



Invincible Southern Extension Project

RESPONSE TO SUBMISSIONS
PART B



March 2017

INVINCIBLE SOUTHERN EXTENSION PROJECT

Response to Submissions – Part B

FINAL

Prepared by
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on behalf of
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1.0 Introduction

This Response to Submissions Part B has been prepared in response to the matters raised in submissions received on the proposed Invincible Southern Extension Project (Southern Extension Project) during the public exhibition period which relate to water resources, including groundwater and surface water management. Matters were raised in relation to water resources by a number of government agency submissions (including Department of Primary Industries – Office of Water (DPI Water) and the Environment Protection Authority (EPA)), and a number of interest group and community submissions. Detailed background to the Southern Extension Project, and analysis of the submissions received, is provided in the Response to Submissions Part A report.

This report includes a background section on the key matters raised in relation to water resources management as part of the Southern Extension Project along with detailed responses to specific matters raised in submissions. In the following sections the matters raised in submissions are outlined in bold italic text with the responses following in plain text.

1.1 Background

As discussed in Section 6.3.4.1 of the Southern Extension Project Environmental Assessment (EA), the volume of water contained within the former Ivanhoe No. 2 Underground workings was not known, and as such impacts were assessed based on an inferred maximum volume of water than may be contained in these workings. This approach was adopted as it provided for a conservative approach to the calculation of potential water volume within these workings (i.e. based on an assumed flooded level of water in the former workings) to determine the requirements to manage this water. It is proposed to dewater these underground workings prior to the establishment of open cut mining operations as part of the Southern Extension Project.

This previous assessment assumed there may be up to approximately 2121 million litres (ML) of water in the Ivanhoe No. 2 Underground workings which would exceed the available storage capacity in the Invincible Underground workings and open cut spoil which is estimated to be between 1585 ML and 2111 ML based on 2012 'tide mark' observations in the former Invincible Underground workings (refer to Appendix 5 of the EA). Accordingly, the assessment of surface water impacts was therefore based on an assumption that additional discharges from the existing approved Invincible Licensed Discharge Point (LD002) would be required to manage this water. These discharges would be in addition to the operational discharges required for the Southern Extension Project, which have occurred as part of previous mining operations at Invincible Colliery (Invincible), in accordance with the existing Environment Protection Licence (EPL).

As outlined in Sections 6.3 and 7.2 of the EA, Castlereagh Coal committed to undertaking further detailed investigations into the water levels within the Ivanhoe No. 2 Underground workings through the establishment of bores into the workings. The details of this drilling program, and associated revised assessment of water management requirements for the confirmed water volumes in the Ivanhoe No. 2 Underground workings is provided in the following sections.

1.2 Revised Assessment of Water in Ivanhoe No. 2 Underground Workings

In December 2016 two bores were installed in the Southern Extension Area:

- BHTH12 was installed at an intersection of two underground roadways within the Ivanhoe No. 2 Underground workings to confirm the water level within the open workings
- BH2 was installed in a large diameter coal quality core hole in the 40 metre coal barrier between the Invincible Underground workings and the Ivanhoe No. 2 Underground workings. This bore was installed to confirm the water level within the coal barrier.

The location of BHTH12 and BH2 are shown on **Figure 1.1**.

Appendix 1 contains further details on the assessment of water within the former Ivanhoe No. 2 Underground workings in response to issues raised by agencies in relation to groundwater issues prepared by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE). **Appendix 1** includes revised calculations of water stored in the Ivanhoe No. 2 Underground workings that would be required to be removed as part of the Southern Extension Project. **Appendix 1** also includes an assessment of the ability of the Invincible Underground workings and open cut spoil to hold the calculated volume of water in the Ivanhoe No. 2 Underground workings and a discussion regarding water quality issues based on the monitoring data available from BHTH12 and BH2.

The AGE assessment in **Appendix 1** concluded that:

- approximately 367 ML of water would be required to be removed from the Ivanhoe No. 2 Underground workings as part of the Southern Extension Project (approximately 17% of the volume conservatively assumed in the EA)
- there is sufficient capacity in the Invincible Underground workings and open cut spoil to store this water and retain adequate freeboard, thereby removing the need to discharge this water off site as part of the dewatering process
- water quality from the Ivanhoe No. 2 Underground workings (BHTH12), the East Tyldsley bore (a bore into underground workings located to the north of Invincible), and the Invincible open cut northern void (refer to **Figure 1.2**) is of comparable quality – generally with pH values of between 6.06 and 6.72 and EC values between 850 $\mu\text{S}/\text{cm}$ and 1,600 $\mu\text{S}/\text{cm}$ and similar ionic composition.

The AGE assessment identified that, following the transfer, approximately 1218 ML to 1,744 ML of storage capacity would remain in the Invincible Underground workings and open cut spoil.

The AGE assessment in **Appendix 1** also considered the difference in groundwater height elevations between BHTH12 and BH2 and concluded that the lower groundwater elevation in BH2 (located within the coal pillar between Ivanhoe No. 2 Underground workings and the Invincible Open Cut/Underground) shows that there is a decreasing gradient between the Ivanhoe No. 2 Underground workings and the Invincible underground/open cut, which suggests that water currently seeps from the former Ivanhoe workings into the Invincible underground/open cut.

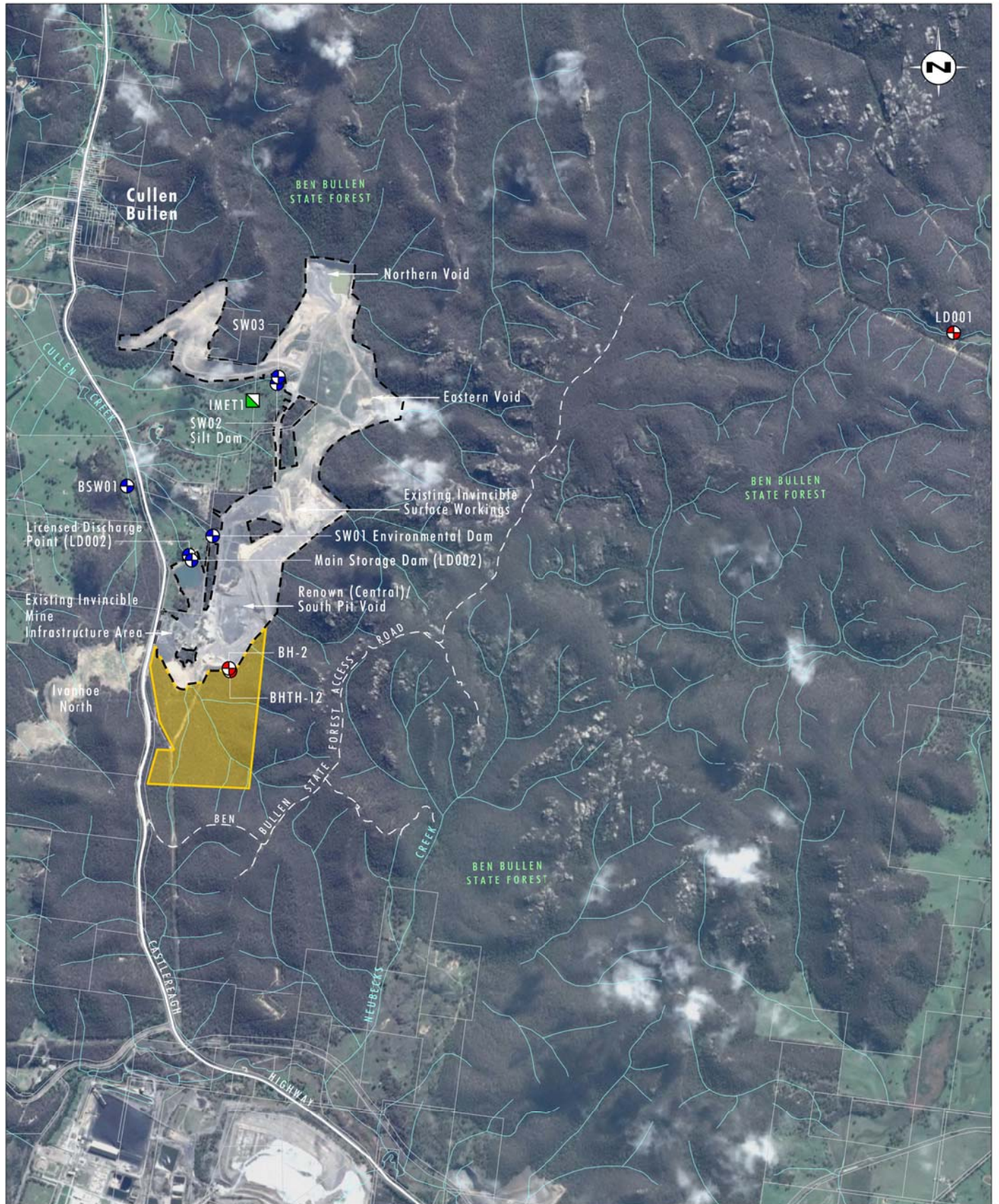


Image Source: Google Earth - CNES/Astrium (Nov 2014)
Data Source: LPI (2016)

0 0.5 1.0 2.0 km
1:35 000

Legend

- Existing Approved Mining Disturbance Area
- Proposed Southern Extension Area
- Surface Water
- ⊗ Groundwater Bore
- Meteorological Station

FIGURE 1.1

Groundwater Monitoring and
Surface Water Monitoring Locations

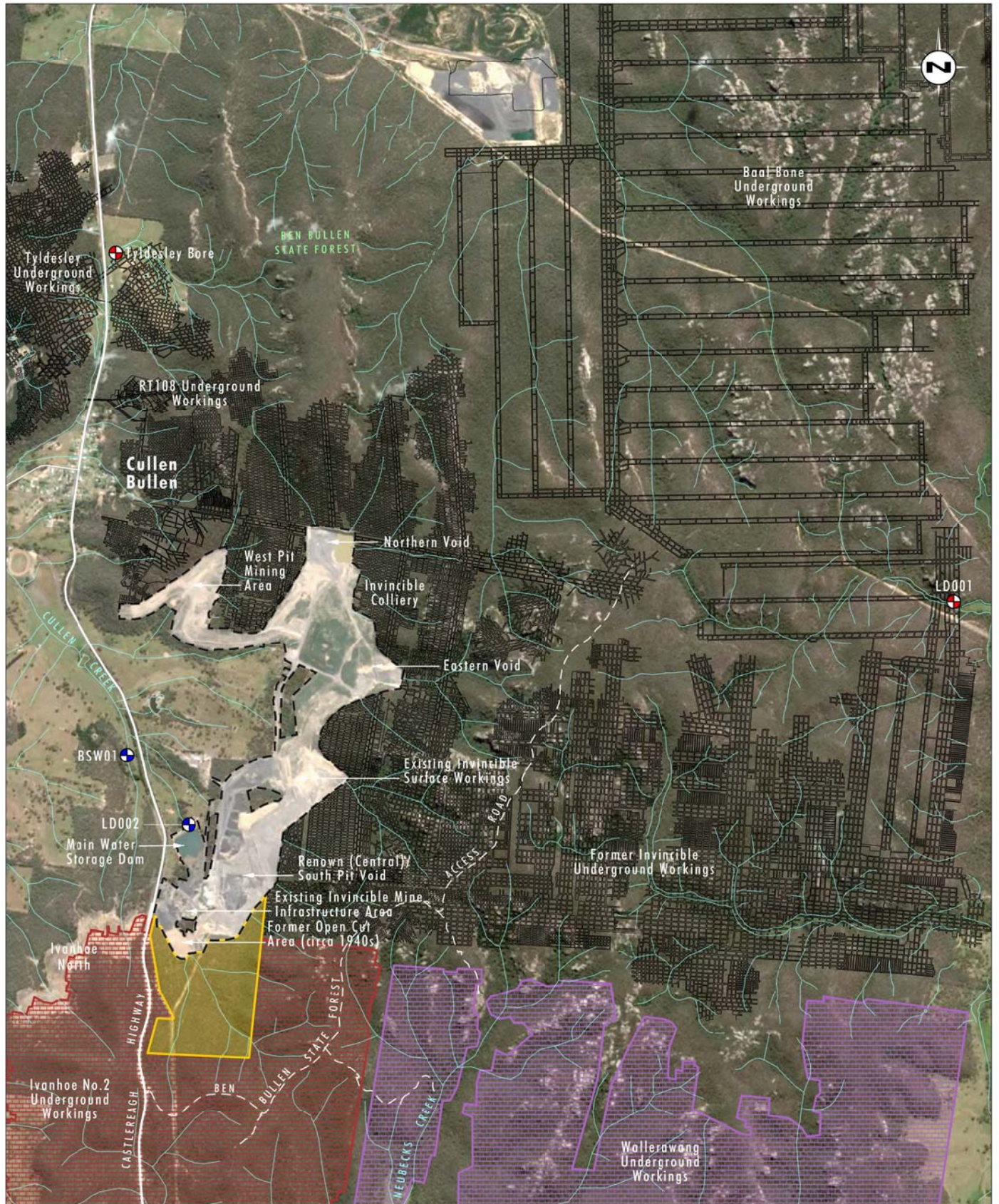


Image Source: Google Earth/CNES/Astrum (Nov 2014)

Data Source: LPI (2016), Department of Industry - MinView (2017)

0 0.5 1.0 2.0 km
1:35 000

Legend

- Existing Approved Mining Disturbance Area
- Proposed Southern Extension Area
- Underground Workings
- Ivanhoe No.2 Underground Workings
- Wallerawang Underground Workings
- Surface Water
- Groundwater Bore

FIGURE 1.2

Underground Workings and
Water Management System Context

1.3 Revised Management of Water Removed From Ivanhoe No. 2 Underground Workings

Based on the assessment in **Appendix 1**, the proposed management of water to be removed from the Ivanhoe No. 2 Underground workings is to transfer the water to the available storage capacity in the Invincible Underground workings. This transfer would be done through either pumping via the Northern Void or through allowing the water to flow into the Renown (Central)/Southern Pit Void area (refer to **Figure 1.2**) in the existing Invincible Open Cut area to then percolate through spoil towards the Northern Void and into the underground workings. It is proposed that there will be no direct discharge of water from the Ivanhoe No. 2 Underground workings via the existing EPL 1095 licensed discharge point at the Main Water Storage Dam (LD002) (refer to **Figure 1.1**).

Under the existing EPL 1095, Castlereagh Coal is able to either discharge surplus water during wet weather to Cullen Creek (via licensed discharge point LD002) or pump surplus water to the Invincible underground voids. As part of the Southern Extension Project the proposed water management system will not seek any change to this existing approved discharge arrangement as water from Ivanhoe No. 2 Underground workings will be transferred into the existing Invincible Underground workings and open cut for storage.

Overall, the proposed water management strategy for the Southern Extension Project is largely unchanged from the previously approved operating scenario and the current care and maintenance management conditions (although the current care and maintenance conditions do not involve usage of water for operational purposes). The only change to the water management system compared to that presented in the EA is that water currently stored in the Ivanhoe No. 2 Underground workings will be transferred to the Invincible Underground workings and this will reduce the available storage in these workings to an estimated 1218 ML to 1744 ML. There are some minor changes to the way in which runoff will be captured and managed during the life of the Southern Extension Project compared to the current approved and care and maintenance management. These changes relate to the location of capture of runoff and do not affect the volume of runoff captured and managed within the water management system. As shown in **Figure 1.3**, there is no change to the catchment area managed by the proposed water management system for the Southern Extension Project relative to the catchment area managed by the existing WMS.

Accordingly, the Southern Extension Project discharge scenario is unchanged from the currently approved operations. As outlined in the following sections the discharge volumes are estimated to be slightly lower than the current care and maintenance scenario due to higher water usage requirements under the proposed operational mine scenario. This is discussed further in the sections below.

The Water Management Plan for Invincible will be updated in consultation with the EPA and DPI-Water to reflect changes in the management of water across the site as mining progresses. Conceptual details of this water management system are contained in Section 6.3.4.3 of the EA.

1.4 Revised Site Water Balance

Appendix 2 to this Report contains a revised site water balance assessment for the Southern Extension Project based on a worst case operating scenario in regard to discharge volumes (Revised Site Water Balance). The water balance presented in the EA has been revised to adopt the proposed management measures for underground volumes (i.e. transfer of water in the Ivanhoe No. 2 Underground workings to the Invincible Underground working with no discharge of this water proposed) and consideration of surface cracking impacting on runoff volumes into the Water Management System (WMS) as requested by the EPA. This revised site water balance assessment for the Southern Extension Project is based on a worst case operating scenario in regard to discharge volumes. This scenario would only occur if pumping from the Invincible Underground workings to the Main Water Storage Dam was required to avoid the underground

workings exceeding storage capacity (i.e. the underground workings are full). This is a conservative assumption given that there is generally capacity within the Invincible underground workings to store water captured in WMS (estimated to be in excess of 1218 ML even with the transfer of water from the Ivanhoe No. 2 Underground workings).

This scenario would only occur if pumping from the Invincible Underground workings to the Main Water Storage Dam was required to avoid the underground workings exceeding storage capacity (i.e. the underground workings are full). Historically, during times of wet weather, there has been a need to discharge water from the site, which is provided for in accordance with the existing EPL 1095 for Invincible. As outlined in the EA, further discharges from Invincible are proposed as part of the Southern Extension Project in accordance with the requirements of the EPL.

The Revised Site Water Balance assumes all discharges from Invincible would remain subject to existing conditions under EPL 1095 which only permit wet weather discharges.

The volume of water discharged under the worst case scenario examined in the Revised Site Water Balance will be higher than occurs in relation to the current water management system due to the ongoing availability of storage in the Invincible Underground workings. Further to this, the expected operating scenario with the Southern Extension Project is considered likely to also result in lower discharges than those predicted in the worst case scenario presented.

1.4.1 Model Set-up

The Revised Site Water Balance includes the following conservative assumptions:

- the former Invincible Underground workings have no additional storage capacity at the start of each rainfall year modelled (as outlined in **Appendix 2**, this is a conservative assumption considering that there is volume in the former Invincible Underground workings to store water captured in the WMS)
- an outflow of 105 ML/year from the Invincible Underground workings via seepage into the coal seams down-dip from the Invincible workings. Groundwater modelling predicts the outflow seepage to range from 105 ML to 315 ML and observations of water levels in the Northern Void suggest that seepage rates may be even higher than these predictions. The use of the lower end of this predicted outflow range is a conservative assumption which would lead to additional water to be managed by Invincible
- runoff from catchment areas upstream of the Southern Extension Area is higher than natural average runoff rates to account for surface cracking in these catchments associated with previous underground mining subsidence (this is discussed further in **Section 2.2.1.2**).

While there is an estimated 1218 ML to 1744 ML of additional storage available in the Invincible Underground workings following the transfer of water from Ivanhoe No. 2 Underground workings, the water balance assumptions are based on the worst case discharge scenario which would only arise if there was limited available storage in the Underground and the site was required to minimise additional increases in water in the Underground workings. As discussed in Section 6.3.8 of the EA, standpipe monitoring bores will be installed in spoil and into the Invincible Underground workings to monitor water levels associated with the storage in the Invincible Underground workings to inform the ongoing management of water at Invincible. This will be detailed further as part of a revised Water Management Plan which will be prepared in consultation with DPI Water and the EPA for the Southern Extension Project.

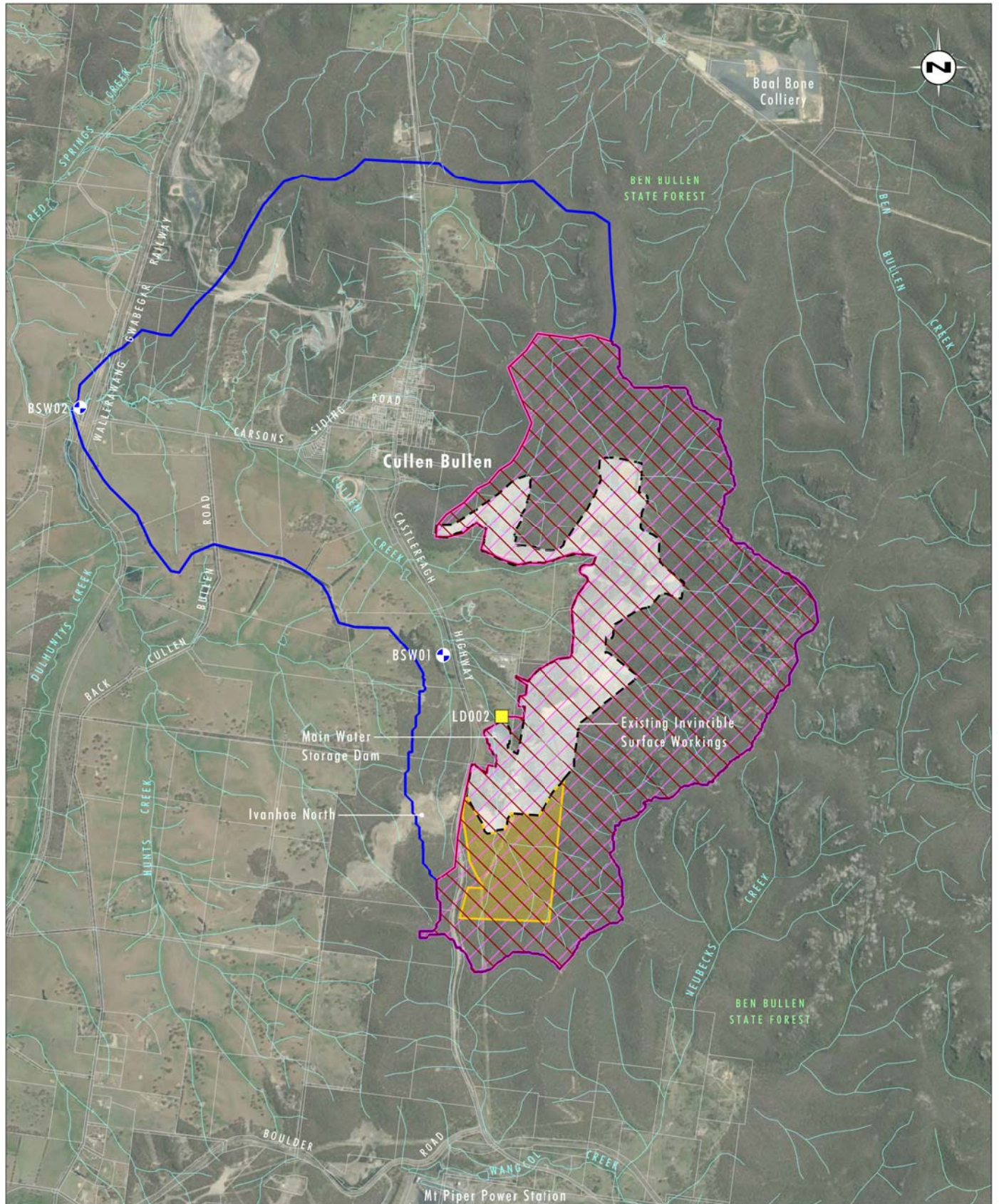


Image Source: Google Earth - CNES/Astrium (Nov 2014)
Data Source: LPI (2016)

0 0.5 1.0 2.0 km

Legend

- Existing Mining Disturbance Area
- Proposed Southern Extension Area
- Cullen Creek Catchment Area
- Existing Water Management System Catchment
- Southern Extension Project Water Management System Catchment
- Licensed Discharge Point
- Water Monitoring Location

File Name (A4): R09/3622_144.dgn
20170220 15.26

FIGURE 1.3

Invincible Water Management
System Catchment

1.4.2 Modelling Results

Modelling results for the predicted wet weather discharges from the Main Water Storage Dam for the 10th percentile, 50th percentile and 90th percentile discharge years, assuming that there is no additional storage volume within the former Invincible Underground workings (i.e. the worst case scenario), are presented in **Table 1.1**.

Table 1.1 Main Water Storage Dam Modelled Discharges (LD002)

Percentile	Discharge (ML)
10 th %ile	223
50 th %ile	625
90 th %ile	1176

The modelled discharge volumes identified in **Table 1.1** are an indication of the wet weather discharges that could occur during the Southern Extension Project from the Main Water Storage Dam (LD002) based on the conservative assumptions of the Revised Site Water Balance. This is a conservative estimate as the assumption regarding runoff from the undisturbed catchment upstream of the mining area and the predicted seepage from the Invincible Underground workings are conservative, as is the model assumption that there is no storage available in the Invincible Underground workings at the start of the each year during the modelling period. The model has also adopted the low end of estimated seepage rates from the Invincible Underground workings (105 ML/year).

Actual discharge volumes will be lower if storage capacity is available in the Invincible Underground workings and/or the outflow seepage to coal seams down dip of the Invincible Underground workings is at the higher end of the estimated range (up to 315 ML/year) and/or the inflows from areas upstream of the mining area through surface cracking are lower than assumed.

Due to there being no change in the Water Management System catchment size for the Southern Extension Project relative to previously approved operations (as detailed in the EA), it is noted that these assumptions would apply equally to the previous operating conditions for Invincible before going into care and maintenance. Under 'care and maintenance', the predicted discharges under each scenario would be higher based on these assumptions due to inflows and outflows associated with coal extraction and processing from the proposed mining operations (a net deficit in the water balance) not occurring.

The modelled average number of days that discharges would occur from the Main Water Storage Dam is 72 days per year based on historical climate data and predicted site water demands. Due to there being a lag time between a rainfall event and runoff, wet weather discharges may potentially extend over several days following heavy rainfall events or extended wet periods. As noted above, discharges associated with the Southern Extension Project are unlikely to be materially different to the previously approved operations and would be slightly lower than the current 'care and maintenance' management conditions due to higher water usage requirements under proposed operational conditions. As discussed in **Section 2.3** below, monitoring of water in the Main Water Storage Dam and discharges via LD002 indicate that water currently discharged from the site in wet weather conditions is not materially different to the water in the receiving catchment. The updated Water Management Plan for the site will include an updated site water balance for operations covered by the plan. The updated Water Management Plan will include triggers for any active management of water levels in the Invincible Underground workings and details of the management system to be implemented should water levels require management.

2.0 Responses to Submissions Received

As noted in **Section 1.0**, submissions were received on water related issues from two agencies, DPI-Water and the EPA. In addition, Department of Planning and Environment (DP&E) requested a specific response in relation the quantity and quality of water in the Ivanhoe No. 2 Underground workings and the quality of water in the receiving environment.

Many of the comments in the submissions from these agencies relate to uncertainties regarding the quality and quantity of water in the Ivanhoe No. 2 Underground workings that would need to be removed as part of the Southern Extension Project and potential impacts associated with the discharge of water from the Ivanhoe No. 2 Underground workings at the existing licensed discharge point (LD002). As discussed in **Sections 1.2** and **1.3**, the quantity of water in the Ivanhoe No. 2 Underground workings is significantly (83%) lower than was conservatively assumed in the EA and the Southern Extension Project no longer proposes the direct discharge of this water from the site via LD002. As outlined in **Section 1.3**, this water will be transferred to the Invincible Underground workings which have been assessed as having sufficient capacity to store this volume of water (refer to **Appendix 1**).

As a result of the significantly lower volume of water in the Ivanhoe No. 2 Underground workings than previously assumed in the EA, many of the comments raised by the agencies are no longer directly relevant. As part of ongoing engagement with the relevant agencies, the findings in relation to water volumes in the former Ivanhoe No 2 workings have been discussed with the agencies, and formally responded to in the following sections.

The following sections contain the response to the individual submissions raised by each agency having regard to the assessment findings in **Appendices 1** and **2** of this report and the proposed management changes detailed in **Section 1.3**.

2.1 Management of Water in the Ivanhoe No. 2 Underground Workings

2.1.1 Agency Submissions

2.1.1.1 DP&E

Provide further information about the quantity and quality of water that would be taken from the Ivanhoe No. 2 workings, including an updated water balance.

Appendix 1 includes a detailed assessment by AGE of both the predicted quantity of water in the Ivanhoe No. 2 Underground workings that will need to be removed to enable the safe extraction of coal in the Lithgow Seam in the Southern Extension Area and the quality of this water. As summarised in **Section 1.3**:

- approximately 367 ML of water would be required to be removed from the former Ivanhoe No. 2 Underground workings as part of the Southern Extension Project (approximately 17% of the volume conservatively assumed for the purposes of the assessment undertaken in the EA)
- water from the former Ivanhoe No. 2 Underground workings (BHTH12), the East Tyldsley bore, and the Invincible open cut northern void is of comparable quality – generally with pH values of between 6.06 and 6.72 and EC values between 850 $\mu\text{S}/\text{cm}$ and 1600 $\mu\text{S}/\text{cm}$ and similar ionic composition.

There is sufficient capacity in the Invincible Underground workings (estimated to be 1585 ML capacity – refer to **Appendix 1**) and open cut spoil to store this water and additional discharge from the existing licensed discharge point is no longer proposed as part of the Southern Extension Project. Accordingly, the proposed Southern Extension Project discharge scenario is unchanged from the previously approved operations and is estimated to be slightly lower than the current care and maintenance scenario due to higher water usage requirements under an operational mine scenario. All discharges will be managed in accordance with the requirements of the existing EPL 1095 for Invincible and discharge point LD002.

Appendix 2 contains a revised site water balance for the Southern Extension Project based on the revised groundwater information and altered approach to the management of water removed from the Ivanhoe No.2 Underground workings.

2.1.1.2 DPI-Water

The proponent should provide further detail of the water balance for the existing Ivanhoe No.2 accumulated water with respect to the 2,121ML requiring dewatering. It is reported in the EA that the mine void is primarily made up of surface water flow through subsidence fractures, but this is calculated in the EA to be 7-20ML/yr which would total a potential maximum of 200ML over a 10 year period.

Appendix 1 includes a revised assessment of the volume of water stored in the Ivanhoe No. 2 Underground workings based on observed groundwater levels from recently installed bores in the former workings and calculates the volume required to be removed to be approximately 367 ML (refer to **Section 1.2** above and the response in **Section 2.1.1.1**), which is 17% of the conservative volume calculations presented in the EA. This conclusion is consistent with the prediction that water in these workings is derived from surface flows intercepted by subsidence cracking in the Southern Extension Area and upstream catchment. A revised site water balance considering the revised groundwater information (refer to **Appendix 1**) and altered approach to the management of water removed from the Ivanhoe No.2 Underground workings is included in **Appendix 2**.

2.1.1.3 EPA

There is a lack of fundamental data on ground water levels in the old Ivanhoe No. 2 workings and therefore the actual volume of water that needs to be removed. This is considered to be a major deficiency in the current EA, one which should have been addressed prior to the public exhibition of the EA.

The EA originally assessed the impacts of the Southern Extension Project assuming a ‘worst case’ scenario of water in the Ivanhoe No. 2 Underground workings. The uncertainties regarding this estimate were acknowledged in the EA, along with a commitment for Castlereagh Coal to undertake further investigations into the volume of water in the former Ivanhoe No. 2 Underground workings. These investigations were undertaken in December 2016 through the establishment of bores into the former Ivanhoe No. 2 Underground workings.

As discussed in **Section 1.1** and **Section 2.1.1.1** above, the installed monitoring bores have enabled the volume of water in the Ivanhoe No. 2 Underground workings to be accurately estimated. This monitoring indicated that the stored water level in the Ivanhoe No. 2 Underground workings was at approximately 901 mAHD. This measured water level means there is significantly less water in the Ivanhoe No. 2 Underground workings that was calculated based on 908 mAHD water level considered in the EA to assess maximum available storage. Based on the measured water level, the volume of water required to be removed from the Ivanhoe No. 2 Underground workings as part of the Southern Extension Project is estimated to be approximately 17% of the conservative volume used for the assessment in the EA. As discussed in **Appendix 1**, this volume of water can be managed through transfer to the Invincible

Underground workings, avoiding the need for any additional discharges from Invincible relative to existing and past operations.

Assumptions used to estimate the volume of mine water to be removed do not allow for the sinkholes that occur in the Cullen Ck tributary upstream of the current open pit area and the potential additional surface inflows into the mine workings from the upstream catchment.

The sinkholes and subsidence cracking associated with past mining at Ivanhoe No.2 Underground was acknowledged in the EA as the likely source of any water in these working however due to uncertainties regarding the timing of subsidence impacts and runoff rates, it was not possible to estimate the volume of water in the Ivanhoe No. 2 Underground workings. The method used in both the EA and **Appendix 1** was based on the assumptions regarding the total available volume of storage in the former Ivanhoe No. 2 Underground workings and potential (in the case of the EA) and actual (as measured in BTH12) fill levels.

The estimated volume of water in the Ivanhoe No. 2 Underground workings (refer to **Section 1.1** and **Appendix 1**) is consistent with the assumption that this water is derived largely from subsidence infiltration rather than any significant groundwater inflows.

Very limited groundwater quality data was provided in the EA and none was provided for the (potentially flooded) Ivanhoe No. 2 workings.

The available groundwater quality data suggests that the mine water appears to have significant differences in the ionic composition when compared to surface waters. The mine water is also likely to be high in Nickel and Zinc and, on occasion, other contaminants. This suggests that any groundwater that is pumped from underground workings will need to be treated prior to discharge.

As detailed in **Section 1.2**, the water removed from the Ivanhoe No. 2 Underground workings will not be discharged directly to the downstream environment as was originally proposed in the EA. This water will be transferred to the Invincible Underground workings which have a capacity of at least 1585 ML, which is sufficient to contain the water from the Ivanhoe No 2 Underground workings.

The water sampling from BTH12 indicates that the water quality in the Ivanhoe No. 2 Underground workings is of comparable quality to the water in the Northern Void (the transfer point for water from Ivanhoe No. 2 Underground workings into the Invincible Underground workings) and East Tyldersley workings (refer to **Appendix 1**). Accordingly, there is no requirement for treatment of this water as part of the Southern Extension Project.

2.2 Water Management System and Water Balance

2.2.1 Agency Submissions

2.2.1.1 DP&E

The DP&E Submission regarding water balance is reproduced and addressed in **Section 2.1.1.1**.

2.2.1.2 EPA

The actual details on the WMS for the operation of the Southern Extension Project are quite vague, especially where stage plans are presented as conceptual and statements suggest the WMS will be constructed and modified as and when required. It is therefore unclear what assumptions have actually been used in the Water Balance Assessment for the proposed expansion.

1. ***The stage plans presented are vague, conceptual in nature only and the WMS will be constructed and modified as and when required.***
2. ***Refinement of the design criteria and capacities are stated to be undertaken during detailed design stages of the Southern Extension Project***
3. ***Several years rehabilitation is necessary to be sufficiently established to be released to the environment***
4. ***Runoff from areas with existing rehabilitation will be released to the environment where runoff can be practically separated from runoff from mine and dirty water catchments (it is unclear what practically separated means in the current context).***

Insufficient details of the WMS and Water Balance are provided in the EA to test the veracity of conclusions that it is capable of containing all dirty water on-site; or that the WMS will ensure that any discharges that do take place will be of appropriate quality. An independent expert peer review of the Water Balance Model (including all its assumptions) should be undertaken.

The Southern Extension Project will not increase the catchment area of the existing water management system (WMS). As can be seen from **Figure 1.3** (also included as Figure 6.4 in the EA) the WMS catchment area for the Southern Extension Project is the same as that of the currently approved operations (currently on 'care and maintenance'). The main difference between the two systems is the internal drainage system implemented to manage runoff from rehabilitated and newly disturbed areas proposed to be implemented as part of the Southern Extension Project.

The WMS described in the EA largely retains the existing WMS already in place at Invincible. As shown in the indicative WMS schematics in Figure 6.7 and 6.8 of the EA, there are minor changes to the WMS over the life of the Southern Extension Project. These changes are associated with additional sediment dams and associated water infrastructure required to manage runoff from existing disturbed areas as they are rehabilitated as part of the project and runoff from disturbed areas associated with the Southern Extension Area.

The level of detail provide in the Schematics shown in Figures 6.7 and 6.8 of the EA are consistent with the level of detail provided in assessments for other mining projects in NSW and are adequate in identifying the conceptual water management strategies to be implemented at the Invincible site. More detailed plans of the water management system will be provided in the updated Water Management Plan and associated erosion and sediment control sub plan for the site should the Southern Extension Project be approved. These plans will be developed in consultation with the EPA and DPI-Water prior to submission to DP&E for approval.

As discussed in **Section 1.3** above, direct discharge of water from the Ivanhoe No. 2 Underground workings is no longer proposed as part of the Southern Extension Project. As there is no material change to the WMS area (and water balance assumptions) both the quantity and quality of water from the wet weather discharges permitted under the current EPL remain largely the same as the previously approved operations. Consistent with existing operations, regular monitoring of water quality in discharges and receiving waters will be undertaken during the Southern Extension Project, and will be detailed as part of the revised Water Management Plan. Water quality and water monitoring is discussed further in **Section 2.3** below.

Using a daily step rainfall-runoff model, the median annual runoff for the nearby Ben Bullen Ck catchment upstream of Baal Bone Colliery (just to the north of Invincible) was estimated at approximately 1.33 ML/Ha (AECOM 2009). Whilst this number obviously needs to be verified for the upper Cullen Ck catchment, it suggests that catchment runoff to the sinkhole could be of the order of

89 ML/year. Most of this runoff appears likely to flow into the sinkhole and therefore into the Ivanhoe No 2 underground workings.

The lack of any estimate of catchment runoff from the upstream catchment area and its potential impact on the mine water balance is considered to be a significant deficiency in the exhibited EA.

The Revised Site Water Balance (refer to **Appendix 2**) includes an allowance for increased inflows to the water management system associated with subsidence cracking by assuming runoff from catchment areas upstream of the Southern Extension Area is higher than natural average runoff rates. The runoff rates assumed for this purpose are the same as that for disturbed areas; this assumption is likely to overestimate the extent of inflows to the WMS from these areas and, as a result, overstate the volume of discharges required from the WMS.

2.3 Discharges and Impacts on Downstream Catchments

2.3.1 Agency Submissions

2.3.1.1 DP&E

Clarify whether Cullen Creek is an upland river system, in accordance with the ANZECC guidelines.

Although Cullen Creek is located at elevations above 150 mAHD, water quality monitoring for Cullen Creek upstream of Invincible and in an adjacent catchment area (monitoring of EC undertaken by DPI-Water) indicates that the water quality in Cullen Creek is aligned to the default ANZECC guidelines for lowland river systems in NSW, not upland river systems.

Table 2.1 includes a comparison of the default ANZECC criteria for upland and lowland rivers and the 20th and 80th percentile surface water quality values resulting from analysis of monitoring points BSW01 (Cullen Creek upstream) and BSW02 (Cullen Creek downstream) (refer to **Figure 1.1**).

Table 2.1 Comparison of ANZECC Criteria and Water Quality Analysis Results for Cullen Creek

	Analyte	pH	Electrical Conductivity (EC) (µS/cm)	Total Suspended Solids (TSS) (mg/L) ²
Default ANZECC Criteria	NSW Upland Rivers (>150 mAHD) ¹	6.5 to 8.0	30 to 350	-
	NSW Lowland Rivers (<150 mAHD) ¹	6.5 to 8.5	125 to 2200	-
EPL	EPL 1095	6.5 to 8.5	-	30

	Analyte	pH	Electrical Conductivity (EC) (µS/cm)	Total Suspended Solids (TSS) (mg/L) ²
Water Quality Analysis	BSW01 (upstream of LD002) ⁵	6.16 ³ to 7.09 ⁴	406 ³ to 790 ⁴	21 ⁴
	LD002	6.74 ³ to 7.42 ⁴	*523 ³ to 655 ⁴	12 ⁴
	BSW02 (downstream of LD002) ⁵	7.29 ³ to 7.78 ⁴	671 ³ to 1600 ⁴	6 ⁴

Note 1: ANZECC Guidelines (2000)

Note 2: Not specified in the ANZECC Guidelines

Note 3: 20th percentile value

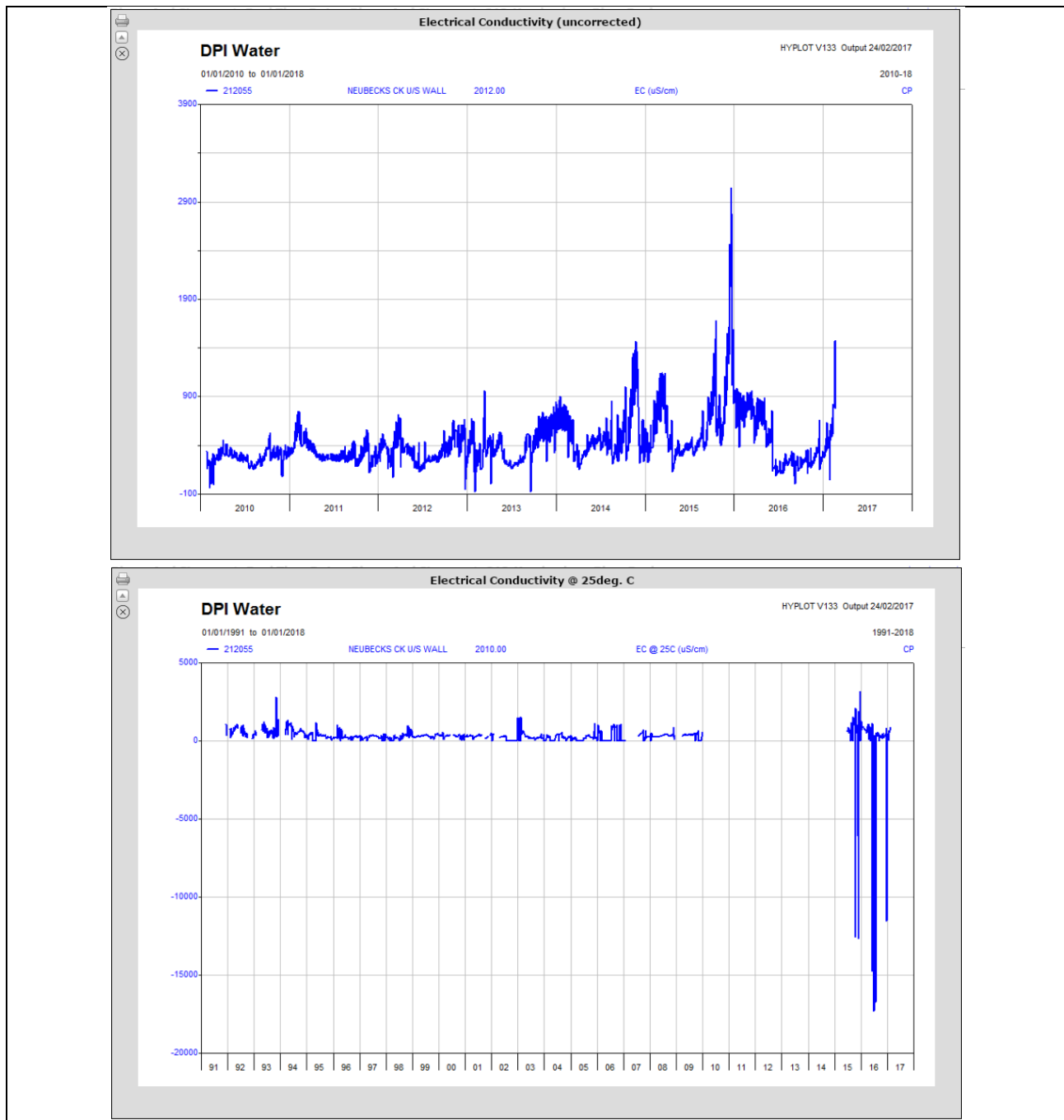
Note 4: 80th percentile value

Note 5: 35 historical monitoring results available for pH, 16 historical monitoring results available for EC and 31 available for TSS.

* six samples only taken to date – continued sampling required to determine trigger levels

As shown in **Table 2.1** analysis of historical surface water monitoring results for BSW01 (upstream of the Project area) indicate a 20th percentile value for EC of 406 µS/cm and an 80th percentile value of 790 µS/cm, these values fall within the default ANZECC criteria for NSW Lowland Rivers indicating that Cullen Creek should be considered as a lowland river system in terms of water quality. Additionally, plots as shown in **Graph 2.1** have been extracted from the NSW Department of Primary Industries (DPI) Office of Water Real-time data portal (<http://realtimedata.water.nsw.gov.au/water.stm>) for site 212055 located on Neubecks Creek to the south of Invincible (Neubecks Creek is underlain by similar geology to the Southern Extension Area and Cullen Creek). As can be seen from **Graph 2.1**, Neubecks Creek also experiences elevated levels of EC which are in line with the default ANZECC criteria for lowland rivers, indicating that other creeks in the local area also experience EC levels consistent with that observed in Cullen Creek at BSW01.

The quality of the receiving water in Cullen Creek is discussed further in **Section 2.3.1.3** below.



Graph 2.1 Plot of Electrical Conductivity for NSW DPI Office of Water monitoring site 212055 (Neubecks Ck U/S Wall)

© NSW Department of Primary Industries Office of Water, 2017

Provide detailed consideration of measures to reduce water quality impacts from discharges into Cullen Creek, including options to treat water prior to discharge.

As discussed above, the Southern Extension Project will not result in any increase in discharge requirements relative to the previously approved operations and discharge volumes are estimated to be slightly lower than the current care and maintenance scenario due to higher water usage requirements under an operational mine scenario.

Water management principles will remain largely the same as under the previously approved operations and, as discussed above and shown in **Table 2.1**, these have been demonstrated to result in discharges of similar water quality to that in the receiving environment.

Discharge water quality at Invincible is monitored as per the requirements of EPL 1095 and water quality in the receiving environment is also monitored at points BSW01 and BSW02 (refer to **Figure 1.1**). Cullen Creek is ephemeral at both monitoring points. Discharges from LD002 flow down an unnamed ephemeral tributary of Cullen Creek and enter Cullen Creek on the western side of the Castlereagh Highway. As shown on **Figure 1.1**, BSW01 is located on Cullen Creek upstream of the point where this unnamed tributary enters Cullen Creek. BSW01 is therefore considered to represent the existing natural catchment conditions (i.e. upstream of Invincible) and is considered to be representative of the receiving waters for discharges from LD002.

With the exception of one instance on 8 November 2016, monitoring indicates that all discharges from LD002 have been within criteria prescribed in the EA¹. The monitoring at LD002 in November 2016 indicated a minor exceedance of pH (6.35 under low flow conditions relative to EPL limits of 6.5 to 8.5). The water sample taken from BSW01 on the same date had a pH of 6.62 (no flow) however the downstream monitoring point BSW02 recorded a pH of 7.45 (slow flow) indicating the lower pH likely had no material effect on the pH of the receiving water. It is also noted that the pH levels recorded at BSW01 in the months of July, August and September 2016 (6.29 – no flow, 6.24 -low flow and 6.18 – low flow, respectively) was below the pH recorded for the November 2016 discharge from LD002 indicating that the pH recorded for the discharge from LD002 on 8 November 2016 was within the historical range of pH values observed in the receiving environment at BSW01. It is noted that subsequent samples from the LD002 monitoring point and the Main Water Storage Dam indicate pH levels within the EPL criteria.

The quality of the receiving water in Cullen Creek is discussed further in **Section 2.3.1.3** below.

2.3.1.2 DPI-Water

The proponent should assess whether the proposed discharge for potentially 93 days in 1 year at 22.8ML/d (26% bankfull flow) will impact the downstream riparian environment. The proponent should consider the need for monitoring and mitigating measures or alternate flow release regimes if necessary.

The discharge rate referred to in the submission was a discharge scenario associated with the discharge of water from the Ivanhoe No. 2 Underground workings directly into Cullen Creek. As discussed in **Section 2.1** discharges of water from the Ivanhoe No. 2 Underground workings are no longer required or proposed as part of the Southern Extension Project.

A worst case discharge scenario associated with the Southern Extension Project is discussed in **Section 1.4** and **Appendix 2**. These rates are significantly lower than the 22.8ML/day volumes outlined in the EA.

¹ The POEO Act Public Register on the EPA website reports a non-compliance for an exceedance of pH limits at LDP2 in the 2014 Annual Return. A review of the Annual Environmental Monitoring Reports and monitoring data from this period does not identify any discharges from LDP2 (LD002). The 2014 Annual Environmental Monitoring Report does indicate three samples from BSW01 (i.e. in the catchment upstream of any discharges from LD002) in February 2014, May 2014 and August 2015 had pH readings of 3.95, 4.08 and 5.67 respectively.

2.3.1.3 EPA

In terms of local water quality data that is available, the EA presented data on two sites (BSW01 and BSW02). Site BSW01 is on Cullen Ck, but downstream of previous rehabilitated open-cut areas for the Cullen Main West mine. It is unclear what effect rehabilitated open-cut areas for the Cullen Main West mine have on water quality at BSW01. In addition, only a very limited number of analytes (pH, TSS and EC) have actually been reported at BSW01. There is insufficient data to provide a proper characterisation of background water quality for the Project Area or the receiving waters for the proposed discharge. There is also insufficient data to calculate local water quality criteria.

An inadequate characterisation of water quality in the Cullen Ck catchment is presented in the EA with very limited water quality data available to calculate 80th/20th percentiles for the determination of Local Water Quality Criteria, as recommended by ANZECC (2000). The EA is considered to be deficient in its understanding and presentation of local water quality data. There is also a lack of consideration of (or proposed amelioration of) potential changes to sediment and nutrient runoff processes.

There is insufficient evidence presented that the pollutants that will be discharged from the site will NOT pose a risk of harm to the environment.

Table 2.2 provides a summary of the analysis undertaken on historical surface water quality monitoring data for the site and upstream and downstream of Invincible on Cullen Creek. The metals presented in **Table 2.2** have been selected as these are the only metals where there were observed exceedances of default ANZECC criteria at one sampling site in the sampling undertaken in either the receiving waters or at Invincible to date.

The results in **Table 2.2** indicate the following:

- pH for all monitoring sites typically falls below the lowland rivers upper default ANZECC trigger value.
- BSW01 appears to have quite low pH whereas BSW02 typically falls within the higher end of the ANZECC default trigger range for lowland rivers.
- Early EC records are intermittent; however BSW02 has consistently higher EC values than BSW01. Monitoring results for LD002 and Main Dam do not account for the difference in EC at the upper and lower monitoring locations on Cullen Creek. All EC values typically fall within the upper and lower ANZECC default trigger values for lowland rivers.
- Typically values for total Aluminium, Copper, Nickel and Zinc were observed to be higher than ANZECC default trigger value at BSW01 (Cullen Creek Upstream). One recent result for Manganese was also recorded above the ANZECC default trigger value at BSW01. Values for total aluminium and zinc were also found to be higher than the ANZECC default trigger value at LD002 and Main Dam, but within the ranges of these metals from monitoring in the receiving waters (BSW01).
- Typically values for total Aluminium, Copper and Zinc were observed to be higher than the ANZECC default trigger value at BSW02.
- There does not appear to be a significant trend between flow condition within Cullen Creek and the observed water quality monitoring results.

In summary, historical discharges from LD002 and water in the Main Water Storage Dam are generally within the historical range of monitoring data from BSW01 (Cullen Creek Upstream).

Table 2.2 Historical surface water quality monitoring results analysis

Site Name	Analysis	pH	EC (µS/cm)	TSS (mg/L)	Aluminium (total) (µg/L)	Chromium (total) (µg/L)	Copper (total) (µg/L)	Manganese (total) (µg/L)	Nickel (total) (µg/L)	Zinc (total) µg/L
ANZECC default trigger for 95% ecosystem protection		-	-	-	55	1	1.4	1900	11	8
BSW01 (Upstream)	Number of samples	35	16	31	7	7	7	7	7	7
	Maximum	7.60	1040	84	1090	1	20	2480	34	112
	Minimum	3.95	235	5	120	1	10	88	6	5
	20 th percentile	6.16	406	12	194	1	10	136	11	14
	80 th percentile	7.09	790	21	628	1	20	135	25	74
	Average	6.53	587	21	406	1	13	919	18	47
BSW02 (downstream)	Number of samples	35	16	31	7	7	7	7	7	7
	Maximum	8.18	2180	12	470	7	2	482	9	13
	Minimum	7.00	93	2	40	1	1	70	4	5
	20 th percentile	7.29	671	5	60	1	1	79	4	7
	80 th percentile	7.78	1600	6	150	1	2	341	8	11
	Average	7.58	1092	5.6	134	1	1.5	218	6	9

Site Name	Analysis	pH	EC (µS/cm)	TSS (mg/L)	Aluminium (total) (µg/L)	Chromium (total) (µg/L)	Copper (total) (µg/L)	Manganese (total) (µg/L)	Nickel (total) (µg/L)	Zinc (total) µg/L
ANZECC default trigger for 95% ecosystem protection		-	-	-	55	1	1.4	1900	11	8
LD002 (EPL licensed discharge point)	Number of samples	18	6	16	7	7	7	7	7	7
	Maximum	8.23	790	56	270	7	1	274	7	104
	Minimum	3.80	512	2	40	1	1	100	2	5
	20 th percentile	6.74	523	5	72	1	1	123	2	5
	80 th percentile	7.42	655	12	106	1	1	225	4	17
	Average	6.96	600	10	107	2	1	175	4	24
Main Dam	Number of samples	58	6	58	7	7	7	7	7	7
	Maximum	8.11	648	47	350	1	1	309	4	18
	Minimum	6.00	513	2	50	1	1	91	1	5
	20 th percentile	6.80	523	4	72	1	1	136	2	5
	80 th percentile	7.50	643	7	114	1	1	223	4	14
	Average	7.17	577	6.50	120	1	1	179	3	9

Monitoring will continue to be undertaken at LD001, Main Water Storage Dam, BSW01 and BSW02 and will include the following analytes: pH, EC, TSS, TDS, SO₄, Ca, Mg, K, Na, Cl, Al, As, Co, Cu, Fe, Mn, Ni and Zn .

This monitoring at BSW01 and BSW02 will be undertaken at least monthly until sufficient samples have been collected to establish site specific triggers for the receiving environment in accordance with ANZECC methodology. Following the establishment of site specific triggers, monitoring of the analytes listed above at BSW01 and BSW02 will be reduced to quarterly sampling.

The water quality monitoring for the Southern Extension Project will be detailed in the updated Water Management Plan to be developed for Invincible. The updated Water Management Plan will be prepared in consultation with DPI Water and the EPA prior to submission of this plan for approval of DP&E.

An additional factor with the proposal is that the upstream catchment currently consists of native forested land which the Proponent is proposing to modify with open cut mining (and later land contouring). It is well known that changing landuse and landform in such situations leads to major alterations in the sediment and nutrient runoff processes and delivery to the downstream catchment (Harris 2001, Bartley et al 2012). Pristine, forested catchments export relatively little nitrogen and phosphorus and the predominant form of nitrogen is dissolved organic nitrogen. As catchments are cleared, exports increase and the predominant form of nitrogen changes from dissolved organic nitrogen to dissolved inorganic nitrogen (Harris 2001). The EA does not address the potential increase in sediment and nutrient loads to the downstream catchment from this area, an effect likely to continue for significant time periods after mining (e.g. see Figure 5). This is considered a deficiency in the information provided and in the assessment of potential environmental impacts on the downstream environment

There is a lack of consideration of potential changes to sediment and nutrient runoff processes as a result of the proposal.

The Southern Extension Project will not involve any material changes to sediment and nutrient runoff processes or water management practices relative to the approved previous operating conditions or current care and maintenance conditions. As shown in **Figure 1.3**, the Southern Extension Project does not result in any changes to the size or location of the catchment area relative to the existing WMS. As shown in **Table 2.2** and discussed above, existing operating arrangements indicate that water discharged from the site in wet weather conditions is not materially different to the water in the receiving catchment.

The subjective opinion that "the Southern Extension Project is expected to have negligible impacts on flows, water quality and water users" is neither substantiated nor supported.

As discussed in **Sections 1.3** and **1.4**, the Southern Extension Project discharge scenario is unchanged from the previously approved operations and the estimated discharge volumes are likely to be slightly lower than the current care and maintenance scenario due to higher water usage requirements under an operational mine scenario. As discussed above, existing operating arrangements indicate that water discharged from the site in wet weather conditions is not materially different to the water in the receiving catchment and there are no material changes to the water management system proposed as part of the Southern Extension Project which would adversely affect water quality in the downstream environment (refer to responses above).

As discussed in Section 6.6.3.1.3 of the EA, the past mining in the area has already depressurised aquifers in the area potentially impacted by the Project. The removal of water from the former Ivanhoe No 2 workings will not adversely affect any groundwater users in the local area.

Licence Conditions to Apply

In the absence of appropriate water quality data for mine water and the receiving environment, the EPA recommended licence discharge quality limits are;

- a) the trigger values detailed under ANZECC (2000) for 95% species protection, in line with the NSW policy that the level of protection applied to most waterways is for slightly to moderately disturbed ecosystems (DEC 2006).***
- b) for other potential contaminants, the recommended licence limits should ideally be based on the ANZECC (2000) default trigger values for NSW upland rivers.***

If the proponent wishes to argue for the use of different default trigger values/Licence limits, then the proponent needs to implement a comprehensive surface water monitoring program and calculate Local Water Quality Criteria using the methodology recommended by ANZECC (2000). For slightly to moderately disturbed ecosystems (Condition 2), ANZECC (2000) recommends:

Define trigger values for physical and chemical stressors for condition 2 ecosystems, in terms of the 80th and/or 20th percentile values obtained from appropriate reference system.

As discussed above, monitoring will be undertaken to determine local water quality criteria in accordance with ANZECC methodology. As shown in **Table 2.1** and discussed in **Section 2.3.1.1**, analysis of historical surface water monitoring results for BSW01 (upstream of the Project area) indicate a 20th percentile value for EC of 406 $\mu\text{S}/\text{cm}$ and an 80th percentile value of 790 $\mu\text{S}/\text{cm}$. These values fall within the default ANZECC criteria for NSW Lowland Rivers indicating that Cullen Creek should be considered as a lowland river system in terms of water quality. Existing monitoring at BSW01 also indicates that the pH for all monitoring sites typically falls below the upland rivers upper default ANZECC trigger value. This monitoring is supported by the DPI Water monitoring undertaken in Neubecks Creek (site 212055) to the south of the Southern Extension Area which also indicate elevated levels of EC which are in line with the default ANZECC criteria for lowland rivers.

Water levels and quality in the Main Water Storage Dam will be managed to ensure EPL licence conditions are met over the life of the Southern Extension Project. The monitoring and management strategies to achieve this will be detailed in the updated Water Management Plan for Invincible which will be developed in consultation with DPI Water and the EPA prior to submission of this plan for approval of DP&E.

2.3.2 Interest Group Submissions

2.3.2.1 The Colong Foundation for Wilderness Ltd

The vast subterranean storages in the old Ivanhoe Number 2 workings are a significant component of the water management problem. Due to the shallow nature of these underground workings in Ben Bullen State Forest which refill after rain, the pumping estimates presented for Invincible Southern extension seem very low. A new water pollution licence will be required as toxic groundwater in the old workings is heavily polluted and must be treated before discharge, yet this is not proposed.

Major environmental problems associated with mine water have not been explained or addressed. In addition, the proposal to mine coal pillars from the old workings in the Ivanhoe Number 2 Colliery is not adequately explained in relation to groundwater disposal.

As discussed above, the Southern Extension Project no longer proposes the discharge of any water from Ivanhoe No. 2 Underground workings and discharges from the site will be limited to wet weather discharges consistent with previously approved operations. As discussed in **Section 2.3.1** above, the quality

of the water historically discharged from the site under existing licensing arrangements is similar in quality to water in the receiving environment. The Southern Extension Project will not have any material impacts on the water management system that would alter the quantity or quality of water discharged as a result of the Southern Extension Project relative to approved previous operations and the current care and maintenance management practices.

The Colong Foundation is concerned that discharges from the Invincible mine have been and will continue to pollute Cullen Creek and the Turon River. The omission of water quality data from the two paragraph section on water quality (section 6.3.5.4) offers no explanation on mine discharge water quality and its impacts on Cullen Creek.

As discussed above, the Southern Extension Project no longer proposes the discharge of any water from Ivanhoe No. 2 Underground workings and discharges from the site will be limited to wet weather discharges consistent with previously approved operations and EPL 1095. Further details on water quality monitoring are presented in **Section 2.3.1**. As discussed in **Section 2.3.1**, ongoing monitoring of discharge water quality will be undertaken during the Southern Extension Project. Details of the monitoring to be undertaken will be identified in the Water Management Plan for Invincible which will be prepared in consultation with DPI Water and the EPA.

Any groundwater from the Invincible mine will be contaminated with metals and salts and should not be discharged without treatment using reverse osmosis technology. It would be better if this water were pumped to the treatment plant at the Springvale coal processing facility three kilometres away, than discharged untreated into Cullen Creek or by Baal Bone mine into Jews Creek.

As discussed above, the Southern Extension Project no longer proposes the discharge of any water from Ivanhoe No. 2 Underground workings and discharges from the site will be limited to wet weather discharges consistent with previously approved operations. **Appendix 1** includes details on water quality monitoring for underground water resources in the area.

The EC figures for surface waters in Cullen Creek downstream of the Invincible open-cut of up to 1080 $\mu\text{S}/\text{cm}$ at BWS02 are in line with Lithgow seam mine water, not surface water runoff. Did the water measured in Cullen Creek come from the Invincible open-cut and dewatering of Ivanhoe Number 2?

There has been no historical active discharge of water from the Ivanhoe No. 2 Underground workings from the Invincible site.

As discussed in **Section 2.3.1** above, monitoring at BSW02 downstream from Invincible consistently shows higher EC levels than EC measured in discharge water at the Invincible Licensed Discharge Point (LD002). This indicates that there are other contributing factors to the elevated EC levels recorded at BSW02.

2.3.3 Community Submissions

Any threat to Sydney's water supply must be averted. We already know that 20% of Warragamba's capacity (the depths of the dam) consists of toxic waters that are not suitable for human consumption (having heavy metal content higher than the safe level). Allowing coal mine waste to enter Warragamba dam is extremely foolish - as a mining engineer and geologist, I know the level of toxic chemicals (including radioactive radon, sulphur chemicals and metals) in "coal dust".

The Southern Extension Project (and current Invincible WMS) is not located within and does not involve any discharges into the catchment of Warragamba Dam or any other part of the Sydney drinking water catchment.

2.4 Licensing under the *Water Management Act 2000*

2.4.1 Agency Submissions

2.4.1.1 DPI-Water

The proponent should quantify existing and proposed water take from each surface and groundwater source and how this is managed at the site in terms of storage, transfer and use. This is to enable further advice to be provided on licensing requirements and for assessment of potential impacts. The current water balance is limited to concepts.

Groundwater

Underground mining at Invincible ceased in 1998 and underground mining at Ivanhoe No. 2 Underground predated this. These underground operations ceased before the date of assent for the *Water Management Act 2000* on 8 December 2000.

The water stored in the former Ivanhoe No. 2 Underground workings is considered to be surface water flow intercepted by subsidence fractures and the final open cut landform. Therefore, any take of this water should be treated as surface water take for the purposes of licensing requirements and not groundwater.

As the proposed (and existing) open cut workings are located up-dip of an already depressurised aquifer system, there will not be any material groundwater inflows to the pit that will require removal or management. Accordingly, there is not considered to be any take of groundwater from any system that would require licensing.

The transfer of water from the Ivanhoe No.2 Underground workings to the Invincible Underground workings (and open cut spoil) is not considered to be an Aquifer Interference activity. While the stored water in the Ivanhoe No. 2 Underground workings may technically be considered to be groundwater for the purposes of the Aquifer Interference Policy, it is in fact intercepted surface water. Additionally, this water would have, in time, naturally seeped into the barrier between the two workings and ultimately into the Invincible Underground workings. As both former workings and the coal barrier are within the Lithgow seam and the proposed transfer does nothing more than would occur under natural processes over time, the transfer is not considered to require an aquifer interference approval.

Surface Water

As discussed in Section 6.3.2.1 of the EA, the Invincible open cut workings and the Southern Extension Area are wholly within the area regulated by the *Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources 2012* and is located in the Turon Crudine River water source. The *Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources 2012* commenced in October 2014.

As discussed in **Section 2.2.1.2** above, the Southern Extension Project does not result in any change to the catchment managed within the water management system compared to the existing or approved operations. As detailed in **Section 1.4** and **Appendix 2**, there is no material difference between the water capture under the existing approved operating scenario, the current care and maintenance scenario or the Southern Extension Project scenario. Additionally, it is noted that the runoff from the Southern Extension Area is already significantly impacted by subsidence from the historical Ivanhoe No. 2 Underground workings; these latter impacts would have been occurring well before 2000 and the commencement of the *Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources 2012* in October 2014.

The existing operations at Invincible were approved in 2008 with the full extent of existing approved operations approved on 12 August 2009. The open cut footprint had reached its full extent (and the WMS catchment was at its full extent) by at least early 2012 and runoff from the Southern Extension Area and upstream catchment (other than that intercepted via subsidence impacts) was captured and managed as part of the Invincible Water Management System from at least the mid-1980s.

As the catchment for the existing Invincible open cut water management system was at its full extent by the time the *Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources 2012* commenced and previous surface water capture within the water management system did not require licensing, it is considered that there is no additional surface water take as part of the Southern Extension Project that would require licensing under the *Water Management Act 2000*.

The Turon Crudine River Water Source and the Sydney Basin Murray Darling Basin Groundwater Source have limited available entitlement for purchase. This should be considered in further detail by the proponent for any entitlement requirements prior to project approval.

As noted above, the Southern Extension Project will not involve any take of surface water or groundwater that would require licensing under the *Water Management Act 2000*.

The proponent should provide further detail of the applicability of Maximum Harvestable Rights Dam Capacity to the dams and proposed licensing for the site.

The existing water management dams and proposed sediment dams do not require licensing under the *Water Management Act 2000* as they:

- are required for pollution control purposes,
- will not be located on 3rd or higher order streams, or
- predate the *Water Management Act 2000*.

The licensing requirements for any dams remaining in the final landform will be considered as part of the final closure process, which will be developed as part of the mine closure plan to be developed for approval by DRE and in consultation with relevant agencies.

The conceptual final landform for the Southern Extension Project does not include any final voids and no dams are presently proposed as part of the final land use for the rehabilitated mine site. Notwithstanding, Castlereagh Coal will consult with DPI Water on the licensing requirements associated with the final landform as part of the detailed mine closure process for the mine required as part of the Mining Operations Plan process.

2.5 Flooding Impacts

2.5.1 Agency Submissions

2.5.1.1.1 DPI-Water

The proponent should clarify whether the flood assessment has considered the proposed discharge of water from the underground workings.

As discussed in **Section 1.2**, water from the Ivanhoe No. 2 Underground workings will not be directly discharged from the site as was originally proposed as part of the EA.

As discussed in **Sections 2.2** and **2.3**, the Southern Extension Project will not result in any material change in wet weather discharge arrangements for Invincible from that which currently occurs from the approved operations. Accordingly, the Southern Extension Project will not result in any changes to downstream flooding impacts relative to the existing approved operations.

2.6 Clean Water Diversions

2.6.1 Agency Submissions

2.6.1.1.1 DPI-Water

The existing and proposed surface water management should be reviewed to achieve the objective of separating clean and dirty water runoff as set out in the previous project approval and water management plan for the Invincible mine.

As discussed in Section 6.3.5.1 of the EA, the Southern Extension Project will not increase the area of Cullen Creek catchment currently managed within the Invincible WMS. The existing WMS catchment includes the capture of runoff from areas of undisturbed catchment (predominately upstream from the Northern and Eastern Voids) and parts of the upstream catchment that are impacted by subsidence cracking which is believed to intercept a significant proportion of surface flows.

The previous Coalpac Modification Project extended open cut mining into the undisturbed catchment areas upstream of the Northern and Eastern Voids; this proposal included the installation of clean water diversions upstream of these extensions to currently approved disturbance areas (refer to Coalpac letter to Mitchell Isaacs dated 1 May 2014 responding to issues raised by the NSW Office of Water). As there is no proposed mining into to the north or east of the existing voids, the clean water drains associated with the previously proposed mining in these areas are not required.

While the Coalpac Modification Project also included the mining of the Southern Extension Area, no clean water diversions were proposed for the catchment upstream of this mining area as this was already considered to be disturbed catchment affected by subsidence impacts.

While it is desirable to maximise the diversion of clean water around disturbed areas, considerations such as the impacts associated with the increased disturbance area necessary to achieve these diversions and the timing and cost of the diversion works need to be taken into consideration.

The terrain upstream of the Northern and Eastern Voids is not amenable to the installation of diversion channels around the existing disturbance areas and any diversions would require the construction of dams and water reticulation infrastructure; both would have additional disturbance impacts in currently undisturbed areas with associated biodiversity impacts. The Southern Extension Project does not increase upstream catchment from these areas relative to the existing approved operations. In addition the up catchment environment to the Southern Extension Area consists of high slopes and would necessitate the design and implementation of extensive works to achieve clean water diversion, with associated areas of disturbance in these areas. As such, the installation of clean water diversions for the Southern Extension Project are not considered necessary or feasible, in consideration of the potential impacts of associated with the establishment of these controls in the up catchment environment.

As the Southern Extension Project includes the rehabilitation of the Northern and Eastern Void areas (including the removal of these voids) and the timeframe for the return of these areas to clean catchment is considered to be similar irrespective of whether the Southern Extension Project is approved, the environmental impacts associated with undertaking the works and the additional costs are considered to outweigh any benefits that any clean water diversion works may achieve.

2.7 Final Landform

2.7.1 Agency Submissions

2.7.1.1 DPI-Water

In the event approval is granted for the modification the proponent should ensure development of a stabilised surface water management system in the final landform, consistent with the DPI Water Guidelines for Controlled Activities on Waterfront Land.

This comment is noted. Castlereagh Coal will ensure that the design principles in these guidelines (or any successor document) are incorporated into the final landform design. Castlereagh Coal will consult with DPI Water on the development of the final landform design as part of the detailed mine closure process for the mine required as part of the Mining Operations Plan process.

2.8 Groundwater

2.8.1 Agency Submissions

2.8.1.1 DPI-Water

The proponent should verify groundwater level and water quality for aquifers potentially impacted. This will aid in quantifying potential dewatering requirements and enable assessment of likely storage and discharge requirements.

Refer to **Section 1.1, 2.1 and Appendix 1.**

The proponent should clarify the potential impacts to Baal Bone Colliery operations due to the potential increase in seepage into their workings. The proponent should consult with the Baal Bone Colliery operators.

Appendix 1 includes an assessment of potential impacts on inflow rates to Baal Bone Colliery (refer to **Figure 1.2**) associated with the additional water stored in the Invincible Underground workings due to the proposed transfer of water from the Ivanhoe No. 2 Underground workings. This assessment indicates that it is likely the seepage rate will only increase by approximately 5%, to a rate in the order of 105 ML/year – 315 ML/year; which is an increase of 5 ML/year – 15 ML/year relative to existing conditions. Considering Baal Bone Colliery has been historically dewatered by Glencore at a rate of 1300 ML/year, this change in seepage from the former Invincible underground is considered to be minor.

Castlereagh Coal will enter into consultation with the operators of Baal Bone Colliery upon approval of the Southern Extension Project.

In the event approval is granted for the modification the proponent should update the existing Water Management Plan in consultation with DPI Water. Including development of an adequate Trigger Action and Response Plan.

In the event approval is granted for the modification the proponent should develop a groundwater monitoring plan in consultation with DPI Water for the monitoring and management of groundwater associated with the Invincible spoil material, Invincible Underground, Ivanhoe No.2 underground, depressurisation of the coal seam aquifers, and water quality management, as outlined in Section 8.0 of Appendix 5 of the EA. This should include the installation of water level loggers in all bores.

In the event approval is granted for the modification the proponent should install automatic measuring devices at all monitoring bores.

This request is acknowledged and Castlereagh Coal will consult with DPI Water, and other agencies including EPA, during the preparation of the updated Water Management Plan for the site with regard to ongoing and future monitoring requirements.

2.8.1.2 EPA

There is no assessment of the effects that mapped regional joint sets in this area may have on groundwater flow pathways.

Underground coal mining at Invincible took place between 1901 and 1998 and open cut operations occurred throughout the 2000's. The project area and surrounds have been highly modified by mining (refer to **Figure 1.2**) and, as a result, the hydrogeological regime has been equally highly modified.

The main coal extraction methodology at Invincible and Ivanhoe No. 2 Underground and surrounds was bord and pillar. Bord and pillar extraction mines extend in a radius of more than 3 km from the Southern Extension Area. As a result, subsidence impacts, goaf areas, and open road ways are the dominant groundwater flow pathways. Whilst a regional joint set may be a groundwater flow path and in an undisturbed setting may contribute to groundwater recharge, the mine workings are by far the more dominant flow pathway and recharge mechanism. This has been considered in detailed groundwater assessment in the EA (refer to Appendix 5 of the EA) and in **Appendix 1**.

Groundwater Quality

AGE (2012) found that groundwater in the Permian aquifers and the water contained within the former underground workings of Invincible, had concentrations of iron and manganese that exceeded Australian Drinking Water Guideline values and the ANZECC guideline for irrigation. In addition, the groundwater resources appeared to have a 'slightly elevated' zinc concentration which may make this water unsuitable for aquatic ecosystems (AGE 2014).

AGE (2016) stated:

No groundwater level data were collected directly from the Ivanhoe No. 2 Colliery underground workings or neighbouring mines for the current assessment. Instead, this assessment has relied upon data gathered during other recent assessments (AGE, 2012 and 2014) that provide groundwater level data for the neighbouring Invincible underground workings.

Very limited groundwater quality data was provided in the EA and none was provided for the (potentially flooded) Ivanhoe No. 2 workings. What data was found to be available (McElroy 1975, AGE 2014, Sedgman 2016) was combined and analysed using Principal Components Analysis (PCA) together with a correlation biplot using the PrimerE Version 6 software package (Clarke and Gorley 2006). PCA results were presented for physico-chemical descriptors (pH, EC, Hardness, Alkalinity), selected dissolved metals (Al, Cd, Cr, Fe, Mn, Ni, Zn), and major salt ions (calcium, sulphate, chloride, magnesium, potassium and sodium) to show site similarities and correlations with each chemical group. The results identify substantial differences in groundwater quality when compared to Newnes Plateau surface waters (Figure 7). In particular, there appears to be significant differences in the ionic composition of mine waters when compared to surface waters.

The available groundwater quality data also suggests that the mine water is potentially high in Nickel and Zinc and, on occasion, other metals/non-metals/inorganic constituents (e.g. chromium and manganese). This supports the findings of AGE (2012, 2014). It is noted that the average Nickel

concentrations in groundwater were approximately twice the ANZECC (2000) default guideline level (11µg/L) to protect 95% of species and average Zinc levels were approximately seventeen times the ANZECC (2000) default guideline level (8 µg/L) to protect 95% of species. This suggests that any groundwater that is pumped from underground workings will need to be treated prior to discharge.

Very limited groundwater quality data was provided in the EA and none was provided for the (potentially flooded) Ivanhoe No. 2 workings. The available groundwater quality data suggests that the mine water appears to be significant differences in the ionic composition of mine waters when compared to surface waters. The mine water is also likely to be high in Nickel and Zinc and, on occasion, other metals/non-metals/inorganic constituents. This suggests that any groundwater that is pumped from underground workings will need to be treated prior to discharge.

Water from the Ivanhoe No. 2 Underground workings will not be discharged from the site and will instead be transferred to the Invincible Underground workings.

As discussed in **Section 1.2** and **Appendix 1** water quality samples from the Ivanhoe No. 2 Underground workings have now been taken and an analysis of the water in these samples indicates that the quality of water in the Ivanhoe No. 2 Underground workings is comparable to water in the Northern Void and East Tyldersley workings. The sampling from BTH-12 in the Ivanhoe No.2 Underground workings shows elevated levels of both zinc and nickel. Recent monitoring (since August 2016) of nickel and zinc levels in discharges at LD002 and BSW01 (upstream of where Invincible discharge water enters Cullen Creek) indicate that there have been no exceedances of default ANZEC criteria for nickel or zinc in discharges from LD002. High levels of zinc have been observed in monitoring from the upstream BSW01 point (101 µg/L, 57 µg/L, 51 µg/L and 68 µg/L) over the same period during periods when the creek at BSW01 was flowing. This would indicate that other broader catchment features, such as geology in the area, may lead to runoff have naturally elevated zinc levels.

Following transfer of water to the Invincible Underground workings, monitoring in the Northern Void, LD001, Main Storage Dam, discharges from LD002, the in-spoil piezometer (to be installed in accordance with commitments outlined in Section 7.0 of the EA) and receiving water monitoring points BSW01 and BSW02, will include ongoing monitoring of nickel and zinc concentrations. Monitoring at these points will include the following analytes: pH, EC, TSS, TDS, SO₄, Ca, Mg, K, Na, Cl, Al, As, Co, Cu, Fe, Mn, Ni and Zn.

As discussed in **Section 2.3**, this monitoring at BSW01 and BSW02 will be undertaken at least monthly until sufficient samples have been collected to established site specific triggers in the receiving environment. Following the establishment of site specific triggers, monitoring at BSW01 and BSW02 will be reduced to quarterly sampling.

All monitoring will be detailed and implemented in the updated Water Management Plan for the Southern Extension Project.

2.8.2 Interest Group Submissions

2.8.2.1 The Colong Foundation for Wilderness Ltd

Apart from mine water potentially flowing to Cullen Creek, current open-cut mining has removed 700 hectares from the Cullen Creek catchment as explained by Table 6.7 on page 114 and also Table 2.1 on page 14 of Appendix 4. The changes to the catchment form previous open-cut mining have captured near-surface groundwater and runoff upslope of the open-cut and directed these flows into the Eastern and Northern Voids. The abandoned underground workings at the old Invincible mine interconnect with Baal Bone underground workings as indicated in Figure 6.5. It seems that flows to the Eastern and Northern Voids of between 111 and 317 ML/year are lost from Cullen Creek. Given these losses, the rehabilitation

strategy should aim to fill and rehabilitate the northern and eastern voids. The voids, however, are instead to be used to dispose of mine water from Ivanhoe Number 2 workings in the southern extension area, increasing the amount of water transferred to Baal Bone.

As discussed in **Section 2.2.1.2**, the Southern Extension Project does not result in any change to the WMS catchment area relative to the current operations.

The predicted seepage from the Invincible Underground workings towards Baal Bone Colliery is a consequence of historical mining operations and the fact the Invincible Workings are flooded. As discussed in **Section 2.8.1.2** the proposed increase in water stored in the Invincible workings as a result of the transfer of water from the Ivanhoe No. 2 Underground workings is considered to have a minimal impact on water seepage into Baal Bone given the magnitude of overall seepage inputs into these workings.

The Rehabilitation Strategy will result in the filling of the Northern and Eastern Voids. The timing of the filling of the Eastern Void is unrelated to water management; rather it is associated with the management of other impacts associated with the Southern Extension Project (i.e. noise and dust). The Northern Void is required to remain open as it can be used as an emergency water supply in the event that water levels in the Main water Storage Dam are insufficient for dust suppression or CHPP purposes.

The Environmental Assessment states that the old Invincible underground workings leak 111 to 317 ML/yr into Baal Bone Colliery. The groundwater salinity of Baal Bone Colliery dewatering discharged to a tributary of Jews Creek measured at 1,125 $\mu\text{S}/\text{cm}$ (Invincible EA, pg 108) is partly due to the current dewatering of the northern void through workings associated with the old Invincible mine.

Groundwater inflows to Baal Bone Colliery are not solely from seepage from Invincible. As discussed in **Appendix 1**, EC levels are most likely a result of the recharge mechanism. The Ivanhoe No. 2 Underground, the East Tyldsley bore, and the Invincible open cut northern void (refer to **Figure 1.2**) are in close proximity to the water source and are more likely to be recharged directly from areas that are close to spoil and weathered rock profiles, and so are receptors of water that may have collected soluble material through contact with those media. LD001 (refer to **Figure 1.1**) is representative of water deep in the former Invincible underground workings and water to this point is likely recharged predominantly through subsidence fractures in fresh rock, resulting in the stored water being less saline. Baal Bone Colliery is similarly likely to have a variety of recharge mechanisms in addition to seepage from Invincible.

Seepage from the East Tyldersley and parts of the Invincible Underground workings located near LD001 will also contribute to seepage into Baal Bone and water quality in both locations is lower than the observed salinity levels at Baal Bone. Accordingly, any higher water contribution to EC than the water in the Northern Void is unlikely to be a significant contributor to the elevated levels of EC observed at Baal Bone.

Notwithstanding, water discharged from Baal Bone is managed through a separate approval and EPL to enable discharges into Jews Creek. The Southern Extension Project will not affect these current approvals or licensing requirements for Baal Bone. As outlined above, Castlereagh Coal will consult with the operators of Baal Bone regarding management activities at each site that may affect the site water balance at each operation should the Southern Extension Project be approved.

The project's water management strategy assumes that pumping from the neighbouring, Baal Bone colliery, will continue, even though this mine is closed and decommissioned.

As outlined above, water discharged from Baal Bone Colliery is managed through a separate approval and EPL to enable discharges into Jews Creek. The Southern Extension Project will not affect these current approval or licensing requirements for Baal Bone. As outlined above, Castlereagh Coal will consult with the operators of Baal Bone should the Southern Extension Project be approved.

Even if dewatering ceases at Baal Bone Colliery, there will be ongoing seepage to these workings over the medium term until equilibrium is reached. The timescale for reaching this equilibrium will be beyond the life of the Southern Extension Project and any impacts on the site water balance are likely to be minimal. It is also noted that the filling of the voids in the Invincible open cut as part of the Southern Extension Project will result in significant reductions to recharge rates in the Invincible underground workings.

2.8.3 Community Submissions

Surface water/groundwater issues were raised in two individual community submissions. The issues raised and relevant response is provided below.

Discharges from Baal Bone Colliery and the Invincible southern extension should not continue to contaminate Baal Bone Creek. Continued pumping is a poor option for enabling access to the Lithgow Seam in the Invincible Colliery open-cut several kilometres away. Terminating pumping at Baal Bone colliery will have significant environmental benefits. Baal Bone Creek and associated shrub swamps would slowly recover when relieved of the constant input of mine water pollution. It would also allow groundwater levels to rise in the abandoned mine workings and that in turn would permit recovery of water levels in Long Swamp, a large shrub swamp forming the headwaters of the Cox's River. This swamp suffered groundwater loss when longwall mining operations passed adjacent to it.

The Southern Extension Project will have a minimal impact on Baal Bone Colliery.

The Southern Extension Project does not propose any discharges into Baal Bone Creek.

Environmental assessment seems to assume amount of water in Ivanhoe No2 and where it will end up. Baal Bone mine has advised that local landholders on Jews Creek that dewatering will cease early 2017. More investigation should be undertaken before any mining commences to ascertain the volume water and what effect it will have on Baal Bone / Jews Creek etc.

As discussed above, the Southern Extension Project will have a minimal impact on overall inflows to Baal Bone Colliery.

2.9 Aquatic Ecology

2.9.1 Agency Submissions

2.9.1.1 EPA

There has been no investigation of the aquatic ecology in the receiving environment (Cullen Ck catchment).

The Southern Extension Project no longer proposes the discharge of water from the Ivanhoe No. 2 Underground workings from LD002 (refer to **Section 1.3**). As discussed in **Section 1.3**, the water management system for the Southern Extension Project is largely unchanged from the previously approved operating scenario or the current care and maintenance management conditions (although the current care and maintenance conditions do not involve usage of water for operational purposes). While there are some minor changes to the way in which runoff will be captured and managed during the life of the Southern Extension Project. These changes relate to the location of capture and do not affect the volume of runoff captured within the WMS.

Discharges under the Southern Extension Project will remain essentially the same as the existing and past operating conditions and, as discussed in **Section 2.3** above, the water discharged from the site is similar in

quality to that observed in the Cullen Creek catchment upstream of the Invincible discharge point. Accordingly, there is unlikely to be any changes to operations which would have observable impact on aquatic ecology in the receiving environment.

2.10 General

2.10.1 Agency Submissions

2.10.1.1 EPA

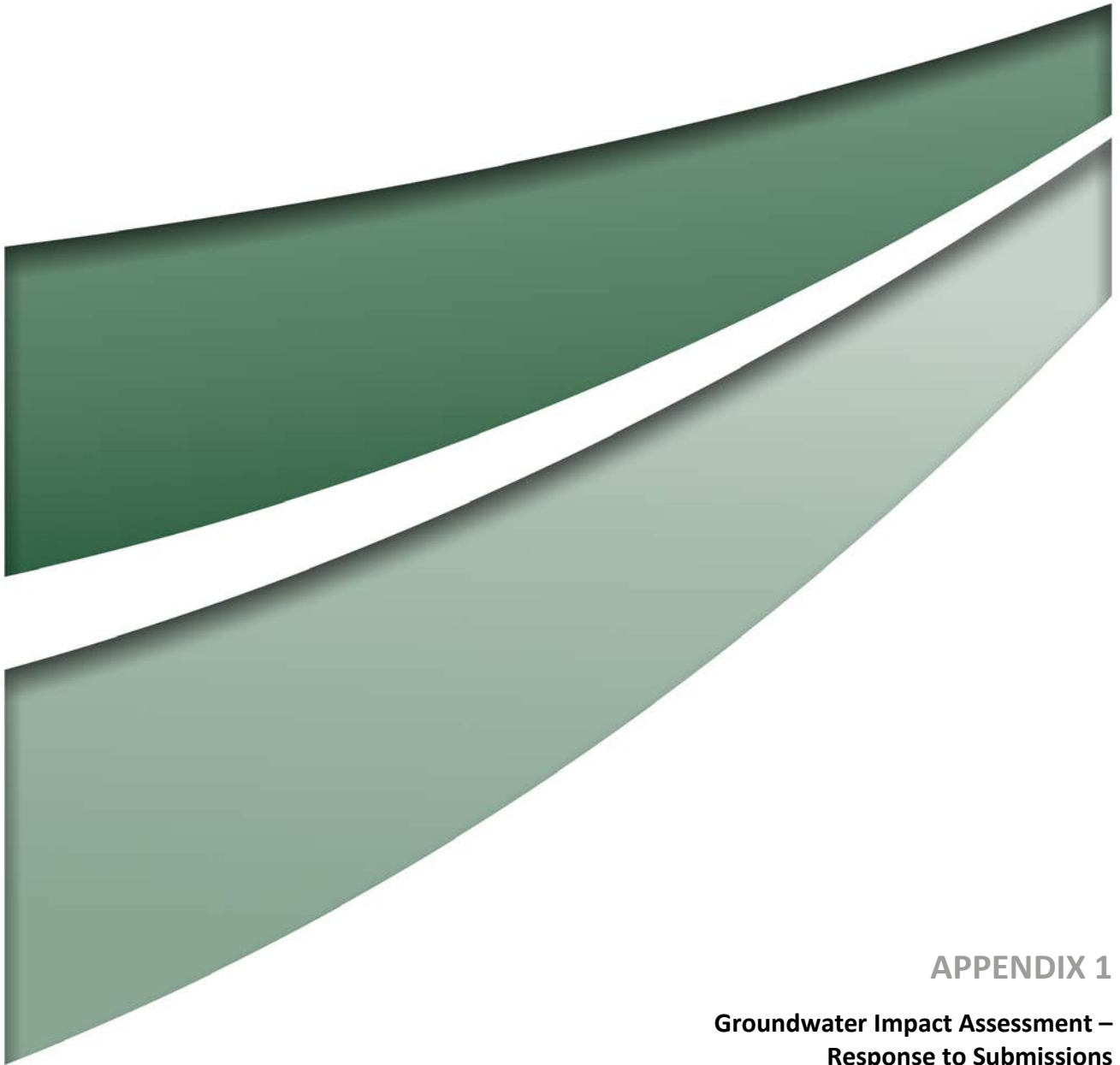
The proponent should provide detail on how potentially acid forming material is to be managed to mitigate impact to surface and groundwater sources.

Section 6.18.3.1 of the EA includes a detailed discussion of geochemical risks associated with the Project and the management measures proposed to manage these risks. These measures have already largely been implemented as part of the existing operations at Invincible and, as discussed in **Section 2.3** above, water discharged from the site is similar in quality to that observed in the Cullen Creek catchment upstream of the Invincible discharge point.

3.0 References

Australia and New Zealand Environment Conservation Council (ANZECC) (2000). *Guidelines for fresh and marine water quality*. Department of Environment and Conservation (NSW) Sydney.

NSW Department of Primary Industries (DPI)(2017). *Office of Water Real-time data portal*. (<http://realtimedata.water.nsw.gov.au/water.stm>)



APPENDIX 1

Groundwater Impact Assessment – Response to Submissions



Australasian
Groundwater
and Environmental
Consultants Pty Ltd
(AGE)



Report on

Invincible Southern Extension Groundwater Impact Assessment - Response to Submissions

Prepared for
Umwelt Pty Ltd

Project No. G1817B February 2017
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Report on

Invincible Southern Extension

Groundwater Impact Assessment – Response to Submissions

1 Introduction

Umwelt Pty Ltd (Umwelt) was engaged by Shoalhaven Coal Pty Ltd (trading as Castlereagh Coal) to manage and prepare an environmental assessment (EA) to support a Section 75W Environmental Planning and Assessment Act 1979 (EP&A Act) modification application for the Invincible Southern Extension Project. Umwelt then engaged Australasian Groundwater and Environmental Consultants Pty Ltd (AGE), as a sub-consultant, to complete the groundwater impact assessment as part of the EA. The EA was submitted to the governing authority, NSW Department of Planning and Environment (NSW DPE), and Umwelt received a series of submissions from agencies, organisations, and members of the public.

This document outlines AGE's responses to submissions from NSW Department of Primary Industries – Water (DPI Water) and the NSW Environmental Authority (NSW EPA), dated 07 November 2016 and 15 November 2016, respectively.

1.1 Objectives and scope of work

The objective of this report is to provide responses to the submissions, in the form of data and hydrogeological interpretation to support the EA. This report outlines each groundwater related comment raised by DPI Water and NSW EPA (copies of the letters are attached in Appendix A) and our response to each comment:

- DPI Water:
 - *“the proponent should provide further detail ...for the existing Ivanhoe No.2 accumulated water with respect to the 2,121 ML requiring dewatering”*
 - *“The Turon Crudine River Water Source and the Sydney Basin Murray Darling Basin Groundwater Source have limited available entitlement for purchase. This should be considered in further detail by the proponent for any entitlement requirements prior to project approval”*
 - *“The proponent should verify groundwater level and water quality for aquifers potentially impacted. This will aid in quantifying potential dewatering requirements and enable assessment of likely storage and discharge requirements”*
 - *“The proponent should clarify the potential impacts to Baal Bone Colliery operations due to the potential increase in seepage into their workings. The proponent should consult with the Baal Bone Colliery operators”.*

- NSW EPA:
 - *“there is a fundamental lack of groundwater levels in the old Ivanhoe No.2 workings and therefore the actual volume of water that needs to be removed”*
 - *“there is no assessment of the effects that the mapped regional joint sets ...may have on groundwater flow paths”*
 - *“very limited groundwater quality data was provided in the EA...”*
 - *“...data suggests that mine water appears to have significant differences in the ionic composition when compared to the surface waters”*
 - *“...the Southern Extension Project is expected to have negligible impacts on flows water quality and water users is neither substantiated nor supported”.*

2 Response to submissions

2.1 NSW DPI Water

NSW DPI - Water provided their advice to NSW DPE on 07 November 2016 (NSW DPI ref: OUT16/42016). A copy of the NSW DPI – Water letter is included in Appendix A. The comments from NSW DPI drew upon aspects of Umwelt’s submission to NSW DPE, and AGE’s groundwater impact assessment (GIA).

The NSW DPI comments are address in the following sections.

2.1.1 NSW DPI Water comment 1

DPI Water Comment, Page 1, Point 4

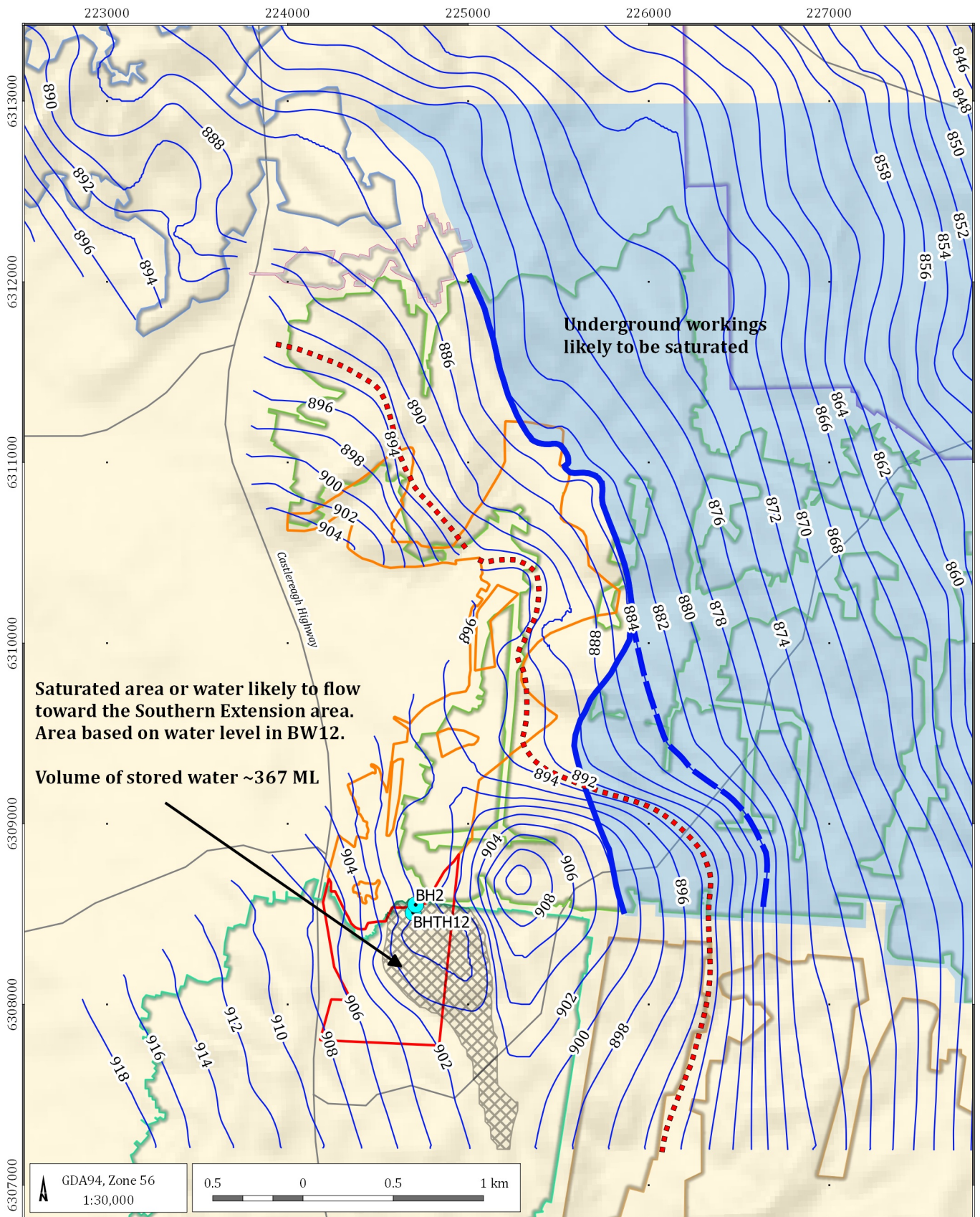
“The proponent should provide further detail of the water balance for the existing Ivanhoe No.2 accumulated water with respect to the 2,121 ML requiring dewatering. It is reported in the EA that the mine void is primarily made up of surface water flow through subsidence fractures, but this is calculated in the EA to be 7-20ML/yr which would total a potential maximum of 200 ML over a 10 year period”.

Response:

- The original calculations were based on a possible recharge from surface water infiltration (200 ML over a 10 year period) and the worst case scenario (2,121 ML of water stored in the old Ivanhoe workings with a maximum water level equal to the elevation of the mine portal). The values presented were to provide a range of volumes that may have needed management. Subsequent investigation since the EA was submitted has confirmed the water level in the former Ivanhoe No 2 Colliery underground workings and the volume of water stored there has been reviewed. The points below describe the findings of the recent work.
- Two monitoring bores were installed within the Southern Extension Project area (refer geological and bore installation logs in Appendix B), including:
 - BHTH12 was installed at an intersection of two underground roadways within the Ivanhoe No.2 Colliery to confirm the water level within the open workings; and
 - BH2 was installed in a large diameter coal quality core hole in the 40 m coal barrier between the Invincible underground and the Ivanhoe No.2 Colliery workings. This bore was installed to confirm the water level within the coal barrier.

- On 10 January 2017, the water level within the workings was slightly higher than the water level within the coal barrier to the north. The groundwater elevations were 900.8 metres above the Australian Height Datum (mAHD) (33.4 m below ground level [mbgl]) in the Ivanhoe workings (BH12) and 899.9 mAHD (31.7 mbgl) in the coal barrier (BH2). This shows that there is a decreasing gradient between the former Ivanhoe workings and the Invincible underground, which suggests that water currently seeps from the former Ivanhoe workings into the Invincible underground.
- The calculation of the volume of water stored within the former Ivanhoe No 2 Colliery underground workings located within the Southern Extension Project area was reviewed using the measured water level from BH12. The same principles used in the EA to calculate the water volume were applied again and the assumptions included:
 - The Invincible underground and the Ivanhoe No.2 Colliery workings are separated by a 20 m to 40 m thick coal seam barrier. This assessment has assumed the coal seam barrier is still intact and has not been breached during historical mining at either site.
 - The rate of groundwater seepage through the coal barrier is dependent upon the hydraulic conductivity of the coal seam and the hydraulic gradient between the flooded Ivanhoe No. 2 Colliery and the adjacent underground workings of Invincible.
 - The water level in the Ivanhoe No. 2 Colliery is constrained (refer Figure 2-1):
 - West – by the groundwater elevation within the Ivanhoe underground at BH12 (900.8 mAHD). A conservative value of 901 mAHD was used;
 - North - by the coal barrier between Ivanhoe No. 2 Colliery and the Invincible underground;
 - East – by the limit of the workings and the seam floor elevation of 901 mAHD as per the BH12 water levels; and
 - South – by groundwater divide based on the 901 mAHD seam floor elevation.
 - The underground working height is assumed to be 2 m. There is anecdotal evidence that the working height was in the order of 5 ft 7 in (~1.7 m).
 - The Project is surrounded by historic underground workings. Complete mine plans for the Ivanhoe No. 2 Colliery are not available. However, it is assumed that the underground mine void extends outside of the calculation area.
 - The underground workings are assumed to be open void spaces. This was confirmed during drilling of BH12 which intersected a void of approximately 2 m. This void coincided with the expected depths and thickness of the Ivanhoe No. 2 mine workings.
 - BH12 also intersected broken ground with complete loss of drilling return, assumed to be goaf, between 25 mbgl and 34 mbgl. Hence, the water in the Ivanhoe No. 2 Colliery is NOT constrained vertically by the working height and could extend into subsidence induced fractures. Despite this fact, the water level measured on 01 December 2016 coincided with the coal seam roof.
 - Once at a steady state, the groundwater level in the underground workings will stabilise with the discharge and recharge rates being similar, as such no allowance for seepage loss has been made.
- If these assumptions hold true, and using the BH12 water level, the former Ivanhoe No 2 Colliery underground workings within the Southern Extension Project area is likely to hold 367,000 m³ (367 ML) (refer Figure 2-1). This volume is in the same order of magnitude as the calculated recharge over 10 years, that is 200 ML (AGE 2016).

- AGE (2016) utilised an anecdotal “tide mark” in the Invincible underground workings to calculate a potential available storage volume within the underground workings and open-cut spoil. This volume totalled 1,585,000 m³ (1,585 ML), of which, 1,219,000 m³ was calculated within the underground and 366,000 m³ calculated to be within the open-cut spoil (refer Figure 2-2).
- AGE (2016) also presented a potential storage area based on a water level in the former Invincible underground of 884 m AHD. This level is correlated to drillhole information from 2012 and follows the coal seam floor contour (at 884 mAHD). A potential storage volume based on a water level at 884 m AHD is in the order of 2,111,000 m³ (2,111 ML); of which 1,745,000 m³ is calculated within the underground and 366,000 m³ calculated within the open-cut spoil (refer Figure 2-3).
- The EA outlined that the water stored in the former Ivanhoe No 2 Colliery underground workings could be drained into the dry portion of the Invincible underground workings up-gradient of the existing “tide mark” (or water level) and saturate underground workings and spoil emplaced in the Invincible open cut. The assumptions for the volume of available storage within the dry Invincible underground workings and spoil emplaced in the Invincible open cut have remained the same and the available storage above the “tide mark” is 1,585,000 m³ (1,585 ML). This volume is approximately four times the volume of water stored in the former Ivanhoe No 2 Colliery underground workings. In the case where the water from the former Ivanhoe underground is transferred to the Invincible underground, the Invincible underground water level is expected to rise, as per the previous assessment (AGE 2016); however, the water level would not rise to the point of day-lighting in the northern void of the Invincible open cut area. The inferred “maximum fill level” shown on is the predicted elevation the Invincible water level is expected to reach with the transfer of the entire volume of water stored in the former Ivanhoe underground.
- The inferred “maximum fill level” shown on Figure 2-3 is the predicted elevation that the Invincible water level is expected to reach with the transfer of the entire volume of water stored in the former Ivanhoe underground, based on a water level in the Invincible underground workings at 884m AHD. The calculated potential storage volume in the Invincible workings with a water level at 884 m AHD is approximately 5.75 times the volume of water stored in the former Ivanhoe No 2 Colliery underground workings.



LEGEND

- BHTH12
- BH2
- Lithgow Seam top of seam floor 893 mAHD
- Invincible Colliery observed "tide mark" 2014
- Invincible Colliery water level at 884mAHD
- Lithgow Seam top seam floor
- Road
- Flooded underground workings 367 ML
- Underground workings likely to be saturated
- Proposed southern extension

- Invincible Colliery Open Cut - existing mine disturbance area
- Land

Colliery locations

- Baal Bone Colliery
- Invincible Colliery
- Ivanhoe Colliery
- RT108 Colliery
- Tyldesley Colliery
- Unknown

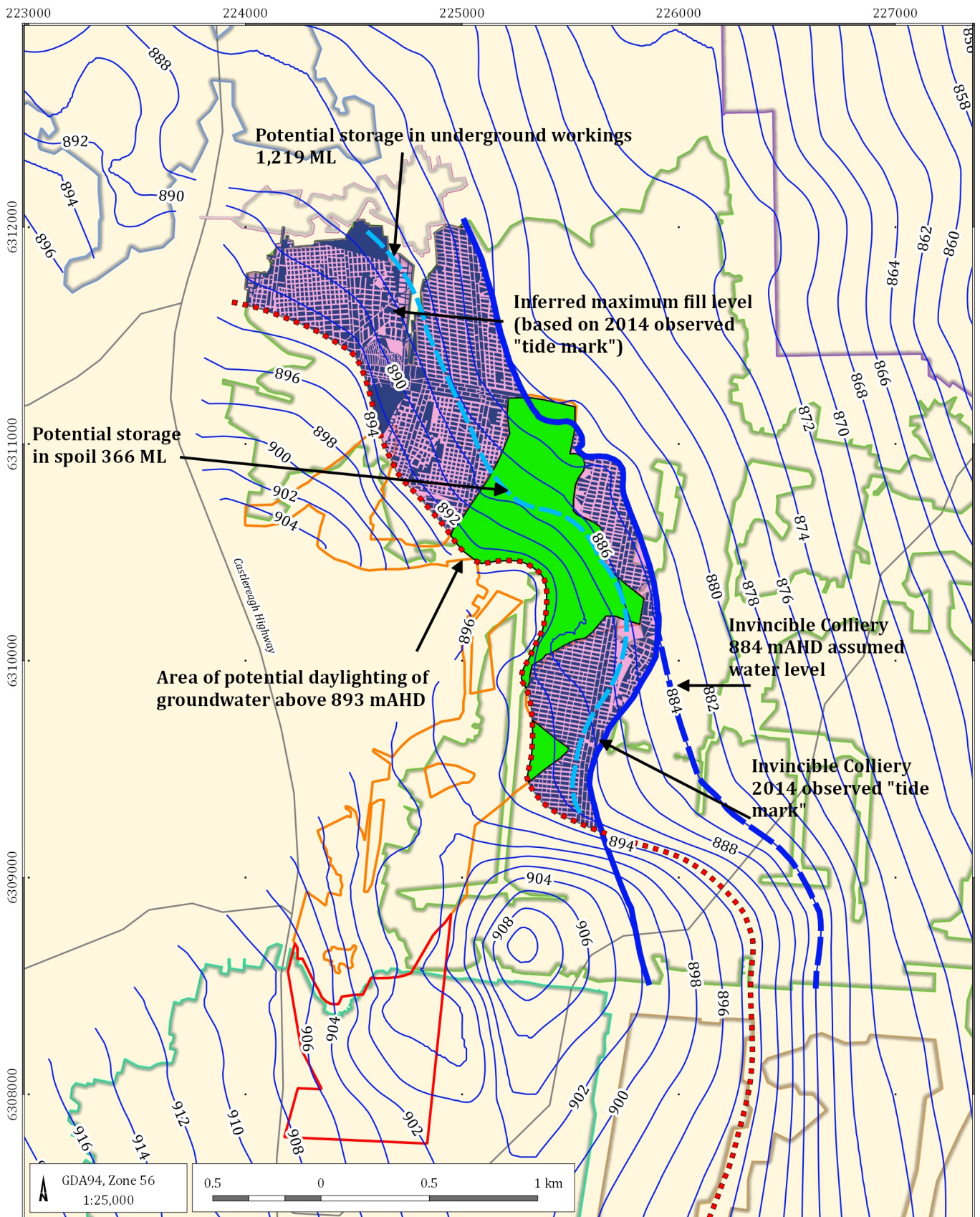
Invincible Southern Extension Project (G1817B)

Flooded workings - interpreted



DATE
15/02/2017

FIGURE No:
2-1



LEGEND

- Inferred Invincible Colliery water level from 884m AHD
- Lithgow Seam floor elevation m AHD
- Road
- Maximum water level possible before daylighting
- Proposed southern extension
- Invincible Colliery Open Cut - existing mine disturbance area
- Potential storage area 1,745 ML
- Open cut area 366 ML
- Coal pillars

- Land
- Colliery locations**
 - Baal Bone Colliery
 - Invincible Colliery
 - Ivanhoe Colliery
 - RT108 Colliery
 - Tyldesley Colliery
 - Unknown

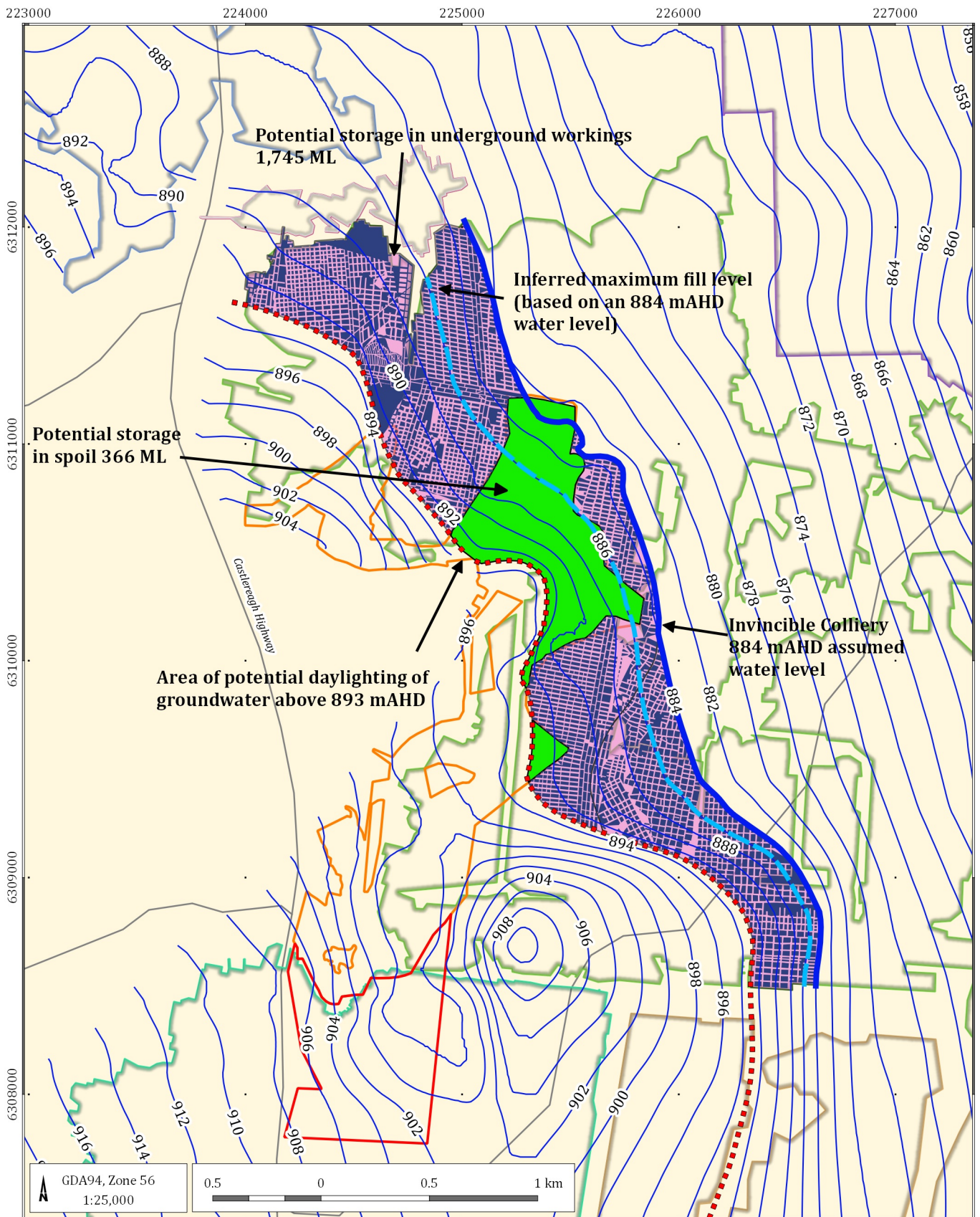
Invincible Southern Extension Project (G1817B)

Potential storage available and inferred maximum fill level (884 m AHD water level scenario)



DATE
15/02/2017

FIGURE No:
2-3



LEGEND

- | | |
|--|---|
| — Inferred Invincible Colliery water level | Land |
| — Lithgow Seam floor elevation m AHD | Colliery locations |
| — Road | Baal Bone Colliery |
| - - - Maximum water level possible before daylighting | Invincible Colliery |
| Proposed southern extension | Ivanhoe Colliery |
| Invincible Colliery Open Cut - existing mine disturbance area | RT108 Colliery |
| Potential storage area 1,745 ML | Tyldesley Colliery |
| Open cut area 366 ML | Unknown |
| Coal pillars | |

Invincible Southern Extension Project (G1817B)

Potential storage available and inferred maximum fill level (884 m AHD water level scenario)



DATE
15/02/2017

FIGURE No:
2-3

2.1.2 NSW DPI Water comment 2

DPI Water Comment, Page 1, Point 5

"The Turon Crudine River Water Source and the Sydney Basin Murray Darling Basin Groundwater Source have limited available entitlement for purchase. This should be considered in further detail by the proponent for any entitlement requirements prior to project approval."

Response:

- The estimate of water stored in the former Ivanhoe No.2 underground workings has been updated to 367 ML. This volume is less than 17% of that originally estimated.
- The water stored in the former Ivanhoe No 2 Colliery underground workings is considered to be surface water flow intercepted by subsidence fractures and the final open cut landform. Therefore, any take of this water should be treated as surface water take for the purposes of licensing requirements and not groundwater.

2.1.3 NSW DPI Water comment 3

DPI Water Comment, Page 2, Point 2

"The proponent should verify groundwater level and water quality for aquifers potentially impacted. This will aid in quantifying potential dewatering requirements and enable assessment of likely storage and discharge requirements."

Response:

- Water level:
 - The water level was verified after the installation of two new monitoring bores; one in the former Ivanhoe No 2 Colliery underground workings, and the other into the coal barrier between the Invincible underground and the Ivanhoe No.2 Colliery workings (refer Section 2.1.1).
 - The calculation of stored water was reviewed and the water stored in the former Ivanhoe No 2 Colliery underground workings can be stored in its entirety in the former Invincible Colliery underground workings. There will be no need to discharge the water currently stored in the Ivanhoe No. 2 Colliery underground workings.
- Water quality:
 - The electrical conductivity (EC) and pH of the Ivanhoe No 2 Colliery underground workings when compared to the quality of the Invincible underground water is slightly different. A summary of the January 2017 water quality results is included in Appendix D. The water from the former Ivanhoe No 2 Colliery underground workings (BH112), the East Tyldsley bore, and the Invincible open cut northern void is of comparable quality – generally with pH values of between 6.06 and 6.72 and EC values between 850 µS/cm and 1,600 µS/cm. For comparison, water of this quality is suitable for irrigation. Water from LD001, which is assumed to be representative of the Invincible underground water, was of a similar pH at 6.6; however the EC was 375 µS/cm. The difference in water quality in these areas is most likely a result of the recharge mechanism. The Ivanhoe underground, the East Tyldsley bore, and the Invincible open cut northern void are in close proximity to the water source and are more likely to be recharged directly from areas that are close to spoil and weathered rock profiles, and so are receptors of water that may have collected soluble material through contact with those media. LD001 is deep in the former Invincible underground workings and water to this point is likely recharged predominantly through subsidence fractures in fresh rock, resulting in the stored water being less saline.

It should be noted that the water quality results from BHTH12 should be considered as being qualitative, as the sample was very turbid and potentially showing signs of impact from the bore's installation.

- It is proposed that the water stored in the former Ivanhoe No 2 Colliery underground workings will be transferred in its entirety to the former Invincible Colliery underground workings via transfer to the Invincible open cut void where it is expected migrate down dip to the Northern Void which is hydraulically connected to the Invincible underground workings. As such, there will be no discharge of water from the underground workings and water quality of stored water in the two underground mines is of similar quality.
- Review of rock geochemistry has shown that the coal from Lithgow seam in parts of the project area is slightly acidic (RGS, 2011). This coal acidity is reflected in the BHTH12 and BH2 groundwater analysis and the pH values are 6.06 and 4.41, respectively. A summary of the January 2017 water analysis results is attached in Appendix C. That said, no water is currently expected to need to be discharged and the significantly larger volume of water in the Invincible underground workings is likely to have a dilution effect.

2.1.4 NSW DPI Water comment 4

DPI Water Comment, Page 2, Point 2

"The proponent should clarify the potential impacts to Baal Bone Colliery operations due to the potential increase in seepage into their workings. The proponent should consult with the Baal Bone Colliery operators"

Response:

- In the case that the water from the former Ivanhoe No 2 Colliery underground workings is transferred to the Invincible Colliery underground workings (refer Section 2.1.1), the increase in head is likely to be considerably less than initially estimated. The head is likely to increase by between 1 m and 2 m, which is considerably less than the 9 m previously assumed.
- AGE (2014) suggested that the potential seepage rate from the Invincible underground to Baal Bone Colliery could increase by up to 30% if the former Invincible underground was filled to capacity. The updated volume of water that may be transferred to the former Invincible underground is approximately 17% of that originally estimated. On this basis, it is likely the seepage rate will only increase by approximately 5%, to a rate in the order of 105 ML/year – 315 ML/year; which is an increase of 5 ML/year – 15 ML/year. Considering Baal Bone Colliery has historically dewatered at a rate of 1,300 ML/year, this change in seepage from the former Invincible underground is minor.
- Nonetheless, Castlereagh Coal will attempt to enter into consultation with the operators of Baal Bone Colliery, upon approval of the Southern Extension Project.

2.2 NSW EPA

NSW EPA provided their advice to NSW DPE on 15 November 2016 (NSW EPA ref: EF158840; DOC16/4844044-01). A copy of the NSW EPA letter is included in Appendix A. The comments from NSW EPA drew upon aspects of Umwelt submission to NSW DPE and AGE's groundwater impact assessment (GIA).

The comments are address in the following sections.

2.2.1 NSW EPA comment 1

NSW EPA Comment, Page 2, Point 3

"There is a lack of fundamental data on groundwater levels in the old Ivanhoe No.2 workings and therefore the actual volume of water that needs to be removed."

Response:

- The water level in the former Ivanhoe No 2 Colliery underground workings was verified after the installation of two monitoring bores; one in the former Ivanhoe No 2 Colliery underground workings, and the other into the coal barrier between the Invincible underground and the Ivanhoe No.2 Colliery workings (refer Section 2.1.1).
- The previous calculations of the water potentially stored in the Ivanhoe workings were a volume based on potential recharge from surface water seepage and a worst case scenario of the Ivanhoe workings being flooded to a level at the mine portal.
- The calculation of stored water was reviewed based on the water level observed in BHTH12 and the water stored in the former Ivanhoe No 2 Colliery underground workings is approximately 17% of the volume initially estimated. The volume of water that will need to be removed from the Ivanhoe workings as part of the Southern Extension Project is in the order of 367 ML.
- It is proposed that the water stored in the former Ivanhoe No 2 Colliery underground workings will be transferred in its entirety to the former Invincible Colliery underground workings. As such, there will be no discharge of water from the underground workings and water quality of stored water in the two underground mines is of similar quality.

2.2.2 NSW EPA comment 2

NSW EPA Comment, Page 2, Point 5

"there is no assessment of the effects that the mapped regional joint sets ...may have on groundwater flow paths."

Response:

- Underground coal mining at Invincible took place between 1901 and 1998 and open cut operations occurred throughout the 2000's. The project area and surrounds have been highly modified by mining and as a result the hydrogeological regime has been equally modified.
- The main coal extraction methodology in the project area and surrounds was bord and pillar. Bord and pillar extraction mines extend in a radius of more than 3 km from the Southern Extension area. As a result, subsidence impacts, goaf areas, and open road ways are the dominant groundwater flow pathways. Whilst a regional joint set may be a groundwater flow path and in an undisturbed setting may contribute to groundwater recharge, the mine workings are by far the more dominant flow pathway and recharge mechanism.

2.2.3 NSW EPA comment 3

NSW EPA Comment, Page 2, Point 3

"very limited groundwater quality data was provided in the EA and none was provided for the potentially flooded Ivanhoe No.2 workings."

Response:

- The quality of the water from BHTH12, screened within the former Ivanhoe No 2 Colliery underground workings, is not dissimilar to the old Tyldsley Colliery bore, and the Invincible open cut northern void (refer Section 2.1.3). These three areas share similar recharge mechanisms being close to spoil and weathered rock profiles, and more likely to contain salt mobilised from the same.
- The analysis of water from BHTH12 shows the water to have a pH of 6.06 (refer Appendix D), which is within the range suggested by ANZECC (2000) for pumping, irrigation and stock watering systems. The sample had an EC of 1,600 $\mu\text{S}/\text{cm}$ (900 mg/L salinity) (refer Appendix D), which is generally suitable for irrigation of moderately sensitive crops and above.
- Dissolved metals concentrations are below the ANZECC (2000) guidelines for irrigation (refer Appendix D).
- The sodium concentration in BHTH12 (January 2017) is above the ANZECC (2000) suggested limit for sodium in irrigation water.
- Figure 2-4 plots the cation and anion ratios of samples from the project area from December 2016 and January 2017. Comments regarding the cation / anion ratios are as follows:
 - Each sample plots in the same location between the two sampling events, with the exception of BHTH12. The sample from BHTH12 may have still been impacted by the installation of the bore.
 - BSW01 and BSW02 are upstream and downstream surface water sample locations, respectively. These two locations are considered the "baseline" for water entering the project area and downstream of the project area. BSW01 and BSW02 are of a similar generic water type with minor sulphate dominance. This is likely due to some moderate contact with weathered rock at the surface, and potentially spoil material.
 - Water from the former Ivanhoe No 2 Colliery underground workings (BHTH12 and BH2), the old Tyldsley Colliery bore and the Invincible open cut northern void are of similar ionic composition. These samples are of a generic water type with a strong sulphate component. This is likely a result of proximity to and sourcing from spoil and weathered rock.
 - Water from LD001 (deep in the former Invincible underground) has a dominant carbonate component. This is likely due to the storage time of the water in the underground workings and recharge from surface water across fresh rock.

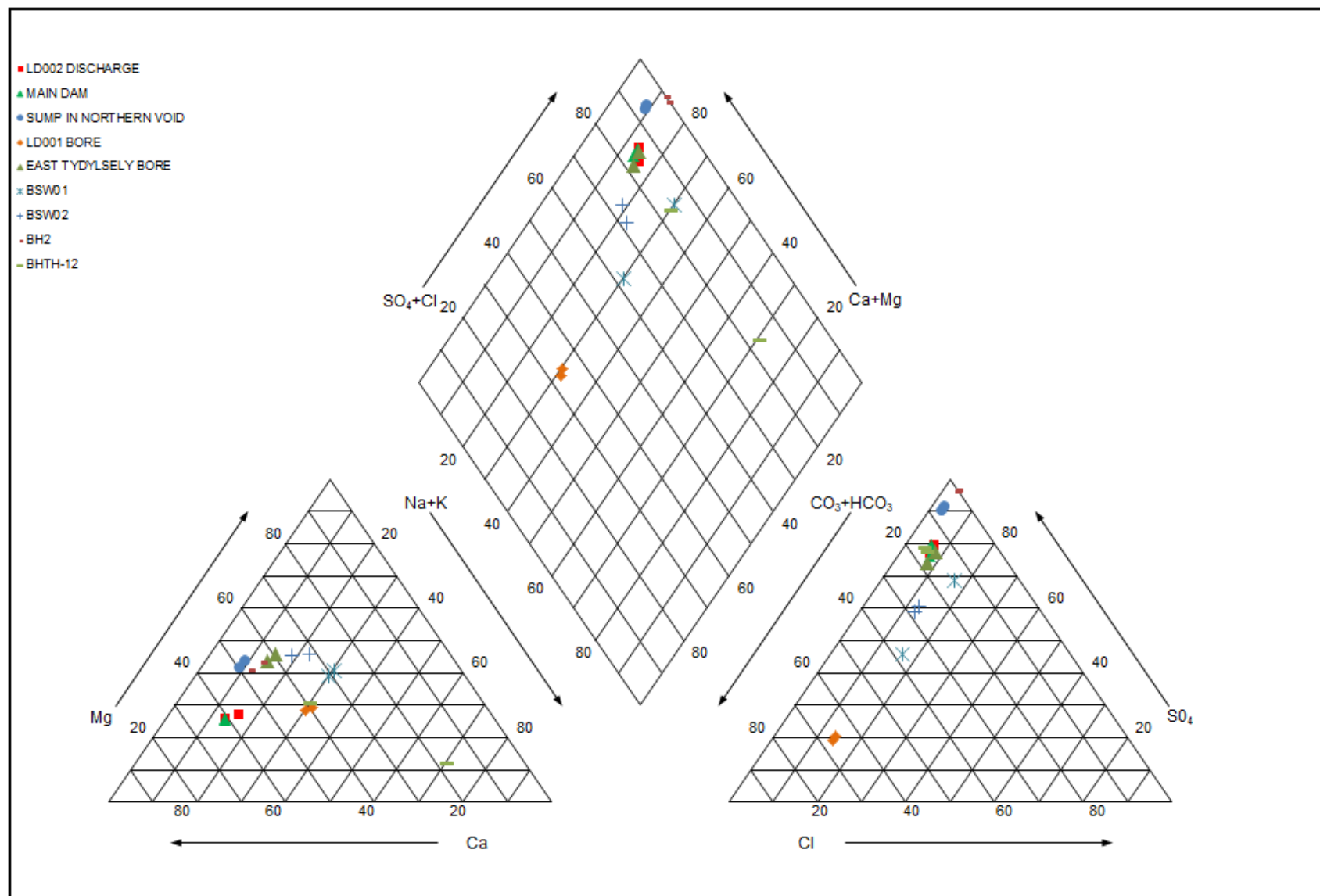


Figure 2-4 Piper plot of cation / anion ratios – December 2016 and January 2017

2.2.4 NSW EPA comment 4

NSW EPA Comment, Page 2, Point 3

"The available groundwater data suggests that mine water appears to have significant differences in the ionic composition when compared to the surface waters. The mine water is also likely to be high in Nickel and Zinc, and on occasion, other contaminants. This suggests that any groundwater that is pumped from underground workings will need to be treated before discharge."

Response:

- The review of the volume of water stored in the former Ivanhoe No 2 Colliery underground workings shows that the water stored in the Ivanhoe workings can be stored in its entirety in the former Invincible Colliery underground workings without the need to neither treat nor discharge excess water (refer Sections 2.1.1, 2.1.3 and 2.2.3 for comments regarding water quality).

2.2.5 NSW EPA comment 5

NSW EPA Comment, Page 2, Point 3

"...the Southern Extension Project is expected to have negligible impacts on flows water quality and water users is neither substantiated nor supported."

Response:

- The objective of this exercise was to review the impacts of the Southern Extension Project. This project is a small modification within a previously approved project.
- Historic mining has previously completely depressurised and dewatered the coal seams and overburden in the project area and surrounds.
- The water within the former Ivanhoe No.2 underground workings is an isolated "pocket" constrained by the geological structure of the coal seam floor and abandoned mine workings. The source of this water is the incidental interception of surface water run-off by subsidence fractures and open cut spoil. The removal of this water will not likely change the regional or the local hydrogeological recharge mechanisms. Also, the proximity of the southern extension to the coal seam outcrop / subcrop suggests that the area is likely to contributing minimally to the regional scale groundwater system.
- The proposed mining will not cause further depressurisation of the coal seam nor the overburden within the project area and surrounds, as both have been historically depressurised and dewatered.

3 Conclusion

AGE has provided data and comment in reply to NSW DPI Water and NSW EPA comments in this document. Relevant key points are:

- The volume estimate of water stored in the former Ivanhoe No. 2 Colliery underground have been revised based on site investigations and data. The revised volume is 367 ML, which is 17% of the original estimated volume. It is also likely to be an isolated pocket of water constrained by the local geology and mine workings and there appears to be a hydraulic gradient from the Southern Extension area toward the former Invincible underground area.
- AGE (2016) estimated that there was at least 1,585 ML of available storage available in the unsaturated areas of the former Invincible underground. The entire revised volume of water can be moved in its entirety to the former Invincible underground without needing to neither treat nor discharge water.
- The transfer of water to the former Invincible underground will likely raise the water head in the Invincible underground, leading to a potential increase in seepage to Baal Bone Colliery. The revised estimate of increased seepage to Baal Bone compared to the 2016 estimate by AGE is in the order of 5% and relatively minor in contrast to the volumes historically dewatered by the Baal Bone colliery annually.
- The project area and surrounds has been highly impacted by both underground and open cut mining operations. As a result the groundwater regime and groundwater and surface water quality is potentially very different to areas not impacted by mining. The proposed mining of the Southern Extension will not cause further depressurisation of the coal seam nor the overburden within the project area and surrounds, as both have been historically completely depressurised and dewatered.
- The quality of the water stored in the former Ivanhoe No. 2 Colliery underground is of similar quality to the water in the East Tyldsley bore and the Invincible open cut northern void. The water is also of a similar ionic composition to the surface water samples. These results show that the water from the former Ivanhoe underground, East Tyldsley bore, Invincible open cut northern void, and surface water sample have been in contact or are sources from areas close to the coal seam outcrop / subcrop, spoil / rehab areas, weathered geological profile and / or areas heavily impacted by subsidence fracturing. The water quality of the deeper part of the former Invincible underground is of a different ionic composition to the other water sources and is likely to be sourcing it water from subsidence fractures in fresh rock. The residence time of the water in the former Invincible underground is potentially longer with minimal evapotranspiration.
- Water in the former Ivanhoe No. 2 Colliery underground is predominantly sourced from surface water intercepted by subsidence fractures and spoil. Accordingly, the water in the Ivanhoe No. 2 workings to be dewatered should be treated as surface water for the purposes of any licensing considerations.

4 References

Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) and the Australian and New Zealand Environment and Conservation Council (ANZECC), (2000). *"Australian Water Quality Guidelines for Fresh and Marine Waters – Volume 1"*. October 2000.

Australasian Groundwater and Environmental Consultants Pty Ltd, (2014), *"Groundwater Impact Study – Invincible Colliery and Cullen Valley Mine Modification"*, Prepared for Hansen Bailey Pty Ltd, Project No. G1515, February 2014.

Australasian Groundwater and Environmental Consultants Pty Ltd, (2016), *"Invincible Southern Extension Project – Groundwater Impact Assessment"*, Prepared for Umwelt Pty Ltd, Project No. G1817, September 2016.

NSW Government, (2011), *"Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2011"*, Current version for 15 February 2013 to date (accessed 22 June 2016).

NSW Government, (2012), *"Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources 2012"*, Current version 08 July 2016.

RGS Environmental, (2011), *"Geochemical Assessment of Overburden and Potential Coal Reject Materials – Coalpac Consolidation Project"*, Prepared for Hansen Bailey Pty Ltd.

Appendix A

Regulator letter / comments - NSW DPI and NSW EPA



Department of Primary Industries

OUT16/42016

Mr Paul Freeman
Resource Assessments
NSW Department of Planning and Environment
GPO Box 39
SYDNEY NSW 2001

Paul.freeman@planning.nsw.gov.au

Dear Mr Freeman

DPI response to request for comment on proposed Modification to Invincible Coal Mine (MP 07_0127 MOD 5)

I refer to your email of 23 September 2016 to the Department of Primary Industries (DPI) in respect to the above matter. Comment has been sought from relevant divisions of DPI. Views were also sought from NSW Department of Industry - Lands that are now a division of the broader Department and no longer within NSW DPI. Any further referrals to DPI can be sent by email to landuse.enquiries@dpi.nsw.gov.au.

DPI has reviewed the application and provides the following comments and recommendations:

- The proponent should consult with the Department of Industry – Lands regarding possible synergies in bush fire management between the Invincible Coal Mine Biodiversity Offset Area and adjacent Crown land Lot 7314 DP 1142023.
- The existing and proposed surface water management should be reviewed to achieve the objective of separating clean and dirty water runoff as set out in the previous project approval and water management plan for the Invincible mine.
- The proponent should quantify existing and proposed water take from each surface and groundwater source and how this is managed at the site in terms of storage, transfer and use. This is to enable further advice to be provided on licensing requirements and for assessment of potential impacts. The current water balance is limited to concepts.
- The proponent should provide further detail of the water balance for the existing Ivanhoe No.2 accumulated water with respect to the 2,121ML requiring dewatering. It is reported in the EA that the mine void is primarily made up of surface water flow through subsidence fractures, but this is calculated in the EA to be 7-20ML/yr which would total a potential maximum of 200ML over a 10 year period.
- The Turon Crudine River Water Source and the Sydney Basin Murray Darling Basin Groundwater Source have limited available entitlement for purchase. This should be considered in further detail by the proponent for any entitlement requirements prior to project approval.

- The proponent should provide further detail of the applicability of Maximum Harvestable Rights Dam Capacity to the dams and proposed licensing for the site.
- The proponent should verify groundwater level and water quality for aquifers potentially impacted. This will aid in quantifying potential dewatering requirements and enable assessment of likely storage and discharge requirements.
- The proponent should clarify whether the flood assessment has considered the proposed discharge of water from the underground workings.
- The proponent should assess whether the proposed discharge for potentially 93 days in 1 year at 22.8ML/d (26% bankfull flow) will impact the downstream riparian environment. The proponent should consider the need for monitoring and mitigating measures or alternate flow release regimes if necessary.
- The proponent should clarify the potential impacts to Baal Bone Colliery operations due to the potential increase in seepage into their workings. The proponent should consult with the Baal Bone Colliery operators.
- The proponent should provide detail on how potentially acid forming material is to be managed to mitigate impact to surface and groundwater sources.
- In the event approval is granted for the modification the proponent should:
 - o Develop a groundwater monitoring plan in consultation with DPI Water for the monitoring and management of groundwater associated with the Invincible spoil material, Invincible Underground, Ivanhoe No.2 underground, depressurisation of the coal seam aquifers, and water quality management, as outlined in Section 8.0 of Appendix 5 of the EA. This should include the installation of water level loggers in all bores.
 - o Update the existing Water Management Plan in consultation with DPI Water. Including development of an adequate Trigger Action and Response Plan.
 - o Ensure development of a stabilised surface water management system in the final landform, consistent with the DPI Water [Guidelines for Controlled Activities on Waterfront Land](#).
 - o Install automatic measuring devices at all monitoring bores.

Yours sincerely



Mitchell Isaacs
Director, Planning Policy & Assessment Advice
 7 November 2016

DPI appreciates your help to improve our advice to you. Please complete this three minute survey about the advice we have provided to you, here:

<https://goo.gl/o8TXWz>



Your reference :
Our reference : EF15/8840; DOC16/484044-01
Contact : Mr Allan Adams; (02) 6332 7610

Mr Paul Freeman
Team Leader, Resource Assessments
NSW Department of Planning & Environment
GPO Box 39
Sydney NSW 2001

15 November 2016

Dear Mr Freeman

I refer to your email dated 23 September 2016 requesting comments and recommendations from the Environment Protection Authority (EPA) for the Invincible Coal Mine – Southern Extension Project. The proponent (Shoalhaven Pty Limited, T/A Castlereagh Coal) is seeking to modify the existing consent to permit the extraction of up to 1.2 million tonnes of run-of-mine (ROM) coal annually for up to 8 years.

The EPA has reviewed the Invincible *Southern Extension Project – Environmental Assessment* (EA) and is not in a position to provide its preferred operating conditions at this stage as the review has revealed several major limitations with particular reference to the water components of the project.

The EPA provides the following key comments below with specific reference to noise and water. Detailed comments on water are provided in Attachment 1.

Noise

The EPA notes that project noise impacts presented in the Noise Impact Assessment (NIA) were undertaken in accordance with the NSW Environment Protection Authority (EPA) *Draft Industrial Noise Guideline* (draft Guideline).

The *Draft Industrial Noise Guideline* is not current Government policy. The EPA advises that until further notice all noise assessments should be undertaken by referring to the NSW EPA *Industrial Noise Policy* (INP). The EPA does however note that the modification application is not seeking to change the existing noise criteria, and will meet the existing noise criteria determined under the INP.

With reference to the potential for the generation of low frequency noise, Section 6.1.1 of the EIA states that “application of modification factors, including low frequency noise was not deemed necessary on review of modelling outputs with reference to the procedure of the draft *Guideline*. While as previously indicated the draft Guideline is not appropriate for NIA, on the basis that the existing approval noise criteria were developed in accordance with the INP, and that the proposed project is not seeking to modify the existing noise criteria, the EPA has determined that the assessment against the draft guideline is for information only.

Licence Conditions to Apply

The EPA reiterates that the noise limits in the current version of the Environment Protection Licence 1095 (EPL 1095) for the premises must not exceed:

- a) 40dB(A) LAeq(15 minute) during the day (7 am to 6 pm); and

- b) 35dB(A) LAeq(15 minute) at all other times except as expressly provided by this licence.

Water

The primary water issues identified for the Invincible proposal in this review are:

- There has been an inadequate characterisation of the receiving water quality in the Cullen Ck catchment.
- There is a lack of consideration of potential changes to sediment and nutrient runoff processes as a result of the proposal.
- There is a lack of fundamental data on ground water levels in the old Ivanhoe No. 2 workings and therefore the actual volume of water that needs to be removed. This is considered to be a major deficiency in the current EA, one which should have been addressed prior to the public exhibition of the EA.
- Assumptions used to estimate the volume of mine water to be removed do not allow for the sinkholes that occur in the Cullen Ck tributary upstream of the current open pit area and the potential additional surface inflows into the mine workings from the upstream catchment.
- There is no assessment of the effects that mapped regional joint sets in this area may have on groundwater flow pathways.
- Very limited groundwater quality data was provided in the EA and none was provided for the (potentially flooded) Ivanhoe No. 2 workings.
- The available groundwater quality data suggests that the mine water appears to have significant differences in the ionic composition when compared to surface waters. The mine water is also likely to be high in Nickel and Zinc and, on occasion, other contaminants. This suggests that any groundwater that is pumped from underground workings will need to be treated prior to discharge.
- The subjective opinion that *"the Southern Extension Project is expected to have negligible impacts on flows, water quality and water users"* is neither substantiated nor supported.
- There has been no investigation of the aquatic ecology in the receiving environment (Cullen Ck catchment).
- Insufficient details of the WMS and Water Balance are provided in the EA to test the veracity of conclusions that it is capable of containing all dirty water on-site; or that the WMS will ensure that any discharges that do take place will be of an appropriate quality.
- There is insufficient evidence presented that the pollutants that will be discharged from the site will NOT pose a risk of harm to the environment.

Licence Conditions to Apply

In the absence of appropriate water quality data for mine water and the receiving environment, the EPA recommended licence discharge quality limits are;

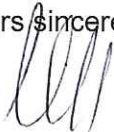
- a) the trigger values detailed under ANZECC (2000) for 95% species protection, in line with the NSW policy that the level of protection applied to most waterways is for slightly to moderately disturbed ecosystems (DEC 2006).
- b) for other potential contaminants, the recommended licence limits should ideally be based on the ANZECC (2000) default trigger values for NSW upland rivers.

If the proponent wishes to argue for the use of different default trigger values/Licence limits, then the proponent needs to implement a comprehensive surface water monitoring program and calculate Local Water Quality Criteria using the methodology recommended by ANZECC (2000). For slightly to moderately disturbed ecosystems (Condition 2), ANZECC (2000) recommends:

*Define trigger values for physical and chemical stressors for condition 2 ecosystems, in terms of the 80th and/or 20th percentile values obtained **from appropriate reference system.***

Should you have any further enquiries in relation to this matter please contact Mr Allan Adams at the Central West (Bathurst) Office of the EPA by telephoning (02) 6332 7610.

Yours sincerely



DARRYL CLIFT
Head Central West Unit
Environment Protection Authority

ATTACHMENT 1

The Catchment Upstream of Invincible Colliery where Open-Cut Mining is Proposed

Invincible Mine is located within the catchment of Cullen Creek, a tributary in the upper reaches of the Turon River. On a regional scale, Invincible open cut and Southern Extension Area are located in the headwaters of the Turon River catchment within the broader Burrendong Catchment Area. Burrendong Dam⁷ is located near Wellington, approximately 100 kilometres north-west of Invincible. Regional drainage flows in a northerly direction along the Turon River, then westerly into the Macquarie River (and Burrendong Dam) – see Figure 1.

The topography surrounding the Southern Extension Project area is generally characterised by steep forested slopes and escarpments within the Ben Bullen State Forest to the north, east and south and the Castlereagh Highway running along the western boundary. Sandstone cliff lines and pagoda formations are key landscape features of the terrain to the north and east of Invincible. Elevations within the Southern Extension Project area range from approximately 912 metres above the Australian height datum (mAHD) in the north to approximately 997 mAHD in the east. The terrain to the east of the Southern Extension Project area rises to over 1,050 mAHD. The Cullen Valley lies to the west of Invincible and topography falls toward an elevation of approximately 840 mAHD within the valley (AGE 2016).



Figure 1. Cullen Creek Catchment. Source: Umwelt (2016b).

On a local scale, both the existing Invincible open cut and the Southern Extension Area lie entirely within the upper catchment of Cullen Creek. Cullen Creek, and its tributaries are largely ephemeral watercourses in this area. A 3rd Order (based on the Strahler stream ordering system) tributary to Cullen Creek flows through the mine site, although it has been extensively modified. This 3rd order tributary crosses under the Castlereagh Highway to join Cullen Creek which is a fourth order watercourse. Cullen Creek flows in a north-westerly direction before joining Dulhunty's Creek approximately 4 kilometres downstream of Invincible, which in turn joins Williwa Creek before

⁷ The main purpose of Burrendong Dam is to supply irrigation, stock and household needs in the Macquarie Valley, and environmental flows to the Macquarie Marshes.

<http://www.watersnsw.com.au/supply/visit/burrendong-dam>

flowing into the Turon River. Williwa Creek's confluence with the Turon River is approximately 25 kilometres downstream of Invincible Mine (Umwelt 2016b).

Umwelt (2016b) suggested that:

- *The Cullen Creek catchment is approximately 1725 hectares in area;*
- *The existing Invincible open cut workings intersect a number of 1st, 2nd and 3rd order tributaries of Cullen Creek with runoff from the catchment areas of these tributaries captured within the Invincible Water Management System (WMS); and*
- *The existing Invincible Water Management System (WMS) encompasses an area of approximately 37 per cent of the pre mining catchment area of Cullen Creek.*

This implies that the catchment for the WMS covers approximately 638 Ha. Of this the southern extension area occupies approximately 50 Ha, however, the contributing catchment surrounding and including the southern extension area is estimated to be around 100 Ha in size.

Significant portions of the Southern Extension Area are affected by pre-existing surface cracking from underground bord and pillar mining in the abandoned Ivanhoe No.2 underground workings. Much of the surface water runoff from the Southern Extension Area does not report to downstream surface water management structures, instead entering a large sinkhole and fractures in the drainage lines and reporting directly to the abandoned Ivanhoe underground workings (Umwelt 2016b). At least two sinkholes appear in the Cullen Ck tributary upstream of the current open pit area (see Figure 2). Approximately 67 Ha of the upper Cullen Ck catchment is estimated to drain to the major sinkhole in this area (see Figure 3).



Figure 2. Cullen Ck Tributary upstream of open cut areas ("sinkholes" top left and top right; natural drainage line bottom).



Figure 3. Invincible Southern Extension Area (orange polygon) and upper Cullen Ck catchment potentially contributing to the major sink hole (blue polygon). Included are streams and stream order above Springvale Mine (Pink=3rd order; Red=4th order; Brown=5th order; Blue =2nd and 1st order). Black lines represent lineaments and green lines regional joint sets mapped by Shepherd and Huntingdon (1981). Source: Shepherd and Huntingdon (1981), Spot satellite imagery and DWE stream layer.

The Quality of Surface Water in the Upstream Catchment

Very limited surface water quality data is presented in the EA, particularly for the catchment upstream of Invincible Mine and the Southern Extension Area. The EA identified that:

Surface water quality monitoring is undertaken at two locations downstream of Invincible on Cullen Creek. BSW01 is located immediately downstream of the southern portion of Invincible and BSW02 is located approximately 3 kilometres further downstream (refer to Figure 2.1). The surface water quality monitoring program commenced in October 2011.

Results of this sampling for BSW01 are summarised in Table 1 and site locations are illustrated in Figure 4. BSW02 is located on Dulhuntys Ck approximately 3.5km downstream of the mine site.

Average annual surface water quality monitoring results, as reported in the AEMRs for the two monitoring locations is presented in Tables 2.2 and 2.3.

Table 2.2 Average Annual Surface Water Quality Monitoring Results – BWS01

Year	pH	TSS (mg/L)	Oil & Grease (mg/L)	Electrical Conductivity (µS/cm)
2011	6.6	21	<2	
2012	6.5	16.8	<5	
2013	6.8		<5	660
2014	4.6		<5	432
2015	7.0	18.9	<2	

Source: Coalpac AEMRs

Table 1. Average Annual Surface Water Quality results. Source: Umwelt (2016).



Figure 4. Invincible Mine monitoring sites.

The EA (Umwelt 2016b) stated:

It is considered that, based on the water quality recorded for Cullen Creek, that the water quality in Cullen Creek is typical of the ANZECC default trigger values for NSW lowland rivers.

This is incorrect. ANZECC (2000) clearly defines Upland Streams as those at >150m altitude. As AGE (2016) identified: *Elevations within the Southern Extension Project area range from approximately 912 metres above the Australian height datum (mAHD) in the north to approximately 997 mAHD in the east.* The 3rd order Tributary to Cullen Creek in the vicinity of the Southern Extension Area is quite clearly an *Upland Stream* under the ANZECC (2000) definition.

The ANZECC (2000) guidelines acknowledge that different levels of protection may be appropriate for different water bodies. The guidelines specify three levels of protection, from stringent to flexible, corresponding to whether the condition of the particular ecosystem is:

- of high conservation value
- slightly to moderately disturbed, or
- highly disturbed.

The policy in NSW is that the level of protection applied to most waterways is the one suggested for slightly to moderately disturbed ecosystems (DEC 2006). In the absence of appropriate local water quality data, the Assessment of water quality for the EA should have been undertaken using ANZECC (2000) default trigger values for NSW upland rivers (based on altitude). If the Proponent wishes to argue for the use of different default trigger values, then they need to implement a comprehensive surface water monitoring program and calculate Local Water Quality Criteria using the methodology recommended by ANZECC (2000).

ANZECC (2000) recommended that for slightly to moderately disturbed ecosystems (Condition 2):

Define trigger values for physical and chemical stressors for condition 2 ecosystems, in terms of the 80th and/or 20th percentile values obtained from appropriate reference system.

In terms of local water quality data that is available, the EA presented data on two sites (BSW01 and BSW02). Site BSW01 is on Cullen Ck, but downstream of previous rehabilitated open-cut areas for the Cullen Main West mine. It is unclear what effect rehabilitated open-cut areas for the Cullen Main West mine have on water quality at BSW01. In addition, only a very limited number of analytes (pH, TSS and EC) have actually been reported at BSW01. There is insufficient data to provide a proper characterisation of background water quality for the Project Area or the receiving waters for the proposed discharge. There is also insufficient data to calculate *local water quality criteria*.

An additional factor with the proposal is that the upstream catchment currently consists of native forested land which the Proponent is proposing to modify with open cut mining (and later land contouring). It is well known that changing landuse and landform in such situations leads to major alterations in the sediment and nutrient runoff processes and delivery to the downstream catchment (Harris 2001, Bartley et al 2012). Pristine, forested catchments export relatively little nitrogen and phosphorus and the predominant form of nitrogen is dissolved organic nitrogen. As catchments are cleared, exports increase and the predominant form of nitrogen changes from dissolved organic nitrogen to dissolved inorganic nitrogen (Harris 2001). The EA does not address the potential increase in sediment and nutrient loads to the downstream catchment from this area, an effect likely to continue for significant time periods after mining (e.g. see Figure 5). This is considered a deficiency in the information provided and in the assessment of potential environmental impacts on the downstream environment.



Figure 5. Existing vegetation (top left) and rehabilitated areas: Invincible Rehabilitation planted in 2008 (top right); planted in 2011 (bottom left); and planted in 2012 (foreground). Source: OEH (top left photo) and Umwelt (2016a; other photos).

An inadequate characterisation of water quality in the Cullen Ck catchment is presented in the EA with very limited water quality data available to calculate 80th/20th percentiles for the determination of Local Water Quality Criteria, as recommended by ANZECC (2000). The EA is considered to be deficient in its understanding and presentation of local water quality data. There is also a lack of consideration of (or proposed amelioration of) potential changes to sediment and nutrient runoff processes.

The Volume of Water Potentially Moving Down Sinkholes in the 3rd Order Tributary to Cullen Ck, upstream of the Current Open Cut Area

Umwelt (2016) stated that significant portions of the catchments draining the Invincible site are affected by pre-existing subsidence from underground bord and pillar mining in the abandoned underground Ivanhoe Colliery workings. Large sinkholes are evident along drainage lines in this portion of the catchment and it is expected that a substantial portion of surface water runoff which drains through these subsidence affected areas does not report to downstream surface water management structures, and instead enters the sinkholes and reports directly to the abandoned underground workings. As identified earlier, approximately 67 Ha of the upper Cullen Ck catchment was estimated to drain to these sinkholes (see Figure 2, 3 & 4 above). There are no rainfall-runoff calculations provided in the EA for the upper Cullen Ck catchment draining to the sinkholes and therefore there appears to be no allowance for catchment runoff contributions or recharge to the potentially flooded Ivanhoe No 2 workings from this source.

Using a daily step rainfall-runoff model, the median annual runoff for the nearby Ben Bullen Ck catchment⁸ upstream of Baal Bone Colliery (just to the north of Invincible) was estimated at approximately 1.33 ML/Ha (AECOM 2009). Whilst this number obviously needs to be verified for the upper Cullen Ck catchment, it suggests that catchment runoff to the sinkhole could be of the order of 89 ML/year. Most of this runoff appears likely to flow into the sinkhole and therefore into the Ivanhoe No 2 underground workings.

The lack of any estimate of catchment runoff from the upstream catchment area and its potential impact on the mine water balance is considered to be a significant deficiency in the exhibited EA.

The Volume and Quality of Groundwater in Invincible Underground Workings and (potentially flooded) Ivanhoe No 2 workings

Groundwater Volume

The groundwater aquifers in the vicinity of the proposed mining appear to be highly connected. AGE (2016) identified that the Northern Void is hydraulically connected to the former Invincible underground workings. The floor of the Invincible open cut workings slopes down toward the north-east. Water collected in the Eastern and Renown/South Pit Voids seeps through the spoil in a north-easterly direction to the Northern Void where it drains into the former Invincible underground workings or is reused for dust suppression or other operational purposes. Stored water in the former Invincible underground workings seeps into the Lithgow seam and this seepage is estimated to range between 111 ML per year to 317 ML per year (AGE 2016).

⁸ This catchment area is very similar to the catchment surrounding Invincible Colliery. Table 8 in AECOM (2009) identifies a median annual runoff of 66ML/annum for the Ben Bullen catchment (49.6 Ha) upstream of Baal Bone Mine.

Historical underground mining at the Old Tyldesley Colliery, Old Invincible Colliery, the Invincible Colliery, Ivanhoe No. 2 Colliery, Wallerawang Colliery, and Baal Bone Colliery have all targeted the Lithgow Coal Seam because it is the deepest, thickest, and most continuous coal seam within the region (AGE 2016). Parts of these historical mine workings have flooded with water that has accumulated since active dewatering ceased. Baal Bone Colliery is the only mine operation nearby the Project that is currently dewatering significant areas of its underground workings⁹. The underground collieries are separated by coal seam barriers which in some cases are coincident with structural lineaments and in other cases by buffer zones around mining lease boundaries (AGE 2016).

The coal seam barrier between the Wallerawang No. 1 and No. 2 Collieries, and Invincible underground workings has previously been considered by Aquaterra (2010) to have been intentionally left intact to provide a barrier between these voids (AGE 2016). Groundwater from the Wallerawang Colliery has previously been assessed to flow into the Invincible Colliery through the coal seam barrier (Bish, 1999). The coal seam barriers between the Ivanhoe No. 2 Colliery (incorporating the Southern Extension Project area) and the adjacent Invincible and Wallerawang Colliery are also assumed to have been intentionally left intact to provide a barrier between these voids. The westernmost parts of Invincible and those immediately adjacent to the Southern Extension Project area are reportedly dry¹⁰ (AGE, 2012 and 2014). As the Invincible underground workings dip to the northeast they become saturated. Very limited information is currently available for this assessment to accurately determine if the historical workings of the Ivanhoe No. 2 Colliery in the Lithgow Seam are dry or flooded (AGE 2016). However, information in the form of survey plans of historical mine workings suggest they are potentially flooded. If these workings are indeed flooded, they are positioned adjacent to dry workings of the Invincible underground workings (AGE 2016).

AGE (2016) also identify that groundwater recharge to the Marrangaroo Formation was likely to occur by direct rainfall infiltration and local runoff into the outcrop in low-lying areas. Similar to the Permian coal seam aquifers, groundwater within the Marrangaroo Formation was expected to flow towards the north-east (down-gradient) and discharge at outcrop areas (i.e. hillsides and gullies including the escarpment of the Wolgan Valley) (AGE 2016). This is potentially illustrative of the potential for long-range impacts that mining (and de-watering) in the current area can have on groundwater/surface water interactions.

AGE(2016) identified groundwater monitoring bores in the vicinity of the Southern Expansion Area, only one of which (CP123) is within 5km of the proposed mining (see Figure 6). AGE (2016) also noted, however, that CP123 was measuring the Marrangaroo Formation (sandstone / conglomerate) and that it was now '*discontinued*'. This suggests that there are no functional groundwater bores within 5 km of the proposed mining in the Southern Extension Area. This potentially explains why there is such high uncertainty in ground water levels in the old Ivanhoe No. 2 workings and therefore the volume of water that needs to be removed. The current set of bores identified in the EA are not considered to provide an appropriate set of groundwater monitoring sites for understanding the effects of future development of this area.

The Groundwater Assessment (AGE, 2016) estimated that up to approximately 2,121 ML of water contained in the Ivanhoe No.2 underground workings may need to be removed to enable the mining

⁹ Although this is proposed to cease in the near future.

¹⁰ Although there also appears to be significant uncertainty in the actual groundwater level contours in the old Invincible Mine workings.

of what is left (35%) of the Lithgow seam in the Southern Extension Area. In making their assessment, AGE (2016) assumed:

- The water level within Ivanhoe No. 2 Colliery underground workings is presumed to be relatively static because the mine has been closed for a long-period and there has been no previous dewatering of the mine workings since closure.
- Therefore, this assessment assumes the water level within the flooded workings has reached steady state equilibrium where water seepage (outflow) is approximately equalled by recharge (inflow).

It is noted that these assumptions do not allow for the sinkholes that occur in the Cullen Ck tributary upstream of the current open pit area. As identified earlier, approximately 67 Ha of the upper Cullen Ck catchment is estimated to drain to the major sinkhole, which could imply that additional inflows from this source are of the order of 89 ML/year¹¹. The groundwater assessment also does not consider the potential for faults or regional joint sets to further impact on groundwater connectivity between adjacent areas¹². The apparent extension of two joint sets into the Southern Extension Area (see Figure 3) has received no consideration/attention in the EA.

The lack of fundamental data on ground water levels in the old Ivanhoe No. 2 workings and therefore the actual volume of water that needs to be removed is a major deficiency in the current EA, one which should have been addressed prior to the public exhibition of the EA. Assumptions used to estimate the volume of mine water to be removed do not allow for the sinkholes that occur in the Cullen Ck tributary upstream of the current open pit area or additional inflows from the upstream catchment. There is also no assessment of the effects that mapped regional joint sets in this area may have on groundwater flows.

¹¹ See *The Volume of Water Potentially Moving Down Sinkholes* section above and rainfall runoff estimates for the nearby Baal Bone mine. This volume could conceivably increase during above average wet weather years (and for individual events such as the June 2016 East Coast low pressure system) and requires further assessment (and/or direct measurement).

¹² Figure 3 in the *The Catchment Upstream of Invincible Colliery* Section above shows the general catchment area and also illustrates the lineaments and regional joint sets mapped by Shepherd and Huntingdon (1981).

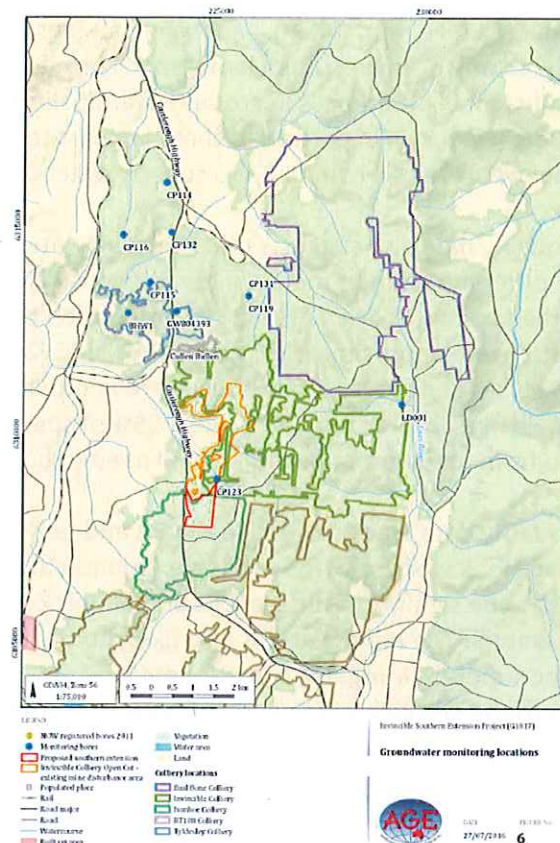


Figure 6. Groundwater bores in the vicinity of Invincible Mine. Source: AGE 2016.

Groundwater Quality

AGE (2012) found that groundwater in the Permian aquifers and the water contained within the former underground workings of Invincible, had concentrations of iron and manganese that exceeded Australian Drinking Water Guideline values and the ANZECC guideline for irrigation. In addition, the groundwater resources appeared to have a 'slightly elevated' zinc concentration which may make this water unsuitable for aquatic ecosystems (AGE 2014).

AGE (2016) stated:

No groundwater level data were collected directly from the Ivanhoe No. 2 Colliery underground workings or neighbouring mines for the current assessment¹³. Instead, this assessment has relied upon data gathered during other recent assessments (AGE, 2012 and 2014) that provide groundwater level data for the neighbouring Invincible underground workings.

Very limited groundwater quality data was provided in the EA and none was provided for the (potentially flooded) Ivanhoe No. 2 workings. What data was found to be available (McElroy 1975, AGE 2014, Sedgman 2016) was combined and analysed using Principal Components Analysis (PCA) together with a correlation biplot using the PrimerE Version 6 software package (Clarke and Gorley 2006). PCA results were presented for physico-chemical descriptors (pH, EC, Hardness, Alkalinity),

¹³ It is noted, however, that Sedgman (2016) provided data for a number of bores sampled on 10/11/2015, but these data were not included/used in the assessment. Sedgman (2016 p18) also stated that *Baseline groundwater monitoring has been undertaken in 6 rounds of sampling at 7 monitoring bores between 2011 and 2014*. None of this data appears to have been included in the EA.

selected dissolved metals (Al, Cd, Cr, Fe, Mn, Ni, Zn), and major salt ions (calcium, sulphate, chloride, magnesium, potassium and sodium) to show site similarities and correlations with each chemical group. The results identify substantial differences in groundwater quality when compared to Newnes Plateau surface waters (Figure 7). In particular, there appears to be significant differences in the ionic composition of mine waters when compared to surface waters.

The available groundwater quality data also suggests that the mine water is potentially high in Nickel and Zinc¹⁴ and, on occasion, other metals/non-metals/inorganic constituents (e.g. chromium and manganese). This supports the findings of AGE (2012, 2014). It is noted that the average Nickel concentrations in groundwater were approximately twice the ANZECC (2000) default guideline level (11 µg/L) to protect 95% of species and average Zinc levels were approximately seventeen times¹⁵ the ANZECC (2000) default guideline level (8 µg/L) to protect 95% of species. This suggests that any groundwater that is pumped from underground workings will need to be treated prior to discharge.

Very limited groundwater quality data was provided in the EA and none was provided for the (potentially flooded) Ivanhoe No. 2 workings. The available groundwater quality data suggests that the mine water appears to be significant differences in the ionic composition of mine waters when compared to surface waters. The mine water is also likely to be high in Nickel and Zinc and, on occasion, other metals/non-metals/inorganic constituents. This suggests that any groundwater that is pumped from underground workings will need to be treated prior to discharge.

¹⁴ AGE (2016) stated that *the groundwater resources appear to have a slightly elevated zinc concentration which may make this water unsuitable for aquatic ecosystems.*

¹⁵ This excludes the very high Zinc value of 11,000 µg/L reported for BHW1 (Sedgman 2016).

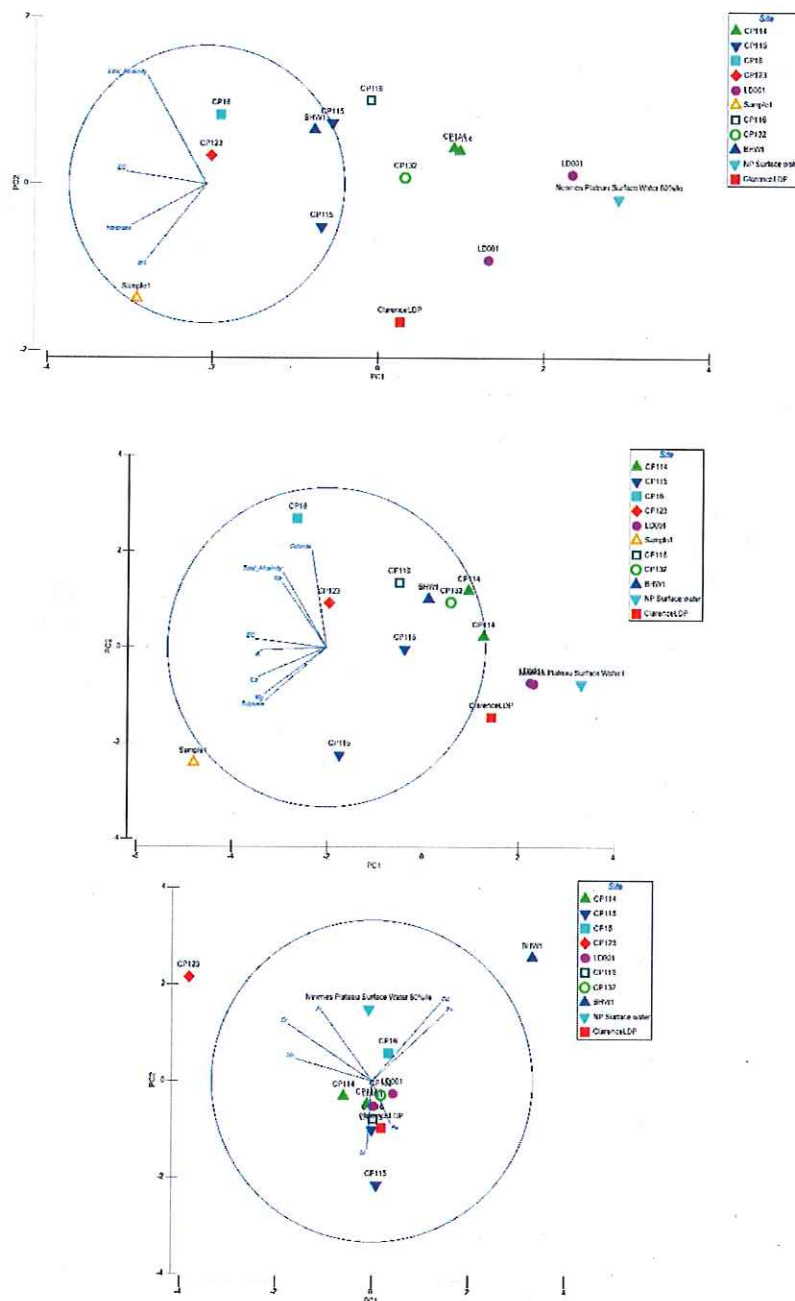


Figure 7. Principal Components Analysis of Groundwater Data (Physico-chemical - top; ionic composition - middle; and metals - bottom). Data for Newnes Plateau Streams and Clarence Colliery Discharge included for comparison¹⁶. Source: McElroy 1975, AGE 2014, Sedgman 2016, OEH 2015.

The Receiving Environment (3rd Order Tributary and 4th Order Cullen Ck) for the Proposed Discharge

The licensed discharge point for Invincible Mine is the Invincible Main Water Storage Dam (LD002). Under the existing Invincible EPL, the site is authorised for **wet weather discharges** into the tributary of Cullen Creek from the Main Water Storage Dam. This discharge point is referred to as LD002. Dirty runoff from the mine infrastructure area and upstream undisturbed catchment drains by gravity to

¹⁶ The point for *Newnes Plateau Surface Waters* is based on 80th percentiles of Newnes Plateau stream data (see OEH 2015). The point for the *Clarence LDP* is the median of measurements taken by OEH in 2014 (see OEH 2015).

the Main Water Storage Dam. In addition, the Environmental Dam is located on the western side of the haul road downstream of the fine reject storage dams and coal stockpile area (see Figure 4 above). The Environmental Dam collects seepage from the fine rejects storage dams and runoff from a minor undisturbed catchment. Water stored in the Environmental Dam is pumped to the Main Water Storage Dam. It is understood that seepage water from the fine reject storage dams is generally acidic and of poor quality (Umwelt 2016b). **It is important to note that the existing water management system (WMS) has no separation of clean and dirty water flowing to the Main Dam.**

Water quality in the Main Dam and Environmental Dam have been reported in various Invinible Annual Environmental Monitoring Reports. These data are illustrated in Figure 8.

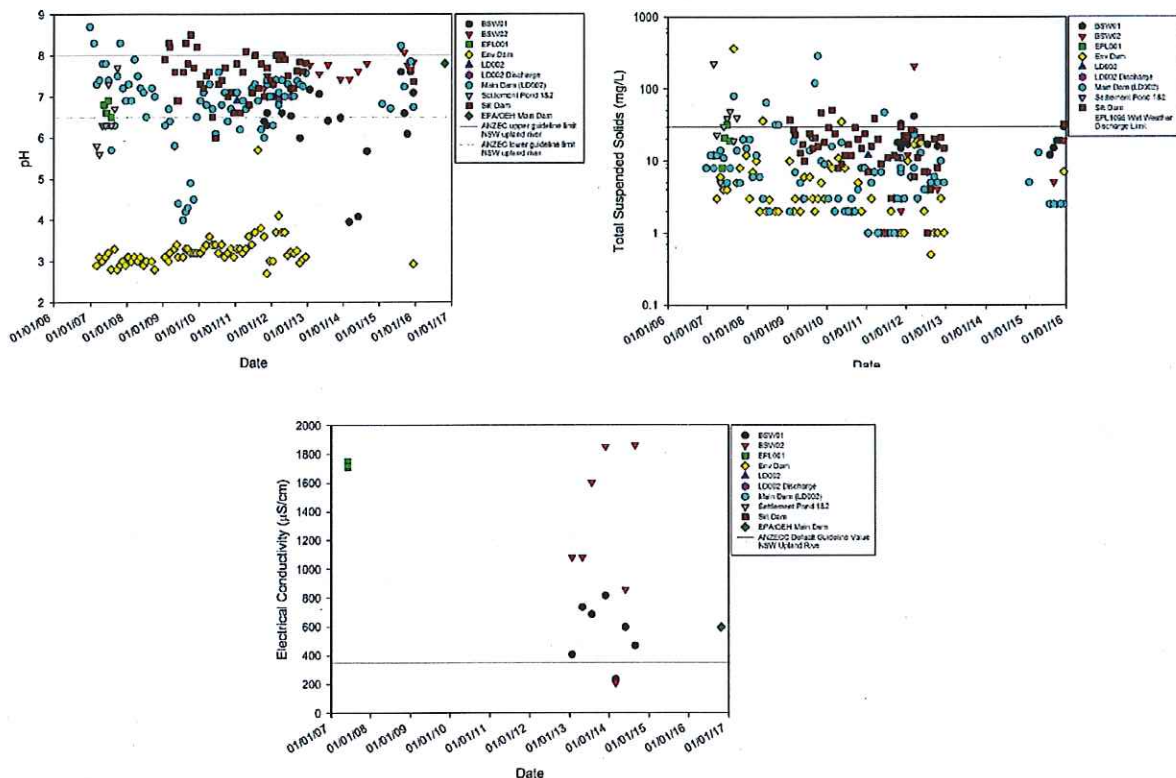


Figure 8. Water Quality in the Main Dam, Environmental Dam, BSW01, BSW02 and other locations. Source: Invinible Annual Environmental Monitoring Reports and EPA/OEH.

The limited data that is available suggests that the Main Dam (LDPO02) can occasionally have relatively high pH¹⁷ and total suspended solid levels. The Environmental Dam usually has very acidic waters (pH≈3). Conductivity levels at BSW01 and BSW02 are often high (relative to the default ANZECC 2000 guideline level for upland streams of 350 µS/cm).

Umwelt (2016b) stated that *Castlereagh Coal is able to either discharge surplus water during wet weather to Cullen Creek (via EPL 1095) or pump surplus water to the underground voids*. The modelled average daily discharge volume from the Main Water Storage Dam for the climatic period modelled was 0.94 ML per day (Umwelt 2016). The Groundwater Assessment (AGE, 2016) has determined that up to approximately 2,121 ML of water contained in the Ivanhoe No.2 underground workings may need to be removed to enable the mining of the Lithgow seam in the Southern Extension Area.

¹⁷ Although at times, the Main Dam has also recorded relatively acidic waters (pH=4 - 5).

Umwelt (2016b) also stated that: *Based on the above data, maintaining the existing EPL discharge limits and restricting discharges to wet weather days only and taking account of existing flows in the receiving catchment, in excess of 2121 ML could be discharged from via the overflow in the Main Water Storage Dam in the first year of operations without exceeding the downstream channel capacity. Based on an analysis of climatic data and channel capacity, discharges from the site associated with dewatering activities would be limited to 260 l/s (22.8ML/day) on wet weather days only. This volume represents 26% of bank full flows.*

To remove 2,121 ML of water in the first year of mine operation¹⁸ would require a continuous discharge of ~5.8 ML/day (or ~6 times the modelled average daily discharge volume from the Main Water Storage Dam), irrespective of wet weather contributions. It is noted however, that the site is authorised only for **wet weather discharges** (EPL 1095). If releases were 22.8 ML/day during 'wet weather' then approximately 93 days would be required to remove 2,121 ML of water in the first year of mine operation. It is noted that there is currently no volumetric limits for LD002 on EPL 1095.

As identified earlier, the estimated mine water volume to be removed (2,121 ML) does not allow for any surface water runoff which currently drains through subsidence affected areas or enters the sinkholes and reports directly to the abandoned underground workings. Any additional annual volume from this source (potentially a recurrent addition) may also require subsequent removal.

Umwelt (2016b) stated that: *An assessment of the receiving watercourses, i.e. Cullen Creek and its tributaries, indicates that the flow capacity of the channel immediately downstream of the Main Water Storage Dam is approximately 1.0 m³ per second (i.e. 86.4 ML per day) which increases to a capacity of approximately 15 m³ per second (i.e. 1,296 ML per day) immediately downstream of the Castlereagh Highway. The abovementioned flow rates have been determined for the bank full conditions using the XP-Storm model used to assess potential flood impacts associated with the Southern Extension Project.*

An inspection of the Cullen Ck catchment downstream of the Main Dam raises serious questions as to the ability of the stream channel to actually absorb such volumes¹⁹ without significant potential for erosion; and the ability of these flows to pass through the culvert under the Castlereagh Highway (without overflow across the road; see Figure 9). The numbers suggested for channel flow capacity and 'appropriate' discharge volumes (22.8ML/day on wet weather days only) for the discharge require further independent expert hydrological review.

The EA (Umwelt 2016) also stated:

The surface water assessment indicates that the Southern Extension Project is expected to have negligible impacts on flows, water quality and water users relative to the current approved impacts immediately downstream of Invincible on Cullen Creek and the Turon River system.

¹⁸ Excluding reuse or storage in other areas.

¹⁹ Flow capacities as stated are approximately 36 Olympic Swimming Pools of water per day immediately downstream of the Main Water Storage Dam (i.e. 86.4 ML per day) and 540 Olympic Swimming Pools of water per day immediately downstream of the Castlereagh Highway (i.e. 1,296 ML per day). The proposed discharge rate during wet weather (i.e. 22.8ML/day) is approximately 9.5 Olympic Swimming Pools of water per day.



Figure 9. Downstream receiving environment: Looking upstream to LD002 (top left); looking downstream from LD002 (top right); armouring on Cullen Creek tributary east of Castlereagh Highway (bottom left); Cullen Creek tributary culvert under Castlereagh Highway (bottom right).

Given

- the paucity of background water quality data actually provided in the EA;
- the uncertainty as to the volume and quality of water required to be removed from the Ivanhoe No. 2 workings;
- the proposal to remove (and discharge to Cullen Ck) an estimated 2,121 ML of water in the first year of mine operation;
- the proposed release of up to 22.8ML/day on wet weather days²⁰;
- the uncertainty surrounding the ability of the stream channel to actually absorb such volumes without significant potential for erosion;
- the uncertainty of the ability of these flows to pass through the culvert under the Castlereagh Highway without overflow;
- the current quality of water within the dam;
- the lack of separation between the mine surface areas, dirty water systems and clean water systems for the site (ie WMS);
- the lack of any aquatic ecology assessment for Cullen Ck;

the subjective opinion that *“the Southern Extension Project is expected to have negligible impacts on flows, water quality and water users”* is neither substantiated nor supported.

²⁰ It is unclear how a ‘wet weather’ day is defined in the EA or whether the third order Cullen Ck tributary is capable of absorbing such flows without adverse environmental outcomes (eg significant erosion).

The Aquatic Ecology in Cullen Ck

There has been no investigation of the aquatic ecology in Cullen Ck despite the proposal to discharge an estimated 2,121 ML of mine water to Cullen Ck in the first year of mine operation. This is considered to be a significant deficiency in the EA. There is little foundation for the statement (Umwelt 2016) that *Water quality monitoring results indicate negligible impact on downstream systems*. Based on the limited groundwater data that is available (which is high in Nickel and Zinc), there is significant potential for adverse toxicological effects on the aquatic biota²¹ of Cullen Ck if untreated mine water is discharged to the environment.

There has been no investigation of the aquatic ecology in the receiving waters of Cullen Ck. A proper assessment of the potential impacts of the project on aquatic ecology is required before any discharge is authorised.

Water Balance for the Mine Site.

The EA (Umwelt 2016) identified that:

- The WMS for the Southern Extension Project will manage water of three distinct types: clean, dirty and mine water.
- Each type of water requires different management measures to minimise the risk of water quality impacts on downstream drainage systems by mining activities.
- The stage plans presented are conceptual, being determined by current mining schedules and in consideration of the maximum disturbance area.
- The WMS will be constructed and modified as and when required so as to support the infrastructure and mine development.
- Similarly, the conceptual storage capacities required for the various water management dams are provided to indicate the quantum of the proposed dams.
- Refinement of the design criteria and capacities will be undertaken during detailed design stages of the Southern Extension Project, as well as the ongoing operational stages.

The actual details on the WMS for the operation of the Southern Extension Project are quite vague, especially where stage plans are presented as conceptual and statements suggest *the WMS will be constructed and modified as and when required*. It is therefore unclear what assumptions have actually been used in the *Water Balance Assessment* for the proposed expansion.

For the *Water Balance* section Umwelt (2016b) stated:

- Diversion of runoff from undisturbed and rehabilitated catchments to the north and east of the active mining area and overburden infill areas is not practicable; runoff from these areas will continue to be managed, as per the existing WMS, within the WMS.
- Only runoff from areas of existing rehabilitation (rehabilitation that has occurred several years prior to commencement of the Southern Extension Project) will be sufficiently established to be released to the environment.
- Runoff from these areas with existing rehabilitation will be released to the environment where runoff can be practically separated from runoff from mine and dirty water catchments.
- As the mining progresses further to the south, overburden material will continue to be progressively placed within the existing pit and behind the advancing highwall of the

²¹ An ecotoxicology assessment should be undertaken on the existing surface water quality within the dams on the Invincible Mine site, the current discharge and the mine water that is proposed to be pumped from the old Ivanhoe No. 2 workings.

Southern Extension Project. Runoff from the mining pit and overburden emplacement area will be managed within the WMS.

- On average, the modelling predicts that the operation will have a positive gross site water balance. The water make associated with the water balance will either be stored in the former Invincible Underground Workings or discharged off site in accordance with the EPL.
- An analysis of the modelled discharges assuming no additional storage volume within the former Invincible underground workings (i.e. the worst case scenario) was included in Table 5.2.

Table 5.2 Main Water Storage Dam Modelled Discharges

Percentile	Discharge (ML)
10 th %ile	21
50 th %ile	206
90 th %ile	785

- The modelled maximum number of days that discharges would occur from the Main Water Storage Dam is 78 days based on historical climate data and predicted site water demands.
- Castlereagh Coal is able to either discharge surplus water during wet weather to Cullen Creek (via EPL 1095) or pump surplus water to the underground voids. The modelled average daily discharge volume from the Main Water Storage Dam for the climatic period modelled is 0.94 ML per day.

It is noted from the above that:

1. The stage plans presented are vague, conceptual in nature only and the WMS will be *constructed and modified as and when required*.
2. Refinement of the design criteria and capacities are stated to be undertaken during detailed design stages²² of the Southern Extension Project
3. Several years rehabilitation is necessary to *be sufficiently established to be released to the environment*
4. Runoff from areas with existing rehabilitation will be released to the environment where runoff can be *practically separated* from runoff from mine and dirty water catchments (it is unclear what *practically separated* means in the current context).

Insufficient details of the WMS and Water Balance are provided in the EA to test the veracity of conclusions that it is capable of containing all dirty water on-site; or that the WMS will ensure that any discharges that do take place will be of appropriate quality. An independent expert peer review of the Water Balance Model (including all its assumptions) should be undertaken.

The Required Level of Treatment of any Discharge

As indicated above, an inadequate characterisation of the mine water proposed to be discharged has been provided in the EA. The lack of fundamental data on ground water levels in the old Ivanhoe No.

²² This should actually have been done for the EA, but the overall level of detail on actual ground water levels in the old Ivanhoe No. 2 workings and therefore the actual volume of water that needs to be removed probably has a significant effect on the exact design of any WMS for the project. As suggested earlier, given the fundamental importance of this information to the project, a better assessment of ground water levels in the old Ivanhoe No. 2 workings and therefore the actual volume of water that needs to be removed should have been undertaken prior to public exhibition of the EA.

2 workings and therefore the volume of water that needs to be removed is considered to be a major deficiency in the current EA, one which should have been addressed prior to public exhibition. Based on the limited groundwater data that is available, this mine water is likely to be high in Nickel and Zinc (and potentially a range of other contaminants). No consideration has been given to the treatment of this water to ensure it is of acceptable quality to be discharged to Cullen Ck. There has also been an inadequate characterisation of the receiving environment for this discharge.

In terms of licensing discharges, the EPA (2013) identifies that it is the responsibility of licence holders to:

- be aware of the pollutants that are discharged to waters from their premises
- be aware of the environmental impacts that pollutants discharged from their premises have on the environment
- ensure that their licence specifically regulates the discharge from their premises of all those pollutants that pose a risk of non-trivial harm to human health or the environment – where the premises discharges a pollutant that is not regulated by the licence, the licence holder does not have a defence against the pollution of waters offence by that pollutant.

There is insufficient evidence presented that the Proponent is fully aware of the pollutants that will be discharged and the effect these pollutants may have on the receiving environment. Based on the limited data that is available, if the project is approved, there is likely to be a need to treat the discharge prior to its release if it is to pose a trivial risk of harm to the environment.

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Martin Krogh
Principal Scientist Major Assessments
Office of Environment and Heritage
8 November 2016

Appendix B

Monitoring bore logs – BHTH12 and BH2



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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

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BHTH12

PROJECT No: G1817

PROJECT NAME: Invincible Drilling Project

DATE DRILLED: 1-Dec-16

LOGGED BY: G. Mallaby

DRILLING COMPANY: DRC

DRILLER:

DRILLING METHOD: Air

DRILL RIG: Sandvik DE880

EASTING: 224716 mE

NORTHING: 6308534 mN

DATUM: MGA94 (z56)

RL: 934.2 mAHD

EOH: 36 mBGL

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) R.L. (mAHD)	Bore Construction	Bore Description
		935 0		Protective lockable steel collar: + 0.80m PVC stick up: + 0.56m
Siltstone: Orange/brown, abundant ferruginous alluvial clasts, distinctly weathered	· ·	933 2		150mm PCD: 0m to 5m
Siltstone: dark orangy grey, many ferruginous alluvial, slightly weathered, base of weathering	· · · · · · · · · ·	931 4		
Siltstone: dark grey, fresh	· · · · ·	929		
Carbonaceous mudstone (80%), dark blackish brown; many coaly laminations. Siltstone (20%), dark grey	· · · · · · · · · ·	927 6		99mm PCD: 5m to 36m (TD)
Carbonaceous mudstone (80%), dark blackish brown. Coal (20%).	· · · · · · · · · ·	925 8		Bentonite grout dry weight (5%): 0m to 20.7m
Tuff, dark brownish buff. Coaly.	· · · · · · · · · ·	923 10		
Carbonaceous mudstone (70%), dark blackish brown, many coaly laminations. Coal (30%); tuffaceous laminations	· · · · · · · · · ·	921 12		50mm blank casing: 0m to 31m
Coal, many tuffaceous laminations	· · · · · · · · · ·	919 14		
Tuff (60%), dark brown buff, many coaly laminations. Coal (40%).	· · · · · · · · · ·	917 16		
Siltstone, dark grey, coaly at base of unit.	· · · · · · · · · ·	915 18		
Coal, muddy in part	· · · · · · · · · ·	913 20		
Sandstone, light grey, fine grained, siltstone in part, carbonaceous laminations	· · · · · · · · · ·	911 22		Bentonite seal: 20.7m to 22m
Sandstone, light grey, fine grained, siltstone laminations, carbonaceous	· · · · · · · · · ·	909 24		
No sample return	· · · · · · · · · ·	907 26		3mm to 5mm quartz gravel : 22m to 34m
	· · · · · · · · · ·	905 28		
	· · · · · · · · · ·	903 30		
	· · · · · · · · · ·	901 32		50 mm PN 18 uPVC machine slotted casing, slot aperture: 0.5 mm, slot length: 50 mm, 672 slots / m, 31 m to 34 m
Void (old workings)	· · · · · · · · · ·	899 34	1-Dec-16	Hole collapse: 34m to 36m
		897 36		End of hole: 36m BGL



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BOREHOLE LOG

page:1 of 1

BH2

PROJECT No: G1817
PROJECT NAME: Invincible Drilling Project
DATE DRILLED: 6-Dec-16
LOGGED BY: G. Mallaby

DRILLING COMPANY: DRC
DRILLER:
DRILLING METHOD: Air
DRILL RIG: Sandvik DE880

EASTING: 224709 mE
NORTHING: 6308551 mN
DATUM: MGA94 (z56)
RL: 931.7 mAHD
EOH: 39.5 mBGL

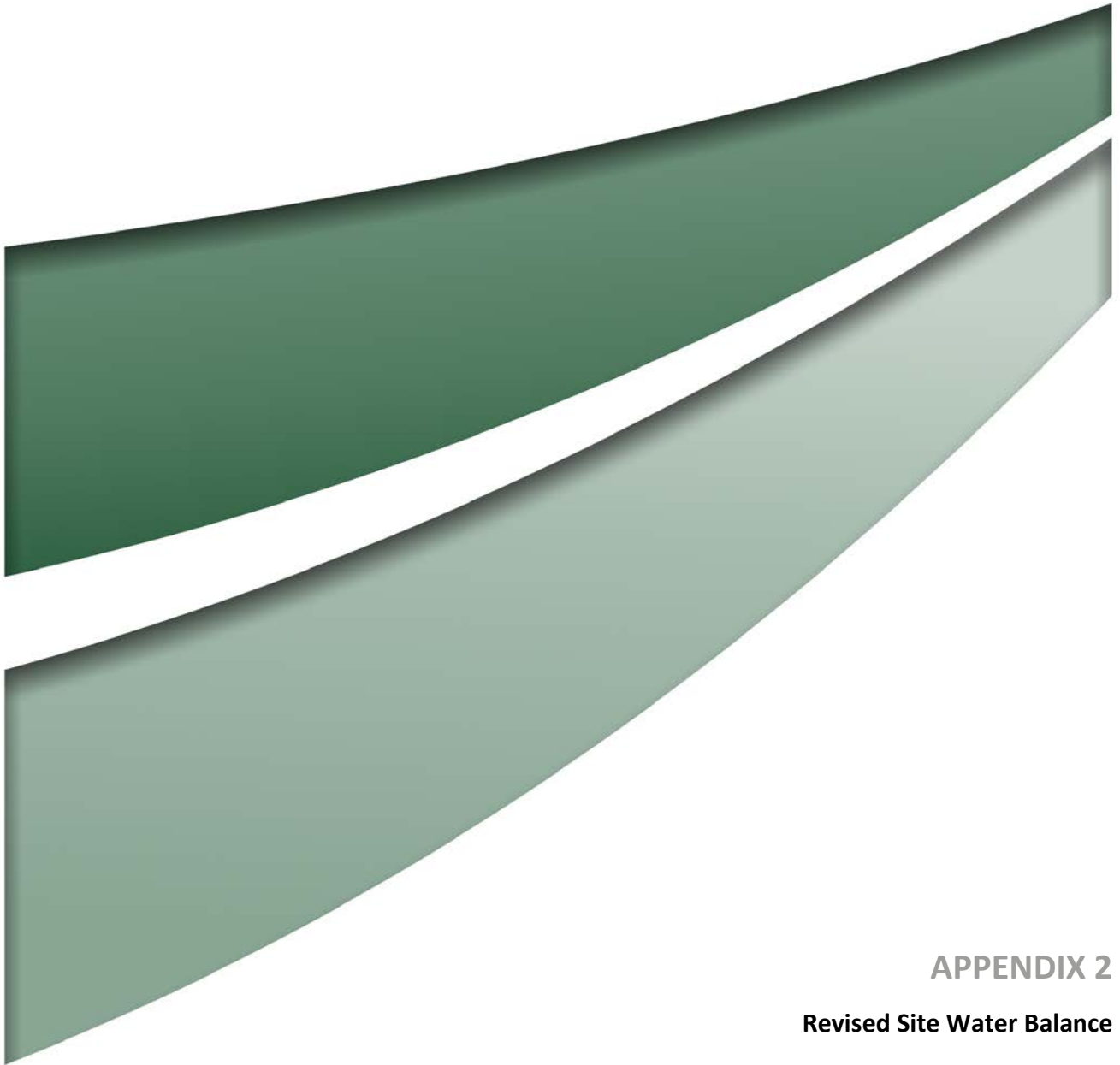
COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) RL (mAHD)	Bore Construction	Bore Description
		2		
		932		Protective lockable steel collar: + 0.8m
Siltstone	•••••			PVC stick up: + 0.1m
Siltstone	•••••	930		200mm PVC surface casing: 0m to 3m
Siltstone and tuff (50/50)	•••••	2		200mm PCD: 0m to 3.2m ()
Tuff	•••••	928		150mm conventional core: 3.2m to 18.2m
Carbonaceous shale	•••••			150mm PCD: 18.2m to 27.3m
Tuff	•••••	926		150mm conventional core: 27.3m to 33.4m
Carbonaceous shale	•••••			150mm PCD: 33.4m to 39.5m
Tuff	•••••	926		
Coal (dull with frequent bright bands (10% - 40%))	•••••	6		
Siltstone	•••••	924		
No sample return	•••••			
Siltstone	•••••	922		
Tuff	•••••	10		
Siltstone	•••••	922		
Coal (Upper Irondale)	•••••			Bentonite grout dry weight (5%): 0m to 26.45m
Sandstone, fine to medium grained, coaly	•••••	920		
Sandstone, fine to medium grained	•••••			50mm blank casing: 0m to 29.9m
Siltstone, graphitic at base	•••••	920		
Coal (Irondale seam top)	•••••			
Tuff	•••••	918		
Sandstone, fine grained	•••••	14		
		916		
		914		
		18		
		912		
		910		
		22		
		908		
		906		
Siltstone	•••••	26		
Coal (dull minor bright)	•••••	904		
Tuff	•••••			Bentonite seal: 26.45m to 28.3m
Coal (dull minor bright)	•••••	902		
Tuff, stony at base	•••••			
Coal (dull minor bright)	•••••	30		
Tuff	•••••			
Coal (dull minor bright)	•••••	900		
Coal (dull and bright banded)	•••••			
Tuff	•••••			
Coal (dull and bright banded, Irondale seam floor)	•••••			
Sandstone, fine to medium grained	•••••	34		
Sandstone, medium to coarse grained	•••••			
Siltstone	•••••	38		
Sandstone, fine to medium grained	•••••			
Siltstone	•••••			

Appendix C

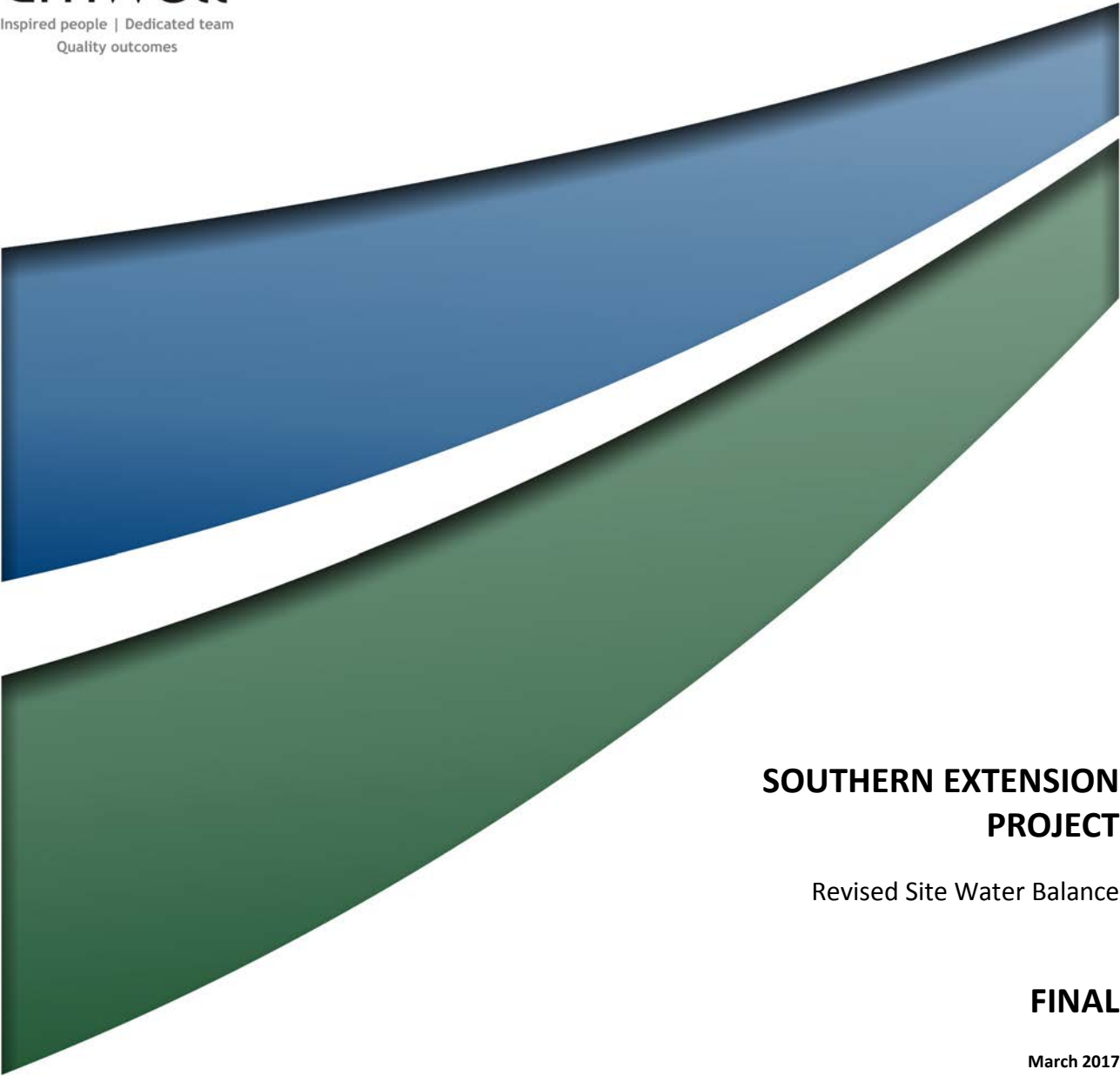
Summary of water analysis results – January 2017

ANALYSIS	UNITS	LD002 DISCHARGE	MAIN DAM	SUMP IN NORTHERN VOID	LD001 BORE	EAST TYDYLSELY BORE	BSW01	BSW02	BH2	BHTH-12
Sample Number	-	011711508001	011711508002	011711508007	011711508008	011711508009	011711508005	011711508006	011711508010	011711508011
Date Sampled	-	10/01/2017	10/01/2017	10/01/2017	9/01/2017	10/01/2017	10/01/2017	10/01/2017	10/01/2017	10/01/2017
Time Sampled	-	9:32	9:40	8:00	17:00	12:50	10:20	11:30	7:50	7:41
Flow	-	Nil	Nil	Nil	(48.36m SWL)	Nil	Nil (-0.2m)	Nil (0.0m)	(31.73m SWL)	(33.40m SWL)
pH	pH unit	7.4	7.43	7.15	6.6	6.72	6.55	7.04	4.41	6.06
Electrical Conductivity	uS/cm	655	648	1360	375	853	495	1168	941	1688
Temperature	°C	21	21	21	17.5	21	21	22	18	18
Total Suspended Solids	mg/L	<5	<5				20	<5		
Total Dissolved Solids	mg/L	377	376	1124	101	534	305	700	620	1414
Oil & Grease	mg/L	<5	<5				<5	<5		
Hydroxide Alkalinity as CaCO3	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	mg/L	48	49	58	48	66	82	180	<1	198
Total Alkalinity as CaCO3	mg/L	48	49	58	48	66	82	180	<1	198
Sulfate as SO4 - Turbidimetric	mg/L	218	214	737	12	278	79	323	403	750
Chloride	mg/L	13	12	15	6	21	21	50	10	46
Fluoride	mg/L	0.2	0.2	0.1	0.1	<0.1	0.2	0.2	<0.1	0.3
Calcium	mg/L	73	74	167	12	70	26	89	84	85
Magnesium	mg/L	19	19	86	5	44	20	68	43	35
Sodium	mg/L	15	15	21	6	19	26	51	16	389
Potassium	mg/L	6	6	20	7	13	6	4	12	12
Dissolved Metals										
Aluminium (filt)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.49	0.01
Antimony (filt)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (filt)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001
Beryllium (filt)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001
Barium (filt)	mg/L	0.024	0.024	0.024	0.17	0.028	0.034	0.026	0.016	0.024
Cadmium (filt)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0018	<0.0001
Chromium (filt)	mg/L	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt (filt)	mg/L	<0.001	<0.001	0.03	<0.001	0.009	0.006	<0.001	0.065	0.042
Copper (filt)	mg/L	<0.001	<0.001	<0.001	0.02	<0.001	<0.001	<0.001	<0.001	<0.001
Lead (filt)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	<0.001
Lithium (filt)	mg/L	0.005	0.005	0.057	0.02	0.059	0.004	0.002	0.081	0.095
Manganese (filt)	mg/L	0.146	0.133	1.12	0.003	1.99	1.12	0.448	2.5	2.1
Molybdenum (filt)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008
Nickel (filt)	mg/L	0.006	0.002	0.126	0.008	0.023	0.008	0.004	0.368	0.274
Selenium (filt)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver (filt)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thorium (filt)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Tin (filt)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Titanium (filt)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium (filt)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.027
Vanadium (filt)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc (filt)	mg/L	0.083	<0.005	0.117	0.144	0.114	0.02	<0.005	0.812	0.03
Boron (filt)	mg/L	<0.05	<0.05	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	0.13
Iron (filt)	mg/L	0.07	<0.05	<0.05	<0.05	9.29	1.81	<0.05	7.75	0.69
Bromine (filt)	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.2
Total Metals										
Aluminium (tot)	mg/L	0.07	0.05	0.02	0.04	0.03	0.21	0.06	0.98	26.4
Antimony (tot)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (tot)	mg/L	<0.001	<0.001	0.002	<0.001	<0.001	0.002	<0.001	0.002	0.01
Beryllium (tot)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.004
Barium (tot)	mg/L	0.025	0.022	0.025	0.169	0.028	0.032	0.023	0.02	0.215
Cadmium (tot)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.002	0.0015
Chromium (tot)	mg/L	0.007	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01
Cobalt (tot)	mg/L	<0.001	<0.001	0.036	<0.001	0.01	0.006	<0.001	0.07	0.07
Copper (tot)	mg/L	<0.001	<0.001	<0.001	0.022	0.002	0.001	<0.001	0.001	0.029
Lead (tot)	mg/L	<0.001	<0.001	<0.001	0.001	0.003	<0.001	<0.001	0.007	0.054
Lithium (tot)	mg/L	0.006	0.006	0.173	0.022	0.057	0.004	0.003	0.079	0.096
Manganese (tot)	mg/L	0.149	0.136	1.07	0.005	1.79	0.95	0.482	2.21	2.28
Molybdenum (tot)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005
Nickel (tot)	mg/L	0.007	0.002	0.146	0.01	0.025	0.01	0.004	0.395	0.41
Selenium (tot)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver (tot)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thorium (tot)	mg/L	0.002	0.003	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.017
Tin (tot)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Titanium (tot)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04
Uranium (tot)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.026
Vanadium (tot)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02
Zinc (tot)	mg/L	0.104	<0.005	0.147	0.187	0.125	0.031	0.009	0.839	0.885
Boron (tot)	mg/L	<0.05	<0.05	0.08	<0.05	<0.05	<0.05	<0.05	<0.05	0.1
Iron (tot)	mg/L	0.2	0.06	0.48	0.26	9.12	7.64	0.17	8.5	10.8
Bromine (tot)	mg/L	<0.05	<0.05	<0.05	<0.05	0.06	0.08	0.12	0.08	0.12
Ionic Balance										
Total Anions	meq/L	5.86	5.77	16.9	1.38	7.7	3.88	11.7	8.67	20.9
Total Cations	meq/L	6.01	6.06	16.8	1.45	8.27	4.23	12.4	8.73	24.3
Ionic Balance	%	1.24	2.44	0.27	2.55	3.6	4.35	2.6	0.35	7.7



APPENDIX 2

Revised Site Water Balance



SOUTHERN EXTENSION PROJECT

Revised Site Water Balance

FINAL

March 2017

SOUTHERN EXTENSION PROJECT

Revised Site Water Balance

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Castlereagh Coal

Project Director: Tim Crosdale
Project Manager: David Holmes
Technical Director: Susan Shield
Technical Manager: Chris Bonomini
Report No. 3622D/R09/FINAL
Date: March 2017



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1.0 Introduction

The water balance presented in the EA was based on the assumption that the volume of water contained within the former Ivanhoe No. 2 Underground workings was not known, and as such impacts were assessed based on an inferred maximum volume of water that may be contained in these workings. As discussed in Section 1.2 of the main text of the RTS Report B, further investigations into the volume of water contained in the Ivanhoe No. 2 Underground workings, which identified that these workings contained 17% of the water assumed in these workings as presented in the EA. This has led to a revised assessment of the volume stored in the Ivanhoe No. 2 Underground workings and as such the proposed management measures for this water.

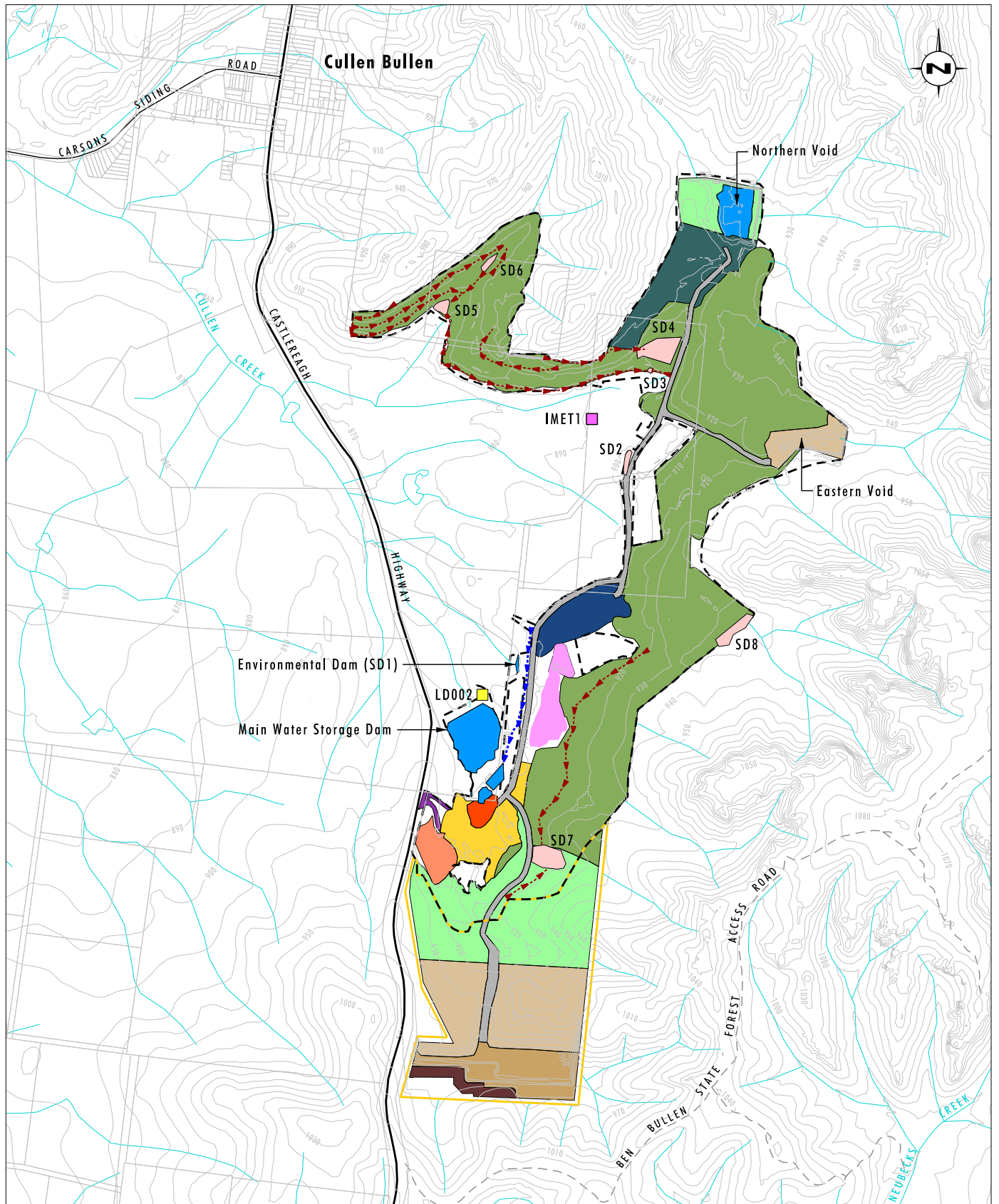
The revised approach to the management of water in the Ivanhoe No. 2 Underground workings means the WMS is largely unchanged with the Southern Extension Project from the historical approved mining at Invincible. Accordingly, the water balance for the Southern Extension Project is considered to be similar to the approved operations and likely to result in lower discharges compared to the current care and maintenance status of the site (due to water usage requirements associated with an operating mine).

The water balance presented in the EA has been revised to adopt the proposed management measures for underground volumes (i.e. transfer of water in the Ivanhoe No. 2 Underground workings to the Invincible underground with no discharge of this water proposed) and consideration of surface cracking impacting on runoff volumes into the Water Management System (WMS) as requested by DPI Water. This revised site water balance assessment for the Southern Extension Project is based on a worst case operating scenario in regard to discharge volumes. This scenario would only occur if pumping from the Invincible Underground to the Main Water Storage Dam was required to avoid the underground workings exceeding storage capacity (i.e. the underground workings are full). This is a conservative assumption given that there is generally capacity within the Invincible underground workings to store water captured in WMS (estimated to be in excess of 1218 ML even with the transfer of water from the Ivanhoe No. 2 Underground workings). During times of wet weather there has been a need to discharge water from the site, which is provided for in accordance with the existing Environment Protection Licence (EPL) for Invincible. As outlined in the EA, further discharges from Invincible are proposed as part of the Southern Extension Project in accordance with the requirements of the EPL.

The revised water balance for the Southern Extension Project is based on conservative assumptions in regards to available storage in the underground workings and surface cracking influences. As such the results from the revised water balance modelling are considered to present a worst case estimate of discharges from Invincible for the approved and proposed operations.

The volume of water discharged under the worst case scenario examined in the Revised Site Water Balance will be higher than occurs in relation to the current water management system due to the ongoing availability of storage in the Invincible Underground workings. Further to this the expected operating scenario with the Southern Extension Project is considered likely to also result in lower discharges than those predicted in the worst case scenario presented.

The revised water balance model is based on the Stage 2 operations, which represent the full extent of proposed disturbance (refer to **Figure 1.1**), and the conceptual site water schematic (refer to **Figure 1.2**).



Data Source: LPI (2016)
Note: Contour Interval 10m

Legend

Existing Approved Mining Disturbance Area	Coal Stockpile - Product	Tailings Drying Area
Proposed Southern Extension Area	Coal Stockpile - ROM	Temporary Stabilisation Area
Active Mining	Haul Road / Access Road	Sediment Dam
Active Overburden Emplacement Area	Sealed Access Road	Mine Water Drain
Pre Strip	Infrastructure / Laydown Area	Dirty Water Drain
Rehabilitation - Vegetated	MIA / Administration	Licensed Discharge Point
Shaped Not Seeded	Water Management Area	Meteorological Station

File Name (A4): R09/3622_146.dgn
20160916 10.08

FIGURE 1.1

Conceptual Water
Management System
Stage 2

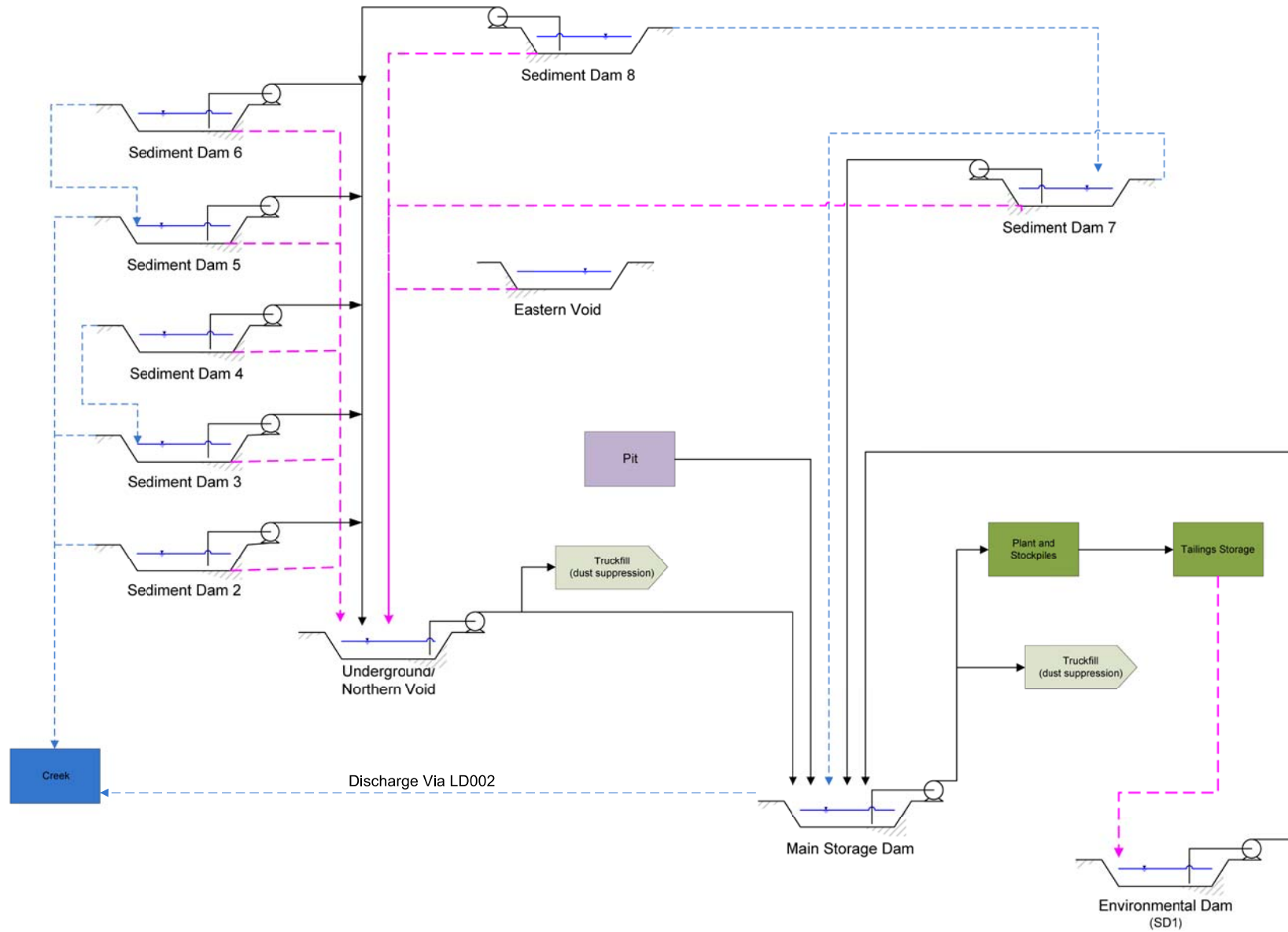


FIGURE 1.2

Schematic of Water Management System - Limited Available Underground Storage

2.0 Model Overview

The water balance model was developed for the Southern Extension Project using the Goldsim modelling package. The model is a daily time step model. The model uses the historical meteorological records from 1960 to 2015 from the Bureau of Meteorology's Lidsdale monitoring station (Station ID 63132) with infill from the Lithgow climate monitoring station (Station ID 63226) in years with data gaps.

Inflows to the water balance include runoff and rainfall. Where possible, dirty and mine water is reused in the Invincible Coal Preparation Plant and for haul road dust suppression. The water balance also considers seepage from existing mining areas/voids to the underground workings and associated seepage out of the underground workings to the north-east into Baal Bone workings.

2.1 Rainfall and Climate

Invincible lies within a cool-temperate climatic zone and is characterised by mild summers and cold winters. The local climate is largely influenced by factors such as topography, altitude, aspect and exposure.

As discussed in the Surface Water Assessment for the Invincible Southern Extension Project, three Bureau of Meteorology (BoM) rainfall stations lie within close proximity to Invincible: Station 63132 Lidsdale (9 kilometres south-east); Station 63071 Portland (6 kilometres south); and Station 63226 Lithgow (21 kilometres south-east). Of these three BoM rainfall stations Lidsdale is considered most representative of rainfall conditions at Invincible due to its topographical location and also the completeness of the data set.

Daily rainfall has been recorded at Lidsdale (Station 63132) since 1960. Rainfall is generally spread evenly across the year, with slightly higher falls in late spring and summer and lower falls in autumn. For use in the water balance, periods of incomplete rainfall data at the Lidsdale gauge have been infilled with data sourced from Lithgow (Station 63226). **Table 2.1** presents the rainfall statistics for the data set used in the water balance (Lidsdale data with infilled Lithgow data).

Table 2.1 Rainfall Data

Statistic	Rainfall (mm)
Minimum	330
10 th %ile	506
50 th %ile	759
90 th %ile	928
Maximum	1171

Source: Bureau of Meteorology, 2016 (combined Lithgow and Lidsdale data set)

Castlereagh Coal operates a meteorological monitoring station at Invincible (refer to **Figure 1.1**). In 2014, the site received 695 millimetres of rainfall over 141 rainfall days, which is consistent with a slightly below average rainfall year for the Lidsdale station. The 2014 rainfall at the Lidsdale BoM station was 735 mm.

Average pan evaporation rates, as used in the water balance model, of approximately 1349 mm/year exceed rainfall throughout most of the year except for the winter months of June, July, and August (BOM Station No. 063005 – Bathurst agricultural station).

3.0 Predicted Water Balance

3.1 Assumptions and Basis

The predictive water balance analysis was undertaken based on the WMS and catchments for Stage 2 of the Southern Extension Project (Refer to **Figure 1.1**) and the following assumptions and basis:

- the former Invincible Underground workings have no additional storage capacity at the start of each rainfall year modelled (as outlined above this is a conservative assumption considering that there is available volume in the former Invincible Underground workings to store water captured in the WMS)
- the CHPP water demands are based on the following coal moistures recoverable water from fine rejects
 - o ROM – 8%
 - o Product Coal – 11%
 - o Coarse Reject – 11%
 - o Fine Reject Slurry Water Volume – 2,165 L/T
 - o Fine Reject recoverable water – 53%
- a maximum haul road watering demand for dust suppression of 4.8 mm/day (National Pollutant Inventory, 2011)
- catchment runoff from disturbed and natural catchments has been estimated using a soil store model with natural catchment runoff calibrated to the average regional runoff of 0.8 ML/year (NSW Farm Dams Calculator). The estimated average annual runoff for catchments with surface cracking and subsidence is 2.1 ML/year based on a proportion of infiltration reporting directly to the WMS
- the natural catchment upslope of the proposed pit has been conservatively modelled with increase total runoff captured to account for increased inflows to the pit as a result of surface cracking in the catchment associated with mine subsidence (as per the rate above)
- an outflow of 105 ML/year from the former Invincible Underground workings. Groundwater modelling predicts the outflow seepage to range from 105 ML to 315 ML
- sediment dams are to be designed and constructed in accordance with Blue Book requirements to manage the 95th percentile 5 day runoff. Consistent with the relevant design criteria and guidelines, the water balance model predicts that on average the Southern Extension Project sediment dams will spill during prolonged or unusually intense periods of rainfall.
- water transfer rates from sediment dams are based on a 5 day pump out of the settling zone volume.

3.2 Results

The modelling predicts that the Southern Extension Project will have a positive gross site water balance for all rainfall years modelled. The water make associated with the water balance will either be stored in the Invincible Underground workings or discharged off site in accordance with the EPL.

Model results for the 10th percentile, 50th percentile and 90th percentile water balance years are presented in **Table 3.1**

Table 3.1 Predictive Gross Water Balance Model Results

Percentile	10 th %ile	50 th %ile	90 th %ile
Inflows			
- Rainfall/runoff (ML)	505	951	1570
- ROM coal moisture (ML)	10	10	10
Total Inflows (ML)	515	961	1580
Outflows			
- Evaporation (ML)	-82	-81	-82
- CHPP (ML)	-16	-16	-16
- Haul Road Dust Suppression (ML)	-100	-103	-104
- Spills from Sediment Dams (ML)	0	-6	-64
- Seepage loss from the Invincible Underground workings	-105	-105	-105
Total Outflows (ML)	-303	-311	-371
Gross Water Balance (ML)	212	650	1209

The gross water balance results provide an estimate of the worst case wet weather discharges that are likely to occur from site as well as spills from sediment dams where rainfall events exceed Blue Book design criteria. This is considered to be a worst case estimate as the assumptions regarding runoff from the undisturbed catchment upstream of the mining area and the predicted seepage from the Invincible Underground Workings are conservative as is the model assumption that there is no storage available in the Invincible Underground Workings at the start of each modelling period. It is noted that these assumptions would apply equally to the previous operating conditions for Invincible before going into care and maintenance if the available storage in the Invincible Underground workings had been filled (for example, due to inflows from an extremely high rainfall year). Under Care and Maintenance, the predicted discharges under each scenario would be higher on these assumptions due to inflows and outflows associated with coal extraction and processing (a net deficit in the water balance) not occurring. As such it is considered that the modelling results would also closely represent the worst case discharge scenario for the existing approved operations.

Modelling results for the predicted wet weather discharges from the Main Water Storage Dam for the 10th percentile, 50th percentile and 90th percentile discharge years, assuming no additional storage volume within the former Invincible Underground workings (i.e. a worst case estimate), are presented in **Table 3.2**.

Table 3.2 Main Water Storage Dam Modelled Discharges

Percentile	Discharge (ML) per annum
10 th %ile	223
50 th %ile	625
90 th %ile	1176

Note: percentile discharge years although similar in volume to, are different to percentile gross water balance years – see below.

The results presented in **Table 3.2** can be considered conservative (i.e. a worst case estimate) given the assumption of no storage capacity in the former Invincible Underground workings at the start of each modelled rainfall year and the outflow seepage to Baal Bone is set in the model at the low end (105 ML) of the predicted range (105 ML to 315 ML) and the conservative assumption regarding runoff from undisturbed areas upstream of the pit areas. Actual discharge volumes will be lower if storage capacity is available in the former Invincible Underground workings and/or the outflow seepage to Baal Bone is at the higher end of the estimated range and/or runoff from areas upstream of the mining area in inflows through surface cracking are lower than assumed. The discrepancy in volumes between the gross water balance results and the Main Water Storage Dam discharge results is associated with variations in stored volumes and total uncontrolled discharges from sediment dams at the end of each modelled rainfall year.

The modelled average number of days that discharges would occur from the Main Water Storage Dam is 72 days based on historical climate data and predicted site water demands. As noted above, this is lower than would occur under current 'Care and Maintenance' conditions but considered similar to the existing approved operations should there be limited storage available in the Invincible Underground workings (for instance due to prolonged wet weather).

Under the existing EPL, Castlereagh Coal is able to either discharge surplus water during wet weather to Cullen Creek (via licensed discharge point LD002 under EPL 1095) or pump surplus water to the underground voids. The modelled average daily discharge volume from the Main Water Storage Dam for the climatic period modelled is 1.85 ML per day. The discharges from LD002 must meet quality criteria prescribed in EPL 1095. As outlined in the EA, Castlereagh Coal proposes to continue to discharge surplus water from the site in accordance with the requirements of the EPL.

Sediment dams for the Southern Extension Project are proposed to be designed in accordance with Blue Book requirements to contain the 95th percentile 5 day runoff. Consistent with the design criteria, the water balance model predicts that on average the Southern Extension Project sediment dams will spill during prolonged or unusually intense periods of rainfall. The average number of spills from sediment dams that spill off site for the climatic period modelled is estimated to be less than one spill per year.

4.0 References

Department of Primary Industries, Water (2017). *NSW Farm Dams Calculator*. NSW Government
<http://www.water.nsw.gov.au/water-licensing/basic-water-rights/harvesting-runoff/calculator>

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