Mineral Waste

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5 Mineral Waste

5.1 Introduction

Waste generated through mining in the form of overburden and coal processing in the form of rejects and tailings has been defined as mineral waste. This section provides an assessment of the geochemical characteristics of the project mineral wastes and their management with a detailed report provided in Appendix H. A detailed description of mining and processing is provided in Section 3.

Coal is deposited within environments that typically have a high potential to produce sulphides within the sediments. The mining of coal and removal of the overburden and interburden can result in the oxidation of the sulphides upon exposure to air and water, generating sulphuric acid. The resulting mine drainage is characterised by highly acidic waters with elevated metal and sulphate concentrations. Accordingly, the geochemical assessment includes the analysis of sulphide content of the spoil and determination as to whether the contained sulphides will potentially form acidic conditions, if oxidised.

The material characterised as part of this EIS, is considered to be representative of the projected rejects material and thus provides a guide to its potential for generating acidic conditions. Should the project proceed, the generated rejects material will be analysed to determine their geochemical characteristics, disposal requirements, and implications for site rehabilitation. It is planned that there will be no disposal of coal rejects or fine coal tailings outside of the pit; instead these will be disposed of as dewatered solids within the in-pit spoil dumps.

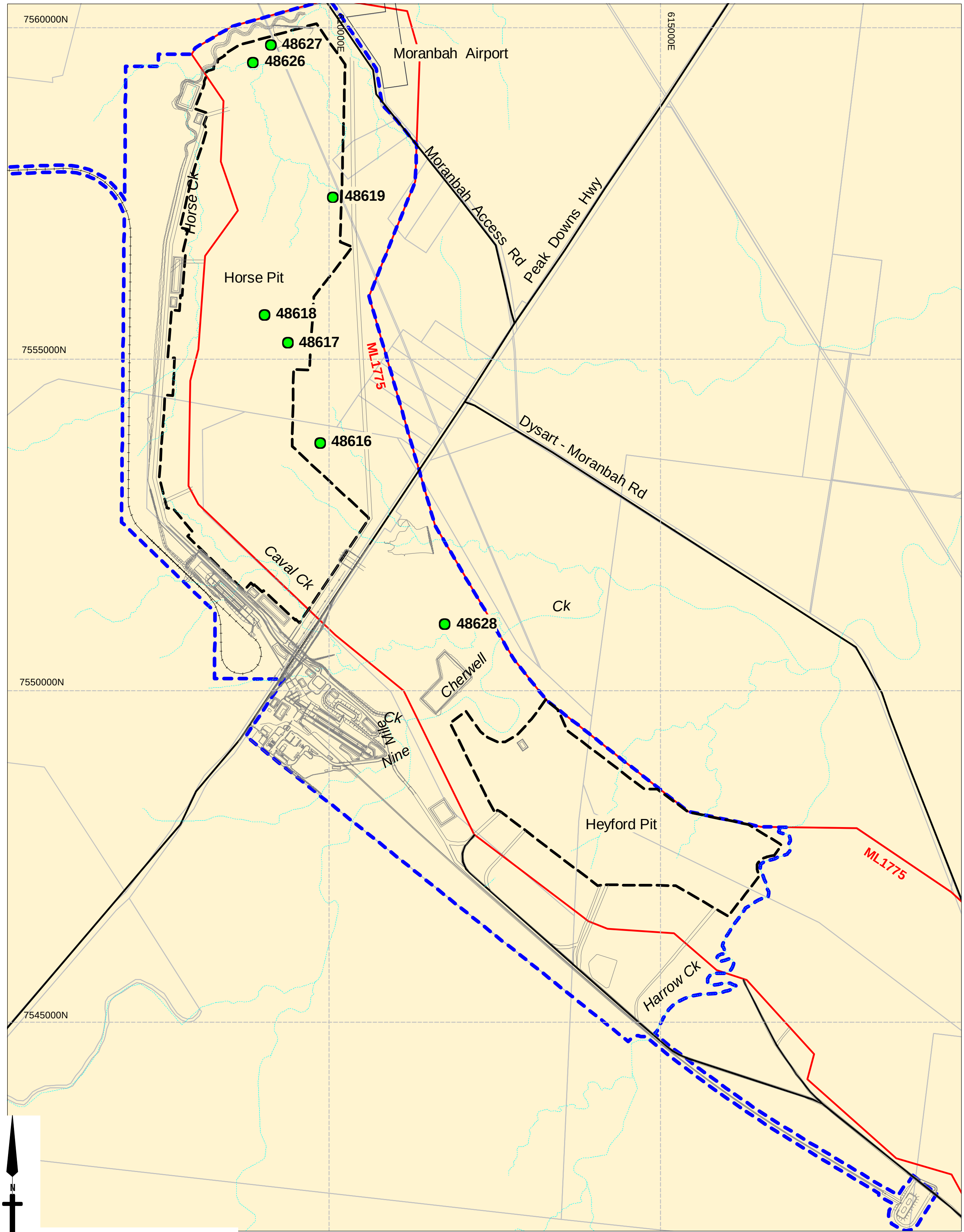
Initially, the overburden produced by mining at Horse Pit will be located within and close to the perimeter of the haul road. This out-of-pit spoil will comprise approximately 28 million cubic metres of overburden mined from the box-cut and will cover an area of approximately 340 ha. When sufficient space is created within the mined areas, subsequent overburden will be placed within in-pit spoil dumps. Overburden from reworking Heyford Pit will be used to stabilise the pit, and will be disposed of in-pit.

The objective of the project geochemical assessment was to determine the following:

- The potential for acid mine drainage.
- The concentrations of trace metals in the spoil, and potential for contamination.
- The feasibility of using the spoil material for site rehabilitation.

5.1.1 Summary of Geology

The target coal seams for the Caval Ridge mine are all the coal seams in the lease that are greater than 0.3 m thickness, with the primary coal targets being the Q seam - P seam zone, the Harrow Creek Seams and the Dysart Seams. Seam splitting is prevalent along the length of the lease, with a general trend to split to the north and also down dip (east). A stratigraphic description of the seams is provided in Section 4.3. Samples for geochemical assessment were collected and tested from coal, roof and floor materials from the Q-, P-, Harrow Creek and Dysart seams (Table 5.1).



0 1 2km
Scale 1:80,000 (A4)
Datum: AGD84, AMG Zone 55

Project Site
Mining Lease
Drill Hole Location (URS, 2007)
Mine Pit Outlines

Source: Client Supplied Data (November 2007)

Client: BMA BHP Billiton Mitsubishi Alliance / URS	Project: CAVAL RIDGE PROJECT ENVIRONMENTAL IMPACT STATEMENT	Title: **DRILL HOLE LOCATIONS FOR GEOCHEMICAL SAMPLES**
Drawn: VH	Approved: RS	Date: 08-05-2009
Job No: **4262 6158**	File No: 42626158-g-580b.wor	Figure: **5.1** Rev:B A4

5.1.2 Mineral Waste Quantities

The total mined overburden and interburden volumes from the Horse and Heyford Pits (combined) are expected to approximate over 1,600 million bulk cubic metres (Mbcm) over a 30-year mine life (i.e. approximately 55 Mbcm per year). This equates to over 2,000 million tonnes over the mine life based on an assumed overburden/interburden (sandstone/siltstone) excavated density of 1.3 to 1.4.

In addition to this coal reject material will be generated by the project; primarily coal seam roof and coal seam floor material from the P, Harrow and Dysart seams, but also including ROM coal from Peak Downs Mine, which will be processed at Caval Ridge. Approximately 161 Mt of coarse rejects and 54 Mt of fine rejects (215 Mt of rejects in total) are expected to be produced from the CHPP at Caval Ridge over a 30-year life (i.e. about 7 Mtpa). Coarse rejects will comprise approximately 80% of the total reject volumes, and fine dewatered tailings the remainder. Rejects (coarse and fine) are expected to comprise in the order of 10% of all geological waste produced by the project.

The proportion of rejects to overburden is marginally greater for the project (compared to similar coal mines in the Bowen Basin, which average about 5% of geological waste) due to the additional rejects generated from processing ROM coal from Peak Downs Mine. All of the rejects are expected to be disposed of within the spoil and into the mined Horse and Heyford Pits. Mineral waste disposal is discussed in the following section.

5.1.3 Mineral Waste Disposal

Mineral waste disposal includes disposal of spoil and rejects, which are intended to be disposed of back into the in-pit spoil dumps associated within mining activities. Details of the final landforms are contained within Section 4.8.5.

5.1.3.1 Spoil Disposal

Overburden and interburden will be predominantly disposed of into the mined Horse and Heyford Pits, behind the operating strip, however an out-of-pit spoil pile will be constructed along the western edge of the Horse Pit box-cut, between the box-cut and the haul road, for the first year of mining (Figure 3.6b). Approximately 28 Mbcm (less than 2%) of all (life-of-mine) mined overburden and interburden is expected to be disposed of in the out-of-pit spoil pile.

5.1.3.2 Reject Disposal

The rejects materials from the CHPP will consist of coarse reject, spiral tailings and flotation tailings generated from Caval Ridge Northern and Southern ROMs. These materials will be managed as follows:

- Coarse rejects will be dewatered and discharged onto the CHPP rejects conveyor, which reports to the rejects bin.
- Fine reject from the spirals will be thickened and dewatered before being discharged onto the coarse rejects conveyor.
- The flotation tailings will also be thickened before reporting to belt press filters.
- The solids discharged from the belt press filters (tailings paste) will be discharged onto the coarse rejects conveyor.

All rejects (coarse and dewatered tailings) from the CHPP (approximately 20% moisture) will be combined (Figure 3.12) and truck-dumped into the Horse and Heyford Pits where they will be mechanically mixing via dozer back into the spoil material. Topsoil will be placed onto the reprofiled slopes

5.2 Geochemical Nature of Mineral Waste Materials

5.2.1 Acid Generating Potential

The geochemical static-test data collected from seven drill holes (Figure 5.1) indicate that all overburden/interburden and almost all potential rejects tested are clearly non acid forming (NAF). In addition, the total sulphur contents of these materials is very low, with 29 of the 31 overburden and interburden samples having total sulphur concentrations ≤0.1% and therefore classed as barren. Similarly for the potential reject samples, where the average and median total sulphur concentrations for the 43 samples analysed were 0.1% and 0.06%, respectively. One coal-seam roof sample from the P08 seam was classified as potentially acid forming (PAF), indicating the some fine-grained sulphide mineral is likely to be present in some materials, most likely the roof and floor (potential reject) materials, but the proportions of such PAF materials are expected to be very low.

From an acid-base perspective almost all materials are NAF, but the high acid neutralising capacity (ANC) of many of the samples combined with the very low sulphur concentrations, indicates there would be excess alkalinity to buffer the small quantity of acid that could potentially be produced by a very small proportion of the likely mineral waste materials.

This is highlighted by the ratio of ANC to MPA (maximum potential acidity). The purpose of the ANC/MPA ratio is to provide an indication of the relative margin of safety (or lack thereof) within a material. Various ANC/MPA values are reported in the literature for indicating safe values for prevention of acid generation. These values typically range from one to three, with significantly higher ratios evident in strongly alkaline materials. As a general rule, an ANC/MPA ratio of two or more generally signifies that there is a high probability that the material will remain circum-neutral in pH and thereby should not be problematic with respect to acid rock drainage. The median ANC/MPA ratio for the project samples tested is 31.

Comparison of Potential Project Rejects with known Coarse Rejects and Tailings from Peak Downs Mine

The geochemical results from potential reject samples likely to be generated by the project are supported by similar geochemistry of coarse rejects and tailings at the adjacent BMA Peak Downs Mine, located immediately south of the proposed Heyford Pit. A geochemical assessment of coarse rejects and tailings at Peak Downs Mine (URS, 2002) found that approximately 36% (10 samples) of coarse reject samples tested were NAF, and a further 57% (16 samples) were classified as PAF-Low Capacity, due to their very low sulphur concentrations. Two coarse reject samples were classified as PAF-High Capacity, but these two samples had low total sulphur concentrations of < 0.5%.

Comparatively, over 60% (22 samples) of fine tailings were NAF and 33% (12 samples) were classified as PAF-Low Capacity, again with low sulphur concentrations. Two fine tailing samples were classified as PAF-High Capacity. The tailing samples had similar sulphur concentrations to the coarse rejects.

These results showed that, overall, the majority of coarse rejects and tailings had little or no capacity to generate acid and all materials appear to retain a modest neutralising capacity. These results are supported in the day-to-day management at Peak Downs Mine where the ROM stockpile and the tailing storage facility (TSF) are not known for generating acid seepage.

Therefore, rejects from Peak Downs Mine coal to be processed and disposed at the project are not expected to generate acid.

5.2.2 Multi-element Composition and Water Quality

Composite overburden and potential reject samples underwent testing for total and water-soluble metals concentrations (Appendix H). The results show that only total Mn is present in solids in concentrations that exceed the applied Draft Qld Guidelines for the Assessment and Management of Contaminated Land (1998), but were still well within the applied NEPC (1999a) health-based investigation level (HIL) guidelines.

Despite the presence of Mn in solids (albeit at concentrations well below the applied NEPC guideline levels), the water extracts1 from all composite samples have soluble metal concentrations below applied ANZECC (2000) values for livestock drinking water and below NEPC (1999b) groundwater investigation levels.

Although soluble metals concentrations are low, the EC of the materials is moderate to high, ranging from 388 to 1,970 µS/cm (median 679 µS/cm), and is similar for both overburden and potential rejects.

These results indicate that metals concentrations in overburden and potential reject materials is low and that the initial water solubility of these materials with respect to metals in mineral waste materials from the project is also low, but the materials may contribute some salt load to the surrounding environment.

Comparison of potential project rejects with known coarse rejects and tailings from Peak Downs Mine

The multi-element analyses undertaken by URS (2002) on coarse rejects and tailings from Peak Downs Mine found that coarse rejects and tailings from Peak Downs Mine also had relatively low concentrations of total and soluble metals, generally below the applied guidelines. Selenium (Se) and sulphate (SO4) were marginally elevated above the applied ANZECC (2000) and NEPC (1999b) water quality guidelines in some leachate water quality samples.

Therefore, rejects from Peak Downs Mine coal to be processed and disposed at the project site are not expected to cause environmental issues with respect to metal and salt concentrations in leachate.

Tailings are thickened and dewatered before reporting to the rejects bin (the collection point for all rejects, both coarse and fine, before in-pit disposal). Rejects are disposed at only 20% moisture content, therefore there is no free water within the rejects.

The geochemical nature of actual CHPP rejects is not known exactly, as the CHPP has not been built. However the geochemistry of the potential rejects from the drillcore and from the tailings and rejects from PDM indicate that these materials pose a low environmental risk. The 1:5 water extract tests of potential

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[1] The water extract test facilitates evaluation of the immediate solubility of multi-elements in solids. It is made from a solution of 1 part solid to 5 parts water. The solution is analysed for the required parameters: primarily soluble metals and salts.

rejects, as discussed in Section 5.2.2, show that soluble metals concentrations are low, but the salinity of these materials may be elevated.

5.3 Use of Overburden Materials for Re-vegetation/Rehabilitation

The discussion below focuses on the geochemical characteristics that need to be considered during rehabilitation. Rehabilitation of the site is discussed in detail in Section 4.8. The proposed mining strategy is to dump all rejects and almost all overburden materials together back into the void behind the mining (stripping) face in Horse and Heyford Pits. Some quantity of overburden materials will need to be set aside for rehabilitation and re-vegetation of the spoil piles (i.e. it is generally not acceptable mining practice to allow rejects to report to final surfaces – typically they are buried well into the overburden material). Also, a small proportion of overburden (<2% of the overall total) will be disposed into an out-of-pit dump along the western edge of the Horse Pit box-cut. With this in mind, the suitability of mineral waste materials for use in re-vegetation and rehabilitation is focused on the overburden materials, even though from a basic soil chemistry viewpoint the overburden materials have similar characteristics compared to the potential reject materials.

All of the tested overburden composite materials (and also the potential reject materials) had variously elevated ESP values, ranging from 8.5% to 25% (median 11%). An ESP value of between 6% and 14% indicates that these materials are regarded as marginally sodic to sodic and may be prone to dispersion (Isbell, 2002). Soil with an ESP value greater than 14% is regarded as strongly sodic (Northcote and Skene, 1972). Strongly sodic materials are likely to have structural stability problems related to potential dispersion (Van de Graaff and Patterson, 2001). Treatment of all sodic overburden (and potential reject materials) would be required if these are to be used as vegetation growth medium.

Ideally, sodic and dispersive materials should be identified, selectively handled and placed within the core of spoil piles away from final surfaces, or returned to voids during mining. However, since most overburden and coarse reject material is expected to be marginally sodic, this method of managing potentially sodic material is unlikely to be cost effective (i.e. it should be assumed that all spoil material will be sodic). Therefore, it is likely that treatment of the sodic waste materials may be required if these were to be used as an additional source of topsoil.

In addition to potential dispersion problems, sodic soils often have unbalanced nutrient ratios that can lead to macro-nutrient deficiencies (Hazelton and Murphy, 2007). Table 5.1 shows the proportions of each exchangeable cation relative to the eCEC. The desirable proportions of each major cation are also shown (Abbott, 1989, in Hazelton and Murphy, 2007).

Table 5.1 Proportions of eCEC of major exchangeable cations

Exchangeable Cation	Desirable ranges	Overburden	Potential Rejects
	% eCEC		
Calcium (Ca)	65 - 80	26 – 65 (average 53)	29 – 65 (average 50)
Magnesium (Mg)	10 - 15	15 – 35 (average 24)	14 – 34 (average 25)
Potassium (K)	1 - 5	3 – 20 (average 11)	10 – 25 (average 14)
Sodium (Na)	0 - 1	9 – 25 (average 13)	9 – 15 (average 12)

The median eCEC of overburden materials is 27 meq/100g, which is regarded as moderate (Metson, 1961, in Hazelton and Murphy, 2007). The shallow clay composite sample tested had a very high eCEC value (50 meq/100g) and high EC (approximately 1,380 µS/cm), which is probably the result of evaporative concentration of salts in shallow soil.

When compared to the desirable ranges for exchangeable cations in soil (Table 5.1) exchangeable cation proportions are outside the average ranges, but are not extreme. The exchangeable proportions of the alkali metals Na and K are high, which supports the naturally alkaline nature of most mineral waste materials. Exchangeable Ca and exchangeable Mg proportions are marginally imbalanced, but are generally acceptable. Exchangeable Ca:Mg ratios less than two typically require some form of amelioration before these materials can be used as a growth layer. The overburden materials have a median exchangeable Ca:Mg ratio of 2.7, whereas the potential reject materials have a median exchangeable Ca:Mg ratio of 1.6, indicating that amelioration of overburden materials for use as a growth layer may not be required.

It should be noted that in soil chemistry a pH 1:5 (solid:water w/v) of between 7.9 and 8.4 is regarded as moderately alkaline and a soil pH 1:5 of between 8.5 and 9.0 is regarded as strongly alkaline. 58% of the overburden samples are regarded as moderately alkaline and 29% are regarded as strongly alkaline. Comparatively, 77% of the potential reject samples are regarded as moderately alkaline and 16% are regarded as strongly alkaline. Therefore some degree of nutrient imbalance is likely to already exist in these materials, despite exchangeable Ca:Mg ratios in these materials being generally acceptable.

In summary, most of the overburden materials are regarded as moderately to strongly alkaline. All have generally moderate salinity (median EC = 700 µS/cm) and display moderate to high eCEC values. All overburden materials can be regarded as being marginally sodic and have a marginal exchangeable cation imbalance.

5.4 Potential Management Measures

The ongoing management of mineral waste (overburden and potential reject materials) should consider the geochemistry of materials with respect to their potential risk to cause harm to the environment and their suitability for use in revegetation. The design of a mineral waste management strategy for the project should focus on:

- Placement of mineral waste materials to minimise run-off and erosion.

- Evaluating the geochemical characteristics of materials from untested areas or lithologies that have not been evaluated.

All rejects, including coarse rejects and paste thickened tailings, will be mechanically mixed via dozer back into the spoil material to form the in-pit spoil dumps. This method of disposal is appropriate for these materials, especially given the expected low environmental risk of these materials. The assessment has identified that almost all overburden and potential reject materials are expected to be overwhelmingly NAF. A very small proportion of potential reject materials may have a low capacity to generate small quantities of acid, however the small quantity of acid that could potentially be produced from these materials (based on the very low sulphur concentrations), would be sufficiently neutralised (buffered) by the relatively high acid neutralising capacity and naturally high alkalinity of the overburden materials. Therefore no specific management measures are likely to be required to manage potential acid generation in spoil or rejects.

The possible exception here is the final void of the Heyford Pit, which will likely have seepage generated from the coal seams, of which a small proportion (from potential coal reject testing) has been shown to be potentially acid forming (albeit at a low capacity). The impact this may have on final void water quality is discussed in Section 6.

5.4.1 Ongoing Geochemical Sampling and Analysis

The distribution of drill holes used for geochemical sampling is shown in Figure 5.1. This shows that the geochemical information to date has largely been derived from the Horse Pit area.

The geology of the project site, from Harrow Creek to the northern boundary of Horse Pit, is relatively uniform (i.e. the same units and lithology) despite seam splits. Therefore, the geochemical characteristics of mineral waste materials from the Heyford Pit (the southern section of the project) are expected to be the same as those tested at Horse Pit and similar to the geochemical characteristics of the existing Peak Downs Mine to the south.

Despite the expectation that the geochemical characteristics of the southern section of the project site will be the same as other areas nearby, BMA will undertake ongoing operational geochemical characterisation of mineral waste materials in the southern section of the project area to confirm the expected geochemical characteristics of these materials.

Characterisation of reject materials from the CHPP will also be undertaken to verify the expected geochemical data of rejects. This data will be used to re-evaluate the management strategies of mineral waste materials.

For future work, in addition to standard acid-base and metals testing (static tests), geochemical characterisation will include assessing the general soil properties (sodicity, exchangeable cations) of mined waste materials to evaluate their suitability for use in revegetation activities.

5.4.2 Water Quality Monitoring and Management

Leachate and site water derived from, or in contact with, spoil piles, reject materials or other mineral waste is not expected to be problematic with respect to pH (acid) and metals, however the moderate EC of the overburden materials suggests that salt concentrations in leachate may need to be monitored to ensure nearby drainages are not receiving salt loads that could impact upon the existing ecosystem. This will be managed by retaining surface seepage and runoff water on-site. This water will be reused in the site water management system. This will be particularly important in the vicinity of the CHPP where coal washing is likely to produce brackish run-off water.

Further information regarding surface water quality and surface water management is provided in Section 6.