CAVAL RIDGE MINE PROJECT

Final Void & Landform Management Plan

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GLOSSARY OF TERMS

AHD	Australian Height Datum
AOC	Approximate Original Contour
BMA	BHP Billiton Mitsubishi Alliance
CPP	Coal Preparation Plant
EA	Environmental Authority
Final Void	The last mining pit and remaining ramps.
EPA	Environmental Protection Agency
EP Act	Environmental Protection Act 1994
EMPlan	Environmental Management Plan
Endwall	The lengthwise extremities of the pit. (As opposed to the side extremities which are the highwall and lowwall).
FRR	Final Rehabilitation Report
Highwall	The pit wall of un-mined land
LOA	'Life of Asset' Mine Planning
Lowwall	The spoil placed immediately adjacent to the pit in the previously mined strip and can rise to crest of a prestrip dump.
Partings	Overburden strata between coal seams
Pre-stripping	The operation to remove overburden with truck and shovel
Rehabilitation	Earthworks and revegetation treatments
Rejects	Coarse coal washery waste stream (non-coal material).
Residual Void	A void remaining after mine site closure.
RO	Runoff Coefficient
Salinity	Generally refers to the concentration of sodium chloride & other salts either in soil or water
Spoil	Overburden after removal to expose the coal seam
Tailings	Fine coal washery waste.
Topsoil	The upper layer of the soil profile removed for reuse in rehabilitation.
TWL	Top Water Level

1 EXECUTIVE SUMMARY

The Caval Ridge EIS has been submitted to the Queensland government and its agencies have requested that the proponent BMA provide further information on the treatment and performance of residual voids. These queries relate to the location and size of the residual void, prospective rehabilitation treatments; possible interaction of the groundwater table with the residual void; long term water levels and the potential for outflows; stratification potential and the long term salinity of the void water. DERM states that the EIS should include a detailed reasoned evidence based assessment for the potential of saline water in the void to recharge groundwater including the alluvial aquifer.

Thus one objective of this Final Void and Landform Management Plan, which is part of supplementary environmental impact study (SEIS) has been to examine the possible hydrological behaviour of the residual void under a number of different scenarios. The modelling includes potential interaction with the regional groundwater table, long term void storage and salinity levels. Strategies for the rehabilitation of the future Caval Ridge spoil landform and residual voids are also proposed. Areas of further research and investigation during the mine operational period which may improve the outcomes for final void stability and potential uses are also discussed.

The main EIS document project description provides a series of preliminary ‘snapshots’ of a feasible mine development and the mine landform at various points in time. That modelling has been based on an understanding of the coal resource, demand forecasts for product coal and preliminary mine design, overburden placement criteria and rehabilitation slope limits. The feasibility modelling based on the aforementioned matters confirmed the viability of mining beyond 30 years. Thus, for the purpose of discussing final landform scenarios the 30 year position was utilized and a number of feasible rehabilitation strategies for voids and spoil areas as detailed in the BMA Guideline for Sustainable Mine Landforms have been examined.

The treatment of final voids and the final configuration of highwalls and endwalls is an area of considerable interest and largely unresolved from an industry viewpoint. Many open cut coal mine operators intend to use a fence and bund scenario and DERM has approved this via Environmental and Integrated Environmental Authorities for many years. Notwithstanding this, DERM (previously EPA) via its Guideline18 Policy determination indicates a reluctance to accept relinquishment of mine leases that include spoil areas and voids left in an unsafe, unstable or unsustainable configuration. In this regard, BMA is firmly committed to stable landform outcomes for all mining disturbed areas.

As indicated above, the Caval Ridge Mine conceptual residual void treatment in the main body of the EIS is provisional and has been based on a number of assumptions regarding stable strata and spoil slopes. Nonetheless, this is the base case and will be followed by a number of iterations in mine planning and scheduling to investigate the prospect of reducing the footprint of the final voids and adoption of more conservative design parameters for the rehabilitated landform.

Once commissioned, the Caval Ridge Mine should remain an operational project well into the foreseeable future and the final configuration of the mine will ultimately depend on demand for coal and other factors. However, in line with its commitments for reducing the footprint of final voids, BMA will seek to infill voids with spoil, reject and dewatered tailings waste to the maximum extent practicable. For example, recent progression of life of mine planning (LOM) plan indicates that all ramps at Caval Ridge Mine will be completely backfilled during operations. This represents a significant reduction in void area. Notwithstanding, some residual void must remain at closure. Mine planning revisions which are routinely carried out during the life of any open cut coal mining operation will result in changes to the final void position, size and configuration. This is a normal situation with large opencut mine operations.

Provision of specific geotechnical and hydrological data pertaining to residual voids at the site will not be feasible for some time. Accordingly, some of the following information contained in this supplementary report is necessarily conceptual. However, pertinent site data has been used to the maximum practicable extent and conservative values have been adopted for those parameters which have yet to be derived from actual field measurements. Overall conservative values have been adopted for predicting standing water and salinity levels in the residual void.

This investigation includes contributions by URS Australia Pty Ltd (URS), PW Baker & Associates Pty Ltd (PWB) and BMA Coal (BMA) and has where appropriate drawn on the findings of several residual void investigations that BMA has completed and submitted to the DERM in 2008 and 2009 as well as the results of earlier studies sponsored by BHP in the early to mid 1990's. Further as indicated above, BMA mine planning have provided initial results for reduced void footprints based on recently commenced LOA plan revisions.

Overall, the hydrological and salinity modelling demonstrates that the projected Caval Ridge final voids and other like voids in the project area will have very little potential to fill and spill, unless unusually large spoil or undisturbed catchment areas report to the void and or extreme regrading or backfilling is undertaken. Nonetheless, with a regraded void situation the void itself becomes a considerable catchment with the potential to store large quantities of water. As with the findings of several other mine void studies undertaken in the Bowen Basin, the URS salinity model shows that increased salinity through time in the final void is likely unless strategies are implemented which modify the relationship between the regional water table and the mine void and its contributing catchments. However, much more work needs to be undertaken before this potential can be confidently assessed.

The results of the preliminary modelled scenarios for the Caval ridge project indicate that there is insufficient water (after 100 years) accumulated in the void above the depressed groundwater table. Thus the void acts as a sink and local groundwater gradients are always towards the void, unless greater amounts of backfill and or catchment areas are utilized. Further work will be undertaken during operations to examining different void configurations to assess the interaction between the groundwater table and the void storage.

During the operational phase BMA will be committed to undertake further investigation in support of firming up residual void stability, hydrological behaviour and void rehabilitation strategies. These studies/investigations include:

1. More detailed hydrological (runoff quantity and quality) and geochemical research aimed at more accurately predicting long term void water levels and mechanisms that may be used to enable the void to self regulate its salinity and not adversely impact on useful groundwater reserves.

2. Groundwater investigation aimed primarily at understanding the behaviour of the regime in particular reference to refining the likely final position and configuration of the final void so that the void's potential to depress (or recharge groundwater in very high backfill situations) is more fully understood and that the refined integrated

hydrological model accounts for groundwater movements more comprehensively in determining long term storage and salinity levels.

3. Ongoing spoil characterisation to determine the characteristics of spoil emplacements surrounding residual voids as well as physical measurements of spoil runoff and leachate to refine the void salinity balance.

4. Durable rock identification to ensure that sufficient material is available for rock mulching steep long slopes into voids – in the event that improved outcomes for landform stability, void hydrology and salinity are indicated.

5. Further investigation into erosion mitigation on long slopes which will be formed when highwalls, endwalls and lowwalls are subjected to substantial regrade treatments.

6. Active liaison with DERM so that the Regulator can more comprehensively understand the complex nature of the final void issues and provide more strategic advice on its requirements for the rehabilitation outcome for large residual voids in Central Queensland. This will assist BMA as it develops strategies for mine closure which are consistent with the Regulators long term view and requirements.

7. The process of refining rehabilitation methods for spoil areas, including residual voids and developing appropriate land use goals for land disturbed by mining is an ongoing one as mining technology develops and mine plans change. Accordingly, in the future, the treatments proposed for residual voids may change. Nonetheless, BMA is committed to stable and sustainable outcomes for the Caval Ridge residual voids.

The desired outcome for the Caval Ridge residual voids is that a stable landform eventuates and that costs/liabilities to BMA are tolerable at closure. The final void and its configuration and its performance characteristics will be progressively refined during the operational life of the Caval Ridge mine.

2 BACKGROUND

EIS Section 3 Project Description provides a detailed description of the project. In summary however, the Project will be an open cut coal mine using a conventional Dragline, excavator and truck fleet. The coal from Caval Ridge Mine will be processed at an on-site Coal Handling and Preparation Plant (CHPP). Development and construction activity is expected to commence 2011, with first coal to be produced in 2013/14. The mine life is expected to be at least 30 years.

The overburden removal process will comprise a combination of truck shovel fleets and draglines. The new Horse Pit is located on the limit of oxidation (LOX) line, with coal reasonably close to surface, whilst the existing Heyford Pit will continue eastwards.

Open cut mining at Caval Ridge will utilise the strip mining technique. The length of the strip ranges from pit to pit but is typically 1.5 to 2 km, with strip widths of 60 m. The strips will be constructed in a north-south direction along the strike of the coal seams. The primary coal seams are the Q seam - P seam zone, the Harrow Creek Seams and the Dysart Seams. The angle of the high wall will be dependent on the nature of the high wall material. Coal ramps will extend into the pits with the surface haul roads connecting them to the CHPP. The mine operation will follow the coal seams and will become progressively deeper from west to east

The depth to the deeper Dysart seams varies, but the deposit dips eastwards and by year 30 both the Horse and Heyford pits are projected to reach approximately 200m depth below natural ground levels. As indicated in the previous section, the final position and configuration of residual voids largely depends on future global market demand for the coal product.

The proposed post-mine land use for disturbed areas is a mosaic of self sustaining vegetation communities and grazing land using appropriate native tree, shrub and grass species, and improved pasture species as appropriate. This includes the batters of the final void, depending on which type of regrade scenario is eventually utilized. Local plant species will be included in the seed mix so as to restore elements of the pre-mining communities to the rehabilitated assemblages. The description of residual void treatment in the main EIS documents is superseded by the discussion and findings in this further submission to the Queensland government.

3 ENVIRONMENTAL CHARACTERISATION

3.1 PRE-MINING LAND SUITABILITY AND USE

Details for pre-mining land use and soils within mine lease areas have been described in the Caval Ridge EIS. Land within all of the project area has been used for beef cattle grazing for many years. The area is under extensive buffel grass with some areas under native grass and tree cover. The majority of the project site has a Class VI land capability – not suitable for cultivation and is moderately susceptible to degradation requiring proper management to sustain the land use. Some Class V land (high quality grazing land) occurs adjacent to Cherwell and Caval Creeks. The land surrounding Horse Creek and its tributaries and two smaller creeks in the southern section of the project site have also been identified as Class V land capability.

3.2 POST MINING LANDUSE

The proposed post-mining land use for the project site is expected to be a mosaic of self sustaining vegetation communities and grazing land. The percentage of the mined area as void will vary depending on the final grade used in rehabilitating void and the extent of backfill. The current EIS preliminary mine plan shows that by year 30 there may be some 2,208 ha of spoil and residual voids at the larger Horse pit. Depending on what scenario for residual void treatment is ultimately utilised, voids may make up between 50% and 70% of the final spoil landform. A 10% spoil regrade for example increases the immediate drainage catchment of the voids considerably from approximately 50 % of the mined out area for a base case, fence and bund scenario to approximately 70% for a 10% spoil regrade treatment.

Use of the resultant void water will be dependent on the actual treatment imposed on the residual void. Nonetheless as indicated in the EIS Appendix Q, it is BMA's intention to provide a usable water storage or biologically viable water resource. Specifically the EMPL states "the water quality of any residual water bodies meets criteria for subsequent uses and does not have the potential to cause environmental harm." This may require reconfiguration of the residual voids to some extent as is discussed in later sections of this document.

This submission expands upon the preliminary advice provided in the EIS document in that the 30 year landform and void scenario is now examined more closely with respect to possible landform configurations that are supported by the BMA Guideline for Sustainable Landforms; and further, the void landform has been remodelled according to these landform strategies and the models have been subjected to hydrological and salinity modelling. Important behavioural aspects highlighted by the hydrological modelling at Caval Ridge and other BMA mine sites in Central Queensland are discussed in this report.

3.3 CLIMATE

The Caval Ridge project is located in the warm subtropics. The area exhibits moderate average annual rainfall and high evaporation rates. The area experiences hot summers and warm winters with an average daily maxima of 33.8^{o}C in December and 23.6^{o}C in July.

Rainfall is highly variable between and within seasons. Most rainfall (approx. 70%) occurs as intense storms and cyclonic rain in summer (December to March).

Overall, the annual rainfall is highly variable and droughts are common. As rainfall is generally concentrated in the cyclone season, temporary water surpluses can occur although evaporation rates are much higher than rainfall. Long term averaged monthly and annual precipitation and evaporation is shown below in
Table 1.

Table 1 Long Term Climate Statistics BOM Moranbah

Month	Temperature ^{o}C		Relative Humidity %		Evap (mm)	Wind Speed Km/Hr	Rainfall (mm)		
	Average Min	Average Max	9am	3pm	DAILY	3pm	Median	Highest Daily	Highest Monthly
Jan	22.0	34.2	69	41	8.5	8.5	66.6	120.4	315.0
Feb	21.8	33.2	73	46	7.7	9.6	85.8	150.8	316.2
Mar	20.1	32.3	70	41	7.2	9.5	34.6	164.8	268.0
Apr	17.6	29.5	73	44	5.8	8.8	25.2	143.8	271.0
May	14.4	26.4	73	45	4.3	6.8	27.6	58.0	196.6
Jun	11.0	23.7	72	43	3.6	6.3	9.4	38.8	55.3
Jul	9.7	23.6	69	39	3.8	6.8	5.9	60.0	103.6
Aug	11.1	25.2	66	36	4.9	7.7	12.5	150.8	247.3
Sep	13.9	29.4	57	28	6.7	9.0	3.8	20.4	39.4
Oct	17.6	32.2	59	31	8.0	8.6	15.8	73.8	146.6
Nov	19.5	33.0	61	35	8.6	8.8	69.4	85.6	220.3
Dec	21.1	33.8	65	40	8.7	8.5	82.6	116.6	318.2
Annual Av.	**16.7**	**29.7**	**67**	**39**	**2,366**	**8.2**	**583.6**	**164.8**	**208.1**

High rainfall events are common hence surface runoff can be substantial. Average evaporation exceeds average rainfall 12 months of the year and the evaporation average is about 4 times the annual rainfall. The long term average annual rainfall is approximately 584mm falling on an average of 55 rain days. Evaporation rates are high through the year, particularly so in the summer period. Annual evaporation is approximately 2,366mm. (Moranbah weather station), thus evaporation greatly exceeds precipitation, hence water stress is expected to be significant factor in the performance of future rehabilitation of disturbed land, particularly on slopes or where topsoil thickness is limited and the under lying spoil may be compacted.

The climate information indicates that evaporative losses from the residual Caval Ridge voids will be high and thus function as one of the prime determinants in establishing the long term water level.

3.4 BACKGROUND SURFACE WATER QUALITY

Refer to the Caval Ridge EIS Section 6, Surface Water Resources for details, but in summary; the project site covers tributary streams of the Isaac River in the headwaters of the greater Fitzroy River catchment. The area is divided by a relatively indistinct ridgeline dividing two watersheds: the northern watershed includes Horse Creek and its tributaries; and the southern watershed includes Nine Mile Creek, Caval Creek, Harrow Creek, Cherwell Creek and their respective tributaries.

All watercourses and tributaries within the project site are ephemeral watercourses. Periods of flow are generally short and limited to periods during and immediately after rainfall. There is no evidence of significant contribution to stream flows from groundwater sources.

Table 2 summarises data collected by monitoring programs at the adjacent BMA Peak Downs Mine.

Table 2 Upstream water qualities – Local Area

Data Averaged from 01/07/2007 - 01/07/2009	pH	EC uS/cm
DS Cherwell Ck	7.2	287
US Cherwell Ck	6.8	373
North Ck	7.0	274
DS Harrow Ck	8.3	282
US Harrow Ck	6.8	223
US Boomerang Ck	6.4	344

Overall, creeks with largely undisturbed catchments exhibit low salinity, typically less than 300 uS/cm.

3.5 SPOIL CHARACTERISTICS

The chemical and physical characterisation of spoil surrounding and residual void will influence residual void stability and water quality. The EIS document (EIS Appendix H Geochemical Assessment) provides comprehensive information on overburden collected and analysed as part of the exploration program.

However, the results of geochemical static-test data collected from seven drill holes can be summarised as follows:

- All overburden (including interburden) and almost all potential rejects tested are non acid forming (NAF). Similar results have been obtained at the adjacent Peak Downs mine.

- All of the tested overburden composite materials (and also the potential reject materials) had variously elevated Exchangeable Sodium Percentage (ESP) values, ranging from 8.5 per cent to 25 per cent (median 11 per cent). Thus all overburden materials can be regarded as being marginally sodic and have a marginal exchangeable cation imbalance.

- Most of the overburden samples 58 are regarded as moderately alkaline and 29 per cent are regarded as strongly alkaline. Comparatively, 77 per cent of the potential reject samples are regarded as moderately alkaline and 16 per cent are regarded as strongly alkaline.

- Most of the overburden and waste material is only moderately saline typically $EC_{1:5}$ 600-700us/cm. Some shallower overburden is quite saline. E.g. 1,000 – 2,000 uS/cm. (Refer EIS Appendix H. See Table 2.1. Acid-Base Test Results for Overburden and Potential Reject Samples - Peak Downs Expansion Project)

Overall, the EIS analyses indicate that the Caval Ridge spoil material will be a more moderate material than occurs at some opencut coal mines in the region. The spoil is confidently expected to be non acid forming, moderately sodic, moderately alkaline and moderately saline.

From a fertility view point, the overburden testing shows that cation exchange capacity is moderate to high, that Ca: Mg ratios are for the main tolerable, but that alkalinity is generally quite high and will predispose the media to favor grasses rather than native eucalypt tree and shrub species which generally prefer a slightly acid environment. However, some of the black clay soil species such as Dawson Gum and Mountain Coolibah may prove to be useful species in areas of future rehabilitation where dark clays are applied. Topsoil will be required to establish a viable vegetation cover for much of the spoil area.

3.6 TOPSOIL QUALITY AND RESOURCES

The soil survey shows that soil types vary greatly in the project area. This is a typical finding in the Moranbah region. Identified soils include:

- Yellow Duplex Soils
- Red Brown Duplex Soils
- Deep Sandy Loams
- Uniform Clays
- Brigalow Clays
- Shallow Heavy Clays
- Skeletal Soils
- Shallow Sandy Soils
- Dark Heavy Clays

As part of the Caval Ridge EIS, topsoil resources have been assessed for soil type, pre-mining land suitability and stripping depths formulated. All topsoil in advance of mining will be stripped to recommended depths and either stockpiled or replaced over rehabilitation. Good quality low salinity topsoil used in rehabilitation is conducive to low salinity surface runoff.

3.7 PIT AND SPOIL WATER QUALITY

Presently, there is insufficient information to accurately predict spoil runoff and seepage qualities into Caval Ridge pits for the purpose of long term predictive void hydrological and salinity modelling. However, as already discussed, the geochemical analyses undertaken at Caval Ridge as part of the EIS submission indicates that runoff from spoil should be moderately and not highly saline. Once covered with topsoil and vegetation, low to moderate salinity in runoff is reasonably expected from these areas.

There is also some further supporting indication that spoil salinity and spoil leach quality may be relatively low for this site. Leach tests were conducted on CQ mine spoils including the adjacent Peak Downs Mine as part of ACARP Project No. C7007 – Water Quality and Discharge Predictions for Final Void and Spoil Catchments. See

Table **3** below.

Table 3 Average Spoil Leach Test Salinity TDS in mg/L*

BMA Mine	Peak Downs	Norwich Park	Gregory	Blackwater	Moura	Saraji	Goonyella
TDS	168	404	539	328	250	502	976

*Extracted from ACARP Project No. C7007: TABLE 7.2 – Summary of Spoil Leach Test Results at Participating Sites;

The leach tests show that spoil leachate is highly variable across the Bowen Basin, but that some spoils can express quite low salinity. The Peak Downs Mine result is most pertinent given its close proximity to the Caval Ridge project. When the Caval Ridge spoil salinity is considered with the leach test result for the adjacent Peak Downs mine, it is reasonable to expect that overall, Caval Ridge spoil runoff including as leachate should not be excessively saline.

Further, the pH of almost all samples measured at Caval Ridge are alkaline to strongly alkaline as reported in EIS Appendix H, thus it is also reasonable to conclude that surface runoff from Caval Ridge spoil areas will be alkaline. (Note a similar alkaline pH regime exists at the adjacent Peak Downs Mine). It follows that pit water accumulating from surface runoff and spoil seepage generated from spoil is also expected to be reflective of these characteristics, <u>at least in the short term.</u> Evaporation will concentrate salts if no release mechanism is present. Refer to Section 5 which discusses longer term void salinity balance.

3.8 GEOLOGY

The Caval Ridge EIS Groundwater Impact Assessment Appendix Section J, 4.1.1 Geology reports that the proposed Caval Ridge Mine is located on the relatively undisturbed western limb of the northern Bowen Basin which overlies the Collinsville Shelf (part of the Clermont Block) in the area. The Bowen Basin in the area is characterized by a relatively thin accumulation of sediments, gentle easterly dips and minor to moderate deformation. Regionally, the stratigraphic sequence is formed by the Permo-Triassic sediments of the Bowen Basin which are overlain by a veneer of unconsolidated Quaternary alluvium and colluvium, poorly consolidated Tertiary sediments and, in places, remnants of Tertiary basalt flows.

The Moranbah Coal Measures, which contain the coal seams proposed to be extracted by the project, conformably overlie the German Creek Formation and are conformably overlain by the Fort Cooper Coal Measures.

The lithology of the Moranbah Coal Measures generally comprises 300 m of fine-grained sandstone, siltstone, mudstone, claystone and coal, which remains uniform throughout the entire site. The Moranbah Coal Measures are characterized by several laterally persistent, relatively thick, coal seams interspersed with several thin minor seams which commonly split and coalesce. The target seams for the proposed Caval Ridge Mine are all the seams in the lease that are > 30 cm thick. The primary targets are the Q seam - P seam zone, the Harrow Creek (H) group of seams, and the Dysart (D) seams.

The poorly consolidated Tertiary sediments unconformably overlie an irregular erosion surface of Permian strata. These sediments consist of lenses of river channel gravels and sands separated by sandy silts, sandy clays, and clays. The Tertiary silts and clays are densely compacted, hard and generally dry. Most of the clean sand and gravel lenses are permeable but are of limited lateral and vertical extent. Lag deposits of sand and gravel are found directly on the Tertiary/Permian unconformity, but can also be present related to recent Quaternary deposition from the drainage lines in the area. In the north remains of Tertiary basalt flows overlay the Permian sequence. The basalt is typically variably weathered.

3.9 GROUNDWATER

3.9.1 Resources

The EIS reports that the Quaternary alluvial formations, Tertiary sediment and basalt formations, and the Permian coal measures generally yield low sustainable volumes of poor quality groundwater and are not recognized aquifers in the area. Overall findings included:

Quaternary Alluvium: Hydraulic testing of the Quaternary alluvium provided hydraulic conductivity rates between 0.09 and 0.4 m/day, which are typical for silt to fine sand. The Quaternary alluvial aquifers are not regionally extensive and, accordingly, groundwater extraction at high rates would not be sustainable in the long term.

Tertiary Sediments: Historically mining issues with Tertiary sediment derived groundwater at the Peak Downs Mine to the south of the proposed Caval Ridge Mine appear to have been limited to pit wall stability rather than ongoing problems with groundwater inflow, indicating the limited lateral extent of the more permeable areas.

Tertiary Basalt Aquifers: The drilling program undertaken as part of this study showed that the Tertiary basalt appears to be highly heterogeneous and discontinuous locally. Historically mining issues with Tertiary basalt derived groundwater at the Peak Downs Mine immediately to the south, appears to have been limited to pit wall stability rather than ongoing problems with groundwater inflow, indicating the limited lateral extent of the more permeable areas on site.

Permian Strata Aquifers
In common with other areas in the Bowen Basin, the coal seams constitute the main aquifers in the Permian strata, but the jointed sandstone overburden and interburden may also be locally important for storage and transmittal of groundwater. The vertical anisotropy in the Permian strata may restrict upward/downward leakage, both between layers within the Permian and from the overlying Tertiary formations and alluvium. Consequently, perched water tables may be present above layers of low permeability material, such as mudstones or unfractured rock within or above the Permian. However there will be local interconnection of aquifers along fault planes.

There are three main coal seams in the proposed Caval Ridge Mine area, the Q seam - P seam zone, the Harrow Creek (H) group of seams and the Dysart (D) seams. These main coal seams form the most extensive aquifers locally. The coal seams subcrop in the western half of the site, and the coal seam aquifers are semi-confined to confined depending on location.

Recharge of coal seams is generally by infiltration of rainfall and overland flow in subcrop areas, and by downward leakage from overlying aquifers in the Tertiary formations and Quaternary alluvium. It is considered that due to the clayey nature of the Tertiary formations unconformably overlying the coal seams, recharge from rainfall infiltration will be limited. Leakage between aquifers through faults is governed by the hydraulic conductivity of the fault, the interburden thickness between the aquifers, and the piezometric level in the aquifers.

The EIS data includes a summary of airlift yield from exploration boreholes. The data indicates that of the 2,427 exploration bores identified on site, 164 had recorded airlift yields. Of bores which produced airlifted water approximately 60% yielded 0.5 L/s or less and approximately 30% of bores yielding between 0.5 and 2 L/s. Less than 2% of the exploration bores yielded greater than 5 L/s. The extremely low airlift yields strongly indicate that groundwater resources are extremely limited in the Caval Ridge Project area.

The EIS also notes that historically, mining issues with the Permian strata derived groundwater in the Peak Downs Mine immediately to the south appears to be limited to pit wall stability rather than ongoing problems with groundwater inflow. This indicates the generally low permeability of the Permian strata on site. Groundwater and surface water inflow are removed by pumping from in-pit sumps.

3.9.2 Groundwater Quality

The Caval Ridge Project EIS presents groundwater quality data available from 15 monitoring wells installed across the site. The salinity (measured as total dissolved solids) of groundwater in these bores is highly variable and ranges from 351 uS/cm for the shallow alluvial through to 21,450 uS/cm for the Dysart Coal Seam. See Table 4.

Table 4 Groundwater Quality - Caval Ridge Project

Bore ID	Aquifer Type	EC (µS/cm)			pH		
		June 2008	September 2008	February-March 2009	June 2008	September 2008	February-March 2009
Pz01	Coal Seam D04	NR	NR	15,610	NR	NR	6.87
Pz02	Basalt	2,580	1,540	2,180	7.94	NR	7.87
Pz03-S	Basalt	13,520	12,470	10,930	6.78	NR	6.96
Pz03-D	Coal Seam D04	19,970	21,450	16,570	7.10	NR	6.72
Pz04	Coal Seam Q	1,529	1,107	1,111	6.74	NR	6.66
Pz05	Coal Seam D04	NR	NR	13,630	NR	NR	7.21
Pz06-S	Basalt NR	1,639	1,688	7.73	NR	7.67	
Pz06-D	Coal Seam P02	1,691	1,981	1,813	6.81	NR	6.89
Pz07-S	Alluvium	NR	351	443	6.35	NR	6.51
Pz07-D	Coal Seam Q01	NR	3,890	3,960	6.84	NR	7.15
Pz08-S	Alluvium	NR	1,861	2,129	6.49	NR	6.99
Pz08-D	Sandstone Interburden	12,510	11,380	6.43	6.43	NR	6.83
Pz09	Coal Seam P08	NR	12,510	9,790	NR	7.15	7.26

Bore ID	Aquifer Type	EC (µS/cm)			pH		
		June 2008	September 2008	February-March 2009	June 2008	September 2008	February-March 2009
Pz10	Coal Seam H08	NR	9,090	Destroyed	NR	7.24	Destroyed
Pz11-D	Coal Seam P08	NR	8,650	7,220	NR	7.62	7.47

Groundwater investigations indicate that most groundwater in the mine area is contained in low yielding aquifers associated with coal measures or with basalt deposits or sandy channels in the local streams. The groundwater associated with the coal seams is generally saline. The shallow aquifers associated with the stream channels are of variable quality and limited quantity.

3.9.3 Groundwater Inflows to Final Void

The Caval Ridge EIS Appendix J Groundwater reports that the final voids if left at end of mining depth and configuration (the base case referred to in this supplementary report) will act as sumps, hence receive inflows of groundwater. The estimated hydraulic conductivity (k) values utilised for the three potential contributing aquifers indicates that the combined ingress of groundwater to the bottom of the pits, some 150 m -180 m below surface, will average 27,900 m^3/day for the Horse Pit and 22,300 m^3/day for the Heyford Pit. However, this is a very conservative (over) estimate, as the EIS acknowledges that in reality, the mine pits are located in or close to the outcrop of the coal seams such that ingress to the pits from up gradient of the pit will be negligible.

The EIS reports that a rise in the final void water salinities may result from evaporative concentration processes, and from atmospheric weathering of excavated exposed bedrock. Although water quality in the final void is expected to deteriorate over time, this deterioration in water quality is not expected to impact the surrounding aquifers as the voids are expected to operate locally as a groundwater sink (i.e. groundwater flow will be toward the void), so that water within the void will not recharge the groundwater system unless water levels in the void rise above existing groundwater levels in the coal seams. Groundwater contours at equilibrium have now been generated, which show groundwater flow towards final void (Appendix D in URS model report). For the three scenarios examined, post-mining water quality within all aquifers surrounding the project area is expected to remain the same as pre-mining water quality.

This supplementary study discusses at a conceptual level how strategies might be implemented beyond the base case which change the salinity and hydrological status of the residual void.

4 RESIDUAL VOID DESIGN STRATEGIES

The Caval Ridge project is committed to undertaking substantial treatments of residual voids in order to ensure that such areas are safe, stable and sustainable after cessation of operations.

In 2007, BMA and its consultants commenced development of a set of generic design criteria to assist its sites with the development of stable landforms. "Guideline for the Design of Sustainable Mine Landforms". This landform guideline has been developed to help BMA mines implement closure planning processes aimed at the achievement of sustainable rehabilitated landforms on a cost effective basis.

The guideline acknowledges that rehabilitation of mine disturbed land is not simply an environmental task. The work is of a complex and expensive nature and satisfactory outcomes can only be available if closure planning is embraced at the corporate, site management and operational levels.

There has been recognition for some time that spoil placement programs have largely been formed on the basis of minimizing haul distance and not necessarily in alignment with the construction of a sustainable final landform. The BMA Sustainable Landform Guideline requires that planning, design and scheduling of excavation and spoil placement should be aligned with a mine closure plan so that cost effective practices can be implemented during the operational phase of mining with a goal of substantially reduced rehabilitation expenditures at closure. This is the essential basis of BMA closure / rehabilitation requirements.

These guidelines provide a framework for implementation of the closure process based on:

1. Embedding closure / landform requirements into the responsibilities and accountabilities of all senior personnel. This is necessary as the ability of mines to implement satisfactory closure planning and implementation processes will necessarily impact on the business and its long term viability.

2. Outlining preferred strategies / practices for improved spoil placement and reduction of void volume by closure, hence progressive backfill when practicable is encouraged.

3. Describing various treatments which could be used to better stabilize spoil placement and in particular recognition that long Tertiary spoil slopes are exceedingly difficult to stabilize without rock mulching.

4. The guideline also discusses rehabilitation resource inventory programs; given that rock mulching is seen to be an important aspect of stabilizing steep slopes. Knowledge of the available resource and routine salvage during stripping / excavation operations will be necessary.

The BMA "Guideline for the Design of Sustainable Mine Landforms" has been developed and is currently subject to site and corporate review. Importantly however, the guideline focuses on progressive backfilling of ramps and final voids during operations to improve spoil fit and reduce haul costs as well as minimise the amount of open void at cessation of mining. The guideline will require annual updating to ensure that improvements in outcomes from operational experiences and learning's are retained.

The guideline provides for a range of conservative treatments aimed at making residual voids safe and stable once rehabilitation of the site has been completed. Treatments for residual (remaining voids at cessation of mining) include:

Ramp:

- Backfilling sequentially with mine spoil or CPP waste.
- Regraded to <10% and capped with Permian spoil as required.
- Steeper slope options should not normally exceed 25% slope and be capped with at least two meters of durable rock and soil matrix.
- Drainage off adjacent prestrip dumps should be integrated into the ramp backfill design.

Lowwall:

- Backfilled sequentially with mine spoil or CPP waste.
- Regraded to <10% and capped with Permian spoil as required.
- Steeper slope options should not exceed 25% slope and be capped with at least two metres of durable rock and soil matrix as described for the highwall.
- Drainage off adjacent prestrip dumps should be integrated into the lowwall treatment design.

Highwall:

- Sequential backfilling of final voids with prestrip spoil or CPP waste is preferred.
- Regrading to <10% slope, covering with at approx. 1m benign rocky Permian spoil before topsoil application.
- Alternatively, a steeper slope up to 25% can be formed and clad with durable rock mulch to at least 2 m deep. If rocky hospitable Permian spoil is placed at least 1m depth first, the thickness of the durable rock mulch cover may be reduced to 1 m. Note that the lowwall should be regraded first to minimize the amount of natural ground that will be disturbed by regrading the highwall.
- Highwalls may remain only in those cases where stability and environmental /sustainability requirements are met.

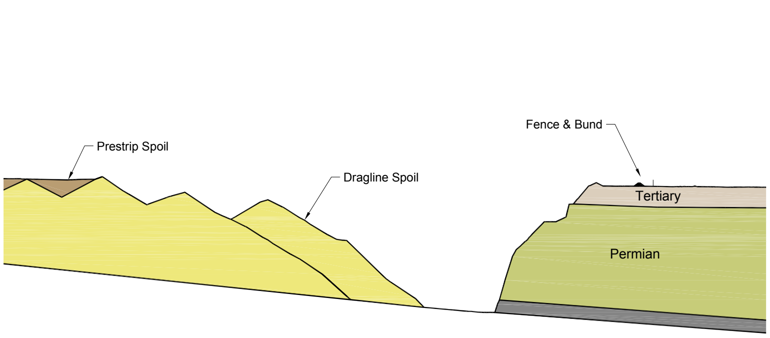
Mine planners will develop mine schedules showing how the mining operation can optimize the backfill of final voids, minimizing lengths of residual highwalls, during operations and satisfy progressive rehabilitation requirements.

It should be noted that the guideline is evolutionary and improvements will be made from time to time. Currently the guideline is focussed more at placement of spoil materials, but in the future may address surface finish and drainage issues.

Further information on the above provisional reclamation strategies which are pertinent to Caval Ridge are as follows:

4.1.1 Fence & Bund Scenario

The fence and bund treatment is reserved for those instances where safe, stable and sustainable highwall and lowwall situations are possible. This is legally allowed under most environmental authorities issued to coal mines in Queensland. However, this scenario may have limited application for the Caval Ridge final highwall treatment given that at the adjacent Peak Downs Mine, there is some occurrence of weak poorly consolidated, sodic, erodible Tertiary material overlaying generally more competent (but not resilient) deeper Permian Strata.

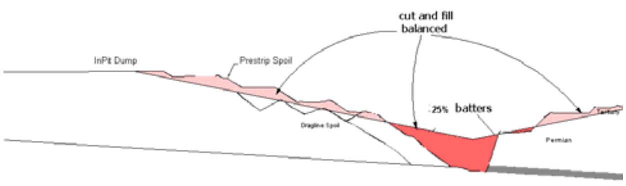


Large open mine void representative of a fence and bund scenario **assuming** competent high and lowwalls.

Figure 1 Fence & Bund Scenario

4.1.2 25% Regrade

The 25:25 regrade concept as described in the BMA Sustainable Landform Guideline which recognises that steep long slopes into the final void will require the application of durable rock mulch. Assessment of rock resources and the development of a durable rock resource inventory will have to be undertaken at an early stage in the mining program to ensure that if this treatment is to be adopted, that sufficient rock resources can be stockpiled to clad the batter of the residual void at closure.

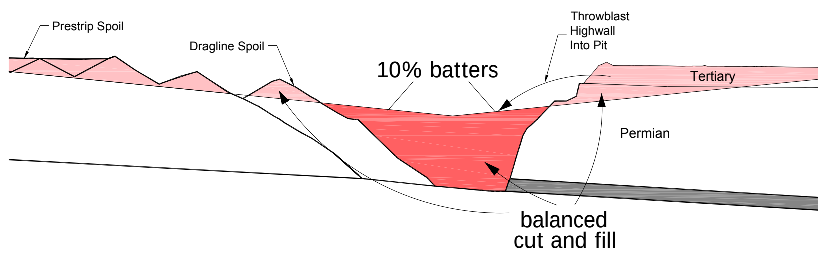


25% Regrade with Rock Mulch Treatment

Figure 2 25% Regrade Highwall & Lowwall

4.1.3 10%Regrade

The 10:10 regrade concept as described in the BMA Sustainable Landform Guideline which recognises that without an extensive application of thick durable rock mulch, long slopes such as occurring on regraded lowwalls and highwalls should be no steeper than 10%.



10% Regrade on Highwall and Lowwall

Figure 3 10% Regrade on Highwall & Lowwall

Drainage control will be an important element of the final design for regraded voids given that the final slopes leading into the voids may range from several hundred metres to a kilometre or more depending on the amount of backfill that is undertaken prior to final regrading. Thus in the future, mine planning and rehabilitation investigations and resultant trials aimed at identifying mitigating strategies to limit erosion on long regraded slopes are warranted. Use of cross slope drainage structures cannot be discounted, but the historical performance of contour banks has been worrisome in CQ mine areas, for the main.

Strategies which could be covered by this further research to develop and refine improved stability outcomes include mine planning studies aimed at reducing relative elevations such as:

- not mining the deeper coal seam in the last one or two mining strips, hence stepping the final void up to shallower levels;
- backfilling to shallow depth before regrading;
- forming a lower elevation prestrip dump above the void by backfilling adjacent voids etc.

Also, investigation of ameliorative treatments is warranted such as:

- application of extensive or localised use of durable rock mulch;
- incorporation of large drainage swales to pass water across the regraded face of the lowwall spoil to deposit water on natural ground or into a ramp entry; and,
- more conventional rock lined and graded bank drainage scenarios may have application in some circumstances.

Use of Rock Mulch has been trialled at Goonyella Riverside Mine on a 60m high out of pit dump. The dump was rock mulched in the mid 1990’s with sandstone rock and sown to native trees and shrubs. The trial has demonstrated that erosion can be largely eliminated if this technique is used. The long term durability of the rock media will probably be the most important aspect in the sustained stability of this spoil landform. In 2006, large area trials of a modified technique involving flatter grades (10%), topsoil and sandstone rock mulch commenced at Saraji Mine 25 km to the south of Caval Ridge project area. To date the results are very promising. The combination of rock mulch and topsoil supporting dense cover of grasses and scattered native trees and shrubs are providing a substantially more erosion resistant cover on the Tertiary spoil rehabilitation.

Ultimately, the Caval Ridge final void regrade/backfill configuration may form a composite of the above scenarios or from others which have yet to be identified. Future operational and industry experiences are likely to provide opportunities to implement improved landform strategies; and further, geotechnical and environmental constraints may vary according to void position and the required landuse outcomes may change in the longer term.

BMA is committed to undertaking substantial treatments of residual voids at its proposed Caval Ridge Mine to ensure that such areas are safe, stable and sustainable after cessation of operations.

Three dimensional models of the large proposed Horse Pit mining area at Caval Ridge mine projected to year 30 have been developed to show the spoil extent and topography under the three landform scenarios. Details are provided in Appendix A of the URS model report and include contours and overall drainage arrangement.

4.2 FINAL VOID SIZE AND LOCATION

The ultimate location and size of the final void can not be projected with certainty and are constrained by economic, statutory and environmental limits. Clearly the rate of pit progression is subject to economic conditions and customer requirements which will impact mine scheduling for both pits. Changes in mine and production schedules, and quality requirements throughout the operational life of a mine are ongoing thus final void positions are for the main a notional concept based on a range of current assumptions.

Nonetheless, BMA recognises that the size and extent of the final void can be reduced by cost effective spoil placement programs in the latter years of the mine life and as already indicated, all BMA operations are currently in the process of developing spoil placement strategies which are aimed at cost effective reduction of the final void foot print. This is an extremely complex and time consuming task which commenced over two years ago. Studies to date show that there are cost and environmental advantages available when final voids are progressively backfilled during operation. Mine planning for the Caval Ridge Project will focus on these issues early in the operational life of the mine to ensure that opportunities for cost effective void and ramp infill are realised; and ultimately, the final void footprint is reduced to the most practicable cost effective extent.

The greatest single challenge for provision of progressive rehabilitation into the future involves effective planning of prestrip operations and spoil placement. This is well recognised by BMA and all of its operations are conducting substantial investigations involving spoil fit, final landform and residual void treatment. Mine planning is an ongoing process and is progressively refined during the life of the operation. Changes in technology, operational costs and product demand require revisions to the mine plan, including the final landform plan.

Long term mine feasibility planning for the Caval Ridge project suggests that truck and shovel will be the primary method for creating the final rehabilitation surface. Further work undertaken to date indicates that by end of operations, all of the lowwall ramps will have been backfilled. It is also likely given preliminary results of long term landform planning at the adjacent Peak Downs Mine, that the final void areas will also be significantly reduced in extent by progressive backfill later in the operational life of the pits. Thus overall, it is expected that the final void footprint areas for both the Horse and Heyford pits will be smaller that the 30 year pit scenario shown in the EIS document.

BMA practice is to review final landform objectives and proposed outcomes annually as part of the Life of Asset monitoring and planning process or in those situations where a material change to the mine plan is required.

5 BACKGROUND VOID STORAGE AND QUALITY BEHAVIOUR

5.1 FACTORS AFFECTING VOID BEHAVIOUR

The long term quality and quantity of water stored in residual voids is dependent on a number of variables including:

1. Climate – particularly rainfall intensity, frequency and evaporation;
2. Catchment areas reporting to the void;
3. Extent of void regrade – regrading voids can substantially increase catchment area and reduce runoff rates;
4. Topographical configuration of the final void and surrounding catchment spoil areas;
5. Effectiveness of rehabilitation in reducing surface and subsurface runoff into the voids;
6. Rapidity of solubilisation of salts being transported by both surface and subsurface drainage to the voids;
7. Remaining amount of process and other water affected by the mine workings pumped into the voids;
8. The salinity potential of the void floor material;
9. The depth and manner of isolation of the coal seams below the rehabilitated/backfilled void floor; and
10. Presence of groundwater inflows and outflows from the voids.

5.2 PREVIOUS STUDIES

Predictive void investigations in Central Queensland have been undertaken by a number of research and consulting groups from time to time since the mid 1990's.

5.2.1 Spoil Hydrology Lumped Parameter Model

The first major investigation was sponsored by BHP Coal Pty Ltd in which PPK consultants (now Parsons Brinkerhoff) prepared a Spoil Hydrology Lumped Parameter Model (SHLPM) for a number of voids at the BHP Coal operations (Now BMA). A daily water balance model was developed in an attempt to assess the long-term hydrological responses of final spoil-void systems in the Bowen Basin. The SHLP Model was designed for situations where containment of water reporting to the final void is required. The model used a 0.6 Runoff Coefficient above water level and Pan Factor of 0.7 for low water level to 1.0 for high-water level.

For the typical void scenario, the PPK modelling indicated that idealised voids would reach a steady state depth in about 40 years post closure. Work by P. Baker in 2003 using OPSIM modelling at Oaky Creek Mine also demonstrated that voids have no potential to spill and are effectively dry most of the time when the catchment area to void area is typically 4:1 or less and where groundwater ingress is minimal. Much greater surface area to void ratios is required to cause a void spill situation.

Whilst it is recognised that in the absence of significant elevated groundwater table, there is little likelihood of typical deep steep sided mining voids storing large quantities of water on a permanent basis, it is conceivable that voids which have large catchment areas and or which have been substantially regraded may have potential to spill in some circumstances. Thus, the potential for voids to spill which have been configured to form either shallower storages and or larger catchment areas has been examined.

5.2.2 ACARP Project No. C7007

A long-term concern for residual voids in arid and semi arid areas is the potential for water to become hyper-saline and perhaps seep into surrounding groundwater tables. This has been recognised for many years. For example, ACARP Project No. C7007 (Water Quality and Discharge Predictions for Final Void and Spoil Catchments) made a number of general / primary findings following completion of their field studies and void water quality modelling. In particular (S7.3 conceptual model of mine water flow) found that:

- There is a correlation between TSS and TDS, thus water quality in final void will be reflective to some extent of the TSS of surface runoff.
- In many situations most of the void water is derived by surface runoff.
- The influence of subsurface flow through spoils might be limited because of low flow volumes moving through the spoil.
- Preferred pathways may exist which may cause rapid movement of seepage water – e.g. along the base of the spoil piles. But preferred pathways may block over time.
- Direct rainfall to the void introduces low concentration water.
- Evaporation has the opposite effect.
- A stable system with no salt build up will occur if groundwater inflows flows are greater than evaporation.
- In a closed system, the water accumulating in the void could come from any of the sources or paths described (groundwater/seepage/preferred pathways/incident rain/surface runoff) but can only leave by evaporation. The water level is maintained by evaporation and evaporation causes continuous deterioration of water quality due to salinity build up.

5.2.3 Gilbert and Assoc Pty Ltd

Gilbert and Associates Pty Ltd conducted computer simulations for final void hydrological assessments in various final configurations at 6 BMA operated mines in the Bowen Basin region of central Queensland in 2008. The work was scoped and managed by PW Baker & Assoc Pty Ltd. Final configurations included: Fence and Bund, 25% batter regrade and 10% batter regrade.

The simulations included inputs of historical rainfall and evaporation data for the region, information on salt concentrations and information on the geology, mining spoil and groundwater conditions provided in various BMA reports. The consultants utilized a version of the Australian Water Balance Model (AWBM) developed by Boughton, W.C. (2004), to estimate the amount of surface water runoff entering pit voids using rainfall data, evaporation data and information on the behaviour of various catchment types contributing water to the voids.

Seep/W was used to determine likely groundwater entry to and exits from the voids using information supplied regarding the local geology and groundwater conditions, so far as this information could be ascertained. Seep/W used the provided information together with information entered regarding water pressure or flow rates at the boundaries of the model to compute flow rates of water across flux lines also drawn in the graphical representation. These flux lines were positioned to measure the rate water entered or left the pit void, as well as the rate water travelled into the pit from expected salt sources such as coal seams.

Seep/W uses a finite element method to solve the Darcy's equations of motion for water through porous media. The model type used in our analysis was a steady state, which computes the rate water would flux through the system once the systems is allowed to settle long term towards the modelled conditions. The flow rates were measured for pit void water set at a variety of depths from empty to full.

The Consultants then applied GOLDSIM software to model the combined effects of surface and groundwater on the depth and salinity levels of void water following the various remediation scenarios considered.

As a result of these BMA void studies, it was found that all void configurations - have high a containment safety factor even when contributing catchment areas are raised by allowing runoff from an additional 500m wide strip of undisturbed catchment adjacent to the void. However in the long term hyper saline water is expected in all instances unless the storage is raised above the groundwater table. Typical results for the three basic void treatment scenarios were as follows:

Fence and Bund - The simulated water levels in the voids reached equilibrium levels after a period of approximately 10 - 20 years and then fluctuated in response to climatic variability. Long term model predictions were for ongoing net groundwater inflows and, as a consequence, salt concentrations as measured by electrical conductivity (EC) units continued to increase slowly throughout the simulation to eventually reach hyper saline levels.

The prolonged increase of salt concentration is due to predicted ongoing net inflows of saline and highly saline groundwater. The void in this situation acts as a groundwater sink. Water is removed due to evaporation and the water surface does not reach a level sufficient to flush dissolved salt back to the underlying aquifer.

25% Regrade Option. The simulated final water levels in the void stabilises to equilibrium very quickly (within 2 to 5 years) and fluctuates about the equilibrium from then on. Net exchange of salt to and from the void stabilised, but salt concentrations in the void fluctuated due to changes in water volume over time. The simulated salt concentrations reached for the 25% regraded void configuration option are typically very high (50,000 to 300,000 μS/cm) and often exceed those for the Fence and Bund situation, however, salt concentration in void stabilise over time as salt eventually enters and leaves the void at similar rates.

10% Regrade Option. The simulated final water levels in the void stabilise to equilibrium very quickly (within 2 to 5 years). Net exchange of salt to and from the void also stabilised but salt concentrations in the void fluctuated due to changes in water volume over time. Importantly concentrations under this scenario are significantly lower than either the Fence and Bund treatment or 25% Regrade options due to transfer of water from the void to the groundwater table.

However, a limiting case was modeled for no transfers between the void and groundwater sources for the 10% regrade situation. This model allowed only surface water runoff from the connected catchment (including spoil) and direct rainfall to enter the pit. That is water leaves only through evaporation and spills. Simulation results from the modelling indicated no spill events (seepage to groundwater) occurred and, as expected, salt concentrations in the void continued to increase throughout the simulations. Thus complete isolation of the void from groundwater transfer would likely produce an “evaporation pan” where salt levels continue to increase at a consistent rate until real world physical constrains limit the process.

5.2.4 SKM – Daunia Project

SKM undertook predictive behavioural modelling of the Daunia mine project as part of supplementary EIS investigations. The work was scoped and directed by PW Baker and Assoc Pty on behalf of BMA Coal. The modelling situations were similar to studies undertaken at all other BMA sites i.e. fence and bund, 25% regrade and 10% regrade; although the modelling methodology utilized different software. The study involved:

- Hydrological assessment of the salt and water balance based on the preliminary residual void concept outlined in the EIS document Project Description using Visual MODFLOW Version 4.2 and Excel modelling techniques.

- Assessment of the long term behaviour of the void and its interaction with local and regional surface and groundwater resources as well as the sensitivity of predicted behaviour to current unknowns;

- Formulation of recommendations for future investigations and research aimed ultimately at developing an acceptable, low risk plan for the final void(s) at the proposed Daunia mine site.

Predictive long term water balance scenarios within the final void were conducted using the model developed for the purpose of identifying environmental impact during mining operation (cf. EIS chapter 05). The model was built within MODFLOW ® software package. MODFLOW is a three-dimensional finite element software product for analysing groundwater seepage and excess pore-water pressure dissipation problems within porous materials such as soil and rock. It allows analyses ranging from simple, saturated steady-state problems to sophisticated, saturated-unsaturated time-dependent problems.

The final void was simulated by attributing a high conductivity (k=9999m/day) to the cells corresponding to the void. For these Cells, the specific yield (unconfined storage parameter) was set to 1.0 (i.e. the entire volume of the cell can be occupied by water). Refill material (Spoil Material) has a hydraulic conductivity set to 10m/day.

The Daunia pit modelling demonstrated that in all cases – the fence and bund Base Case, the 25% and the 10% regrade case - high salinity outcomes were inevitable. Fundamentally unless salts can be released from a residual void – high salinity must eventuate. Larger catchments offer lower salinity concentrations on a relative time basis, but nonetheless all void configurations have increasing salinity trends. As with other modelling studies, the SKM void salinity modelling results show that seepage of saline groundwater into the pits and flows of lower salinity surface runoff from spoil heaps cause salinity to progressively rise. Unless a mechanism is available to shed salt and isolate the void from the saline groundwater table, high salinity outcomes eventuate.

6 CAVAL RIDGE VOID WATER BALANCE AND SALINITY

6.1 INTRODUCTION

The actual size and extent of the Caval Ridge final void cannot be predicted with confidence until optimised Life of Asset Planning (LOA) has been completed, even then, changes in demand, economics and technology have potential to impact the LOA plan and result in change to the location and size of the residual void, as well as the extent of contributing catchments. Nonetheless, the following generalisations regarding void water quality can be made for the Caval Ridge project based on the existing information:

- Ground water monitoring from nearby local coal aquifers confirms that the water for the main is saline. Minor aquifers in shallow Tertiary and Quaternary paleochannels might contribute amounts of less saline groundwater in wetter years. Overall airlift test from exploration drilling demonstrates extremely low yields.
- During mine operations in Central Queensland localised lowering of groundwater level due to pit seepage is likely. But evaporation rates are very high and for the main, the experience in the region and at the adjacent Peak Downs Mine is that ground water seepage into mine pits is negligible during operations. Surface runoff from spoil and tamps is the major cause of water ingress to mine pits.
- The overburden at the Caval Ridge project is moderately saline and alkaline, thus the future spoil mass surrounding the future voids will be reflective of this. Catchment dams below un-rehabilitated spoil areas should also necessarily capture moderate to low salinity, alkaline runoff; and flows of storm driven surface water to the pit from spoil runoff should also be of moderate salinity and alkaline.
- Strata in close contact with coal e.g. coal basement strata are generally saline in the Bowen Basin, thus direct contact with this material may cause elevated salinity; however this may be remedied by backfill with low salinity spoil at closure.

The Caval Ridge Project is located in very similar climatic and geological settings to most of the BMA Central Queensland coal mines. The approximate long term average rainfall reported in the EIS is 597mm and evaporation is some 4 times greater at approximately 2,300 mm. Evaporation exceeds average rainfall 12 months of the year and approximately 43% of rainfall occurs in the summer (Dec, Jan, and Feb) months. Thus studies dealing with predicted hydrological and salinity behaviour undertaken at several BMA mine sites and other sites as discussed in the previous section are quite relevant to the Caval Ridge project.

6.2 URS MODELLED CAVAL RIDGE VOID STORAGE AND SALINITY BEHAVIOUR

Final void water and salt balance modelling has been undertaken for this supplementary report to investigate a range of final void configuration options to provide a likely indication of the behaviour of residual voids at the Caval Ridge Project. The aim of the URS study which is largely conceptual is to demonstrate probable void behaviour under different regrade, catchment and climatic circumstances, sufficient for BMA to formulate recommendations for future investigations and research aimed ultimately at developing an acceptable, low risk plan for the final void(s) at the proposed Caval Ridge mine site.

The void water balance study has focussed on one pit, the larger Horse Pit and it is reasonable to assume that the hydrological behaviour and salinity outcomes for the base case and alternative treatments would be equally applicable to the smaller Heyford Pit. Both pits share similar geological, groundwater table and overburden characteristics.

Void modelling undertaken by URS consultants has covered a number of scenarios specified by PW Baker & Associates in general accordance with the BMA Sustainable Landform Guidelines. The URS approach has been to use integrated modelling to address the long-term water and salt balances for three final void configurations. The modelling aimed to assess decant and flooding risks, connections to groundwater resources, and water quality parameters in the long term. The three final void configurations include a base case which is 156 m deep at the end of 30 years of mining; a 25% regrade (25p) resulting in a shallower 123 m deep final void and reduced low and high walls, and a 10% regrade (10p) final void which results in a much shallower 55m deep final void with gentle slopes. The void regrade configurations were prepared by PW Baker & Assoc Pty Ltd and based on 3D Vulcan digital terrain models of the base case provided by Runge consultants. See Attachments 1, 2 and 3 which provide contour plans of the three scenarios/

The hydrological modelling by URS for this supplementary report has included:

- Hydrological assessment of the salt and water balance based on the preliminary residual void concept outlined in the EIS document with two alternative regrade scenarios also investigated.
- Assessment of the long term behaviour of the void and its interaction with local and regional surface and groundwater resources as well as the sensitivity of predicted behaviour to current unknowns;

URS have developed water balance models for each of these three regrade cases and each has been examined for a range of catchment and climatic circumstances as described below. The sensitivity to the model on key performance parameters has been tested. Modelled aspects dealing with the sensitivity of the model to changed performance parameters included catchment area, climatic influence and aquifer hydraulic parameters. The parameters examined to observe the sensitivity of the model included:

1. Two disturbed area catchment configurations:

    a) Limited Catchment Area – limit to those surfaces which drain to the void, i.e. the void and ramps. This is typically the entire spoil area model less the externally draining regraded west face spoil.

    b) Maximum catchment area, i.e. the void, the ramps, and all of the associated spoil including the west facing spoil. It has been assumed that a drainage system has been created to capture all spoil surface runoff which would otherwise flow away from the void and direct that surface runoff back into the void. There is no runoff from any other area - just the spoil dump and it's void.

The modelling assumed all clean water runoff, including flood events, would be diverted around the final void.

2. Climatic Change Affects

The affects of a changed climate on void hydrological behaviour have also been considered by reducing and increasing the mean annual rainfall by 10%. Thus the following climate scenarios have been examined for each void regrade scenario:

a) Dry case – the annual long term rainfall reduces by 10%
b) Median case – the annual long term rainfall based on the last 100 years of data.
c) Wet – annual - the annual long term rainfall increases by 10%.

3. Aquifer Hydraulic Parameters

Hydraulic conductivity values, low, medium, and high; and

4. Surface Runoff Coefficient

Estimated volumes of rainfall runoff were calculated using a rainfall-runoff model based on daily rainfall and evaporation data from a 100 year dataset. The estimated volumes were injected into the model, along the backfill spoil areas, and using various ranges of Manning coefficients, rill heights, and obstruction heights for the backfill spoil areas volumes of water reporting to the final void were calculated. A sensitivity analysis of combinations of runoff factors was undertaken to obtain optimum estimates.

6.2.1 Modelling Methodology

A steady state model, using MODHMS software, was constructed based on the available data and represented envisaged groundwater flow conditions after 30 years of mine dewatering. The steady state model outcome was used as initial conditions for the transient model, which undertook the predictive scenarios.

A nine layer (based on site geology) model comprised a 100 m x 100 m grid across a 74.4 km^2 area was constructed. The model extent was deemed sufficiently large to assign constant head boundaries (based on extrapolated groundwater level data) and predict long term groundwater trends. Mean annual rainfall and evaporation data, based on 100 year records, and selected representative aquifer hydraulic parameters were used as input into the model set up.

The transient model was constructed, based on representative model parameters, sensitivity analyses, and the review of resultant model water budgets, to simulate the predicted groundwater level drawdown and extent around the final void after 30 years of mining. The model was then used to predict groundwater rebound, runoff and climate (rainfall and evaporation) influences resulting in final void level simulations. The final void equilibrium water levels were estimated for the three final void configurations and compared to the pre-mining groundwater levels.

A salt balance for each of the final void configurations was calculated to determine long-term water quality trends. The salinity balance was based on:

- 9 000 mg/L for groundwater ingress based on a 60% contribution from coal (10 000 mg/L TDS) and 40% from the inter/overburden units (7 500 mg/L); and
- 450 mg/l for all runoff modelled is derived from disturbed areas.

Using this model URS compiled the following outputs:

1. Final void water level simulations for each of the three void configurations (base, 25p regrade, and 10p regrade), using two catchment configurations (minimum and maximum), and three climate conditions (mean annual rainfall, + 10%, and – 10%).
2. A comparison of predicted equilibrium void water levels to pre-mining groundwater levels;
3. A salt balance for each of the final void configurations based on predicted groundwater ingress, variable climate data, and different (disturbed) catchment sizes, for 100 years; and
4. An estimate of void space within each of the three void configurations after equilibrium is reached, which allowed for an evaluation of spill risk.

6.2.2 Summary of URS Void Modelling Results

6.2.2.1 Hydrological Performance

Table 5 summarises the hydrological performance of each of the final void scenarios under the two catchment size conditions.

Table 5 Hydrological Performance Summary – Minimum and Maximum Catchments

Final void configuration	Pre-mining groundwater level at selected point	Bottom elevation of pit (m AHD)	Void equilibrium water level (m AHD)	Lowest surface elevation (m AHD)	Void equilibrium depth (m below surface[1])	Time to reach equilibrium (years)
Base case min	208.07	68.92	91.703	220	128	45
Base case max			91.739		128	50
25p regrade min	208.07	127.12	140.68		79	50
25p regrade max			144.51		75	40
10p regrade min	208.07	184.66	194.39		26	45
10p regrade max			195.00		25	30

The modelling shows that none of the scenarios has spill potential under mean annual rainfall based on historical weather records and limited catchment areas.

The sensitivity of the void hydrology was also examined by varying annual rainfall by (-)10% and (+)10%. See Table 6. An increase of 10% in average annual rainfall simply raise void levels by a very modest few metres amount with no substantive lowering of available freeboard.

[1] Metres below lowest void surface elevation

Table 6 Hydrological Performance – Climate Change Summary

Final void configuration	Pre-mining groundwater level at selected point	Bottom elevation of pit (m AHD)	Void equilibrium water level (m AHD)		
			Average	+10%	-10%
Base case min	208.07	68.92	91.703	91.707	80.18
Base case max			91.739	100.36	91.73
25% regrade min	208.07	127.12	140.68	142.96	130.38
25% regrade max			144.51	147.02	144.51
10% regrade min	208.07	184.66	194.39	194.98	190.06
10% regrade max			195.00	195.00	194.74

6.2.2.2 Void Salinity Behaviour

The predictions of salt accumulation in the final void for the three void configurations was estimated based on salt contributions from groundwater ingress, rainfall, and runoff. Salt balance estimates were calculated for mean annual rainfall, mean +10%, and mean – 10% for each scenario. The URS modelling demonstrates that in all cases salinity increases with time.

For the base case final void scenario, void water is recognised to deteriorate with time due to increased salinity. An increase in rainfall (mean +10%) and the larger catchment area results in a reduced deterioration with time. Void water, in this instance, results in an increase from ~ 5 000 mg/L TDS to ~ 12 000 mg/L TDS over 100 years.

For the most likely base case scenario; minimum catchment and average rainfall, the TDS will increase from ~ 9 800 mg/L TDS to ~ 19 800 mg/L TDS over 100 years.

The salt accumulation for the regrade scenarios indicates similar increases with time. However, the initial increases in TDS are lower as groundwater rebound is required before it can enter the void

The projected salinity and stored volumes for the minimum and maximum catchment configurations for the three regrade scenarios; base case, 25% regrade and 10% regrade for average climate conditions one hundred years post closure are summarised in Table 7.

Table 7 Storage and Salinity 100 yrs Post Closure

Scenario	Catchment Area	Stored Volume ML	Salinity after 100 years mg/L
Base Case	Min	2 400	20 000
	Max	5 400	5 200
25% Regrade	Min	1 600	22 000
	Max	3 250	20 500
10% Regrade	Min	1 060	58 000
	Max	1 900	36 500

Attachments 4 and 5 show time based projections for water quality and quantity prepared by URS consultants.

6.2.3 Discussion

The URS salinity modelling indicates fairly rapid salt accumulation for all void configurations to levels well beyond use for stock water as suggested by the ANZECC Guidelines in Table 8. Use of the water would be tolerable for cattle and sheep for a few years post closure.

Table 8 ANZECC Guideline* for Beef Cattle Tolerance to Salinity

Salinity ppm (EC uS/cm)	ANZECC GUIDELINE
0 – 4,000 (0-6,000)	No adverse effects on animals expected
4,000 – 5,000 (6,000 – 7,500)	Animals may have initial reluctance to drink or there may be some scouring, but stock should adapt without loss of production
5,000 – 10,000 (7,500 -15,000)	Loss of production and a decline in animal condition and health would be expected. Stock may tolerate these levels for short periods if introduced gradually to Beef cattle
>10,000 (15,000)	Totally unfit for stock.

* Salt limits to 10,000ppm derived from Table 4.1.3 in National Water Quality Management Strategy - Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000.

The modelling shows that the extent of salinity increase is time dependent but in all instances will be considerable. A significantly higher salinity rate is predicted for the 10p regrade scenario; this is a logical outcome given that the flatter grades of the 10p treatment will cause a relatively larger surface water area to depth ratio than for the steeper sided storages - 25p and the base case. Thus evaporation losses for the 10p scenario in terms of stored volumes will be greater and salinity will be higher.

The initial increases in TDS for the void scenarios are low as saline groundwater rebound is required before it can enter the void. It follows that if groundwater can be isolated from the void, then much improved water quality would be anticipated for quite a lengthy period. Further, if it were possible to substantially increase the void catchment area, overall lower salinity levels would eventuate for a much longer period. It is also reasonable to assume that if the void were configured to spill water of accepted salinity to the down stream environment or to the regional groundwater table, it would be possible to sustain useful quality of water in the void.

Overall the modelling shows that pit salinity will increase and not decrease through time for any void which cannot spill and or cannot shed salts through groundwater discharge, nor receive fresher water via a groundwater seepage mechanism.

Infilling to make the pit to be self draining would be costly unless undertaken as part of an operational spoil backfill. This may be a useful remedy to maintain the salinity of the residual void at a suitable quality for livestock in particular. Further investigation of this strategy is warranted if use of void water for a productive purpose is anticipated.

6.3 STRATIFICATION POTENTIAL

It is possible that stratification of the residual void will occur, particularly the base case void which is deep and steeply sided. Shallow water storages are unlikely to develop stratification. However there is little or no information available regarding the incidence of stratification and its consequences in central Queensland open cut mine situations as very few voids have been finalised; and for the main, water held in mine voids tends to be on a temporary basis. Further large pumped transfers between and from voids after periods of wet weather tends to cause remixing of the stored mine water, hence would shield or nullify measurable indicators of stratification.

For permanent deep voids however, the chemical and biological processes within the void water, which can influence the mobility and fate of solutes, are closely linked to stratification and de-stratification. Changes in speciation and solubility across oxic, suboxic, and anoxic boundaries control the solubilities of redox sensitive metals. Metals, such as chromium, lead, and selenium, are less soluble in the reduced state than in the oxidised state. Dissolved oxygen levels have been measured in a number of CQ mine voids as part of environmental monitoring programs and in some instances very marked reduction of dissolved oxygen has been recorded within a few metres of the surface of a residual void. Thus providing some support for anoxic conditions being present and also reduced solubilities of redox sensitive metals.

A suitable void may become available at one or more BMA mines over the next several years. This may provide an opportunity to instrument one or more voids in different configurations to examine the potential for thermal or chemical stratification on a seasonal or progressive basis, and the effect on local aquifers.

6.4 EXTREME EVENT IMPACTS

6.4.1 Void Spill Events

Spill Risk
The probability of decant from the final void was considered by URS using a very simplistic but rational approach for each of the three final void configurations. The method used was to simply calculate the equilibrium void freeboard capacity for each scenario, then calculate the probability of an event or series of events occurring which could cause the void to spill and fill

URS examined extreme rainfall events on record, maximum volume if all water from storm went into void (i.e. all water went directly into the void with no loss to evaporation or infiltration) would be approximately 9 Mm^3. This volume was insufficient to fill the large final void space in any configuration, thus the spill risk was deemed as being negligible.

Spills may be possible, but only if deliberate design measures are made to direct surface runoff from large unmined areas to the void or perhaps back fill the residual void to a very substantial extent, hence greatly reducing potential storage capacity.

Flood Risk
It is considered that major flooding in the area could result in the flooding into the void.
URS are currently remodelling the Caval Ridge hydrology to assess flooding. The flood scenario to be modelled will include a 1: 3000 flood event, based on 1% of the life of the mine (30 years). Based on these scenario recommendations regarding flood protection measures along the north and east of the Horse Pit will be made.

Comments regarding backfill spoil pile runoff management and ramp modifications (to prevent flooding) have been made in the URS Flood Risk study.

6.5 POST MINE DEWATERING – RECOVERY OF GROUNDWATER AQUIFERS

Modelling by URS for the residual void scenarios demonstrates that the voids are predicted to function as sumps; hence flows of groundwater will tend to the void and not from it. See URS Caval Ridge **Error! Unknown document property name. - Error! Unknown document property name.**, Sept. 21 2009. The modelling shows that the drawdown effect on groundwater levels is localised. The results of modelled drawdown at equilibrium (post mining) are shown as groundwater contours. It is also noted that the extremely low airlift yields conducted during the exploration program for Caval Ridge strongly indicates that groundwater resources are extremely limited in the Caval Ridge area; hence no substantive effect on the regional groundwater is likely.

6.6 CONCLUSIONS

It is clear for the Caval Ridge project and much of the Bowen basin where annual evaporation far exceeds average rainfall (and extreme rainfall as well), that in the absence of significant surface runoff from external areas, overflow from deep pits including regraded pits is most unlikely. This situation could change if the catchment area above the void is sufficiently large to cause water levels to rise on an annual basis; Even though a spill is unlikely, it is acknowledged that regraded voids (e.g. to 1V:4H to 1V:10H slopes) have sufficient insitu catchment to form a substantial body of water from time to time.

Although spill levels are very unlikely to be encountered (unless large catchments are configured to spill to the void and this would require regulatory approval), a substantial body of water will form in the void and its usefulness (salinity) will ultimately depend on void configuration with respect to the regional groundwater table. The modelling suggests that if isolation from the groundwater table is possible and a spill/drainage mechanism is available, it may be possible to configure a final void to provide a sustainable useful source of water for livestock and native fauna. Considerable research will be required as the mine develops to identify strategies and remedies which could be implemented to bring about improved water quality outcomes for residual voids.

The important aspect of the preliminary modelling undertaken to date is that it will enable the Caval Ridge Mine operator to conceptualise various combinations of spoil topography and catchment sizes around designated residual voids and determine what the storage behaviour of a particular residual void might be. Improved future understanding of groundwater behaviour and the permeability of regraded spoil in pits will enable the Caval Ridge Project to further understand the hydrology of deep voids and identify the amount of backfill which may be required to either isolate the regional water table or design for positive mechanisms to equilibrate saline water in the voids to beneficial levels.

More modelling and investigation will be undertaken as the final landform planning becomes firmer and as more comprehensive environmental monitoring data becomes available during mine operations in the immediate vicinity of the final location of the residual void. The monitoring would include void and bore water levels and water quality. Further it would be desirable if the research be extended to provide more specific information including the physical and geochemical characteristics of spoil and pit water contributions from exposed contributing aquifers.

7 GEOTECHNICAL STABILITY OF THE RESIDUAL VOID

7.1 INTRODUCTION

BMA routinely carries out highwall stability investigations as part of mine planning to ensure the safety of personnel and the security of the exposed coal. However, from a closure perspective, it is recognised that further specific investigation would be required if the intention were to leave standing highwalls and endwalls.

Highwall and endwalls of mine pits in Central Queensland are often comprised of dispersible, unconsolidated Tertiary material sitting above firmer consolidated Permian sediments. Endwalls usually exhibit greater instability than highwalls due to the exposed alignment of bedding and faulting planes. Some highwalls exhibit reasonable short to medium term stability, others do not.

BMA does not propose to leave standing highwalls and endwalls at the Caval Ridge Mine unless the walls are considered stable and that safety, stability and water quality criteria can be met. That is, BMA will undertake sufficient investigation to demonstrate that these performance criteria can be met before any void is decommissioned in a mine configuration.

7.2 RELEVANT STUDIES

Studies by ACARP researchers (Rehabilitation of Highwalls - ACARP Project C14048 - Final Report) based on inspections of several mines across the Bowen Basin concluded that most of the highwalls in Tertiary and weathered overburden would not be geomechanically stable in the long term. These sedimentary materials are not strong enough for the main to resist failures due to water incursion and failures due to physical erosion damage.

The stability of regraded spoils has been discussed by Sherwood Geotechnical and Research Services in several BMA residual void investigation reports prepared by PW Baker & Assoc Pty Ltd and submitted to the EPA in mid 2008. The consultant noted in all instances that regraded slopes for final voids in the range of 10% - 25% are inherently stable overall and that based on typical short-term shear strengths and likely surface and groundwater scenarios, regrading to 25% would produce geotechnically stable landforms for lowwall spoil highwalls and endwalls with an outer surfacing of primarily Permian materials. Further that the intervening final void might have a seasonally variable water ponding function, and this would be extremely unlikely to create conditions where geotechnical instability could develop.

Thus from a geotechnical perspective, the proposed range of regraded Caval Ridge void spoil batters which include 25% down to 10% or flatter do not present significant risks of geotechnical failure (e.g. such as mass slumping). Grades of 25% and flatter are not likely to be affected by variable water levels in the final void. Local settlement is possible, but can only be gauged if and when it occurs at a future time.

8 VOID CAPABILITY TO SUPPORT NATIVE FLORA AND FAUNA

8.1 SCENARIO DEPENDENCY

There are a number of scenarios that will cause marked differences in the capability of a residual void to support flora and fauna.

- Intensive treatment such as backfilling will yield a similar environment to the balance of the rehabilitated spoil areas. Fauna monitoring by WBM (WBM 1999 Assessment of Fauna Diversity in Rehabilitation) at nearby BMA Peak Downs mine demonstrates that a return of native fauna occurs in the rehabilitation, as would be expected, given a variety of shrubs and trees and pasture cover have been established which can provide food and shelter for avifauna and macropods.
- Regrading lowwalls will provide safe access for fauna to temporary or permanent water which may pond on the pit floor during rainfall. However, as discussed in earlier sections the usefulness of the water storage will be dependent on the nature of the interaction of the void with the regional ground water table and areas and types of contributing catchments.
- Also, provided the catchment area of the residual void exceeds a specified ratio it is possible that the water may be available on a permanent basis. More advanced hydrological and geochemical modelling will be required in the future to support this strategy. Use of void to support specific uses such as aquatic fauna for aquaculture will require further investigation.

The ability of voids to support significant life will depend on whether there is permanent water stored in the void and the ultimate salinity of the void water. The modelling undertaken by URS and others indicates that in the longer term, void water for all cases will be very saline to extremely saline. Unless mechanisms to shed salt are available, all void scenarios at Caval Ridge will not be able to sustain useful habitat for freshwater species. However, stratification of surface runoff water and incident rainfall may occur from time to time, if this is the case there may be limited potential for a hospitable water supply for native species on some occasions.

The oxygen flux of the void may also have important implications for the ability of the water to sustain aquatic fauna. Measurements of some typical mine voids with standing highwalls in Central Queensland has shown that oxygen levels can diminish very rapidly as depth increases, thus limiting use of the deeper voids for aquaculture without active and costly oxygenation.

Decisions in the future will have to be made regarding mechanisms to maintain water quality in final void at a useful level to support fauna or livestock. Some modelling undertaken by BMA consultants (Gilbert and Baker 2008) indicates that shallow voids in which the deeper saline groundwater table is below the void base, have potential to provide reasonable quality water in the initial period after closure as the rate of groundwater rebound is limited. Further studies may result in a need to utilize more backfill to reduce storage capacity or open up greater areas of catchment to improve yield. The chemical and physical dynamics of the void water body require investigation; for example, the development of a thermoclines and chemoclines are likely to be dependent on a host of topographic and hydrological variables such as void depth, batter length and slope, orientation to wind, catchment area and yield, and perhaps groundwater incursion. BMA will commission studies to better understand these issues well before mine closure of the Caval Ridge Mine.

9 FINAL LANDFORM AND RESIDUAL VOID REHABILITATION PERFORMANCE OBJECTIVES AND CRITERIA

9.1 INTRODUCTION

DERM has provided an indication of its acceptance criteria for residual voids in Guideline 18. The stated principal performance outcomes for void rehabilitation required by the Qld Regulator include:

- safe to humans and wildlife
- non-polluting
- stable ; and
- able to sustain an agreed post-mining land use

The objectives for rehabilitation of mine disturbance at Caval Ridge Mine align with Guideline 18 and the BMA sustainable landform guidelines. Overall BMA plans that mined land should be returned to a condition that is:

- Safe – no residual dangers for humans, stock or wildlife.
- Non Polluting – downstream waters and groundwater quality are not diminished
- Stable – erosion processes are limited to the extent that vegetation cover and management practices are preventing development of sheet, rill and gully erosion.
- Sustainable – sustained grazing or native fauna habitat is viable.

9.2 REHABILITATION PERFORMANCE OUTCOMES

The objectives/outcomes for the rehabilitated spoil and void areas at the proposed Caval Ridge Mine are consistent with DERM Guideline 18 and BMA's landform stability requirements. Required outcomes include:

- **Geotechnical stability**
  - **Spoil:** All spoil must be reduced to geotechnically stable grades.
  - **Voids:** Standing highwalls will remain only on a geotechnically stable basis and when safety and sustainability can be demonstrated.
- **Erosional Stability** – All spoil areas including voids must be reduced to grades that are sufficient to support sustained vegetation cover comparable to surrounding productive grazing land or as areas used primarily for fauna habitat. Rills, sheetwash and gully erosion should not be significant features of the rehabilitated

landform and monitoring efforts will confirm that stable situations have been achieved or should be achieved as demonstrated by sufficient monitoring.

- **Drainage Stability** – Gullies and rills not developing in the landform. Cross slope drainage structures will be utilized if erosion control using other strategies, such as rock mulching and cladding; or dense pasture scenarios are not sustainable.
- **Creek Diversions** - Performance of the low and high flow channel are sustainable with no adverse flow impacts up or down stream. The diversions will be designed and approved in accordance with contemporary Qld Government requirements that include restoration of function in terms of low and high flow stability and riparian vegetation establishment
- **Downstream Water Quality** – Water discharges from rehabilitated spoil will comply with conditions of the Environmental Authority during operations and after closure down stream water quality will be similar to upstream with less than 10% increase in salinity, and suspended solids.
- **Landuse Capability** – The majority of rehabilitated land will be suitable for sustained low intensity grazing and provide for wildlife habitat and corridors. Grazing trials in Central Queensland and in the NSW Hunter Valley show that this use is feasible. The aim is return a landscape that does not require more maintenance than is required on land in the locality used for that purpose. A suitability assessment will be conducted to confirm this grazing capability has been achieved prior to lease relinquishment.

9.3 PERFORMANCE CRITERIA

Performance criteria have been devised with due regard to the environmental characteristics of the site; some existing draft EM Plan commitments; typical contemporary conditions in mine Queensland Environmental Authorities; DERM's (EPA) Guideline 18; and BMA's internal sustainable landform guideline.

Scheduling this following large range of performance criteria as unique entities in the Environmental Authority is not proposed as changes will occur to rehabilitation methods and measures throughout the mine life which are reflective of new learning's. It is therefore proposed that the agreed rehabilitation outcomes are scheduled in the EA, rather than attempting to applying a range of prescriptive measures which simply cannot be suitable for all circumstances and which will change as the industry and regulatory knowledge base expands. The performance criteria which BMA will use to underpin the required rehabilitation performance outcomes are described in Table 9. These criteria will be incorporated into the sites operational EM Plan when approved.

Table 9 Caval Ridge Mine - Proposed Landform & Rehabilitation Criteria

Aspect	Attribute or Location or Domain	Measure	Value	Method of Measurement
	All spoil areas - in and out of pit.	Percent Slope (%)	No less than 75% of the area has slopes <10% with the balance of slopes <25%. Where reject layers or inhospitable spoil are present and exposed, the landform is capped with 2m or more of benign spoil. Sloped areas will be clad with rock mulch if erosion can not be controlled by pasture cover alone. Graded banks will only be used where favourable spoil occurs are where other stability measures cannot limit erosion.	Survey or DTM.
LANDFORM DESIGN	Lowwalls and Ramps	Percent Slope (%)	Backfill ramps to the most practical extent. Conventional Regrade or backfill ramps and lowwalls to <10%slope or: Regrade or backfill to 25% and clad with rock mulch.	Survey or DTM
	Highwalls	Slope in Degrees (^{0})	Competent rock – geotechnical and erosional stability requirement. Highwall to have slope of <65 degrees and fence and bund, or: Benched and battered to < 65 degrees with fence and bund. Incompetent rock highwall to have slope of <17 degrees and clad with 2m durable rock mulch or Regraded to 5 degrees and rock mulched as required and topsoiled and pastured if stability not practicable with steeper treatments.	Survey or DTM and:
GEOTECHNICAL STABILITY	Spoil areas	Landslide, slumps and slips.	Safe, Stable and Sustainable. Absence of slumps and slips and very low likelihood of an event occurring.	Inspection and determination by suitably qualified geotechnical engineer.
	Highwall Areas	Landslide, slumps and slips.	Safe, Stable and Sustainable. Absence of slumps and slips and very low likelihood of an event occurring.	as above
EROSIONAL STABILITY	All Rehabilitation Areas	Rills, sheetwash and Gullies	Nil or stable for grazing purpose. Demonstrates progression to stability.	Three tiered monitoring program. Final Inspection and determination by suitably qualified rehabilitation / land resources scientist
SOIL	Application	Mapped identifiable areas	On all areas including tails dams, rejects dumps and spoil areas where spoil is not a proven growth media	Determined by spoil analysis -

Aspect	Attribute or Location or Domain	Measure	Value	Method of Measurement
	Depth	TS depth by field survey	>25cm where placed.	Field Checks
	Salinity	Electrical Conductivity EC (1:5)	< 600uS/cm.	Conductivity Meter
	Acidity – Alkalinity	Soil pH(1:5)	5.5 – 8.5	pH Meter
	Fertility	NPK ppm	In range of comparable insitu soil or fertilised as required.	Lab Analysis
	Sodicity	Exchangeable Sodium Percentage (ESP)	Use of low to moderate ESP soils e.g. (<7) on slopes. Use of higher ESP soils (e.g. <15) on other areas.	Lab Analysis
VEGETATION	Pasture Cover	% cover	>50% for grazing use. Cover stable or increasing. Not retreating.	Three tiered monitoring program.
	Species established	Suitable for final landuse	Suitable for grazing or wildlife corridor. Cover stable or increasing. Not retreating.	Three tiered monitoring program.
DOWNSTREAM WATER	Salinity	Conductivity uS/cm	Annual average no more than 10% above upstream level.	Grab sample or auto
	Acidity-Alkalinity	pH	Annual average range within +/-1 unit of upstream level.	Grab sample or auto
	Suspended Solids	TSS mg/L	Annual average no more than 10% above upstream level.	Grab sample or auto
SEDIMENT DAMS	Salinity	uS/cm	Suitable for stock water	Grab sample or auto
	Acidity - Alkalinity	pH	Suitable for stock water	Grab sample or auto
RESIDUAL VOID	Salinity	Conductivity uS/cm	Suitable for stock water or not impactive of groundwater or surface water resources. Electrical conductivity of any void water may exceed 1,500 µS/cm if an ecological assessment shows the long-term ecological stability and groundwater quality is not adversely affected. Equilibrium pH to be determined.	Void investigation at least 5 years prior to planned closure.
	Acidity - Alkalinity	pH	Suitable for stock water or not impactive of groundwater or surface water resources. Equilibrium pH to be determined.	Void investigation at least 5 years prior to planned closure.
LANDUSE				
Grazing on Recontoured Spoil	Cattle production	Stocking rate	Meet Shire average for the assessed capability/suitability Class of the rehabilitation landform.	Land suitability determined by experiences land resources consultant using QLD DPI methodology and, 5 year Grazing trial.
Wildlife Habitat or Corridor on Recoutoured Spoil	Trees and shrubs suitable for fauna habitat	% of mine disturbed area	Greater than 10% of rehabilitated area under trees and shrubs. Return of a representative selection of reptiles and marsupials and avifauna.	Aerial imagery and fauna surveys.
Infrastructure	Roads and other	Remove unless agreed to leave by local authorities.	Safe, useful and stable.	Written agreement with local stakeholders.

Aspect	Attribute or Location or Domain	Measure	Value	Method of Measurement
Creek Diversions	Creek and Flood Plain	Refer to the performance parameters in the Water works license.	Sustainable performance.	Approved as built design. ACARP - The Index of Diversion Condition (IDC) Monitoring.

Materials Inventory:
Use of topsoil and durable rock mulch treatments will be required to achieve stable landforms at Caval Ridge. Thus understanding of the extent of these resources and their management will be an important element of the rehabilitation program. Accordingly, the Caval Ridge rehabilitation program will be supported by the development and maintenance of a rehabilitation materials resources inventory which includes:

- Topsoil resources and stripping depths identified ahead of disturbance.
- Topsoil stockpiles mapped and volumes quantified on an annual basis.
- Rock resources for surface treatments delineated in geological models sufficient to enable rock to be salvaged for closure requirements as well as to be direct placed on progressive rehabilitation areas.
- Rock resource stockpiles/spoil heaps mapped and volumes quantified on an annual basis.

9.4 MONITORING PROGRAM

It is proposed that the Caval Ridge rehabilitation monitoring program includes a three tiered level of rehabilitation monitoring based on performance evaluations at discrete representative locations which can be extrapolated across to wider minesite areas using aerial imagery and mapping techniques supported by ground survey and observations. Rehabilitation monitoring at discrete locations serves no purpose unless the data has application across wider areas of the sites rehabilitation. The focus of the program will be on surface stability and soil-spoil profile attributes coupled with the cover, density and diversity of vegetation established on the landform. Three levels of rehabilitation assessment are proposed:

Micro Level
A range of specific diagnostic attributes will be measured at representative locations. Aspects to be measured include soil pH and salinity on the surface and down the profile to ensure that spoil geochemical properties are not impacting the applied topsoil; and, that over time a leaching profile or steady state profile is developing. Five yearly basis after rehabilitation passes into the established category.

Intermediate Level
Transect based surface monitoring of vegetation performance and erosional stability will be undertaken to monitor trends in pasture cover development and the existence of sheetwash, rill and gully erosion. Two yearly basis after rehabilitation passes into the established category.

Macro Level
Extrapolation of data from micro and intermediate levels will be ultimately necessary for the Caval Ridge Mine to validate the overall performance of its rehabilitation programs. Use of high-resolution aerial photogrammetry and site inspections will

enable the results of the Micro and Intermediate monitoring programs to be extended across the rehabilitated landscape. The basic aim is to confirm attainment of satisfactory rehabilitation performance across broad mine-site areas. Two yearly basis following completion of seeding.

9.5 PERFORMANCE REVIEW & CORRECTIVE ACTIONS

Review and update of the monitoring and rehabilitation programs will be undertaken to ensure that:

- Significant changes to the long-term mine plan resulting in material impacts to the projected final landform are incorporated.
- Improved understandings of rehabilitation performance captured by monitoring programs or industry experience are implemented.
- The rehabilitation monitoring program is being conducted to the required standards of the EA.
- Suitably qualified persons conduct reviews of all monitoring data to determine data trends, coverage is adequate and methods are appropriate.
- Rehabilitation performance is trending towards final completion criteria and required rehabilitation repair/maintenance works are scheduled.
- Spoil and topsoil chemistry characterization across the site is adequate.
- Topsoil records (stockpiles and spread over rehab) are current and,
- Legislative and Government Policy initiatives are being addressed.

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10 REFERENCE AND INFORMATION DOCUMENTS

Caval Ridge EIS and Appendices.

ACARP (Dec 2001) Project No C7007 – Water Quality and Discharge Predictions for Final Void and Spoil Catchments - Vol 1 & 2.

ACARP (1998) Post Mining Landscape Parameters for Erosion and Water Quality Control Project.

ACARP Project C14048 Final Report Rehabilitation Of Highwalls, Nov 2006.

BMA (2008) Draft Sustainable Landform Guideline

BHP Billiton (2004) Closure Standard. HSEC.

Gilbert & Associates – Final Void Hydrological Assessments June 2008 - Gregory Crinum, Blackwater, Goonyella Riverside, Peak Downs, South Walker Creek and Saraji Mines.

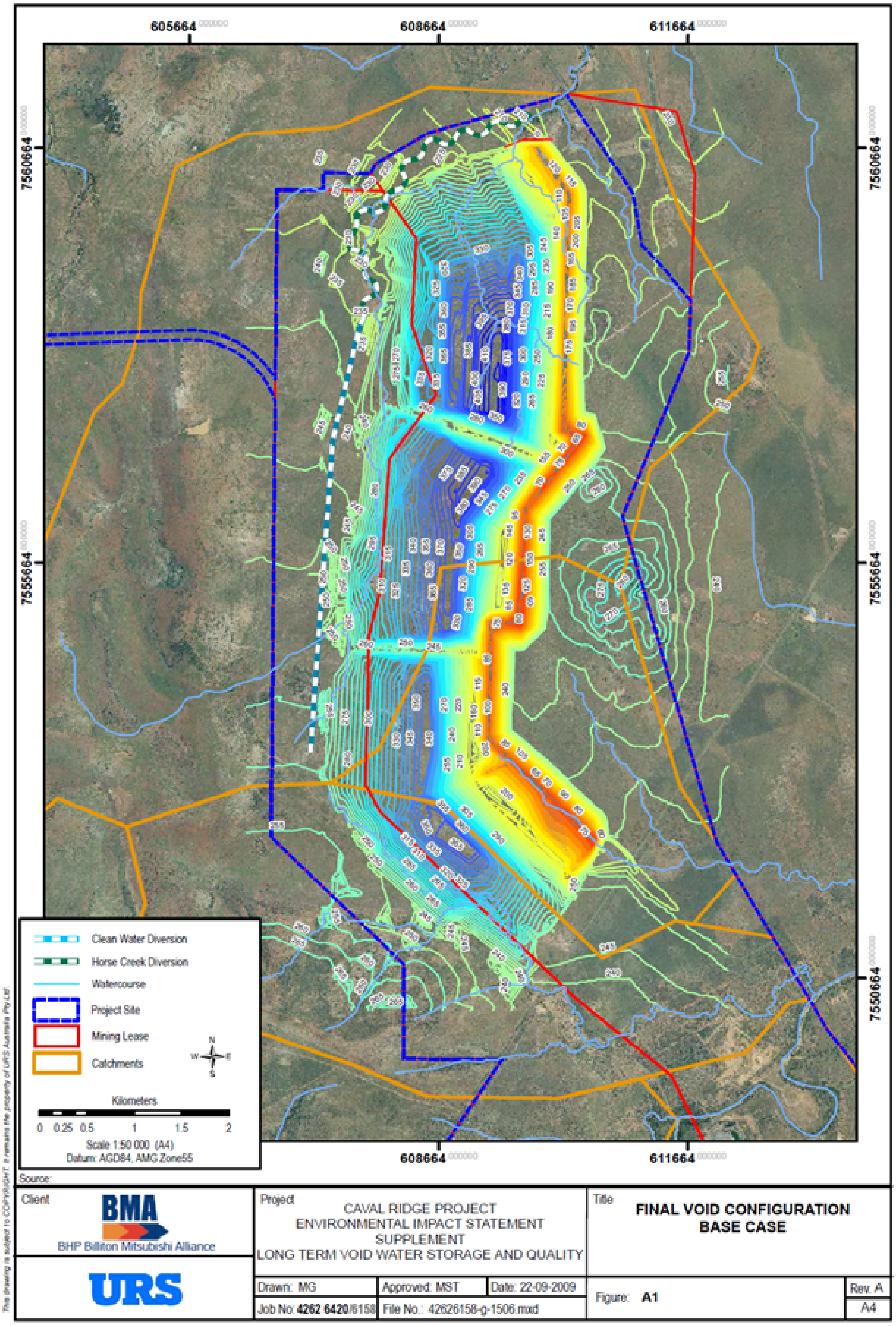
John Simmons Pty Ltd (Geotechnical (Sherwood Geotechnical and Research Services) Final Void Stability Review – Peak Downs, Saraji, South Walker Creek, Goonyella Riverside, Gregory Crinum and Blackwater mines.

PW Baker & Associates & Gilbert * Associates Residual Void Investigations A series of reports for BMA Peak Downs, Norwich Park, Goonyella Riverside, Saraji, Gregory Crinum, South Walker Creek, & Blackwater Mine. June 2008.

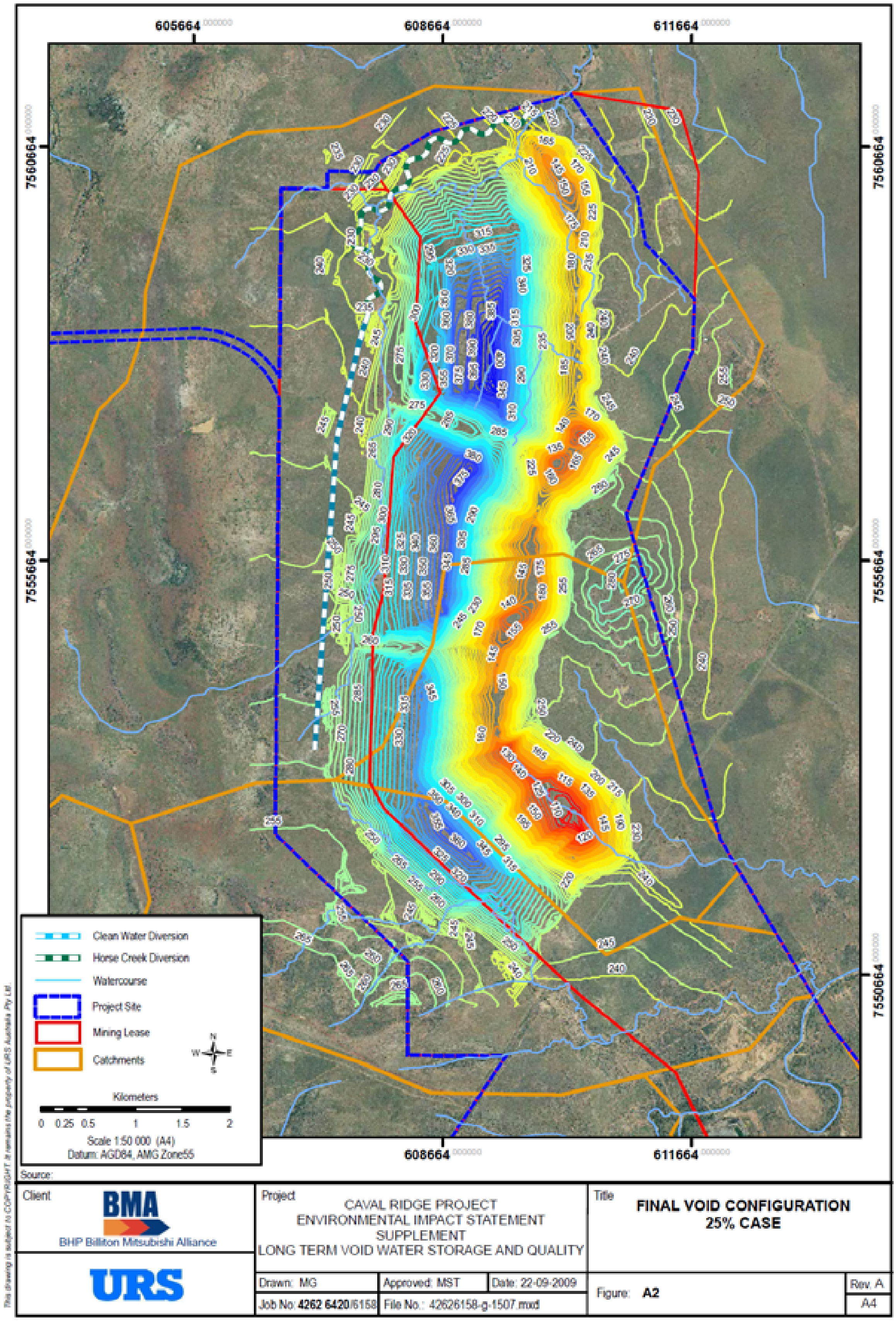
SKM – Residual void hydrology and salinity balance models. March and May 2009.

URS Caval Ridge **Error! Unknown document property name.** - **Error! Unknown document property name.**, Sept. 21 2009.

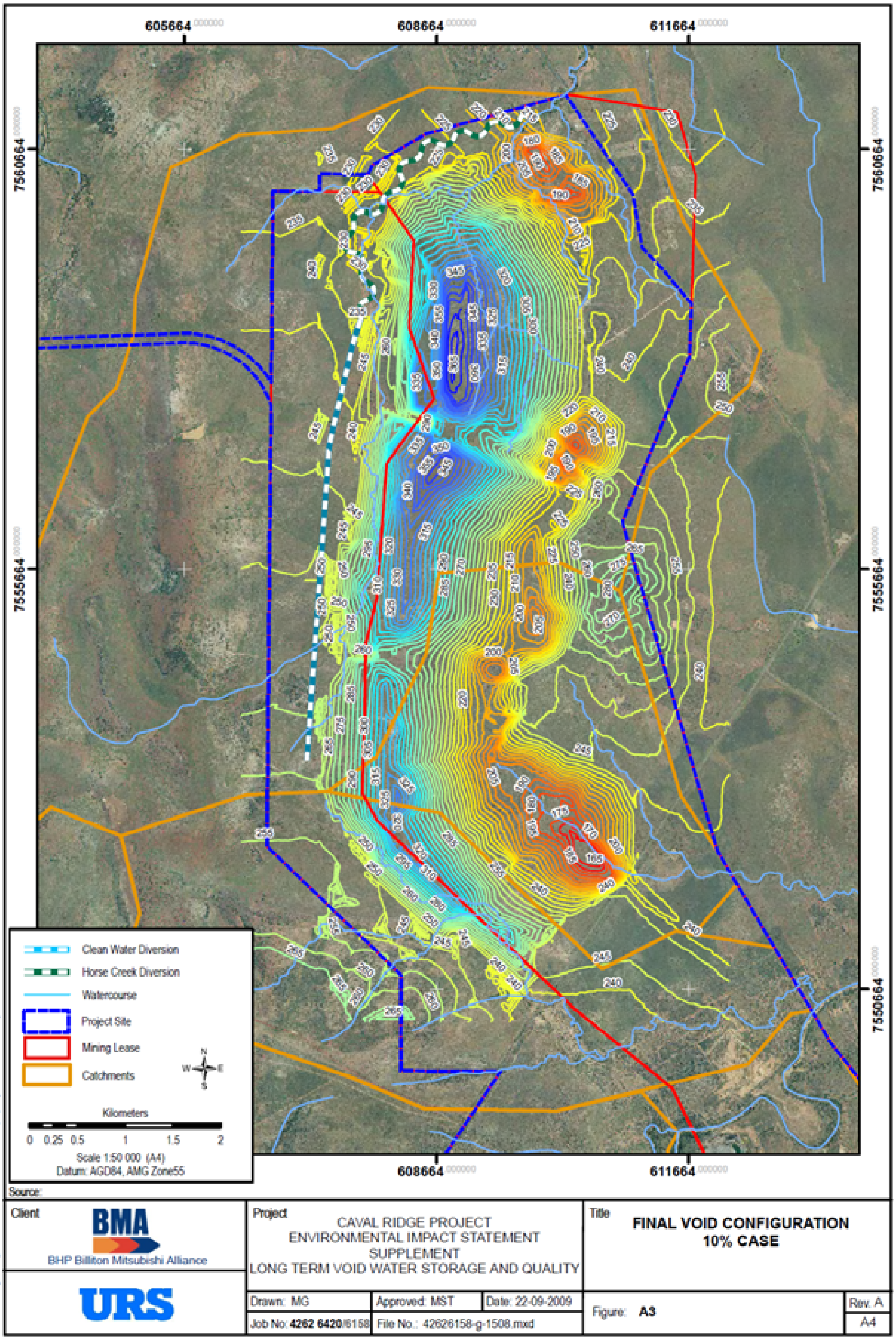
Attachment 1 Caval Ridge Rehabilitated Landform Fence and Bund



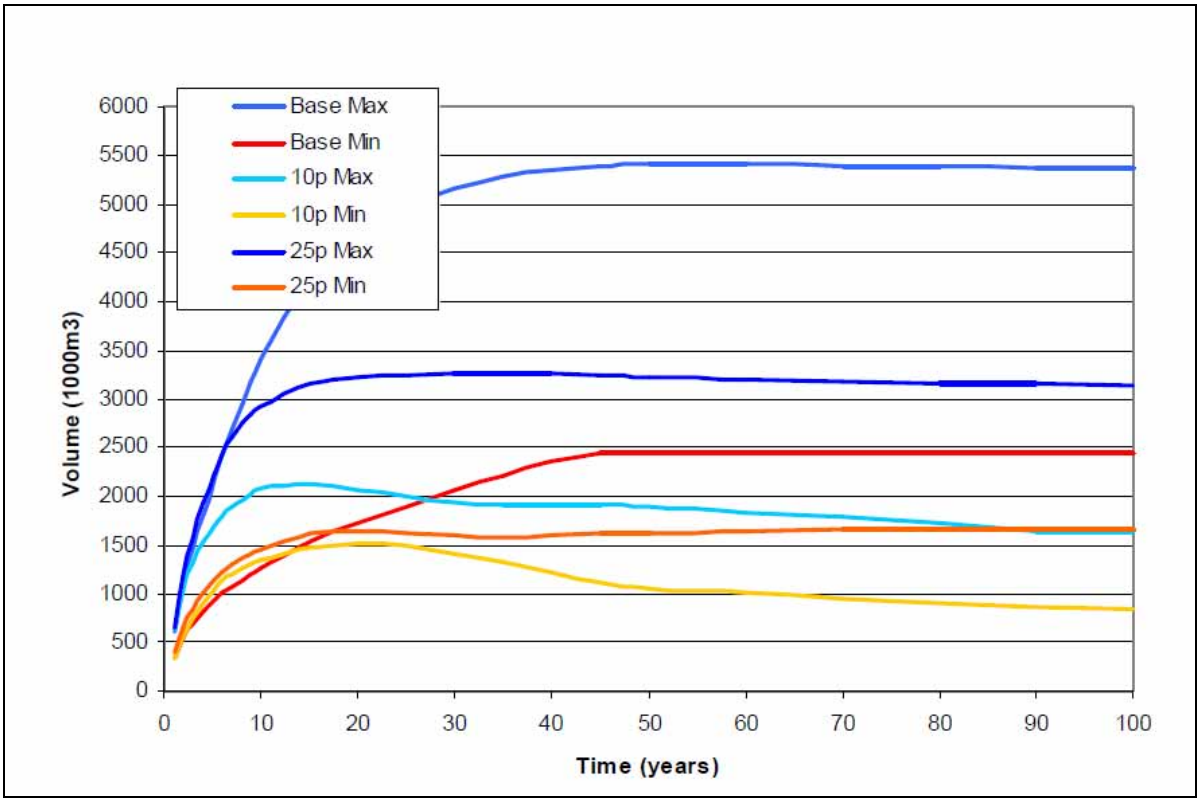
Attachment 2 Caval Ridge Rehabilitated Landform 25% void Regrade



Attachment 3 Caval Ridge Rehabilitated Landform – 10% Regrade



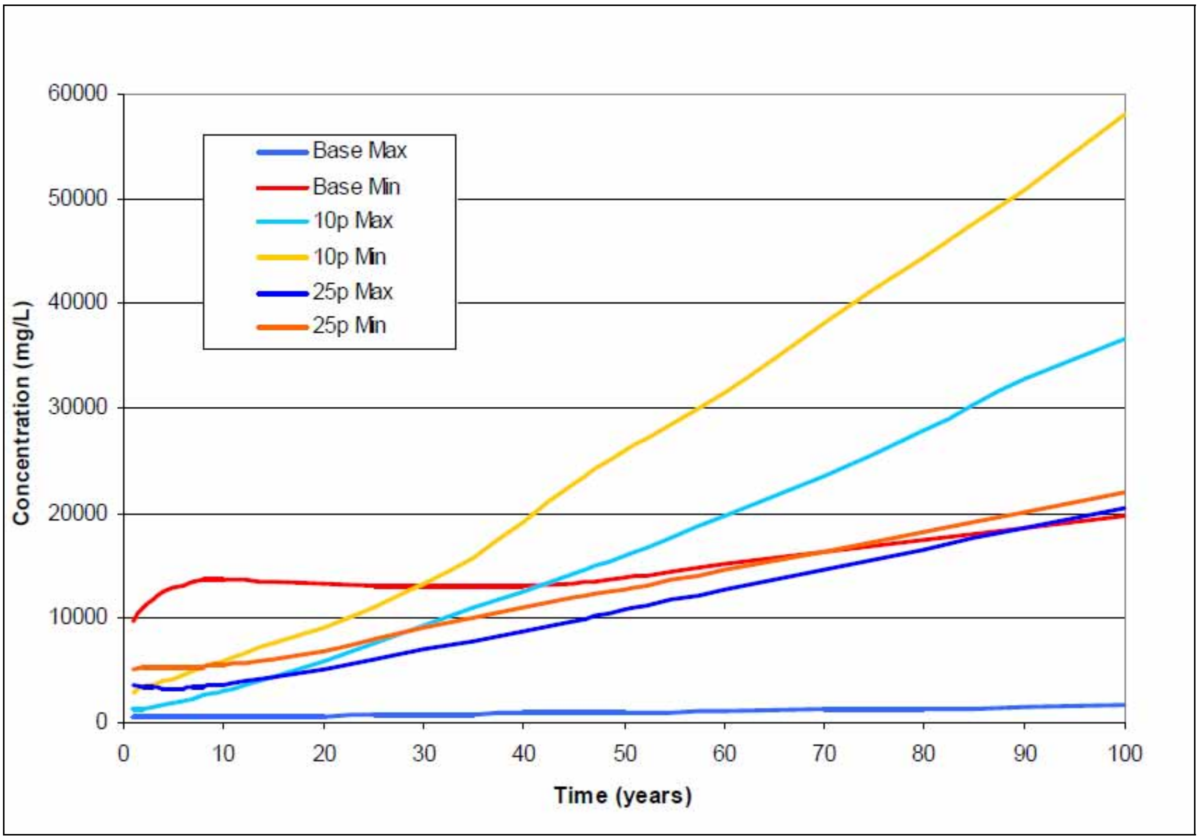
Attachment 4 Caval Ridge Long Term Pit Storage Projections



Av Climate Min and Max Catchment Areas – Horse Pit

Extracted from URS Report, Long Term Void Water Storage and Quality – Prepared for BMA Coal, 21 September 2009.

Attachment 5 Caval Ridge Long Term Pit Salinity Projections



Av Climate Min and Max Catchment Areas – Horse Pit

Extracted from URS Report - Long Term Void Water Storage and Quality – Prepared for BMA Coal, 21 September 2009.