



RUSSELL VALE COLLIERY

Underground Expansion Project
Response to Public Hearing

for

Wollongong Coal Limited

February 2015

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RUSSELL VALE COLLIERY

UNDERGROUND EXPANSION PROJECT

RESPONSE TO PUBLIC HEARING

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1 OVERVIEW

1.1 BACKGROUND

Wollongong Coal Limited (WCL) owns and operates the Russell Vale Colliery (formerly known as NRE No. 1 Colliery). WCL seeks approval for the Underground Expansion Project (UEP) under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

A Project Application (MP 09_0013) for the UEP was made on 12 August 2009. This Project Application sought approval for the extraction of 11 longwalls in the Wonga East area and 7 longwalls in the Wonga West area. The Project Application was supported by the "*NRE No.1 Colliery Project Application (09_0013) Environmental Assessment*" (ERM, 2009) (UEP EA). The UEP EA was placed on public exhibition from 18 February 2013 to 5 April 2013. A total of 840 submissions were received from 2 regulators, two special interest groups and 826 individuals (446 of which were in support of the UEP and 380 were in objection).

In October 2013, WCL submitted a Preferred Project Report (PPR) to modify the application. The PPR made significant modifications to the UEP to reduce impacts on sensitive environmental features. The PPR proposed the following changes to the mine plan for the UEP:

- Removal of the Wonga West area from the proposed mine plan;
- Removal of Longwall (LW) 8 in the Wonga East area; and
- Amendments to the alignments and dimensions of the other longwalls in the Wonga East area.

The Preferred Project mine plan that is currently proposed comprises eight longwall panels (LW1-3, LW6-7 and LW9-11).

The PPR included a response to the submissions received during the public exhibition period.

The UEP PPR was provided by various NSW regulatory authorities for comment. Submissions were received from 10 regulatory authorities and three independent peer reviewers engaged by the Department of Planning & Environment (DP&E).

WCL responded to the regulatory submissions on the PPR in the *Preferred Project Residual Matters* Report (Residual Matters Report) (Hansen Bailey, 2014). The Residual Matters Report included new and revised studies to assess the impacts of the Preferred Project.

1.2 ENVIRONMENTAL ASSESSMENT REPORT

The Secretary of DP&E provided the *'Major Project Assessment: Russell Vale Colliery Underground Expansion Project (MP 09_0013) Secretary's Environmental Assessment Report'* (Assessment Report) in December 2014.

The Assessment Report concluded that:

> *"The Department has concluded that the preferred UEP would generate a number of positive benefits and that the predicted impacts can be effectively managed through the implementation of strict conditions. Consequently, the Department considers that the project is in the public interest and should be approved, subject to stringent conditions (p. 2)."*

1.3 PLANNING ASSESSMENT COMMISSION

On 9 December 2014, the Minister for Planning requested the Planning Assessment Commission (PAC) to conduct a review of the UEP, assessing the merits of the Project as a whole.

The PAC held a public hearing on 3 February 2015. WCL did not formally address the meeting, leaving the day entirely for individuals and Special Interest Groups (SIGs) to express their views.

This document responds to issues raised verbally in presentations at the public hearing. The PAC did not request any additional information to address issues raised by regulatory authorities or other matters following the public meeting.

Submissions and documentation referred to in presentations at the public hearing were not made available to WCL. Also, none of the written submissions were made publicly available (as at 17 February 2015) and were therefore not able to be considered in this document.

1.4 REPORT STRUCTURE

Section 2 outlines the key issues described in the presentations made by speakers at the public hearing on 3 February 2015 and provides a detailed response to each.

Section 3 provides a list of documents referred to in this response.

Appendix A provides a copy of the 'draft PAC's registered Speaker's List' (NB: each is allocated an individual number).

Appendix B provides a general list of issues raised by the speakers listed in **Appendix A**. This document provides a response to 'collated' issues where several speakers raised identical issues. The speaker numbers referenced in **Section 2** correlate with the speaker ID numbers in **Appendix A**.

Appendix C provides a copy of WCL's response to the federal Independent Environmental Scientific Committee's (IESC) Advice for the UEP (IESC 2014-057) dated 24 November 2014.

Appendix D provides a copy of the *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a) prepared for the Commonwealth application.

Appendix E provides a copy of the *Bellambi Gully Flood Study* (Cardno, 2015), which suggests measures to reduce the risk of flood impacts associated with Bellambi Gully.

Appendix F provides a copy of the supplementary Economic Assessment (Gillespie Economics, 2015) for the Preferred Project.

1.5 LIMITATIONS

This document has been prepared in reliance upon notes transcribed by WCL representatives at the public meeting. All reasonable efforts have been made to accurately represent the verbal submissions made by the Registered Speakers at the Public meeting.

As copies of written submissions were not provided to WCL for the purposes of verification of the information and data transcribed, WCL, while making every effort to ensure the issues have been accurately recorded, does not accept any liability for any incorrect recording or interpretation of any issues raised by any of the Registered Speakers.

This document has been prepared in conjunction with WCL and its' specialist consultants including: Biosis Pty Ltd (Biosis), Gillespie Economics, SCT Operations Pty Ltd (SCT) and GeoTerra Pty Ltd (GeoTerra).

2 RESPONSES TO PUBLIC HEARING ISSUES

This section provides a response to issues raised at the public meeting held on 3 February 2015. Issues raised are shown in italics with WCL's response in normal type.

Speaker issue numbers relate to the PAC's speaker's list as reproduced in ***Appendix A*** *and the list of issues raised by speakers at the public meeting is summarised in* ***Appendix B****.*

2.1 CATARACT RESERVOIR IMPACTS

Issues were raised in relation to impacts of the UEP on Cataract Reservoir.

Speakers stated that the UEP is 300 m from Cataract Reservoir. They further referenced a situation where mining occurred within 1.5 km of the Cataract Dam wall and caused it to move 30 mm. It was also suggested that the Dams Safety Committee (DSC) issues in relation to potential impacts to the reservoir had not been addressed.

It was suggested that if impacts to Cataract Reservoir occur, a desalination plant would need to be constructed at great cost to the NSW taxpayer.

Speaker IDs: 12, 20, 54, 56.

The mine plan for the UEP maintains a lateral setback from the full supply level (FSL) of Cataract Reservoir greater than 0.7 times the depth of cover (equivalent to a 35º angle of draw). Such a setback is considered by the DSC to be sufficient for protecting the stored waters of Cataract Reservoir.

Previous mining undertaken within 1.5 km of the dam wall resulted in movement of this structure. As a result, mining is now prohibited within 1.5 km of this structure. The nearest longwall panel is located more than 9 km south-east of the Cataract Dam wall. As a result, SCT advises that the UEP does not have the potential to result in any movement of the dam wall.

The predicted reduction in storage in Cataract Reservoir due to the UEP is approximately 6.83 ML/year through reduced stream baseflow to the reservoir, and 1.83 ML/year through depressurisation affecting the reservoir (GeoTerra / GES, 2014). These losses represent 0.009% of the full storage capacity of Cataract Reservoir (97,190 ML). Due to the negligible magnitude of the impact, the construction of a desalination plant is not warranted.

The DSC Notification Area is a risk management zone designed to give the DSC sufficient time to be notified of and respond to mining related issues before they have the potential to result in impacts. The DSC Notification Area is not an absolute restriction to mining. The DSC guidelines are based on a 35° angle of draw from the full supply level of the dam. The subsidence predictions have been clarified in the IESC Response (see **Appendix C**).

The geological structures are well understood at this site because they have been completely delineated in the Bulli and Balgownie Seams over the area of mining in these two seams. This delineation is not usually possible in single seam mining. The Corrimal Fault tapers out and does not extend close to the reservoir (Gujarat NRE Coking Coal Ltd, 2014). SCT advises that there has been no historic record of water entering the Bulli Seam workings through the Corrimal Fault. The fault tapers to the north-west and has only a small displacement in the vicinity of LW6.

Figure 1 shows a conceptual water balance diagram for the Cataract Reservoir catchment. Based on average annual rainfall, the catchment of Cataract Reservoir receives an average of 350 ML/day from rainfall. Of this amount, approximately 100 ML/day accumulates in the reservoir, where it is used to supply environmental flows or drinking water. The remaining 250 ML/day is lost from the water supply system through either evapotranspiration or infiltration into the groundwater system. The predicted inflows to the mine workings (up to 2.3 ML/day) are taken from the component of rainfall that is lost to infiltration. That is, mine inflows do not substantially affect the volumes of water that are available for water supply purposes or environmental flows.

2.2 DRINKING WATER CATCHMENT IMPACTS

Speakers expressed concern that no mining should take place within the SCA water catchment areas. References were made to the Chief Scientist's report stating that this is the only place in the world which allows mining under a publicly owned drinking water catchment area.

Speaker IDs: 2, 4, 6, 16, 17, 20, 24, 25, 29, 34.

Some speakers at the public meeting referred to the report of the Chief Scientist titled "*Measuring the cumulative impacts of all activities which impact ground and surface water in the Sydney Water Catchment"* (2014). The Chief Scientist's report states:

> *"It was noted that there are no international examples of longwall mining operating in publicly owned drinking water catchments but there are examples of it occurring under streams and aquifers connected to privately owned wells in the Appalachians of the U.S.A".*

The speakers correctly state that the Chief Scientist did not identify any other locations where longwall mining was being undertaken beneath a publicly owned drinking water catchment. However, the Chief Scientist's statement does not provide any opinion on the appropriateness of longwall mining beneath a drinking water catchment. The speakers have suggested that the lack of comparable examples is an indication that longwall mining is not acceptable within a drinking water catchment. The Chief Scientist does not draw any conclusion to this effect.

The Chief Scientist's report concludes that:

> *"The current cautionary approach by the Dams Safety Committee and other government agencies seems to be preventing development that could cause obvious disastrous cumulative impacts, and therefore there is no reason to stop longwall mining immediately. However, there is still significant uncertainty around cumulative impacts on water quantity and the recommendations above, if implemented, should help address this matter"* (p. 33).

The purpose of the Chief Scientist's report was to recommend measures for the Government to implement in order to improve the understanding of cumulative impacts on water catchments. The Chief Scientist's article did not purport to assess the acceptability of mining in a drinking water catchment.

2.3 WATER INFLOWS FROM MINING ADJACENT 'SPECIAL AREAS'

It was stated that there are significant inflows resulting from mining activities around the 'special areas'.

Several speakers noted that mining should not be approved in 'special areas'.

Speaker IDs: 2, 4, 12, 13, 20, 54.

The groundwater modelling has accounted for the storage of subsurface water in completed mine workings. A component of the predicted groundwater inflows is attributed to seepage from upgradient workings. The groundwater model predicts 0.2 ML/day of seepage to the Wonga East workings from upgradient workings within the decommissioned Bulli Colliery. The model also predicts 0.2 ML/day of seepage to the historical workings in the Wonga West area from upgradient workings in the decommissioned Cordeaux Colliery.

The DSC has a statutory responsibility to protect the stored waters of Cataract Reservoir and other reservoirs in the Southern Coalfield. The DSC has fulfilled this responsibility for more than 30 years by imposing minimum setback distances for mining operations near reservoirs. An angle of draw of 35° (or 0.7 times the depth of cover) has been found to be sufficient setback for protecting reservoirs. The UEP proposes a setback greater than 0.7 times the depth of cover.

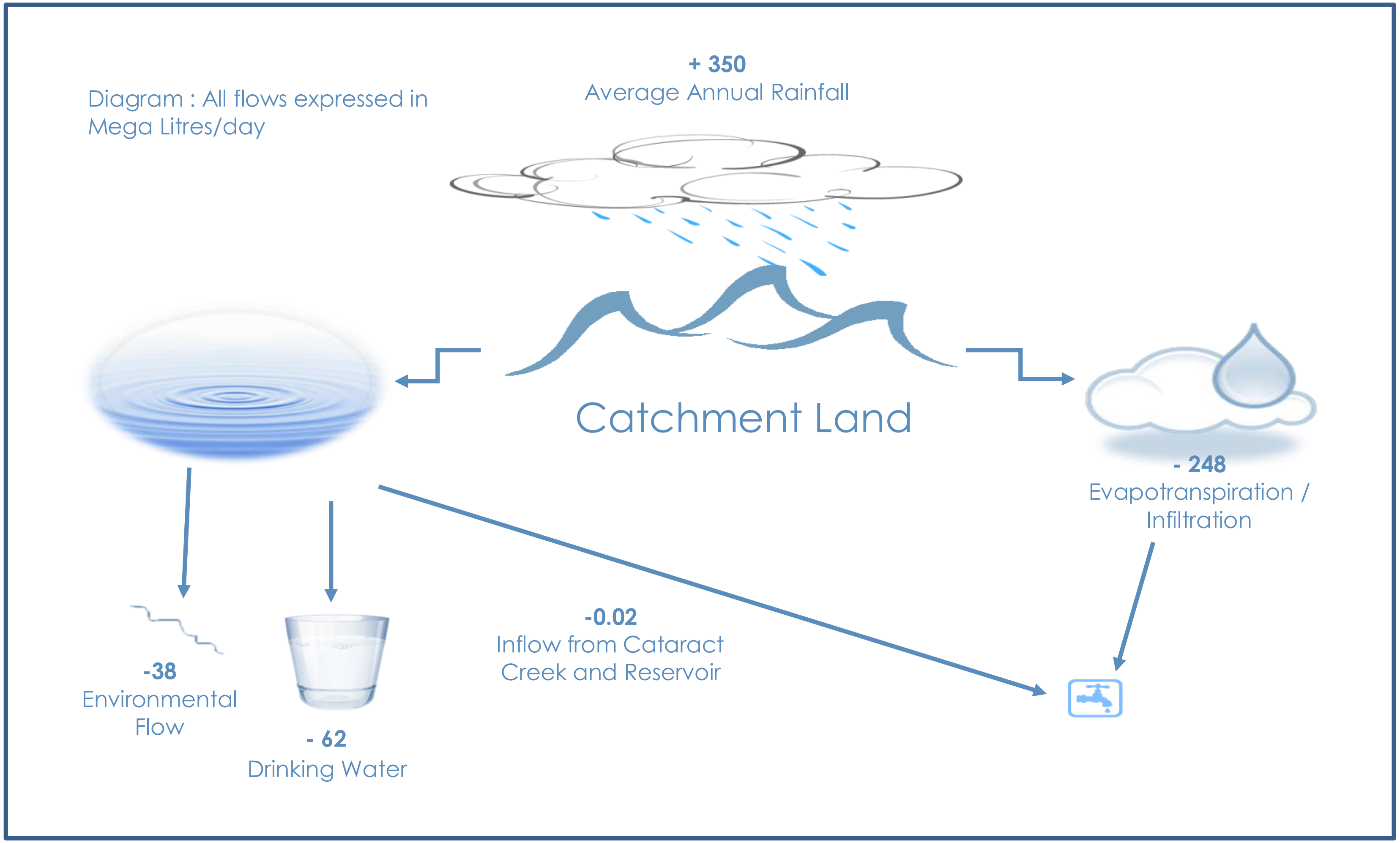

Figure 1
Conceptual Water Balance for Cataract Reservoir (WCL, 2014)

2.4 GROUNDWATER DRAWDOWN EFFECTS NOT QUANTIFIED

It was noted by a speaker that inputs to downstream outflow from swamps had not been adequately quantified.

Speaker ID: 8.

GeoTerra advises that the downstream outflow from swamps was not calculated in the groundwater model as they are contained within thin and regionally isolated (on an overall model scale) lithological units that are separated from the underlying regional groundwater system by unsaturated strata. These swamps are effectively too small for the model to “see” in its current set up as the objective of the modelling was to assess the local and regional scale groundwater impacts.

The swamps were not assessed in the current model for the following reasons:

- The minimum cell size is 25 m x 25 m wide x 20 m thick, and the data within each cell is an amalgam of all lithologies, so any groundwater changes that may occur within a swamp are a collective of all lithological responses within each cell. Setting up a swamp specific model would require a much smaller cell size to exclude non swamp areas;
- The swamps are a maximum of 2 m thick, so the current surface cell thickness of 20 m is too thick to exclude all non-swamp lithological responses. A minimum cell thickness of 0.5 – 1.0 m would be required;
- There is insufficient data on the distribution of hydraulic conductivity, water level variability and variability of lateral and vertical position of the swamp / sandstone interface to support realistic modelling of the swamps;
- There are constraints associated with accessing the swamps to install deep / shallow paired piezometers inside or in the vicinity of the swamps; and
- There is insufficient data on swamp discharge outflows to streams, and it is logistically difficulty to get realistic monitoring as the majority of swamp discharge occurs as sheet flow through highly vegetated terrain with no definitive out flow path constrictions.

Additional stream flow monitoring locations along Cataract Creek and its tributaries were established in 2014 to gather data on outflows from upland swamps (see **Section 2.5**).

2.5 ROLE OF SWAMPS IN CATCHMENT YIELD

A concern was raised that the role of swamps in catchment surface water yield should be studied and quantified.

Speaker IDs: 4, 8.

WRM (2014) determined that upland swamps represented 0.9% of the catchment area of Cataract Reservoir. As a result, upland swamps provide only a minor contribution to catchment yield. As a key swamp of concern, GeoTerra estimates that swamp CCUS4 is yielding less than 0.01 ML/day at its downstream edge for less than two weeks after heavy rain.

Based on observations of the sheet wash discharging from swamp CRUS1, GeoTerra determined that CRUS1 is yielding very minor flow from the catchment above the UEP.

The surface water yield from swamps is being studied through the installation of an additional eight piezometers and associated soil moisture probes in swamps CRUS1, CCUS4 and CCUS5. Monitoring data to date indicates that CRUS1 is a very shallow swamp that drains to Cataract River. The portion of swamp CRUS1 overlying LW6 has no moist humic organic matter, is generally dry and has a very shallow (<0.4 m) colluvial sandy clay soil profile. As a result, swamp CRUS1 does not yield significant delayed drainage after rainfall events. Both CCUS4 and CCUS5 are well developed swamps with substrate depths of up to 1.84 m and 1.31 m, respectively, with typical moist, humic black / brown sandy clay swamp facies.

Monitoring of outflows from CCUS4 indicates that the swamp only discharges water after significant rainfall events. Two periods of outflow have been identified since monitoring commenced in December 2014. The first outflow period occurred for 3 days following 2.4 mm of rainfall. The total outflow over this 3 day period was determined to be 0.04 ML. The second outflow period occurred for 6 days, during which there was 13.4 mm of rainfall. Approximately 0.25 ML of outflow was measured over this 6 day period. WCL will continue this monitoring.

A further eight piezometers were installed in the swamps to the north of Cataract Creek during November 2014 in BCUS4, CCUS10 and CUS12. These additional piezometers complement the existing monitoring network of 18 swamp piezometers. In addition, seven surface water flow monitoring tributary and main stream weirs have recently been installed in the tributary outflow channels of the swamps to the south of Cataract Creek.

2.6 HISTORICAL LONGWALL MINING IMPACTS

Historical examples of negative impacts from other projects were raised including the Blue 4 panel inundation, Waratah Rivulet and Burial of longwall at Wongawilli Mine which were deemed to be low probability occurrences but with high consequences.

Speaker IDs: 8, 12, 13, 22, 24, 32.

SCT explains that the Blue 4 panel inflow occurred approximately 30 years ago at shallow depth through a geological structure within half depth of the reservoir. The basis for determining setbacks / barriers for mining was changed as a result of this event and there have been no similar events since these reforms.

The example of mining directly under Waratah Rivulet at Metropolitan Mine is not applicable to the UEP due to important differences between Metropolitan Mine and the Wonga East mining domain at Russell Vale Colliery. Firstly, Metropolitan Mine conducted longwall mining directly under Waratah Rivulet. Mining directly beneath a stream involves a greater risk of stream bed cracking. In contrast, the UEP does not involve any mining directly beneath the main channel of Cataract Creek.

Secondly, Waratah Rivulet is hosted within Hawkesbury Sandstone, which is prone to delamination resulting in subsurface flow of water. As explained in GeoTerra / GES (2014), the 3rd and 4th order sections of Cataract Creek are hosted within the massive Bulgo Sandstone and Bald Hill Claystone units, which are notably less susceptible to cracking than Hawkesbury Sandstone. The main channel of Cataract Creek has not been subject to any stream bed cracking, stream flow loss or pool level reduction as a result of previous direct undermining in both the Bulli and Balgownie coal seams.

The burial of the longwall at Wongawilli Mine is an unrelated event that has no potential to impact surface features or groundwater systems.

2.7 CORRIMAL FAULT

Some submissions suggested that there was a potential for a direct hydraulic connection between the Corrimal fault and water resources.

Speaker IDs: 4, 8, 56.

The Corrimal Fault does not exist below the reservoir and is located below a topographic ridge remote from the reservoir. SCT advises that there is no credible pathway between the reservoir and the mine workings via the Corrimal Fault.

The Corrimal Fault has been previously intersected by workings in the Bulli Seam and the Wongawilli Seam, yet there is no evidence of inflows. The UEP is not considered to have potential to cause significant movement on the fault.

2.8 TRIPLE SEAM MINING CERTAINTY

Queries were raised in relation to the ability of the subsidence predictions to model impacts with certainty in relation to triple seam mining.

Speaker IDs: 4, 6, 16, 48.

SCT explains that subsidence modelling is based on measured subsidence values for the mining of LWs 4 and 5, where three seams have been extracted.

The monitoring results indicate that there are differences in subsidence behaviour associated with triple seam mining compared to single seam mining, but there are also many similarities. Longwall panels 1, 2, 3, 6 and 7 are located beneath previous second workings in the Bulli and Balgownie seams. Subsidence resulting from these longwall panels is not expected to be greatly different in character to the measured subsidence behaviour above LWs 4 and 5 (which the predictions are based on).

The groundwater model predicted maximum mine inflows of approximately 2.3 ML/day (840 ML/year) during the UEP (GeoTerra / GES, 2014). The major component of the inflows is sourced from the coal seam and previous workings. Only a very minor proportion of the inflows is derived from surface water systems.

2.9 MONITORING DATA

It was stated that limited data had been gained from previously mined longwall panels LW4&5. Further speakers noted that more groundwater data was needed.

Speaker IDs: 4, 8, 12, 16, 25, 30, 34, 35, 46.

The groundwater effects associated with mining of LWs 4 and 5 (and previous overlying workings) were monitored by piezometers GW1 (vibrating wire piezometer array) and GW1A (open standpipe piezometer). The data collected (post LW4 extraction) was used to set up the groundwater model (Geoterra / GES, 2014).

WCL has recently installed additional vibrating wire piezometers and open standpipe piezometers (RV16, 17, 18, 19, 22) over completed mine workings. WCL has also installed piezometer RV20 in an area of triple seam mining over LW4. These new monitoring locations, in association with the pre-existing piezometers, will be used further improve understanding of the effects of triple seam mining on groundwater systems.

Initial indications are that RV16 is notably depressurised between 197 m to 242 m below ground level (mbgl) in the Stanwell Park Claystone to Scarborough Sandstone region. RV17 has been observed to be depressurised in the lower Hawkesbury Sandstone to upper / mid Bulgo Sandstone region (to the lowest intake at 80 mbgl). RV22 is observed to be depressurised in the Hawkesbury Sandstone to Scarborough Sandstone region (to the lowest intake at 230 mbgl). RV23 has been observed to be depressurised in and below the Bulgo sandstone at 90 mbgl.

2.10 PRECAUTIONARY PRINCIPLE

It was stated that the precautionary principle had not been demonstrated for the UEP.

Some speakers suggested that the benefits do not outweigh the risks of the UEP.

Speaker IDs: 2, 22, 32.

The precautionary principle is defined under section 6 of the *Protection of the Environment Administration Act 1991* (POEA Act). The precautionary principle states that:

> *"if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation".*
>
> *In the application of the precautionary principle, public and private decisions should be guided by:*
>
> *(i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and*
> *(ii) an assessment of the risk-weighted consequences of various options".*

In the case of *Telstra Corporation Ltd v Hornsby Shire Council [2006] NSWLEC 133*, Chief Justice Preston noted that section 79C of the EP&A Act required that consent authorities have regard to the public interest, which in turn obliged them to have regard to the principles of Ecologically Sustainable Development, one of which is the Precautionary Principle.

In relation to the Precautionary Principle, Preston CJ held it was to be triggered by two cumulative threshold tests or conditions precedent:

- Threat of serious or irreversible environmental damage; and
- Scientific uncertainty as to the environmental damage.

In these circumstances, Preston CJ held that there was a shifting of the burden of proof on the question of environmental damage, where the proponent must demonstrate that the threat of serious or irreversible environmental damage is negligible.

The precautionary principle is only invoked where there is a lack of full scientific certainty. It is acknowledged that there is a degree of scientific uncertainty over the impacts of subsidence on upland swamps (Biosis, 2014a). A precautionary approach was therefore adopted during the development of the mine plan. The changes to the mine plan described in the PPR resulted in a 4.7 ha reduction in the areas of upland swamps that are directly undermined.

2.11 IMPACTS TO SWAMPS OF SPECIAL SIGNIFICANCE

Speakers noted that the 'drier swamps' were just as significant as 'wetter' swamps. It was further suggested that prior mining activities contributed to the 'dryness' of some 'swamps'. Comparisons to impacts from other mining projects in the Southern Coalfield, including impacts to Swamp 1 and Swamp 15b in Dendrobium, were made.

Speaker IDs: 8, 12.

The concept of 'special significance' of upland swamps was first raised Southern Coalfield Inquiry and developed in the PAC report for the Metropolitan Coal Project (2009) and Bulli Seam Operations (2010). The initial concept of 'special significance' was to identify upland swamps that deserved a higher level of protection and conservation due to unique features, such as substantial size, unusual complexity, contiguous habitat, presence of an EEC or threatened species, etc.

In this context, not all upland swamps should be considered 'significant', and drier swamps are likely to be less significant than wetter swamps due a variety of features, including lower contribution to catchment yield, less diverse vegetation, and exhibit a lower potential to support threatened species. The Southern Coalfield Inquiry recognised that to maintain a viable community of swamps does not require the protection of all upland swamps.

The concept of special significance (now adopted by OEH and Department of the Environment) uses six criteria to assess the significance of upland swamps. This assessment was designed to identify upland swamps requiring further assessment and protection. This significance assessment identified that some upland swamps would be considered to be of 'special significance' despite not supporting a significant perched water table and providing little overall contribution to ecosystem function and catchment yield. Whilst the concept of significance is now well established, it does not necessarily recognise the potential for impact. Coastal upland swamps have since been listed as an EEC under both NSW and Commonwealth legislation. A greater level of protection is provided to EECs.

Upland swamps that do not support a significant perched water table are at a lower risk of impact when compared to swamps that do. Further, the contribution of 'drier swamps' to overall catchment yield and water quantity and quality, as well as habitat for threatened species, is likely to be much lower than larger 'wetter' swamps in other areas. This is supported by recent data showing that CCUS4 is yielding less than 0.01 ML/day at its downstream edge less than two weeks after heavy rain. Swamp CRUS1 is yielding no flow from the section above LW6.

The listing of coastal upland swamps under NSW and Commonwealth legislation requires more detailed assessment of impacts and commitment to the principles of avoidance, minimisation and mitigation of impacts.

A lack of past monitoring data makes it difficult to make firm conclusions regarding the degree of impact from prior mining activities. However, the assessment of the historic impacts to upland swamps in the study area from mining of the Bulli and Balgownie seams indicates that the majority of upland swamps in the study area have been subject to subsidence criteria sufficient to have placed these upland swamps at risk of negative environmental consequences (Biosis, 2014a). Despite this, some swamps maintain a perched water table (e.g. CCUS4). The assessment of historic impacts to upland swamps is provided in the *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a) which is included as **Appendix D**.

In its peer review of the UEP, Evans & Peck undertook an assessment of water levels in each upland swamp to determine whether there was evidence of impact. Their review identified that water levels in some upland swamps appeared to drain more rapidly than expected, whilst others showed no signs of increased drainage rates. This result was mixed between 'drier' and 'wetter' swamps. However, it is equally possible that many of the 'drier' swamps have little storage capacity due to a lack of humic matter with numerous shallow outcropping or subcropping sandstone, resulting in more rapid drainage than swamps with more humic material and deeper soils.

Data from the swamp impact assessment indicates that not all swamps subject to levels of tilts >4 mm/m, tensile strain >0.5 mm/m, compressive strain >2 mm/m and valley closure >200 mm will be impacted.

Whilst discussion of impacts to upland swamps in other areas is useful to inform the planning process, any discussion must be placed in context. Swamp 1 at Dendrobium Mine is comparable to upland swamps in the UEP. However, Swamp 15b at Dendrobium Mine is much larger in size, has a much greater catchment area, is a valley in-fill swamp and supports a much more significant water table and significant outflow at the base of the swamp. Upland swamps in the UEP area are smaller, have smaller catchment areas, are headwater swamps, support a less significant water table and have much smaller outflows. In addition, longwall panels in Dendrobium Area 3A are 300 m wide compared to the 140 m wide panels for the UEP. Therefore, comparison between these areas and the potential impacts to upland swamps arising from these two projects should be made with a high degree of caution.

2.12 REMEDIATION OF SWAMPS OF SPECIAL SIGNIFICANCE

Some comments were made that swamps have not been shown to be able to be successfully remediated and as such, impacts from mining should not be approved.

Speaker IDs: 12, 23, 30, 39, 48, 54.

Environmental impact assessment principles require proponents to avoid, minimise and mitigate impacts to the environment when considering impacts of a development. WCL has undertaken substantial redesign of the UEP mine plan in an attempt to avoid impacts to upland swamps, and other significant natural features. This redesign has reduced the coal resource by 26.4 million tonnes compared to the original proposal.

Minor amendments to longwall layouts have further minimised impacts to upland swamps. Any further amendments to the mine plan have a potential to render the project uneconomic.

To mitigate impacts, a detailed monitoring program will be implemented including 3D subsidence monitoring, a network of shallow piezometers to monitor water levels, a network of weirs to monitor base flow from upland swamps and inflows into Cataract Creek, soil moisture probes, local weather stations, and vegetation monitoring. An adaptive management plan will be developed to use the monitoring program to detect the need for adjustment to future mining operations so that the subsidence predictions are not exceeded and subsidence impacts creating a risk of negative environmental consequences in upland swamps are minimised.

Whilst it is recognised that remediation of upland swamps is difficult to achieve, WCL has shown a strong commitment to the principles of avoidance, minimisation and mitigation of impacts.

2.13 OFFSETTING SWAMPS OF SPECIAL SIGNIFICANCE

It was noted that the Coastal Upland Swamps were of such significance that it is not adequate to offset any impact from the UEP. It was noted that 'swamps' are not like other EECs and should be assessed and managed differently. In relation to offsetting, it was noted that as the majority of 'swamps' are on public land, how could any required offset be achieved by WCL.

Speaker IDs: 2, 4, 8, 16, 22, 23, 25, 30, 32, 35, 39, 53.

As explained in **Section 2.12**, WCL has followed the principles of avoid, minimise and mitigate impacts. Any residual impacts that cannot be avoided would be offset. The principle of offsetting requires gains in the quality of protected and managed vegetation at an offset site to offset the impacts of development. Therefore, gains at any offset site would need to be proportional to the losses at the development site.

The NSW Government has recently released the NSW Biodiversity Offset Policy for Major Projects (the Offset Policy). The Offset Policy sets out the requirements for the provision of offsets for ' major projects' in NSW. This application is being assessed under Part 3A of the EP&A Act, and is therefore considered a 'major project'.

The Offset Policy recognises that guidance around certain types of impacts, where direct clearing does not occur, is difficult to provide. This includes subsidence associated with mining developments. It is difficult to provide guidance as longwall mining projects do not result in direct impacts (i.e. clearing of vegetation). It is also difficult to assess 'losses' in upland swamps, as assessment of historic impacts from mining indicates that although fracturing of the base of upland swamps may occur, this does not necessarily result in the loss of upland swamps. Therefore, offset ratios adopted for other mining projects should not be applicable to indirect impacts to upland swamps from longwall mining projects. In this respect, impacts to upland swamps due to mining induced subsidence are not like impacts to other EECs. If required, any offsets would need to be proportional to the degree of impact.

The Offset Policy also recognises that in some circumstances, like-for-like offsets may be difficult to obtain. In these instances, supplementary measures may be funded. Supplementary measures include actions outlined in recovery plans, actions that contribute to threat abatements plans, biodiversity research and survey programs and rehabilitation (OEH, 2014).

Draft Condition 3 under Schedule 3 of MP 09_0013 requires WCL to obtain offsets for any impacts which are greater than the specified performance measures (as per the predictions) and cannot be reasonably or feasibly remediated, or if measures implemented by WCL to remediate a specific issue have failed to work satisfactorily. If any impacts greater than those predicted are encountered, WCL will provide appropriate offsets in accordance with this condition, to the satisfaction of the Secretary of DP&E.

Biosis advises that whilst changes in piezometric pressure indicate changes to the water table within upland swamps, assessment of historic impacts indicates that despite potential fracturing of the bedrock beneath upland swamps due to past mining, some upland swamps still support a healthy and diverse ecosystem. For this reason, changes in piezometric pressure should not be used as the sole criterion for impacts to upland swamps. The detailed upland swamp monitoring program being implemented will assist in determining the overall impacts of subsidence on upland swamps. This information will allow additional information to incorporate into any future mining proposals.

2.14 ECONOMIC SIGNIFICANCE OF SWAMPS

A BHP 2009 social economic assessment was referred to which noted that swamps had an economic value of approximately $2M/hectare and as such, the benefits of the UEP would be limited.

Speaker ID: 4, 22, 27, 36, 48.

The socio-economic assessment for the Bulli Seam Operations Project assessed the community values associated with impacted upland swamps at $2 M/hectare. This figure was determined through Choice Modelling and is based on one survey for a different project in the past.

Gillespie Economics advises that this figure represented what the community were willing to pay to avoid impacts to upland swamps. The study did not take account of the principle of diminishing marginal utility - that as more and more areas of upland swamp are protected the community's value for the remaining swamps will reduce.

WCL has avoided mining beneath 4.7 ha of upland swamps by altering the mine plan for the UEP. If the value of $2 M/hectare is applied to the UEP, the avoidance measures adopted by WCL have resulted in a potential saving of $8.2 M. The impact of the Project on upland swamps is discussed in **Section 2.11**.

2.15 WCL ENVIRONMENTAL & SAFETY COMMITMENTS

It was suggested that the previous owners of Russell Vale Colliery had not met commercial obligations to its workforce, contractors or regulators; and as such should not be granted approval of the UEP. Some speakers indicated that WCL does not have the intention or ability to meet its obligations.

Speaker IDs: 2, 3, 16, 54, 55.

WCL was formerly known as Gujarat NRE Coking Coal Limited and was a subsidiary of Gujarat NRE Mineral Resources Limited. On 15 November 2013, there was a change in principal shareholder and subsequent management change. The proponent subsequently changed its name to WCL in February 2014.

WCL advises that with the full support of the principal shareholder, it has met all prior liabilities and will meet all requirements in the future.

2.16 PIECEMEAL APPROACH TO APPROVALS

Speakers noted that WCL's approach to planning approvals at Russell Vale Colliery has been 'piecemeal'.

Speaker IDs: 6, 16, 20, 23, 24, 27, 29, 48, 49, 53.

The significant retraction of the mine plan in the PPR was made in response to subsidence monitoring results for LWs 4&5 and stakeholder concerns. WCL recognised that the longwall layout needed to be re-designed to minimise impacts on sensitive environmental features. Although the retraction of the mine plan has reduced the coal resource for this proposal, the UEP will nevertheless allow for the development of an economic resource for up to 5 years.

The UEP will allow operations at Russell Vale Colliery to continue until further mine planning is completed. The UEP will maintain employment of the existing workforce and economic benefits to the region and state.

2.17 COMMITMENTS

Some non-compliances with previous approval requirements were also noted as not being met (particularly the Bellambi Gully realignment, riparian restoration and flood assessment) and as such, the UEP should not be granted to WCL.

It was also stated that if any approval was granted, WCL must be made to meet its commitments and penalised if not achieved.

Speaker IDs: 3, 6, 11, 33, 45, 46, 48, 54.

WCL obtained approval for a realignment of Bellambi Gully as part of the Preliminary Works Project (MP 10_0046). WCL has investigated alternative measures to control the flood risks associated with Bellambi Gully, and as such, a channel realignment is not required. To support this position, Cardno (2015) (see **Appendix E**) has undertaken a Flood Study for the Bellambi Gully catchment to assess existing flood conditions and to determine the necessary flood mitigation measures. The Flood Study modelled a number of scenarios to assess flooding through the site, and has taken into account the blockage criteria contained within the *Wollongong Development Control Plan 2009* (see **Appendix E** for Wollongong City Council correspondence supporting the study).

It has been concluded that overland flows are mainly contained within the stockpile area before continuing as sheet flow downstream towards Bellambi Lane.

Consistent with Draft Condition 11 under of Schedule 4 of the draft Project Approval, WCL will implement the following flood controls recommended by Cardno (2015):

- Upgrade stockpile area access road and upgrade culvert;
- Install debris control structures at the inlet of the 1,800 mm pipe; and
- Formalise swale in the vicinity of the 600 mm pipe.

2.18 AMENITY ISSUES

Some speakers referred to existing operational amenity issues from the pit top (specifically two new 140,000 tonne stockpiles) and coal haulage which included air and noise impacts (and resulting health impacts), water discharge, traffic noise and hours of operation.

It was suggested that Russell Vale was not located in an appropriate location, being in close proximity to residences, a childcare centre and a school. Speakers also criticised WCL for not implementing quieter reversing alarms on all vehicles. A speaker also stated that the ERM EA (p21) stated that the 'emplacement area' would not be used.

Speaker IDs: 11, 24, 45, 46, 48.

WCL will continue to manage amenity impacts in accordance with its existing management plans which shall be amended to ensure the best practice commitments in the UEP documentation is included.

WCL has established a real time air quality and noise monitoring program as part of its Noise Management Plan and Air Quality and Greenhouse Gas Management Plan. The new air quality monitoring network includes monitoring of PM_{10} and $PM_{2.5}$. WCL has also extended its depositional dust network to include monitoring at three local schools in the area to provide better background data on local dust levels and coal particle distribution from Russell Vale Colliery. Dust gauges have already been installed in two of the three schools. The final gauge has not yet been installed.

New quieter reversing alarms or modifications to existing reversing alarms have been fitted to underground personnel transport vehicles that regularly access the surface and have significantly reduced the noise emitted during reversing. Testing of the surface storage yard forklift undertaken by a specialist noise consultant confirmed that no additional work was required to quieten that vehicle. All but one vehicle in the stockpile heavy equipment fleet has had new quieter reverse alarms fitted. The one vehicle that has not been refitted is currently locked out of use until the new alarms are fitted.

The ERM EA (p. 21) states:

> *"Emplacement Area*
> *The Russell Vale Emplacement Area (RVEA) land is jointly owned by Wollongong City Council (WCC) and Gujarat NRE Coking Coal Ltd and lies north of the Russel Vale site. All but a small section of the RVEA is located outside the lease area and outside the PAA. The RVEA operates under a development consent from Wollongong Council, which allows refuse to be emplaced on the site from the workings of the NRE No.1 Colliery (see Section 4.7.1). Since 1986, a section of the RVEA has been used as a golf course.*
> *The long term intention of this area, as reflected in the current Development Consent D89/839, is that the entire freehold area will be eventually used for recreational purposes as a golf course."*

There is no intention to use this emplacement area as part of the UEP. In order to comply with D89/839, WCL is required to complete the RVEA to approved final landform contour levels utilising the material that is dry screened and crushed as part of the existing mining operations at Russell Vale Colliery.

The purpose of the statement that there "*is no intention to use this emplacement area as part of this Project*" (p. 21 of the EA) was to explain that the RVEA was developed under a separate DA granted by Wollongong City Council, and therefore was not a component of the UEP. This statement was not intended to communicate that Russell Vale Colliery would not continue to emplace dry screened and crushed material from its operations to ensure it maintained compliance with its obligations to meet final landform levels as required by DA 89/839.

2.19 AMENITY ISSUES – BELLAMBI LANE

A speaker stated that no monitoring or management measures were implemented to protect neighbours from exhaust fumes or reversing alarms from WCL contracted trucks on Bellambi Lane.

A neighbour stated that there was no noise monitoring on Bellambi Lane and that there is no criteria in place for the south side of Bellambi Lane. The neighbour also requested 24 hour air quality monitoring on Bellambi Lane and stated that a dust monitor was on the property but not monitored.

Speaker IDs: 3, 11, 24, 45, 46.

WCL will continue to manage amenity impacts in accordance with its existing management plans which shall be amended to ensure the best practice commitments in the UEP documentation are included.

WCL has established a real time air quality and noise monitoring program as part of its Noise Management Plan and Air Quality and Greenhouse Gas Management Plan. The new air quality monitoring network includes monitoring of PM_{10} and $PM_{2.5}$. WCL has also extended its depositional dust network to include monitoring at three local schools in the area to provide better background data on local dust levels and coal particle distribution from Russell Vale Colliery. Dust gauges have already been installed in two of the three schools.

There is currently no 24-hour noise monitor located along Bellambi Lane. However, WCL has included a site along Bellambi Lane in its Quarterly Attended Noise Monitoring program. There are dust deposition gauges located at three residential locations along the northern and southern extent of Bellambi Lane. There are currently no 24-hour PM_{10} air quality monitoring devices or diesel exhaust fume monitoring devices along Bellambi Lane.

WCL is unaware of any existing RMS noise, dust or fume monitoring installed along Memorial Drive or the M1 despite the high volume of diesel traffic that utilises these roads.

2.20 MINING SOCIAL & ECONOMIC BENEFITS

It was suggested that mining employs only a small percentage of the workforce in the Illawarra region and NSW. Some speakers suggested that the UEP was a short term benefit.

Speakers noted that Blue Scope steel would not benefit from the UEP.

Some speakers further stated that mining should be phased out as an industry in NSW.

Speaker IDs: 4, 17, 27, 32, 53, 57.

Mining is a significant industry for both NSW and the Illawarra Region. Mining in the Illawarra Region directly generates 1,738 full-time equivalent jobs, $1.1 B in wages and $1.2 B in direct spending on goods and services, local councils and community groups. Total employment estimated to be supported by the mining sector is 18,422 or 9.3% of the region (NSW Minerals Council 2014, NSW Mining Industry Economic Impact Assessment).

As explained in **Section 2.14**, significant economic benefits will accrue from the UEP.

Speakers claimed that the Assessment Report (DP&E, 2014) incorrectly states that the Bluescope Steelworks at Port Kembla would benefit from the UEP. Russell Vale Colliery does not provide any coal to Bluescope Steel.

However, the Assessment Report (p. 3) states that Bluescope Steel is supported by mines in the Southern Coalfield, not Russell Vale Colliery specifically. Therefore, the Assessment Report does not incorrectly establish a relationship between Russell Vale Colliery and Bluescope Steelworks.

2.21 COST OF ASSESSMENT

It was suggested that the cost to taxpayers to assess the approval by IESC, PAC, regulators and the community was excessive.

Speaker ID: 32.

WCL has paid the application fee for the UEP as required under clause 245K of the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation).

In addition, WCL is also subject to fee recovery arrangements for its application under the EPBC Act, in accordance with Division 5.6 of the *Environment Protection and Biodiversity Conservation Regulations 2000* (Commonwealth). These fees are utilised to fund the assessment of UEP by the relevant regulators.

2.22 SOUTHERN COALFIELDS INQUIRY

It was stated that the 2008 Southern Coalfields Inquiry had been ignored by DP&E.

Speaker IDs: 20.

DP&E considers the recommendations of the Southern Coalfield Inquiry in Section 3.3 of the Assessment Report (2014). DP&E also considered the PAC reports for the Metropolitan Coal Project (2009) and Bulli Seam Operations Project (2010), both of which adopted the concept of 'special significance' described in the Southern Coalfield Inquiry.

However, DP&E explains that subsequent to these PAC merits reviews, coastal upland swamps have been listed as an Endangered Ecological Community (EEC) under both NSW and Commonwealth legislation. OEH has released the *NSW Biodiversity Offset Policy for Major Projects*. DP&E supports the approach outlined in this offset policy for minimising, mitigating and remediating impacts to EECs.

2.23 NSW CHIEF SCIENTISTS REPORTS

Numerous references were made to comments in the Chief Scientist's Reports.

It was the interpretation of a speaker that the Chief Scientist intended that were was no need to stop currently approved mining, however this should not apply to current and future proposals.

Further, it was noted that this report stated that there was insufficient cumulative data to assess projects.

Speaker IDs: 20, 23, 34.

As explained in **Section 2.2**, the purpose of the Chief Scientist's report (2014) was to recommend measures for the government to improve the understanding of cumulative impacts on water catchments. The Chief Scientist stated that although there is currently uncertainty regarding cumulative impacts on water resources, the controls adopted by government agencies are sufficient to prevent unacceptable cumulative impacts.

The Chief Scientist concludes that "therefore there is no reason to stop longwall mining immediately" (p. 33). There is no basis for reading this statement as an acceptance of only existing mines.

2.24 INDEPENDENT COMMISSIONED ASSESSMENT

A speaker referred to four independent peer reviews commissioned by the Environmental Defenders Office (EDO).

Speaker ID: 4.

The reports were not provided to WCL and therefore cannot be responded to.

2.25 MINING INDUCED EARTHQUAKES

A speaker suggested that mining activity has induced earthquakes.

Speaker ID: 20.

SCT advises that micro-seismicity is commonly observed as part of mining activities because it is associated with the release of energy associated with rock fracture. The energies released in coal measure strata are typically events of less than about 1-2 on the Richter Scale. These events are usually imperceptible.

SCT is aware of three events in the last 25 years that have occurred in the vicinity of mining activity and with an intensity that was sufficient to be felt by people. Only one of these events (in the Hunter Valley) was clearly linked to mining, was sufficient to cause minor damage, and had a magnitude in the range 3-4.

The other two events (in the Southern Coalfield) were of a magnitude sufficient to be perceptible but not sufficient to cause damage. Both of the events in the Southern Coalfield were centred much deeper (kilometres deep) than the mining horizon at 300-500 m and appear to be coincidental with mining rather than caused by mining.

The Newcastle Earthquake in 1989 had a magnitude of 5.6 on the Richter Scale, with an epicentre about 15 km south of the Newcastle central business district at an estimated depth of 11 km (http://www.ga.gov.au/scientific-topics/hazards/earthquake/basics/historic). The deepest mining in the area is of the order of 300 to 400 m deep. Mining activity is well above the level of the geological fault structures that caused this event. The changes in stress caused by mining activity are insignificant by comparison with those at a depth of 11 km.

2.26 ECOLOGICAL OFFSETS ADEQUACY

Some speakers comments that there would be net loss of habitat if the UEP was approved.

Speakers had concerns in relation to the NSW Government's offset policy and stated that monetary contributions were not suitable to offset swamps which may be impacted by the UEP. Like-for-like offsets within the Southern Coalfields should be required, if the UEP was approved.

Speaker IDs: 2, 4, 8, 16, 22, 23, 30, 32, 35, 39, 53.

The NSW Office of Environment and Heritage has recently released the NSW Biodiversity Offsets Policy for Major Projects (OEH, 2014). This policy clearly outlines a process that proponents of major projects must follow during the biodiversity assessment process. The principles underpinning the policy requires proponents to ensure any offset requirements sit within a hierarchy of avoid, minimise and offset. As outlined in **Sections 2.10, 2.11, 2.12** and **0**, WCL has undertaken significant steps to avoid and minimise impacts to upland swamps, consistent with the principles of this policy.

The Major Projects Offset Policy also requires the use of like-for-like offsets, but allows for variations where like-for-like offsets are not available.

As noted above in **Section 0**, Draft Condition 3 under Schedule 3 of MP 09_0013 requires that WCL to obtain offsets for any environmental impacts which exceed specific performance measures and that it is not reasonable or feasible to remediate. Offsets would also be required if measures implemented by WCL to remediate a specific issue have failed to work satisfactorily. If required under this draft condition, WCL are required to implement any appropriate offsets to the satisfaction of the Secretary of DP&E.

2.27 ECOLOGICAL SURVEY INADEQUACY

A speaker was commissioned by the EDO to undertake a terrestrial fauna study peer review. The review considered Annex S of the ERM EA. It criticised survey effort in relation to various fauna species and recommended further investigations be undertaken.

Speaker IDs: 52.

This paper commissioned by the EDO was not made available for WCL to respond to.

The review undertaken appeared to focus on Annex S of the ERM EA and was critical that a full suite of survey techniques was not applied. Since this time, a number of additional surveys have been undertaken to supplement and update data obtained by ERM. These surveys have been undertaken in a manner consistent with the recommendations of the PAC reports for the Metropolitan Coal Project and Bulli Seam Operations Project, which concluded that impacts to terrestrial environments (and associated species) were negligible, and that surveys should focus on those significant natural features at greatest risk of impacts, and species associated with them.

Additional surveys have focused on documenting the impacts to rocky environments (cliffs and rocky outcrops), streams and creeks and upland swamps. Comprehensive detailed and targeted surveys have been undertaken of all significant natural features within the UEP area. These surveys did not identify any significant habitat for threatened species, other than habitat for the Giant Dragonfly, and therefore concluded that the potential for impacts to the majority of threatened species was low. The species identified by the speaker were thoroughly considered and no significant habitat was located (Biosis, 2013, 2014a, 2014b).

The biodiversity surveys undertaken as part of the UEP are consistent with the recommendations of previous inquiries into the coal mining industry in the Southern Coalfield, and have been reviewed by the OEH and found to be suitable. In their recent submission, OEH did not critique the type or level of survey undertaken.

2.28 SWAMP PROPERTIES

Speakers stated that swamps store water and contribute to catchment yield in times of drought or low rainfall.

Various references to work by 'Tanya Mason' was made which appeared to refer to swamps in an area remote from the site. Stated that Wonga west swamps had been impacted by mining as 'remote' sites were wetter. Criticism of piezometers in the swamps and relevant groundwater sources.

Speakers also noted that there was a discrepancy between reports as to how many swamps were predicted to be impacted: 14, 12 or 9.

Some presenters stated that the IESC had stated that 14 upland swamps would experience cracking and tilting to the base.

A presenter also stated that the IESC stated best way to mitigate impacts is redesign the mine.

Speaker IDs: 2, 4, 8, 12, 13, 20, 23, 24, 30, 32, 34, 39, 40.

The work by Dr Tanya Mason was not provided in hard copy as at the date of this response.

The contribution of upland swamps to catchment yield is addressed in **Section 2.5**.

This speaker made comparisons between upland swamps being studied by Dr Tanya Mason in Dharawal Nature Reserve. Upland swamps located in Dharawal Nature Reserve are not comparable to the upland swamps within the UEP area. The upland swamps studied by Dr Mason have much larger catchment areas, and consist largely of valley in-fill swamps located along drainage lines, compared with small catchment sizes and headwater swamps located in the UEP area which are located at the headwaters of first-order streams. This difference is noted by the speaker when stating the swamps being studied are Cyperaceous.

Cyperoid Heath, one of the vegetation sub-communities within upland swamps, is indicative of a perched water table as species associated with this community require intermittent to permanent water-logging to survive. Cyperoid Heath usually occurs in the lower, central drainage lines of upland swamps. Only CCUS4, BCUS4 and a small section of CRUS1 support either Cyperoid Heath or Tea-tree Thicket, vegetation sub-communities reliant on a perched water table for survival. Other swamps communities such as Banskia Thicket, Sedgeland and Restioid Heath, which represents the vast majority of vegetation sub-communities within the UEP area, are reliant on rainfall and not a perched water table (Commonwealth of Australia 2014).

Whilst some swamps may provide significant contributions to baseflow into local creeks, particularly during times of drought, we contend that the upland swamps in the UEP area do not. Swamp CCUS4, which is recognised by the OEH, WCL consultants and other local experts as the 'wettest' swamp in the UEP area, yields only minor outflows for short periods after rain (see **Section 2.5**). This upland swamp, which is considered to be in good condition by the groups listed above, is representative of the contribution of upland swamps in this area to catchment yield, particularly when compared to upland swamps in other areas. I.e. this level of outflow could not be considered to provide a significant contribution to catchment yield.

Biosis (2014a) concluded that two upland swamps within the study area were at greater than a low risk of impact. OEH has concluded that there were nine upland swamps at risk of impact. OEH's assessment did not take into account whether the swamps that will be mined beneath support a perched water table. Additional installation of piezometers in these swamps indicates that many do not, and thus are at negligible risk of impact. This conclusion was supported by an independent peer review undertaken by Evans & Peck. The IESC concluded that 14 swamps were at risk of negative environmental consequences; this assessment requires further investigation and is not a conclusion that the swamp will be impacted. The IESC also stated that 12 upland swamps will be partially or wholly undermined.

WCL has substantially altered its mine layout to minimise risks to upland swamps associated with subsidence. The only swamp that remains at a high risk of impact is CCUS4. Avoiding impacts to CCUS4 is not practicable as this would render the Wonga East area economically unviable.

The modifications to the mine plan have reduced the coal resource for the Wonga East area from 6.5 Mt to 4.7 Mt. This amounts to sterilisation of approximately 28% of the original Project's coal resource for the Wonga East area.

2.29 ROAD TRANSPORTATION OF COAL

Speakers noted that WCL should contribute to maintenance costs on Bellambi Lane due to impacts from increased coal transport and should be required to seal and mark the car park.

Speaker IDs: 3, 11, 25, 45, 46, 48.

WCL contributes to the maintenance of Bellambi Lane through the payment of rates to Wollongong City Council. In addition, the haulage contractor pays registration fees which are used by RMS to maintain the road network. This issue was previously addressed in Section 2.5.1 (pg. 244) of the *Underground Expansion Project Preferred Project Report including Response to Submissions* (Gujarat NRE Coking Coal Ltd, 2013).

2.30 AIR QUALITY MODELLING

A speaker noted that the air quality modelling undertaken for the project was far in excess of that undertaken for Dendrobium.

Speaker IDs: 24.

The report referred to is a publically available report prepared by PAE Holmes which forms part of an EPA state-wide study of coal mining. This study predicted potential dust emissions from Russell Vale Colliery rather than actual emissions. PAE Holmes (2012) predicted a total of 388 tonnes of total dust emissions from Russell Vale Colliery in 2011. Most emissions were predicted to come from the reject emplacement area (approved by WCC) which has been used for approximately 30 years (see **Section 2.18**). The emplacement area is highly compacted and contains many large rocks that do not have the potential to become airborne. The likelihood of airborne dust is further reduced by the ongoing use of dust suppressant on the exposed areas of the emplacement. These characteristics of the emplacement area were not considered by PAE Holmes. As a result, the emissions from the site are likely to have been overestimated.

Neither the PAE Holmes report nor the EPA required WCL to take any action to reduce dust from the emplacement area. WCL uses stockpile sprays and water carts to suppress dust in the active stockpile areas, has enclosed the Wongawilli Conveyor system from the transfer point to the start of the tripper gantry and has installed real time air monitors in two locations. Permanent real time air quality monitors were installed by PAE Holmes in 2013.

Damon Roddis, General Manager of PAE Holmes in NSW, recently attended the Russell Vale Colliery Community Consultative Committee and gave a presentation on its 2012 report. He concluded that dust sources are well understood at the site and that there are targeted control strategies in place. Real time air quality monitoring is extensive and ongoing, and shows compliance with air quality goals.

2.31 UEP DESIGN JUSTIFICATION

Various speakers queried why a conveyor could not be constructed to convey product coal, rather than continued haulage.

It was also requested that WCL explain and justify why it needed to exceed the currently approved production limit of 1 Mtpa to 3 Mtpa, especially in consideration that the total resources of 4.7 Mt available for the UEP.

Speakers stated that the UEP application area is far larger than required and it should be reduced to account for the removal of the western area as part of the PPR. It was further stated that any future applications for mining should be made under Part 4 of the EP&A Act, not as a modification to any part 3A approval granted for the UEP.

Speaker IDs: 3, 4, 24, 25.

The option of transporting coal via a conveyor to a rail loading facility is not considered to be desirable because the loading of trains and rail transportation will generate significant noise at receivers near such a rail loading facility, in comparison to the currently approved arrangements for the transportation of product coal. Further, it was considered that the development costs in constructing a conveyor would not be viable due to the relatively short haulage distances involved. This issue is addressed in full in Section 2.9.1 (pp. 275-276) of the *Underground Expansion Project Preferred Project Report including Response to Submissions* (Gujarat NRE Coking Coal Ltd, 2013).

Although the coal resource for the UEP has been reduced to 4.7 Mt as a result of the PPR, WCL needs to ensure it has the stockpile, processing and coal loading capacity to support a production rate of up to 3 Mtpa.

The Project Application Area is the total area of the mining authorities for Russell Vale Colliery. Although the UEP only proposes additional mining in the Wonga East domain, WCL undertakes existing activities and uses operational assets across the entire Project Application Area including ventilation shafts, electricity and road easements, surface facilities, and water management facilities.

Exploration and environmental monitoring activities are being undertaken in the Wonga West domain to assess the feasibility of future mining in this area. If WCL decides to pursue mining in the Wonga West domain in the future, the appropriate modification application will be made to the UEP under the EP&A Act. As the UEP is a *'Transitional Part 3A Project,'* Clause 3 of Schedule 6A of the EP&A Act provides that the provisions of Part 3A continue to apply in relation to the project. Should it be required, WCL is entitled to modify the UEP under repealed section 75W of the EP&A Act provided that the modification meets the requirements of the clause. Accordingly, if future mining in the Wonga West domain would not meet the required thresholds, approval would be sought via a modification application under section 75W of the EP&A Act. However, if future mining would not qualify for modification under Section 75W, WCL would apply under Part 4 of the EP&A Act to modify the Project.

2.32 ECONOMICS MODELLING

Speakers stated that the modelling done for the UEP was not adequate.

Values of swamps were stated to be greater than $2 M.

Some speakers stated that the coal price used at the time of the report was high which equated to $28M in royalties. This has significantly reduced as at today and coal prices were likely to continue to fall over the life of the UEP. Various revised calculations were provided.

Speaker IDs: 3, 4, 6, 16, 17, 22, 23, 27, 29, 30, 36, 48, 53, 55, 57.

The Economic Assessment indicated that the Project would provide royalties of $34M dollars over the life of the Project. In present value terms (using a 7% discount rate), this is equivalent to $29 M. This provides a minimum threshold value that any residual environmental, social and cultural costs of the Project (after mitigation, compensation and offset) would need to exceed for the Project to be unjustifiable from an economic efficiency perspective. It is a minimum threshold value since the Project will also generate company tax for Australia, which has not been quantified in the analysis. DP&E (2014) tested the sensitivity of these estimates and concluded that the benefits of the project would remain positive to the local and regional area, and to the NSW economy.

Although it is possible to attempt to value the residual environmental, social and cultural impacts of the Project (after mitigation, compensation and offsets), this has proven highly contentious in recent projects. This threshold value approach therefore leaves it up to decision-makers to decide whether the community would value the residual environmental, social and cultural impacts (after mitigation, offset and compensation) at greater than $29 M. A supplementary Economic Assessment outlines the economic efficiency trade-offs associated with the Project.

The Economic Assessment in the PPR utilised an economic value for swamps taken from a Choice Modelling study undertaken for the Metropolitan Coal Project. Submissions have been critical of the use of this value. However, this is the only non-market study in existence that has examined community values for upland swamps. The value represents the Willing To Pay (WTP)/ha of the NSW community to avoid certain (100% probability) impacts on upland swamps. The application of this value to all areas of swamp that will be completely or partially undermined by the Project will overstate the value of impacts because undermining of swamps may not translate into actual impacts.

Further, if the Project has more than a negligible impact on swamps, offsets will be provided to compensate for lost swamp values. Provided that the value held by the community for these offsets is equal to or greater than the value held by the community for the impacted swamps, then the community is no worse-off and it is the cost of providing these offsets that is the appropriate value to include in the benefit cost analysis (BCA). These ecological offset costs would be considerably less than $2 M/ha and would form part of the capital and operating costs of the Project. In the minimum threshold value framework adopted here, these costs would not be subtracted from the estimate of royalties (which is unaffected by the costs of the Project) but would reduce the unquantified level of company tax payable. DP&E (2014) also tested the sensitivity of these estimates and concluded that the benefits of the project would remain positive to the local and regional area, and to the NSW economy.

The estimate of royalties in the PPR has been criticised because of the coal prices assumed for the analysis (i.e. $150/tonne for metallurgical coal and $90/tonne for thermal coal). One submissions refers to the price at the time of the report of $81 for thermal coal. It is important to understand that coal prices are quoted in United States Dollars (USD) and that it is not the current or historical coal price that is relevant to an analysis of future coal mining but the price in the future in USD and the AUD/USD exchange rate. NAB (2014) Minerals and Energy Commodities Update predict thermal coal prices of $80/t and metallurgical coal prices of $150 at the end of 2015 and in 2016.

The current AUD/USD exchange rate is around 0.76. This is considered a reasonable long term exchange rate. On this basis, coal prices in AUD would be AUD$105 and AUD$197. Therefore, the coal prices used in the analysis are conservative. Nevertheless, there is uncertainty about future coal prices, as well as production levels and product coal splits.

The supplementary Economic Assessment estimates royalties to NSW under 20% higher and 20% lower AUD prices than assumed in the PPR and 20% lower production and different product coal splits. The range in royalty estimates is from $23M to $35M, present value. The supplementary Economic Assessment is provided in **Appendix F**.

2.33 EMPLOYMENT MULTIPLIER

Speakers stated that the wrong employment multiplier which exaggerates the flow-on benefits to the community has been used. It was suggested that a factor of 1.75 or less would be more realistic. It was stated that $273 / ha of land was used in an attempt to value the asset in the economics.

Some speakers stated that it the economic multiplier had been ‘debunked by the Australia Institute (e.g. Warkworth, Ashton and Wallarah Coal projects). It was also suggested that if the multipliers were applied, there would be three times the amount of jobs available in Australia.

A speaker stated that the Australia Institute has published several paper that many figures provided by the mining companies are inflated.

It was stated that the ABS labour portal stated that unemployment was more like 5% rather than 15%.

Speaker IDs: 4, 16, 17, 22, 23, 30, 36, 53.

Flow-on employment arises because mining Projects spend substantial amounts of money on the goods and services that they require as inputs to production and employees spend their wages (which are higher than average) on the goods and services that they demand. This generates increased economic activity for the businesses directly supplying these goods and services and the businesses who supply the businesses who directly supply these goods and services and so on.

The existence of multiplier effects is undisputed in economics, the debate is over the size of the multipliers for different projects. The level of this flow-on effect will depend on:

- The expenditure pattern of the Project and the ability of a region to manufacture and provide the goods and services required by the Project. Because of the long history of coal mining in the Wollongong and Illawarra region and high concentration of manufacturing in these areas relative to NSW, strong economic linkages and hence production-induced flow-ons are likely to occur; and
- The residential location of workers. 90% of the existing workforce resides in the Illawarra Statistical Division and hence this area is likely to capture a considerable proportion of employee expenditure.

Capital intensive industries (i.e. mining projects) tend to have a high level of linkages with other sectors in an economy thus contributing substantial flow-on employment while at the same time only having a lower level of direct employment (relative to output levels). This tends to lead to high employment ratio multipliers. A contributing factor to the high ratio multipliers is that the economy being examined is relatively large and with a long history of coal mining. Hence leakages from the economy are more limited than would be the case for a smaller or less specialised economy.

The level of multipliers are project specific and depend on, among other things, the ratios of employment to output of a project, the profitability of a project, the expenditure profile of a project and how much is spent in the region, the residential location of the workforce, the size and structure of the region within which a project is located. There is no "universal" set of multipliers for coal mining projects. The employment multiplier used for the Project is from an input-output study of the Bulli Seam Operations based on a financial survey of expenditure patterns of the BSO. This is a similar mining operation to the Project and is located in the same region and hence is a reasonable project from which to infer employment multipliers.

Notwithstanding, the supplementary Economic Analysis looks at a range of other studies to undertake some sensitivity analysis on employment flow-ons. An analysis of the Metropolitan Coal Project (Gillespie Economics, 2008), which is also an underground coal mine in the Southern Coalfield, estimated an employment multiplier of 3.52. Studies in the Hunter Valley (BAE 2014; Economic Consulting Services 2012 and Hunter Valley Research Foundation 2009) for open cut coal mines (which are less likely to reflect the Project) suggest employment multipliers of between 1.49 and 4.79. Based on this range total employment impacts of the Project would be between 428 and 1,375.

The most widely used method for estimating multipliers at the regional level is input-output analysis. Gillespie Economics states that criticisms made by the Australia Institute of the input-output method and referred to in PAC hearing are based on The Australia Institute misrepresenting the Productivity Commission, NSW Treasury and ABS. The primary concern these agencies have with input-output analysis is its use as a substitute for benefit cost analysis not its use to estimate regional economic activity.

The most contemporary data on unemployment rates by small areas are those of the Commonwealth Department of Employment Small Area Labour Markets publication. The unemployment rate in the Wollongong Local Government Area in September 2014 was 6.1% or 6,045 people.

2.34 CLIMATE CHANGE & RENEWABLE ENERGY

Various speakers stated that the UEP would significantly contribute to global climate change and should be refused on this basis.

It was suggested the WCL should invest in renewable energy developments to ensure the integrational equity was considered.

Speaker IDs: 7, 9, 10, 25, 29, 40, 57.

A greenhouse gas assessment was undertaken as part of the PPR (Gujarat NRE Coking Coal, 2013) for the UEP. The direct greenhouse gas emissions (Scope 1 & 2) for the peak year have been estimated at 200,849 tonnes of CO_2-e per annum. These direct emissions represent 0.1% and 0.03% of annual scope 1 and 2 emissions for NSW and Australia respectively.

Therefore, the contribution of the Project to global greenhouse gas emissions would be very minor.

2.35 LEGALITY OF ANY APPROVAL IN DRINKING WATER CATCHMENT

A speaker stated that under Section 34B of the EP&A Act, a SEPP should not allow a DA in any part of the Sydney Drinking Water Catchment unless the consent authority is satisfied that the carrying out the development would have neutral or beneficial effects on the quality of drinking water.

Speaker IDs: 29.

Section 34B of the EP&A Act provides that a State Environmental Planning Policy (SEPP) must require a consent authority to refuse to grant consent to a development application relating to any part of the Sydney drinking water catchment unless the consent authority is satisfied that carrying out the proposed development would have a neutral or beneficial effect on the quality of water.

The *State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011* (Drinking Water SEPP) was enacted to fulfil the requirements of section 34B. Clause 10 of the Drinking Water SEPP provides that:

> *' A consent authority must not grant consent to the carrying out of development under Part 4 of the Act on land in the Sydney drinking water catchment unless it is satisfied that the carrying out of the proposed development would have a neutral or beneficial effect on water quality.'*

While the UEP is located within the Sydney Drinking Water Catchment, we note that the Department of Planning (DoP) is not bound by Clause 10 of the Drinking Water SEPP in determining the UEP for the following reasons:

(a) Clause 10 of the Drinking Water SEPP only applies where the consent authority is granting consent under Part 4 of the EP&A Act and not to Part 3A applications such as the UEP; and

(b) In accordance with section 75R of the EP&A Act (as continued under transitional arrangements in respect of the UEP), SEPPs generally only apply to the declaration or carrying out of Part 3A projects, and not the determining of Part 3A projects.

2.36 IESC CRITICISMS

Various speakers noted specific concerns in the IESC Advice on the UEP. Speakers noted that the IESC had stated that 'adaptive management' is not suitable.

Speaker IDs: 13, 16, 20, 23, 30, 32, 39.

WCL's response to the IESC Response is reproduced in **Appendix C**.

2.37 SUBMISSIONS IN SUPPORT

Various speakers noted the importance of the continuation of mining at Russell Vale Colliery for the existing workforce and to provide continuity until the determination of the UEP. They also noted the flow on effects to the community from the 250 workers at the Colliery who largely reside in the area with their families.

Speakers noted the long history of mining in the area for over 100 years, the employment opportunities for University of Wollongong graduates and the hope for ongoing work with WCL for its workforce.

Speaker IDs: 19, 28, 41, 42, 44, 47, 50, 51.

The submissions in support of the UEP are noted.

* * *

for
HANSEN BAILEY

Andrew Wu
Environmental Engineer

Dianne Munro
Principal

3 REFERENCES

- Biosis (2013), *NRE No. 1 Colliery – Underground Expansion Project: Preferred Project Report – Biodiversity.*
- Biosis (2014a), *Russell Vale Colliery Underground Expansion Project EPBC Referral (EPBC2014/7268): Coastal Upland Swamp Impact Assessment Report*.
- Biosis (2014b), *Russell Vale Colliery – Underground Expansion Project: Preferred Project Report – Biodiversity*.
- Cardno (2015), *Wollongong Coal Limited, Bellambi Gully Flood Study*.
- Commonwealth of Australia (2014), *Temperate Highland Peat Swamps on Sandstone: ecological characteristics, sensitivities to change, and monitoring and reporting techniques*.
- Department of Planning & Environment (2014), *Major Project Assessment: Russell Vale Colliery Underground Expansion Project (MP 09_0013), Secretary's Environmental Assessment Report*.
- ERM (2013), *NRE No. 1 Colliery Project Application (09_0013) Environmental Assessment*.
- GeoTerra / GES (2014), *Russell Vale Colliery Underground Expansion Project Preferred Project Report Wonga East Groundwater Assessment*.
- Gillespie Economics (2008), *Metropolitan Coal Project Socio-Economic Assessment*
- Gillespie Economics (2015), *Russell Vale Colliery Underground Expansion Project Economic Assessment.*
- Gujarat NRE Coking Coal Ltd (2013), *NRE Underground Expansion Project Preferred Project Report, including Response to Submissions*.
- Gujarat NRE Coking Coal Ltd (2014), *Gujarat NRE No. 1 Colliery: Geological Report on the Wonga East Area.*
- Hansen Bailey (2014), *Preferred Project Residual Matters Report.*
- NSW Chief Scientist & Engineer (2014), *On measuring the cumulative impacts of all activities which impact ground and surface water in the Sydney Water Catchment*.
- Office of Environment and Heritage (2014), *NSW Biodiversity Offsets Policy for Major Projects*.
- Planning Assessment Commission (2009), *The Metropolitan Coal Project Review Report.*
- Planning Assessment Commission (2010), *Bulli Seam Operations PAC Report*.

- Wollongong Coal Ltd (2014) *Wollongong Coal Ltd (EPBC 2014/7268) Response to advice of the Independent Expert Scientific Committee on the Russell Vale Colliery Underground Expansion Project*.
- WRM (2014), *Russell Vale Colliery Wonga East Underground Expansion Project Surface Water Modelling*.

Appendix A

List of Registered Speakers

Planning Assessment Commission

Planning Assessment Commission Hearing

Russell Vale Colliery Underground Project

Date & Time: 9.00 am Tuesday, 3 February 2015

Place: WIN Entertainment Centre, Corner Crown & Harbour Streets, Wollongong

Hearing Schedule	
9 am	Opening Statement from the Chair – Paul Forward
Registered Speakers:	1. Lock the Gate Alliance Nell Scholfield
	2. Nature Conservation Council Kate Smolski, CEO
	3. Wollongong Transport Coalition Irene Tognetti
	4. Illawarra Branch of the National Parks Association Peter Turner
	5. Keith Horton & Emma Rooksby
	6. Rod Plant
	7. Tom Hunt
	8. Ann Young
	9. Miguel Heatwole
	10. Dallas de Brabander
15 min Break	
	11. Susan Fawaz
	12. National Parks Association Macarthur Branch Julie Sheppard
	13. Peter Turner
	14. Diana Covell
	15. Mitchell Bresser
	16. Protect Sydney's Water Alliance Isabel McIntosh
	17. Elena Martinez
	18. Blake Thomas
	19. Illawarra Business Chamber Debra Murphy
	Continue over page

Please note

Speakers are generally allocated 5 minutes for an individual, or 15 minutes for groups. The hearing is open to the public, and as such not all parties present will speak.

The Commission has copies of all written submissions made to the Department of Planning and Environment (DP&E) on the proposal in response to its exhibition, so it is not necessary to restate those views. The purpose of this hearing is to hear views on the proposal including on the Department of Planning and Environment's preliminary assessment report. These views will be considered by the Commission in preparing its Review Report in accordance with the Minister's request dated 7 July 2014.

No audio recording is permitted.

The assessment report and recommended conditions are available on the PAC website at www.pac.nsw.gov.au. If you have registered to speak but your name is not on the list, or if you have any other questions, please contact Stephanie Calderaro on 9383 2112 or (pac@pac.nsw.gov.au).

Hearing Schedule continued	
	20. Rivers SOS Caroline Graham
	21. Joshua Larsen
	22. Georges River Environmental Alliance Sharyn Cullis
30 min Break	23. Western Sydney Environment Network Michael Streatfeild
	24. Illawarra Residents for Responsible Mining Inc (IRRM) Kaye Osborn, President
	25. Public Health Association of Australia Anna Bethmont
	26. Doctors for the Environment Australia Dr Melissa Haswell
	27. Southern Sydney Branch National Parks Association Murray Scott
	28. Kristen Lee
	29. The Parramatta Climate Action Network Michael Rynn
	30. Oatley Flora and Fauna Society Melina Amerasinghe
	31. Environmental Defenders Office Tanya Mason
	32. Ann Brown
	33. Gavin Workman
	34. Susan Benham
	35. Shirley Gladding
	36. Kaye Osborn
	37. David Giles, MA, BFA
	38. Anne Wagstaff
	39. Kim Wagstaff
15 min Break	40. Romana Lesnjakovic
	Continue over page

Please note

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Hearing Schedule continued	
	41. Scott Jones
	42. Nick Karakolevski
	43. Beth Mitchie
	44. Dominic Tier
	45. Richard Knappett
	46. Maureen Magee
	47. David Bitz
	48. Dr Alison Edwards
	49. Dr Graham Heath
	50. Bruce Rowles
	51. Jeff Brown
	52. Martin Denny
	53. Deidre Stuart
	54. Anne O'Brien
	55. Natasha Watson
	56. Dr Keith Tognetti
	57. Wollongong Climate Action Group Rowan Huxtable
	Hearing Conclusion

Please note
Speakers are generally allocated 5 minutes for an individual, or 15 minutes for groups. The hearing is open to the public, and as such not all parties present will speak.

The Commission has copies of all written submissions made to the Department of Planning and Environment (DP&E) on the proposal in response to its exhibition, so it is not necessary to restate those views. The purpose of this hearing is to hear views on the proposal including on the Department of Planning and Environment's preliminary assessment report. These views will be considered by the Commission in preparing its Review Report in accordance with the Minister's request dated 7 July 2014.

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Appendix B

Table of Issues Raised by Registered Speakers

ID	Issues
1.	• Did Not Attend (DNA)
2.	• Risks to water catchment special areas, upland swamps, surface water features, reduction in air quality, and cumulative impacts with other projects in the catchment • Agrees with national parks association position • Sydney water catchment and cumulative impacts • Precautionary principle should apply given uncertainty • Swamps destroyed by mining – mining is Key Threatening Process. • 4 mega litres per day will be the total water usage, 2.3 mega litres per day will be used. • Sydney is one of the only 'urban areas' that allow LW mining in water catchment areas. • Biodiversity impacts – will lead to permanent changes in vegetation and pH levels in neighbouring areas. Threatened species will be impacted at mine entrance. Will see a net loss of habitat if the project is approved. • Grave concerns re the offset policy implemented by the NSW government. • Offsets are not 'like for like' if you look at e.g. Warkworth (i.e. replacing with an area that has been rehabilitated where there was an open cut mine. Says there will be no scope for like for like in this project. • Monetary contributions not suitable. • WCL has a total loss of $92 million in 2014 – Suggested the company cannot be trusted to implement the offset program. • Long term damage to Sydney water catchment and surrounding region. This will go against principles of ESD. • Notes that there interests as the peak environmental body is NSW wide and not just the local area. • Drops in pH and oxygen levels creating unsuitable conditions, particularly threatened species • Impacts to protected threatened species, Giant Burrowing Frog, GGBF, Littlejohn's Tree Frog and more
3.	• Formed 25 years ago by residents concerned about the transportation of coal especially along Mount Ousley Road • Opposes the Project in any form • Concerned about more trucks on Bellambi Lane and at Port Kembla terminal • Suggests that WCL should be required to contribute to maintenance of Bellambi lane (rather than Wollongong city rate payers). • Damage to pavement should be fully funded by the company and the passage of just one B double is equivalent to 10,000 cars based on the weight ratio. The cost of road is three to five times that of rail. • Supports council's proposal that WCL should be required to seal and line mark the car park. • 2 mil tonnes per annum limit on the previous colliery. Conveyor construction was agreed in 1979 – these were not mentioned in the 2014 secretary's environmental assessment report. • Cumulative impacts along with the expansion of Port Kembla in 2011 on roads from 200 to 500 thousand tonnes. There are also Hanson Bass Point and Boral quarry materials on the road. Concerns regarding congestion, air quality, increased road crash risk • Referred to page 4 of 2006 – 2031 Illawarra Strategy (DP&E) to support economic growth and maximise the efficiency of freight transport. Increase the freight transport by rail. Department of Planning should adhere to this policy – that all coal should be transported by rail and road transport should be subject to though conditions • Referred to draft condition 13 and says that they should be reported not quarterly but monthly • Traffic management plan should extend consultation to include Wollongong council and residents and coal transport should cease at 6pm, not 10pm. • 14 km haul from colliery to port Kembla recommended that charge of 50 cents per tonne be levied. Consideration be given to a new rail outlet, or WCL should be required to should show cause why not construct a conveyor from the loadings to rail as agreed by the previous owners of the mine • Level of coal should be no more than 1 million tonnes per annum
4.	• Direct connection between surface and mine

ID	Issues
	• Tammetta's model may be an underestimate of depressurisation • No tests to date on triple seam mining to see where depressurisation meets surface • GW model is poorly calibrated • The use of asset values to value SCA catchment at $2,106 per hectare is incorrect and Input / Output valuation method is widely discredited • Swamps • Western area described in UEP not permanently sterilised • Project against special significance and assumption of protection • DP&E Conclusion of EEC results in all swamps being considered special significance • Offset policy should be rejected • Value of swamps greater than $2 M based on prior Choice modelling • Red flag for swamps should be invoked • Contribution of swamps to water quality and maintenance of water quantity • Swamps store water and contribute to catchment yield • Doesn't agree with conclusion of no evidence of large scale loss – evidence form Swamp 20 at Metrop given • Member of CCC • Shows diagram from the original groundwater assessment – highlights that there is an underestimate and could be wider impact than this suggests • No direct tests to find out where the collapse and void through triple seam mining. • Alleges information deficit (i.e. environmental calibration is limited and reflects limited data). • EDO has acquired 4 expert reviews. One is an economics review which is damming of the project and that it should not be approved in its current state. • Critical of use of 2009 Gillespie economics valuation. Assumed that the asset value reflects the land value of the Sydney catchment areas – argues that the land component is only a small portion of the value – taken the wrong approach to valuing. • Use of wrong employment multiplier which exaggerates the flow on benefits to the community - 4.22 indirect employment multiplier is used which relies on 7.5 million tonnes per year for the mine and other underlying mines (Appin, Westcliff), however says the multiplier should be half of what WCL have contended – more like 1.75. The real multiplier for jobs would be less than this number. • Asset value used in attempt to value the land - $273 dollars a hectare is not a true reflection of value of the land. • DP&E should take an independent economic assessment and not take the numbers of the minerals council at face value. • Unemployment in area is at 15.3 % (Fin Review article in 2013). The assessment report accepts this figure but is not supported by other data – argues that the employment numbers are around the national average. Graph from the ABS labour portal says it is more like 5% and not 15%. 15% refers to youth unemployment. • Persons employed by the mine in the SCA special areas is 1% of the Illawarra workforce. • Special areas produce 4% of national production of coal. • NSW offset policy referred to – that developers can buy themselves out of any obligations. Should not be able to buy way out of it but to protect it. • Attempt to value swamps using 2009 Gillespie economics valuation.
5.	• DNA
6.	• Local Corrimal resident • Alleged there is a lot of Aboriginal heritage in the area • Mine has been uneconomic for years – Gujarat did not make money and this company will go broke. • Project has not been scientifically tested • Planning system does not penalise companies after damage has been done • Desperate attempt to extend life through 'ecological vandalism.' • Will undermine swamps and water catchment.

ID	Issues
	• Levee should be applied for road maintenance • Interim 'drib drab' expansions have been poorly planned. • No faith in the process and that has produced terrible results. • No way that the roads will have capacity for three times the trucks nor is there any level to repair the damage done by the trucks • Mine and its infrastructure are old • Creek has been used as a drain, diverted, dammed, goes black when the discharge comes through. • Triple seam mining, cannot find the subsidence of one seam and then double or triple it, not accurate and there will be other impacts. • Dependant on aquifers for drinking water. • Do not have any control over the PAC process, but there is a state election coming up and will vote accordingly.
7.	• Supports most of the bodies today but wants to look at it from a big picture review. • Consequences of climate change – refers to article in last week's Illawarra mercury – not just more rain (as in the article) but that more things will be impacted and damage will be irreversible. • CO_2 is 40% higher already and will result in increased droughts, less food, more intense but less frequent rainfall and swamping of coastal areas. • This price will be paid by our children – i.e. no intergenerational equity consideration vs short term profit for WCL • Recommends WCL invest in renewable energy.
8.	• Want to see matter properly assessed, not wait for disastrous impacts. • It is now widely acknowledged that swamps are impacted by undermining. Swamps of Wonga East show impacts of past mining. • CCUS4 in good quality as shown in piezo data. CCUS3 and CCUS6 piezometers are rain responsive. • Evidence of past impacts shown on piezometer graphs. Curves show response to current monitoring. • Swamps are important to storage of water. • Mining impacts not only swamps but also ridges. • Referenced Tanya Mason (EDO) work. • Swamps in Dharawal in low rainfall/high evapotranspiration area are rainfall dependent. Still contribute to seepage • Swamps to the west in higher rainfall are cyperaceaous and are wetter. Comparable to Wonga East • Wonga East swamps are drier. Contends these are mine affected and that there is insufficient pre-mining data on swamps as only go back up to 3 years not 30 years. • Impacts on catchment yield cannot be reliably predicted. Do not know enough about surface hydrology and connectivity between swamps, fractured zone and goaf. Do not know if water lost from swamps re-emerges downstream. • There is very little water storage capacity in the surrounding areas and as such headwater swamps are the only storage in headwater catchments • Stated that damage to swamps is permanent. • Offsets policy is designed for biodiversity and not appropriate for hydrological issues. Also predicated on total loss; proportional offsets not appropriate. Referenced Dendrobium Colliery offset requirements from 2013 which are still being debated between OEH and company with regard to offsetting actual impacts rather than predicted impacts. • If we are going to have offsets we need like-for-like. Establish permanent conservation of swamp clusters in the catchment and yield coal lease in these areas. • Does not believe presence Tea-tree Thicket is indicator of complexity. • Offsets must be within the Southern Coalfield. • CCUS3 and CCUS6 – entirely rain responsive but 0.9 metres of sediment and therefore should not be rain responsive and they should be water close to the surface permanently. Considers this is evidence of previous damage by the mine to bedrock cracking. The peaks are narrower since the previous mining than they were previously. • Says that the comparable swamps in the national park are wetter and more cyperaceous than the Wonga east swamps.

ID	Issues
	• Draws the conclusion that this comparison shows that the Wonga West swamps have been previously mine affected. • Dr Larson's (provided independent advice to the EDO) views that the impacts on swamps and catchment yield cannot be accurately predicted as we do not have the baseline data and do not have a good sense of the hydrology or a serious of piezometers between the swamps, fractured zone and connective cracking coming up from the goaf. • Appalled at how offsets are presented in the DP&E Report. If there are offsets, must be 'like for like'. Permanent reservation of swamp clusters within the catchment and extinguish the mining leases. Opposes the direct payment option.
9.	• Climate change. Concert featuring a Capella versions of "Remember Mother Earth" and "We Don't Need Your Filthy Coal"
10.	• Climate change • Renewable energy
11.	• Lives in Corrimal and considers that the mine is too close to residential areas. • Expansion would bring two new 140000 tonne stockpiles. • House experiences high levels of coal dust. • Increased serious health risks: increased serious history of respiratory problems and the impacts of mining on physical health. • Records the views of neighbour of black dust on back steps and window sills who also objects. • Has no confidence in proposed measures as has not been effectively managed in the past. • Noise pollution and Bellambi lane. • Project has no social benefit in the community, is too close to residents and not worth the risk. Risk to air quality is too great.
12.	• Subsidence induced impacts to natural features, including drainage of swamps, loss of surface flows. • Impacts to Waratah Rivulet and Swamp 15b shown including loss of water, upsidence, iron staining and gas. Assumes similar damage to Cataract Creek will occur. • Iron flocculent exacerbation • No data on loss of water from fracturing of Waratah Rivulet: examples of swamps at other projects shown and remediation of Waratah Rivulet not successful. Has not seen Cataract Creek or seen photos of the creek. • Catchments are the sole water support for MacArthur and Illawarra regions. • 5 million people solely rely on the water catchment. • SCA website – noted that cataract dam is only at 57% which is lower than the other dams. • 3 billion litres a year are lost from the catchment per year due to mining referred to report by Peter Turner.
13.	• 25% of the special areas have been undermined. • Alleged that 35 – 40 ML a day going into coal mines. • Current proposal 10 ML a day loss. • Loss of rainfall into surface cracks are increased permeability unknown. • SCA had a hydraulic expert do a study which showed that 5 megalitres a day were lost into the Waratah Rivulet (at other operation and other catchment). • Risks to stored water. • Not sure if IESC, DSC and DSA issues addressed.
14.	• DNA
15.	• DNA
16.	• Agrees with concerns of the DSC • Represents alliance of more than 50 groups. • Triple seam mining impacts are unknown due to it being undertaken for the first time • Cumulative damage must be considered

ID	Issues
	• WCL has a $600,000 bond with SCA but damage will be much higher • Offsets • IESC report • Gaps in knowledge should be filled before proceeding with mine • Loss of water from swamps and whether it appears downstream • Doesn't accept that any impact is acceptable • Supports monitoring of swamps to assess damage if project is approved – but wants phased approval based on damage to swamps • 70% of the remaining water on earth (2% if world's water) is locked up as ice. • 370,000 hectares of special catchments is publicly owned land. • 'other countries do not mine their catchments,' Indonesia, France etc. • Economic multiplier was debunked by the Australian institute (e.g. Warkworth project). • Mining has no interest in jobs and would fully automate if it could • Ten of thousands of manufacturing jobs that have lost from the mining boom. • Desalinisation plant cost $1 billion and will be required if catchment water affected but would only provide Sydney with 10% water in a crisis. • Case has not been made that we need mining in the water catchments, do not need the coal for Australia as it is exported around the world. • SCA and the EPA say the mining should not go ahead and there was a debate between the EPA and department about this. • No data on long term costs of treating water contaminated by iron. • Asked the minister whether it should be permitted in Sydney water catchments – the minister declined to give an answer. • WCL was forced to sack 400 workers this year, share price is low, $92 mil loss in 2014, $1 mil in unpaid bonuses, pay cuts. • If approved, put conditions in regarding the swamps and damage to swamps and that any damage from MOD 2 – the next phase should not go ahead and there should be a phased approval process based on data and monitoring.
17.	• Nil • Greens candidate for Keira. • Not true that mining economically benefits the area. Once employed 2,000, now 250 people employed at the mine. • LW mining is not labour intensive. • Job multipliers have been proven to be grossly exaggerated otherwise would have three times the amount of jobs in Australia. • Over 300,000 people employed in NSW. • Maximum is $34 m dollars over five years in mining royalties. • Per person people using the drinking water – this is $8.00 per person. • Coal companies pay a small tax rate – 12% compared to other companies. In report it is 100 mil over next 5 years – per person that is a small amount of money to put water supply at risk. • Government gave the company $10.6 M to provide targeted assistance to ease introduction of carbon price. • Profit is going to go overseas. • Coal mines in Sydney catchment area drains 3 billion litres of water. • WCL expect to start work on 15 Feb 2015 and this process is just a formality.
18.	• DNA
19.	• Economic impact study done in 2014 by the NSW Minerals Council and Wollongong University. • Represent 1,250 business members and consider themselves voice of Illawarra business. Represent small business. • More members in the professional services area – mining small portion. • Long history of mining in region in 1797.

ID	Issues
	• Nearly 10% of Illawarra jobs rely on mining. • 1,738 employees directly employed – 18,422 jobs in the economy in relation to mining. • Participation rate is at 56.5% which is low due to underemployment. • Research with PWC – mining on compound has added the most amount of growth in the economy. • Wollongong Uni Research – mining companies make $1.5 billion direct spend, flow on effect is 3 billion dollars or 14.4 percent of gross regional product. • 6,111 business which directly service the mining industry. • 45 community groups were supported. • Supports continuation of mining in the Illawarra. • Provides almost 10% of jobs in the community.
20.	• IESC advice indicated adaptive management not suitable. • Resignation of David Paull from OEH due to conflict between environment and mining. • No impact so great that it cannot be approved. • Acid mine drainage in derelict mines. • Call for special areas to be transformed into National Parks. • Only country in world that allows mining in publicly owned drinking catchments.' • Referred to the southern coal field inquiry and the chief scientist report. • LW only going 300 m from the storage dam – whereas experts had previously be concerned about 700 m. • Referred to institutional corruption and ICAC enquiry regarding mining leases. • Dr Pells stated that Thirlmere Lakes will dry up due to mining depressurisation and drought. • Lack of transparency in the selection of PAC panellists and that they are often consultants of the mining industry • MOD 2 was approved by a mining consultant and a retired pro-coal politician. • SCA will be merged and concerned that water would be privatised. • 50% of the global water supply is owned by two French companies. • Adelaide started paying 400% more on desalinisation. If Sydney goes on desalinisation $700 dollars more a year. • Earth quakes can be mining induced and this is widely accepted, referenced book By Dr Christian Close. • Jindal has other mines in Queensland and will leave this mine and go to Queensland.
21.	• DNA
22.	• Swamps will be shattered and drained from mining and cannot be remediated. • Impacts to swamps from current longwall layout • Like-for-like offsets not feasible and non like-for-like not acceptable • Cannot maintain or improved biodiversity values • OEH position of nil or negligible damage to swamps • Showed Darrawell photographs and Waratah Rivulet • PAC should reject the proposal based on the current longwall layout • Swamp impacts and impacts on drinking water is unacceptable, like for like offset is not feasible. • Cumulative impacts to water supply are not considered. • Economic benefits are overstated and do not justify the risk of the project. • Where the economic benefits should be weighed against impacts. ESD and precaution should prevail over significance of coal resource. • Residual concerns of other agencies – OEH remains concerns and that mining layout should be amended. • ABS multipliers are inappropriate as they 'based on limiting assumptions which result in multipliers being a biased estimator of the benefits or costs of a project.'

ID	Issues
	• Proponent admits that 'they did not attempt to ascribe a value to the external costs because it was very difficult' 'there is no accepted standard guidelines' there is choice modelling for this purpose. This has been broadly endorsed by metropolitan and BSO PACs in the past. • In 2014 planning minister promised would require separate expert analysis for mining projects – however have not been provided publicly.
23.	• Destructive subsidence impacts to 14 upland swamps and associated threatened species. DP&E says 9 swamp to be impacted and proponent says 4. Explain discrepancy. • DP&E has taken little heed of advice from IESC, OEH and SCA or independent expert scientific report. • DPE report only focuses on economic benefits, not economic costs. • IESC report: subsidence impacts to 14 upland swamps. • No know measures to remediate swamps and adaptive management not suitable. • Objection to offsets, should be like-for-like. • Swamps are habitat for threatened species, including frogs and toadlets, dragonflies. • Irreversible damage to upland swamps. • DP&E has not taken notice of the independent expert report. • Notes that the offsets will be monetary – which they are not. • Alleges that will donate to politicians in the next political campaign in exchange for the approval of the project. • WCL states there will be $35M in royalties but coal was $81 a tonne at time of report - $28 million in royalties. $20 million royalty payment if mined today. • Multiplier effect: taking estimates of 300 jobs – insignificant in context of 196,000 in Illawarra.
24.	• Two speakers together: 24 and 33. • Believes that any risk to drinking water catchment is unacceptable. • UEP application area: potential for further expansion. Preliminary works project was approval for 3 years of mining for bord and pillar and extraction of 4 and 5 as modifications is an abuse of process. • MOD 2 PAC Report refers to the piecemeal process for approvals. • Argues that the application area should be reduced not to include Wonga West. • Argues that any further mining would have to be part of a new application under Part 4 not a Mod. • Only 6 of 11 noise mitigation undertakings have been completed. Balgownie and Bulli belts have not been decommissioned. • Air Quality: 2012 study commissioned by WCL estimates that the Russell Vale Colliery emits 779 tonnes per year. Dendrobium 80.4 tonnes per year. • That the two stockpiles will bring the particulate pollution from 779 to 3,000 tonnes per year. • That the stockpiling should increase at port Kembla and not at the Colliery. • Preliminary works and initial EA were going to have noise levels based on the background noise, now working to historical levels when there was a washery there. • Newsletter from 2003 – that reversing alarms on vehicles. Last CCC meeting, they have only done two which demonstrates a contempt to the residential area. • Emplacement area: noise emitted from the exhaust which is not monitored. The emplacement area has the highest particulate emissions of anywhere on the site and should be part of the assessment • Stated page 21 of ERM EA stated emplacement area won't be used. • They are processing coal on site and current crusher is noisy. They should not be allowed to process coal near a residential area. • Questioned the need for 3 million tonnes per annum and why existing 1 million tonnes is not acceptable. The PPR does not justify 3 million tonnes. • Calling for an independent investigation into the process and DP&E report errors.
25.	• Two speakers together 25 & 26. • Impacts to water quality and quantity from impacts to upland swamps. • Concerned regarding the total quantity of coal: 4.7 extracted but 3 million production rate.

ID	Issues
	• Local health concerns: air pollution as there are no safe levels of emissions, and potential for stress from noise traffic and worry. • Are there baseline air quality data in residential areas and is this being done by independent experts. • Double B trucks along Bellambi Land increases exposure to diesel. • Requests full health impact assessment and toxin issues in collaboration with the community. • 4.5 million households and businesses rely on Sydney catchment. 60% of NSW population. Illawarra region has a great deal of water line stress: water withdrawal relative to water supply. Using 40-80% of water supply, therefore the water supply requires utmost protection from stress. • IPCC report referred to in relation to climate change. • Additional risk imposed by UEP is unacceptable. • Encouraged recycling of steel.
26.	• See above, spoke with 25.
27.	• Economic value of catchment is in vegetation, due to runoff protection. • Migration of fauna has been overlooked. Re-colonisation critical following fire. • Key factor in mobility is water. • Mine cannot succeed so should be phased out, for no further approvals.
28.	• Supports project. • Employee at Wollongong Coal. • Local person with five local, team members from Wollongong Uni.
29.	• Part time climate activist: carbon emissions are a crime against future generations. • Asked the PAC where an ecological economist assessed the project. • Stated desalinisation plant need to be built as coalmines will destroy our water source which will massively increase drinking water costs and GHG emissions. • Referred to Clause 34b of the EP&A Act that a SEPP should not allow for a DA in any part of the Sydney drinking water catchment unless the consent authority is satisfied that the carrying out of the proposed development would have a neutral or beneficial effect on the quality of water." Looking at a High Court challenge to this issue. • Company is achieving approvals in sneaky little bits
30.	• Mining will cause draining of upland swamps. • Confusion on number of upland swamps. • 9 hectares of upland swamp will be undermined. • Stated that Dharawahl area comparable to project. • Upland swamps provide breeding area for a number of invertebrate species, provide sponges, feeding dams during low rainfall. • Lack of data on past impacts from mining. • IESC report ignored • Little evidence of successful remediation of upland swamps. • Offsetting using monetary contributions not acceptable. • Impacts to endangered species. • Australian institute has published several papers that many figures by the mining companies are inflated. Tax deductions and fuel rebates are given to the mining sector @ $4.5 billion per year.
31.	• DNA
32.	• Local person on CCC • Cumulative impacts from 100 years of mining • Adding this proposal to other mines raised local extraction to 17 Mt

ID	Issues
	• BHP coal goes to local Bluescope both of which are Australian owned. WCL foreign owned and profits go offshore • Consulted with Prof Graham Harris at Wollongong University on offsets which are 'a total furfy'. • Swamps will be severely damaged. • Says look at independent peer review – especially Evans & Peck. • Asks the PAC to look at IESC conclusions and the independent reviews. • Wonga west – proponent states that the UEP is just in the Wonga East area which will just raise capital to get into the Wonga West area. • Questioned tax payer paying for this assessment process and federal EIS review. • Exercise the Precautionary principle.
33.	• 2nd time speaking, originally with 24. • Document produced by the DP&E – alleges the document contains many errors. • Statement of commitments in the draft conditions has no timing on them.
34.	• Cumulative impacts on drinking water will impact on intergenerational equity and harm our children. • Local resident. • Speaking on behalf of future generations. • Page 10 of DP&E Report – quotes the chief scientists report – 'insufficient data available to provide a deep and reliable understanding of the cumulative impacts of mining in the catchment.' 'Current approaches to managing cumulative impacts are limited'. 'Australia is the only country to allow longwall mining in its drinking water catchment area.' • Referenced Phillip Pells independent study stating surface water and groundwater impacts are unacceptable (2012). • While WCL has made commendable reductions from its original proposal the entire proposal should be removed not reduced
35.	• Local resident from Woonona. • Opposes project based on the environmental and health risks. • SCA concerns re: upland swamps as experts. • Water loss predicted to grow to 2.3 ML/day. • Irreversible impacts to 9 upland swamps. Differing views between DP&E and OEH. Difficulties with predicting impacts to upland swamps. • Difficulty with like-for-like offsets, and unacceptability of monetary contributions. • 1.5 – 2.6 millimetres subsidence comes from a small data base. • Human health impacts due to increases in noise and dust through increases in coal trucks.
36.	• Same speaker as 24 although speaking as resident. • Works at Wollongong University. • Criticised Chamber of Commerce presentation validity. • Refereed 'Neil Perry' review which criticised economics assessment that it was not done adequately in that it has an inconsistent base case and benefits and undervalues costs and overestimates benefits. • Multiplier models have been heavily criticised in the Ashton case in the LEC and Wallarah 2 Coal Project.
37.	• DNA
38.	• DNA
39.	• Serious damage expected to the upland swamps not just the one WCL claim. • Upland swamps play important role in capturing, filtering and releasing water. • Expected to impact 9 upland swamps, 7 of which are at high risk of impact (OEH). • Impacts to upland swamp EEC. • SCA and OEH are experts not been listed to.

ID	Issues
	• IESC estimate cracking and tilting to base of 14 upland swamps. • Remediation not possible. • Offsets not acceptable – issues with like-for-like. • IESC says best way to mitigate impacts is redesign mine to avoid undermining swamps • 2 ML of water per day will be used in the mining operations. • IESC quote in relation to there not being any way to remediate the impacts including fracture networks and the most effective way to prevent the mine layout so that swamps are not undermined.
40.	• Woronora plateau supports significant proportion of upland swamps. • Water resources impact. • Climate change.
41.	• Supports project. • Transportation contractor for WCL. • Flow on economic and employment. • Able to upgrade fleet due to WCL work. • Supports local sporting teams to WCL work.
42.	• Supports. • WCL employee. • Local resident of Corrimal. • Flow on effects to bakery, childcare and service station.
43.	• DNA
44.	• Supports project. • Grew up in Therroul and lives at Russell Vale. • Works at WCL which enabled him to remain in the area when friends have had to leave area to get work.
45.	• Resident of Bellambi Lane. • Objects to approval. • Full studies should be undertaken on Bellambi Lane – no noise monitoring has been put in place. • Bellambi Lane must be made a priority. • Page 50 of assessment report, states there is no criteria for the south side of Bellambi Lane which is not zoned residential but has 100 residents – all residents have no criteria to refer to. • All criteria relate to the property, or to where the trucks leave Bellambi Lane. • Bellambi Lane has only been used by trucks since 1993. • Bellambi Lane was rezoned in 2009 from residential to light industrial • Requests reduction in the coal haulage hours to 8 pm. • When trucks are running residents have to close their doors and windows • Current road transport restrictions only state truck loading times, does not say they are not allowed to enter the property. • No 24 hour air quality monitoring on Bellambi Lane, install immediately. • Dust monitor on property but not registered with any relevant parties. • WCL to be held accountable for breaches. • Not providing best practice offsite dust and noise monitoring

ID	Issues
46.	• Long-time Illawarra resident. • Proponent's noise study is insufficient that the nearby residents have chosen to build near an industrial site and therefore should not expect the same amenity as other citizens. • Reports are wrong when they say there was a coal washery and coal preparation plant was operating on the site between 1996-2004. Neighbours did not expect it to reopen. • WCL originally said would spend $285 M on capital works that has dropped to $80 M. • Local residents will be impacted by noise and vibration and will have to pay (thru Council) for Bellambi Lane maintenance • Truck reversing alarms and drivers voices carry to residential areas • DPE does not take WCC's concerns seriously in its assessment report. • The data shows the proposed noise levels will be less than it is now. • The report does not show sound contours. • p 46 of report states the expected noise on Bellambi Lane will be less than 2 decibels. • The company is not financially viable and unable to undertake this project.
47.	• Supports project. • Excavation Company employing local people. • WC work enables them to support sporting groups and charities.
48.	• Presented with Speaker 49. • Does not oppose mining but they should only occur in a well-planned and safe manner. • Value of upland swamps is large. Lloyds can provide reliable estimates of insurance value. • Residents of Russell vale – both scientists. • Safety test for the proposal is not being met. • Colliery to date has accepted approvals and evaded conditions. • Bellambi Creek realignment requirement of previous approval due to be done in December 2012 and has never been commenced. • A lot has been said about the history of the mine's operations but nothing has been said of the recent closure • Any new approvals should be required to meet modern standards and regulatory requirements. • Now a residential area which needs to be assessed on modern terms. • "We were here first" is not a valid argument • Economics assessment is flawed • ABS statistics – the main industries in Wollongong are health and education. • Remediation will be impossible and the amounts of money required for them is high. • Modelling for the initial longwalls underestimated the subsidence (triple seam mining predictions untested). • Notes that the project should be rejected as it doesn't meet the safety test for local health, community health or water security. • However, if approved, it should be subject to stringent conditions which must be enforced.
49.	• Presented with Speaker 48.
50.	• Supports proposal. • Aspect South coast school Principal with around 130 autistic students. • Land and house previously provided to school by WCL's predecessors. • Grounds maintained presently by WCL. • Gave carpark for school 3-4 years ago.
51.	• Supports proposal.

ID	Issues
	• Fourth generation coal miner.
52.	• Reviewed impact assessment on terrestrial fauna for EDO. • Focused on Annex S in the EIS (ERM 2012) and indicated a diminished approach to surveys. Impact assessment to threatened species inadequate. • Survey methodology used is limited amount of survey. Major survey techniques missing such as trapping, hair funnels and no use of remote cameras • OEH/DoE guidelines recommend full range of survey techniques which have not been followed. • Several species involved with wetlands that were not adequately assessed – Koala, Eastern Pygmy Possum, NHM, Sooty Owl, Southern Brown Bandicoot, Spotted-tailed Quoll. • No call playback for Sooty Owl or Squirrel Glider. Not all bat species can be found by call. Radio tracking of bats should have been undertaken • OEH has advised only concentrate on certain matters in relation to wetlands however other species were left out (e.g. pigmy possum, southern brown bandicoot, spotted tailed quoll sugar glider) • Some assessments have been less than correct and should be reassessed once further investigations have been undertaken.
53.	• Environmental offsets difficult to find. • Object to the bias and lack of scrutiny of DoPE. Rather onus on the NSW citizens and groups and other agencies to investigate thoroughly • the DPE shows a curious lack of scrutiny • I echo the thoughts of the people who have spoken here today against the project • Object that residents spend so much of their time, and that the DoPE is not doing their job • Thousands of pages about the risks, but not many • This company manages to bury one of their longwalls. They cannot be trusted. • The DoPE is too short term. • I question the indirect employment figures in the proposal. I contacted the Australia Institute to verify these numbers (green organisation), no extra jobs • Coal prices used in DPE report, at worst coal prices would remain at the current levels. Coal prices are trending downwards. I note that recent media reports are incredulous at Australia's continuing faith in coal. Proper scrutiny of all of the reported economic benefits. • Each approval is a missed opportunity to change course. We will be economically worse off. • Suggested a bias by DP&E to WCL with parts of DP&E report misleading. • Economics: criticised indirect employment multipliers, spoke with Rod Campbell at IAR (WCL used 5.5, DP&E used 4). Suggested in QLD, IAR stated impacts were negative. • Criticised Warkworth and Ashton assessments. Coal prices in DP&E report 12-15% lower than UEP. Coal is trending down.
54.	• Many of the streams and creeks in special area that have been impacted have not been remediated, and where undertaken have not fully addressed impacts. • Concerned how the DoPE systematically approaches these proposals • Why should the SCA justify themselves? Is it any surprise that SCA is being amalgamated • The public is expected to carry the risks of projects like this – we need to guarantee that the company would do remediate. • The company's financial viability seems unlikely to be able to do so, leaving the tax payer to pick up the bill to remediate. • August 2014 UNSW released a report – there are no proven mitigation strategies other than the exclusion of sections from mining. • Dr Leslie Hughes – threatened species – repair to cracked creek beds are still considered experimental. • Need to expand the areas of swamps – danger with this mine that the sites of future restoration will be undermined • Think about the cataract dam in 50 years' time, there will be loses of 68 ML per year? How many jobs will there be in mining. We owe to our children to value public infrastructure.
55.	• Heathcoate candidate for the Greens. • Objects to proposal • Coal is Australian public property but is being sold off to foreign companies

ID	Issues
	• Quick scan of WCL annual report reveals revenue of 166 Million dollars. Total income tax was minus 35 million. Outstanding bank loans. They will continue to compound and roll on these losses. They will continue to make a loss no matter how much coal is extracted. Questioned WCL economic viability. • They will not pay tax • As a public company WCL has responsibility to shareholders not the local community • Government only holds $600k restoration fund which is not enough if WCL goes under.
56.	• Mine is couple of hundred metres from dam wall which has been subsided by 3cm from working kilometres away. • Possibility of hydraulic connection to the mine cannot be assessed. • Hydraulic column could extend to the dam with potential to fill workings and affect local landowners. • Premier came down to open the new electrified rail in Wollongong but it was cancelled due to damage caused from underground mining from coal cliff • Catastrophe – closeness of approach of the mine to the cataract dam. Mr Stone could not guarantee that the mine would not damage the dam. • Trying to predict what is really going to happen in subsidence, when you already have two seams above the proposed coal seam. Deep cracks coming down all over the place. Can't predict the subsidence on the dam • The possibility of hydraulic connection from the dam to the mine can't be assessed. Pressure in the mine, with hydraulic connection could be probable. • Proposed mine has to go through a major fault – you can't predict what is going to happen – gas burst, water? I suggest that this could be the source of a hydraulic connection from the dam. If that happens the mine fills up and then the water than comes down to the mine and community – we don't know what the effect will be on that. The whole of the escarpment would be effected. Major slip areas. Could get major landslides. These factors must be taken into account – you could be looking at a major catastrophe. Studies need to be done, should have money from the coal mine put in trust in case this happens • PAC commissioners – need to put in place a contingency statement
57.	• Climate change • Economics assessment should have independent CBA and justification with quantifiable costs. • Employment benefits not quantified. • 850 Mt of carbon dioxide by Australia last year • Australia stands to suffer from climate change more than other countries. Compromises our ability to feed ourselves • Emissions that we put out have an economic cost. It can be quantified. Federal government has committed to a low estimate of cost • There are other independent bodies that put a higher cost of greenhouse abatement. Greenhouse emissions can be quantified they are a concern to the tax payer. Anything that increases greenhouse emissions has a cost to tax payers. • Emissions from the mine itself which are mainly fugitive gas emissions, fugitive methane. Very large amount in the proposal estimated of over 2Mt per year. Equivalent to 90 m2 of mature forest per year. In the revised assessment this methane emission has come down to 20,000 per year. This seems like good news. • PAC – should not consider this in isolation, the DoPE recommendation that has a small effect on levels, but it looks in isolation and you should look at the totality of the picture. • Economic assessment, preliminary assessment – looking for a summary independent cost benefit analysis, an independent justification, but never found it. The DoPE had quoted the PPR which was a document written by Gujarat. Needs to be a thorough independent analysis. It should include cost factors that can be quantify, the cost of emissions, cost of council, cost of risks can be quantified. Benefits of employment should be quantified. Automotive industry faced job losses, CSIRO job losses. Employment patterns are changing all the time, we need to ask ourselves what is the best way to employ people. • It is not acceptable for the PAC or the government to consider just this mining approval. WE need to look at the proposal in totality, a thorough traceable economic assessment, at the front of the report. Relying on the statement that there will be a green house gas management put in place, is not enough. Companies should be given a license and they should be fined for breaching these licenses.

Appendix C

WCL Response to the UEP IESC Advice

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24 November 2014

Assistant Secretary, South-Eastern Australian Assessment Branch
Environmental Assessment and Compliance Division
Department of the Environment
GPO Box 787
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Dear Mr Tregurtha,

WOLLONGONG COAL LTD (EPBC 2014/7268)
RESPONSE TO ADVICE OF THE INDEPENDENT EXPERT SCIENTIFIC COMMITTEE ON THE RUSSELL VALE COLLIERY UNDERGROUND EXPANSION PROJECT

1 INTRODUCTION

Wollongong Coal Limited (WCL) operates the Russell Vale Colliery, located approximately 8 km north of Wollongong and 70 km south of Sydney. On 11 July 2014, WCL made a Referral (EPBC 2014/7268) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) with respect to the "Russell Vale Colliery Underground Expansion Project".

On 22 July 2014, the Commonwealth Department of the Environment (the Department) requested further information, particularly with respect to potential impacts on Coastal Upland Swamps in the Sydney Basin Bioregion (which was listed as an endangered ecological community on 17 July 2014). On 14 August 2014, WCL provided the information requested by the Department, including a *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a).

On 14 November 2014, the Department declared the Action to be a 'controlled action'. On 12 August 2014, the Department made a request to the Independent Expert Scientific Committee (IESC) to provide an advice on the Action.

The IESC issued its advice (IESC 2014-057) on 11 September 2014. This letter responds to the issues raised in the IESC's advice for the Underground Expansion Project.

This letter has been prepared based on input from key technical specialists, including Biosis, SCT, WRM Water & Environment and GeoTerra.

2 RESPONSE TO THE IESC ADVICE

2.1 ISSUE 1

The subsidence assessment does not provide a reasonable estimation of the risk of impacts to overlying swamps as it does not take into account potential increased subsidence implications of multiple goaf strata settling after longwall extraction, and possibly underestimates the risks of cracking beneath swamps by using less stringent strain criteria than elsewhere in the Residual Matters Report.

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)
- Sections 3, 5 and 6.1.2 of *Update of Subsidence Assessment for Wollongong Coal Preferred Project Report Russell Vale No 1 Colliery* (SCT, 2014)

Response

The subsidence predictions provided by SCT (2014) represent the effects of multi-seam mining by separating the movements that occurred prior to mining in the Wongawilli Seam from the movements that are expected to occur as a result of mining in the Wongawilli Seam. Movements that have occurred as a result of previous mining in the Bulli and Balgownie seams are estimated in Section 3 of SCT (2014). The predicted subsidence effects for the proposed mining activities in the Wongawilli seam are presented in Section 5 of SCT (2014) and take account of the previous mining.

These subsidence predictions were used in the risk assessment for upland swamps undertaken by Biosis (2014a).

In the past, impact assessment for upland swamps in the Southern Coalfield has focused on the use of the criteria outlined in DoP (2010), OEH (2012) and DoE (2014) to determine the risk of negative environmental consequences to upland swamps. DoP (2010) states that these criteria are a "*threshold for investigation – not a conclusion that the swamp will be impacted or suffer consequences*" (p. 120). There is now mounting evidence to indicate that the maintenance and persistence of upland swamps in areas subject to subsidence is much more complex than has been previously recognised. This is illustrated by the historic impact assessment for upland swamps that shows that some swamps (such as CCUS4 and CCUS5) have undergone subsidence levels above thresholds outlined in DoP (2010), OEH (2012) and DoE (2014) and maintain a perched water table and a healthy swamp ecosystem (Biosis, 2014a). Thus these thresholds should not be used to assert that fracturing of bedrock and associated negative environmental consequences to upland swamps will occur, rather that further investigation is required. Accordingly, a risk assessment was undertaken for the 14 swamps that were identified as requiring further investigation. This risk assessment is presented in Section 4 of Biosis (2014a). The risk assessment concluded that one swamp (CCUS4) was at a high risk of impact, one swamp was at a moderate risk of impact (BCUS4) and all other swamps were at a low risk of impact.

2.2 ISSUE 2

The surface water assessment only predicts the area of swamps impacted by subsidence but does not assess the surface water related risks to swamps.

Relevant Sections of Documentation

- Section 9 of *Russell Vale Colliery Wonga East Underground Expansion Project Surface Water Modelling* (WRM, 2014)
- Section 4.3 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

As explained in Section 9 of WRM (2014), upland swamps account for only a small portion of the catchments at Wonga East. Upland swamps represent approximately 1.1% of the Cataract Creek catchment and 0.9% of the Cataract Reservoir catchment. Assuming that the contributions of swamps to streamflow are proportional to their contribution to the catchment area, upland swamps contribute to a relatively low percentage of total streamflow (see **Section 2.34**).

The impacts to flow regimes within upland swamps was assessed using flow accumulation modelling, as described in Section 4.3 of Biosis (2014a). This analysis indicated that for the majority of upland swamps in the study area, changes to flow regimes were predicted to be negligible or minor. Two upland swamps (CCUS5 and CCUS11) are predicted to be subject to a decrease in catchment area of greater than 10%, whereas swamp BCUS4 is predicted to experience an increase in catchment area of greater than 10%.

2.3 ISSUE 3

The proponent is justified in not including swamps which are known to be disconnected from the regional groundwater system, in the regional scale numerical groundwater model. However, the connectivity of all swamps to the regional groundwater system has not yet been assessed. Swamps whose hydrology is connected to, or influenced by, the regional groundwater system should be included in the regional groundwater model. Where localised perched aquifers are likely to support overlying swamps, finer scale groundwater modelling is necessary to predict the risk of impacts to swamps.

Relevant Sections of Documentation

- Section 10.3.4 of *NRE No. 1 Colliery Major Expansion Groundwater Assessment* (GeoTerra, 2012)
- Section 7.10.3 of *LW5 Water Management Plan* (Gujarat NRE Coking Coal Ltd, 2013)

Response

As explained in Section 10.3.4 of GeoTerra (2012) and Section 7.10.3 of the *LW5 Water Management Plan* (Gujarat NRE Coking Coal Ltd, 2013), combined basement and swamp piezometers installed at swamp CCUS2 (piezometers NRE1A and PCc2) have determined that in the Wonga East area, perched swamps and the regional groundwater systems are disconnected by unsaturated strata. GeoTerra / GES (2014) subsequently reviewed the monitoring data available at the time and confirmed that the swamps at Wonga East are ephemeral with highly variable water levels dependent upon rainfall. It has also been recognised by GeoTerra / GES (2014) that the upland swamps are relatively thin (less than 2 m thick). The upland swamps were not included within the groundwater model for the following reasons:

- The minimum cell size is 25 m x 25 m wide x 20 m thick, and the data within each cell is an amalgam of all lithologies, so any groundwater changes that may occur within a swamp are a collective of all lithological responses within each cell. Setting up a swamp specific model would require a much smaller cell size to exclude non swamp areas;
- The swamps are a maximum of 2 m thick, so the current surface cell thickness of 20 m is too thick to exclude all non-swamp lithological responses, so a minimum cell thickness of 0.5 – 1.0 m would be required;
- There is insufficient data on the spread of hydraulic conductivity, water level variability and variability of lateral and vertical position of the swamp / sandstone interface to warrant realistic modelling of the swamps;
- There are constraints associated with transporting a drill rig onto site to install paired deep / shallow paired piezometers within or in the vicinity of the swamps; and
- There is insufficient data on swamp discharge outflows to streams, and it is difficult to obtain realistic monitoring data as the majority of swamp discharge occurs as sheet flow through highly vegetated terrain with no definitive out flow path constrictions.

WCL has recently installed additional swamp piezometers and stream flow monitoring measures to monitor the hydrological responses of swamps to subsidence (see **Section 2.7** and **Section 2.30**).

2.4 ISSUE 4

The proponent's subsidence assessment predicts fracturing of bedrock where tensile and compressive strains are greater than 1-2 mm/m and 2-3 mm/m respectively. The proponent's biodiversity assessment uses the more stringent criteria (>0.5 mm/m and >2 mm/m for tensile and compressive strains) for identification of swamps at risk of negative environmental consequences, such as bedrock cracking, as stated by the NSW Planning Assessment Commission and referenced in Conservation Advice for Coastal Upland Swamps in the Sydney Basin Bioregion.

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

The more stringent criteria used in the biodiversity assessment are the thresholds outlined in DoP (2010), OEH (2012) and DoE (2014). As stated in **Section 2.1**, these criteria act as a "*threshold for investigation – not a conclusion that the swamp will be impacted or suffer consequences*" (p. 120).

Section 3 of Biosis (2014) assesses the historic impacts to upland swamps from extraction of the Bulli and Balgownie seams. This assessment considers modelled (Bulli seam) and measured (Balgownie seam) subsidence values and assesses these values against the thresholds outlined in DoP (2010), OEH (2012) and DoE (2014). This analysis indicates that many of the swamps in the Wonga East area have been subject to subsidence levels substantially above the thresholds outlined in DoP (2010). However, analysis of piezometric data indicates that whilst some swamps show enhanced drainage recession rates, possibly indicating adverse effects resulting from prior subsidence, other swamps show little to no impact. For example, CCUS4 maintains a perched water table despite being subject to subsidence effects above the thresholds outlined in DoP (2010), OEH (2012) and DoE (2014).

2.5 ISSUE 5

The regional-scale numerical groundwater model is not constructed to assess the potential risks as a result of subsidence on localised perched aquifers. Where shallow ephemeral perched aquifers within the Hawkesbury Sandstone contribute to the water balance of swamps, there is a risk that surface cracking associated with subsidence will drain perched aquifers and reduce inflows to swamps. All sources of water, including contributions from perched aquifers and potential losses associated with surface cracking need to be considered in the assessment of risk of impacts to swamps. Finer scale models are needed to characterise the hydrology of swamps and quantify likely changes as a result of the proposed project. These models should be informed by detailed site specific studies, and include time series data and predicted changes to runoff within swamp catchments.

Relevant Sections of Documentation

- Section 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a).

Response

Section 2.3 explains why it was not feasible to undertake numerical modelling for the perched groundwater systems in this instance.

WCL has installed additional swamp piezometers and soil moisture probes to improve the understanding of the perched groundwater systems in the Wonga East area. Biosis (2014a) conducted an assessment of the overall risk to upland swamps posed by the following impact mechanisms:

- Fracturing of the bedrock below the swamp due to tensile strains, resulting in vertical drainage of the swamp;
- Subsidence related tilting resulting in increased scour and erosion, or altered water distribution across the swamp; and
- Buckling and bedding shear resulting in increased lateral drainage from the swamp.

Unlike the shrub swamps and hanging swamps of the Newnes Plateau, the distribution and maintenance of upland swamps within the Wonga East area is not directly attributable to lithology. The Burralow Formation, which drives the development and persistence of swamps on the Newnes Plateau (Corbett, White & Kirsch, 2014a), consists of medium to coarse grained sandstone embedded with horizons of claystone. These horizons act as aquitards and provide discharge horizons in the Burralow Formation, which drives swamp development and maintenance. However, the Hawkesbury Sandstone occurring within the Wonga East area does not have the same defined stratigraphy, with no defined horizons of claystone. Rather, bedding planes that provide for the horizontal distribution of groundwater within the Hawkesbury Sandstone may aid in the development and maintenance of upland swamps. However, these bedding planes are not continuous over large areas and are difficult to define during conventional drilling operations.

Additional swamp piezometers, soil moisture probes and tributary weir flow monitoring have been installed to characterise the swamps' contribution to streams.

2.6 ISSUE 6

The initial risk assessment within the biodiversity assessment used established criteria, which indicated that 14 swamps are likely to experience negative environmental consequences. The final risk assessment potentially underestimates the risks to swamps from cracking by equally weighting risks to perched water and flow accumulation, resulting in the proponent's final ranking of risks as low, where there remains a high likelihood of cracking and tilting. The risks assigned to compressive tilts and strains within the final risk assessment should be considered high where they exceed established criteria.

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

As explained in **Section 2.1**, the maintenance and persistence of swamps is more complex than previously recognised, and is affected by a number of factors.

DoP (2010), OEH (2012) and DoE (2014) define six criteria used to identify upland swamps at risk of negative environmental outcomes. It is understood that these criteria were formulated using values defined by MSEC for determining longwall setback distances from major creeks, and were used by DoP (2010) and OEH (2012) for assessment of upland swamps to be considered at risk of negative environmental impacts.

As stated in DoP (2010), these criteria are a '*threshold for investigation – not a conclusion that the swamp will be impacted or suffer consequences*' (p. 120). The initial risk assessment presented in Section 4.1 of Biosis (2014a) determined that further investigation is required for 14 swamps. Accordingly, a detailed risk assessment was undertaken for these swamps, as described in Section 4 of Biosis (2014a). This risk assessment considered multiple impact mechanisms, as recommended by DoP (2010).

Changes in groundwater availability through fracturing of bedrock beneath an upland swamp is one potential impact mechanism. Fracturing of the bedrock beneath upland swamps, and/or changes in groundwater availability have been observed at a number of upland swamps on the Woronora Plateau. To date, secondary impacts, including erosion, gullying, changes in size of an upland swamp or changes in vegetation within an upland swamps have only been observed at a limited number of upland swamps that have experienced subsidence. This may be due to a lack of suitable quantitative monitoring (DoP, 2010).

Given the long history of mining beneath the Woronora plateau, and evidence of significant, observable impacts to only a limited number of previously undermined upland swamps, Biosis considers that the available scientific evidence supports a conclusion that subsidence will not always result in secondary impacts or catastrophic loss of upland swamps. For this reason, Biosis determined that criteria other than subsidence should be considered.

DoP (2009) identifies three potential impact mechanisms to upland swamps:

- The bedrock below the swamp cracks as a consequence of tensile strains and allows water to drain into the fracture zone. If the fracture zone is large enough or connected to a source of escape (e.g. a deeper aquifer or bedding shear pathway to an open hillside) then it is possible for sufficient water to drain to alter the hydrologic balance of the swamp.
- Tilting of sufficient magnitude occurs to either re-concentrate runoff leading to scour and erosion, potentially allowing water to escape from the swamp margins (possibly affecting the whole swamp) or to alter water distribution in parts of the swamp, thus favouring some flora species associations over others.
- Buckling and bedding shear enhances fracture connectivity in the host bedrock which promotes vertical then lateral drainage of the swamp. This mechanism is similar to redirected surface flow observed in subsidence-upsidence affected creek beds.

The use of multiple criteria in Biosis (2014a) is an attempt to address all three possible impact mechanisms, by assessing other factors such as groundwater availability (and thus potential for draining), changes in flow accumulation (to assess risk of erosion and scouring and potential changes in water distribution), orientation in relation to longwalls (to assess potential for ponding) and vegetation sub-communities (to assess the presence of species reliant on soil moisture and thus with greatest risk of change).

Biosis considers this multi-criteria approach to be a valid methodology for assessing the overall risk to upland swamps.

2.7 ISSUE 7

The biodiversity assessment provides reasonable descriptions of swamp locations and ecological characteristics, however, the assessment of perched water within swamps is based on a limited number of piezometers installed in swamps, with only swamp CCUS5 having more than one installed piezometer (two). To better determine ecosystem reliance on perched water, assessment of swamp hydrology should include measurement of the distribution of perched water and soil moisture content using multiple piezometers distributed within each potentially impacted swamp, and within un-impacted control swamps.

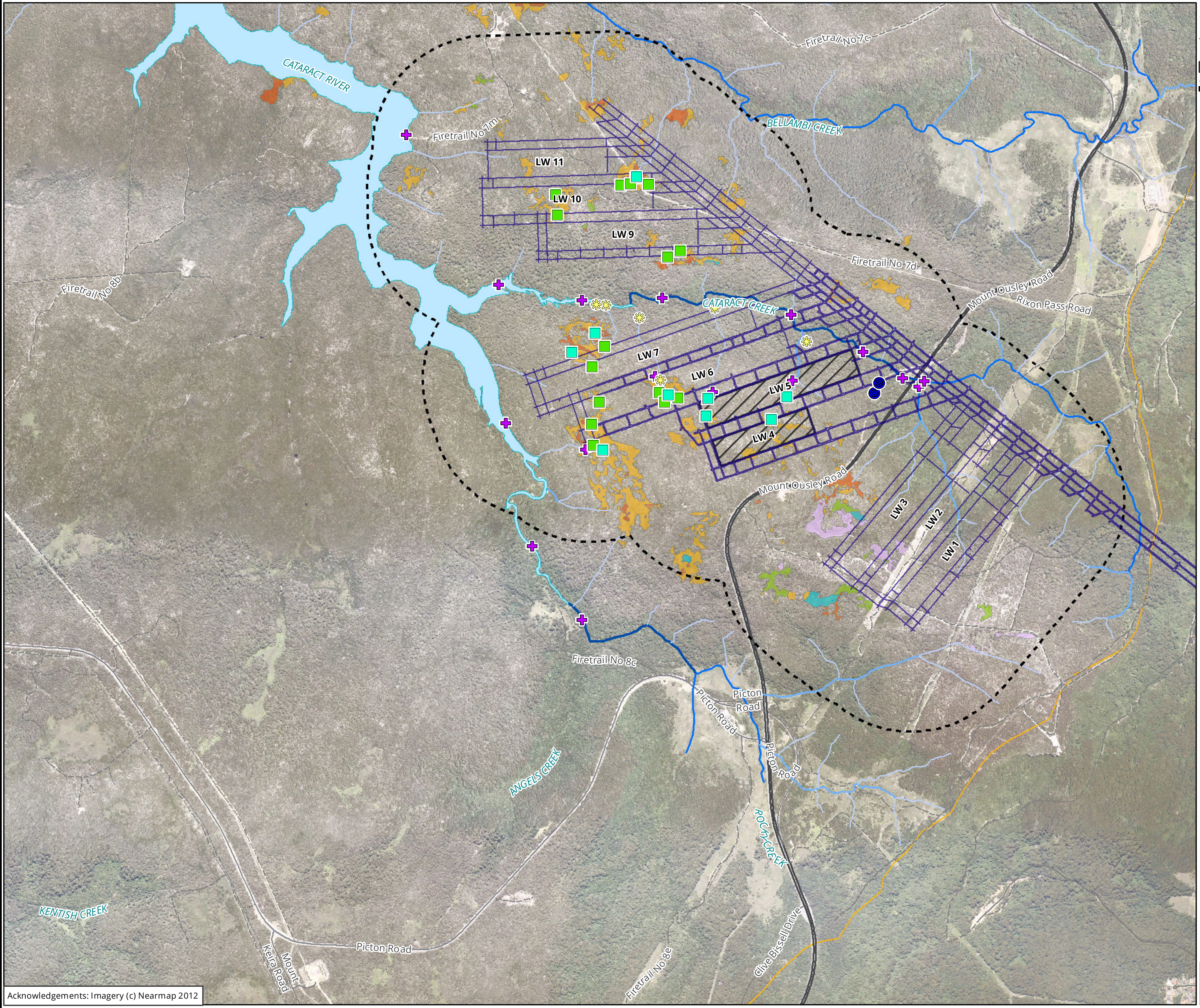
Response

To assist in characterising the hydrological regimes of swamps in the Wonga East area, WCL has installed additional swamp piezometers and soil moisture probes in accordance with approval D2014/49983 from the Sydney Catchment Authority (SCA). Piezometers have been installed in the swamps identified in **Table 1**. Locations of these piezometers are shown in **Figure 1**.

Table 1
Wonga East Swamp Piezometers

Bore	Swamp	Installed	E	N	Total Depth (mbgl)	Intake Screen (m)	Intake Lithology
PCc2	**CCUS2**	May 12	303745	6146080	1.60	1.1 – 1.6	humic sandy clay / wthrd sast
PCc3	**CCUS3**	Mar 12	302820	6196810	1.2	0.7 – 1.2	sandy clay / wthrd sast
PCc4A	**CCUS4**	Oct 14	302678	6196900	1.61	1.11 – 1.61	humic sandy clay / wthrd sast
PCc4B	**CCUS4**	Oct 14	302604	6196877	1.84	1.34 – 1.84	humic sandy clay / wthrd sast
Pcc4C	**CCUS4**	Oct 14	302579	6196931	1.27	0.77 – 1.27	humic sandy clay / wthrd sast
PCc4D	**CCUS4**	Mar 12	302615	6196925	0.9	0.4 – 0.9	humic sandy clay / wthrd sast
PCc5A	**CCUS5**	May 12	302110	6197150	1.24	0.7 – 1.2	humic sandy clay / wthrd sast
PCc5B	**CCUS5**	May 12	302245	6197250	1.31	0.8 – 1.3	humic sandy clay / wthrd sast
PCc5C	**CCUS5**	Oct 14	302234	6197073	0.85	0.5 – 0.85	humic sandy clay / wthrd sast
PCc5D	**CCUS5**	Oct 14	302296	6197168	1.23	0.73 – 1.73	humic sandy clay / wthrd sast
PCc6	**CCUS6**	Mar 12	303165	6196790	1.2	0.7 – 1.2	weathered sast
PCr1A	**CRUS1**	Mar 12	302330	6196625	0.55	0.3 – 0.55	humic sandy clay / wthrd sast
PCr1B	**CRUS1**	Oct 14	302247	6196655	0.69	0.44 – 0.69	humic sandy clay / wthrd sast
PCr1C	**CRUS1**	Oct 14	302229	6196762	1.15	0.65 – 1.15	humic sandy clay / wthrd sast
PCr1D	**CRUS1**	Oct 14	302263	6196879	0.37	0.22 – 0.37	sandy clay / wthrd sast
PB4	**BCUS4**	May 12	302485	6198060	0.6	0.25 – 0.6	humic sandy clay / wthrd sast
SP1	**N/A**	Mar 12	303245	6196955	0.60	0.1 – 0.6	sandy clay / wthrd sast
SP2	**N/A**	Mar 12	302830	6196905	1.05	0.55 – 1.05	sandy clay / wthrd sast

NOTE: AMG coordinates based on GPS readings
SP1 – shallow soil / weathered sandstone piezometer No.1
Wthrd sast – Weathered Sandstone



Legend

- Underground Expansion Project Longwall Layout
- Completed Longwalls
- Study Area

Proposed Monitoring Sites

- Constructed Weir
- Swamp Piezometer

Existing Monitoring Sites

- Ground Water Monitoring
- Surface Water Monitoring Site
- Swamp Piezometer

Figure 1: Existing and Proposed Additional Swamp Piezometers and Surface Water Monitoring

0 190 380 570 760 950

Metres

Scale: 1:18,500 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

Biosis Pty Ltd

Ballarat, Brisbane, Canberra, Melbourne, Sydney, Wangaratta & Wollongong

Matter: 18996
Date: 22 November 2014,
Checked by: AW, Drawn by: NMG, Last edited by: ngarvey
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18996_F1_Swamp_Monitoring_20141122

2.8 ISSUE 8

The likelihood that cracking and tilting will occur to the base of at least 14 swamps within the project area is considered high. While there is limited evidence available on ecological impacts on the Woronora Plateau, research from the Newnes Plateau (NSW) indicates impacts are likely to be severe and irreparable where the ecology is dependent on standing water levels; and where desiccation and induced slope are sufficient to initiate erosion.

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

The initial risk assessment undertaken by Biosis (2014a) indicated that 14 swamps are predicted to experience subsidence effects exceeding the criteria specified in DoP (2010). As stated in DoP (2010), these criteria are a '*threshold for investigation – not a conclusion that the swamp will be impacted or suffer consequences*' (p. 120). Predicted exceedances of these thresholds alone do not support the conclusion that there will be a high risk of cracking.

As stated in **Section 2.5**, data from the Newnes Plateau cannot be directly correlated with the Woronora Plateau as the mechanisms driving the development and maintenance of upland swamps are different due to differing lithologies between the two environments.

Commonwealth of Australia (CoA, 2014) discusses impacts to a number of upland swamps. Impacts to East Wolgan Swamp, Narrow Swamp, Kangaroo Creek Swamps and Long Swamp on the Newnes Plateau; and Swamp 18, Swamp 19, Drillhole Swamp and Swamp 36 on the Woronora Plateau are noted (CoA, 2014).

Corbett, White & Kirsch (2014) analysed impacts to upland swamps above the Angus Place and Springvale collieries. They determined that impacts to Narrow Swamp resulted from mine water discharge and were not related to subsidence. Impacts to East Wolgan Swamp were deemed to result from mine water discharge and mine subsidence. Impacts to Kangaroo Creek Swamp were deemed to have resulted from subsidence.

Tompkins & Humphrey (2006) undertook an assessment of three upland swamps within the Avon and Woronora catchments to assess the causes and triggers for erosion of upland swamps. They looked at past aerial photography, swamp stratigraphy, subsidence effects and fire history of Swamp 18, Swamp 37a (Drillhole Swamp) and Flatrock Swamp. All of these swamps have undergone erosion, scouring and gully formation and have all been mined beneath, either by longwall mining or bord and pillar mining. By looking at swamp stratigraphy, Tompkins and Humphrey (2006) were able to deduce that the erosion and filling of upland swamps is part of a natural process and that the development of scour pools is the first indication of the potential for such an event. The causes of the initial formation of scour pools is not known, but is likely to be triggered by heavy rainfall.

Tompkins and Humphrey (2006) also concluded that upland swamps erode as a result of a unique set of circumstances where internal thresholds are breached. It is likely that a combination of factors, including prior erosion, fire, anthropomorphic impacts and heavy rainfall breach these thresholds. Tompkins and Humphrey (2006) concluded that dewatering and drying of upland swamps as a result of fracturing of the bedrock may have increased the erosion potential of these upland swamps. This drying, in conjunction with fire and substantial rainfall, is likely to have increased the susceptibility of upland swamps to erosion, particularly Swamp 18. However, they also found that no single factor could be directly implicated in the erosion of these upland swamps. The presence of scour pools was a likely indicator of future erosion.

This conclusion is supported by information from Swamp 1b, located in Dendrobium Area 3B. This swamp was noticed to have eroded severely in 2003, prior to mining being commenced in 2013. It was concluded that this swamp eroded in the same fire and rainfall event as swamp 18.

Drying of swamps may increase sensitivity to natural stressors, such as fire and scouring, resulting in lower thresholds for erosion events. However, this drying must coincide with these other contributing factors for erosion to occur. To date there is little evidence as to whether drying of upland swamps results in changes to the size of swamps, or the species composition within upland swamps. Further ecological and groundwater monitoring will be undertaken to determine the impacts of declining groundwater levels on upland swamps.

2.9 ISSUE 9

The hydrological and soil conditions within the swamps provide habitats for an array of threatened flora and fauna communities. Where these threatened species occur, the loss or severe decline of the swamps within the project area would be expected to negatively impact these species.

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

The Environmental Assessment (ERM, 2013), Referral documentation and associated reports outline the survey effort undertaken as part of the assessment of the Underground Expansion Project. Detailed and targeted surveys of upland swamps within the study area have also been undertaken.

The only threatened species recorded in upland swamps within the study area is the Prickly Bush-pea (*Pultenaea aristata*). This species is distributed widely within the region, and is not reliant on permanent or intermittent water logging. It has been recorded in numerous upland swamps that have been previously subsided.

Although there is potential for other species to utilise these swamps during periods of drought or other stress, the majority of upland swamps in the study area are drier swamp types and do not support a significant perched water table or organic soils.

2.10 ISSUE 10

Impacts to undermined Coastal Upland Swamps in the Sydney Basin are variable and poorly understood. Mining has occurred in the area over many years and impacts to swamps in many cases are not apparent, however ecological change may occur over decadal timeframes. While a number of studies have assessed impacts to water-holding capacity of swamps, the IESC is not aware of any long term ecological impact studies.

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

A large number of upland swamps on the Woronora Plateau have been mined beneath using a combination of bord and pillar mining, pillar extraction and / or longwall mining. A lack of past monitoring data does not allow any firm conclusions to be reached. The current condition of swamps can be assessed against criteria for the Coastal Upland Swamp Endangered Ecological Community (EEC) and against other upland swamps that have not been mined beneath. The upland swamps in the study area are consistent with the EEC and exhibit similar species composition and piezometric data as other upland swamps in the greater region. The persistence of upland swamps in these areas indicates that swamps are more resilient to subsidence than previously thought, and that impacts may take decades (or longer) to manifest or that upland swamps are able to self-ameliorate. This is illustrated by the historic impact assessment for upland swamps (Biosis, 2014a).

However, this information is based on back analysis of available data. To date, little information is available on the long term impacts to upland swamps from subsidence, and the factors that increase or mitigate this risk.

WCL is currently implementing a detailed upland swamp monitoring program to assess the hydrological, ecosystem and ecological condition of the swamps (see **Figure 1**).

2.11 ISSUE 11

Evidence of undermining of Swamp 12 and 15b at the adjacent Dendrobium mine presented in Appendix G of the Residual Matters Report and further evidence at Swamp 1b indicate loss of perched water and reduction in soil moisture as a result of subsidence. The ecological impacts of these changes are yet to be determined but are likely to lead to ecosystem change over extended time periods.

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

A lack of long term ecological monitoring data from past mining inhibits the ability to make firm conclusions regarding the longevity of subsidence impacts to upland swamps and the long term consequences of any impacts. As explained in **Section 2.1**, the persistence of upland swamps in areas subject to past mining indicate that the relationship between subsidence and persistence of upland swamps is more complex than previously understood.

Swamps 12, 15b and 1b at Dendrobium Mine support a perched water table and outflow at the base of these swamps is visible. Whilst data from these upland swamps is applicable to wetter swamps in the study area, it may not be representative of drier swamps in the study area which do not support a significant perched water table.

The Upland Swamps Management Plan by WCL will assist in determining the factors which increase the susceptibility of upland swamps to subsidence impacts, as well as defining the long term ecological impacts should the perched water table be impacted.

2.12 ISSUE 12

Impacts have been identified in swamp CCUS4 which overlies the proposed longwall 6. These impacts included collapse of the sandstone cliffs and fracturing within sandstone bedrock. Further fracturing has been identified on ridgelines following the extraction of longwalls 4 and 5. Fracturing is predicted to occur within shallow bedrock and may not be visible below surface soil cover within swamps.

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

The risks to upland swamps associated with fracturing of bedrock has been assessed in Section 4 of Biosis (2014a). It is acknowledged that fracturing at the base of swamps may not be visible. As explained in **Section 2.1**, swamp CCUS4 supports a perched water table and healthy swamp ecosystem despite having experienced subsidence movements above the thresholds that are expected to result in fracturing (Biosis, 2014a).

SCT advises that there is no evidence of bedrock fracturing in the stream bed, where it is most likely to occur as a result of previous mining activities. However, this does not exclude the possibility that fracturing from previous mining has occurred in areas that are not visible. SCT advises that a section of sandstone cliff overhang on the western side of the stream channel appears likely to have been destabilised as a result of previous mining in the Balgownie Seam in the early 1980s.

2.13 ISSUE 13

The Residual Matters Report does not identify any significant impacts to swamp ecology within the project area; however this assessment does not include identification of cracks beneath swamps or a long term assessment of ecosystem change. As noted in the NSW Planning Assessment Commission (2010) report on Bulli Seam Operations "There are compounding problems in the current lack of ability to detect and quantify all but the most obvious change and the possibility that vegetation compositional changes will take time (possibly decades). However, the bottom line appears to be if mine subsidence has the potential to impact on near surface formations to an extent that could cause changes in the hydrology of a swamp, then the swamp is at risk of serious negative environmental consequences in whole or in part".

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

The historic impact assessment undertaken attempted to assess the risk of impacts to upland swamps from past mining using thresholds outlined in DoP (2010), OEH (2012) and DoE (2014) using modelled and actual subsidence data from previous extraction of the Bulli and Balgownie seams in the study area. This assessment determined that "*all upland swamps in the study area, except CCUS9, CCUS13, CCUS17, CCUS18, CCUS19 and BCUS6, have been subject to subsidence criteria sufficient to have placed these upland swamps at risk of negative environmental consequences*" (Biosis, 2014a). This assessment then compared hydrological data from piezometers installed in upland swamps as well as qualitative assessment of the extent and condition of vegetation in these swamps to assess if any impacts were evident and provide a context for assessment of cumulative impacts.

Whilst this data is not based on long term monitoring during and after mining, it does provide some context for the current condition of these upland swamps. This analysis indicated that although impacts to some swamps may be evident, other swamps appeared to be healthy and supported a significant perched water table despite subsidence from past mining.

2.14 ISSUE 14

Changes to the slope (through subsidence induced tilt) above the established subsidence criteria are predicted to occur in 14 headwater swamps within the project area. Tilts are predicted to range between 19 and 32 mm/m at various points within these swamps. Tilt is predicted to be most severe where multiple underlying goaves are directly adjacent to multiple underlying chain pillars (for example, between proposed longwalls one to three and between longwall five and proposed longwalls six and seven). In these locations, changes to surface flow regimes are expected to be more severe, and therefore these localities represent a higher risk to headwater swamps.

Relevant Sections of Documentation

- Section 4.3 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

The impacts to flow regimes within upland swamps in the study area was assessed using flow accumulation modelling. This analysis indicated that for the majority of upland swamps in the study area there was likely to be negligible or minor changes in flow regimes. Two upland swamps (CCUS5 and CCUS11) are predicted to be subject to a decrease in catchment area of greater than 10%, whereas swamp BCUS4 is predicted to experience an increase in catchment area of greater than 10%.

2.15 ISSUE 15

Assessment of water level responses within headwater swamps indicates short residence times for perched water within a number of headwater swamps, in some cases possibly indicating impacts due to prior subsidence. The limited number and distribution of piezometers may underestimate reliance of swamp ecosystems on standing water levels and soil moisture levels.

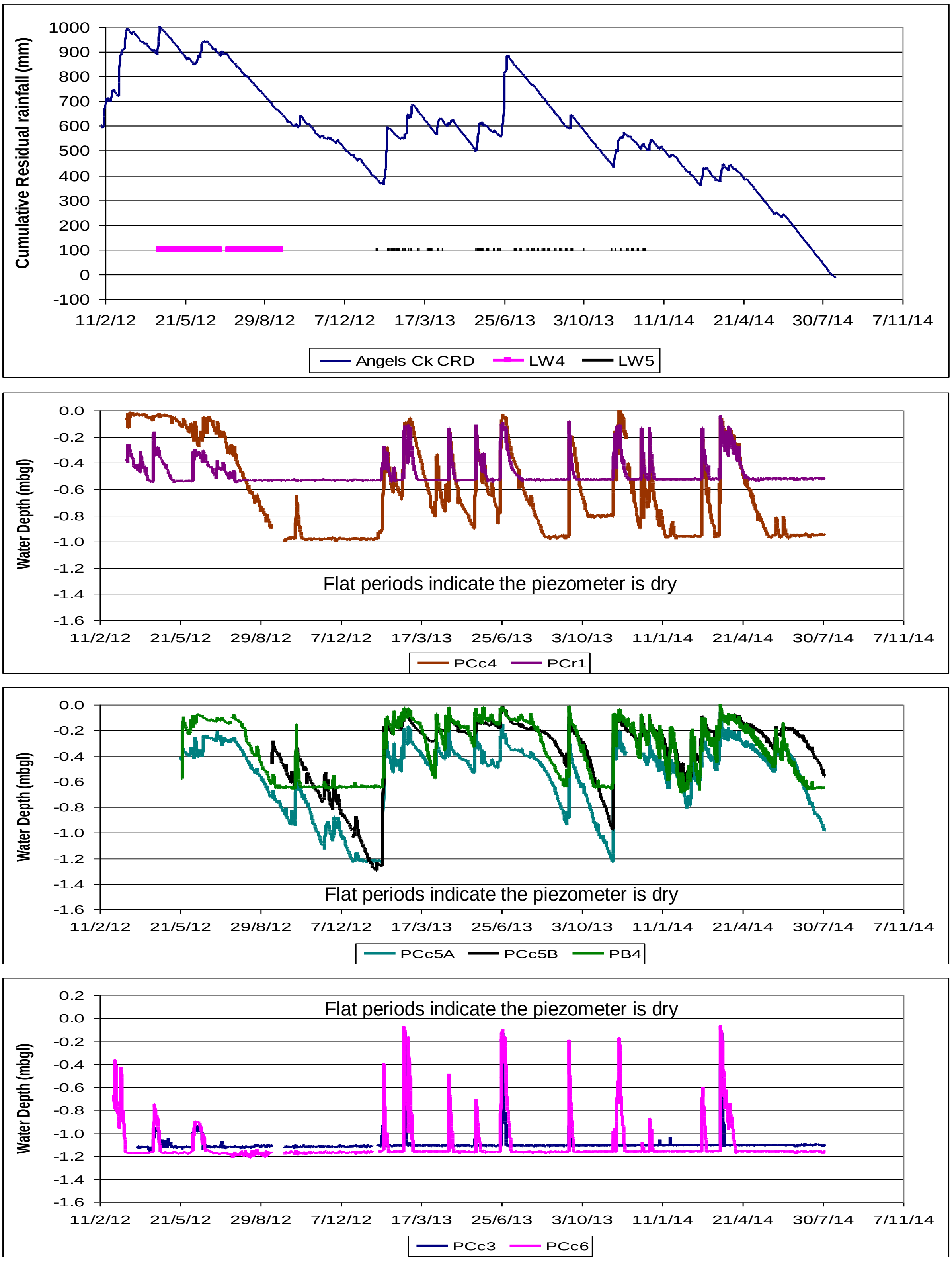
Response

The swamps at Wonga East are highly variable in their size, hydraulic connectivity, surface water discharge characteristics, thickness, lithology, humic content and associated moisture retention capacity. As a result, different swamps exhibit varying responses to rainfall recharge.

It cannot be assumed that desiccation of a swamp during a mining period is necessarily a response to mining. **Figure 2** shows that although piezometer PCc4 in swamp CRUS4 indicated desiccation during mining of Longwall 4, the same response was observed in other Wonga East swamps that were not being directly undermined. This suggests that the observed desiccation was a result of lower rainfall recharge.

As explained in **Section 2.7**, WCL has installed additional swamp piezometers and soil moisture probes to improve its understanding of swamp hydrological responses to mining activity.

Figure 2
Hydrographs



2.16 ISSUE 16

Assessment of impacts to a headwater upland swamp at the nearby Dendrobium mine indicates undermining has resulted in impacts to perched aquifer levels, soil moisture levels and flows to the down gradient tributary. A reliable assessment of impacts to perched water levels, soil moisture levels and associated ecological communities needs a robust Before-After Control-Impact study design approach including assessment of the spatial and temporal distribution of standing water levels and soil moisture within each swamp.

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

The detailed upland swamp monitoring program currently being installed by WCL includes multiple piezometers installed in upland swamps and paired with soil moisture probes. This detailed monitoring program will provide information on the temporal and spatial distribution of water within these upland swamps. The recently installed piezometers and stream flow monitors will provide baseline information prior to mining as well as during mining.

2.17 ISSUE 17

*The Coastal Upland Swamps provide important habitats for a number of threatened species, including the EPBC listed vulnerable green and golden bell frog (*Litoria aurea*) and giant burrowing frog (*Heleioporus australiacus*). The red-crowned toadlet (*Pseudophryne australis*), which is listed as vulnerable in NSW, is also known to be present. The ecological community also provides habitat for the NSW listed endangered giant dragonfly (*Petalura gigantea*) which is now uncommon in the coastal regions of NSW.*

*The proponent's biodiversity assessment identified the giant burrowing frog (tadpoles), the red-crowned toadlet, and the giant dragonfly onsite, with suitable habitats for the stuttering frog (*Mixophyes balbus*). Where these threatened species occur, the loss or severe decline of Coastal Upland Swamps within the project area would be expected to negatively impact the reproductive cycle and thus the long term viability of these species.*

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)
- Section 9 of *Russell Vale Colliery Wonga East Underground Expansion Project Surface Water Modelling* (WRM, 2014)

Response

Biosis advises that the upland swamps within the study area do not provide habitat for the species identified by the IESC (other than the Giant Dragonfly).

Targeted surveys for all other species have been undertaken and none have been recorded within the upland swamps within the study area. Suitable habitat for the Green and Golden Bell Frog does not occur within the study area. The Giant Burrowing Frog has been recorded in a tributary of Cataract River below upland swamps CRUS2; however this upland swamp is located outside of the predicted subsidence impact limit for the Underground Expansion Project. No impacts to this habitat will occur. The Red-crowned Toadlet has been recorded in a number of small depressions below ridges, but not within upland swamps. This species is widely distributed within the region in similar habitat. Upland swamps do not provide suitable habitat for the Stuttering Frog.

Surface water modelling for the Underground Expansion Project indicates that although the perched, ephemeral groundwater water table associated with upland swamps could undergo a water level reduction, it is not anticipated to have a significant overall effect on stream baseflow or stream water quality (WRM, 2014). However, temporary, localised effects may be observed.

2.18 ISSUE 18

While the proponent has reduced the likelihood of impacts to a number of swamps through a change of the mine plan associated with the Preferred Project Report, the mine plan still proposes to wholly or partially undermine 12 swamps, which the proponent predicts will experience fracturing within shallow bedrock at their base. No other strategies are provided that are likely to effectively avoid or mitigate impacts to swamps.

Relevant Sections of Documentation

- Section 3.3 of *Preferred Project Report – Biodiversity* (Biosis, 2014b)

Response

WCL has undertaken substantial revision of the mine plan to avoid and minimise impacts to upland swamps by reducing subsidence to below these thresholds. Significant modifications to the mine plan for the Underground Expansion Project were proposed in the Preferred Project Report (Gujarat NRE Coking Coal Ltd, 2013b). The modifications to the mine plan include removal of all longwall panels in the Wonga West area, and significant changes to the alignments and dimensions of longwall panels in the Wonga East area. These changes have reduced the impacts of the Underground Expansion Project on upland swamps, as discussed in Section 3.3 of the *Preferred Project Report – Biodiversity* (Biosis, 2014b).

The area of upland swamps that is predicted to be impacted was reduced by 4.14 ha as a result of the changes to the mine plan.

WCL has endeavoured to develop a mine plan that minimises impacts on upland swamps whilst still providing for economically viable resource recovery.

WCL will implement an Upland Swamps Management Plan to monitor impacts to upland swamps and determine measures to mitigate or remediate impacts (where required).

2.19 ISSUE 19

The proponent has reduced the likelihood of impacts to a number of swamps through a change of the mine plan associated with the Preferred Project Report that has reduced the number of swamps that will be undermined. The redesign includes moving longwall extraction areas resulting in significantly reduced but still partial undermining of swamps CCUS1, CCUS5 and CCUS10.

Response

Refer to response to Issue 18 in **Section 2.18**.

2.20 ISSUE 20

The Residual Matters Report outlines a Biodiversity Management Plan and associated adaptive management measures. The associated measures involve identifying impacts during and post mining which may provide important information for future mining proposals in this area. However, as they do not include conditions to reduce ground movement and strains below swamps to less than the established criteria, these measures are considered ineffective in avoiding or mitigating impacts to swamps.

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

The criteria outlined in DoP (2010), OEH (2012) and DoE (2014) are a "*threshold for investigation – not a conclusion that the swamp will be impacted or suffer consequences*" (p. 120).

The avoidance measures adopted by WCL are summarised in **Section 2.18**. In accordance with the principles of avoid, minimise and mitigate, WCL will implement a monitoring plan to assess impacts to upland swamps that may arise and determine measures to mitigate and / or remediate any impacts wherever possible.

2.21 ISSUE 21

Triggers outlined in the Trigger Action Response Plan (TARP) for recently mined longwall 5 will not determine swamp reliance on perched water, or mitigate impacts to swamps, because they occur after, not prior, to impacts. Further, the TARP does not require changes to the mine plan or cessation of mining associated with an unacceptable level of impact, therefore limiting its capacity to avoid or mitigate impacts.

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

As outlined above, WCL has undertaken substantial revision of the mine plan to avoid and minimise impacts to upland swamps. Any further reduction of the mine plan would render the project unviable. Further, mine plan modification is not suitable as an adaptive management approach because fracturing is already likely to have occurred if the triggers in the TARP are exceeded. Mine plan modification is only suitable as an avoidance measure and has already been undertaken by WCL.

WCL has applied the principles of avoid, minimise and mitigate, by substantially revising the mine plan to avoid and minimise impacts to upland swamps. Further, WCL will implement a detailed upland swamp monitoring plan to assess the temporal and spatial distribution of water within upland swamps in the study area. Although this monitoring plan will not provide for adaptive management, it will inform the discussion around impacts to upland swamps from mining and provide information that will assist in minimising impacts to upland swamps in the future.

2.22 ISSUE 22

The only known strategy to avoid the risk of impacts to swamps is to ensure mining does not cause ground movement and strain in excess of the established criteria. This strategy should also be applied to any ephemeral perched groundwater systems which contribute a significant proportion of a swamp's water balance.

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

The criteria outlined in DoP (2010), OEH (2012) and DoE (2014) are a "*threshold for investigation – not a conclusion that the swamp will be impacted or suffer consequences*" (p. 120).

As explained in **Section 2.18**, WCL has undertaken substantial revision of the mine plan to avoid and minimise impacts to upland swamps. Any further revision of the mine plan would render the project unviable.

2.23 ISSUE 23

The irreversible nature of impacts to swamps in combination with the potential delay before identification of impacts diminishes the likelihood of success of adaptive management measures.

Relevant Sections of Documentation

- Section 4.3 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

There is currently no data on the long term impacts of subsidence on upland swamps, or on the capacity of upland swamps to self-ameliorate. However, the persistence of upland swamps in areas that have been mined previously indicates that swamps are more resilient to subsidence than previously thought, impacts take decades (or longer) to manifest or the ability of upland swamps to self-ameliorate. This is illustrated by the historic impact assessment for upland swamps (Biosis, 2014a).

If mining results in impacts to swamps that cannot be remediated, WCL will provide suitable offsets in accordance with the conditions of its approvals and in consultation with the relevant regulatory authorities.

2.24 ISSUE 24

A recent evaluation of remediation techniques was not able to identify any examples of mitigation or remediation of undermined peat swamps, and in instances where impacts have occurred there have been no signs of self-amelioration in swamps impacted more than 25 years ago.

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

It is acknowledged that remediation of impacts to upland swamps is currently not feasible, and that remediation may result in additional impact. However, analysis of impacts to upland swamps resulting from past mining indicates that the responses of swamps to subsidence may be more complex that previously understood (Biosis, 2014a).

Analysis of subsidence associated with historic mining on the Woronora plateau indicates that despite tilts and strains above thresholds identified in in DoP (2010), OEH (2012) and DoE (2014), some upland swamps in the study area continue to support healthy vegetation and a perched water table. In addition, the persistence of upland swamps across the Woronora Plateau in areas subject to past mining since the late 1800s indicates that swamps are more resilient to subsidence than previously thought, impacts take decades (or longer) to manifest or the ability of upland swamps to self-ameliorate.

2.25 ISSUE 25

Remediation strategies such as sealing fracture networks of exposed rock in creeks and tributaries have been found to be costly, risky and likely to have a limited lifespan. The successful use of this approach is likely to be limited due to presence of overlying sediments, issues with detection of fracture networks, and potential significant impacts to swamps associated with the remediation process such as clearance of vegetation and swamp substrate to determine extent of cracking.

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

It is acknowledged that there are no successful examples of the remediation of impacts to upland swamps from subsidence induced fracturing.

WCL has undertaken substantial revision of the mine plan to avoid and minimise impacts to upland swamps and proposes additional monitoring (refer to **Section 2.18**).

2.26 ISSUE 26

Given the variable nature of impacts to swamps and difficulties in their accurate and confident prediction, the most effective strategy to reduce the risk of impact to swamp communities within the proposed project area would be to alter the mine layout such that swamps are not undermined by longwall panels and are not subjected to strains in excess of the established criteria. Further, surface flows that contribute water to swamps should not be disrupted. There is no scientific evidence to demonstrate that remediation activities are able to successfully restore the hydraulic and ecological functions of these ecological communities to pre-impact condition.

Response

As explained in **Section 2.1**, the established criteria act as a "*threshold for investigation – not a conclusion that the swamp will be impacted or suffer consequences*" (p. 120). These criteria therefore do not act as absolute limits on the magnitudes of subsidence effects. Nevertheless, WCL has significantly modified the mine plan for the Underground Expansion Project to reduce the risk of impacts to upland swamps (as discussed in **Section 2.18**).

2.27 ISSUE 27

The only currently known measures to successfully minimise impacts to swamps involve modification of mine layout to prevent stresses greater than established criteria.

Response

As explained in **Section 2.1**, the established criteria act as a "*threshold for investigation – not a conclusion that the swamp will be impacted or suffer consequences*" (p. 120). Nevertheless, WCL has significantly modified the mine plan for the Underground Expansion Project to reduce the risk of impacts to upland swamps (as discussed in **Section 2.18**).

2.28 ISSUE 28

Adaptive management is not a suitable approach to minimise impacts to swamps due to the irreversible nature of impacts and the potential for long time delays before identification of irreversible ecological impacts.

Response

Refer to **Sections 2.21** and **2.23**.

2.29 ISSUE 29

Measures to reduce uncertainty in impact prediction include:

a. *Detailed swamp water balance studies assessing extent and temporal distribution of standing water and soil moisture within swamps, including identification of all water inputs and outputs. Assessment of water sources should consider but not be limited to potential contributions from catchment run-off and seepage from shallow perched groundwater systems.*

b. *The development of long term Before-After Control-Impact studies which enable identification and quantification of cracking and tilting, altered flow paths and changes to water quality, subsequent erosion and ecological responses of flora and fauna.*

Response

a. The data obtained from the additional swamp piezometers, soil moisture probes and tributary weir flow monitoring suite (shown in **Figure 1**) will help to characterise the hydrology of the upland swamps in the Wonga East area.

b. Refer to **Section 2.16**.

2.30 ISSUE 30

The groundwater and surface water models are not suitably robust for the quantitative predictions provided. The key uncertainties regarding the groundwater model are related to the hydraulic and spatial characteristics of the fracture zone and its unsuitability to predict impacts at a scale relevant to swamp hydrology.

The key uncertainties with the surface water model include the lack of justification for predicted stream flow loss scenarios, and lack of stream flow data for calibration in Cataract Creek.

Relevant Sections of Documentation

- *Peer Review – Russell Vale Colliery Groundwater Impact Assessment* (HydroSimulations, 2014)
- *Russell Vale Colliery (formerly the NRE No. 1 Mine) Underground Expansion Project Groundwater Review* (Coffey Geotechnics, 2014)

Response

GeoTerra / GES (2014) describes the groundwater modelling that was developed to assess the impacts of the Underground Expansion Project. The key object of the groundwater model was to predict the impacts associated with mining induced depressurisation of the regional aquifer.

To account for uncertainties in the groundwater model, a sensitivity / uncertainty analysis was completed to test the sensitivity of various assumptions included within the model, including hydraulic conductivity of the strata overlying the longwall mining operations. This analysis utilised 30 model runs with randomised arrays of hydraulic conductivity centred around the calibrated value for each layer, as well as a sensitivity analysis on the rainfall recharge. The sensitivity analysis indicated the base case estimates of mine inflow and streamflow losses were acceptable.

HydroSimulations (2014) completed a peer review of the groundwater modelling completed by GeoTerra / GES (2014). This review indicated that the groundwater model is suitable for generating quantitative groundwater predictions for the Underground Expansion Project. HydroSimulations also concluded that the hydraulic conductivity values / calibration process used in the model were appropriate. The review commissioned by DP&E also supported this conclusion (Coffey, 2014).

Uncertainties associated with the surface water modelling are discussed in the response to Issue 32 (see **Section 2.32**).

To obtained stream flow data, WCL has installed additional stream flow monitoring equipment in Cataract Creek and tributaries draining from swamps to the south of Cataract Creek. The updated monitoring suite includes:

- Improved weirs at CC3 and CC4 in the main channel, upstream of the freeway; and
- Tributary weirs draining into Cataract Creek to the north from swamp CCUS3 (site CT2), swamp CCUS4 (sites CT3 and CT3A), swamp CCUS5 (sites CT4A and CT4B) and swamp CCUS6 (site CT1 and CT1A).

The locations of these weirs are shown in **Figure 1**.

2.31 ISSUE 31

Quantitative predictions made using the regional groundwater model include predictions of drawdown, mine inflow and stream baseflow. There is low confidence in these predictions for the following reasons:

a. There is a lack of long term calibration data for groundwater pressure, and no calibration data for baseflow and mine inflows resulting in low confidence in the predicted range of baseflow and mine inflow.

b. The calibrated hydraulic conductivity values, particularly within the impacted zone, are lower than values measured in other studies within the Southern Coalfields. Given the low hydraulic conductivity values utilised, the groundwater model potentially underestimates drawdown, including lateral and vertical extent, as well as the quantity of mine inflows induced by the effect of multiple overlying goaves and their associated fracture network.

c. *The Tammetta Model used to predict subsidence effects on groundwater pressure and hydraulic conductivity is not supported by evidence from the site. Measurements of groundwater pressure and horizontal and vertical hydraulic conductivity, prior to and post undermining, would improve confidence in model representation of subsidence impacts on groundwater systems.*

d. *The predictive uncertainty analysis is limited in that it does not explore a full range of vertical and horizontal hydraulic conductivities. Confidence in the predictions of this analysis are low due to:*

   i. *The limits placed on the range of randomly generated horizontal hydraulic conductivity values whereby values are centred around the calibrated value for each model layer. Uncertainty analysis should enable consideration of the effects of higher horizontal hydraulic conductivity on baseflow and mine inflow.*

   ii. *The analysis not including scenarios which consider increased vertical hydraulic conductivity through the profile. Given the high likelihood of increased vertical conductivity above goaves and the potential effect this can have on reducing groundwater pressures and increasing downward flow, uncertainty analysis predictions should consider the potential effect of increased vertical hydraulic conductivity.*

Relevant Sections of Documentation

- *Peer Review – Russell Vale Colliery Groundwater Impact Assessment* (HydroSimulations, 2014)
- Section 12 of *Russell Vale Colliery Underground Expansion Project Preferred Project Report Wonga East Groundwater Assessment* (GeoTerra / GES, 2014)

Response

The HydroSimulations review (2014) concluded that sufficient groundwater level and mine inflow data was used for calibration (see **Section 2.30**). WCL has recently installed updated flow monitoring apparatus along Cataract Creek at Sites CC3 and CC4, as well as in tributaries to the south of Cataract Creek to collect additional stream baseflow data for ongoing model calibration.

As explained in Section 12 of the Groundwater Assessment (GeoTerra / GES, 2014), the groundwater model has been calibrated against site specific hydraulic parameters and mine inflow data.

Additional data is being obtained from recently installed open standpipe and vibrating wire piezometers at Wonga East. Data from these piezometers will assist in assessing the site specific height of depressurisation. WCL has undertaken packer tests in all bores drilled to date, with the available data at the time of model preparation being deemed suitable by HydroSimulations (2014).

The uncertainty / sensitivity analysis undertaken for the groundwater modelling is discussed in **Section 2.30**.

NOW also confirmed in their submission on the Residual Matters Report that they consider the approach used to be acceptable. This supported HydroSimulations' conclusions that the modelling was fit for purpose and robust. The additional monitoring data that is being collected will assist in validating and to enhance the conceptual and analytical assessments.

2.32 ISSUE 32

Quantitative predictions made using the surface water model include loss of streamflow to locations along Cataract Creek, complete loss of tributaries to Cataract Creek, and loss of catchment yield to Cataract Reservoir (see paragraphs 61-64). There is low confidence in these predictions as:

a. *The model does not predict the magnitude of actual streamflow losses, or the lengths of streams likely to be impacted by subsidence; rather it assumes a range of streamflow losses, which are not supported by adequate justification.*
b. *There is no link provided between the scenarios and the physical factors influencing streambed fracturing. Predictions of streamflow losses as a result of streambed fracturing should explicitly consider mining-related factors, topographic factors, near-surface geological factors and in-situ stresses.*
c. *Streamflow loss is modelled as a constant value per day up to the total flow. Confidence in predictions would be increased by consideration of the variation of impacts: over time (cracks may develop, then fill with sediment; fracture networks may be flooded, then drain); along the length of the creek (rock bars are more susceptible to cracking, natural pools may drain more rapidly, in other areas subsidence is likely to result in ponding); and under a variety of flow conditions (losses are more likely to be significant in low flows).*
d. *Given the limited justification for the scenarios chosen, a sensitivity analysis is recommended, including: the potential for streamflow losses of greater than 0.5 ML/day to Cataract Creek; more realistic scenarios for loss of tributary flow; and a range of fracturing behaviour, including that the Bald Hill Claystone and Bulgo Sandstone fracture in the same manner as the Hawkesbury Sandstone.*
e. *There is no flow data available for calibration of the model in Cataract Creek (see recommendation in paragraph 46), despite water monitoring in pools along Cataract Creek and Cataract River since September 2009.*
f. *Daily runoff for the Cataract Creek catchment was estimated using Australian Water Balance Model (AWBM) parameters transposed from the Bellambi Creek catchment. There is low confidence in the predictions for Cataract Creek as the Bellambi Creek AWBM rainfall-runoff model:*

    i. *Was calibrated with under five years of streamflow data, with significant periods of missing, or questionable data; and*

ii. *Could not replicate a number of cease to flow periods in actual streamflow data for Bellambi Creek (9% of days). The proponent states that this would be consistent with a loss of streamflow to seepage of approximately 0.3 ML/day or due to inaccuracies in the flow data.*

g. *The complete results of verification of the model against available water level data from Cataract Creek were not presented. Presentation of the performance of the model against the full period of measured data at all sites along the creek would improve confidence in predictions.*

Relevant Sections of Documentation

- Section 8.2 of *Russell Vale Colliery Wonga East Underground Expansion Project Surface Water Modelling* (WRM, 2014)

Response

a. WRM advises that it is not feasible to predict the exact nature, extent and hydraulic capacity of a mining induced fracture network along the creek system. Even if the properties of a fracture network could be accurately predicted, extrapolating this information to estimate specific loss or underflow rates from pools is not possible. Instead, the modelling has assumed rates of stream flow loss based on previous experience in the Southern Coalfield. Based on pool water level reduction rates, overland stream flow losses of the order of 0.5 ML/d have been estimated at similar mining operations in the Southern Coalfields (Gilbert, 2008).

However, the stratigraphy of the Wonga East area is different to other sites in the Southern Coalfields, where streams are generally formed in Hawkesbury Sandstone. In the Wonga East area, the main lithology in the creek bed is the Bald Hill Claystone/Newport/Garie Formations and Bulgo Sandstone. The Hawkesbury Sandstone is generally only present in the upper headwaters. The non-Hawkesbury Sandstone creek beds respond differently to subsidence compared to other creeks in the Southern Coalfield. The uplifted sandstone sheets and fractured sandstone diversions observed in Hawkesbury Sandstone based channels are not expected to occur in the Wonga East area (GeoTerra, 2012).

The catchment models developed for the Underground Expansion Project were therefore used to describe how the range of assumed loss rates could impact on stream flow downstream of potentially affected subsidence areas. Based on observations of groundwater inflows and piezometer behaviour in the area, the credible range of subsidence induced stream flow loss from Cataract Creek due to all Wonga East operations is estimated to be in the range 0.1-0.5 ML/day (SCT, 2014; Geoterra, 2012). This is consistent with the observations at other sites in the Southern Coalfield (Gilbert, 2008).

b. Refer to previous response.

c. The mechanisms affecting loss rates raised by the IESC are likely to be factors affecting stream flow rates to some extent. However, to realistically represent these factors would require knowledge of the exact nature of the fracture network and detailed loss rate data from other areas where stream bed cracking is known to occur. WCL and its water experts are not aware of the existence of a dataset that would support the use of such a detailed methodology as a predictive tool. In the absence of such information, the assumption of a constant loss rate is generally likely to provide a conservative estimate of the relative impact of losses during low flows.

d. As explained above, the assumed loss rates are based on site specific groundwater monitoring data (GeoTerra, 2012; SCT, 2014) and experience at other sites in the Southern Coalfield (Gilbert, 2008). Given that the Bulgo Sandstone and Bald Hill Claystone are less susceptible to cracking than Hawkesbury Sandstone, the maximum assumed loss of 0.5 ML/day is likely to be conservative.

e. The stream flow monitoring regime that is currently being implemented (as discussed in **Section 2.30**) will provide a wider range and sensitivity of stream flow data.

f. It is often the case that site-specific long duration datasets are not available to calibrate catchment models. The calibration was the best that could be achieved with the available information. The fact that the model under-predicts the frequency of existing cease-to-flow periods suggests that it is likely to tend to overestimate the impact of losses on their occurrence.

g. As shown in Figure 6.11 of WRM (2014), there is a strong correlation between the modelled flow hydrograph and observed water levels. This provides some confidence in the model predictions. WCL has installed additional stream flow monitoring measures, as described in **Section 2.30**. This monitoring suite will provide improved data for future model calibration.

2.33 ISSUE 33

The subsidence, groundwater assessment and surface water assessment do not provide reasonable estimations of the combined impacts as a result of the Russell Vale Expansion to Cataract Creek and Cataract Reservoir.

a. The proponent should quantify the potential for impacts to Cataract Creek surface water flow and quality as a result of: impacts to swamps in the headwaters; shallow subsidence effects (see also paragraphs 32, 40 & 43); deep connective cracking; and groundwater drawdown.

b. Assessment of impacts to water resources should include potential for impacts to all water related assets and associated ecological communities.

c. *The mitigation measure of a lateral setback of 0.7 times the depth of cover, proposed for protecting Cataract Reservoir, requires further justification (see Question 11 for further explanation). Such a setback might not be adequate to ensure the integrity of Cataract Reservoir.*

Relevant Sections of Documentation

- Section 8 of *Russell Vale Colliery Wonga East Underground Expansion Project Surface Water Modelling* (WRM, 2014)
- Section 10 of *Russell Vale Colliery Underground Expansion Project Preferred Project Report Wonga East Groundwater Assessment* (GeoTerra / GES, 2014)
- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)
- Section 6.3.3 of *Update of Subsidence Assessment for Wollongong Coal Preferred Project Report Russell Vale No 1 Colliery* (SCT, 2014)

Response

a. Predictions relating to the effects on Cataract Creek and Cataract Reservoir are provided in Section 10 of the Groundwater Assessment (GeoTerra / GES, 2014). The predicted impacts include the effects of deep cracking and groundwater drawdown. As explained in **Section 2.1**, swamps and shallow unsaturated substrate were not assessed specifically within the groundwater model.

b. Impacts to groundwater and surface water resources have been assessed in GeoTerra / GES (2014) and WRM (2014). Impacts to swamps have been assessed in Biosis (2014).

c. The Dams Safety Committee (DSC) has a statutory responsibility to protect Cataract Reservoir, as well as the expertise to perform this role effectively. A setback distance of 0.7 times the depth of cover (equivalent to a 35° angle of draw) has been found by the DSC to be an effective method of protecting stored reservoir water (except at shallow depth in close proximity to geological structures). The provision of a lateral setback greater than the 35°angle of draw is expected to provide sufficient protection to the reservoir due to the large overburden depths at Russell Vale Colliery.

   As explained in Section 6.3.3 of SCT (2014), there are a number of small pre-existing Bulli Seam mining areas that are located within the 0.7 times depth protection zone around the reservoir's Full Supply Level (FSL). There does not appear to be any direct connection between the reservoir and the mining horizon through these pre-existing mining areas. Although their presence appears to reduce the effectiveness of the 0.7 times depth barrier between the FSL and the proposed mine plan, particularly for mining of Longwalls 7 and 9, the pathway for seepage from the reservoir to the mine is likely to be predominantly along horizontal shear planes at or just below the level of the valley. Using the method developed by Tammetta (2012), the calculated height of depressurisation for a Bulli Seam pillar extraction panel is well below the level of any horizontal shear planes capable of interacting with the reservoir.

Therefore, the presence of pre-existing Bulli Seam goaf areas within the 35° angle of draw barrier is not considered to be a significant hazard because the fracturing associated with these isolated goaf areas does not extend high enough to interact with the potential pathways for flow between the reservoir and the proposed longwall panels. Proposed mining is not expected to significantly affect the stability of the Bulli Seam goaf. Even if this did occur, the potential for instability is not expected to cause interaction with the surface.

2.34 ISSUE 34

The proponent's surface water assessment compares the relative extent (in hectares) of: swamps likely to be impacted by subsidence; swamps not predicted to be impacted by subsidence; and the remaining catchment areas of Cataract Creek, Cataract River and Bellambi Creek. The assessment has not considered:

a. The existing contribution of each swamp to streamflow ;

b. The extent or significance of subsidence impacts to each swamp; or

c. The consequential impacts to streamflow, water quality and aquatic ecosystems as a result of subsidence beneath swamps.

Relevant Sections of Documentation

- Sections 8 and 9 of *Russell Vale Colliery Wonga East Underground Expansion Project Surface Water Modelling* (WRM, 2014)

Response

a. In the absence of any monitoring data to support an alternative approach, the surface water assessment implicitly assumes that the contribution of each swamp to streamflow is proportional to its catchment area contribution. WRM advises that it is likely that on an average basis, swamps contribute significantly less to total streamflow than adjacent catchments due to comparatively high evapotranspiration losses.

b. The risks to upland swamps associated with subsidence are assessed in Section 4 of Biosis (2014), as summarised in **Section 2.1**.

c. The consequential impacts to streamflow as a result of subsidence beneath swamps is conservatively assessed in the results in Section 8.3.2 of WRM (2014), which examines the loss of all upstream tributary inflows.

2.35 ISSUE 35

There is a risk to stream flow and connectivity to Cataract Creek and its tributaries as a result of valley closure (up to 650 mm on the third order unnamed tributary above longwalls 1-3). This is likely to result in cracking of the streambed and rock bars and bed delamination, diverting flow beneath the surface and reducing pool capacity.

Relevant Sections of Documentation

- Section 8.3.3 of *Russell Vale Colliery Wonga East Underground Expansion Project Surface Water Modelling* (WRM, 2014)
- Section 5.2 of *Update of Subsidence Assessment for Wollongong Coal Preferred Project Report Russell Vale No 1 Colliery* (SCT, 2014).

Response

Mine subsidence related effects to the upper tributaries of Cataract Creek over Longwalls 1 to 3 are possible due to the predicted 150 – 700 mm valley closure and associated stream bed fracturing as discussed in Section 5.3 of SCT Operations (2014). However, no adverse effects on Cataract Creek or Cataract River are predicted to occur as a result of mining longwalls 6, 7, 9, 10 or 11.

The surface water modelling has assessed the contributions of each tributary of Cataract Creek to the total streamflow. Section 8.3.3 of WRM (2014) estimates the loss of streamflow that would occur if surface flow was completely lost from the tributaries.

2.36 ISSUE 36

The proponent's assessments disregard the potential for significant changes to the streambed profile. Given the change in stream profile along the length of Cataract Creek, further justification is needed to support the proponent's lack of assessment of bedload transport mechanisms or afflux.

Relevant Sections of Documentation

- Section 8.1, Figure 3.1 and Figure 3.3 of *Russell Vale Colliery Wonga East Underground Expansion Project Surface Water Modelling* (WRM, 2014).

Response

Although the predicted subsidence could cause localised changes to the longitudinal profile of the stream, impacts on the extent of inundation will be minimal due to the steepness of the existing bed profile compared to the relatively small magnitude of the impacts. The longitudinal profile of Cataract Creek is shown in Figure 3.1 of WRM (2014). This shows that the existing bed level varies by more than 10 m over the extent of the predicted 20 mm subsidence zone.

As explained in section 8.1 of WRM (2014), given the bedrock control in the affected reaches, it is not anticipated that localised impacts on bedload mechanisms will have long-term downstream impacts.

2.37 ISSUE 37

The proponent suggests that impacts on surface flow will be minimal, since water lost through surface cracks (up to 15 metres deep) will flow laterally and then re-emerge downstream. The NSW Office of Environment and Heritage, in its submission on the Preferred Project Report, showed that there is mounting evidence to suggest that water is being lost from upland swamps and streams into Southern Coalfield mines or lower aquifers due to deep connective cracking. Given this evidence and historical mining activity, deep connective cracking and its role in preventing re-emergence of surface flows should be explicitly assessed by the proponent.

Relevant Sections of Documentation

- *Update of Subsidence Assessment for Wollongong Coal Preferred Project Report Russell Vale No 1 Colliery* (SCT, 2014).

Response

There is the potential for connective cracking based on the height above the mine workings, the thickness of coal mined, the panel width, and the overburden depth (GeoTerra / GES, 2014). The mine water balance provides a measure of the significance of connective fracturing (if any). For the mining geometries at Russell Vale Colliery, the low mine water balance (inflow from strata) is consistent with the depth of mining and the level of subsidence. Connective cracking is not expected to occur within main stream channels because there is no proposed mining directly beneath these main channels.

Based on the vibrating wire piezometer array data that was available at the time of the assessment (SCT Operations, 2014; GeoTerra / GES, 2014), as well as monitoring data from recently installed bores, there is no evidence (to date) of connective cracking from the surface to the underground mine workings.

The stream flow monitoring that has recently been installed will provide further data to enable assessment of the impacts on stream flow volumes (if any) as a result of mining. Improvements to mine inflow monitoring will allow WCL to identify variations in mine inflows (if any) subsequent to significant rain events.

2.38 ISSUE 38

The predicted reductions in baseflow to Cataract Creek (0.006-0.03 ML/day) should consider the existing temporal (baseflow is shown to vary substantially between months) and spatial (e.g. groundwater seeps at various locations) variability, which may be masked by presentation of averaged results. In particular, the potential impacts to water related assets as a result of modifying the point that Cataract Creek changes from ephemeral to perennial need to be assessed (see paragraph 45).

Relevant Sections of Documentation

- Section 10.4.1 of *Update of Subsidence Assessment for Wollongong Coal Preferred Project Report Russell Vale No 1 Colliery* (SCT, 2014).
- *Peer Review – Russell Vale Colliery Groundwater Impact Assessment* (HydroSimulations, 2014)

Response

The Groundwater Assessment (GeoTerra / GES, 2014) adopted a whole of catchment approach, and used the data available at the time of the model preparation, which was deemed appropriate by the HydroSimulations (2014) peer review.

As explained in Section 10.4.1 of GeoTerra / GES (2014), the predicted reduction in baseflow to Cataract Creek (average of 0.013 ML/day) represents a negligible reduction (0.12%) in the average daily stream flow (11.2 ML/day). The magnitude of the reduction in baseflow would not materially alter the flow regime of Cataract Creek.

Data from the recently updated stream flow monitoring network will be used to validate the model and provide more temporal variability assessment capacity when sufficient flow-duration data is available.

2.39 ISSUE 39

The proponent assumes that, as a result of groundwater drawdown, redirected surface flow will re-emerge down gradient within Cataract Creek or directly into Cataract Reservoir. This assumption needs to be supported by further evidence (see paragraph 47), as shallow groundwater levels associated with longwalls 4 and 5 indicate an increased downward gradient. If subsurface flows do not re-emerge, actual baseflow losses to Cataract Creek and subsequently Cataract Reservoir may be greater than predicted.

Relevant Sections of Documentation

- Section 6.4 of *Russell Vale Colliery Underground Expansion Project Preferred Project Report Wonga East Groundwater Assessment.*

Response

The re-emergence of redirected surface flows is discussed in **Section 2.37**.

GeoTerra explains that based on data from the GW1 vibrating wire piezometer array, there is no evidence of an increase in the hydraulic gradient overlying Longwalls 4 & 5 following the extraction of Longwall 5 (noting that GW1 was installed after Longwall 4 was mined).

Further data on the effect of mine subsidence on stream flows will be provided by the recently updated stream flow and piezometer network, which includes monitoring of stream flow in Cataract Creek.

2.40 ISSUE 40

The Residual Matters Report, particularly Appendix F, does not provide a reasonable estimation of impacts to streamflow and runoff volume as a result of subsidence. The resultant impacts on aquatic ecosystems of predicted extended cease to flow periods, or the potential draining of pools, including loss of refugial habitat and stream connectivity, are not assessed.

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)
- Sections 6.5 of *Russell Vale Colliery Wonga East Underground Expansion Project Surface Water Modelling* (WRM, 2014)
- Section 10.4.1 of *Russell Vale Colliery Underground Expansion Project Preferred Project Report Wonga East Groundwater Assessment.*

Response

Detailed and targeted surveys of streams within the study area have been undertaken. These surveys identified that significant natural values are largely limited to Cataract Creek, with other waterways in the study area providing only intermittent and ephemeral flows with few pools and little permanent connectivity (Biosis, 2014c).

The catchment model (WRM, 2014) indicates that the average daily stream flow from Cataract Creek to Cataract Reservoir is 11.2 ML/day, of which 3.5 ML/day is baseflow. The groundwater model predicts a 0.013 ML/day (0.12%) loss of stream baseflow following mining (GeoTerra / GES, 2014). This level of change is unlikely to be detectable and unlikely to result in observable changes to flow regimes in Cataract Creek. It is considered unlikely that these impacts will result in observable changes to the existing flow regime or water quality in Cataract Creek.

2.41 ISSUE 41

There is inadequate streamflow monitoring to enable future impacts to the flow regime to be assessed. Pool water level data along Cataract Creek and its tributaries has not been converted to flow. Converting to flow would enable characterisation of existing gaining and losing reaches, calibration of the rainfall-runoff model and verification of streamflow impacts due to mining of longwalls 4 and 5.

Response

Additional stream flow monitoring has recently been installed by WCL, as described in **Section 2.30**.

2.42 ISSUE 42

To monitor impacts in future, quantitative flow monitoring should commence and surface water quality monitoring should continue. Visual observations should also include any visible cracking in the vicinity of rock bars as well as signs of erosion or sedimentation where there are changes in stream gradient. To minimise impacts in future, mitigation measures should be applied when triggers are exceeded to avoid, restrict or isolate subsidence impacts on drainage features.

Response

WCL will implement a Stream Water Management Plan, which will include visual inspections of stream health, and quantitative monitoring of water quality and quantity. WCL has recently installed stream flow monitoring locations along Cataract Creek and its tributaries (as described in **Section 2.30**). The TARP included in the Stream Water Management Plan will detail mitigation and remediation measures for impacts that exceed the prescribed triggers.

2.43 ISSUE 43

There is low confidence in the proponent's prediction of impacts to streamflow in Cataract Creek as a result of cracking, streambed fracturing and bed delamination from the Russell Vale Expansion. Predictions include:

a. No flow in Cataract Creek midstream (monitoring station 5) 21% of the time under the maximum streamflow loss scenario (0.5 ML/day). Whilst the model predicts no cease to flow periods under existing conditions, it predicts the creek at this location could have no flow for up to 78 days per year as a result of the Russell Vale Expansion.

b. Decrease in median streamflow in Cataract Creek downstream (monitoring station 9) by 0.9 ML/day as a result of the loss of the nine upper tributaries. The largest impact on streamflow is seen with the loss of the third order unnamed tributary 1 overlying longwalls 1-3.

c. Estimates for impacts to runoff, baseflow and total streamflow. It is unclear how impacts to baseflow and runoff have been separated.

Relevant Sections of Documentation

- Section 6.5 of *Russell Vale Colliery Wonga East Underground Expansion Project Surface Water Modelling* (WRM, 2014).

Response

Issues regarding the surface water modelling are addressed in **Section 2.32**.

Baseflow and total stream flow for Cataract Creek have been estimated using the partitioning of flow performed by the Australian Water Balance Model (AWBM). Modelled baseflow and stream flow values are presented in section 6.5 of WRM (2014). The catchment modelling used assumed stream flow losses to predict the impacts of subsidence induced fracturing.

These assumed losses have been applied to total flow. As discussed in Section 8.3 of WRM (2014), the assumed losses sometimes exceed the baseflow during low flow periods.

In addition, the groundwater model has predicted the reductions in baseflow due to depressurisation of the regional aquifer. The predicted reductions in baseflow have been compared to the total stream flow calculated using the AWBM.

The surface water model and groundwater model assess separate impact mechanisms. The groundwater modelling (GeoTerra / GES, 2014) assesses the impacts to baseflow due to groundwater depressurisation. The surface water modelling (WRM, 2014) assesses the impacts to stream flow due to subsidence induced cracking.

2.44 ISSUE 44

Assessment of the likely impacts to water-related assets as a result of changes to flow predicted in Appendix F of the Residual Matters Report has not been undertaken. How the maximum predicted streamflow loss to Cataract Creek may impact on habitat connectivity and the viability of instream and riparian ecosystems is not considered. A decrease or complete loss of flow could remove refugial habitat in pools, would likely further increase iron flocculent in streams and has the potential to isolate fish or reduce ability to feed and distribute eggs as connectivity between pools is lost. The impact on listed frog species has not been considered by the proponent.

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

Refer to response to Issue 40 in **Section 2.40**.

2.45 ISSUE 45

Further information on water-related assets needs to be provided in the Environmental Management Plan including: pre-mining condition of water related assets; the water regime required to maintain assets; impacts to the assets from Russell Vale Expansion (changes to flow regimes, water quality, habitat, channel morphology and erosion zones with consideration of seasonal variations and extreme events such as floods); monitoring requirements with measurable thresholds and triggers; and options to minimise, mitigate or avoid impacts.

Response

Refer to response to Issue 42 in **Section 2.42**.

2.46 ISSUE 46

Flow monitoring should be undertaken at various locations along Cataract Creek, ideally by developing height-discharge relationships for existing pool monitoring locations. Records of the existing, or subsidence-induced, subsurface or overland diversion of flow along the creek would assist the proponent in providing evidence for the existing behaviour of the stream, so that impacts as a result of the proposed Russell Vale Expansion can be assessed.

Response

The monitoring measures that have been installed by WCL are described in **Section 2.30**. The implementation of stream flow monitoring will provide information on the behaviour of surface flows.

2.47 ISSUE 47

Installations of additional shallow piezometers along Cataract Creek, as well as the monitoring of stream flow, are needed to provide evidence to support the proponent's assertion that surface flows will re-emerge downstream.

Response

The additional stream flow monitoring that has been installed along Cataract Creek and its northerly draining tributaries is described in **Section 2.30**.

Shallow piezometers are not planned to be installed along Cataract Creek due to the difficulty of the terrain and unsuitability for drill rig access. Further, it has been confirmed from field inspections that there is no significant riparian alluvium associated with the main channel of Cataract Creek. Therefore shallow piezometers in the vicinity of Cataract Creek would serve minimal use.

2.48 ISSUE 48

Stream features particularly prone to subsidence effects should be monitored regularly. The location of all rock bars should be mapped and recorded with photos on a regular basis during mining. Similar attention should be paid to areas where ponding or erosion/sedimentation (indicated by a significant change in stream gradient) are likely.

Relevant Sections of Documentation

- *LW5 Water Management Plan* (Gujarat NRE Coking Coal Ltd, 2013a).

Response

Monitoring of stream features will be undertaken in accordance with the Stream Water Management Plan. Monitoring activities for streams include:

- Field and laboratory water quality analyses;
- Volumetric stream flow and pool depth measurements;
- Photographic recording; and
- Visual inspections for cracking or stream bed and bank changes.

2.49 ISSUE 49

The TARP for longwall 5 does not require changes to mine plan or cessation of undermining associated with an unacceptable level of impact on surface water features, only a requirement to report and undertake remediation works. The effectiveness of remediation measures, such as grouting, has not been proven.

Response

SCT explains that grouting and other similar intervention strategies have been demonstrated to be effective as a method of reducing sub-surface flows; however, such strategies are recognised as being intrusive.

The TARP requires WCL to inform the relevant regulators of exceedances or unexpected impacts, and to develop a mitigation plan in consultation with these regulators.

2.50 ISSUE 50

Mitigation measures for Cataract Creek are recommended when subsidence, surface water quality or flow triggers are exceeded. Measures should preferentially avoid (stop mining, change mine layout) or restrict (decrease extraction height, increase pillar width) subsidence impacts on streams.

Response

WCL will implement a Stream Water Management Plan (including a TARP) to manage potential impacts to Cataract Creek. If a trigger in the TARP is exceeded, WCL will consult with the appropriate regulatory stakeholders to develop a mitigation plan.

2.51 ISSUE 51

The Residual Matters Report does not adequately consider the potential for further increases in iron rich discharges to creeks or its potential impact to water quality and the downstream environment. Given the high likelihood of further cracking of Cataract Creek and its tributaries and the history of related iron seepages, the potential for increased iron seepages is considered highly likely. This has the potential to impact water quality as well as in stream and riparian ecological communities.

Relevant Sections of Documentation

- *LW5 Water Management Plan* (Gujarat NRE Coking Coal Ltd, 2013a)
- *Section 2.3 of Preferred Project Report Groundwater & Surface Water Response to Submissions Residual Matters Addendum* (GeoTerra, 2014)

Response

WCL has been advised by its water experts that based on monitoring in the Wonga East catchments, iron levels are already significantly elevated in Cataract Creek and its tributaries, whilst the potential for additional significant negative effects on the water quality within Cataract Creek due to newly induced iron seepages resulting from mining operations is considered to be low.

As discussed in GeoTerra (2014) and outlined in Gujarat NRE Coking Coal (2013a), the effects on Cataract Creek and Cataract River water quality have been monitored during extraction of LW 4 & 5, and were addressed in the LW5 Water Management Plan. Water quality impacts will also be addressed in the Water Management Plan.

Monitoring to date has indicated no observable change in stream or tributary water quality as the catchments already contain pervasive, highly ferruginous hydroxide impacted seepage waters in the tributaries and streams.

Longwall mining is also not anticipated to result in an observable change in stream / tributary water quality as there is already a very high iron content in the creek.

2.52 ISSUE 52

The Residual Matters Report acknowledges the potential for further increases in iron rich discharges to Cataract Creek and the associated development of large quantities of iron oxidising bacteria to smother eggs of threatened fish. However, the potential for future increases in iron oxides/hydroxides and associated water quality changes in the future has not been quantified, nor has the tolerance of aquatic biota and threatened species to changes in water quality been assessed.

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)

Response

Refer to response to Issue 51 in **Section 2.51**.

Cataract Creek has been subject to a degree of impact from past mining, with the upper reaches of the creek subject to high levels of iron flocculent. Despite these historic impacts, threatened fish species persist in the lower reaches of Cataract Creek, within the dam impoundment. Surveys have not identified any threatened fish species further upstream. This is likely due to the shallower water levels inhibiting fish movement rather than impacts on water quality.

Given the effects of past mining, it is considered unlikely that the Project will result in observable changes to the existing water quality in Cataract Creek.

2.53 ISSUE 53

Where there is increased subsurface flow and re-emergence resulting from cracking, impacts are likely to include increased salinity, iron, manganese and other metals, cations and anions, combined with depleted oxygen concentrations. Re-emerging water is rapidly oxidised to precipitate iron oxides/hydroxides out of solution and is more concentrated under low flow conditions where baseflow is the major flow component. Mats of bacteria commonly develop on iron oxides/hydroxides and in doing so can reduce interstitial habitat, available food, oxygen content and can negatively impact macroinvertebrate communities and smother eggs of threatened fish species. These changes have the potential to negatively impact the ecological integrity of instream and riparian systems resulting in loss of plant and animal populations.

Response

Refer to response to Issue 51 in **Section 2.51**.

2.54 ISSUE 54

*Threatened fish species present within Cataract Creek include EPBC-listed macquarie perch (*Macquaria australasica*), silver perch (*Bidyanus bidyanus*) and murray cod (Maccul*lochella peelii*). An assessment of potential impacts to these species from increased iron seepages and associated mats of bacteria has not been undertaken. Where it is considered possible that threatened fish species will be negatively impacted, monitoring and mitigation measures should be developed.*

Relevant Sections of Documentation

- Sections 3 and 4 of *Coastal Upland Swamp Impact Assessment Report* (Biosis, 2014a)
- Section 3.2 of *Matters of National Environmental Significance Report – Ecology* (Biosis, 2014b)

Response

The *Matters of National Environmental Significance Report – Ecology* (Biosis, 2014b) outlines the current distribution of these species in Cataract Creek and currently observed levels of iron flocculent. Cataract Creek supports a population of these threatened fish species despite the effects of past mining. Increases in iron flocculent from the Underground Expansion Project are unlikely to be observable in the context of these past impacts (Biosis, 2014b).

The Biodiversity Monitoring Plan for the Underground Expansion Project will include detailed Before-After Control-Impact (BACI) monitoring of threatened fish species. This plan outlines proposed management and mitigation measures to address impacts should they occur.

2.55 ISSUE 55

While the EPBC-listed stuttering frog (Mixophyes balbus) was not identified in surveys undertaken by the proponent, Cataract Creek is within its range and provides suitable habitat. As this species relies on shallow running water, it is likely to be impacted by the loss of baseflow and increased iron seepages resulting from bedrock fracturing.

Relevant Sections of Documentation

- Sections 3 and 4 of *Russell Vale Colliery – Underground Expansion Project: EPBC Act Matters of National Environmental Significance Report - Ecology* (Biosis, 2014b)

Response

Detailed and targeted surveys for the Stuttering Frog have been undertaken since 2012. These surveys, far in exceedance of the requirements of State and Commonwealth survey guidelines, have not recorded the species within Cataract Creek (Biosis, 2014b). Although Cataract Creek provides suitable habitat for this species, the Stuttering Frog is sensitive to pollution of waterways, and it is likely that upstream impacts from Mt Ousley Road reduce the viability of this waterway for this species.

2.56 ISSUE 56

The information provided is not sufficient to determine the likelihood of subsidence induced fracturing and potential drainage from Cataract Reservoir outside the proposed mitigation zone of 0.7 times the depth of cover. Considering the significant consequences should potential cracking associated with mining activities occur beneath the reservoir, even low likelihoods of fracturing and drainage equate to considerable overall risks.

Response

Refer to response to Issue 33(c) in **Section 2.33**.

2.57 ISSUE 57

The information provided is not sufficient to confidently predict changes to water quantity within Cataract Creek and their subsequent impacts on storage within Cataract Reservoir as a result of the proposed mining. Consequences for storage in Cataract Reservoir are presented across a large range, including very significant losses of storage in the upper range, but there is little evidence that predictions are realistic.

Relevant Sections of Documentation

- *Peer Review – Russell Vale Colliery Groundwater Impact Assessment* (HydroSimulations, 2014)

Response

Refer to response to Issue 51 in **Section 2.51**.

NOW and HydroSimulations endorse the approach used, and further monitoring data is being collected to enhance the conceptual and analytical assessments.

2.58 ISSUE 58

The information provided is not sufficient to predict changes to water quality in Cataract Reservoir as the proponent has not modelled the likely changes as a result of the proposed project. However based on existing water quality and flow volumes in Cataract Creek the water quality consequences for Cataract Reservoir are not likely to be significant.

Response

Refer to response to Issue 51 in **Section 2.51**. WCL agrees that impacts on the water quality of Cataract Reservoir are not likely to be significant.

2.59 ISSUE 59

Detailed assessment of the effects of potential changes in water quality in Cataract Creek on water quality in Cataract Reservoir has not been undertaken. However, the information provided in the Residual Matters Report indicates the current water quality in Cataract Creek meets Australian drinking water guidelines though occasionally exceeds ANZECC and ARMCANZ South-east Australia trigger values for total nitrogen and total phosphorus and the trigger values for protection of 95% of aquatic ecosystems for zinc, copper and aluminium.

Response

Refer to response to Issue 51 in **Section 2.51**.

2.60 ISSUE 60

The proponent's primary measure to prevent leakage from the Cataract Reservoir through subsidence induced connective fracturing is through a lateral set back distance between the Cataract Reservoir full supply level and proposed longwalls equal to 0.7 times the depth of cover. This distance is equal to approximately 203 m at the closest point, which correlates to a 35 degree angle of draw. However it is also stated that in several places the presence of overlying historical pillar extraction areas reduces the protection afforded by the setback distance.

Relevant Sections of Documentation

- Section 6.3.3 of *Update of Subsidence Assessment for Wollongong Coal Preferred Project Report Russell Vale No 1 Colliery.*

Response

Refer to response to Issue 33(c) in **Section 2.33**.

2.61 ISSUE 61

Further, there is a risk that the 0.7 times depth of cover (35 degree angle of draw) is not an adequate distance to prevent subsidence induced leakage from the Cataract Reservoir where the full supply level extends upwards along Cataract Creek and Cataract River. Evidence from the western coalfield suggests an angle of influence for impact, characterised by deformation of underlying strata, to a maximum of 45 degrees.

Evidence from the western coalfields aligns closely with observations discussed by Ouyang and Elsworth (1993) who identified a "probable angle of influence" of 42 degrees. In their current proposed layout, a 45 degree angle of influence for impact due to the proposed longwalls would intersect the full supply level of Cataract Reservoir. As a result, there is a risk that subsidence induced fractures will cause connectivity and leakage between the Cataract Reservoir and mine workings. The use of a 0.7 times depth of cover set back needs to be justified, given its proximity to the multiple overlying historical extraction zones.

Relevant Sections of Documentation

- Section 6.3.3 of *Update of Subsidence Assessment for Wollongong Coal Preferred Project Report Russell Vale No 1 Colliery.*

Response

The basis for the lateral setback distance of 0.7 times depth is explained in **Section 2.33**.

SCT advises that there is a significant difference between mining induced deformation and potential for leakage from the Cataract Reservoir. The ground can be influenced by mining subsidence without there being any significant change in its hydraulic conductivity. Low level ground movements are routinely observed at distances of up to several kilometres in the Southern and Western Coalfields, but these movements are of no practical significance in terms of changes in hydraulic conductivity that might significantly affect flow from the surface to underground. The potential for significant subsidence induced fracturing is limited to a height of 1-1.7 times panel width directly above the panel and, in steep terrain, to mobilising of existing bedding plane shears at the level of valley floors that may extend outside the footprint of the longwall panels being mined (Mills, 2012).

The bedding plane shears may be a conduit for lateral flow for rainfall recharge from the high ground toward the reservoir or from the reservoir toward the mine, or both. The direction of flow depends on the height of fracturing above each longwall panel relative to the bedding plane shear horizon, the amount of rainfall recharge, the conductivity of the bedding plane shear horizon, and the lateral distance between the valley and the nearest longwall panel.

The Reynold's Inquiry (1977) recommended a horizontal offset based on an angle of draw of 26.5° or a vertical offset within this zone whereby mining panel widths are limited to less than one third of the depth of cover to prevent the height of fracturing and elastic relaxation from interacting with the surface. The DSC has adopted an even more conservative horizontal offset (equivalent to 35° angle of draw) to provide a high level of protection to the stored waters.

The offset distance has the effect of extending the length of the horizontal pathway between the reservoir and the mine sufficiently that any flows from the reservoir into the mine are of a much lower magnitude than other environmental effects such as evaporation, evapotranspiration and reservoir yield.

2.62 ISSUE 62

While the existing mining voids associated with historical underground mining within the proposed project area do not appear to have induced leakage from Cataract Reservoir, the extraction of further underlying coal beneath these historical workings presents a risk of remobilisation of the previously collapsed overlying strata. Re-mobilisation and the resulting increased vertical subsidence are potential causes of fracturing which may result in connectivity between the reservoir, historical underground voids and the proposed longwalls. Any fracturing that results in connectivity between the existing Bulli Seam board and pillar voids (shallowest) and the Cataract Reservoir will result in connectivity to the Wongawilli longwalls of the proposed project, as the historical underground voids and the proposed longwalls are hydraulically interconnected through the collapsed goaves.

Relevant Sections of Documentation

- Section 6.3.3 of *Update of Subsidence Assessment for Wollongong Coal Preferred Project Report Russell Vale No 1 Colliery.*

Response

As explained in **Section 2.33**, there are some existing mining voids in the Bulli Seam located within the 35° angle of draw. These pre-existing mining voids are not being directly mined under within the marginal zone. The proposed mining is not expected to cause any destabilising of the existing goafs in the Bulli Seam within the marginal zone. Even if some further destabilising were to occur, the geometries of the Bulli Seam goafs are narrow enough that there is no potential for them to interact with the bedding plane shears at reservoir level.

Subsidence monitoring from Longwalls 4 and 5 in the Wongawilli Seam and Longwalls 1-11 in the Balgownie Seam have indicated that subsidence associated with mining below existing goaf areas in the Bulli Seam does not cause changes in subsidence behaviour outside the footprint of the longwall panels that would be significant in terms of increasing the fracture network or potential for vertical flow from the surface to the mine. Previous mining of the Bulli Seam has not provided a significant pathway for flow and without directly mining under these voids within the marginal zone, there is not considered to be any potential for the existing low level flow pathways to change.

2.63 ISSUE 63

The maximum modelled loss in Cataract Reservoir storage as a result of subsidence impacts from the Russell Vale Expansion ranges from 550 ML (0.5 ML/day loss in yield) to greater than 10 GL (10 ML/day loss in yield). The upper prediction is reported inconsistently in Appendix F of the Residual Matters Report: 10,890 ML in the text (P51); and at least 20,000 ML in Figure 8.2 (P52). However, the reservoir is not modelled to drop below 10% storage under the historical climate record for any scenario.

Relevant Sections of Documentation

- Section 8.3.1 of *Russell Vale Colliery Wonga East Underground Expansion Project Surface Water Modelling* (WRM, 2014).

Response

The modelled reduction in storage of 10,890 ML occurs during the period of lowest storage. It is true that reduction in stored volume exceeds 10,890 ML in later periods. At the stored volume minimum occurring in mid-2006, the difference is approximately 20,000 ML as noted. In later periods, the modelled reduction is greater (exceeding 30,000 ML). However, during these periods the reduction is less likely to cause a supply shortfall, as the stored volume is higher.

2.64 ISSUE 64

While the range of modelled potential losses of storage in the Cataract Reservoir are significant, there is low confidence in the assumptions made in the modelling and the applicability of model results (see paragraph 32). No justification is provided for the selection of modelled losses in catchment yield.

However, given the reported lack of measurable risk to water storage volumes from longwall mining in the Southern Coalfield, these scenarios are likely to be worst-case.

Relevant Sections of Documentation

- Section 8.3.1 of *Russell Vale Colliery Wonga East Underground Expansion Project Surface Water Modelling* (WRM, 2014).

Response

Justification for the losses assumed in the surface water model is provided in **Section 2.32**.

There is very limited reliance on rainfall/runoff modelling in the calculation of inflows to Cataract Reservoir. The sequence of inflows to the reservoir is simply back-calculated from SCA's observations of changing stored water volume and measured releases. This approach is a relatively accurate estimate of historical inflows to the reservoir.

Rainfall-runoff modelling was used to supplement the inflow calculations during low flow sequences, but as these periods contribute a comparatively small portion of the total inflow to the reservoir, any inaccuracies in the rainfall/runoff model have a negligible effect on the conclusions of the assessment. In any case, the fact that the observed time history of stored water levels so closely matches the back-calculated time series indicates that there is high confidence in the assumptions.

It is debatable whether the historical series of inflows is relevant to the impact of losses on the future behaviour of losses. An alternative simple approach is presented in Table 8.2 of WRM (2014).

WCL agrees that the scenarios in the surface water modelling are likely to be worst-case. The range of losses assumed in the assessment represent a considerable loss of water, much larger than would be expected, and is therefore likely to be conservative.

2.65 ISSUE 65

The greatest immediate risks associated with the project are largely as targeted by the questions:

a. Impacts to Coastal Upland Swamps and associated communities;
b. Impacts to Cataract Creek, its tributaries; and
c. Impacts to the integrity of Cataract Reservoir.

Response

These issues have been addressed in the previous responses regarding upland swamps and water resources.

2.66 ISSUE 66

However, further risks to water resources are likely to arise from the cumulative impacts of the additional proposed mining at Wonga West, and these should be considered together with the current proposal.

Responses

The impact assessments undertaken for the Underground Expansion Project (as modified by the PPR) have assessed the impacts of all proposed mining activities at Russell Vale Colliery. Assessments of cumulative impacts have considered previous mining activities in the Bulli and Balgownie seams.

The current application does not include any mining in the Wonga West area.

2.67 ISSUE 67

Further, there are risks associated with mine discharges to Bellambi Gully, due to the increase in mine discharge associated with the proposed project, and a history of flooding at the site.

Relevant Sections of Documentation

- *Bellambi Gully Flood Study* (Cardno, 2014)

Response

WCL currently discharges water to Bellambi Gully in accordance with Environmental Protection Licence (EPL) 12040. Given that WCL will continue to operate under this EPL, discharges to Bellambi Gully are not expected to result in any additional impacts.

WCL had commissioned Cardno to undertake a flood study for the Bellambi Gully catchment. Cardno (2014) has recommended flood controls to prevent a recurrence of the flooding incident that occurred in 1998.

2.68 ISSUE 68

There is no flood study yet available for the proposed project and the proponent has not evaluated the capacity of the mine water management system to handle revised groundwater inflows or discharge mine-affected water in a manner which enables water quality objectives for the Bellambi Gully to be achieved. A complete assessment of the potential impact of mine affected discharges on water resources and water related assets as a result of the Russell Vale Expansion is needed. Discharges of water with low pH and elevated concentrations of toxicants including metals are likely to increase risks to aquatic ecosystems and other water related assets.

Relevant Sections of Documentation

- *Bellambi Gully Flood Study* (Cardno, 2014)
- Water Management Report Gujarat NRE No.1 Colliery Major Works Part 3A (Beca, 2011)

Response

Refer to response to Issue 67 in **Section 2.67**.

A review of the water management system at Russell Vale Colliery was undertaken by Beca (2011), as reported in Annex B of the Environmental Assessment (ERM, 2013). This review recommended that an additional 6 ML dry sediment dam be constructed to provide sufficient additional temporary storage for dirty stormwater. This sediment dam is a component of the Underground Expansion Project. Beca (2011) determined that volumes of mine water generated by operations will be less than the process water demand. Therefore, volumes of water being discharged to Bellambi Creek are not expected to increase as a result of the Underground Expansion Project.

2.69 ISSUE 69

The Southern Sydney Basin, which includes the Hawkesbury-Nepean subregion, has been identified as a Bioregional Assessment priority region. Data and relevant information from the proposed project should be made accessible to this Bioregional Assessment to assist the knowledge base for regional scale assessments.

Response

WCL is willing to provide the relevant information when requested.

3 CONCLUSION

We trust that the above response is satisfactory to the Department.

Please do not hesitate to contact me on 0458 059 564 if you have any questions.

Yours sincerely
Wollongong Coal Ltd

David Clarkson
Group Environment Manager

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Appendix D

Coastal Upland Swamp Impact Assessment Report

Russell Vale Colliery Underground Expansion Project EPBC Referral (EPBC2014/7268):

Coastal Upland Swamp Impact Assessment Report

FINAL REPORT

Prepared for Wollongong Coal Ltd

11 August 2014

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Prepared by:	Nathan Garvey
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- Hansen Bailey: Dianne Munro, Andrew Wu
- Geoterra: Andrew Dawkins
- SCT Operations: Ken Mills

The following Biosis staff were involved in this project:

- Ashleigh Pritchard for mapping
- Monica Campbell for quality assurance

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1. Introduction

1.1 Project background

Wollongong Coal Pty Ltd (WCL) have submitted a referral (EPBC 2014/7268)under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) for the extraction of coal from eight longwalls in an area located west of Wollongong, NSW. This project is known as the Underground Expansion Project (UEP).

Following submission of the referral on 11 July 2014, the Commonwealth Department of the Environment has listed the Coastal Upland Swamps in the Sydney Basin Bioregion (Coastal Upland Swamps) as an Endangered Ecological Community (EEC) under the EPBC Act. This decision means the Minister (or his delegate) must now consider Coastal Upland Swamps in determining whether this referral requires assessment under the EPBC Act. The Department of the Environment have now requested additional information on Coastal Upland Swamps in the project area.

Biosis (2014a) has previously prepared an impact assessment for Coastal Upland Swamps as listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act). This prior assessment follows the methodology outlined in *Upland swamp environmental assessment guidelines. Guidance for the underground mining industry operating in the southern coalfield (Draft)* (OEH 2012) to assess potential impacts to Coastal Upland Swamps. This includes six criteria to identify upland swamps at risk of negative environmental consequences that require further investigation. Further analysis, looking at the groundwater and surface water hydrology and subsidence are used to determine risk of impact.

The listing of this EEC under the EPBC Act mirrors the listing under the TSC Act (DoE 2014), including the use of six criteria to determine upland swamps at risk of negative environmental consequences. Therefore, this report relies on this prior impact assessment (Biosis 2014a).

1.2 Definition of the study area

The study area is located approximately 7.5 kilometres (km) north-west of Wollongong NSW, within the Local Government Areas (LGAs) of Wollongong and Wollondilly. Coal handling facilities are situated at the Russell Vale Site, located at the corner of the Princes Highway and Bellambi Lane, Russell Vale, approximately 7.2 km north of Wollongong, NSW.

The study area is located beneath the Woronora plateau and the Metropolitan Special Areas, administered by the Sydney Catchment Authority (SCA) for Sydney's drinking water supply. The Metropolitan Special Area is managed in accordance with the *Special Areas Strategic Plan of Management 2007* (SCA and DEC, 2007), with a vision "to protect water quality and provide high quality raw water in reservoirs, by protecting ecological integrity and natural and cultural values of the area".

Along with other special areas and National Parks to the northwest and south, the study area forms part of the large band of native vegetation surrounding the Sydney Metropolitan Area, providing a largely connected corridor of vegetation that supports a diverse range of vegetation communities and associated flora and fauna species.

No direct impacts to ecological features within the study area are expected to occur.

Indirect impacts resulting from subsidence will be restricted to the 20 millimetre (mm) Subsidence Impact Boundary (see Biosis 2014b).

For the purpose of environmental impact assessment, a comprehensive area extending 600 metres (m) from the edge of secondary extraction (longwalls) was investigated. This area is referred to hereafter as the study area (see EPBC ecology report). The study area encompasses an area of 859 ha.

1.3 Objectives

The objectives of this report, as per the request from the Department of the Environment, are to:

- Provide a description of the Coastal Upland Swamps in the proposal location, the surrounding areas and the region that may be affected by the proposed action.
- Provide a description and the likelihood and consequence of any potential direct, indirect and cumulative impacts to Coastal Upland Swamps as a result of the proposed action.
- Provide a description of the feasible mitigation measures, changes to the proposed action or procedures proposed, which are intended to minimise impacts to Coastal Upland Swamps as a result of the proposed action.

This report includes an assessment of impacts to upland swamps in the study area, undertaken in several steps:

- An assessment of historic impacts to upland swamps in the study area from past mining (Section 3)
- An initial risk assessment using criteria outlined in DoP (2010), OEH (2012) and DoE (2014) (Section 4.1).
- A summary of available data on groundwater and surface water for upland swamps within the study area (Section 4.2).
- An analysis of flow accumulation based on changes in water flow due to subsidence levels (Section 4.3).
- An analysis of subsidence data, particularly tensile and compressive strains, to assess where fracturing of bedrock may occur, and potential resultant impacts to upland swamp vegetation communities (Section 4.4).
- A final risk assessment incorporating all of these factors (Section 4.5).
- An assessment of the significance of potential impacts based on the significant impact criteria for EECs (Section 4.5.2).

Following this, measures to avoid, minimise and mitigate impacts to upland swamps within the study area from the proposed action are discussed in Section 5.

2. Description of Coastal Upland Swamps

2.1 Regional distribution of Coastal Upland Swamps

Conservation advice for Coastal Upland Swamps (DoE 2014) highlights two main occurrences of this EEC, with the study area located within the southern distribution of this EEC on the Woronora plateau. For the purpose of this report, this is considered the regional distribution of this EEC.

Mapping of native vegetation across the Woronora plateau was undertaken by the NSW National Parks and Wildlife Service (NPWS 2003). The distribution of Coastal Upland Swamps on the Woronora plateau is shown in Figure 1.

A total of 4,739 hectares (ha) of upland swamp vegetation is mapped across the Woronora plateau by NPWS (2003).

2.2 Distribution of Coastal Upland Swamps in the Study Area

Mapping and characterisation of upland swamps in the study area was undertaken by Biosis (2012b). This assessment identified 39 upland headwater swamps, with a total area of 49 hectares and an average size of 1.26 ha (Figure 2). No valley fill swamps are present.

The majority of upland swamps in the study area (34/39) support Banksia Thicket (MU42), with 20 upland swamps supporting only this vegetation sub-community. Ten upland swamps support Tea-tree Thicket (MU43). Six upland swamps support a complete range of upland swamp vegetation sub-communities (MU42 Banksia Thicket, MU43 Tea-tree Thicket, MU44 Sedgeland–Heath Complex).

Mapping of upland swamps by Biosis (2012b) highlighted the complexity and variability of the soils and associated vegetation communities, with some swamps having a fully developed, saturated, humic sandy clay matrix up to 1.8 m deep, through to essentially dry, shallow sandy clay locations with a high degree of shallow or subcropping sandstone and a thin weathered, colluvial, sandy clay soil profile.

Upland swamps within the study area are markedly different to other upland swamps on the Woronora plateau in that they are predominantly drier, generally smaller with shallower soils, have less humic material, have more interspersed sandstone outcrops within their outlines and are less spatially continuous than a "typical" humic, saturated swamp.

Swamps in the study area have relatively small upstream catchments, with their saturation relying on rainfall recharge directly into the sandy sediments, seepage out of upslope Hawkesbury Sandstone and their organic (humic) content. The storage and water transmission characteristics of the surrounding and underlying Hawkesbury Sandstone is critical in sustaining these environments. Whilst in other areas of the Woronora plateau upland swamps occur along the riparian zone of the major creeks or in headwater valleys, upland swamps in the study area occur in headwater tributary valleys that are characteristically derived from colluvial sand erosion from Hawkesbury Sandstone dominated ridgelines only. The swamps in the study area are only located over Hawkesbury Sandstone which provides a low permeability base on which the swamp sediments and organic matter accumulate. Regional groundwater flow within the Hawkesbury Sandstone is hydraulically beneath, and separated by approximately 15 m from the surficial swamps.

The headwater swamps are predominantly located within gently sloping, shallow trough-shaped gullies although can partially extend onto steep slopes, benches or valley sides, where the plateau is not dissected by creeks. The central axes of some swamps can become saturated after substantial recharge events, though the margins can comparatively dry out after extended dry periods.

The sand and humic material increases the swamp's water holding capacity and subsequently discharges rainfall infiltration, groundwater seeps and low-flow runoff into the local streams. Rainfall saturates the swamp after storms and with a slow, delayed discharge due to the low slopes when the recharge exceeds evaporation. Sediments below and laterally lensing into the humic material are variable in nature and can be composed of fine to medium grained sands that can contain clayey bands and comprise a grey to mottled red-orange colour due to in-situ weathering.

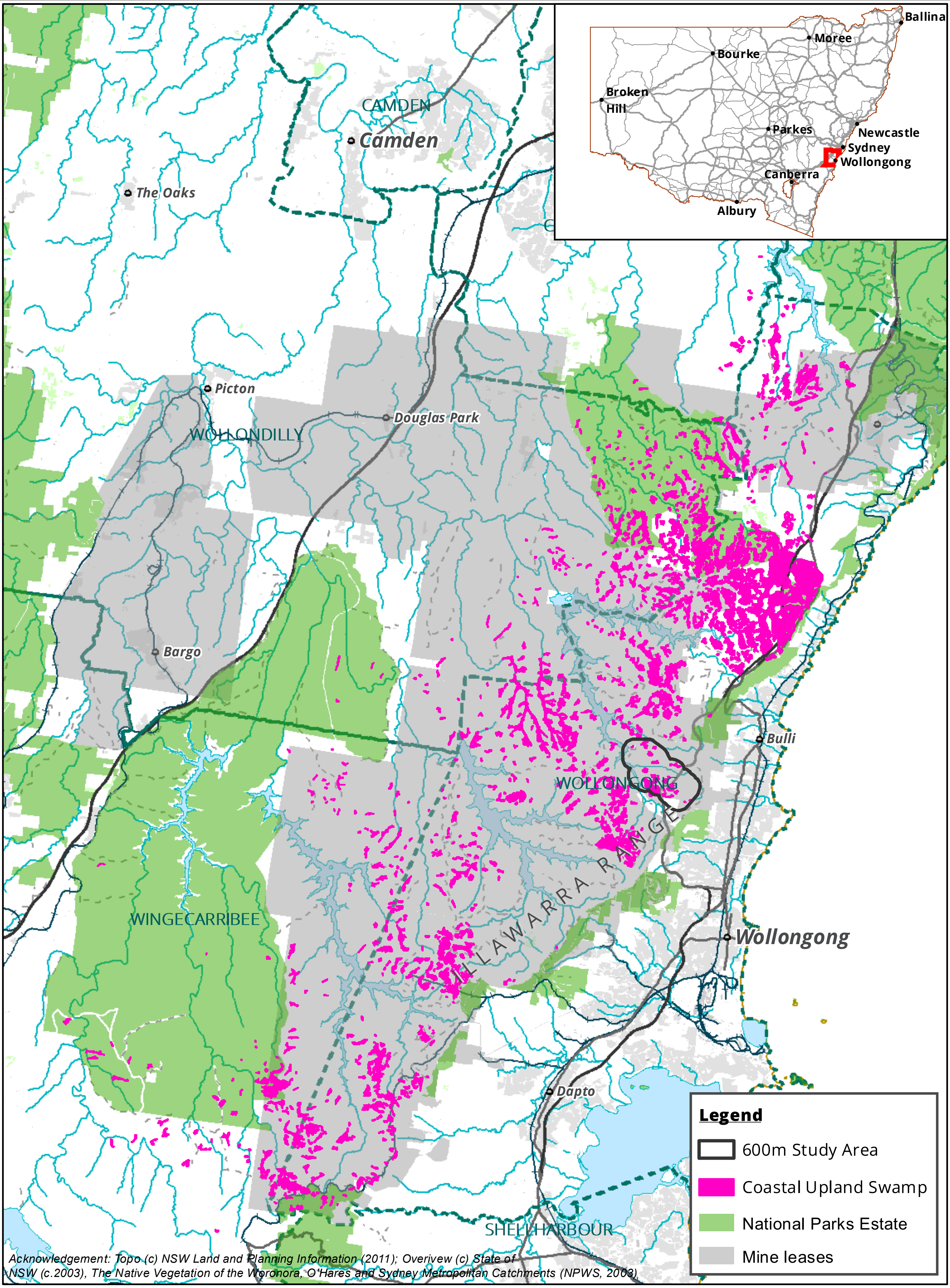

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Figure 1: Regional distribution of Coastal Upland Swamps on the Woronora plateau

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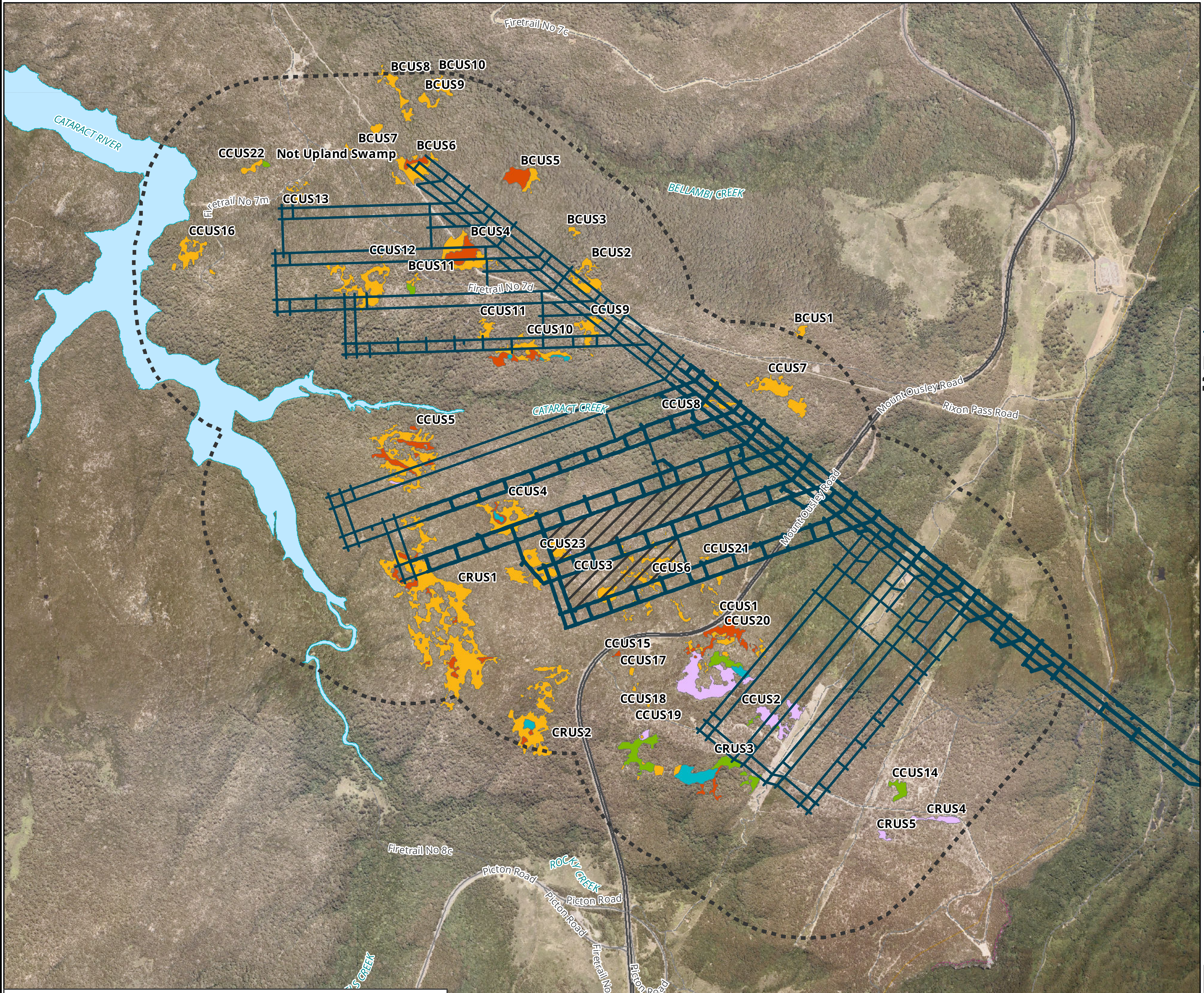

Acknowledgements: Topo (c) NSW Land and Planning Information(2011); Overivew (c) State of NSW (c.2003)

Legend

Vegetation Sub-Communities

- MU42, Upland Swamps: Banksia Thicket
- MU43, Upland Swamps: Tea-Tree Thicket
- MU44a, Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Longwall Layout

- Proposed Wongawilli seam workings
- Completed Longwalls
- 600m Study Area

Figure 2: Distribution of Coastal Upland Swamps in the study area

0 150 300 450 600 750

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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3. Assessment of the Historic Impact to Upland Swamps in the Study Area

Extraction of the Bulli and Balgownie seams has occurred within the study area, with the Bulli Seam extracted via hand workings and pillar extraction between 1890 and 1960, and the Balgownie Seam extracted using continuous miner pillar extraction in 1969 and the retreat longwall mining method from 1970 to 1982.

The location of upland swamps in the study area in relation to previous mining is shown in Figure 3 (Bulli seam) and Figure 4 (Balgownie seam). Table 1 (Bulli seam), Table 2 (Balgownie seam) and Table 3 (Bulli and Balgownie seam cumulative) provide modelled subsidence data for upland swamps within the study area and assess these values against criteria identified by DoP (2010), OEH (2012) and DoE (2014) for upland swamps that may be at risk of negative environmental consequences and, thus, require further investigation.

Table 1: Incremental subsidence data from extraction of the Bulli seam for upland swamps within the study area (values in bold exceed criteria in DoP 2010, OEH 2012 and DoE 2014)

Swamp	Subsidence (m)	Overburden Depth (m)	Void Width	Ratio of Overburden Depth to Panel Width	Max Tensile Strain (mm/m)	Max Compressive Strain (mm/m)	Max Tilt (mm/m)
CCUS1	0.7	285	945	**0.3**	**3.7**	**7.4**	**12**
CCUS2	0.1	285	-	-	0.5	1.1	2
CCUS3	1	300	55	5.45	**5**	**10**	**17**
CCUS4	0.1	290	50	5.8	0.5	1	2
CCUS5	0.5	272	230	**1.18**	**2.8**	**5.5**	**9**
CCUS6	1	285	605	**0.47**	**5.3**	**10.5**	**18**
CCUS7	1	270	276	**0.98**	**5.6**	**11.1**	**19**
CCUS8	0.1	270	20	13.5	**0.6**	1.1	2
CCUS9	0.1	293	25	11.72	0.5	1	2
CCUS10	0.5	280	185	1.51	**2.7**	**5.4**	**9**
CCUS12	0.5	355	185	1.92	**2.1**	**4.2**	**7**
CCUS13	0.1	335	195	1.72	0.4	0.9	1
CCUS14	1	275	-	-	**5.5**	**10.9**	**18**
CCUS15	0.1	325	40	8.13	0.5	0.9	2
CCUS16	0.5	300	-	-	**2.5**	**5**	**8**
CCUS17	0.1	325	45	7.22	0.5	0.9	2

Swamp	Subsidence (m)	Overburden Depth (m)	Void Width	Ratio of Overburden Depth to Panel Width	Max Tensile Strain (mm/m)	Max Compressive Strain (mm/m)	Max Tilt (mm/m)
CCUS18	0.1	325	30	10.83	0.5	0.9	2
CCUS19	0.1	325	10	32.5	0.5	0.9	2
CCUS20	1	290	570	**0.51**	**5.2**	**10.3**	**17**
CCUS21	1	280	490	**0.57**	**5.4**	**10.7**	**18**
CCUS22	0.5	317	150	2.11	**2.4**	**4.7**	**8**
CCUS23	0.1	310	45	6.89	0.5	1	2
CRUS1	0.5	300	310	**0.97**	**2.5**	**5**	**8**
CRUS2	0.5	210	280	**0.75**	**3.6**	**7.1**	**12**
CRUS3	0.4	295	45	6.56	**2**	**4.1**	**7**
BCUS1	1	270	270	**1**	**5.6**	**11.1**	**19**
BCUS2	0.5	285	40	7.13	**2.6**	**5.3**	**9**
BCUS3	0.5	265	80	3.31	**2.8**	**5.7**	**9**
BCUS4	0.5	295	230	**1.28**	**2.5**	**5.1**	**8**
BCUS5	0.5	273	105	2.6	**2.7**	**5.5**	**9**
BCUS6	0.1	308	15	20.53	0.5	1	2
BCUS11	0.5	335	225	1.49	**2.2**	**4.5**	**7**

Table 2: Incremental subsidence data from extraction of the Balgownie seams for upland swamps within the study area (values in bold exceed subsidence criteria in OEH 2012)

Swamp	Subsidence Used (m)	Overburden Depth (m)	Longwall Panel Width	Ratio of Overburden Depth to Panel Width	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
CCUS1	0.8	295	130	2.27	**4.1**	**8.1**	**14**
CCUS2	1	295	130	2.27	**5.1**	**10.2**	**17**
CCUS3	1	310	170	1.82	**4.8**	**9.7**	**16**
CCUS4	0.8	300	170	1.76	**4**	**8**	**13**
CCUS5	0.1	282	-	-	0.5	1.1	2
CCUS6	1	295	170	1.74	**5.1**	**10.2**	**17**
CCUS7	0.1	280	-	-	0.5	1.1	2

Swamp	Subsidence Used (m)	Overburden Depth (m)	Longwall Panel Width	Ratio of Overburden Depth to Panel Width	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
CCUS8	0.1	280	-	-	0.5	1.1	2
CCUS9	0.1	303	-	-	0.5	1	2
CCUS10	0.1	290	-	-	0.5	1	2
CCUS12	0.1	365	-	-	0.4	0.8	1
CCUS13	0.1	345	-	-	0.4	0.9	1
CCUS14	0.1	285	130	2.19	0.5	1.1	2
CCUS15	0.5	335	-	-	**2.2**	**4.5**	**7**
CCUS16	0.1	310	-	-	0.5	1	2
CCUS17	0.3	335	-	-	**1.3**	**2.7**	4
CCUS18	0.1	335	-	-	0.4	0.9	1
CCUS19	0.1	335	-	-	0.4	0.9	1
CCUS20	1	300	170	1.76	**5**	**10**	**17**
CCUS21	1	290	170	1.71	**5.2**	**10.3**	**17**
CCUS22	0.1	327	-	-	0.5	0.9	2
CCUS23	1	320	170	1.88	**4.7**	**9.4**	**16**
CRUS1	0.1	310	-	-	0.5	1	2
CRUS2	0.1	220	-	-	**0.7**	1.4	2
CRUS3	0.1	305	-	-	0.5	1	2
BCUS1	0.1	280	-	-	0.5	1.1	2
BCUS2	0.1	295	-	-	0.5	1	2
BCUS3	0.1	275	-	-	0.5	1.1	2
BCUS4	0.1	305	-	-	0.5	1	2
BCUS5	0.1	283	-	-	0.5	1.1	2
BCUS6	0.1	318	-	-	0.5	0.9	2
BCUS11	0.1	345	-	-	0.4	0.9	1

Table 3: Subsidence data from extraction of the Bulli and Balgownie seams for upland swamps within the study area (values in bold exceed subsidence criteria in OEH 2012)

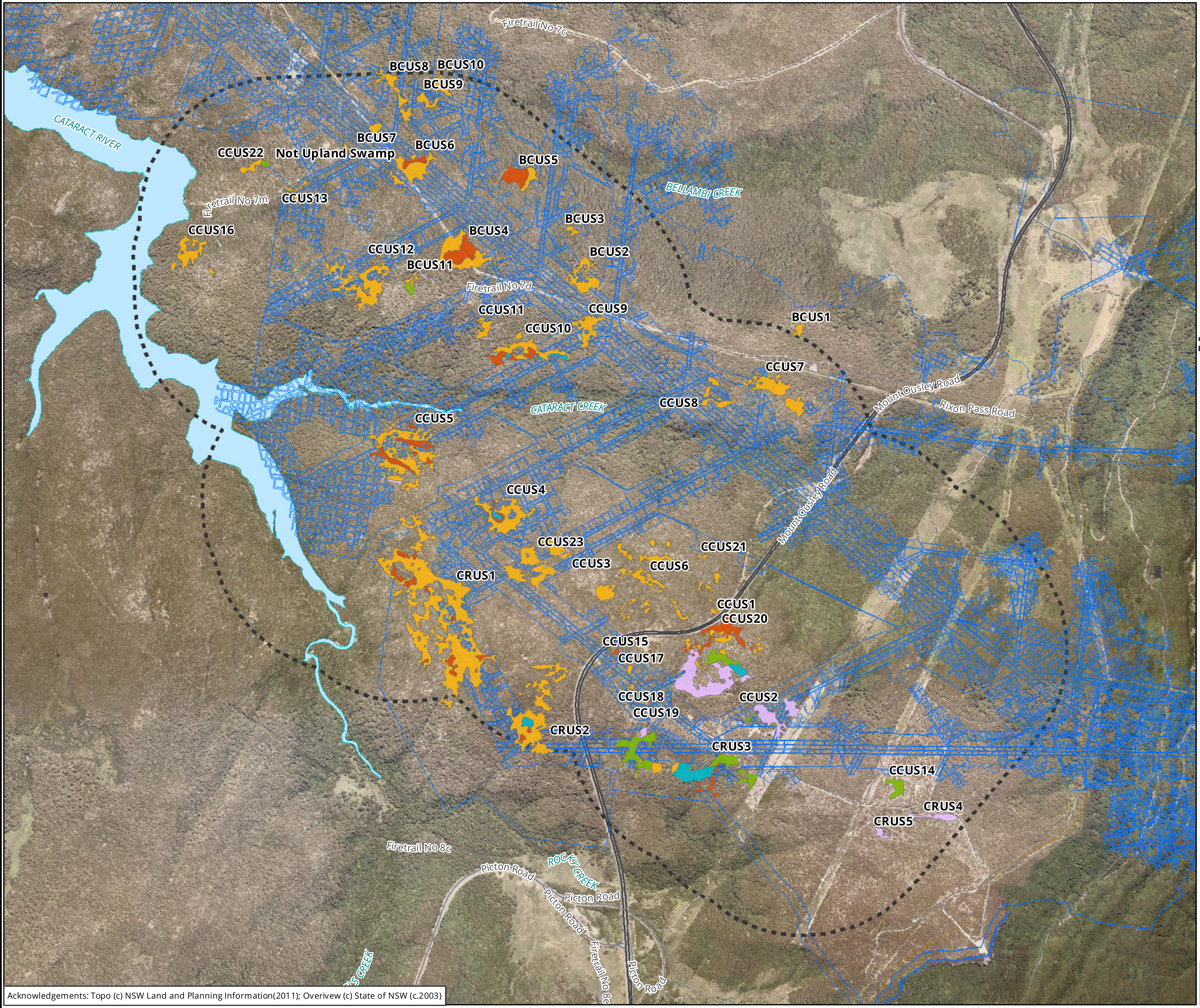
Swamp	Relevant Workings	Subsidence Used (m)	Overburden Depth (m)	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
CCUS1	Bulli PE / Bg LW	2	285	**10.5**	**21.1**	**35**
CCUS2	Bulli 1st wkgs / Bg LW	1.1	285	**5.8**	**11.6**	**19**
CCUS3	Bulli 1st wkgs / Bg LW	1.1	300	**5.5**	**11.0**	**18**
CCUS4	Bulli 1st wkgs / Bg LW	0.9	290	**4.7**	**9.3**	**16**
CCUS5	Bulli PE, 1st wkgs / Bg 1st wkgs	0.6	272	**3.3**	**6.6**	**11**
CCUS6	Bulli PE / Bg LW	2	285	**10.5**	**21.1**	**35**
CCUS7	Bulli PE	1	270	**5.6**	**11.1**	**19**
CCUS8	Bulli 1st wkgs	0.1	270	**0.6**	1.1	2
CCUS9	Bulli 1st wkgs	0.1	293	0.5	1.0	2
CCUS10	Bulli PE, 1st wkgs / Bg LW	0.6	280	**3.2**	**6.4**	**11**
CCUS12	Bulli PE, 1st wkgs	0.5	355	**2.1**	**4.2**	**7**
CCUS13	Bulli 1st wkgs	0.1	335	0.4	0.9	1
CCUS14	Bulli PE / Bg LW	1.2	275	**6.5**	**13.1**	**22**
CCUS15	Bulli 1st wkgs	0.2	325	**0.9**	1.8	3
CCUS16	Corrimal wkgs	0.5	300	**2.5**	**5.0**	**8**
CCUS17	Bulli 1st wkgs	0.1	325	0.5	0.9	2
CCUS18	Bulli 1st wkgs	0.1	325	0.5	0.9	2
CCUS19	Bulli 1st wkgs	0.1	325	0.5	0.9	2
CCUS20	Bulli PE / Bg LW	2	290	**10.3**	**20.7**	**34**
CCUS21	Bulli PE / Bg LW	2	280	**10.7**	**21.4**	**36**

Swamp	Relevant Workings	Subsidence Used (m)	Overburden Depth (m)	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
CCUS22	Bulli PE, no wkgs	0.5	317	**2.4**	**4.7**	**8**
CCUS23	Bulli1st wkgs / Bg LW	0.9	310	**4.4**	**8.7**	**15**
CRUS1	Bulli PE	0.5	300	**2.5**	**5.0**	**8**
CRUS2	Bulli PE, 1st wkgs	0.6	210	**4.3**	**8.6**	**14**
CRUS3	Bulli PE, 1st wkgs	0.6	295	**3.1**	**6.1**	**10**
BCUS1	Bulli PE	1	270	**5.6**	**11.1**	**19**
BCUS2	Bulli 1st wkgs	0.5	285	**2.6**	**5.3**	**9**
BCUS3	Bulli PE	0.5	265	**2.8**	**5.7**	**9**
BCUS4	Bulli PE	0.6	295	**3.1**	**6.1**	**10**
BCUS5	Bulli PE	0.5	273	**2.7**	**5.5**	**9**
BCUS6	Bulli Headings	0.1	308	0.5	1.0	2
BCUS11	Bulli PE	0.5	335	**2.2**	**4.5**	**7**

NOTE: RV = Russell Vale Colliery, BG = Balgownie, PE = Pillar Extraction, LW = Longwall

Subsidence data for upland swamps in the study area from extraction of the Bulli and Balgownie seams indicates that all upland swamps in the study area, except CCUS9, CCUS13, CCUS17, CCUS18, CCUS19 and BCUS6, have been subject to subsidence criteria sufficient to have placed these upland swamps at risk of negative environmental consequences, according to criteria outlined in DoP (2010), OEH (2012) and DoE (2014).

This assessment of past mining in the study area indicates that natural features in the study area have been subject to subsidence resulting from extraction of the Bulli and Balgownie Seams sufficient to have placed the majority of upland swamps in the study area at risk of negative environmental consequences. This data provides a baseline against which assessments of potential impacts resulting from extraction of the Wongawilli Seam must be assessed.



Legend

Vegetation Sub-Communities

- MU42, Upland Swamps: Banksia Thicket
- MU43, Upland Swamps: Tea-Tree Thicket
- MU44a, Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Longwall Layout

- Bulli Seam workings
- 600m Study Area

Figure 3: Location of upland swamps in the study area, showing mining of the Bulli seam

0 150 300 450 600 750

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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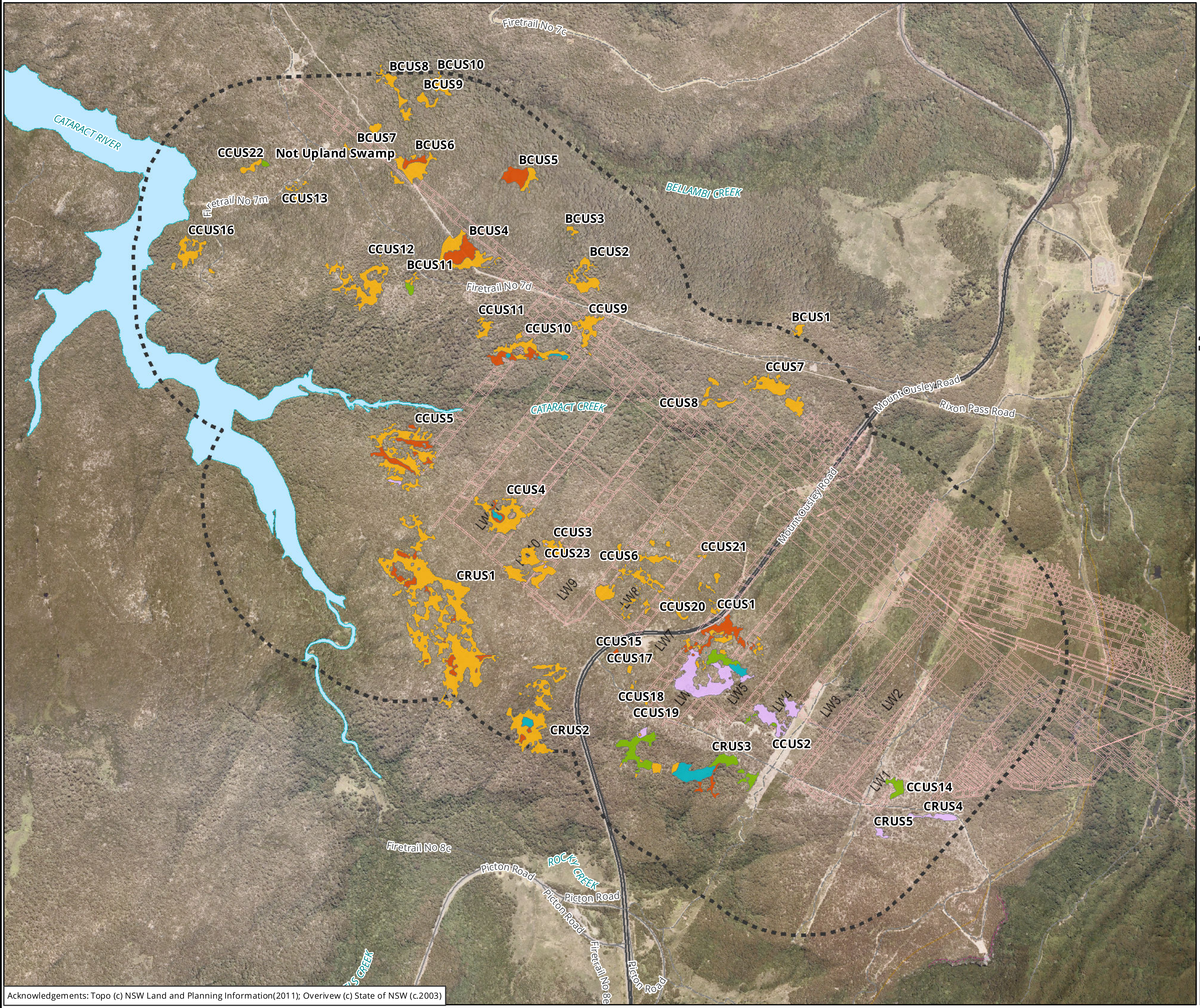

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Vegetation Sub-Communities

- MU42, Upland Swamps: Banksia Thicket
- MU43, Upland Swamps: Tea-Tree Thicket
- MU44a, Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Longwall Layout

- Balgownie Seam workings
- 600m Study Area

Figure 4: Location of upland swamps in the study area, showing mining of the Balgownie seam

0 150 300 450 600 750

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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4. Upland Swamp Impact Assessment

This section provides an impact assessment for upland swamps within the study area. Whilst DoP (2010), OEH (2012) and DoE (2014) identify criteria to determine upland swamps at risk of negative environmental consequences, DoP (2010) states that these criteria are a "*threshold for investigation – not a conclusion that the swamp will be impacted or suffer consequences*" (p. 120).

To date, there is no accepted methodology for undertaking an assessment of the impacts of subsidence on upland swamps. Biosis, in consultation with hydrogeologists (GeoTerra) and experts in subsidence (SCT Operations) have developed a methodology for assessing impacts to upland swamps. The rationale for our impact assessment methodology is outlined below.

DoP (2009) identifies three potential impact mechanisms to upland swamps:

1. The bedrock below the swamp cracks as a consequence of tensile strains and water drains into the fracture zone. If the fracture zone is large enough or connected to a source of escape (e.g. a deeper aquifer or bedding shear pathway to an open hillside) then it is possible for sufficient water to drain to alter the hydrologic balance of the swamp.
2. Tilting of sufficient magnitude occurs to either re-concentrate runoff leading to scour and erosion, potentially allowing water to escape from the swamp margins (possibly affecting the whole swamp) or to alter water distribution in parts of the swamp, thus favouring some flora species associations over others.
3. Buckling and bedding shear enhances fracture connectivity in the host bedrock which promotes vertical then lateral drainage of the swamp. This mechanism is similar to redirected surface flow observed in subsidence-upsidence affected creek beds.

In the past, impact assessment for upland swamps in the Southern Coalfield has focused on the use of the criteria outlined in DoP (2010), OEH (2012) and DoE (2014) to determine the risk of negative environmental consequences. Changes in groundwater availability resulting from fracturing of bedrock beneath an upland swamp is one type of environmental consequence that is expected to adversely impact swamps. There is now mounting evidence to indicate that the maintenance and persistence of upland swamps in areas subject to subsidence is much more complex than has been previously recognised. Upland swamps within the study area have been subject to historic mining, and some upland swamps have been subsided twice and some show signs of fracturing (see Sections 3 and 4.2.1). Yet analysis of available data indicates these upland swamps persist and continue to support a perched water table.

In addition, DoP (2008) recognises that certain swamp characteristics mean some upland swamps are more susceptible to impacts from subsidence than others. Analysis of available piezometric data indicates that some sections of upland swamps behave, hydrologically, like surrounding sandstone environments, with little retention of groundwater following recharge. These areas often correspond with subcropping sandstone, shallow sandy soils with little humic material and support vegetation communities that are not reliant on permanent or intermittent water logging (MU42 Banksia Thicket, MU44a Sedgeland and MU44b Restioid Heath). Other piezometers indicate substantial retention of groundwater following recharge, with these areas supporting deeper, organic soils and vegetation communities reliant on intermittent and permanent groundwater (MU43 Tea-Tree Thicket and MU44c Cyperoid Heath). Changes in hydrological regimes could be posited to impact more on vegetation communities reliant on permanent and intermittent groundwater. Further research, monitoring and assessment is required to understand the complex processes that maintain upland swamps, particularly in relation to changes brought about by longwall mining.

In previous upland swamps assessments (e.g. BHPBIC 2009) changes in water flow through an upland swamp have been assessed using a single cross-section of an upland swamp. This methodology was criticised in DoP (2010) due to the reliance on a single cross-sectional representation. Biosis (2012b) and Biosis (2014a) used flow accumulation modelling across an entire swamp to assess changes in flow through each individual upland swamp to addresses this concern.

The impact assessment methodology developed by Biosis, and used in this report, utilises the initial risk assessment criteria (DoP 2010, OEH 2012 and DoE 2014) to determine upland swamps at risk of negative environmental consequences.

In accordance with DoP (2010) we have used multiple criteria to determine the potential for impacts to upland swamps. These criteria have been developed with reference to the three potential upland swamp impact mechanisms outlined in DoP (2009) and outlined previously. This report utilises data on the hydrology of upland swamps in the study area and vegetation sub-communities within upland swamps, along with subsidence modelling and flow modelling to assess the potential for impacts to upland swamps within the study area. The swamp impact assessment methodology employed herein assesses multiple upland swamp characteristics to determine the potential for impact, in line with the recommendation of DoP (2010) that upland swamps that exceed these thresholds (indicating they are at risk of negative environmental consequences) require further investigation.

4.1 Initial risk assessment

An initial risk assessment has been undertaken to determine upland swamps at risk of negative environmental consequences. This initial risk assessment has been undertaken for all upland swamps within the study area. Subsidence values for upland swamps are presented in Table 4 and Figure 5.

Table 4: Initial Risk Assessment for Wonga East

Figures in bold are greater than criteria outlined in DoP (2010), OEH (2012) and DoE (2014).

Swamp	Maximum subsidence within swamp boundary (m)	Adjacent subsidence used to calculate strains and tilts (m)	Overburden Depth (m)	Longwall panel width (m)	Ratio of Overburden Depth to Panel Width	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
BCUS1	< 0.2	0.1	270	-	-	0.5	1	2
BCUS2	< 0.2	0.1	285	-	-	0.5	0.9	2
BCUS3	< 0.2	0.1	265	-	-	0.5	1	2
BCUS4	1.0	1.5	295	150	1.97	**6.8**	**13.6**	**23**
BCUS5	< 0.2	0.1	273	-	-	0.5	1	2
BCUS6	< 0.2	0.1	308	-	-	0.4	0.9	1
BCUS11	1.4	1.5	335	150	2.23	**6.1**	**12.2**	**20**
CCUS1	0.6	1.5	285	-	-	**7**	**14.1**	**23**
CCUS2	1.8	2.0	285	150	1.90	**9.4**	**18.8**	**31**
CCUS3	1	1.5	300	125	2.40	**6.7**	**13.4**	**22**
CCUS4	1.4	2.0	290	150	1.93	**9.2**	**18.5**	**31**
CCUS5	1.2	1.5	272	131	2.08	**7.3**	**14.7**	**24**
CCUS6	2	2.0	285	125	2.28	**9.4**	**18.8**	**31**
CCUS7	< 0.2	0.1	270	-	-	0.5	1	2

Swamp	Maximum subsidence within swamp boundary (m)	Adjacent subsidence used to calculate strains and tilts (m)	Overburden Depth (m)	Longwall panel width (m)	Ratio of Overburden Depth to Panel Width	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
CCUS8	< 0.2	0.1	270	-	-	0.5	1	2
CCUS9	< 0.2	0.1	293	-	-	0.5	0.9	2
CCUS10	0.8	0.8	280	150	1.87	**3.8**	**7.6**	**13**
CCUS11	1.8	2.0	340	150	2.27	**8.8**	**18**	**29**
CCUS12	1.2	1.5	355	150	2.37	**5.8**	**11.5**	**19**
CCUS13	< 0.2	0.1	335	-	-	0.4	0.8	1
CCUS14	< 0.2	0.1	275	-	-	0.5	1	2
CCUS15	< 0.2	0.1	325	-	-	0.4	0.8	1
CCUS16	< 0.2	0.1	300	-	-	0.4	0.9	1
CCUS17	< 0.2	0.1	325	-	-	0.4	0.8	1
CCUS18	< 0.2	0.1	325	-	-	0.4	0.8	1
CCUS19	< 0.2	0.1	325	-	-	0.4	0.8	1
CCUS20	< 0.2	0.1	290	-	-	0.5	0.9	2
CCUS21	< 0.2	2.0	280	-	-	**9.5**	**19**	**32**
CCUS22	< 0.2	0.1	317	-	-	0.4	0.9	1
CCUS23	0.2	1.5	310	125	2.48	**6.5**	**13**	**22**
CRUS1	1.4	1.5	300	150	2.00	**6.7**	**13.4**	**22**

Swamp	Maximum subsidence within swamp boundary (m)	Adjacent subsidence used to calculate strains and tilts (m)	Overburden Depth (m)	Longwall panel width (m)	Ratio of Overburden Depth to Panel Width	Max Tensile Strain (mm/m)	Max Comp Strain (mm/m)	Max Tilt (mm/m)
CRUS2	< 0.2	0.1	210	-	-	0.6	1.2	2
CRUS3	< 0.2	0.1	295	-	-	0.5	0.9	2

Re-assessment of subsidence predictions following monitoring of Longwalls 4 and 5 indicates that past mining has resulted in the softening of the bridging capacity of the underlying rock strata, and that subsidence is largely restricted to the area immediately overlying the goaf. Whilst this means that subsidence movements occur over a smaller area, it also means that tilts and strains are greater than previously predicted (SCT Operations 2014).

The initial risk assessment has identified that 14 upland swamps within the study area are at risk of negative environmental consequences, including upland swamps BCUS4, BCUS11, CCUS1, CCUS2, CCUS3, CCUS4, CCUS5, CCUS6, CCUS10, CCUS11, CCUS12, CCUS21, CCUS23 and CRUS1. Upland swamps not identified to be at risk of negative environmental consequences are not discussed further.

4.2 Hydrogeological investigations

4.2.1 Swamp piezometers

Eight shallow piezometers have been installed in upland swamps within the study area, with five auger holes not completed with piezometers as they were too shallow, dry or did not encounter swamp materials within a designated swamp domain. In addition, 2 shallow soil piezometers (SP1 and SP2) were installed down slope of two swamps as shown in Table 5.

Table 5: Piezometers within the study area (# indicates dry hole with no piezometer)

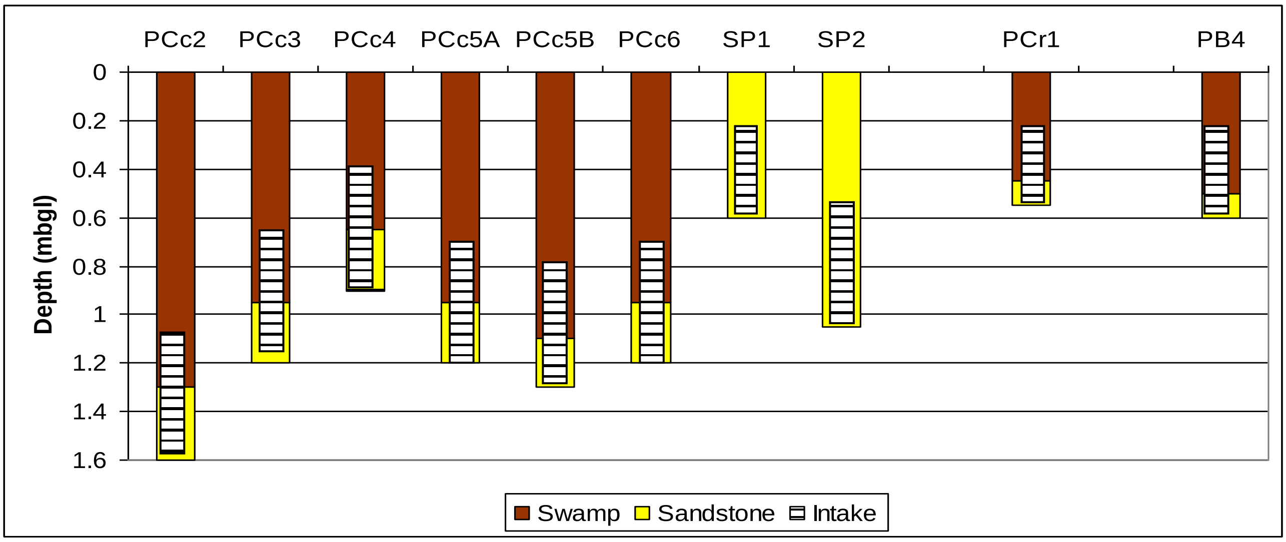
Bore	Swamp	Installed	Easting	Northing	Total Depth (mbgl)	Intake Screen (m)	Intake Lithology
PCc2	CCUS2	May 12	303745	6196095	1.60	1.1 – 1.6	humic sandy clay / weathered sandstone
	CCUS2#	May 12	303735	6196100	-	Dry at 0.75	weathered sandstone
	CCUS2#	May 12	303730	6196080	-	Dry at 0.75	weathered sandstone
PCc3	CCUS3	Mar 12	302820	6196810	1.2	0.7 – 1.2	sandy clay / weathered sandstone
PCc4	CCUS4	Mar 12	302615	6196925	0.95	0.45 – 0.95	sandy clay / weathered sandstone
PCc5A	CCUS5	May 12	302110	6197135	1.24	0.7 – 1.2	humic sandy clay / weathered sandstone
	CCUS5#	May 12	302135	6197155	-	Dry at 0.3	weathered sandstone
	CCUS5#	May 12	302135	6197160	-	Dry at 0.5	weathered sandstone
	CCUS5#	May 12	302105	6197130	-	Dry at 1.6	weathered sandstone
PCc5B	CCUS5	May 12	302245	6197250	1.31	0.8 – 1.3	humic sandy clay / weathered sandstone
PCc6	CCUS6	Mar 12	303165	6196790	1.2	0.7 – 1.2	weathered sast
PCr1	CRUS1	Mar 12	302290	6196625	0.55	0.3 – 0.55	humic sandy clay / weathered sandstone
PB4	BCUS4	May 12	302485	6198060	0.6	0.25 – 0.6	humic sandy clay / weathered sandstone

Bore	Swamp	Installed	Easting	Northing	Total Depth (mbgl)	Intake Screen (m)	Intake Lithology
SP1	No swamp	Mar 12	303245	6196955	0.60	0.1 – 0.6	sandy clay / weathered sandstone
SP2	No swamp	Mar 12	302830	6196905	1.05	0.55 – 1.05	sandy clay / weathered sandstone

NOTE: mbgl = metres below ground level

Drill hole depth and piezometer construction details are shown in Graph 1.

Graph 1: Wonga East Swamp Piezometers

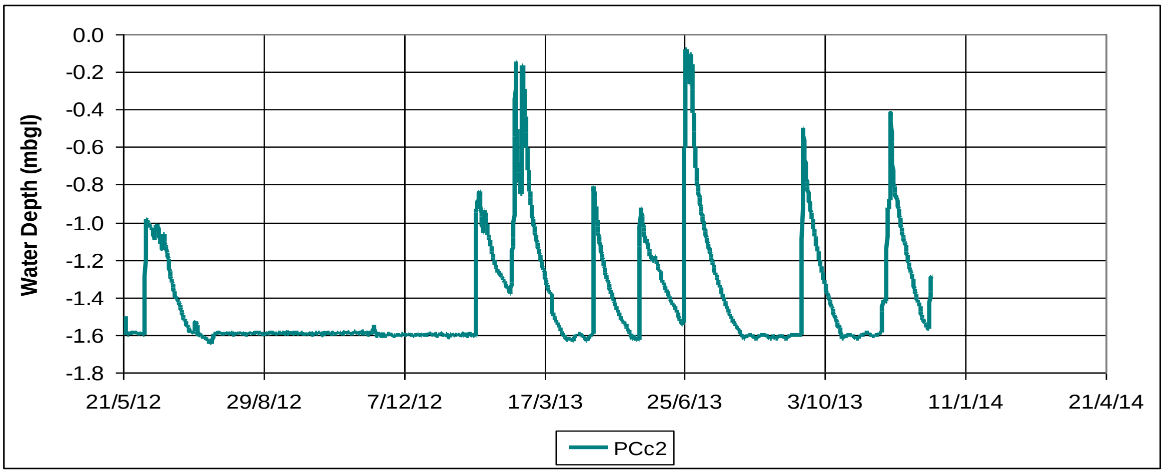


4.2.2 Swamp water levels

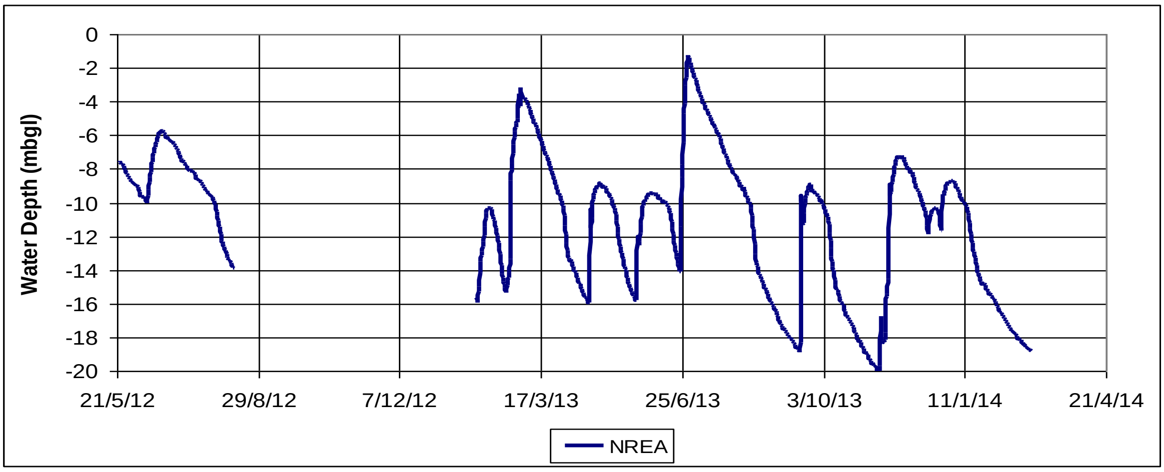
The upland swamps are perched systems that are hydraulically separated from the deeper, regional groundwater table in the Hawkesbury Sandstone by an unsaturated zone. This is illustrated in two examples below.

Paired upland swamp and Hawkesbury Sandstone monitoring at PCc2 and NRE-A, as shown in Graph 2 and Graph 3 respectively, indicate the two systems have variable separation thicknesses of unsaturated sandstone, which ranges from 1.3 – 18.4 m. Recharge following rain events through the sandstone to the regional aquifer is apparent, with the swamp and regional sandstone aquifer having similar temporal, although different quantum responses to rainfall recharge.

Graph 2: Hydrograph – Upland Swamp CCUS2

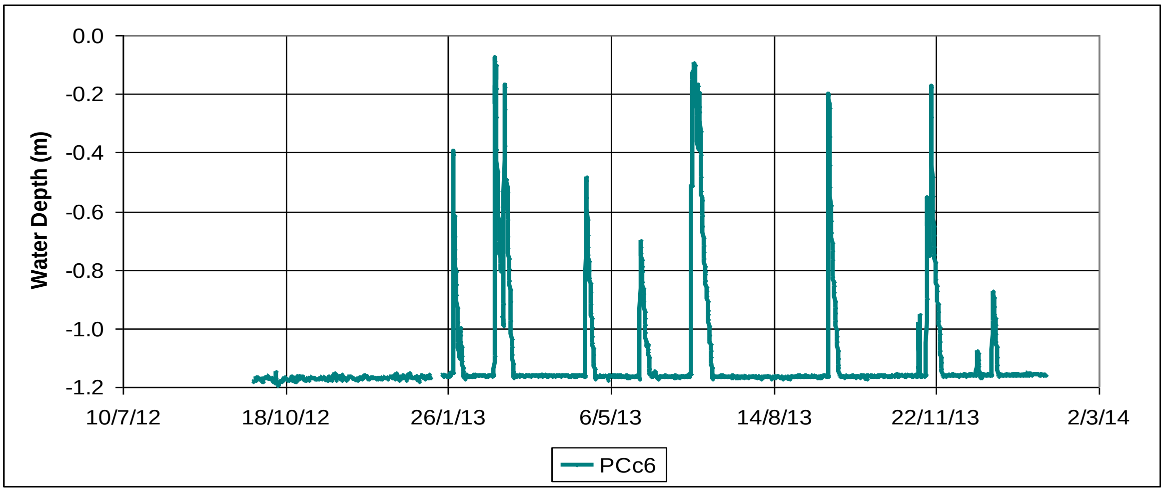


Graph 3: Hydrograph – Borehole NRE-A

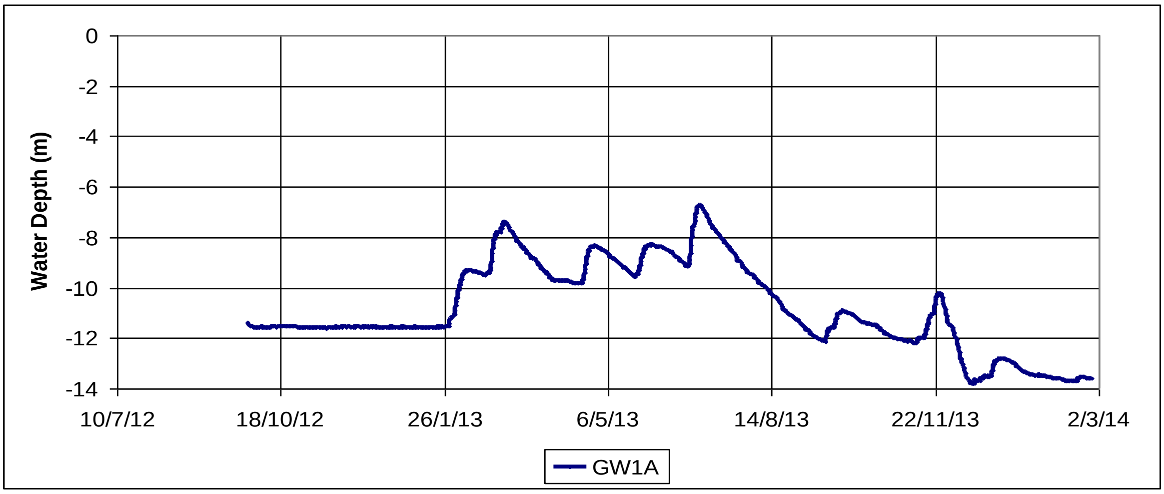


Although they are not immediately adjacent to each other, comparison of water levels in GW1 and PCc6 in swamp CCUS6, as shown in Graph 4 and Graph 5 respectively, indicate a 6.8 – 11.9m unsaturated sandstone separation thickness. Recharge following rain events through the sandstone to the regional aquifer is apparent, with the swamp and the regional sandstone aquifer having similar temporal, although different quantum responses to rainfall recharge.

Graph 4: Hydrograph – Upland Swamp CCUS6



Graph 5: Hydrograph – Borehole GW1A



Although hydraulically separated from the deeper, regional groundwater table in the Hawkesbury Sandstone, upland swamps can be connected to shallower, ephemeral seepage from the upper Hawkesbury Sandstone where bedding discontinuities or low permeabilities enhance horizontal flow into a swamp after high rainfall periods. Depending on the relative height of the ephemeral, perched and regional water tables, groundwater seepage can supplement swamp moisture or, alternatively, unsaturated swamp moisture can seep into the underlying shallow ephemeral sandstone aquifer. In turn, the shallow bedrock aquifers are also usually ephemeral, and are hydraulically disconnected via an unsaturated zone from the deeper, regional aquifers within the Hawkesbury Sandstone.

The water table within the swamps is dependent on surface inflow recharge after rain and can be supported by ephemeral seepage of near surface groundwater from the Hawkesbury Sandstone. Water storage is usually limited within the humic, clayey, rich sandy sediments, although this can allow relatively small inflows to support a highly variable ephemeral water table in the more organic layers.

Recharge into the Hawkesbury Sandstone shallow aquifer that seeps into a swamp is generally moderated by connate water stored in a swamp, which is also recharged by rainfall. Water can enter a swamp from ephemeral seeps located at the upper and lower section of any topographic or basement steps that may be present.

Episodes of inundation and surface run off within a swamp are directly related to the extent and duration of storm events, with the short term, post storm drainage occurring within indistinct channels or dispersed flow paths in the swamp.

Groundwater seepage into a swamp is usually transmitted within the more sandy or humic layers and can "daylight" where the water table extends to surface. Water accumulation within a swamp is a balance between:

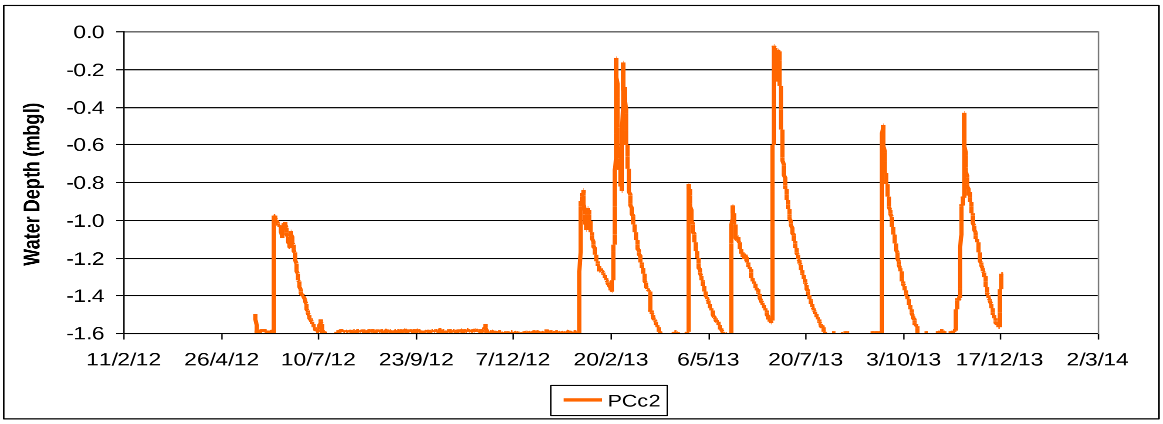
- Rainfall / surface runoff recharge
- Horizontal seepage and downstream outflow
- Swamp storage capacity, based on the size and depth of the swamp, its humic organic material as well as sand and clay composition
- Vertical seepage rates into the underlying weathered sandstone
- Swamp evapotranspiration.

Groundwater levels within the upland swamps listed in Table 5 have been monitored since February 2012. Hydrographs for all monitored swamps, two shallow soil piezometers and rainfall data are presented in Graph 6 to Graph 11. Data from this monitoring indicates that swamp water levels are variable, and can range from fully saturated to dry. Some of the swamps have been essentially dry since piezometers were installed.

Analysis of the swamp hydrographs shown in Graph 6 to Graph 10 indicates:

- PCc2 in upland swamp CCUS2 overlies first workings in the Bulli Seam, as well as the end of LW4 in the Balgownie workings. CCUS2 undergoes evapotranspiration as well as gradual drainage after rainfall with overland seepage outflow to a northerly draining gully then to Cataract Creek. Evans and Peck (2014) assert that water level lowering follows a characteristic gradual slowing in the rate that suggests drainage from a swamp to a creek, which would help sustain baseflow. There is no evidence of adverse effects due to prior subsidence in this swamp.

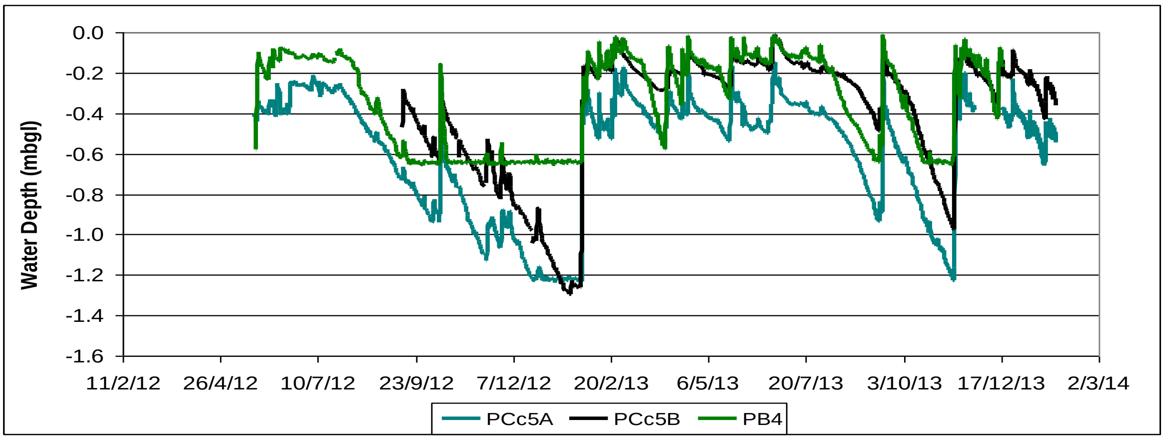
Graph 6: Hydrograph – Upland Swamp CCUS2



- PCc5A and PCC5B in upland swamp CCUS5 overlie both first workings and pillar extraction in the Bulli Seam, as well as first workings in the Balgownie workings. CCUS5 undergoes evapotranspiration as well as gradual drainage after rainfall with overland seepage outflow to a northerly draining gully then to Cataract Creek. Evans and Peck (2014) assert that water level reduction can be accounted for by evapotranspiration loss. There is no evidence of adverse effects due to prior subsidence in this swamp.

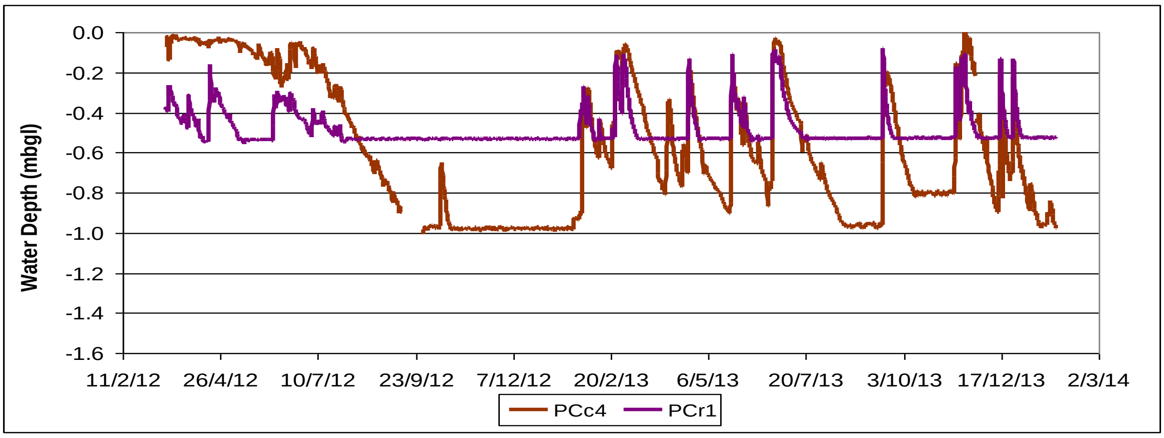
- PB4 in upland swamp BCUS4 overlies only pillar extraction in the Bulli Seam. BCUS4 also undergoes evapotranspiration as well as gradual drainage after rainfall with overland seepage outflow to a southerly draining gully then to Bellambi Creek. There is no evidence of adverse effects due to prior subsidence in this swamp.

Graph 7: Hydrograph – Upland Swamps CCUS5 and BCUS4



- PCc4 in upland swamp CCUS4 overlies first workings in the Bulli Seam as well as LW11 in the Balgownie workings. CCUS4 undergoes evapotranspiration as well as drainage after rainfall with overland seepage outflow to a northerly draining gully then to Cataract Creek. Evans and Peck (2014) concludes that water level reduction can be largely, but not fully, accounted for by evapotranspiration loss. Possible adverse effects due to prior subsidence may be evident in this swamp, due to its enhanced drainage recession rates.
- PCr1 in upland swamp CRUS1 overlies pillar extraction workings in the Bulli Seam. CRUS1 undergoes evapotranspiration as well as drainage after rainfall with overland seepage outflow to a southerly draining gully then to Cataract River. Evans and Peck (2014) concludes that water level reduction can be largely, but not fully, accounted for by evapotranspiration loss. Possible adverse effects due to prior subsidence may be evident in this swamp, due to its enhanced drainage recession rates. However, as the swamp has limited humic matter with numerous shallow outcropping or subcropping sandstone outliers, it is equally possible that the swamp has little storage capacity and drains / evaporates rapidly as a result.

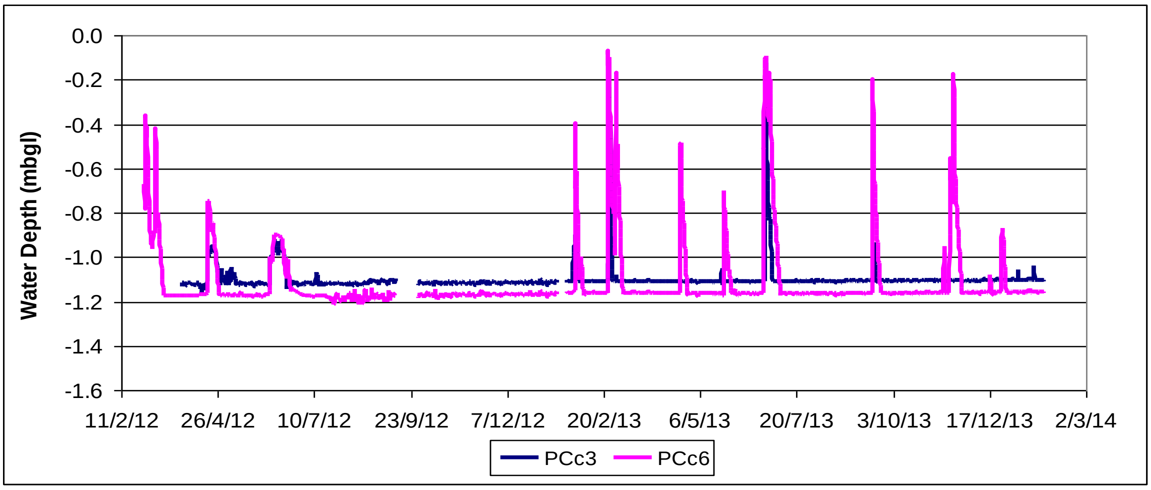
Graph 8: Hydrograph – Upland Swamps CCUS4 and CRUS1



- PCc3 in upland swamp CCUS3 overlies first workings in the Bulli Seam as well as LW10 in the Balgownie workings. CCUS3 undergoes evapotranspiration as well as rapid drainage after rainfall with overland seepage outflow to a northerly draining gully then to Cataract Creek. Evans and Peck (2014) assert that rapid water level lowering following rainfall suggests that water is being lost from the base of the swamp into the underlying sandstone. Possible adverse effects resulting from prior subsidence may be evident in this swamp, due to its enhanced drainage recession rates. However, as the swamp is small, has essentially no humic matter with numerous shallow outcropping or subcropping sandstone outliers, it is equally possible that the swamp has little storage capacity and drains / evaporates rapidly as a result.

- PCc6 in upland swamp CCUS6 overlies pillar extraction in the Bulli Seam as well as LW8 in the Balgownie workings. CCUS6 undergoes evapotranspiration as well as rapid drainage after rainfall with overland seepage outflow to a northerly draining gully then to Cataract Creek. Evans and Peck (2014) assert that rapid water level lowering following rainfall suggests that water is being lost from the base of the swamp into the underlying sandstone. Possible adverse effects resulting from prior subsidence may be evident in this swamp, due to its enhanced drainage recession rates. However, as the swamp is small, has essentially no humic matter with numerous shallow outcropping or subcropping sandstone outliers, it is equally possible that the swamp has little storage capacity and drains / evaporates rapidly as a result.

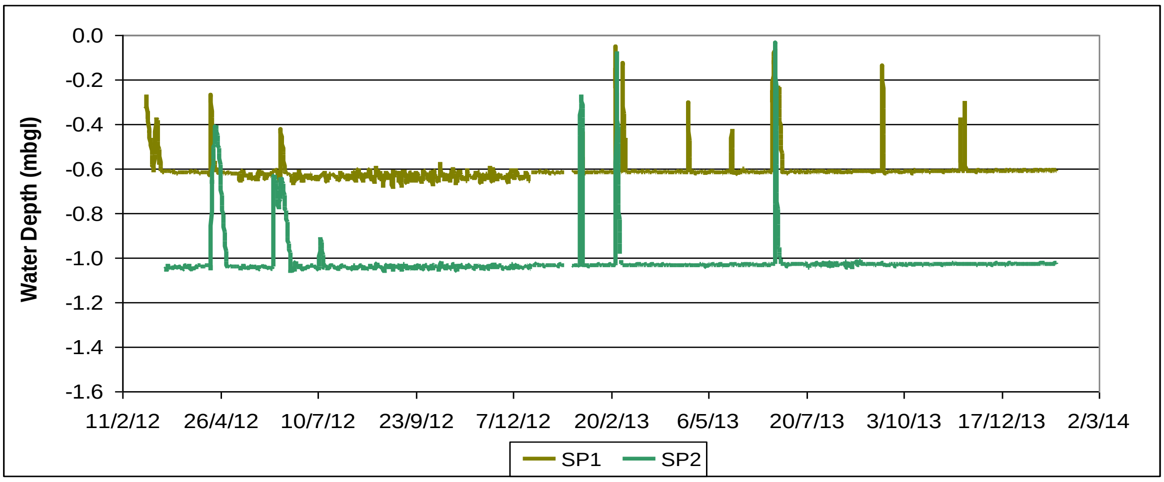
Graph 9: Hydrograph – Upland Swamps CCUS3 and CCUS6



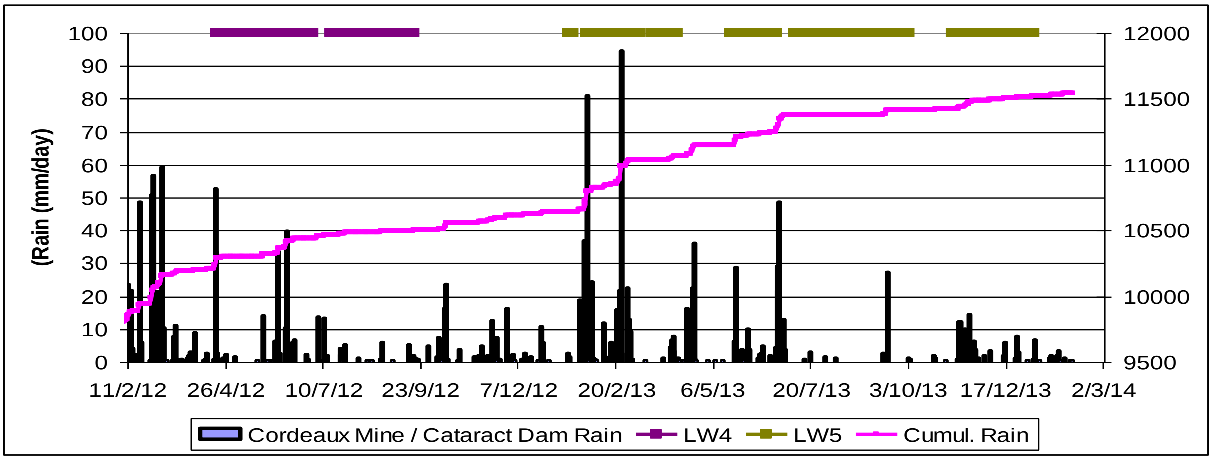
- SP1 is located external to a swamp community to the west of Mount Ousley Road, and overlies the edge of a pillar extraction area in the Bulli Seam as well as LW9 in the Balgownie Seam workings. The piezometer, which is located down gradient of swamp CCUS6, undergoes evapotranspiration as well as rapid drainage after rainfall with overland seepage outflow to a northerly draining gully then to Cataract Creek. It is possible that adverse effects due to prior subsidence may be evident. However, as the piezometer is located in a sandy clay soil / weathered sandstone profile, with no humic matter and numerous shallow outcropping or subcropping sandstone outliers, it is interpreted that the colluvial soil profile has little storage capacity and drains / evaporates rapidly as a result.

- SP2 is also located external to a swamp community to the west of Mount Ousley Road, and overlies the edge of a pillar extraction area in the Bulli Seam as well as LW10 in the Balgownie workings. The piezometer, which is located down gradient of swamp CCUS3, undergoes evapotranspiration as well as rapid drainage after rainfall with overland seepage outflow to a northerly draining gully then to Cataract Creek. It is possible that adverse effects due to prior subsidence may be evident. However, as the piezometer is located in a sandy clay soil / weathered sandstone profile, with no humic matter and numerous shallow outcropping or subcropping sandstone outliers, it is interpreted that the colluvial soil profile has little storage capacity and drains / evaporates rapidly as a result.

Graph 10: Hydrograph – SP1 and SP2



Graph 11: Rainfall



Groundwater data from piezometers located in upland swamps within the study area indicates that there are varying water levels in these upland swamps. The monitored locations within swamps CCUS4 and CCUS5 show sustained groundwater levels for prolonged periods following rainfall, CCUS2 shows gradual recession of groundwater following rainfall, while CCUS3 and CCUS6 show little groundwater recharge following rainfall. This corresponds with the vegetation communities within these upland swamps, with CCUS4 and CCUS5 supporting areas of MU43 Tea-tree Thicket (both upland swamps) and MU44c Cyperoid Heath (CCUS4 only), which both rely on permanent to intermittent waterlogging. In contrast upland swamps CCUS2, CCUS3 and CCUS6 support MU42 Banksia Thicket (CCUS3 and CCUS6) or MU44a Sedgeland and MU44b Restioid Heath (CCUS2) which are less reliant on waterlogging. CRUS1, which supports a mix of MU42 Banksia Thicket and MU43 Tea-tree Thicket, is an anomaly. This upland swamp has shallow soils and some areas of MU43 Tea-tree Thicket are known to be located in "bowls" within the underlying geology, resulting in water accumulation in depressions in bedrock.

It is worth noting that all of the upland swamps listed above have been subject to significant tilts and strains from past mining (see Table 1 and Table 2), substantially above what has been predicted by Mine Subsidence Engineering Consultants (MSEC) to result in fracturing of bedrock in waterways (DoP 2010) and the criteria listed in OEH (2012) and DoE (2014) for assessing the risk of negative environmental consequences to upland swamps. These levels of tilts and strains are likely to have resulted in fracturing of the bedrock beneath these upland swamps from past mining. Despite this, the majority of upland swamps in the study area maintain a perched water table (Evans and Peck 2014). The degree of past impact and / or self-healing that may have occurred cannot be adequately assessed and monitoring data is not available to confirm whether this has occurred.

It is also worth noting that only two upland swamps within the study area exhibit piezometric data consistent with the hypothesised significant contribution to baseflow from upland swamps (Evans and Peck 2014).

4.2.3 Groundwater model

Geoterra and Groundwater Exploration Services (2014) have recently completed the groundwater modelling and associated revised groundwater assessment for the Preferred Project Report for the UEP. Aspects of the model that are of relevance to upland swamps are discussed below.

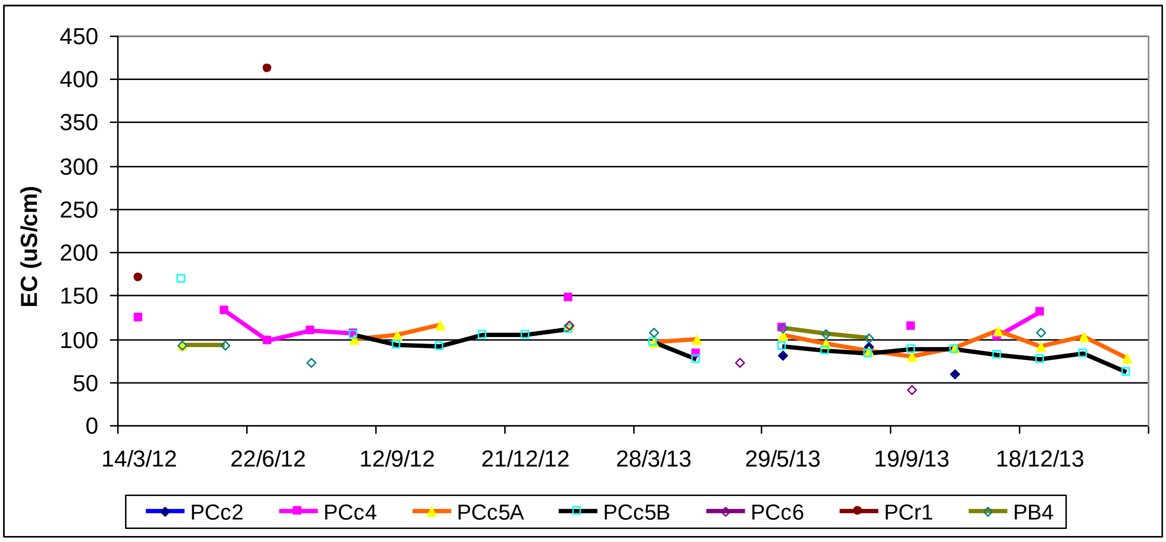
The model indicates that the depressurisation zone may reach the surface over the eastern and central sections of Longwall 6 and 7 and over the eastern and central sections of Longwalls 1 to 3. It should be noted that although the zone of depressurisation may extend to the surface this does not mean that this will result in a "full" direct connection between the perched ephemeral water table associated with upland swamps and the mine workings. This is supported by the model predicting depressurisation over the extracted Longwalls 4 and 5; however there have not been any observable adverse change in piezometric water levels in upland swamps above Longwalls 4 and 5 (Graph 9).

The modelling indicates that although the perched, ephemeral groundwater water table associated with upland swamps could undergo a water level reduction it is not anticipated to have a significant overall effect on stream baseflow or stream water quality. However, temporary, localised effects may be observed.

4.2.4 Groundwater chemistry

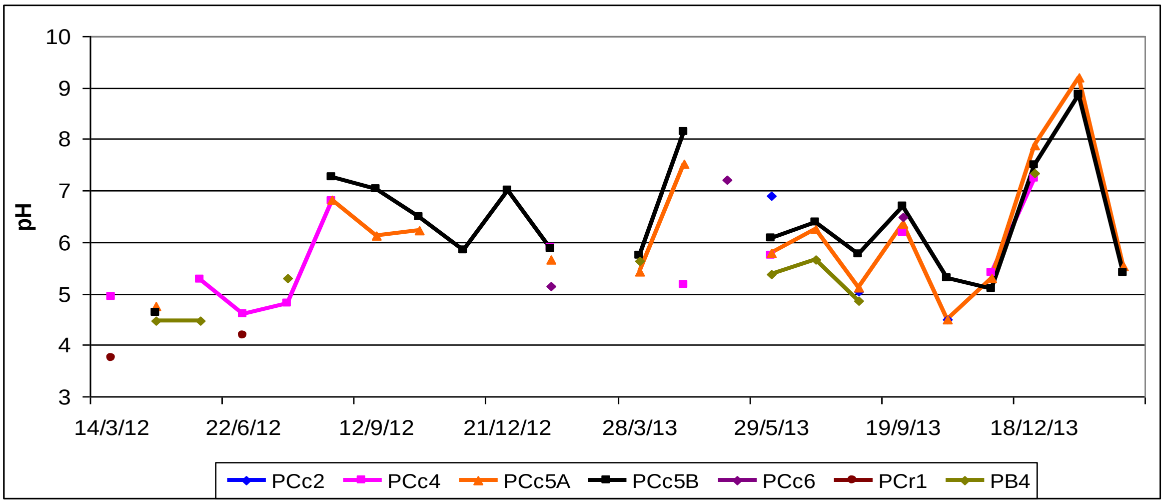
The Cataract Creek, Bellambi Creek and Cataract River swamps in the study area have electrical conductivities ranging from 70 – 170 µS/cm (Graph 12), with the salinity varying in relationship to rainfall recharge that occurs prior to sampling, along with the degree of brackish seepage from the weathered Hawkesbury Sandstone.

Graph 12: Electrical conductivity – Wonga East upland swamps



The pH ranges from 3.8 – 7.3 as shown in Graph 13.

Graph 13: pH – Wonga East upland swamps



Monitoring indicates the swamp salinity is within the acceptable range for potable water; however it is generally outside the ANZECC (2000) South Eastern Australia Upland Stream criteria for pH and can be above the ANZECC (2000) 95% Species Protection Level for Freshwater Aquatic Ecosystem Guidelines for:

- Filtered copper, lead, zinc, nickel, and occasionally aluminium (where its pH exceeds 6.5, which rarely occurs).
- Total nitrogen, and total phosphorous.

4.3 Flow accumulation

Flow accumulation modelling was undertaken based on the revised longwall layout and revised subsidence predictions (SCT Consultants 2014). The methodology for undertaking flow accumulation modelling is presented in Biosis (2012b).

Flow accumulation modelling pre- and post-mining is undertaken by modelling flow pathways across a catchment using a digital elevation model (DEM) constructed from LiDAR data. Changes in surface topography are modelled by deducting predicted subsidence values (Smax) from the pre-mining DEM. Flow accumulation is then re-modelled. This is used to predict changes to surface and sub-surface flow through an upland swamp in relation to changes in ground level (tilt) and is unrelated to tilts and strains. This method directly addresses swamp impact mechanism 2 outlined at the start of Section 4, and in particular addresses dot point 2 on page 116 of DoP (2010), which states that changes in water distribution in parts of the swamp can lead to changes in swamp health or vegetation composition.

The percentage change in flow accumulation following mining is presented in Table 6, in addition to a discussion on flow accumulation.

Table 6: Discussion of changes in flow accumulation pre- versus post-mining for upland swamps in Wonga East

Swamp	Percentage change in flow accumulation following mining	Discussion of changes in flow accumulation
BCUS4	114.64	Flow accumulation modeling for BCUS4 pre-mining indicates that there is a dispersed flow through this upland swamp, with four exit points from the base of the upland swamp. Modeling of post-mining flow indicates an increase in catchment yield of 14.64%. There are minimal changes to the exit points within this upland swamp; however a redistribution of water within the swamp may result in decreased water flow through a small patch of MU43 Tea-tree Thicket. This may result in changes to vegetation composition in this area.
BCUS11	108.29	Flow accumulation modeling for BCUS11 pre-mining indicates that this small upland swamp has three flow pathways through the swamp. Following mining, changes in tilt are likely to result in a very minor increase in summed flow within this upland swamp of 8.29%. There is unlikely to be any change to flow pathways through the upland swamp. Changes to vegetation composition are predicted to be negligible.
CCUS1	98.32	Flow accumulation modeling pre-mining indicates the presence of two main flow pathways through this upland swamp – one exiting the swamp in the northeast section of the swamp and one in the southeast section of the swamp. These exit points coincide with area of MU42 Tea-tree Thicket and MU44c Cyperoid Heath. Flow accumulation modeling post-mining indicates that tilts associated with Longwall 3 will result in a minor change to the flow pathway through the southeast section of the upland swamp with a minor (8.32%) increase in catchment area. This is likely to result in an increase in water availability for a small section of MU44a Sedgeland in this southeastern section. Any changes to vegetation composition are likely to be minor.
CCUS2	99.62	Pre-mining flow accumulation modeling for CCUS2 indicates a dispersed flow of water through this upland swamp. Tilts associated with Longwalls 2 and 3 will result in only a negligible (0.38%) decrease in water availability across the swamp. Flow pathways through the swamp are likely to change following mining; however there are no significant concentrations of water, and given the dispersed nature of flow prior to mining this is predicted to result in minor changes to vegetation composition.
CCUS3	99.18	Modeling of pre-mining flow accumulation through CCUS3 indicates the presence of two main flow pathways through this upland swamp, largely through areas of MU42 Banksia Thicket. Tilts associated with extraction of Longwall 5 are likely to result in only negligible (0.72%) changes in overall catchment yield for this upland swamp, and a minor re-direction of flow from the western edge of CCUS3 to the centre. This change

Swamp	Percentage change in flow accumulation following mining	Discussion of changes in flow accumulation
		will result in negligible impacts to this upland swamp.
CCUS4	95.23	Flow accumulation modeling pre-mining indicates the presence of two main flow pathways through this upland swamp. One minor flow path passes through the eastern section of the swamp, while the main flow pathway passes through the western section of the swamp. The western flow pathway corresponds with areas of MU43 Tea-tree Thicket and MU44c Cyperoid Heath. Post-mining, tilts will result in a minor (4.77%) decline in overall catchment yield. Only negligible changes in the western flow accumulation pathway are predicted to occur, with minor changes in flows through the patches of MU43 and MU44c. Tilts will result in result in a new flow pathway through the centre of this upland swamp, with resultant increases in water availability to patches of MU42 Banksia Thicket. A shift in the flow pathway through the eastern section of the swamp will result in a minor redistribution of water in this eastern section. This may result in minor impacts to vegetation communities reliant on permanent and intermittent waterlogging, such as an increase in the abundance of species more tolerant of dry conditions.
CCUS5	73.49	Pre-mining flow accumulation modeling indicates that this upland swamp has a dispersed flow accumulation, with numerous flow pathways through the swamp. There is a significant flow pathway through the eastern section of the swamp, corresponding with an area of MU43 Tea-Tree Thicket. Substantial benching within this swamp appears to be correlated with vegetation sub-communities; with areas of Tea-Tree Thicket (MU43) corresponding with the location of rockbars within the swamp, and it is likely that community composition in this swamp relates to a combination of flow and these rockbars allowing pooling of water at these locations. Tilts associated with Longwall 7 are likely to result in a significant (26.51%) decline in overall water availability within this swamp. This decline is likely to impact most on the eastern section of this upland swamp, diverting flow away from the major flow pathway mentioned above, resulting in a decrease in water availability for a patch of MU43. This may result in changes to vegetation composition within this swamp; however it is predicted to impact on a small section of the swamp only.
CCUS6	97.69	Flow pathways through CCUS6 prior to mining are dispersed, with multiple entry and exit points reflecting the disconnected nature of this upland swamp. Tilt associated with extraction of Longwall 4 and 5 may result in a minor (2.31%) decrease in flow accumulation, but is unlikely to result in any significant changes in these pathways. Minor changes to vegetation composition are predicted to occur.
CCUS10	106.91	Flow accumulation modeling pre-mining indicates a dispersed flow accumulation across this upland swamp. This swamp has a small catchment

Swamp	Percentage change in flow accumulation following mining	Discussion of changes in flow accumulation
		area that commences just above Longwall 9. Vegetation sub-communities appear to correspond with area of benching down the slope, with these rockbars resulting in accumulation of water in these areas. Post-mining flow accumulation modeling indicates a small (6.91%) increase in catchment yield, and only minor changes in flow pathways through this swamp.
CCUS11	50.35	Flow accumulation modeling indicates that this upland swamp has a small catchment, with the upland swamp likely to be reliant on terracing and accumulation of water. Post-mining modeling indicates a significant (49.65%) decline in this catchment yield. Tilts associated with extraction of Longwall 8 are likely to result in a diversion of this flow pathway around this upland swamp, reducing water availability. There is potential that this decline in water availability may result in impacts to this upland swamp.
CCUS12	103.58	CCUS12is located at the boundary between the catchments of Cataract Creek and Bellambi Creek, and as a result, has a very small catchment area. Pre- versus post-mining flow accumulation modeling indicates that only minor (3.58%) increases in catchment yield and no change in flow pathways. Negligible changes to vegetation compositions are predicted to occur.
CCUS23	97.06	Given the orientation of the flow pathway perpendicular to the longwall, flow accumulation modeling pre- versus post-mining indicates only a minor (2.94%) increase in catchment yield for this upland swamp. There is unlikely to be any change in flow pathways through this swamp. Negligible changes in water availability due to flow are predicted.
CRUS1	100.21	Only the upper northern section of CRUS1 is located above Longwall 6. An assessment of pre- versus post-mining flow accumulation through the upland swamp indicates a negligible (0.21%) increase in catchment yield and negligible changes in flow pathways through this upland swamps. No changes in water availability are predicted to occur.

Flow accumulation modelling for upland swamps within the study area indicates that, for the majority of upland swamps, only negligible or minor changes in both cumulative flow and flow pathways are likely to occur following mining. No significant reconcentration of flows that may result in increased erosion risk, are likely to occur. For the majority of upland swamps mining is likely to result in only minor changes in water availability.

Flow accumulation modelling indicates that BCUS4, CCUS5 and CCUS11 are at risk of impact due to changes in water availability, particularly to vegetation communities sensitive to decreases in water availability.

4.4 Subsidence

Reassessment of subsidence predictions following monitoring of Longwalls 4 and 5 indicates that previous mining has resulted in the softening of the underlying rock strata, and that subsidence is occurring over a much shorter distance than has previously occurred in un-mined areas, with subsidence largely restricted to immediately above the goaf. Whilst this means that subsidence movements occur over a smaller area, it also means that tilts and strains are greater than previously predicted (SCT Operations 2014).

Maximum subsidence within the bounds of the swamp may not necessarily be a good indicator of the maximum subsidence parameters of strain and tilt given that maximum strain and tilt typically occur on the fringes of a subsided area. The maximum strain and tilt values have been estimated based on the level of subsidence within the general proximity of a swamp that would contribute to maximum strains and tilts within the swamp boundary (SCT Operations 2014).

When strains are greater than about 1 – 2 mm/m in tension and 2 –3 mm/m in compression, perceptible fracturing of the sandstone strata below swamps may occur (SCT Operations 2014) and this may result in a decrease in the perched water table and water availability.

Upland swamps form across a range of soil moisture gradients supporting different flora species and vegetation communities (Keith et al. 2006, NSW Scientific Committee 2012, DoE 2014). The model of upland swamp response to climatic change outlined in Keith et al. (2006) describes a transition between MU43 Tea-tree Thicket to MU44c Cyperoid Heath and MU44a Sedgeland / MU44b Restioid heath / MU42 Banksia Thicket in response to changes on soil moisture. MU43 Tea-tree Thicket is likely to be reliant on semi-permanent to permanent waterlogging and MU44C Cyperoid heath on intermittent waterlogging, whilst the water table is likely to reach the root zone in other vegetation communities only following heavy rains. Similar changes in vegetation community composition within an upland swamp would be expected to occur due to changes in soil moisture resulting from fracturing of bedrock beneath an upland swamp.

Changes in soil moisture can occur in two ways; either through loss of water through fracturing of the bedrock and / or through changes in water flow through an upland swamp resulting in changes in water availability. Whilst we use the flow accumulation model to assess the second potential mechanism of change, we must use predictions for tensile and compressive strain to assess the potential for fracturing of the base of upland swamps and potential for loss of groundwater availability. In light of this, we have used these parameters to assess potential for impacts to particular vegetation communities within an upland swamp.

Subsidence predictions are presented in Table 4. This data indicates that tensile and compressive strains and tilts are of sufficient magnitude to result in fracturing of bedrock beneath upland swamps within the Wonga East area. Table 7 assesses the risk of a significant impact to these upland swamps based on vegetation communities present, and recorded response to groundwater (for upland swamps with groundwater data available).

Table 7: Discussion of tensile and compressive and strains for upland swamps within the study area

Swamp	Discussion of tilts and strains
BCUS4	BCUS4 is located over the edge of Longwall 9. Soils in BCUS4 are up to 160 centimetre (cm) in depth and consist of humic sandy clay. Tilts and strains affect a small section of MU43 Tea-tree Thicket. Lower sections of the upland swamp are unlikely to be subject to strains of sufficient magnitude to fracture bedrock. BCUS4 undergoes evapotranspiration as well as gradual drainage after rainfall. There is no evidence of adverse effects due to prior subsidence in this swamp.

Swamp	Discussion of tilts and strains
	Risk is assessed as low due to impacts to a small section of this swamp.
BCUS11	BCUS11 does not support vegetation communities reliant on waterlogging. No groundwater data is available. Risk is assessed as low.
CCUS1	Potential impacts are likely to be restricted to a very small section of this upland swamp at the eastern end. Any changes here are likely to be limited in extent, and are unlikely to result in a significant impact to this upland swamp. No groundwater data is available. Risk is assessed as low.
CCUS2	CCUS2 does not support vegetation communities reliant on waterlogging. Undergoes evapotranspiration as well as gradual drainage after rainfall. There is no evidence of adverse effects due to prior subsidence in this swamp. Risk of impact is considered low.
CCUS3	CCUS3 supports MU42 Banksia Thicket and MU44a Sedgeland, which are not reliant on waterlogging and are thus deemed less susceptible to decreased groundwater availability. Groundwater data indicates rapid recession to basement levels following rainfall. Risk is assessed as low.
CCUS4	CCUS4 supports MU43 Tea-tree Thicket and MU44c Cyperoid heath, which are reliant on permanent to semi-permanent water availability, as well as MU42 Banksia Thicket. Soils are 15 – 179 cm in depth and consist of humic sandy clays to minerals sands. Undergoes evapotranspiration as well as gradual drainage after rainfall. The location of water-dependent communities, including MU44C Cyperoid Heath and MU43 Tea-tree Thicket at the base of the longwall, in areas of lowest strain and tilt, are likely to mitigate impacts to some degree. An overhanging sandstone formation, approximately 7.1 m high, forms a waterfall at the base of CCUS4. This sandstone formation forms a rockbar at the downstream extent of upland swamp CCUS4. There is evidence of impacts from previous mining, including collapse of a section of this sandstone formation and some cracking of the sandstone outcrop to the west of the waterfall below CCUS4. Horizontal compression of this sandstone formation has the potential to result in rockfall or tensile cracking of this sandstone formation (SCT Operations 2014). As this sandstone formation forms a rockbar at the downstream extent of CCUS4 any fracturing is likely to result in changes in hydrology. Any rockfall that impacts on the integrity of the sandstone formation may result in significant impacts to the water holding capacity of CCUS4. There is no evidence of adverse effects due to prior subsidence in this swamp. Risk is assessed as high.
CCUS5	CCUS5 supports a mix of MU43 Tea-tree Thicket, which depends on permanent water availability, and MU42 Banksia Thicket and MU44a Sedgeland. Upper sections of CCUS5, overlying Longwall 6, consist of MU42 and MU44a. Soils in this section of CCUS5 are up to 80 cm in depth and consist of a mix of humic sandy clay and sandy clay to minerals sands. Only a small section of this swamp will be subject to subsidence, and areas of MU43 Tea-tree Thicket are located in areas of lower strain. Undergoes evapotranspiration as well as gradual drainage after rainfall. There is no evidence of adverse effects due to prior subsidence in this swamp.

Swamp	Discussion of tilts and strains
	Risk is assessed as low.
CCUS6	CCUS6 supports MU42 Banksia Thicket, which is not reliant on waterlogging and is thus deemed less susceptible to decreased groundwater availability. Groundwater data indicates rapid recession to basement levels rapidly following rainfall. Risk is assessed as low.
CCUS10	CCUS10 supports a mix of MU43 Tea-tree Thicket and MU44c Cyperoid Heath, which depends on permanent water availability, and MU42 Banksia Thicket. Only a small section of this swamp will be subject to subsidence, and areas of MU43 Tea-tree Thicket and MU44c Cyperoid Heath are located in areas of lower strain. Soils in the section of CCUS10 overlying Longwall 9 are up to 75 cm in depth and consist of sandy clay. No groundwater data is available. Risk is assessed as low.
CCUS11	CCUS11 supports MU42 Banksia Thicket, which is not reliant on waterlogging and is thus deemed less susceptible to decreased groundwater availability. No groundwater data is available. Risk is assessed as low.
CCUS12	CCUS12 supports MU42 Banksia Thicket, which is not reliant on waterlogging and is thus deemed less susceptible to decreased groundwater availability. Soils are between 5 and 85 cm in depth and consist largely of minerals sands with little organic material. No groundwater data is available. However this upland swamp is unlikely to support significant groundwater. Risk is assessed as low.
CCUS23	CCUS23 supports MU42 Banksia Thicket and MU44a Sedgeland. No groundwater data is available. Risk is assessed as low.
CRUS1	CRUS1 supports a mix of MU43 Tea-tree Thicket and MU42 Banksia Thicket. Based on shallow soil profile, MU43 Tea-tree Thicket is likely to persist in areas of water accumulation resulting from rock terracing, as evident from analysis of slope and testing of soil depths. Only a small, upper section of this upland swamp is located within the predicted subsidence impact zone. Soils in this area are between 25 and 70 cm, and consisting of mineral sands. These areas are unlikely to support significant groundwater. Vegetation in this area consists of MU42 Banksia Thicket. Undergoes evapotranspiration as well as gradual drainage after rainfall. Possible adverse effects due to prior subsidence may be evident in this swamp due to its enhanced drainage recession rates. However, as the swamp has limited humic matter with numerous shallow outcropping or subcropping sandstone outliers, it is equally possible that the swamp has little storage capacity and drains / evaporates rapidly as a result. Risk is assessed as low.

4.5 Final risk assessment

4.5.1 Potential impacts

Potential impacts to upland swamps in the study area may result from the following mechanisms:

- Fracturing of bedrock beneath upland swamps, resulting in increased secondary porosity and permeability, with potential to drain into deeper sandstone strata.
- Tilting in upland swamps resulting in the re-distribution of perched water levels and surface run-off. This may result in changes in in-flow to upland swamps and / or changes in saturation of vegetation sub-communities.
- Tilting in upland swamps resulting in increased potential for development of nick points, scouring and erosion.
- Changes in baseflow discharge and from upland swamps.

Subsidence could affect upland swamps directly overlying the proposed longwalls due to either transient and/or spatial changes in secondary porosity and permeability of a swamp or its underlying weathered sandstone substrate through generation of cracks or differential displacement of the perched aquifer. If a swamp overlies an extracted panel, it may undergo temporary extensional "face line" cracking (perpendicular to the long axis of the panel) as a panel advances, followed by re-compression as the maximum subsidence occurs at any one location. In addition, where a swamp overlies a longwall, it may also undergo both longer term extensional "rib line" cracking (parallel to the long axis of the panel) along the outer edge and compression within the central portion of a panel's subsidence trough. The more susceptible portions of a swamp to increased secondary porosity and / or permeability changes are where it undergoes "rib line" cracking. Any adverse effects, if they occur, would be related to the extent and degree of cracking that occurs in the underlying weathered sandstone, as cracking is unlikely to manifest in a swamp due to its saturated, clayey, humic, plastic nature, as well as the reliance of vegetation within the upland swamp on the perched water table (compared with surface water in-flow).

It should be noted that the headwater swamps in the study area have undergone up to an estimated 3.8 m of subsidence in the centre of Longwall 4 with up to 1.0 m of subsidence estimated for mining in the Bulli Seam, 1.0 m measured during mining in Balgownie Seam and 1.8 m is predicted to occur during mining in Wongawilli Seam. This level of subsidence would be expected to cause up to an estimated 21 mm/m of tensile strain, 41 mm/m of compressive strain, and 68 mm/m of tilt. Bulli Seam mining occurred from the late 19th Century through to about 1950. Balgownie Seam longwalls were mined between 1970 and 1982. Longwalls 4 and 5 in the Wongawilli Seam were mined in 2012 and 2013.

Where a swamp straddles a chain pillar, or is on the edge of the subsidence bowl, it could experience temporary, localised, re-distribution of perched water levels through differential subsidence of the ground. Tilting of a swamp could also potentially re-distribute surface runoff, resulting in a re-distribution of water flow and storage, thereby causing changes to the saturation characteristics which may alter the vegetation associations within a swamp.

Changes in flow regimes within swamps can result in changed flow paths or runoff characteristics within a swamp, with the potential for development of knick points, scouring and erosion. Dewatering and drying of swamps due to subsidence fracturing of the bedrock may increase the erosion potential of swamps. Negative environmental consequences may be caused by erosion and drying out of the swamp via channel erosion, by redistribution of water, or by water diversion through connected pathways exposed by buckling or shearing of the underlying sandstone. The swamps, however, contain sediment and organic material that may either seal or reduce water loss into the underlying fracture network. Drying, in conjunction with fire and substantial rainfall, can increase the susceptibility of swamps, particularly valley fill swamps, to erosion. However, it is often the case that no single factor can be directly implicated in enhanced erosion of upland swamps. The only swamp in the Russell Vale lease area that has undergone notable erosion is the valley fill swamp LCUS4 at Wonga West, which is outside the study area for this assessment.

Upland swamp water is stored within the shallow, perched, ephemeral groundwater system, whilst regional water is contained within the deeper Hawkesbury Sandstone aquifers. Empirical observation and field mapping (Biosis, 2013a, b) indicates that past undermining of swamps in the Wollongong Coal lease area has not generated any noticeable adverse ecological effects on swamps. It is therefore anticipated that observable reduction of swamp discharge to the study area catchments will not occur following subsidence across the subject catchment areas, although generation of potentially enhanced leakage from the base of the swamps may occur. Seepage from the swamp is currently highly ephemeral, with the volume and duration of baseflow being directly related to the degree of rainfall recharge and stream flow in the catchment.

4.5.2 Detailed risk assessment

Following assessment of a variety of risk factors, Table 8 provides an overall assessment of the potential for a significant impact to occur. This final risk assessment assesses the overall risk of a primary impact (based on the initial risk assessment) and the consequent risk of a secondary impact (based on factors such as groundwater data, reliance of vegetation communities on water availability, changes in flow accumulation and the position of water dependent communities within the upland swamp compared to areas of greatest tilt and strain).

The changes in storativity and permeability are estimated to have no observable impact above the water level variability due to climatic influences. Connective cracking to deeper strata is not predicted and, as such, it is not anticipated that the swamps could freely drain into the deeper sandstone strata. Based on observation of previously undermined swamps in the study area that have undergone similar strains to those predicted due to undermining by the previous Bulli and Balgownie workings, no observable adverse consequences are anticipated on the water holding capacity, water quality or ecosystem health of the majority of swamps, except possibly CCUS4. In addition to fracturing of the base of CCUS4, there is potential for impacts to the sandstone formation that forms a rockbar at the downstream extent of this upland swamp. Any rockfall that impacts on the integrity of this rockbar is likely to result in a significant impact to the water holding capacity of CCUS4.

Although the upper margins of upland swamps CCUS5 and CCUS10 overlie Longwalls 6 and 9 respectively, soil depths indicate that these upper margins are shallow, largely dry and unlikely to support significant groundwater resources. All other designated upland swamps are not anticipated to undergo sufficient compressional or extensional strains to generate cracks in the underlying or adjacent sandstone, and therefore are not anticipated to undergo any adverse effects or consequences from the proposed mining.

While there is some limited potential for redistribution of perched water levels and surface water run-off in some upland swamps, significant changes in water run-off are likely to be limited to small sections of upland swamps.

Although erosion of swamps is possible where elevated tilts occur due to subsidence, it is only generally valley fill swamps which have been directly mined beneath that are susceptible to erosion and scouring. No valley fill swamps are present in the study area.

It is not anticipated that the ephemeral water levels or baseflow seepage will be significantly adversely affected. The groundwater model (Geoterra and Groundwater Exploration Services 2014) indicates that the average daily stream flow from Cataract Creek to Cataract Reservoir is 11.2 ML/d, of which 3.5 ML/d is baseflow. The model predicts a 0.013 ML/d (0.12%) loss of stream baseflow following mining. This level of change is unlikely to be detectable and unlikely to result in observable changes to flow regimes in Cataract Creek.

This final risk assessment indicates that there is a risk of a secondary impact to upland swamps BCUS4 and CCUS4 from the proposed extraction of coal in the study area.

Table 8: Final risk assessment for upland swamps in the study area

Swamp	Initial risk assessment (risk of negative environmental consequences?)	Groundwater	Flow accumulation	Compressive tilts and strains	Final risk assessment
BCUS4	No	Low	Moderate	Low	Moderate
BCUS11	Yes	N/A	Negligible	Low	Low
CCUS1	Yes	N/A	Low	Moderate	Low
CCUS2	Yes	Low	Low	Low	Low
CCUS3	Yes	Low	Low	Moderate	Low
CCUS4	Yes	Moderate	Low	High	High
CCUS5	Yes	Low	Moderate	Low	Low
CCUS6	Yes	Low	Low	Low	Low
CCUS10	Yes	N/A	Low	Low	Low
CCUS11	Yes	N/A	Moderate	Low	Low
CCUS12	Yes	N/A	Negligible	Low	Low
CCUS23	Yes	N/A	Negligible	Low	Low
CRUS1	Yes	Low	Low	Low	Low

The following section provides for a Significant Impact Assessment for the Coastal Upland Swamp EEC, according to the factors outlined in the *Matters of National Environmental Significance Significant Impact Guidelines 1.1* (DoE 2013).

An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:

- *reduce the extent of an ecological community*

  No clearing of upland swamp vegetation is proposed.

  There is some potential for a reduction in the extent of upland swamps due to changes in the perched water table and transition of upland swamp vegetation communities to woodland.

  Analysis of the historic impacts to upland swamps in the study area from mining of the Bulli and Balgownie seams indicates that at least some of the upland swamps in the study area have experienced levels of subsidence considered likely to have resulted in fracturing of bedrock and an increased risk of negative environmental outcome. A previous report by Biosis (2013) concluded that data from piezometers located in some of these upland swamps show regression of groundwater consistent with a 'fractured' swamp (e.g. CCUS3, CCUS6 and CRUS1), whilst others do not (e.g. CCUS2, CCUS4 and CCUS5). A subsequent review undertaken by Evans & Peck (2014), on behalf of DP&E, concluded that the water retention characteristics of upland swamps had not been affected by past mining and that the majority of upland swamps in this area have maintained a perched groundwater system and do not show any evidence of cracking (see below for further information).

  It should be noted that despite upland swamps CCUS3 and CCUS6 showing signs of impacts from past mining the vegetation in these upland swamps remains characteristic of the Coastal Upland Swamp EEC. The paucity of suitable monitoring data from past mining does not allow for a determination as to whether past mining has resulted in changes in the extent of this EEC.

  Although there is potential for a reduction in the extent of the Coastal Upland Swamp EEC this is likely to be localised in nature and occur over long time frames (i.e. decades). There is currently 4,739 ha of Coastal Upland Swamp EEC across the Woronora plateau, with 49 ha (1.03%) within the study area.

  There is a negligible likelihood of the complete loss of upland swamp vegetation within the study area. All upland swamps that intersect the predicted subsidence impact zone total 32 ha. This equates to 0.68% of the extent of the community across the Woronora plateau. Based on the risk assessment outlined above impacts are likely to be restricted to upland swamps CCUS4 and BCUS4. These two upland swamps total 4.24 ha, equating to 0.09% of the extent of the community across the Woronora plateau.

  Upland swamps are not co-dependent and impacts to one swamp unless located on the same flow pathway which is not the case in the study area. Impacts to one upland swamp will not impact others.

  Any reduction in the extent of the community from the proposed activity is likely to be negligible when considered in a regional context.

- *fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines*

  No clearing of upland swamp vegetation is proposed.

  Although a reduction in the perched water table has the capacity to reduce the size of individual upland swamps, given the existing fragmented nature of this EEC, it is considered unlikely that further fragmentation will occur.

- *adversely affect habitat critical to the survival of an ecological community*

  DoE (2014) identifies all areas currently occupied and the associated sub-catchments as habitat critical to the survival of the Coastal Upland Swamp EEC.

  No clearing of upland swamp vegetation is proposed.

  Potential impacts to upland swamps within the study area are outlined in Section 4.5.1. Some adverse impacts are predicted to occur, particularly for upland swamps CCUS4 and BCUS4. This may include changes in the species composition of these swamps, with an increase in species more tolerant of dry conditions and a decrease in species requiring permanent to intermittent waterlogging.

- *modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns*

  The proposed action is likely to result in a reduction in the perched water table in one upland swamp, CCUS4. Two of the vegetation communities in upland swamps CCUS4, MU43 Tea-tree Thicket and MU44c Cyperoid Heath, are reliant on this perched water table. There is also potential for re-distribution of surface water flows in upland swamp BCUS4, which may result in decreased water flow through a small patch of MU43 Tea-tree Thicket. This may result in changes to vegetation composition in this area.

  However, although this may result in impacts to two vegetation sub-communities in CCUS4 and BCUS4, it is unlikely to result in the loss of the Coastal Upland Swamp EEC in the study area or impacts on the EEC at a regional level. This conclusion is supported by the assessment of historic impacts to upland swamps in the study area (refer Section 3 herein).

  Changes to the hydrology of upland swamps in the study area will be monitored as a part of the detailed upland swamp monitoring program and management plan. The management plan will specify performance measures and management actions to be undertaken should these be exceeded.

- *cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting*

  There is some potential for a change in the distribution of upland swamp vegetation communities in upland swamp CCUS4 if the base of this upland swamp is fractured and the perched water table drops. Sections of CCUS4 support MU43 Tea-Tree Thicket and MU44c Cyperoid Heath, both of which rely on permanent to intermittent water logging for maintenance.

  There is also potential for re-distribution of surface water flows in upland swamp BCUS4, which may result in decreased water flow through a small patch of MU43 Tea-tree Thicket. This may result in changes to vegetation composition in this area.

  If there are changes in water availability this may result in drying of the substrate in these areas which may result in the transition of these vegetation sub-communities to drier variants of the EEC (e.g. MU42 Banksia Thicket, MU44a Sedgeland or MU44b Restioid Heath).

  Vegetation composition of upland swamps will be monitored as a part of the detailed upland swamp monitoring program. The management plan will specify performance measures and management actions to be undertaken should these be exceeded.

- *cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to:*
  - *assisting invasive species, that are harmful to the listed ecological community, to become established, or*
  - *causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community, or*

  No clearing of upland swamp vegetation is proposed.

  Activities associated with the proposed action are unlikely to result in increased invasion of exotic species, or release of any chemicals of pollutants in upland swamps in the study area. No water discharges are proposed. All personnel accessing the study area do so under strict environmental controls.

  It is unlikely that any activities associated with the proposed action will result in a substantial reduction in the quality or integrity of this EEC.

- *interfere with the recovery of an ecological community.*

  There is currently no recovery plan for this EEC, and DoE (2014) considers that a recovery plan is not required at this time.

This assessment indicates:

- That whilst there is potential for a reduction in the extent of the EEC, any reduction resulting from the proposed action is likely to be negligible when considered in a regional context.
- The proposed action is unlikely to fragment or increase fragmentation of the EEC.
- Some adverse impacts to habitat critical to the survival of the EEC are predicted to occur, particularly for upland swamps CCUS4 and BCUS4.
- There is some potential to modify abiotic factors for individual swamps; any changes are unlikely to result in the loss of the Coastal Upland Swamp EEC in the study area or impact on the EEC at a regional level.
- There is potential for change in the distribution of upland swamp vegetation communities, particularly in upland swamps CCUS4 and BCUS4. However, analysis of data from past mining indicates that this will result in transition from wetter to drier sub-communities rather than loss of the EEC.
- It is unlikely that any activities associated with the proposed action will result in a substantial reduction in the quality or integrity of this EEC.
- The proposed action will not interfere with the recovery of the EEC.

Although there is potential for localised impacts to occur, significant impacts are likely to be restricted to upland swamps CCUS4 and BCUS4. Impacts are not likely to be significant at a regional scale, with upland swamps in the study area accounting for 1.03% of the extent of the EEC in the region.

Based on the information presented above and the assessment undertaken in above, we conclude that the proposed action is unlikely to result in a significant impact to the Coastal Upland Swamp EEC. Any impacts are likely to be localised and affect only a small occurrence of the EEC at a regional scale.

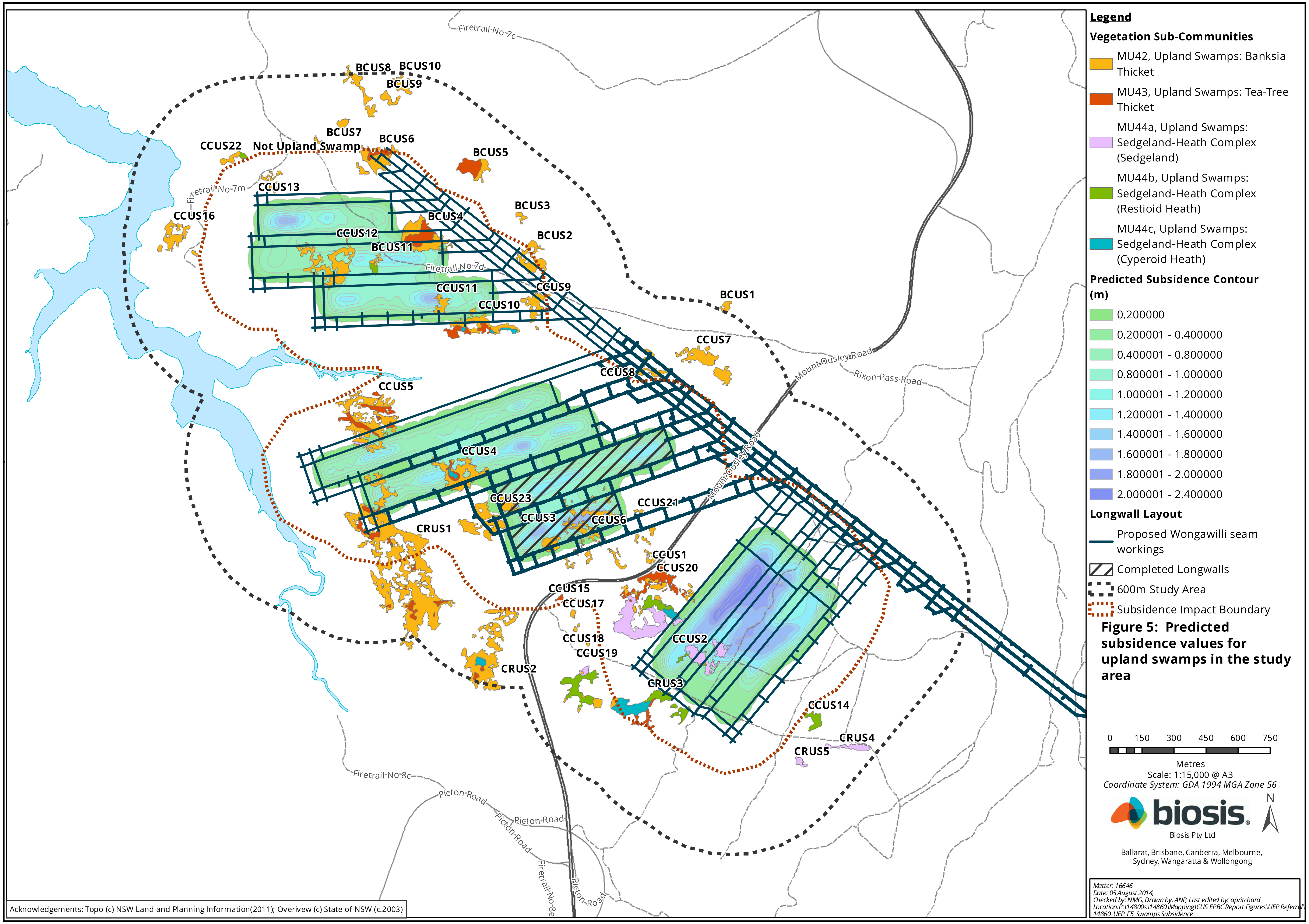


Figure 5: Predicted subsidence values for upland swamps in the study area

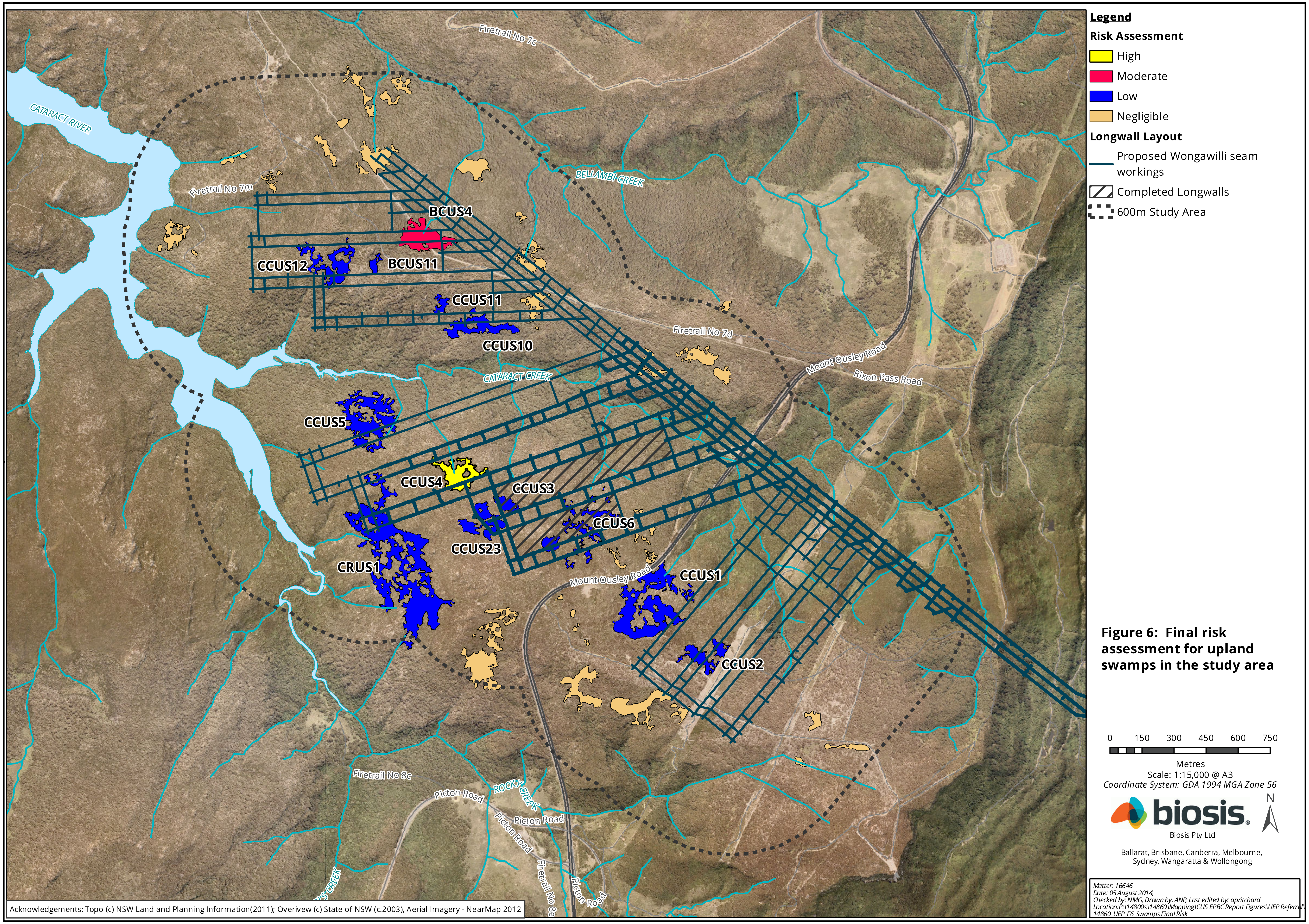


Figure 6: Final risk assessment for upland swamps in the study area

5. Impact Avoidance and Mitigation

The principal means to reduce impacts on biodiversity values within the study area has been to incorporate significant features into the mine planning process, and thus avoid and minimise impacts to upland swamps (and other natural features)

This section outlines how the four step process, to avoid, minimise, mitigate and then offset any residual impacts, has been incorporated into the planning process for the UEP.

5.1 Measures to avoid and minimise impacts to upland swamps

Multiple options for the longwall layout have been canvassed over the development phase of the UEP. Consultation with key regulators, including the NSW Department of Planning and Environment (DP&E), Office of Environment and Heritage (OEH), Division of Resources and Energy (DRE), submissions received during the initial adequacy assessment and exhibition period and feedback for engineering professionals and environmental specialists have been fundamental in modifying the UEP to meet economic, social and environmental objectives of the project. In October 2013, WCL submitted a Preferred Project Report for the UEP, which proposed significant changes to the mine plan to reduce impacts to sensitive environmental features (including upland swamps). Section 1 of the Preferred Project Report (NRE 2013) provides a comparison of the original project with the current mine plan.

A comparison of the original mine plan to the current mine plan in relation to upland swamps in the study area is provided in Figure 7. Key measures to avoid and minimise impacts to upland swamps in the study area during the planning process have included:

- Shortening of Longwall 4 to avoid impacts to upland swamp CRUS1.
- Shortening of Longwall 5 to avoid impacts to upland swamp CRUS1 and minimise impacts to CCUS3.
- Re-orientation of Longwalls 1 – 3 to avoid impacts to upland swamp CCUS1.
- Reduction in the width of Longwall 7 to minimise impacts to upland swamp CCUS5.
- Re-orientation of Longwalls 9 – 11 to minimise impacts to upland swamp CCUS10.

Measures to further avoid residual impacts to upland swamps CCUS4, CCUS5, CCUS10 and CRUS1 were considered; however, and further reduction in longwall lengths and or widths will render the Underground Expansion Project uneconomic.

5.2 Measures to further mitigate impacts

The primary measure to further mitigate impacts will be to undertake detailed monitoring, set performance measures in line with Conditions of Approval, and determine adaptive management measures, mitigation strategies and remediation works should performance measures be exceeded.

The existing Biodiversity Management Plan (BMP) for Longwalls 4 and 5 (Biosis 2012a), which currently outlines the above for Longwalls 4 and 5, will be updated. A monitoring plan consistent with the monitoring plan outlined in the existing BMP for Longwalls 4 and 5 (Biosis 2012a) will be adopted and expanded for the and included in the revised BMP. The current monitoring focuses on natural features at risk of subsidence effects, including upland swamps. The BMP includes:

- Monitoring of vegetation in upland swamps according to the Before-After Control-Impact (BACI) design where data is collected before (baseline) and after impact at control and impact sites. Data collected during baseline monitoring will be used for comparison of data collected during and after mining and data collected at impact sites will be compared to data collected at control sites (control-impact).
- Monitoring of upland swamps using shallow piezometers to gauge any changes in standing water levels and swamp groundwater quality (see Geoterra 2012b).

The BMP will be updated to include Longwalls 1 – 3 and 6 – 11. The BMP will be further updated to include a detailed upland swamp monitoring plan. The purpose of this detailed monitoring plan will be to determine, as far as possible, the historic impacts on swamps and establish a comprehensive monitoring regime for water, ecology and geotechnical elements of swamp communities.

Key elements of the monitoring plan will include:

- 3D subsidence surveys to gather detailed data on subsidence levels, particularly in upland swamps CCUS4 and CCUS5.
- Shallow piezometers to monitor changes in water levels and quality in upland swamps.
- A network of weirs to monitor base flow from upland swamps and inflows into Cataract Creek.
- Monitoring to get detailed data on climatic conditions.
- Detailed vegetation monitoring, as outlined above.

The aim of the upland swamp monitoring plan will be to determine whether subsidence associated with longwall mining results in impacts to the ecological functioning of upland swamps. The specific objectives of the upland swamp monitoring program will be to

- Assess upland swamp hydrology.
- Provide advance warning of potential breaches of subsidence predictions.
- Allow for detection of adverse impacts on upland swamp and underlying strata hydrology.
- Allow for the detection of secondary impacts, such as erosion or changes in the size or distribution of vegetation within an upland swamp, should primary impacts occur.
- Characterise the relationship between swamp/s and their role in recharging the regional groundwater systems.
- Characterise the relationship between swamp/s and their role in providing baseflow to local catchments.

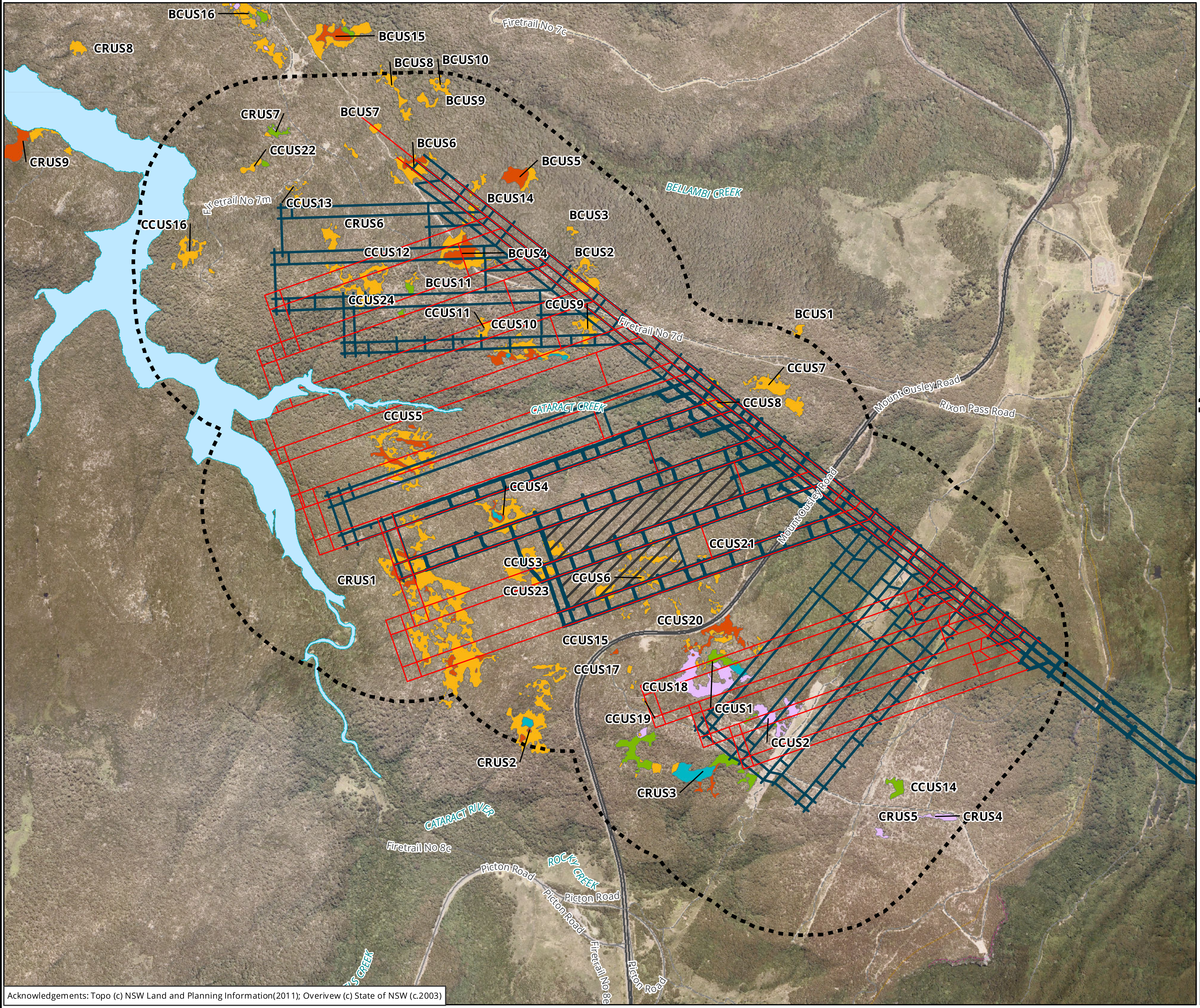
The plan will be developed in consultation with relevant stakeholders.

An adaptive management plan will be developed to use the monitoring program to detect the need for adjustment to the mining operations so that the subsidence predictions are not exceeded and subsidence impacts creating a risk of negative environmental consequences in upland swamps are minimised.

Further measures to mitigate potential small scale effects of subsidence will be considered as required.

5.3 Measures to offset residual impacts

A Biodiversity Offset Strategy would be developed if triggers, outlined in the Conditions of Approval and detailed in the Biodiversity Management Plan, are exceeded. If the project is deemed a controlled action and threatened species and communities are considered controlling provisions due to impacts to upland swamps, a full assessment of impacts will be undertaken in accordance with the designated assessment approach. If required, an offset strategy will be developed, in line with the Commonwealth Environmental Offsets Policy (DSEWPaC 2012).



Acknowledgements: Topo (c) NSW Land and Planning Information(2011); Overview (c) State of NSW (c.2003)

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Vegetation Sub-Communities

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- MU43, Upland Swamps: Tea-Tree Thicket
- MU44a, Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Longwall Layout

- Proposed Wongawilli seam workings
- Completed Longwalls
- Original mine plan
- 600m Study Area

Figure 7: Original mine plan and current mine plan, showing measures to avoid and minimise impacts to upland swamps in the study area

0 150 300 450 600 750

Metres

Scale: 1:15,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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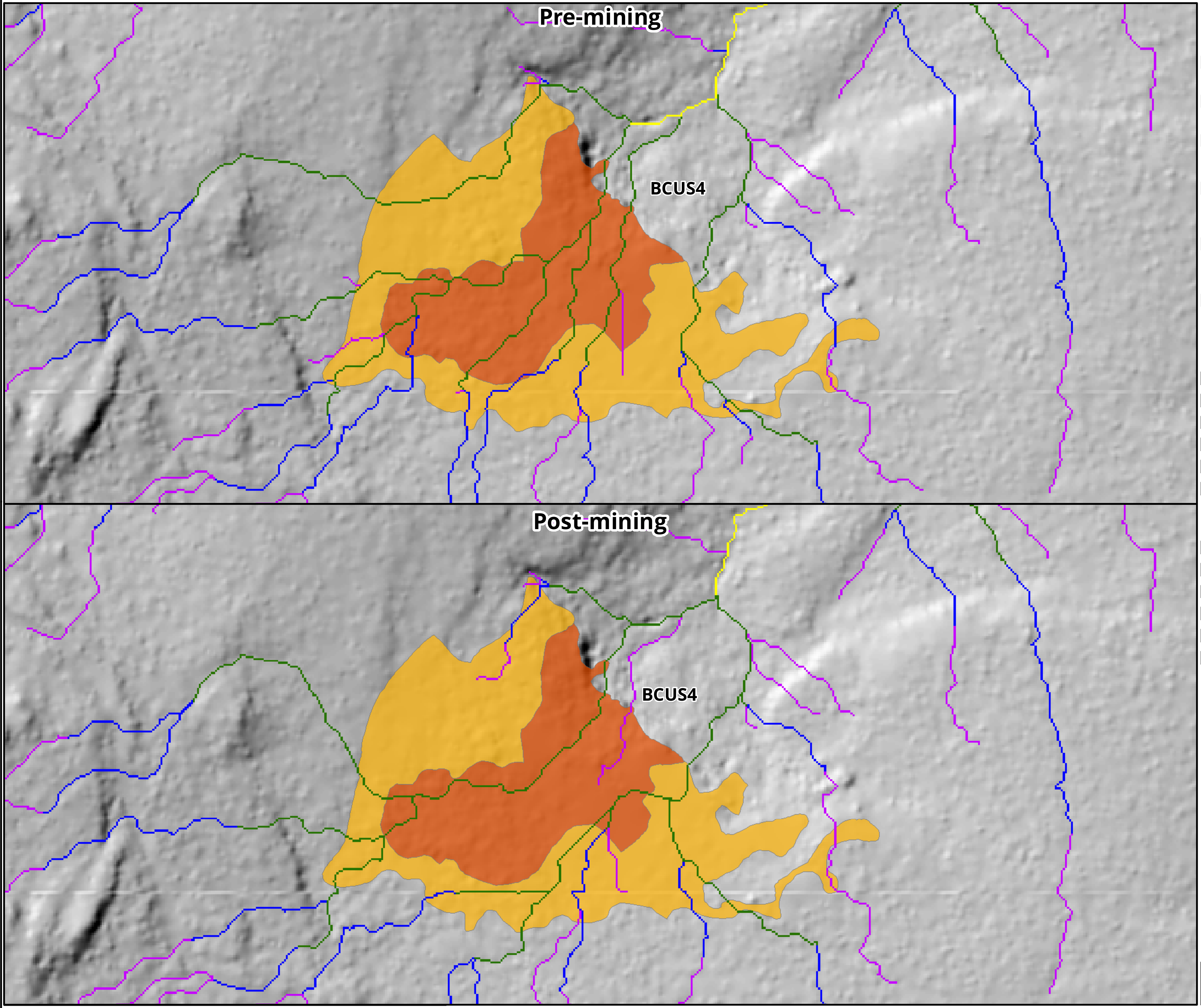
Appendix

Appendix 1



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Vegetation Sub-Communities

- MU42, Upland Swamps: Banksia Thicket
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- MU44a, Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Flow accumulation pre-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 17,179,869,180

Flow accumulation post-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 18,609,328

Figure 8: Flow accumulation pre- and post-mining, upland swamp BCUS4, Underground Expansion Project (UEP)

0 10 20 30 40 50

Metres

Scale: 1:1,750 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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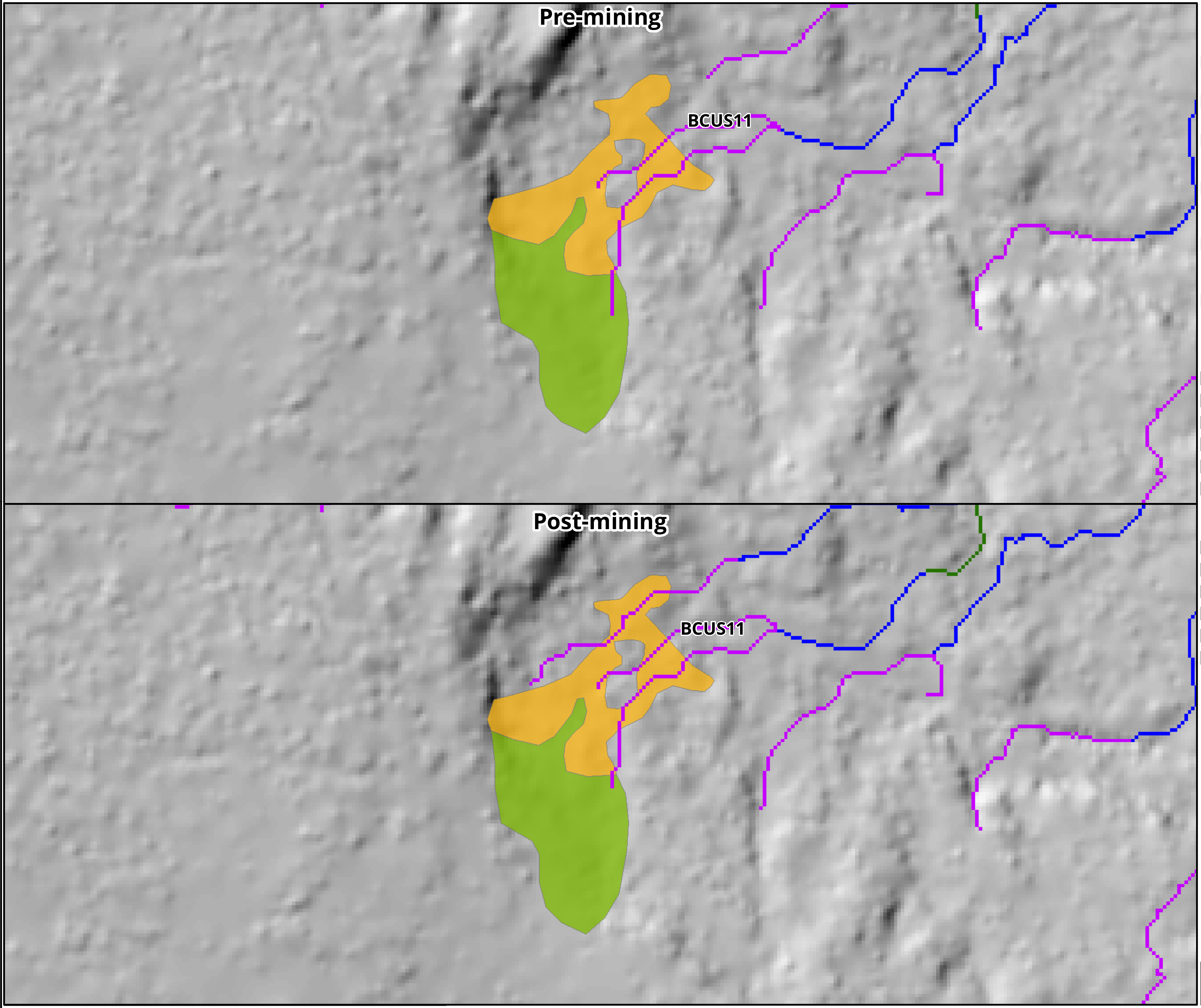

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- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Flow accumulation pre-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 17,179,869,180

Flow accumulation post-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 18,609,328

Figure 9: Flow accumulation pre- and post-mining, upland swamp BCUS11, Underground Expansion Project (UEP)

0 10 20 30 40 50

Metres

Scale: 1:1,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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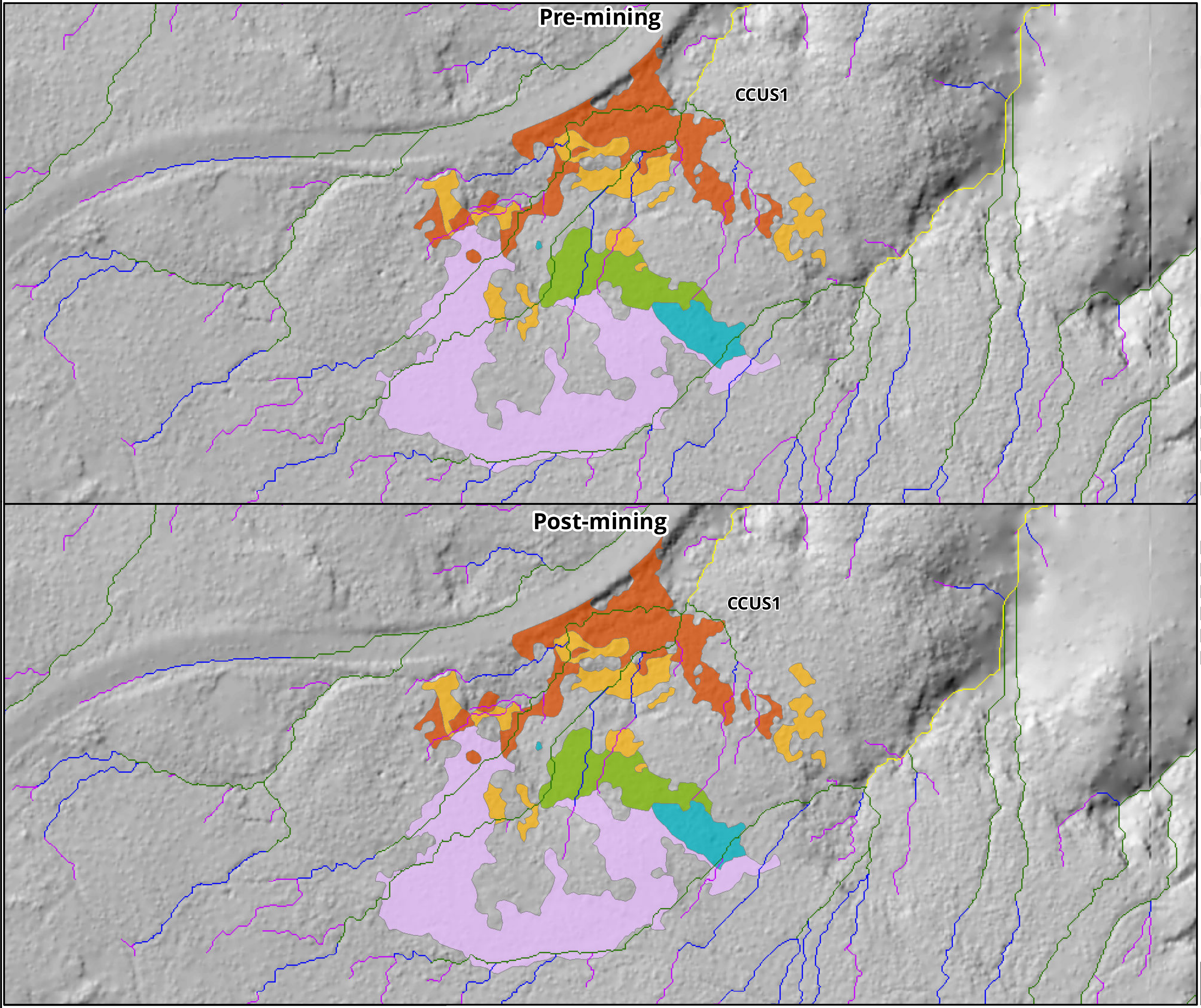

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Vegetation Sub-Communities

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- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Flow accumulation pre-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 17,179,869,180

Flow accumulation post-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 18,609,328

Figure 10: Flow accumulation pre- and post-mining, upland swamp CCUS1, Underground Expansion Project (UEP)

0 30 60 90 120 150

Metres

Scale: 1:3,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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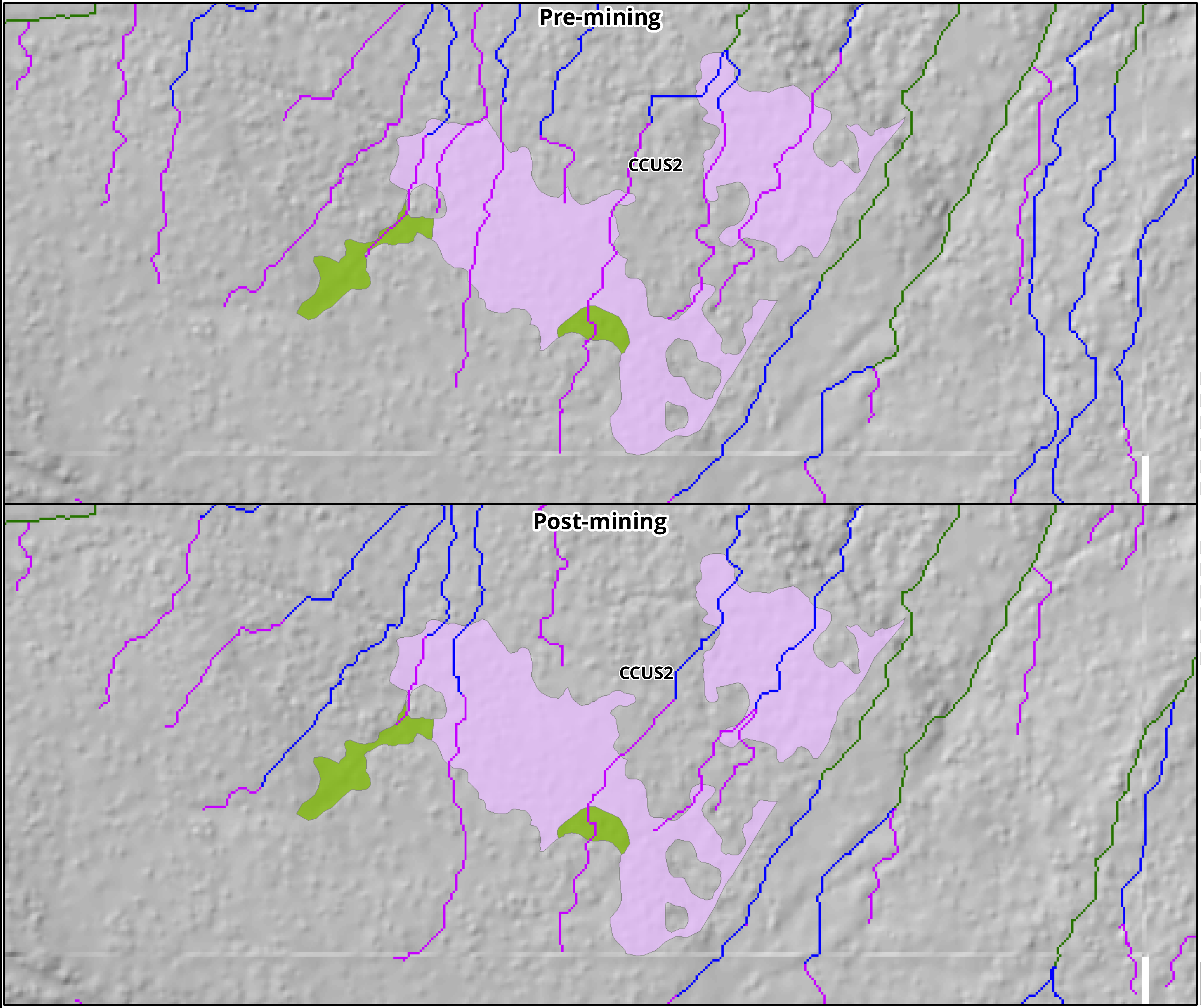

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Vegetation Sub-Communities

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- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Flow accumulation pre-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 17,179,869,180

Flow accumulation post-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 18,609,328

Figure 11: Flow accumulation pre- and post-mining, upland swamp CCUS2, Underground Expansion Project (UEP)

0 10 20 30 40 50

Metres

Scale: 1:1,500 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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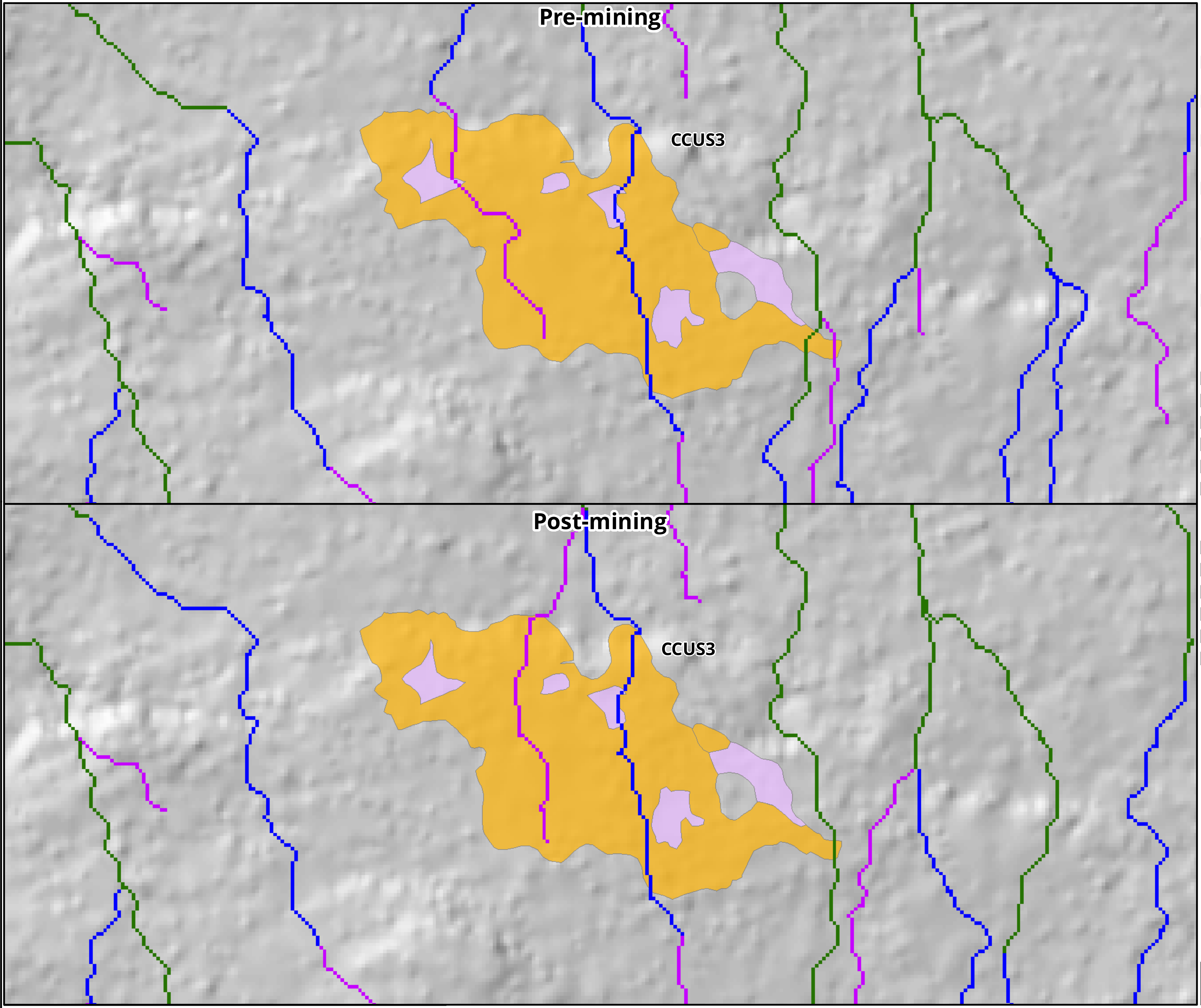

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- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Flow accumulation pre-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 17,179,869,180

Flow accumulation post-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 18,609,328

Figure 12: Flow accumulation pre- and post-mining, upland swamp CCUS3, Underground Expansion Project (UEP)

0 10 20 30 40 50
Metres
Scale: 1:1,000 @ A3
Coordinate System: GDA 1994 MGA Zone 56

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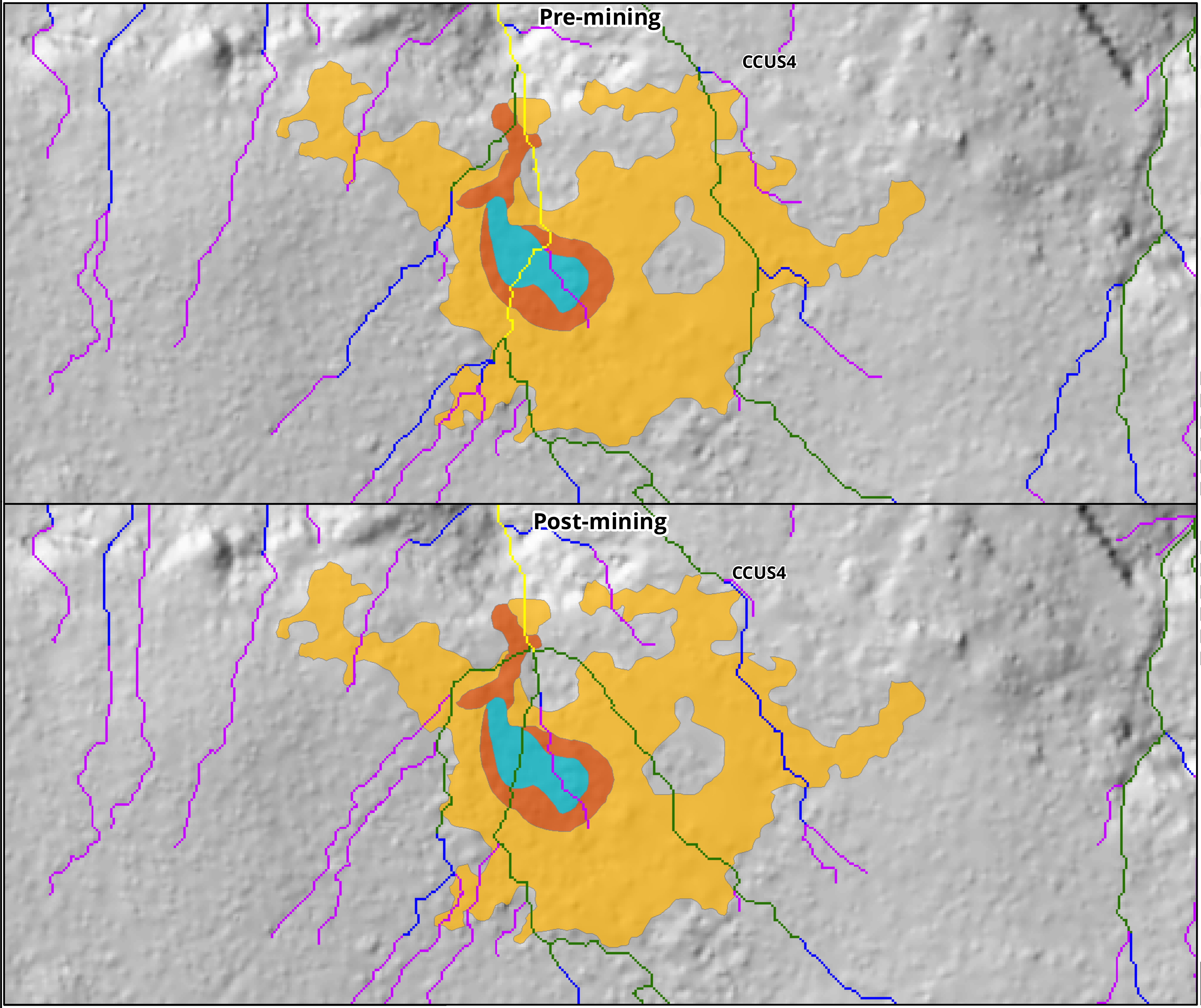

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- MU44, Upland Swamps: Sedgeland-Heath Complex
- MU44a, Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Flow accumulation pre-mining (m^2)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 17,179,869,180

Flow accumulation post-mining (m^2)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 18,609,328

Figure 13: Flow accumulation pre- and post-mining, upland swamp CCUS4, Underground Expansion Project (UEP)

0 10 20 30 40 50

Metres

Scale: 1:1,500 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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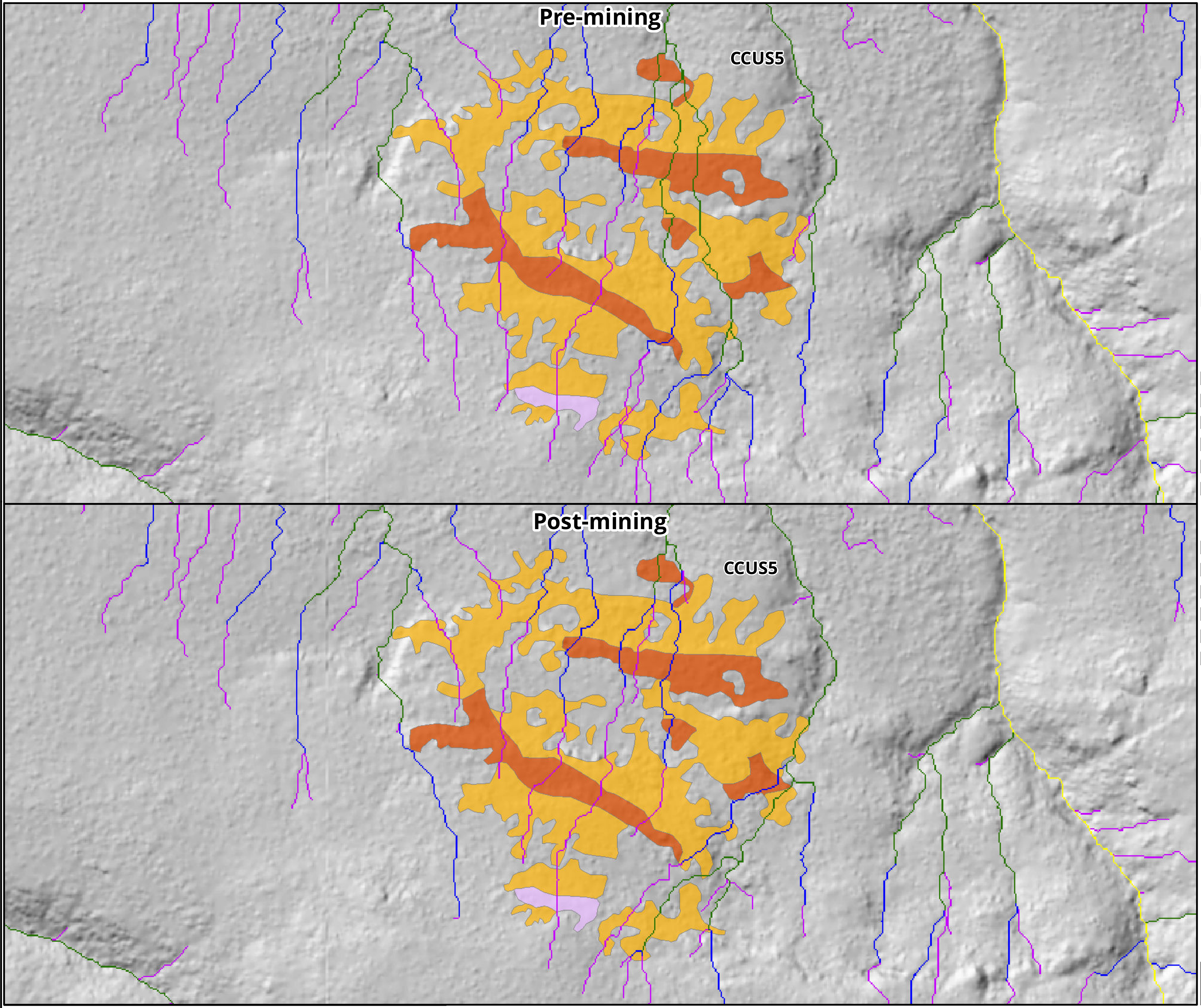

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- MU44, Upland Swamps: Sedgeland-Heath Complex
- MU44a, Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Flow accumulation pre-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 17,179,869,180

Flow accumulation post-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 18,609,328

Figure 14: Flow accumulation pre- and post-mining, upland swamp CCUS5, Underground Expansion Project (UEP)

0 25 50 75 100 125

Metres

Scale: 1:2,500 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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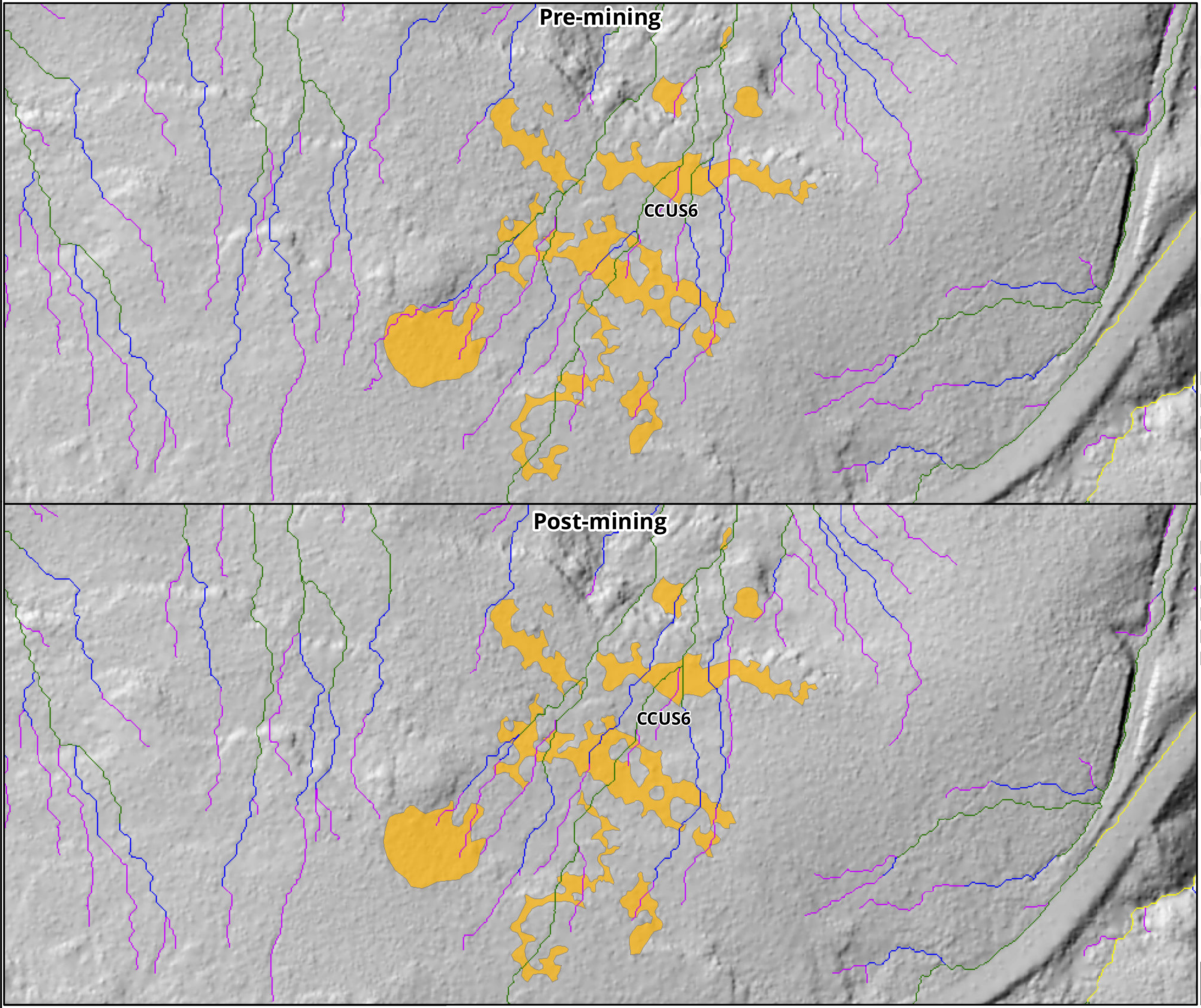

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Vegetation Sub-Communities

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- MU43, Upland Swamps: Tea-Tree Thicket
- MU44, Upland Swamps: Sedgeland-Heath Complex
- MU44a, Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Flow accumulation pre-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 17,179,869,180

Flow accumulation post-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 18,609,328

Figure 15: Flow accumulation pre- and post-mining, upland swamp CCUS6, Underground Expansion Project (UEP)

0 30 60 90 120 150

Metres

Scale: 1:3,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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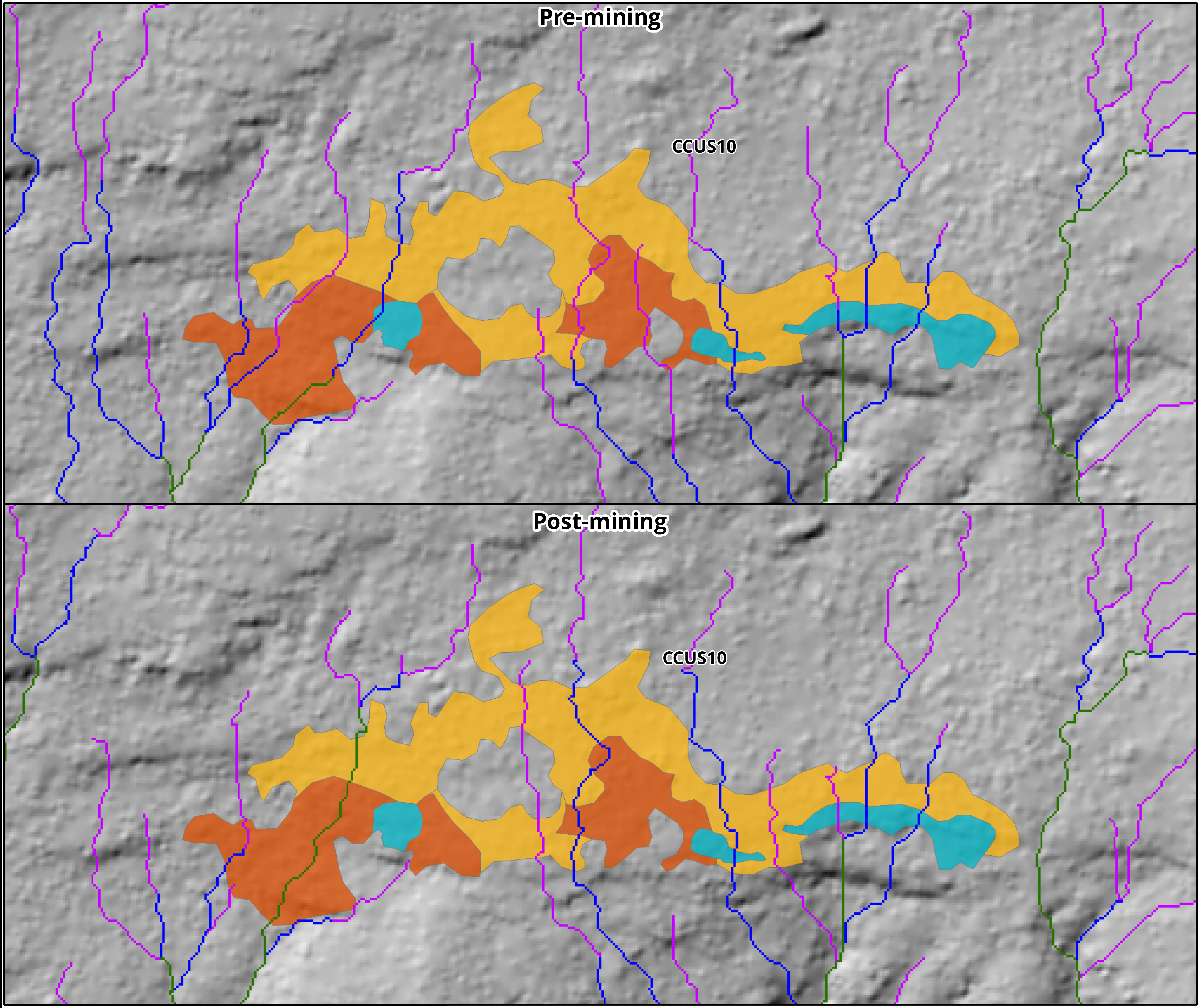

Legend

Vegetation Sub-Communities

- MU42, Upland Swamps: Banksia Thicket
- MU43, Upland Swamps: Tea-Tree Thicket
- MU44, Upland Swamps: Sedgeland-Heath Complex
- MU44a, Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Flow accumulation pre-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 17,179,869,180

Flow accumulation post-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 18,609,328

Figure 16: Flow accumulation pre- and post-mining, upland swamp CCUS10, Underground Expansion Project (UEP)

0 10 20 30 40 50

Metres

Scale: 1:1,500 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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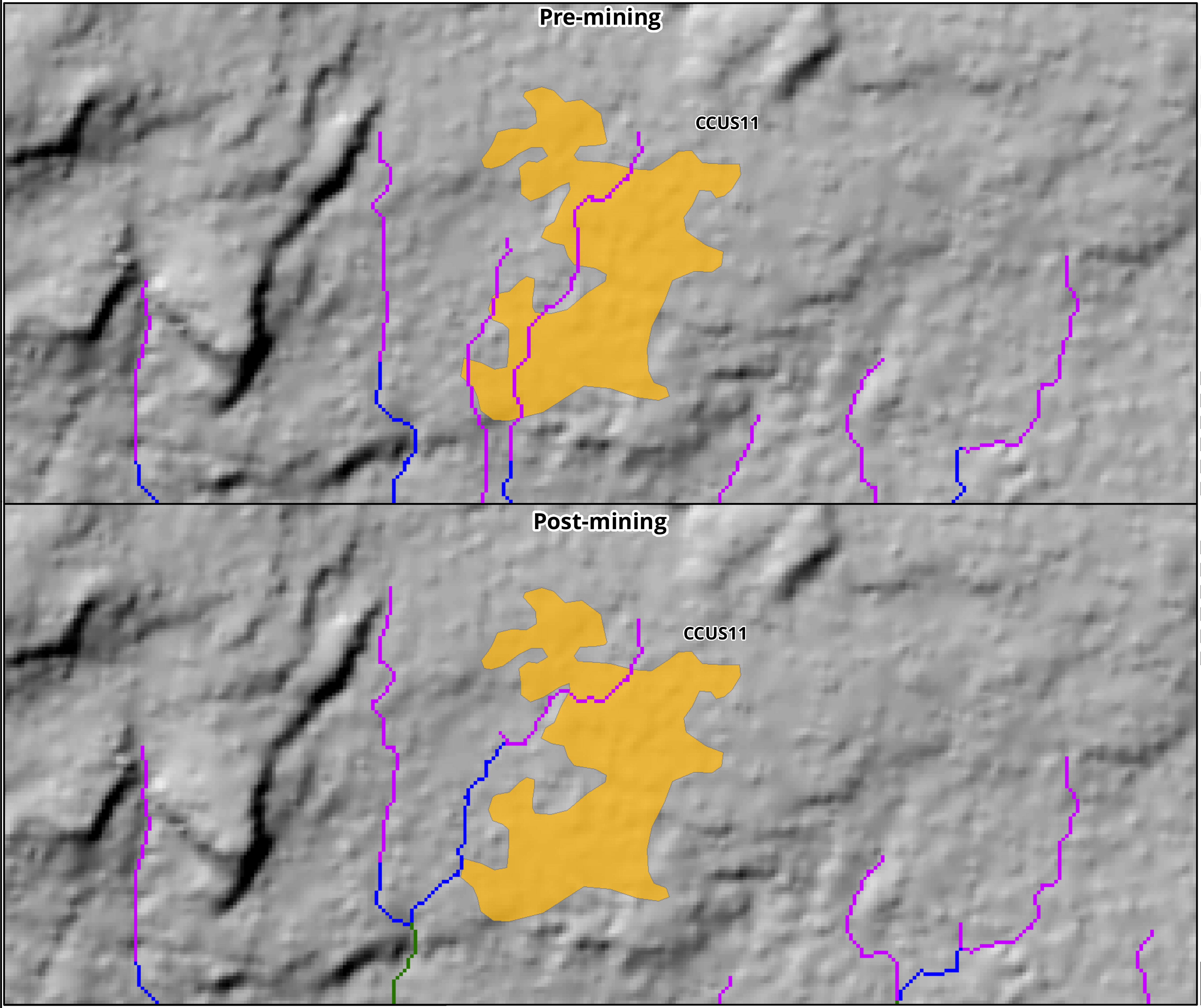

Legend

Vegetation Sub-Communities

- MU42, Upland Swamps: Banksia Thicket
- MU43, Upland Swamps: Tea-Tree Thicket
- MU44, Upland Swamps: Sedgeland-Heath Complex
- MU44a, Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Flow accumulation pre-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 17,179,869,180

Flow accumulation post-mining (m²)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 18,609,328

Figure 17: Flow accumulation pre- and post-mining, upland swamp CCUS11, Underground Expansion Project (UEP)

0 10 20 30 40 50
Metres
Scale: 1:1,000 @ A3
Coordinate System: GDA 1994 MGA Zone 56

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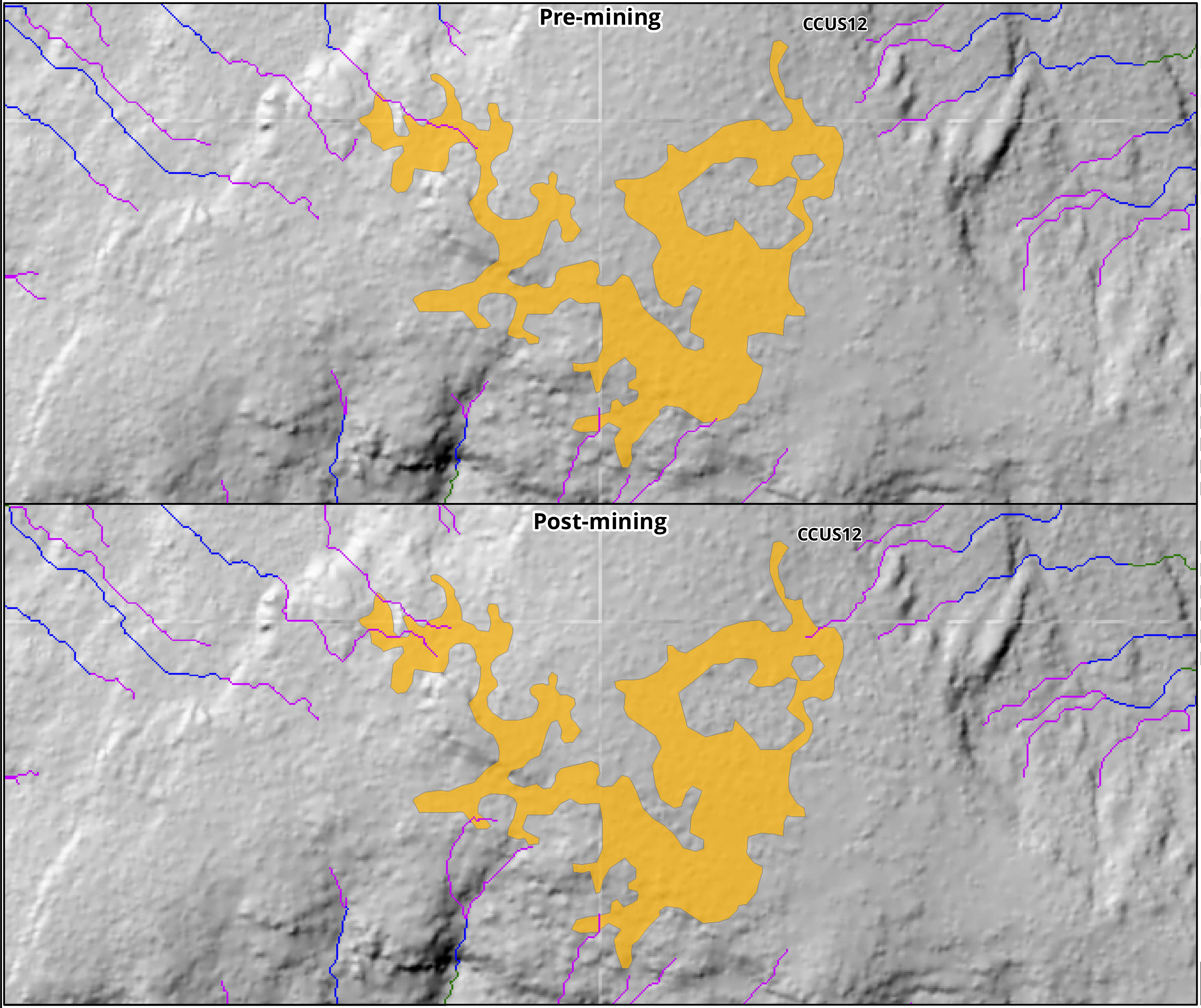

Legend

Vegetation Sub-Communities

- MU42, Upland Swamps: Banksia Thicket
- MU43, Upland Swamps: Tea-Tree Thicket
- MU44, Upland Swamps: Sedgeland-Heath Complex
- MU44a, Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Flow accumulation pre-mining (m^2)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 17,179,869,180

Flow accumulation post-mining (m^2)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 18,609,328

Figure 18: Flow accumulation pre- and post-mining, upland swamp CCUS12, Underground Expansion Project (UEP)

0 20 40 60 80 100
Metres
Scale: 1:2,000 @ A3
Coordinate System: GDA 1994 MGA Zone 56

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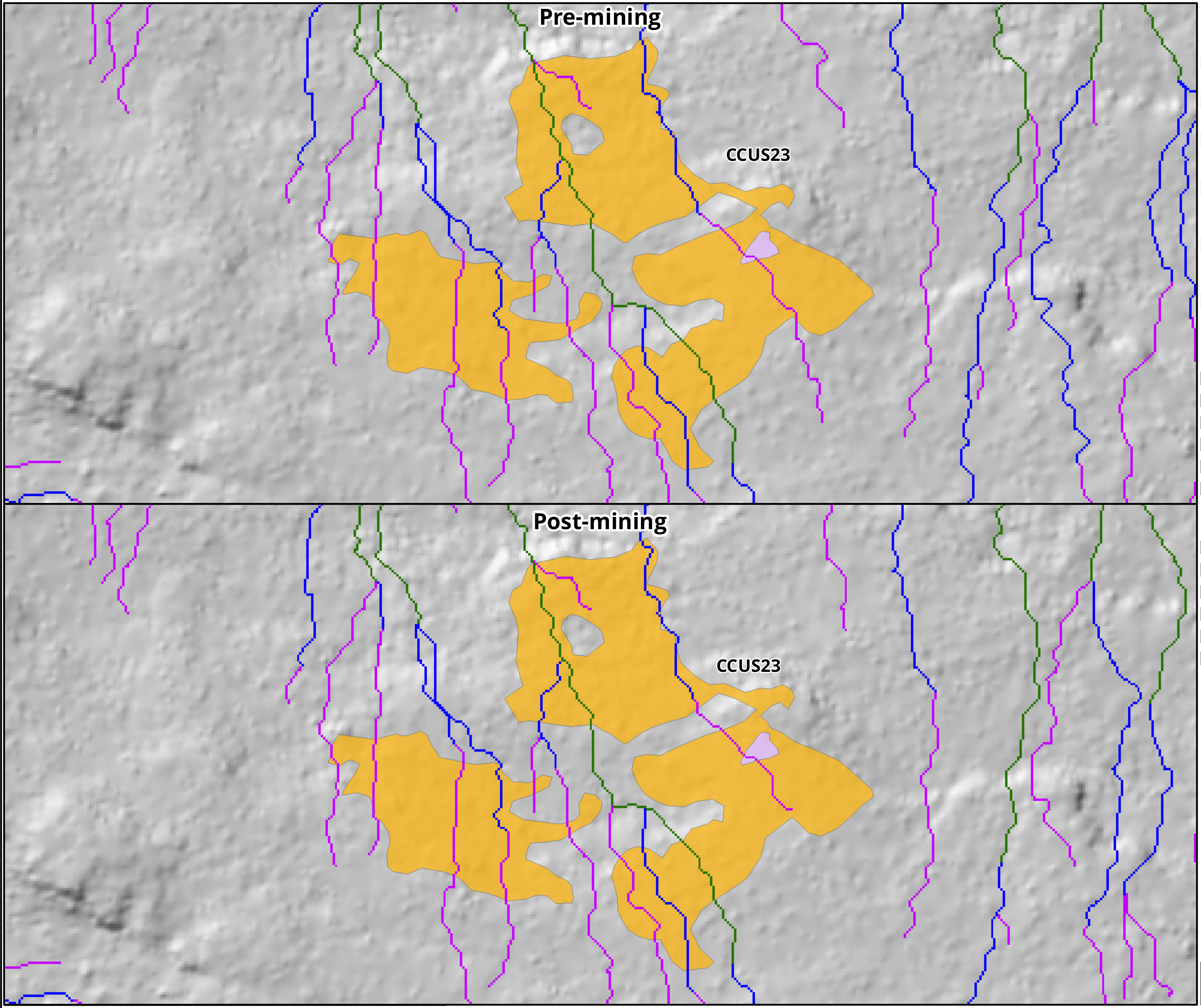

Legend

Vegetation Sub-Communities

- MU42, Upland Swamps: Banksia Thicket
- MU43, Upland Swamps: Tea-Tree Thicket
- MU44, Upland Swamps: Sedgeland-Heath Complex
- MU44a, Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Flow accumulation pre-mining (m^2)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 17,179,869,180

Flow accumulation post-mining (m^2)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 18,609,328

Figure 19: Flow accumulation pre- and post-mining, upland swamp CCUS23, Underground Expansion Project (UEP)

0 10 20 30 40 50

Metres

Scale: 1:1,500 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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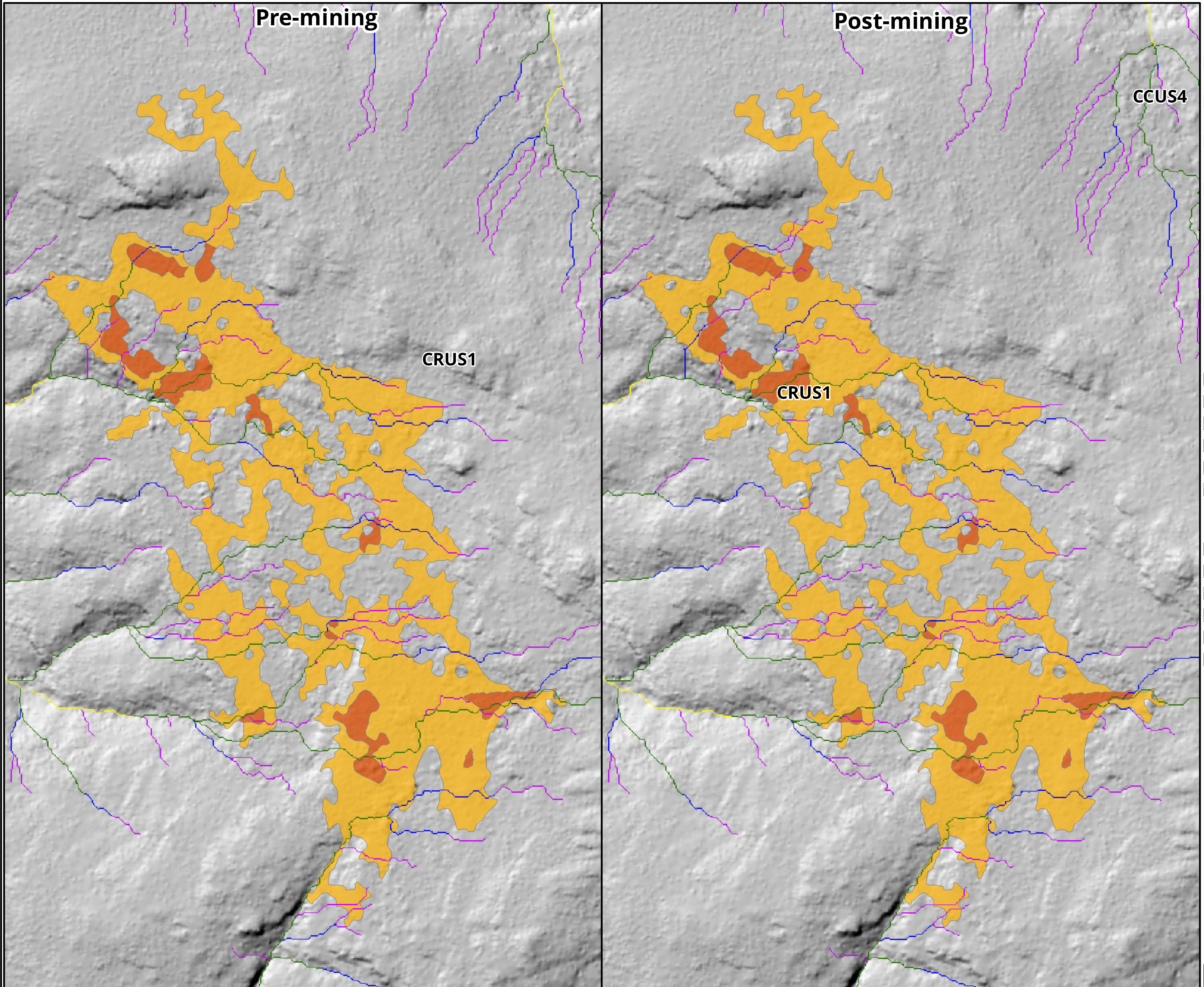

Acknowledgements: Topo (c) NSW Land and Planning Information(2011); Overivew (c) State of NSW (c.2003)

Legend

Vegetation Sub-Communities

- MU42, Upland Swamps: Banksia Thicket
- MU43, Upland Swamps: Tea-Tree Thicket
- MU44, Upland Swamps: Sedgeland-Heath Complex
- MU44a, Upland Swamps: Sedgeland-Heath Complex (Sedgeland)
- MU44b, Upland Swamps: Sedgeland-Heath Complex (Restioid Heath)
- MU44c, Upland Swamps: Sedgeland-Heath Complex (Cyperoid Heath)

Flow accumulation pre-mining (m^2)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 17,179,869,180

Flow accumulation post-mining (m^2)

- 0 - 2,500
- 2,500.000001 - 5,000
- 5,000.000001 - 10,000
- 10,000.00001 - 100,000
- 100,000.0001 - 1,000,000
- 1,000,000.001 - 18,609,328

Figure 20: Flow accumulation pre- and post-mining, upland swamp CRUS1, Underground Expansion Project (UEP)

0 30 60 90 120 150

Metres

Scale: 1:3,500 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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Appendix E

Bellambi Gully Flood Study

Wollongong Coal Limited

Bellambi Gully Flood Study

NA82014089 – Ver 06

Prepared for
Wollongong Coal Limited

January 2015

WOLLONGONG COAL

Cardno®
Shaping the Future

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Document Control

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4	27 August 2014	Revised Final	SBR		OdJ	
5	25 November 2014	Revised Final	SBR		OdJ	
6	9 January 2015	Revised Final	SBR		OdJ	

Version	Reason for Issue	Approved for Release By	Approved (Signature)	Approved Release Date
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2	For Issue	OdJ		27/6/2014
3	For Council	OdJ		2/7/2014
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5	Revision	OdJ		25/11/2014
6	Revision	OdJ		9/1/2015

Table of Contents

Appendices

1 Introduction

1.1 Background

Wollongong Coal Limited (WCL) has engaged Cardno (NSW/ACT) Pty Ltd to undertake a flood study for Bellambi Gully to determine the existing flood conditions at the Russell Vale Colliery site and recommend potential flood mitigation measures.

A hydrological assessment of the site was previously carried out in 2009 by BECA. The main outcome of the study suggests that stormwater conveyance through the site may be improved through diversion of flows from Bellambi Gully around coal stockpile areas. Maintenance measures were also recommended as methods to improve the conveyance of the existing channel and minimise the likelihood of failure.

This study aims to present alternative mitigation measures for WCL to undertake in order to reduce flooding impacts downstream of the site, particularly those associated with coal stockpile washouts as a result of flooding.

1.1.1 Site Description

The Russell Vale Colliery site is located within the Southern Coalfields Region of NSW. The site is approximately 8 km north of Wollongong and 70 km south of Sydney and lies within the local government areas (LGAs) of Wollongong and Wollondilly in the Illawarra region.

The Russell Vale Colliery site is located on the lower slopes and foothills of the Illawarra Escarpment. The vicinity surrounding the site to the north, south and east is mainly comprised of residential properties of Russell Vale, Bellambi and Corrimal respectively. The Russell Vale golf course is situated to the north of the site. The west and east of the site is directly bounded by the Woronora Plateau and Princes Highway respectively.

The site study area includes the Illawarra Escarpment and extends towards the Bellambi Creek approximately 250m west of the Princes Highway.

1.1.2 Bellambi Gully

The total Bellambi Gully catchment area is 427 ha and the total creek length is 4.3km. Runoff originating from the Illawarra Escarpment flows down the heavily vegetated steep slopes of the escarpment to the Russell Vale Colliery site at the foothills, where it enters the Bellambi Gully watercourse. Some reaches of the watercourse are conveyed by pipes and constructed channels within the site.

The main Bellambi Gully watercourse within the site connects to an 1800 mm diameter clean-water pipeline (approx. 660 m in length) before discharging into Bellambi Creek. Another 600 mm diameter pipe collects a fraction of the upstream stormwater runoff and also connects to the 1800 mm diameter clean-water pipeline. The site stormwater captured by the pipe bypasses the main stockpile area, and discharges to the licensed discharge point (LDP2) into Bellambi Creek approximately 250 m to the west of the Princes Highway.

Bellambi Creek flows underneath the Princes Highway via a 2.4 m W x 1.5 m H box culvert. Flows are conveyed via a number of culvert structures under roads and rail ultimately discharging at Bellambi Beach. The length of the creek from the colliery discharge point to the ocean outfall is approximately 3 km.

1.2 Scope of Work

The scope of work consists of the following:

> Review existing flood studies relevant to the catchment;

> Compile and review topographic survey and ALS information of the study area and develop a Digital Terrain Model (DTM);

> Identify sub-catchments and peak flows derived in previous flood studies (5, 10 and 100 year ARI from BECA 2009);

> Develop a 1D flood model (configure parameters, baseline conditions and incorporate existing culvert structures) and simulate to establish existing conditions;

> Identify key areas to be addressed based on flood modelling results;

> Identify opportunities for flood mitigation such as vegetation management, channel / culvert upgrades etc. with consideration of site constraints; and

> Incorporate alternative flood mitigation measures and quantify improvements to flooding/ conveyance.

2 Available Data

2.1 Previous Studies

2.1.1 Combined Catchments of Whartons, Collins and Farrahars Creeks, Bellambi Gully and Bellambi Lake Flood Study (Lyall & Associates Consulting Water Engineers, 2011)

The flood study combines the Whartons, Collins and Farrahars Creeks catchment area along with the Bellambi Gully and Bellambi Lake catchments. The flood study is referred to as the Combined FS in this report.

The study was undertaken to assess and define the flood behaviour within the study area under current conditions. The information obtained from the assessment forms the basis of the Floodplain Risk Management Plan for the study area.

The flood behaviour was assessed using hydrological and hydraulic computer modelling. Sensitivity analyses were also carried out to verify the parameters adopted and assumptions made in the development of the hydraulic model. The flood information obtained from the analysis was presented in terms of flows, levels and velocities ranges between the 5 to 500 year Average Recurrence Interval (ARI) storm events including the Probable Maximum Flood (PMF).

2.1.2 Water Management Report No.1 Colliery Russell Vale (BECA, 2010)

A Water Management Report for the operation of Wollongong Coal Limited (previously known as Gujarat NRE), No.1 Colliery at Russell Vale was prepared by BECA in 2010. The information presented in the report includes the current and future water management at the Russell Vale and Shaft No. 4 sites, water balance for the Russell Vale site, the collection and treatment of mine water and dirty storm water, the quantity and quality of water discharged to Bellambi Gully as well as the impacts in terms of water quality discharged to Bellambi Gully.

The report recommends further investigation of water treatment and reuse on site, including the management of solids from the water treatment plant site and also recommends improving the stormwater conveyance across the site to reduce the risk of failure to the current system.

2.1.3 Gujarat NRE Stormwater Hydrology Review (BECA, 2009)

A hydrological investigation of the clean stormwater system at the Russell Vale mine site was undertaken by BECA. The stormwater system on site was deemed inadequate following the 1998 flood event which resulted in large quantities of runoff diverting through the existing coal stockpile originating from the steep escarpment slopes.

The objective of the assessment was to review the existing stormwater system, identify inefficiencies in the system and propose measures and potential upgrades to the current system to reduce the likelihood of future failures.

The proposed measures include the maintenance and upgrade of existing diversion channels and flowpaths, the construction of open channels and diversion drains around the proposed stockpile area, and the maintenance and implementation of scour protection devices in areas susceptible to erosion. Some of the recommended measures suggested have since been undertaken on site.

The hydrological investigation report produced from this assessment was included in the appendix of the Water Management Report (BECA, 2010).

2.2 Survey

2.2.1 Detailed Site Survey

A detailed site survey was undertaken in 2010 by Wollongong Coal Limited (WCL) and provided in **Appendix A**. The survey includes the escarpment to the west and extends towards Princes Highway to the east of the WCL Russell Vale Colliery site.

2.2.2 Aerial Laser Survey (ALS) Data

The ALS data tile W3066194 collected by AAM between May 2005 and October 2006 was used to define catchment boundaries and to represent the existing surface beyond the extent of the detailed site survey.

An updated laser survey of the site, collected in May 2014 was used to better define the current site topography specifically through the stockpile area. This survey was used to model the existing site conditions in the hydraulic analysis.

3 Hydrological Data

3.1 Sub-Catchment Topology

Sub-catchments delineated from the previous study by BECA (2009) were based on the proposed scenario catchments (**Appendix A**). As such, peak flows derived from the previous study were re-assessed and delineated based on the detailed site survey and ALS data to represent the existing conditions on site. Stormwater runoff from the north western sub-catchments discharges towards the north while the remaining sub-catchments discharge towards the stormwater systems. The stormwater systems are separated into the dirty water (DW) and clean water (CW) systems.

The two stormwater systems are as follows:

1. DW – runoff primarily from the stockpile area and along the conveyor portal are directed to the dirty water stormwater system to be treated before discharging into Bellambi Creek.

2. CW – runoff through the southern extent of the site flows through the natural Bellambi Gully watercourse before connecting to the 1800 mm diameter main stormwater pipeline. Runoff generated through the centre and along the northern access road falls towards the stockpile area where it enters a 600 mm diameter pipe. The pipe then connects to the 1800mm diameter main stormwater pipeline. The main stormwater pipeline is 660 m long and conveys the upstream runoff towards the Bellambi Creek licensed discharge point (LDP2), approximately 250 m upstream of Princes Highway.

3.2 Design Storms

Peak flows presented in the BECA report were used as a basis for this assessment (review of these flows is beyond the scope of this assessment). Peak flows of the upstream catchments entering the multiple discharge points downstream were determined, and are presented in **Table 3-1**.

Table 3-1 Peak Flows

Catchments (BECA)	Area (ha)	Discharge Location	Adopted Peak Flows (m^3/s)		
			5 year ARI	10 year ARI	100 year ARI
U1	10.69	CW	2.83	3.58	6.39
U2	9.76	CW	2.5	3.13	5.66
U3	8.63	North	2.21	2.77	5
U4	0.5	North	0.226	0.274	0.459
U5	0.4	North	0.189	0.237	0.367
M1	6.12	DW & CW	1.89	2.28	3.92
M2	1.28	North	0.528	0.625	0.995
M3	3.31	CW	0.734	0.923	1.73
M4	0.43	CW	0.149	0.181	0.3
M5	3.34	CW	0.874	1.1	1.98
M6	1.36	CW	0.368	0.47	0.818
M7	1.73	DW	0.654	0.778	1.29
M8	1.78	CW	0.473	0.615	1.09
L1	4.84	CW	0.738	0.951	1.94
L2	12.07	DW	2.84	3.52	6.51

4 Hydraulic Analysis

4.1 Selection of Hydraulic Model

4.1.1 Model Parameters

A HECRAS 1D steady-state hydraulic model was developed for the site, using ALS data and detailed site survey. Runoff generated from the site is conveyed beneath the stockpile area before discharging into Bellambi Creek. As such, the upstream model boundary was established within the stockpile area and extends towards the Bellambi Creek discharge. A plan view of the model is presented in **Appendix B**.

The Manning's n roughness values along the channel were adopted from the Combined FS report (Lyall & Associates, 2011) and are presented in **Table 4-1.**

Table 4-1 Manning's 'n' Roughness Values

Surface Type (Combine FS)	Surface Type (Cardno)	Manning's 'n' Value
Asphalt, river bed or pillowcrete	Roads, stockpile area, creek bed	0.02
Grass or lawns	Grassed areas	0.045
Dense vegetation	Dense vegetated areas	0.135

Building structures within the modelling extents were represented as obstructions. Tailwater levels were adopted from the Collins Creek Flood Study (Lyall & Associates, 2011) and taken immediately downstream of the discharge location within Bellambi Creek. Tailwater levels for the modelled storm events are presented in **Table 4-2**.

Table 4-2 Downstream Tailwater Levels (Bellambi Creek Discharge)

Storm Event	Tailwater Levels
5 year ARI	30 m AHD
10 year ARI	30 m AHD
100 year ARI	30 m AHD

4.1.2 Modelling Approach

Three main pipes located within the stockpile area were identified to receive the DW and CW flows from the upslope catchments. **Table 4-3** presents the pipe capacities, the total flows and the corresponding contributing catchments for the DW and CW pipes in the 5, 10 and 100 year ARI storm events.

The full capacities for the pipes (no blockage assumed) were determined using the Manning's Equation. Flows in excess of the pipe's capacity were modelled as overland flows at the pipe inlets in the 1d hydraulic model.

The 450 mm DW pipe underneath the stockpile area was formerly designed to receive the first flush flow from catchment M1 as well as stormwater flows from catchments L1 and L2. However, based on the information presented in the report by BECA (2009), the maximum flow rate of the DW first flush pipe in catchment M1 is 0.02 m^3/s, which is lower than the 5 year ARI catchment flows. Hence, it was assumed that all the designed flows from M1 bypasses the first flush system and are completely captured by the CW system.

The report also states that flows from catchment M7 should be considered "dirty". Based on the topographical data, it has been confirmed that flows from M7 are currently directed to the 450 mm DW pipe.

Flows from catchments M5, M6 and M8 as well as flows within the north extent of catchments M1 and M3 are directed towards the 600mm CW pipe. The main 1800 mm CW pipe receives flows from the 600 mm CW pipe as well as catchments M4, U1, U2 and the remaining flows within the south extents of catchments M1 and M3.

Table 4-3 Steady State Flows

Pipe Type	Contributing Catchments	Pipe Capacity (m^3/s)	Peak Flow Rate (m^3/s)		
			5 year ARI	10 year ARI	100 year ARI
450 mm DW	M7, L1 and L2.	0.817	4.23	5.25	9.74
600 mm CW	North of M1 and M3. M5, M6 and M8.	1.63	3.03	3.79	6.71
1800 mm CW	M1, M3, M4, M5, M6, M8, U1 and U2.	24.9	9.82	12.28	21.89

Based on the values presented in **Table 4-3**, it can be seen that the 450 mm DW and 600 mm CW pipes do not have sufficient capacity to convey flows exceeding and including the 5 year ARI event. Runoff is generated from the excess flows, causing coal stockpile washout in all modelled scenarios (see **Section 4.1.3** for details of scenarios).

However, the 1800 mm CW pipe has adequate capacity to receive the upstream catchment flows including flows from the 600 mm CW pipe.

4.1.3 <u>Model Scenarios</u>

The model was established based on the three scenarios presented in **Table 4-4**.

Table 4-4 Model Scenarios

Scenario	Details
1	This model is based on the event where the stormwater systems are completely blocked, i.e. catchment flows are entirely conveyed as overland flows.
2	A conservative model is established as the second scenario where a 20% blockage was applied to the receiving stormwater pipes (i.e. CW and DW systems within the stockpile area). Flows exceeding the capacity of the pipes were modelled as overland flows.
3	The third modelled scenario is based on the event where the stormwater systems are fully functional i.e. CW and DW pipes are flowing full. Flows exceeding the capacity of the pipes were modelled as overland flows.

4.2 Modelling Results

Results generated indicate that flooding within the site is significant, and is mainly contained within the stockpile area in all modelled scenarios. Flooding within the site remains significant in the third modelled scenario (i.e. unblocked) although the majority of flows are captured within the stormwater pipes.

Runoff from the stockpile area overtops the access road near the settling ponds and continues as sheet flow downstream towards Bellambi Lane in all modelled scenarios. Overtopping flows conveyed along Bellambi Lane have the potential to convey coal stockpile washouts downstream. Flood modelling results are included in **Appendix B** while the flood extents maps for the modelled scenarios are presented in **Appendix C**.p

5 Flood Mitigation

5.1 Proposed Flood Mitigation Measures

Based on the flood assessment results and information gathered from the site inspection, flooding caused by site runoff can be alleviated by optimising the existing structures in addition to implementing upgrades on site.

The key flooding issues identified and the corresponding proposed mitigation measures are presented as follows. The locations of the proposed mitigations are presented in **Appendix D** (refer numbers 1-5).

1. **Raise stockpile area access road, install new culvert and formalize open channel**

   The location where the overflow occurs should be upgraded to prevent coal washout downstream. Flooding can be contained within the site by raising the stockpile area access road and installing a culvert. The access road should be constructed with a low point (sag) to allow for overtopping of flows in excess of the culvert capacity. The culvert would connect to the proposed grass-lined swale on the east side of the stockpile area access road before discharging into Bellambi Creek.

2. **Debris control structures at the 1800mm pipe inlet and the M3 Culvert**

   The probability of blockage of the 1800 mm pipe, and the M3 culvert (near the conveyor) can be reduced by implementing a Debris Control Structure (DCS) at the respective inlets. Additionally, rehabilitation and opening up of the M3 culvert will further reduce the probability of blockage of the M3 culvert. This would increase the efficiency of the stormwater systems and reduce occurrence of overflows from the natural Bellambi Gully watercourse into the stockpile area.

   The efficiency of the DCS's can be improved by inclusion of a Debris Control Management Procedure (DCMP) in the existing Surface Water Management Plan. The DCMP would include measures to ensure the DCS is maintained regularly with additional maintenance both before predicted storms and after storm events.

3. **Formalisation of the 600 mm clean stormwater**

   The existing 600 mm clean stormwater pipe has a capacity of 1.6 m^3/s (6% slope), which is not sufficient to convey the 100 year ARI catchment runoff (6.7 m^3/s). However, the operation of the pipe inlet can be improved by formalising the swale in the vicinity of the inlet. The swale functions to capture the clean water (CW) flows from the upslope catchments (M5, M6, M8 and north of M1 and M3) and convey it towards the CW pipeline system. Formalisation of the swale will provide sufficient capacity to capture the CW flows and ensure CW does not overtop into the stockpile area.

   A Manning's calculation confirms that upgrading to an 825 mm diameter pipe would convey flows up to the 100 year ARI storm, between the pipe inlet and the 1800 mm pipe. This can be considered as an additional measure, and would likely present challenges in implementation due to the coal stockpiles and existing structures.

4. **Maintenance to existing structures**

   It was observed in the site inspection that the existing debris control screens (trash racks) were fully blocked with rocks and boulders conveyed from the upstream creek banks.

   Appropriate maintenance should be carried out immediately upstream and downstream of the existing debris control structures within the Bellambi Gully to avoid any blockage of the system. Blockage of these upstream culverts tends to lead to uncontrolled surface flows into the stockpile area.

5. **Upgrade through roads**

   To decrease the amount of clean stormwater runoff entering the stockpile area, culverts may be installed across the access road along the northern boundary of the site to direct flows from the catchment M8 directly towards Bellambi Creek.

   This option is considered as an alternative and can decrease runoff conveyed towards the existing 600 mm CW pipe, which has a limited capacity (as discussed in Option 3).

5.2 Discussion

It was proposed in the Stormwater Hydrology Review report (BECA, 2009) that the clean water system be diverted around the stockpile area through a proposed diversion channel. Implementation would require that diversion drains, land grading, bunds and road crests be constructed within the steep batters and access roads within the upstream catchments to ensure that all clean water flows be directed towards the proposed diversion channel. Reno mattresses and drop structures using gabion basket within catchments M1, M3, M5 and M6 were also proposed to improve the efficiency of the stormwater conveyance through the site. Implementation of the proposed measures would require annual inspections and ongoing maintenance to the existing and proposed structures. Geotechnical assessment would be required to determine the stability of the proposed channel realignment area prior to any detailed design works. Given the significant capital and maintenance costs associated with this approach, the potential for alternative approaches have been explored in this report.

Based on the assessments undertaken, it was demonstrated that the existing stormwater system is adequate for managing flows on site (except the capacity of the 600 mm CW pipe); on the condition that maintenance is undertaken regularly. The alternative measures explored in this report were focused on providing more effective structures through optimising the existing stormwater systems on site. Flood modelling was undertaken to confirm the validity of the alternative measures proposed and are discussed in **Section 5.3**. Factors to be considered when implementing the measures are discussed in the following sections.

5.2.1 <u>Blockage</u>

Mitigation Option 2 proposes the design and construction of debris control structures at the M3 culvert (near the conveyor) and the 1800 mm diameter culvert. According to Council's blockage policy, both culverts should be considered blocked for the 100 year ARI flood event. The implication of assuming these culverts as blocked is that clean water would be diverted from the existing watercourse, down the conveyor portal and through the coal stockpile before being discharged into Bellambi Creek (see **Table 4-3** for culvert capacity and 100 year ARI flows from contributing catchments). However, if the inlets are rehabilitated and an additional DCS constructed and maintained as part of a DCMP, it is considered likely that the culverts will remain relatively free of debris. As such, clean-water flows would avoid the coal stockpile area, reducing the potential for pollution of the downstream watercourse.

5.2.2 <u>Water Quality</u>

Water quality requirements are beyond the scope of this report. Notwithstanding, given the importance of runoff water quality leaving the site (and that water quality issues are somewhat connected to flooding issues in this case), this section has been compiled to provide a preliminary discussion of the potential water quality implications resulting from the proposed flood mitigation methodology.

A 6ML dry sediment basin near the proximity of the stockpile access road as proposed in Appendix C (Stormwater Hydrology Review) of the Water Management Report (BECA, 2010) is currently being assessed by Wollongong Coal Limited. The Stormwater Hydrology Review (BECA, 2009) advises that all existing and proposed dirty water from the site up to the 10 year ARI event should be directed into the dry sediment basin for treatment before discharging through the licensed discharge point (LDPs) at Bellambi Creek.

It is noted that some site discharge will still flow through the coal stockpiles even in the 20% blockage scenario. Based on the previous submission, the sizing and assessment of this basin has been based on hydrographs for the entire stockpile area and the requirement to contain all storms up to and including a 10 year ARI event. However, further investigations will be required to confirm that the basin size will be adequate to treat excess flows not captured by the 20% blocked dirty and clean stormwater pipes within the stockpile area.

5.2.3 Earthworks

The embankment upstream of the proposed culvert should be excavated to allow unrestricted conveyance towards the structure. Additionally, the embankment downstream of the culvert will have to be excavated for the construction of the swale. Further modelling and surface design should be undertaken in subsequent design phases. We also recommend detailed survey of the current site be undertaken prior to any design works.

5.3 Hydraulic Modelling of the Proposed Scenario

Flood modelling was undertaken to confirm the validity of the alternative measures proposed. The proposed culvert and grass lined swale discussed for mitigation Option 1 (refer **Section 5.1**) was modelled using a HEC-RAS steady state hydraulic model, incorporating 100 year ARI flows provided in the BECA Stormwater Hydrology Review report (BECA, 2009).

Existing structures were modelled as per Council's DCP (2009). 25% blockage was applied to the proposed 6m span Reinforced Concrete Box Culvert (RCBC), while 100% blockage was applied to all culverts upstream. The proposed culvert would consist of (1x) 6000W x 1200H RCBC. The proposed access road slopes 3% towards the proposed low point, which is approximately 16 m west of Bellambi Lane. The proposed swale has been adequately sized to convey the 100 year ARI flow towards Bellambi Creek in the event where the upstream structures are fully blocked.

5.3.1 Modelling Results

Results indicate that the 100 year ARI flows overtop the culvert and flow across the access road at the low point before discharging into the proposed swale downstream. This demonstrates that the proposed upgrades are effective in eliminating flooding on Bellambi Lane. However, it should be noted that although the model represents the worst case scenario for the site (i.e. assuming existing structures upstream are fully blocked), the suggested measures to maintain and upgrade the existing structures should nonetheless be carried out for optimum operations of the stormwater system.

The flood extents map is presented in **Appendix F** and a typical cross section detail of the proposed RCBC and swale is presented in **Appendix G**.

6 Conclusions

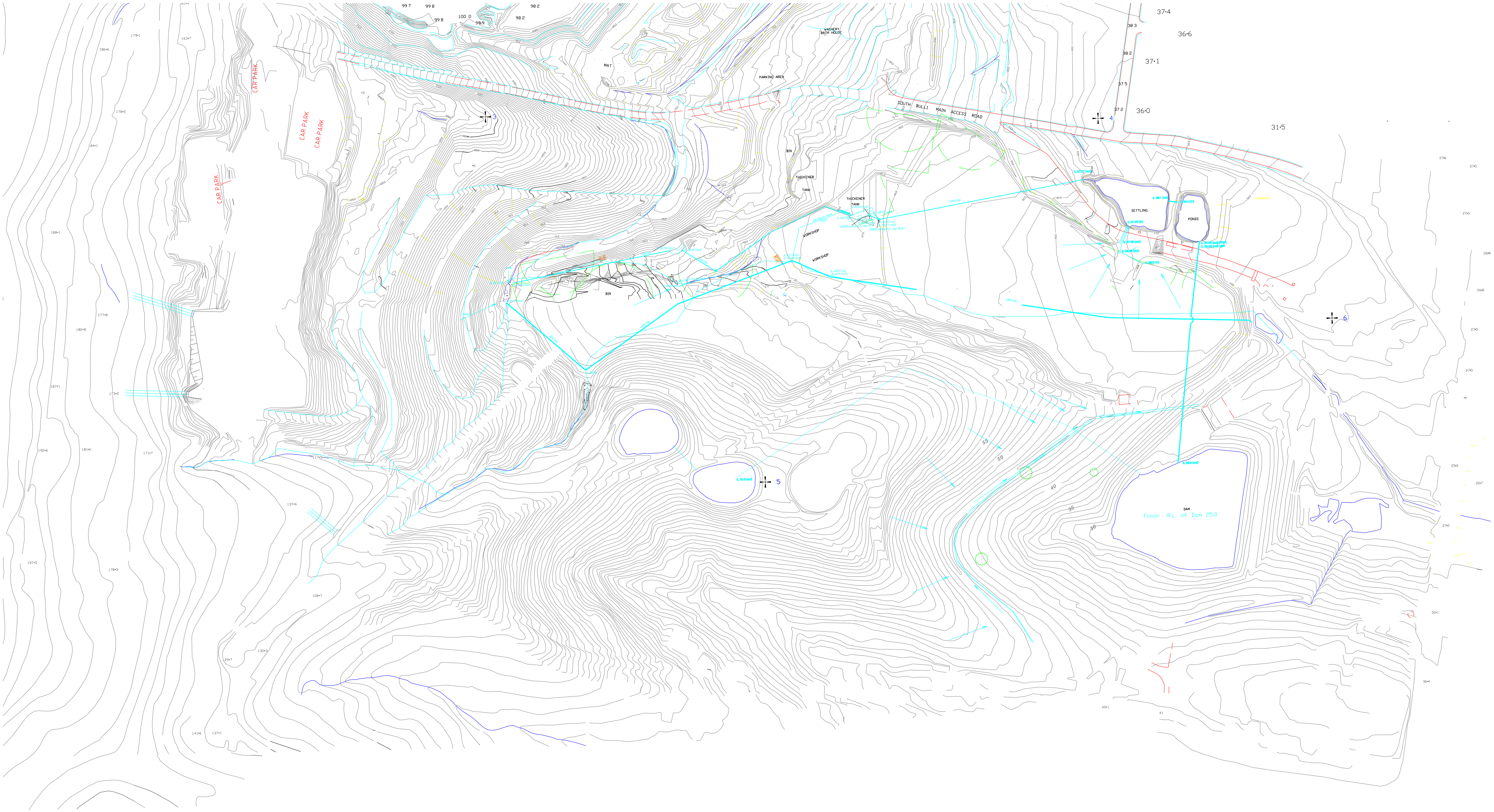
The following can be concluded from the Bellambi Gully flood assessment:

1. Runoff generated within the site is currently conveyed under the stockpile area before discharging into Bellambi Creek.
2. Three scenarios were modelled to assess flooding throughout the site. The models represent events where the stormwater pipes are completely blocked, 20% blocked and fully operational.
3. Results indicate that flooding within the site is significant in all modelled scenarios; however overland flows are mainly contained within the stockpile area in all modelled storm events.
4. Modelling results indicate that overland flows currently overtop the access road and continue as sheet flow downstream towards Bellambi Lane in all modelled scenarios.
5. The proposed mitigation measures are aimed to reduce clean runoff entering the stockpile area, while conveying all site runoff in a controlled way to Bellambi Creek.
6. Mitigation measures suggested for the site are as follows:
    - Upgrading the stockpile area access road and installing a 6m span culvert to convey the site runoff across the access road, into a proposed grass-lined swale before discharging into Bellambi Creek.
    - Implementing a debris control structure at the 1800 mm diameter pipe and M3 culvert opening to reduce probability of blockage within the system due to debris from upstream catchment.
    - Formalising the swale in the vicinity of the existing 600 mm clean water inlet. This would provide increased temporary storage for stormwater which helps to manage peak flows from the upstream catchment and to ensure all the clean water runoff is captured before entering the stockpile area.
    - Upgrading the existing 600 mm diameter clean water pipe to an 825 mm diameter pipe should be considered although the other proposed mitigation measures does not rely on this upgrade (and was not modelled in the proposed scenario model).
    - Appropriate maintenance should be carried out immediately upstream and downstream of the existing debris control structures within the Bellambi Gully to minimise the potential for blockage of the system.
    - Culverts may be installed across the access road along the northern boundary of the site to direct flows from catchment M8 directly towards Bellambi Creek, in order to reduce clean water runoff conveyed into the stockpile area.
7. Flood mitigation measures presented in this report may provide an alternative to the measures presented in the Stormwater Hydrology Review (BECA, 2009), with the exception of water quality measures (e.g. sediment basin) which have not been considered in this report.
8. Further investigations should be undertaken to confirm that the dry sediment basin proposed in the Stormwater Hydrology Review (BECA, 2009) will be adequate to treat excess flows not captured by the 20% blocked dirty and clean stormwater pipes within the stockpile area before discharging into Bellambi Creek (design of treatment measures to achieve this is beyond the scope of this report).
9. 25% blockage was applied to the proposed 6 m RCBC, while 100% blockage was applied to all culverts upstream as per Council's blockage policy in the DCP (2009). The results demonstrate that the proposed road upgrade, 6m culvert and swale are adequate to convey the 100 year ARI flows.
10. Although the solution has been designed for a worst case scenario where existing structures upstream are fully blocked, the suggested measures should nonetheless be carried out to maintain and upgrade the existing structures for optimum operations on site.

11. Designs presented in this report are preliminary only. Detailed survey of the current site is required prior to any subsequent design works.

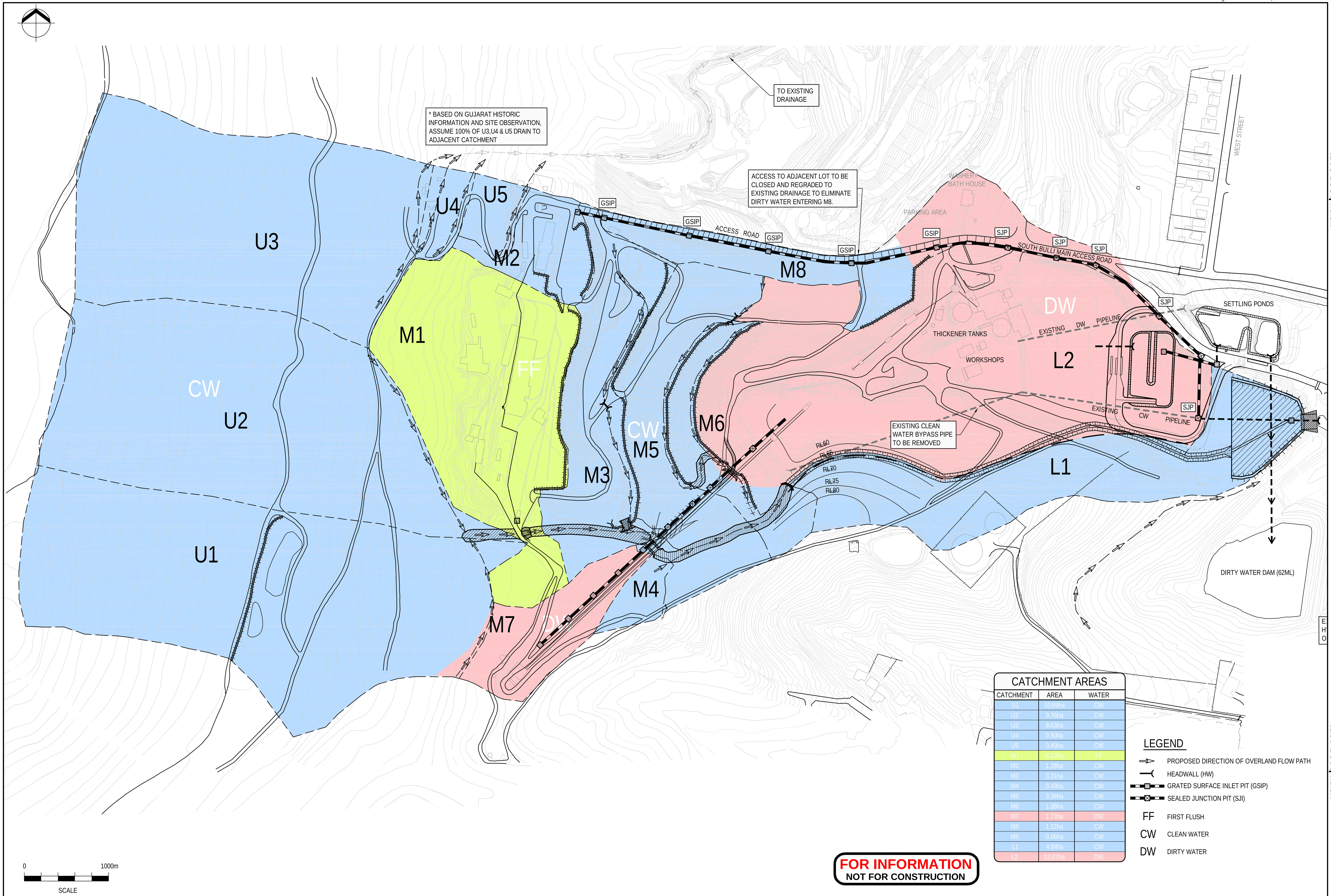
APPENDIX A
AVAILABLE INFORMATION

Site Survey



CAR PARK
CAR PARK
CAR PARK
CAR PARK
PARKING AREA
WASHERY BATH HOUSE
SOUTH BULLI MAIN ACCESS ROAD
THICKENER TANK
THICKENER TANK
WORKSHOP
WORKSHOP
BIN
BIN
SETTLING
PONDS
DAM
Floor R.L. of Dam 25.0

Drawing Plotted: 04 May 2010 13:51



CATCHMENT AREAS

CATCHMENT	AREA	WATER
U1	10.69ha	CW
U2	9.76ha	CW
U3	8.63ha	CW
U4	0.50ha	CW
U5	0.40ha	CW
M1	6.12ha	FF
M2	1.28ha	CW
M3	3.31ha	CW
M4	0.43ha	CW
M5	3.34ha	CW
M6	1.36ha	CW
M7	1.73ha	DW
M8	1.12ha	CW
M9	0.66ha	CW
L1	4.84ha	CW
L2	12.07ha	DW

LEGEND

- PROPOSED DIRECTION OF OVERLAND FLOW PATH
- HEADWALL (HW)
- GRATED SURFACE INLET PIT (GSIP)
- SEALED JUNCTION PIT (SJI)
- FF FIRST FLUSH
- CW CLEAN WATER
- DW DIRTY WATER

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NOT FOR CONSTRUCTION

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No.	Revision	By	Chk	Appd	Date
B	CONCEPT DESIGN - NOT FOR CONSTRUCTION	AS	SM		8/10/09
A	CONCEPT DESIGN - ISSUED FOR REVIEW	SK	SM		23/7/09

Drawing Originator: Beca

Original Scale (A1) 1:2000
Reduced Scale (A3) 1:4000

Design	PI	23/7/09	Approved For Construction*
Drawn	SK	23/7/09	
Dsg Verifier	SM	29/9/09	
Dwg Check			Date

* Refer to Revision 1 for Original Signature

Client: GUJARAT NRE

Project: GUJARAT No. 1 HYDROLOGICAL INVESTIGATION

Title: SITE LAYOUT CLEAN/DIRTY WATER REGIONS

Discipline: CIVIL

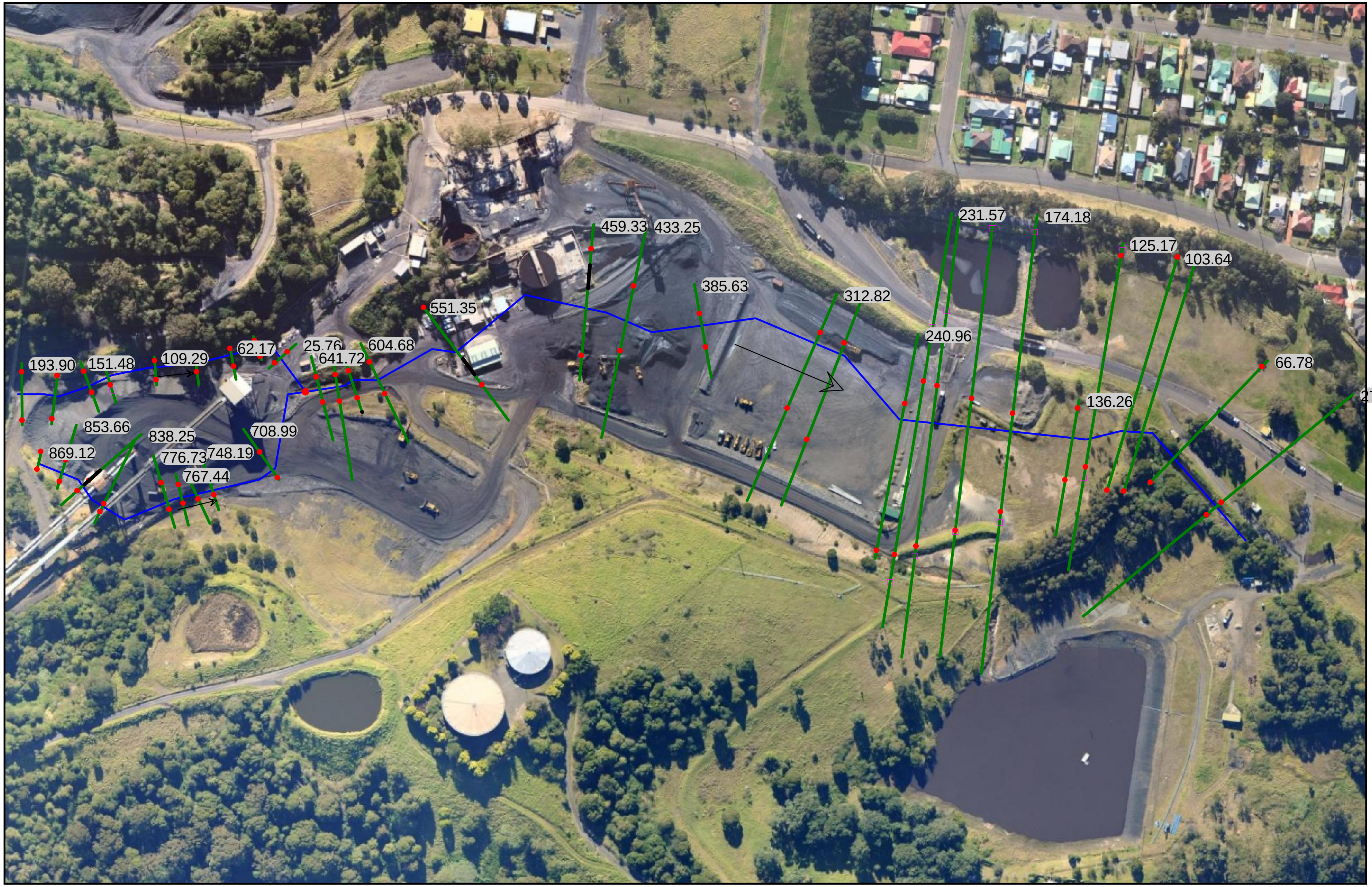
Drawing No. 2591308-C-SK7 Rev. B

Document No. 2591308-C-SK7.dwg

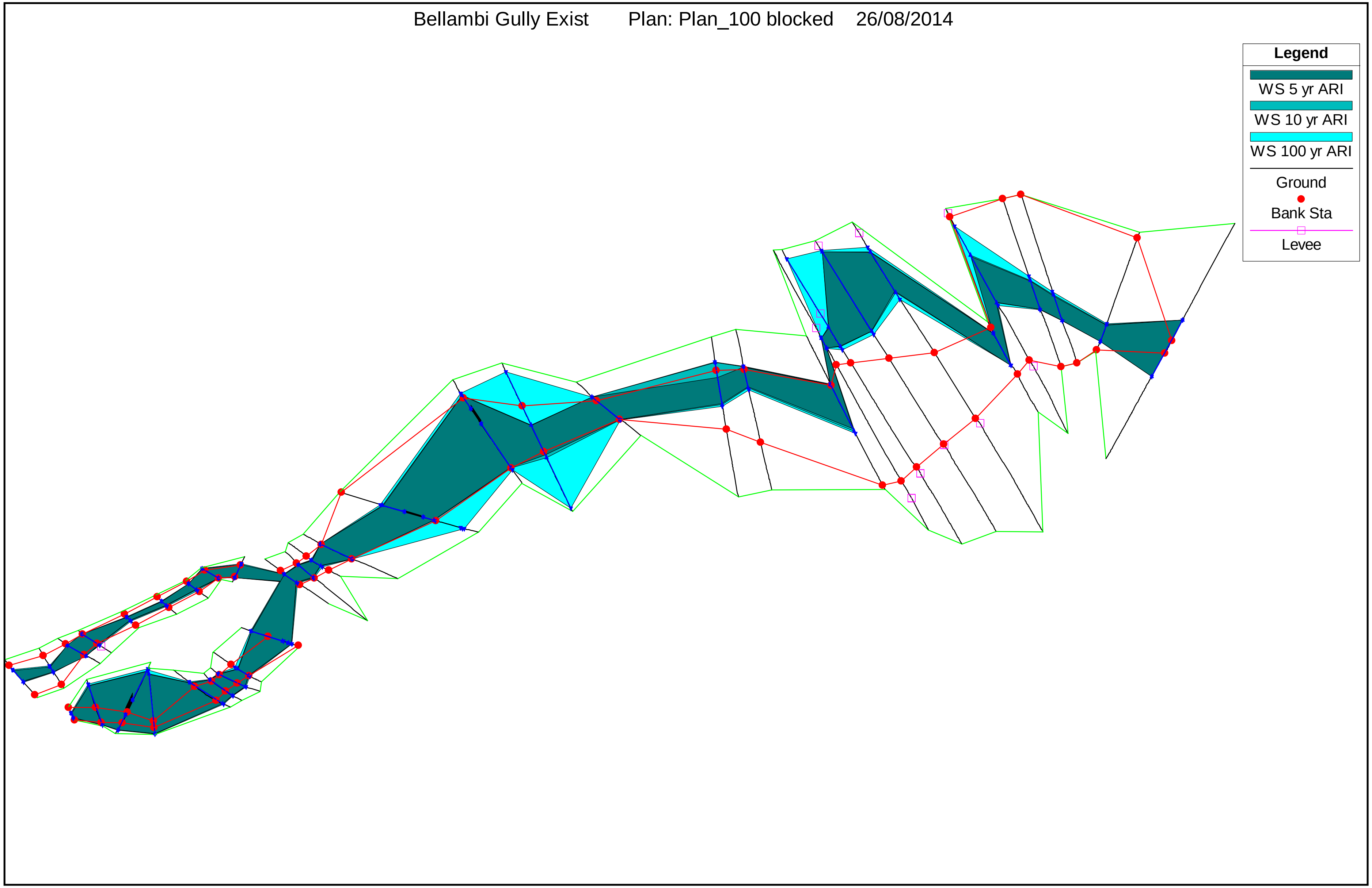
DO NOT SCALE IF IN DOUBT ASK.

APPENDIX B
EXISTING HYDRAULIC FLOOD MODEL

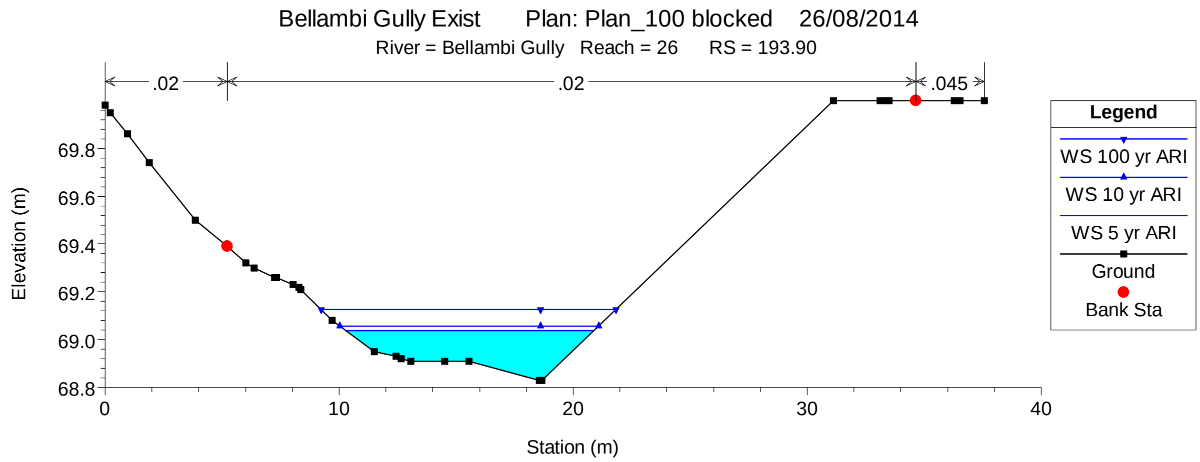
HECRAS Model View

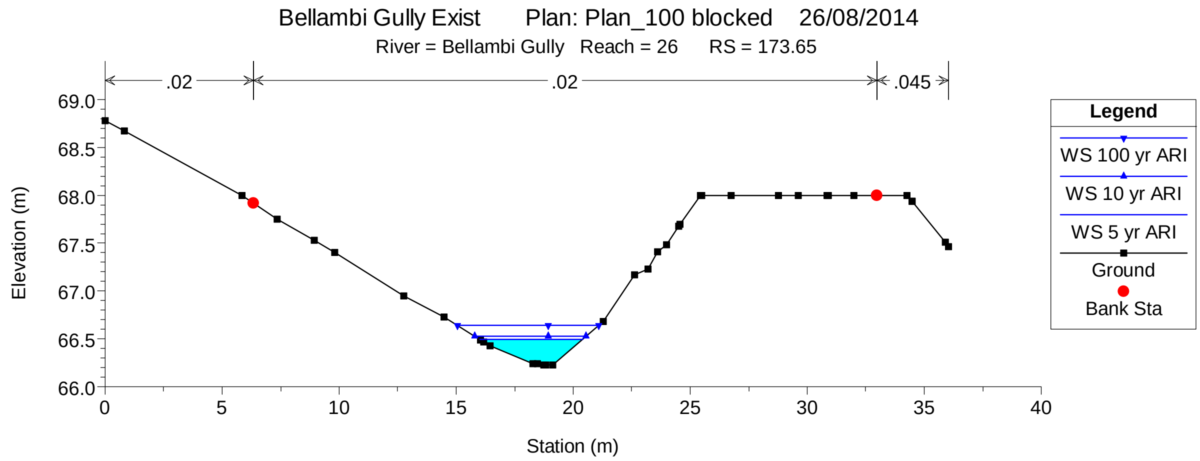


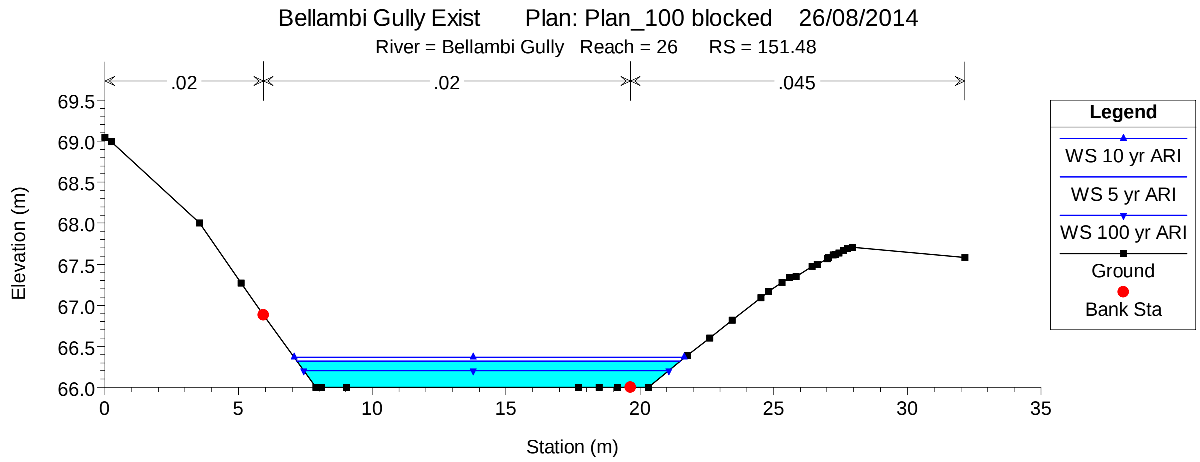
Plan View Scenario 1

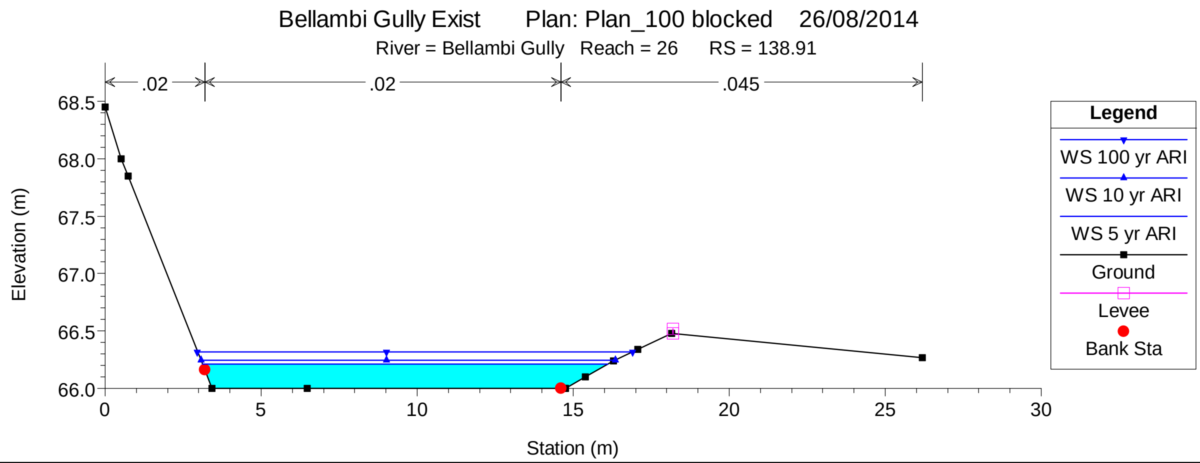


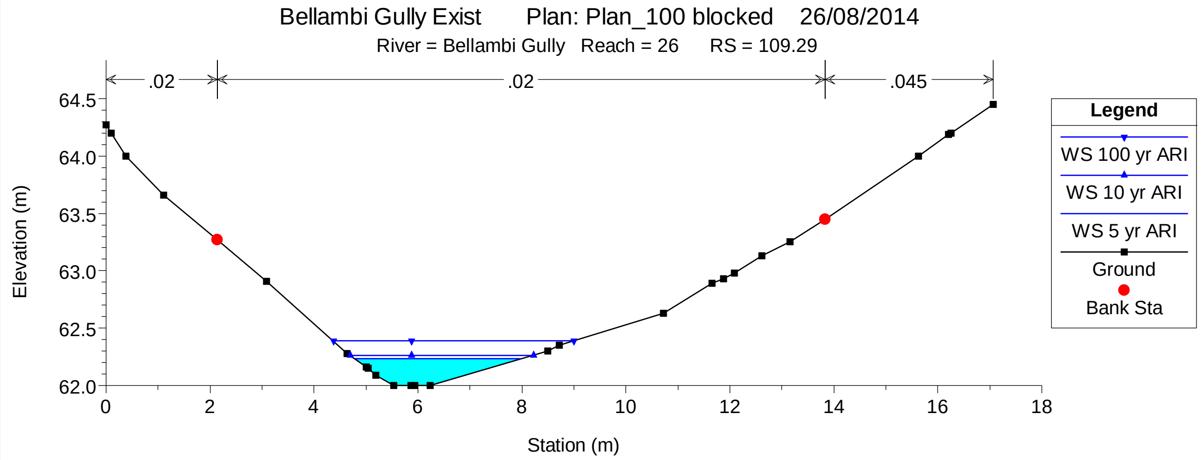
Cross Sections







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.02
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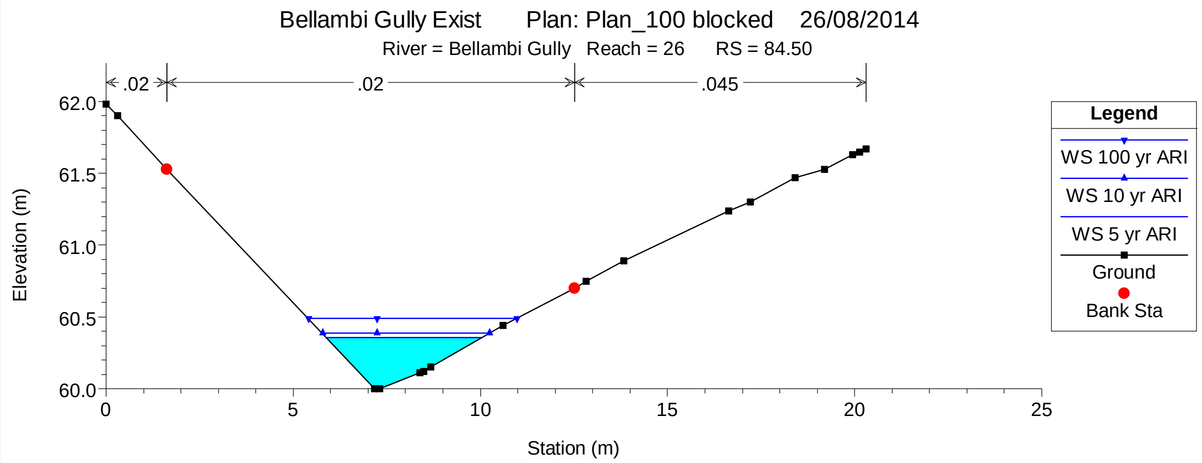
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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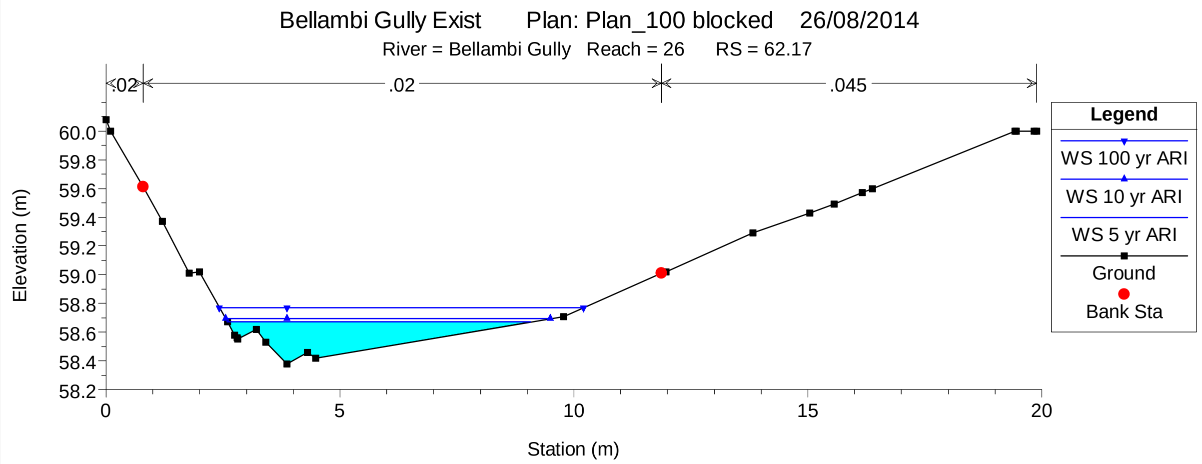
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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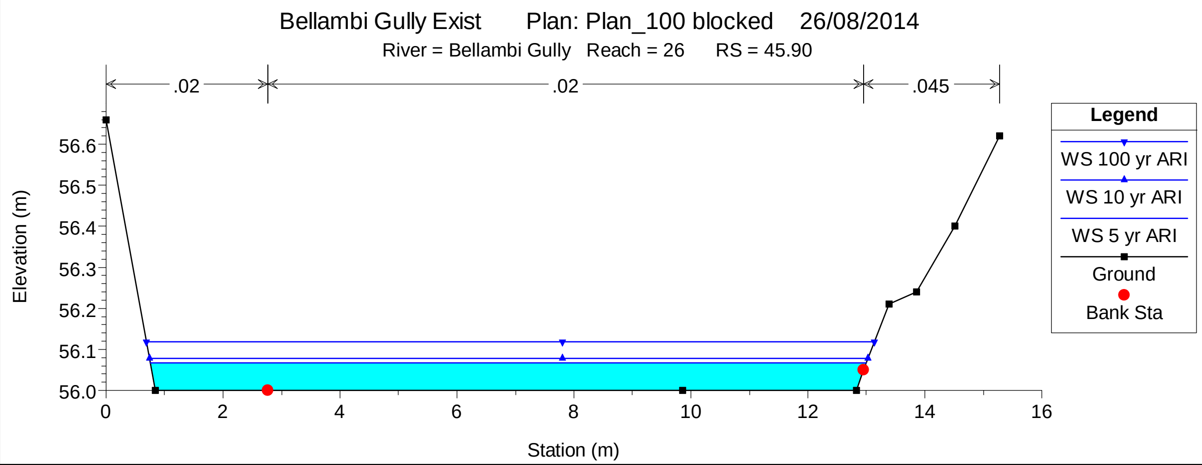
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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Station (m)
Legend
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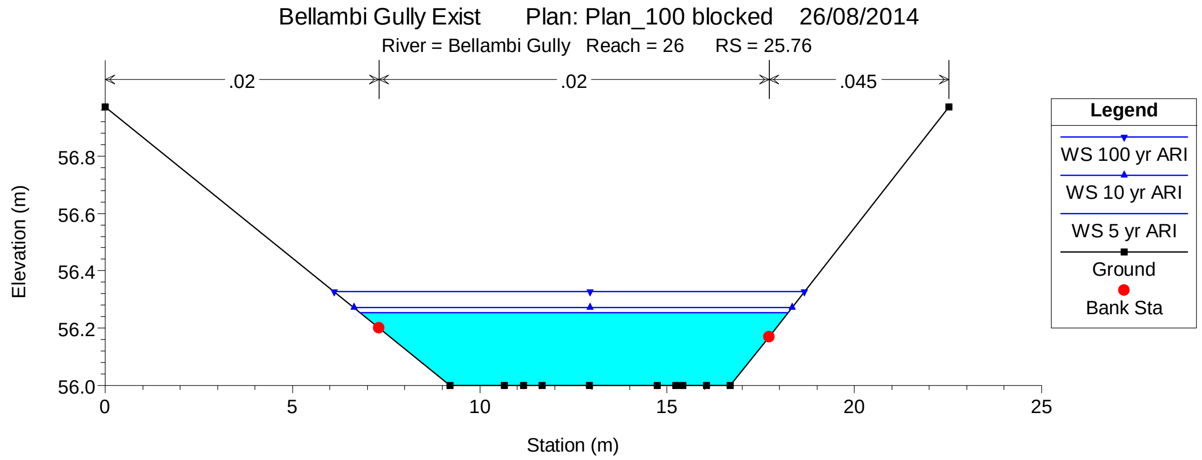
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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Station (m)
Legend
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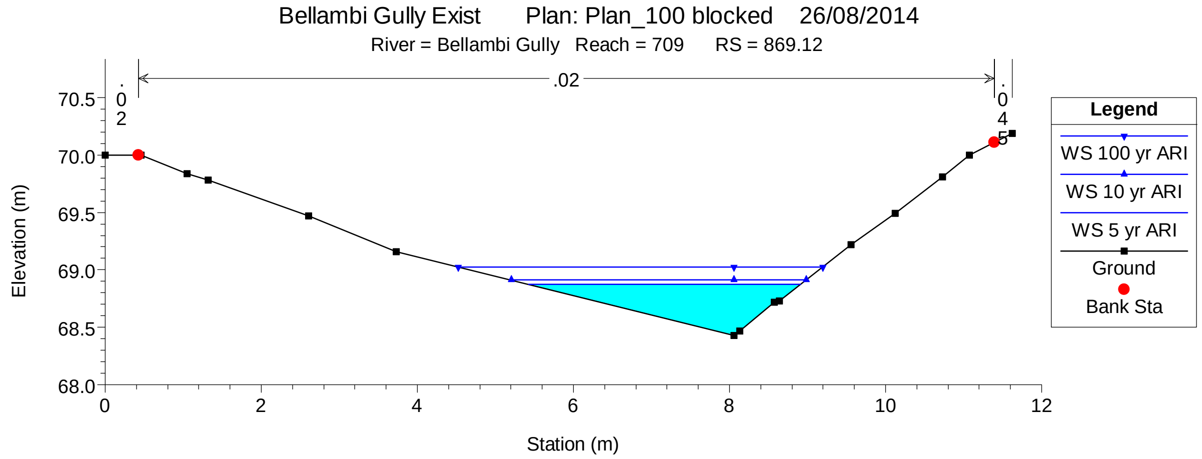
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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Station (m)
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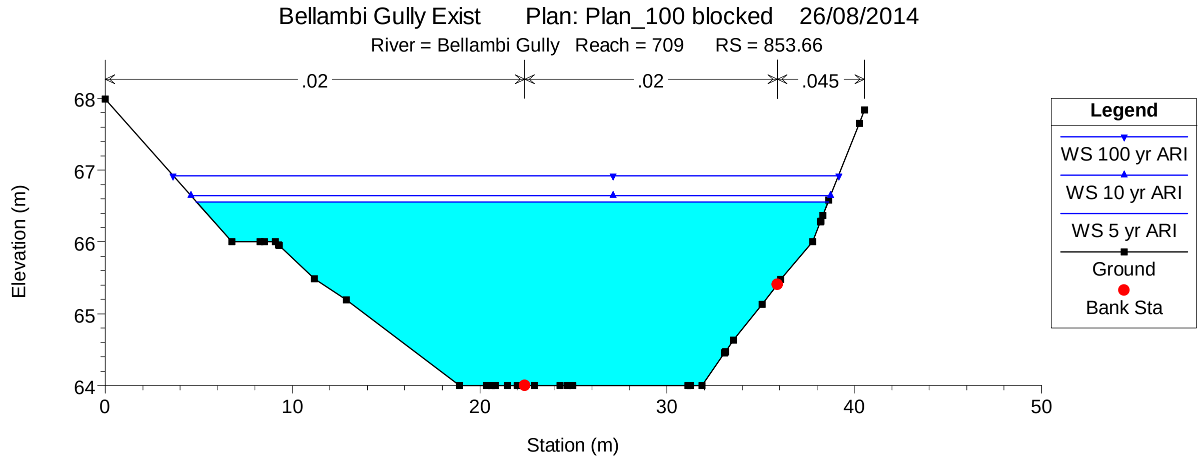
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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Station (m)
Legend
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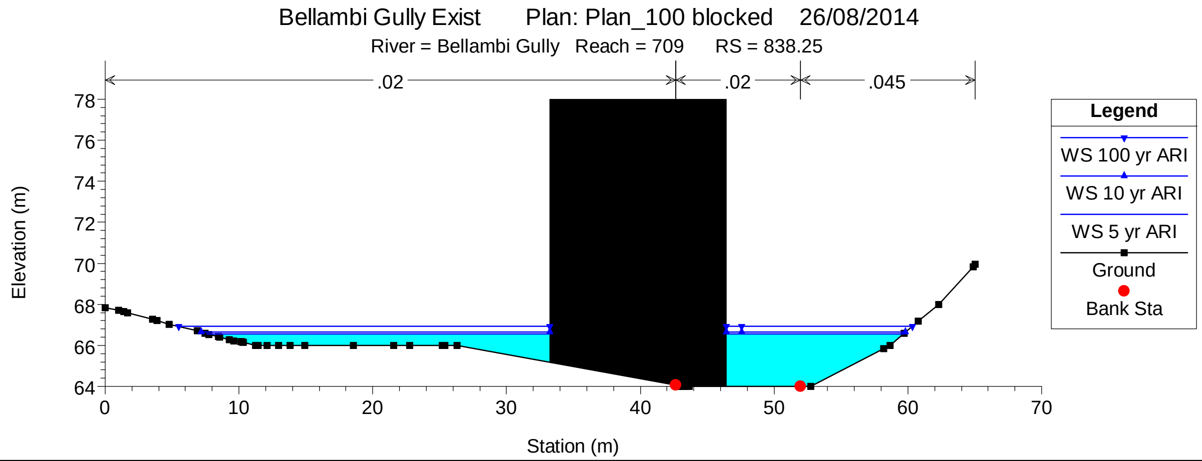
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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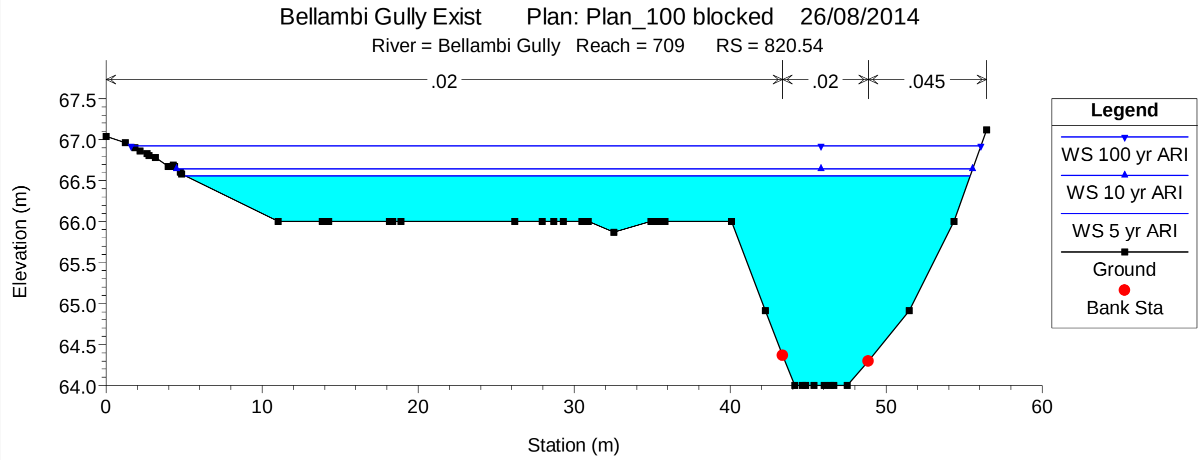
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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Station (m)
Legend
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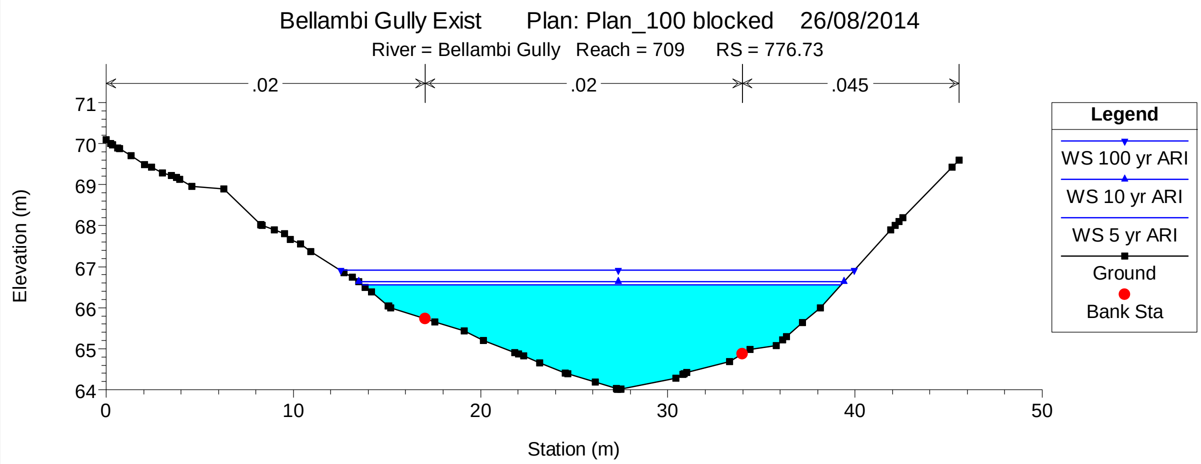
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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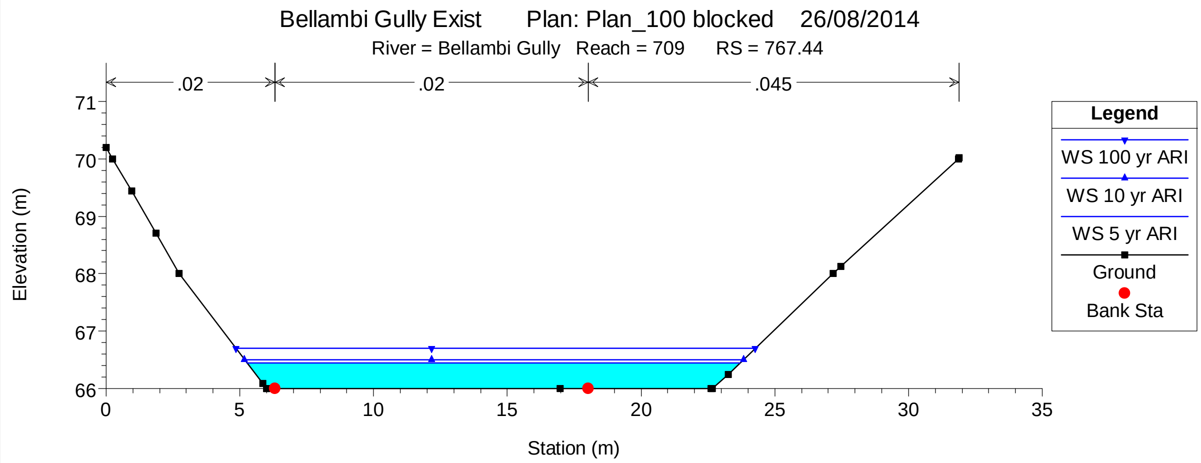
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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Station (m)
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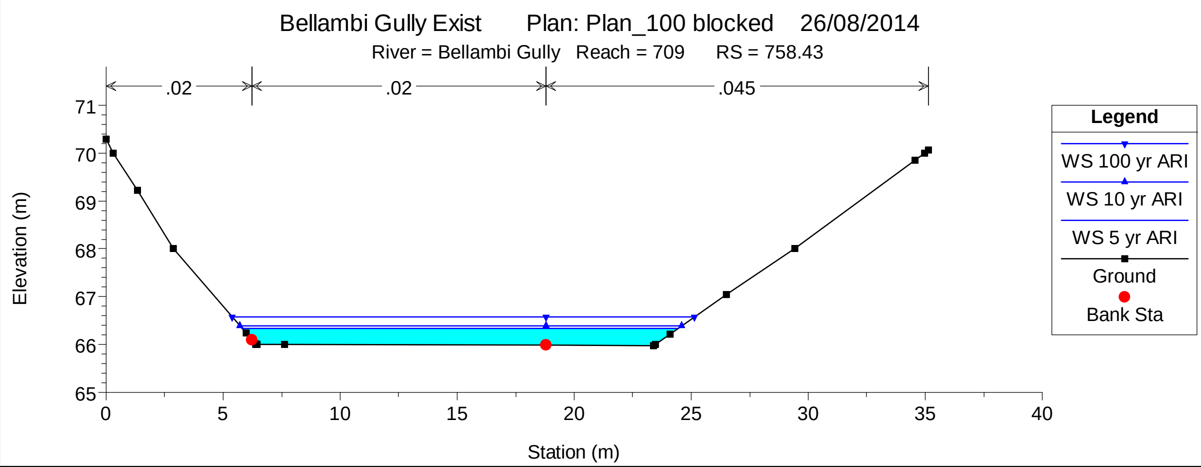
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

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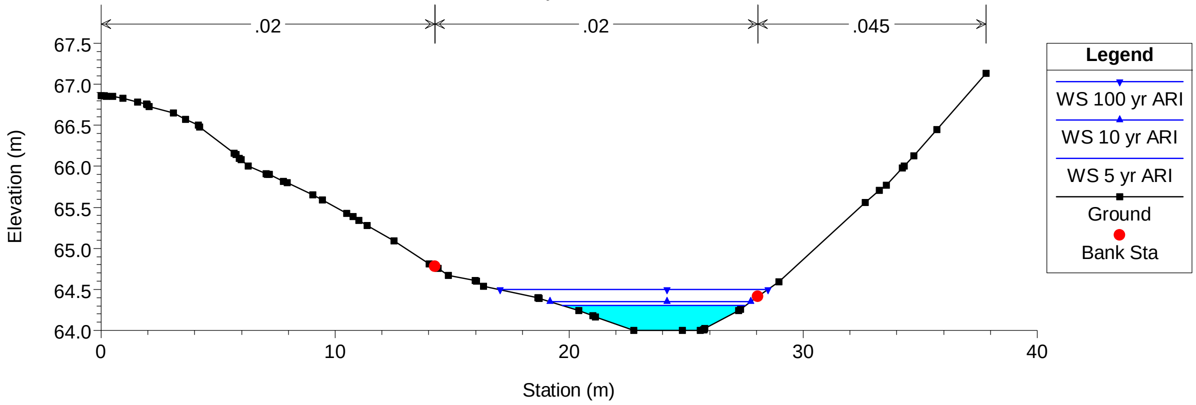

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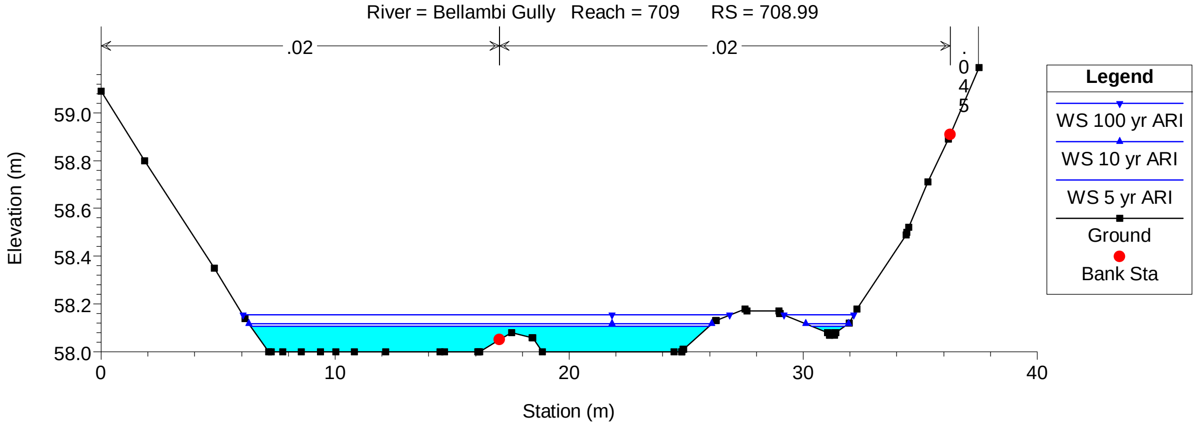

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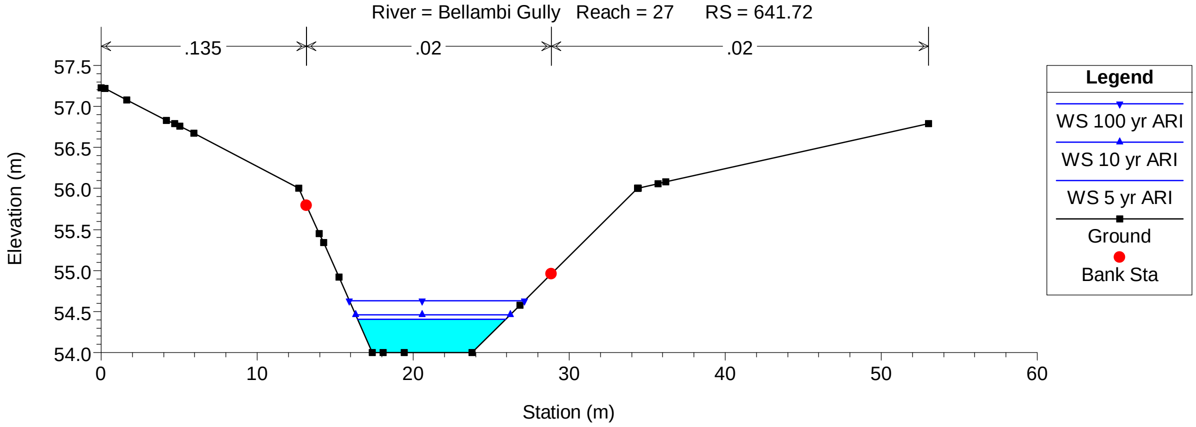

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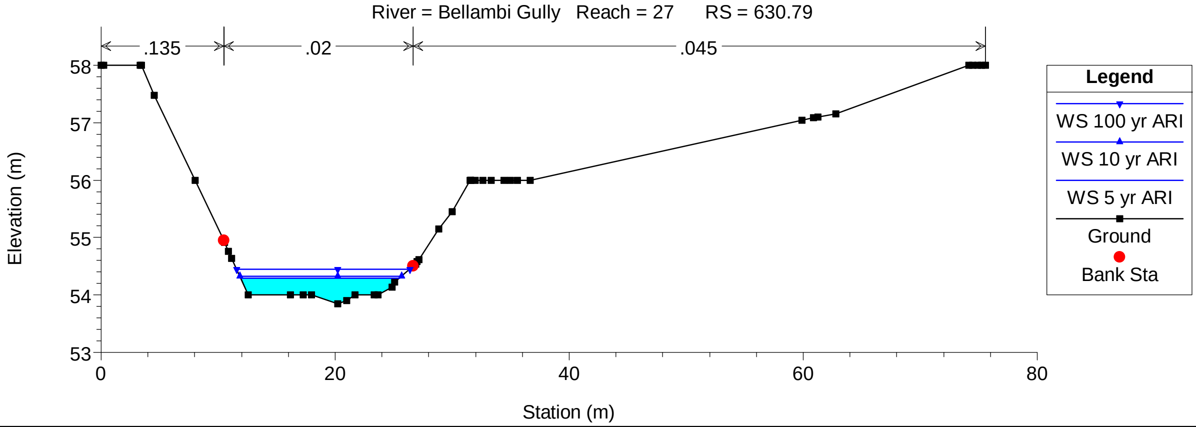

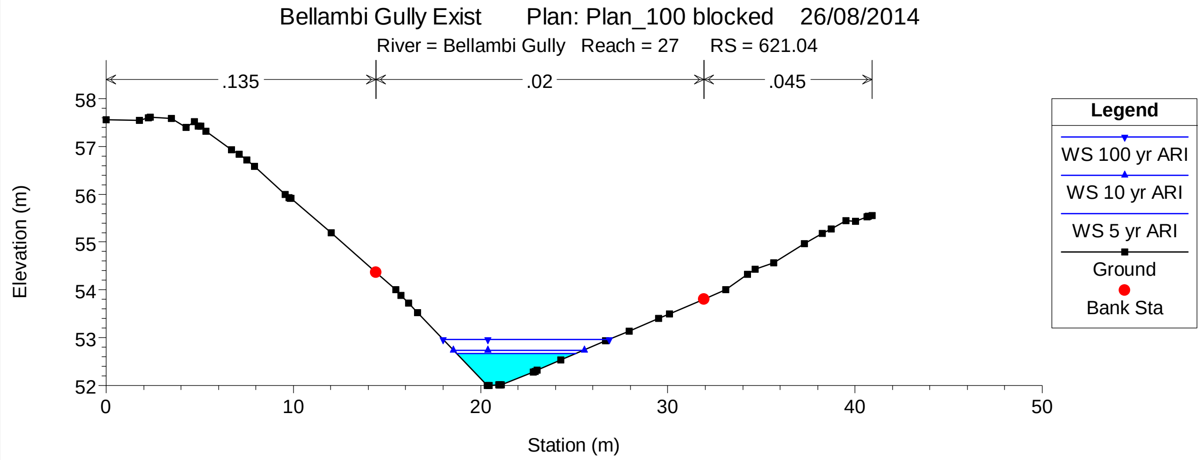
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.02
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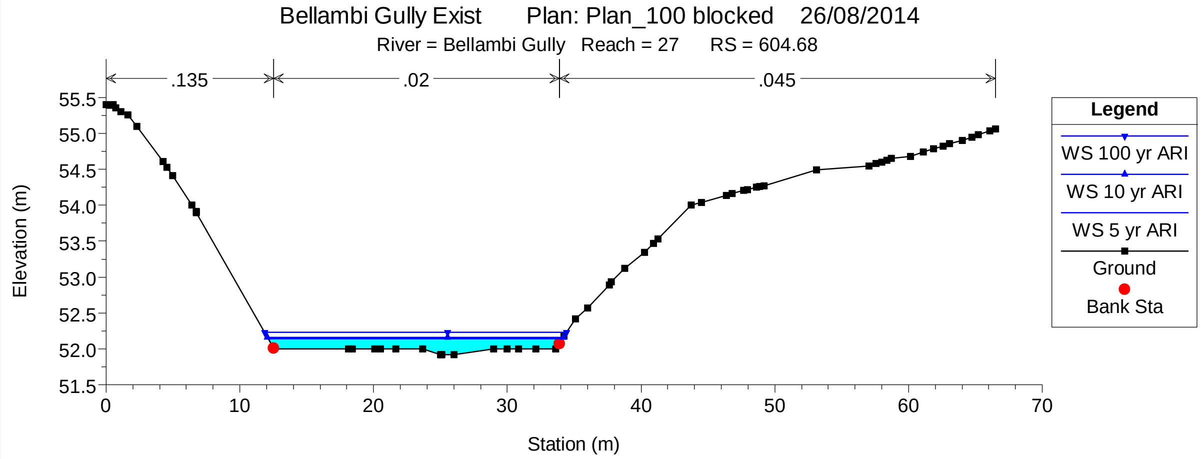
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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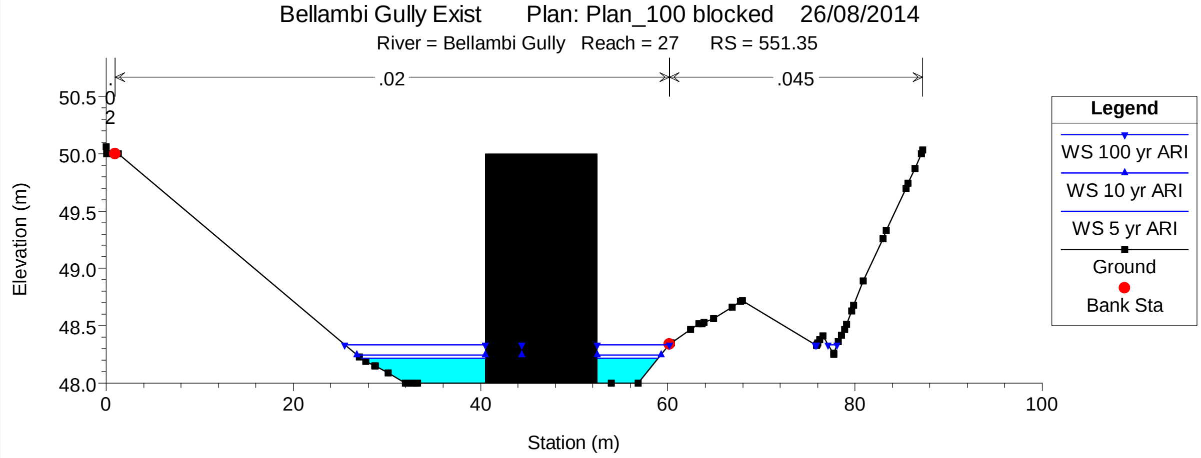
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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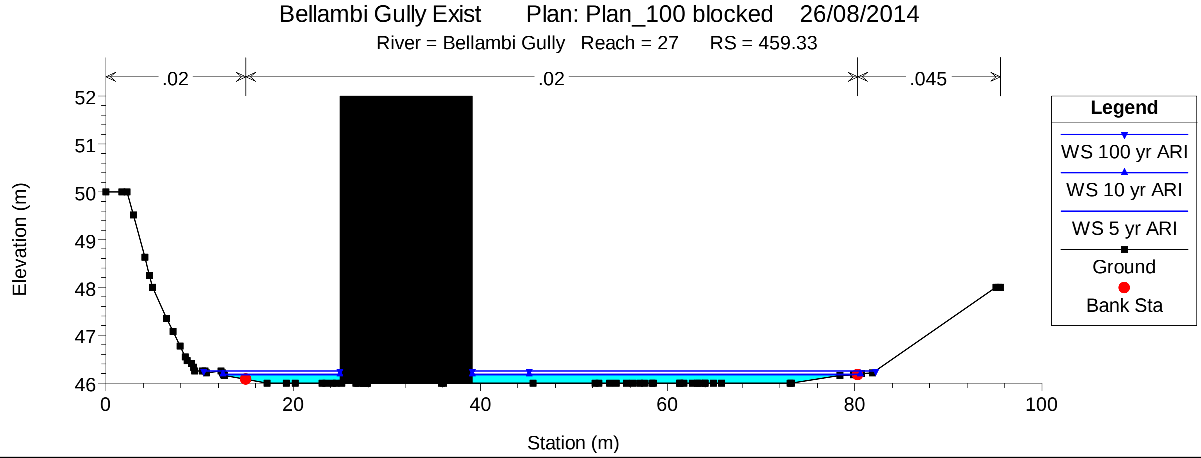
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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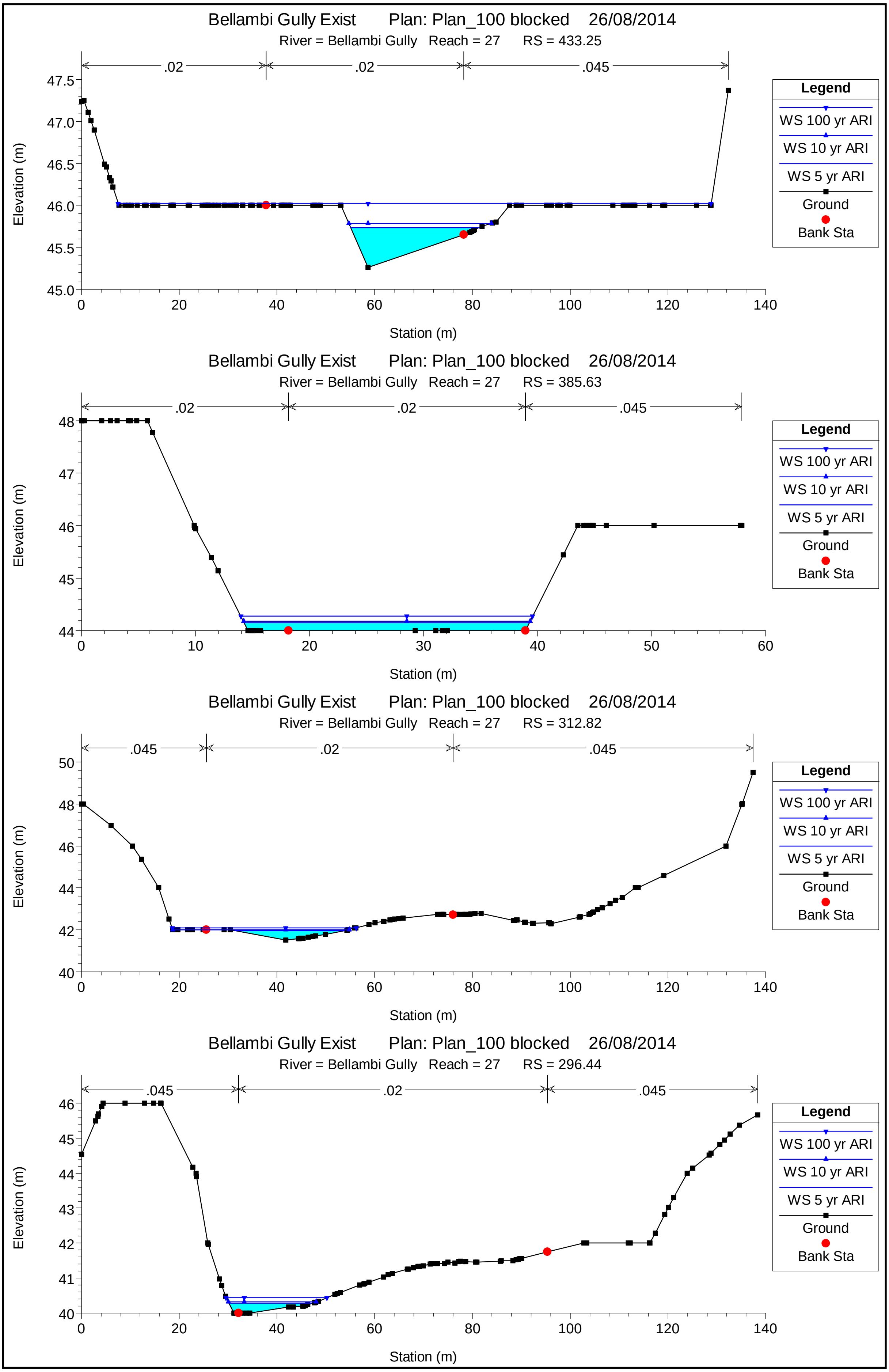
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta



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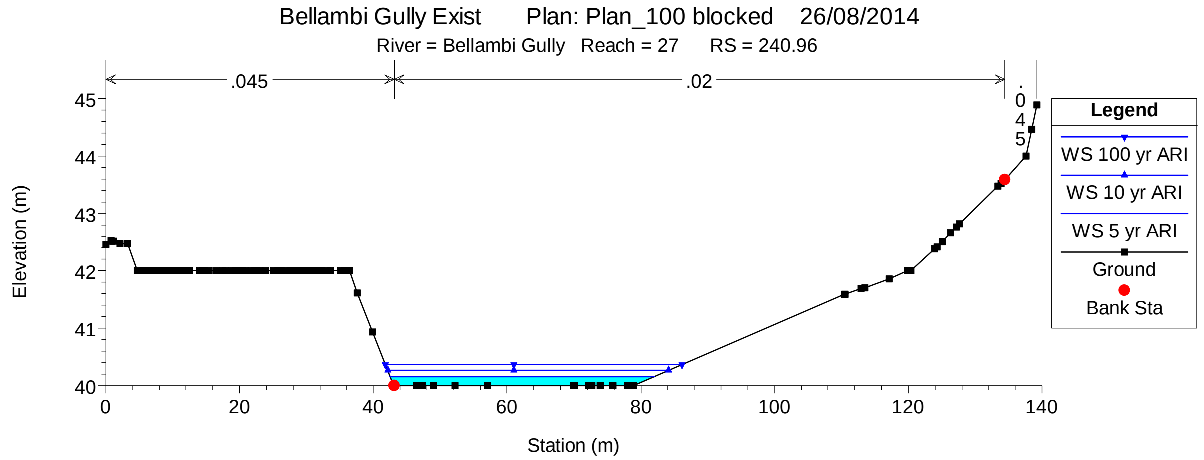
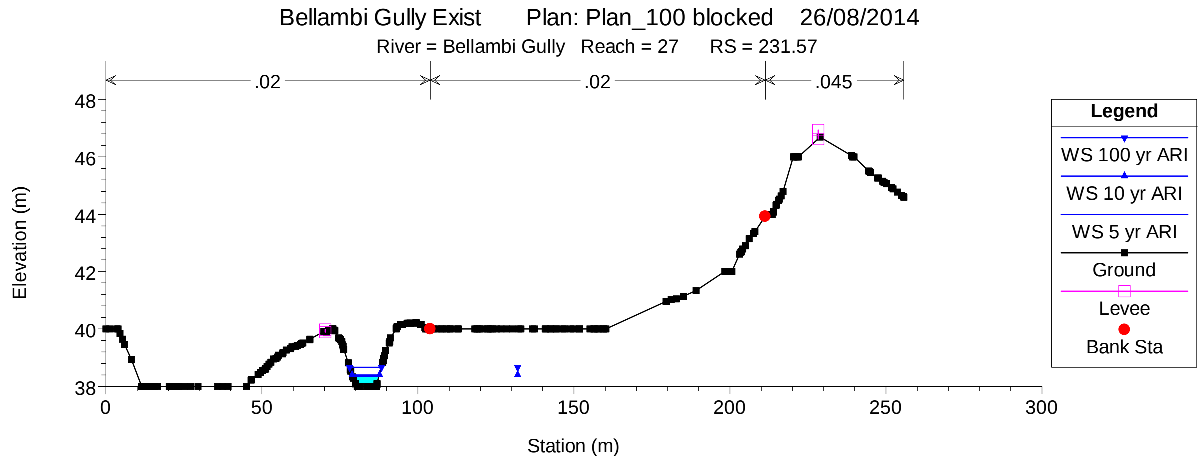
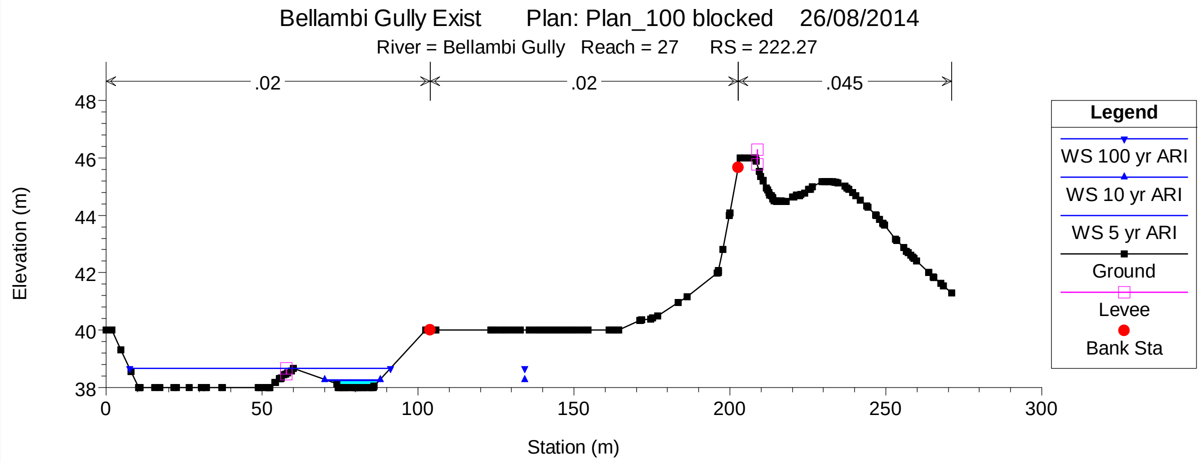
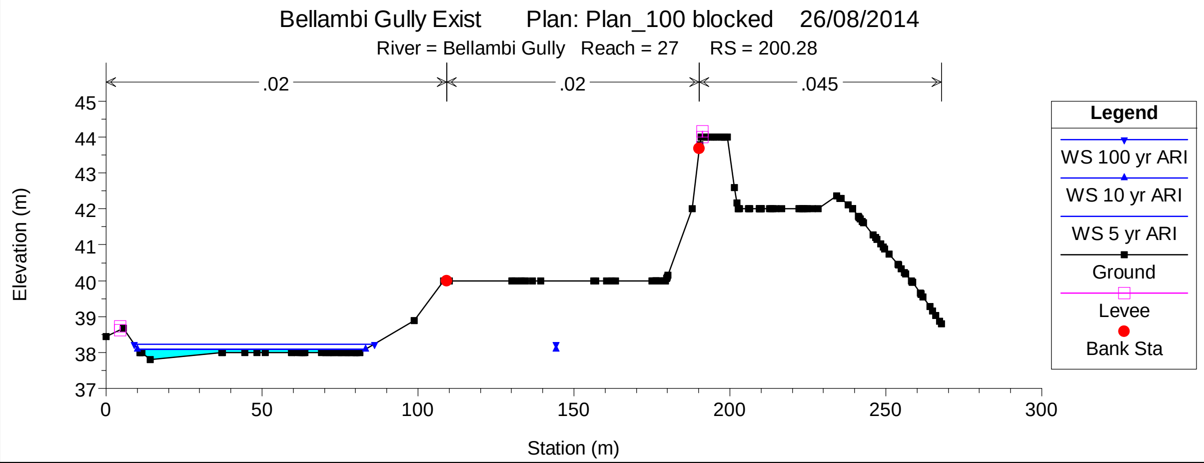
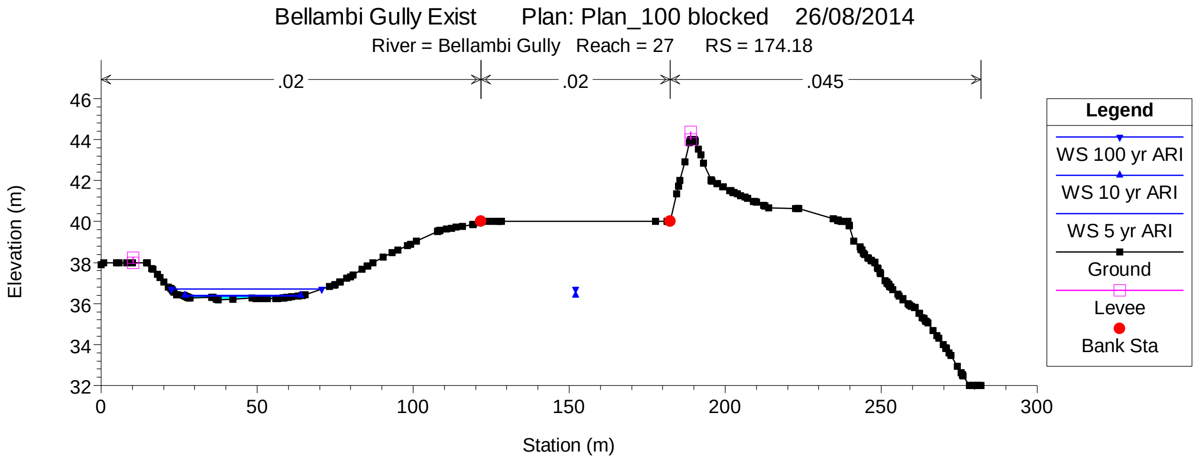
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta
Bellambi Gully Exist Plan: Plan_100 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 385.63
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta
Bellambi Gully Exist Plan: Plan_100 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 312.82
.045
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta
Bellambi Gully Exist Plan: Plan_100 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 296.44
.045
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

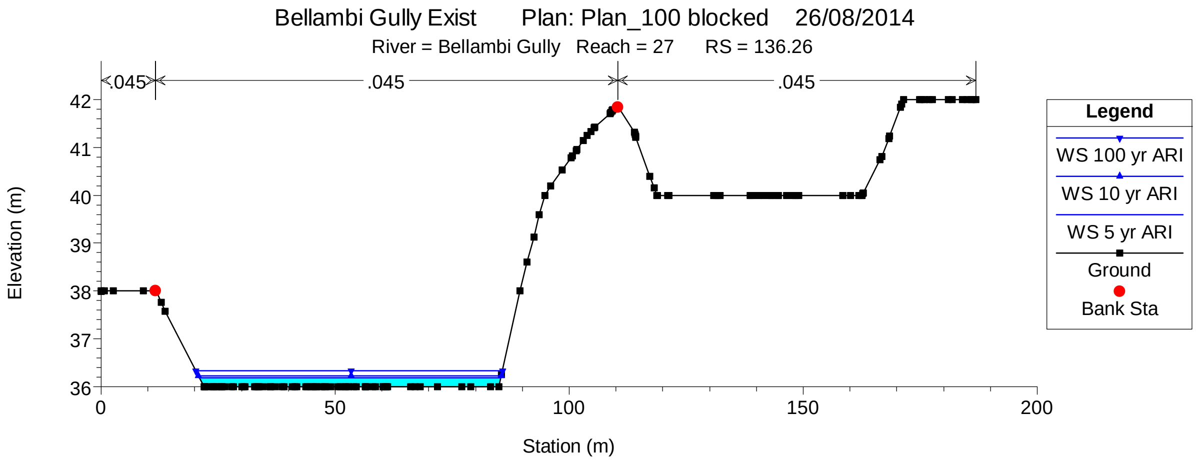

Bellambi Gully Exist Plan: Plan_100 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 240.96
.045
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

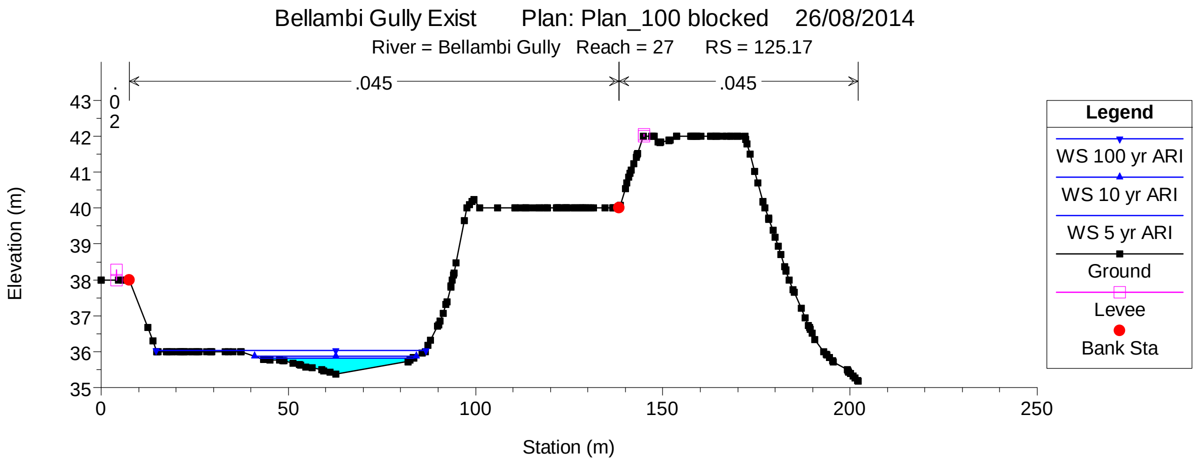

Bellambi Gully Exist Plan: Plan_100 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 231.57
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Levee
Bank Sta

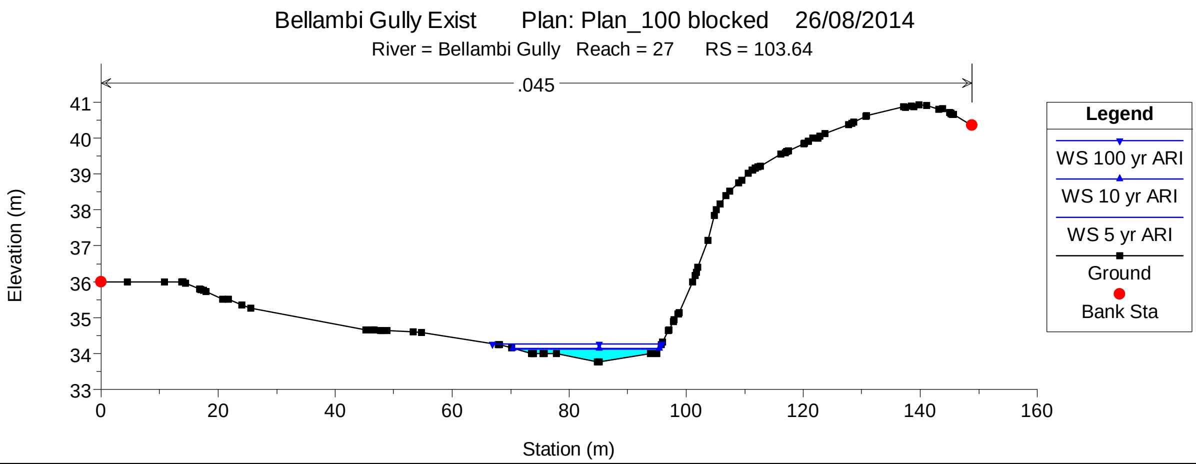

Bellambi Gully Exist Plan: Plan_100 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 222.27
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Levee
Bank Sta

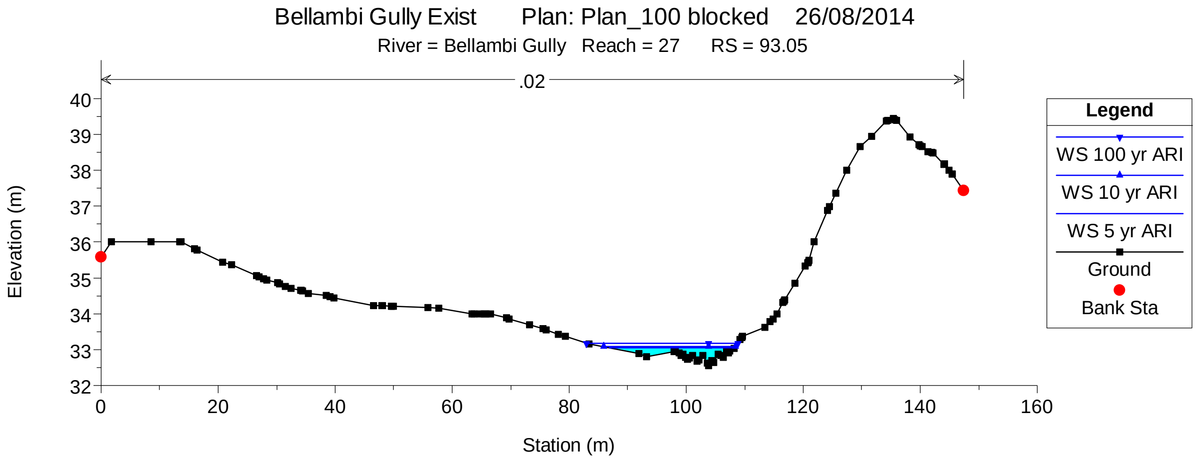

Bellambi Gully Exist Plan: Plan_100 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 200.28
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Levee
Bank Sta

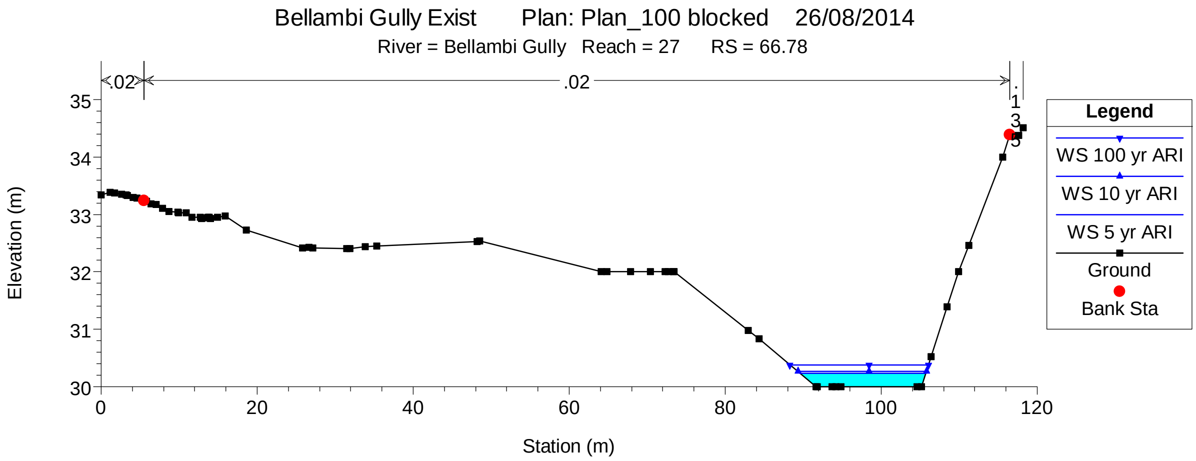

Bellambi Gully Exist Plan: Plan_100 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 174.18
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Levee
Bank Sta

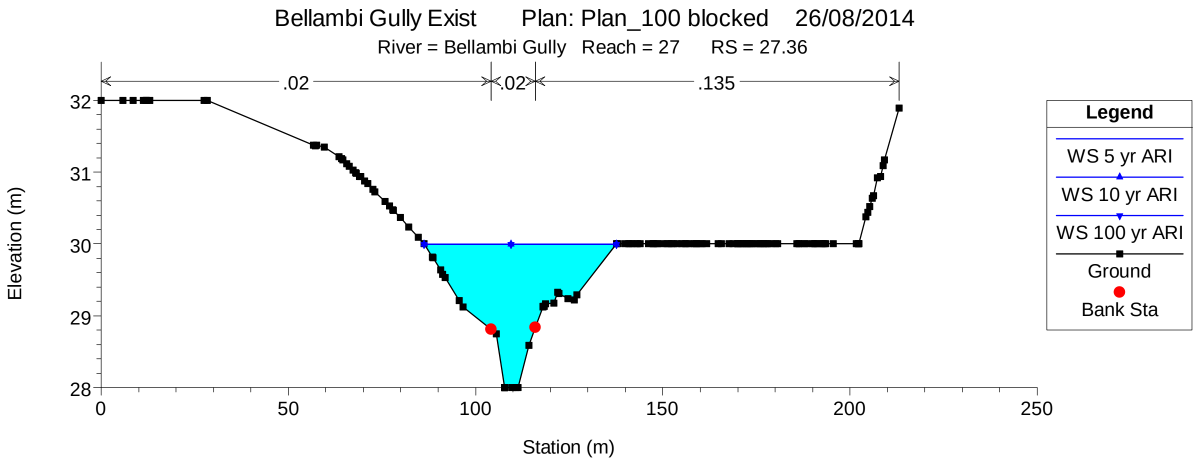

Bellambi Gully Exist Plan: Plan_100 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 136.26
.045
.045
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta


Bellambi Gully Exist Plan: Plan_100 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 125.17
.02
.045
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Levee
Bank Sta


Bellambi Gully Exist Plan: Plan_100 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 103.64
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta


Bellambi Gully Exist Plan: Plan_100 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 93.05
.02
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta


Bellambi Gully Exist Plan: Plan_100 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 66.78
.02
.02
.135
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta


Bellambi Gully Exist Plan: Plan_100 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 27.36
.02
.02
.135
Elevation (m)
Station (m)
Legend
WS 5 yr ARI
WS 10 yr ARI
WS 100 yr ARI
Ground
Bank Sta

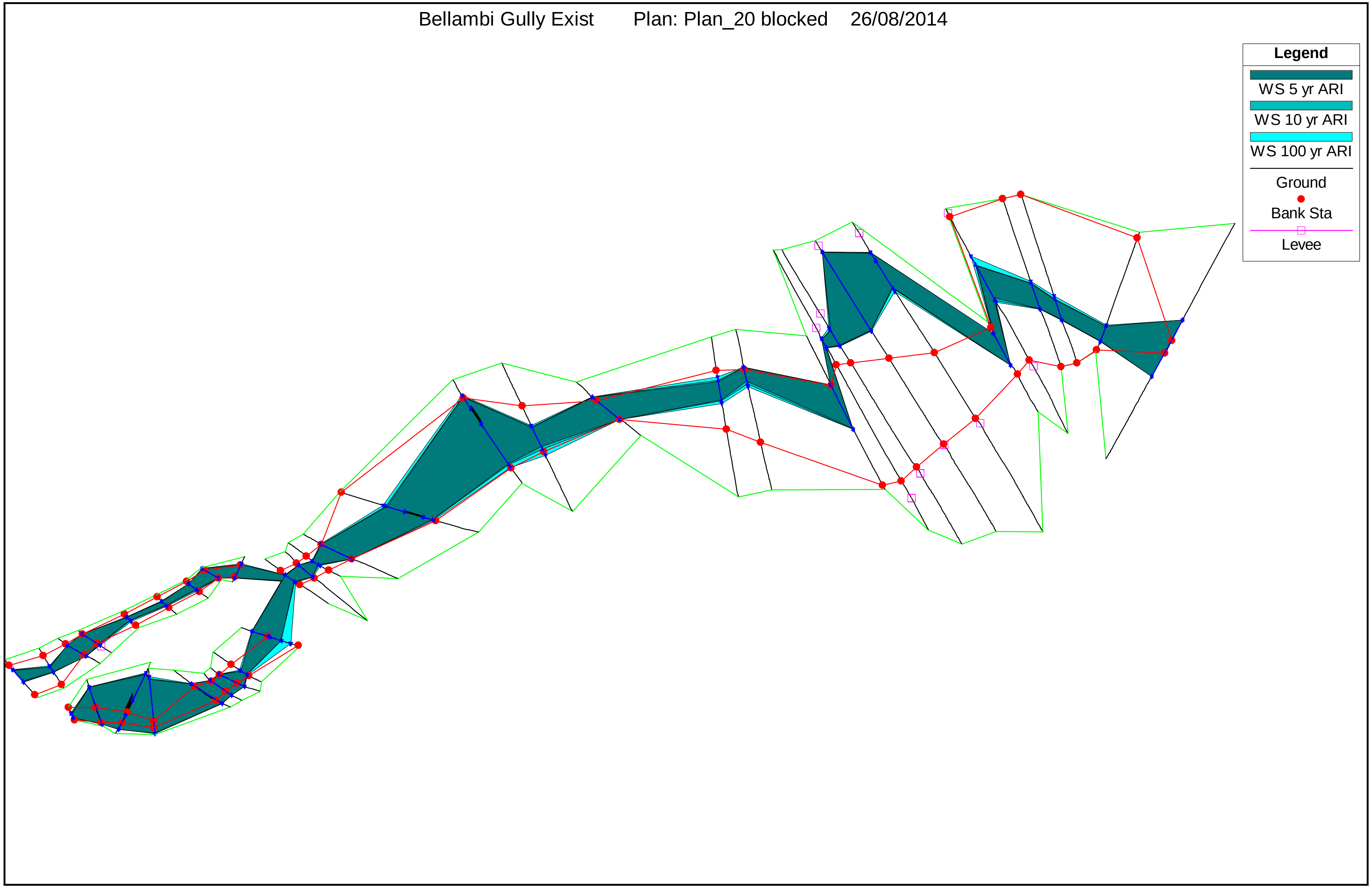
HEC-RAS Plan: 100block

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Hydr Depth
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)
26	193.90	5 yr ARI	3.58	68.83	69.04	69.14	69.43	0.050030	2.76	1.30	0.12
26	193.90	10 yr ARI	4.47	68.83	69.06	69.18	69.50	0.050062	2.96	1.51	0.14
26	193.90	100 yr ARI	8.45	68.83	69.13	69.31	69.80	0.050036	3.63	2.33	0.18
26	173.65	5 yr ARI	3.58	66.23	66.50	66.74	67.83	0.122719	5.12	0.70	0.16
26	173.65	10 yr ARI	4.47	66.23	66.53	66.79	67.95	0.112730	5.28	0.85	0.18
26	173.65	100 yr ARI	8.45	66.23	66.64	66.98	68.36	0.091113	5.80	1.46	0.24
26	151.48	5 yr ARI	3.58	66.00	66.32	66.20	66.36	0.001501	0.89	4.30	0.30
26	151.48	10 yr ARI	4.47	66.00	66.36	66.24	66.41	0.001543	0.97	4.91	0.34
26	151.48	100 yr ARI	8.45	66.00	66.21	66.36	66.75	0.037652	3.33	2.68	0.20
26	138.91	5 yr ARI	3.58	66.00	66.21	66.21	66.32	0.006889	1.46	2.57	0.20
26	138.91	10 yr ARI	4.47	66.00	66.25	66.25	66.37	0.006327	1.56	3.04	0.23
26	138.91	100 yr ARI	8.45	66.00	66.32	66.37	66.57	0.009500	2.26	4.02	0.29
26	109.29	5 yr ARI	3.58	62.00	62.23	62.56	65.38	0.339075	7.86	0.46	0.14
26	109.29	10 yr ARI	4.47	62.00	62.26	62.62	65.48	0.299590	7.95	0.56	0.16
26	109.29	100 yr ARI	8.45	62.00	62.39	62.82	65.54	0.177988	7.87	1.07	0.23
26	84.50	5 yr ARI	3.58	60.00	60.35	60.58	61.37	0.072849	4.46	0.80	0.19
26	84.50	10 yr ARI	4.47	60.00	60.39	60.64	61.55	0.075442	4.79	0.93	0.21
26	84.50	100 yr ARI	8.45	60.00	60.49	60.83	62.21	0.082851	5.81	1.45	0.26
26	62.17	5 yr ARI	3.58	58.38	58.67	58.85	59.49	0.092625	4.02	0.89	0.14
26	62.17	10 yr ARI	4.47	58.38	58.69	58.89	59.62	0.092361	4.26	1.05	0.15
26	62.17	100 yr ARI	8.45	58.38	58.77	59.05	60.17	0.091494	5.24	1.61	0.21
26	45.90	5 yr ARI	3.58	56.00	56.07	56.20	57.04	0.282651	4.39	0.82	0.07
26	45.90	10 yr ARI	4.47	56.00	56.08	56.24	57.21	0.270561	4.74	0.95	0.08
26	45.90	100 yr ARI	8.45	56.00	56.12	56.36	57.86	0.239159	5.89	1.45	0.12
26	25.76	5 yr ARI	3.58	56.00	56.25	56.26	56.37	0.006557	1.51	2.41	0.21
26	25.76	10 yr ARI	4.47	56.00	56.27	56.30	56.43	0.008015	1.75	2.60	0.22
26	25.76	100 yr ARI	8.45	56.00	56.33	56.44	56.69	0.014217	2.67	3.28	0.26
709	869.12	5 yr ARI	3.03	68.43	68.87	69.09	69.67	0.050055	3.96	0.76	0.22
709	869.12	10 yr ARI	3.79	68.43	68.91	69.15	69.81	0.050059	4.19	0.90	0.24
709	869.12	100 yr ARI	6.71	68.43	69.03	69.33	70.22	0.050076	4.84	1.39	0.30
709	853.66	5 yr ARI	3.03	64.00	66.56	64.17	66.56	0.000000	0.06	59.84	1.77
709	853.66	10 yr ARI	3.79	64.00	66.64	64.20	66.64	0.000001	0.07	62.71	1.84
709	853.66	100 yr ARI	6.71	64.00	66.92	64.29	66.92	0.000001	0.11	72.46	2.04
709	838.25	5 yr ARI	3.03	64.00	66.56		66.56	0.000002	0.11	41.83	1.08
709	838.25	10 yr ARI	3.79	64.00	66.64		66.64	0.000003	0.13	45.13	1.15
709	838.25	100 yr ARI	6.71	64.00	66.92		66.92	0.000005	0.18	56.44	1.36
709	820.54	5 yr ARI	3.03	64.00	66.56		66.56	0.000002	0.12	44.97	0.89
709	820.54	10 yr ARI	3.79	64.00	66.64		66.64	0.000002	0.14	49.25	0.97
709	820.54	100 yr ARI	6.71	64.00	66.92		66.92	0.000004	0.19	64.00	1.18
709	776.73	5 yr ARI	9.82	64.01	66.56		66.56	0.000014	0.29	39.23	1.53
709	776.73	10 yr ARI	12.28	64.01	66.64		66.64	0.000019	0.34	41.36	1.59
709	776.73	100 yr ARI	21.89	64.01	66.91		66.92	0.000038	0.53	48.60	1.77
709	767.44	5 yr ARI	9.82	66.00	66.44		66.55	0.002807	1.54	7.80	0.42
709	767.44	10 yr ARI	12.28	66.00	66.51		66.63	0.002826	1.69	8.95	0.48
709	767.44	100 yr ARI	21.89	66.00	66.70	66.59	66.90	0.002994	2.16	12.65	0.65
709	758.43	5 yr ARI	9.82	65.99	66.34	66.34	66.50	0.006423	1.95	6.11	0.33
709	758.43	10 yr ARI	12.28	65.99	66.39	66.39	66.58	0.006175	2.10	7.10	0.38
709	758.43	100 yr ARI	21.89	65.99	66.57	66.57	66.85	0.005296	2.52	10.70	0.54
709	748.19	5 yr ARI	9.82	64.00	64.30	64.63	66.16	0.119464	6.04	1.62	0.21
709	748.19	10 yr ARI	12.28	64.00	64.35	64.69	66.26	0.104834	6.13	2.00	0.23
709	748.19	100 yr ARI	21.89	64.00	64.50	64.90	66.54	0.076054	6.34	3.47	0.30
709	708.99	5 yr ARI	9.82	58.00	58.11	58.29	59.53	0.268377	4.72	1.88	0.09
709	708.99	10 yr ARI	12.28	58.00	58.12	58.33	59.92	0.305430	5.29	2.09	0.10
709	708.99	100 yr ARI	21.89	58.00	58.15	58.46	61.08	0.354168	6.64	2.93	0.12
27	641.72	5 yr ARI	14.05	54.00	54.41	54.68	55.36	0.031874	4.32	3.25	0.34
27	641.72	10 yr ARI	17.53	54.00	54.46	54.77	55.56	0.032028	4.65	3.77	0.38
27	641.72	100 yr ARI	31.63	54.00	54.63	55.07	56.28	0.033713	5.69	5.56	0.50
27	630.79	5 yr ARI	14.05	53.85	54.29	54.48	54.95	0.027276	3.59	3.91	0.29
27	630.79	10 yr ARI	17.53	53.85	54.33	54.56	55.14	0.029695	3.99	4.39	0.32

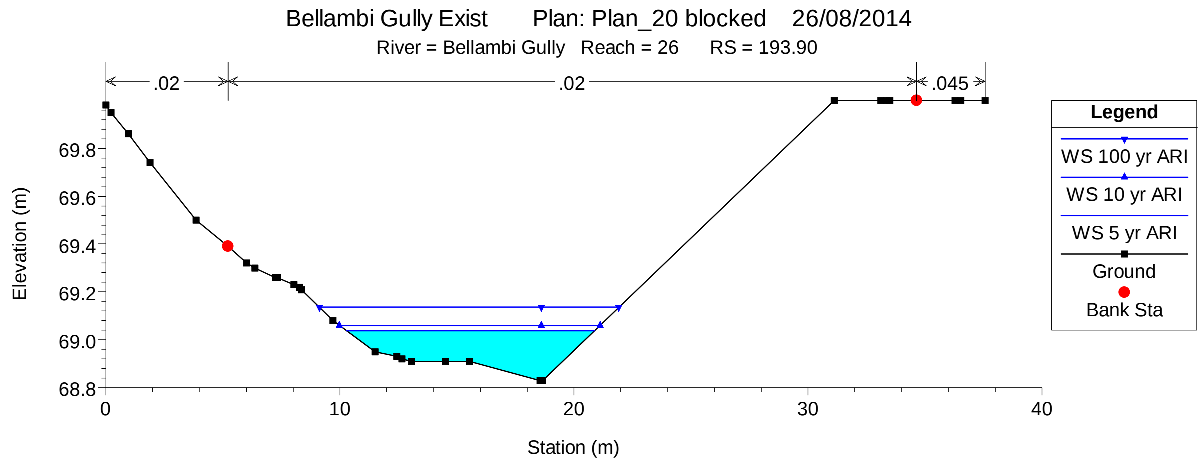
HEC-RAS Plan: 100block (Continued)

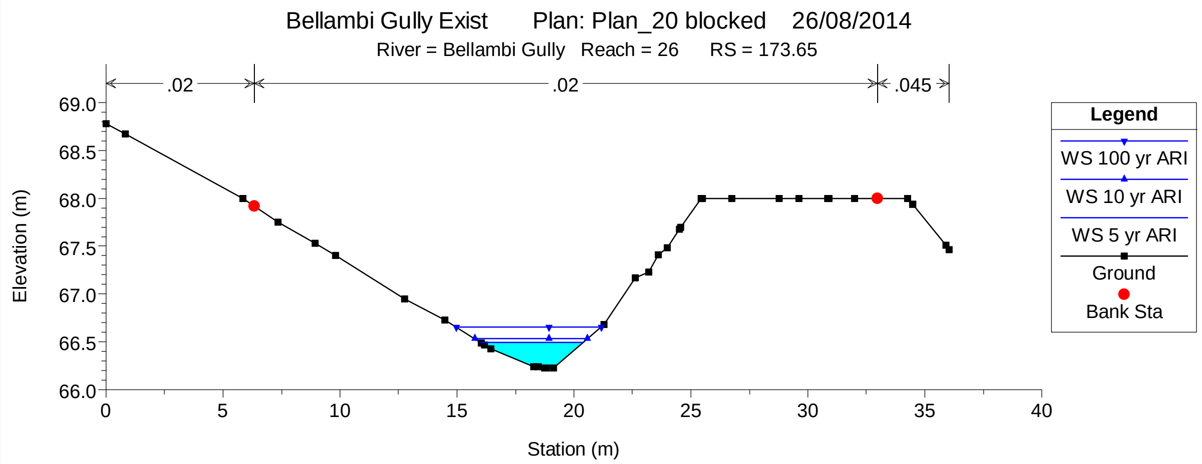
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Hydr Depth
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)
27	630.79	100 yr ARI	31.63	53.85	54.44	54.81	55.81	0.035410	5.18	6.10	0.41
27	621.04	5 yr ARI	14.05	52.00	52.67	53.09	54.46	0.055056	5.94	2.37	0.37
27	621.04	10 yr ARI	17.53	52.00	52.74	53.20	54.65	0.051478	6.12	2.86	0.41
27	621.04	100 yr ARI	31.63	52.00	52.97	53.54	55.33	0.045848	6.81	4.65	0.52
27	604.68	5 yr ARI	14.05	51.92	52.14	52.34	53.08	0.089622	4.29	3.31	0.15
27	604.68	10 yr ARI	17.53	51.92	52.16	52.40	53.31	0.094391	4.76	3.73	0.17
27	604.68	100 yr ARI	31.63	51.92	52.23	52.59	54.12	0.099065	6.11	5.28	0.23
27	551.35	5 yr ARI	14.05	48.00	48.22	48.41	49.02	0.064310	3.97	3.54	0.18
27	551.35	10 yr ARI	17.53	48.00	48.25	48.47	49.16	0.063276	4.25	4.13	0.20
27	551.35	100 yr ARI	31.63	48.00	48.34	48.66	49.72	0.065685	5.21	6.11	0.26
27	459.33	5 yr ARI	14.05	46.00	46.17	46.21	46.33	0.014913	1.76	8.04	0.15
27	459.33	10 yr ARI	17.53	46.00	46.19	46.24	46.38	0.015576	1.94	9.12	0.17
27	459.33	100 yr ARI	31.63	46.00	46.26	46.35	46.58	0.017619	2.54	12.71	0.22
27	433.25	5 yr ARI	14.05	45.26	45.73	45.80	45.98	0.011090	2.21	6.46	0.25
27	433.25	10 yr ARI	17.53	45.26	45.79	45.86	46.06	0.009665	2.30	7.93	0.27
27	433.25	100 yr ARI	31.63	45.26	46.03	46.10	46.26	0.008004	2.18	18.02	0.15
27	385.63	5 yr ARI	14.05	44.00	44.15	44.32	44.86	0.067873	3.74	3.80	0.15
27	385.63	10 yr ARI	17.53	44.00	44.18	44.37	45.02	0.068241	4.09	4.34	0.17
27	385.63	100 yr ARI	31.63	44.00	44.27	44.55	45.39	0.050179	4.72	6.83	0.27
27	312.82	5 yr ARI	14.05	41.52	41.96	42.08	42.32	0.019629	2.67	5.26	0.24
27	312.82	10 yr ARI	17.53	41.52	42.01	42.12	42.37	0.020406	2.65	6.71	0.19
27	312.82	100 yr ARI	31.63	41.52	42.09	42.28	42.70	0.025233	3.49	9.58	0.25
27	296.44	5 yr ARI	14.05	40.00	40.28	40.53	41.58	0.118659	5.21	2.90	0.17
27	296.44	10 yr ARI	17.53	40.00	40.31	40.59	41.64	0.097690	5.26	3.59	0.20
27	296.44	100 yr ARI	31.63	40.00	40.44	40.80	41.98	0.066082	5.64	6.04	0.29
27	240.96	5 yr ARI	14.05	40.00	40.16	40.24	40.44	0.027760	2.37	5.96	0.15
27	240.96	10 yr ARI	17.53	40.00	40.27	40.28	40.41	0.007522	1.71	10.33	0.25
27	240.96	100 yr ARI	31.63	40.00	40.37	40.41	40.61	0.008041	2.17	14.76	0.33
27	231.57	5 yr ARI	14.05	40.00	38.36	38.70	39.79	0.054696		2.65	0.31
27	231.57	10 yr ARI	17.53	40.00	38.41	38.80	40.04	0.053014		3.10	0.35
27	231.57	100 yr ARI	31.63	40.00	38.67	39.14	40.28	0.028599		5.64	0.55
27	222.27	5 yr ARI	14.05	40.00	38.25	38.47	39.12	0.058698		3.40	0.20
27	222.27	10 yr ARI	17.53	40.00	38.28	38.54	39.36	0.066834		3.80	0.21
27	222.27	100 yr ARI	31.63	40.00	38.67	38.67	38.70	0.000452		45.14	0.54
27	200.28	5 yr ARI	14.05	40.00	38.09	38.12	38.22	0.018636		8.58	0.12
27	200.28	10 yr ARI	17.53	40.00	38.10	38.15	38.28	0.022554		9.26	0.13
27	200.28	100 yr ARI	31.63	40.00	38.24	38.24	38.37	0.006184		19.87	0.26
27	174.18	5 yr ARI	14.05	40.00	36.36	36.51	37.12	0.125273		3.65	0.10
27	174.18	10 yr ARI	17.53	40.00	36.39	36.55	37.13	0.094497		4.59	0.12
27	174.18	100 yr ARI	31.63	40.00	36.71	36.67	36.86	0.003901		18.92	0.39
27	136.26	5 yr ARI	14.05	36.00	36.19	36.17	36.26	0.024550	1.15	12.23	0.19
27	136.26	10 yr ARI	17.53	36.00	36.22	36.20	36.30	0.022992	1.23	14.27	0.22
27	136.26	100 yr ARI	31.63	36.00	36.33		36.44	0.019476	1.47	21.48	0.33
27	125.17	5 yr ARI	14.05	35.38	35.82	35.82	35.94	0.034400	1.52	9.24	0.22
27	125.17	10 yr ARI	17.53	35.38	35.87	35.87	36.00	0.032223	1.60	10.96	0.25
27	125.17	100 yr ARI	31.63	35.38	36.03	36.03	36.17	0.031228	1.63	19.35	0.27
27	103.64	5 yr ARI	14.05	33.76	34.12	34.26	34.59	0.175939	3.07	4.58	0.19
27	103.64	10 yr ARI	17.53	33.76	34.15	34.31	34.70	0.174752	3.30	5.31	0.21
27	103.64	100 yr ARI	31.63	33.76	34.27	34.48	34.96	0.141328	3.70	8.55	0.30
27	93.05	5 yr ARI	14.05	32.56	33.05	33.22	33.69	0.048622	3.56	3.95	0.19
27	93.05	10 yr ARI	17.53	32.56	33.08	33.27	33.81	0.047865	3.79	4.62	0.21
27	93.05	100 yr ARI	31.63	32.56	33.18	33.45	34.17	0.043482	4.41	7.18	0.28
27	66.78	5 yr ARI	14.05	30.00	30.23	30.45	31.09	0.053602	4.11	3.42	0.21
27	66.78	10 yr ARI	17.53	30.00	30.26	30.51	31.26	0.052531	4.42	3.96	0.24
27	66.78	100 yr ARI	31.63	30.00	30.38	30.74	31.81	0.048655	5.31	5.96	0.34
27	27.36	5 yr ARI	14.05	28.00	30.00	28.86	30.01	0.000054	0.51	44.69	0.87
27	27.36	10 yr ARI	17.53	28.00	30.00	28.96	30.02	0.000085	0.64	44.69	0.87
27	27.36	100 yr ARI	31.63	28.00	30.00	29.26	30.05	0.000276	1.15	44.69	0.87

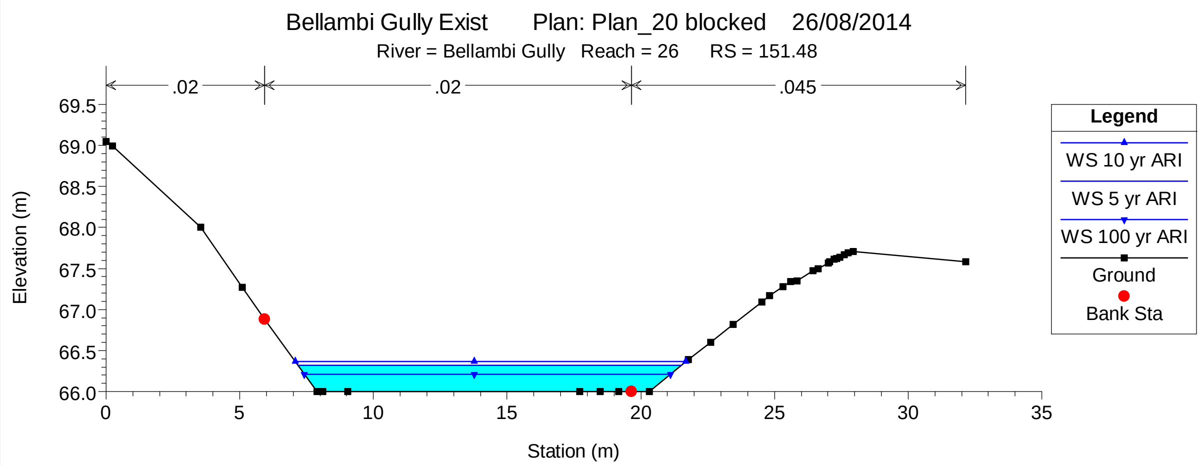
Plan View Scenario 2

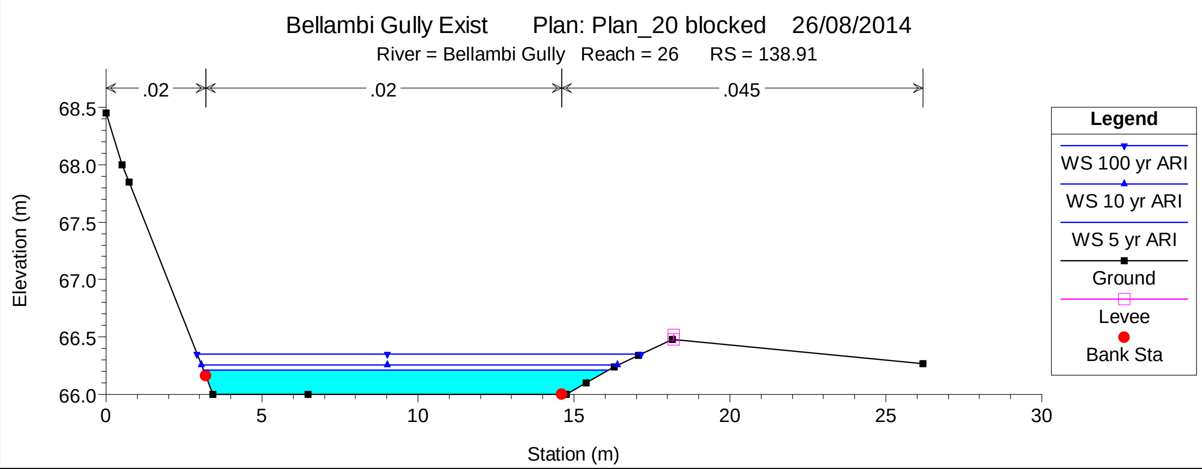


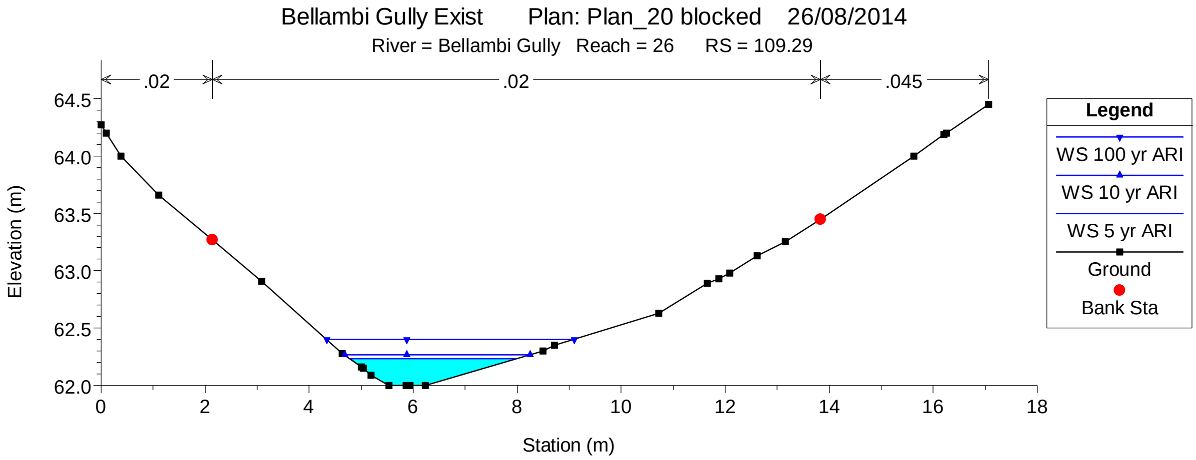
Cross Sections



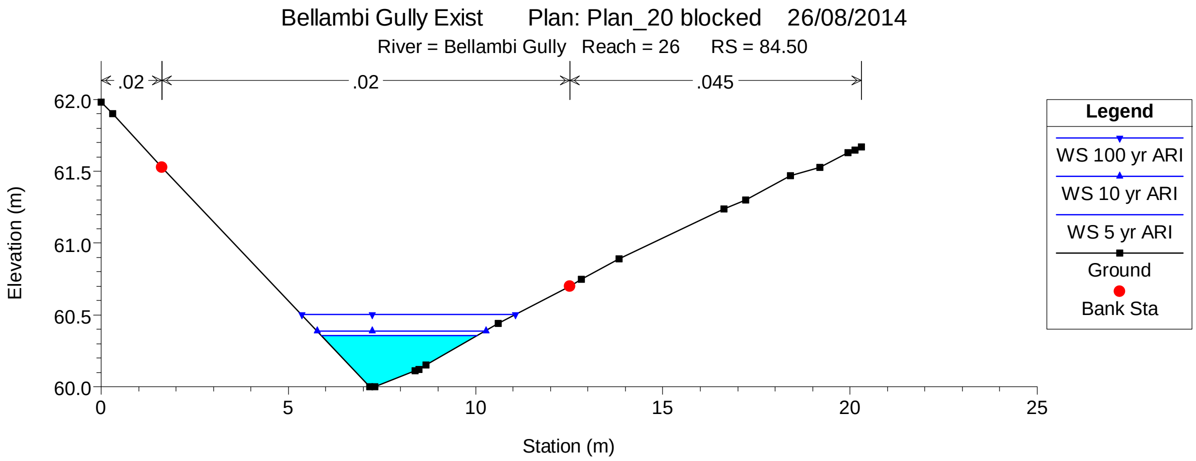




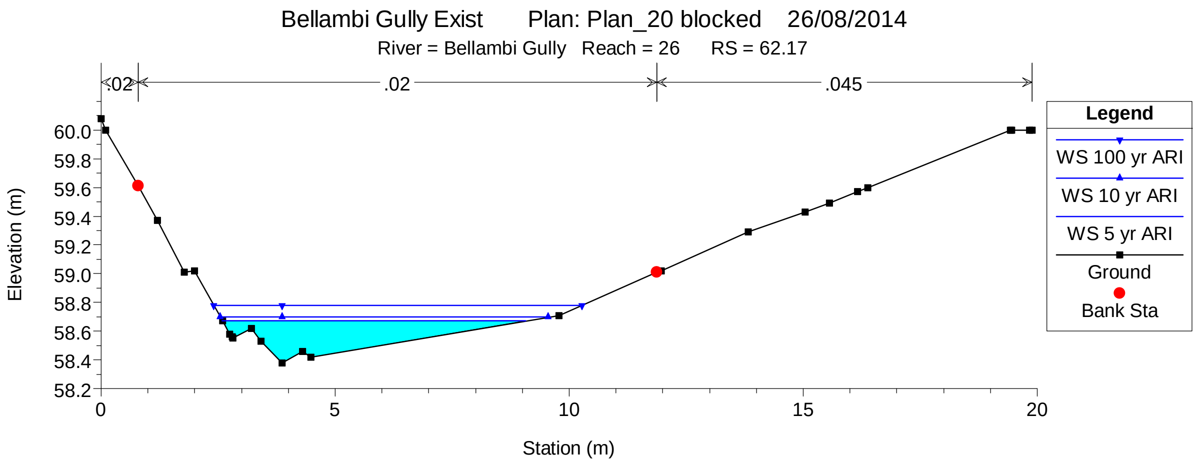




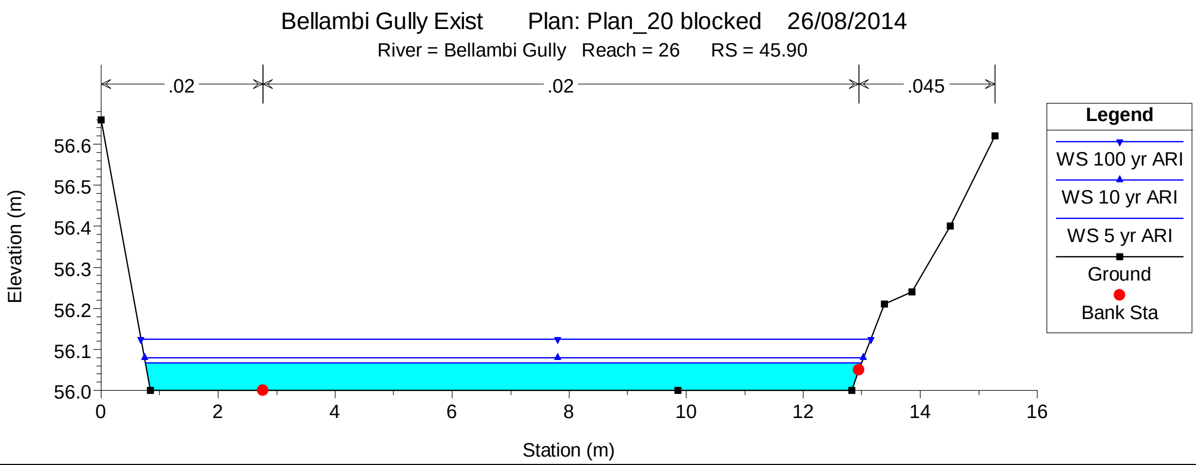
Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 26 RS = 109.29
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta



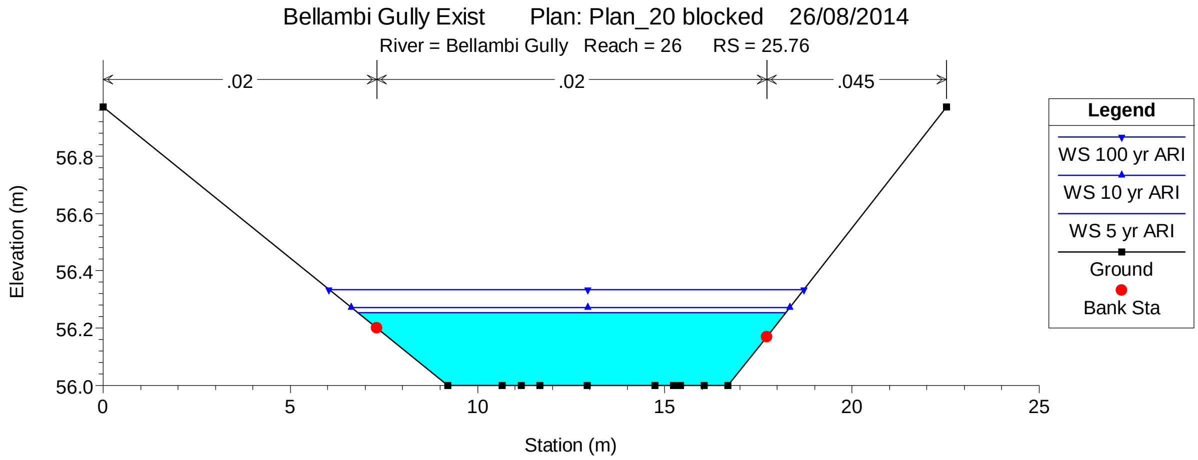
Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 26 RS = 84.50
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

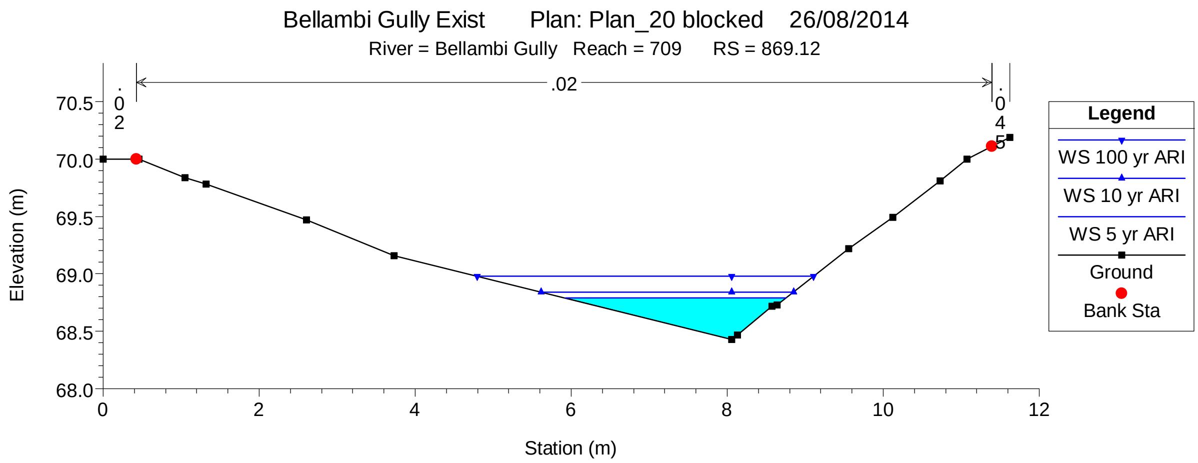


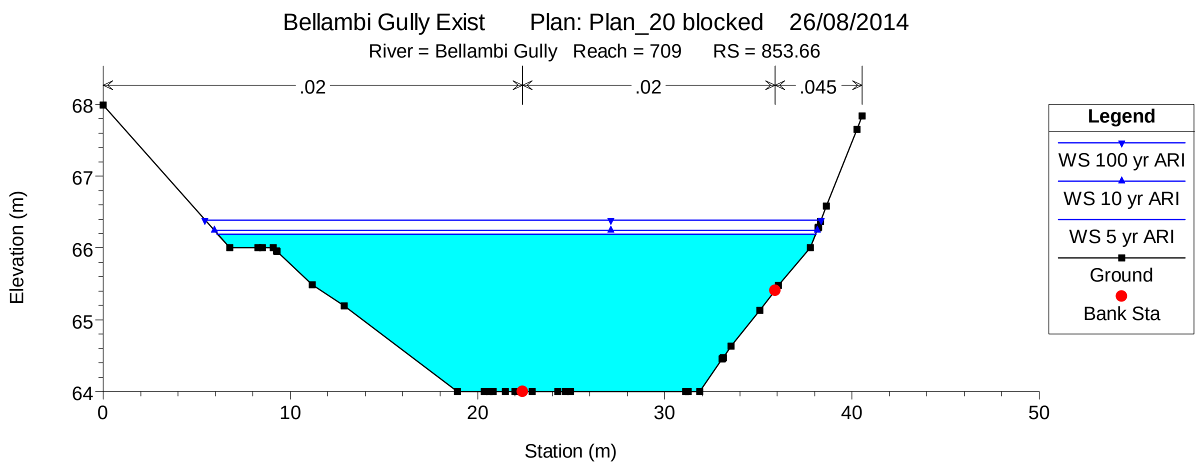
Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 26 RS = 62.17
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

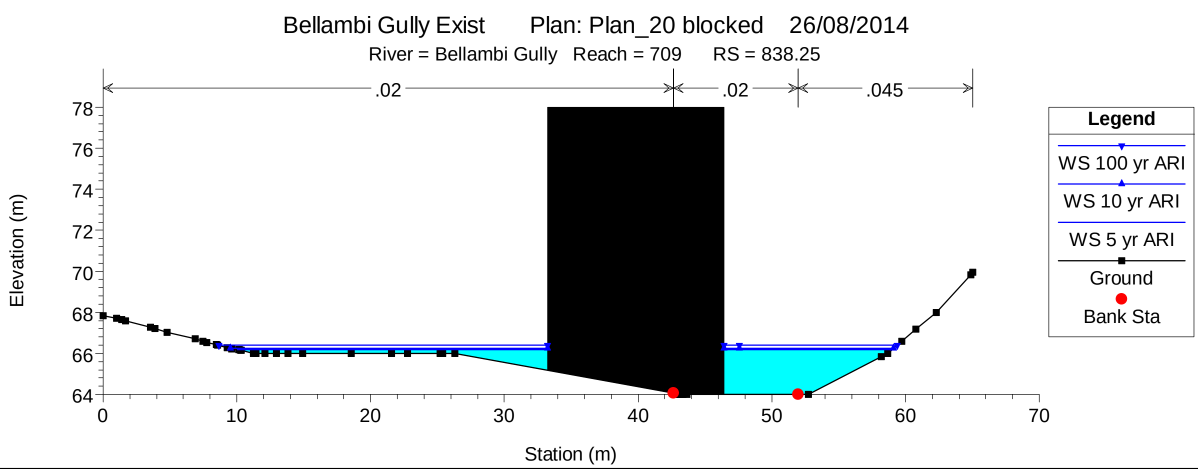


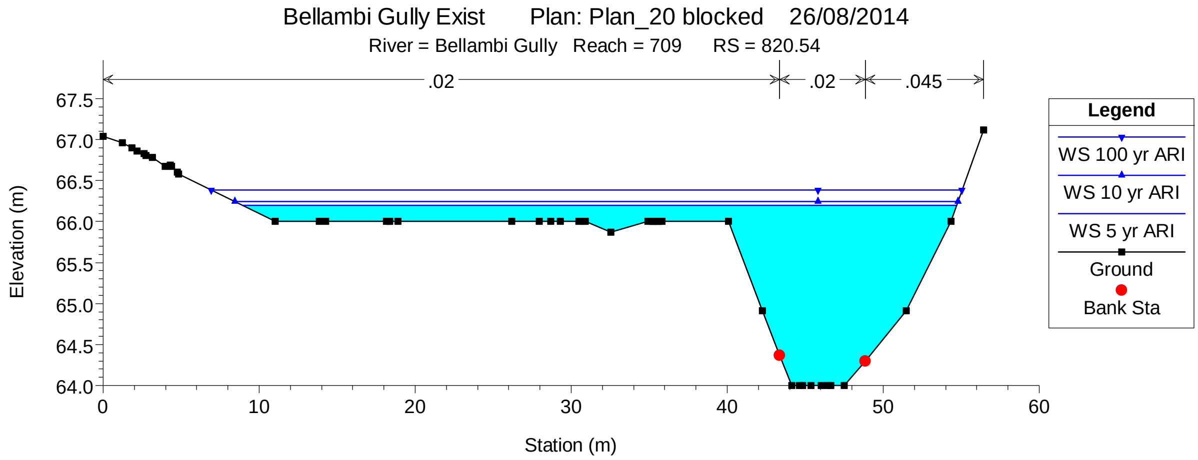
Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 26 RS = 45.90
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

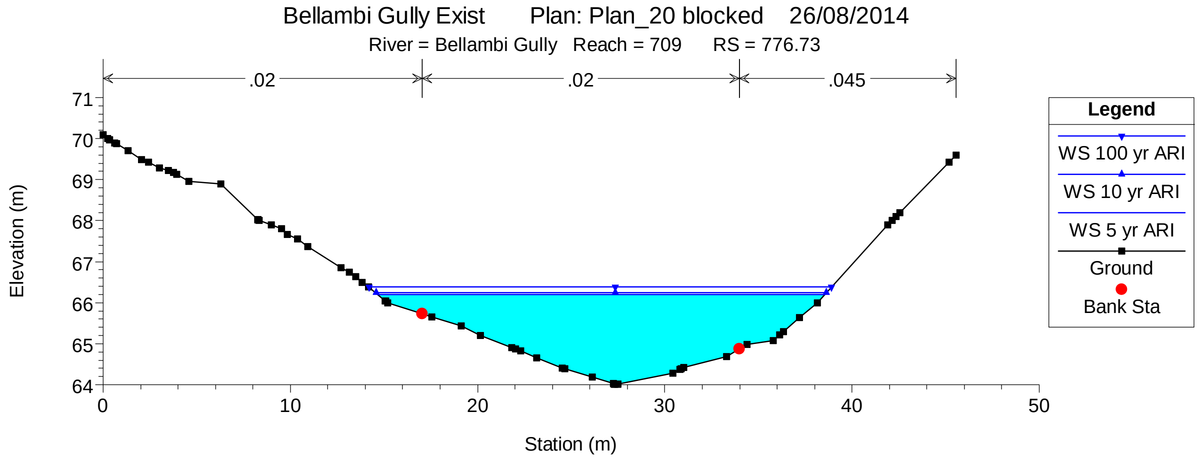

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 26 RS = 25.76
.02
.02
.045
Elevation (m)
56.0
56.2
56.4
56.6
56.8
Station (m)
0
5
10
15
20
25
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

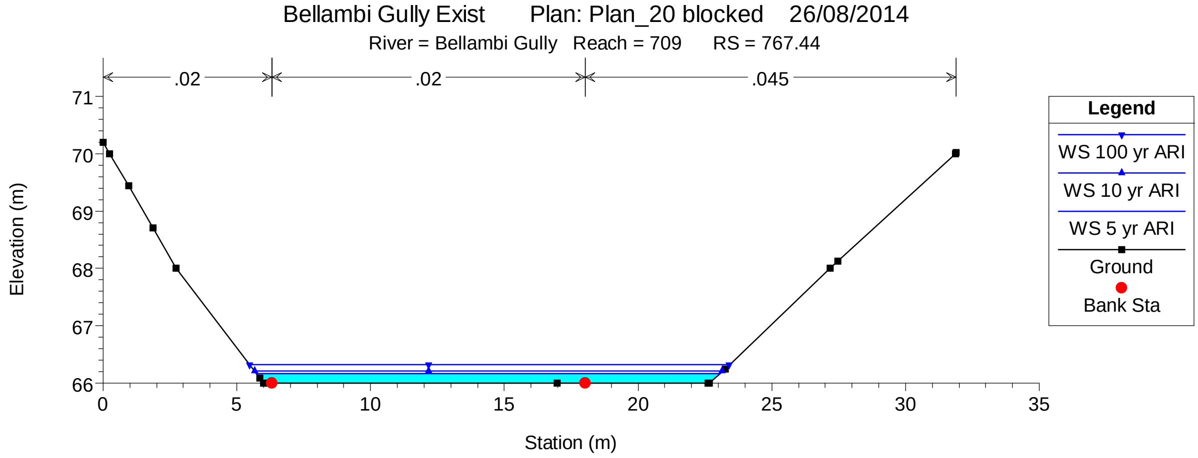

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 709 RS = 869.12
.02
.02
.045
Elevation (m)
68.0
68.5
69.0
69.5
70.0
70.5
Station (m)
0
2
4
6
8
10
12
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

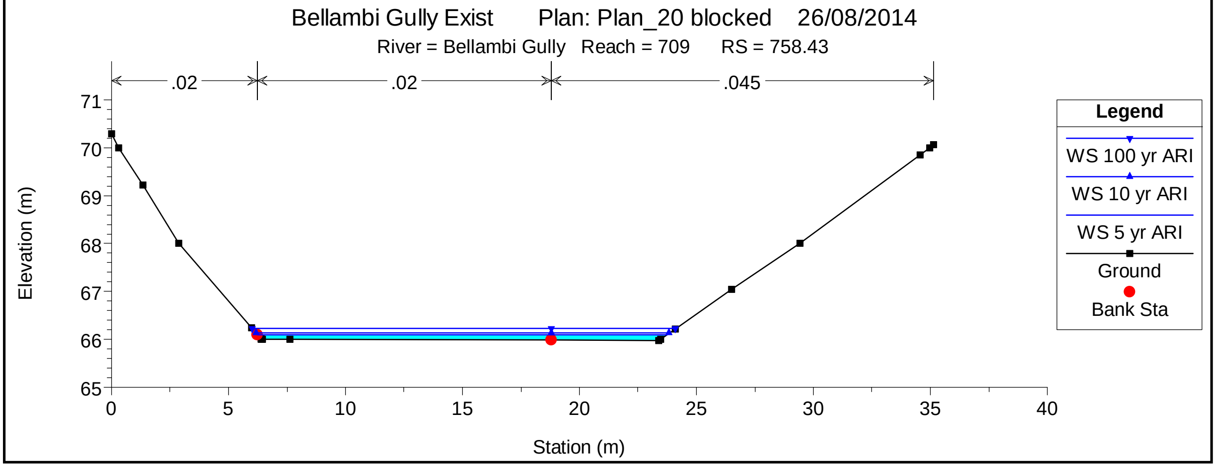

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 709 RS = 853.66
.02
.02
.045
Elevation (m)
64
65
66
67
68
Station (m)
0
10
20
30
40
50
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

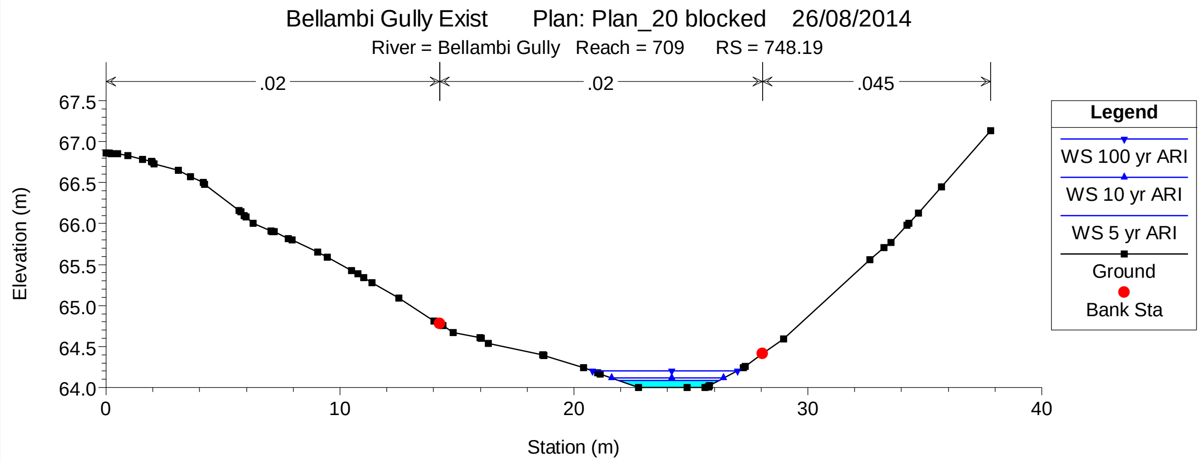

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 709 RS = 838.25
.02
.02
.045
Elevation (m)
64
66
68
70
72
74
76
78
Station (m)
0
10
20
30
40
50
60
70
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

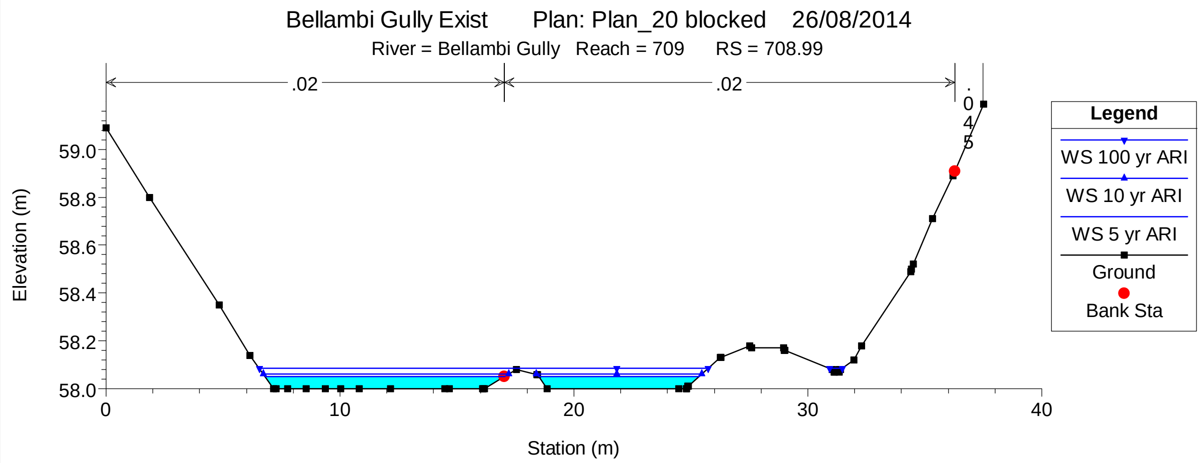

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 709 RS = 820.54
.02
.02
.045
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta
Elevation (m)
Station (m)

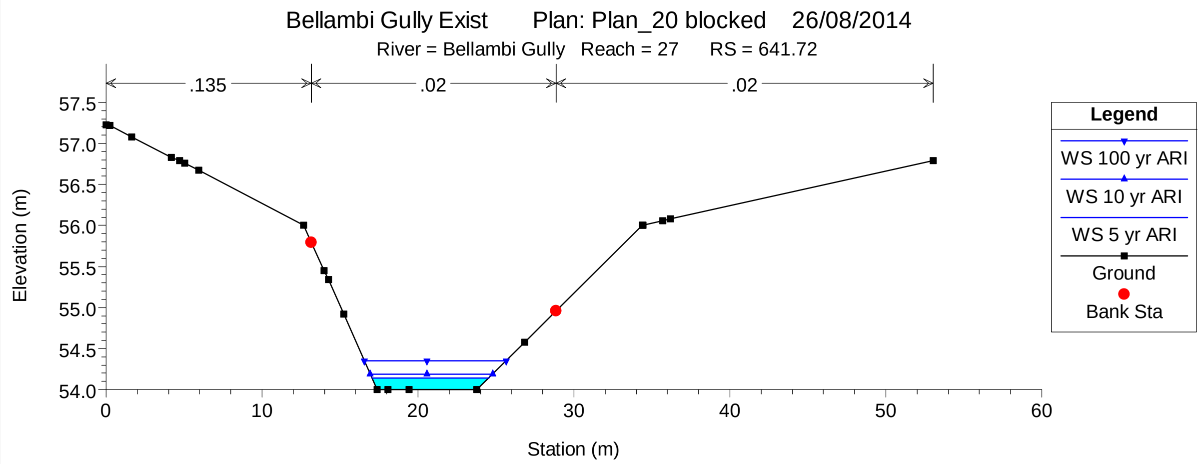

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 709 RS = 776.73
.02
.02
.045
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta
Elevation (m)
Station (m)

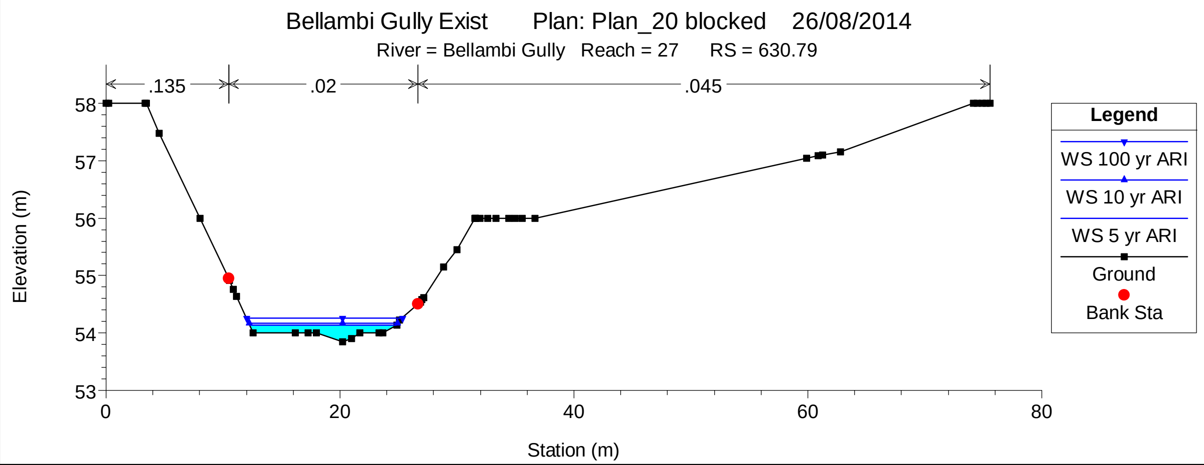

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 709 RS = 767.44
.02
.02
.045
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta
Elevation (m)
Station (m)


Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 709 RS = 758.43
.02
.02
.045
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta
Elevation (m)
Station (m)

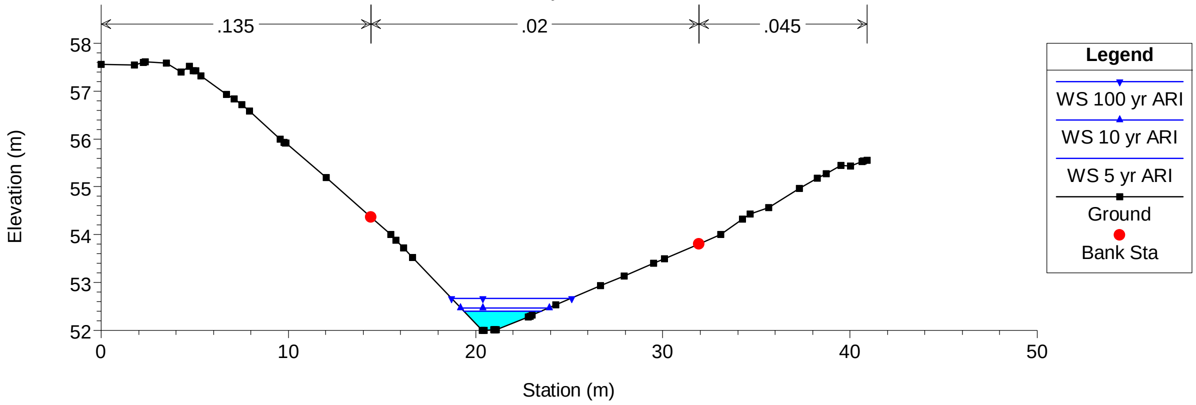

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 709 RS = 748.19
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta


Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 709 RS = 708.99
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

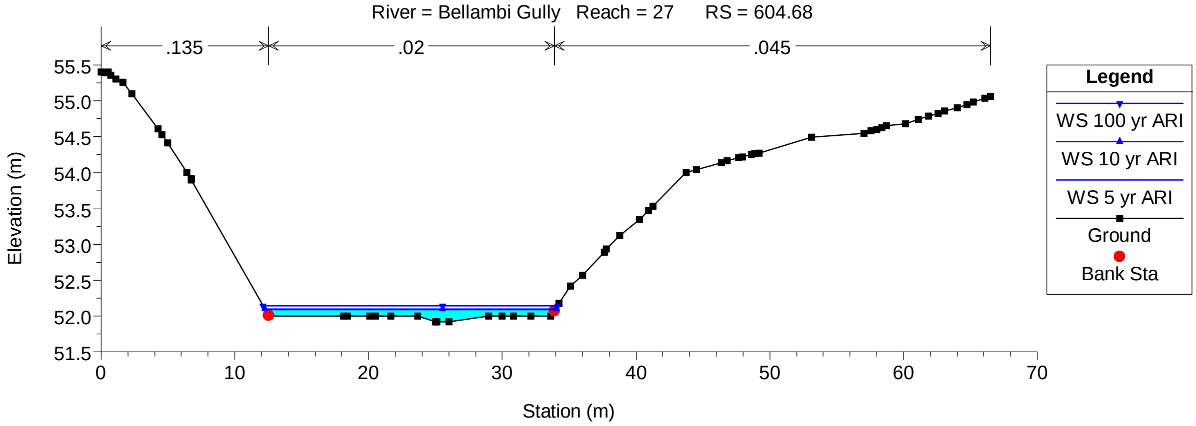

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 641.72
.135
.02
.02
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta


Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 630.79
.135
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

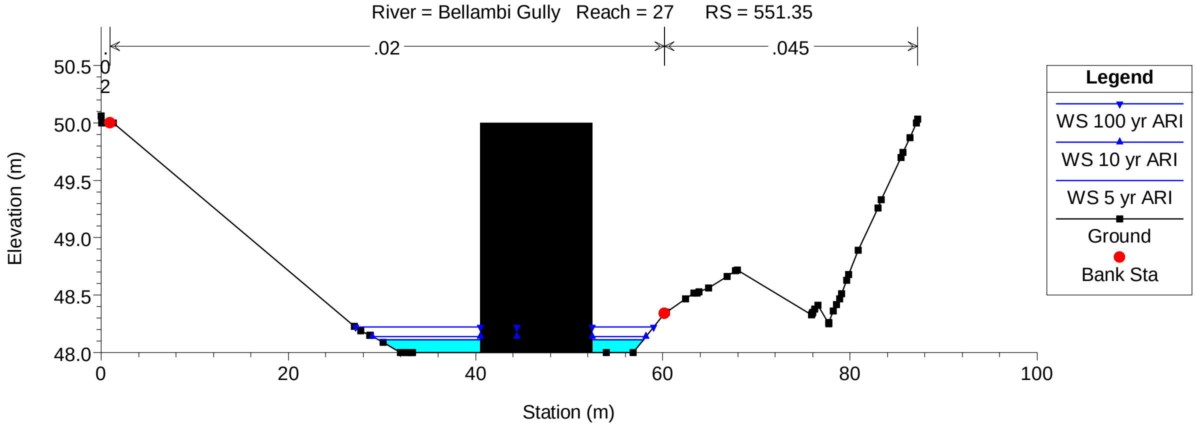
Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 621.04



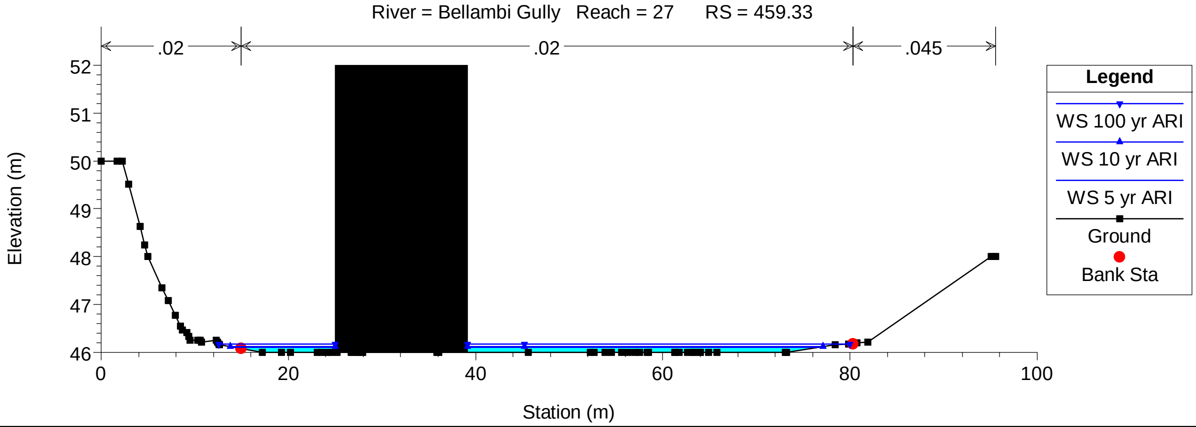
Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 604.68

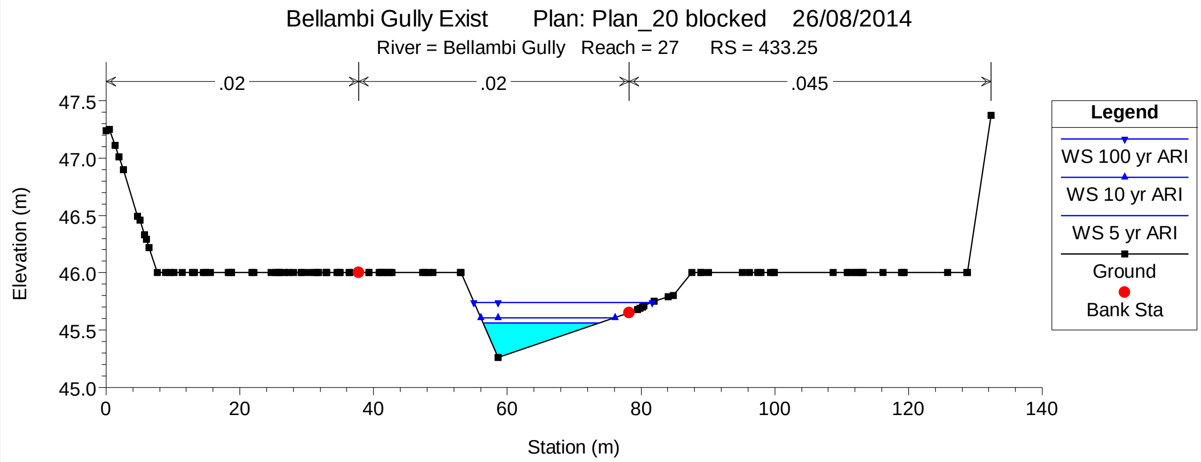


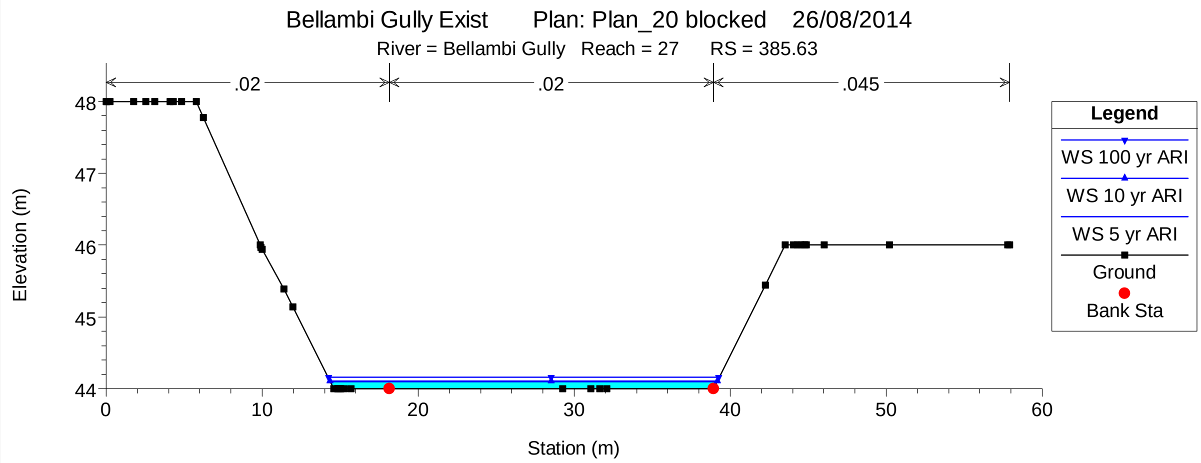
Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 551.35

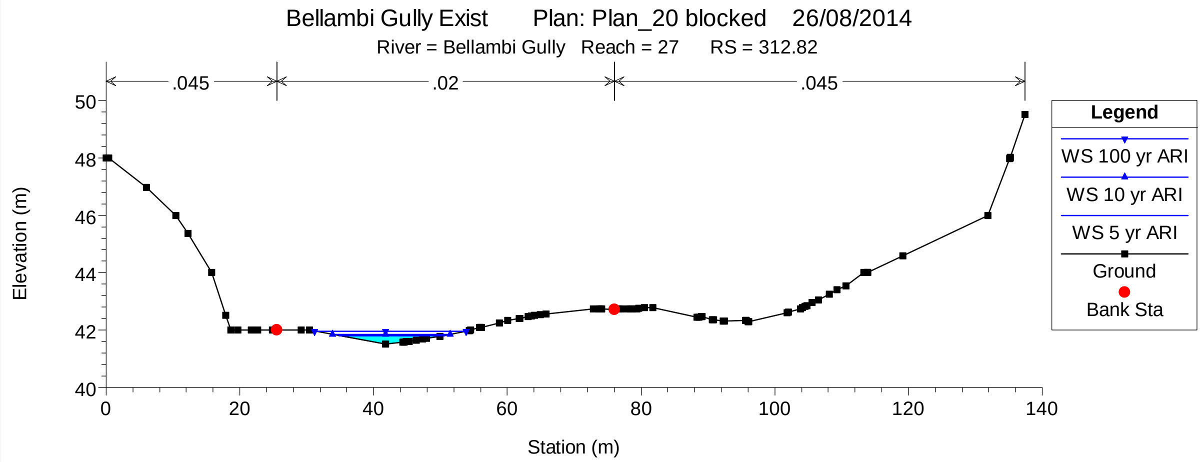


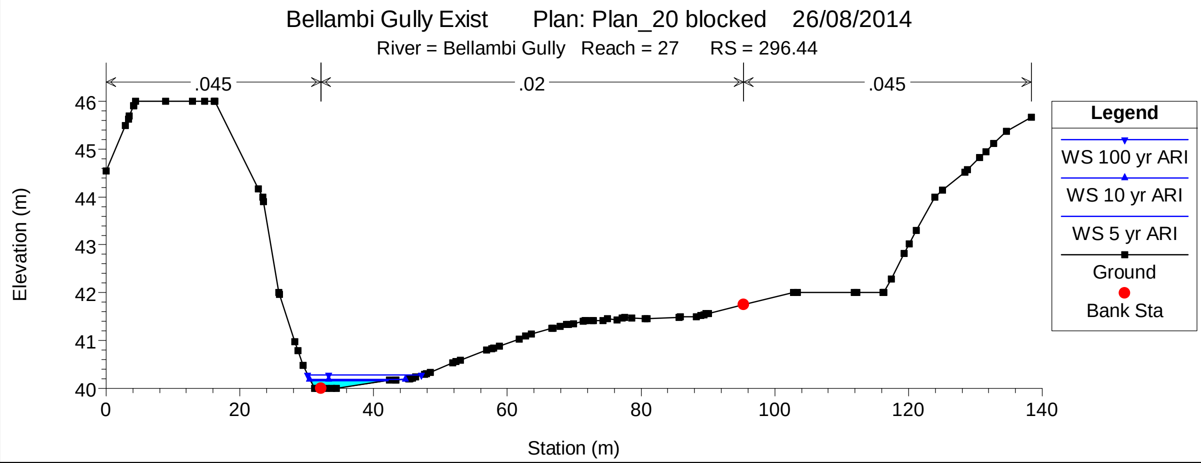
Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 459.33

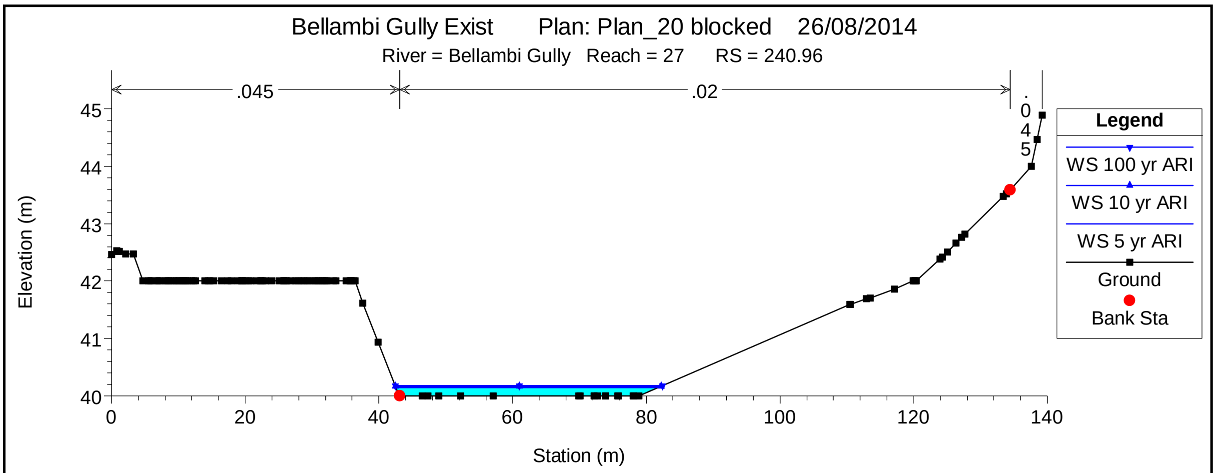


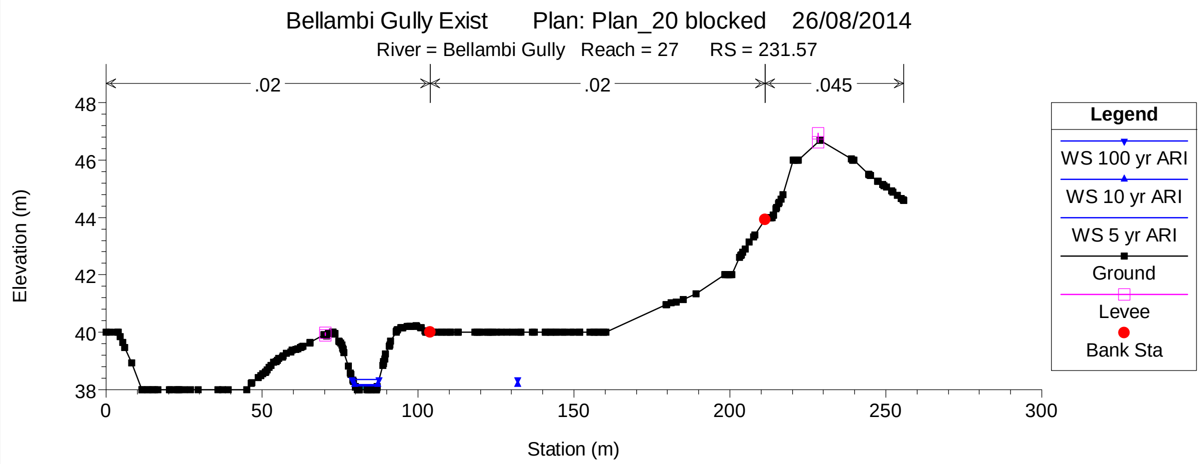

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 433.25
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

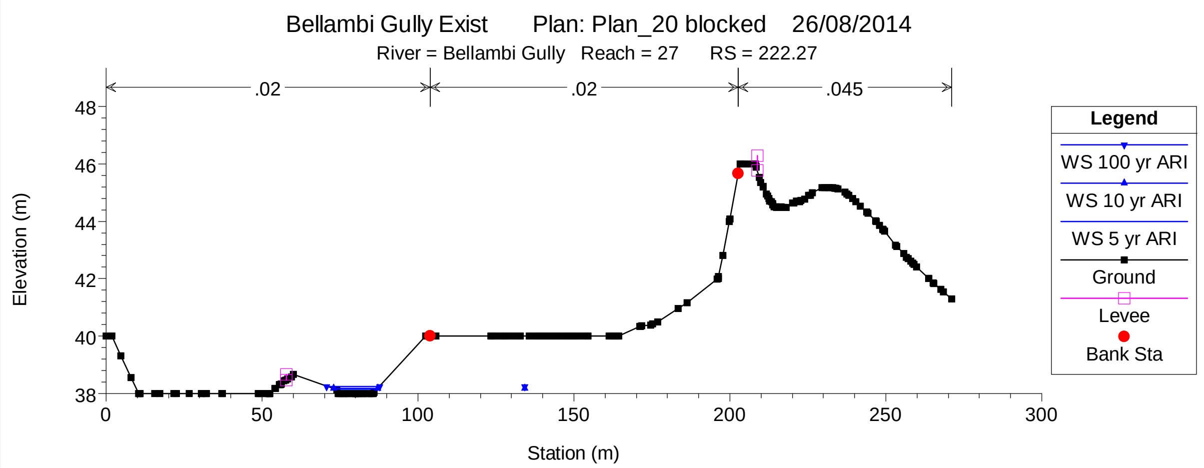

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 385.63
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

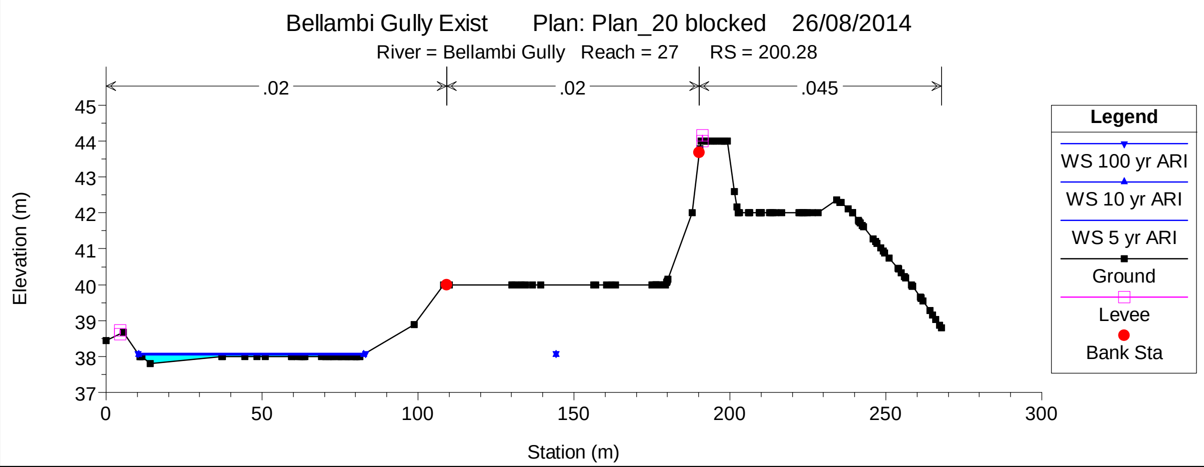

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 312.82
.045
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

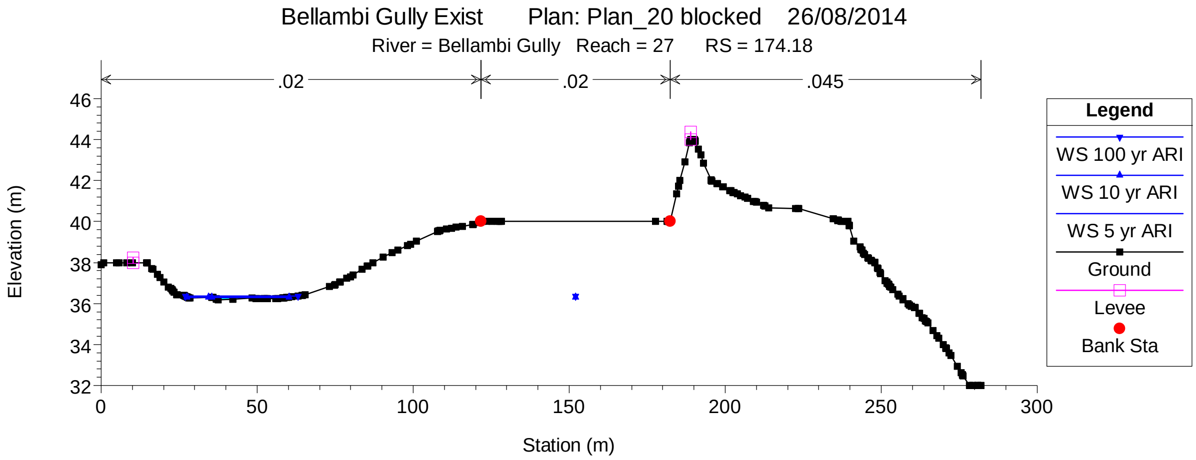

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 296.44
.045
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

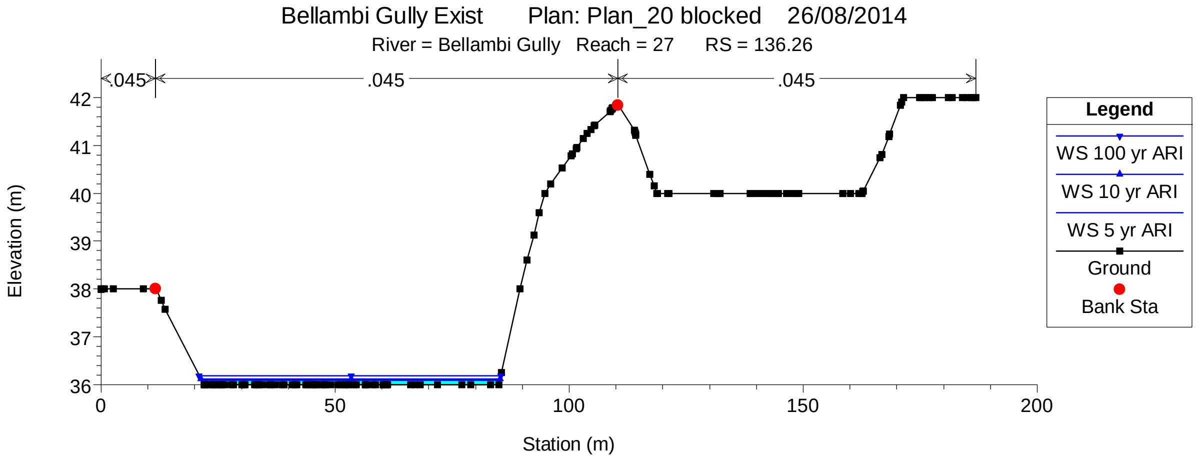

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 240.96
.045
.02
.045
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta
Elevation (m)
Station (m)
40
41
42
43
44
45
0
20
40
60
80
100
120
140

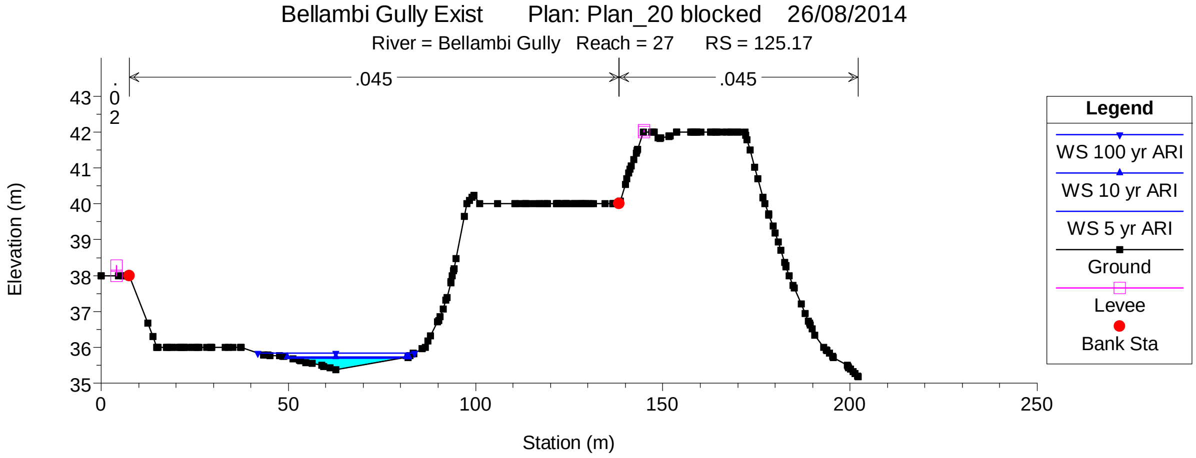

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 231.57
.02
.02
.045
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
38
40
42
44
46
48
0
50
100
150
200
250
300

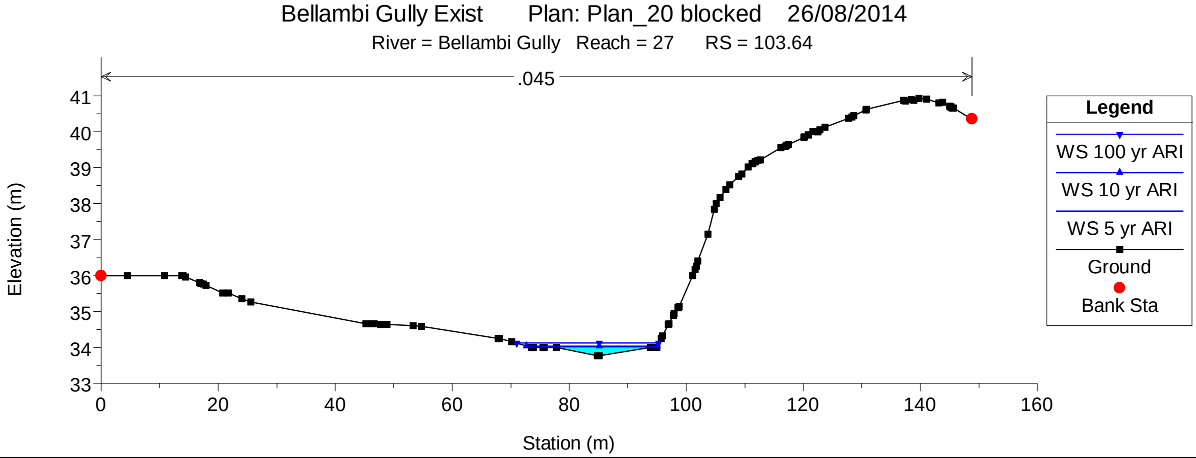

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 222.27
.02
.02
.045
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
38
40
42
44
46
48
0
50
100
150
200
250
300

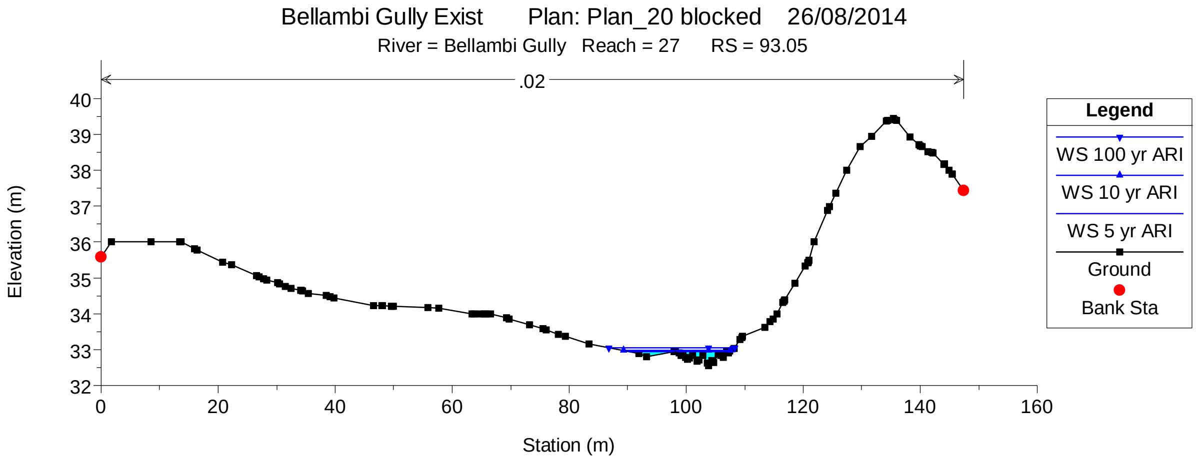

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 200.28
.02
.02
.045
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
37
38
39
40
41
42
43
44
45
0
50
100
150
200
250
300

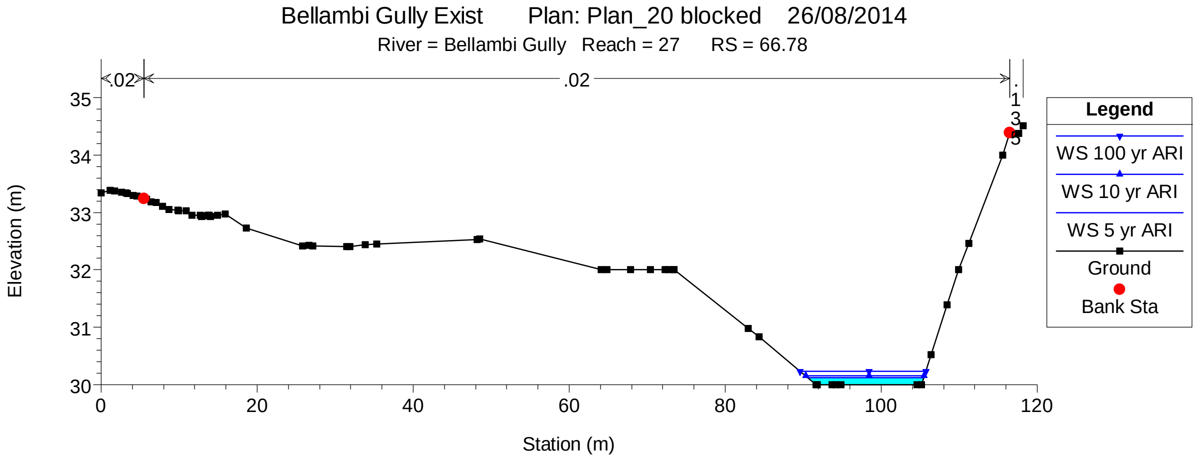

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 174.18
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Levee
Bank Sta

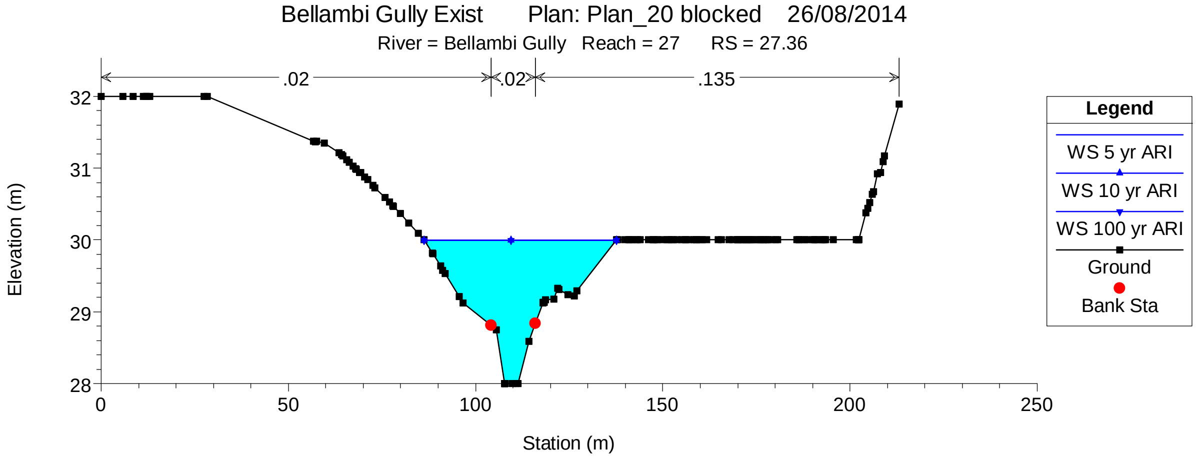

Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 136.26
.045
.045
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta


Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 125.17
.02
.045
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Levee
Bank Sta


Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 103.64
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta


Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 93.05
.02
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta


Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 66.78
.02
.02
.135
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta


Bellambi Gully Exist Plan: Plan_20 blocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 27.36
.02
.02
.135
Elevation (m)
Station (m)
Legend
WS 5 yr ARI
WS 10 yr ARI
WS 100 yr ARI
Ground
Bank Sta

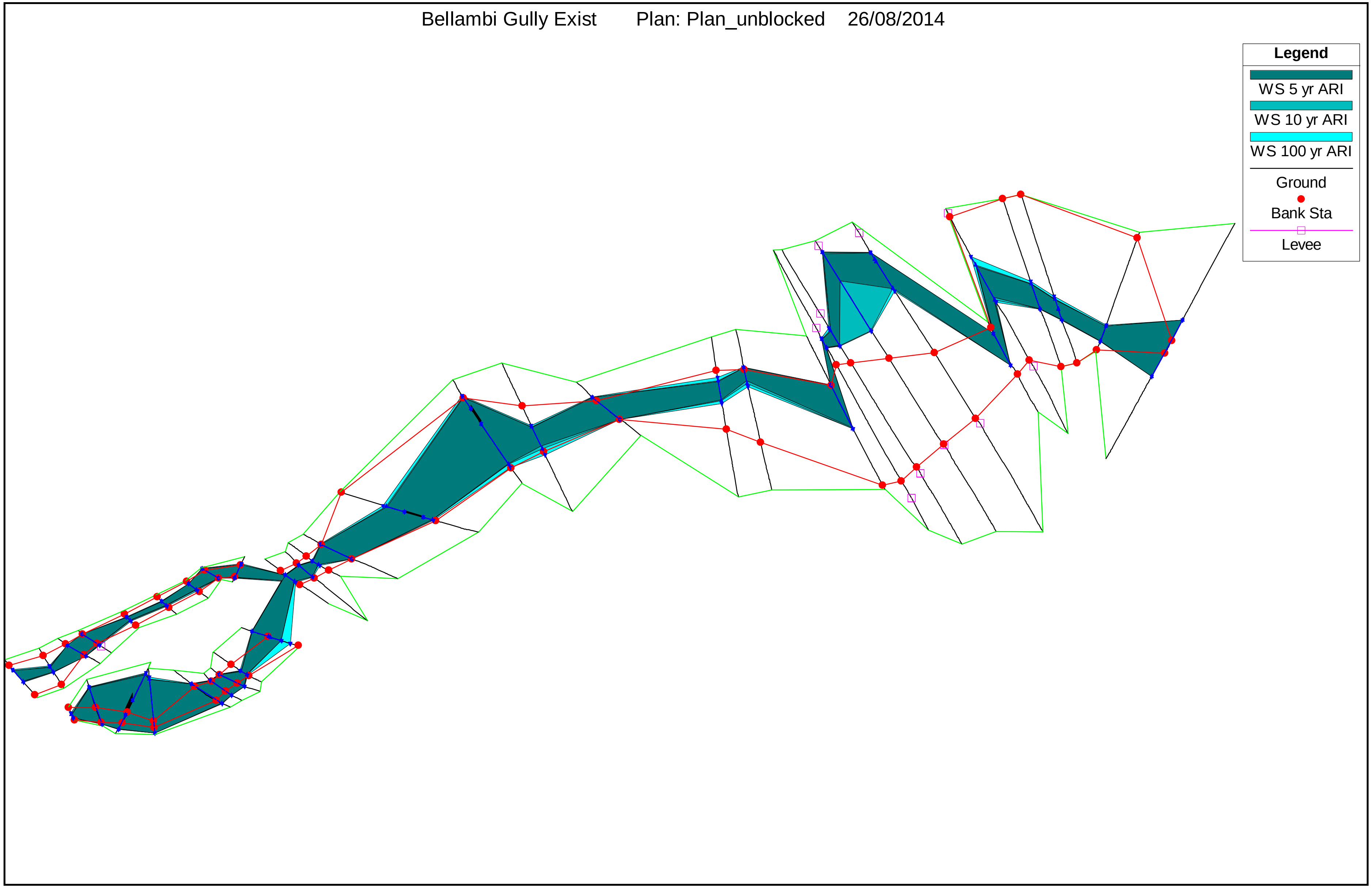
HEC-RAS Plan: 20block

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Hydr Depth
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)
26	193.90	5 yr ARI	3.58	68.83	69.04	69.14	69.43	0.050030	2.76	1.30	0.12
26	193.90	10 yr ARI	4.60	68.83	69.06	69.18	69.52	0.050066	2.99	1.54	0.14
26	193.90	100 yr ARI	9.09	68.83	69.14	69.32	69.84	0.050041	3.71	2.45	0.19
26	173.65	5 yr ARI	3.58	66.23	66.50	66.74	67.83	0.122719	5.12	0.70	0.16
26	173.65	10 yr ARI	4.60	66.23	66.53	66.80	67.96	0.111586	5.30	0.87	0.18
26	173.65	100 yr ARI	9.09	66.23	66.66	67.00	68.41	0.089055	5.87	1.55	0.25
26	151.48	5 yr ARI	3.58	66.00	66.32	66.20	66.36	0.001501	0.89	4.30	0.30
26	151.48	10 yr ARI	4.60	66.00	66.37	66.24	66.42	0.001555	0.99	4.99	0.34
26	151.48	100 yr ARI	9.09	66.00	66.21	66.38	66.80	0.038499	3.44	2.78	0.20
26	138.91	5 yr ARI	3.58	66.00	66.21	66.21	66.32	0.006889	1.46	2.57	0.20
26	138.91	10 yr ARI	4.60	66.00	66.25	66.25	66.37	0.006126	1.56	3.13	0.23
26	138.91	100 yr ARI	9.09	66.00	66.35	66.39	66.59	0.007947	2.20	4.47	0.31
26	109.29	5 yr ARI	3.58	62.00	62.23	62.56	65.38	0.339075	7.86	0.46	0.14
26	109.29	10 yr ARI	4.60	62.00	62.27	62.63	65.51	0.295906	7.97	0.58	0.16
26	109.29	100 yr ARI	9.09	62.00	62.40	62.84	65.65	0.176263	7.99	1.14	0.24
26	84.50	5 yr ARI	3.58	60.00	60.35	60.58	61.37	0.072849	4.46	0.80	0.19
26	84.50	10 yr ARI	4.60	60.00	60.39	60.65	61.58	0.075821	4.83	0.95	0.21
26	84.50	100 yr ARI	9.09	60.00	60.50	60.86	62.30	0.083950	5.95	1.53	0.27
26	62.17	5 yr ARI	3.58	58.38	58.67	58.85	59.49	0.092625	4.02	0.89	0.14
26	62.17	10 yr ARI	4.60	58.38	58.70	58.90	59.64	0.092428	4.30	1.07	0.15
26	62.17	100 yr ARI	9.09	58.38	58.78	59.07	60.25	0.091302	5.36	1.69	0.22
26	45.90	5 yr ARI	3.58	56.00	56.07	56.20	57.04	0.282651	4.39	0.82	0.07
26	45.90	10 yr ARI	4.60	56.00	56.08	56.24	57.24	0.268676	4.78	0.97	0.08
26	45.90	100 yr ARI	9.09	56.00	56.12	56.38	57.96	0.235598	6.04	1.52	0.12
26	25.76	5 yr ARI	3.58	56.00	56.25	56.26	56.37	0.006557	1.51	2.41	0.21
26	25.76	10 yr ARI	4.60	56.00	56.27	56.30	56.43	0.008378	1.79	2.61	0.22
26	25.76	100 yr ARI	9.09	56.00	56.33	56.46	56.73	0.015097	2.80	3.37	0.27
709	869.12	5 yr ARI	1.72	68.43	68.79	68.95	69.39	0.050041	3.43	0.50	0.18
709	869.12	10 yr ARI	2.48	68.43	68.84	69.03	69.56	0.050044	3.77	0.66	0.20
709	869.12	100 yr ARI	5.41	68.43	68.98	69.25	70.05	0.050064	4.59	1.18	0.27
709	853.66	5 yr ARI	1.72	64.00	66.20	64.12	66.20	0.000000	0.04	47.86	1.50
709	853.66	10 yr ARI	2.48	64.00	66.24	64.15	66.24	0.000001	0.06	49.38	1.53
709	853.66	100 yr ARI	5.41	64.00	66.39	64.26	66.39	0.000002	0.12	54.09	1.64
709	838.25	5 yr ARI	1.72	64.00	66.20		66.20	0.000002	0.10	28.20	0.79
709	838.25	10 yr ARI	2.48	64.00	66.24		66.24	0.000004	0.13	29.91	0.82
709	838.25	100 yr ARI	5.41	64.00	66.39		66.39	0.000012	0.25	35.20	0.94
709	820.54	5 yr ARI	1.72	64.00	66.19		66.20	0.000002	0.11	27.47	0.60
709	820.54	10 yr ARI	2.48	64.00	66.24		66.24	0.000003	0.15	29.64	0.64
709	820.54	100 yr ARI	5.41	64.00	66.39		66.39	0.000010	0.27	36.39	0.76
709	776.73	5 yr ARI	1.72	64.01	66.19		66.20	0.000001	0.06	30.34	1.27
709	776.73	10 yr ARI	2.48	64.01	66.24		66.24	0.000002	0.09	31.47	1.31
709	776.73	100 yr ARI	5.41	64.01	66.39		66.39	0.000006	0.17	34.96	1.41
709	767.44	5 yr ARI	1.72	66.00	66.17		66.19	0.002145	0.71	2.90	0.17
709	767.44	10 yr ARI	2.48	66.00	66.21		66.24	0.002280	0.84	3.56	0.20
709	767.44	100 yr ARI	5.41	66.00	66.32		66.38	0.002639	1.20	5.50	0.31
709	758.43	5 yr ARI	1.72	65.99	66.10	66.10	66.15	0.010115	1.11	1.85	0.11
709	758.43	10 yr ARI	2.48	65.99	66.13	66.13	66.20	0.009045	1.24	2.38	0.13
709	758.43	100 yr ARI	5.41	65.99	66.22	66.22	66.34	0.007387	1.60	4.06	0.22
709	748.19	5 yr ARI	1.72	64.00	64.09	64.26	65.69	0.430529	5.61	0.31	0.07
709	748.19	10 yr ARI	2.48	64.00	64.11	64.31	65.77	0.319950	5.70	0.44	0.09
709	748.19	100 yr ARI	5.41	64.00	64.20	64.47	65.96	0.176676	5.88	0.92	0.15
709	708.99	5 yr ARI	1.72	58.00	58.05	58.11	58.28	0.102314	2.10	0.82	0.05
709	708.99	10 yr ARI	2.48	58.00	58.06	58.14	58.39	0.119898	2.47	0.98	0.06
709	708.99	100 yr ARI	5.41	58.00	58.08	58.21	58.82	0.185242	3.44	1.43	0.07
27	641.72	5 yr ARI	5.30	54.00	54.14	54.38	55.60	0.171448	5.35	0.99	0.13
27	641.72	10 yr ARI	7.08	54.00	54.19	54.45	55.61	0.118479	5.28	1.34	0.17
27	641.72	100 yr ARI	14.50	54.00	54.35	54.69	55.82	0.058963	5.37	2.70	0.30
27	630.79	5 yr ARI	5.30	53.85	54.14	54.25	54.52	0.037012	2.75	1.93	0.15
27	630.79	10 yr ARI	7.08	53.85	54.17	54.30	54.65	0.037720	3.09	2.29	0.18

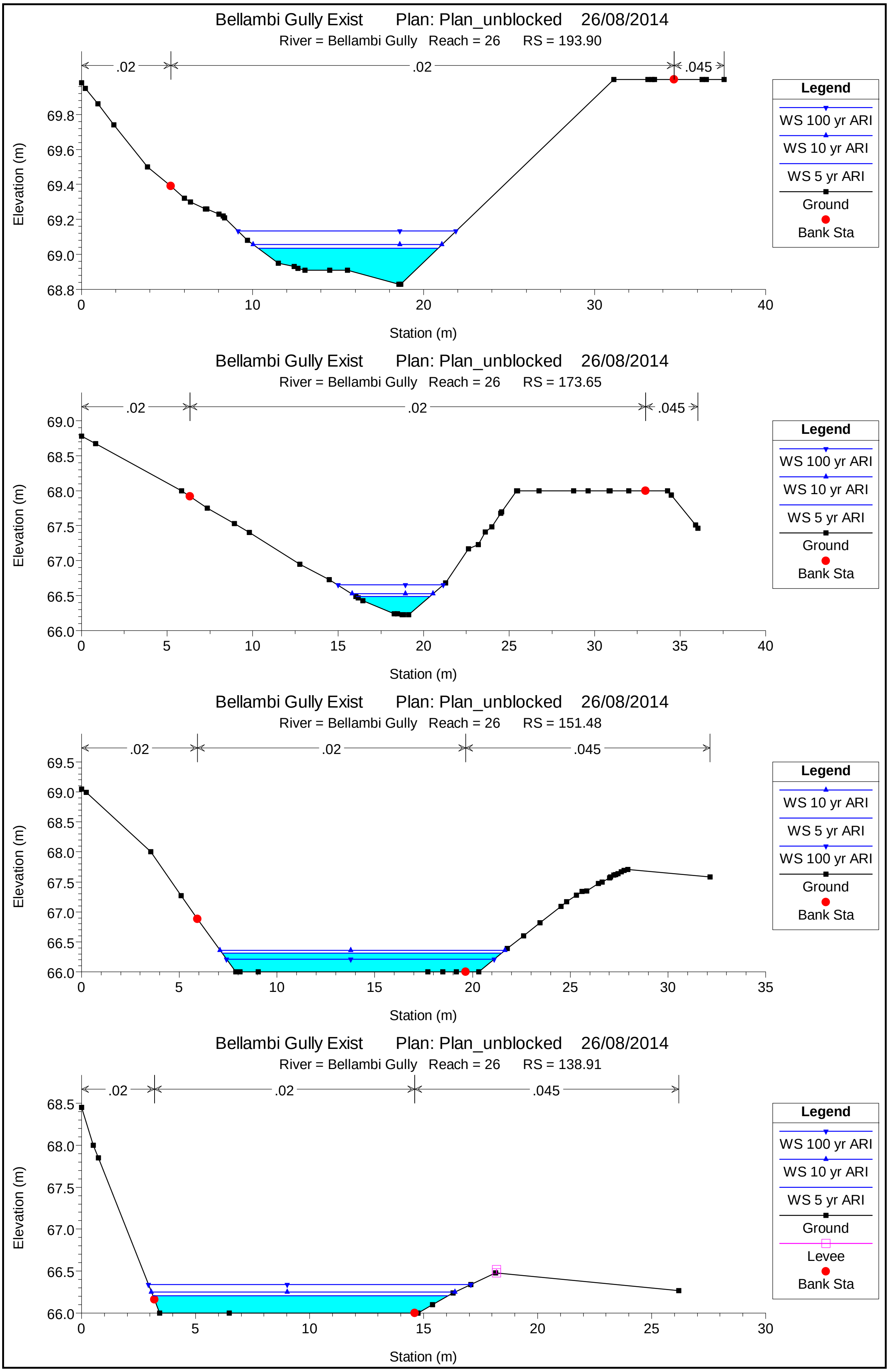
HEC-RAS Plan: 20block (Continued)

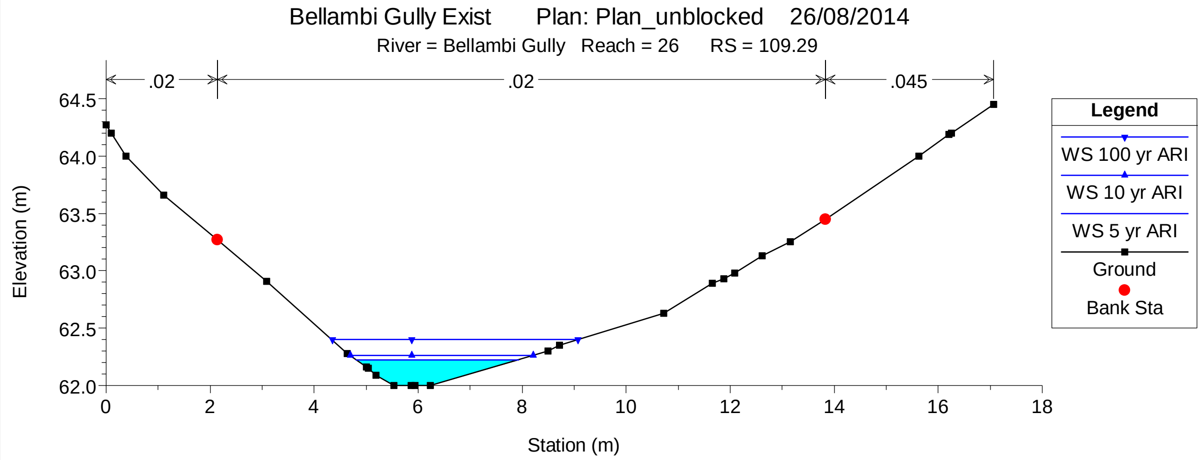
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Hydr Depth
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)
27	630.79	100 yr ARI	14.50	53.85	54.26	54.49	55.12	0.039578	4.09	3.54	0.27
27	621.04	5 yr ARI	5.30	52.00	52.40	52.72	53.90	0.083871	5.41	0.98	0.23
27	621.04	10 yr ARI	7.08	52.00	52.47	52.81	54.05	0.074143	5.57	1.27	0.27
27	621.04	100 yr ARI	14.50	52.00	52.67	53.11	54.55	0.057382	6.08	2.39	0.37
27	604.68	5 yr ARI	5.30	51.92	52.09	52.17	52.42	0.058724	2.56	2.08	0.10
27	604.68	10 yr ARI	7.08	51.92	52.10	52.21	52.56	0.067605	3.00	2.38	0.11
27	604.68	100 yr ARI	14.50	51.92	52.14	52.35	53.11	0.091387	4.37	3.35	0.15
27	551.35	5 yr ARI	5.30	48.00	48.11	48.23	48.63	0.086963	3.18	1.67	0.10
27	551.35	10 yr ARI	7.08	48.00	48.14	48.28	48.72	0.076743	3.36	2.10	0.12
27	551.35	100 yr ARI	14.50	48.00	48.22	48.42	49.03	0.063627	4.00	3.63	0.18
27	459.33	5 yr ARI	5.30	46.00	46.10	46.11	46.17	0.011831	1.15	4.63	0.10
27	459.33	10 yr ARI	7.08	46.00	46.12	46.14	46.21	0.012630	1.31	5.43	0.11
27	459.33	100 yr ARI	14.50	46.00	46.17	46.22	46.34	0.015071	1.79	8.18	0.15
27	433.25	5 yr ARI	5.30	45.26	45.56	45.63	45.77	0.020119	2.01	2.64	0.15
27	433.25	10 yr ARI	7.08	45.26	45.61	45.67	45.82	0.017003	2.03	3.49	0.17
27	433.25	100 yr ARI	14.50	45.26	45.74	45.81	45.99	0.010850	2.23	6.65	0.25
27	385.63	5 yr ARI	5.30	44.00	44.10	44.17	44.36	0.047300	2.27	2.35	0.09
27	385.63	10 yr ARI	7.08	44.00	44.11	44.20	44.47	0.053817	2.65	2.69	0.11
27	385.63	100 yr ARI	14.50	44.00	44.16	44.33	44.88	0.068267	3.80	3.86	0.15
27	312.82	5 yr ARI	5.30	41.52	41.81	41.89	42.05	0.022389	2.16	2.45	0.16
27	312.82	10 yr ARI	7.08	41.52	41.85	41.94	42.12	0.020901	2.28	3.11	0.18
27	312.82	100 yr ARI	14.50	41.52	41.97	42.09	42.34	0.019680	2.69	5.38	0.24
27	296.44	5 yr ARI	5.30	40.00	40.17	40.33	41.18	0.178800	4.63	1.25	0.11
27	296.44	10 yr ARI	7.08	40.00	40.19	40.38	41.28	0.183063	4.78	1.60	0.11
27	296.44	100 yr ARI	14.50	40.00	40.28	40.54	41.59	0.116120	5.23	2.98	0.17
27	240.96	5 yr ARI	5.30	40.00	40.14	40.13	40.19	0.005797	1.01	5.29	0.14
27	240.96	10 yr ARI	7.08	40.00	40.17	40.17	40.23	0.005382	1.10	6.49	0.16
27	240.96	100 yr ARI	14.50	40.00	40.18	40.25	40.41	0.019383	2.15	6.80	0.17
27	231.57	5 yr ARI	5.30	40.00	38.14	38.39	39.73	0.188640		0.95	0.13
27	231.57	10 yr ARI	7.08	40.00	38.18	38.46	39.85	0.146789		1.23	0.16
27	231.57	100 yr ARI	14.50	40.00	38.36	38.72	39.85	0.056404		2.68	0.31
27	222.27	5 yr ARI	5.30	40.00	38.15	38.27	38.61	0.053661		1.76	0.13
27	222.27	10 yr ARI	7.08	40.00	38.17	38.32	38.76	0.060023		2.08	0.15
27	222.27	100 yr ARI	14.50	40.00	38.26	38.48	39.17	0.060834		3.43	0.20
27	200.28	5 yr ARI	5.30	40.00	38.05	38.05	38.09	0.008308		6.06	0.08
27	200.28	10 yr ARI	7.08	40.00	38.06	38.07	38.12	0.011087		6.62	0.09
27	200.28	100 yr ARI	14.50	40.00	38.09	38.12	38.23	0.019257		8.66	0.12
27	174.18	5 yr ARI	5.30	40.00	36.29	36.39	37.31	0.436637		1.19	0.05
27	174.18	10 yr ARI	7.08	40.00	36.31	36.42	37.20	0.294531		1.69	0.05
27	174.18	100 yr ARI	14.50	40.00	36.37	36.51	37.12	0.119257		3.78	0.10
27	136.26	5 yr ARI	5.30	36.00	36.10	36.09	36.14	0.031770	0.84	6.28	0.10
27	136.26	10 yr ARI	7.08	36.00	36.12	36.11	36.16	0.027507	0.91	7.81	0.12
27	136.26	100 yr ARI	14.50	36.00	36.19	36.17	36.26	0.025537	1.18	12.32	0.19
27	125.17	5 yr ARI	5.30	35.38	35.69	35.69	35.76	0.036826	1.21	4.37	0.15
27	125.17	10 yr ARI	7.08	35.38	35.72	35.72	35.81	0.036059	1.30	5.45	0.17
27	125.17	100 yr ARI	14.50	35.38	35.84	35.84	35.95	0.031962	1.50	9.68	0.23
27	103.64	5 yr ARI	5.30	33.76	34.02	34.10	34.29	0.214165	2.30	2.31	0.11
27	103.64	10 yr ARI	7.08	33.76	34.04	34.13	34.36	0.203872	2.52	2.81	0.13
27	103.64	100 yr ARI	14.50	33.76	34.11	34.26	34.63	0.191088	3.18	4.55	0.19
27	93.05	5 yr ARI	5.30	32.56	32.94	33.06	33.31	0.050775	2.69	1.97	0.12
27	93.05	10 yr ARI	7.08	32.56	32.97	33.09	33.40	0.050237	2.91	2.43	0.13
27	93.05	100 yr ARI	14.50	32.56	33.05	33.22	33.71	0.048446	3.59	4.04	0.19
27	66.78	5 yr ARI	5.30	30.00	30.13	30.24	30.57	0.058172	2.94	1.80	0.12
27	66.78	10 yr ARI	7.08	30.00	30.15	30.29	30.69	0.057089	3.26	2.17	0.14
27	66.78	100 yr ARI	14.50	30.00	30.24	30.46	31.11	0.053451	4.15	3.49	0.22
27	27.36	5 yr ARI	5.30	28.00	30.00	28.49	30.00	0.000008	0.19	44.69	0.87
27	27.36	10 yr ARI	7.08	28.00	30.00	28.58	30.00	0.000014	0.26	44.69	0.87
27	27.36	100 yr ARI	14.50	28.00	30.00	28.87	30.01	0.000058	0.53	44.69	0.87

Plan View Scenario 3



Cross Sections

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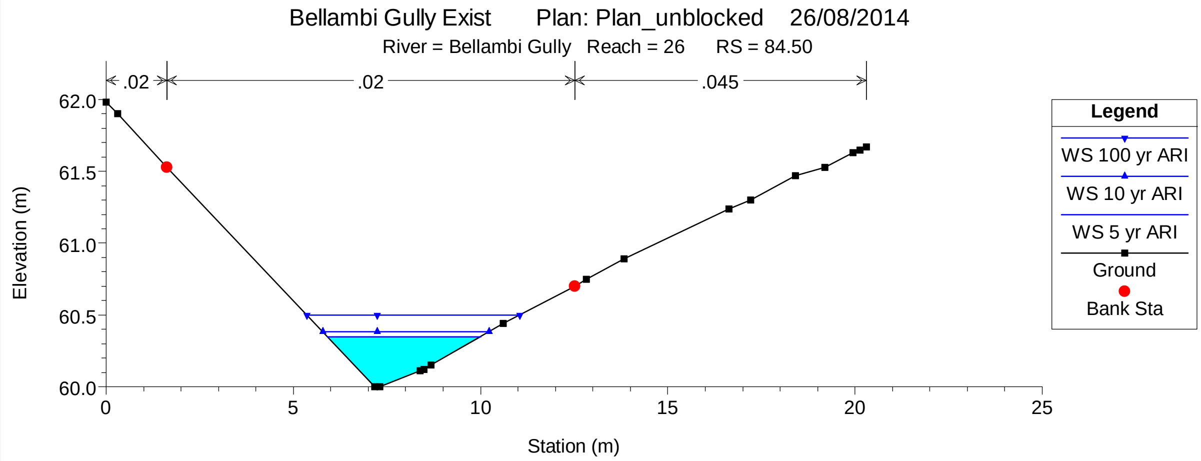
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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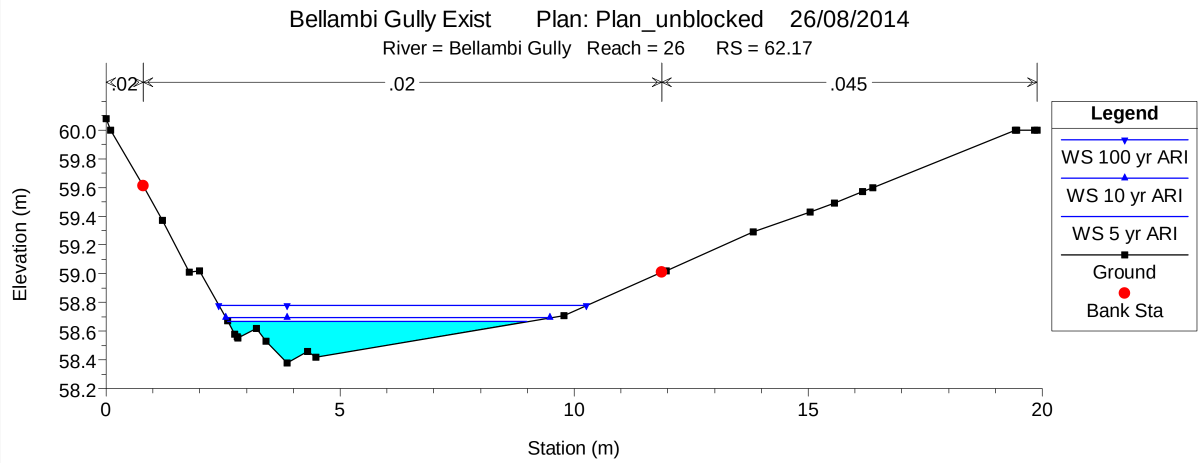
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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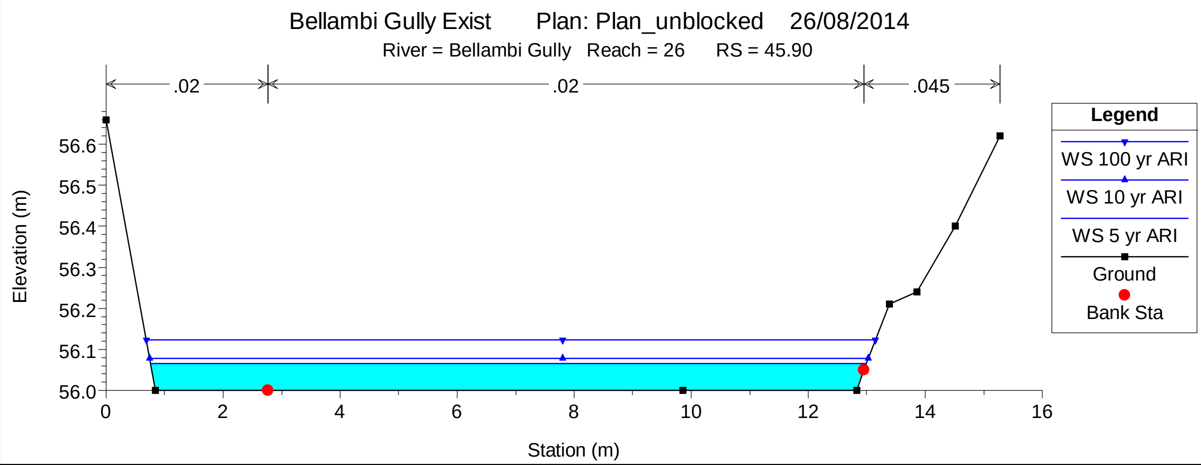
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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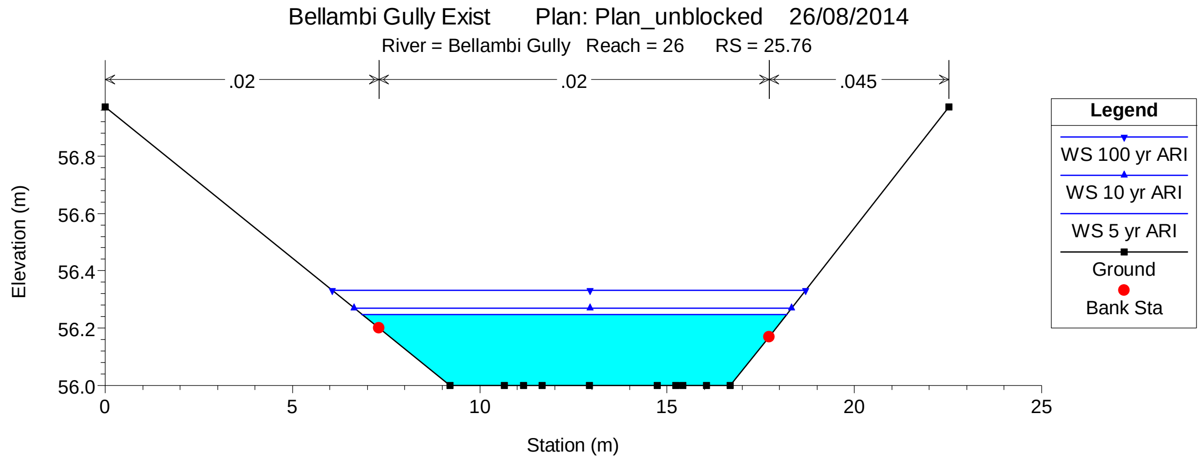
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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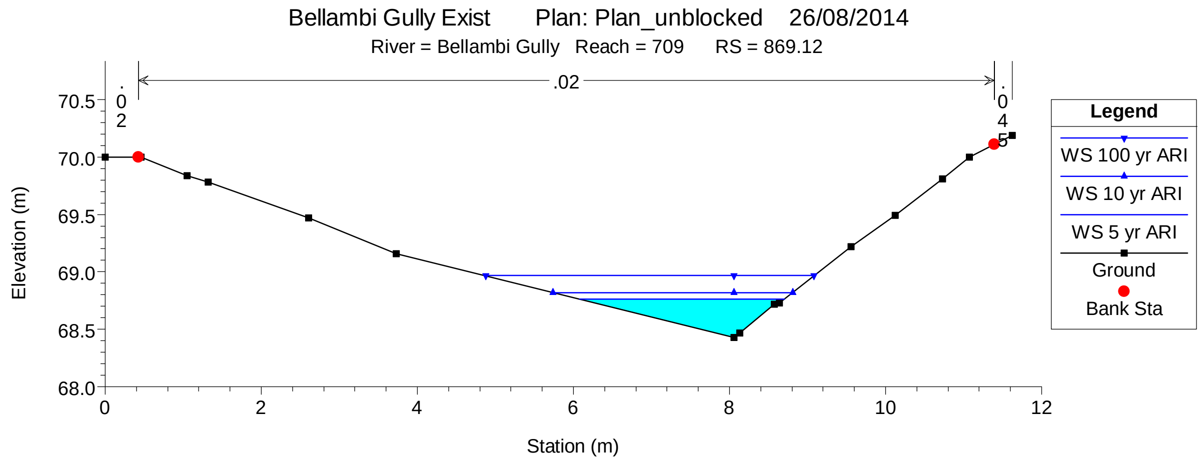
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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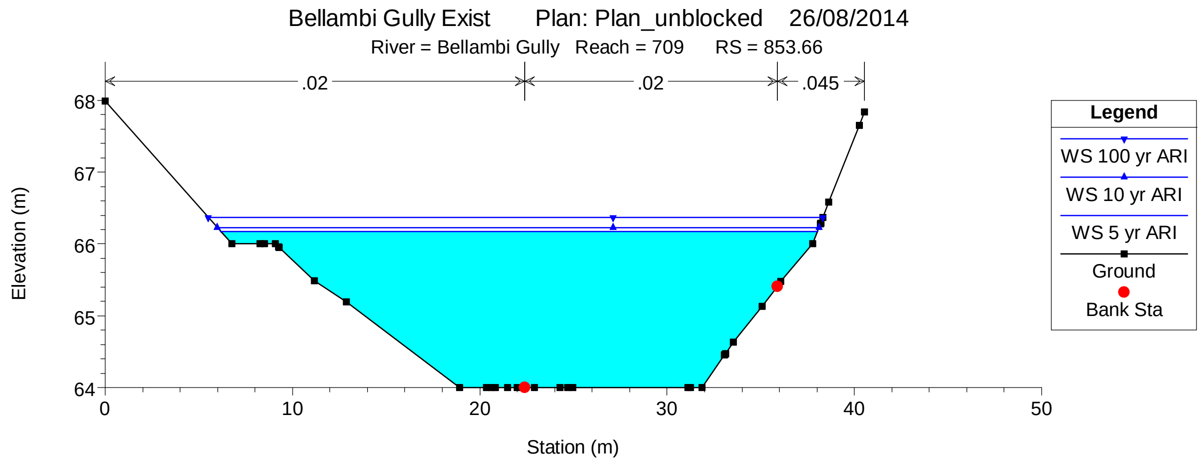
.02
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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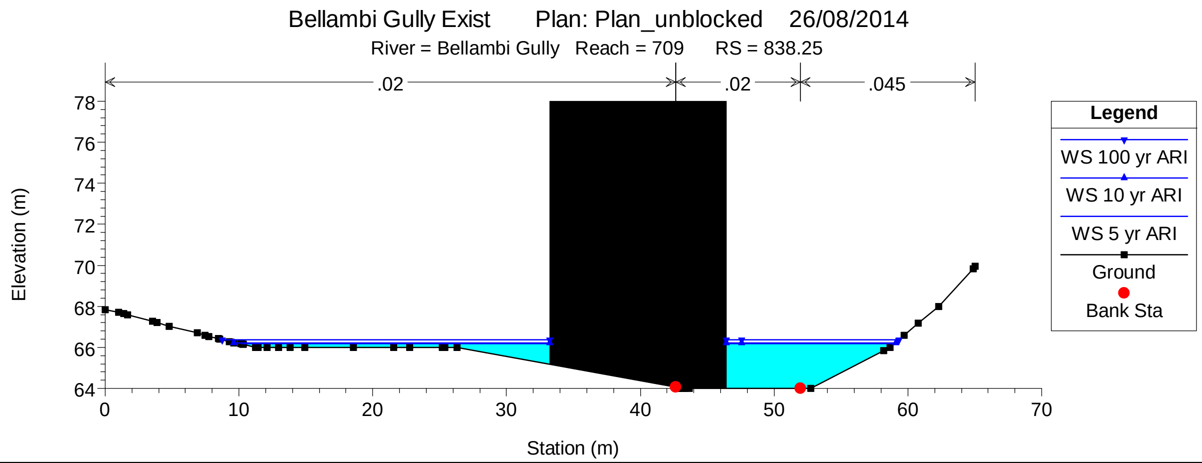
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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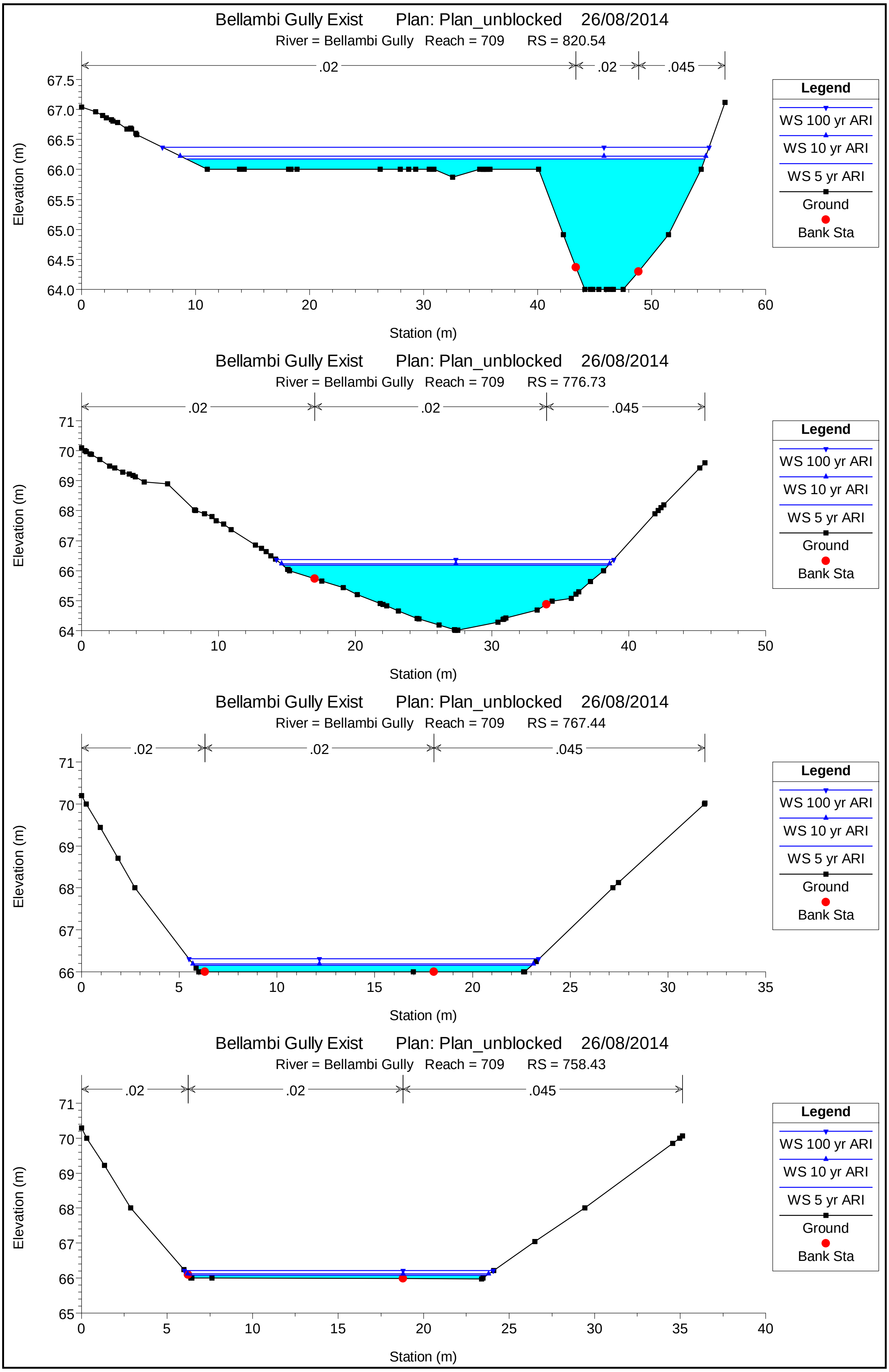
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta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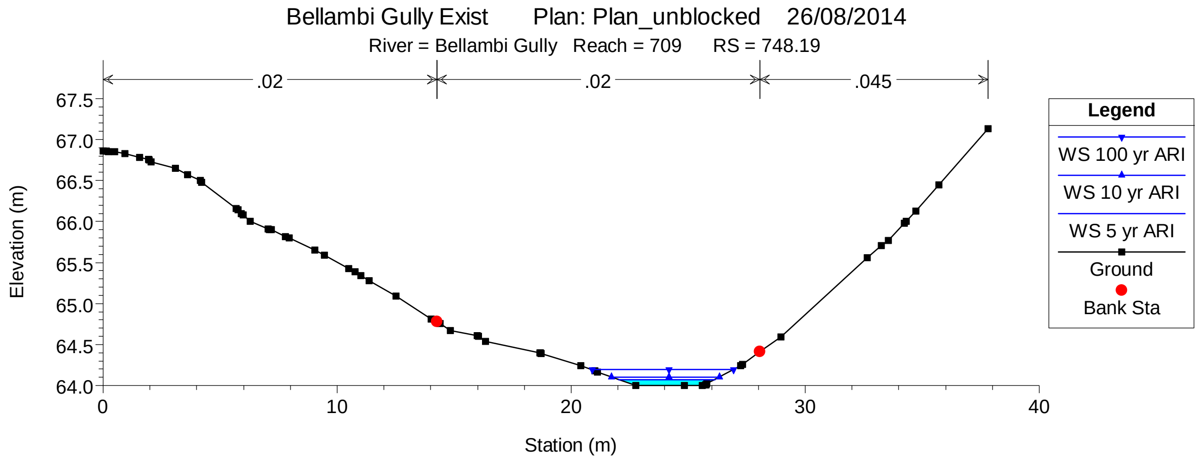
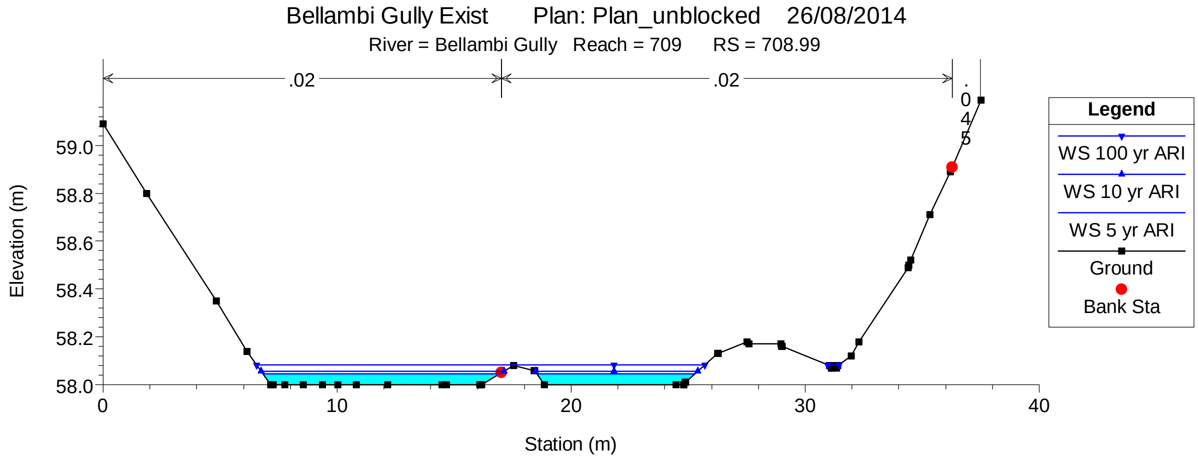
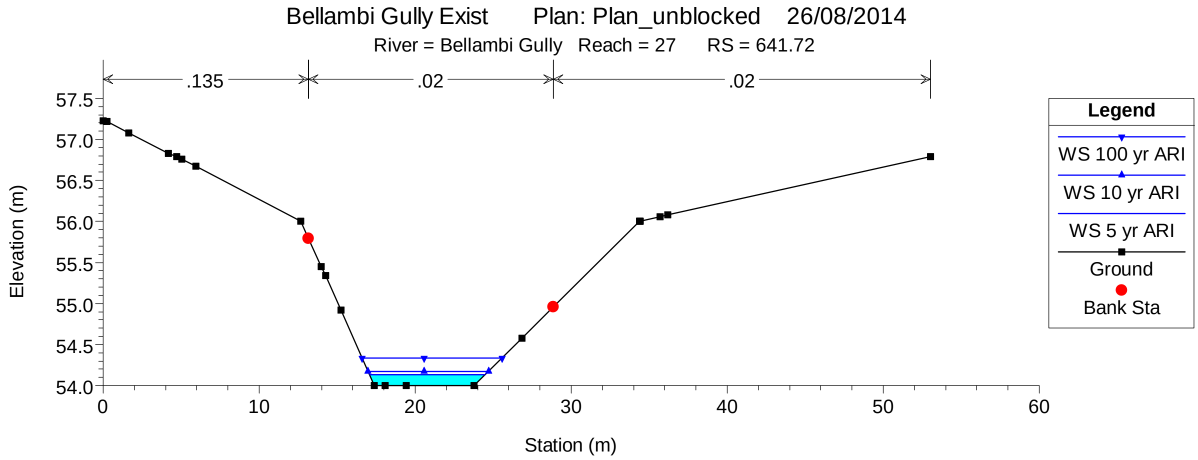
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta
Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 709 RS = 776.73
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta
Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 709 RS = 767.44
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta
Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 709 RS = 758.43
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta



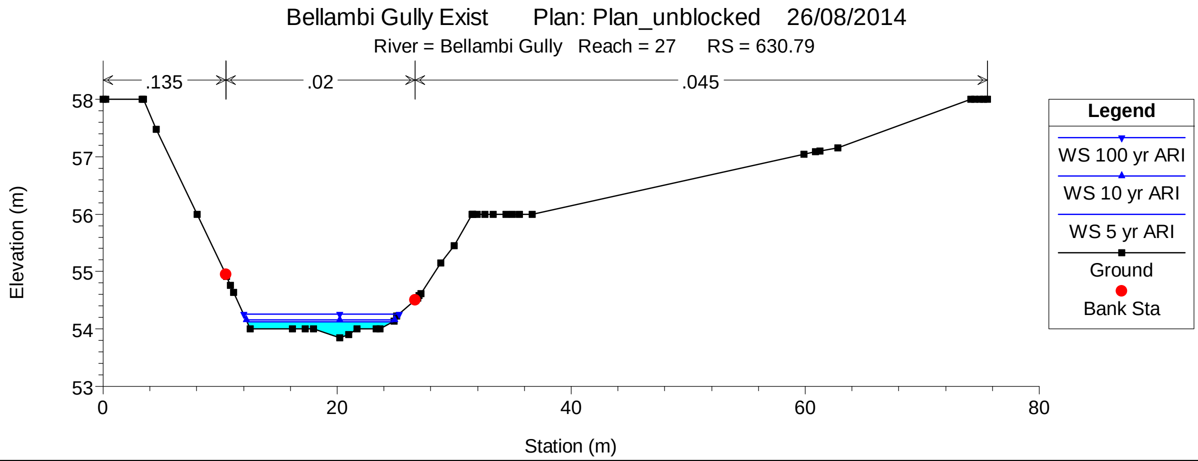
Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 709 RS = 748.19
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta



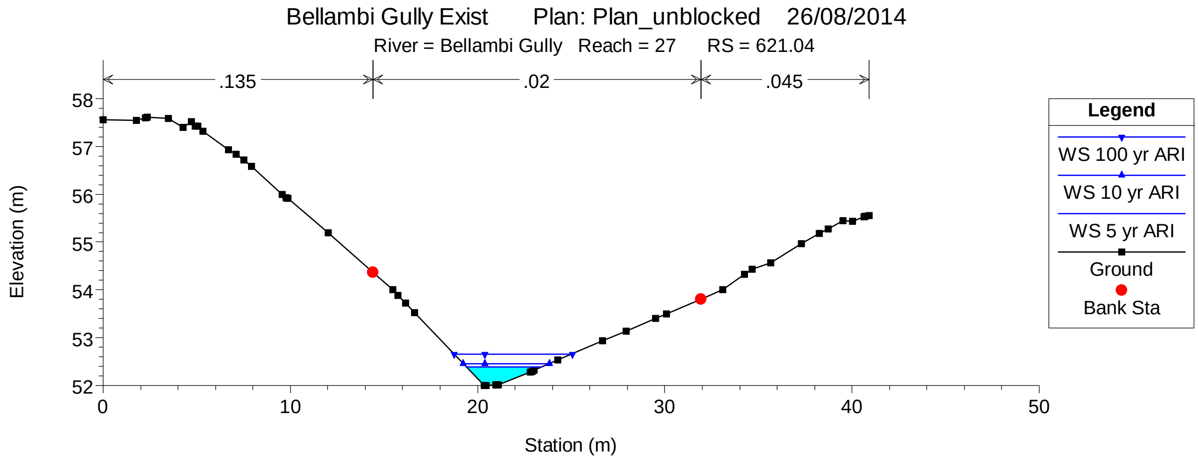
Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 709 RS = 708.99
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

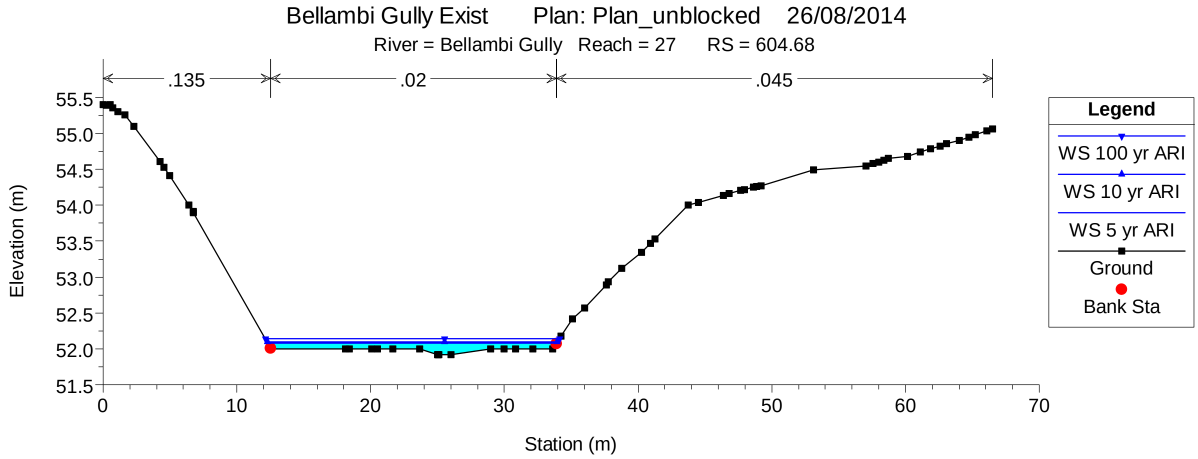


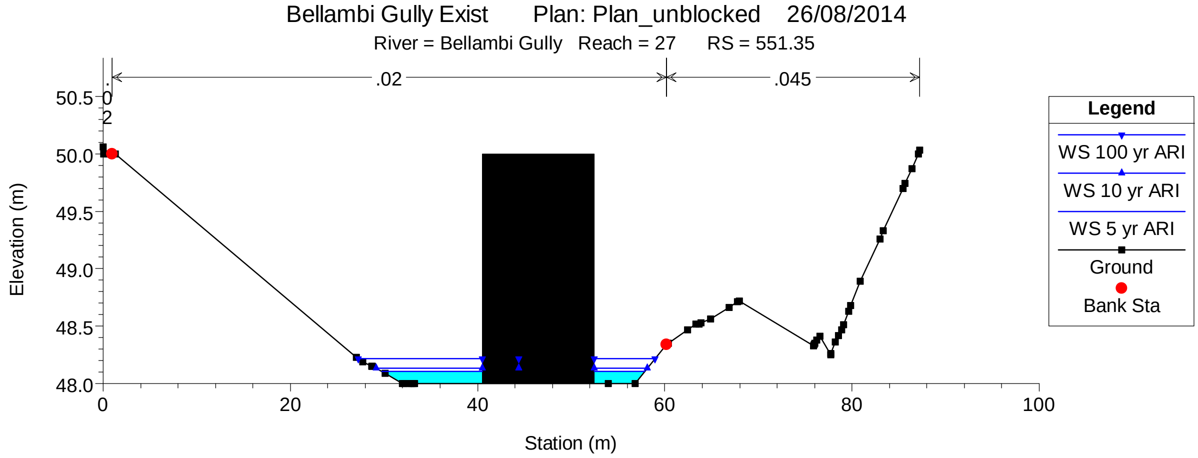
Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 641.72
.135
.02
.02
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

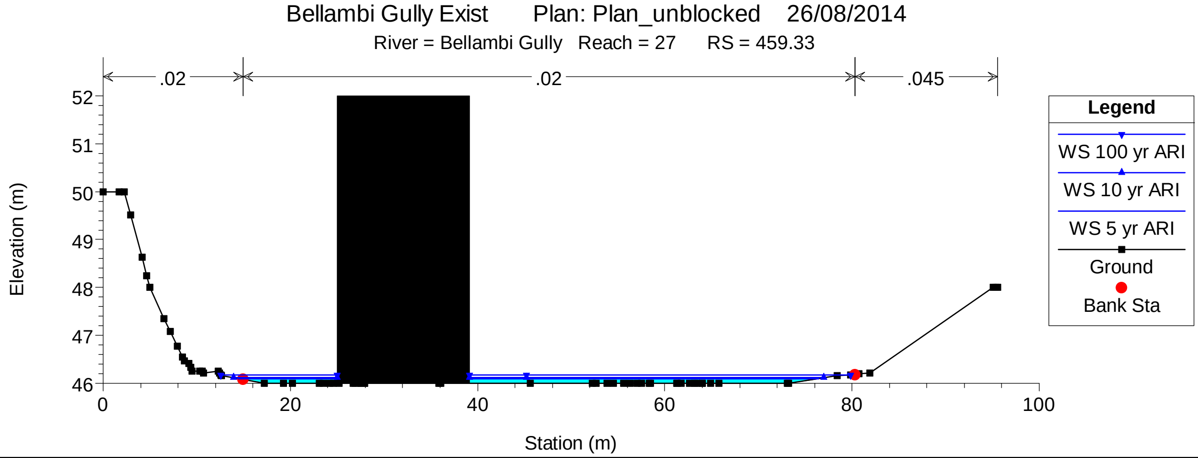


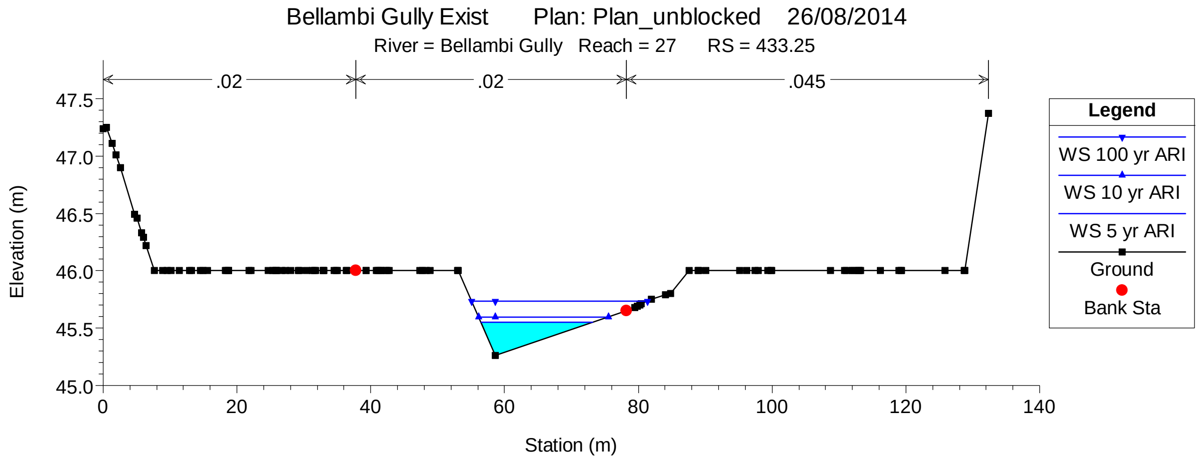
Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 630.79
.135
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

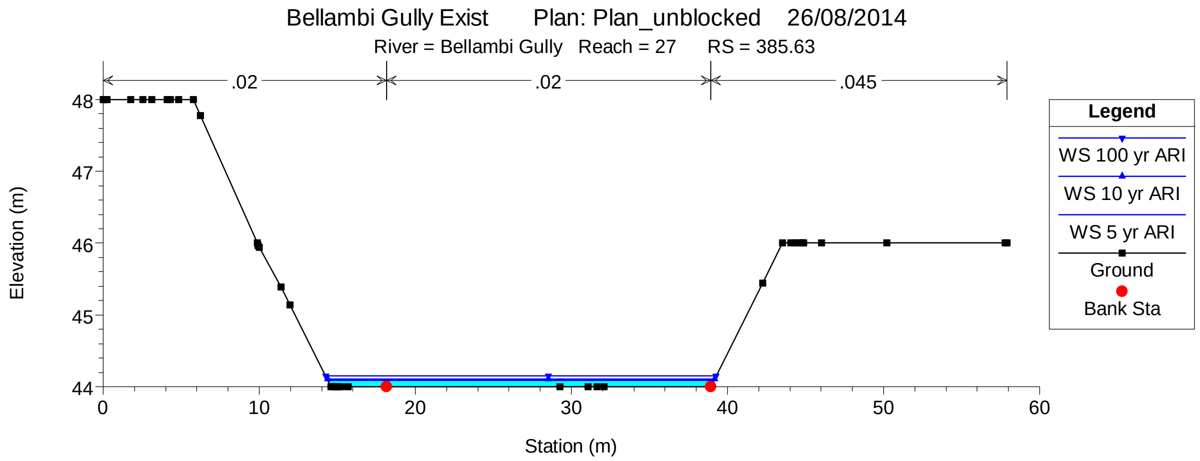

Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 621.04
.135
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

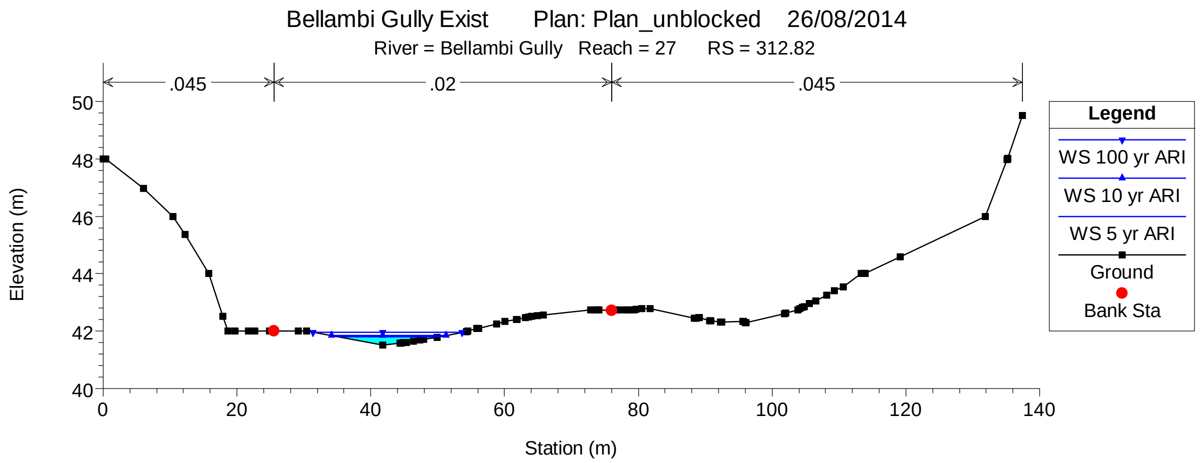

Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 604.68
.135
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

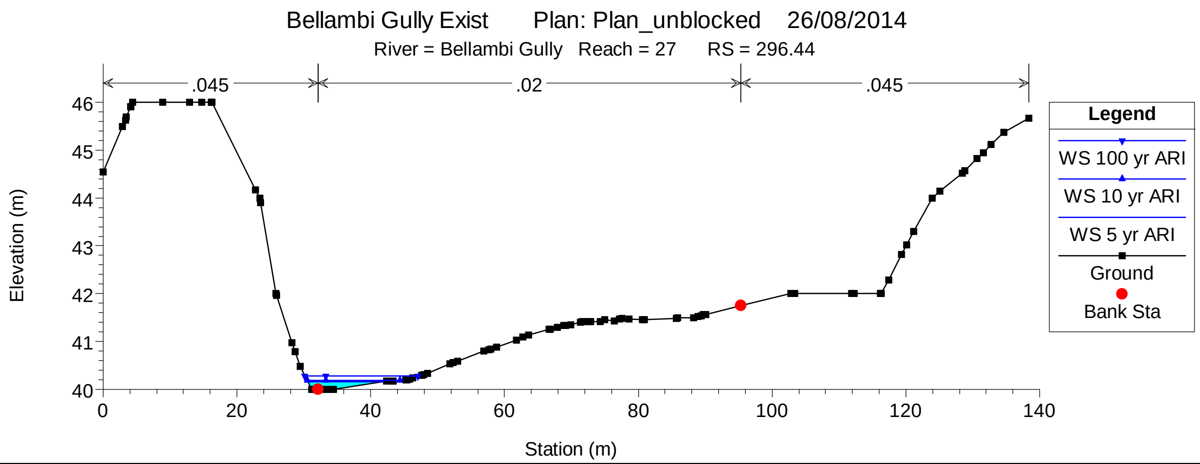

Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 551.35
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

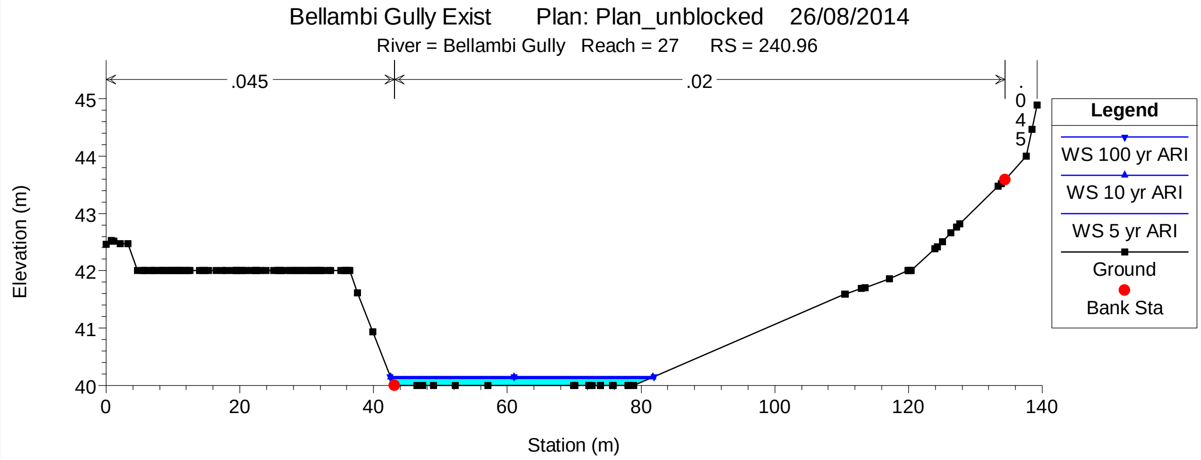

Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 459.33
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta


Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 433.25
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

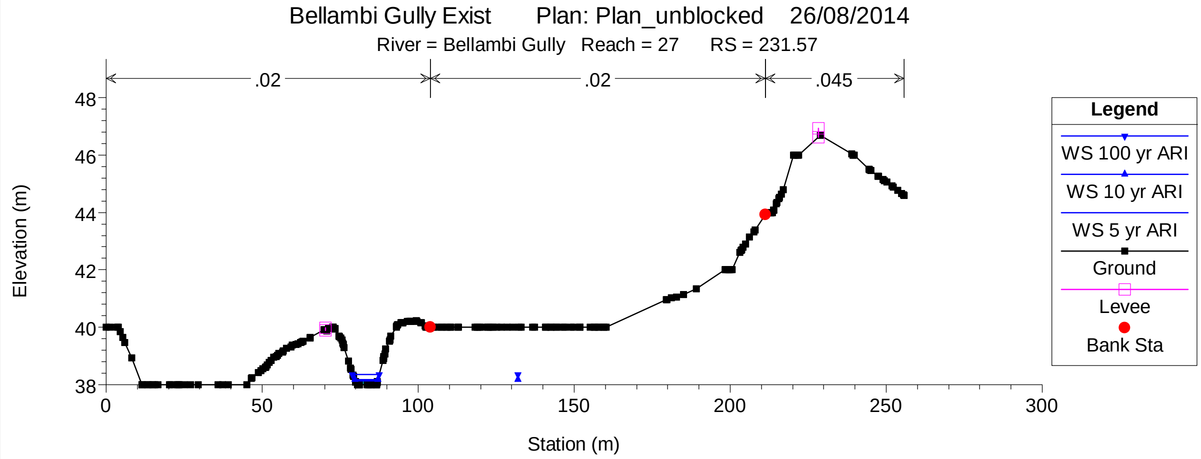

Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 385.63
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta


Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 312.82
.045
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta

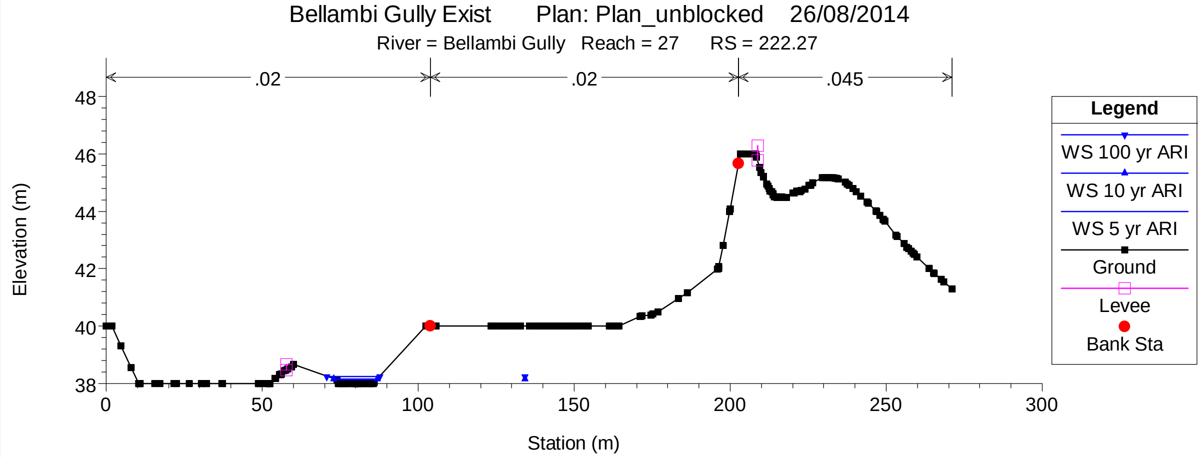

Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 296.44
.045
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta



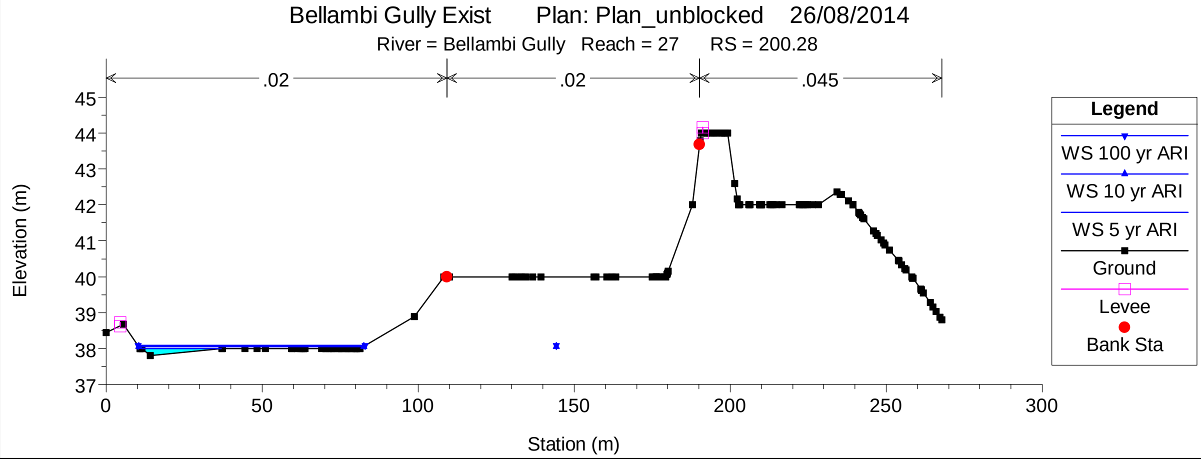
Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 240.96
.045
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta



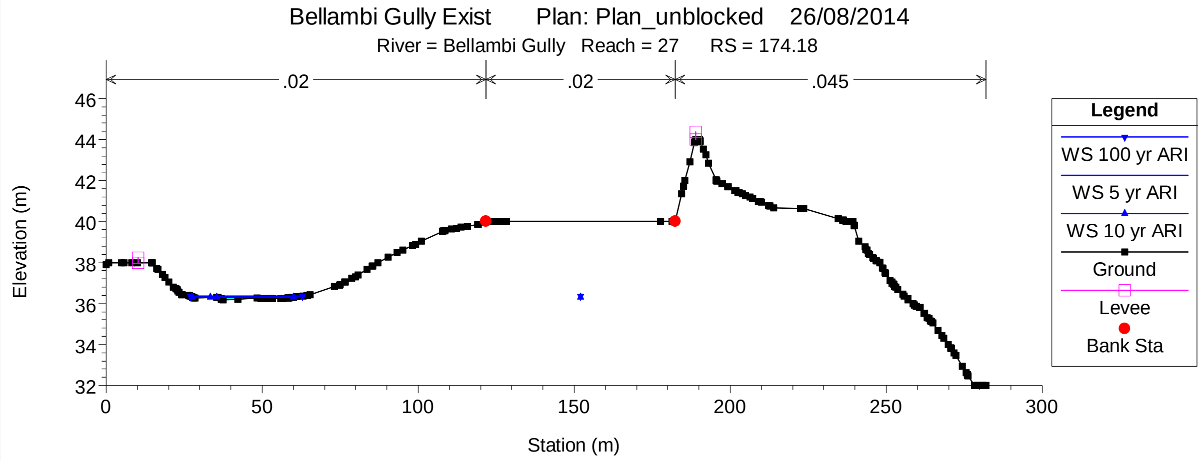
Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 231.57
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Levee
Bank Sta



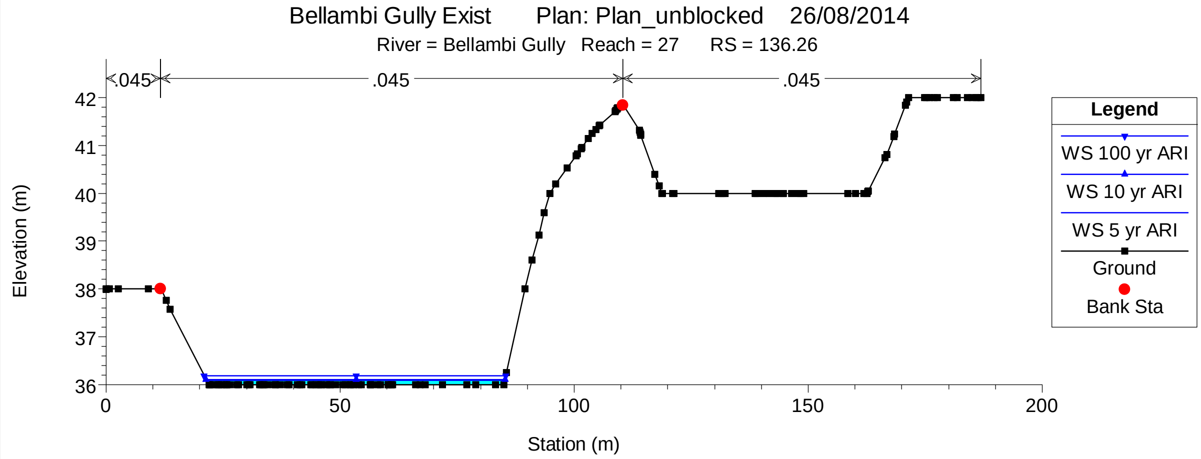
Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 222.27
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Levee
Bank Sta



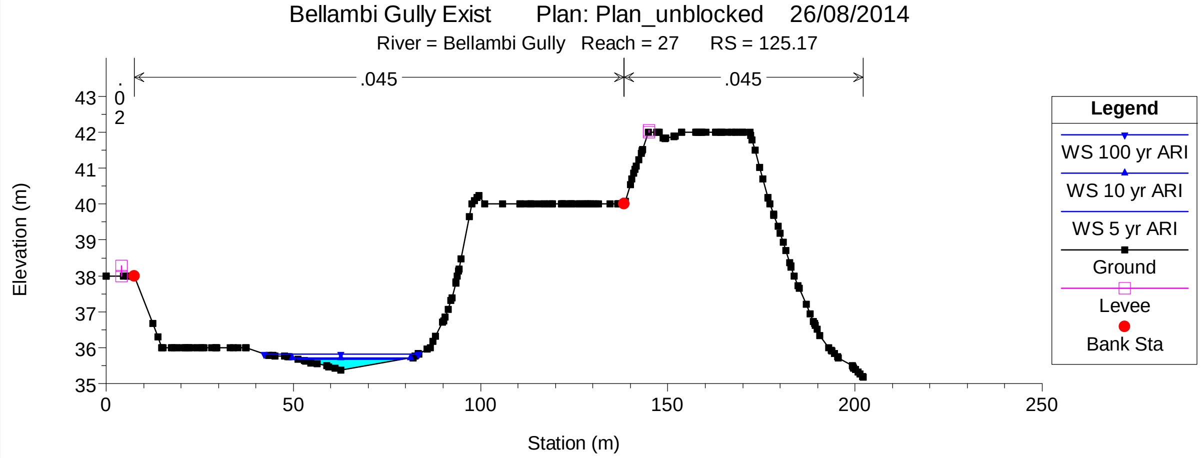
Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 200.28
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Levee
Bank Sta



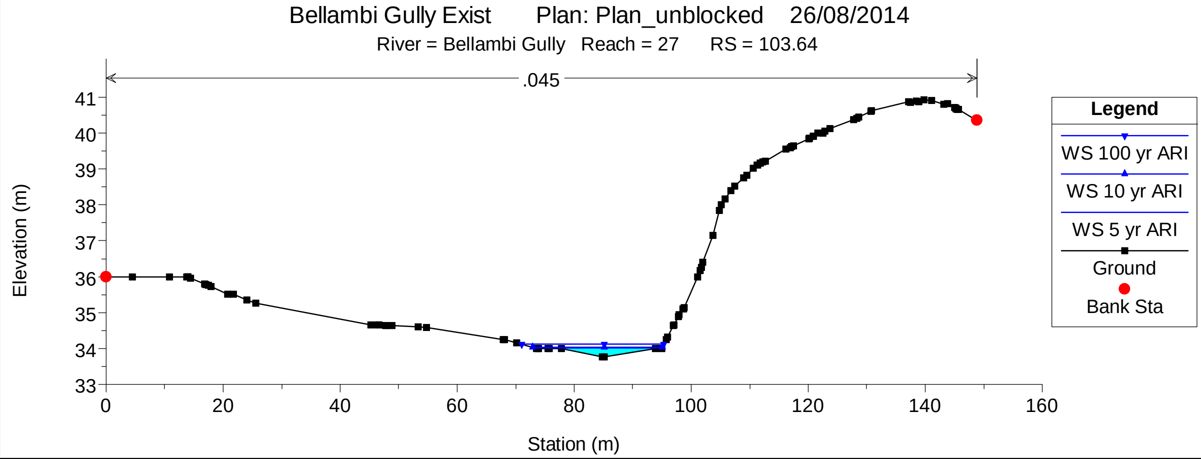
Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 174.18
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 5 yr ARI
WS 10 yr ARI
Ground
Levee
Bank Sta



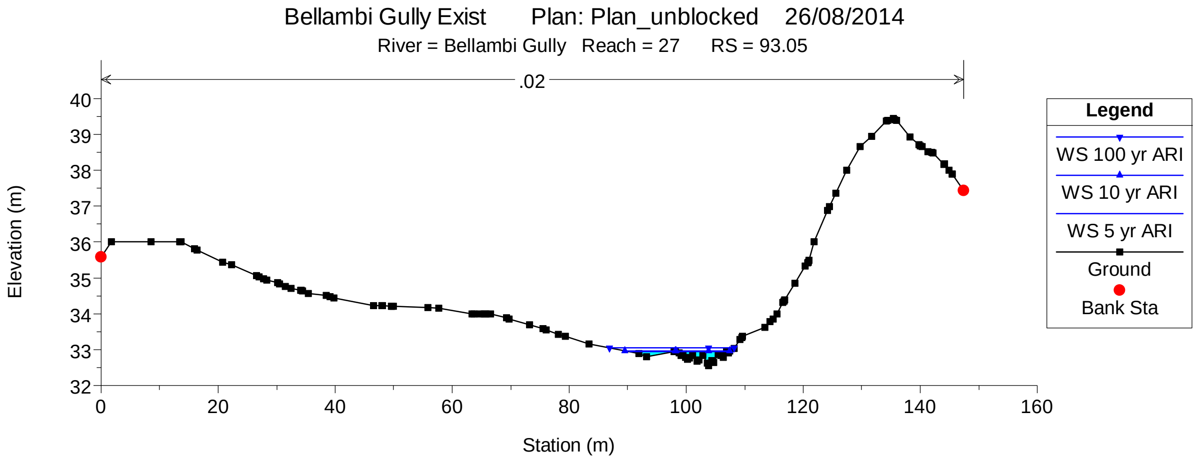
Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 136.26
.045
.045
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta



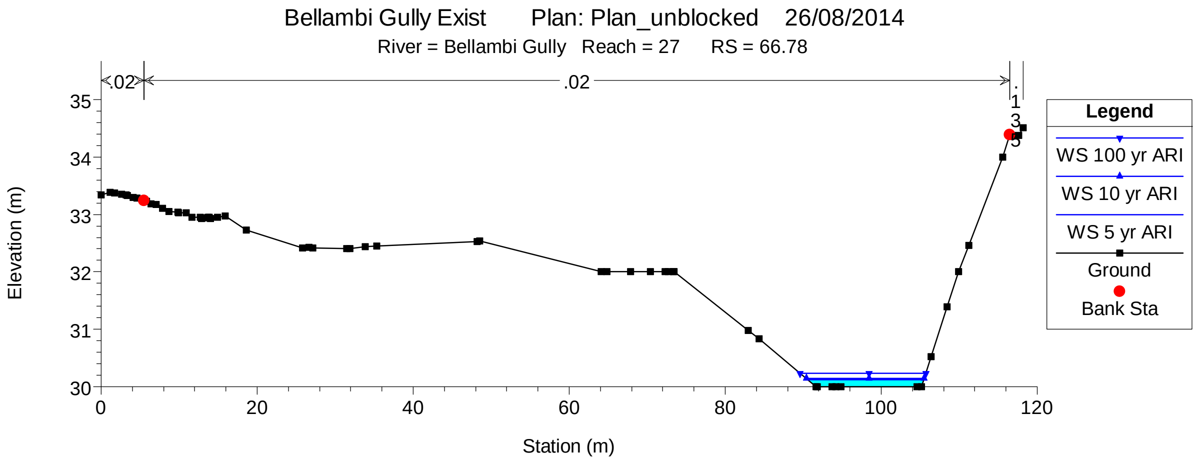
Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 125.17
.02
.045
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Levee
Bank Sta



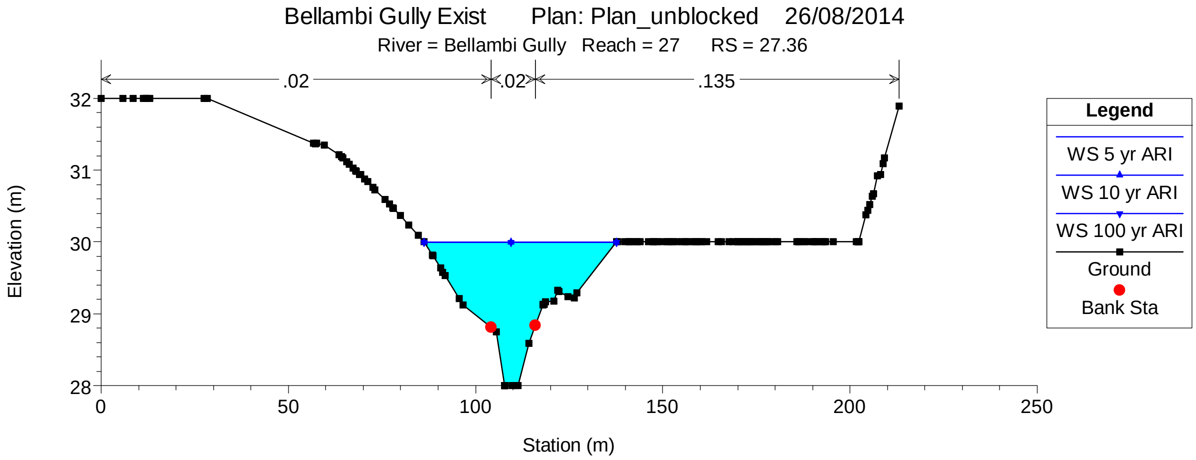
Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 103.64
.045
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta



Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 93.05
.02
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta



Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 66.78
.02
.02
.135
Elevation (m)
Station (m)
Legend
WS 100 yr ARI
WS 10 yr ARI
WS 5 yr ARI
Ground
Bank Sta



Bellambi Gully Exist Plan: Plan_unblocked 26/08/2014
River = Bellambi Gully Reach = 27 RS = 27.36
.02
.02
.135
Elevation (m)
Station (m)
Legend
WS 5 yr ARI
WS 10 yr ARI
WS 100 yr ARI
Ground
Bank Sta

HEC-RAS Plan: unblock

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Hydr Depth
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)
26	193.90	5 yr ARI	3.42	68.83	69.03	69.14	69.41	0.050026	2.72	1.26	0.12
26	193.90	10 yr ARI	4.43	68.83	69.06	69.18	69.50	0.050066	2.95	1.50	0.14
26	193.90	100 yr ARI	8.92	68.83	69.13	69.32	69.83	0.050039	3.69	2.42	0.19
26	173.65	5 yr ARI	3.42	66.23	66.49	66.73	67.80	0.124755	5.08	0.67	0.16
26	173.65	10 yr ARI	4.43	66.23	66.53	66.79	67.94	0.113084	5.27	0.84	0.18
26	173.65	100 yr ARI	8.92	66.23	66.65	66.99	68.40	0.089580	5.85	1.52	0.25
26	151.48	5 yr ARI	3.42	66.00	66.31	66.19	66.35	0.001488	0.87	4.19	0.29
26	151.48	10 yr ARI	4.43	66.00	66.36	66.23	66.41	0.001558	0.97	4.87	0.33
26	151.48	100 yr ARI	8.92	66.00	66.21	66.37	66.79	0.038292	3.41	2.76	0.20
26	138.91	5 yr ARI	3.42	66.00	66.20	66.20	66.31	0.007016	1.44	2.49	0.19
26	138.91	10 yr ARI	4.43	66.00	66.25	66.25	66.37	0.005991	1.52	3.08	0.23
26	138.91	100 yr ARI	8.92	66.00	66.34	66.39	66.59	0.008359	2.22	4.34	0.31
26	109.29	5 yr ARI	3.42	62.00	62.23	62.55	65.37	0.349035	7.85	0.44	0.14
26	109.29	10 yr ARI	4.43	62.00	62.26	62.62	65.50	0.304257	7.98	0.56	0.16
26	109.29	100 yr ARI	8.92	62.00	62.40	62.84	65.62	0.176648	7.95	1.12	0.24
26	84.50	5 yr ARI	3.42	60.00	60.35	60.57	61.33	0.072360	4.40	0.78	0.19
26	84.50	10 yr ARI	4.43	60.00	60.38	60.64	61.55	0.075484	4.78	0.93	0.21
26	84.50	100 yr ARI	8.92	60.00	60.50	60.85	62.28	0.083659	5.91	1.51	0.27
26	62.17	5 yr ARI	3.42	58.38	58.67	58.83	59.46	0.092117	3.96	0.86	0.14
26	62.17	10 yr ARI	4.43	58.38	58.69	58.89	59.61	0.092271	4.25	1.04	0.15
26	62.17	100 yr ARI	8.92	58.38	58.78	59.07	60.23	0.091352	5.33	1.67	0.21
26	45.90	5 yr ARI	3.42	56.00	56.07	56.20	57.01	0.285735	4.33	0.79	0.06
26	45.90	10 yr ARI	4.43	56.00	56.08	56.24	57.21	0.271267	4.72	0.94	0.08
26	45.90	100 yr ARI	8.92	56.00	56.12	56.38	57.93	0.236518	6.00	1.50	0.12
26	25.76	5 yr ARI	3.42	56.00	56.25	56.25	56.36	0.006542	1.48	2.34	0.21
26	25.76	10 yr ARI	4.43	56.00	56.27	56.29	56.42	0.007971	1.74	2.59	0.22
26	25.76	100 yr ARI	8.92	56.00	56.33	56.45	56.72	0.014866	2.76	3.35	0.26
709	869.12	5 yr ARI	1.40	68.43	68.76	68.91	69.30	0.050032	3.26	0.43	0.16
709	869.12	10 yr ARI	2.16	68.43	68.82	69.00	69.49	0.050041	3.64	0.59	0.19
709	869.12	100 yr ARI	5.08	68.43	68.97	69.23	70.00	0.050062	4.51	1.13	0.27
709	853.66	5 yr ARI	1.40	64.00	66.18	64.12	66.18	0.000000	0.03	47.23	1.48
709	853.66	10 yr ARI	2.16	64.00	66.22	64.14	66.22	0.000000	0.05	48.77	1.52
709	853.66	100 yr ARI	5.08	64.00	66.37	64.24	66.37	0.000002	0.11	53.61	1.63
709	838.25	5 yr ARI	1.40	64.00	66.18		66.18	0.000001	0.08	27.50	0.77
709	838.25	10 yr ARI	2.16	64.00	66.22		66.22	0.000003	0.12	29.22	0.81
709	838.25	100 yr ARI	5.08	64.00	66.37		66.37	0.000011	0.23	34.66	0.93
709	820.54	5 yr ARI	1.40	64.00	66.18		66.18	0.000001	0.09	26.57	0.58
709	820.54	10 yr ARI	2.16	64.00	66.22		66.22	0.000003	0.13	28.77	0.62
709	820.54	100 yr ARI	5.08	64.00	66.37		66.37	0.000009	0.26	35.71	0.74
709	776.73	5 yr ARI	1.40	64.01	66.18		66.18	0.000001	0.05	29.87	1.26
709	776.73	10 yr ARI	2.16	64.01	66.22		66.22	0.000001	0.08	31.01	1.29
709	776.73	100 yr ARI	5.08	64.01	66.37		66.37	0.000005	0.17	34.61	1.40
709	767.44	5 yr ARI	1.40	66.00	66.16		66.17	0.001921	0.63	2.65	0.15
709	767.44	10 yr ARI	2.16	66.00	66.19		66.22	0.002214	0.79	3.30	0.19
709	767.44	100 yr ARI	5.08	66.00	66.31		66.37	0.002609	1.16	5.30	0.30
709	758.43	5 yr ARI	1.40	65.99	66.08	66.08	66.13	0.013062	1.10	1.51	0.09
709	758.43	10 yr ARI	2.16	65.99	66.12	66.12	66.18	0.009437	1.19	2.16	0.12
709	758.43	100 yr ARI	5.08	65.99	66.21	66.21	66.32	0.007560	1.57	3.88	0.21
709	748.19	5 yr ARI	1.40	64.00	64.07	64.23	65.59	0.485661	5.46	0.26	0.06
709	748.19	10 yr ARI	2.16	64.00	64.10	64.29	65.73	0.355905	5.66	0.38	0.08
709	748.19	100 yr ARI	5.08	64.00	64.19	64.45	65.95	0.184210	5.87	0.87	0.14
709	708.99	5 yr ARI	1.40	58.00	58.05	58.09	58.23	0.095911	1.91	0.73	0.04
709	708.99	10 yr ARI	2.16	58.00	58.06	58.12	58.34	0.112844	2.33	0.91	0.05
709	708.99	100 yr ARI	5.08	58.00	58.08	58.20	58.77	0.178725	3.33	1.39	0.07
27	641.72	5 yr ARI	4.81	54.00	54.13	54.36	55.61	0.195907	5.39	0.89	0.12
27	641.72	10 yr ARI	6.59	54.00	54.18	54.43	55.61	0.131291	5.32	1.24	0.16
27	641.72	100 yr ARI	14.01	54.00	54.34	54.68	55.80	0.060685	5.36	2.61	0.29
27	630.79	5 yr ARI	4.81	53.85	54.13	54.23	54.49	0.036651	2.65	1.82	0.15
27	630.79	10 yr ARI	6.59	53.85	54.16	54.29	54.62	0.037734	3.01	2.19	0.17

HEC-RAS Plan: unblock (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Hydr Depth
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)
27	630.79	100 yr ARI	14.01	53.85	54.26	54.48	55.09	0.039707	4.05	3.46	0.26
27	621.04	5 yr ARI	4.81	52.00	52.38	52.69	53.85	0.087769	5.36	0.90	0.22
27	621.04	10 yr ARI	6.59	52.00	52.45	52.79	54.01	0.076318	5.53	1.19	0.26
27	621.04	100 yr ARI	14.01	52.00	52.66	53.09	54.52	0.058029	6.05	2.32	0.37
27	604.68	5 yr ARI	4.81	51.92	52.08	52.16	52.38	0.055159	2.41	2.00	0.09
27	604.68	10 yr ARI	6.59	51.92	52.10	52.20	52.52	0.064594	2.87	2.31	0.11
27	604.68	100 yr ARI	14.01	51.92	52.14	52.34	53.08	0.090517	4.29	3.29	0.15
27	551.35	5 yr ARI	4.81	48.00	48.11	48.22	48.61	0.092437	3.13	1.53	0.09
27	551.35	10 yr ARI	6.59	48.00	48.13	48.27	48.70	0.079565	3.32	1.98	0.12
27	551.35	100 yr ARI	14.01	48.00	48.22	48.41	49.01	0.063880	3.96	3.54	0.18
27	459.33	5 yr ARI	4.81	46.00	46.10	46.11	46.16	0.011510	1.10	4.39	0.09
27	459.33	10 yr ARI	6.59	46.00	46.12	46.13	46.20	0.012458	1.27	5.22	0.11
27	459.33	100 yr ARI	14.01	46.00	46.17	46.21	46.33	0.014932	1.76	8.02	0.15
27	433.25	5 yr ARI	4.81	45.26	45.55	45.61	45.75	0.021091	2.00	2.41	0.14
27	433.25	10 yr ARI	6.59	45.26	45.60	45.66	45.80	0.017580	2.02	3.27	0.17
27	433.25	100 yr ARI	14.01	45.26	45.73	45.80	45.98	0.011105	2.21	6.45	0.25
27	385.63	5 yr ARI	4.81	44.00	44.09	44.16	44.33	0.045342	2.16	2.24	0.09
27	385.63	10 yr ARI	6.59	44.00	44.11	44.19	44.44	0.052556	2.56	2.59	0.10
27	385.63	100 yr ARI	14.01	44.00	44.15	44.32	44.86	0.067870	3.74	3.79	0.15
27	312.82	5 yr ARI	4.81	41.52	41.80	41.88	42.03	0.022984	2.12	2.27	0.15
27	312.82	10 yr ARI	6.59	41.52	41.84	41.93	42.10	0.021131	2.24	2.94	0.17
27	312.82	100 yr ARI	14.01	41.52	41.96	42.08	42.32	0.019622	2.67	5.25	0.24
27	296.44	5 yr ARI	4.81	40.00	40.16	40.32	41.14	0.183366	4.55	1.15	0.10
27	296.44	10 yr ARI	6.59	40.00	40.19	40.36	41.25	0.186988	4.73	1.50	0.11
27	296.44	100 yr ARI	14.01	40.00	40.27	40.53	41.58	0.118899	5.21	2.89	0.17
27	240.96	5 yr ARI	4.81	40.00	40.12	40.12	40.18	0.007994	1.07	4.51	0.12
27	240.96	10 yr ARI	6.59	40.00	40.15	40.15	40.22	0.007971	1.21	5.49	0.14
27	240.96	100 yr ARI	14.01	40.00	40.16	40.24	40.45	0.028918	2.40	5.88	0.15
27	231.57	5 yr ARI	4.81	40.00	38.13	38.37	39.71	0.208884		0.86	0.12
27	231.57	10 yr ARI	6.59	40.00	38.17	38.45	39.78	0.150244		1.17	0.16
27	231.57	100 yr ARI	14.01	40.00	38.36	38.70	39.78	0.054503		2.65	0.31
27	222.27	5 yr ARI	4.81	40.00	38.14	38.25	38.57	0.051850		1.66	0.13
27	222.27	10 yr ARI	6.59	40.00	38.16	38.31	38.71	0.056651		2.02	0.14
27	222.27	100 yr ARI	14.01	40.00	38.25	38.47	39.12	0.058484		3.40	0.20
27	200.28	5 yr ARI	4.81	40.00	38.00	38.04	38.21	0.038634		2.37	0.09
27	200.28	10 yr ARI	6.59	40.00	38.06	38.06	38.11	0.010414		6.45	0.09
27	200.28	100 yr ARI	14.01	40.00	38.09	38.12	38.22	0.018578		8.57	0.12
27	174.18	5 yr ARI	4.81	40.00	36.32	36.38	36.61	0.100700		1.99	0.06
27	174.18	10 yr ARI	6.59	40.00	36.30	36.41	37.22	0.324145		1.55	0.05
27	174.18	100 yr ARI	14.01	40.00	36.36	36.51	37.12	0.125849		3.63	0.10
27	136.26	5 yr ARI	4.81	36.00	36.09	36.09	36.13	0.033032	0.82	5.85	0.09
27	136.26	10 yr ARI	6.59	36.00	36.11	36.10	36.16	0.031175	0.92	7.20	0.11
27	136.26	100 yr ARI	14.01	36.00	36.19	36.17	36.26	0.024786	1.15	12.17	0.19
27	125.17	5 yr ARI	4.81	35.38	35.68	35.68	35.75	0.035713	1.17	4.12	0.15
27	125.17	10 yr ARI	6.59	35.38	35.72	35.72	35.80	0.033435	1.24	5.32	0.17
27	125.17	100 yr ARI	14.01	35.38	35.83	35.83	35.94	0.034098	1.51	9.25	0.22
27	103.64	5 yr ARI	4.81	33.76	34.01	34.08	34.27	0.230352	2.27	2.12	0.10
27	103.64	10 yr ARI	6.59	33.76	34.03	34.12	34.37	0.237968	2.57	2.56	0.12
27	103.64	100 yr ARI	14.01	33.76	34.12	34.26	34.60	0.178161	3.08	4.56	0.19
27	93.05	5 yr ARI	4.81	32.56	32.94	33.04	33.28	0.049739	2.60	1.85	0.11
27	93.05	10 yr ARI	6.59	32.56	32.97	33.08	33.37	0.049349	2.83	2.33	0.13
27	93.05	100 yr ARI	14.01	32.56	33.05	33.22	33.69	0.048616	3.55	3.94	0.18
27	66.78	5 yr ARI	4.81	30.00	30.12	30.23	30.53	0.059605	2.86	1.68	0.11
27	66.78	10 yr ARI	6.59	30.00	30.14	30.28	30.66	0.058243	3.19	2.06	0.14
27	66.78	100 yr ARI	14.01	30.00	30.23	30.45	31.09	0.053628	4.11	3.41	0.21
27	27.36	5 yr ARI	4.81	28.00	30.00	28.47	30.00	0.000006	0.18	44.69	0.87
27	27.36	10 yr ARI	6.59	28.00	30.00	28.56	30.00	0.000012	0.24	44.69	0.87
27	27.36	100 yr ARI	14.01	28.00	30.00	28.86	30.01	0.000054	0.51	44.69	0.87

Bellambi Gully Flood Study

APPENDIX C
EXISTING SCENARIO FLOOD MAPS

WOLLONGONG COAL

Scenario 1 (100% blocked pipes)

BELLAMBI GULLY FLOOD STUDY

1:2,500 Scale at A3

Metres

0 40 80 120 160

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2014-06-27
Coordinate System: GDA 1994 MGA Zone 56
Project: 82014089-01
Map: G1001_Scenario1_100perc.mxd 02
Aerial imagery supplied by nearmap (July 2013)

WOLLONGONG COAL

Scenario 2 (20% blocked pipes)

BELLAMBI GULLY FLOOD STUDY

1:2,500 Scale at A3

Metres

0 40 80 120 160

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2014-06-27
Coordinate System: GDA 1994 MGA Zone 56
Project: 82014089-01
Map: G1002_Scenario2_20perc.mxd 02
Aerial imagery supplied by nearmap (July 2013)

WOLLONGONG COAL

Scenario 3 (Unblocked)

BELLAMBI GULLY FLOOD STUDY

1:2,500 Scale at A3

Metres

0 40 80 120 160

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2014-06-27
Coordinate System: GDA 1994 MGA Zone 56
Project: 82014089-01
Map: G1003_Scenario3_unblocked.mxd 02
Aerial imagery supplied by nearmap (July 2013)

Bellambi Gully Flood Study

APPENDIX D
PROPOSED MITIGATION MEASURES

Cardno®
Shaping the Future

WOLLONGONG COAL

Proposed Flood Mitigation

BELLAMBI GULLY FLOOD STUDY

1:3,000 Scale at A3

Metres

0 50 100 150 200

N

Cardno

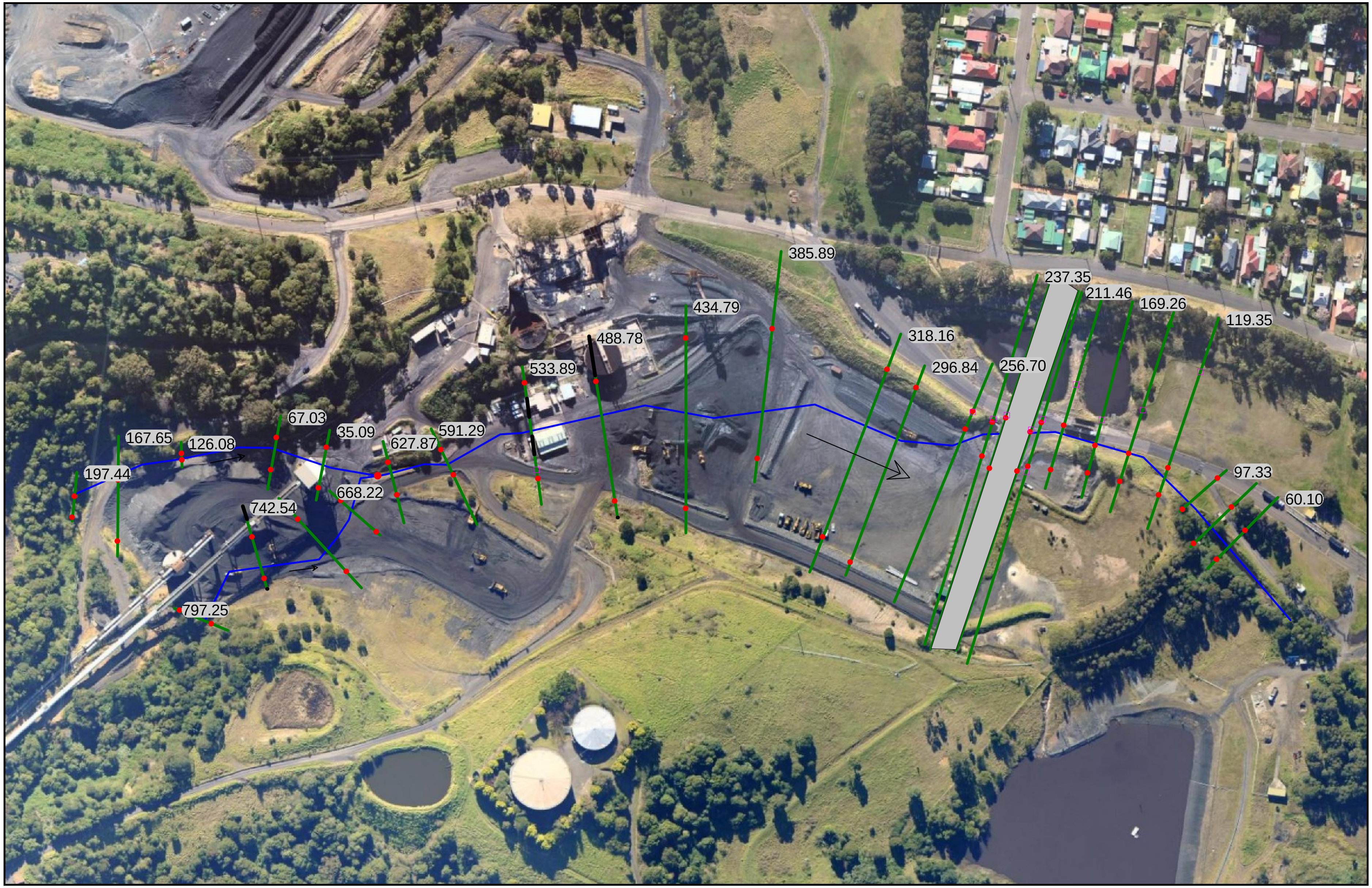
Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2014-07-01
Coordinate System: GDA 1994 MGA Zone 56
Project: 82014089-01
Map: G1004_ProposedFloodMitigation.mxd 02
Aerial imagery supplied by nearmap (July 2013)

Bellambi Gully Flood Study

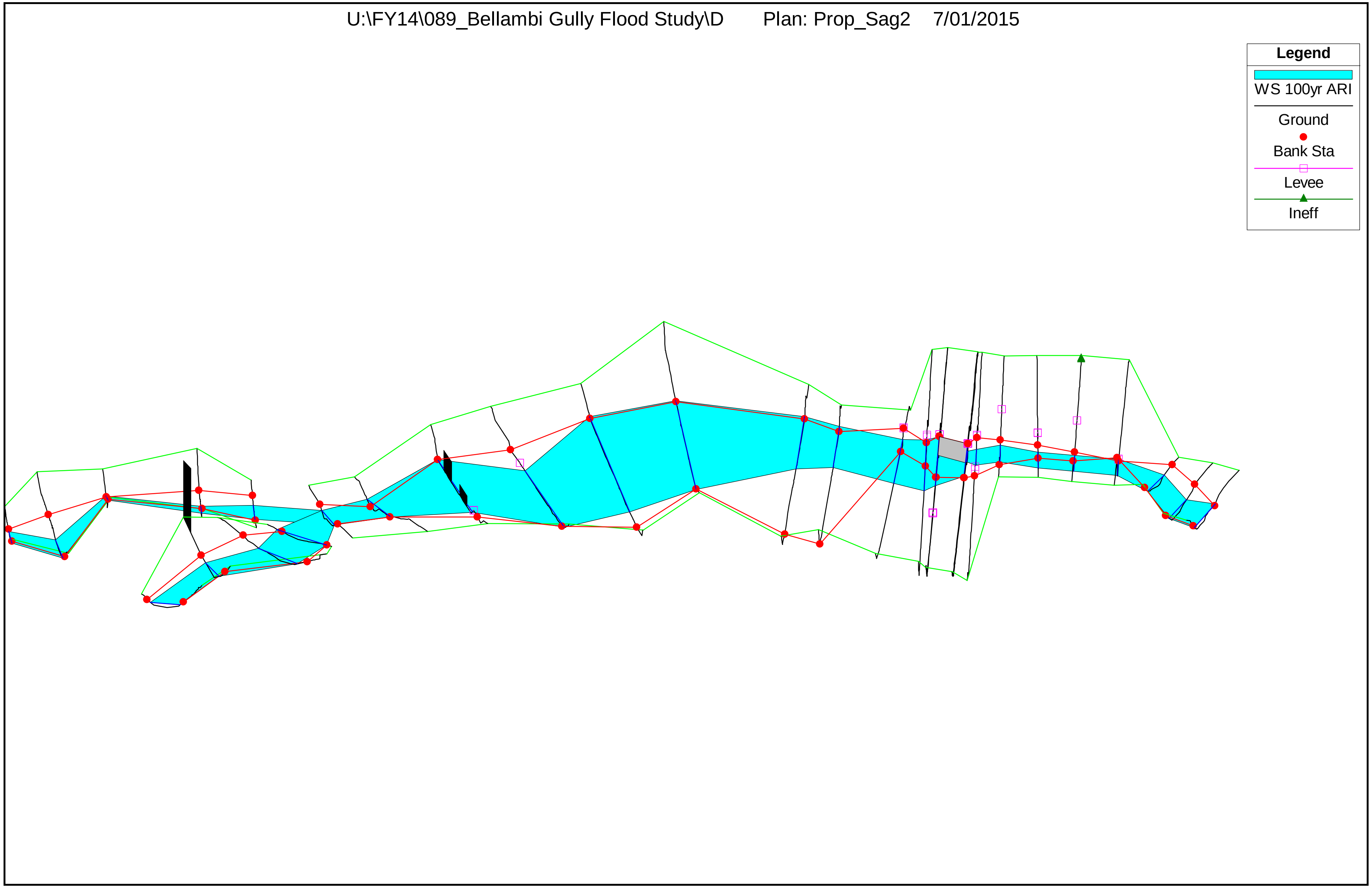
APPENDIX E

PROPOSED SCENARIO HYDRAULIC MODEL

HECRAS Model View

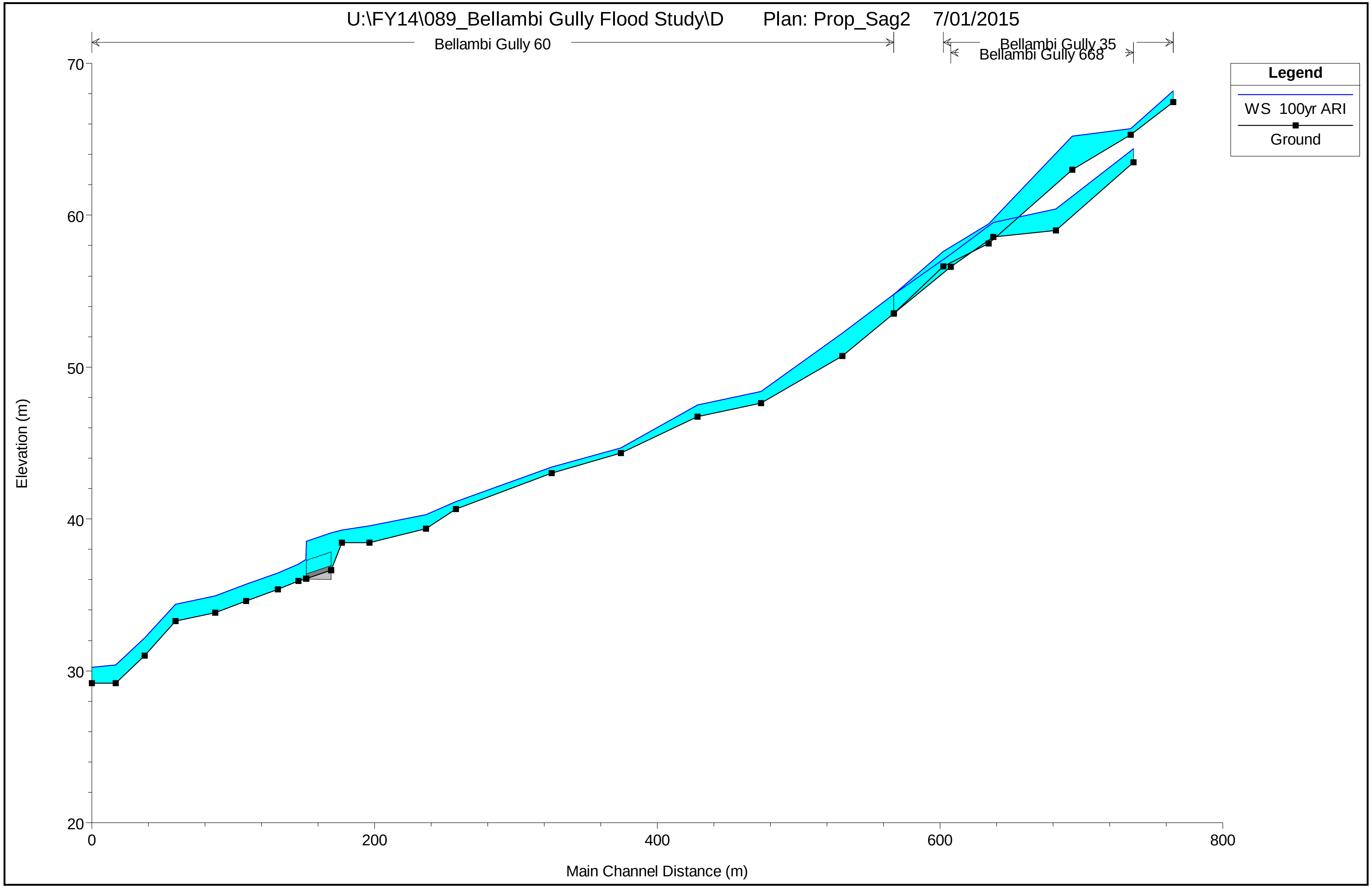


Plan View

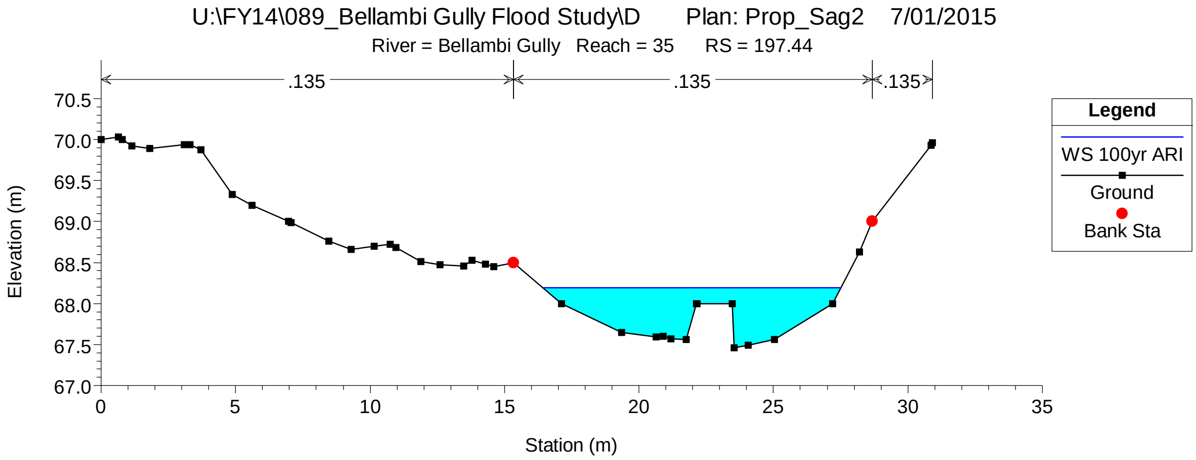


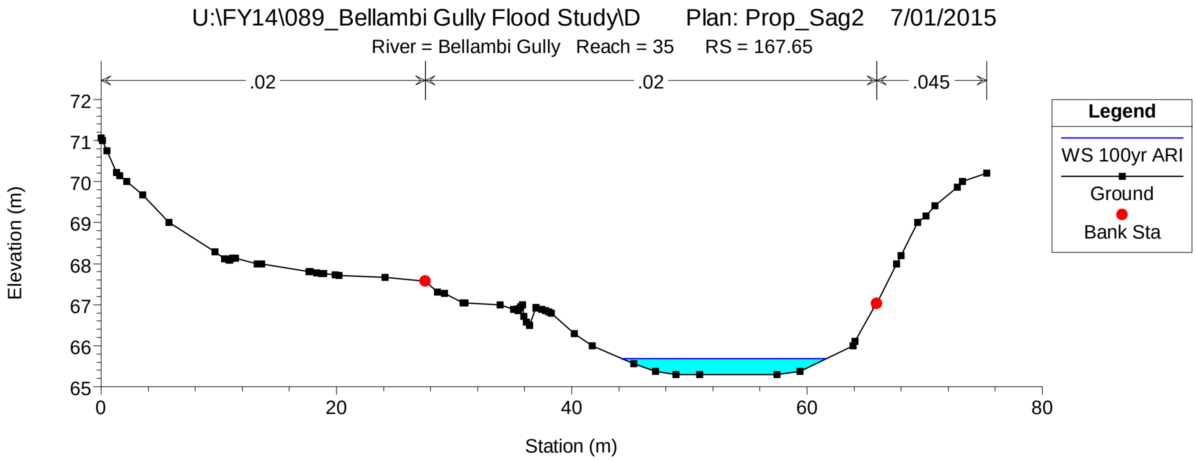
U:\FY14\089_Bellambi Gully Flood Study\D Plan: Prop_Sag2 7/01/2015
Legend
WS 100yr ARI
Ground
Bank Sta
Levee
Ineff

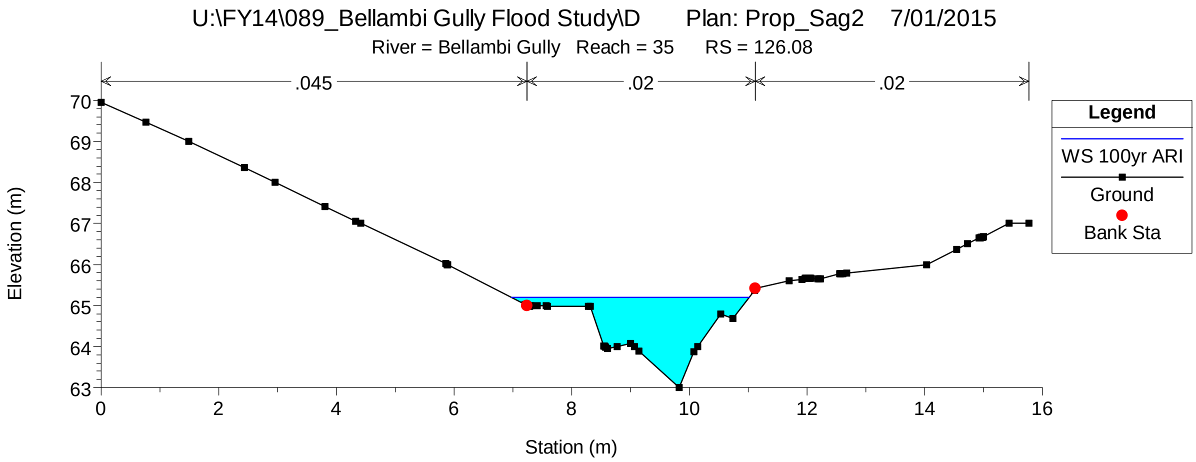
Long Section View

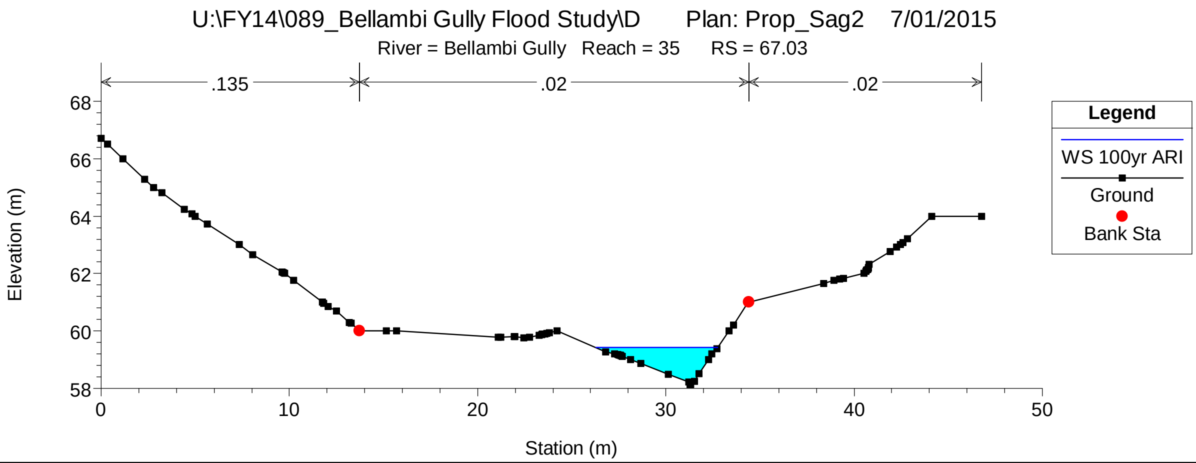


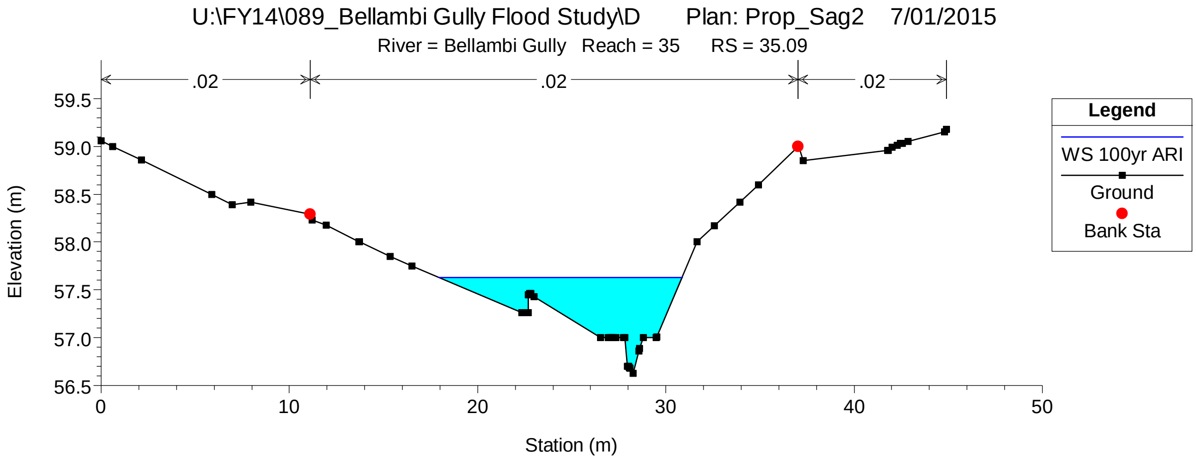
Cross Sections

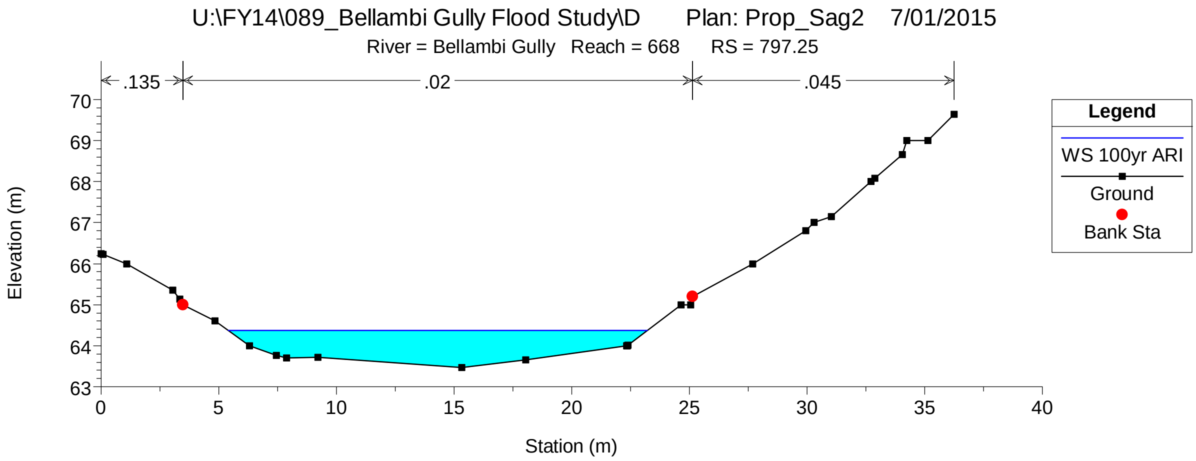


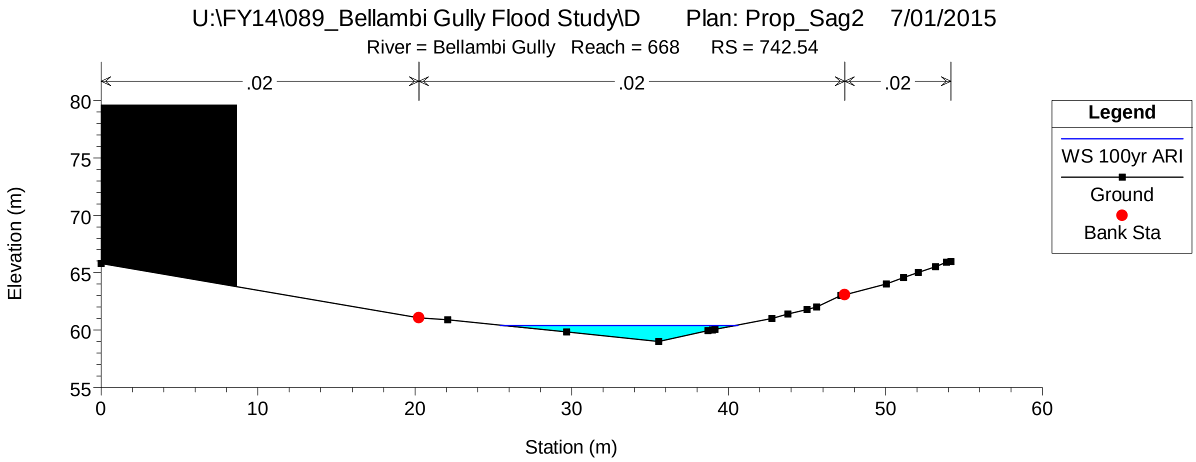







U:\FY14\089_Bellambi Gully Flood Study\D Plan: Prop_Sag2 7/01/2015
River = Bellambi Gully Reach = 35 RS = 35.09
.02
.02
.02
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Bank Sta


U:\FY14\089_Bellambi Gully Flood Study\D Plan: Prop_Sag2 7/01/2015
River = Bellambi Gully Reach = 668 RS = 797.25
.135
.02
.045
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Bank Sta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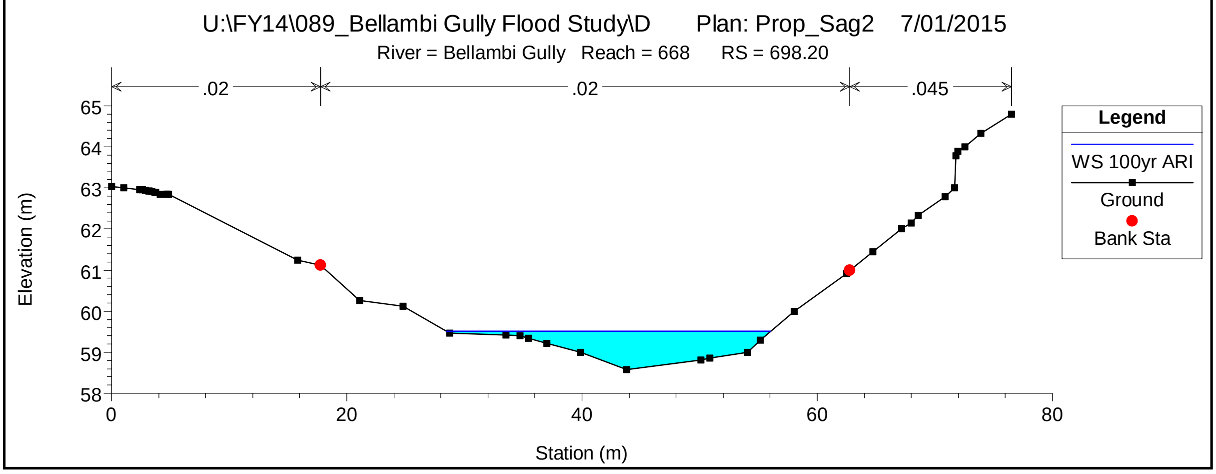
River = Bellambi Gully Reach = 668 RS = 742.54
.02
.02
.02
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Bank Sta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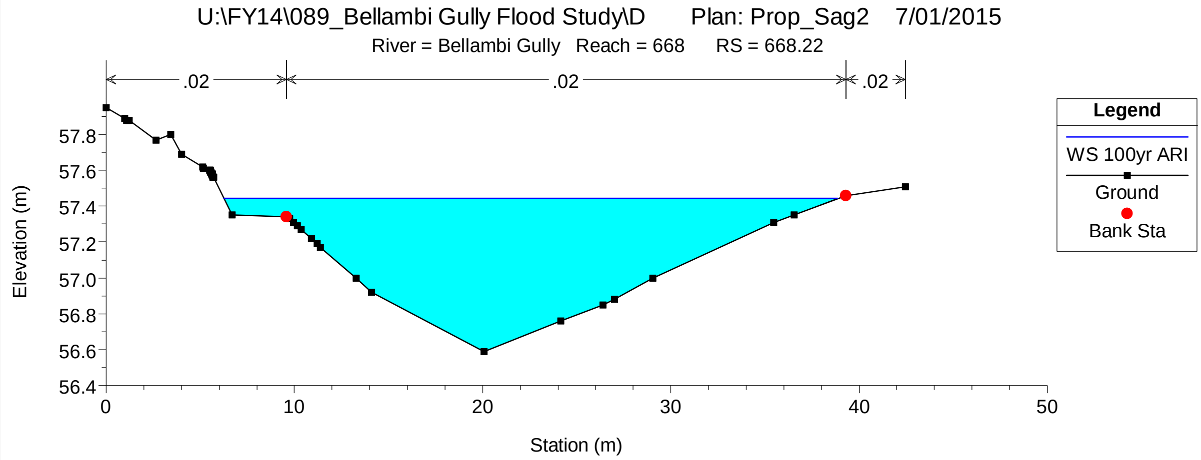
River = Bellambi Gully Reach = 668 RS = 698.20
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Bank Sta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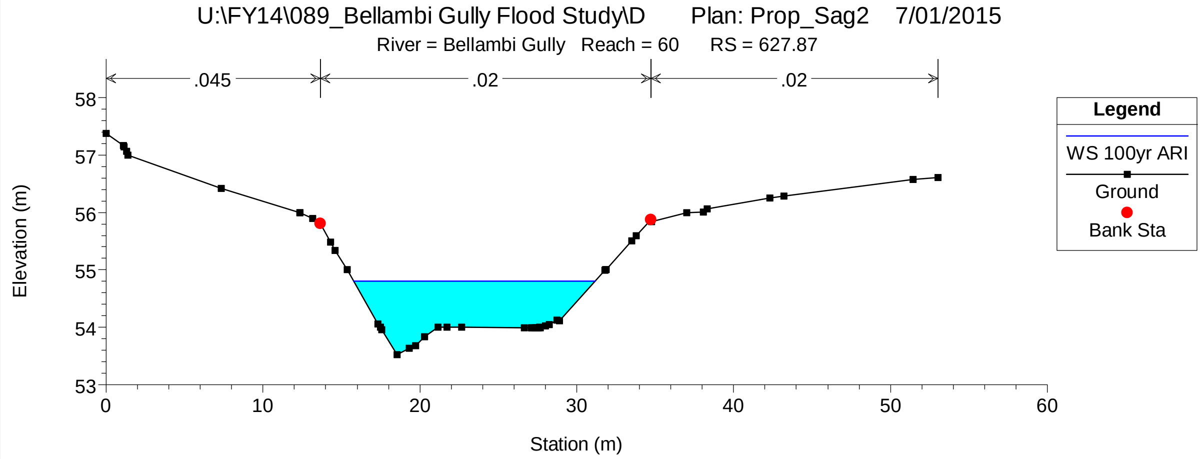
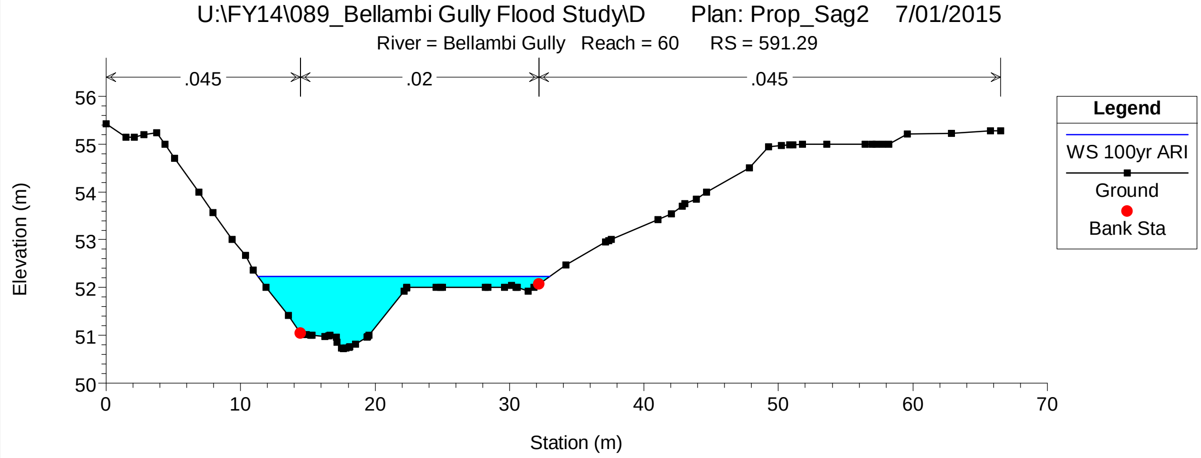
River = Bellambi Gully Reach = 668 RS = 668.22
.02
.02
.02
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Bank Sta


U:\FY14\089_Bellambi Gully Flood Study\D Plan: Prop_Sag2 7/01/2015
River = Bellambi Gully Reach = 60 RS = 627.87
.045
.02
.02
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Bank Sta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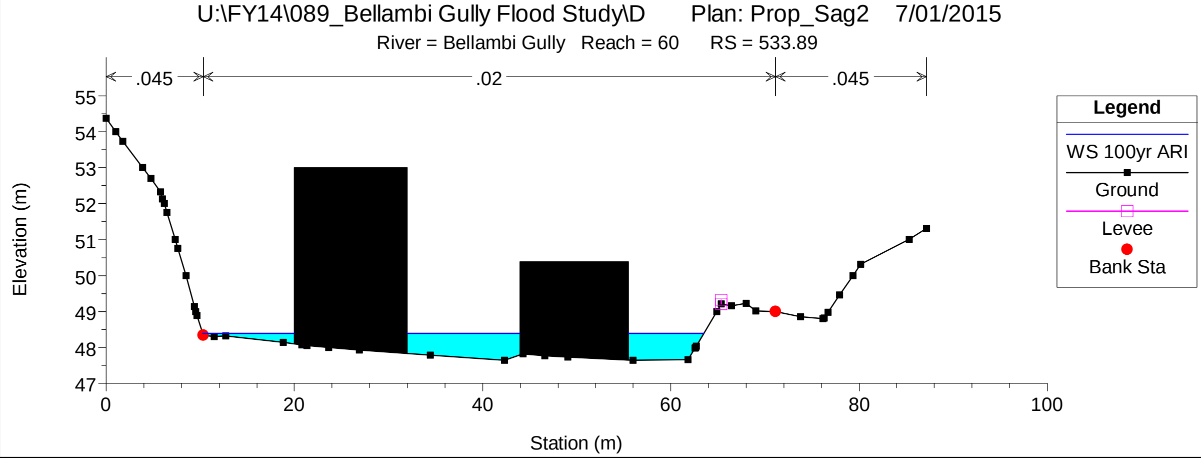
River = Bellambi Gully Reach = 60 RS = 591.29
.045
.02
.045
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Bank Sta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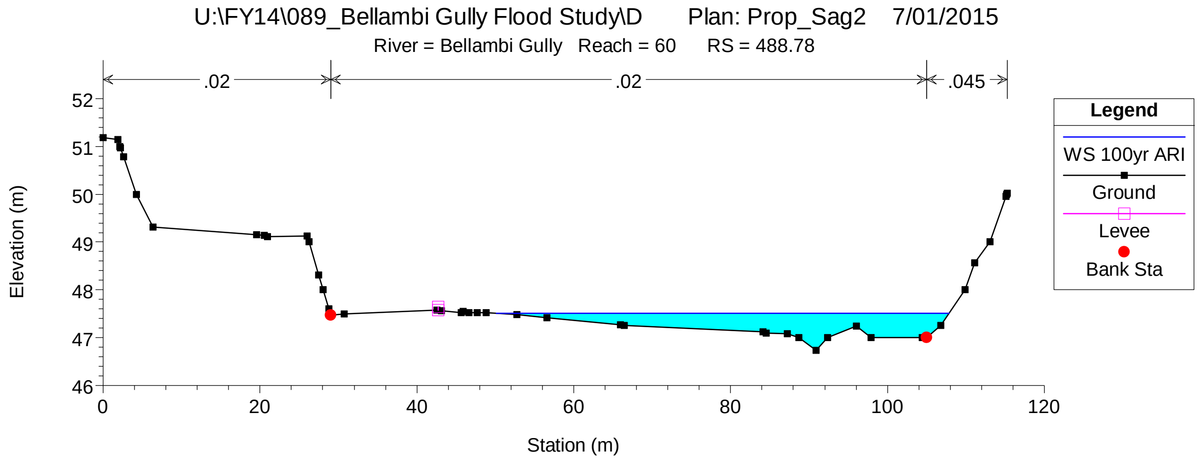
River = Bellambi Gully Reach = 60 RS = 533.89
.045
.02
.045
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Levee
Bank Sta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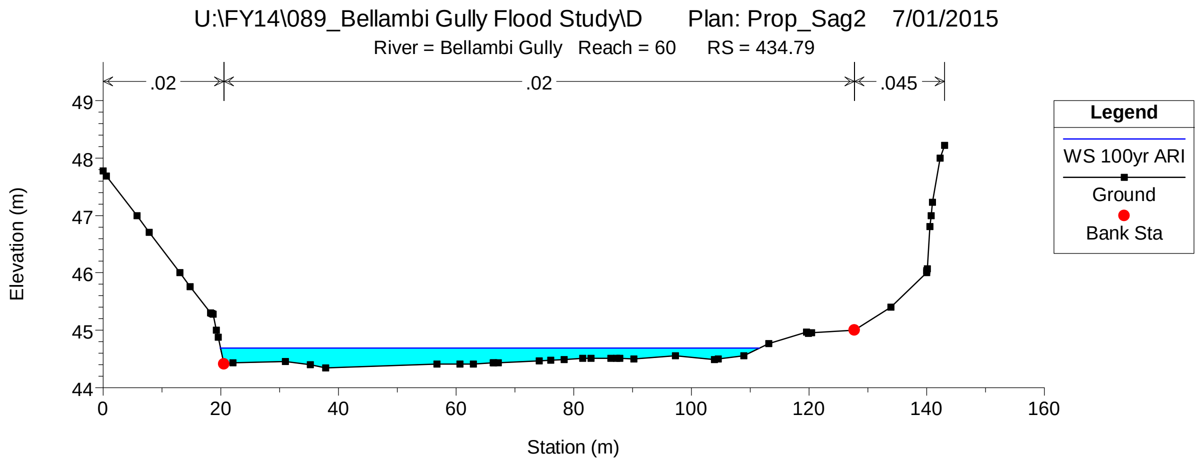
River = Bellambi Gully Reach = 60 RS = 488.78
.02
.02
.045
Legend
WS 100yr ARI
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
46
47
48
49
50
51
52
0
20
40
60
80
100
120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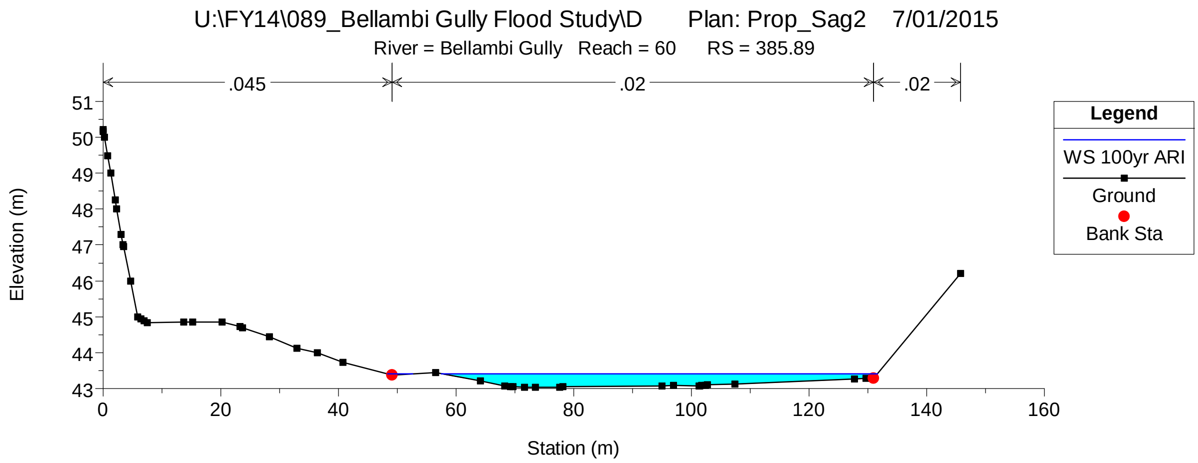
River = Bellambi Gully Reach = 60 RS = 434.79
.02
.02
.045
Legend
WS 100yr ARI
Ground
Bank Sta
Elevation (m)
Station (m)
44
45
46
47
48
49
0
20
40
60
80
100
120
140
160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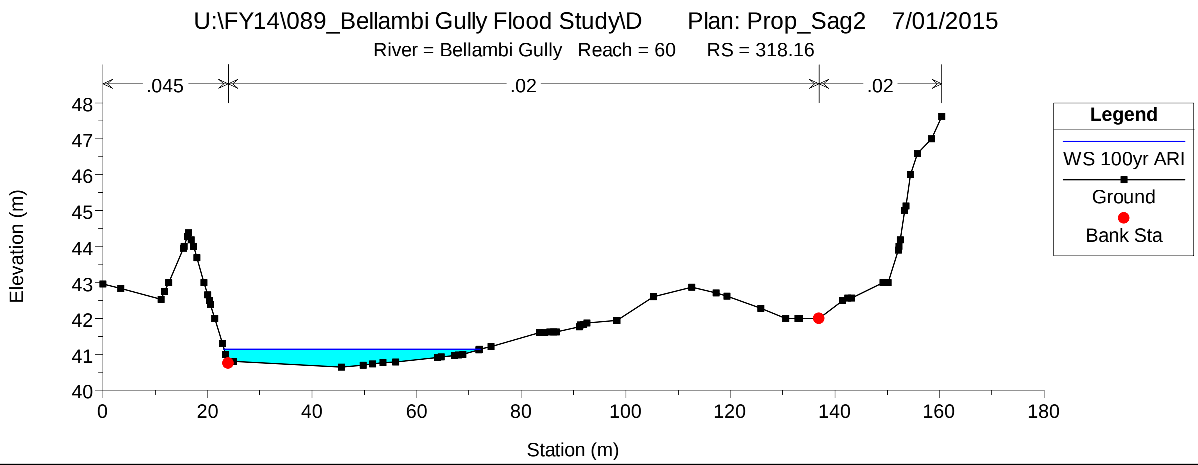
River = Bellambi Gully Reach = 60 RS = 385.89
.045
.02
.02
Legend
WS 100yr ARI
Ground
Bank Sta
Elevation (m)
Station (m)
43
44
45
46
47
48
49
50
51
0
20
40
60
80
100
120
140
160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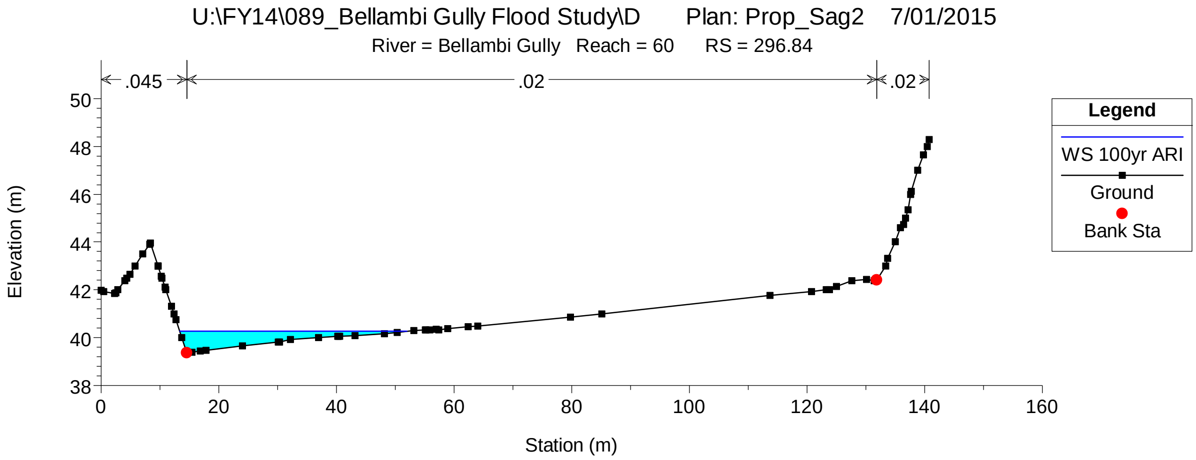
River = Bellambi Gully Reach = 60 RS = 318.16
.045
.02
.02
Legend
WS 100yr ARI
Ground
Bank Sta
Elevation (m)
Station (m)
40
41
42
43
44
45
46
47
48
0
20
40
60
80
100
120
140
160
180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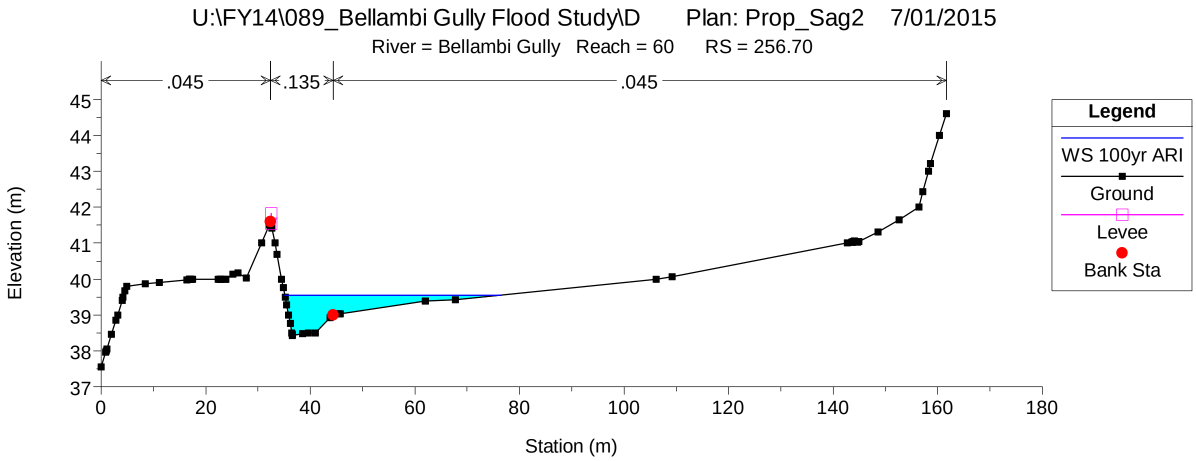
River = Bellambi Gully Reach = 60 RS = 296.84
.045
.02
.02
Legend
WS 100yr ARI
Ground
Bank Sta
Elevation (m)
Station (m)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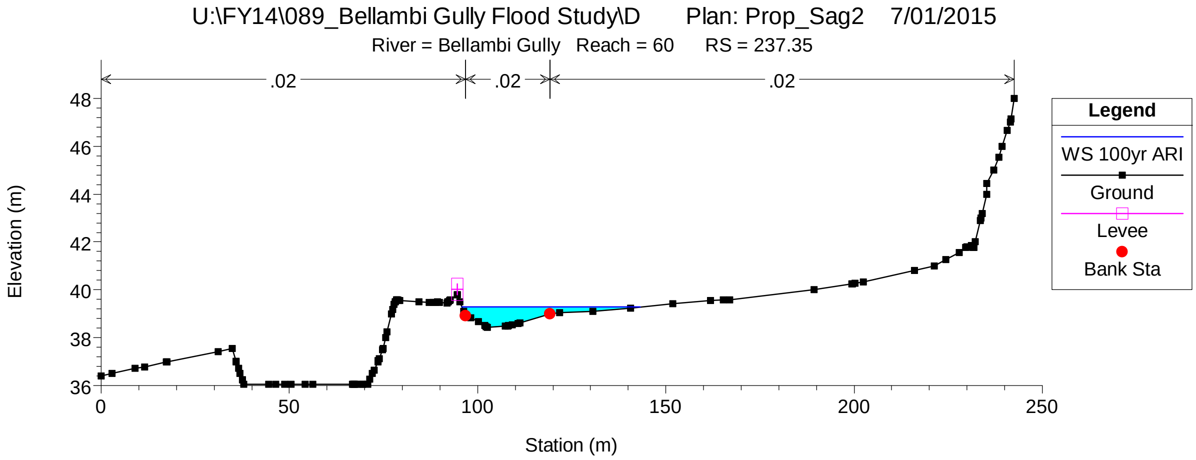
River = Bellambi Gully Reach = 60 RS = 256.70
.045
.135
.045
Legend
WS 100yr ARI
Ground
Levee
Bank Sta
Elevation (m)
Station (m)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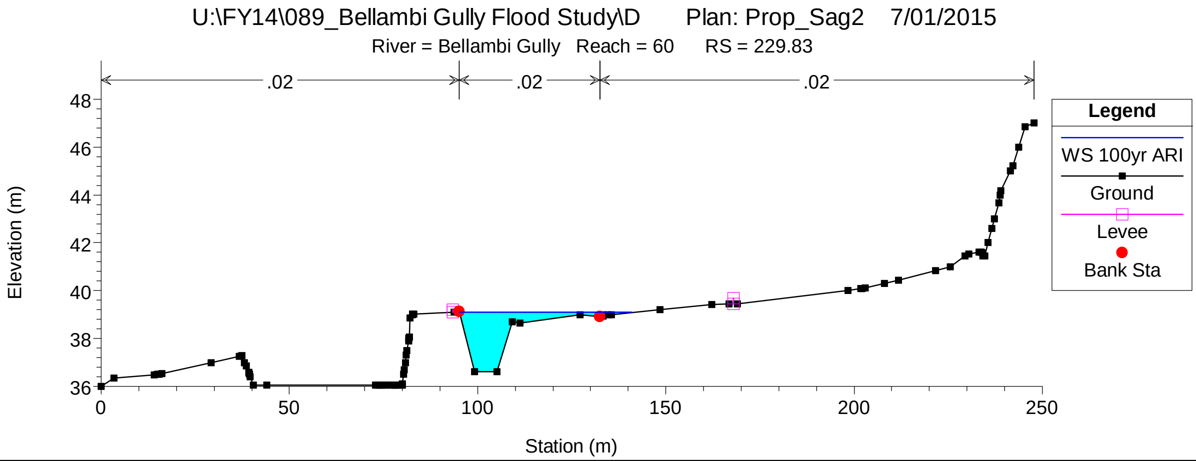
River = Bellambi Gully Reach = 60 RS = 237.35
.02
.02
.02
Legend
WS 100yr ARI
Ground
Levee
Bank Sta
Elevation (m)
Station (m)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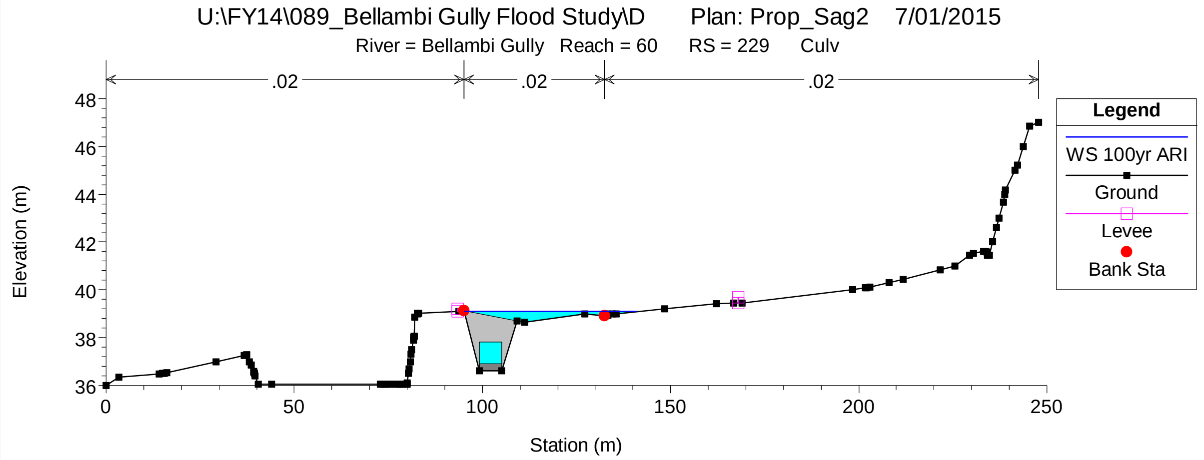
River = Bellambi Gully Reach = 60 RS = 229.83
.02
.02
.02
Legend
WS 100yr ARI
Ground
Levee
Bank Sta
Elevation (m)
Station (m)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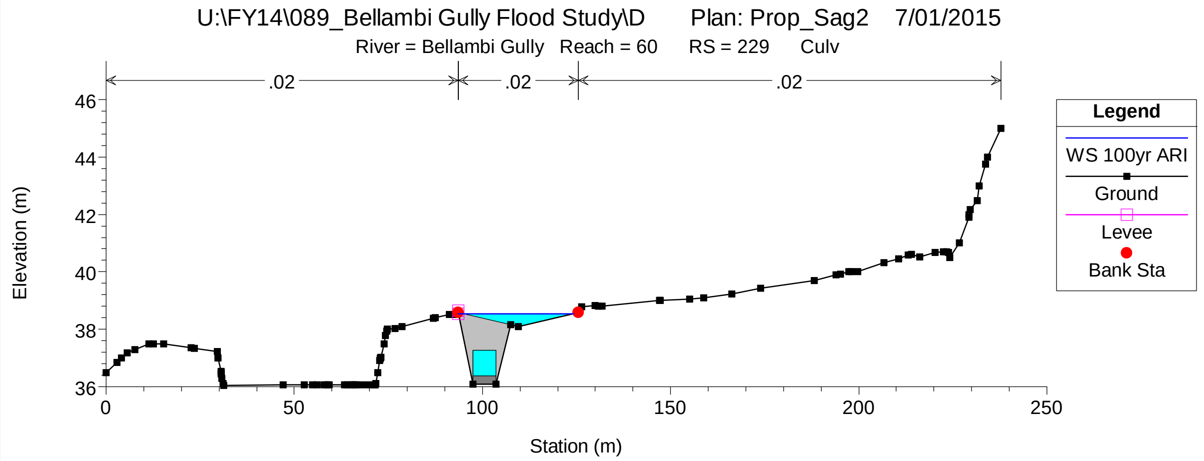
River = Bellambi Gully Reach = 60 RS = 229 Culv
.02
.02
.02
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Levee
Bank Sta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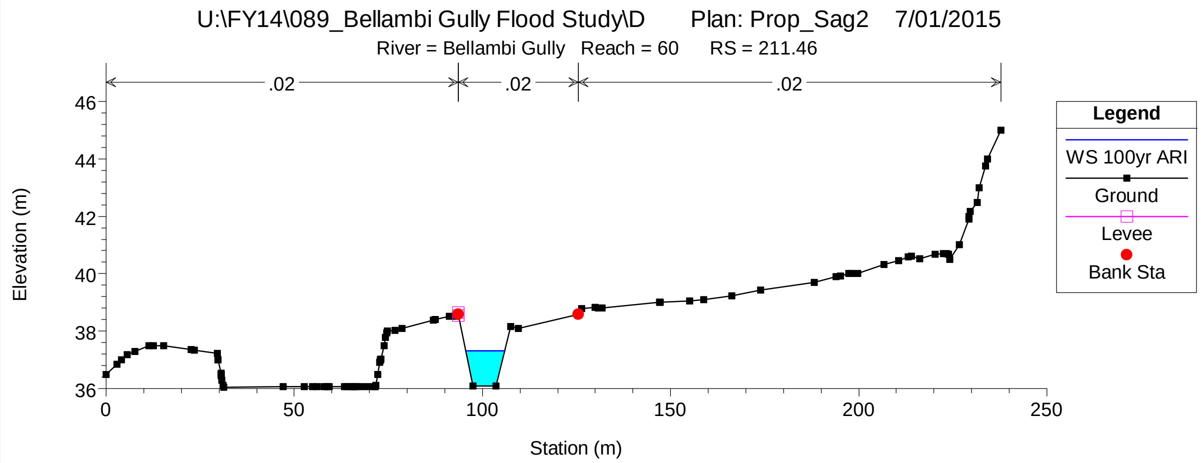
River = Bellambi Gully Reach = 60 RS = 229 Culv
.02
.02
.02
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Levee
Bank Sta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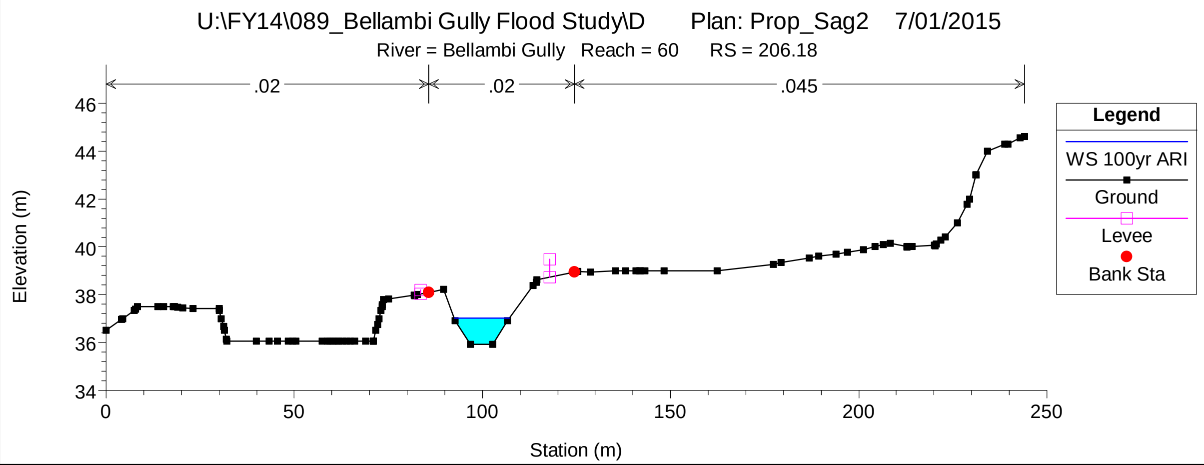
River = Bellambi Gully Reach = 60 RS = 211.46
.02
.02
.02
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Levee
Bank Sta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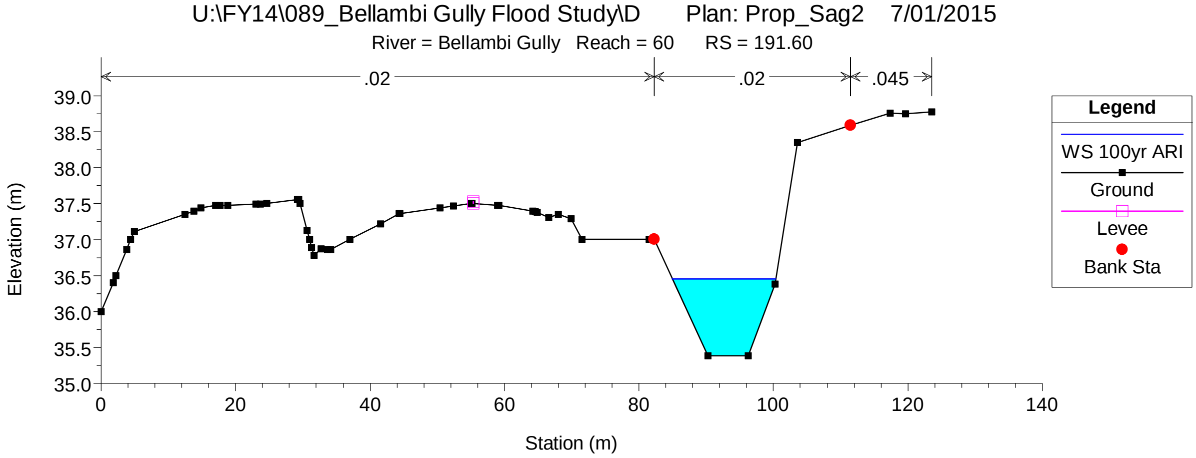
River = Bellambi Gully Reach = 60 RS = 206.18
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Levee
Bank Sta



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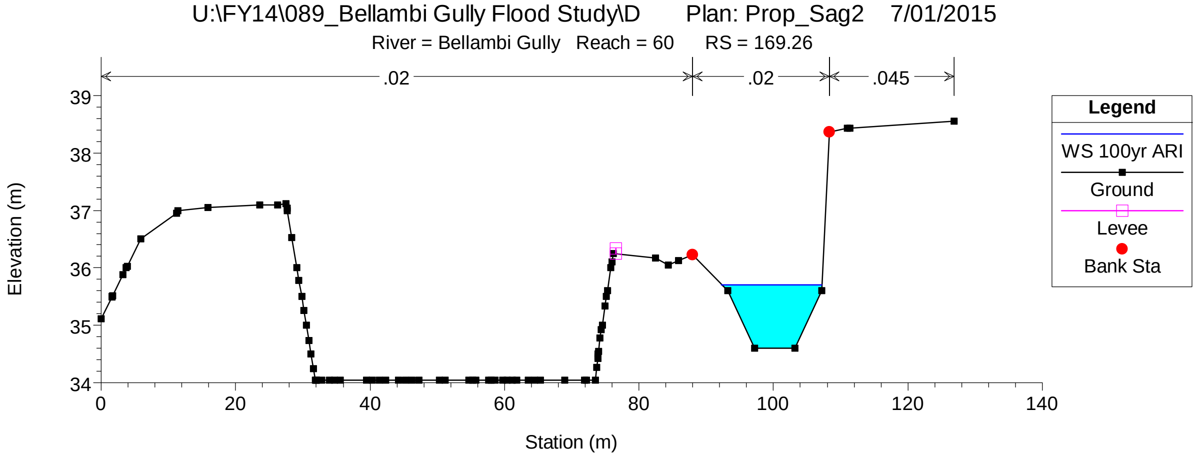
River = Bellambi Gully Reach = 60 RS = 191.60
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Levee
Bank Sta



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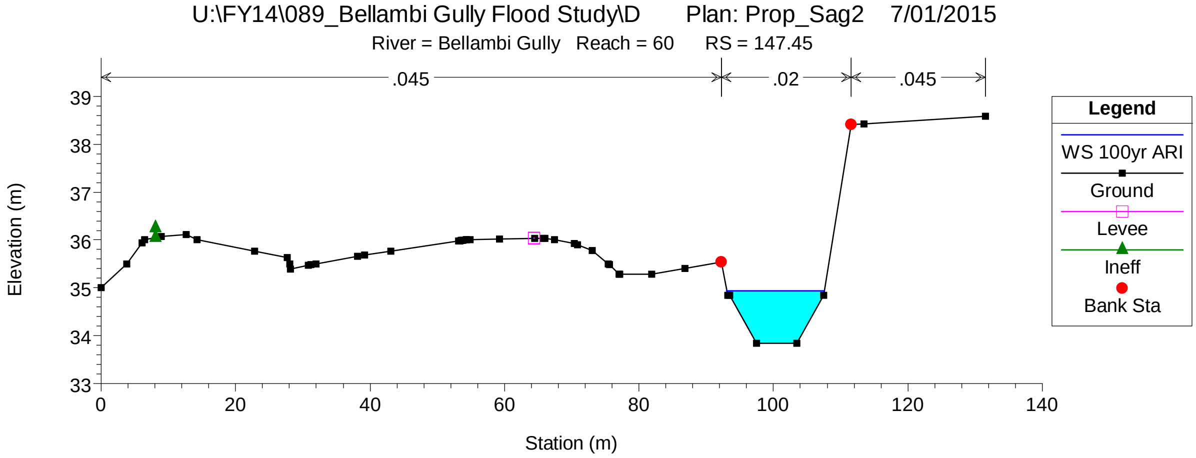
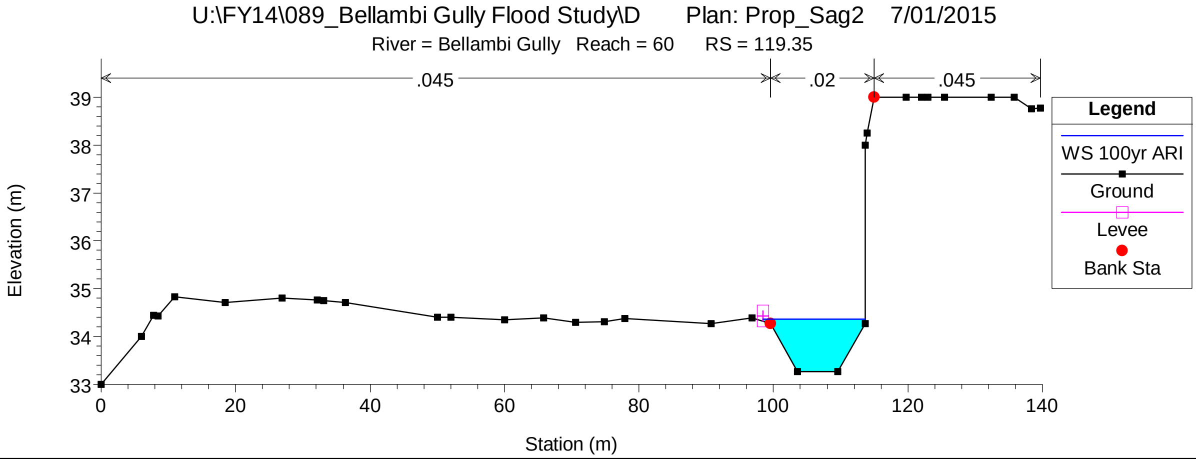
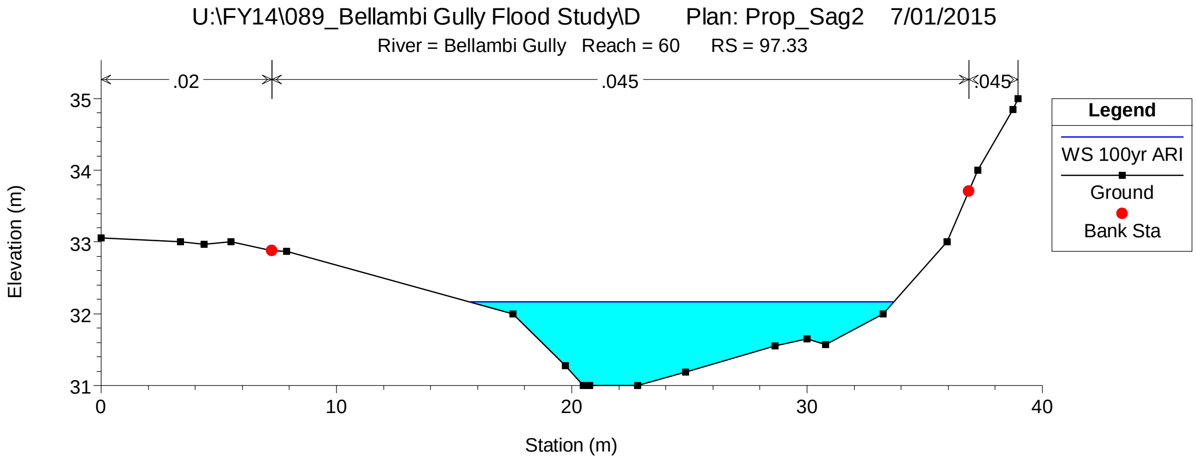
River = Bellambi Gully Reach = 60 RS = 169.26
.02
.02
.045
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Levee
Bank Sta



U:\FY14\089_Bellambi Gully Flood Study\D Plan: Prop_Sag2 7/01/2015
River = Bellambi Gully Reach = 60 RS = 147.45
.045
.02
.045
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Levee
Ineff
Bank Sta



U:\FY14\089_Bellambi Gully Flood Study\D Plan: Prop_Sag2 7/01/2015
River = Bellambi Gully Reach = 60 RS = 119.35
.045
.02
.045
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Levee
Bank Sta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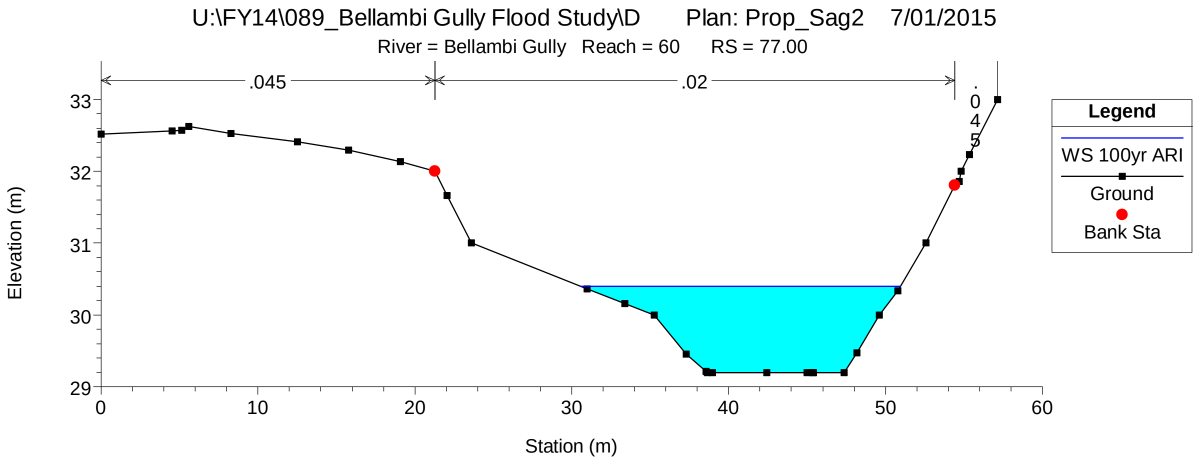
.02
.045
.045
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Bank Sta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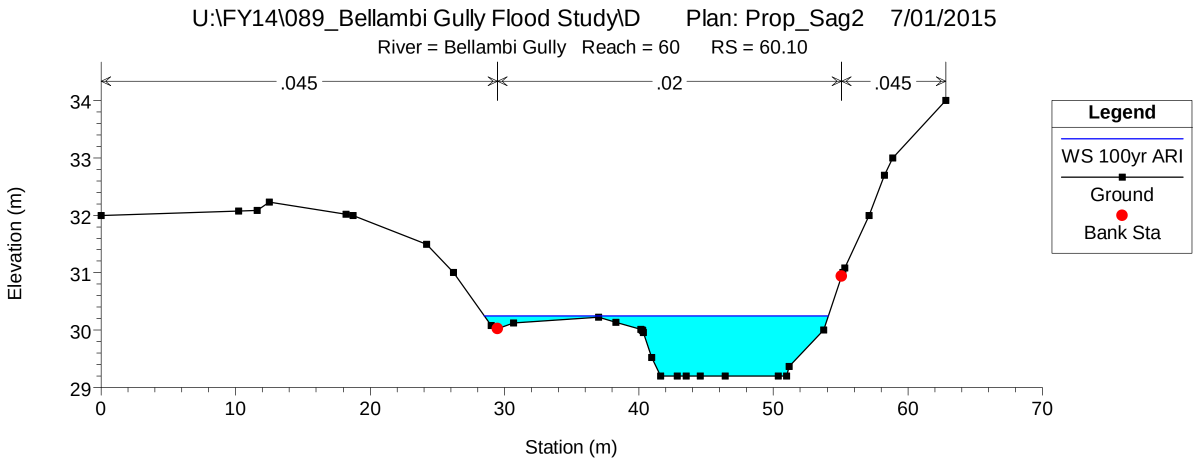
.045
.02
.045
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Bank Sta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River = Bellambi Gully Reach = 60 RS = 60.10
.045
.02
.045
Elevation (m)
Station (m)
Legend
WS 100yr ARI
Ground
Bank Sta

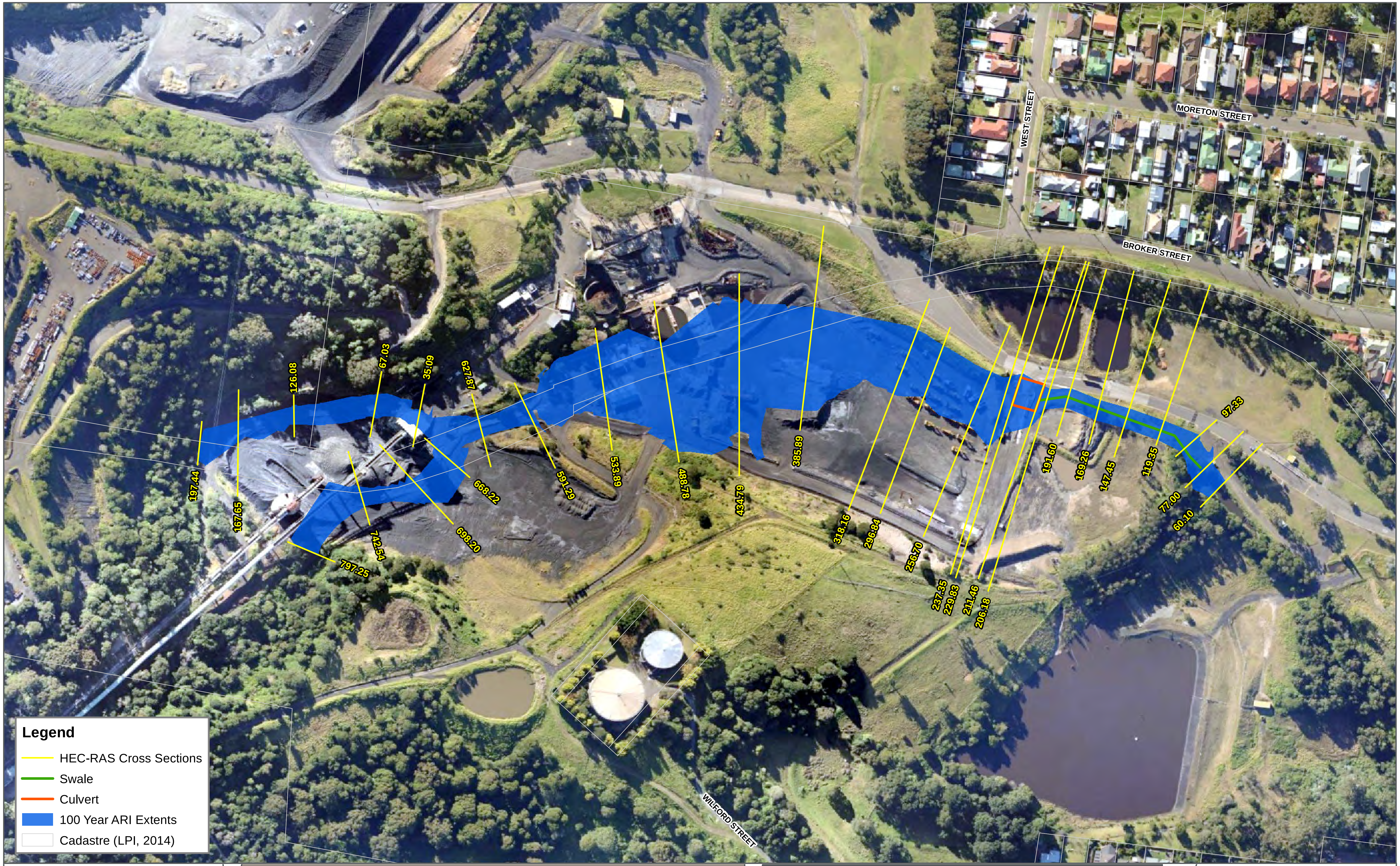
Results Table

HEC-RAS Plan: Prop_sag2 Profile: 100yr ARI

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Hydr Depth
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)
35	197.44	100yr ARI	9.74	67.46	68.19	68.19	68.41	0.270153	2.07	4.70	0.42
35	167.65	100yr ARI	9.74	65.29	65.69	65.69	65.85	0.005791	1.76	5.52	0.32
35	126.08	100yr ARI	9.74	63.00	65.20	65.20	65.64	0.008790	2.93	3.35	0.83
35	67.03	100yr ARI	9.74	58.14	59.42	59.42	59.73	0.005463	2.48	3.92	0.61
35	35.09	100yr ARI	9.74	56.63	57.63	57.63	57.83	0.005917	1.96	4.96	0.38
668	797.25	100yr ARI	28.60	63.47	64.37	64.37	64.69	0.004705	2.52	11.35	0.64
668	742.54	100yr ARI	28.60	59.00	60.43	60.43	60.79	0.004660	2.67	10.70	0.71
668	698.20	100yr ARI	28.60	58.57	59.51	59.51	59.76	0.005331	2.20	12.98	0.47
668	668.22	100yr ARI	28.60	56.59	57.44	57.44	57.67	0.004954	2.10	13.82	0.42
60	627.87	100yr ARI	31.63	53.52	54.80	54.80	55.19	0.004619	2.75	11.52	0.75
60	591.29	100yr ARI	31.63	50.72	52.24	52.24	52.57	0.005330	2.65	13.09	0.60
60	533.89	100yr ARI	31.63	47.64	48.38	48.38	48.63	0.005597	2.20	14.40	0.48
60	488.78	100yr ARI	31.63	46.73	47.51	47.51	47.66	0.005638	1.76	18.44	0.32
60	434.79	100yr ARI	31.63	44.35	44.69	44.69	44.80	0.006344	1.50	21.11	0.23
60	385.89	100yr ARI	31.63	43.03	43.41	43.41	43.54	0.006205	1.59	19.88	0.25
60	318.16	100yr ARI	31.63	40.64	41.14	41.14	41.32	0.005680	1.87	17.01	0.35
60	296.84	100yr ARI	31.63	39.35	40.28	40.28	40.49	0.005609	2.05	15.75	0.41
60	256.70	100yr ARI	31.63	38.43	39.55	39.55	39.76	0.067705	1.73	16.02	0.39
60	237.35	100yr ARI	31.63	38.43	39.28	39.28	39.48	0.003253	2.07	17.61	0.37
60	229.83	100yr ARI	31.63	36.62	39.09	37.87	39.14	0.000532	1.01	31.93	0.70
60	229		Culvert								
60	211.46	100yr ARI	31.63	36.08	37.32	37.32	37.81	0.004282	3.10	10.20	0.98
60	206.18	100yr ARI	31.63	35.92	37.02	37.02	37.41	0.004339	2.76	11.48	0.78
60	191.60	100yr ARI	31.63	35.38	36.46	36.46	36.83	0.004417	2.72	11.62	0.75
60	169.26	100yr ARI	31.63	34.60	35.71	35.71	36.09	0.004319	2.73	11.58	0.77
60	147.45	100yr ARI	31.63	33.84	34.94	34.94	35.33	0.004426	2.78	11.37	0.78
60	119.35	100yr ARI	31.63	33.27	34.37	34.37	34.76	0.004218	2.78	11.45	0.75
60	97.33	100yr ARI	31.63	31.00	32.17	32.17	32.51	0.023347	2.59	12.21	0.68
60	77.00	100yr ARI	31.63	29.20	30.40		30.59	0.002085	1.94	16.27	0.80
60	60.10	100yr ARI	31.63	29.20	30.24	30.24	30.53	0.005061	2.35	13.58	0.53

Bellambi Gully Flood Study

APPENDIX F
PROPOSED SCENARIO FLOOD MAP



WOLLONGONG COAL

Proposed Scenario

BELLAMBI GULLY FLOOD STUDY

1:2,500 Scale at A3

Metres

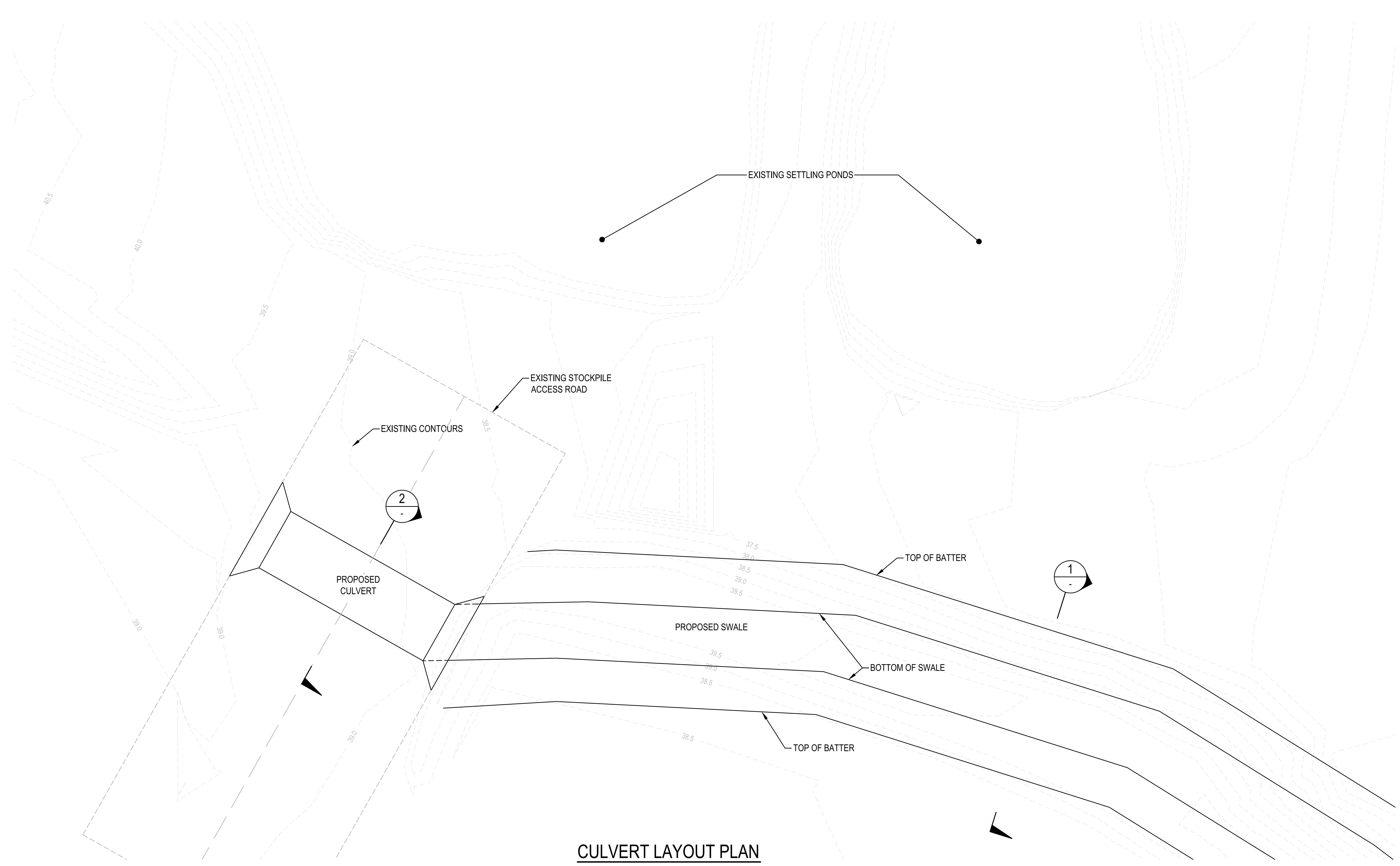
0 50 100 150 200

Cardno

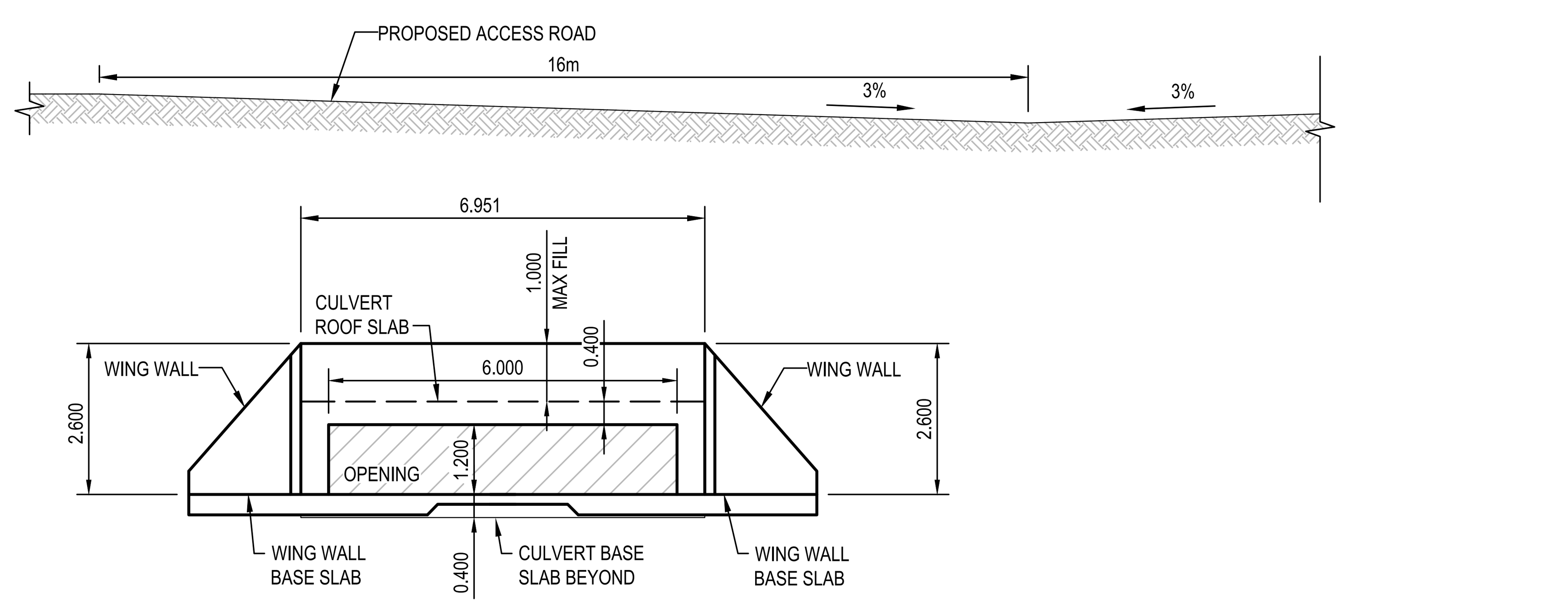
Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2015-01-07
Coordinate System: GDA 1994 MGA Zone 56
Project: 82014089-01
Map: G1005_ProposedScenario.mxd 04
Aerial imagery supplied by Nearmap (July, 2013).

APPENDIX G
PROPOSED MITIGATION STRUCTURES

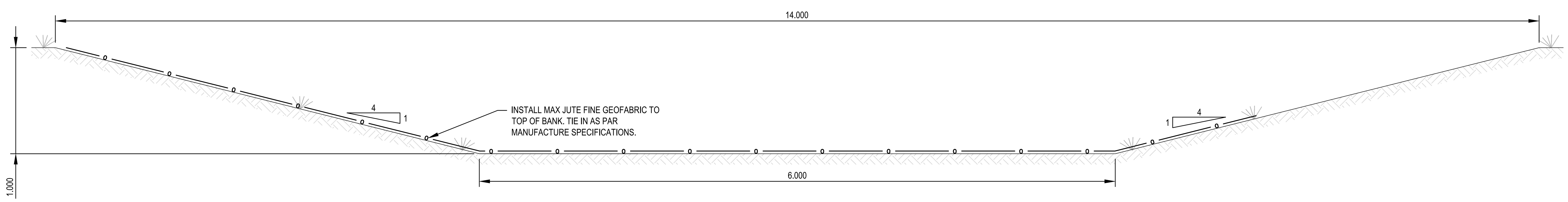
DATE PLOTTED: 7 January 2015 3:25 PM BY : BROOKE HENDERSON



CULVERT LAYOUT PLAN
SCALE 1:250



SECTION 2
SCALE 1:100



SECTION 1
SCALE 1:25

0 0.5 1 1.5 2 2.5m
SCALE 1:25 @A1

0 1 2 4 6 8 10m
SCALE 1:100 @A1

0 5 10 15 20 25m
SCALE 1:250 @A1

Rev.	Date	Description	Des.	Verif.	Appd.
2	7/01/2015	MINOR AMENDMENTS AS PER COUNCIL COMMENTS	BAH	SBR	ODJ
1	24/11/2014	ISSUED FOR APPROVAL	AMW	SBR	ODJ

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Web: www.cardno.com.au

		Date
Drawn	AMW	24/11/2014
Checked	FK	24/11/2014
Designed	AMW	24/11/2014
Verified	SBR	24/11/2014
Approved	ODJ	24/11/2014

Client: WOLLONGONG COAL LIMITED

Project: BELLAMBI GULLY FLOOD STUDY

Title: PROPOSED CULVERT AND SWALE SECTIONS AND DETAILS

Status: FOR APPROVAL
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DATUM	Scale	Size
AHD	AS SHOWN	A1

Drawing Number: 82014089-01-C1000 | Revision: 2

XREF's:
CAD File: U:\FY14089_Bellambi Gully Flood Study\Drawings\Build\82014089-01-C1000.dwg

David Clarkson

From: Ron Zwicker <RZwicker@wollongong.nsw.gov.au>
Sent: Monday, 16 February 2015 8:45 AM
To: David Clarkson
Cc: Sara Wilson (Sara.Wilson@planning.nsw.gov.au); Howard.Reed@planning.nsw.gov.au
Subject: FW: TRIM: FW: Updated Bellambi Gully Flood Study for Russell Vale Colliery Site (82014089-01)

Hi Dave

Please see comments from Sasho – The revised January 2015 Flood Study has addressed Council's previous comments.

Therefore, Council requests that the revised January 2015 Flood Study form part of the conditions of any consent granted for the Russell Vale Colliery Underground Expansion Project. This advice was also communicated to the PAC Commissioners when Council met the PAC recently.

Regards

Ron Zwicker
Special Projects Manager
Wollongong City Council
Locked Bag 8821
WOLLONGONG DC NSW 2500
Ph. (02) 4227 7639
Email:rzwicker@wollongong.nsw.gov.au

From: Sasho Srbinovski [mailto:SSrbinovski@wollongong.nsw.gov.au]
Sent: Thursday, 29 January 2015 3:50 PM
Subject: RE: TRIM: FW: Updated Bellambi Gully Flood Study for Russell Vale Colliery Site (82014089-01)

Hi Ron

The revised Bellambi Gully Flood Study by Cardno dated January 2015 submitted in support of alternative flood mitigation measures on the Russellvale Colliery site has been assessed against Chapters E13/E14 of the Wollongong DCP 2009 and previous stormwater comments dated 17 December 2014.

It is considered that the previous flooding comments raised have now been addressed. In particular, the flood modelling has now considered all culverts <6m in diagonal as 100% blocked and (proposed) culverts >6m in diagonal as 25% blocked btm up. This has resulted in a proposed culvert 6m wide x 1.2m high under access road with low point in access road to direct overflows into proposed swale designed to carry the 100 year flows from the site.

The following condition is recommended with respect to the proposed flood mitigation works on the site:

The proposed flood mitigation works for the site should be undertaken in accordance with the measures put forward within the Bellambi Gully Flood Study report 001 version 06 by Cardno dated January 2015.

regards

Sasho Srbinovski | Senior Stormwater Development Engineer | Wollongong City Council
T: 02 4227 7111| F: 02 4227 7048 | E: ssrbinovski@wollongong.nsw.gov.au
41 Burelli Street, Wollongong NSW 2500

From: Ron Zwicker
Sent: Tuesday, 27 January 2015 10:23 AM
To: Sasho Srbinovski
Subject: TRIM: FW: Updated Bellambi Gully Flood Study for Russell Vale Colliery Site (82014089-01)

Sasho

Please see revised flood study.

Cheers

Ron

From: Dianne Munro [mailto:DMunro@hansenbailey.com.au]
Sent: Tuesday, 27 January 2015 9:46 AM
To: Ron Zwicker

Cc: Howard Reed; Sara Wilson; David Clarkson; Andrew Wu
Subject: RE: Updated Bellambi Gully Flood Study for Russell Vale Colliery Site (82014089-01)

A file has been sent to you via the **YouSendIt** File Delivery Service.

Download the file - Report 001 V06 Bellambi Gully Flood Study_(Amendments_Highlighted).pdf

Your file will expire after 14 days or 500 downloads.

Hi Ron, find attached updated flood study as forwarded by Dave Clarkson on 14 January.

Please let us know if you require anything further.

Regards,
Dianne.

Dianne Munro
Principal
MEnvLaw BSc

HANSEN BAILEY
Tel: (02) 6575 2003
Fax: (02) 6575 2001
Mobile: 0428 772 566
Email: dmunro@hansenbailey.com.au

From: David Clarkson [mailto:dclarkson@wcl.net.au]
Sent: Wednesday, January 14, 2015 10:38 AM
To: rzwicker@wollongong.nsw.gov.au
Cc: Dianne Munro; Howard Reed; Sara Wilson
Subject: Updated Bellambi Gully Flood Study for Russell Vale Colliery Site (82014089-01)

Hi Ron,

Please find attached a revised Bellambi Gully flood study to incorporate Council's requests in your email below.

The revised report adopts Council blockage policy upstream of the 6m culvert, and increases the sag over the culvert to convey 100 year ARI flows overtopping the road in this scenario. Amended sections have been highlighted for reference.

The revised modelling does not affect the conclusion or recommendations.

We look forward to your early approval of the attached report.

Cheers

Dave Clarkson
Group Environment Manager
WOLLONGONG COAL
☎ Mob: 0458 059 564
✉ Email: dclarkson@wcl.net.au

From: Ron Zwicker <RZwicker@wollongong.nsw.gov.au>
Date: 18 December 2014 9:27:41 am AEST
To: "David Clarkson (dclarkson@wcl.net.au)" <dclarkson@wcl.net.au>, "Owen de Jong (owen.dejong@cardno.com.au) (owen.dejong@cardno.com.au)" <owen.dejong@cardno.com.au>
Cc: Sasho Srbinovski <SSrbinovski@wollongong.nsw.gov.au>, "Sara Wilson (Sara.Wilson@planning.nsw.gov.au)" <Sara.Wilson@planning.nsw.gov.au>, "Howard.Reed@planning.nsw.gov.au" <Howard.Reed@planning.nsw.gov.au>
Subject: FW: review of Bellambi Gully Flood Study for Russell Vale Colliery Site

Hi Dave / Owen

Please see Sasho's comments regarding the revised Bellambi Gully Flood Study.

Regards

Ron Zwicker
Special Projects Manager
Wollongong City Council
Locked Bag 8821
WOLLONGONG DC NSW 2500
Ph. (02) 4227 7639
Email:rzwicker@wollongong.nsw.gov.au

From: Sasho Srbinovski
Sent: Thursday, 18 December 2014 9:50 AM
To: Ron Zwicker
Subject: review of Bellambi Gully Flood Study for Russell Vale Colliery Site

Hi Ron

Please find my comments below.

The Bellambi Gully Flood Study by Cardno dated November 2014 submitted in support of alternative flood mitigation measures on the Russellvale Colliery site has been assessed against Chapters E13/E14 of the Wollongong DCP 2009 and previous stormwater comments dated 22 September 2014. The following comments are made:

The proposed mitigation option within the current (November 2014) flood study by Cardno for the subject site has assumed a portion of the contributing stormwater flows at the site will be catered for within the existing stormwater pipes, which is considered unrealistic in light of the flood impacts experienced both on site and downstream in 1998.

Whilst the proposal to implement debris control structures across existing inlets together with management procedures has merit, these measures are not considered as 'failsafe' and therefore unlikely to prevent a recurrence of the flood impacts experienced in this area in 1998.

In order to address the concerns raised above, the proposed mitigation option for the site should be based on the Wollongong Council 'policy based' conduit blockage criteria. This approach adopts 100% blockage of all stormwater pipes having less than 6m diagonal opening and 25% bottom up blockage for stormwater pipes having greater than 6m diagonal opening. This would result in a culvert design of greater than 6m in diagonal located at the stockpile access road to cater for the contributing stormwater flows arriving on the site for a 100 year ARI event or greater. The proposed swale alongside the stockpile access road should also be designed to cater for the contributing 100 year ARI flows or greater to ensure these flows are conveyed to the licensed discharge point at Bellambi Creek.

The proposed flood mitigation measures for the site should be accurately reflected within Appendix E of the updated study.

Final dimensions of the proposed culvert and swale including calculations demonstrating the capacity of each in line with the abovementioned conduit blockage policy should be included within the study for further assessment.

regards

Sasho Srbinovski | Senior Stormwater Development Engineer | Wollongong City Council
T: 02 4227 7111 | F: 02 4227 7048 | E: ssrbinovski@wollongong.nsw.gov.au
41 Burelli Street, Wollongong NSW 2500

From: Ron Zwicker
Sent: Tuesday, 25 November 2014 3:29 PM
To: Owen de Jong; Sasho Srbinovski
Cc: David Clarkson (dclarkson@wcl.net.au); Shaza Raini; Wollongong Document Control
Subject: RE: Bellambi Gully Flood Study (82014089-01)

Hi Owen

Thanks for the revised flood study.

The revised flood study will be reviewed and we will provide appropriate feedback within the next 2 weeks.

In light of this, I agree that the meeting this week is no longer necessary.

Can you also ask Wollongong Coal to formally lodge the revised flood study with the NSW Department of Planning & Environment since the Department will also need to be involved in any decision making concerning this revised flood study.

Regards

Ron Zwicker
Special Projects Manager
Wollongong City Council
Locked Bag 8821
WOLLONGONG DC NSW 2500
Ph. (02) 4227 7639
Email:rzwicker@wollongong.nsw.gov.au

From: Owen de Jong [mailto:owen.dejong@cardno.com.au]
Sent: Tuesday, 25 November 2014 2:59 PM
To: Ron Zwicker; Sasho Srbinovski
Cc: David Clarkson (dclarkson@wcl.net.au); Shaza Raini; Wollongong Document Control
Subject: Bellambi Gully Flood Study (82014089-01)

Ron / Sasho,

Please find attached the updated Bellambi Gully flood study for your consideration, which has been revised following the outcomes of our recent meeting.

With regards to the culvert sizing, we reviewed sizing of the 6m RCBC designed for the Ridge (as discussed), and found that 1.2m H was adopted following liaison / agreement with Council. On this basis we've adopted 1.2m H for this site also.

Happy to meet on Thursday to discuss (if necessary), otherwise if any further clarity is required please don't hesitate to contact me.

Regards,

Owen de Jong
SENIOR WATER ENGINEER - MIEAUST CPENG
CARDNO

Phone +61 2 4231 9633 Fax +61 2 4228 6811
Address Level 1, 47 Burelli Street, Wollongong 2500 NSW Australia
Postal P.O. Box 1285, Wollongong NSW 2500
Email owen.dejong@cardno.com.au Web www.cardno.com

Appendix F

Economic Assessment

Russell Vale Colliery Underground Expansion Project
Economic Assessment

Prepared

for

Hansen Bailey

By

Gillespie Economics
Tel: (02) 9804 8562
Email: gillecon@bigpond.net.au

February 2015

TABLE OF CONTENTS

1 INTRODUCTION

This report examines the projected economic costs and benefits of the Project, including the basis for their estimation, through benefit cost analysis (BCA). It is supplemented with the consideration of potential economic activity (including employment) impacts of the proposal at the local, regional and national levels. The analysis has been prepared by Gillespie Economics based on information provided by Wollongong Coal Limited (WCL) in the Preferred Project Report.

2 BENEFIT COST ANALYSIS

2.1 Introduction

Benefit Cost Analysis (BCA), undertaken at a national level, is the primary way that economists evaluate the net benefits of projects and policies (Boardman et al. 1990).

BCA has its theoretical underpinnings in neoclassical welfare economics. BCA applications in NSW are guided by these theoretical foundations as well as the NSW Treasury (2007). BCA applications within the NSW environmental impact assessment framework are further guided by the NSW Government (2012) *Draft Guidelines for the use of Cost Benefit Analysis in mining and coal seam gas proposals*. Guidelines for application of BCA at the Commonwealth level include *Handbook of Cost Benefit Analysis* (Commonwealth of Australia, 2006).

BCA is concerned with a single objective of governments (i.e. economic efficiency). It provides a comparison of the present value of aggregate benefits to society, as a result of a project, policy or program, with the present value of the aggregate costs. These costs and benefits are defined and valued based on the microeconomic underpinnings of BCA. In particular, it is the values held by individuals in the society that are relevant, including both financial and non-financial values. Provided the present value of aggregate benefits to society exceed the present value of aggregate costs (i.e. a net present value of greater than zero), the project is considered to improve the well-being of society and hence is desirable from an economic efficiency perspective.

In attempting to value the impacts of a project on the well-being of people there is also the practical principle of materiality. Only those impacts which are likely to have a material bearing on the decision need to be considered in BCA.

Even when no quantitative valuation is undertaken of the environmental, social and cultural impacts of a project, the threshold value approach can be utilised to inform the decision-maker of the economic efficiency trade-offs. The estimated net production benefits of a project provides the threshold value that the non-quantified environmental, social and cultural impacts of a project (based on the assessments in the EIS), after mitigation, offset and compensation by the proponent, will need to exceed for them to outweigh the net production benefits.

While BCA can provide qualitative and quantitative information on how costs and benefits are distributed, welfare economics and BCA are explicitly neutral on intra and intergenerational distribution of costs and benefits. There is no welfare criterion in economics for determining what constitutes a fair and equitable distribution of costs and benefits. Judgements about equity are subjective and are therefore left to decision-makers.

Similarly, BCA does not address other objectives of governments. Decision-makers therefore need to consider the economic efficiency implications of a project, as indicated by BCA, alongside the performance of a project in meeting other conflicting goals and objectives of governments.

2.2 Potential Costs And Benefits

Relative to the base case or "without" Project scenario, the Project may have the potential incremental economic benefits and costs shown in **Table 2.1**. The main potential economic benefit is the producer surplus (net production benefits) generated by the Project and any nonmarket employment benefits it provides, while the main potential economic costs relate to any environmental, social and cultural costs.

Table 2.1
Incremental Economic Benefits and Costs of the Project

Category	Costs	Benefits
Net production benefits	Opportunity costs of capital equipment Opportunity cost of land[1] Development costs including labour, capital equipment and acquisition costs for impacted properties and offsets[1] Operating costs of mine including labour and mitigation, offsetting and compensation measures Rehabilitation and decommissioning costs at end of the Project life	Value of coal Residual value of capital equipment and land at end of Project life
Potential environmental, social and cultural impacts	Greenhouse gas impacts Noise impacts Air quality impacts Surface water impacts Groundwater impacts Ecology impacts Road transport impacts Infrastructure impacts Aboriginal heritage impacts Non-Aboriginal heritage impacts Visual impacts	Any nonmarket benefits of employment

[1] The value of foregone agricultural production is included in the value of land.

The costs and benefits of the Project can therefore be simplified to a trade-off between:

- The net production benefits of a project; and
- The environmental, social and cultural impacts (most of which are costs of mining but some of which may be benefits).

2.3 Net Production Benefits

By combining resources in ways that increase their value to society, mining projects create a net production benefit (a producer surplus). This net production benefit can be estimated based on market data on the projected financial[1] value of the resource less the capital and operating costs of projects, including opportunity costs of capital and land already in the ownership of mining companies.

Net production benefits can be generally thought of as comprising royalties, company tax and net profits. Where a project is foreign owned it is the royalties and company tax that accrue to Australia that comprise the net production benefits of the Project. Increases in the capital and operating costs of a project to mitigate, compensate or offset environmental, social and cultural impacts will reduce

[1] In limited cases the financial value may not reflect the economic value and therefore it is necessary to determine a shadow price for the resource.

the company tax component (and net profit component) of the net production benefits of a project but have no impact on the royalties component.

The Project will result in Run-of-Mine (ROM) coal production of 4.7 million tonnes (mt) and gross revenue of $400 M[2] (present value at 7% discount rate). The project will generate total royalties of $34 M based on an average royalty rate of 7.2%. Using a 7% discount rate the present value of royalties from the Project are estimate at $29 M. This is a minimum estimate of the net production benefits of the Project[3] and provides a minimum threshold value against which the environmental, social and cultural costs of the Project, after mitigation, offsetting and compensation, can be compared.

2.4 Environmental, Social And Cultural Impacts

Introduction

The consideration of nonmarket environmental, social and cultural impacts in BCA relies on the assessment of other experts contributing information on the biophysical impacts. The environmental impact assessment process results in (nonmonetary) consideration of the environmental, social and cultural impacts of a project and the proposed means of mitigating the impacts. When environmental, social and cultural impacts are mitigated, offset or compensated to the extent where community wellbeing is insignificantly affected (i.e. costs are borne by the proponent), then no environmental, social or cultural economic costs should be included in the Project BCA apart from the mitigation, compensation or offset costs.

Greenhouse Gas

Over the lifetime of the Project it would generate 767,789 t of direct carbon dioxide equivalent (CO_2-e) emissions associated with mining (Scope 1 emissions) and Scope 2 emissions from consumptions of grid electricity. In addition it would generate 5,545 t of indirect (Scope 3) CO_2-e emissions associated with the road transport of product coal to the Port Kembla Coal Terminal (PKCT).[4]

To place an economic value on CO_2-e emissions, a shadow price of CO_2-e is required that reflects its global social costs. For the purpose of this analysis the Commonwealth Government's previous carbon tax price of AUD$23/t CO_2-e is used as a proxy for the global damage cost of carbon (i.e. the cost of carbon emissions to the population of the whole world). In the absence of any studies that have focused on the social damage cost of carbon emissions to Australians, some means of apportioning global damage costs borne by Australians is required. For the purpose of the economic assessment this has been undertaken using Australia's share of global GDP (around 1%). An alternative approach would be Australia's share of world population which is considerably less than 1%.

On this basis the present value of the cost of greenhouse gas emissions from the Project is estimated at $0.15 M. This is not offset, mitigated or compensated for and needs to be compared to the net production benefits of the Project.

Noise Impacts

A revised noise assessment for the Project was undertaken in 2014. New noise criteria are specified in the draft Project Approval. Predicted noise levels exceed the criteria at 12 receiver locations. The

[2] Based on 52.6% coking coal at $150/tonne and 28.6% thermal coal at $90/tonne and average annual production of 934,000 tonnes.

[3] It is a minimum estimate since net production benefits to Australia also includes company tax. No estimate of company tax was available.

[4] Other Scope 3 emissions associated with the shipping and use of coal are beyond the scope of a BCA of a mining project.

exceedances are in the magnitude of 2-5 dBA. This potentially gives rise to management liabilities but not acquisition liabilities in accordance with the new Land Acquisition Policy (DP&E, 2015). These noise management costs would form part of the capital and operating costs of the Project. In the minimum threshold value framework adopted in this analysis, these costs would not be subtracted from the estimate of royalties but would reduce the unquantified level of company tax payable.

Air quality

No significant air quality impacts are predicted. While air quality modelling indicates potential exceedance of the PM_{10} 24-hr criterion at Receptor 1 on one day of the year, this is due to extraordinary events and under the Project Approval conditions is not considered to be an exceedance that gives rise to any acquisition liability. No material impact therefore arises that would be included in the BCA.

Surface water

Reductions in raw water supply due to groundwater depressurisation resulting from subsidence are estimated at 8.66 ML/year from the water supply catchment comprising a loss of:

- 6.83 ML/year from the tributaries flowing into Cataract Reservoir; and
- 1.83 ML/year directly from the reservoir.

To the extent that this reduction in water supply impacts the water yield (the volume of water that can be supplied reliably over the long term[5]) there is an economic cost. One approach to valuing this economic cost is the cost of replacing it from alternative sources. Assuming an opportunity cost of water of $2,000 per ML/year and water loss occurring in perpetuity, these impacts equate to $235,000 (present value at 7% discount rate). These surface water costs would form part of the capital and operating costs of the Project. In the minimum threshold value framework adopted in this analysis, these costs would not be subtracted from the estimate of royalties but would reduce the unquantified level of company tax payable.

Groundwater

Groundwater inflows to underground mine workings were modelled using the MODFLOW-SURFACT numerical groundwater model. The maximum volumetric inflow to the mine workings is predicted to be 2.31 ML/day (834 ML/year).

WCL will require Water Access Licences (WALs) under the *Water Management Act 2000* to account for these mine inflows. WCL currently holds an aquifer WAL with a share component of 365 ML/year. WCL has applied for the additional shares required. These shares are estimated to have an opportunity cost of $800/ML (i.e. $1.7 M). These groundwater costs would form part of the capital and operating costs of the Project. In the minimum threshold value framework adopted in this analysis, these costs would not be subtracted from the estimate of royalties but would reduce the unquantified level of company tax payable.

Ecology

Impacts on aquatic ecology and terrestrial ecology have been assessed as negligible. However, there will be 11 upland swamps that are completely or partially undermined by the Project. Undermining of swamps may not translate into actual impacts. However, if the Project has more than a negligible impact on swamps, offsets will be provided to compensate for lost swamp values. Provided the value held by the community for these offsets is equal to or greater than the value held by the community

[5] Which changes with changes to inflows, infrastructure, demographics, the system design criteria, regimes of restrictions and the operating rules for the system.

for the impacted swamps, then the community is no worse-off and it is the cost of providing these offsets that is the appropriate value to include in the BCA. These ecological offset costs would form part of the capital and operating costs of the Project. In the minimum threshold value framework adopted in this analysis, these costs would not be subtracted from the estimate of royalties but would reduce the unquantified level of company tax payable.

Traffic and Transport

Traffic and transport from the Project is associated with coal haulage to PKCT via Bellambi Lane, Northern Distributor, Southern Freeway, Masters Road, Springhill Road and Port Kembla Road, as well as employee, visitors and courier vehicles accessing the Colliery. The Road Traffic Assessment did not identify any significant issues from a road traffic performance or safety perspective. Consequently, there are no material economic effects for inclusion in the BCA.

Infrastructure

Negligible impacts are anticipated to Mt Ousley Road or Picton Road interchange and no impacts are predicted for Cataract Reservoir. Potential impacts could occur to a number of electrical transmission lines. A monitoring regime will be implemented and a technical committee comprising representatives from Russell Vale, the power utility companies, the Mine Subsidence Board, and government regulators is proposed to manage potential impacts. The Mine Subsidence Levy paid by WCL is the mechanism by which preventative measures and structural repairs are funded. The levy forms part of the operating costs of the Project. In the minimum threshold value framework adopted in this analysis, these costs would not be subtracted from the estimate of royalties but would impact the unquantified level of company tax payable.

Aboriginal Cultural Heritage

Of the 21 Aboriginal cultural heritage sites potentially affected by the Project, one site of low scientific significance is estimated to be at greater than low risk of impact (moderate risk). Sites of low scientific significance are likely to have low community economic values and hence a moderate risk to these sites is unlikely to lead to any material economic effects for inclusion in the BCA.

Historic Heritage

No impacts are predicted for historic heritage sites and hence there are no material economic effects for inclusion in the BCA.

Visual Impacts

Russell Vale Colliery is well established in an area historically used for coal mining. Changes to the existing viewscape from the Project, to publicly accessible viewpoints outside the colliery, are minor. The management measures proposed will ensure that the Project will not significantly impact the visual amenity at any sensitive receiver. These management costs would form part of the capital and operating costs of the Project. In the minimum threshold value framework adopted in this analysis, these costs would not be subtracted from the estimate of royalties but would reduce the unquantified level of company tax payable.

Employment

In standard BCA, the wages associated with employment are considered an economic cost of production with this cost included in the calculation of net production benefits (producer surplus). Where labour resources used in a project would otherwise be employed at a lower wage or would be unemployed a shadow price of labour is included in the estimation of producer surplus rather than the actual wage (Boardman et al. 2001[6]). The shadow price of labour is lower than the actual wage and has the effect of increasing the magnitude of the producer surplus benefit of a project.

These treatments of employment in BCA relate to the market value or opportunity cost of labour resources. However, BCA also includes nonmarket values (i.e. the values that individuals in a community hold for things even though they are not traded in markets). For example, people have been shown to value environmental resources even though they may never use the resource. These are referred to as existence values and are underpinned by the view in neoclassical welfare economics that individuals are the best judge of what has value to them. As identified by Portney (1994[7]), the concept of existence values should be interpreted more broadly than just relating to environmental resources and may also apply to the employment of others.

Empirical evidence for these values was found in three choice modelling studies of mining project in NSW. In a study of the Metropolitan Colliery in the NSW Southern Coalfields, Gillespie Economics (2008) estimated the value the community would hold for the 320 jobs provided over 23 years at $756 M (present value). In a similar study of the Bulli Seam Operations, Gillespie Economics (2009a) estimated the value the community would hold for the 1,170 jobs provided over 30 years at $870 M (present value). In a study of for the Warkworth Mine extension, Gillespie Economics (2009b) estimated the value the community would hold for 951 jobs from 2022 to 2031 at $286M (present value).

The Project will provide continued employment for the approximately 287 employees for a period of up to five years. Using benefit transfer from the more conservative Bulli Seam Operation study and applying the employment value to the estimated direct employment of the Project[8] gives an estimated $36 M for the nonmarket employment benefits of the Project. In the context of a fully employed economy there may be some contention about the inclusion of this value. Consequently, the results are reported with and without these values.

2.5 Net Social Benefits of the Project

The Project is estimated to have minimum net production benefits (royalties) of $29 M to Australia. In addition, there would be unquantified company tax benefits to Australia and potentially nonmarket benefits of employment of in the order of $36 M.

The estimated minimum net production benefits of $29 M can be used as a threshold value or reference value against which the relative value of the residual environmental impacts of the Project, after mitigation, may be assessed. This threshold value is the opportunity cost to society of not proceeding with the Project. The threshold value indicates the price that the Australian community must value any residual environmental impacts of the Project (be willing to pay) to justify in economic efficiency terms the no development option.

For the Project to be questionable from an economic efficiency perspective, all incremental residual environmental, social and cultural impacts from the Project, to Australia[9], after mitigation, offset and compensation, would need to be valued by the community at greater than the estimate of the Australian net production benefits (i.e. greater than $29 M).

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[6] Boardman, A., Greenberg, D., Vining, A. and Weimer, D. (2001) *Cost-benefit analysis: concepts and practice*, Prentice Hall, New Jersey.

[7] Portney, P. (1994) The Contingent Valuation Debate: Why Economists Should Care, *Journal of Economic Perspectives* 8:4, 3-18.

[8] This is consistent with the non-market valuation studies which focused on direct employment.

[9] Consistent with the approach to considering net production benefits, environmental impacts that occur outside Australia would be excluded from the analysis. This is mainly relevant to the consideration of greenhouse gas impacts.

Instead of leaving the analysis as a threshold value exercise, an attempt has been made to quantitatively consider the potential residual impacts of the Project that are not already mitigated, compensated or offset. No material impacts are considered likely in relation to air quality, traffic and transport, Aboriginal cultural heritage and historic heritage. Noise impacts, surface water impacts, groundwater impacts, visual amenity, upland swamp impacts and infrastructure impacts will be mitigated, compensated for or offset, with these costs forming part of the costs of the capital or operating costs of the Project. These costs would have no impact on the estimated minimum threshold value of the Project. Only impacts from greenhouse gas emissions would remain unmitigated and these impacts are estimated at in the order of $0.15 M, present value, which is considerably less than the estimated minimum Australian net production benefits.

Consequently, the Project is estimated to have net social benefits to Australia of a minimum of $29 M and hence is desirable and justified from an economic efficiency perspective.

Any other residual environmental, cultural or social impacts that remain unquantified would need to be valued at greater than $29 M for the Project to be questionable from an Australian economic perspective.

2.6 Distribution of Costs and Benefits

Introduction

As identified above, BCA is only concerned with the single objective of economic efficiency. BCA and welfare economics provide no guidance on what is a fair, equitable or preferable distribution of costs and benefits. Nevertheless, BCA can provide qualitative and quantitative information for the decision-maker on how economic efficiency costs and benefits are distributed.

Intra Generational

The net production benefit of the Project is potentially distributed amongst a range of stakeholders including:

- The proponent in the form of after tax (and after voluntary contributions) profits;
- The Commonwealth Government in the form of any Company tax payable (unquantified in this analysis) which is subsequently used to fund provision of government infrastructure and services across Australia and NSW, including the local and regional area;
- The NSW Government via royalties ($29 M present value) which are subsequently used to fund provision of government infrastructure and services across the State, including the local and regional area; and
- The environmental, social and cultural impacts of the Project may potentially initially accrue to a number of different stakeholder groups at the local, State, National and global level, however, the regulatory framework applying to coal mining aims to minimise the environmental, social and cultural costs and internalise these into the production costs of proponents by making proponents responsible for mitigation, offsetting and compensation.

As identified above, no material impacts are considered likely in relation to air quality, traffic and transport, Aboriginal cultural heritage and historic heritage. Noise impacts and visual impacts would initially accrue to members of the local community who own or rent residences that are adversely impacted but would be mitigated by management actions of the proponent.

Surface water and groundwater impacts will occur at the local level but will be internalised into the production costs of the Proponent through the acquisition of WALs. Infrastructure impacts will potentially effect government agencies who manage infrastructure on behalf of the community, however, these impacts will be internalised into the production costs of the proponent via the mine subsidence levy and managed by the Mine Subsidence Board. Upland swamp impacts would affect those people in the community who value the conservation of these environments. This may include members of the local, regional, state and national communities. However, to the extent that any negative impacts are adequately offset, no net impacts on these communities will arise. Greenhouse gas impacts from the Project will occur at the national and global level. Any nonmarket benefits associated with employment provided by the Project would accrue at the local or State level[10] to those people who value knowing that the employment of others is secure.

Intergenerational

Some of the environmental, social and cultural impacts of the Project may be felt by future generations. This is particularly the case for nonmarket environmental impacts. However, as identified above BCA is not concerned with distributional issues. The consideration of intergenerational equity issues is therefore outside the scope of BCA.

Nevertheless, it should be noted that the costs and benefits in BCA are defined and valued based on the microeconomic underpinnings of BCA. They are based on the values held by individuals in the current generation. There is no way to measure the value that future generations hold for impacts of current day projects as they are not here to express it.

Nevertheless, as identified by Boardman et al (2001) this is not considered a serious problem for BCA because:

- Few policies involve impacts that only appear in the far future. Consequently, the willingness to pay of people alive today can be used to predict how future generations will value them;
- Most people alive today care about the well-being of their children, grandchildren and great grandchildren, whether or not they have yet been born. They are therefore likely to include the interests of these generations to some extent in their own valuations of impacts. Because people cannot predict with certainty the place that their future offspring will hold in society, they are likely to take a very broad view of future impacts; and
- Discounting used in BCA also reduces the influence of costs and benefits that occur a long way into the future.

Furthermore, increased wealth (e.g. royalties and taxes) generated by projects that have a net benefit to the current community can be used to improve the services (e.g. health, school and community services) and environment (e.g. protected areas) that are passed on to future generations.

2.7 Sensitivity Analysis

The minimum threshold value approach used in this analysis is based an average annual production of 934,000, with 52.6% coking coal at $150/tonne and 28.6% thermal coal at $90/tonne.[11]

The estimated minimum threshold value of the Project to Australia is based on a range of assumptions about production around which there is some level of uncertainty. Uncertainty in a BCA can be dealt with through changing the values of critical variables in the analysis (James and Gillespie, 2002) to determine the effect on the net present value.

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[10] It should be noted that the study from which the employment values were transferred, surveyed NSW households only.

[11] This is equivalent to a product coal split of 65% coking coal and 35% thermal coal[11].

In this analysis, as shown in **Table 2.3** the estimated minimum threshold value of the Project was tested for changes to the following variables at a 4%, 7% and 10% discount rate for:

- 20% decrease in annual ROM production;
- Changes in product coal mix; and
- 20% increase or decrease in coal price.

Table 2.1
Project Minimum Threshold Value Sensitivity Testing (Net Present Value $M)

Parameter	4%	7%	10%
Core Result	$25.5	$28.9	$26.7
Decrease 20% production	$20.4	$23.1	$21.3
70%/30% metallurgical/thermal product coal split	$26.8	$30.2	$27.9
55% /45% metallurgical/thermal product coal split	$24.4	$27.5	$25.5
20% price decrease	$20.4	$23.1	$21.3
20% price increase	$30.7	$34.6	$32.0

What this analysis indicates is that the minimum threshold value is most sensitive to a change in production levels or price. A 20% decrease in production or price would reduce the minimum threshold value to $23 M. An increase in coal prices by 20% would increase the Project minimum threshold value to $35 M.

3 REGIONAL ECONOMIC IMPACT ASSESSMENT

The Project will provide economic activity to the local, regional, State and national economies for up to five years.

The Project will directly provide average annual output of $98 M, average annual income (wages) of approximately $34 M[12] and employment of 287[13].

Flow-on economic activity will also arise from:

- Production expenditure in the course of the operation of mine (production-induced effects); and
- Expenditure of employees (consumption-induced effects).

The level of this flow-on effect will depend on:

- The expenditure pattern of the Project and the ability of a region to manufacture and provide the goods and services required by the Project. Because of the long history of coal mining in the Wollongong and Illawarra region and high concentration of manufacturing in these areas relative to NSW, strong economic linkages and hence production-induced flow-ons are likely to occur; and
- The residential location of workers. As shown in **Table 3.1,** 63% of workers reside in the Wollongong LGA and 90% reside in the Illawarra Statistical Division and hence this area is likely to capture a considerable proportion of employee expenditure.

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12 Assuming an average wage of $120,000.
13 Based on employment levels on 4 April 2013.

Table 3.1
Employee Residence Locations

Location	No. *	% of workforce
Local Region (Shellharbour, Wingecarribee, Wollondilly, Sutherland & Wollongong LGAs)	265	92%
Illawarra Statistical District (Shellharbour, Wingecarribee, Wollongong, Kiama and Shoalhaven LGAs)	259	90%
Wollongong LGA	182	63%
Local Area (Suburbs bounded by Mt Ousley Rd, Bulli Pass, the escarpment and coast)	97	34%

** NRE Employees Residential (287 total NRE No. 1 Colliery employees as of 4 April 2013)*

An indication of economic impact of the Project at a regional level can be obtained by using multipliers generated for the Bulli Seam Operations for the combined Illawarra Statistical Division and the Outer South Western Sydney Statistical Subdivision (Gillespie Economics, 2009). **Table 3.2** shows regional economic impacts from the Project.

Table 3.2
Regional Economic Impacts of the Project

Indicators	Direct	Production-induced flow-ons	Consumption-induced flow-ons	Total flow-ons	Total Impact
Output ($000)	97,734	31,275	11,728	43,980	141,714
Type 11A Ratio	1.00	0.32	0.12	0.45	1.45
Income ($000)	30,486	45,425	20,121	65,850	96,337
Type 11A Ratio	1.00	1.49	0.66	2.16	3.16
Employment (no.)	287	758	453	1,211	1,498
Type 11A Ratio	1.00	2.64	1.58	4.22	5.22

At the regional level the Project would have annual total impacts of up to:

- $142 M in direct and indirect output;
- $96 M in direct and indirect household income; and
- 1,498 in direct and indirect employment.

Type 11A ratio multipliers used in the analysis range from 1.45 for output to 5.22 for employment. The high ratio multiplier for employment and income reflect the relatively capital intensive nature of mining projects. Capital intensive industries tend to have a high level of linkages with other sectors in an economy thus contributing substantial flow-on employment and income while at the same time only having a lower level of direct employment and income. This tends to lead to high ratio multipliers for indicators that are related to employment (employment and income). A contributing factor to the high ratio multipliers is that the economy being examined is relatively large and with a long history of coal mining. Hence leakages from the economy are more limited than would be the case for a smaller or less specialised economy.

The level of multipliers are Project specific and depend on, among other things, the ratios of employment to output of a project, the profitability of a project, the expenditure profile of a project and how much is spent in the region, the residential location of the workforce, the size and structure of the region within which a project is located. There is no "universal" set of multipliers for coal mining projects. An analysis of the Metropolitan Coal Project (Gillespie Economics 2008) estimated an employment multiplier of 3.52. Studies in the Hunter Valley (BAE 2014; Economic Consulting Services 2012 and Hunter Valley Research Foundation 2009) suggest employment multipliers of between 1.49 and 4.79. Based on this range total employment impacts of the Project would be between 428 and 1,375.

At the local area level flow-on impacts would be less than reported in **Table 3.2** for the region as higher levels of expenditure would leak out the area to major centres such as Wollongong.

The economic impacts of Project on the NSW and Australian economy would be larger than they are on regional economies because larger economies are able to capture more of the incremental expenditure and have greater intersectoral linkages.

Economic activity impacts discussed above represent the gross or positive economic activity associated with the Project. Where employed and unemployed labour resources in the region are limited and the mobility of in-migrating or commuting labour from outside the region is restricted there may be competition for regional labour resources that drives up regional wages. In these situations, there may be some 'crowding out' of economic activity in other sectors of the regional economy.

'Crowding out' would be most prevalent if the regional economy was at full employment and it was a closed economy with no potential to use labour and other resources that currently reside outside the region. However, the regional economy is not at full employment[14] and it has access to external labour resources. Consequently, little 'crowding out' of economic activity in other sectors in the region would be expected as a result of the Project. Crowding out would be expected to be greater at the NSW and national levels.

However, even where there is some 'crowding out' of other economic activities this does not indicate losses of jobs but the shifting of labour resources to higher valued economic activities. This reflects the operation of the market system where scarce resources are reallocated to where they are most highly valued and where society would benefit the most from them. This reallocation of resources is therefore considered a positive outcome for the economy not a negative.

4 CONCLUSION

The Project is estimated to have minimum net production benefits (royalties) of $29 M to Australia and NSW. In addition, there would be unquantified company tax benefits to Australia and potentially nonmarket benefits of employment of in the order of $36 M.

The estimated minimum net production benefits of $29 M can be used as a minimum threshold value or reference value against which the relative value of the residual environmental impacts of the Project, after mitigation, compensation and offset, may be assessed. For the Project to be questionable from an economic efficiency perspective, all incremental residual environmental, social and cultural impacts from the Project, to Australia, after mitigation, offset and compensation, would need to be valued by the community at greater than $29 M.

In this respect, no material impacts are considered likely in relation to air quality, traffic and transport, Aboriginal cultural heritage and historic heritage. Noise impacts, surface water impacts, groundwater impacts, visual amenity, upland swamp impacts and infrastructure impacts will be mitigated, compensated for or offset, with these costs forming part of the costs of the capital or operating costs of the Project. These costs would have no impact on the estimated minimum threshold value of the

[14] Unemployment level in Wollongong SA2 in September 2014 was 7.5% (Department of Employment (2014) Small Area Labour Markets)

Project. Only impacts from greenhouse gas emissions would remain unmitigated and these impacts are estimated at in the order of $0.15 M, present value, which is considerably less than the estimated minimum Australian and NSW net production benefits.

Consequently, the Project is estimated to have net social benefits to Australia and NSW of a minimum of $29 M and hence is desirable and justified from an economic efficiency perspective.

Any other residual environmental, cultural or social impacts that remain unquantified would need to be valued at greater than $29 M for the Project to be questionable from an Australian economic perspective.

The Project would also provide direct and indirect economic activity to the local, regional, State and national economies for up to five years. Flow-on economic activity would arise from production expenditure in the course of the operation of the mine and expenditure of employees who mainly reside within the region.