Angus Place Amended Project

Project approval (Project Application 06_0021) for Angus Place mine was granted in September 2006 under Part 3A of the *Environmental Planning and Assessment Act 1979*. The current project approval has since been declared a State Significant Development (SSD) under clause 6 of Schedule 2 to the *Environmental Planning and Assessment (Savings, Transitional and Other Provisions) Regulation 2017*, for the purposes of the EP&A Act. Angus Place Colliery now operates under a SSD approval.

The Angus Place Colliery project approval and its subsequent modifications authorise the extraction of up to 4 million tonnes of run of mine (ROM) coal per annum. The current project approval will expire in August 2024 and a new development consent is required to enable Angus Place Colliery to operate beyond this date. A new SSD application (SSD 5602) and supporting Environmental Impact Statement (EIS) was submitted to NSW Department of Planning, Industry and Environment (DPIE) in April 2014 (2014 EIS) for the Angus Place Mine Extension Project (APMEP). In 2015 a decision was made by Centennial Angus Place Pty Limited (Centennial Angus) to place the Angus Place Colliery into care and maintenance following the completion of secondary extraction within longwall panel 900W. Secondary extraction of longwall panel 900W was completed on 15 February 2015 and the mine was placed in care and maintenance on 28 March 2015. At that stage, the assessment of the APMEP was placed on hold.

A review of the APMEP was completed by Centennial proposed changes to the APMEP from that presented in the 2014 EIS. On 23 October 2019 DPIE issued a letter to Centennial Angus Place confirming that the changes to the Project could be considered in an Amendment Report to Development Application (SSD 5602).

As stated in the Amended EIS the APMEP, as amended, will include all currently approved operations, facilities, and infrastructure of the Angus Place Colliery, except to:

- Extend the life of the mine to 31 December 2053;
- Increase in Project Application Area from 10,460ha to 10,551ha;
- Increase in full time equivalent (FTE) personnel from 300 to 450;
- Increase the extraction rate up to 4.5 million tonnes per annum of ROM coal from the Lithgow Seam underlying the Project Application Area;
- Continue the development of new roadways to enable access to the proposed 1000 panel longwall mining area;
- Extraction of existing approved longwall 910;
- Development and extraction of 15 longwalls (LW1001-1015) with void widths of 360m;
- Development of underground roadway connections between the Angus Place Colliery underground mine workings and the Springvale Mine underground mine workings;
- Transfer up to 4 Mtpa of run-of-mine (ROM) coal to the Angus Place pit top for processing and handling before being transported off site in accordance with the Western Coal Services Project development consent (SSD 5579)
- Transfer up to 4.5 Mtpa of ROM coal by underground conveyor to the Springvale Mine pit top via proposed new underground connection roadways for handling and processing in accordance with the Springvale Mine Extension Project development consent (SSD 5594);
- Enlargement of the ROM coal stockpile at the Angus Place Colliery pit top from 90,000 t to 110,000 t capacity
- Construction of the approved but not yet constructed 4.5 m shaft at the Angus Place Ventilation Facility (APC-VS2) on the Newnes Plateau.
- Installation and operation of the ventilation fan at the Angus Place Ventilation Facility (APC-VS2) on the Newnes Plateau.

- Construction and operation of one additional downcast shaft and mine services boreholes within the proposed Angus Place Ventilation Facility (APC-VS3) on the Newnes Plateau to support mining in the 1000 panel area;
- Construction and operation of additional dewatering facilities and associated infrastructure on the Newnes Plateau to support mining in the 1000 panel area to facilitate the transfer of mine water into the Springvale Delta Water Transfer Scheme (SDWTS);
- Transfer of mine inflows from the existing and proposed workings at Angus Place Colliery to the Springvale Water Treatment Project (SSD 7972) for treatment and beneficial reuse at the Mount Piper Power Station
- Operation of the Angus Place Colliery 930 Bore and associated infrastructure for raw mine water
- transfer from the SDWTS to the underground mining area; and
- Connection to the Lithgow City Council main sewer line prior to the commencement of longwall
- extraction (subject to a separate development application through Lithgow City Council).

Biodiversity and Conservation Division requested SD to review/provide comments on the Angus Place proposal. These comments have been written to fulfil that request.

Introduction

EES (previously OEH) has consistently stated that it does not support the direct undermining of the Newnes Plateau Shrub Swamp Endangered Ecological Community (BC Act listed EEC) using the longwall mining technique unless there has been a modification to the mining techniques that will ensure that impacts will be prevented. This is because of the direct and long-term damage that has already occurred to a large number of Newnes Plateau Shrub Swamps (NPSS) EECs as a result of previous Springvale and Angus Place mining operations. NPSS and Newnes Hanging Swamps are also listed as an endangered ecological community under the EPBC Act (Temperate Highland Peat Swamp on Sandstone (THPSS))

There is significant concern that environmental impacts and consequences from the proposed mine are again understated. OEH previously referred to the claim made for the original 2006 Springvale mining application:

> *Given the available data and previous experience, there can now be a high level of confidence that the shrub swamps will suffer no long-term adverse impacts from the proposed mining. At worst there may be minor transient changes to groundwater and surface water flow, which may produce minimal short-term impacts*. Connell Wagner (2005).

This has clearly not been the reality, with 15 impacted swamps above Centennial's Angus Place and Springvale mines now having permanently altered hydrology and a further 4 swamps showing initial signs of similar alterations to their hydrology. The changes to swamp hydrology meant that in the recent 2019/2020 fires, the undermined and desiccated swamps experienced some of the most catastrophic changes of any peat swamp system in NSW (incineration of peat to ash down to depth, extensive habitat loss, extremely poor seedling recruitment and the likely loss of viable populations of endangered species such as the Blue Mountains Water Skink and Giant dragonflies). Recent monitoring of impacted and non-impacted swamps can now quantitatively demonstrate many of these very serious changes[1]. These undermined, desiccated and now burnt swamps may no longer remain peat-forming swamp communities.

[1] EES/UNSW unpublished data. Photographs to illustrate some of these changes appear in Appendix 1.

The Amended Angus Place Mine Extension Project has one of the most destructive mine layouts in NSW in recent times, with 360m wide longwalls proposed. The proposed longwalls are 55m wider than the longwalls currently being extracted and proposed for Areas 5 & 6 at Dendrobium Mine; and almost 100m wider than the longwalls currently being extracted at Springvale Mine. What is clear from previous experiences at Dendrobium, Springvale and earlier Angus Place mine operations is a very high level of impact and consequences to surface water, groundwater, endangered ecological communities and threatened and endangered species (Aurecon 2009, Krogh 2007, 2013, 2017, DECC 2007, Commonwealth of Australia 2014, IEPMC 2019, DECCW 2010, Pells and Pells 2015, Young 2017).

The Amended Angus Place Mine Extension Project will lead to extremely high levels of subsidence for the area and is predicted to cause:

- Surface to seam fracturing over large areas of the mine layout;
- Loss of groundwater aquifers above the mine layout (including those that feed the NPSS/THPSS EECs lying above and adjacent to the mine footprint);
- Complete loss of flow and aquatic habitat above the mine layout[2];
- The direct loss (fracturing, desiccation, altered hydrology) of 5 Newnes Plateau Shrub Swamps (NPSS) [3]; as well as several Newnes Plateau Hanging Swamps (NPHS);
- Loss of BC and EPBC listed endangered/vulnerable species populations (Blue Mountains Water Skink; Giant Dragonfly; Red Crowned Toadlet);
- Significant groundwater drawdown immediately outside and within the Greater Blue Mountains World Heritage Area;
- Loss of surface flows to streams which flow into the Greater Blue Mountains World Heritage Area.

Centennial's operations have already permanently altered the hydrology of approximately 13% of the entire NPSS EEC in existence, to the point that post-fire these areas may no longer remain peat-forming swamp communities. Nine (9) years ago Centennial agreed to a $1.4M enforceable undertaking ($1.4M) for impacts to Temperate Highland Peat Swamps on Sandstone (Commonwealth Government 2011). The EIS identifies that*: According to Centennial Coal (2018) there is increasing evidence that directly undermining lineaments in the strata overlying Lithgow Coal seam can cause changes to standing water levels in swamps overlying the lineaments*. OEH first raised the issue of lineaments interacting with subsidence in 2011, after major impacts to East Wolgan Swamp[4]. For many years, this issue was ignored or understated (see discussion in Young 2017), and this has led on to further serious damage to (loss of water in) Sunnyside East, Carne West, Gang Gang East & West and Carne Central swamps. Aquifer drainage[5] has also recently occurred in parts of Sunnyside Swamp, Nine Mile Swamp, Pine Swamp and Paddys swamp (see MSEC 2019 and Appendix 2). This means that mining has impacted every NPSS above or adjacent to longwall mining at Springvale and Angus Place. Despite the experience and outcomes from previous mining, the Amended Angus Place Mine Extension Project continues to make no effective modifications to the way mining is conducted in the vicinity of THPSS and are proposing new mining that will cause further irreparable damage and loss to the NPSS/THPSS EEC. This mining is also likely to lead to the loss of populations of the endangered Blue Mountains Water Skink and Giant Dragonfly (e.g. Baird 2012, Benson & Baird 2012).

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[2] Except perhaps during very high rainfall events.
[3] Possibly 7 NPSS if Wolgan River and Wolgan River Upper Swamps are impacted.
[4] See Aurecon 2009 for a detailed description of impacts and consequences.
[5] To the base of the piezometer.

NSW can quite easily have both the economic stimulus that mining provides whilst at the same time protecting and conserving endangered ecological communities like the Newnes Plateau Shrub Swamp community. It is entirely feasible to produce a mine layout that achieves both outcomes. The proponent has, however, failed to implement any effective avoidance or mitigation measures, despite the many options[6] available to reduce the impact of the proposal on NPSS/THPSS EECs and the endangered species they contain.

The EIS identifies that:

> *Given the predicted impacts to a high priority groundwater dependant ecosystem, the project does not meet the Level 1 Minimal Impacts Considerations of the NSW Aquifer Interference Policy. However, it is the intention of Centennial to offset the predicted impacts via the environmental offset facility of the EPBC Act.*

Since the environmental offset facility of the EPBC Act includes a requirement for direct offsetting of impacts and Centennial do not own equivalent areas of NPSS/THPSS to offset, the Amended Angus Place Mine Extension Project will lead directly to further loss of (permanently altered hydrology in) a further ~3.5% of the NPSS endangered ecological community. This is likely to mean that one company alone could be responsible for irreparable impacts to over 18% of the entire NPSS EEC in existence. The Angus Place Biodiversity Assessment cites a total swamp impact area for Angus Place and Springvale mines of 131.1 Ha. A significant review of the longwall dimensions and layout is recommended so that it affords far greater protection to the NPSS/THPSS EEC, streams and threatened species in the area.

Recommended alterations to the mine layout include:

- Reduction of longwall widths to avoid surface to seam fracturing;
- Avoidance of undermining the Type 2 lineament under Tri Star swamp that is connected to the Type 1 Wolgan River lineament zone;
- Avoidance of direct undermining of Twin Gully Swamp;
- Shortening of LW1014 so that it does not undermine the Burralow aquifer that feeds Trail 6 (Japan) swamp;
- Reduction in the proximity of longwall mining to Crocodile and the Birds Rock swamps to maintain the Burralow formation aquifers that sustain these swamps.

The evidence based for this assessment and conclusions is provided below.

Subsidence and Mine Layout

The Amended Angus Place longwall configuration is summarised in MSEC (2019) as:

- The overall void width including first workings is 360m.
- The overall tailgate chain pillar width is 55m.
- The thickness of the Lithgow Seam within the proposed mining area varies between 1.8 m and 3.9 m. The seam is thickest in the south-western part of the proposed mining area and thinner in the eastern and northern parts of the mining area.
- The depths of cover above the proposed longwalls vary between 270 m and 450 m. The lower depths of cover occur along the drainage lines above the finishing (i.e. western) ends of LW1005, LW1009, LW1010 and LW1012. The higher depths of cover occur along the ridgeline above LW1008. The average depth of cover across the proposed mining area is 370m.

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[6] For example, reduction of longwall panel width, increase in pillar width, mine layout design that avoids/minimises undermining of THPSS.

The maximum *conventional* subsidence predictions are given by MSEC (2019) in Table 4.2 (see below). Compared to the previous longwall layout (2014 EIS; see Table 4.3), under the current plan maximum subsidence will be increased (by 18%), maximum tilt will be increased (by 25%), maximum hogging curvature[7] will be increased (by 17%), maximum sagging curvature will be increased (by 14%). No reasons are given for why and where these substantial increases will occur[8]. These predicted subsidence increases demonstrate a failure of management response to avoid or mitigate mining impacts to NPSS/THPSS.

Table 4.2 Maximum predicted total vertical subsidence, tilt and curvature after the extraction of each of the proposed longwalls

After longwall	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
LW1001	850	7	0.09	0.15
LW1002	1450	12	0.20	0.20
LW1003	1950	12	0.20	0.20
LW1004	2000	14	0.20	0.25
LW1005	2150	20	0.40	0.35
LW1006 to LW1015	2250	25	0.35	0.40

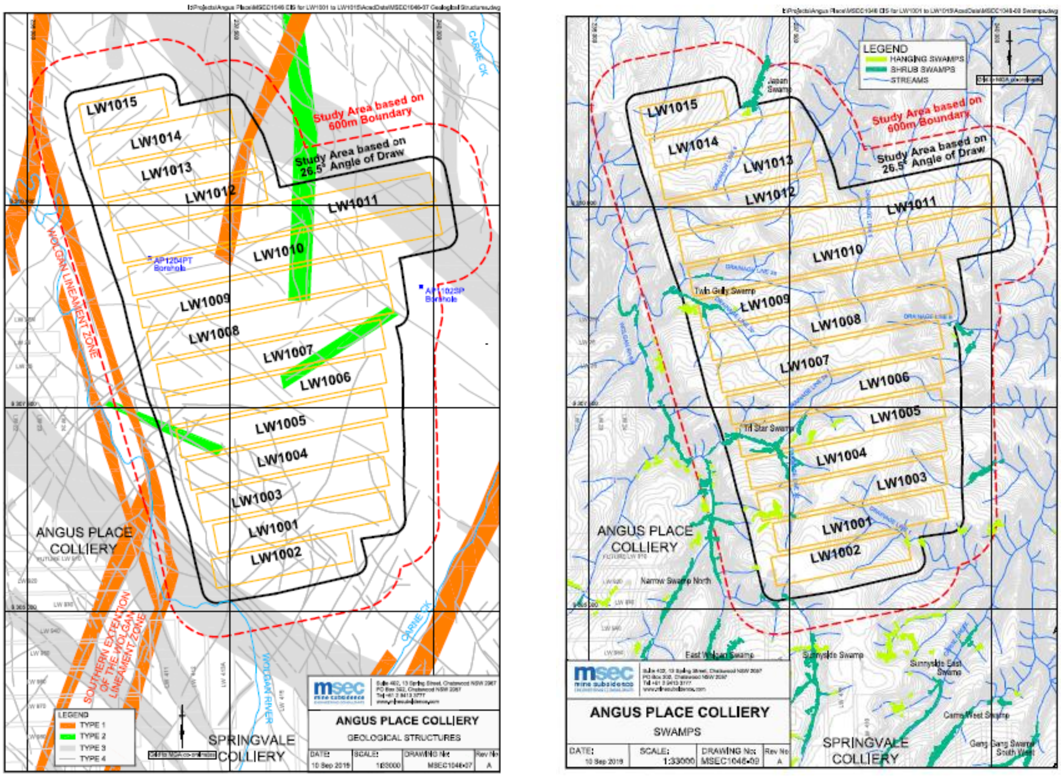
Table 4.3 Comparison of maximum predicted total subsidence effects

Application (Report)	Maximum predicted total conventional subsidence (mm)	Maximum predicted total conventional tilt (mm/m)	Maximum predicted total conventional hogging curvature (km^{-1})	Maximum predicted total conventional sagging curvature (km^{-1})
APMEP EIS (Report No. MSEC593)	1900	20	0.30	0.35
Amended Project Report (Report No. MSEC1042)	2250	25	0.35	0.40

MSEC (2019) identify that it is likely non-conventional ground movements will also occur within the Study Area, due to near surface geological conditions, steep topography and valley related effects. These non-conventional movements are often accompanied by elevated tilts and curvatures that are likely to exceed the conventional predictions.

MSEC (2019) also acknowledge the importance of lineaments and other geological structures in the area, having the ability to interact with subsidence and leading to adverse (at times severe) environmental impacts. An investigation of the geological structures within the proposed mining area was originally undertaken by Palaris (2013). The locations of the main geological structures and swamps are shown in Drawings MSEC1046-07 & 08 (see below).

[7] Maximum conventional tensile stresses are predicted to be of the order of 5.25 mm/m and maximum compressive stresses are likely to be of the order of 6 mm/m using a factor of 15 X curvature. These are likely to increase significantly in incised streams and above lineaments. Tensile stresses up to 18mm/m were recorded at East Wolgan Swamp and are considered likely in many areas of the Angus Place proposal.
[8] Most of the 2014 EIS longwalls were also proposed to be 360m in width.



Lineaments and Swamps associated with the Angus Place proposal, Source: MSEC (2019).

Subsidence Impacts to Swamps

The NPSS/NPHS/THPSS EEC swamps above or adjacent to the mine can be impacted in 3 main ways:

- Depressurisation/removal of the aquifer supplying water to the swamp[9];
- Bedrock fracturing under the swamp and downward aquifer drainage into the fracture network - leading to desiccation and reductions in soil moisture in the swamp;
- Movement along pre-existing geological structures (faults & lineaments) opening connected pathways leading to aquifer loss within the swamp.

All these causal mechanisms have been implicated in permanent impacts to NPSS/NPHS/THPSS swamps above or adjacent to previous longwall mining on the Newnes Plateau. If surface to seam connective fracturing occurs (as predicted), surface and swamp aquifer water can move down into the mine itself[10]. If fire subsequently occurs on a dewatered/desiccated swamp, then the peat is likely to turn to ash, leading to extensive habitat loss, extremely poor seedling recruitment and likely loss of viable populations of the endangered species that are restricted to these habitats

[9] Which is what led to the evolution of the swamps in these locations in the first place.

[10] The IEPMC have assessed that this has occurred over Dendrobium mine in the southern coalfields. It also appears likely based on assessments of SPR66 and Gang Gang swamp monitoring and the experience at East Wolgan swamp.

(particularly the Blue Mountains Water Skink and Giant Dragonfly). Undermined, desiccated, and burnt swamps may no longer remain peat-forming swamp communities. There is now quantitative evidence available to demonstrate this for the 2019/2020 fires (see also Appendix 1).

The largest and most important swamps above and adjacent to the Amended Angus Place mine layout are Tri Star Swamp, Twin Gully Swamp, Trail 6 (Japan) Swamp, Crocodile Swamp, the Birds Rock Swamps, Wolgan River Upper Swamp and Wolgan River Swamp. Sunnyside Swamp also has the potential to suffer subsidence impacts and consequences, but potential impacts to Sunnyside Swamp and their consequences have not been assessed in the EIS.

McHugh (2013) identified that previous studies of the Angus Place/Springvale area did not typically include the presence of the Burralow Formation, and instead referred to the Banks Wall Sandstone as the uppermost outcropping unit. McHugh (2011)[11] studied the upper stratigraphy of the Angus Place/Springvale leases, in particular the Burralow Formation, and identified both a lithological and topographic link between the presence of the Burralow Formation and the occurrence of the Newnes Plateau Hanging Swamps (NPHS). Several of the claystone horizons, together with clay-rich, fine-to-medium grained sandstones and shales were found to be acting as aquitards, or low permeability layers. These aquitards decrease the hydraulic gradient of rainwater and groundwater movement percolating through the weathered and semi-weathered strata of the Burralow Formation and form a permanent water source for the formation and maintenance of the hanging swamps. In total, McHugh identified seven units, designated YS1 to YS6 (including the areally limited YS5a), which were capable of sustaining the hanging swamps in the area, provided the topographic conditions were amenable to the formation of a hanging swamp. McHugh (2013) stated that: *The Burralow Formation is **crucial in the development and maintenance** of both the Newnes Plateau Shrub Swamps (NPSS) and, in particular, the Newnes Plateau Hanging Swamps (NPHS).* **The presence of these aquitards in the Burralow sequence perform a vital function in the presence and persistence of the Newnes Plateau Shrub Swamps (McHugh 2011, 2013, 2014). Destroying or depressurising these aquifers will potentially lead directly to loss of NPSS/NPHS/THPSS.**

Tri Star Swamp

McHugh (2014) described Tri Star Swamp as follows:

> *Tri-Star Shrub Swamp comprises a complex of three individual swamps which lie in a bifurcated host gully draining westward into the Wolgan River. Three shrub swamps overlie the longwalls. Associated with these shrub swamps are numerous hanging swamps to the east and south-east.*
>
> *The principal western gully trends roughly east-west and is approximately 500 metres in length. It averages 35 metres in width with the exception of the extreme lower reaches where topographic influences result in a maximum width of 80 metres. It has a drop of approximately 20 metres. Stratigraphically, this section of the Tri-Star complex lies wholly within the Banks Wall Sandstone but receives drainage flow from the two upper tributaries.*
>
> *The north-eastern tributary is 375 metres in length with a width of 30 metres. It has a drop of approximately 18 metres. This arm of the Tri-Star swamp complex is a "mixed-type" swamp, with its upper reaches located stratigraphically in the Burralow Formation and its lower reaches in the Banks Wall Sandstone. The south-eastern tributary is divided into an upper and lower section. The lower section is 150 metres in length with a maximum width of 40 metres. The upper section is 185 metres in length with a maximum width of 30 metres.*

[11] McHugh, E., 2011. Hanging Swamps within the Angus Place/Springvale Lease Areas. *Preliminary Report*

Like the north-eastern tributary, this arm of Tri-Star is a "mixed-type" with its upper reaches located stratigraphically in the Burralow Formation and the lower reaches in the Banks Wall Sandstone.

The hanging swamps in this vicinity are hydrologically supported by the YS6 (with additional input from YS5a and YS5), YS4, YS2 and YS1. The majority of the swamp relies on valley wall seepage from the YS6 and YS5a aquitard together with direct in-gully input from these latter plies.

The presence of several hanging swamps in this locale is suggestive of relatively high groundwater levels within the strata.

Tri Star swamp is predicted to experience maximum subsidence of 2.25m; maximum tilt of 25mm/m; maximum conventional curvature of 0.35 km-1; maximum conventional tensile stress of 5.25[12]mm/m; maximum conventional sagging curvature of 0.4 km-1; maximum conventional compressive stress of 6mm/m[13]; maximum upsidence of 750mm; and maximum closure of 1000mm. It is highly unlikely that the swamp can survive such high levels of subsidence. Tri Star Swamp is also coincident with a Type 2 geological structure, as shown in Drawing No. MSEC1046-07 & 09. Twin Gully Swamp has a known population of the endangered (BC & EPBC listed) Blue Mountains Water Skink and provides suitable habitat for the endangered Giant Dragonfly. Red Crowned Toadlets (vulnerable BC Act) also occur in the drainages of Tri Star Swamp.

Twin Gully Swamp

McHugh (2104) described Twin Gully Swamp as follows:

This swamp trends roughly west-east, with the lower reaches of the host gully emptying into the Wolgan River to the west, and is distal from any known structure zones (Section 4, Figure 4). Twin Gully Shrub Swamp forks in its upper reaches (Figure 30) and has a maximum length in its longer tributary of just under 1200 metres. The average maximum width is 40 metres with a fall of 65 metres.

Twin Gully is "mixed-type" swamp, with its extreme upper reaches located stratigraphically within the Burralow Formation, topographically above the point where the host gully bifurcates. At this location, the swamp is supported by groundwater from the YS6 and YS5a aquitards. These plies provide direct in-gully seepage at this location thus widening the shrub swamp where the aquitard transects the gully floor (Figure 30). Relatively high groundwater availability in the general vicinity is indicated by the presence of two hanging swamps (Figure 30) which are both hydrologically supported by the YS6 and YS5a aquitards.

Twin Gully swamp is predicted to experience maximum subsidence of 1.6m; maximum tilt of 16mm/m; maximum conventional curvature of 0.25 km-1; maximum conventional tensile stress of 3.75[14]mm/m; maximum conventional sagging curvature of 0.3 km-1; maximum conventional compressive stress of 4.5mm/m[15]; maximum upsidence of 750mm; and maximum closure of 1000mm. It is highly unlikely that the swamp can survive such high levels of subsidence, upsidence and closure. It is also likely that mining will drain the *groundwater from the YS6 and YS5a*

[12] Using a factor of 15 X hogging curvature.

[13] Using a factor of 15 X sagging curvature.

[14] Using a factor of 15 X hogging curvature.

[15] Using a factor of 15 X sagging curvature.

aquitards. **Twin Gully Swamp has a known population of the endangered (BC & EPBC listed) Blue Mountains Water Skink and provides suitable habitat for the endangered Giant Dragonfly.**

Trail 6 (Japan) Swamp

McHugh (2104) described Trail 6 (Japan) Swamp as follows:

> *Japan Shrub Swamp (also known as Trail 6 Swamp) trends approximately north south, with a length of 750 metres and a maximum width of 75 metres. It has a fall of 32 metres, is wholly contained within the Banks Wall Sandstone and is distal from any known structure zones. The gully in which Japan shrub swamp lies forms part of the extreme upper reaches of a tributary of the Wolgan River.*
>
> *Japan Shrub swamp is the largest shrub swamp in the Angus Place lease and its relatively expansive width as compared to Twin Gully, Tri-Star and Crocodile is due to its topographic positioning and presence of three aquitards along the length of the host valley. This swamp lies in a narrow, steep gully due to the characteristics of the Banks Wall Sandstone substrate which displays a different erosional pattern to gullies with Burralow substrates. Hence the narrow nature of the Japan gully results in the close proximity of aquitards YS6, YS5a and YS5 which supply valley wall seepage along the length of the gully such that a shrub swamp can be formed and sustained within the aquitard-poor Banks Wall Sandstone.*

Trail 6 (Japan) Swamp is predicted to experience maximum subsidence of 0.2m; maximum tilt of 0.5mm/m; maximum conventional curvature of 0.01 km-1; maximum conventional tensile stress of 0.15[16]mm/m; maximum conventional sagging curvature of <0.01 km-1; maximum conventional compressive stress of <0.15mm/m[17]; maximum upsidence of 90mm; and maximum closure of 120mm. It is likely that the swamp will be fractured and drained due the high upsidence and valley closure. It is also likely that mining will drain groundwater associated with the *YS6, YS5a and YS5 aquitards which supply valley wall seepage along the length of the gully such that a shrub swamp can be formed and sustained.* Trail 6 (Japan) Swamp has a known population of the endangered (BC & EPBC listed) Blue Mountains Water Skink and provides suitable habitat for the endangered Giant Dragonfly.

Crocodile Swamp

McHugh (2104) described Crocodile Swamp as follows:

> *Crocodile Shrub Swamp trends southwest – northeast and the host gully is an upper tributary of Carne Creek. It is approximately 500 metres long and 50 metres wide (not including the fringing hanging swamps on the north-western flank of the gully). The fall is approximately 44 metres.*
>
> *Crocodile Shrub Swamp is a "mixed-type" swamp with its upper reaches supported hydrologically by the YS6, YS5a and YS5 aquitards. For the bulk of its length, the swamp relies on valley wall seepage from the above plies plus the YS4 aquitard, all of which crop out along the steep northern flank of this shrub swamp.*

MSEC (2019) do not specifically provide any subsidence estimates for Crocodile Swamp. The *Carne Creek Tributary swamps* are predicted to experience maximum subsidence of 0.6m; maximum tilt of 1mm/m; maximum conventional curvature of 0.02 km-1; maximum conventional tensile stress

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[16] Using a factor of 15 X hogging curvature.
[17] Using a factor of 15 X sagging curvature.

of 0.3[18]mm/m; maximum conventional sagging curvature of <0.01 km-1; maximum conventional compressive stress of <0.15mm/m[19]; maximum upsidence of 260mm; and maximum closure of 350mm. It is likely that the swamp will be fractured and drained due the high predicted upsidence and valley closures. It is also likely that mining will drain water from the aquifers that support *valley wall seepage from the YS6, YS5a and YS5 aquitards plus the YS4 aquitard, all of which crop out along the steep northern flank of this shrub swamp.* Crocodile Swamp has a known population of the endangered (BC & EPBC listed) Blue Mountains Water Skink and provides suitable habitat for the endangered Giant Dragonfly.

Birds Rock Swamp.

McHugh (2014) referred to the Birds Rock swamps as the *Smithston Hanging Swamp Complex,* all of which are contained within the Birds Rock Flora Reserve (see MSEC Drawings Nos. MSEC1046-01 and MSEC1046-02). McHugh (2014) describes the *Smithston Hanging Swamp Complex* as follows:

> *The Smithston Hanging Swamp Complex covers an area of appropriately 18 hectares. This suite of swamps is hydrologically supported by the YS5, YS5a and YS6 aquitards. The larger swamps drape between 100 and 300 metres down the slopes of this western tributary of Carne Creek.*
>
> *The large central hanging swamp in this complex has a total drop of 100 metres at its widest point and is supported hydrologically by the YS5a and YS6 aquitards.*
>
> *SRK (2012) identified a Type 2 structure zone trending east-north-east to the immediate west of this hanging swamp complex. This, together with the more dominant Type 1 NNW-oriented basement to surface structural trend, may account for the composite topographic patterning at this locality and its immediate vicinity.*

MSEC (2019) do not specifically provide any subsidence estimates for the Birds Rock Swamps. The Carne Creek Tributary swamps are predicted to experience maximum subsidence of 0.6m; maximum tilt of 1mm/m; maximum conventional curvature of 0.02 km-1; maximum conventional tensile stress of 0.3[20]mm/m; maximum conventional sagging curvature of <0.01 km-1; maximum conventional compressive stress of <0.15mm/m[21]; maximum upsidence of 260mm; and maximum closure of 350mm. It is likely that the swamp will be fractured and drained due the high predicted upsidence and valley closures. It is also likely that there will be loss of the groundwater associated with the *YS5, YS5a and YS6 aquitards* that *hydrologically support* the swamps. The Birds Rock swamps have not been surveyed for endangered fauna but provide suitable habitat for the endangered (BC & EPBC listed) Blue Mountains Water Skink and endangered Giant Dragonfly (EES SD survey).

Wolgan River Swamp

Very little information is provided on the Wolgan River Swamp. MSEC (2019) do not provide individual subsidence estimates for the Wolgan River Swamp, but the Wolgan River swamps collectively are predicted to experience maximum subsidence of <0.02m; maximum tilt of <0.5mm/m; maximum conventional curvature of <0.01 km-1; maximum conventional tensile stress of <0.15[22]mm/m; maximum conventional sagging curvature of <0.01 km-1; maximum

[18] Using a factor of 15 X hogging curvature.
[19] Using a factor of 15 X sagging curvature.
[20] Using a factor of 15 X hogging curvature.
[21] Using a factor of 15 X sagging curvature.
[22] Using a factor of 15 X hogging curvature.

conventional compressive stress of <0.15mm/m[23]; maximum upsidence of 290mm; and maximum closure of 370mm. McHugh (2014) did not discuss Wolgan River Swamp. It is likely that Wolgan River Swamp will be fractured and drained due the high predicted upsidence and valley closures. Wolgan River Swamp has a known population of the endangered (BC & EPBC listed) Blue Mountains Water Skink and provides suitable habitat for the endangered Giant Dragonfly.

Wolgan River Upper Swamp

Very little information is provided on Wolgan River Upper Swamp. MSEC (2019) do not provide individual subsidence estimates for the Wolgan River Swamp, but the Wolgan River swamps collectively are predicted to experience maximum subsidence of <0.02m; maximum tilt of <0.5mm/m; maximum conventional curvature of <0.01 km-1; maximum conventional tensile stress of <0.15[24]mm/m; maximum conventional sagging curvature of <0.01 km-1; maximum conventional compressive stress of <0.15mm/m[25]; maximum upsidence of 290mm; and maximum closure of 370mm. McHugh (2014) did not discuss Wolgan River Upper Swamp. It is likely that Wolgan River Upper Swamp will be fractured and drained due the high predicted upsidence and valley closures. Wolgan River Upper Swamp has a known population of the endangered (BC & EPBC listed) Blue Mountains Water Skink and provides suitable habitat for the endangered Giant Dragonfly..

Hanging Swamps

Very little if any information is provided for the majority of Newnes Plateau Hanging Swamps (NPHS) above and adjacent to the project.

McHugh (2014) discussed the *Rattlesnake Gorge Hanging Swamp Complex* located east of LW1002 stating:

> *All five of the upper hanging swamps at this location are hydrologically supported by the YS5, YS5a and YS6 aquitards (Figure 45). The kidney-shaped "hanging swamp" north-east of AP1105SP has been observed only from the northern escarpment and has not been formally ground-truthed due to access difficulties (Lembit, 2014).*
> *It can be noted from Figure 42 that the Rattlesnake Gorge suite of swamps is hydrologically contiguous with the hanging swamp system adjoining Crocodile shrub swamp.*

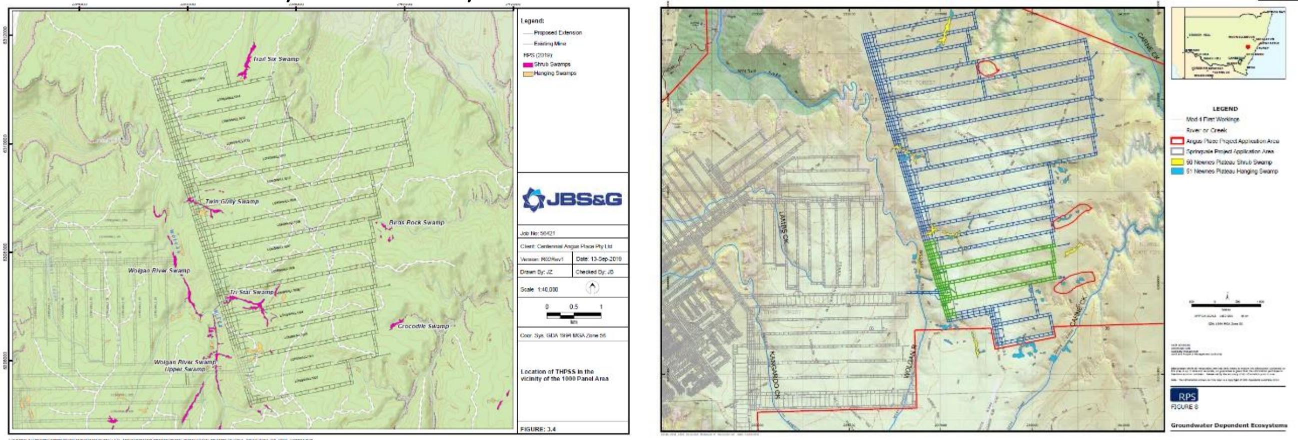
An extremely poor assessment of existing condition or potential subsidence impact to the Newnes Plateau Hanging Swamp (NPHS) community has been undertaken in the EIS. Many NPHS appear to have been incompletely mapped (see Missing Swamps section). The Newnes Plateau Hanging Swamp forms part of the EPBC listed Temperate Highland Peat Swamp on Sandstone Community, and, as the name suggests, is entirely restricted to the Newnes Plateau. It is likely that many of the Newnes Plateau Hanging Swamps will be fractured and drained due the high predicted subsidence, upsidence and valley closures.

Missing Swamps

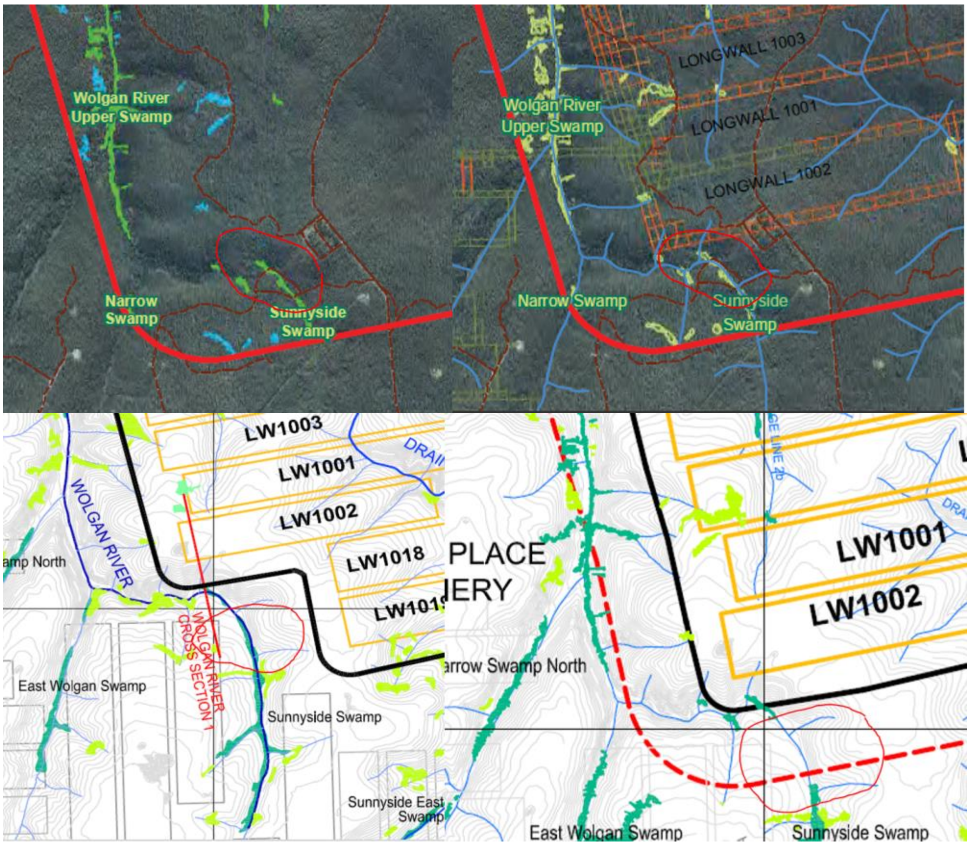
It is noted that several swamps mapped as Hanging Swamps in the 2014 assessment of RPS do not appear in the latest assessment by JBS&G (see below). The extent of Sunnyside Swamp also appears to have been seriously reduced in MSEC Drawing MSEC1046-09, taking it outside the 600m boundary, despite almost all other mapping (e.g. RPS 2019 and MSEC's own 2014 mapping) showing

[23] Using a factor of 15 X sagging curvature.
[24] Using a factor of 15 X hogging curvature.
[25] Using a factor of 15 X sagging curvature.

it well within the 600m boundary and much closer to longwall 1002. Fryirs and Hose's (2016) mapping of THPSS suggests the lower end of Sunnyside Swamp is ~185m from LW1002, and therefore Sunnyside Swamp has the potential to experience subsidence related impacts and consequences[26]. MSEC (2019) have not justified their depiction/mapping of Sunnyside Swamp, or explained why it differs so radically from their 2014 depiction, so that it is now portrayed as ending outside the 600m study area boundary.



Swamps mapped by JBS&G (2019) and RPS (2014). Missing swamps circled in red. Top circle refers to a swamp identified by Henson (swamp 71). JBS&G (2019) and RPS (2014)



Altered Sunnyside swamp boundaries. RPS (2019) depiction of Sunnyside Swamp relative to longwall 1002 (circled above) compared to MSEC's 2014 & 2019 depictions of Sunnyside Swamp (circled below). Source: MSEC (2014, 2019) & RPS (2019).

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[26] Especially from upsidence and valley closure.

Notably MSEC (2019) have avoided discussing or providing any subsidence estimates for Sunnyside Swamp or its downstream drainage line[27]. **There is obviously an incomplete assessment of all swamps above and adjacent to the mine. The most serious issue is the complete exclusion of Sunnyside Swamp from the MSEC (2019) subsidence assessment. An explanation/ justification is required for why these swamps have not been included or assessed in the Amended Angus Place proposal.**

Subsidence and Swamps

In relation to subsidence impacts to swamps, MSEC (2019) state:

- *Fracturing in bedrock has been observed due to previous longwall mining where the tensile strains have been greater than 0.5 mm/m or where the compressive strains have been greater than 2 mm/m. It is likely, therefore, that fracturing would occur beneath the swamps that are located directly above the proposed mining area. Fracturing can also occur outside the mining area, with minor and isolated fracturing occurring at distances up to approximately 400 m.*
- *There are two shrub swamps located directly above the proposed mining area. Tri Star Swamp is located above the western ends of the proposed LW1004 and LW1005 and it is also coincident with a Type 1 geological structure. Twin Gully Swamp is located above the western ends of LW1009 and LW1010.*
- *Fracturing and dilation of the bedrock is expected to develop beneath Tri Star Swamp, Twin Gully Swamp and the hanging swamps within their catchments, and this could result in cracking of the overlying peat layers. Fracturing and dilation of the bedrock can also occur beneath the swamps located adjacent to the mining area, within minor and isolated fracturing occur up to 400 m outside the proposed mining area.*
- *Tri Star Swamp is coincident with a Type 2 geological structure, as shown in Drawing No. MSEC1046-09. This swamp is also predicted to experience the maximum predicted subsidence effects above the proposed mining area, as it is located where the depth of cover is shallowest and the mining height is greatest. It is likely, therefore, that this swamp would experience adverse impacts due to the proposed mining.*
- *Twin Gully Swamp is also likely to experience adverse impacts, to a lesser extent, as it is not coincident with a Type 1 or 2 geological structure and due to the lower predicted subsidence effects.*
- *The impacts to Tri Star Swamp and Twin Gully Swamp could be similar to those previously observed at Junction Swamp, Narrow Swamp North, Narrow Swamp South and East Wolgan Swamp.*
- *Japan Swamp and the shrub swamps within the Carne Creek Catchment are located outside the proposed mining area at minimum distances of 85 m and 100 m, respectively. These swamps are also not coincident with Type 1 or 2 geological structures. However, the shrub swamps adjacent to the commencing end of LW1007 are located to the south of a Type 2 geological structure.*
- *It is unlikely therefore that surface cracking or deformation of the overlying soil and peat layers would occur at Japan Swamp and the shrub swamps located within the Carne Creek Catchment due to the proposed mining.*
- *The National Park will experience far-field horizontal movements towards the proposed mining area. The measured total far-field horizontal movements due to longwall mining in*

[27] Due to previous impacts to Junction, Narrow and East Wolgan swamps, the Sunnyside Swamp drainage line is the main upper Wolgan River drainage line providing permanent flows to the Wolgan River in this area. Recent monitoring has also identified impacts (altered hydrology) in the upper areas of Sunnyside Swamp.

the Southern and Western Coalfields are shown in Fig. 4.7. The predicted far-field horizontal movements at the National Park boundary (i.e. at a distance of 1000 m from the proposed longwall mining) is 80 mm based on the 95 % confidence level.

MSEC (2019) also discusses previous impacts to swamps from longwall mining at Springvale and Angus Place in Table 5.17, identifying:

- *Kangaroo Creek Swamp - Reduction in swamp piezometer levels when LW940 mined directly beneath the swamp and lineament. Following declines, all water levels remain predominantly below base of piezometer.*
- *Sunnyside Swamp - No detected mining-related changes in swamp piezometers levels.*
- *Sunnyside East - Temporary changes in swamp piezometer levels when LW414 mined beneath the Deanes Creek lineament at a distance of 2.25 km. Reduction in swamp piezometer levels when LW415 mined beneath the Deanes Creek lineament at a distance of 1.5 km. Following declines, all water levels remain predominantly below base of piezometer.*
- *Carne West - Temporary changes in swamp piezometer levels when LW415 mined beneath the Deanes Creek lineament at a distance of 1.8 km. Reduction in swamp piezometer levels when LW416 mined beneath the Deanes Creek lineament at a distance of 1.6 km. Following declines, all water levels remain predominantly below base of piezometer.*
- *Gang Gang West Reduction in swamp water levels at GW1 and GW2 prior to being directly mined beneath. Possibly related to LW417 and LW418 intersection of structures. Decline at GW3 following undermining of swamp and intersection of lineament at GW1. Following declines, all water levels remain predominantly below base of piezometer.*
- *Gang Gang East - Slow decline at GG1 from August 2016 consistent with CRD. Decline accelerates in August 2017 as LW420 intersects underlying lineament. GG2 decline in October 2016, no apparent correlation to longwall activity (but noting limited baseline data). Abrupt decline at GG3 from March 2018 as LW421 approached lineament beneath GG1. Following declines, all water levels remain predominantly below base of piezometer.*
- *Pine Swamp - Declines in water levels at BS1 and BS2 from October 2017 that are consistent with CRD. Further strong declines from January 2019 that coincide with intersection of LW425 with underlying lineament. Following declines, all water levels remain predominantly below base of piezometer.*
- *Paddys Creek Swamp - Several water level declines and recoveries following commencement of LW425 in August 2018. Temporary changes in swamp piezometer levels which may be related to the extraction of LW425.*

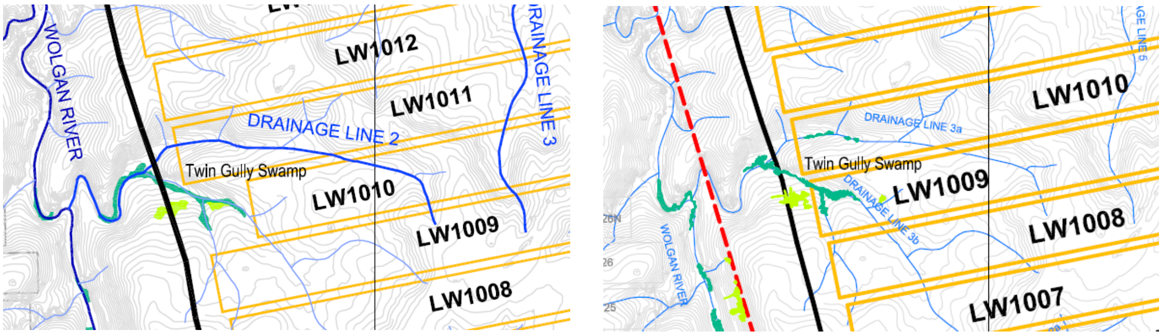
Whilst generally a reasonable summary of past impacts, it is noted that:

- **Undermining lineaments on the Newnes Plateau has led to impacts to swamps up to 2.25 km from the advancing longwall (MSEC 2019).**
- **Undermining the Deanes Creek Lineament Zone by previous longwalls lead to catastrophic changes to the hydrology of Sunnyside East, Carne West, Gang Gang West, Gang Gang East and Carne Central Swamps; complete drainage and desiccation of swamps, loss of permanent swamp aquifer, loss of water flow from the swamp to downstream drainage lines, probable direct connections to the mine itself based on SPR66 and Gang Gang Swamp aquifer monitoring results (see Connective Fracturing Section, Appendix 2 and MSEC 2019).**
- **Contrary to MSEC's (2019) conclusion, undermining the Deanes Creek Lineament Zone has also impacted on water levels in the upper part of Sunnyside Swamp (see Surface Water Assessment Section and Appendix 2). This may eventually lead to the complete drainage of Sunnyside Swamp.**

- **MSEC (2019) provided no subsidence, upsidence or valley closure estimates for the lower end of Sunnyside Swamp, despite it potentially being affected by mining subsidence.**
- **MSEC (2019) have not fully utilised the existing knowledge of far-field impacts caused by undermining lineaments when assessing the consequences of the amended Angus Place Mine plan. This leads to underestimation of potential mining impacts and consequences.**

Modifying Longwall Layouts

Originally the 2014 Angus Place Mine Layout proposed not to directly undermine Twin Gully Swamp. Under the amended plan, however, LW1009 now goes directly under Twin Gully Swamp EEC.



Longwall layout near Twin Gully Swamp in the 2014 (left) proposal and 2019 (right) proposal. Source: MSEC (2014, 2019)

Shortening the western ends of LW1009 and LW1010 to avoid direct impacts to Twin Gully Swamp are quite clearly a feasible management strategy to reduce impacts to important surface features like NPSS/THPSS EECs. Centennial have instead now chosen to directly undermine Twin Gully Swamp. The proposed mining will drain and desiccate Twin Gully Swamp. It will also likely to lead to the extinction of the Blue Mountains Water Skink population in Twin Gully Swamp.

Subsidence Impacts to Streams

Wolgan River

The Wolgan River is located at a minimum distance of 180 m from the proposed longwalls. The Wolgan River is a 4th order perennial stream with small base surface water flows derived from the shrub swamps and perched aquifers. The bed of the river comprises surface soils derived from the Burralow Formation of the Triassic Narrabeen Group, with sandstone bedrock outcropping in some locations. The Wolgan River thalweg (lowest point in the channel) is within the 26.5° angle of draw for some areas of the mine (see below). The predicted total subsidence effects due to the existing and proposed longwalls are less than 20 mm vertical subsidence, but it is predicted there will be up to 290 mm upsidence and 370 mm closure in the Wolgan River. These high levels of upsidence and valley closure have the potential to fracture and drain pools in the Wolgan River. The Wolgan River lies above the Wolgan lineament. Based on previous experience, complete drainage of pools is likely, and this would cause the Wolgan River to cease to flow in these areas.

MSEC (2019) state:

> *Fracturing has been observed in the NSW coalfields at distances up to approximately 400 m outside of longwall mining. However, at these distances, the fracturing is minor and isolated and it did not result in adverse impacts.*

The thalweg of the Wolgan River is located at a minimum distance of 180 m from the proposed LW1002. The total length of river located within 400 m of the mining area is approximately 0.8 km. It is possible that fracturing could occur along the section of the river to the south of LW1002, where it is located closest to the proposed mining area. However, at these distances, the fracturing is expected to be minor and not result in adverse impacts on the surface water flows.

The subjective opinions that fracturing is '*minor*', '*isolated*' and '*not result in adverse impacts on the surface water flows* ' are contradicted by the IEPMC (2018) report with regards to the Eastern Tributary (Woronora Reservoir), where serious impacts (complete drainage of pools) were observed 400m from Metropolitan Mine longwalls[28]. MSEC (2019) also identify the potential significance of subsidence interacting with lineaments (geological structures) to produce serious impacts up to 1.5km - 2.25km from an advancing longwall (see Swamp Section above and MSEC Table 5.17).

The Wolgan River lies above the Wolgan Lineament (see Drawing No. MSEC1046-07; part illustrated below) and intersects with the Type 2 lineament underlying Tri Star swamp. Undermining the Type 2 lineament underlying Tri Star swamp could have serious adverse consequences for both the THPSS EEC and the 4th order Wolgan River. It is highly likely that all water will be lost from Tri Star swamp and the Wolgan River fractured and drained. It is highly likely that the Angus Place proposal will cause the Wolgan River in this area to cease to flow under all but the wettest conditions. Based on past experience of mining interacting with geological lineaments[29], MSEC (2019) have seriously understated the potential level of impacts to the Wolgan River. Undermining the Tri Star lineament could lead to permanent irreparable damage to the Wolgan River.

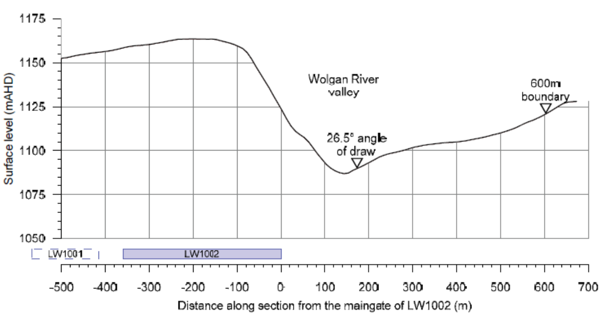
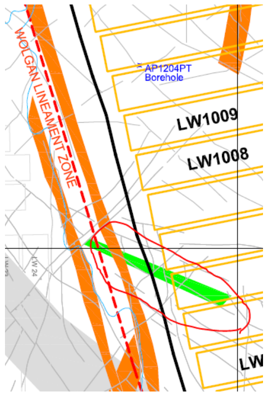


Fig. 5.2 Wolgan River cross-section 1 (looking east)



Thalweg of the Wolgan River near LW1002 (left) and Wolgan Lineament Zone (right). Source: MSEC (2019)

Carne Creek

Carne Creek is located 900 m south-east of the LW1001, at its closest point to the proposed mining area. The Deanes Creek Lineament Zone is coincident with Carne Creek and a tributary of this creek that lies above LW416 to LW419. Undermining the Deanes Creek Lineament Zone by previous longwalls has led to catastrophic changes to the hydrology of Sunnyside East, Carne West, Gang Gang West, Gang Gang East and Carne Central Swamps; complete drainage and desiccation of swamps, loss of permanent swamp aquifer, loss of water flow from the swamp to downstream drainage lines, probable direct connections to the mine itself based on SPR66 and Gang Gang Swamp

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28 These longwalls (163m wide) were less than half the width of the currently proposed Angus Place longwalls.
29 Which MSEC have themselves identified.

aquifer monitoring results. It has also impacted on water levels in the upper part of Sunnyside Swamp. The upper parts of Carne Creek lie directly above the Deanes Creek lineament. **The mine layout appears to present a much lower direct subsidence risk to Carne Creek, however, there remains a significant concern given the association of Carne Ck with the Deanes Creek lineament and noting that far-field impacts have occurred with previous longwalls undermining the Newnes Plateau (up to ~2km). The proposed mining is likely to lead directly to loss of flows to Carne Creek from tributary swamps and springs. The Groundwater Assessment identifies groundwater drawdown in Carne Creek, including sections of Carne Creek well within the World Heritage Area. MSEC (2019) have understated the potential level of impacts to Carne Creek.**

Third order and other streams

MSEC (2019) did not undertake a comprehensive analysis of all streams above the longwalls, simplistically stating there are *unnamed drainage lines* located directly above the proposed longwalls. Simply not having a *name* does not decrease the ecological value of streams in the area, especially since some sections of the drainage lines are located within and downstream of the swamps. Most are third order streams and the very presence of swamps means that these streams are likely to have permanent water/flow. The total length of third order streams above the proposed mining area is stated as approximately 2 km. Conventional subsidence predictions for third order and other streams are provided in MSEC (2019) Tables 5.4 and 5.5 (see below). It is noted that MSEC did not provide any estimates of upsidence and valley closure for the majority of these streams, despite the third order (and in some cases 2nd order) streams being associated with swamps and having permanent or near-permanent flow. Upsidence and valley closure are likely to be similar to those predicted for the swamps (Table 5.15).

Table 5.4 Maximum predicted total vertical subsidence, tilt and curvature for Drainage Lines 1 to 6

Drainage line	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
Drainage Line 1	1950	11	0.12	0.25
Drainage Line 2a	1950	7	0.15	0.25
Drainage Line 2b	2200	20	0.30	0.40
Drainage Line 3a	1500	14	0.20	0.25
Drainage Line 3b	1800	11	0.19	0.25
Drainage Line 4	1200	6	0.09	0.15
Drainage Line 5	1600	8	0.12	0.18
Drainage Line 6	1050	4	0.07	0.05

Table 5.5 Maximum predicted total vertical subsidence, tilt and curvature for the third order sections of the drainage lines within the Study Area

Drainage line	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
Drainage Line 2a	1950	7	0.15	0.25
Drainage Line 2b	2200	20	0.30	0.40
Drainage Line 3a	1500	14	0.20	0.25
Drainage Line 3b	400	10	0.19	0.02
Drainage Line 5	< 20	< 0.5	< 0.01	< 0.01
Drainage Line 6	< 20	< 0.5	< 0.01	< 0.01

Table 5.15 Maximum predicted total upsidence and closure for the shrub swamps

Shrub swamp	Maximum predicted total upsidence (mm)	Maximum predicted total closure (mm)
Tri Star Swamp	750	1000
Twin Gully Swamp	750	1000
Japan Swamp	90	120
Wolgan River Swamps*	100 (proposed longwalls only) 290 (existing and proposed longwalls)	160 (proposed longwalls only) 370 (existing and proposed longwalls)
Carne Creek Tributary Swamps	260	350

Drainage Lines 2a & 2b are associated with Tri Star Swamp. Drainage lines 3a and 3b are associated with Twin Gully Swamp. Drainage Line 1 is associated with small hanging swamps to the east of LW1002. Drainage Line 4 is associated with Trail 6 (Japan) swamp. Drainage Line 5 is associated with a Type 2 lineament. Drainage Line 6 is associated with the Birds Rock swamps, which lie inside the Birds Rock Flora Reserve. The drainage line from Sunnyside Swamp is called the *Wolgan River East Branch* in MSEC (2019) but it receives no assessment in MSEC's report. This is considered a serious omission since, after impacts to Junction Swamp, East Wolgan Swamp and Narrow Swamp, this stream currently provides most of the flow to the Upper Wolgan River.

MSEC (2019) state:

> *It is expected that fracturing of the bedrock would occur beneath the sections of the drainage lines that are located directly above and adjacent to the proposed longwalls. Where the bedrock is shallow or exposed, then the fracturing will be visible at the surface. Fracturing can also occur outside the extents the proposed longwalls, with fracturing possible at distances up to approximately 400 m outside the mining area.*

Based on previous experience and given the very high levels of subsidence, stress, upsidence and valley closure, surface water flow diversions and loss are highly likely to occur along all sections of 3^{rd} order drainage lines that are located directly above and immediately adjacent to the proposed longwalls. It is also likely that fracturing and drainage will occur in the *Wolgan River East Branch.* Centennial have not committed to remediating any of these impacts and have no experience in remediating such features. Once impacted it is highly unlikely they can ever be repaired, especially where they underlie the swamps (Commonwealth of Australia 2014, Planning Assessment Commission 2010). Impacts to streams if approved are likely to remain in perpetuity.

Connective Fracturing & Lineament Interaction

The height of fracturing above a longwall panel can be described as the zone from which the overburden transitions between bridging characteristics and observed fracture dilation of new fractures or remobilisation of existing fractures (SCT 2019). SCT (2019) suggest the height of fracture zone, as observed from monitoring and modelling of goafs, is typically between 1-1.75 times the panel width and can be approximated to 1.5 times the panel width. Under such rough rules of thumb, 360m wide longwalls would lead to heights of the fracture zone extending 360m to 630m above the coal seam; or 540m above the coal seam if approximated using 1.5 times the panel width. **Since the depth of cover over the Amended Angus Place Mine is stated to be 270 to 450m, then this would mean that surface to seam fracturing is likely to occur over the entire longwall layout area using the 1.5 times panel width approximation.**

SCT (2019) however note that:

> *The height of fracture zone however, does not necessarily equate to the zone of increased conductivity as the conductivity is dependent on the networking and connectivity of the fracture system (Gale, 2008). Likewise, the height of fracture may not equate to the height of total depressurisation due to the connectivity of the fracture network.*

The IEPMC (2019) recently summarised many of the current issues surrounding surface to seam connective fracturing associated with longwall mining; much of this based on the study by PSM in the southern coalfields. The IEPMC (2019) stated:

> *The height of complete groundwater drainage is an important consideration in groundwater modelling and the Tammetta equation and the Ditton equations were developed in Australia for this purpose some 5 years ago. Considerable controversy and confusion surround their predictive capacities in the Special Areas. The Panel has given detailed consideration to the equations and, notwithstanding that uncertainty is associated with all, recommends erring on the side of caution and deferring to the Tammetta equation until:*
>
> *i. field investigations quantify the height of complete drainage at the Dendrobium Mine and Metropolitan Mine, and/or*
>
> *ii. alternative geomechanical modelling of rock fracturing and fluid flow is utilised to inform the calibration of groundwater models.*

Using Tammetta's relationship for the recent Tahmoor South proposal, SCT (2019) identified that with an overburden depth of 390m, an extraction height of 2.5m and panel width of 300m, U = 3568, which equates to a total depressurisation height of 210m. Their Figure 7 illustrated a plot of the height of total depressurisation using Tammetta's relationship. The height of total depressurisation was generally found to be 208-210m, however it increased to approximately 216m in the northeast areas where there were greater depths. They concluded that this would not lead to surface to seam connectivity for the Tahmoor South proposal.

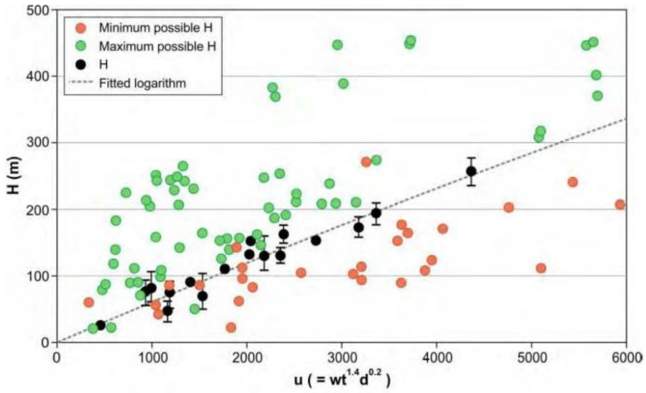


Figure 7: Estimation of the height of total depressurisation above a longwall panel (Ref: Tammetta, 2012).

Height of Total Depressurisation plot. Source: SCT (2019).

The main Amended Angus Place EIS documents barely touch on the issue of connective fracturing, however, connective fracturing is referred to in the JBS&G (2019) report. Unfortunately, the JBS&G (2019) report provided to EES is a photocopy which at times is barely legible[30]. **It is, nevertheless, noted that neither the Groundwater Report nor the JBS&G (2019) report specify what Tammetta's equation would yield in terms of predicted height of total depressurisation above the mine.** To rectify this, Tammetta's equation calculations have been undertaken using the dimensions of the proposed longwalls for the Amended Angus Place Mine proposal (Table 1). It is noted that the IEPMC (2019) stated that it recommended erring on the side of caution and deferring to the Tammetta equation: *until further field investigations quantifying the height of complete drainage;* and/or *geomechanical modelling of rock fracturing and fluid flow are shown to be sufficiently reliable for informing the calibration of groundwater models at mine sites in the catchment*[31].

With 360m wide longwalls and a seam height extraction of 3.4m, Tammetta's equation yields predicted height of total depressurisation ranging between 342m and 374m. This would mean that total depressurisation and surface to seam fracturing will likely reach the surface over much of the mine layout.

For comparative purposes, Table 1 also includes calculations made for previous longwalls over Springvale and Angus Place mines, particularly in areas where past impacts have clearly been demonstrated. It is relevant to point out that there are a number of case studies where significant amounts of water have been lost at the surface over earlier Angus Place (Kangaroo Ck impacts; LW940 and LW950), and Springvale longwalls (East Wolgan Swamp, Gang Gang Swamp[32]; especially LW411 & LW420). Notably no scientific evidence has been provided that demonstrates lost water returns to the stream systems. These impacts are discussed further below.

[30] An original legible copy of this report should be forwarded to EES.

[31] Whilst these recommendations were made for Dendrobium and Metropolitan mines in the Southern Coalfield, the focus of the IEPMC's terms of reference, they apply equally well to longwall mining in the Western Coalfields.

[32] Loss of water also occurred in Carne West Swamp, and MSEC stated *Reduction in swamp piezometer levels when LW416 mined beneath the Deanes Creek lineament at a distance of 1.6 km. Following declines, all water levels remain predominantly below base of piezometer.*

Longwalls	Width	Height	DOC	HoCF
Angus Place LW1001 to 1015	360	3.4	270	342
	360	3.4	370	362
	360	3.4	450	374
	360	2.5	270	231
	360	2.5	370	245
	360	2.5	450	254
Angus Place LW940	261.9	3.25	380	258
	261.9	3.25	270	242
Angus Place LW950	282.5	3.2	325	263
Tahmoor South as cited by SCT	300	2.5	390	209
Springvale LW420	261	3.2	380	252
Springvale LW411	305	3.2	290	276
	305	3.2	400	293
	305	3.2	300	278

Table 1. Height of Total Depressurisation (HoCF) above the Mine using Tammetta's equation. DOC=Depth of Cover. Height=seam extraction height.

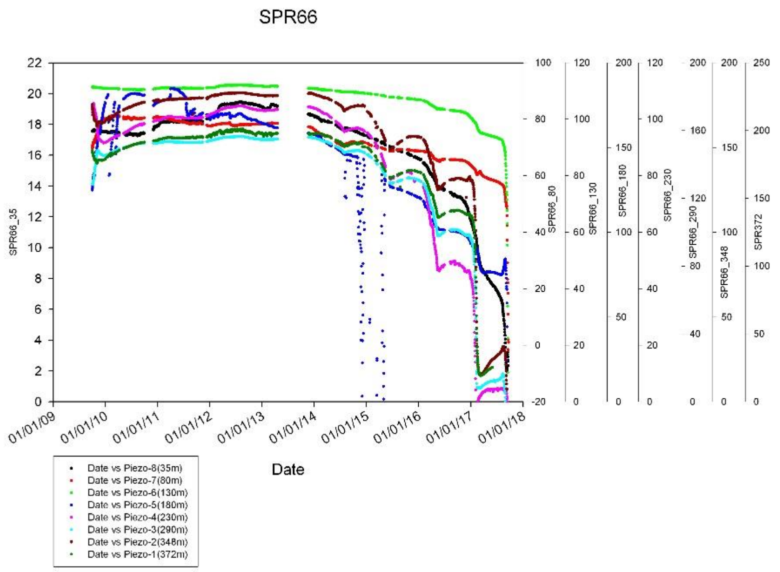
Gang Gang Swamp

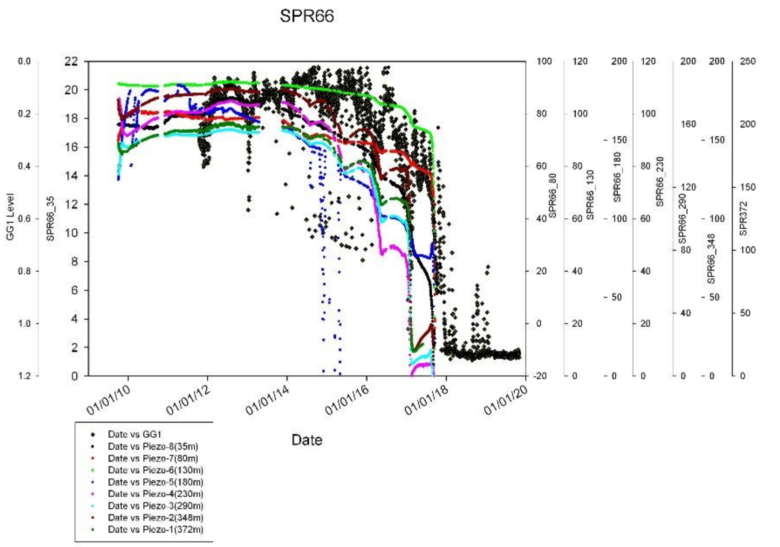
Jacobs (2019) state that:

> *It is noted that propagation of depressurisation from development headings is not considered likely as that would require a continuous hydraulic connection between the seam and the swamp. As is seen from the VWP data (Appendix C) and previous studies delineating the hydrostratigraphic units (CSIRO, 2004), this has not been observed.*

This statement is genuinely concerning since Appendix C is a very selective and incomplete presentation of VWP data. It is also contradicted by the data presented in JBS&G (2019) – especially Figures 4.42 and 4.23, which illustrate the groundwater behaviour of the SPR66 VWP. SPR66 is located above the centre line of Springvale LW420. The plots are difficult to read in the JBS&G report, so are recreated from SPR66 data previously supplied to OEH (see below).

Tammetta's equation for the Springvale LW420 configuration would suggest a height of complete depressurisation of 252m for a depth of cover of ~380m (see Table 1). As can be seen in Figure 2, all the VWP water levels are depressurised (from 35m down to 372m). When this is compared to the piezometric response in Gang Gang Swamp, the obvious inference is that, based on SPR66 and GG1 monitoring data, water in the aquifers up to 35m and in the overlying swamp have potentially drained down into the mine.





Plot of aquifer levels monitored in SPR66 and Gang Gang Swamp above Springvale LW420. Source: Various Centennial data files provided to OEH.

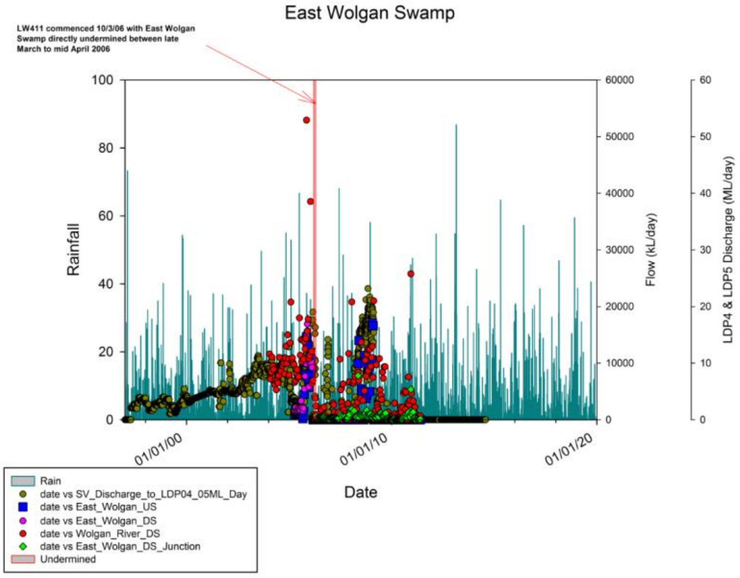
East Wolgan Swamp

Aurecon (2009) wrote a particularly good report on their investigation into irregular surface movement in East Wolgan swamp. Aurecon's (2009) report identified that Centennial had been releasing up to 16ML/day into the upper part of East Wolgan Swamp, however in 2006 it was noted that none of this water was reaching the downstream monitoring site. Slump holes were seen in East Wolgan swamp with mine water draining into it. Aurecon (2009) was one of the first recognitions of the role of geological structures interacting with subsidence to cause serious surface consequences.

Aurecon (2009) identified that during the period of continuous discharge before March 2006, annual average discharge flows through LDP004 for the years 2002 to 2005 ranged from 1.9 ML/day to 4.2 ML/day. Throughout, 2006 and 2007, eight emergency discharges occurred with durations ranging from 1 to 18 days totalling 34 days of discharge over the 2 year period. Daily volumes ranged from 2 ML/day to 16.4 ML/day. The average discharge in 2006 was around 4.8 ML/day. Daily volumes in 2007, ranged from 2 to 3.2 ML/day. The average volume discharged over 2007 was 3.1 ML/day.

Due to technical problems with the water transfer scheme, emergency discharges during 2008 increased, with a total of 253 days of discharge between March and December 2008. Discharge continued into 2009 ceasing in February 2009. This period of discharge included substantially elevated volumes of water (compared to that over the 2002 – 2007 period) being released into the swamp. The average discharge over this period was 9.4 ML/day and ranged between 1.8 to 11.95 ML/day. During the 2008/2009 discharge event, the number of days when the discharge rate was equal to or exceeded 9ML/day totalled 235. An illustration of the actual discharge volumes and flow monitoring data is illustrated below.

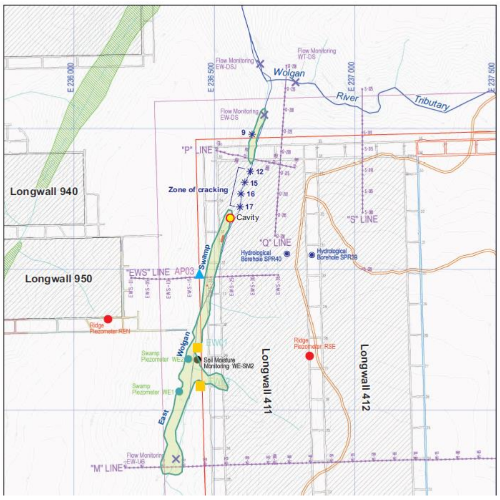
Several inspections were carried out in an attempt to determine if the water entering the cavity was reappearing downstream. These inspections were limited to times when Springvale was discharging water. The inspections followed the full length of the downstream portion of the East Wolgan drainage line, upstream and downstream in the Wolgan River, Narrow Swamp drainage line and the confluence of Sunnyside Swamp with the Wolgan River. **These inspections did not locate any reappearance of the mine water discharge (Aurecon 2009).**

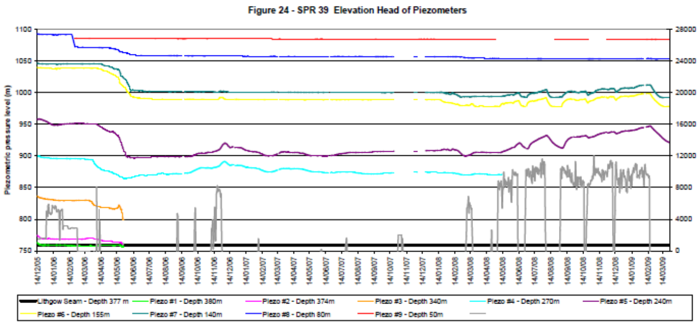


Monitored flow at East Wolgan upstream, East Wolgan Downstream, East Wolgan Downstream of Junction, Wolgan River Downstream and LDP4&5 discharges. Source: Various Centennial data files provided to OEH.

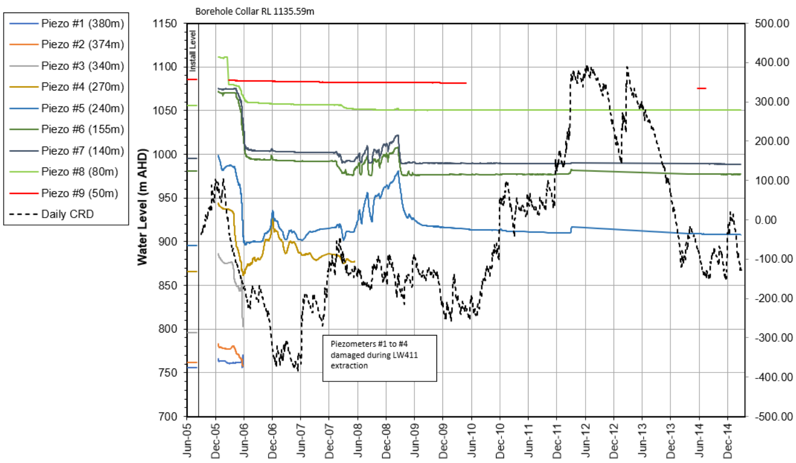
Aurecon (2009) note:

> *During the extended emergency discharge starting in May 2008, the pressure in piezometers #5, #6 and #7 (at depths of 240, 155 and 140 m respectively) rose noticeably and appeared to respond to changes in discharge volumes with a delay of about one week. This suggests that water is pooling in cavities in the strata over the longwall panel. Most water appears to be ponding above a depth of 140 metres (RL 995 m, this is 70 metres beneath the base of the swamp), which is the depth of the highest piezo (#7) that shows the pressure response. The upper two piezometers (#8 and #9) are stratigraphically above the base of the swamp and hence show no impact from the inflow into the cavity, as would be expected.*
>
> *The only feasible explanation for this phenomenon is that discharge water enters the cavity in the base of the swamp and percolates vertically (probably through a fault or other structure) and finds its way into cavities formed by the opening of bedding planes above the goaf. The structure that is the conduit for the water is possibly the same as that which has caused the cavity in the creek bed.*





Location of East Wolgan Swamp relative to LW411 (left) and SPR39 piezometer levels (right). Source: Aurecon 2009.



More recent illustration of SPR39 piezometer levels. Source: Centennial data file supplied to OEH.

Aurecon (2009) stated that the piezometric monitoring in SPR 39 also suggested that the surface water did not penetrate any deeper than 240 metres (170 metres beneath the swamp). However, it is interesting to note that:

- The bottom 3 piezometers were directly affected by LW411 mining and ceased to record shortly after LW411 commenced;
- After initially declining then rising[33] before finally declining again, SPR39 (270m) ceased recording in mid-2008, leaving SPR39 (240m) as the lowest recording VWP;
- The upper aquifers appear to have no water, water levels at or below the remaining VWP recording depths – piezometers 6, 7 & 8;
- SPR39 lies above the pillar inbetween LW411 & LW412 and is therefore not actually directly above LW411;
- Tammetta's equation yields estimates of complete depressurisation using the configuration and depth of cover for LW411 of 276 -278m[34].

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[33] Potentially as a direct response to mine water moving down the East Wolgan cavity.

[34] See Table 1. Tammetta only includes centreline piezometers in his database to derive height of depressurisation, which would exclude SPR39 seeing it sits over the pillar between LW411 & LW412.

- ➢ This would suggest complete depressurisation occurred to a height above the 240m and 155m[35] levels discussed by Aurecon (2009)
- ➢ There is no explanation for the decline in levels in SPR39 (240m) by ~50m by mid-2009.
- ➢ Aurecon's inspections did not locate any reappearance of the mine water discharge

In response to OEH questioning mine water make in the Angus Place Mod 5, Centennial produced a mine water make diagram identifying a "*step change in water make due to Springvale LW411*" – see below. From the discussion above, it is noted that mine discharge water (up to ~10ML/day) was first identified to have moved into the cavity with no transmission downstream in about April 2006 and Centennial stated in their Angus Place Mod 5 response that *LW411 extraction in 2006 lead to an increase in 10 ML/day in mine inflows*. Centennial's Figure 1 circled mine water increases in mid 2008 - 2009, two years after mining impacts due to LW411. Centennial stated that *a step change in water make of 10 ML/day was observed to peak in mid-2009 and that was due to mining commencing in new or 'virgin' areas*.

This statement is unconvincing since there is still no explanation for where all the mine water that went down the East Wolgan cavity[36] ended up. Aurecon identified that it was not coming back into the stream network. Tammetta's equation yields estimates of complete depressurisation to a height above the 240m and 155m VWP levels. Any suggestions that lost water returns to surface in these systems remains speculative and lacks objective data, let alone scientific proof that it occurs. The obvious inference from the evidence above is that it most likely went into the mine itself.

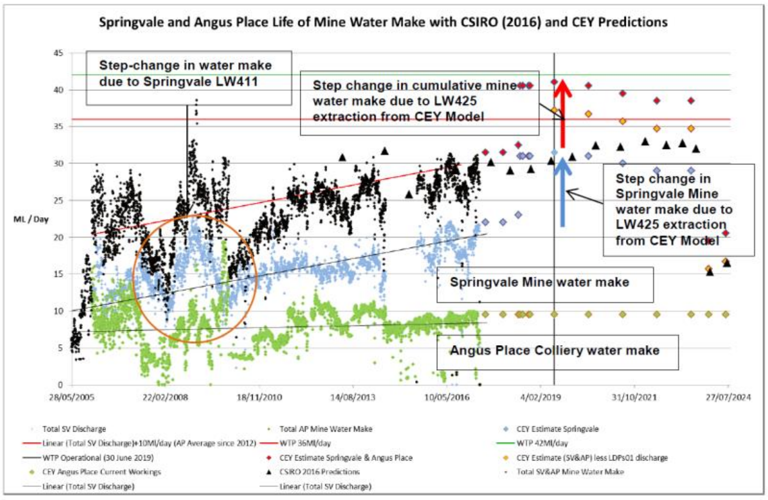

Figure 1 – COSFLOW and Centennial Empirical (CEY) Mine Inflow Predictions

Mine water make. Source: Centennial (2018).

Biodiversity Assessment

The Biodiversity Assessment (RPS 2019) identifies that impacts to NPSS/THPSS may include vegetation dieback, major incision and erosion (in some instances down to bedrock), associated with loss of peat layer, significant loss of ecosystem function and ecological resilience, and ecological and geomorphic threshold exceedance. It also identifies a wide range of impacts to threatened and endangered species including the BC and EPBC listed Blue Mountains Water Skink.

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[35] Assuming a coal seam depth of ~380m.

[36] Averaging 9.4 ML/day and ranging between 1.8 to 11.95 ML/day (Aurecon 2009). Summing discharge volumes for Springvale transfer to LDP4/5 over the period 1 May 2006 to 5 September 2010 yielded a total volume of 769ML potentially lost into the cavity.

Whilst identifying potential impacts to swamps, the Biodiversity Assessment also includes several unsubstantiated subjective statements, including:

- The predicted impacts at Wolgan River, Wolgan River Upper and Crocodile Swamps are not considered to be significant (Jacobs 2019a); and
- Nevertheless, given the current THPSS monitoring results, it is considered unlikely that the THPSS systems will be lost in entirety.

The groundwater assessment predicted impacts to Crocodile swamp (2m to 5m groundwater drawdown) which are considered sufficient to drain the aquifers in and feeding Crocodile swamp. It is likely that the proposed mining will remove the water lying above the YS6, YS5a and YS5 aquitards, the source of water to Crocodile Swamp (see McHugh 2014). McHugh (2013) stated that the presence of swamps in catchment headwaters cannot be fully explained by rainfall alone and require an additional continuous source of hydration though periods of restricted rainfall. As identified earlier, the presence of aquitards in the Burralow sequence perform a vital function in the presence and persistence of the Newnes Plateau Shrub Swamps (NPSS; McHugh 2011, 2013, 2014). Based on previous experience with longwall mining under the Newnes Plateau, this function will be lost either through surface fracturing and/or groundwater depressurisation. The Wolgan River and Wolgan River Upper Swamps lie above the Wolgan lineament and are predicted to experience high levels of upsidence and valley closure (see Stream Assessment Section below). Impacts to Junction Swamp, East Wolgan Swamp and Narrow Swamp have already reduced flows to the Wolgan River swamps and further fracturing and drainage from the Angus Place proposal is likely to lead to further flow losses. **The potential impacts and consequences to all swamps, including the Wolgan River, Wolgan River Upper and Crocodile Swamps are understated.**

The alteration to swamp hydrology from previous mining meant that in the recent 2019/2020 fires, the undermined and desiccated swamps experienced some of the most catastrophic changes of any peat swamp system in NSW (incineration of peat to ash down to depth, extensive habitat loss, extremely poor seedling recruitment and the likely loss of viable populations of endangered species such as the Blue Mountains Water Skink and Giant dragonflies). These undermined, desiccated and now burnt swamps may no longer remain peat-forming swamp communities. In contrast, while non-undermined swamps were also burnt in the recent 2019/2020 fires, water is still readily observable in the swamps, soil moisture remains high (see below and photographs in Appendix 1), vegetation regrowth is already advanced and BMWS populations remain viable[37]. **The potential impacts and consequences to swamps are understated in RPS (2019).**

While RPS (2019) acknowledge likely impacts to NPSS/THPSS and BC & EPBC listed threatened and endangered species, they say that that they will be offset in accordance with the BC Act and EPBC Act and in accordance with the NSW Biodiversity Offset Scheme and the Commonwealth Environmental Offsets Policy.

However, Centennial and RPS (2019) fail to address the basic principles of the NSW and Commonwealth Offsets policies to first avoid and then mitigate impacts, prior to any offsetting.

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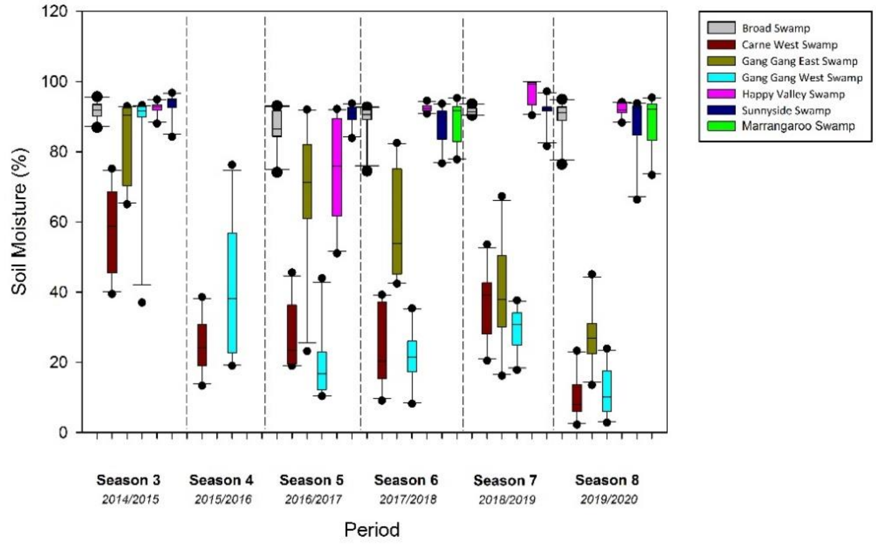
[37] EES BMWS SOS data.



Boxplots[38] of surface soil moisture levels in undermined swamps (Carne West Swamp – dark red box, Gang Gang West Swamp - light blue, Gang Gang East Swamp - olive) and non-undermined swamps (Sunnyside Swamp[39] - dark blue, Happy Valley Swamp - pink, Broad Swamp - grey, Marrangaroo Swamp - green). Source: Unpublished data from EES SOS Swamped by Threats Program & Dr. S. Gorissen.

The Swamp Amendment to the NSW Offsets Policy clearly states:

> *The overarching principles, definitions and policy settings of the BOP and the FBA are all directly applicable to this addendum. This includes the principle that biodiversity offsets sit within the assessment hierarchy of '**avoid, minimise**, offset'. **Offsets should only be used to compensate for impacts when all feasible measures have first been taken to avoid and minimise those impacts.***

The Commonwealth Offsets policy website clearly identifies:

> *Offsets are measures that compensate for the residual impacts of an action on the environment, **after avoidance and mitigation measures are taken**. Where appropriate, offsets are considered during the assessment phase of an environmental impact assessment under the EPBC Act.*

The first four Commonwealth Offset Principles are stated as:

Suitable offsets must:

1. *deliver an overall conservation outcome that **improves or maintains the viability of the aspect of the environment that is protected by national environment law and affected by the proposed action***
2. *be built around direct offsets but may include other compensatory measures*
3. *be in proportion to the level of statutory protection that applies to the protected matter*
4. *be of a size and scale proportionate to the residual impacts on the protected matter*

Centennial and RPS fail to address the basic tenets of the NSW and Commonwealth Offsets policies to first undertake Avoidance and Mitigation Measures before moving to Offsets. What then follows in the Biodiversity Assessment are some highly questionable offset calculations, with

[38] The boxes/rectangles represent 75% of the data for each site/season. The whiskers represent 95% of the data.

[39] Note that hydrological impacts have now occurred in the upper reaches of Sunnyside Swamp (above the location of this monitoring). Marrangaroo Swamp is also proposed to be undermined in the future by Springvale longwalls.

some of the stated figures/totals being mathematically incorrect. They appear to suggest that they can offset impacts to NPSS/THPSS with swamps[40] that Centennial do not own and have no legislative ability/approval to either impact or protect. They fail to identify that there are only approximately 100 NPSS (~550Ha – 600Ha) in total in existence which, as the name suggests, only occur on the Newnes Plateau. Previous mining has already led to irreparable damage to 15 (~77 Ha) of these swamps or ~13% of the entire NPSS in existence. Marrangaroo Swamp (8.3 Ha) is also likely to be impacted by future mining at Springvale. The Amended Angus Place mine proposes damage/loss to a further 5-7 (~21 Ha) of NPSS. This takes the total amount to ~20-22 swamps (~106 Ha) impacted or ~18% of the entire NPSS EEC in existence. The Angus Place Biodiversity Assessment cites a total impact area for swamps over the Angus Place and Springvale mines of **131.1 Ha**[41].

The proposal will also impact on threatened/endangered species. The endangered (BC and EPBC listed) Blue Mountains Water Skink (BMWS) is one of the most restricted species in NSW, known to occur in just 70 swamps in the Blue Mountains and Newnes Plateau (Gorissen et al 2017). Initial mapping suggests 60-70% of habitat of the endangered Blue Mountains Water Skink has been affected by fire since August 2019 (see below). It is noted that **all** the Newnes Plateau swamps were burnt during the recent fires.

Research also indicates that there are genetic differences between populations in the Blue Mountains and Newnes (Dubey 2010, Dubey et al 2013). Dubey (2010) suggested the Blue Mountains and Newnes Plateau skink populations have been isolated from each other for at least a million years. Little is known of the genetic differences of individuals in different swamps, however there is only very limited evidence of individuals moving between swamps within nearby areas. Skink populations in individual swamps are likely to be genetically distinct from one another.

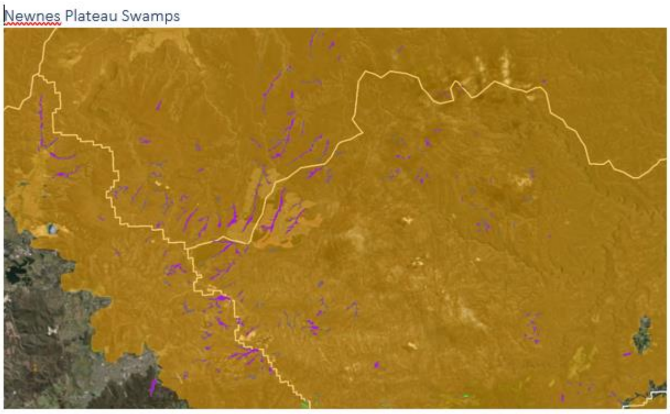
Dubey et al (2013a) concluded that:

> *Gene flow between populations is very limited, and animals within each of the two major parts of the species' distribution (Blue Mountains versus Newnes Plateau) have been isolated from each other for at least a million years. In addition, this species has low annual fecundity (one to five neonates per annual litter), further reducing the ability of populations to recover from the effects of episodes of higher-than-usual mortality; and*
>
> *The endangered Blue Mountains Water Skink (Eulamprus leuraensis) exhibits several traits predicted to imperil it under climate change: ectothermy, low reproductive output, specialisation to a restricted habitat type, montane endemicity, and a small geographic range. On balance, the greatest threat to population persistence for E. leuraensis under climate change is likely to involve indirect effects mediated via habitat degradation (especially, drying-out of the hanging swamps) rather than direct thermal effects on lizard reproductive output or offspring phenotypes.*

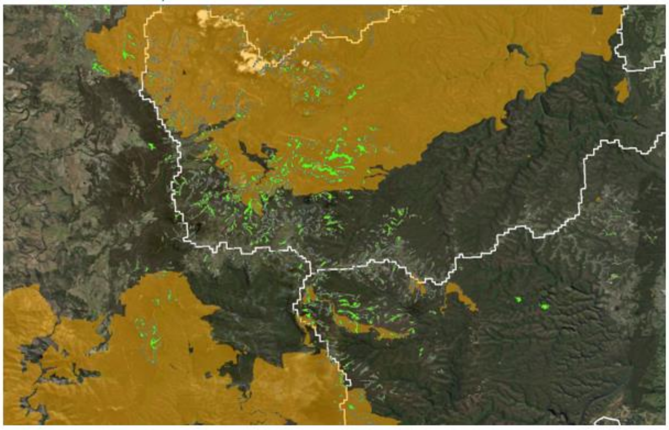
[40] The swamps proposed for offsetting largely occur on Crown land under the administration of FC NSW. Centennial do not own these swamps and have not paid for them or have any legislative ability to preserve them in perpetuity.

[41] RPS do not provide any breakdown for the individual swamps affected or how they arrived at this figure. If taken as the area of NPSS affected, this takes damage/loss of the NPSS EEC to well over 20% of the entire community.

Newnes Plateau Swamps



Blue Mountains Swamps



2019/2020 Fire extent map relative to Newnes Plateau Swamps (above; purple) and Blue Mountains Swamps (below; green). Source: EES unpublished data using the GEEBAM fire extent GIS layer.

Blue Mountains Water Skinks have already been extirpated from Junction Swamp and numbers in Carne West Swamp are now so low[42] that none were caught in post-fire trapping for EES's BMWS SOS program (see below). Small numbers were caught in Gang Gang East & West swamps, but it is likely that post-fire conditions will lead to the skinks disappearing from these swamps as well. Recently identified hydrological impacts to Sunnyside[43], Nine Mile, Carne Central and Paddys swamps also present a threat to their individual BMWS populations. The Amended Angus Place mine is proposing to cause yet further loss of swamps (at least 5-7 swamps) four of which have known populations of BMWS[44]. The species is obviously in danger of contracting even further in the future due to a variety of pressures on their habitat, the most obvious one being the Angus Place proposal.

The Amended Angus Place Mine increases the proposed extraction of coal, increases the amount of subsidence to be experienced on the Newnes Plateau and does not reasonably avoid or mitigate the impacts of the proposal on NPSS/THPSS. It will lead to a loss and decline in the viability of the NPSS community (protected by National law as part of the THPSS community and affected by the proposed action). In the longer term, the Angus Place Mine is likely to lead to further loss of BC/EPBC listed THPS Swamps and loss of the BC/EPBC listed Blue Mountains Water Skink populations in those swamps.

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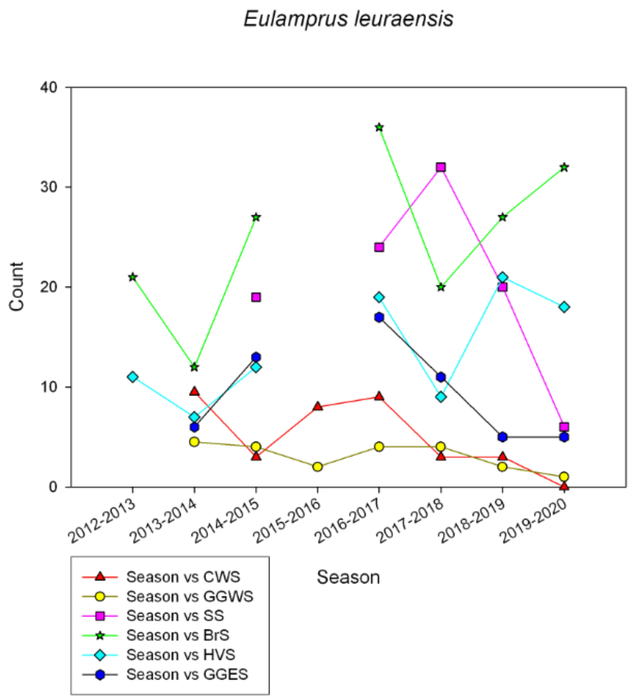
[42] Only a couple of individual BMW skinks were seen throughout the entire swamp.

[43] There was a substantial decline in Sunnyside Swamp BMWS numbers in the latest sampling, but this needs further sampling over a longer term to ascertain whether this is a fire response or a mining response (or a combination of both).

[44] RPS did not survey the Birds Rock Swamps for BMWS/dragonflies but the swamps contain suitable habitat for both BMWS and the Giant Dragonfly. No surveys were undertaken in Wolgan River Upper or Wolgan River Swamps.



Blue Mountains Water Skink (*Eulamprus leuraensis*) caught over time in Carne West Swamp (CWS; mining impacted – red line), Gang Gang West Swamp (GGWS; mining impacted - yellow), Sunnyside Swamp (SS; initially a reference, but now potentially impacted - pink), Broad Swamp (BrS; reference - green), Happy Valley Swamp (HVS; reference – light blue) and Gang Gang East Swamp (GGES; mining impacted – dark blue). Source: Unpublished data from SOS *Swamped by Threats* Monitoring Program and Dr S. Gorissen.

Groundwater Assessment

EES (formerly OEH) has previously expressed serious reservations about Jacobs' modelling of groundwater and surface water for the Springvale and Angus Place developments (and for the Coxs River). This is because previous models have been poorly calibrated, and the models have remained unvalidated. The last iteration of the Coxs River model reported to OEH did not include daily discharge volumes for Centennial's Angus Place, Springvale, or Lamberts Gully in the model. Unfortunately, the groundwater and their linked surface water/swamp model for the Amended Angus Place proposal are again poorly calibrated and again there has been no validation of these models. The models are highly unlikely to provide a reasonable prediction of reality in relation to existing conditions, let alone conditions after mining occurs.

Jacobs (2019) state that:

> *A detailed numerical groundwater model has been built on the MODFLOW USG platform for the purposes of assessing mine dewatering requirements and informing a groundwater impact assessment for the Project, as has a swamp water balance model. The swamp water balance model is a combined GoldSIM/Australian Water Balance Model and incorporates outputs from seepage faces and baseflow contribution generated from the groundwater model.*
>
> *A numerical groundwater flow model (the hydrogeological model) has been developed in MODFLOW for Unstructured Grid (MODFLOW-USG) (USGS, 2013). The version of MODFLOW-*

USG used was MODFLOWUSG-Transport which allows for the calculation of variably saturated flow and multiple water tables. MODFLOW-USG-Transport was run under the Groundwater Vistas (Version 7.24 Build 56) graphical user interface.

The model mesh was constructed with Quadtree Refinement, incorporating cell sizes ranging from 100m in areas of interest to 400m in areas where detailed resolution was not required, with 200m transitional cells. The model was constructed with 28 layers for a total of 793,884 cells.

The calibration included 18,624 target observations

The model itself could potentially be described as a '*monster*' model, attempting to link groundwater modelling with swamp aquifer levels and surface water flows. Under such circumstances adequate calibration is essential to avoid cascading errors in prediction and to demonstrate that the model provides a reasonable prediction of reality. It is not all that surprising that JBS&G cite run-times of 13.5 hours for 'calibration simulation' and 30 hours for the 'combined calibration/prediction simulation[45].

Whilst the number of observations cited (*18,624 target observations*) sounds large, it potentially represents only one observation for every 43 cells[46] in the MODFLOW model. Far fewer *target observations* appear in the plot of observed vs computed target values in Figure 5.6 (see below). Jacobs (2019) suggests that there is an *acceptable match* to data over Springvale and the Scaled Root Mean Square error between observed and modelled heads is given as 6.6% with the Root Mean Square Error (RSME) as 30.1m.

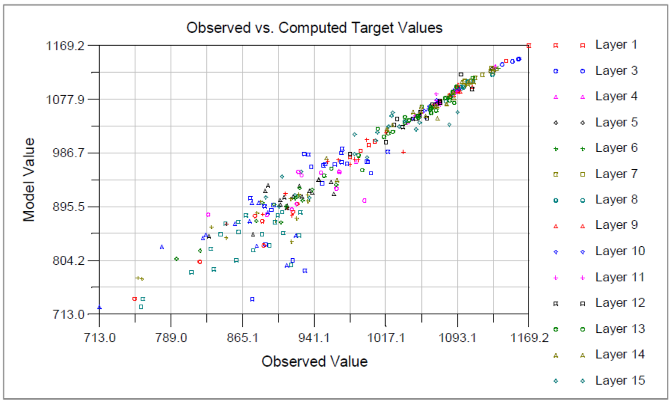


Figure 5.6: Observed vs Modelled Heads

Observed versus modelled heads in the Groundwater Assessment. Source: Jacobs (2019).

What such an assessment fails to adequately inform readers, is that the observed head (real water level) can be up to 70m or more different to the predicted head (predicted water level) – see Figure above. This could potentially be very important depending on exactly where the water head is being predicted in relation to the mine. Jacobs' (2019) groundwater assessment only appears to provide modelled outputs and there appears to be no time series plots where observed and predicted heads

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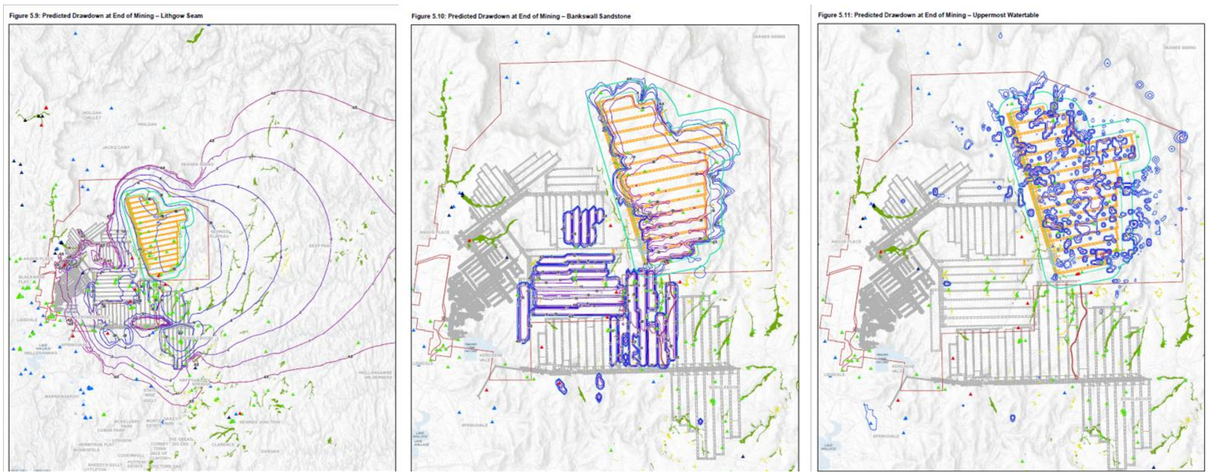
[45] It was suggested that *the excessive run-time, considering the model only had 506058 cells, is due to difficulties in solving Richards Equation*.

[46] When considering the total of 793,884 cells. Each cell appears to be 100m X 100m (1 Ha) for the detailed areas or 400m X 400m (16Ha) for the less detailed areas. So this potentially represents 1 observation per 43-688 Ha depending on cell sizes used. Even at the lower cell number cited (506058), this represents 1 observation per 27-435 Ha.

are provided simultaneously. There are many boreholes above Angus Place & Springvale mines where temporal measurements exist. Such matters could and should have been assessed in the EIS, and observed and predicted data presented. This does not occur. The issue of highly selective and incomplete presentation of VWP data was also raised earlier (see Connective Fracturing section). It is noted that the Groundwater Assessment does not provide full details for the Vibrating Wire Piezometer (VWP) or Open Borehole monitoring bores above the proposed Angus Place longwalls. **There is also a dearth of monitoring in the upper-most 20m of rock strata over the proposed Angus Place Mine with very few if any piezometers monitoring the important aquifers of the Burralow Formation.**

Leaving aside the issues with poor calibration, lack of validation and selective presentation of data, it is still informative to consider what the groundwater model does predict (see below).



Groundwater drawdown predictions over the Amended Angus Place Mine. Source: Jacobs (2019).

The results of the groundwater modelling can be summarised as:

- Groundwater drawdown and propagation within the Lithgow Seam extends towards the east and northeast with the 1m drawdown contour extending approximately 17 km to the east. **This takes it well within the Greater Blue Mountains World Heritage Area.**
- *Drawdown in overlying layers, beneath the Mount York Claystone, is of similar extent and magnitude*; **so presumably also taking it well within the Greater Blue Mountains World Heritage Area**.
- The Mount York Claystone, drawdown is suggested to be *limited to the immediate mining area, largely due to the Banks Wall Sandstone being truncated and isolated from the east by the deeply incised Carne Creek valley*.
- Predicted groundwater drawdown in the Banks Wall sandstone is limited to generally be within ~600m of the longwalls (Figure 5.10). **This is concerning since groundwater modelling for other coal mines in NSW suggests much greater distances of sandstone groundwater drawdown than that predicted for the Amended Angus Place proposal (despite Angus Place having the widest longwalls of all coal mines in recent times)**.
- For example, for the Hume Coal proposal in the Southern Highlands, Coffey (2016) stated: *The drawdown footprint achieves a maximum size at about 17 years since the start of mining* and At 17 years, the 2m differential drawdown contour at the water table extends a maximum of about 2km past the southeast corner of the mine footprint. And this was for a mine with negligible subsidence. **The drawdown extent predictions for Banks Wall sandstone are concerning and require further scrutiny.**

- **Predicted drawdown in the uppermost water table[47] extends into the Greater Blue Mountains World Heritage Area with drawdown 'hotspots' identified in Carne Creek well within the WHA.** Jacobs (2019) state: *At 38 years post mining there is no significant increase in the extent of drawdown at the uppermost water table, there is also no significant recovery.* **This means that impacts to the uppermost water table will likely be permanent.**
- **The model does not assess the cumulative impacts on groundwater from both Angus Place and Springvale mines.** It is likely that predictions are already starting from a very altered groundwater baseline compared to prior to mining. Cumulative groundwater drawdowns in the area are highly likely to be significantly greater than those presented in the Groundwater Assessment.

The World Heritage Area should be protected from impacts due to groundwater drawdown. This could easily be achieved with modifications to the mine layout (especially by reductions in panel width to reduce potential for surface to seam connective fracturing).

Surface Water Assessment

The surface water assessment is considered deficient in many areas. There is high selectivity in the sites and time periods of data used to assess past impacts and to model future impacts. None of the impact assessments adopt a BACI design to estimate flow losses due to previous mining. As a result, many of the conclusions regarding impact and flow loss are subjective, lacking a sound scientific foundation. Anyone familiar with the Newnes Plateau area before and after previous mining impacts can see what used to be permanent or semi-permanent streams prior to mining, now no longer flowing. Direct evidence (flow data) to quantify this is available for Kangaroo Creek, Junction Swamp, Carne West Swamp, East Wolgan Swamp, Narrow Swamp and Gang Gang East and West Swamps. Very little if any of this data is presented or used to inform the EIS.

As identified earlier, the surface water and swamp models are poorly calibrated and remain unvalidated. Figure 4.1 of the Surface Water Impact Assessment illustrates numerous sites above the Springvale and Angus Place mines where flow has been monitored at some stage in the past. Of all these sites, only a *restricted calibration*[48] has been applied using 'Coxs River monitoring points, Tri-Star Swamp and Twin Gully Swamp'. Even then, the modelling discards 3 years of (hourly/daily) measured weir flow data in Tri Star swamp due to it being *considered unreliable*[49]. This leaves 30-40 or fewer spot flow measurements[50] for Tri-Star and Twin Gully Swamp (see below) and no calibration to flow sites over earlier longwalls in earlier time periods. As can be seen below, there is a poor agreement between modelled and observed flow for Tri-Star Swamp and Twin Gully Swamps.

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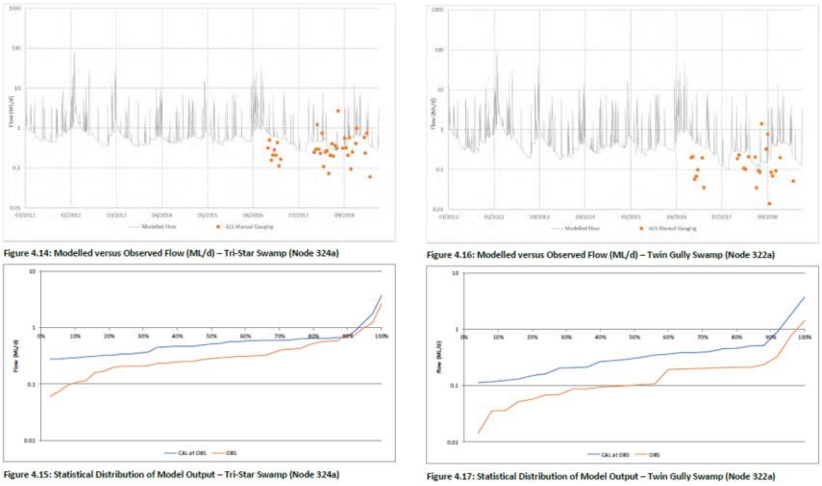
[47] It is noted that the 'uppermost water table' is not well defined. For example, it is unclear whether this is meant to apply to aquifers associated with the YS1 to YS6 aquitards described by McHugh (2013); the source of water to the NPSS/THPSS shrub swamps and hanging swamps.

[48] It is unclear what Jacobs (2019) actually means when they say *The duration of simulation of the SAPSWBM was from 1 January 1994 through to 31 December 2061, as a continuous model, rather than as a distinct calibration and prediction phase.*

[49] The 3.5 years of daily weir flow monitoring from March 2013 to November 2016 yielded a median flow from Tri Star Swamp of ~5 ML/day. In the file supplied to OEH, most of these data were given the Quality Code of '*Reliable Edited Data'.*

[50] The majority of which were collected under relatively severe drought conditions.



Modelled and observed flow data for Tri-Star Swamp and Twin Gully Swamps. Source: Jacobs (2019).

The flow and swamp monitoring designs are also flawed since there is limited if any baseline monitoring being undertaken in many important streams and swamps likely to be affected by the proposal. There is:

- No data illustrated on recent flows for the Wolgan River Downstream[51], East Wolgan Downstream of Junction and Sunnyside Upstream of Junction sites;
- No flow monitoring in the Wolgan River downstream of Wolgan River Upper Swamp;
- No flow monitoring in the Wolgan River downstream of Wolgan River Swamp;
- No flow monitoring in Carne Creek;
- No flow monitoring in Carne Creek tributaries[52];
- No flow monitoring at Trail 6 (Japan) Swamp;
- No piezometric or soil moisture monitoring of Wolgan River Upper Swamp, Wolgan River Swamp, Crocodile Swamp, the Birds Rock Swamps, or any of the hanging swamps.

There has also been no statistically rigorous assessment of past mining impacts on stream flow (e.g. using a BACI design). These are all serious omissions from the EIS, as there is limited ability to assess the veracity of impact conclusions or validate flow estimates/losses from the model over large parts of the modelling domain. The surface water model is not considered to provide credible flow results under existing conditions let alone conditions in a post-mining environment.

Due to the serious concerns about the data used/presented and surface flow model predictions, EES SD undertook an independent analysis of observed flow (real data) and level (real data) for streams and swamps in the vicinity of the Angus Place and Springvale mines. These data had previously been supplied to OEH by Centennial, usually after formal requests for the data had been made to the company. Swamp piezometer level data are now required to be supplied to OEH as a licence condition. Plots of swamp levels were compared to reference swamps (Sunnyside Swamp and Carne West Swamp prior to it being impacted; see Appendix 2). Conclusions from these independent analyses are included below.

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[51] Whilst summary statistics are provided for the Wolgan River Downstream & East Wolgan Downstream sites, the period of monitoring is not mentioned.

[52] Previous flow monitoring at the Carne West Swamp and Gang Gang Swamp tributary monitoring locations, which drain to Carne Creek, identified that after mining impacts, no flow has occurred in these drainages except after very heavy rain.

Swamp Impacts

MSEC (2019) identified impacts due to mining on

- *Kangaroo Creek Swamp*
- *Sunnyside East Swamp*
- *Carne West Swamp*
- *Gang Gang West Swamp*
- *Gang Gang East Swamp*
- *Pine Swamp*
- *Paddys Creek Swamp*

These impacts are readily apparent and illustrated with swamp piezometer data in Appendix 2.

To this can be added impacts to Junction Swamp and West Wolgan Swamps.

Based on EES SD's independent assessment of Centennial's data, additional hydrological impacts are also evident (see Appendix 2) for:

- Sunnyside Swamp (upper SS1, SS2 and possibly SS3, upstream of where BMWS skinks monitoring occurs for the SOS project; lower piezometers SS4 & SS5 still appear unaffected, but eventually it may mean in the future Sunnyside Swamp could dry out altogether; new assessment)
- Carne Central Swamp (new assessment)
- Nine Mile Swamp (upper section; new assessment, but see Centennial's 2019 trigger level notification to the Commonwealth)

Hydrological impacts to Sunnyside & Carne Central swamps have not previously been identified and impacts appear to coincide with undermining the Deanes Ck lineament – the same mining that drained Gang Gang West & East swamps (see Appendix 2).

Stream Flow Impacts

Kangaroo Creek Swamp

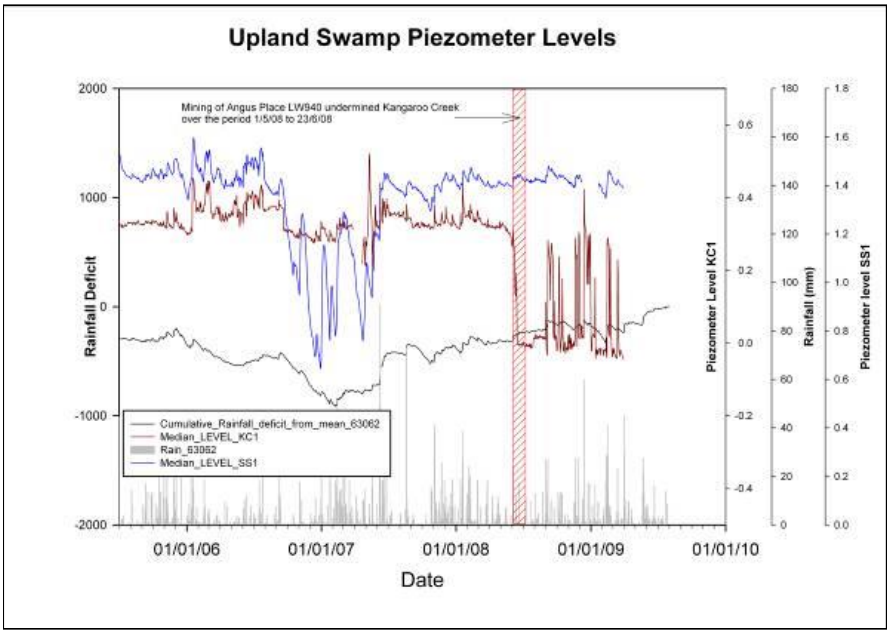
Jacobs (2019) cites the following monitoring for Kangaroo Creek:

Kangaroo Creek Waterhole (KWH)	Undermined	2008 to present	Pool water depth (logger) Water quality
Kangaroo Creek Weir 1 (KCW1)	Downstream of undermined section	2008 to present	Weir depth/flow (logger)
Kangaroo Creek Upstream	Upstream of mine water discharge at LDP001	2008 to present	Water quality Manual flow gauging (from 2016)
Kangaroo Creek Downstream	Mine water discharge at LDP001	2008 to present	Water quality Manual flow gauging (from 2016)

In contrast to the information on Kangaroo Ck flows provided in Jacobs (2019), EES SD's independent assessment of the data identified:

- Manual monitoring of flows at Kangaroo Ck US and Kangaroo Ck DS sites (see Appendix 2) commenced in 2005
- Monitoring of swamp aquifers in KC1 also commenced in 2005
- KC1 was undermined by LW940 around May 2008 at which time the swamp aquifer was drained (see below and Appendix 2)
- Flow also ceased to occur at Kangaroo Ck US at the time LW940 was mined.

- Weirs KCW1 & KCW2 were put in after impacts to Kangaroo Ck Swamp and were therefore monitoring a mining altered system
- KCW2 recorded no flow (0 kL/day) from 6/11/08 to 27/1/10 at which time the weir was stated to have been destroyed by mining subsidence (from LW950).
- Pool KWH used to be described as a permanent pool. Pool KWH is located downstream of KCW2 and upstream of swamp monitoring location KC1. KWH monitoring commenced in November 2008 after impacts due to LW940. KWH was undermined by LW950 around January 2010 leading to the complete drainage of KWH. KWH filled for short periods of time in October 2010 and March 2012 but has been completely dry since February 2013 (see Appendix 2).
- If a before-after comparison of flows is undertaken, then it suggests that the mining effects of LW940 led to:
    - a decrease in flows at Kangaroo Ck US from a median=9 kL/day before to no flow after (a loss of 9kL/day; 0.009 ML/day).
    - a decrease in flows at Kangaroo Ck DS from a median=483 kL/day before to a median=280kl/day after[53] (a potential loss of 200kL/day; 0.2 ML/day).



Piezometer Levels in Kangaroo Creek Lower Swamp (KC1; red line) compared to levels in Sunnyside Swamp (SS1; blue line). Source: DECCW 2010.

Jacobs (2019) stated that *It is noted that a statistical summary is not provided for Kangaroo Creek or Narrow Swamp, as flows in these drainages have historically been influenced by mining or mine water discharge.* If the surface model was actually of any value in predicting flows in this area, then time series of flow predictions at a node situated at KCW1 under the 'base case' would still be of significant value to determine how much the model predicts should be flowing and how much is actually observed/measured to be flowing.

[53] The latter occurred despite slightly higher rainfall occurring in the after period (Mean rainfall before=2.047mm; Mean rainfall after=2.469mm - see Appendix 2).

Junction Swamp

Jacobs (2019) does not mention flow monitoring at Junction Swamp. Junction swamp is at the upper end of the East Wolgan drainage line above East Wolgan Swamp. LW408 passed under the western edge of Junction Swamp around April 2003. LW409 passed under the remainder of Junction swamp around April 2004. Flow essentially ceased after April 2004 (see Appendix 2).

An independent assessment of flow monitoring for Junction Swamp by EES SD identified:

- Prior to March 2003 median flows recorded below Junction swamp were 0.06 ML/day.
- Between March 2003 & March 2004 flows reduced to a median 0.02 ML/day.
- After March 2004, the drainage line below Junction Swamp ceased flowing and it continues to have no flow to this day[54].
- This suggests a median flow loss of ~0.06 ML/day to the East Wolgan catchment.

Wolgan River

Jacobs (2019) cites the following monitoring for the Wolgan River:

Wolgan River Downstream	Upstream tributaries Narrow Swamp, East Wolgan Swamp and Sunnyside Swamp previously undermined. Mine water discharge to Narrow Swamp and East Wolgan Swamp.	2008 to present	Manual flow gauging Water quality
East Wolgan D/S Junction	Upstream tributaries East Wolgan Swamp and Sunnyside Swamp previously undermined. Mine water discharge to East Wolgan Swamp.	2008 to present	Manual flow gauging Water quality

A variety of summaries of observed and predicted flow at various points in the Wolgan River were provided by Jacobs (2019) in Tables 4.2, 5.4, 5.5, 5.12, 5.13 & 5.14.

Jacobs (2019) state:

> *The Wolgan River is observed to have flows 99% of the time at the downstream gauging site (Wolgan River Downstream) from the available monitoring data, compared to flows 96% of the time at the upstream gauging site (East Wolgan D/S Junction). Mean flows are of the order of 3,477 kL/day at the downstream site, increasing significantly from 649 kL/day at the upstream site.*
>
> *It is noted that flows in the Wolgan River during 2008 and 2009 were influenced by emergency mine water discharges to Narrow Swamp and East Wolgan Swamp. The discharges would have comprised a significant component of the upstream flow volumes, but only a relatively minor portion of the downstream flow volumes.*

In contrast to the information on Wolgan River flows provided in Jacobs (2019), an independent assessment of flow monitoring by EES SD (see also Appendix 2) identified:

- Manual monitoring of flows at *Wolgan River Downstream* commenced in January 2004[55]
- Manual monitoring of flows at *Sunnyside Swamp*[56] *Downstream* commenced in January 2004
- Manual monitoring of flows at *Sunnyside Swamp Upstream* commenced in December 2004

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[54] Except after extremely high rainfall events and then of very short duration.
[55] Not 2008.
[56] The Sunnyside Swamp drainage line joins the Wolgan River Downstream of East Wolgan Swamp.

- Manual monitoring of flows at *Sunnyside Upstream of Junction* and *East Wolgan Downstream of Junction* commenced in April 2006.
- Manual monitoring of flows at *East Wolgan Upstream* and *East Wolgan Downstream* commenced in April 2005.
- Discharges from LDP4 upstream of East Wolgan Swamp and LDP5 upstream of Narrow Swamp commenced in 1997 (see Connective Fracturing section).
- LW411 caused slumping in the peat and complete loss of discharge flows in East Wolgan Swamp in April 2006. Despite Aurecon (2009) searching for return of flows, none were found, and all the discharge waters were reporting to the slump holes and moving down into a 'cavity'.
- After April 2006 *East Wolgan Downstream* recorded 0 flows.
- Prior to April 2006 flows recorded at *East Wolgan Upstream, East Wolgan Downstream* and *Wolgan River Downstream* are confounded with upstream mine discharges.
- After April 2006 flows recorded at *East Wolgan Downstream and East Wolgan Downstream of Junction* were not confounded with upstream mine discharges from LDP4, since all the discharge water was moving into the slump holes/cavity and not returning downstream.
- This means that the period of data assessed by Jacobs (2019) for Wolgan River Downstream (after 2008) are, in the main, not influenced by LDP4 discharges. However, they are not representative of 'natural' flows either since they represent monitoring data for an impacted system with no water being supplied by Junction, East Wolgan, or Narrow swamp.
- Discharges to Narrow Swamp may still have had some influence on Wolgan River Downstream flows up until LDP5 ceased discharging in September 2009.
- After LW411 impacts and complete discharge diversion underground, flows at *East Wolgan Downstream of Junction* were made up almost entirely of flows coming from the Sunnyside Swamp drainage line (Appendix 2).
- After April 2006 median flows at *Sunnyside Upstream of Junction* were 395 kL/day.
- After April 2006 median flows at *East Wolgan Downstream of Junction* were 374 kL/day.
- After April 2006 median flows at the *Wolgan River Downstream* site were 1836 kL/day. This figure is close to Jacobs' (2019) figure in Table 4.2. It is, however, not indicative of what would have occurred prior to longwall mining impacts to Junction, East Wolgan & Narrow Swamps.

In relation to future mining impacts on the Wolgan River as a result of the Amended Angus Place mine it is noted from EES SD's independent analysis of flow and swamp piezometer data:

- Recent loss of water in the upper parts of Sunnyside Swamp may indicate that water will also be eventually lost from Sunnyside Swamp in the future. Mining at Angus Place also has the potential to impact on the lower end of Sunnyside Swamp and the Sunnyside Swamp Drainage line, but this has not been appropriately assessed in the EIS. For an unknown reason, MSEC (2019) show a very altered extent of Sunnyside Swamp that takes it outside their 600m study area, despite their 2014 mapping showing it extending well below their 2019 depiction.
- Fracture and drainage in the Sunnyside Drainage line could mean that, in the future, the median flow of ~0.7 ML/day recorded at *Sunnyside Upstream of Junction* and *East Wolgan Downstream of Junction* may no longer occur. This would obviously impact on Wolgan River Upper Swamp and Wolgan River Swamp.
- Jacobs (2019) provided predicted flows for the Wolgan River below Carne Creek. Median flows were stated as 20-21ML/day (Table 5.12). Flow monitoring at the old DLWC gauge (212028) on the Wolgan River at Newnes from 1973 to 1993 yielded a median flow of 48.6

ML/day. Jacobs' (2019) model potentially underestimates flows in the Wolgan River downstream of Carne Creek[57].

- Jacobs (2019) provided predicted flows for the Wolgan River upstream of Carne Creek. Median flows were stated as 7.9-8.3 ML/day. Flow monitoring at the old DLWC gauges (212015 Wolgan Gap 1970-1974; 212038 Cape Pinnacle 1976-1984) on the Wolgan River upstream of Carne Creek yielded median flows of 9.5-19 ML/day. Jacobs' (2019) model potentially underestimates flows in the Wolgan River upstream of Carne Creek.
- Flow losses are predicted but not quantified in relation to impacts to Tri Star Swamp and Twin Gully Swamp. This is likely to lead to additional loss of flow to the Wolgan River.
- Upsidence and Valley closure have the potential to fracture pools and bedrock in the Wolgan River.
- Undermining the Type 2 lineament underlying Tri Star Swamp and connecting to the Wolgan River lineament is also likely to impact on the Wolgan River. If this occurs in a similar manner to mining impacts on the Deanes Ck lineament, then the Wolgan River is likely to be drained and cease to flow altogether.
- All of these potential consequences are considered likely as a result of Angus Place mining and this could lead to the Wolgan River losing surface water flows, pools/reaches being drained and ceasing to flow altogether in the vicinity of the proposed mining.

Many of these impacts could be either avoided or mitigated by:

- Reduction of longwall widths to avoid surface to seam fracturing;
- Avoiding undermining the Type 2 lineament under Tri Star swamp that is connected to the Type 1 Wolgan River lineament zone;
- Avoiding direct undermining of Twin Gully and Tri Star swamps.

Flow impacts to the Wolgan have already occurred and Jacobs' (2019) model potentially underestimates flows in the Wolgan River in the Wolgan Valley. Despite identifying significant amounts of flow data for the Wolgan River Downstream site, it is not chosen as a site to calibrate or validate the surface water model. This is a significant omission. The consultants appear to be unaware of or decided not to use the previous DLWC Wolgan River gauge data to either calibrate or validate their model. Flow losses are also predicted but not quantified in relation to impacts to Tri Star Swamp and Twin Gully Swamp which subsequently flow to the Wolgan River. **Assessments that the mining will have a minimal impact on the Wolgan River are not considered credible, especially since some impacts have already been demonstrated to have occurred and more are likely to follow as a direct result of the Angus Place proposal.**

Carne West Swamp

Whilst the Carne West Swamp monitoring site is identified in Jacobs (2019) Figure 4.1, no assessment of the data has been made, despite mining impacts to Carne West Swamp from earlier Springvale mining. Jacobs (2019) has not used past flow data from Carne West Swamp to inform their assessment of impacts likely to be associated with the Angus Place Proposal.

An independent assessment by EES SD of flow monitoring (see also Appendix 2) identified:

- Manual monitoring of flows at *Carne West Swamp* commenced in December 2004;
- Carne West Swamp had slightly higher flows than Sunnyside Swamp;
- Median flows recorded at *Carne West Swamp* were 544 kL/day;

[57] No details are provided for exactly where WR02 is in the Wolgan River. Only two relatively small creeks (Capertee & Barton Cks) have the potential to add permanent flow in this area and both are much smaller than either Carne Ck or the Wolgan River. Similarly, there is no information on exactly where WR03 and WR04 are.

- Carne West Swamp was drained over the period from October 2014 to March 2015 due largely to Springvale LW416;
- MSEC (2019) state: *Temporary changes in swamp piezometer levels when LW415 mined beneath the Deanes Creek lineament at a distance of 1.8 km. Reduction in swamp piezometer levels when LW416 mined beneath the Deanes Creek lineament at a distance of 1.6 km. Following declines, all water levels remain predominantly below base of piezometer.*
- Median flows after mining impact have been 0 ML/day (i.e. most of the time it does not flow; see Appendix 2).
- This represents a median flow loss of ~0.54 ML/day to the Carne Creek catchment.

Despite having significant amounts of flow data for the Carne West Swamp site, it is not chosen as a site to either calibrate or validate the surface water model or assess potential impacts for the Angus Place proposal. This is a significant omission.

Gang Gang East & West Swamps

Whilst the Gang Gang Swamp monitoring site is identified in Jacobs (2019) Figure 4.1, no assessment of the data has been made, despite mining impacts to the Gang Gang Swamps from earlier Springvale Mining. Jacobs (2019) has not used past impact data from the Gang Gang Swamps to inform their assessment of impacts likely to be associated with the Angus Place Proposal.

An independent assessment by EES SD of flow monitoring for Gang Gang Swamp (see also Appendix 2) identified:

- Automated monitoring of flows at *Gang Gang Swamp* commenced in February 2013 with the installation of a weir downstream of the confluence of the Gang Gang West and Gang Gang East Swamp drainage lines[58].
- Data on flows for Gang Gang Swamp and Tri Star Swamp were provided to OEH. Average flows were around 5 ML/day and are illustrated below.
- Median flows were 4.8ML/day over the period March 2013 to November 2016.
- Gang Gang West & East Swamps was severely impacted by mining interacting with the Deanes Creek lineament.
- The upper end of Gang Gang West Swamp drained over the period from October 2014 to March 2015 due largely to Springvale LW416.
- The lower end of Gang Gang West Swamp drained completely over the period from June 2016 to June 2017
- MSEC (2019) state*: Reduction in swamp water levels at GW1 and GW2 prior to being directly mined beneath. Possibly related to LW417 and LW418 intersection of structures. Decline at GW3 following undermining of swamp and intersection of lineament at GW1. Following declines, all water levels remain predominantly below base of piezometer.*
- Median flows after mining impact flows from Gang Gang West Swamp have been 0 ML/day (i.e. most of the time it no longer flows).
- Gang Gang East Swamp drained completely over the period from March 2017 to June 2018.
- MSEC (2019) state*: Slow decline at GG1 from August 2016 consistent with CRD. Decline accelerates in August 2017 as LW420 intersects underlying lineament. GG2 decline in October 2016, no apparent correlation to longwall activity (but noting limited baseline data). Abrupt decline at GG3 from March 2018 as LW421 approached lineament beneath GG1. Following declines, all water levels remain predominantly below base of piezometer.*

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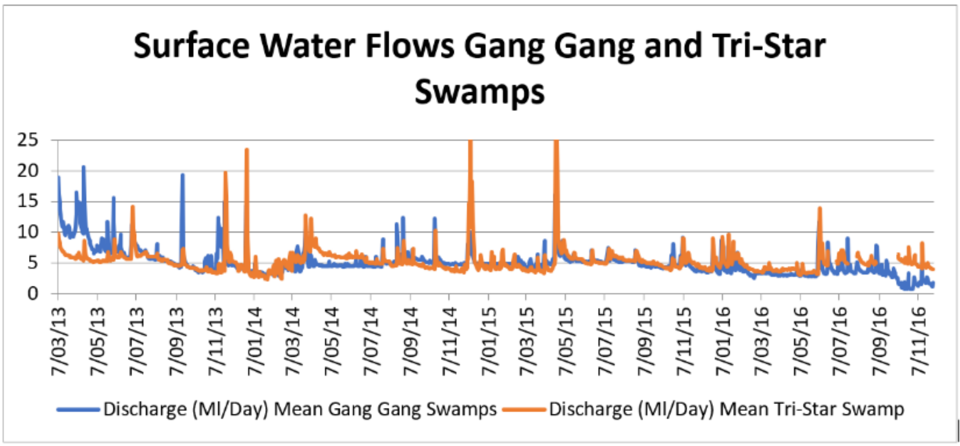
[58] Much more flow came out of the Gang Gang East swamp drainage than from Gang Gang West dainage. Gang Gang East flows were also much higher than flows coming out of Carne West Swamp. Early impacts to flows from Gang Gang swamp can be seen towards the end of the flow record shown below.

- If the Gang Gang Weir data is used, undermining of Gang Gang East and West swamps has led to a median loss of ~4.8ML/day to Carne Creek.



Gang Gang & Tri Star Swamp gauged flows. Source: Centennial data file provided to OEH.

Despite having significant amounts of flow data for the Gang Gang Swamp site, it is not chosen as a site to either calibrate or validate the surface water model or assess potential impacts for the Angus Place proposal. This is a significant omission.

Jacobs (2019) Summary of Impacts to THPSS

The following section summarises Jacobs' (2019) conclusions of impacts to THPSS (*in italics*), together with comments on the veracity of those conclusions.

Wolgan River Swamp

Given the above, it is considered that the impact of the modelled change on Wolgan River Swamp is not significant.

Comment: Wolgan River Swamp will lose all water from Tri Star Swamp. Fracturing of the Wolgan River itself is likely due to upsidence and valley closure. If the connection between the Wolgan Lineament and Tri Star lineaments behaves in a similar manner to the Deanes Ck-Sunnyside East-Carne West lineament when mined, the Wolgan River in this area is likely to cease to flow altogether. Upstream flow losses are also likely (see Wolgan River Upper Swamp). There is no flow monitoring in the Wolgan River downstream of Wolgan River Swamp. There is no piezometric or soil moisture monitoring of Wolgan River Swamp. The surface water model is poorly calibrated, and it has not been validated. Previous mining has impacted every NPSS above or adjacent to longwall mining at Springvale and Angus Place. **The conclusions reached about non-significant impacts to Wolgan River Swamp are not considered credible. The endangered Blue Mountains Water Skink population in Wolgan River Swamp is likely to be impacted.**

Wolgan River Upper Swamp

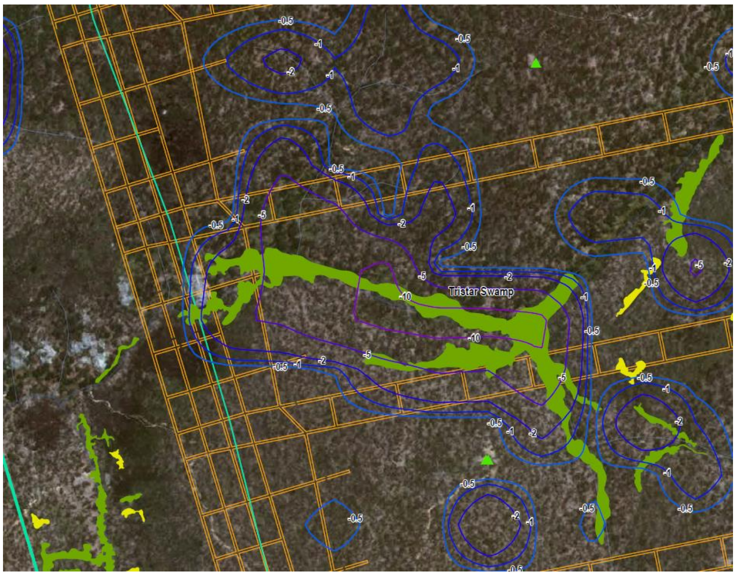
The modelled change in flow is up to a moderate increase and a negligible decrease. Accordingly, the modelled change in flow on Wolgan River Upper Swamp is not considered to be significant, because the magnitude of decrease is negligible.

Comment: The upper areas of Sunnyside swamp are now showing altered hydrology associated with mining through the Deanes Creek lineament. Fracturing of the Sunnyside Swamp drainage line (referred to in MSEC as the Wolgan River East Branch) has not been adequately assessed but is likely to occur due to upsidence and valley closure. This drainage line is currently the major source of water (Median=~0.4 ML/day) to the Wolgan River Upper Swamp; due in large part to past impacts to Junction, East Wolgan and Narrow Swamps (which do not flow outside extreme wet weather events). If flows from the Sunnyside drainage are lost, the Wolgan River Upper Swamp will receive little to no water from upstream. There is no flow monitoring in the Wolgan River downstream of Wolgan River Upper Swamp. There is no piezometric or soil moisture monitoring of Wolgan River Upper Swamp. The surface water model is poorly calibrated, and it has not been validated. Previous mining has impacted every NPSS above or adjacent to longwall mining at Springvale and Angus Place. **The conclusions reached about negligible impacts to Wolgan River Upper Swamp are not considered credible. The endangered Blue Mountains Water Skink population in Wolgan River Upper Swamp is likely to be impacted.**

Tri-Star Swamp

The modelled change in surface water flow is large and the impact of that magnitude of change is expected to be significant.

Comment: **It is agreed that impacts to Tri Star Swamp will be significant.** There will likely be surface to seam fracturing above the longwalls in the vicinity of Tri Star Swamp (see Connective Fracturing Section). This will likely drain the Burralow Formation aquifers that feed this swamp. Groundwater levels are predicted to decrease by up to 10m (Jacobs 2019). It is likely that all the water in the swamp will be drained and this will lead to no flow downstream. This flow currently reports to the Wolgan River upstream of the Wolgan River Swamp. If the connection between the Wolgan Lineament and Tri Star lineaments behaves in a similar manner to the Deanes Ck-Sunnyside East-Carne West lineament when mined, the Wolgan River in this area will be impacted and likely to cease to flow altogether. Monitoring does occur in Tri Star swamp. The surface water model is poorly calibrated, and it has not been validated. Previous mining has impacted every NPSS above or adjacent to longwall mining at Springvale and Angus Place. **The endangered Blue Mountains Water Skink population in Tri Star Swamp is likely to go extinct.**

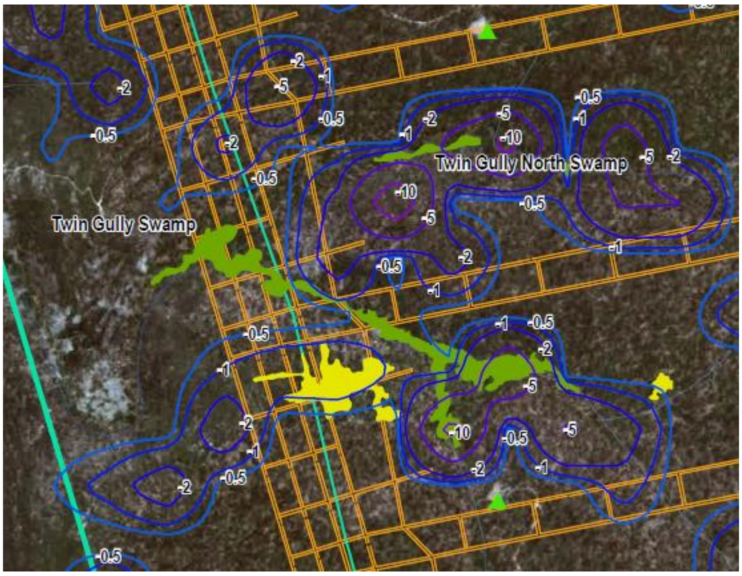


Source: Jacobs (2019)

Twin Gully Swamp

The predicted changes range between a minor to moderate increase and a minor to moderate decrease. It is considered that the impact of the magnitude of change in flows in Twin Gully Swamp may be moderate, and is less than that predicted for Tri-Star Swamp. This is expected to be influenced by the difference in extraction height and depth of cover between the two locations.

Comment: **Impacts to Twin Gully Swamp will be significant.** There will likely be surface to seam fracturing above the longwalls in the vicinity of Twin Gully Swamp (see Connective Fracturing Section). This will likely drain the Burralow Formation aquifers that feed this swamp. Groundwater levels are predicted to decrease by up to 10m (Jacobs 2019). It is likely that all the water in the swamp will be drained and this will lead to no flow downstream. This flow currently reports to the Wolgan River. Monitoring does occur in Twin Gully Swamp. The surface water model is poorly calibrated, and it has not been validated. Previous mining has impacted every NPSS above or adjacent to longwall mining at Springvale and Angus Place. **The endangered Blue Mountains Water Skink population in Twin Gully Swamp is likely to go extinct.**

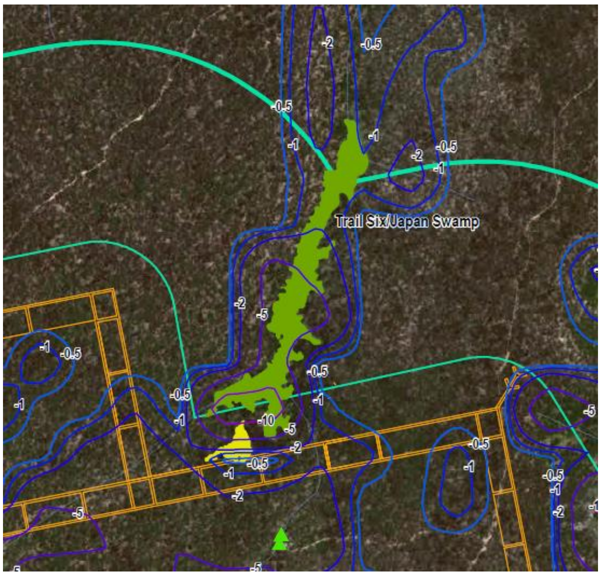


Source: Jacobs (2019)

Trail Six /Japan Swamp

The magnitude of the changes in the U90 results range from moderate to large and are expected to be significant. This is due to the low value of flow in the THPSS, being ~0.20ML/d (2.3L/s) at 50th% level and ~01.2ML/d (1.4L/s) at the 10th% level. Accordingly, small changes in numerical value lead to large changes by percentage and because the THPSS is a low flow environment, changes to flow are likely to be significant.

Comment: **It is agreed that impacts to Trail 6 (Japan) Swamp will be significant.** There will likely be surface to seam fracturing above the longwalls in the vicinity of Trail 6 (Japan) Swamp (see Connective Fracturing Section). This will likely drain the Burralow Formation aquifers that feed this swamp. Groundwater levels are predicted to decrease by up to 10m (Jacobs 2019). It is likely that all the water in the swamp will be drained and this will lead to no flow downstream. This flow currently reports to Drainage Line 4, the stream flowing into the Gardens of Stone National Park, part of the Greater Blue Mountains World Heritage Area. This will therefore cause an impact to the WHA in terms of loss of flow. There is no flow monitoring downstream of Trail 6 (Japan) Swamp. There is one piezometer in the swamp (XS1) but no soil moisture monitoring. The surface water model is poorly calibrated, and it has not been validated. Previous mining has impacted every NPSS above or adjacent to longwall mining at Springvale and Angus Place. **The endangered Blue Mountains Water Skink population in Trail 6 (Japan) Swamp is likely to go extinct.**



Source: Jacobs (2019)

Birds Rock Swamps

From Table 5.9, the modelled change is a moderate to large decrease, and is considered to be significant because the magnitude of flow at the 50th% level is 0.2 to 0.3ML/d and is 0.12 to 0.17ML/d at the 10th% level.

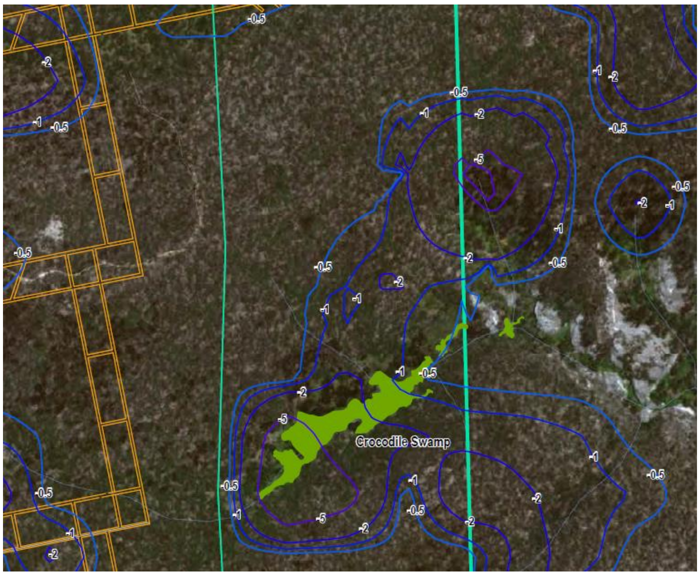
Comment: **Impacts to the Birds Rock Swamps will be significant.** There will likely be surface to seam fracturing above the longwalls in the vicinity of the Birds Rock Swamps Swamp (see Connective Fracturing Section). This will likely drain the Burralow Formation aquifers that feed this swamp. Groundwater levels are predicted to decrease by up to 10m in these swamps (Jacobs 2019). It is likely that all the water in the swamp will be drained and this will lead to no flow downstream. This flow currently reports to Carne Creek, which subsequently flows to the Gardens of Stone National Park, part of the Greater Blue Mountains World Heritage Area. This will therefore cause an impact to the WHA. There is no flow monitoring downstream of the Birds Rock Swamps. There is no piezometric or soil moisture monitoring of the Birds Rock Swamps. The surface water model is poorly calibrated, and it has not been validated. Previous mining has impacted every NPSS above or adjacent to longwall mining at Springvale and Angus Place. **No surveys were conducted for the endangered Blue Mountains Water Skink in the Birds Rock Swamps, but suitable habitat exists. This habitat is likely to be lost.**

Source: Jacobs (2019)

Crocodile Swamp

From Table 5.10, the modelled magnitude of decrease is negligible, therefore the expected impact of that change on Crocodile Swamp is insignificant.

Comment: Impacts to Crocodile Swamp will be significant. There will likely be surface to seam fracturing above the longwalls in the vicinity of Crocodile Swamp (see Connective Fracturing Section). This will likely drain the Burralow Formation aquifers that feed this swamp. Groundwater levels are predicted to decrease by up to 5m in the swamp (Jacobs 2019). It is likely that all the water in the swamp will be drained and this will lead to no flow downstream. This flow currently reports to Carne Creek which subsequently flows to the Gardens of Stone National Park, part of the Greater Blue Mountains World Heritage Area. This will therefore cause an impact to the WHA. There is no flow monitoring downstream of Crocodile Swamp. There is no piezometric or soil moisture monitoring of Crocodile Swamp. The surface water model is poorly calibrated, and it has not been validated. Previous mining has impacted every NPSS above or adjacent to longwall mining at Springvale and Angus Place. **The endangered Blue Mountains Water Skink population in Crocodile Swamp is likely to go extinct. The conclusions reached about insignificant impacts to Crocodile Swamp are not considered credible.**

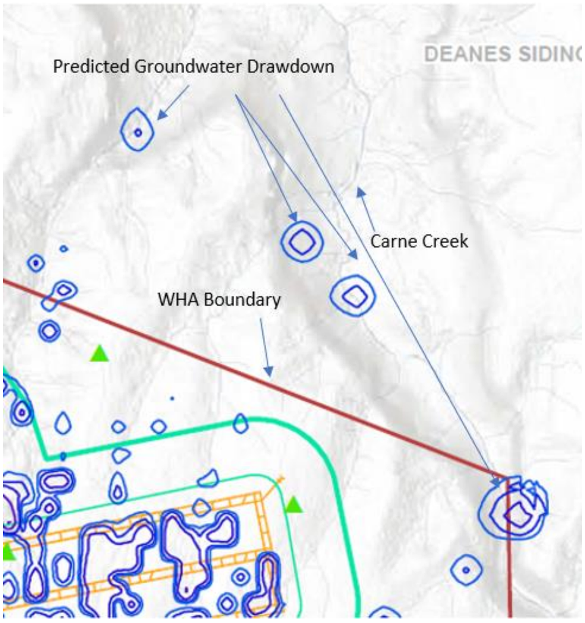


Source: Jacobs (2019)

Carne Creek

The magnitude of change is relatively minor, and the impact is not considered to be significant as the flow volume is much higher.

Comment: There will likely be surface to seam fracturing above the longwalls in the vicinity of the eastern ends of the longwalls (see Connective Fracturing Section). This will likely drain the Burralow Formation aquifers that feed the swamps and springs in this area. It is likely that all the water in the swamps will be drained and there will be no flow downstream to Carne Creek except after significant rain events. No monitoring of flows has been undertaken for the project in these areas, but at least some of flows are of a reasonable magnitude (see below). Significant loss of flow has already occurred in the upper reaches of Carne Ck (i.e. Sunnyside East Swamp, Carne West Swamp, Gang Gang East & West Swamps). The cumulative loss of all these flows has not been accounted for in the assessment but are already likely to be of the order of at least 6ML/day using previous flow monitoring data. These flows no longer report to Carne Creek which subsequently flows to the Gardens of Stone National Park, part of the Greater Blue Mountains World Heritage Area. There is no upstream and downstream flow monitoring in Carne Creek in the vicinity of the mining. There is no flow monitoring of Carne Creek tributaries potentially affected by the mine. The surface water model is poorly calibrated, and it has not been validated. **Groundwater drawdown is also predicted to occur in Carne Creek, some at sites well within the Gardens of Stone National Park, part of the Greater Blue Mountains World Heritage Area (see Jacobs 2019). This will therefore cause a direct impact to the WHA. Significant impacts on flows to Carne Creek have already occurred due to previous mining and loss of flows and groundwater drawdown from the current project will add to this loss. This will affect flows into the WHA. The conclusions reached about *relatively minor* impacts to Carne Creek are not considered credible.**



Predicted Groundwater Drawdown for uppermost water table (Left; Source: Jacobs 2019) & Flow from the end of Crocodile Swamp (Right; Photo M. Krogh)

Wolgan River- below confluence with Carne Creek

The magnitude of change is considered to be minor to moderate and the impact is not considered to be significant.

***Comment:* The cumulative loss of all flows to the Wolgan River and Carne Creek as a result of mining have not been properly accounted for in the assessment.** Jacobs' (2019) model appears to underestimate flows in the Wolgan River downstream of Carne Creek when compared to the old DLWC Wolgan River at Newnes gauging station. The surface water model is poorly calibrated, and it has not been validated. If the connection between the Wolgan Lineament and Tri Star lineaments behaves in a similar manner to the Deanes Ck-Sunnyside East-Carne West lineament when mined, the Wolgan River adjacent to the mining area is likely to be directly impacted and cease to flow altogether. **Cumulative impacts to the Wolgan River could be significant.**

Wolgan River – above confluence with Carne Creek

The magnitude of change is considered to be minor to moderate and the impact is not considered to be significant.

***Comment:* The cumulative loss of all flows to the Wolgan River as a result of mining have not been properly accounted for in the assessment.** Jacobs' (2019) model appears to also underestimate flows in the Wolgan River upstream of Carne Creek based on the old DLWC gauges (212015 Wolgan Gap 1970-1974; 212038 Cape Pinnacle 1976-1984) on the Wolgan River upstream of Carne Creek. The surface water model is poorly calibrated, and it has not been validated. If the connection between the Wolgan Lineament and Tri Star lineaments behaves in a similar manner to the Deanes Ck-Sunnyside East-Carne West lineament when mined, the Wolgan River adjacent to the mining area is likely to be directly impacted and cease to flow altogether. **Cumulative impacts to the Wolgan River could be significant.**

Wolgan River – west of 1000 panel area

From Table 5.14, the change in modelled median flow (50^{th}%) is +2% in the U10 results and is -4% in the U90 results. At the 10^{th}% flow level, the modelled change is +4% in the U10 results and is -5% in the U90 results. The magnitude of change in flow at the 50^{th}% and 10^{th}% level is minor to moderate. The modelled change is not considered to be significant because the flow rate at the 50^{th}% level is of the order of 5.5ML/day and at the 10^{th}% level is approximately 3ML/day.

***Comment:* The cumulative loss of all flows to the Wolgan River have not been properly accounted for in the assessment.** Significant loss of flow has already occurred due to impacts to Junction Swamp, East Wolgan Swamp and Narrow Swamp. The upper parts of Sunnyside Swamp are now showing signs of altered hydrology (drainage of aquifers). Fracturing of the Sunnyside Swamp drainage line (referred to in MSEC (2019) as the *Wolgan River East Branch*) has not been adequately assessed but is likely to occur due to upsidence and valley closure. This drainage line is currently the major source of water (Median=~0.4 ML/day) to the Upper Wolgan River in this area. There is very limited flow monitoring of the Wolgan River in the vicinity of the mining west of the 1000 panel area. Recent flow data for the Wolgan River (*Wolgan River Downstream* and *East Wolgan Downstream of Junction*) were not illustrated and the time period for monitoring was not stated. The surface water model is poorly calibrated, and it has not been validated. If the connection between the Wolgan Lineament and Tri Star lineaments behaves in a similar manner to the Deanes Ck-Sunnyside East-Carne West lineament when mined, the Wolgan River adjacent to the mining area is likely to be directly impacted and cease to flow altogether. Major impacts have already occurred to the Wolgan River upstream of the 1000 panel area and future mining from Angus Place will add to this. It is possible that the Wolgan River west of 1000 panel area could cease to flow altogether due to the cumulative effects of past impacts and impacts from the current project. **The conclusions reached about non-significant impacts to the Wolgan River west of 1000 panel area are not considered credible.**

Mine Water Make/Take

Jacobs (2019) identifies:

> *Recharge to the deeper aquifers is not expected to be significant from overlying formations and will be via slow and tortuous infiltration and leakage from overlying aquifers. A component of recharge to deeper aquifers may also occur where the formation is exposed by incised valleys and to a lesser extent on escarpments.*
>
> *The Wolgan River is likely a point of discharge for the Bankswall Sandstone (AQ4) from up-dip, but during times of high flow could potentially be a source or recharge to the formation in the down-dip direction.*
>
> *Inflows can be seen to increase significantly in 2025 with the re-commencement of mining in the new 1000 Panel area, with predicted inflow peaking at over 25 ML/day. Following the initial peak, inflows are then predicted to be relatively stable and in the range 18 to 20 ML/day as mining progresses to the north. Following extraction of LW1015 in 2038, the formations surrounding and overlying the workings become increasingly depressurised and inflows begin to decline, falling to around 7 ML/d at the end of mining in 2053.*
>
> *Residual inflows to Springvale mine peak at approximately 19ML/d at the resumption of dewatering, reducing to around 14.6ML/day in 2038, and 12.9ML/day prior to the pumps being turned off in 2053.*

If Table 6.1 - Licensable Take (Groundwater): Angus Place Colliery including 1000 Panel Area (Jacobs 2019) is considered, the total predicted water take is **~89 GL** for the period 2025/2026 to 2038/2039. A further water take of **~89 GL** is then predicted for the post mining period 2039/2040 to 2053/2054. Presumably, further water make will continue after 2054. This is in addition to the **~2.8 GL** of mine water discharged from Angus Place LDP001 over the period 1/05/2018 till cessation of discharge on 7/12/19 (Angus Place Environmental Monitoring Reports May 2018 to Dec 2019)[59]. Since Energy Australia[60] identify the active storage of Lake Wallace as ~2.4 GL, Thompsons Ck Reservoir as ~24 GL and Lake Lyell as ~30 GL, then:

- the water discharged through LDP1 over the period 1/05/2018 to 7/12/19 (~2.8 GL) was slightly larger than the storage volume of Lake Wallace;
- the predicted water take for the period 2025/2026 to 2038/2039 is equivalent to ~37 Lake Wallace's, or greater than 1.5 times the storage volume of Lake Lyell, Thompsons Ck and Lake Wallace combined.

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[59] This includes the period of mine dewatering from 14/9/18 to 7/12/19 as approved for the Angus Place Mod5

[60] https://www.energyaustralia.com.au/sites/default/files/2017-10/EnergyAustraliaNSW_water%20storage_20171027.pdf

- the predicted water take for the post mining period 2039/2040 to 2053/2054 is also equivalent to ~37 Lake Wallace's, or greater than 1.5 times the storage volume of Lake Lyell, Thompsons Ck and Lake Wallace combined.

To this needs to be added the mine water take from the adjacent Springvale Mine.

The water take is substantial, and it is very unclear where all this water really comes from (i.e. which aquifers and their water storage and recharge capacity). A major question needs to be asked whether such a take of groundwater or surface water for the Newnes Plateau is sustainable, especially given the potential issues identified with respect to connective fracturing and baseflow loss to streams and swamps.

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