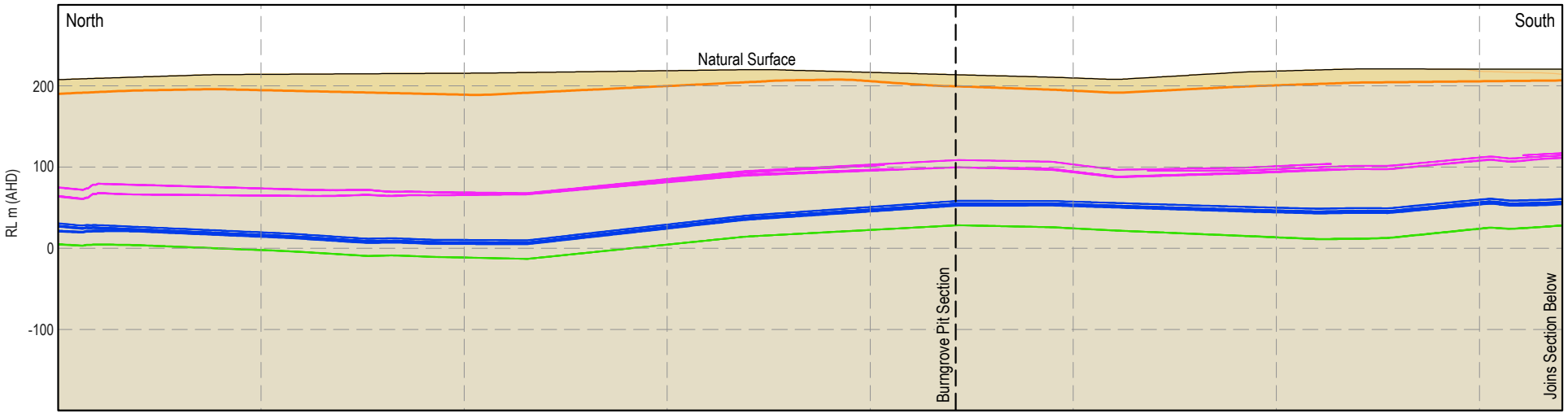
The RCM are overlain by the Early Triassic-age Rewan Formation; and most of the northern mining area is also capped by a thin veneer of Quaternary-age sediments (typically alluvial sediments).

Underlying the RCM is the Late Permian-age Burngrove Formation (which outcrops west of the site) and has geological similarities with the host rock of the RCM.

A geological long-section (indicatively north-south) through the Project is provided in **Figure 1-2**. Geological cross-sections (indicatively west-east) through two of the BWM pits and into the Project area (including current topography) are provided at **Figure 1-3**. The seam groups are shown in the geological sections. The locations of the geological sections are shown in **Figure 1-1**.

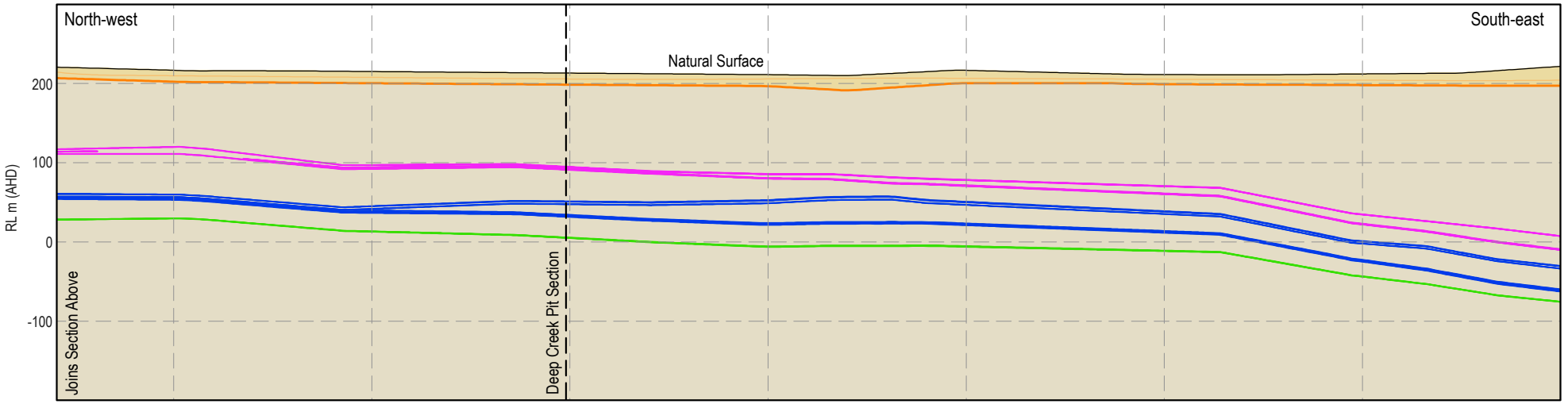
LONG SECTION | Sagittarius Pit to Besgrove Pit

Viewed Looking East



LONG SECTION | Besgrove Pit to Stewarton Pit

Viewed Looking North-west



Legend

- Natural Surface
- Base of Tertiary
- Base of Weathering

Coal Seams

- T Seam Group
- MR Seam Group
- P & L Seam Group
- SG Seam Group

Horizontal Scale

0 (V/H = 4) 800m

Vertical Scale

0 200m

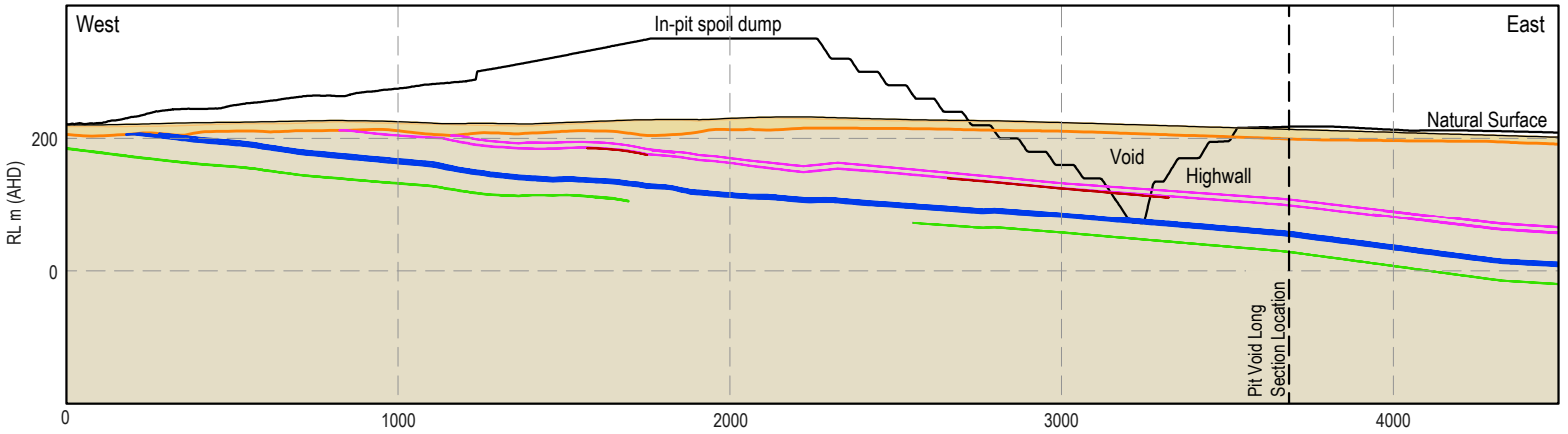
Minserve CAD File: Bhpb008m05.dwg

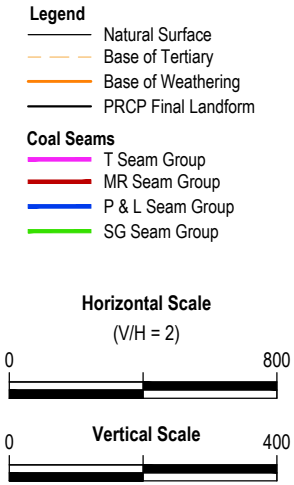
Pit/void highwall long-section

Figure **1-2**

CROSS SECTION | Burngrove Pit

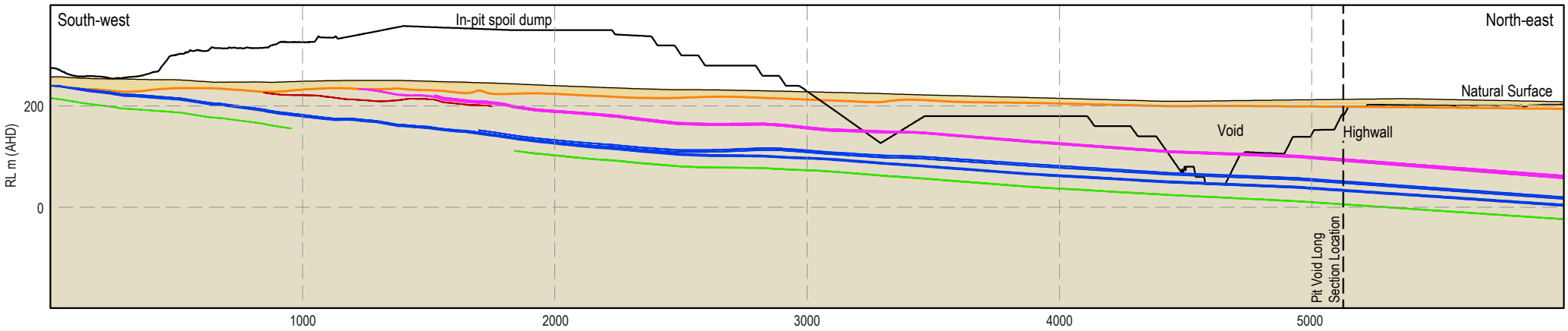
Viewed Looking North





CROSS SECTION | Deep Creek Pit

Viewed Looking North-west



Minserve CAD File: Bhpb008m06.dwg

Pit cross-sections

Figure **1-3**

2 Potential Environmental Geochemical Hazards

2.1 Acid and Metalliferous Drainage

The term 'AMD' is used to describe low-quality seepage or drainage (from soil and rock) that has been affected by the oxidation of sulfide minerals (primarily pyrite and marcasite) and/or by the dissolution of acid generating sulfate minerals and associated neutralisation reactions, if any. The term AMD is used to describe any drainage type affected by this process.

- AMD may be produced when sulfide minerals (such as pyrite) are exposed to oxygen and water. Oxidation of sulfide minerals may result in the production of acid(ity), sulfate (SO_4) and, depending on mineralogy, the release of metals and salinity. AMD comprises three key components, which are defined below as per recognised Australian and international guidelines (International Network for Acid Prevention [INAP], 2009[1], Department of Industry, Innovation and Science [DIIS], 2016[2]).
- Acid drainage (AD): where contact water is acidic and, in most cases, also contains 'elevated' concentrations of metals and metalloids. This drainage type is generated when the acid generating capacity exceeds the acid neutralisation capacity of a sample.
- Neutral and metalliferous drainage (NMD): where contact water is pH-neutral/alkaline and contains 'elevated' concentrations of metals and metalloids. This drainage type is generated when the acid neutralising capacity exceeds the acid generating capacity of a sample.
- Saline drainage (SD): where contact water contains elevated sulfate concentration due to oxidation of sulfide minerals, and very low metal and metalloid concentrations. This drainage type is generated when the acid neutralising capacity vastly exceeds the acid generating capacity of a sample with high sulfide concentration.

Whether contact water is impacted by AD, NMD and/or SD largely depends on the relative proportion of acid generating minerals (sulfide / sulfate) and acid neutralising minerals (carbonate) in the source materials. In this assessment unless specified otherwise, the term AMD is broadly used to describe AD, NMD and/or SD.

2.2 Salinity, Sodicity and Dispersion

An assessment of salinity characteristics of mineral waste materials has been undertaken on materials using available electrical conductivity (EC) data. An assessment of sodicity and dispersion characteristics of potential final landform materials has also been undertaken using exchangeable cation and Emerson Class data from overburden/interburden samples. Salinity released from the dissolution of geogenic salts (non-oxidative) is a separate and distinct process from SD associated with sulfide oxidation.

1 INAP, 2009. Global Acid Rock Drainage Guide. https://www.gardguide.com/index.php?title=Main_Page.

2 DIIS, 2016, Preventing Acid and Metalliferous Drainage. Handbook from Australian Federal Government's Leading Practice Sustainable Development Program for the Mining Industry. https://www.industry.gov.au/data-and-publications/leading-practice-handbook-preventing-acid-and-metalliferous-drainage.

3 Assessment Methodology

This section provides the methodology used for the geochemical assessment of spoil, tailings and rejects (mineral wastes) and coal at BWM and for these same mineral wastes and coal expected to be generated by the Project.

3.1 Information Review

Sampling and laboratory test-work has been undertaken by previous site owners (BM Alliance Coal Operations Pty Ltd [BMA]), WHC and consultants throughout the development and operation of BWM. The BWM geochemical database contains all available geochemical data for mineral waste samples at BWM, including data from drill-holes located within the Project footprint. The geochemical database was provided to Terrenus for this assessment.

The Project proposes to mine the same geologic materials as are currently mined from the existing BWM northern mining area. Therefore, drill-hole, tailings and rejects samples from, or associated with, the current approved northern mining area at BWM are representative of these same materials to be mined from the Project – hence geochemical data from the northern mining area at BWM is representative of materials expected to be mined at the Project.

3.2 Sample Collection

Drill-hole Samples – Representing Spoil, Run-of-Mine Coal, Pit Walls and Pit Floor

All data used to assess spoil, ROM coal (and potentially pit walls and floor) has been derived from drill-hole sampling. Drill-hole samples of relevance to the Project have been collected between 2020 and 2025 from 22 drill-holes located throughout the northern mining area at BWM (Figure 1-1); including one drill-hole (hole 108688) located approximately 1.5 km east of the proposed disturbance area at the Project and approximately 3.5 km east of current Besgrove Pit highwall.

Most drill-holes are distributed along geological strike (approximately north-south) typically within about one km east of the current pit highwalls at BWM and intersect all current and near-future mined geological units. Drill-hole 108688, located east of the Project, intersects the same geological units and coal seams as per the holes closer to the current mining area. As such, the drill-hole samples that have undergone test-work are representative of the geology/stratigraphy at BWM from existing mining (disturbance areas) and the proposed new mining area associated with the Project. At all drill-holes, sampling was undertaken from surface or near-surface to full drill-hole depth (approximately to below the lowest mined seam).

Geochemical data comprising, at a minimum, total S and acid neutralising capacity (ANC) results, is available for 2474 drill-hole samples collected from the 22 drill-holes in the vicinity of the Project (geochemical data from drill-holes away from the Project is excluded from this assessment).

Geochemical samples collected and tested were sourced from the following key mineral waste domains:

- Weathered, non-carbonaceous spoil: 176 samples, identified as "Spoil Weath". No carbonaceous spoil material was encountered or sampled in the drill-holes.
- Fresh, non-carbonaceous spoil: 1924 samples, identified as "Spoil Fresh Non-Carb".
- Fresh, carbonaceous spoil. Carbonaceous samples typically include carbonaceous siltstone, carbonaceous sandstone, carbonaceous mudstone and coaly shale, but also includes similar coaly and carbonaceous materials other than coal: 160 samples, identified as "Spoil Fresh Carb".
- Fresh, coal: 214 samples, identified as "Coal Fresh".

All samples were collected from drill-core. Samples were collected as discrete samples – typically a 20 centimetre (cm) interval of core within targeted sampling zones. Most samples were collected semi-continuously across the entire stratigraphic sequence, with greater emphasis placed on those stratigraphies posing a greater AMD hazard, such as carbonaceous spoil plus material located within and very close to coal seams, which includes roof/parting/floor (carbonaceous and non-carbonaceous), and coal.

Approximately 12% of the spoil samples were sampled close to seams – typically interburden or parting between plys of the same seam group. As such, seam and near-seam zones were proportionally oversampled (relative to sampling of thick overburden/interburden areas well away from seams) to target seam zones that were interpreted as posing a higher AMD hazard compared to general spoil well away from seams. Therefore, this sampling technique is potentially biased towards higher AMD hazard materials.

Most fresh coal would report to ROM coal and be processed. A small fraction of coal would be mined as spoil (waste) due to coal quality and mining considerations, and a small proportion of coal would remain exposed in seams on pit walls and floor at closure. The coal samples discussed herein represent 'pure' coal and do not include non-coal roof, parting and floor samples that would ordinarily be mined with the seam as ROM coal. Carbonaceous roof, parting or floor samples are included in the "fresh, carbonaceous" sample group.

The geochemical sampling locations are shown on **Figure 1-1**. Drill-hole information is provided in **Appendix A**.

Tailings Samples – Representing Very Fine to Fine-Grained Coal Process Waste

Geochemical data is available (within the geochemical database) for 471 tailings samples of relevance to the Project, comprising:

- 305 fresh tailings samples collected from the NCPP (identified as "Tailings NCPP Fresh"); and
- 166 aged tailings samples collected from shallow grab samples and geotechnical investigation drill-holes within NCPP TSF (identified as "Tailings NCPP TSF Aged").

Tailings samples collected from the NCPP are deemed to be representative of fresh tailings currently and recently produced at BWM. Tailings samples collected from NCPP TSF are deemed to be representative of aged tailings within the TSF at BWM.

ROM coal from the Project is expected to produce tailings that are geochemically similar to (consistent with) tailings produced from processing ROM coal from current BWM operations.

Rejects Samples – Representing Mid- to Very Coarse Coal Process Waste

Geochemical data is available (within the geochemical database) for 237 rejects samples of relevance to the Project, comprising:

- 48 fresh rejects samples collected from the NCPP (identified as "Rejects NCPP Fresh");
- 45 aged rejects samples collected from geotechnical investigation drill-holes within NCPP TSF (identified as "Rejects NCPP TSF Aged"); and
- 144 aged rejects samples collected from investigation drill-holes within Ramp 36 rejects dump (identified as "Rejects Dump Aged").

Rejects samples collected from the NCPP are deemed to be representative of fresh rejects currently and recently produced at BWM. Rejects samples collected from Ramp 36 rejects dump, primarily, and other rejects (e.g. NCPP TSF embankments) are deemed to be representative of aged rejects that may be found at older rejects disposal areas. Ramp 36 rejects dump was operational between approximately 1967 and 2007. Since 2007, rejects from NCPP have primarily been disposed into in-spoil rejects dumps within the Besgrove and Deep Creek pit shells.

ROM coal from the Project is expected to produce rejects that are geochemically similar to (consistent with) rejects produced from processing ROM coal from current BWM operations.

3.3 Sample Characterisation

The aim of the environmental geochemical test-work is to understand the geochemical characteristics of the mineral waste materials with respect to AMD, geogenic salinity, erosion and dispersion potential; and to inform management and closure options for these materials.

A phased approach was implemented to define the geochemical behaviour of the key material types generated at BWM (and expected to be generated at the Project), as discussed below.

Solid Samples – Static Tests

Samples have generally undergone similar test-work methods. Test-work was generally undertaken in stages, with most samples being subjected to 'screening' tests followed by more detailed test-work undertaken on selected samples. Almost all samples have undergone 'screening' tests (stage 1 tests) for:

- pH and electrical conductivity (EC) on 1:5 weight:volume (w:v) water extract – an end-over-end bottle leach at 1:5 w:v solid:water ratio using deionised water. The procedure was undertaken on pulped samples (100% passing 212 microns).
- Net acid producing potential (NAPP) test, which comprises total S and ANC determination. The NAPP test provides the fundamental information about the theoretical maximum amount of acid-producing and acid-neutralising material that a sample could produce.

Based on the results of the screening tests, selected samples were subjected to some or all of the following tests:

- Total carbon (total C), and organic carbon (C-org);
- Total sulfate (SO_4);
- Sulfide (chromium reducible sulfur – Scr) – a test to determine the proportion of total S present as sulfide;
- Acid buffering characterisation curve (ABCC) – a test to determine the proportion of ANC that's in a readily-available form, and to provide an indication of the carbonate mineralogy of the neutralising material;
- Net acid generation (NAG) (single addition) – a test that encourages the oxidation of a sample to determine if acid can be produced, and how much acid could be produced;
- Sequential net acid generation test (S-NAG) – a refinement of the single addition NAG test to resolve potential issues associated with incomplete oxidation of samples with high sulfide concentration;
- Extended boil net acid generation test (NAG extended) – a refinement of the NAG test to resolve uncertainty due to potential organic acid interference (where non-acid generating organic acids can provide false positive results in the NAG test);
- Total metals and metalloids by 4-acid (mixed) or 2-acid (aqua regia) digest with analysis by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and/or Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) and Flow Injection Mercury System (FIMS);
- Quantitative x-ray diffraction (QXRD) – to determine the mineralogical composition;
- Short-term leaching tests, including:
    - Deionised water extract leach procedure – a one hour end-over-end bottle leach at 1:5 w:v (solid:water) ratio using de-ionised water, with filtered leachate analysed for:
        - major and minor ions (calcium [Ca], magnesium [Mg], sodium [Na], potassium [K], SO4, chloride [Cl] and fluoride [F]);
        - alkalinity (total alkalinity, bicarbonate [HCO_3] and carbonate [CO_3]) and acidity (pH dependent);
        - soluble metals and metalloids (approximately 28 elements by ICP-MS, ICP-AES and FIMS).
    - Saline water extract leach procedure – a one-hour end-over-end bottle leach at 1:5 w:v (solid:water) ratio using saline water (2 g/L sodium chloride [NaCl]), with filtered leachate analysed for the soluble analytes listed above.
    - Peroxide (NAG) leach – analysis of the solution on completion of the NAG or NAG Extended test, with filtered leachate analysed for the same (or similar) suite of soluble analytes as listed above.
- Exchangeable cations (Ca, Mg, Na, K) with pre-treatment for salinity, if required. Results were used to calculate the cation exchange capacity (CEC); and
- Emerson Aggregate Class testing.

For most samples, laboratory test work was undertaken by ALS Environmental (ALS) Brisbane, using National Association of Testing Authorities (NATA) accredited methods (where such accreditation exists). Mineralogical analysis (QXRD) was undertaken by a university (research) mineralogical laboratory in Melbourne (via Earth Systems Consulting).

Solid Samples – Kinetic OxCon Tests

Oxygen consumption and carbon dioxide (CO_2) generation test-work (referred to herein as OxCon tests) was undertaken by Earth Systems (Melbourne) on five fresh tailings samples from NCPP, one aged tailings sample collected from NCPP TSF, and three composite carbonaceous spoil samples from drill-cores. The samples were selected on the basis of earlier static test results.

OxCon is a laboratory-scale kinetic geochemical test for the estimation of sulfide oxidation rates, acidity generation rates and carbonate neutralisation rates for sulfidic geological materials.

Prior to the OxCon test the sample is 'washed' to remove any pre-existing salts and oxidation products (e.g. sulfate). Test-work then involves isolating a known mass of sulfide-bearing material in a known volume of oxygen inside a sealed vessel and allowing sulfide oxidation to proceed. Once the test is initiated, oxygen in the vessel is consumed via sulfide oxidation. Oxygen consumption is measured directly and logged over the test-work period (1-8 weeks, depending upon the sample). CO_2 generation is measured hourly and logged to estimate of the extent of acid neutralisation by carbonate minerals or the rate of biological C-org oxidation, if any, during testing.

At the conclusion of the OxCon test, the solid undergoes a bottle leaching procedure at a 1:2 w:v (solid:water) ratio and the leachate was analysed to determine the pH, acidity/alkalinity and concentration of soluble metals and metalloids, and salts.

Solid Samples – Kinetic Leaching Tests

Free-draining kinetic column leaching data is available for five fresh NCPP tailings samples and one aged tailings sample collected from NCPP TSF. The samples were selected for column leaching test-work on the basis of earlier static test results. These are the same tailings samples that also underwent OxCon test-work.

Column leaching is a laboratory-scale kinetic geochemical test for the estimation of sulfide oxidation rates, acidity generation rates and element leaching – over time – for geological materials. The intent of the column leaching program was to characterise leachate from samples subjected to routine wetting and drying cycles, which simulates exposure to 'atmospheric conditions'. Crushed samples are loosely packed into a two litre funnel and a known quantity/mass of deionised water is slowly added to the top of each sample and the water allowed to slowly free-drain through the sample matrix and collected as 'column leachate'. The leachate collected from each column test was analysed to determine the pH, acidity/alkalinity, and concentration of soluble metals and metalloids, and salts. Between leaching (wetting) events the sample matrix was allowed to dry and oxidise using heat lamps. The column leaching test method was based upon a modified AMIRA (2002) method.

Tailings Liquor Samples

Tailings samples collected from the NCPP are collected as a slurry – representative of the tailings slurry that reports to TSFs for disposal. At the TSF the water drains to one end of the TSF, called a decant pond/area, and is collected for re-use in the NCPP. Geochemical data is available (in the geochemical

database) for tailings liquor from 51 sampling events undertaken at the NCPP between August 2020 and August 2023. The liquor samples were analysed for a typical suite of water quality parameters, such as pH and EC, major ions, and soluble metals and metalloids.

3.4 Geochemical Source Hazard Assessment

Geochemical data was assessed with regard to the samples potential to generate AMD. Only after making such an assessment to understand the potential AMD hazard can appropriate AMD specific management measures be formulated to adequately mitigate the risks, as required.

Acid and Metalliferous Drainage Classification

The Acid-Base Account (ABA) method was used to assess the acid-neutralising and acid-generating characteristics of the samples in order to determine an acid (AD) classification for the rejects.

The maximum potential acidity (MPA) and ANC represent each side of the acid-base account. MPA is calculated from total S and is the theoretical maximum potential acidity that can be generated if all of the S, assumed to be associated entirely with pyritic sulfide, is able to oxidise and generate acid (H_2SO_4). ANC represents the theoretical maximum amount of acid-neutralising capacity of a sample assuming all neutralising material is in a readily available form. The net acid producing potential (NAPP) is the difference between the MPA and the ANC. In simple terms, a negative NAPP indicates an excess of ANC and the sample is likely to be non-acid forming (NAF) and a positive NAPP indicates an excess of MPA and the sample is likely to be potentially acid forming (PAF) – though there can be exceptions to this simplified interpretation. Note that NAF samples have the potential to generate NMD and SD, depending on the sulfide concentration.

Sample classification of mineral wastes follows some general rules. Samples were initially classified using total S, NAPP and ANC/MPA ratio (and NAG data, where available), into three broad categories:

- **NAF:** Non-acid Forming;
- **PAF:** Potentially Acid Forming; and
- **Uncertain (UC):** Those samples with inconclusive results, leading to a degree of uncertainty about their ability to generate acid.

Where available, additional geochemical information such as pH, Scr, ABCC, NAG extended and NAG sequential results were used to resolve acid classification uncertainties. The general approach was to build in a level of conservatism in the preliminary classification, as shown in **Table 3-1**.

Samples with a UC classification are given a tentative sub-classification of UC(NAF) or UC(PAF), where preliminary data suggests the sample is expected to be NAF or PAF, respectively.

Table 3-1. Preliminary acid and metalliferous drainage classification criteria

Preliminary Classification	Sulfur %	NAPP kg H_2SO_4/t	ANC/MPA ratio	NAG pH (if data available)
NAF	≤ 0.01	-	-	-
	≤ 1	< 0	≥ 2	-
	≤ 1	< 0	-	≥ 4.5
NAF-Sulfur (NAF-S)	> 1	< 0	≥ 2	-
	> 1	< 0	-	≥ 4.5
PAF – Low Capacity (PAF-LC)	≤ 1	≥ 0 and < 10	< 2	-
	-	≥ 0 and < 10	-	< 4.5
PAF	-	≥ 10	< 2	-
	-	≥ 10	-	< 4.5
Uncertain	Any result outside of the above criteria, or results that appear to significantly conflict with the expected result based on lithology			

Sulfur Category

To ensure a consistent approach to describe the samples geochemical characteristics, specific total S cut-off values were used to discuss S data, as shown in Table 3-2.

Table 3-2. Sulfur category

Sulfur category	Total S (wt. %)	Sulfur category	Total S (wt. %)
Very low	< 0.1	Moderate	1.0 – 1.5
Low	0.1 – 0.5	High	> 1.5
Low-moderate	0.5 – 1.0		

Acid Neutralising Capacity Category

To ensure a consistent approach to describe the samples geochemical characteristics, specific ANC cut-off values were used to discuss ANC data as shown in Table 3-3.

Table 3-3. ANC category

ANC category	ANC (kg H_2SO_4/t)	ANC category	ANC (kg H_2SO_4/t)
Very low	< 5	High	30 - 50
Low	5 - 15	Very high	> 50
Moderate	15 - 30		

Soil Salinity

The term 'soil' salinity (and 'soil' pH – refer below) is an industry-adopted term to refer to the salinity and pH measured on any solid geologic matrix, such as soil, spoil, rock, sediment, tailings, reject, *etc*. That is, in this context, the term 'soil' applies to all solid samples, not just shallow surface (root zone) material.

Classifying whether a sample is non-saline, highly saline, or somewhere in between will depend upon the methods used to measure soil salinity. Soil salinity data is obtained from a 1:5 (w:v) water extract procedure on pulp samples (pulping the sample minimises the potential to underestimate salinity of sandy samples/materials). The soil salinity classes shown in Table 3-4 are expressed in units of microSiemens per centimetre (μS/cm) and are based on a 1:5 w:v method. These soil salinity classes are used as an indicative guide. The classes are broadly based on soil salinity classes reported by DME (1995).

Table 3-4. Soil salinity classification

Soil salinity classification	EC1:5 (µS/cm)	Soil salinity classification	EC1:5 (µS/cm)
Non-saline	< 450	Saline	2000 - 4000
Slightly saline	450 - 900	Strongly saline	> 4000
Moderately saline	900 - 2000	--	--

Soil pH Type

Classifying whether a sample is acid, pH-neutral or alkaline (or somewhere in between) depends upon the methods used to measure soil pH. Soil pH data is obtained from a 1:5 (w:v) water extract procedure on pulp samples. The soil pH types shown in Table 3-5 are used as an indicative guide.

Table 3-5. Soil pH type

Soil pH type	pH1:5	Soil pH type	pH1:5
Highly acid	< 3.0	Near neutral	6.0 – 7.5
Moderately acid	3.0 – 4.5	Alkaline	7.5 – 9.0
Weakly acid	4.5 – 6.0	Highly alkaline	> 9.0

Mineralogy

Potential Mineralogical data (QXRD) provides supporting information for the geochemical data, particularly with regard to sulfide and carbonate mineralogy of a sample, showing results for mineralogical forms (e.g. what sulfide or carbonate minerals are present) and their concentrations (reported in weight per cent [wt.%]). These data are also used to validate the results from ABCC test-work and assist with interpretation of the ABA data.

Element Enrichment

The total concentrations for each element were compared to the average elemental abundance in soil in the Earth's crust (Australian Institute of Mining and Metallurgy [AusIMM] 2011; Bowen 1979) to measure how the total elemental concentrations in the samples compare against average elemental concentrations in un-mineralised soil (worldwide). Such a comparison is undertaken to identify samples that contain what may be regarded as 'elevated' concentrations of metals and metalloids to identify potential elements of concern. However, enrichment in any metals and metalloids in the solids does not directly translate to enhanced leachability or mobilisation and/or bioavailability of that specific element.

From the comparison with average crustal abundance in rocks a geochemical abundance index (GAI) was calculated. The GAI quantifies an assay result for a particular element in terms of the average

abundance for that element (in sedimentary rocks). The index, based on a log 2 scale, is expressed in seven integer increments (0 to 6), which correspond to enrichment factors from 0 to over 96 times average crustal abundance, as shown in Table 3-6.

Table 3-6. Geochemical abundance index

GAI	Enrichment factor	GAI	Enrichment factor
0	Less than 3-fold enrichment	4	24 to 48-fold enrichment
1	3 to 6-fold enrichment	5	48 to 96-fold enrichment
2	6 to 12-fold enrichment	6	Greater than 96-fold enrichment
3	12 to 24-fold enrichment		

As a general rule, a GAI greater than or equal to three indicates enrichment compared to un-mineralised soil/rock that may warrant further investigation to assess the mobility of these elements under laboratory conditions.

Elements identified as enriched may not necessarily be a concern for revegetation and rehabilitation, human and animal health or drainage water quality. Similarly, if an element is not enriched it does not mean it would not be mobilised, because under some conditions (e.g. low pH, reducing conditions) the geochemical behaviour of metals and metalloids such as aluminium (Al), arsenic (As), copper (Cu), cadmium (Cd) and zinc (Zn) can change (i.e. become less or more mobile).

Solubility

Metal and metalloid mobility from samples has been assessed using deionised water and peroxide (NAG) leaching methods. The deionised water leaches assess the initial solubility under fresh water conditions, whereas the peroxide leach assesses the solubility after the samples have been oxidised.

The solubility data from bottle leaching provides an indication of likely solubility/release of salt, and metals and metalloids under field pH and redox (oxidation) conditions (and/or low-pH conditions, where applicable). Peroxide (NAG) leachate data provides an indication of potential acidity and concentrations of metals and metalloids that could be released from samples that are fully and rapidly oxidised. This test provides an assumed 'worst case' scenario in terms of metal and metalloid mobility.

To ensure a consistent approach to describe the samples geochemical characteristics, specific concentration cut-off values were used to discuss leachate composition as shown in Table 3-7.

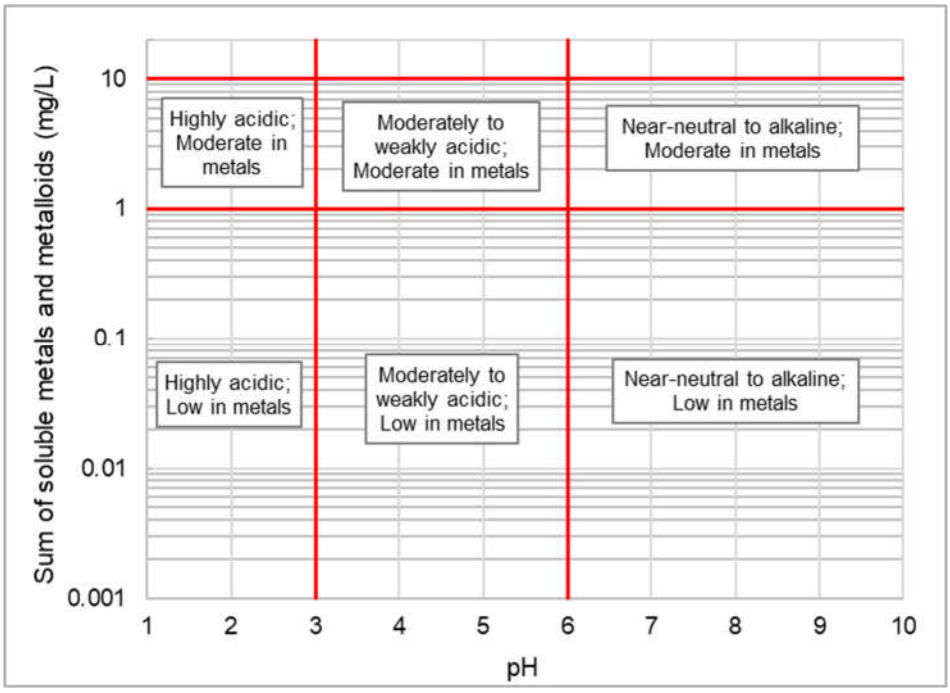
Table 3-7. Soluble trace element concentration category and associated cut-off values

Classification	Trace element soluble concentration (mg/L)	Classification	Trace element soluble concentration (mg/L)
Close to detection	≤ 0.001	Moderate	>0.1 – 1.0
Very low	>0.001 – 0.05	High	> 1.0 - 10
Low	>0.05 – 0.1	Very high	> 10

A classification scheme initially developed by Ficklin *et al*. (1992) has been adapted to summarise major attributes of the solubility data by plotting pH against the sum of soluble metal and metalloid concentrations for groups of elements, with the classification scheme shown in Figure 3-1. The soluble

metal and metalloid concentrations are shown as the sum of soluble (dissolved) metal and metalloid concentrations for Al, antimony (Sb), As, Cd, cobalt (Co), chromium (Cr), Cu, lead (Pb), mercury (Hg), manganese (Mn), molybdenum (Mo), nickel (Ni), selenium (Se), uranium (U) vanadium (V) and Zn. These elements are chosen because they're potentially environmentally important elements (as relevant to Permian coal deposits) and/or many of the elements remain in solution across a wide range of pH and are not only associated with AD conditions, but also with NMD/SD conditions.

Figure 3-1. Classification of soluble metals and metalloids as a function of pH



No comparison is made between leachate results and water quality guideline values, such as Australian and New Zealand Guidelines [ANZG] (2018) (or the draft ANZG 2023 guidelines), as such a comparison is inappropriate. The guideline values provided in ANZG (2018/2023) are for receiving water environments (e.g. creeks), whereas the soluble element data in this assessment is 'point source' obtained from a finely pulped sample subjected to rigorous and artificial extraction to obtain a concentration approaching 'near maximum'. Furthermore, contact water will undergo a number of geochemical reactions along a pathway from source to receptor, including retardation, adsorption and precipitation. Dilution is also likely, which would attenuate the concentration as seepage/contact water migrates from the source. These processes are not accounted for in a laboratory setting.

Sodicity and Dispersion

Potential spoil samples (representing material that is likely to report to final landform surface) are broadly classified with respect to sodicity on the basis of the exchangeable sodium percentage (ESP) value, as shown in Table 3-8 (after Northcote and Skene, 1972; and Isbell, 2002).

The sodicity will depend upon a range of factors, such as clay mineralogy, soil sodium concentration, soil salinity and irrigation water (rainwater) chemistry, which may enhance or limit that potential for soil to be sodic or become sodic over time. Therefore, values of 6% ESP and 14% ESP to represent soils as being sodic or strongly sodic are used as a general guide only and should not be taken as definitive. Sodicity assessments only apply to materials likely to report to final landform surfaces, such as overburden/interburden (i.e. not rejects, tailings or waste coal).

Table 3-8. Sodicity classification

Sodicity classification	ESP (%)
Non-sodic	≤ 6
Sodic	6 - 14
Strongly sodic	> 14

Sodicity information is broadly used to understand potential revegetation and dispersion aspects, and is supported by Emerson aggregate test information, which provides a direct measure of soil slaking and dispersion based on the Standards Australia (2017) classification. Soils are divided into classes on the basis of their coherence in water and presence (or absence) of calcium-rich minerals (Table 3-9). Slaking occurs when dry soil crumbs, after being immersed in deionised water, break up and run along the bottom of the beaker into a flat pile. Most dry soil crumbs slake when immersed in deionised water. Dispersion describes the tendency for the clay fraction of a soil to go into colloidal suspension in deionised water. Materials are generally regarded as being dispersive (or prone to dispersion) if they have an Emerson aggregate class number of three or less.

Table 3-9. Emerson classification

Class	Description	Class	Description
1	Slaking and complete dispersion	5	No calcite or gypsum present; dispersion
2	Slaking and some dispersion	6	No calcite or gypsum present; flocculation
3	Dispersion (remoulded)	7	Non-slaking and swelling
4	Calcite or gypsum present; no dispersion	8	Non-slaking and non-swelling

Using Coal Quality Data for Acid and Metalliferous Drainage Classification

Coal quality data has been used to aid with the assessment of AMD hazard associated with coal seams. In particular, the BWM coal quality database was used to supplement the geochemical database and provide additional understanding of the AMD potential of likely ROM coal, remnant coal, waste coal and rejects. Coal plys were grouped into their respective seam groups on a per-pit basis, such as T, MR, P & L Upper, P & L Lower for each pit group.

Total S concentration can be used conservatively to assess the AMD hazard for any given sample; thus, statistical analyses were conducted on total S as a function of seam group and for all seams combined to define the AMD hazard of coal. The data was used to understand the S grade range for each seam group to gain an understanding of the potential AMD hazard posed by each coal seam group. The results were then compared with detailed geochemical data available for coal to 'calibrate' the coal quality total S data.

Acid producing sulfate minerals, such as jarosite, may be present within weathered coal and carbonaceous material, however, mineralogical data available from BWM shows that jarosite is an insignificant mineral at BWM.

4 Results

The geochemical results are discussed herein, and are graphically presented by way of comparison between the different mineral waste types.

4.1 Mineralogy

Data is available for 44 samples that underwent mineralogical analysis by QXRD. The samples comprised 21 spoil samples from exploration drill-holes, 22 tailings samples (fresh and aged) and one aged rejects sample. The samples were selected to cover a broad range of mineral waste types. The results are summarised in Figure 4-1 for spoil samples and Figure 4-2 for tailings and rejects samples.

Across the material types tested, the key acid generating mineral is pyrite (+/- marcasite), and the key acid neutralising minerals are iron-dolomite (ankerite-dolomite), calcite and lesser rhodochrosite (a manganese carbonate mineral). All samples have appreciable concentration of siderite (an iron carbonate mineral), however, siderite provides no net acid neutralising capacity. In particular:

- Spoil samples are dominated by clay and quartz minerals (silicate group minerals) with variable contributions of non-crystalline (amorphous) material, carbonate and other silicate minerals. Amorphous (non-crystalline) material was detected in most spoil samples, and was generally present in greater proportions in the carbonaceous samples (median 18%) compared to the non-carbonaceous spoil (median 6%). The nature of the non-crystalline material is largely unknown, although for carbonaceous spoil it's likely associated with C-org.
- Tailings and rejects samples are dominated by clay and quartz minerals (silicate group minerals) and non-crystalline (amorphous) material, with variable contributions of carbonate and other silicate minerals. Generally, the fresh tailings samples had a greater proportion of amorphous (non-crystalline) material (median 40%) compared to the aged tailings (median 15%). The nature of the non-crystalline material in tailings and rejects is likely associated with C-org.
- Spoil samples have low sulfide mineral proportions (median 0.3%). Comparatively, tailings samples have higher sulfide mineral proportions (median 1.1%), of which the aged tailings had generally higher sulfide proportions compared to fresh tailings. Sulfide minerals, where present, are represented by pyrite, which was detected in all samples, and marcasite, which was detected in approximately 38% of spoil samples and 83% of tailings and rejects samples.
- Spoil samples (all fresh) have very low sulfate mineral concentrations (median 0.2%, and present in 14 samples), with sulfate present as jarosite. Aged tailings samples have higher sulfate mineral concentrations (median 1.0%), with sulfate preset in all of the aged tailings and rejects samples. The main sulfate minerals observed in aged tailings (and the aged rejects sample) are jarosite, bassanite, gypsum and/or barite – the presence of these minerals (especially jarosite) suggests that sulfide oxidation has occurred. Fresh tailings have no sulfate present.
- Overall, carbonate group minerals predominantly comprise iron-dolomite, calcite and siderite in variable proportions, with lesser rhodochrosite. ABCC data suggested that iron-dolomite (i.e. ankerite), dolomite and siderite were the likely dominant carbonate minerals, which is broadly consistent with the mineralogy data.

- In non-carbonaceous spoil iron-dolomite, calcite and siderite are the main carbonate minerals. In carbonaceous spoil, iron-dolomite and siderite are present in similar proportions to non-carbonaceous spoil, however calcite concentrations are much lower.
- Carbonate concentrations were generally similar between fresh NCPP tailings samples compared to aged NCPP TSF samples, although the aged samples had a much greater range of carbonate proportions compared to fresh tailings – the highest being two aged tailings samples from NCPP TSF containing 24% and 29% carbonate, present mostly as siderite in both samples.

Figure 4-1. Mineral distribution within spoil samples

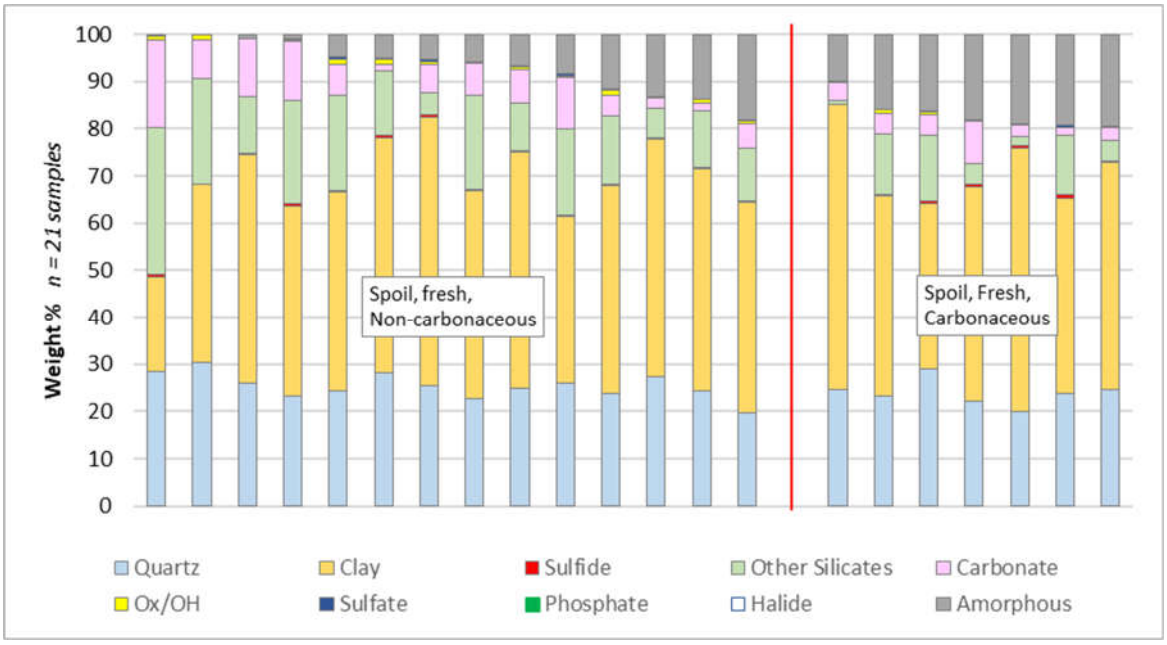
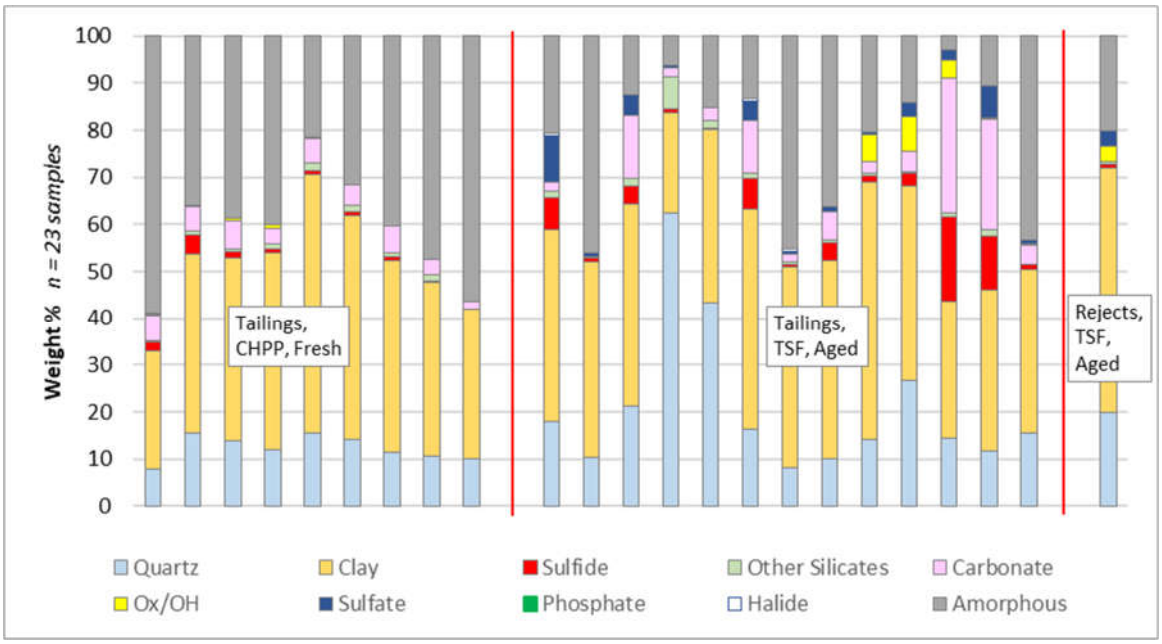


Figure 4-2. Mineral distribution within tailings and rejects samples



4.2 Acid-Base Accounting (Potential for Acid Generation)

ABA is a theoretical balance between the potential for a sample to generate acid and neutralise acid, and is expressed in units of kilograms of sulfuric acid per tonne of sample (kg H_2SO_4/t). The ABA results are statistically summarised in **Table 4-1** (spoil), **Table 4-2** (tailings and rejects) and **Table 4-3** (coal) and discussed. As explained in **Section 3.3**, not all samples were subjected to all tests.

Table 4-1. Acid-base accounting results statistics for spoil samples

		Total S[1]	Scr[2]	ANC	MPA	NAPP	ANC/MPA	NAGpH[3]
		%	%	kg H2SO4/t			ratio	pH units
Spoil Weath. Non-carbonaceous	Count (n)	176	97 (97)	176	176	176	176	1
	Maximum	0.35	0.03 (0.35)	408	11	-0.8	2266	-
	95th percentile	0.04	0.02 (0.04)	124	1.2	-8.0	538	-
	75th percentile	0.02	0.01 (0.02)	49	0.6	-16	196	-
	Median	0.01	0.01 (0.01)	25	0.3	-24	85	10.0
	25th percentile	<0.01	0.01 (<0.01)	16	<0.3	-49	39	-
	5th percentile	<0.01	<0.01 (<0.01)	8.2	<0.3	-123	17	-
	Minimum	<0.01	<0.01 (<0.01)	4.7	<0.3	-407	1.1	-
Spoil Non-carbonaceous	Count (n)	1924	602 (602)	1924	1924	1924	1924	39
	Maximum	1.84	1.67 (1.84)	842	56	44	3546	11.2
	95th percentile	0.09	0.11 (0.16)	214	2.8	-15	368	10.6
	75th percentile	0.04	0.03 (0.05)	80	1.2	-26	110	10.1
	Median	0.03	0.03 (0.03)	48	0.9	-47	56	8.4
	25th percentile	0.02	0.02 (0.02)	27	0.6	-79	30	7.3
	5th percentile	0.01	0.02 (0.01)	16	0.3	-213	10	2.7
	Minimum	<0.01	<0.01 (<0.01)	4.7	<0.3	-842	0.2	2.6
Spoil Carbonaceous	Count (n)	160	96 (96)	160	160	160	160	45
	Maximum	2.58	1.79 (2.58)	300	79	25	240	9.2
	95th percentile	0.52	0.52 (0.69)	105	16	-0.4	85	8.5
	75th percentile	0.21	0.19 (0.31)	43	6.4	-9.9	20.0	7.5
	Median	0.1	0.08 (0.18)	21	3.1	-16	7.2	6.8
	25th percentile	0.04	0.03 (0.12)	15	1.2	-37	3.1	4.6
	5th percentile	0.02	0.02 (0.04)	7.8	0.6	-105	1.1	2.9
	Minimum	<0.01	0.01 (0.02)	<0.5	<0.3	-296	0.4	2.8
Spoil ALL	Count (n)	2260	795 (795)	2260	2260	2260	2260	85
	Maximum	2.58	1.79 (2.58)	842	79	44	3546	11.2
	95th percentile	0.13	0.16 (0.27)	205	4.0	-11	369	10.6
	75th percentile	0.04	0.04 (0.07)	76	1.2	-23	109	8.5
	Median	0.03	0.03 (0.03)	43	0.9	-42	55	7.4
	25th percentile	0.02	0.02 (0.02)	24	0.6	-74	28	4.9
	5th percentile	<0.01	0.01 (<0.01)	13	<0.3	-204	6.3	2.9
	Minimum	<0.01	<0.01 (<0.01)	<0.5	<0.3	-842	0.2	2.6

1. Total S values less than laboratory limit of reporting (LOR) were assigned a value of 0.5xLOR for statistical calculations.
2. Values in parentheses are the total S statistics for samples with Scr results.
3. NAGpH is final pH as NAG single addition and/or NAG extended and/or Stage 1 sequential NAG.

Table 4-2. Acid-base accounting results statistics for tailings and rejects samples

		Total S[1]	Scr[2]	ANC	MPA	NAPP	ANC/MPA	NAGpH[3]
		%	%	kg H2SO4/t			ratio	pH units
Tailings NCPP Fresh	Count (n)	304	302 (302)	302	304	302	302	286
	Maximum	20.5	16.3 (20.5)	129	628	583	6.6	9.8
	95th percentile	6.05	5.41 (6.08)	65	185	113	3.2	9.0
	75th percentile	1.16	0.88 (1.17)	40	36	6.8	1.9	8.3
	Median	0.76	0.53 (0.76)	32	23	-5.4	1.2	6.4
	25th percentile	0.54	0.32 (0.54)	24	17	-16	0.8	3.4
	5th percentile	0.35	0.17 (0.35)	16	11	-29	0.3	2.5
	Minimum	0.20	0.08 (0.20)	<0.5	6.1	-54	<0.1	1.8
Tailings TSF Aged	Count (n)	166	124 (124)	166	166	166	166	64
	Maximum	8.68	7.29 (8.68)	236	266	222	88	9.6
	95th percentile	4.12	3.07 (5.26)	50	126	72	2.5	7.9
	75th percentile	0.78	0.54 (0.85)	25	24	8.0	1.3	4.0
	Median	0.57	0.30 (0.58)	17	17	1.9	0.9	3.2
	25th percentile	0.44	0.21 (0.44)	13	14	-4.2	0.7	2.9
	5th percentile	0.24	0.09 (0.26)	7.3	7.4	-16	0.3	2.3
	Minimum	0.02	0.03 (0.03)	<0.5	0.6	-208	<0.1	2.1
Rejects NCPP Fresh	Count (n)	48	48 (48)	48	48	48	48	48
	Maximum	0.78	0.63 (0.78)	86	24	-1.3	17	9.4
	95th percentile	0.57	0.47 (0.57)	77	17	-7.8	8.6	9.3
	75th percentile	0.42	0.34 (0.42)	47	13	-24	5.7	8.8
	Median	0.28	0.20 (0.28)	40	8.6	-29	4.4	8.6
	25th percentile	0.21	0.14 (0.21)	34	6.4	-37	2.8	8.4
	5th percentile	0.17	0.10 (0.17)	20	5.2	-64	2.0	7.9
	Minimum	0.14	0.05 (0.14)	13	4.3	-81	1.1	6.3
Rejects TSF Aged	Count (n)	45	4 (4)	45	45	45	45	3
	Maximum	1.19	0.44 (0.76)	72	36	5.8	8.9	8.3
	95th percentile	0.84	0.38 (0.71)	48	26	4.1	4.8	8.2
	75th percentile	0.56	0.15 (0.51)	33	17	-3.9	2.4	8.0
	Median	0.46	0.04 (0.29)	21	14	-9.9	1.8	7.6
	25th percentile	0.35	0.03 (0.14)	18	11	-16	1.2	7.1
	5th percentile	0.13	0.02 (0.12)	9.3	3.9	-37	0.7	6.6
	Minimum	0.04	0.02 (0.12)	<0.5	1.2	-55	<0.1	6.5
Rejects Dump Aged	Count (n)	144	144 (144)	144	144	144	144	144
	Maximum	3.45	3.06 (3.45)	104	106	88	11	9.2
	95th percentile	1.68	1.37 (1.68)	66	51	17	3.1	8.8
	75th percentile	0.93	0.67 (0.93)	42	29	-1.8	2.0	8.0
	Median	0.68	0.44 (0.68)	29	21	-7.8	1.4	6.8
	25th percentile	0.47	0.18 (0.47)	21	14	-17	1.1	4.1
	5th percentile	0.26	0.05 (0.26)	10	8.0	-38	0.6	2.9
	Minimum	0.09	0.02 (0.09)	6.8	2.8	-90	0.2	2.3

1. Total S values less than laboratory limit of reporting (LOR) were assigned a value of 0.5xLOR for statistical calculations.
2. Values in parentheses are the total S statistics for samples with Scr results.
3. NAGpH is final pH as NAG single addition and/or NAG extended and/or Stage 1 sequential NAG.

Table 4-3. Acid-base accounting results statistics for coal samples

		Total S[1]	Scr[2]	ANC	MPA	NAPP	ANC/MPA	NAGpH[3]
		%	%	kg H2SO4/t			ratio	pH units
Coal	Count (n)	214	202 (202)	214	214	214	214	112
	Maximum	1.1	0.78 (1.11)	282	34	17	29	11.1
	95th percentile	0.6	0.31 (0.61)	108	18	6.1	12	8.6
	75th percentile	0.32	0.07 (0.33)	24	9.8	-0.4	3.1	6.5
	Median	0.22	0.02 (0.22)	12	6.7	-4.9	1.7	4.3
	25th percentile	0.17	0.02 (0.17)	7.5	5.2	-14	1.0	3.0
	5th percentile	0.12	<0.01 (0.12)	<0.5	3.7	-90	<0.1	2.5
	Minimum	0.06	<0.01 (0.06)	<0.5	1.8	-270	<0.1	2.2

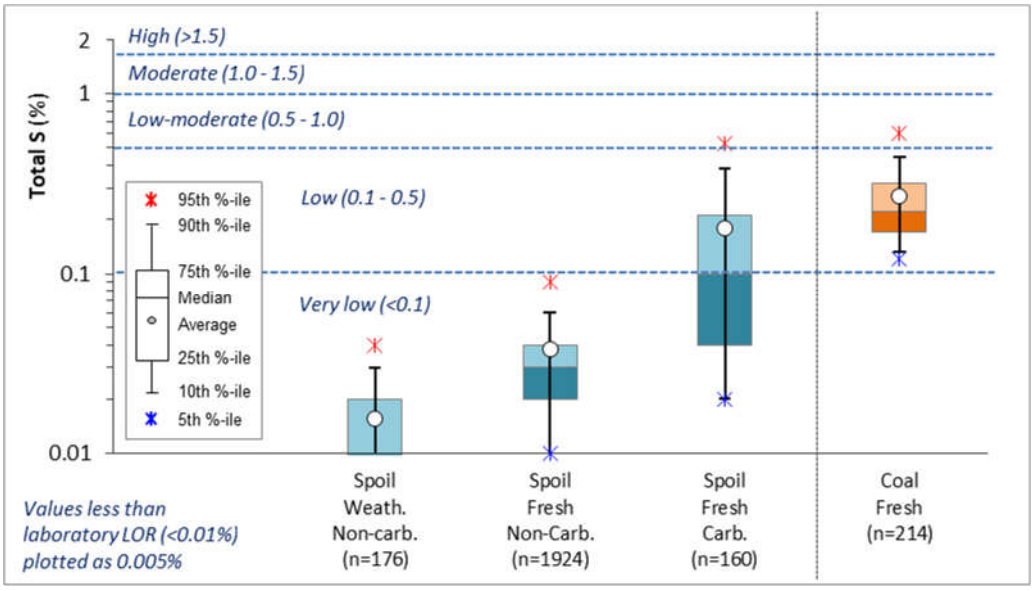
1. Total S values less than laboratory limit of reporting (LOR) were assigned a value of 0.5xLOR for statistical calculations.
2. Values in parentheses are the total S statistics for samples with Scr results.
3. NAGpH is final pH as NAG single addition and/or NAG extended and/or Stage 1 sequential NAG.

Sulfur and Sulfide

The total S distribution is presented in **Figure 4-3** (spoil and coal) and **Figure 4-4** (tailings and rejects). The total S concentration for spoil samples was generally very low to low. Spoil has a very low median total S of 0.03% and a low 95th percentile value of 0.13%. Carbonaceous spoil samples had higher total S values compared to non-carbonaceous spoil. Of the 2260 spoil samples, only five samples had moderate or high total S values (greater than 1%) and were all closely associated with seams (i.e. parting or thicker interburden between plys).

Coal samples from drill core had generally low total S values, with median and 75th percentile values of 0.22% and 0.32%, respectively.

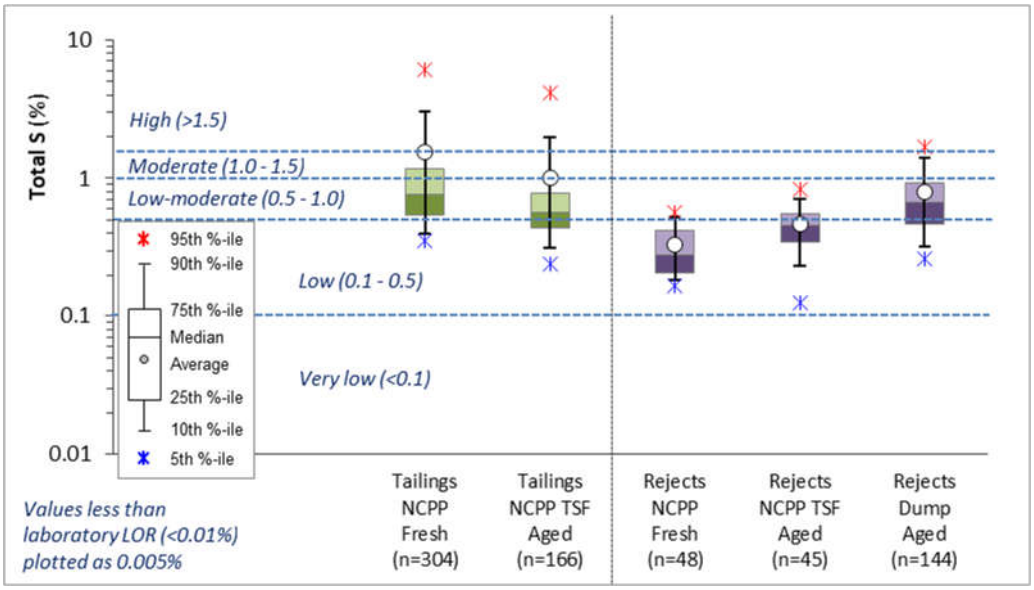
Figure 4-3. Distribution of total sulfur in spoil and coal



The total S concentration of most rejects and tailings samples was generally higher than most spoil samples and generally in the range of low to low-moderate. As evident in **Figure 4-4**, NCPP tailings had slightly higher, but similar total S concentration compared to tailings samples from the NCPP TSF.

Comparatively, the total S concentration of fresh NCPP rejects was lower than aged rejects from the NCPP TSF and lower again compared to aged rejects from Ramp 36 rejects dump.

Figure 4-4. Distribution of total sulfur in tailings and rejects



Scr data is available for 795 spoil samples, 426 tailings samples, 196 rejects samples and 202 coal samples (Table 4-1). The total S and Scr distribution for all samples is shown at Figure 4-5 (spoil and coal) and Figure 4-6 (tailings and rejects). Total S values are shown only for the same samples that underwent Scr tests.

Figure 4-5. Distribution of total sulfur and chromium reducible sulfur (sulfide) in spoil and coal

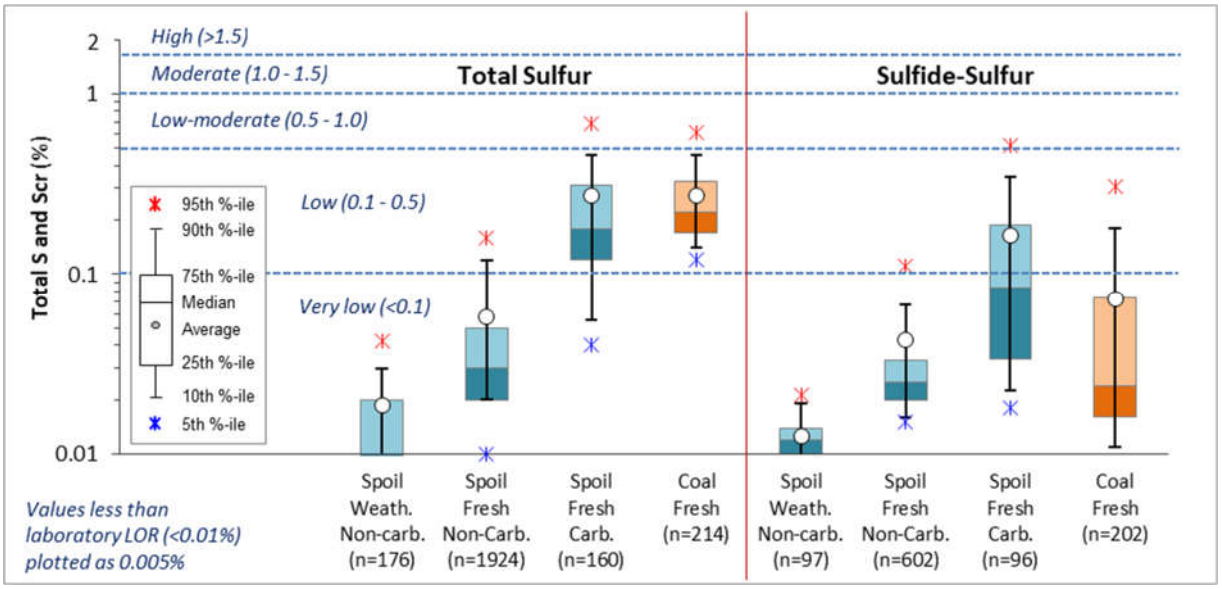
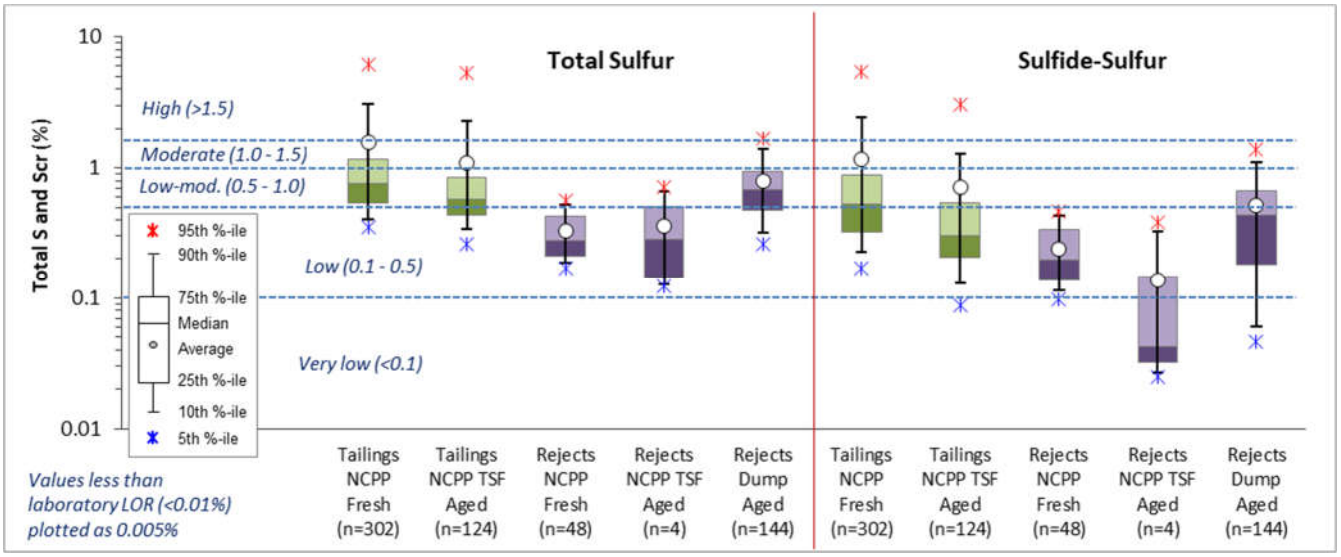


Figure 4-6. Distribution of total sulfur and chromium reducible sulfur (sulfide) in tailings and rejects



As a proportion of total S, Scr accounts for:

- Spoil samples: 83% (median value) of total S in all spoil, which ranges from 57% (median value) in fresh carbonaceous samples through to 85% (median value) in fresh non-carbonaceous samples and 100% in weathered samples. The lower proportion, generally, of Scr in carbonaceous spoil (compared to non-carbonaceous spoil) is likely due to a larger proportion of total S being present as organic S (S-org) in the carbonaceous samples.
- Tailings samples: Scr accounts for approximately 69% (median value) of total S in fresh NCPP tailings and 50% (median value) of total S in aged tailings – the slightly lower proportion of Scr in aged tailings (compared to fresh tailings) is likely due to some sulfide in aged tailings being oxidised to sulfate. No sulfate data is available for aged samples.
- Rejects samples: Based on median values, Scr accounts for approximately 74% of total S in fresh NCPP rejects and 61% of total S in aged rejects – of which almost all aged rejects samples are from the Ramp 36 rejects dump. Again, the slightly lower proportion of Scr in aged rejects (compared to fresh rejects) is likely due to some sulfide in aged rejects being oxidised to sulfate. No sulfate data is available for aged rejects samples.
- Coal samples: Scr accounts for approximately 13% (median value) of total S in coal samples. The very low proportion of Scr (compared to other fresh material types) is likely due to a significant proportion of total S being present as S-org in the coal samples.

These results indicate that the MPA that could be generated by most samples from these material domains is generally low and that using total S as an indication of AMD hazard will result in a conservative outcome.

Maximum Potential Acidity

The MPA is calculated from total S, therefore the MPA distribution for each material type mimics the total S distribution for the same samples (refer to **Figure 4-3**). Due to the generally very low to low total S (and Scr) values for spoil samples the MPA was correspondingly low, with 75th and 95th percentile MPA values of 1.2 and 4.0 kg H_2SO_4/t, respectively (n=2260 samples). As such, spoil represented by these samples is expected to have negligible potential to generate acid/acidity and negligible potential to release

sulfate-derived salinity from sulfide oxidation. The small proportion of spoil with 'high' MPA (as a result of the high total S) would be well mixed throughout the bulk spoil and, as such, would not lead to spoil generating acid/acidity or sulfate-derived salinity. Additionally, of the nine spoil samples with 'high' MPA (>20 kg H_2SO_4/t), all were closely associated with coal seams.

Coal samples (n=214) produced MPA values generally higher than spoil – as expected by the higher overall total S values of coal samples. Coal samples had 75th and 95th percentile MPA values of 9.8 and 18 kg H_2SO_4/t, respectively. As discussed above, the proportion of total S associated with sulfide minerals in coal samples is low (13% of total S as Scr), with most S associated with S-org. Therefore, MPA values calculated from total S for coal samples is very conservative. Comparatively, the 95th percentile MPA value for coal samples calculated from Scr (n=202) is 9.5 kg H_2SO_4/t – i.e. about half of the 95th percentile MPA value calculated from total S.

Tailings and rejects produced total S values generally ranging from low to low-moderate (with some moderate and higher values), which resulted in a correspondingly similar low to low-moderate range of MPA values. Tailings and rejects have 75th percentile MPA values ranging from 13 to 36 kg H_2SO_4/t, with fresh NCPP tailings having the highest MPA values corresponding to their higher total S values.

Acid Neutralising Capacity

The ANC distribution is presented in **Figure 4-7** (spoil and coal) and **Figure 4-8** (tailings and rejects) which shows that ANC values of spoil samples is generally moderate to very high and spans a very large range, from less than 0.5 to 842 kg H_2SO_4/t, with a high median ANC value of 43 kg H_2SO_4/t. Over 90% of spoil samples have an ANC greater than 17 kg H_2SO_4/t which, if all ANC was readily available, would neutralise the acidity generated by material containing 0.56% S. Less than 0.6% of spoil samples had total S values greater than 0.56%.

Coal samples had a wide range of ANC values from very low to very high, but the overall ANC was low, with 10th percentile and median ANC values of 2.0 and 12 kg H_2SO_4/t, respectively.

The ANC for tailings and rejects samples (combined) was generally moderate to high, with median ANC values ranging from 17 to 40 kg H_2SO_4/t and an overall (combined) median ANC of 29 kg H_2SO_4/t.

Figure 4-7. Distribution of acid neutralising capacity in spoil and coal

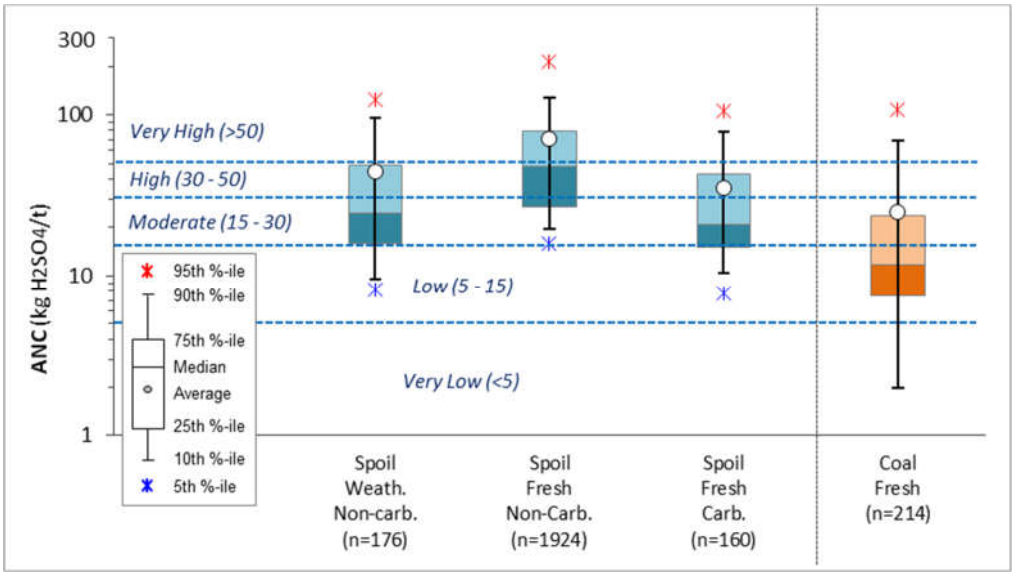
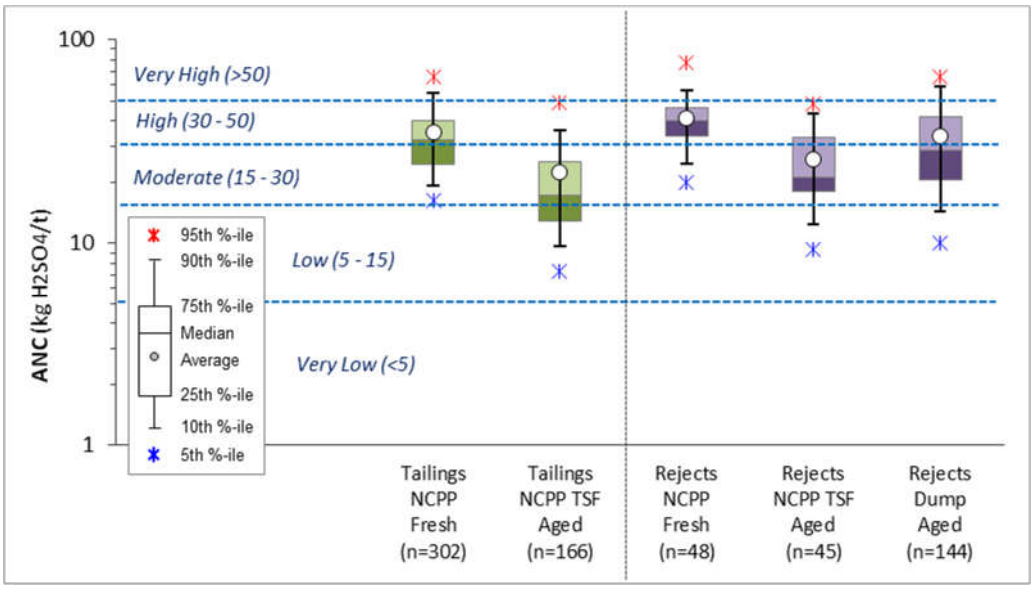


Figure 4-8. Distribution of acid neutralising capacity in tailings and rejects



Available Acid Neutralising Capacity

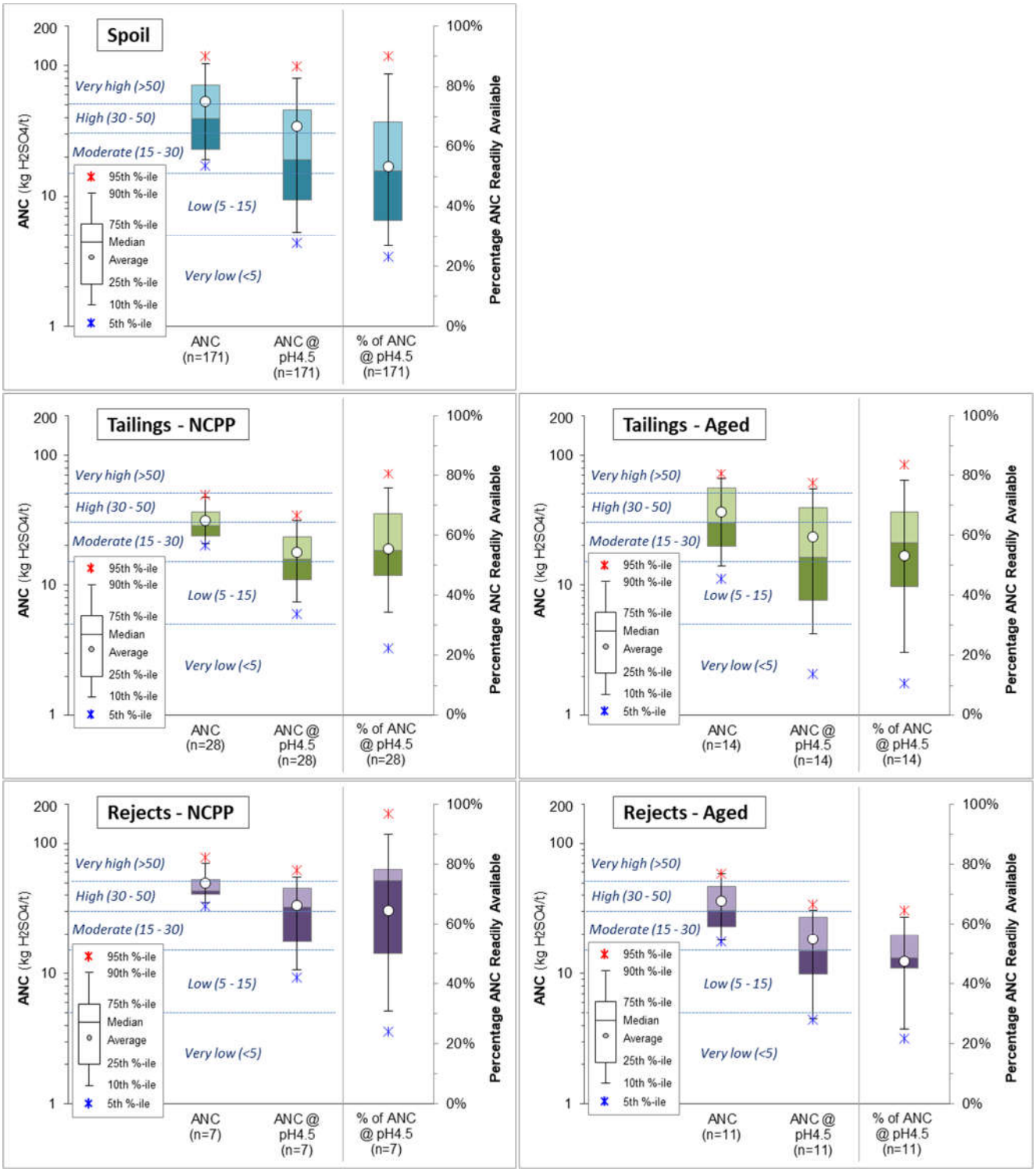
ABCC tests were undertaken on samples to assess the proportion of ANC that may be 'readily available' (i.e. short-acting) in these materials under field conditions. 'Readily availability' is regarded as the proportion of ANC that is available for buffering reactions at pH 4.5. The results are summarised as follows and in Figure 4-9.

- Spoil samples (n=171). The proportion of ANC likely available under field conditions ranged from eight to nominally 100% of the ANC, with a median of approximately 52%.
- Tailings, fresh (n=28). The proportion of ANC likely available under field conditions ranged from 18 to 84% of the ANC, with a median of approximately 55%;
- Tailings, aged (n=14). The proportion of ANC likely available under field conditions ranged from zero to 93% of the ANC, with a median of approximately 58%;
- Rejects, fresh (n=7). The proportion of ANC likely available under field conditions ranged from 17 to nominally 100% of the ANC, with a median of approximately 74%;
- Rejects, aged (n=11). Comprising 10 samples from Ramp 36 rejects dump and one sample from NCPP TSF embankment. The proportion of ANC likely available under field conditions ranged from 19 to 67% of the ANC, with a median of approximately 49%.

The shape of the ABCCs (the reaction rate curves) can also be used to infer potential carbonate mineralogy based on standard curves/data for different carbonate minerals at varying ANC values. For the spoil samples, iron dolomite appears to be the dominant carbonate mineral based on the ABCCs, with dolomite, calcite and siderite. Of the 171 spoil sample results, about 60 of the samples appear to have some presence of siderite, based on the ABCC data alone. Siderite is fairly common throughout the Permian sediments of the Bowen Basin, albeit in relatively small amounts. For the tailings and rejects samples, iron dolomite is also the dominant carbonate mineral based on the ABCCs, with minor siderite. Several samples appear to have trace amounts of dolomite.

Based on the above, and supported by the mineralogy data (**Section 4.1**), the carbonate mineral in bulk spoil, tailings and rejects is likely to be iron dolomite +/- siderite with varying influence from dolomite and calcite.

Figure 4-9. Distribution of acid neutralising capacity as total, acid neutralising capacity at pH 4.5 and proportion (%) of acid neutralising capacity expected to be readily available

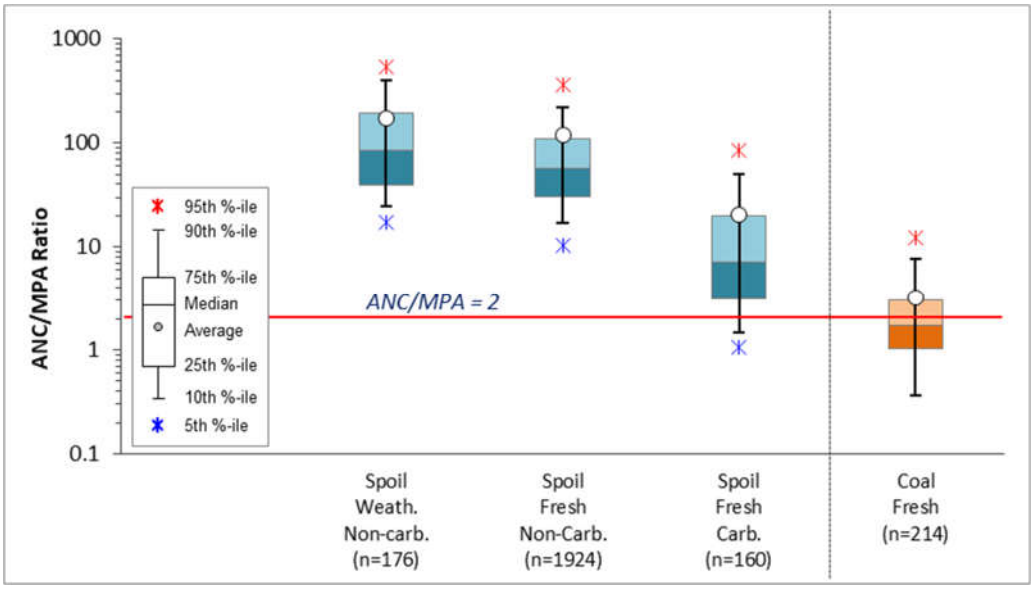


Acid Neutralising Capacity / Maximum Potential Acidity Ratio

Generally, those samples with an ANC/MPA ratio greater than two are considered to have a negligible/low risk of acid generation (DIIS, 2016; INAP, 2009[3]), especially where sulfide concentration is very low and reactive ANC is moderate to high. The results, illustrated in **Figure 4-10** (spoil and coal) and **Figure 4-11** (tailings and rejects) show that:

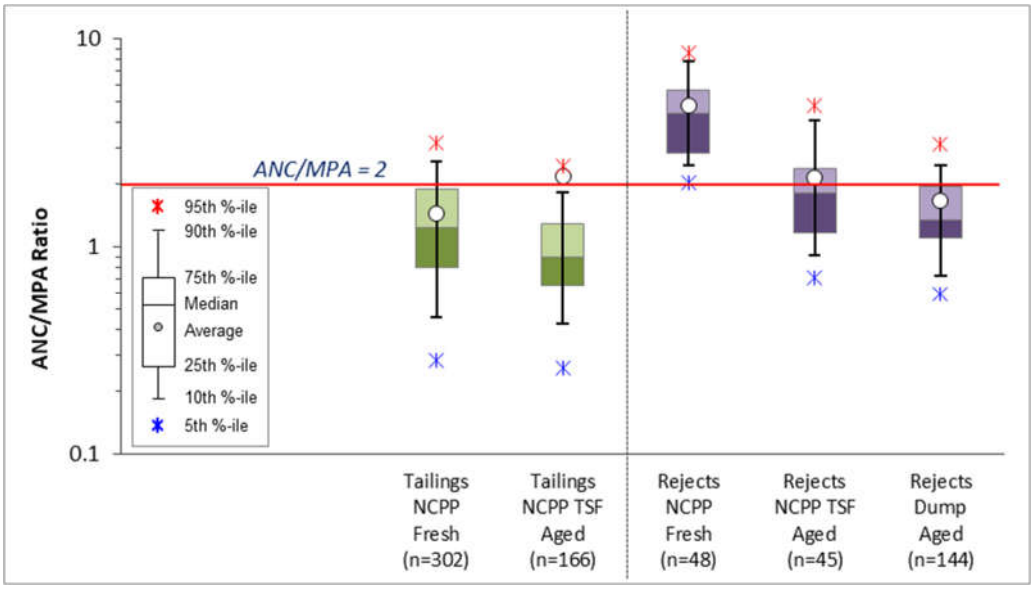
- Just under 99% of 2260 spoil samples have an ANC/MPA ratio greater than two – noting that 85% of all spoil samples are fresh, non-carbonaceous. Approximately 86% of fresh carbonaceous spoil samples (137 out of 160 samples) have an ANC/MPA ratio greater than two.
- Approximately 77% and 92% of fresh and aged tailings, respectively, had ANC/MPA ratios less than or equal to two. Similarly, 77% of aged dump rejects also had ANC/MPA ratios less than or equal to two. Approximately 64% of aged TSF rejects had ANC/MPA ratios less than or equal to two.
- In stark contrast to all other tailings and rejects samples, only 6% of 48 fresh NCPP rejects samples had ANC/MPA ratios less than or equal to two. Fresh NCPP rejects samples generally have higher ANC and lower total S (therefore lower MPA) compared to all other rejects and tailings types – resulting in an overall higher ANC/MPA ratio compared to other rejects and tailings.
- Approximately 45% of coal samples had ANC/MPA ratios greater than two.

Figure 4-10. Distribution of the ratio of acid neutralising capacity to maximum potential acidity in spoil and coal



3 INAP (2009) considers that mine materials with an ANC/MPA ratio greater than two are likely to be NAF unless significant preferential exposure of sulfide minerals occurs along fracture planes, in combination with insufficiently reactive ANC.

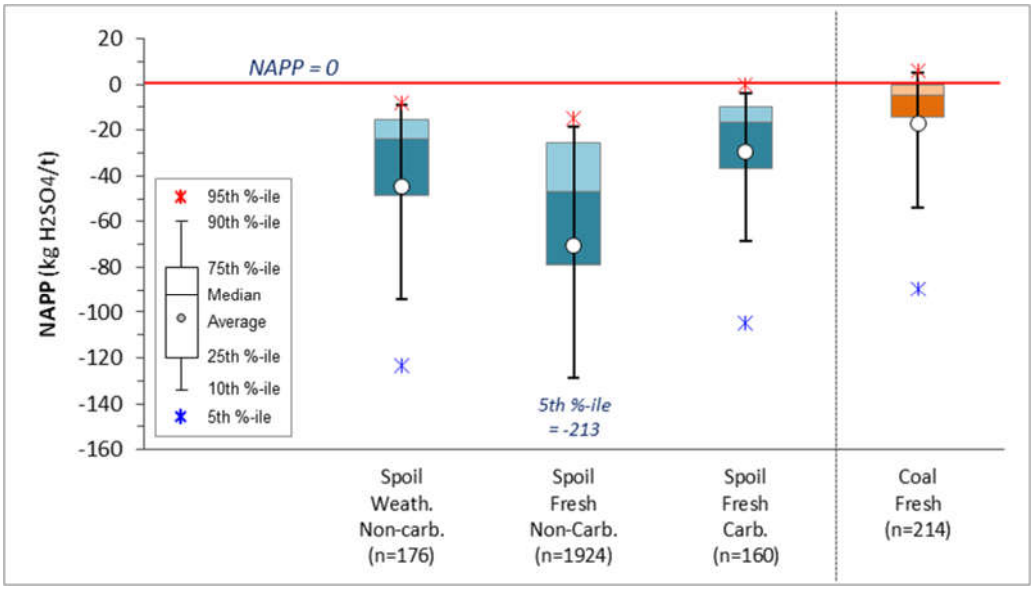
Figure 4-11. Distribution of the ratio of acid neutralising capacity to maximum potential acidity in tailings and rejects



Net Acid Producing Potential

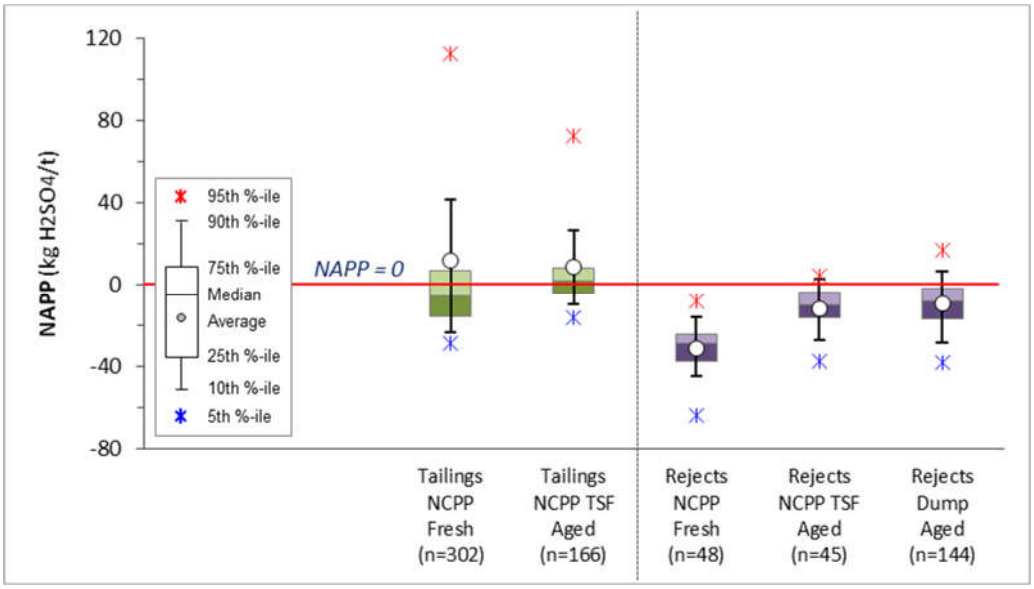
Based on the generally low MPA and higher ANC values (relative to the MPA), the calculated NAPP values are negative for over 99% of spoil samples (10 out of 2260 spoil samples had positive NAPP values, of which most were carbonaceous spoil samples). The results, shown in **Figure 4-12** (spoil and coal) indicate that overall, there is significantly excess neutralising capacity (ANC) compared to potential acidity (MPA) for spoil samples. The calculated NAPP values are low negative for about 77% of the coal samples; and about 23% of the coal samples had low positive NAPP values, with a maximum NAPP value of 17 kg H_2SO_4/t.

Figure 4-12. Distribution of net acid producing potential in spoil and coal



The results for tailings and rejects samples are presented in **Figure 4-13**. Tailings samples have a mix of low negative and low positive NAPP values, with about 56% of all tailings samples having negative NAPP values. Comparatively, about 83% of all rejects samples have negative NAPP values, including all 48 fresh NCPP rejects samples.

Figure 4-13. Distribution of net acid producing potential in tailings and rejects



Net Acid Generation Capacity

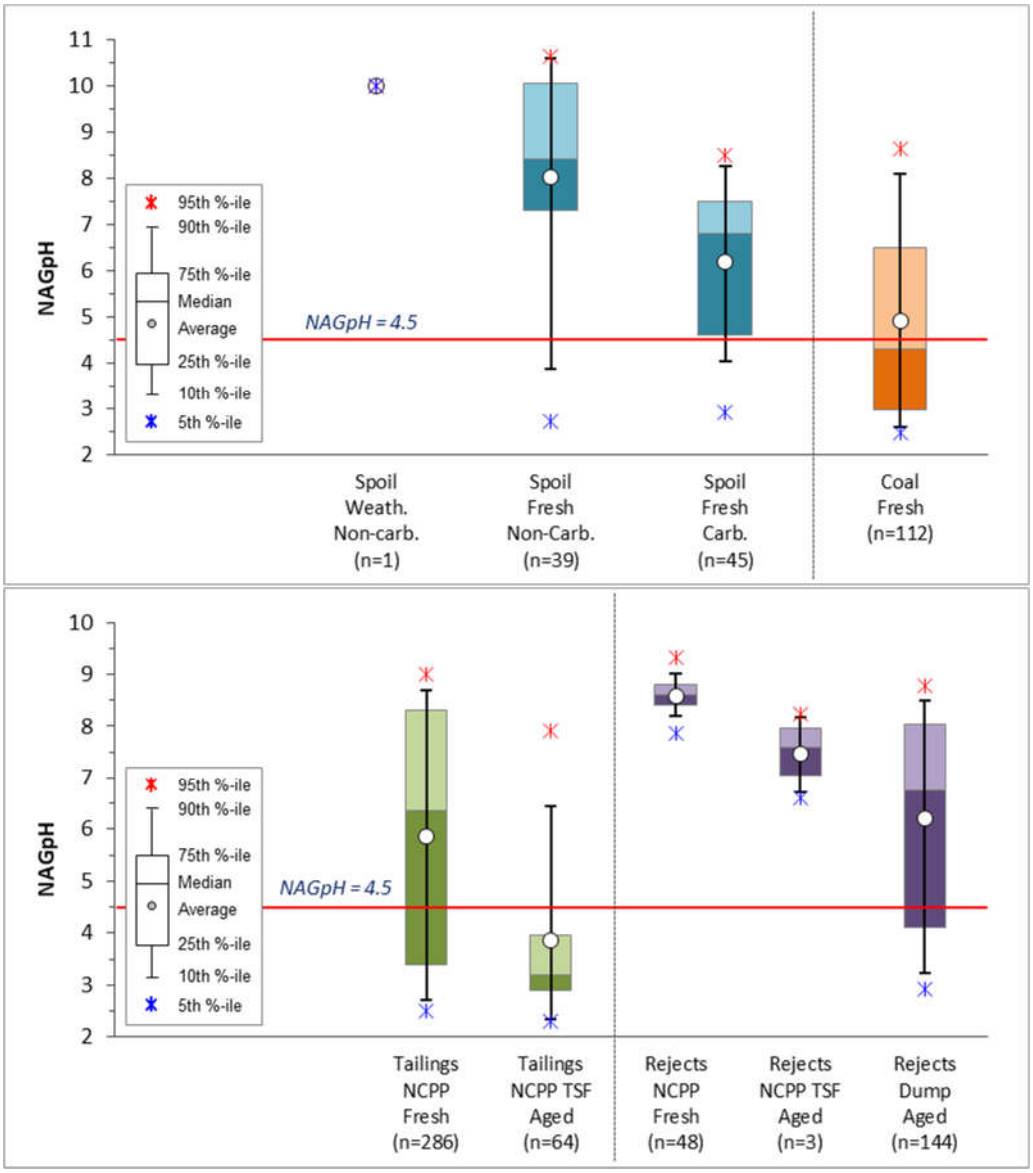
NAG test results are used in conjunction with NAPP values in determining the acid classification of samples. The calculated NAPP value assumes that all S (or sulfide) will oxidise to generate acid (MPA) and that all neutralising material in a sample is in a readily available form to neutralise any acid that could be generated (ANC). Unlike the theoretical basis of the NAPP test, in a NAG test a sample is encouraged to oxidise by reaction with hydrogen peroxide and any acid generated through oxidation may be consumed by neutralising components in the sample. Any remaining acidity is measured and expressed as kg H_2SO_4/t.

Samples with NAGpH values greater than pH 4.5 are considered to be NAF. Samples with NAGpH values less than or equal to pH 4.5 (i.e. acid-generating) would also be expected to have measurable NAG capacity (i.e. NAG capacity greater than 0.1 kg H_2SO_4/t). As a guide, NAG capacity values between 0.1 and 5 kg H_2SO_4/t are considered 'low capacity' (AMIRA, 2002).

NAG test data (a combination of single addition and extended boil NAG) is available for 85 spoil samples (all except one sample being fresh), 112 coal samples, 350 tailings samples and 195 rejects samples (**Table 4-1**) – with the NAGpH distribution for these samples shown in **Figure 4-14**.

It should be noted that NAG test data is predominantly available for carbonaceous and coal samples, much more so than non-carbonaceous samples. Therefore, the number and percentage of samples with a given NAGpH value (e.g. greater than or less than pH 4.5) is not a proportional representation of NAGpH statistics for each mineral waste and coal group.

Figure 4-14. Distribution of net acid generation pH



Fifteen (15) spoil samples (out of 85) had NAGpH values less than or equal to pH 4.5 and, of these 15 samples, 10 samples were located close to coal seams. For spoil samples, NAG tests were typically undertaken on samples with moderate or higher total S and on samples that had an 'uncertain' preliminary AMD classification. As such, the number of spoil samples that underwent NAG testing is not a proportional representation of all spoil. Only about 4% of all spoil samples underwent NAG testing.

Approximately 77% of all tailings and rejects samples (combined) have NAG test data available. Of those tailings and rejects samples that underwent NAG testing, about 58% of fresh NCPP tailings and about 22% of aged tailings tested had NAGpH values greater than pH 4.5. For the rejects samples, all of the fresh NCPP rejects samples and 73% of the aged rejects samples tested had NAGpH values greater than pH 4.5 (noting that all except three of the aged rejects samples were from the Ramp 36 rejects dump).

Of the 214 coal samples with geochemical data, 112 samples underwent NAG testing. Of these 112 samples, 47% had NAGpH values greater than pH 4.5.

The NAG test can be influenced by organic acid (i.e. organic acid can produce NAGpH between approximately pH 4 to 4.5, thus providing a 'false positive' for sulfuric acid). Organic acid is typically produced by samples with high C-org content, such as coal and highly carbonaceous samples. To attempt to resolve some of the uncertainty with the 'single addition' NAG test for coaly and carbonaceous samples, 139 samples underwent an Extended Boil NAG method (NAG extended). These samples included spoil (3 samples), tailings (26 samples), rejects (5 samples) and coal (105 samples).

Sixty-four (64) of these 139 samples (i.e. 46% of samples) returned Extended NAGpH values greater than pH4.5, suggesting that for just under half of the mostly coal and tailings samples tested the acidity generated in the 'single addition' NAG test was likely associated – to some extent – with the oxidation of C-org and potentially less so with sulfide oxidation.

Acid and Metalliferous Drainage Classification

The ABA results presented in this section have been used to classify the acid forming nature of the samples following the classification criteria outlined in **Section 3.4**. Additional relevant data, such as ABCC and Extended NAG test results were used to aid in the classification of samples where there was uncertainty following the preliminary AMD classification. The acid forming nature of these samples is summarised in **Figure 4-15** and **Table 4-4**.

Figure 4-15. Geochemical classification of samples

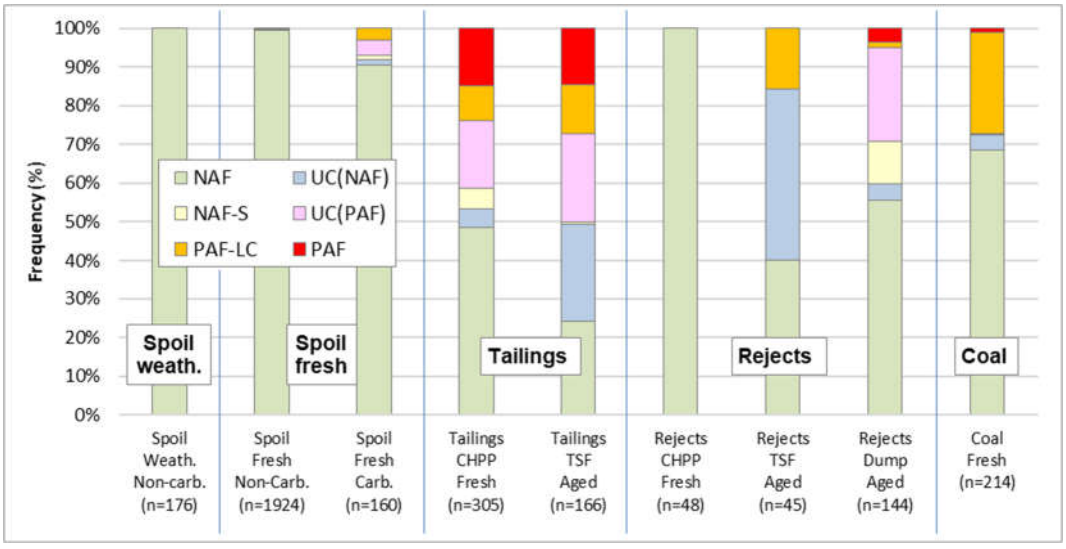


Table 4-4. Geochemical classification of samples

Material Type	NAF	UC(NAF)	NAF-S	UC(PAF)	PAF-LC	PAF
	No. and percentage of samples					
Spoil samples						
Spoil: weathered, non-carb. (n=176)	176 (all)	0	0	0	0	0
Spoil: non-carbonaceous (n=1924)	1916 (>99%)	1 (<0.1%)	0	4 (0.2%)	1 (<0.1%)	2 (0.1%)
Spoil: carbonaceous (n=160)	145 (91%)	2 (1.3%)	2 (1.3%)	6 (3.8%)	5 (3.1%)	0
All Spoil (n=2260)	*2237 (99%)*	*3 (~0.1%)*	*2 (~0.1%)*	*10 (~0.4%)*	*6 (~0.3%)*	*2 (~0.1%)*
	2240 (99 %)		***20 (1 %)***			
Coal samples						
Coal: fresh (n=214)	147 (69%)	8 (3.7%)	1 (0.5%)	0	56 (26%)	2 (0.9%)
	155 (72 %)		***59 (28 %)***			
Tailings samples						
Tailings: NCPP, fresh (n=305)	148 (49%)	15 (4.9%)	16 (5.2%)	53 (17%)	28 (9.2%)	45 (15%)
Tailings: TSF, aged (n=166)	40 (24%)	42 (25%)	1 (0.6%)	38 (23%)	21 (13%)	24 (14%)
All Tailings (n=471)	188 (40%)	57 (12%)	17 (3.6%)	91 (19%)	49 (10%)	69 (15%)
	245 (52 %)		***226 (48 %)***			
Rejects samples						
Rejects: NCPP, fresh (n=48)	48 (all)	0	0	0	0	0
Rejects: TSF, aged (n=45)	18 (40%)	20 (44%)	0	0	7 (16%)	0
Rejects: R34/36 dump, aged (n=144)	80 (56%)	6 (4.2%)	16 (11%)	35 (24%)	2 (1.4%)	5 (3.5%)
All Rejects (n=237)	146 (62%)	26 (11%)	16 (6.8%)	35 (15%)	9 (3.8%)	5 (2.1%)
	172 (73 %)		***65 (27 %)***			

Percentages are approximate (rounded).

Spoil

The classifications in **Table 4-4** show that approximately 99% of spoil samples were classified as NAF or were expected to be NAF and have been classified as UC(NAF). These spoil samples and spoil material represented by these samples have very low to low S concentration, significant excess ANC (relative to the MPA) and clearly have negligible capacity to generate AMD. Approximately 1% of spoil samples were classified as 'PAF' of some type, including two spoil samples classified as NAF-S.

Data show that potential spoil, as a bulk material, would be overwhelmingly NAF – and essentially all spoil away from seams (which is the overwhelming bulk of spoil) is expected to be NAF. Furthermore, the very low to low S concentration in spoil indicates that the sulfate concentration that could be generated in spoil from sulfide oxidation (in addition to any salinity unrelated to sulfide oxidation) would also be very low. New spoil generated from the Project is expected to have similar geochemical characteristics to existing spoil.

Spoil expected to be 'PAF' of some type is mostly carbonaceous and is mostly associated with seams, as seam roof, parting or floor, which may largely report to the NCPP as ROM coal and leave the NCPP as rejects. PAF spoil is also likely to be associated with thicker interburden zones between seam plys of the same seam group. That is, PAF spoil is rarely encountered well away from seams. In context, of the 20 'PAF' / NAF-S spoil samples, 15 samples (i.e. 75%) were located within 1 m above or below seams.

Coal

Approximately 72% of coal samples (155 out of 214) were classified as NAF or UC(NAF). Coal represented by these samples has low sulfur values, excess ANC (relative to the MPA) and clearly has negligible capacity to generate acidity or release significant sulfate from sulfide oxidation. New coal generated from the Project is expected to have similar geochemical characteristics to existing coal.

Coal samples had higher total S values and marginally lower ANC compared to spoil, which resulted in 26% of coal samples classified as PAF-LC, two samples classified as PAF and one sample classified as NAF-S. The proportion of PAF (of any kind) and NAF-S samples is comparable across all coal seam groups currently being mined at BWM. It is worth noting that most of the 'PAF' samples were classified as PAF-LC, suggesting that 'PAF' coal is unlikely to generate significant acid(ity). Furthermore, the Scr content of coal samples was generally very low, suggesting that the 'PAF' (of any type, including NAF-S) classification is conservative for most coal samples. On the other side of the acid-base account, it is recognised that ANC is likely an overestimate, however the AMD classification already takes this into account by requiring an ANC/MPA ratio greater than two for a sample to be assessed as NAF.

These results suggest that coal represented by these samples and stored on a ROM pad, located within pit walls and un-economic coal seam material reporting as spoil (mixed with non-coal spoil) would likely be bulk NAF. A small proportion of coal from all seam groups poses a greater, but relatively low AMD source hazard. As the same coal seams dip eastwards from the existing BWM into the Project, coal generated at the Project is expected to have similar geochemical characteristics to existing coal at BWM (from existing pits in the vicinity of the Project).

Tailings

Just under half (48%) of tailings samples across both fresh and aged types were classified as 'PAF' of some type, including 17 tailings samples classified as NAF-S. Of the 226 'PAF' / NAF-S tailings samples, 69 samples (i.e. approximately 31%) were classified as PAF specifically and 140 were classified as UC(PAF) or PAF-LC. From an acid generating perspective, a significant proportion of tailings located at NCPP TSF and Bonnie Doon TSF pose a potential AMD source hazard with respect to AD and/or NMD/SD; and overall, are expected to generate low to moderate acidity loads.

Since ROM coal generated at the Project is expected to be very similar to existing ROM coal at BWM (from existing pits in the vicinity of the Project), tailings generated from ROM coal at the Project are expected to have similar geochemical characteristics to existing tailings.

Rejects

The results show that all 48 fresh NCPP rejects samples and about 66% of aged rejects samples (124 of 189 samples) were classified as NAF or UC(NAF). The remaining 34% of aged rejects samples had some type of broader 'PAF' classification, including 16 samples classified as NAF-S. Therefore, from an acid generating perspective, about one-third of the aged rejects samples pose a potential AMD source hazard with respect to AD and/or NMD/SD. Since ROM coal generated at the Project is expected to be very

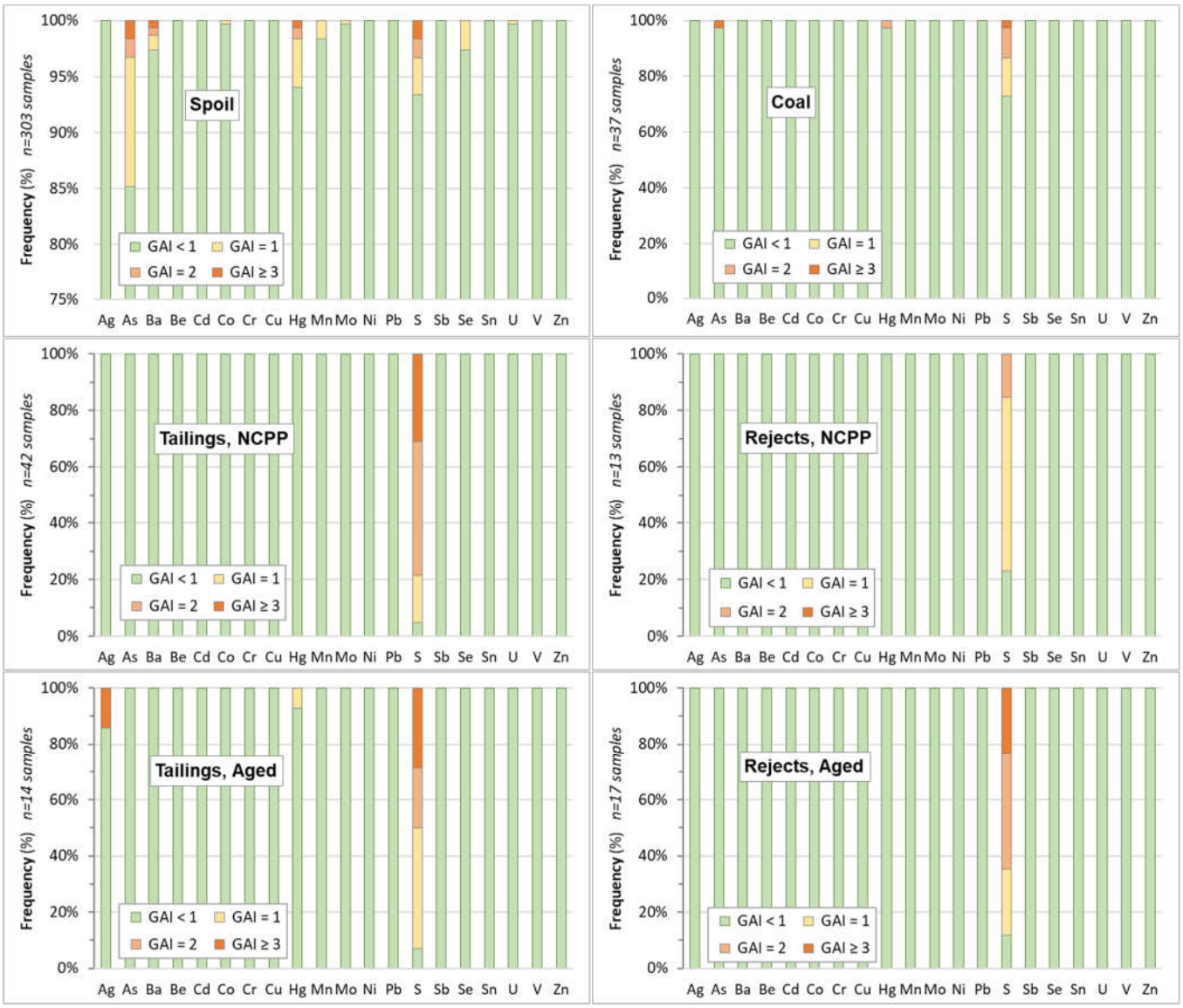
similar to existing ROM coal at BWM (from existing pits in the vicinity of the Project), rejects generated from ROM coal at the Project are expected to have similar geochemical characteristics to existing rejects.

4.3 Total Metals and Metalloids

Multi-element (metal and metalloid) data is available for 426 samples comprising 303 spoil samples, 37 coal samples, 56 tailings samples (42 fresh and 14 aged) and 30 rejects samples (13 fresh and 17 aged). The degree of enrichment with respect to elements potentially of environmental interest for the spoil, coal, tailings and rejects materials is shown in Figure 4-16.

Overall, the results suggest that bulk mineral waste materials have generally low levels of metal and metalloid enrichment. These results are consistent with Permian-age coal measures throughout eastern Australia. Excluding total S, a small proportion of samples (of all material types) have a moderate or higher degree of enrichment in some metals, such as silver (Ag), As, barium (Ba), Hg and/or Se, however, enrichment in these materials in a small number of samples is not cause for concern.

Figure 4-16. Frequency distribution of geochemical abundance indices of selected elements



The GAI values show that 13 (out of 303) spoil samples were significantly enriched [GAI ≥3] with regard to one or more of As, Ba, Hg and/or S. The level of S enrichment in these samples is consistent with the ABA data for these same samples. The enrichment in As, Ba and/or Hg in a small number of samples is not cause for concern. The GAI values also show that about 21% of spoil (~16% of non-carbonaceous spoil and ~54% of carbonaceous spoil) samples tested had minor or moderate enrichment (GAI = 1 or 2) with regard to As, Ba, Co, Hg, Mn, Mo, S, Se and/or U.

One coal sample was significantly enriched in As and S, and 10 coal samples had minor or moderate enrichment (GAI = 1 or 2) with regard to Hg and/or S.

About one-quarter of fresh NCPP tailings samples, about half of the aged tailings samples and four of the aged rejects samples were significantly enriched with S, including two aged tailings samples with significant enrichment in Ag. No fresh NCPP rejects showed significant enrichment in these same (or any) elements. The GAI values also show that most tailings and rejects samples tested, including most fresh NCPP rejects samples, had minor or moderate enrichment (GAI = 1 or 2) with regard to S.

4.4 Initial Solubility in Deionised Water

Water extract test results are available for a wide range of samples (**Table 4-5**). EC and pH results are available for 3178 and 3179 samples, respectively, and test results for major ions and soluble metals and metalloids are available for 431 samples.

Therefore, a large dataset is available to assess the potential for leaching of salt and environmentally important elements from mineral wastes (spoil, tailings and rejects) and coal at BWM – and the Project, given that the Project would produce mineral wastes comparable to those already produced at BWM. Water extract tests provide a preliminary indication of the elements that may be readily mobilised from any given material type.

Table 4-5. Samples subjected to deionised water solubility tests

Material type	pH and EC	Soluble metals and metalloids
	Number of samples	
Spoil	2260	303
Tailings	468 (pH) / 467 (EC)	59
Rejects	237	32
Coal	214	37

The samples underwent a 1:5 w:v (solid:water) deionised water bottle leach procedure on fine pulps. Note that the use of fine pulped materials in water extract tests enables a high level of reaction and dissolution. The results from these tests are summarised and discussed below.

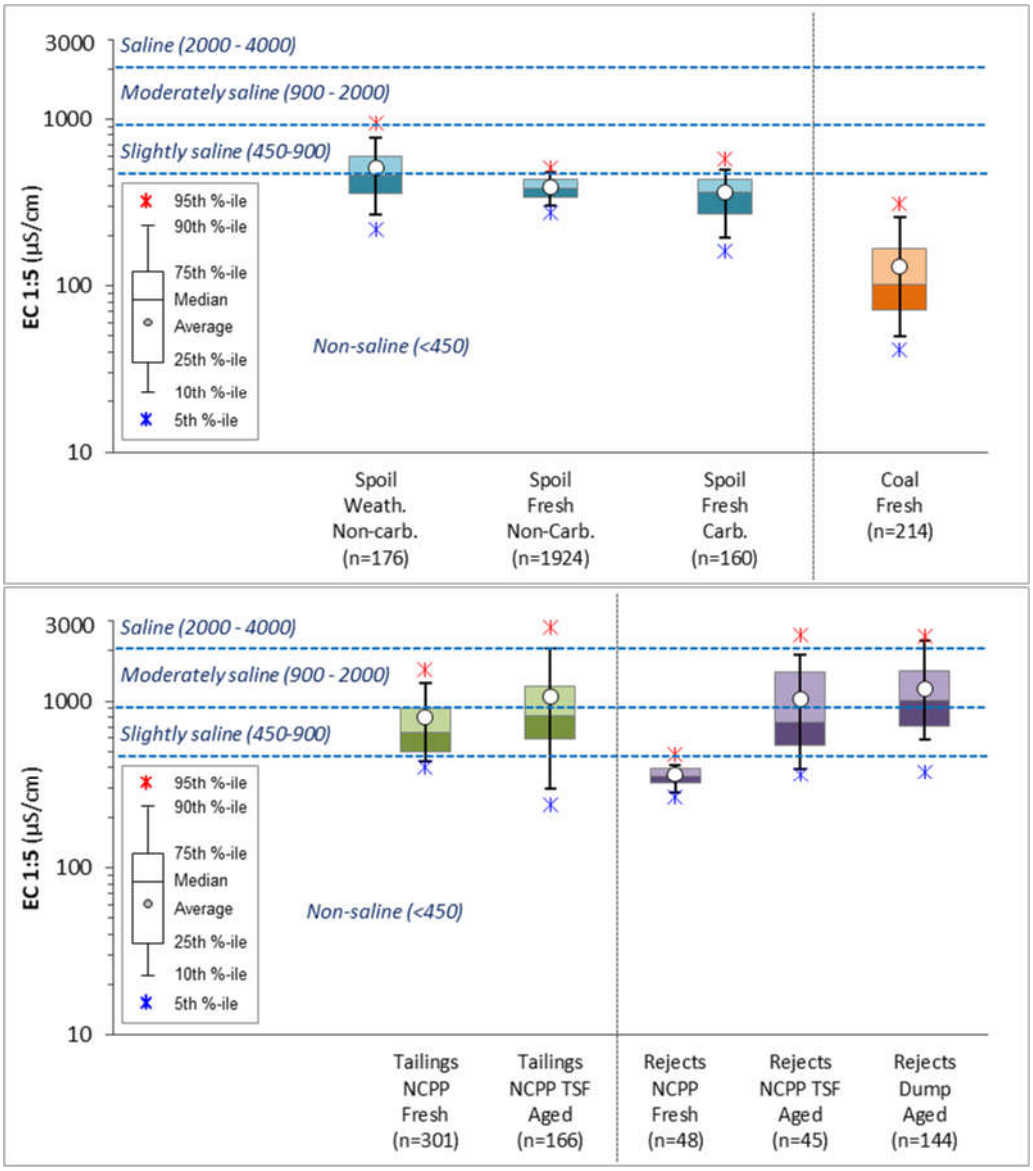
The test-work has found that spoil is generally pH-alkaline to highly alkaline and non-saline to slightly saline; and that tailings and rejects are generally pH-alkaline and slightly to moderately saline. All mineral wastes generally have low concentrations of soluble metals and metalloids – within the range typical for Permian sedimentary materials in the Bowen Basin. For many samples, the soluble metal and metalloid concentrations are below or marginally above the laboratory limit of reporting (LOR).

Electrical Conductivity and pH

$EC_{1:5}$ data is available for 3178 samples at 1:5 w:v on pulp (**Figure 4-17** and **Table 4-5**). The $EC_{1:5}$ of 2260 spoil samples spanned a large range from 69 to 1670 μS/cm, with low median and 75th percentile $EC_{1:5}$ values of 389 and 440 μS/cm, respectively. The results show that spoil, as a bulk material, is generally non-saline to slightly saline. These $EC_{1:5}$ results are common (if not typical) for Bowen Basin Permian-age and Tertiary-age material in the region.

Coal samples are generally non-saline. Fresh NCPP tailings samples and aged rejects samples are generally slightly to moderately saline, whereas fresh NCPP rejects samples have lower $EC_{1:5}$ values and are generally non-saline. Tailings samples have a 75th percentile $EC_{1:5}$ of 711 μS/cm. Rejects samples have a 75th percentile $EC_{1:5}$ of 761 μS/cm.

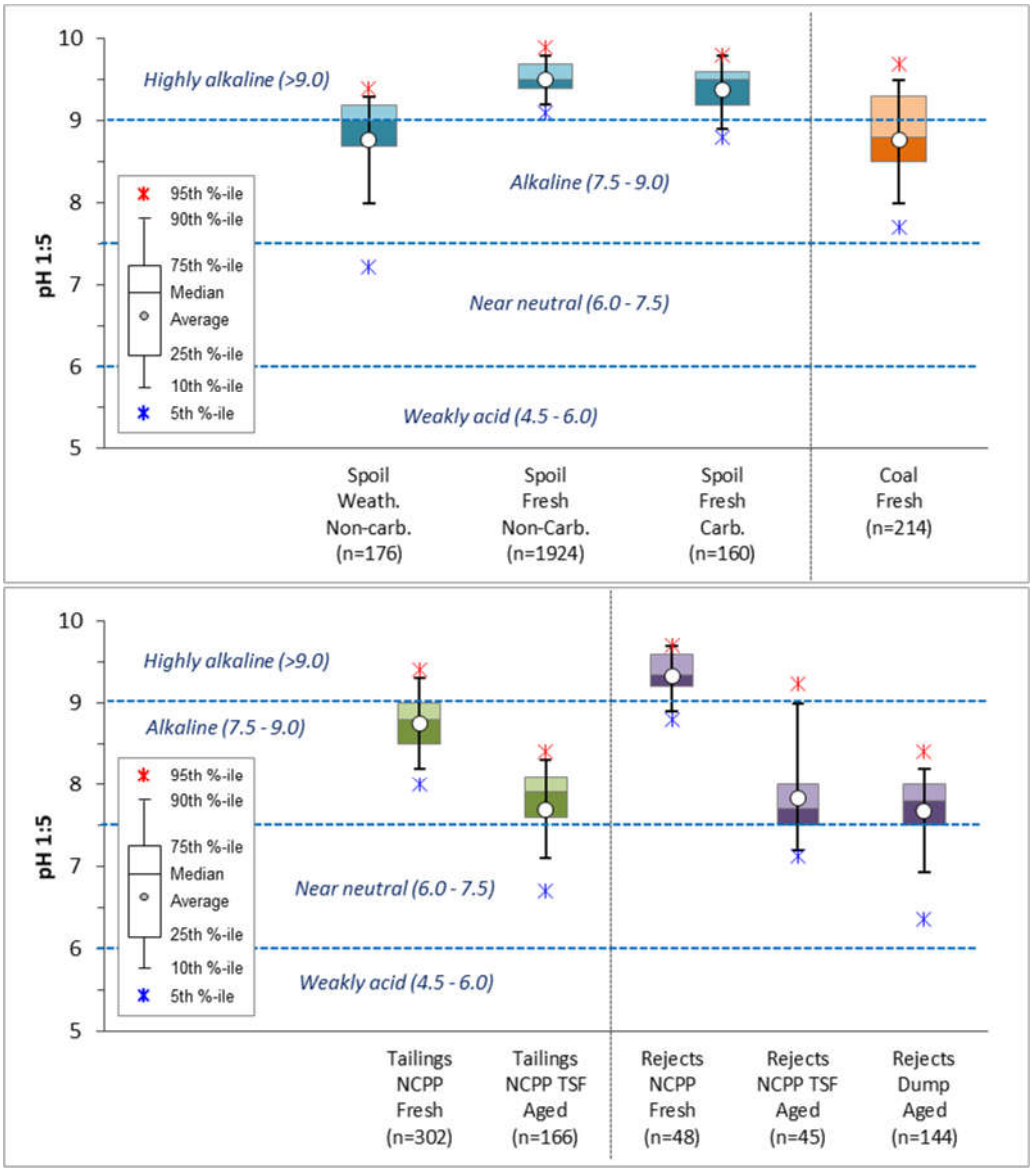
Figure 4-17. Electrical conductivity distribution



As shown in **Table 4-5** and presented in **Figure 4-18**, $pH_{1:5}$ data is available for 3,179 samples at 1:5 w:v on pulp. The pH distribution by material type shows most samples to be generally alkaline to highly alkaline. Some aged tailings and aged rejects samples were weakly to moderately acidic. These pH results are common (if not typical) for Bowen Basin Permian-age and Tertiary-age material in the region.

Of the 3,179 samples, 21 samples (less than 1% of samples) had $pH_{1:5}$ values less than or equal to pH 6.0; comprising three spoil samples, two coal samples, eight tailings samples and eight rejects samples. Of the 21 samples with $pH_{1:5}$ values less than or equal to pH 6.0, 15 were weakly acid with $pH_{1:5}$ values between 4.5 and 6.0; five samples (four tailings and one coal) were moderately acid with $pH_{1:5}$ values between 3.0 and 4.5 and the remaining sample (an aged tailings sample) was highly acidic with a $pH_{1:5}$ value of 2.3.

Figure 4-18. pH distribution

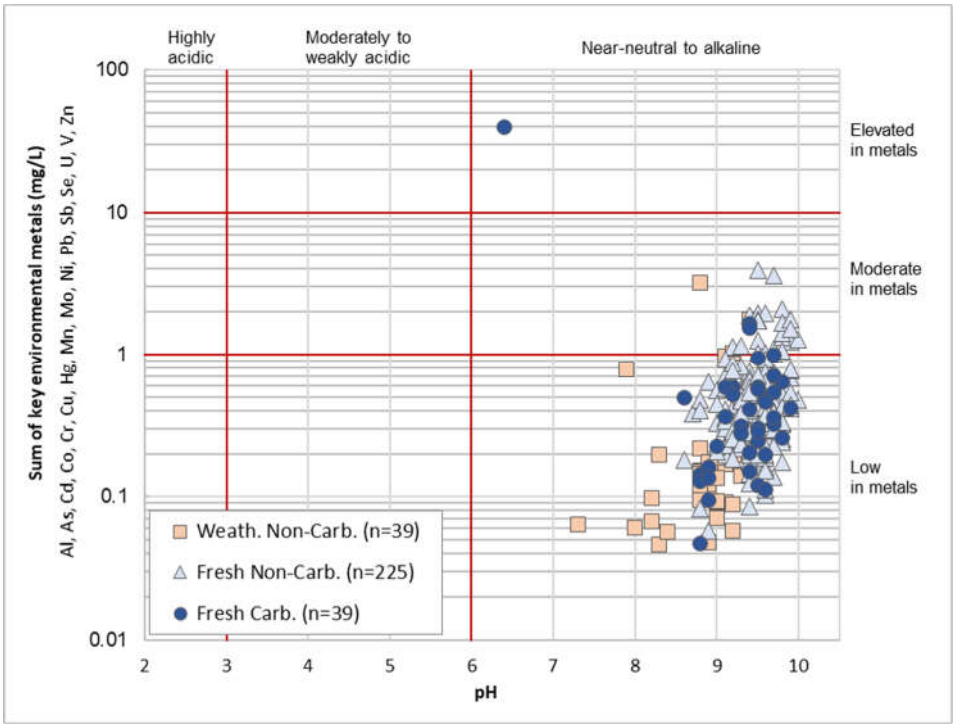


Soluble Metals and Metalloids

Deionised water extract (leaching) data for major ions and a broad suite of metals and metalloids are available for 431 samples (**Table 4-5**). All samples underwent a 1:5 w:v (solid:water) water extract procedure on pulps, and were analysed under ICP-MS method. The sum of 16 potentially environmentally important elements are plotted as a function of pH in **Figure 4-19** (spoil) and **Figure 4-20** (tailings, rejects and coal) in a modified version of what is referred to as a Ficklin plot (after Ficklin et al., 1992). The 16 selected metals and metalloids comprise: Al, As, Cd, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Sb, Se, U, V and Zn.

Of the 431 samples, 387 samples (90% of samples tested) have low soluble metal and metalloid concentrations and have near-neutral to alkaline pH – indicating that under freshwater leaching conditions soluble metal and metalloid concentrations are low for most mineral waste and coal materials.

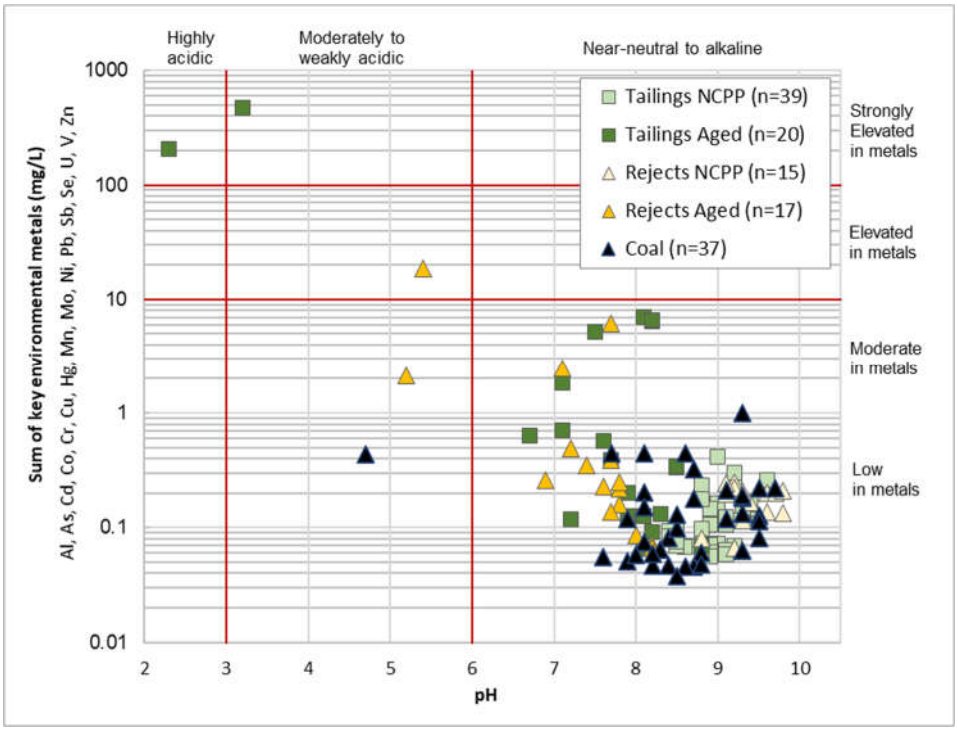
Figure 4-19. Sum of key environmental metals versus pH in deionised water extracts in spoil



One tailings sample and two rejects samples have moderate to very high soluble metal and metalloid concentrations associated with moderately to weakly acidic pH (pH 3.0 to 6.0); and all three samples were classified as PAF. One additional tailings sample, classified as PAF, was highly acidic (pH 2.3) and produced leachate with very high soluble metal and metalloid concentrations. One coal sample produced low soluble metal and metalloid concentrations at pH 4.7 (weakly acid) – and was classified as PAF-LC.

An additional 38 samples (30 spoil, five aged tailings, two aged rejects and one coal) had moderate soluble metal and metalloid concentrations associated with pH-neutral to alkaline conditions. One of the 30 spoil samples was classified as UC(PAF) and the remaining 29 spoil samples were classified as NAF. The tailings and rejects samples had a range of NAF and UC(PAF) classifications.

Figure 4-20. Sum of key environmental metals versus pH in deionised water extracts in tailings, rejects and coal



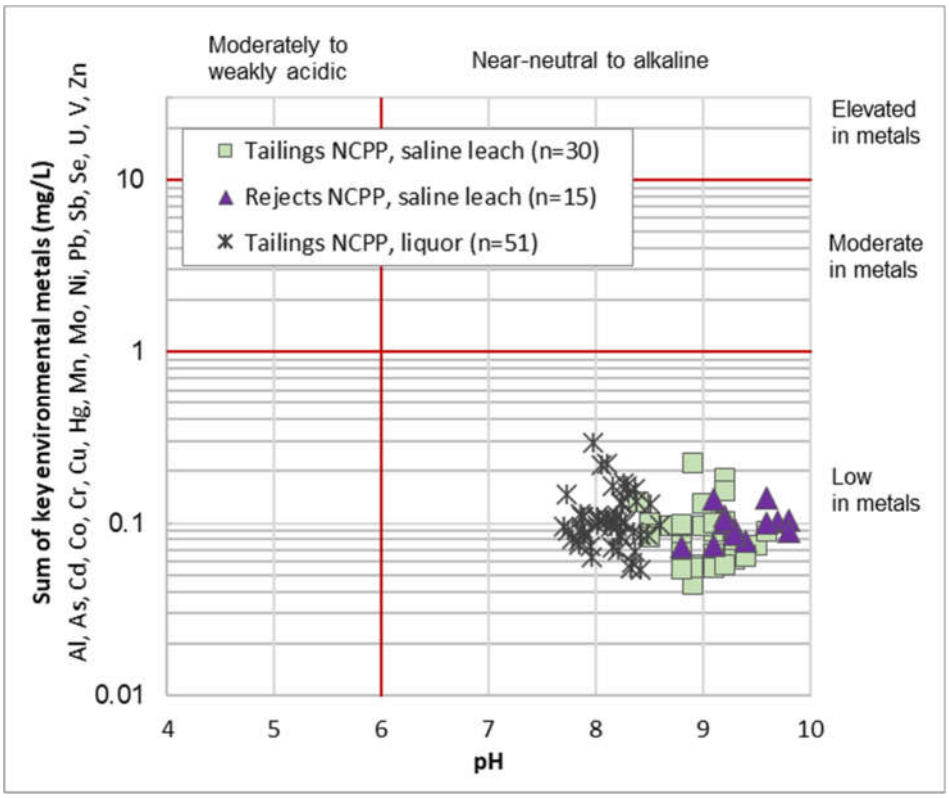
In pH-neutral to alkaline waters, many metals and metalloids cannot remain in solution and, thus, trace metal and metalloid concentrations are generally low. Comparatively, in acid(ic) waters, many metals and metalloids are moderately to highly soluble and will remain in solution and, thus, trace metal and metalloid concentrations in acid(ic) water are generally high. Notable exceptions to these general rules include elements such as As, Mn, Sb and Se, which remain soluble through a wide pH range. Other trace metals that are somewhat soluble under pH-neutral to alkaline conditions include Cd, Cr, Mo and Zn. As such, under the pH-alkaline conditions of the leachate, the mobility of these elements would not be inhibited.

4.5 'Saline' Water Solubility of Tailings and Rejects

Thirty (30) tailings and 15 rejects samples underwent a 1:5 w:v (solid:water) mildly saline (brackish) water extract procedure on pulps using a 2 g/L NaCl leaching solution. This leach was undertaken to determine the solubility of metals and metalloids under 'brackish' conditions – which better simulate the normal (brackish) water quality of the NCPP process water. Note that the salinity of NCPP process water varies from fresh to brackish on a day-to-day basis depending upon the source of the water from within the mine water management system. The sum of the concentration of 16 environmentally important elements are plotted as a function of pH from the saline leach solution for tailings and rejects in Figure 4-21 (along with the data for the tailings liquor solutions – see Section 4.6 below). The 16 selected metals and metalloids are the same elements as per the 1:5 deionised water leach. The calculated total dissolved solids (TDS) concentration of the saline leachate from the tailings and rejects samples ranged from approximately 1600 mg/L to 2480 mg/L, with a median calculated TDS value of 2295 mg/L for the tailings samples and 1961 mg/L for the rejects samples.

The results have shown that the solubility of tailings and rejects is low under 'brackish' leaching conditions.

Figure 4-21. Sum of key environmental metals versus pH in saline water extracts and tailings liquor



4.6 Characteristics of Tailings Liquor (Water)

Water quality data for tailings liquor is available for 51 tailings slurry samples collected from the NCPP (at the thickener underflow). The sum of the concentration of 16 environmentally important elements are plotted as a function of pH from the tailings liquor solution in **Figure 4-21** (along with the data for the saline leach solutions from **Section 4.5**). The 16 selected metals and metalloids are the same elements as per the 1:5 deionised water leach, saline water leach and peroxide leach.

All liquor samples have near neutral to alkaline pH and low soluble metal and metalloid concentrations. The liquor is highly saline, with EC values ranging from 2210 to 5410 μS/cm (median 4220 μS/cm) and a median calculated TDS concentration of 2820 mg/L. The dominant cation is Na and the dominant anions are Cl and SO_4 (equally dominant). Tailings liquor has generally moderate alkalinity, typically 290-425 mg/L as $CaCO_3$, and essentially all present as bicarbonate alkalinity.

4.7 Peroxide Leachate Solutions

Peroxide leachate (NAG leach) data is available for 50 samples, namely:

- 3 spoil samples (non-carbonaceous and carbonaceous; classified as UC[NAF] and UC[PAF]);
- 41 tailings samples of all classifications (NAF, UC[NAF], NAF-S, UC[PAF], PAF-LC and PAF); and
- 6 rejects samples of mixed classifications (UC[NAF], UC[PAF],PAF-LC and PAF).

Peroxide leachate is the solution resulting from a single addition (standard) NAG test after the sample has been oxidised with peroxide to encourage oxidation and associated neutralising reactions, if ANC is available. The test encourages complete and rapid oxidation and associated neutralisation, with the

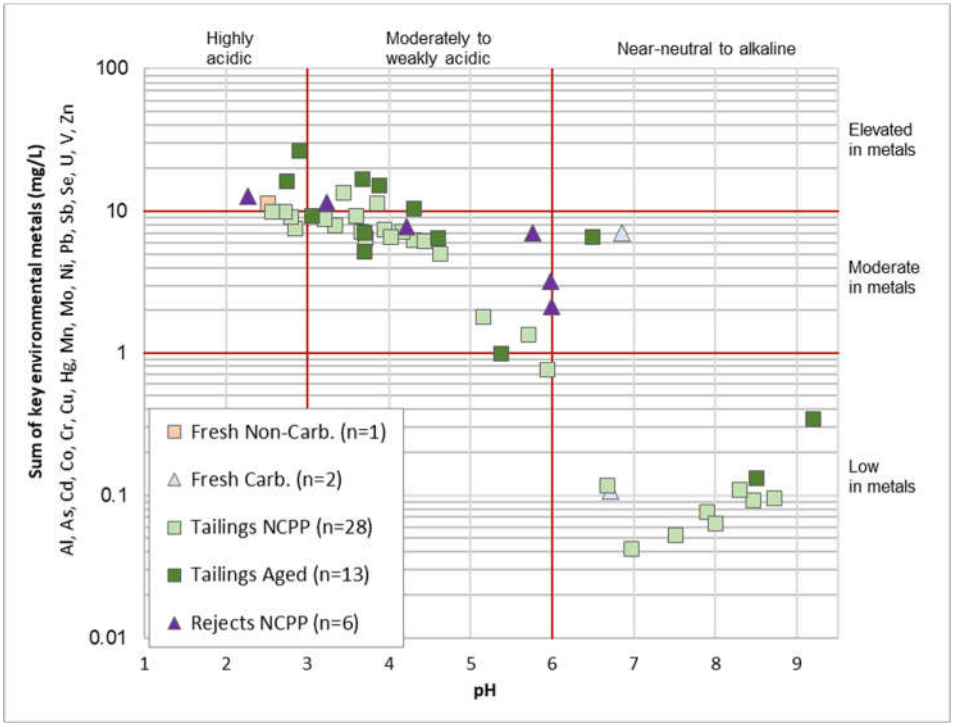
resulting leach representing an assumed 'worse case' scenario in term of metal and metalloid mobility. The purpose of this test is to understand what metals and metalloids can be mobilised following full oxidation. The samples submitted for this test were selected to assess the hazard of similar waste type or to assist clarifying borderline geochemical properties.

It must be noted that samples with potentially high C-org concentration, such as some tailings and some reject samples, may be influenced by organic acids producing acidity and correspondingly elevated soluble metal and metalloid concentrations unrelated to AMD. As such, the results for highly carbonaceous samples should be interpreted with this in mind.

The sum of the concentration of 16 environmentally important elements are plotted as a function of pH from the peroxide leachate solution in **Figure 4-22**. The 16 selected metals and metalloids are the same elements as per the 1:5 deionised water leach and the saline leach.

After undergoing a peroxide (NAG) leach a significant number of samples have acidic pH (ranging from weakly to highly acidic) and moderate to elevated soluble metal and metalloid concentrations – primarily due to the low pH enhancing solubility.

Figure 4-22. Sum of key environmental metals versus pH in peroxide (NAG) leachate solution



The results suggest that under acid/acidic conditions, materials represented by these samples are capable of generating elevated metal and metalloid loads for several metals and metalloids. Of the 50 samples subjected to peroxide (NAG) leaching, 33 samples (66% of samples) had total S concentration greater than 0.5%, and of these 33 samples, 17 samples had total S concentration greater than 1% – meaning those samples with moderate or greater total S are capable of generating SO_4 (and salinity). However, for the most part, SO_4 (and salinity) loads are not expected to be elevated due to the generally low total S concentrations. These data suggest that if PAF/PAF-LC material is allowed to oxidise without ANC available in the bulk media to buffer acidity, material similar to that tested might mobilise metals and metalloids at elevated concentrations, over time.

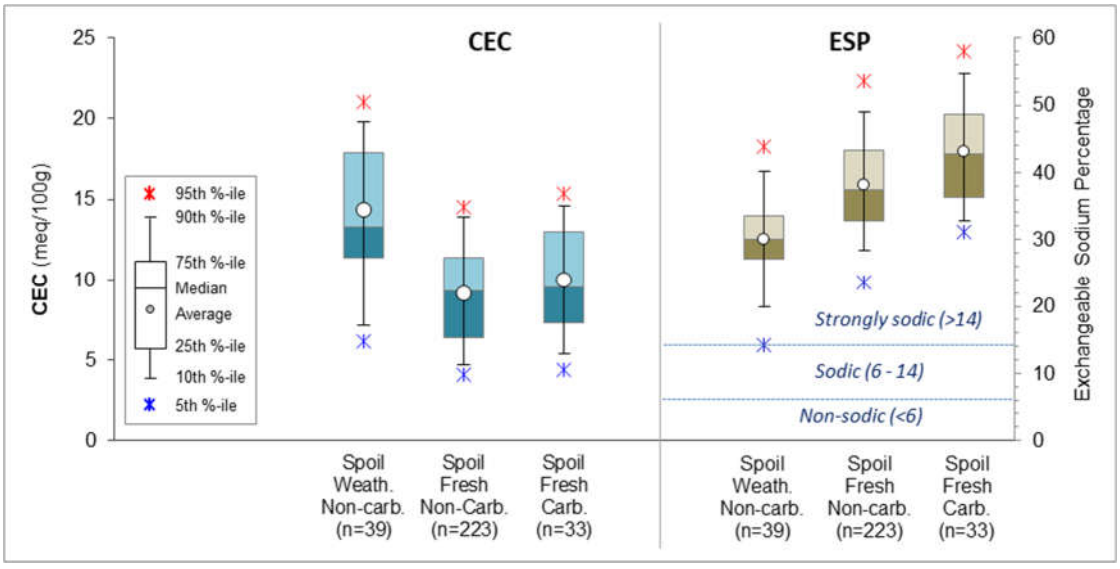
4.8 Cation Exchange Capacity, Sodicity and Dispersion of Spoil

Exchangeable cation concentrations are used to evaluate the potential 'soil quality' of materials. CEC and ESP data are available for 295 spoil samples. The results are summarised in **Figure 4-23**.

The CEC spans a large range from less than one milliequivalents per 100 grams (meq/100g) to 30 meq/100g, with a relatively low median CEC value of 9.6 meq/100g. The CEC for weathered spoil was generally higher than fresh spoil.

The ESP results generally ranged from 8.1% to 100%, with a high median ESP of 37%. Approximately 98% of samples had ESP values greater than 14% and a further 2% of samples had ESP values between 6% and 14%. Therefore, based on the ESP values alone, all of the spoil samples are regarded as being 'sodic' to 'strongly sodic' and, as such, mine spoil at BWM and the Project can be expected to have potential for dispersion.

Figure 4-23. Cation exchange capacity and exchangeable sodium percentage of spoil



All 295 spoil samples also underwent Emerson aggregate class tests to determine whether these samples were dispersive. Emerson aggregate class tests are a direct measure of soil dispersion, whereas ESP values are used as an indirect measure of the potential for a sample to have structural stability problems and hence may be dispersive. It should be noted that Emerson aggregate tests are designed for soil testing, not for crushed drill-core. Therefore, the results should be interpreted with this in mind.

The results show that about 55% of samples (162 out of 295 samples) had an Emerson Class of two (some dispersion; slaking) and three samples had an Emerson Class of three (dispersion; calcite or gypsum present) – meaning about 56% of samples were dispersive to some degree. The remaining 44% of samples (130 samples out of 295) had Emerson Class values suggesting no dispersion. In summary, the Emerson Class testing suggests a significant proportion of the samples (about 56% of samples) may be prone to dispersion. Refer to **Section 3.4** for class descriptions.

Therefore, based on the CEC, ESP and Emerson aggregate class test results, a significant proportion of spoil at BWM and the Project is expected to be sodic and dispersive to varying degrees. These

exchangeable cation (and Emerson aggregate class) results are common for Bowen Basin Permian-aged and Tertiary-aged material in the region.

The environmental significance of exchangeable cation values and sodicity levels in spoil material in terms of potential erosion and dispersion is outlined in **Section 6**, however readers should consult the separate soils assessment undertaken as part of the environmental approvals for the Project for a detailed assessment of soil properties with regard to rehabilitation.

4.9 Kinetic Column Leaching of Tailings

Data is available for free-draining kinetic column leaching test-work on one aged tailings sample from NCPP TSF classified as PAF and five fresh NCPP tailings samples with mixed classifications (NAF, NAF-S, PAF-LC and PAF).

The samples were selected for column leaching test-work on the basis of static test results and had a range of AMD classifications from NAF to PAF (based on the static test-work). The column leaching method followed a modified AMIRA (2002) method[4], where samples were leached at four-weekly intervals with moistening and drying steps between the leaching events. The aged tailings sample and two of the fresh tailings samples were leached for 32 weeks (nine leach cycles including initial flush). The remaining three fresh tailings samples were leached for 52 weeks (14 leach cycles including initial flush).

The sum of the concentration of 15 environmentally important elements are plotted as a function of pH from the column leaching solutions in **Figure 4-24**. The 15 selected metals and metalloids are the same as the elements as per the 1:5 deionised water leach, saline leach and peroxide leach – excluding vanadium (V), for which no data was available.

For the fresh NCPP tailings samples, most of the leachate was low in soluble metal and metalloid concentrations with the exception of the initial (Week 0) leaching events for three samples, which produced initial leachate with moderate soluble metal and metalloid concentrations. Solute concentrations are typically higher in the initial flush as pre-existing salts are leached. Excluding the initial flush from one of the fresh NCPP tailings samples that produced weakly acidic leachate, all fresh tailings samples had near neutral to alkaline pH.

For the aged NCPP TSF tailings sample, the initial (Week 0) flush was elevated in soluble metals and metalloids, followed by moderate metal and metalloid concentrations during the leaching events at Weeks 4, 8 and 12. Beyond the Week 12 leach, the soluble metal and metalloid concentration from aged tailings leachate was low – and at near-neutral to alkaline pH.

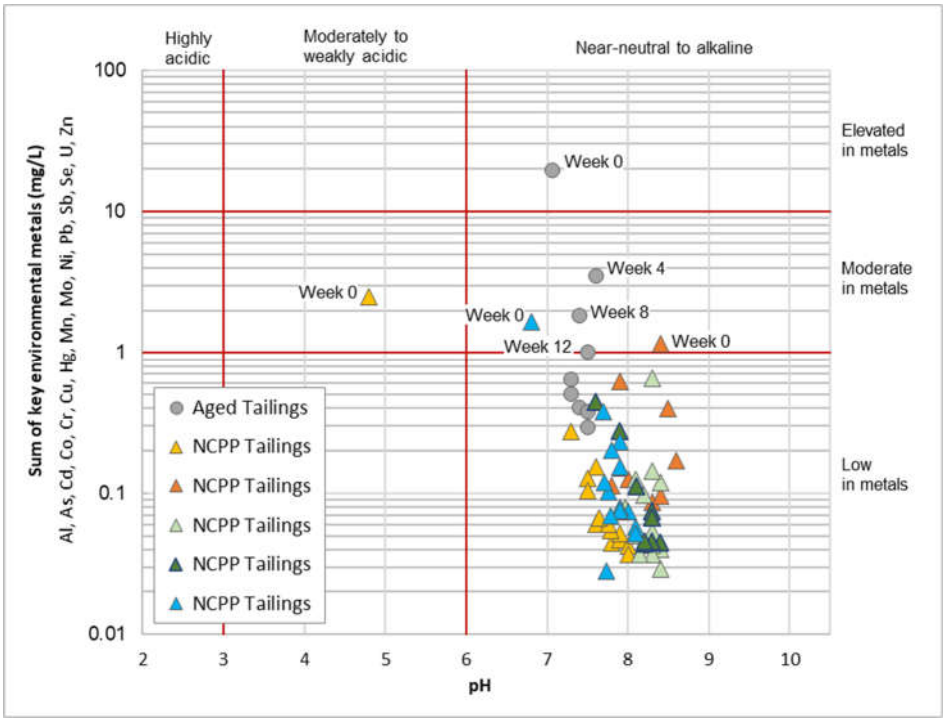
The salinity of the samples (column leachate) for fresh tailings samples ranged from 563 to 9460 μS/cm, with a moderately saline median value of 1230 μS/cm. The sulfate release rates for fresh NCPP tailings samples ranged from 22 mg/kg/week to 57 mg/kg/week.

For the aged tailings sample, the salinity ranged from 2110 to 6930 μS/cm with a saline median value of 2210 μS/cm. The aged tailings sample released sulfate at a rate of 147 mg/kg/week, which was the highest among all samples leached.

4 Modifications to the 'standard' method were needed due to the very fine particle size of the samples

The column leaching showed that none of the tailings samples were acid forming (i.e. no samples produced AD) throughout the leaching period. The aged tailings sample released higher levels of salt and elevated metal and metalloid concentrations compared to fresh samples.

Figure 4-24. Sum of key environmental metals versus pH in kinetic column leachate solution



4.10 OxCon Test-work of Tailings

Data is available for OxCon test-work undertaken on six samples, comprising one aged tailings sample from NCPP TSF classified as PAF and five fresh NCPP tailings samples with mixed classifications (NAF, NAF-S, PAF-LC and PAF). The test-work – summarised in **Table 4-6** – found that:

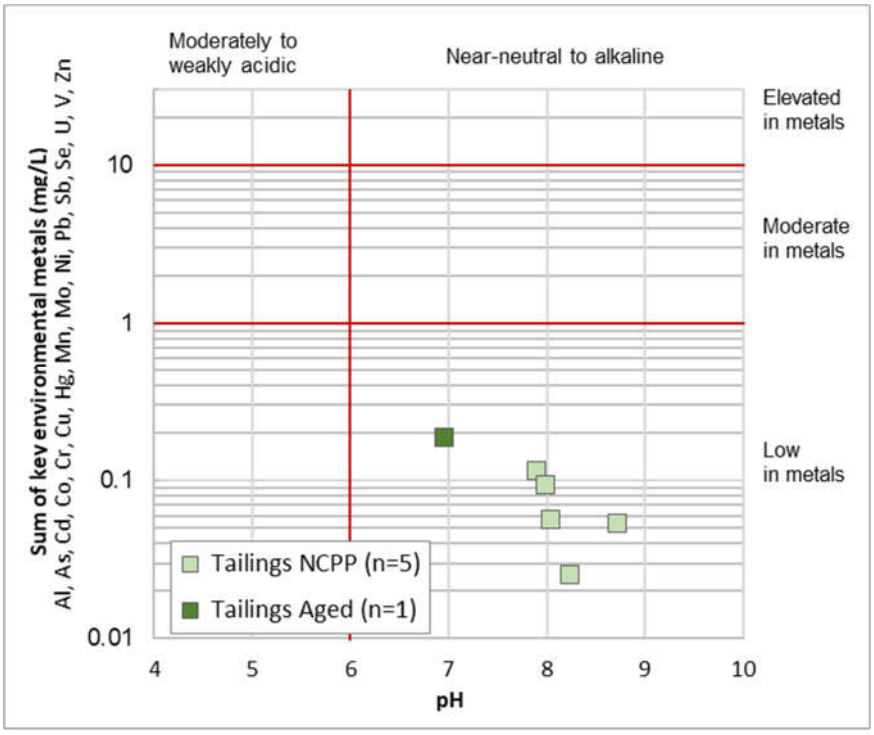
- Two of the five fresh NCPP tailing samples were confirmed to be NAF and are unlikely to generate AD or NMD (negligible risk) and with a low/negligible risk of generating SD. The remaining three fresh NCPP tailings samples were confirmed as PAF or PAF-LC and were found to pose a moderate to moderate-high risk of generating AD and low potential for SD.
- The aged tailings sample from NCPP TSF was confirmed as PAF and found to pose a high potential for generating AD and low potential for SD.

At the conclusion of the OxCon test, the solid underwent a bottle leaching procedure at a 1:2 w:v (solid:water) ratio and the leachate was analysed to determine the pH, acidity/alkalinity and concentration of soluble metals and metalloids, and salts. The sum of the concentration of 16 environmentally important elements are plotted as a function of pH from the post-OxCon leachate solution in **Figure 4-25**. The 16 selected metals and metalloids are the same elements as per the 1:5 deionised water leach, saline leach and peroxide (NAG) leach. As evident in **Figure 4-25** all six samples have near-neutral to alkaline pH and low soluble metal and metalloid concentrations.

Table 4-6. Summary of OxCon results for the tailings samples

Sample ID:	BWM Tails 31-08-20	BWM Tails 03-09-20	BWM Tails 04-09-20	BWM Tails 09-09-20	BWM Tails 18-09-20	BWM-NCPP-CPT51-INT06
Type / Source	Tailings fresh NCPP	Tailings fresh NCPP	Tailings fresh NCPP	Tailings fresh NCPP	Tailings fresh NCPP	Tailings aged NCPP TSF
Preliminary (pre-OxCon) AMD Classification	PAF	PAF	NAF-S	PAF-LC	NAF	PAF
Avg. O_2 consumption rate (mmol O2/kg /day)	0.48	0.31	0.60	0.51	0.43	0.63
Max. acidity generation Rate (kg H_2SO_4/t /year)	9.3	5.9	11	9.7	8.2	12
Pyrite oxidation rate (wt.% pyrite/year)	55	12	53	80	0.57	11
Longevity of sulfide Oxidation (years)	10	35	10	5	2	38
Lag time until ANC Consumed (years)	approx. 4	approx. 9	n/a	<1	n/a	approx. 4
Peak net acidity generation Rate (kg H_2SO_4/t /year)	1.2	2.1	<0.1	8.3	<0.1	7.9
AMD Classification Based on OxCon Test	PAF-LC	PAF	NAF	PAF-LC	NAF	PAF

Figure 4-25. Sum of key environmental metals versus pH in OxCon leachate solution



5 Summary of Geochemical Characteristics

The geochemical characteristics of overburden/interburden (spoil) from the northern mining area at BWM and the Project have been assessed, as have the geochemical characteristics of tailings and rejects from BWM. Also assessed were coal samples that may report as ROM coal or as waste to the spoil dumps. The assessment was undertaken to understand the environmental geochemical characteristics of these samples, as being representative of their respective mineral waste types at BWM and the Project.

Based on the BWM Progressive Rehabilitation and Closure Plan (WHC, 2025) spoil comprises approximately 99% of the mineral waste at BWM, of which about 92% is non-carbonaceous. Tailings and rejects comprise approximately 0.5% each of mineral waste at BWM. These approximate proportions are expected to remain the same as mining progresses into the Project.

Spoil is overwhelmingly comprised of non-carbonaceous material. Carbonaceous spoil (of which almost all is fresh/unweathered) comprises a small proportion of the spoil. These proportions are expected to remain unchanged as mining progresses eastwards into the Project.

5.1 AMD Potential of Mineral Waste and Coal

Acid and Metalliferous Drainage Potential of Spoil – Non-Carbonaceous

Non-carbonaceous spoil, which comprises about 92% of spoil at BWM (WHC, 2025), is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage), which is typical for mine spoil in the Bowen Basin.

Based on the results of 2100 samples, non-carbonaceous spoil from the Project has a negligible potential to generate AMD as either AD and/or NMD and/or SD.

The total S concentration of non-carbonaceous spoil is very low, with a 95th percentile total S concentration of 0.09%. As such, and combined with moderate to high ANC values (median 45 kg H_2SO_4/t), which is significantly higher than the MPA (median 0.9 kg H_2SO_4/t), greater than 99% of non-carbonaceous spoil samples tested were classified as NAF, with one sample classified as UC(NAF). Less than 0.4% of non-carbonaceous spoil samples were classified as PAF, PAF-LC, UC(PAF) or NAF-S.

The test-work undertaken has demonstrated that the ANC for the non-carbonaceous spoil is generally expected to be about 40-70% available under field conditions (based on 25th and 75th percentile values). Mineralogical (QXRD) analysis indicates that iron-dolomite and calcite are the main carbonate minerals contributing to the acid buffering potential of non-carbonaceous spoil. Overall, non-carbonaceous spoil has excess acid neutralising capacity and is expected to be bulk acid consuming.

Total metal and metalloid concentrations from 264 non-carbonaceous spoil samples tested are very low compared to the average elemental abundance in soil in the Earth's crust. Six samples (out of 264) were significantly enriched with regard to one or more of As, Ba, Hg and/or S. The enrichment in these elements in a very small number of samples is not cause for concern. In summary, non-carbonaceous spoil (as a bulk material) has low enrichment in total metals and metalloids compared to un-mineralised rocks.

Soluble multi-element results (from 264 non-carbonaceous samples) indicate that leachate from this material is expected to contain low concentrations of soluble metals and metalloids. Approximately 11%

of these samples (almost all NAF) produced leachate with moderate soluble metal and metalloid concentrations under near-neutral to alkaline pH, largely driven by higher concentrations of soluble Al and/or As. Peroxide (NAG) leaching undertaken on a single non-carbonaceous spoil sample classified as UC(PAF), showed that 'PAF' material, when oxidised, has the potential to generate low pH leachate (AD) with elevated sulfate and soluble metal and metalloid concentrations.

For the key aspects assessed, including ABA components (total S, Scr, ANC), total metals and metalloids, and soluble metals and metalloids, the assessment has demonstrated that non-carbonaceous spoil from the Project can be expected to have AMD characteristics that are comparable to non-carbonaceous spoil currently mined at BWM.

Acid and Metalliferous Drainage Potential of Spoil – Carbonaceous

Carbonaceous spoil represents approximately 8% of spoil material at BWM (WHC, 2025) and, as a bulk material, is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage), similar to non-carbonaceous spoil. Essentially all carbonaceous spoil is fresh (unweathered).

Based on the results from 160 samples, most carbonaceous spoil has a generally low to moderate potential to generate AD and/or NMD and/or SD. Some carbonaceous spoil – mostly associated with coal seams – has a greater potential to generate low-level AD and/or NMD and/or SD.

The total S concentration of carbonaceous spoil is very low to low, with a 95th percentile total S concentration of 0.52%.

Approximately 92% (147 out of 160 samples) of carbonaceous spoil samples were classified as NAF, which includes two samples classified as UC(NAF). The remaining 8% of carbonaceous spoil samples were classified as PAF-LC or UC(PAF), including two samples classified as NAF-S. Only three samples had moderate to high total S concentrations (S >1%). Of the 13 samples classified as 'PAF' (of any type), all except two were closely associated with coal seams and could potentially end up as coarse reject if mined with ROM coal.

The test-work undertaken has demonstrated that the ANC for the carbonaceous spoil is generally expected to be about 20-35% available under field conditions (based on 25th and 75th percentile values), which is only about half that of non-carbonaceous spoil. Mineralogical (QXRD) analysis indicates that iron-dolomite is expected to be the main carbonate mineral contributing to the acid buffering potential of carbonaceous spoil. ANC is only slightly lower, overall, compared to non-carbonaceous spoil. However, the much lower availability of the ANC under field conditions in carbonaceous spoil (compared to non-carbonaceous spoil) is likely due to carbonaceous spoil having less calcite than non-carbonaceous spoil coupled with a much higher amorphous content and lower overall carbonate content.

Total metal and metalloid concentrations from 39 carbonaceous spoil samples tested are generally very low compared to the average elemental abundance in soil in the Earth's crust, and very similar to the assay concentrations from non-carbonaceous spoil. Seven out of 39 carbonaceous spoil samples – all classified as 'PAF' of some type – were significantly enriched with regard to one or more of As, Hg and/or S – and all seven samples were closely associated with coal seams. The enrichment in these elements in a small proportion of spoil is not cause for concern. In summary, carbonaceous spoil (as a bulk material) has low enrichment in total metals and metalloids compared to un-mineralised rocks.

Soluble multi-element results (from 39 samples) indicate that leachate from carbonaceous spoil is expected to contain generally low concentrations of soluble metals and metalloids – similar to the non-

carbonaceous spoil samples. Of the 39 samples, all except three had low soluble metal and metalloid concentrations under pH-neutral to alkaline conditions. Three samples (two NAF and one UC[PAF]) had moderate soluble metal and metalloid concentrations under pH-neutral to alkaline conditions.

Two fresh carbonaceous spoil samples, both classified as UC(NAF), underwent peroxide leaching and both were confirmed as NAF, however one of the samples produced leachate with moderate metal and metalloid concentrations.

For the key aspects assessed, including ABA components (total S, Scr, ANC), total metals and metalloids, and soluble metals and metalloids, the assessment has demonstrated that carbonaceous spoil from the Project can be expected to have AMD characteristics that are comparable to non-carbonaceous spoil currently mined at BWM.

Acid and Metalliferous Drainage Potential of Tailings

The geochemical characteristics differed slightly between fresh tailings from the NCPP versus aged tailings from NCPP TSF for different parameters. However, the overall geochemical (AMD) hazard posed by tailings from the two sources (fresh vs aged) was generally similar. As such, the discussion that follows only differentiates between the two tailings sources where the differences between the two sources was significant for some parameters and worthy of discussion. Else, the AMD potential of tailings is discussed as a bulk material.

Based on the results, approximately half of BWM tailings has a moderate to high potential to generate AMD as either AD and/or NMD and/or SD, and the remaining half (approximately) has a relatively low potential to generate AMD as either AD and/or NMD and/or SD. ROM coal from the Project is expected to produce tailings with AMD potential similar to fresh tailings currently produced at BWM NCPP.

Fresh tailings from the NCPP are expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage). Overall, aged tailings have lower pH compared to fresh tailings, however the pH in aged tailings was generally pH-neutral to alkaline. The difference in pH observed between fresh and aged tailings (and the differences within the aged tailings) may be due to a number of factors, however the most likely cause is oxidation processes consuming readily available neutralising minerals, leading to aged tailings generally having a low(er) acid neutralising potential.

The total S concentration of tailings ranges from low to high, but is generally low-moderate to moderate, with a 75th percentile total S concentration of 1.04%; with total S in fresh NCPP tailings being only marginally higher than aged tailings. Based on median values, Scr accounts for approximately 69% of total S in fresh NCPP tailings and 50% of total S in aged tailings – the lower proportion of Scr in aged tailings (compared to fresh tailings) is likely due to some sulfide in aged tailings being oxidised to sulfate.

As a bulk material, tailings have generally moderate ANC (median 28 kg H_2SO_4/t); with ANC in fresh NCPP tailings being higher than aged tailings. Combined with low-moderate MPA values (median 21 kg H_2SO_4/t) reflective of the range of total S values, approximately 52% of the tailings samples were classified as NAF or UC(NAF). The remaining 48% of samples were classified as PAF, PAF-LC or UC(PAF), including 4% of tailings samples classified as NAF-S.

The test-work undertaken has demonstrated that the ANC for both fresh and aged tailings (combined) is generally expected to be about 45-68% available under field conditions. However, the 'field availability' of ANC generally ranged from about 20-85%. Iron-dolomite and calcite are expected to be the main carbonate minerals contributing to the acid buffering potential of tailings. All tailings have appreciable

concentrations of siderite (an iron carbonate mineral), however, siderite provides no net acid neutralising capacity. Overall, carbonate concentrations were similar between fresh and aged tailings.

Total metal and metalloid concentrations from 42 fresh and 14 aged tailings samples tested are very low compared to the average elemental abundance in soil in the Earth's crust. However, about one-quarter of fresh NCPP tailings samples and about half of the aged tailings samples were significantly enriched with S, including two aged tailings samples with significant enrichment in Ag. All of the tailings samples that were significantly enriched in S were classified as 'PAF' of some type.

Solubility data indicate that fresh NCPP tailings samples under freshwater (deionised water) leaching conditions are expected to have low soluble metal and metalloid concentrations and have near-neutral to alkaline pH. For the aged tailings, five of the 20 samples had moderate soluble metal and metalloid concentrations under pH-neutral to alkaline conditions. A further two aged tailings samples (both classified as PAF) produced acidic leachate with highly elevated metal and metalloid concentrations – confirming their PAF classification. These results suggests that, overtime, some tailings can generate AD as field ANC is consumed. Under saline leaching conditions tailings produced low concentrations of soluble metals and metalloids.

Peroxide leaching undertaken on 41 tailings samples (fresh and aged, and about half of the samples classified as 'PAF') showed that when exposed to highly oxidising conditions 'PAF' tailings can produce weakly to highly acidic leachate with moderate to elevated soluble metal and metalloid concentrations. It must be noted that samples with potentially high C-org concentrations, such as some tailings samples, may be influenced by organic acids producing acidity and correspondingly elevated soluble metal and metalloid concentrations unrelated to AMD. As such, the results for such coaly/carbonaceous samples should be interpreted with this in mind. Nevertheless, 'PAF' tailings have typically produced moderate to elevated soluble metal and metalloid concentrations from the freshwater and peroxide (NAG) leaching tests. These results indicate that 'PAF' tailings have the potential to generate low pH leachate (AD), however the salinity (sulfate) loads are not expected to be high – due to generally low total S concentrations (with minor exceptions).

Acid and Metalliferous Drainage Potential of Rejects

The geochemical characteristics differed markedly between fresh and aged rejects for several geochemical parameters – unlike tailings, where the geochemical differences were minor between fresh and aged tailings. For context, some of the aged rejects sampled from deep within Ramp 36 rejects dump are from the early 1970s, and are 40-50 years older than the fresh NCPP rejects.

Based on the results, fresh NCPP rejects have a low potential to generate AMD as either AD and/or NMD and/or SD. Comparatively, about one-third of aged rejects – more from Ramp 36 rejects dump than NCPP TSF – have a moderate to high potential to generate AMD as either AD and/or NMD and/or SD. The remaining two-thirds of aged rejects have a relatively low to low-moderate potential to generate AMD as either AD and/or NMD and/or SD. ROM coal from the Project is expected to produce rejects with AMD potential similar to fresh rejects currently produced at BWM NCPP.

Fresh rejects from the NCPP are expected to generate highly pH-alkaline contact water (run-off and seepage). Aged rejects have much lower pH compared to fresh rejects and are expected to generate pH-neutral to alkaline contact water (run-off and seepage). The difference in pH observed between fresh and aged rejects may be due to a number of factors, however the most likely cause is oxidation processes in

aged rejects consuming readily available neutralising minerals, leading to aged rejects having a low(er) remnant acid neutralising potential.

The total S concentration of fresh rejects is generally low, with a median value of 0.28%. Aged rejects from NCPP TSF generally had low to low-moderate total S values (median 0.46%). Aged rejects from Ramp 36 rejects dump generally had low-moderate total S values (median 0.68%). The reason(s) for differences in total S between the three sources of rejects (NCPP, NCPP TSF and Ramp 36 rejects dump) is unclear. However, the most likely reason is due to changes in geochemistry of ROM coal being processed. That is, ROM coal becoming less S-rich over time due to a change in the relative proportions of the various coal seams/plys being mined and processed.

Based on median values, Scr accounts for approximately 74% of total S in fresh NCPP rejects and 61% of total S in aged rejects – the difference between fresh and aged likely due to sulfide oxidation from the aged samples.

Rejects have generally moderate to high ANC (median 30 kg H_2SO_4/t); with ANC in fresh rejects being generally higher (median 40 kg H_2SO_4/t) compared to aged rejects (median 27 kg H_2SO_4/t). Combined with low to moderate MPA values (median 16 kg H_2SO_4/t), resulted in all of the fresh rejects and about two-thirds of the aged rejects being classified as NAF or UC(NAF). Approximately one-third of aged rejects – predominantly from Ramp 36 rejects dump – were classified as PAF, PAF-LC or UC(PAF), including 11% of aged dump rejects classified as NAF-S.

Test-work indicated that about 50-78% of the ANC in fresh rejects (based on 25th and 75th percentile values) is expected to be available under field conditions; and about 45-56% available for the aged rejects (also based on 25th and 75th percentile values).

Total metal and metalloid concentrations from 13 fresh and 17 aged rejects samples tested are very low compared to the average elemental abundance in soil in the Earth's crust. No fresh NCPP rejects showed significant enrichment in any elements, and four of the aged rejects samples were significantly enriched with S, which is consistent with ABA data for these samples – and all four were classified as 'PAF' of some type.

Solubility data from 32 rejects samples tested (fresh and aged, and most of the samples classified as NAF or UC[NAF]) indicate that leachate from rejects under freshwater (deionised water) leaching conditions is generally expected to have low soluble metal and metalloid concentrations, and have near-neutral to alkaline pH, with minor exceptions.

Peroxide leaching undertaken on six aged rejects samples (four classified as 'PAF' and two as UC[NAF]) showed that when exposed to highly oxidising conditions 'PAF' rejects can produce weakly to highly acidic leachate with moderate soluble metal and metalloid concentrations. The results suggest that under acid/acidic conditions, some rejects are capable of generating moderate metal and metalloid loads, however the salinity (sulfate) loads are not expected to be high – due to the generally low total S concentration (with some exceptions).

Acid and Metalliferous Drainage Potential of Coal

Coal is not regarded as waste and ROM coal remains on-site for a relatively short period of time. However, some minor coal seams/plys will report directly as waste, and remnant coal (seams) will be exposed on the highwalls of residual voids at closure.

Coal represents about 7% (on average) of all lithological material at BWM in the vicinity of the Project and about 5-7% of the highwall meterage along the approximate line of the geological long-section. Assuming the large majority of this will report as ROM coal, we can conservatively assume that coal will represent a very small proportion of mineral waste (i.e. nominally 1-2% at the most). Most ROM coal from the Project will be from the same seams as are currently mined at BWM in the vicinity of the Project.

Based on the results, and as a bulk material, ROM coal is conservatively assessed as having a low-moderate to moderate potential to generate AMD as either AD, NMD and/or SD. A small proportion of coal would have a moderate to moderate-high potential to generate AMD. ROM coal, as a bulk material, is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage).

The total S concentration of coal is generally low; with a median value of 0.22%. Approximately 13% (median value) of the total S is present as Scr (sulfide), with the bulk of the total S likely present as S-org, which does not contribute to AMD. Coal samples have a wide range of ANC values; however, the median ANC, overall, is low (median 12 kg H_2SO_4/t). As such, 72% of coal samples were classified as NAF or UC(NAF). Of the remaining 28% (approximately) of coal samples, almost all were classified as PAF-LC. Two samples were classified as PAF and one sample classified as NAF-S – noting that the AMD classification is based on total S, which for coal samples likely leads to a highly conservative classification.

Of the 59 coal samples classified as 'PAF' (including NAF-S), all except two samples were from the P and L seam group; with two samples from the T seam group.

These results suggest that coal stored on the ROM pad, coal located within pit walls and un-economic coal seam material reporting as spoil (mixed with non-coal spoil) would likely be bulk NAF. The exception is predominantly coal from the P and L seam group, where it is expected that a small proportion of coal may pose a higher AMD hazard due to the higher S grade. However, it is expected that the bulk AMD source hazard for all coal is low.

Assay data for 37 coal samples show that the total metal and metalloid concentrations are low compared to the average elemental abundance in soil in the Earth's crust. One coal sample was significantly enriched with regard to As and S.

Soluble multi-element results from 37 coal samples tested, with a range of NAF to PAF classifications, indicate that contact water (run-off and seepage) from coal is generally expected to contain low concentrations of soluble metals and metalloids. One coal sample classified as PAF-LC produced weakly acidic leachate with low soluble metal and metalloid concentrations.

5.2 Salinity, Sodicity and Dispersion Potential of Mineral Waste and Coal

Salinity, Sodicity and Dispersion Potential of Spoil – Non-Carbonaceous

Non-carbonaceous spoil has low median and 95th percentile $EC_{1:5}$ values of 390 and 549 μS/cm, respectively, and has very low total S concentration. On this basis, contact water (run-off and seepage) is expected to be generally non-saline to slightly saline, as a result of dissolution of geogenic salts more so than from sulfide oxidation (sulfate salinity). Weathered non-carbonaceous spoil generally has slightly higher $EC_{1:5}$ values, overall, compared to fresh non-carbonaceous spoil.

Non-carbonaceous spoil has modest CEC values and high ESP values, resulting in all samples being classified as 'sodic' to 'strongly sodic' based on CEC and ESP data alone and, therefore, with potential

for dispersion. Based on Emerson aggregate class testing to directly measure dispersion, about 56% of the 262 non-carbonaceous samples tested displayed some degree of dispersion. Therefore, based on the CEC, ESP and Emerson aggregate class test results, a significant proportion of non-carbonaceous spoil at BWM and the Project is expected to be sodic and dispersive to varying degrees.

Salinity, Sodicity and Dispersion Potential of Spoil – Carbonaceous

Carbonaceous spoil has low median and 95th percentile $EC_{1:5}$ values of 362 and 547 μS/cm, respectively, and has very low to low total S concentration. On this basis, contact water (run-off and seepage) is expected to be similar to non-carbonaceous spoil. That is, generally non-saline to slightly saline, primarily as a result of dissolution of geogenic salts more so than from sulfide oxidation (sulfate salinity).

Carbonaceous spoil samples (all fresh) had similar CEC values compared to fresh non-carbonaceous spoil, but generally higher ESP values compared to non-carbonaceous spoil – resulting in all carbonaceous samples being classified as 'strongly sodic', with potential for dispersion. Based on Emerson aggregate class testing to directly measure dispersion, about 52% of the 33 carbonaceous samples tested displayed some degree of dispersion. Therefore, based on the CEC, ESP and Emerson aggregate class test results, a significant proportion of carbonaceous spoil at BWM and the Project is expected to be sodic and dispersive to varying degrees.

Salinity Potential of Tailings

Tailings samples have $EC_{1:5}$ values ranging from 97 to 8900 μS/cm, with median and 95th percentile $EC_{1:5}$ values of 711 and 2070 μS/cm, respectively. Fresh and aged tailings are generally slightly to moderately saline – and both tailings types have generally low-moderate to moderate total S concentration. Therefore, tailings are generally slightly to moderately saline with a low to low-moderate potential for SD (from sulfide oxidation).

Salinity Potential of Rejects

Rejects samples have $EC_{1:5}$ values ranging from 229 to 2830 μS/cm, with median and 95th percentile $EC_{1:5}$ values of 761 and 2404 μS/cm, respectively. Fresh NCPP rejects were generally non-saline, whereas aged rejects were generally slightly to moderately saline. Overall, as a bulk material, rejects are assessed as being slightly to moderately saline. Most fresh rejects have low total S concentration, whereas most aged rejects have low to low-moderate total S concentration. Therefore, based on the total S concentrations, the potential for SD (from sulfide oxidation) from rejects is low to low-moderate.

Salinity Potential of Coal

Coal has low median and 95th percentile $EC_{1:5}$ values of 103 and 309 μS/cm, respectively; and has generally low total S concentration. On this basis, contact water (run-off and seepage) from coal, as a bulk material, is expected to be non-saline, either as a result of dissolution of geogenic salts and/or from sulfide oxidation (sulfate salinity).

6 Management and Mitigation Measures

6.1 Spoil Management Strategy

The management of spoil (overburden and interburden) generated by the Project will be consistent with the current approved BWM waste management strategy – comprising the disposal of spoil from the Project into in-pit dumps behind the active mining face, then progressively rehabilitated – with run-off and seepage captured by the mine water management system.

Spoil comprises approximately 99% of the mineral waste at BWM, of which about 92% of spoil is non-carbonaceous. These approximate proportions are expected to continue as mining progresses eastwards into the Project. The assessment has found no difference between the geochemical characteristics of spoil from current BWM compared to the spoil expected to be mined from the Project.

Spoil is overwhelmingly NAF with excess ANC and has a negligible risk of developing AMD, including AD, NMD and/or SD. Furthermore, surface water run-off and seepage from bulk spoil is expected to be non-saline to slightly saline with low soluble metal and metalloid concentrations. However, spoil is expected to be sodic to strongly sodic with potential for dispersion and erosion.

Where highly sodic and/or dispersive spoil is identified it should, wherever practicable, not report to final landform surfaces and should not be used in construction activities. Tertiary spoil has generally been found to be unsuitable for construction use or on final landform surfaces (Australian Coal Association Research Program [ACARP], 2004 and 2019).

It is unlikely that sodic and potentially dispersive spoil will be able to be selectively handled and emplaced during operation of the Project, as is the case at BWM. Therefore, in the absence of such selective handling, spoil landforms would need to be constructed and progressively rehabilitated to minimise erosion.

Surface water run-off and seepage from spoil, including any rehabilitated areas, should be monitored for 'standard' water quality parameters including, but not limited to, pH, EC, major anions, major cations and a broad suite of soluble metals and metalloids at high resolution analysis.

With the implementation of the proposed management and mitigation measures spoil is regarded as posing a low risk of environmental harm.

6.2 Validation of Spoil Characteristics

The AMD hazard posed by existing spoil at BWM is well understood, and the geochemical characteristics (AMD hazard) of future spoil generated by BWM and the Project are expected to be similar to the current spoil being produced at BWM. Nevertheless, WHC will continue to undertake geochemical test-work of overburden and interburden throughout development of the Project. Test-work would, at minimum, comprise a broad suite of environmental geochemical parameters, such as pH, EC (salinity), ABA parameters, S speciation, and total and soluble metals and metalloids analysis at high resolution.

6.3 Tailings and Rejects Management Strategy

Fresh tailings and rejects samples from the NCPP are those types regarded as being most representative of current tailings and rejects at BWM and are likely to represent short- to medium-term tailings and

rejects expected to be generated in the early years of the Project. Tailings and rejects each comprise approximately 0.5% of mineral waste at BWM; and these approximate proportions are expected to be similar from the Project.

Approximately half of BWM tailings has a moderate to high potential to generate AMD as either AD and/or NMD and/or SD, and the remaining half (approximately) has a relatively low potential to generate AMD as either AD and/or NMD and/or SD. ROM coal from the Project is expected to produce tailings with AMD potential similar to fresh tailings currently produced at BWM NCPP.

Fresh NCPP rejects have a low potential to generate AMD as either AD and/or NMD and/or SD. Comparatively, about one-third of aged rejects have a moderate to high potential to generate AMD as either AD and/or NMD and/or SD, with the remaining two-thirds of aged rejects having a relatively low to low-moderate potential to generate AMD. ROM coal from the Project is expected to produce rejects with AMD potential similar to fresh rejects currently produced at BWM NCPP.

At BWM, tailings are currently being disposed into Bonnie Doon in-pit TSF and rejects are currently primarily disposal into in-pit spoil disposal areas within Besgrove and Deep Creek pits. The management of tailings and rejects generated by the Project will be consistent with the current approved strategies for managing tailings and rejects at BWM, including potential future dewatering of tailings and subsequent co-disposal of coal rejects (mixed fine and coarse rejects) into spoil dumps, subject to the conditions of the BWM Environmental Authority.

6.4 Validation of Tailings and Rejects Characteristics

The AMD hazard posed by existing tailings and rejects at BWM is well understood, and the geochemical characteristics (AMD hazard) of future tailings and rejects generated by the Project are expected to be similar to the current tailings and rejects being produced at BWM. Nevertheless, WHC will continue to undertake geochemical test-work of tailings and rejects samples during operations at BWM and throughout development of the Project. Test-work would, at minimum, comprise a broad suite of environmental geochemical parameters, such as pH, EC (salinity), ABA parameters, S speciation, and total and soluble metals and metalloids analysis at high resolution.

6.5 ROM Coal

ROM coal is not mining waste, and surface water run-off and seepage from ROM pads will be managed as part of the mine water management system.

ROM coal from BWM is conservatively assessed as having a low-moderate to moderate potential to generate AMD as either AD, NMD and/or SD. A small proportion of coal – mostly from the P and L seam group – would have a moderate to moderate-high potential to generate AMD. ROM coal, as a bulk material, is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage).

ROM coal is stored for a very short period of time (days to weeks) compared to mineral waste materials, which are stored in perpetuity. Management practices are therefore different for ROM coal (compared to mineral wastes) and are largely based around the operational (day-to-day) management of surface water run-off from ROM pads.

Surface water run-off from ROM pads would be monitored for 'standard' water quality parameters including, but not limited to, pH, EC, major anions, major cations, and a broad suite of soluble metals and metalloids at high resolution analysis.

7 References

ACARP (2004) [Australian Coal Association Research Program]. *Rehabilitation of Dispersive Tertiary Spoil in the Bowen Basin*. Report C12031, July 2004.

ACARP (2019) [Australian Coal Association Research Program]. *Prediction of Long-Term Salt Generation from Coal Spoils*. Report C25039, January 2019.

AMIRA (2002). *ARD Test Handbook – AMIRA Project P387A: Prediction & Kinetic Control of Acid Mine Drainage*. EGi and Ian Wark Research Institute.

ANZG (2018). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Governments and Australian state and territory governments, Canberra, ACT. Available at www.waterquality.gov.au/anz-guidelines.

AusIMM (2011) [Australasian Institute of Mining and Metallurgy]. *Field Geologist's Manual. Fifth Edition. Monograph 9.* December 2011. Carlton, VIC.

Bowen, H.J.M. (1979). *Environmental Geochemistry of the Elements*. Academic Press, New York.

DIIS (2016) [Department of Industry, Innovation and Science]. Leading Practice Sustainable Development Program for the Mining Industry. Preventing Acid and Metalliferous Drainage. September 2016, Canberra ACT.

DME (1995) [Queensland Department of Minerals and Energy]. *Draft Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland, Technical Guideline – Assessment and Management of Acid Drainage*. Part B – Section 13 – Assessment and Management of Saline/Sodic Wastes. January 1995.

Ficklin, W.H., Plumlee, G.S., Smith, K.S., and McHugh, J.B. (1992). Geochemical classification of mine drainages and natural drainages in mineralized areas: Proceedings, 7th Internal Water-Rock Interaction Conference, Park City, Utah, 1992, pp. 381–384.

INAP (2009) [International Network on Acid Prevention]. Global Acid Rock Drainage Guide (GARD Guide). Available at: http://www.gardguide.com.

Isbell, R.F. (2002). *The Australian Soil Classification* (revised edition). CSIRO Publishing. Victoria.

Northcote, K.H. and Skene, J.K.M. (1972). *Australian Soils with Saline and Sodic Properties*. CSIRO Australia, Soil Publication No. 27, Canberra.

WHC (2025). Blackwater Mine – Progressive Rehabilitation and Closure Plan. Version 2.0, 16 May 2025.

Appendix A

Drill-hole Information for Spoil and Coal Samples

Table A1. Drill-hole information for spoil and coal samples

Drill-hole ID	Easting (m)	Northing (m)	General Location (pit area)	Collar RL (m)	Depth (m)	Type of Samples	Zone Sampled	Total No. of Samples	No. of Weath. Samples	No. of Fresh Samples	Year Drilled & Sampled
BWM_EIS_05	685874	7384430	Mimosa	218.13	131.41	core	All (incl. seams)	116	25	91	2020
BWM_EIS_09	685420	7379087	Airstrip (north)	228.63	126.33	core	All (incl. seams)	100	10	90	2020
BWM_EIS_11	685382	7376066	Besgrove	233.65	149.70	core	All (incl. seams)	115	9	106	2020
BWM_EIS_13	685520	7373834	Deep Creek (north)	235.04	128.69	core	All (incl. seams)	117	11	106	2020
BWM_EIS_15	687308	7372572	Deep Creek (south)	229.32	131.71	core	All (incl. seams)	117	13	104	2020
BWM_EIS_17	689718	7370690	Stewarton	233.92	167.25	core	All (incl. seams)	119	14	105	2020
BWM_EIS_19	690949	7368459	Between Stewarton & Tannyfoil	244.60	129.84	core	All (incl. seams)	104	15	89	2020
BWM_EIS_WC03	686379	7387132	Bonnie Doon	unknown	111.52	core	All (incl. seams)	93	18	75	2021
BWM_EIS_WC07	685968	7381298	Sagittarius	unknown	163.74	core	All (incl. seams)	168	12	156	2021
BWM_EIS_WC10	685448	7377438	Airstrip / Besgrove	unknown	138.45	core	All (incl. seams)	211	22	189	2021
BWM_EIS_WC12	685912	7375212	Besgrove	unknown	135.49	core	All (incl. seams)	165	12	153	2021
BWM_EIS_WC14	688645	7373170	Deep Creek	unknown	148.21	core	All (incl. seams)	208	4	204	2021
108149	690379	7369944	Stewarton	232.95	189.50	core	over/inter burden	140	0	140	2020
108586	690656	7368859	Stewarton / Tannyfoil	242.08	162.44	core	over/inter burden	38	2	36	2024
108620	686018	7374426	Deep Creek	223.21	152.61	core	over/inter burden	80	0	80	2025
108626	685520	7378253	Airstrip	219.83	147.22	core	over/inter burden	76	0	76	2025
108660	689036	7371854	Stewarton	224.81	156.28	core	over/inter burden	69	0	69	2025

Drill-hole ID	Easting (m)	Northing (m)	General Location (pit area)	Collar RL (m)	Depth (m)	Type of Samples	Zone Sampled	Total No. of Samples	No. of Weath. Samples	No. of Fresh Samples	Year Drilled & Sampled
108664	690355	7370550	Stewarton	229.52	207.77	core	over/inter burden	85	0	85	2025
108669	686055	7379851	Burngrove	232.59	165.17	core	over/inter burden	75	0	75	2025
108674	685930	7375759	Besgrove	224.03	192.94	core	over/inter burden	80	0	80	2025
108677	687045	7373549	Deep Creek	220.89	174.96	core	over/inter burden	78	0	78	2025
108688	688757	7376617	Besgrove (east of Project)	200.79	189.48	core	All (incl. seams)	120	9	111	2025

TERRENUS
EARTH SCIENCES