Surface Water Impact Assessment Addendum

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0770-01-AB2
27 August 2013

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Daniel Sullivan
Hansen Bailey
6/127-129 John Street
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Dear Daniel,

SUBJECT: DRAYTON SOUTH COAL PROJECT PREFERRED PROJECT REPORT SURFACE WATER IMPACT ASSESSMENT ADDENDUM

1 INTRODUCTION

WRM Water & Environment Pty Ltd (WRM) has been engaged by Hansen Bailey Environmental Consultants (Hansen Bailey) on behalf of Anglo American Metallurgical Coal Pty Ltd (Anglo American) to prepare an addendum to the surface water impact assessment completed as part of the *Drayton South Coal Project Environmental Assessment* (EA) (Hansen Bailey, 2012) for the Drayton South Coal Project (the Project). The purpose of this addendum is to form an appendix to a Preferred Project Report (PPR) being prepared by Hansen Bailey to support project application 11_0062 under section 75H, Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

Following submission and public exhibition of the EA in late 2012, Anglo American has further evaluated and tested the functionality of the conceptual Project layout presented in the EA as part of the detailed engineering design phase. This work has resulted in the development of an optimised design for key infrastructure components required to facilitate the Project and amendments to the conceptual Project layout for which approval is being sought. Further to this, following a review of the Project mine plan by DP&I, Anglo American has agreed to make additional changes to the Project in order to improve the outcomes for neighbouring stakeholders and the environment.

The amendments sought as part of the Preferred Project are described below and shown on Figure 1.1.

- Minor amendments to the required infrastructure (collectively referred to as the amended infrastructure areas) including;
  - a minor modification to the alignment of the haul road and conveyor option within the transport corridor, including repositioning the required Macquarie Generation conveyor overpass and associated infrastructure;
  - an alternative alignment for the discharge pipeline from the Houston Dam to the Hunter River; and
  - subsequent revision of the Project Boundary to encompass the infrastructure amendments proposed above.
- Amendments to the Houston Visual Bund in order to comply with the option proposed in the public submission received from Coolmore Australia;

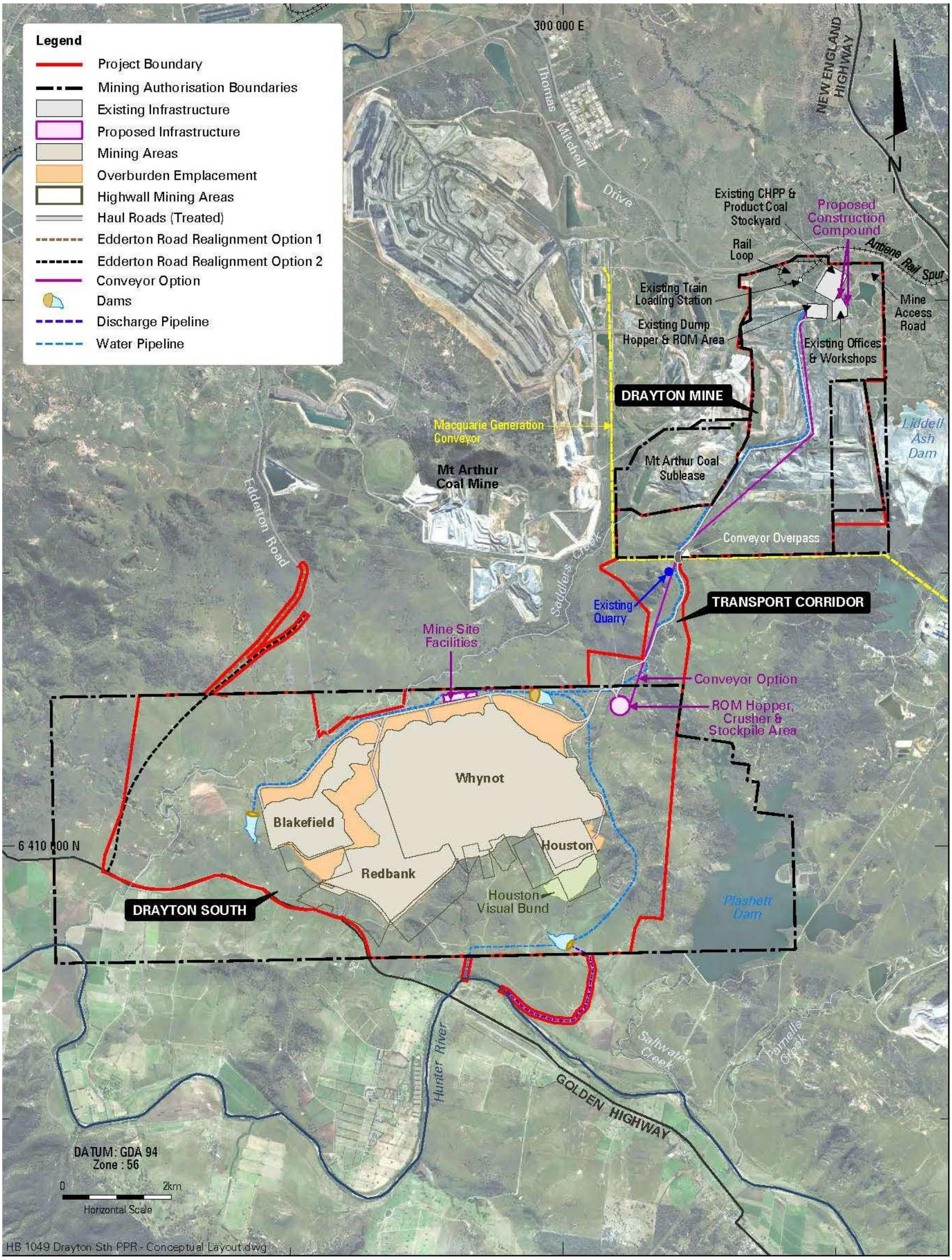

Figure 1.1 Drayton South Conceptual Project Layout

- A revised conceptual final landform design to reduce the size of the final void, reduce the slope of the final highwall and provide a more natural landscape incorporating principles of micro-relief; and
- Amendments to the location of the northern haul road to ensure that it is set back from Saddlers Creek a minimum 40 metres in all areas.

With regards to surface water impacts, the revised conceptual final landform design is the only amendment that requires further assessment. The changes to the infrastructure areas, Houston visual bund and the additional set back of the haul road from Saddlers Creek will not change the findings of the surface water impact assessment prepared as part of the EA. As such these amendments are not discussed any further in this report.

Hansen Bailey engaged WRM to update the final landform/void water balance model and associated surface water impact assessment that was first prepared for the EA in 2012, and then simulate and report the potential impacts arising from the modified final landform addressing the requirements of DP&I. The amendments to the final landform OPSIM water balance model are described and the results of the simulations are presented. A summary of differences between these results and those previously presented within the EA report is also given. This report should be read in conjunction with WRM's Surface Water Impact Assessment for the Drayton South Coal Project EA (Appendix M of the EA) for more information on assumptions and modelling methodologies as well as the Groundwater Impact Assessment Addendum prepared by AGE (2013) for information relating to the groundwater inflows to the final void.

2 UPDATED FINAL LANDFORM DESCRIPTION

Figure 2.1 shows the configuration and the major drainage catchments of the indicative final landform at Drayton South. The final landform and drainage configuration have been designed to replicate the surrounding geomorphic landform using the Geofluv method. This method attempts to design erosion resistant upland slopes and related stream channels and to integrate them into a functional and stable landform. The design of the final landform may be refined prior to the completion of mining once there is a better understanding of the overburden material characteristics. The general drainage characteristics of the final landform at Drayton South are as follows:

- The Blakefield Dam, Houston Dam, Transfer Dam and ROM Dam (if utilised) will be removed and rehabilitated;
- The Houston mining area will be rehabilitated to drain back to the final void left by the Whynot mining area;
- The overburden emplacement area will be rehabilitated so that the northern face will drain directly to Saddlers Creek and a large portion to the north-eastern area will drain to Saddlers Creek via a first order gully;
- The Blakefield mining area and western sections of the Redbank mining area will be rehabilitated so they drain to the Blakefield Dam catchment to the west. A drain will be constructed to divert some isolated first order gully catchments around the overburden emplacement area to the Blakefield Dam catchment. The drain will be designed with a bed slope and characteristics consistent with its revised catchment;
- The remaining overburden emplacement area catchment will drain into the final void of the Whynot mining area; and
- The resultant changes to the final landform have reduced the catchment draining to the final void to 688 ha (compared to 1,138 ha proposed in the EA) and returned it to Saddlers Creek.

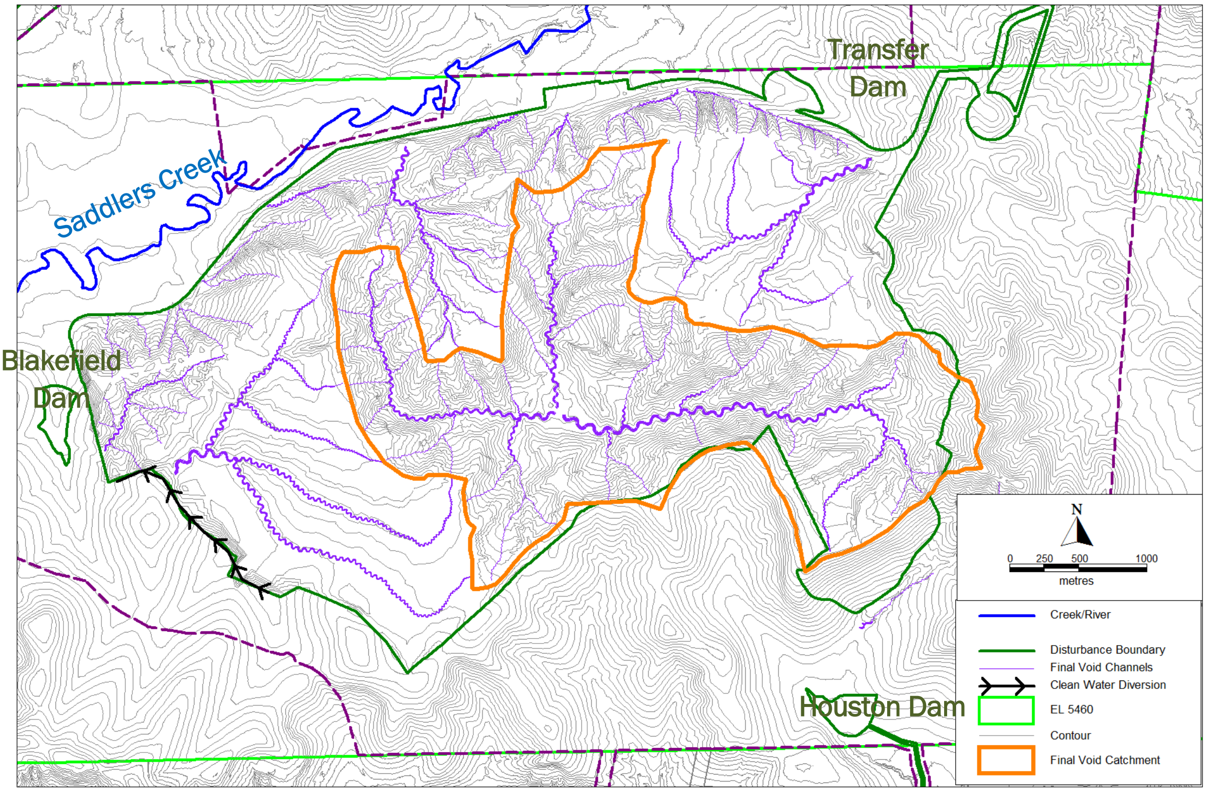

Figure 2.1 Drayton South Conceptual Final Landform

3 FINAL VOID STORAGE BEHAVIOUR

3.1 Overview

The Drayton South final void OPSIM simulation has been updated incorporating the latest changes to the final void configuration and catchments as shown in Figure 2.1 and the revised groundwater inflows as provided by AGE (2013). Considerably more rigour has been applied to understand groundwater behaviour of both the final void and the surrounding spoil when compared to the assessment made for the EA. This has been necessary because the base of the final void is now above both the bed level of Saddlers Creek and the Hunter River and therefore is likely to promote a greater loss of water from the void into the surrounding geology than what was originally presented in the EA (AGE, 2013). Also, the first measurable seepage of water from the spoil into the surrounding geology is likely to occur earlier than previously predicted for the original void design. Changes in the OPSIM modelling methodology are discussed further in the following sections.

3.2 Groundwater Behaviour

The groundwater model of the final landform developed by AGE (2013) consists of two connected components: the backfilled spoil and the final void area.

- The backfilled spoil will collect and accumulate water sourced from deep percolation of rainfall recharge from the spoil surface and it will also receive groundwater inflow from surrounding geological units.
- The void will collect and accumulate water from direct rainfall and surface runoff from the void catchment and also from the surrounding and underlying backfilled spoil material (once it has saturated). The void will lose water through evaporation from the lake surface and seepage back into the surrounding backfilled spoil.

The modelling of the groundwater system by AGE (2013) predicts the following:

- Groundwater from the surrounding geology (i.e. Permian coal measures) migrates into the spoil for the first 143 years of recovery, and (combined with rainfall recharge) increases the head within the spoil;
- When the head within the spoil reaches about 120mRL (after 143 years of recovery) a hydraulic gradient is established away from the spoil area (i.e. towards the northwest, west, southwest and south), which induces water to migrate from the spoil into the surrounding geology;
- A hydraulic gradient towards the spoil remains present from the northeast;
- The spoil will act as a 'flow through system', recharged from the north-east and discharging towards the northwest, west, southwest and south;
- Saturation of the spoil beneath the final void is predicted to take about 160 years before water enters the void from the underlying spoil;
- Rainfall runoff captured in the void prior to this is predicted to seep into the underlying spoil. The estimated seepage outflow rate for the first 160 years (prior to the potentiometric groundwater surface reaching the base of the void) is a constant rate of 1.16 ML/d, as shown in Figure 3.1;
- After 160 years, the gross outflow of water from the void to the surrounding spoil was assumed to be constant at 1 ML/d, as shown in Figure 3.1;
- Water levels within the final void attain their post-mining equilibrium level of about 153 mRL after 850 years;
- Evaporation from the final void water surface increases from 0ML/day to a maximum of 3.18ML/day as the area of the void water surface increases; and
- Net water movement from the spoil into the void increases from 0ML/day to a maximum of 1.33ML/day to replace void water that is lost to evaporation. This is represented graphically in Figure 3.1.
- The salinity concentration of the water held in the spoil (which then is predicted to seep into the void) was calculated using the relative concentrations of the Permian geology seepage to spoil (3,500 mg/L) and of the rainfall recharge to spoil (200 mg/L) and assuming complete mixing occurs. The resulting time series of salinity concentration of water stored in the spoil was calculated by AGE (2013) and is shown in Figure 3.2.

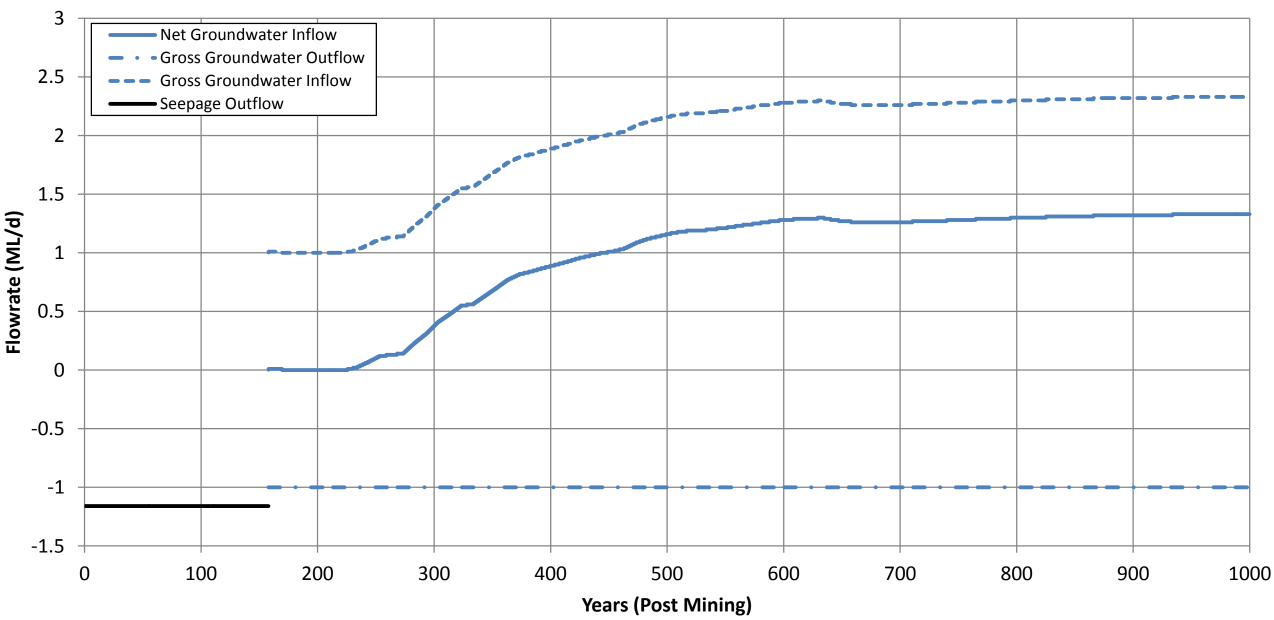

Figure 3.1 Adopted Long Term Gross Groundwater and Seepage Inflows and Outflows to the Final Void

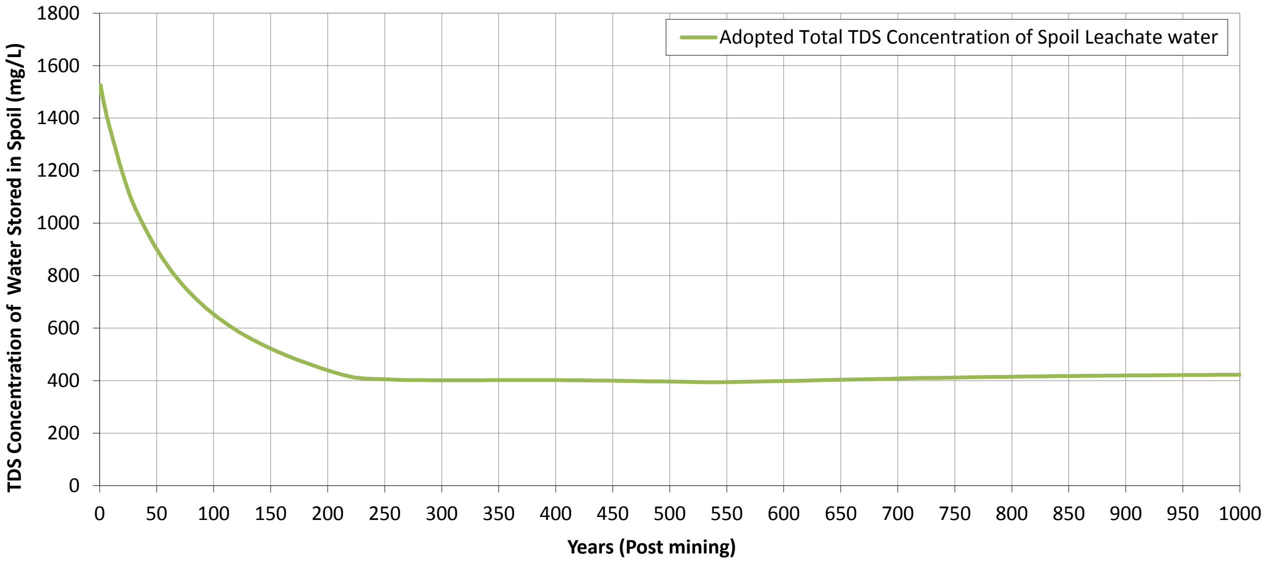

Figure 3.2 Adopted Time Series of TDS Concentration of Water Stored in Spoil

3.3 OPSIM Model Configuration

The OPSIM water balance model was reconfigured to replicate the final void behaviour estimated by AGE (2013) to assess the long term build up of salts in the Drayton South final void. The final void configuration and contributing catchment area are shown in Figure 2.1.

For the previous OPSIM modelling of the final void undertaken for the EA, a net inflow of groundwater was applied to the model. This was a simplification that was deemed suitable because the final void was predicted to remain a groundwater “sink” for a period of about 700 years after mining (AGE, 2012). The revised groundwater modelling suggests that the higher water level within the spoil and void is likely to promote a greater loss of water from the spoil into the surrounding geology (at a maximum rate of 0.54 ML/d) than what was originally presented in the EA and that the first measurable seepage of water from the spoil into the surrounding geology is likely to occur earlier than previously predicted and prior to groundwater entering the void. It was therefore necessary for the revised OPSIM model to incorporate a gross inflow to and gross outflow from the final void (rather than the net inflow adopted previously).

Also, for the previous OPSIM modelling of the final void, as presented in WRM’s EA report (Appendix M of the EA), the adopted net groundwater inflow rate was assumed constant, which resulted in the void water level in the OPSIM model recovering quickly. Considering the revised AGE modelling (2013) indicates that the net inflow of water from the spoil to the void is not predicted to occur until about 160 years post-mining and the net groundwater inflow then increases over time (as shown in Figure 3.1), a longer simulation period was required for the revised OPSIM model to reach an equilibrium void water level. To achieve this, the historical rainfall and evaporation sequences were looped numerous times to create a long term climate record and run as a static simulation.

The configuration of the OPSIM model is described in the EA. The changes made to the OPSIM model are as follows:

- The adopted final void catchment area is reduced to 688 ha;
- The adopted stage-storage curve was updated based on the final landform contours, shown in Figure 1.1;
- The final void spill height is between 172 and 174 mRL;

- The time series of long term gross groundwater inflows and outflows to the final void, adopted for the OPSIM modelling are shown in Figure 3.1. This gross inflow was calculated by adding the assumed outflow rate of 1 ML/d (as advised by AGE) to the net inflow rate; and
- The TDS concentration time series shown in Figure 3.2 was applied to the gross inflow of groundwater. The TDS concentration leaving the void was calculated by OPSIM assuming full mixing of groundwater and surface water flows.

3.4 OPSIM Model Results

The predicted water level and salt concentration represented as total dissolved solids (TDS) in the final void is shown in Figure 3.3 and Figure 3.4, respectively. The results of the assessment are summarised as follows:

- The final void will reach an equilibrium water level of approximately 150-155 mRL after about 700 years. This result is consistent with the results produced by AGE (2013).
- The freeboard between the final water level surface and the void spill height is approximately 20m. Hence, the final void is never likely to fill (nor spill), as a rainfall event causing enough catchment runoff to fill the void is unlikely.
- The salinity in the final void will not begin to increase until seepage out of the void ceases and net groundwater inflow begins at about 160 years post-mining.
- The final void will reach an equilibrium salinity level of between 750 and 1,300 mg/L (depending on the climatic conditions) after about 700 years.
- Equilibrium is reached due to the final void acting as a “flow through system”, as described in AGE’s Groundwater Impact Assessment Addendum (2013), which provides a pathway for removal of salts from the void.

The potential impacts of the predicted void salinity on the groundwater system are described in AGE’s Groundwater Impact Assessment Addendum (2013).

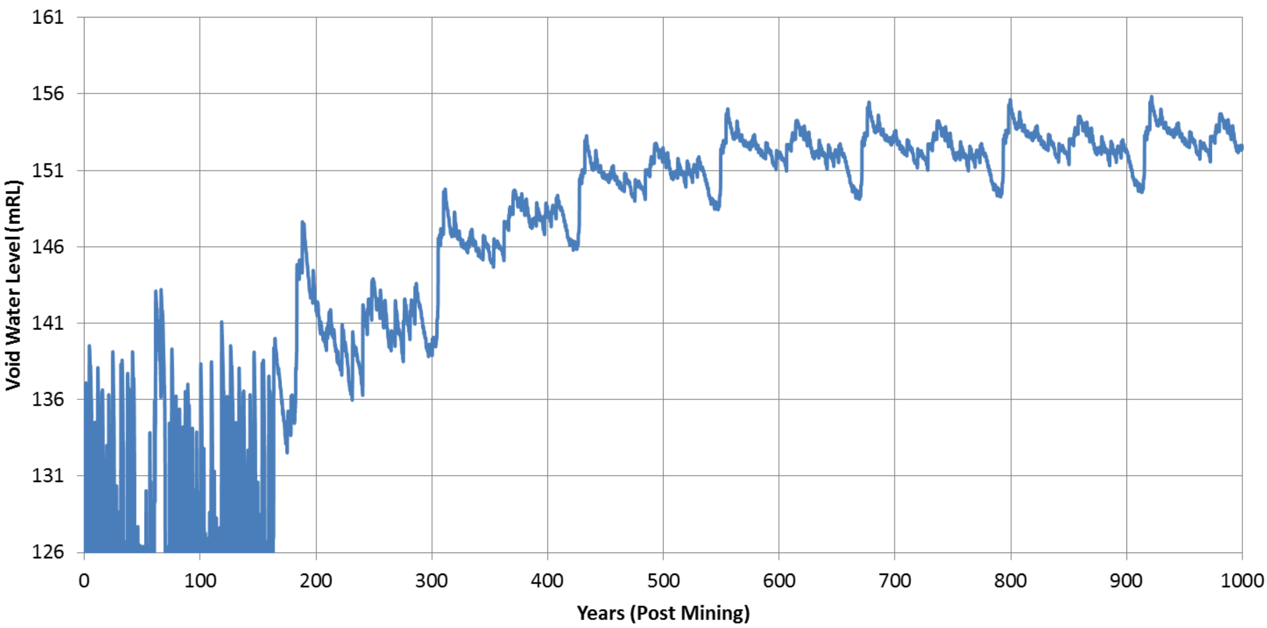

Figure 3.3 Final Void Water Level

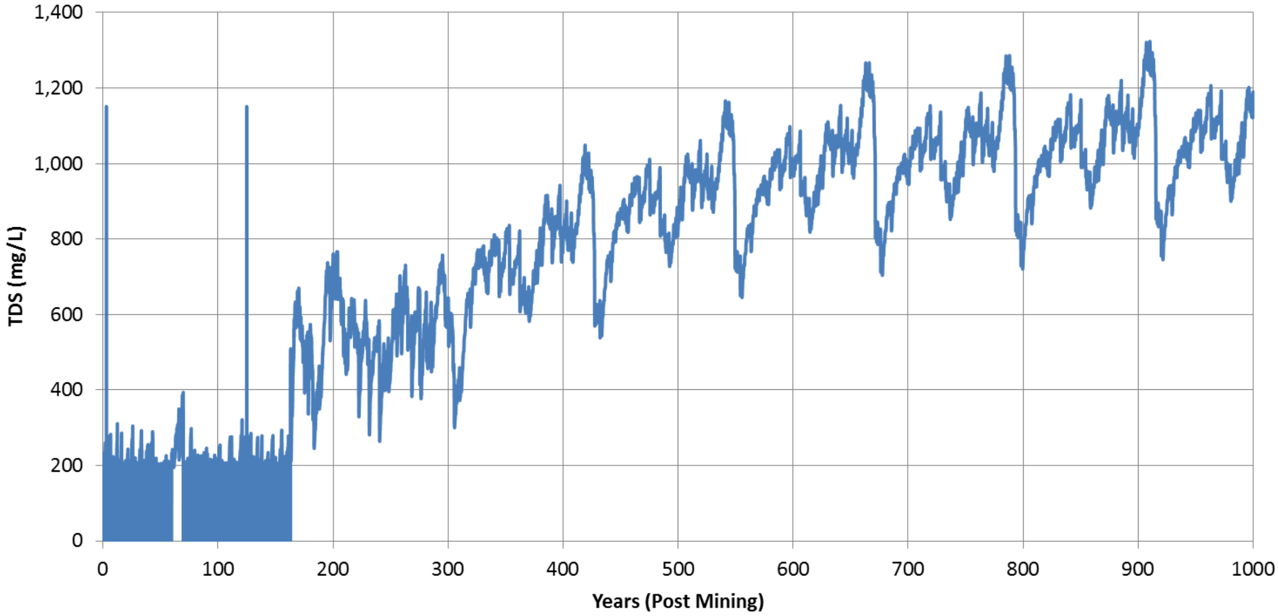

Figure 3.4 Final Void Total Dissolved Solids Concentration

4 SURFACE WATER IMPACTS

4.1 Loss of Catchment

The revised final void mine plan as presented in the PPR and shown on Figure 2.1 have the following impacts when compared to the final void plan presented in WRM's EA report (Appendix M of the EA):

- Final Void:
  - The catchment draining to the final void decreases from 1,138 ha to 688 ha, a decrease of 39.4%.
  - The volume of surface water take that will require licensing under the HRUWSP will decrease.
  - The water take that will require licensing for the updated final void footprint (taking into account harvestable right), is as per Table 4.1. This has been calculated based on the following assumptions:
    - the intercepted peak annual water take has been estimated using maximum annual rainfall of 1,164mm (from SILO Datadrill) and a volumetric runoff coefficient of 12% based on the runoff coefficient utilised for harvestable rights calculations (10% of runoff = 0.07 ML/ha = 7 mm runoff. 100% of runoff = 70 mm. 70mm/572.3 mm average annual rainfall = 12%);
    - the estimated 95th percentile annual take was calculated as above, but using the 95th percentile rainfall of 787mm from the 122 year data series;
    - the estimated 90th percentile annual take was calculated as above, but using the 90th percentile rainfall of 752mm from the 122 year data series; and
    - the harvestable right available to the Project is 314 ML (based on the Project's landholding of 4,766 ha, a harvestable rights multiplier value of 0.07 ML/ha for the relevant area and existing farm dams total capacity on the landholding of 20ML).
- Saddlers Creek:
  - The loss of catchment to Saddlers Creek (including the Savoy Dam final void of 41 ha) will decrease from 989 ha to 498.6 ha (including 525 ha diverted to the Drayton South final void

and Savoy Dam and 26.4 diverted from the Saltwater Creek catchment) This results in a total reduction in the pre-mining Saddlers Creek catchment (9,718 ha) of 5.1%.

- Saltwater Creek:
  - The loss of catchment to Saltwater Creek will not change from that reported in Appendix M of the EA.
- Hunter River:
  - The catchment draining directly to the Hunter River will increase by 13.7 ha.
  - The total loss of catchment for post-mining conditions to the Hunter River at Liddell gauging station will remain less than 0.1%.

Table 4.1 Annual Take Requiring Licensing (After Allowing for Harvestable Right)

Updated Final Void Captured Catchment (ha)	Peak (ML)	95th percentile (ML)	90th percentile (ML)
689	664	347	318

4.2 Surface Drainage Modification

Substantial channel modification will be required downstream of the areas being diverted into Saddlers Creek to the north-east (Area 1), the north (Area 2) and to the south-west (Area 3) of the final void, as shown in Figure 4.1. The revised final void mine plan and contours indicate a significant increase in catchment area being diverted to the natural channels at locations A , B and C (see Figure 4.1). The proposed changes in catchment area draining to the three channels from existing conditions are:

- Channel A will increase from 8.6 ha to 233 ha;
- Channel B will increase from 22.9 ha to 114 ha; and
- Channel C will increase from <5 ha to 565 ha.

It is proposed to reconstruct the natural channels at locations A, B and C to cater for the additional flows using natural channel design principles generally in accordance with the guideline *Management of Stream/Aquifer Systems in Coal Mining Developments Hunter Region* (DIPNR, 2005). The channels will be designed by a suitably qualified person in consultation with the Catchment Management Authority and the regulators. The modified channels will be designed using nearby gullies with similar catchment areas as a template. The locations of these nearby gullies are shown in Figure 4.2.

- Channel A will have a catchment area of approximately 235 ha, a channel length of 540 m and an average bed slope 5.5%. The channel will be designed using the pre-mining Blakefield Gully as the template. This gully has an existing catchment area of 240 ha and an average bed slope of 3.3%.
- Channel B will have a catchment area of about 114 ha, a channel length 300m, and an average bed slope of 10%. The channel will be designed using the pre-mining neighbouring gully to the west as the template. This gully has an existing catchment area of 145 ha and an average bed slope of 3.1%.
- Channel C will have a catchment area of about 565 ha, a channel length 510m, and an average bed slope of 6.8%. The channel will be designed using the pre-mining gully located between Edderton Road and Blakefield Gully as the template. This gully has an existing catchment area of ~860 ha and an average bed slope of 1%.

To achieve a similar bed slope in the modified channels as the template gullies, the channel will be constructed with a meander geometry similar to the template channel. It may also be necessary to modify the final landform from that shown in Figure 3.1 to lower the entry level from the overburden to achieve the required channel slope.

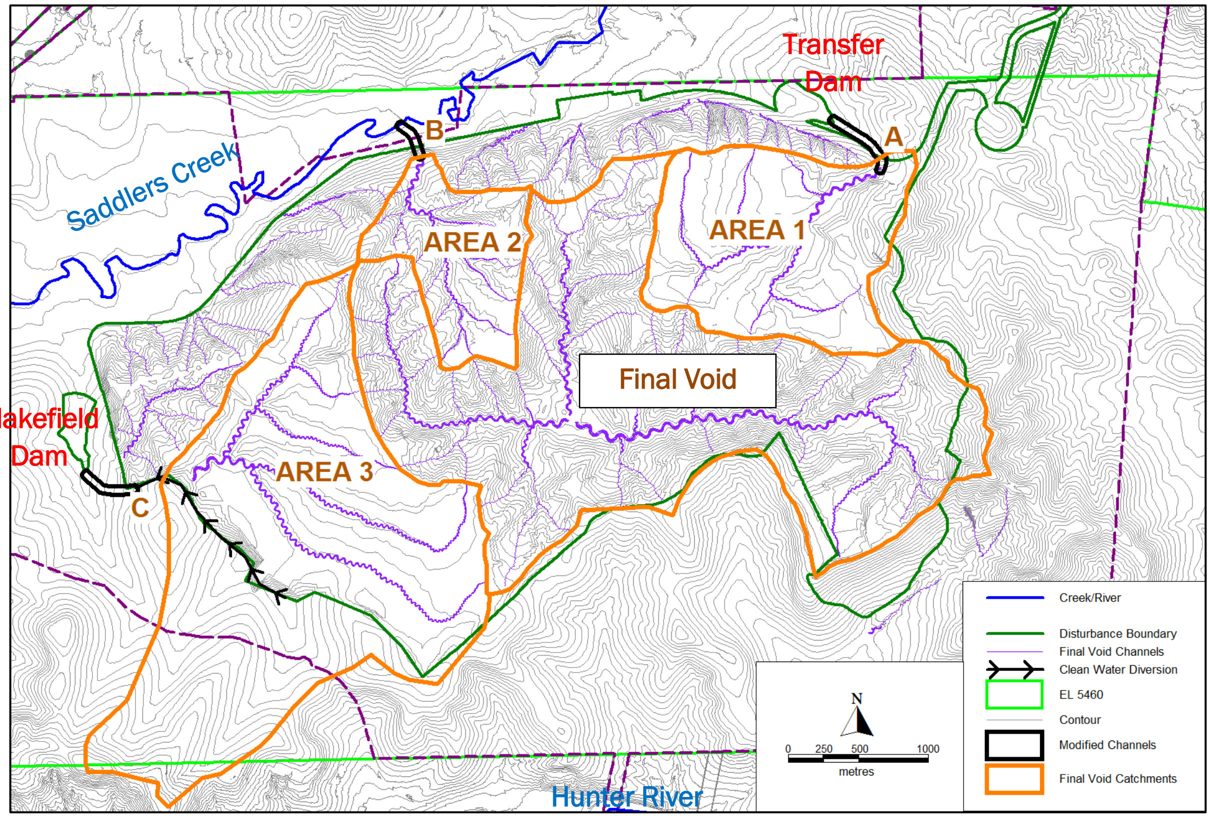

Figure 4.1 Conceptual Final Void Catchment Plan

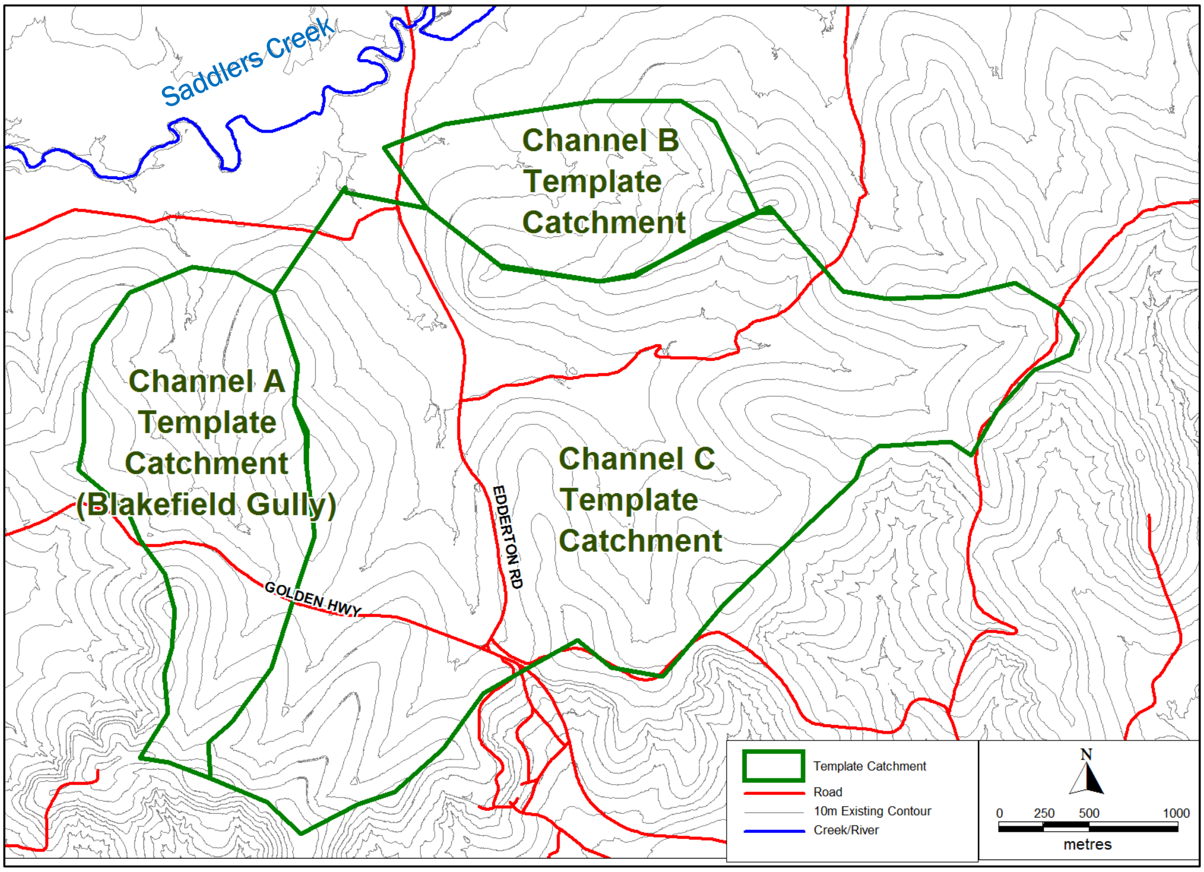

Figure 4.2 Template Catchments for Channel Modification

5 SUMMARY OF FINDINGS

A summary of the revised final void assessment is as follows:

- The final void is predicted to equilibrate at a water level of between 150-155 mRL, about 18-23 m below the overflow level, and a salinity of 750 – 1,300 mg/L (depending on the climatic conditions) after about 700 years. The potential impacts of the predicted void salinity on the groundwater system are described in AGE's Groundwater Impact Assessment Addendum (2013).
- The volume of surface water take that will require licensing under the HRUWSP will decrease as a result of the reduced final void catchment.
- There is a subsequent increase in the catchment draining to Saddlers Creek compared to that presented in the EA. The overall loss of Saddlers Creek catchment is now 5.4% (compared to 10% in the EA).
- There is no further loss of catchment draining to Saltwater Creek.
- Significant channel modification will be required in the three channels where spoil catchment has been directed to mitigate erosion potential. The channels will be modified using natural channel design principles generally in accordance with the guideline *Management of Stream/Aquifer Systems in Coal Mining Developments Hunter Region* (DIPNR, 2005).

For and on behalf of
WRM Water & Environment Pty Ltd

Greg Roads
Principal Engineer

6 REFERENCES

AGE, 2012	*Drayton South Coal Project: Groundwater Impact Assessment,* prepared by Hansen Bailey Environmental Consultants for Anglo American Metallurgical Coal Pty Ltd, 2012 (Appendix N of the EA).
AGE, 2013	*Drayton South Coal Project Preferred Project Report Groundwater Impact Assessment Addendum* prepared by Hansen Bailey Environmental Consultants for Anglo American Metallurgical Coal Pty Ltd, 2013.
Hansen Bailey, 2012	*Drayton South Coal Project Environmental Assessment,* prepared by Hansen Bailey Environmental Consultants for Anglo American Metallurgical Coal Pty Ltd, 2012.
WRM, 2012	*Surface Water Impact Assessment – Drayton South Coal Project EA*, Report 0770-01-I(rev 5) WRM Water and Environment, October 2012 (Appendix M of the EA).

DRAYTON SOUTH

Groundwater Impact Assessment Addendum

F

Australasian
Groundwater & Environmental
Consultants Pty Ltd

REPORT on

DRAYTON SOUTH COAL PROJECT PREFERRED PROJECT REPORT

GROUNDWATER IMPACT ASSESSMENT ADDENDUM

prepared for
HANSEN BAILEY ENVIRONMENTAL CONSULTANTS PTY LTD

Project No. G1544/F
August 2013

AGE

ABN:64 080 238 642

Australasian
Groundwater & Environmental
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REPORT on

DRAYTON SOUTH COAL PROJECT PREFERRED PROJECT REPORT

GROUNDWATER IMPACT ASSESSMENT ADDENDUM

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Project No. G1544/F
August 2013

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Project No. G1544/F
August 2013

REPORT ON

DRAYTON SOUTH COAL PROJECT – PREFERRED PROJECT REPORT

GROUNDWATER IMPACT ASSESSMENT ADDENDUM

1 INTRODUCTION

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) has been engaged by Hansen Bailey Environmental Consultants Pty Ltd (Hansen Bailey) on behalf of Anglo American Metallurgical Coal Pty Ltd (Anglo American) to prepare an addendum to the groundwater impact assessment completed as part of the *Drayton South Coal Project Environmental Assessment* (EA) (Hansen Bailey, 2012) for the Drayton South Coal Project (the Project). The purpose of this addendum is to form an appendix to a Preferred Project Report (PPR) being prepared by Hansen Bailey to support project application 11_0062 under section 75H, Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

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The amendments sought as part of the Preferred Project are described below, and include:

- Minor amendments to the required infrastructure (collectively referred to as the amended infrastructure areas) including;
  - A modified alignment for a portion of the haul road and conveyor option within the transport corridor. This includes repositioning the required Macquarie Generation conveyor overpass and associated infrastructure to accommodate the modified alignment for the haul road and conveyor option;
  - An alternative alignment for the required discharge pipeline from the Houston Dam to the Hunter River; and
  - Subsequent revision of the Project Boundary to encompass the infrastructure amendments proposed above.
- Amendments to the Houston Visual Bund in order to comply with the option proposed in the public submission received from Coolmore Australia;
- A revised conceptual final landform design to reduce the size of the final void, reduce the slope of the final highwall and provide a more natural landscape incorporating principles of micro-relief; and
- Amendments to the Project to ensure the set back from Saddlers Creek of the northern haul road is at minimum 40 metres in all areas.

With regard to the above, only the revised conceptual final landform design requires additional assessment for inclusion in this report. The changes to the infrastructure areas, Houston Visual Bund and the additional set back of the haul road from Saddlers Creek will not have any significant influence over the groundwater impact assessment. As such these components are not discussed any further in this report.

Hansen Bailey engaged AGE to update the groundwater model that was first prepared for the EA in 2012, and then simulate and report the potential impacts arising from the modified final landform. This report describes the amendment of the groundwater model, the predictive simulations undertaken, the results of the simulations, and a summary of differences between these results and those previously presented within the EA report.

2 OBJECTIVES AND SCOPE OF WORK

The objective of this study is to re-assess the potential impacts to the local groundwater regime resulting from the changed design of the final landform of the project.

The current groundwater model consists of three components, these being:

1. pre-mining simulations;
2. mining simulations; and
3. post-mining simulations.

The modified final landform design does not change the overall mine plan. That is, the proposed mine will excavate the same coal seams, and have the same depth, extent, and lifespan as the original mine plan included within the 2012 EA assessment. Therefore, the pre-mining and mining groundwater model components did not require significant updates and their results are still relevant to include within the PPR. However, the post-mining model structure and simulations required significant revision to include the modified final landform.

Once the post-mining model had been reconfigured, predictive simulations were undertaken to evaluate the groundwater recovery and potential long-term impacts arising after mining. These simulations were specifically undertaken to assess the:

- final void water balance;
- groundwater heads and hydraulic gradients; and
- elevation of water level within the final void.

Modelling of the final void water balance required collaboration between AGE and surface water consultants, WRM Water and Environment Pty Ltd (WRM). WRM initially updated their two dimensional OPSIM hydrology model prior to AGE commencing the groundwater model simulations. The initial OPSIM results were used by AGE to help guide the input/output of the groundwater model.

3 CONCEPTUAL GROUNDWATER MODEL OF THE FINAL LANDFORM

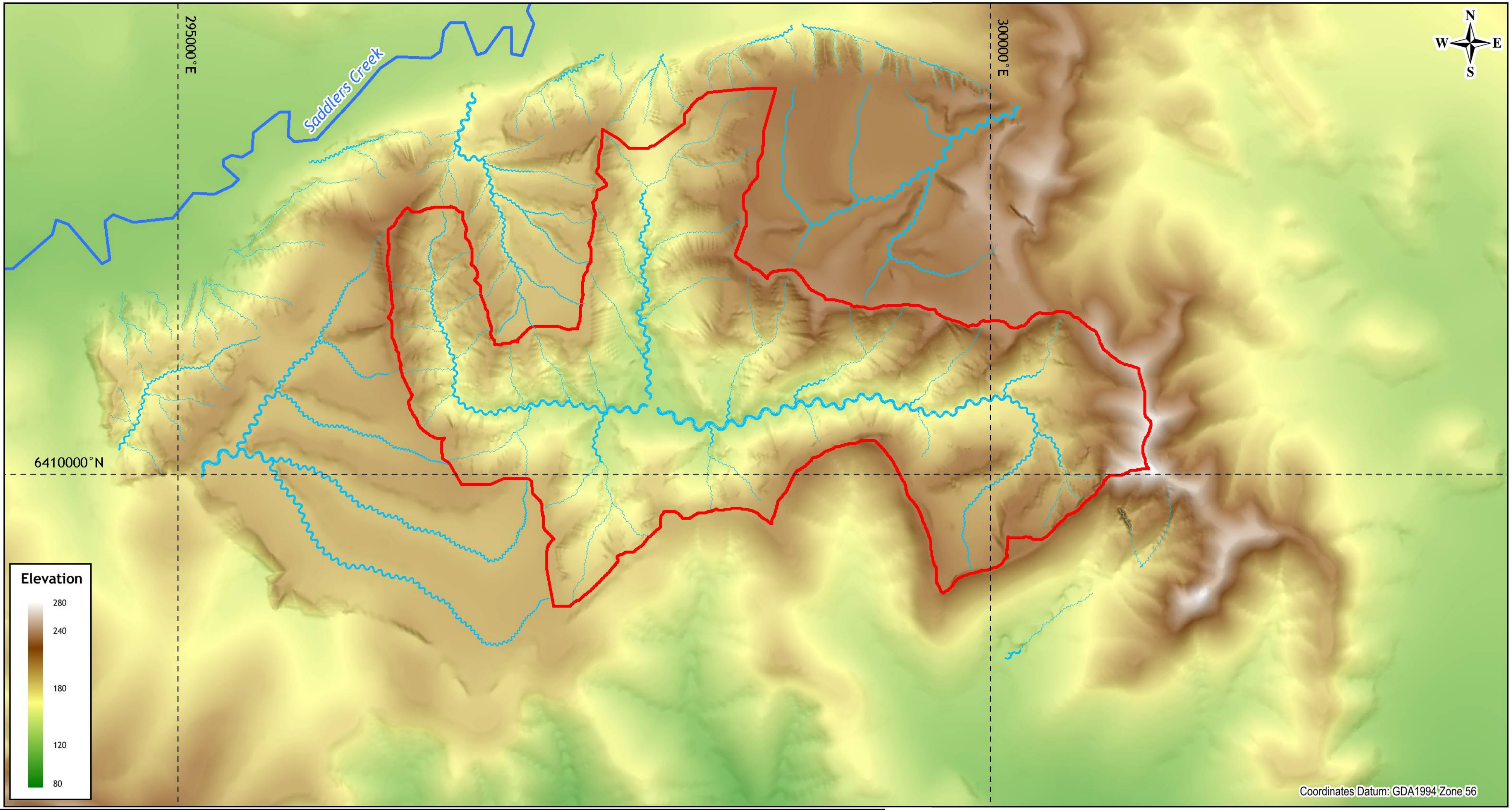
The modified final landform will consist of spoil areas that have been re-worked across the entire mining area. The spoil will be shaped in a manner that promotes free drainage away from the northern and western mining areas. Drainage of the majority of the eastern and central areas will be directed towards a central void area. The final void will have a catchment area of about 688 ha and have a depth up to about 75 m below the pre-mining surface topography. The lowest elevation of the final void is about 125 mRL. The deepest elevation of the mined area prior to reshaping the spoil areas will be about 50 mRL. The final void catchment area and drainage system is shown on Figure 1.

The water balance of the mining area will consist of two connected components, these being associated with the backfilled spoil and the final void area. The backfilled spoil will collect and accumulate water sourced from deep percolation of rainfall recharge and it will also receive groundwater inflow from surrounding geological units.

The void will collect and accumulate water sourced from the surrounding backfilled spoil material (eventually), direct rainfall into the void, and from the slopes of the spoil draining into the void. All undisturbed catchment flows will be diverted around the void, to limit the impact on overland flow. Water inflow and losses from the final void post mining are conceptually illustrated in Figure 2. Generally, the water balance of the void post mining consists of:

- Inflows:
    - surface runoff;
    - direct rainfall into the void; and
    - seepage from the spoil.
- Outflows:
    - evaporation from the lake surface; and
    - seepage to the surrounding spoil.

The moderate levels of evaporation experienced in the Hunter Valley will slow the rate of recovery of water in the void by constantly removing water from the final void water surface. Average evaporation in the region is almost two and a half times the average annual rainfall.



Channels

Saddlers Creek

Catchment Boundary

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
LEVEL 2, 15 MALLON ST, BOWEN HILLS, 4006, AUSTRALIA

TITLE: DRAYTON SOUTH MINE PROJECT EA - GROUNDWATER ASSESSMENT
FINAL VOID CATCHMENT AREA

CLIENT: Anglo American			OFFICE: Brisbane
DRAWN BY: MU	SCALE: 1 : 35,000 (A4)	PROJECT No: G1544	DRAWING No: 1
APPROVED BY:	DATE: 6/8/2013		

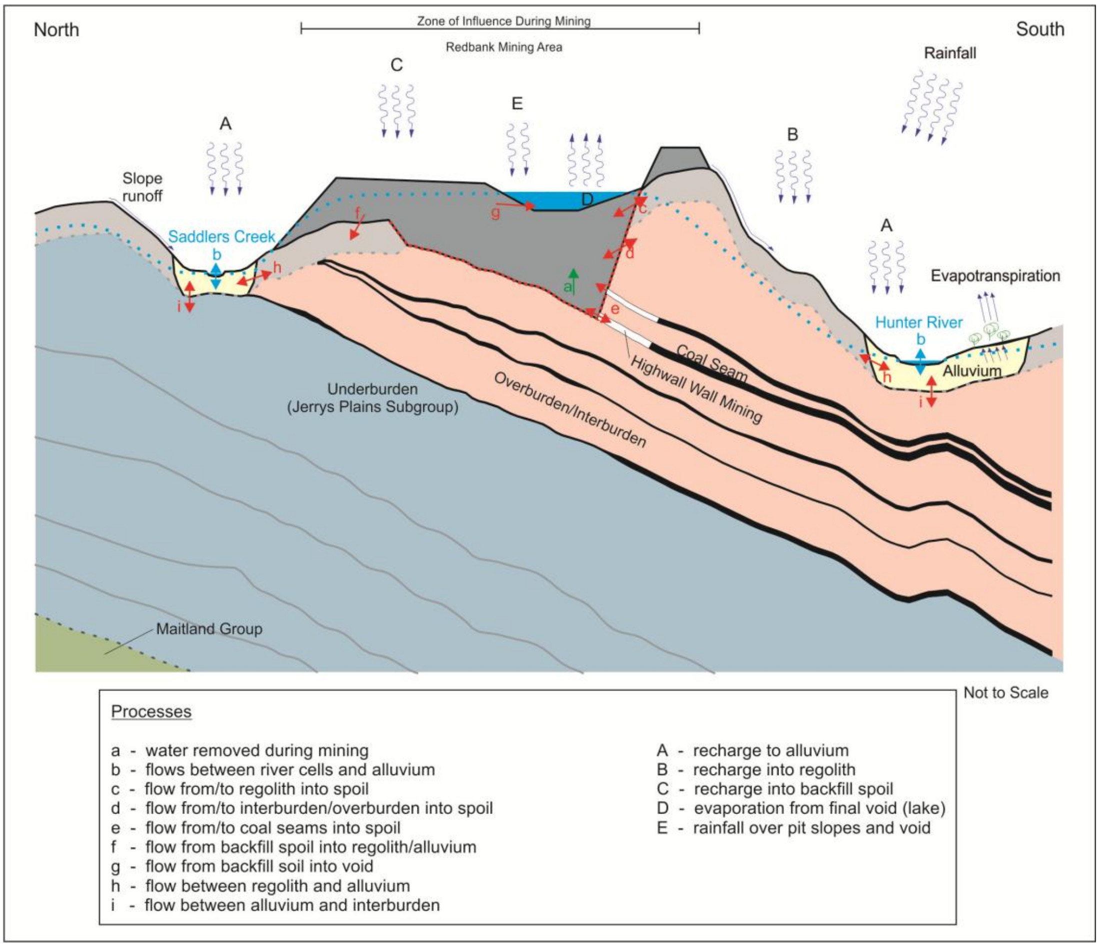


Figure 2: Conceptual Model Cross Section

4 MODELLING OF THE FINAL VOID WATER BALANCE

The simulation of the modified final landform was configured as described by AGE (2012), with the inclusion of an updated catchment area and spoil layout. Groundwater modelling of the final landform was achieved by assigning the open pit void area an arbitrary high horizontal and vertical hydraulic conductivity (1000 m/day) and storage parameters (specific yield and storage coefficient) of 1.0, in order to simulate free water movement within the void. This approach is often referred to as 'high K lake'.

Rainfall recharge rates of 90% of average historical rainfall were applied to the final void lake area to simulate a direct input of rainfall to the lake surface. A surface water catchment area of 700.3 ha and a long-term runoff (yield) of about 20% of average annual rainfall were applied to the catchment area. A recharge rate of 22 mm/year (3.3% annual rainfall) was adopted for spoil areas. The spoil recharge rate was adopted to simulate increased infiltration through disturbed rock/ backfill in these areas.

The effect of evapotranspiration across the spoil areas and the final void water surface was simulated as a percentage of the pan evaporation rate. The rates of pan evaporation applied were:

- 20% (240 mm/year / 0.6mm/day) to the spoil as it was progressively emplaced behind the advancing highwall;
- 60% (723 mm/year / 2 mm/day) to the spoil runoff area; and
- 90% (1479 mm/year / 4 mm/day) to the final void lake surface to account for the effects of sun and wind on the lake surface.

5 ESTIMATE OF FINAL VOID WATER LEVEL

The predicted water level recovery in the original final void is presented in Figure 3, and the predicted water level recovery in the modified final void is presented in Figure 4.

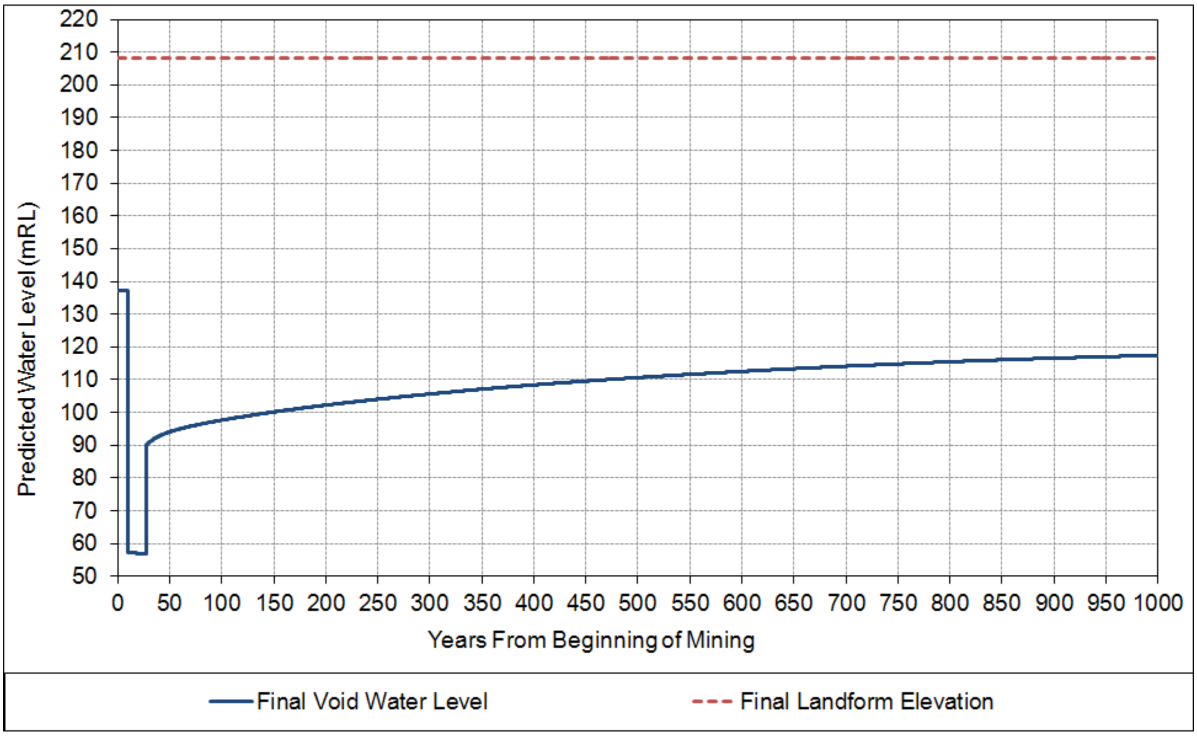


Figure 3: Predicted Water Level in Final Void – Original Void Design

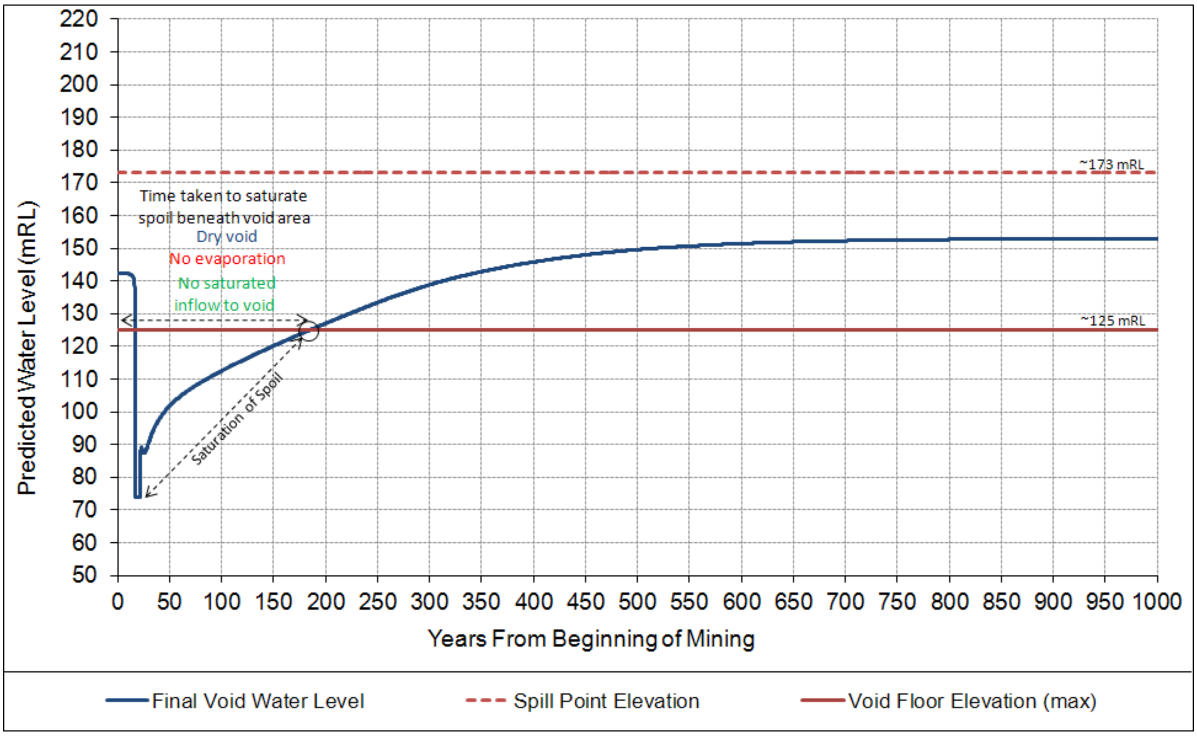


Figure 4: Predicted Water Level in Final Void – Modified Void Design

For the modified void design, saturation of the backfilled spoil is predicted to take about 160 years (after mining), before seepage from the spoil would begin to enter the final void. The void water level is predicted to reach 85% of the post-mining equilibrium level within 450 years after mining, as illustrated in Figure 4. This water level is equivalent to about 147 mRL. Water levels within the final void attain their post-mining equilibrium level of about 153 mRL after 850 years. Effectively, at this elevation, the amount of water entering the void via runoff, direct rainfall, and seepage from the spoil is equivalent to the amount of water lost to evaporation from the void water surface. These recent results are in contrast to the results predicted for the original void design, where the void water level reached an equilibrium elevation of about 117 mRL after about 1000 years (Figure 3).

The surface water spill height of the modified final void is located at an elevation of about 172-174 mRL. The freeboard between the spill point of the modified final void design and the surface water elevation is therefore predicted to be about 20 m. The freeboard of the original void design is predicted to be about 90 m.

The higher predicted surface water level for the modified void design is a result of reducing the storage capacity of the void. Filling the lowermost section of the void with spoil reduces the storage capacity (i.e. specific yield) of the filled section from 100% down to about 1%. Therefore, the section of the void that is backfilled with spoil (within the modified design) will become completely saturated by a volume of water that is 100 times smaller than the original design. The rate of recovery will also be enhanced by the smaller storage capacity and the absence of evaporation as the spoil saturates.

In summary, the storage capacity of the final void has been reduced which leads to a higher predicted water level within the modified void compared to the original void design.

6 FINAL VOID WATER BALANCE

The predicted water balance for the original void design is presented in Figure 5, and the predicted water balance for the modified void is presented in Figure 6.

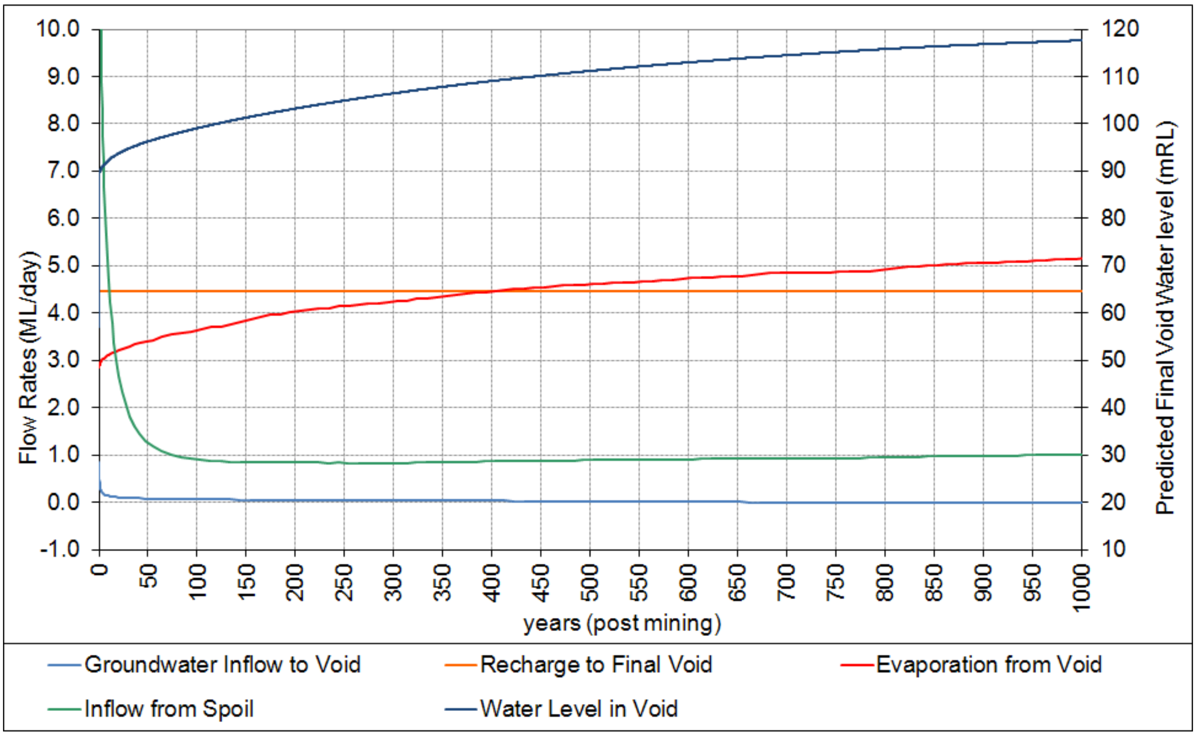


Figure 5: Water Budget and Predicted Water Level – Original Void Design

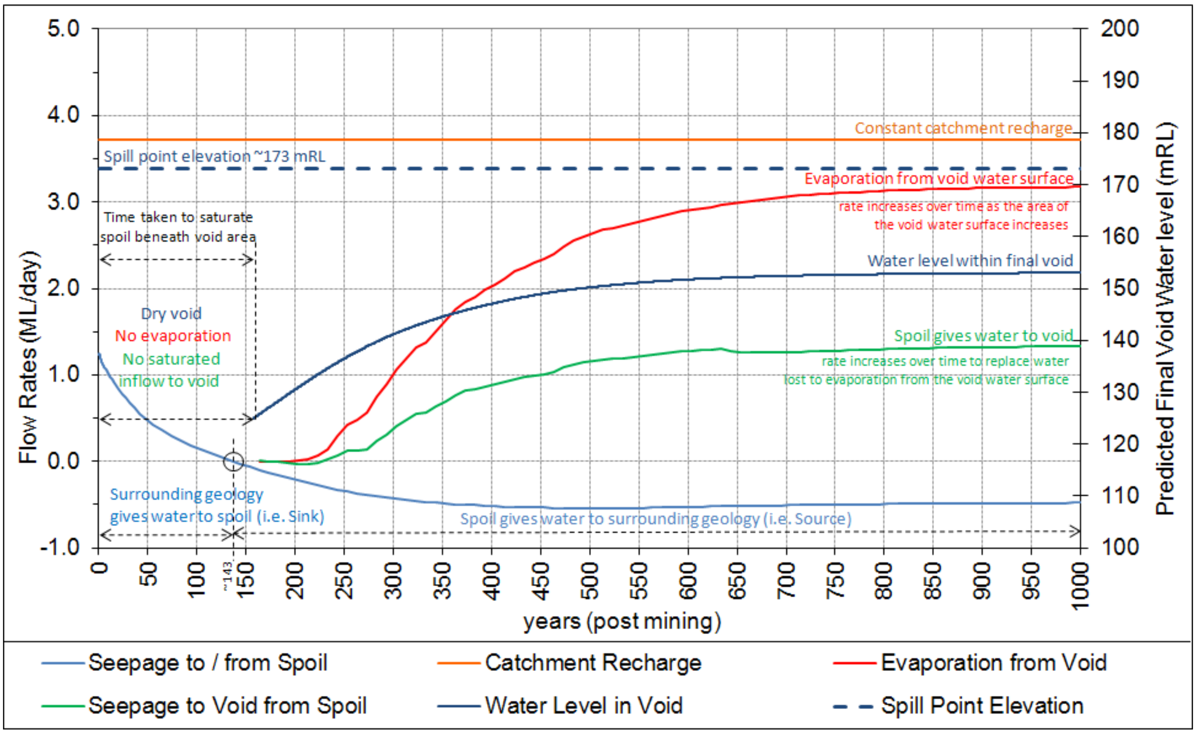


Figure 6: Water Budget and Predicted Water Level – Modified Void Design

For the modified void design, the net groundwater contribution from the surrounding geology (i.e. Permian coal measures) into the backfilled spoil is predicted to decrease from 1.24 ML/day down to zero, over a period of about 143 years following mining. Therefore, no outflow of spoil water into the surrounding aquifers is predicted to occur whilst a hydraulic gradient exists towards the spoil area (i.e. a “groundwater sink”). The hydraulic gradient is predicted to be reversed away from the spoil area after 143 years, when heads within the spoil reach an elevation greater than 120 mRL. The loss of water from the backfilled spoil into the coal measures is predicted to rise from zero up to 0.54 ML/day during the period between 143 and 450 years after mining (i.e. a groundwater “source”).

The effect of evaporation on recovering water levels is absent for about the first 160 years after mining. This is due to the head within the spoil being lower than the base of the void area. The absence of evaporation during this period enhances the rate at which the water level recovers within the spoil.

Evaporation from the final void water surface, after 160 years, increases from zero to a maximum of 3.18 ML/day, as the area of the void water surface increases. Water movement from the spoil into the void increases from zero to a maximum of 1.33 ML/day to replace void water that is lost to evaporation.

These recent results are in contrast to the results predicted for the original void design, where the void water balance indicated that the void would remain a sink for a period of about 700 years after mining. Also, the loss of water from the original void design into the coal measures is predicted to be less than that predicted for the modified void design. The loss of water from the original void design is predicted to rise from zero up to 0.02 ML/day, which is less than the rate of 0.54 ML/day predicted for the modified void design.

In summary, the recent results suggest the higher water level within the modified void design is likely to promote a greater loss of water from the void into the surrounding geology. Also, the first measurable seepage of water from the spoil into the surrounding geology is likely to occur earlier than previously predicted for the original void design.

7 GROUNDWATER HEADS AND HYDRAULIC GRADIENT

The predicted groundwater heads surrounding the original void design are presented in Figure 7, and the predicted heads surrounding the modified void design are presented in Figure 8.

For the modified void design, the predicted heads at 1000 years after mining show a very flat hydraulic gradient within the spoil area. This is typical for spoil areas where the hydraulic conductivity of the material is relatively high compared with the surrounding geology (e.g. Permian coal measures). The contours shown on Figure 8 illustrate the head within the spoil attains an elevation of about 153 mRL throughout most of the spoil area. The head contours also suggest the void will act as a “window” into the water table of the saturated spoil.

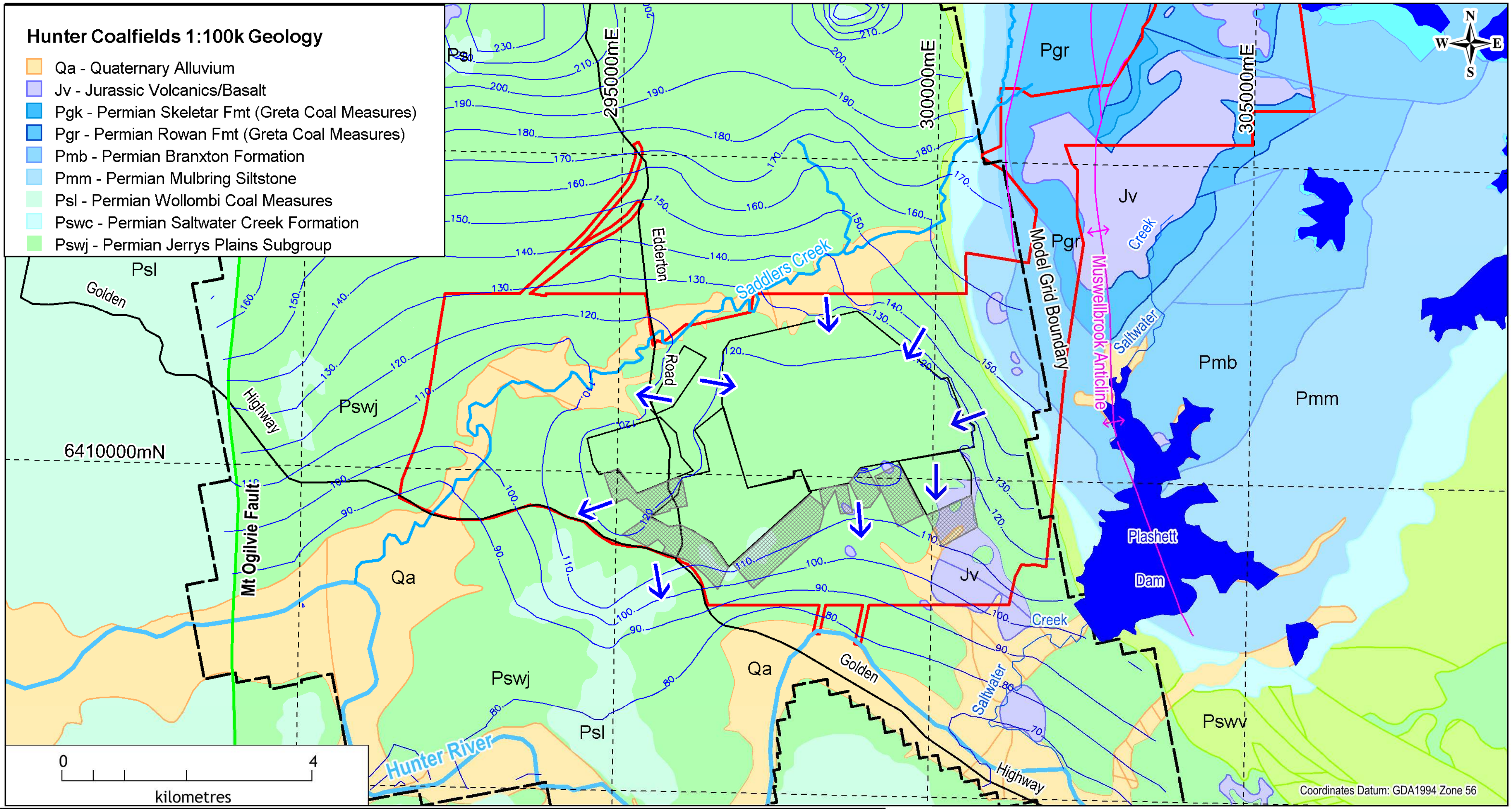
The hydraulic gradients shown on Figure 8 suggest the spoil profile and the final void will act as a “flow through system”, which is recharged from the northeast and discharged towards the north, northwest, west, southwest, and south. The predicted head gradients suggest that seepage from the spoil area is likely to migrate beyond the mining area and into the surface drainage of Saddlers Creek and the Hunter River, via migration through the Permian coal measures and alluvial aquifers.

These recent predictions are broadly similar to those predicted for the original void design, where similar hydraulic gradient patterns were established, as shown in Figure 7. The main difference between the predictions is the elevation of the equilibrium water level within the spoil and void. The original void design attained an equilibrium water level of about 120 mRL compared to an elevation of about 150 mRL for the modified void design. The original predictions suggest hydraulic gradients would promote discharge from the spoil towards the northwest, west, southwest and south. The main difference being that less seepage was predicted to be directed towards Saddlers Creek for the original void design.

Although the head elevation within the spoil for the modified void design is predicted to be raised above the natural topographic elevation in a number of areas, the head is predicted to not extend above the modified landform. Therefore, discharge of water from the spoil directly onto the land surface is not anticipated to occur. Similarly, discharge of water from the spoil directly onto the land surface was predicted to not occur for the original void design. The head elevation within the spoil profile was predicted to never be above the natural topographic elevation.

The predicted head gradients for a cross-section through the original void design are presented in Figure 9, and the predicted head gradients for the same cross-section through the modified void design are presented in Figure 10. The cross-sections show the hydraulic gradient established between the head within the spoil profile and the discharge areas of Saddlers Creek alluvium and the Hunter River alluvium.

The existing (i.e. pre-mining) hydraulic gradient already promotes upward leakage of Permian coal measure (basement) water into the Hunter River alluvium and Saddlers Creek alluvium. Evidence of this process has been confirmed by groundwater head measurements and the occurrence of moderate salinity within some sections of the alluvial aquifers. The predicted changes to the net inflow of water into the alluvium of Saddlers Creek and the Hunter River are shown on Figure 11 for the original void design and Figure 12 for the modified void design.

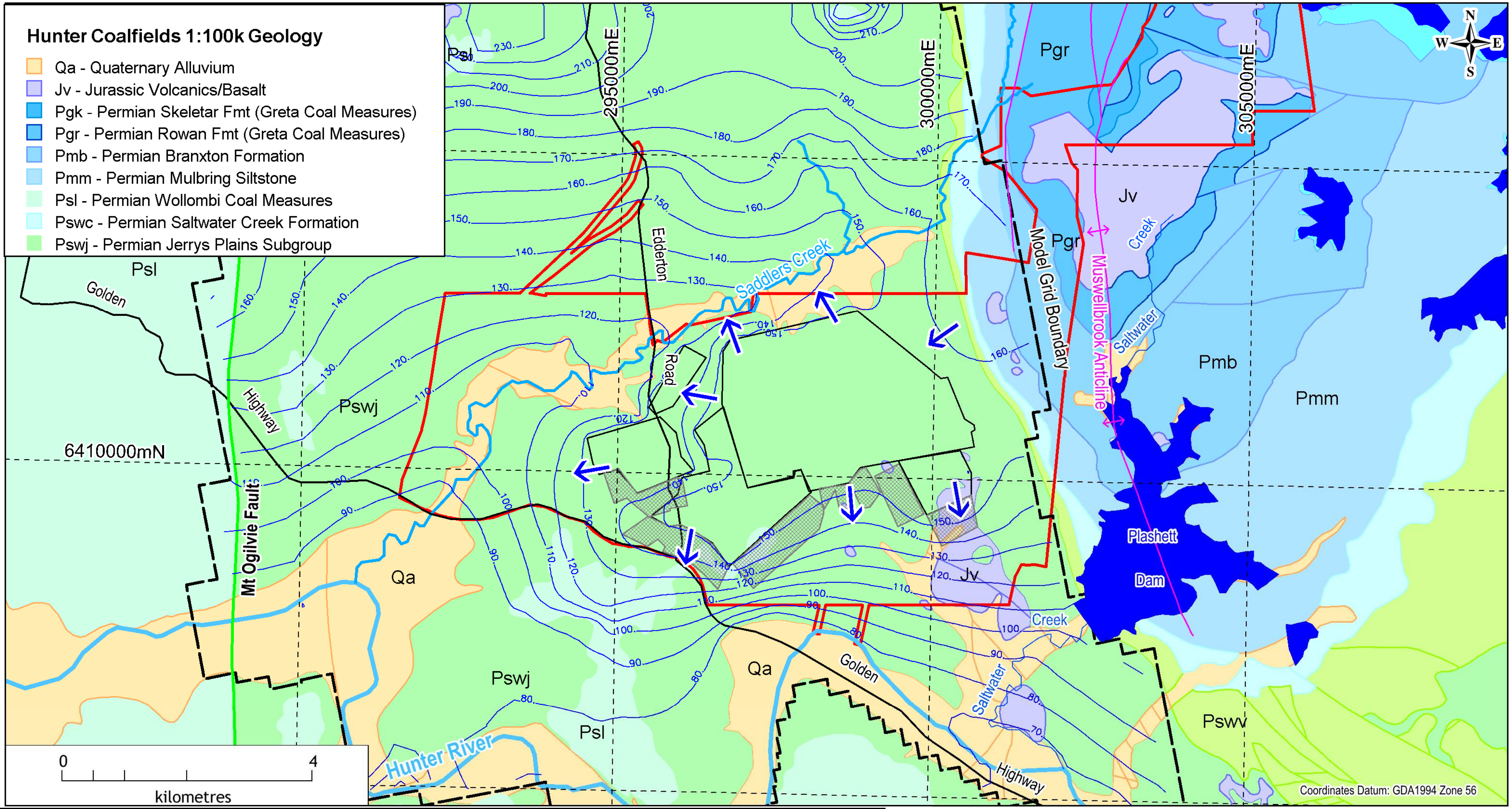


- LEGEND -

Predicted Groundwater Contour (mAHD)
Model Grid Boundary
Proposed Highwall Mining
Proposed Open Cut Pit
Project Boundary
Dam / Reservoir
Major Road
Major River
Creek

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
LEVEL 2, 15 MALLON ST, BOWEN HILLS, 4006, AUSTRALIA

TITLE:	DRAYTON SOUTH MINE PROJECT EA - GROUNDWATER ASSESSMENT PREDICTED GROUNDWATER HEADS - ORIGINAL FINAL VOID DESIGN - 1000 YEARS
CLIENT:	Anglo American
OFFICE:	Brisbane
DRAWN BY:	MU
SCALE:	1 : 90,000 (A4)
PROJECT No:	G1544
DRAWING No:	7
APPROVED BY:	
DATE:	6/8/2013



- LEGEND -

Predicted Groundwater Contour (mAHD)	Project Boundary
Model Grid Boundary	Dam / Reservoir
Proposed Highwall Mining	Major Road
Proposed Open Cut Pit	Major River
	Creek

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
LEVEL 2, 15 MALLON ST, BOWEN HILLS, 4006, AUSTRALIA

TITLE: DRAYTON SOUTH MINE PROJECT EA - GROUNDWATER ASSESSMENT
PREDICTED GROUNDWATER HEADS
- MODIFIED FINAL VOID DESIGN - 1000 YEARS

CLIENT: Anglo American			OFFICE: Brisbane
DRAWN BY: MU	SCALE: 1 : 90,000 (A4)	PROJECT No: G1544	DRAWING No: 8
APPROVED BY:	DATE: 6/8/2013		

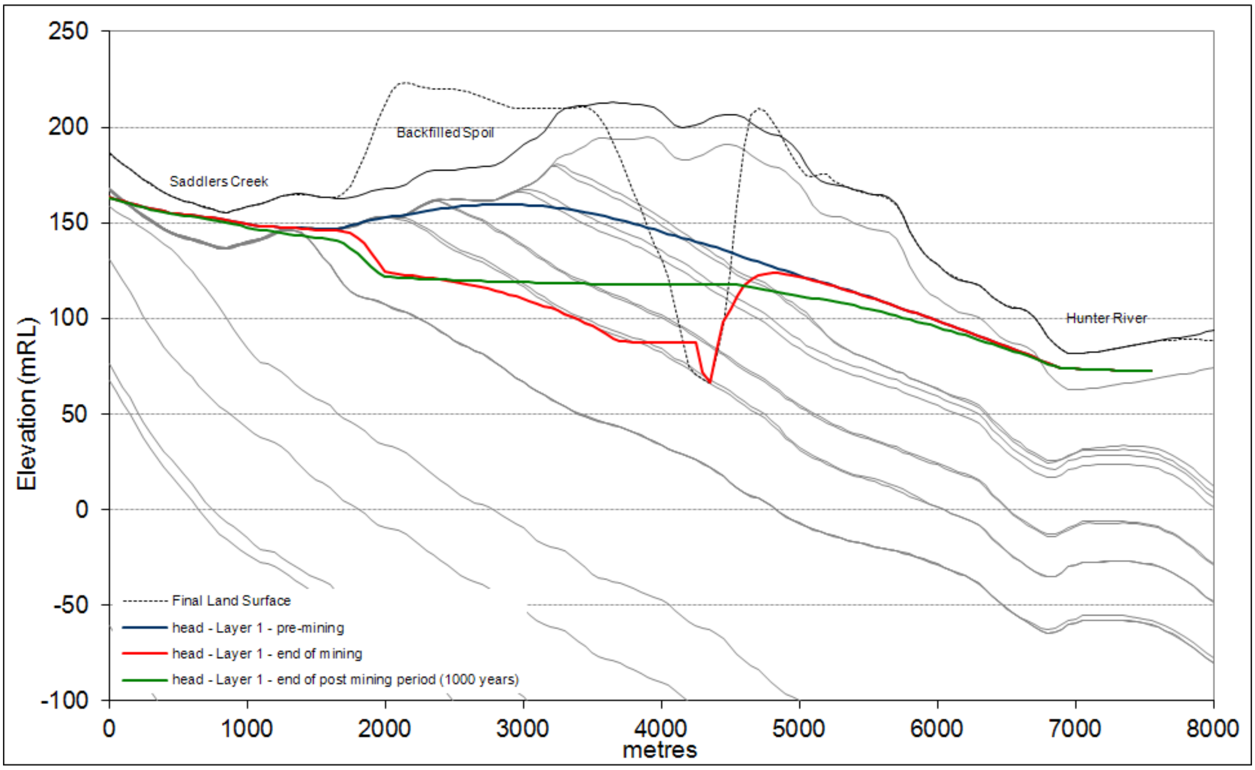


Figure 9: Cross-section of Head Gradients – Original Void Design

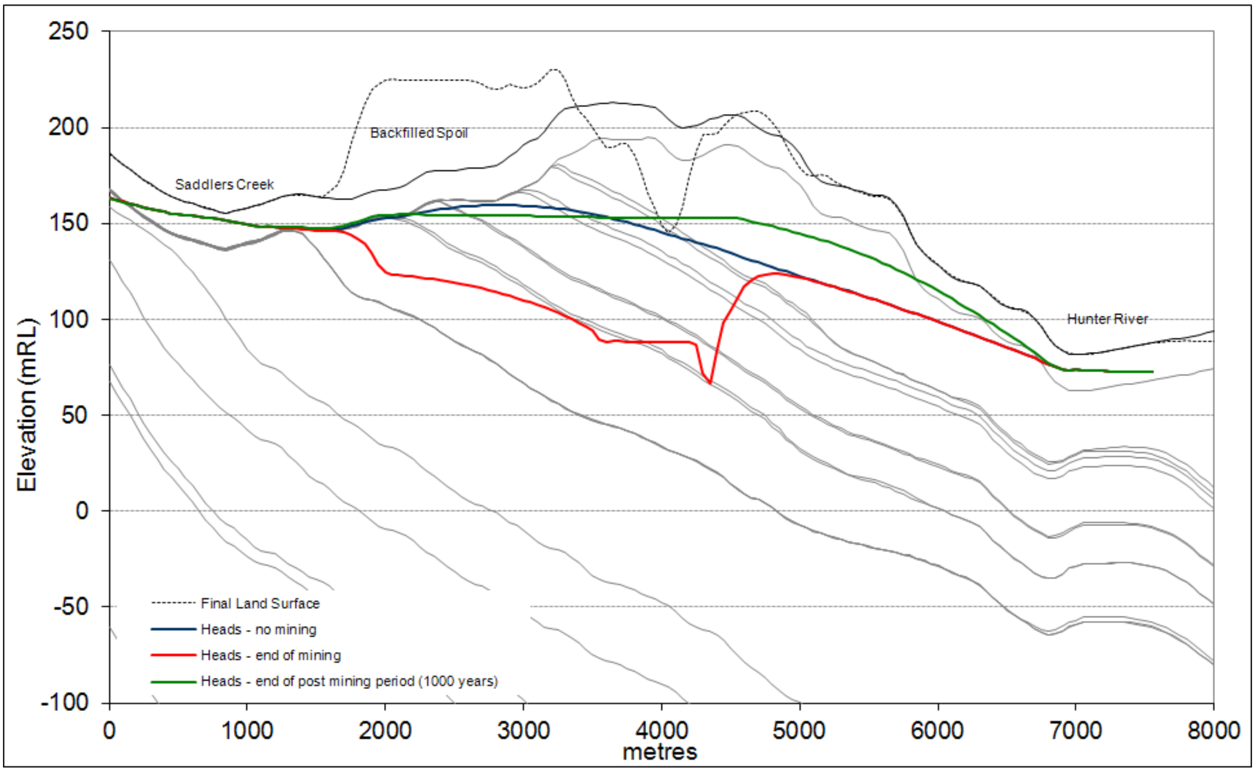


Figure 10: Cross-section of Head Gradients – Modified Void Design

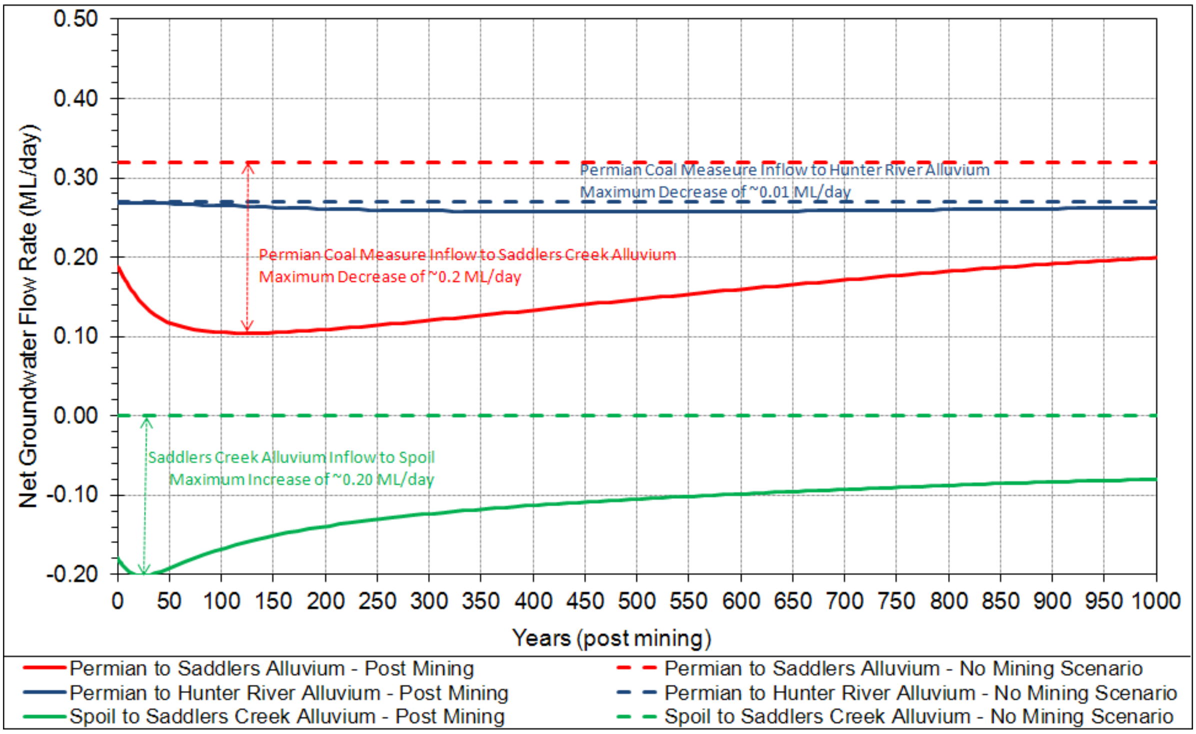


Figure 11: Net Flow to Alluvial Aquifers – Original Void Design

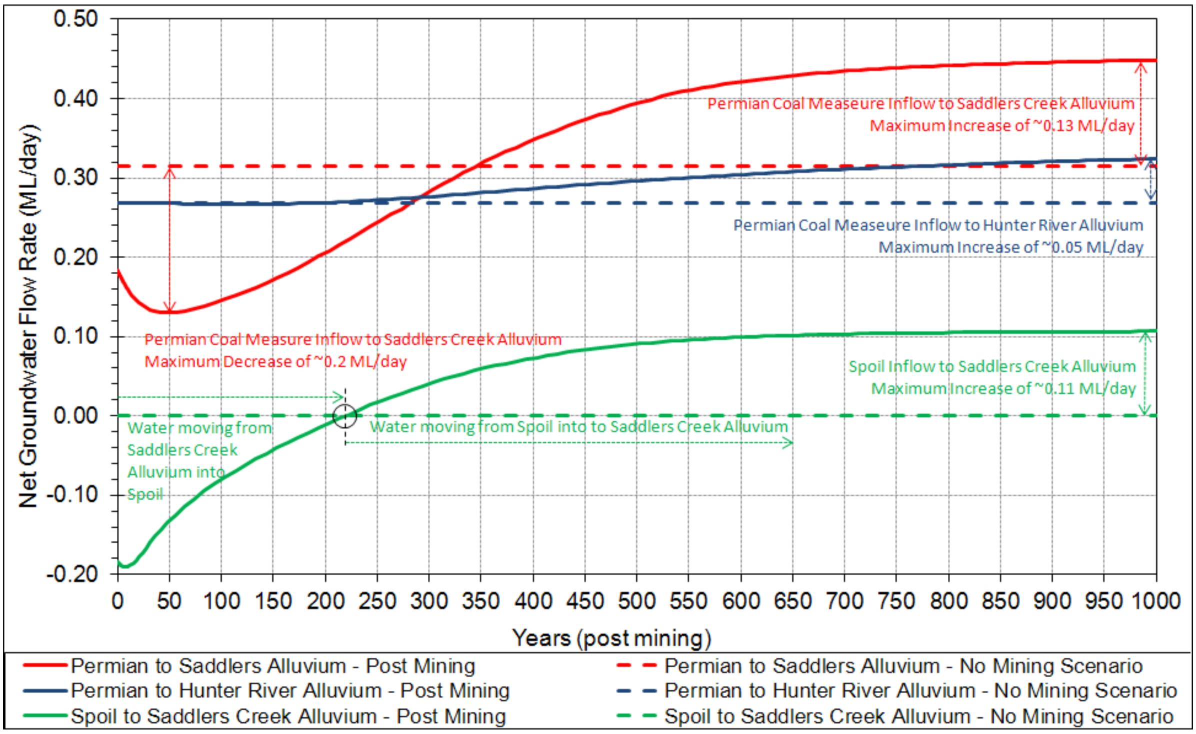


Figure 12: Net Flow to Alluvial Aquifers – Modified Void Design

The net movement of water from the Permian coal measures into the alluvium is increased for both the Hunter River alluvium and Saddlers Creek alluvium as a result of the increased head gradients associated with the modified void design. The increased flow to the Hunter River alluvium from the Permian coal measures steadily increases over time to a rate that is about 0.05 ML/day higher than natural conditions. The rate of increased seepage into the Hunter River alluvium is predicted to account for about 0.1% of the total water budget for the alluvium, and therefore the increase will not be measureable.

Depressurisation beneath Saddlers Creek during mining is predicted to reduce the natural movement of water from the Permian coal measures into the alluvium. The maximum decrease in net seepage to the alluvium is predicted to be about 0.2 ML/day, occurring about 50 years after mining. These results are in broad agreement with those obtained for the original void design. However, the more rapid recovery associated with the modified void design reduces the duration of the impact to the Saddlers Creek alluvium.

The impact of the depressurisation on seepage to the Saddlers Creek alluvium lessens over time as the head elevation within the spoil and surrounding geology recover towards a new equilibrium level. For the modified void design, the impact of depressurisation of the Permian coal measures is predicted to cease about 350 years after mining (Figure 12). As the head within the spoil continues to recover after 350 years, the head gradient promotes flow to occur from the spoil into Saddlers Creek Alluvium. The increased rate of seepage to the Saddlers Creek alluvium from the Permian coal measures is predicted to increase over time to a rate that is about 0.13 ML/day higher than natural conditions.

The boundary of the Saddlers Creek alluvium used within the groundwater model abuts the spoil profile along a small section of the northern boundary of the Whynot mining area. Direct connection between the spoil and the alluvium is predicted to occur at this location. This connection will allow movement of water between the spoil and the alluvium without first moving through the Permian coal measures. For the modified void design, water is predicted to initially migrate from the Saddlers Creek alluvium into the spoil as shown on Figure 12. However, when the hydraulic gradient reverses towards the alluvium, a maximum seepage rate of 0.11 ML/day into Saddlers Creek alluvium is predicted to occur.

The combined increased rate of seepage into the Saddlers Creek alluvium (i.e. 0.24 ML/day above natural conditions) is predicted to account for about 30% of the total water budget for the alluvium, and therefore it will lead to a significant contribution in baseflow to the creek. The salinity of water stored within the spoil is predicted to range from slightly brackish to brackish, which is a better quality than the natural, moderately saline, base flow within Saddlers Creek. The total dissolved solids (TDS) of spoil water is predicted to range between ~500 mg/L and ~1500 mg/L, and the groundwater sourced from the Saddlers Creek alluvium has a TDS concentration of about ~5000 mg/L.

The salinity of water can be categorised based on TDS concentrations, as follows:

- Fresh water <500 mg/L
- Slightly Brackish 500 to 1000 mg/L
- Brackish 1000 to 3000 mg/L
- Moderately saline 3000 to 7000 mg/L
- Saline 7000 to 14000 mg/L
- Highly saline 14000 to 35000 mg/L
- Brine >35000 mg/L

The TDS of water stored within the spoil is discussed in further detail in Section 9.

The predicted time taken for water to move from the original void design to the Hunter River alluvium was calculated using the principles of Darcy's Law. The calculation used a hydraulic gradient towards the Hunter River of 0.016, an average coal seam hydraulic conductivity of 0.02 m/day, and an effective porosity of 1%. The length of time for a water particle to migrate towards the Hunter River alluvium was calculated to be about 200 years after the hydraulic gradient towards the river was established (i.e. 700 years after mining).

For the modified void design, the hydraulic gradient towards the Hunter River increases to 0.033. Recalculation of the travel time using this hydraulic gradient results in a timeframe of about 100 years. The time taken for the hydraulic gradient to be established towards the Hunter River is predicted to be about 140 years after mining. Therefore, a water particle sourced from the modified void design may seep into the Hunter River alluvium about 240 years after mining.

In summary, both void designs are likely to establish flow through systems, which have hydraulic gradients away from the spoil area promoting loss of water from the void into the surrounding geology and drainage systems. However, the timeframe taken for the loss of water to initially occur and water travel times are reduced for the modified void design. The modified void design is predicted to reduce the duration and magnitude of impacts associated with aquifer depressurisation as a result of promoting a faster head recovery. The rate of seepage into the alluvial aquifers associated with the Hunter River and Saddlers Creek is predicted to increase above natural (i.e. pre-mining) conditions. Importantly however, the predicted seepage increase is insignificant compared to the total budget of the Hunter River alluvium. The seepage increase into the Saddlers Creek alluvium is however potentially significant, though it will likely be at a lower TDS concentration than what is naturally occurring as baseflow.

8 BASEFLOW TO HUNTER RIVER AND SADDLERS CREEK

The predicted change to the baseflow of the Hunter River and Saddlers Creek is shown in Figure 13 for the modified void design. Baseflow to the Hunter River is predicted to be impacted by an insignificant increase of 0.05 ML/day. This increase equates to about a 0.02% increase to the river flow during average flow conditions (i.e. ~250 ML/day), and about a 0.05% increase to the river flow during low flow events (i.e. 90 ML/day).

The baseflow of Saddlers Creek is likely to be impacted more significantly compared to the Hunter River. A reduction in baseflow is anticipated to occur initially after mining in response to the hydraulic gradient being towards the recovering head within the spoil. However, the baseflow is returned to pre-mining conditions at about 325 years after mining. The baseflow within Saddlers Creek is predicted to continue to increase to a rate that is 0.23 ML/day higher than natural conditions. The increased baseflow is promoted by the equilibrium hydraulic gradient that is established away from the spoil towards Saddlers Creek. The increase in baseflow within Saddlers Creek is predicted to be about 30% higher than it was pre-mining. Increased baseflow within Saddlers Creek is likely to sustain longer periods of flow.

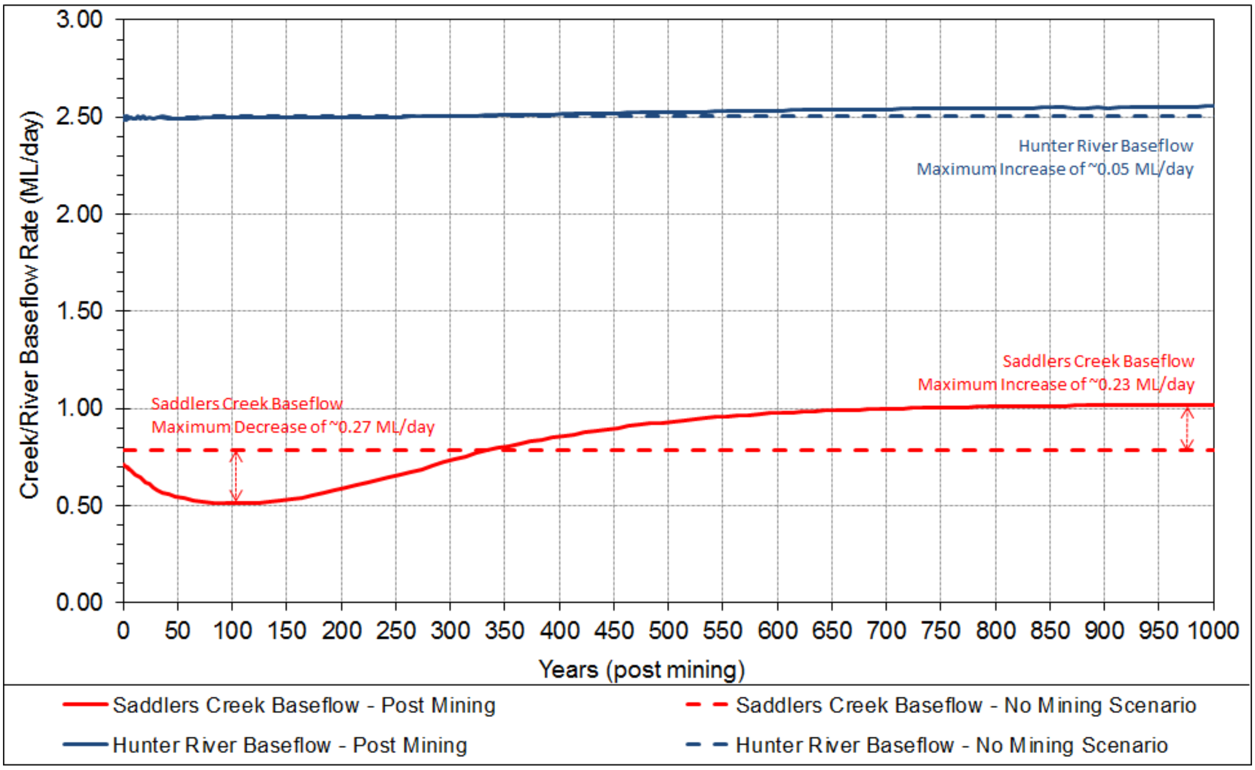


Figure 13: Predicted Change to Creek and River Baseflow

9 FINAL VOID AND SPOIL WATER QUALITY

As previously discussed, saturation of the modified void spoil profile is predicted to take about 160 years before seepage from the spoil would enter the void. Therefore, the void is predicted to remain dry during the initial 160 years after recovery. As a result, evaporation will not be able to concentrate the salinity of water stored within the spoil profile. Therefore, the salinity of the water stored within the spoil could only be affected by the generation of spoil leachate.

RGS Environmental[1] characterised the overburden, interburden, and potential coal reject material and concluded that:

- Overburden and most coal reject materials are expected to have very low oxidisable sulphur content, significant excess acid neutralising capacity, and be classified as non-acid forming;
- Overburden and most coal reject materials are likely to have a high factor of safety with respect to potential acid generation;
- The concentration of total metals in overburden materials is well below applied guideline criteria for soils and is unlikely to present any environmental issues associated with revegetation and rehabilitation;
- Overburden and coal reject materials reporting to emplacement areas will generate pH neutral to slightly alkaline run-off/seepage with low and moderate salinity values, respectively, following surface exposure. The salinity of run-off/seepage from these materials is expected to decrease with time;

[1] RGS Environmental Pty Ltd, (2011), *"Geochemical Impact Assessment of Overburden and Coal Reject Materials – Drayton South Coal Project",* Prepared for Hansen Bailey Pty Ltd.

- The concentration of trace metals in run-off and seepage from most overburden and coal reject material is likely to be low with some minor exceptions (molybdenum and selenium);
- Overall, the risk of potentially significant water quality impacts from overburden and coal reject materials is low; and
- Some overburden and most coal reject materials may be sodic and have structural stability problems related to potential dispersion and erosion.

Specifically, RGS Environmental[1] found that the "*Leachate from overburden typically has a low EC value (<500 µS/cm)*"… this being equivalent to a concentration of TDS that is less than 335 mg/L. RGS Environmental[1] also found that the salinity of the spoil leachate decreased with time during their 12 week kinetic leach column (KLC) test program. The KLC test TDS concentrations ranged between 32 mg/L and 470 mg/L, with an average TDS concentration of 144 mg/L.

The salinity of water stored within the spoil can be predicted by calculating the TDS concentration of the mixture between groundwater inflow from surrounding Permian coal measures, and deep percolation through the spoil originating from rainfall recharge. The predicted salinity of water stored within the spoil is shown on Figure 14.

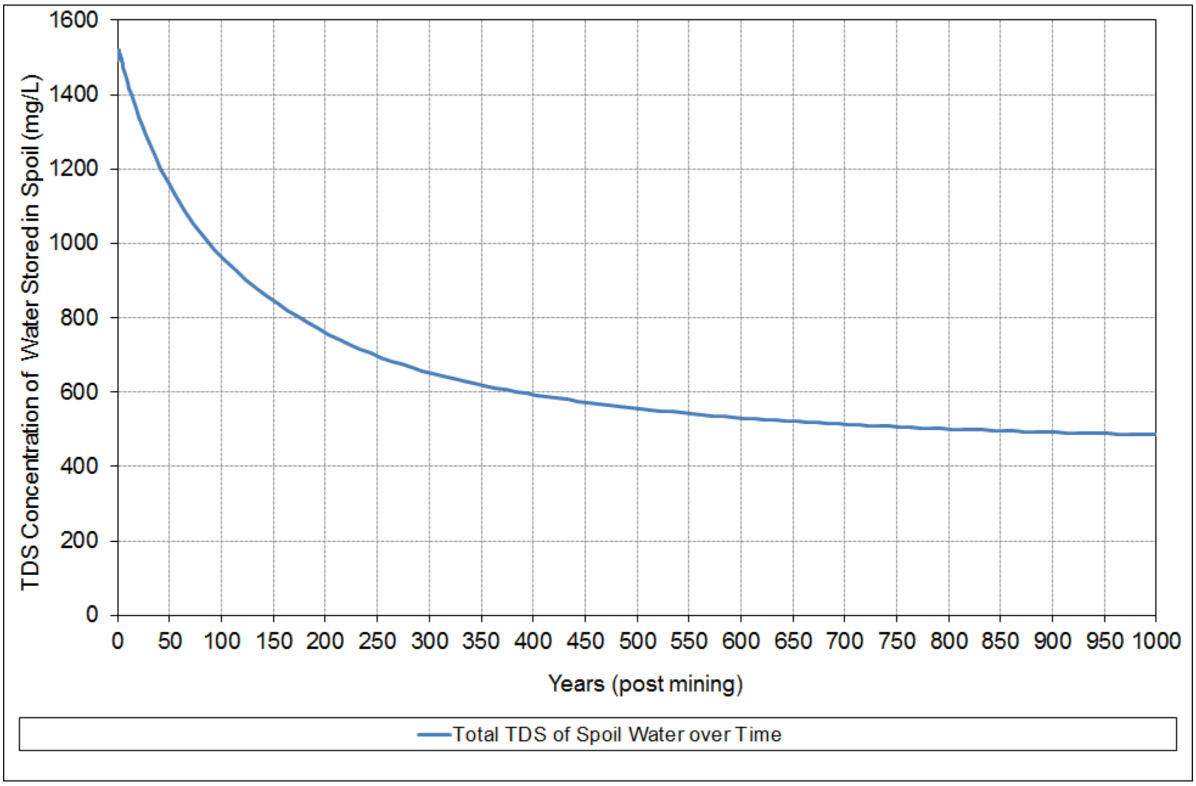


Figure 14: TDS of Water Stored within the Spoil – Modified Void Design

The adopted TDS concentration of the Permian coal measures seepage to the spoil is anticipated to remain at a constant rate of about 3500 mg/L. Rainfall onto the spoil area is anticipated to have a TDS concentration of about 10 mg/L. However, the TDS concentration of this water increases as deep percolation leaches salts from the sandstone and siltstone (sourced from the original overburden) within the spoil profile. A conservative TDS concentration of 200 mg/L was adopted for the spoil leachate water, based on the tests undertaken by RGS Environmental[1].

The gross rate of seepage from the Permian coal measures is predicted to reduce from an initial rate of about 1.45 ML/day down to an equilibrium rate of about 0.15 ML/day. The gross rate of deep percolation through the spoil profile is predicted to be about 2.25 ML/day, which will obviously remain constant over time assuming average rainfall conditions.

The mixture of the spoil leachate water with seepage from the coal measures is predicted to have a significantly lower TDS concentration compared to the surrounding coal measures. The TDS concentration is predicted to be initially about 1500 mg/L, which then decreases down to about 486 mg/L over time, as shown in Figure 14. These results assume complete mixing occurs between the two different water types within the spoil (i.e. seepage from surrounding geology and deep percolation from rainfall recharge).

The assumption that mixing is complete provides a worst case scenario. In reality, complete mixing of water within the spoil profile is not likely to occur, as fresher (less dense) rainfall recharge water is likely to sit above the more saline (more dense) groundwater seepage. The stratification is likely to lead to preferential seepage of fresher water from the spoil into the final void area and surrounding geological units.

The long term build-up of salts in the modified void design was assessed by WRM[2] using an OPSIM water balance model which was configured to replicate the void behaviour. The OPSIM model adopted a historical rainfall data sequence from 1889 to 2010, which was repeated for 1000 years after mining.

For the modified void design, the OPSIM water balance model predicted salt concentrations within the final void water body would gradually increase, with TDS concentrations reaching an equilibrium salinity level of between 800 mg/L and 1300 mg/L (i.e. slightly brackish to brackish) after about 700 years. The range of TDS concentration is predicted to fluctuate in response to climatic conditions (i.e. during high rainfall and low rainfall periods). The equilibrium salinity level is reached in response to the "flow through system", whereby continual movement of water will occur from the spoil and through the void water body. This process will lead to mixing of water within the void to form a combination of water derived from spoil, direct rainfall, and rainfall runoff. In addition, salinity in the final void will not begin to increase until evaporation begins on the water surface about 160 years after mining.

These recent results are in contrast to the results predicted for the original void design as part of the EA, where TDS concentrations were predicted to gradually increase to about 5600 mg/L (i.e. moderately saline) about 120 years after mining and between 8000 mg/L and 13000 mg/L after about 1000 years. The primary factor leading to this increase in TDS for the original void design was due to the effects of evaporation off the water body surface within the final void. For the original design within the EA evaporation was predicted to occur immediately after mining, leading to a higher TDS concentration compared to the modified void design.

Also, the calculations used to determine the TDS concentration within the original void design assumed that the TDS concentration within the spoil was equal to the average TDS concentration of groundwater within the surrounding Permian coal measures. This assumption did not include significant dilution by rainfall recharge into the spoil profile. Therefore, the original assumption of TDS concentration was an overly conservative estimate of the TDS concentration of water stored within the spoil.

A hypothetical mixture between Hunter River water (i.e. 250 ML/day average flow at 507 mg/L TDS) and spoil water (i.e. 0.54 ML/day loss from the void at 1300 mg/L TDS) equates to a TDS increase within the Hunter River by about 0.24%. This hypothetical mixture represents a worst case scenario as it does not account for the significant dilution that would occur as the void water migrates through the alluvial aquifers.

[2] WRM Water and Environment Pty Ltd, (2013), "*Final Void Modelling Update*", email correspondence.

These recent results are not dissimilar to the results predicted for the original void design, where a lower TDS increase within the Hunter River is predicted. The previous results were based on a loss of water from the spoil of 0.02 ML/day with a range of TDS concentration from 8000 mg/L to 13000 mg/L. The predicted TDS increase within the Hunter River for the original void design is about 0.02% to 0.1%. Furthermore, the natural variability of TDS concentrations of Hunter River water (i.e. standard deviation) is greater than any predicted TDS increase from the model.

Therefore, the worst case scenario impact on the Hunter River salinity is less than the NSW Aquifer Interference Policy trigger level of 1% change for both the original and modified void designs.

The TDS concentration of current natural base flow within Saddlers Creek ranges between 3000 mg/L and 5000 mg/L. Therefore, the predicted TDS concentration of water sourced from the spoil and/or the void will be lower than the present baseflow concentration. An increase of 0.23 ML/day to the baseflow of Saddlers Creek, with a TDS concentration of about 1300 mg/L is therefore predicted to not degrade the water quality within Saddlers Creek. In fact, the higher baseflow at a TDS lower than natural conditions may improve the quality of the creek system.

In summary, the water that saturates the spoil profile is likely to have a salinity that is significantly lower than groundwater stored within the surrounding Permian coal measures. Spoil water will migrate into the void as surface water in the void is removed by evaporation. Evaporation from the void water surface is likely to increase the TDS concentration within the void. However, the TDS concentration within the void is predicted to only approach a slightly brackish to brackish salinity.
Groundwater within the Permian coal measures is known to be moderately saline with a mean TDS concentration of about 3500 mg/L. The poor quality of this water is typical of coal seam water aquifers. The generally low yield and poor quality of the groundwater in the coal seams indicates the environmental value can be classified as “primary industry” with the main potential use being for stock watering. Groundwater from the Permian coal measures is suitable for salt tolerant stock, that is, sheep and beef cattle. The Permian coal measures groundwater typically has a TDS concentration that is too high for irrigation. Therefore, any movement of water from the spoil into the surrounding Permian coal measures is unlikely to pose a risk of water quality degradation. In fact, where water movement from the spoil occurs, this is likely to improve groundwater quality within the coal measures and adjacent alluvial aquifers.

10 CONCLUSIONS AND SUMMARY

A summary of the predictions for the modified void design is provided below:

- Saturation of the spoil is predicted to take ~160 years before water enters the void from the surrounding spoil;
- Groundwater from the surrounding geology migrates into the spoil for the first ~140 years of recovery, and (combined with rainfall recharge) increases the head within the spoil;
- When the head within the spoil reaches about 120 mRL (after ~143 years) a hydraulic gradient is established away from the spoil area (i.e. towards the northwest, west, southwest and south), which induces water to migrate from the spoil into the surrounding geology;
- A hydraulic gradient towards the spoil remains present from the northeast;
- The spoil will act as a ‘flow through system’, recharged from the northeast and discharging towards the northwest, west, southwest and south;
- Net movement of water from the Permian coal measures into the spoil will decrease from ~1.2 ML/day down to zero at about 140 years of recovery;

- Net movement of water out of the spoil and into the surrounding geology will increase from zero at 140 years, up to ~0.54 ML/day at about 450 years of recovery;
- The initial head in the void is ~125 mRL after 160 years, and increases to ~153 mRL;
- Evaporation from the final void water surface increases from zero to a maximum of 3.18 ML/day as the area of the void water surface increases;
- Net movement of water from the spoil into the void increases from zero to a maximum of 1.33 ML/day to replace void water that is lost to evaporation;
- The TDS concentration of water stored within the spoil is predicted to decrease from about 1500 mg/L down to a concentration of about 486 mg/L;
- The TDS concentration of the water stored within the void is predicted to increase to an equilibrium level of about 1300 mg/L, which is lower than the TDS concentration of groundwater stored within the surrounding Permian coal measures;
- The TDS concentration of water that migrates away from the spoil (up to 0.54 ML/day) is therefore predicted to not degrade the beneficial use of the surrounding groundwater;
- The TDS concentration of the Hunter River is unlikely to be impacted by greater than 1%, which is below the NSW Aquifer Interference policy trigger guideline; and
- The natural moderately saline TDS concentration of baseflow within Saddlers Creek is predicted to be reduced (i.e. improved) as a result of dilution with seepage from the spoil.

A comparison of the predictions made for the original and modified void designs are presented in Table 1

Table 1: COMPARISON OF PREDICTIONS	
Original Final Void Design (EA)	**Modified Final Void Design (PPR)**
Elevation of Final Void Water Surface	
the equilibrium elevation head within the spoil and void is predicted to be **~117 mRL**	the equilibrium elevation head within the spoil and void is predicted to be **~153 mRL**
a hydraulic gradient will exist towards the final void creating a groundwater sink for a period of **~700 years** after mining	a hydraulic gradient will exist towards the final void creating a groundwater sink for a period of **~143 years** after mining
the available freeboard between the spill point and the surface water elevation is predicted to be about **90 m**	the available freeboard between the spill point and the surface water elevation is predicted to be about **20 m**
Seepage from Mining Area	
the maximum rate of water that may migrate away from the mining area is predicted to **~0.02 ML/day**	the maximum rate of water that may migrate away from the mining area is predicted to **~0.54 ML/day**
Groundwater Heads and Hydraulic Gradients	
a reversed hydraulic gradient **is likely to** induce water migration away from the final void	a reversed hydraulic gradient **is likely to** induce water migration away from the final void
a hydraulic gradient of about **0.016** may be established towards the Hunter River	a hydraulic gradient of about **0.033** may be established towards the Hunter River

Table 1: COMPARISON OF PREDICTIONS	
Original Final Void Design (EA)	**Modified Final Void Design (PPR)**
the length of time for a water particle to migrate towards the Hunter River alluvium may be about **200 years** after the hydraulic gradient towards the river is established	the length of time for a water particle to migrate towards the Hunter River alluvium may be about **100 years** after the hydraulic gradient towards the river is established
Final Void Water Chemistry	
the water quality within the final void will gradually degrade over time towards a **moderately saline to saline** classification	the water quality within the final void will gradually degrade over time towards a **slightly brackish to brackish saline** classification
the water quality within the final void **will be comparable** to the salinity of natural background concentrations of groundwater sourced from the Permian coal measures	the water quality within the final void **will be more fresh** compared to the salinity of natural background concentrations of groundwater sourced from the Permian coal measures
the water quality of water migrating from the final void is **not likely** to have a measurable impact on the Hunter River water quality	the water quality of water migrating from the final void is **not likely** to have a measurable impact on the Hunter River water quality

AUSTRALASIAN GROUNDWATER AND ENVIRONMENTAL CONSULTANTS PTY LTD

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LIMITATIONS OF REPORT

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) has prepared this report for the use of Hansen Bailey Environmental Consultants Pty Ltd in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 10 July 2013.

The methodology adopted and sources of information used by AGE are outlined in this report. AGE has made no independent verification of this information beyond the agreed scope of works and AGE assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to AGE was false.

This study was undertaken between 25 July 2013 and 21 August 2013 and is based on the conditions encountered and the information available at the time of preparation of the report. AGE disclaims responsibility for any changes that may occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. It may not contain sufficient information for the purposes of other parties or other users. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing and other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. Where borehole logs are provided they indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of the site, as constrained by the project budget limitations. The behaviour of groundwater is complex. Our conclusions are based upon the analytical data presented in this report and our experience.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, AGE must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

Whilst to the best of our knowledge, information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.