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3 March 2023

South32 Illawarra Metallurgical Coal
Level 3, Enterprise 1
Innovation Campus, Squires Way
North Wollongong NSW 2500

For the attention of: Cody Brady, Principal Mining Approvals

Dear Cody,

Dendrobium – Area 3A – Longwall 19A – Subsidence Management Plan
Addendum to Report No. MSEC1234 (Rev. B)

Mine Subsidence Engineering Consultants (MSEC) has prepared Report No. MSEC1234 (Rev. B) which provides the subsidence predictions and impact assessments for Longwall 19A (LW19A) in support of the Subsidence Management Plan Application.

The dimensions of LW19A provided in Table 1.1 of Report No. MSEC1234 are for an overall void length of 1009 m, an overall void width of 275 m and a solid chain pillar width of 45 m. However, the dimensions provided in Table 1.1 of Report No. MSE1234 are not correct and do not reflect the actual dimensions of LW19A that were adopted in the subsidence report.

A summary of the actual dimensions of LW19A adopted in Report No. MSEC1234 is provided in Table 1 below. Hence, the subsidence report was prepared using these revised longwall dimensions; however, incorrectly stated the redundant longwall dimensions.

Table 1 Actual geometry of LW19A adopted in Report No. MSEC1234

Longwall	Overall void length including installation heading (m)	Overall void width including first workings (m)	Overall tailgate chain pillar width (m)
LW19A	1051	281	40

The subsidence predictions, impact assessments, recommendations, all tables (excluding Table 1.1), all figures and all drawings presented in Report No. MSEC1234 are based on the revised dimensions of LW19A provided in Table 1 above.

I trust that this addendum report clarifies the dimensions of LW19A adopted in Report No. MSEC1234

Yours sincerely,

James Barbato

Dr James Barbato
Mine Subsidence Engineering Consultants

23 February 2023

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To: Kai Whitaker
Environmental Approvals
Niche / Illawarra Metallurgical Coal

cc: Cody Brady

From: Will Minchin

Addendum to Groundwater Assessment of Longwall 19A re: revised longwall geometry

Your Ref: Request by IMC, 03/02/2023 Our Ref: IMC112–M049d

1 Introduction

Since the completion of the Area 3A Longwall 19A SMP impact assessments, the dimensions for Longwall 19A have been revised by Illawarra Metallurgical Coal (IMC). In discussion with Department of Planning and Environment (DPE), a series of addenda to the specialist impact assessments have been prepared to outline the change to the longwall geometry in comparison with the previously reported dimensions and assess the key changes that this update would have on predicted impacts.

This memorandum describes the changes with respect to groundwater, and is designed to be an Addendum to the existing Longwall 19A Groundwater Assessment (Watershed HydroGeo, 2022b).

2 Revised longwall geometry for Longwall 19A

Table 2-1 presents the revised longwall geometry ("revised layout") for Longwall 19A in comparison to that reported and modelled previously. **Figure 2-1** presents both versions of the mine plan for comparison.

The Groundwater Assessment for Longwall 19A had assumed a void width of 305 m, as per Dendrobium Longwalls 8-19. The revised void width is 281 m, i.e. slightly narrower than that considered previously, and narrower than Area 3A Longwalls 8 and 19.

Table 2-1 Previously adopted and revised longwall geometry for Longwall 19A

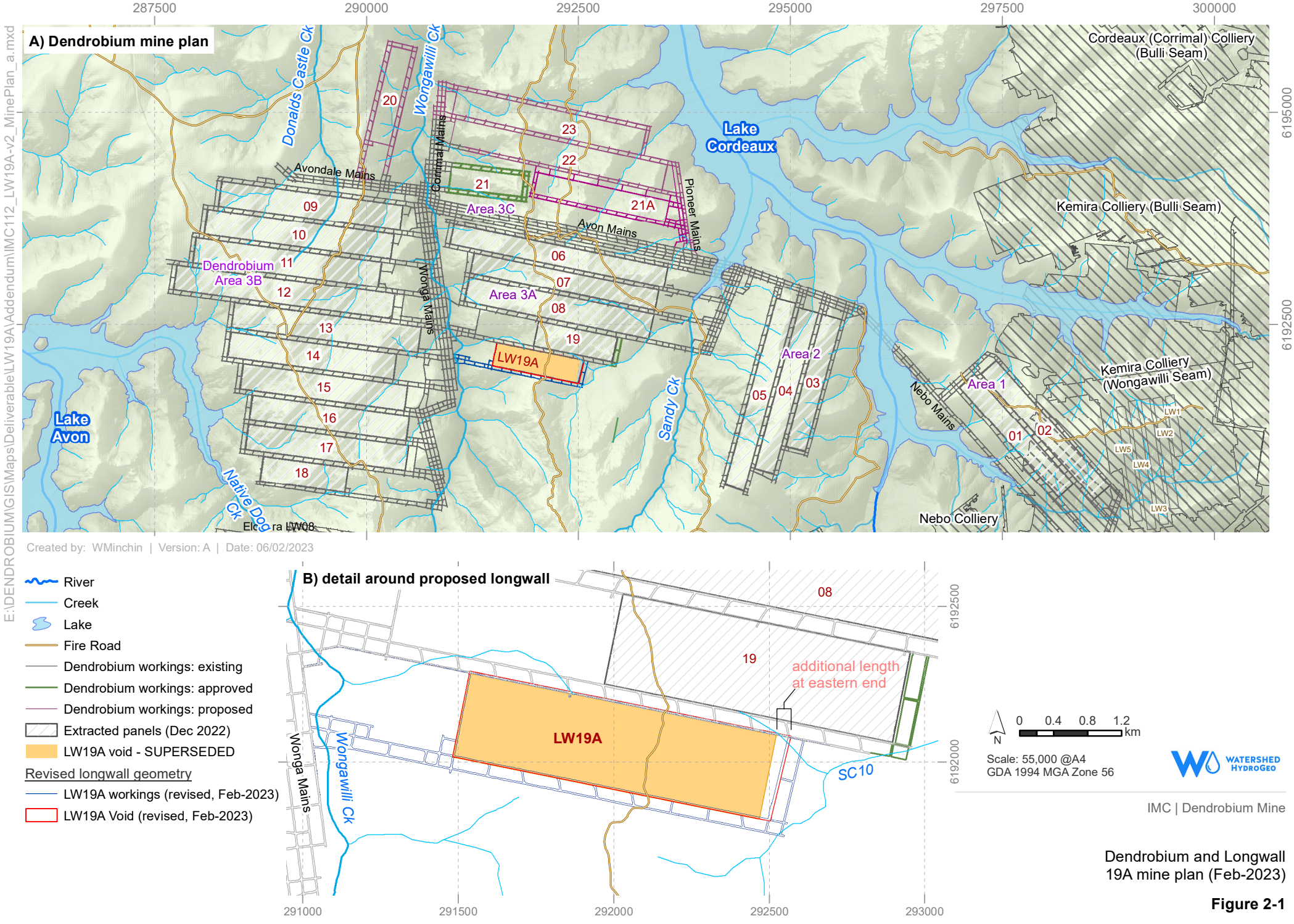
Mine plan	Void width (m)	Length (m)
2022 - Previously modelled	305	1009
2023 - Revised layout	280.8	1050.8

The revised layout for Longwall 19A is 41 m (+4%) longer than previously reported and modelled.

Conceptually, the changes to longwall geometry would likely result in the following:

- the increase to length would lead to a slightly greater groundwater inflow and slightly greater surface water losses;
- the increased length reduces the distance between the eastern edge of the panel and tributary SC10;
- the decrease in the assessed void width would lead to a reduction in the height of connected fracturing and (probably) a mild reduction in the magnitude of surface cracking.

These items are addressed in more detail in Section 3, with numerical modelling in Section 4.



Dendrobium and Longwall 19A mine plan (Feb-2023)

Figure 2-1

3 Environmental context and conceptual model of impacts

The key environmental factors that describe the location of receptors and govern risk pathways and how these pathways might change with the revised layout for Longwall 19A are:

- Hydrology and Upland Swamps;
- Geology, including structures.

These are described in the following sub-sections, followed by an over-arching assessment of the risk pathways related to the revised Longwall 19A.

3.1 Hydrology and receptors

The hydrological features relevant to Longwall 19A are mapped on Error! Reference source not found.. The change to the layout of Longwall19A with respect to these features is described in **Table 3-1**, based on the reported nearest distances, and also considering changes to lengths of water features that might be affected.

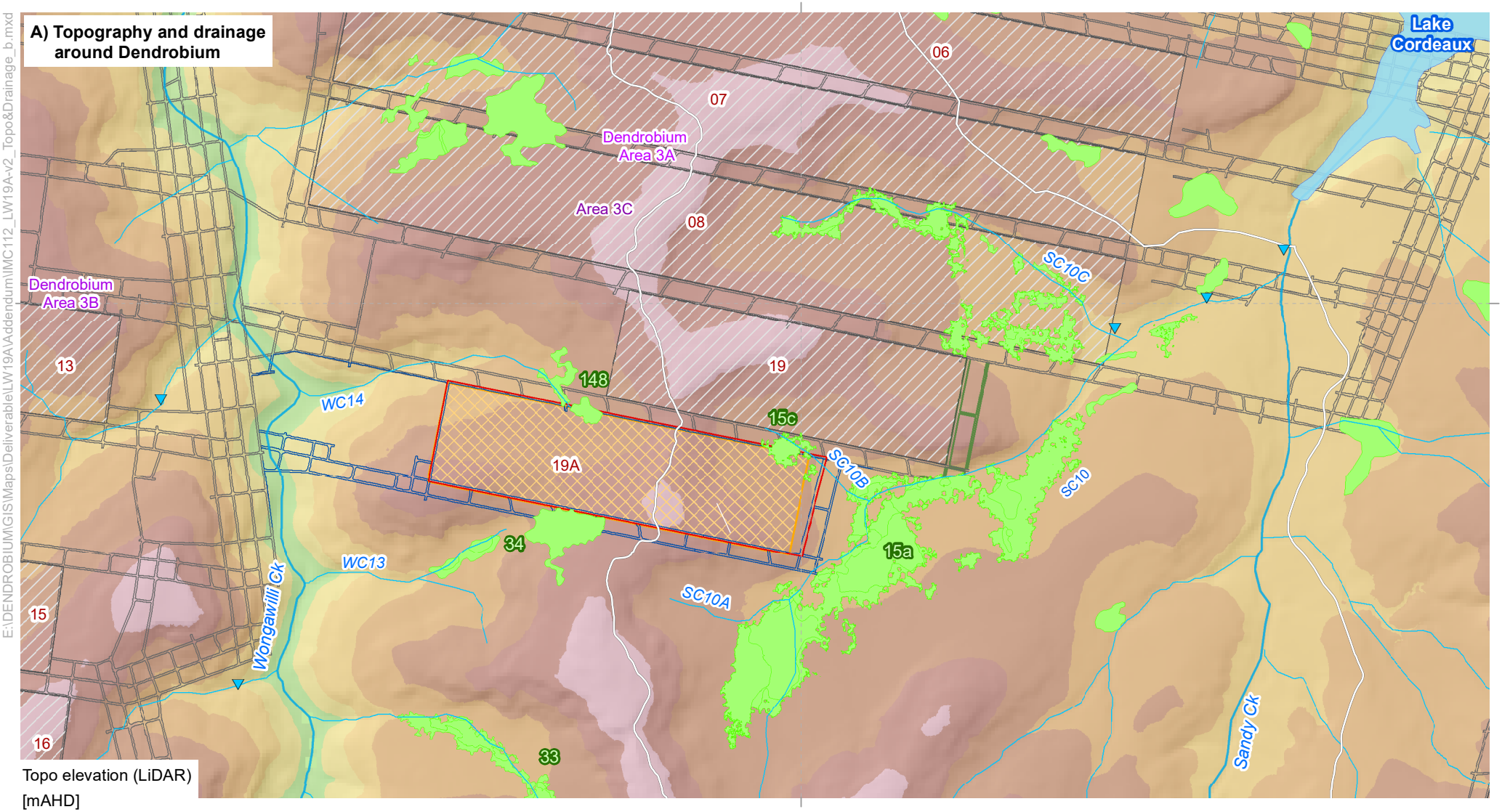
The changes in distances have been colour-coded to highlight those where:

- there would be no change to the impact based on the distances,
- a negligible change based on the distances involved, or
- potentially a more significant change on the relevant feature.

Table 3-1 Distance to hydrological features and change to likely impacts

Feature	Previous distance	Revised distance	Comment
Reservoirs			
Cordeaux Reservoir	1,490 m	1,460 m	2% reduction in distance
Avon Reservoir	3,230 m	3,230 m	No change
Watercourses			
Wongawilli Creek	390 m	390 m	No change
Sandy Creek	1,250 m	1,210 m	3% reduction in distance
Tributaries			
WC13	80 m	80 m	No change
WC14	0	0	No change
SC10A	125 m	120 m	4% reduction in distance
SC10B	0	0*	50 m of this tributary would be mined directly beneath by Longwall 19A (previously zero)
SC10C	630 m	630 m	No change
SC10	75 m	70 m	33% reduction in distance
Upland Swamps			
Den34, 148, 33			No change to distance.
Den15a	75 m	61 m	20% reduction in distance; more of this swamp would be closer to Longwall 19A (but still >60 m)
Den15c	0	0	No change to distance, but an increased area of the swamp would be mined beneath

More discussion of the length of watercourses and areas of swamps likely to be affected is in the Addendum to the Surface Water Assessment (HGEO, 2023).


A) Topography and drainage around Dendrobium
292500
6192500
Lake Cordeaux
06
07
08
Dendrobium Area 3A
Area 3C
Dendrobium Area 3B
13
19
148
15c
19A
WC14
SC10C
SC10B
SC10
34
15a
WC13
SC10A
Wongawilli Ck
15
16
33
Sandy Ck
E:\DENDROBIUM\GIS\Maps\Deliverable\LW19A\Addendum\IMC112_LW19A-v2_Topo&Drainage_b.mxd
Version: A | Date: 22/02/2023
Topo elevation (LiDAR)
[mAHD]
-24.1 - 100
100.1 - 200
200.1 - 300
300.1 - 325
325.1 - 350
350.1 - 375
375.1 - 400
400.1 - 425
425.1 - 500
500.1 - 700
Surface water monitoring site
Existing
Approved
Proposed
Weather station
River
Creek
Lake
Upland Swamp (validated Niche, 20220308)
Fire Road
Dendrobium workings: existing
Dendrobium workings: approved
Dendrobium workings: proposed
LW19A void - SUPERSEDED
LW19A workings (revised, Feb-2023)
LW19A Void (revised, Feb-2023)
N
0 0.1 0.2 0.3
km
Scale: 15,000 @A4
GDA 1994 MGA Zone 56
WATERSHED HYDROGEO
IMC | Dendrobium Mine
Topography and Drainage
Figure 2-1

Based on this assessment of distances, the most likely effects on surface water hydrology would be to SC10B and SC10. Impacts on the other tributaries, the main watercourses (Wongawilli Creek and Sandy Creek) and the water supply reservoirs would be negligible.

The effects on surface water flows and changes to groundwater fluxes are addressed further via assessment of distance and longwall geometry parameters (Section 3.3), and by subsequent groundwater modelling (Section 4) and the Addendum to the Surface Water and Swamp Assessment (HGEO, 2023). In particular, HGEO (2023) describes potential effects on Upland Swamps including Den15a and Den15c in more detail.

3.2 Geology

3.2.1 Seam geometry and depth of cover

As shown by the topography on Error! Reference source not found., the most incised topography around Longwall 19A is along the WC14 tributary, while topography around SC10 and its tributaries is less incised, leading to the development of the relatively wide area of Upland Swamp deposits at Den15A.

The incised valley at WC14 means that the lowest depth of cover (**Figure 3-2**) is at or beneath that valley. The revised layout is no different near WC14 as the previous layout. As such, the minimum depth of cover for this longwall is unchanged from that reported in the Longwall 19A Groundwater Assessment (Watershed HydroGeo, 2022b), although the minimum depth of cover at the eastern end would decline slightly (from 310 m to 305 m, approximately).

The seam thickness is relatively similar through the whole of the Longwall 19A panel (3.85-4.2 m), and at the eastern end in particular is 3.85-4 m. As a result, the increased length at the eastern end would not have any implications for changes to cutting height, and therefore for fracturing that is partly a function of this height.

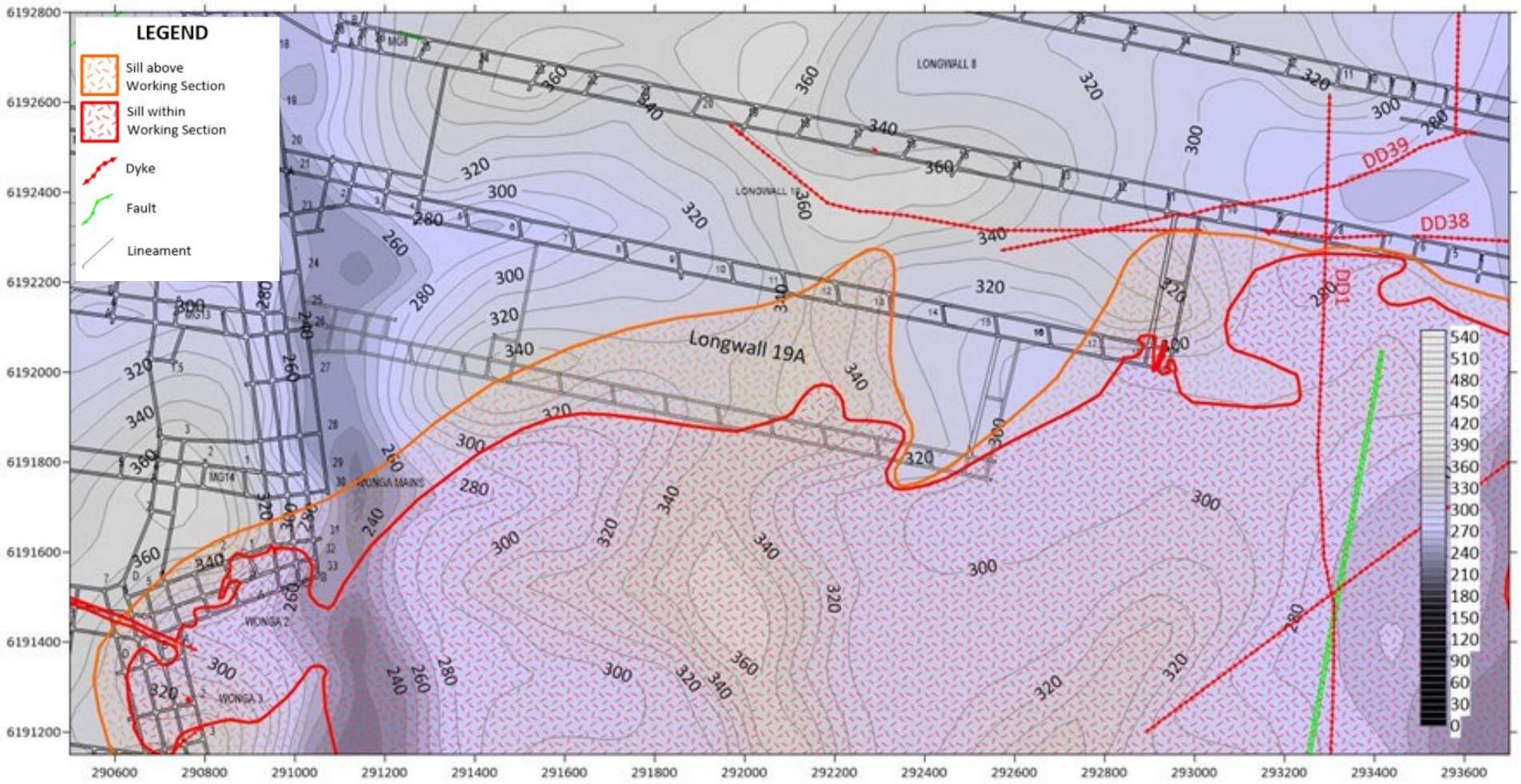
3.2.2 Geological Structures

Figure 3-2 displays the latest geological structure mapping from IMC geologists (Illawarra Metallurgical Coal, 2023), which incorporates recent knowledge and mapping around the current longwall block (Longwall 19).

The key geological structures potentially relevant to groundwater are faults. There are very few faults in proximity to Longwall 19A. Most geological structures in proximity to Longwall 19A are related to igneous intrusions, specifically sills and dykes encountered within or just above the coal seam. While these can cause problems for mining rate and equipment, at Dendrobium Mine they have not influenced environmental (hydrological or hydrogeological) impacts.

However, the dykes that were encountered through much of Longwall 19, i.e. DD38 and DD39 (**Figure 3-2**), have been mapped as terminating or being orientated away from MG19 (the gate road between Longwalls 19 and 19A, and so are not considered relevant to Longwall 19A.

It is noted that no dykes or faults mapped by IMC extend from (or above) Longwall 19A toward Wongawilli Creek, Sandy Creek or SC10, Cordeaux Reservoir or Swamp Den15a.



Source: (Illawarra Metallurgical Coal, 2023)

Figure 3-2 Depth of cover and geological structures mapped around Longwall 19A

3.3 Risk Pathways

Watershed (2022b) summarised the primary risk pathways whereby the mining of Longwall 19A could or would interact with environmental or water features based on the distance to the features and the depth of cover and longwall void width. This analysis is repeated here to illustrate the difference between the previous (superseded) layout of Longwall 19A and the revised layout.

3.3.1 Water supply reservoirs

Groundwater drawdown around many longwalls at Dendrobium has or would cause reduced baseflow and/or result in leakage from water supply reservoirs. It is considered that leakage from Cordeaux Reservoir (or Avon) would not occur as a result of mining at Longwall 19A due to the distances involved, as indicated in **Figure 3-3**.

Despite the slight reduction in distance from this longwall to the reservoir (Section 3.1), we consider that the potential for this to occur has declined slightly with the change in modelled or assumed longwall geometry (specifically, due to void width).

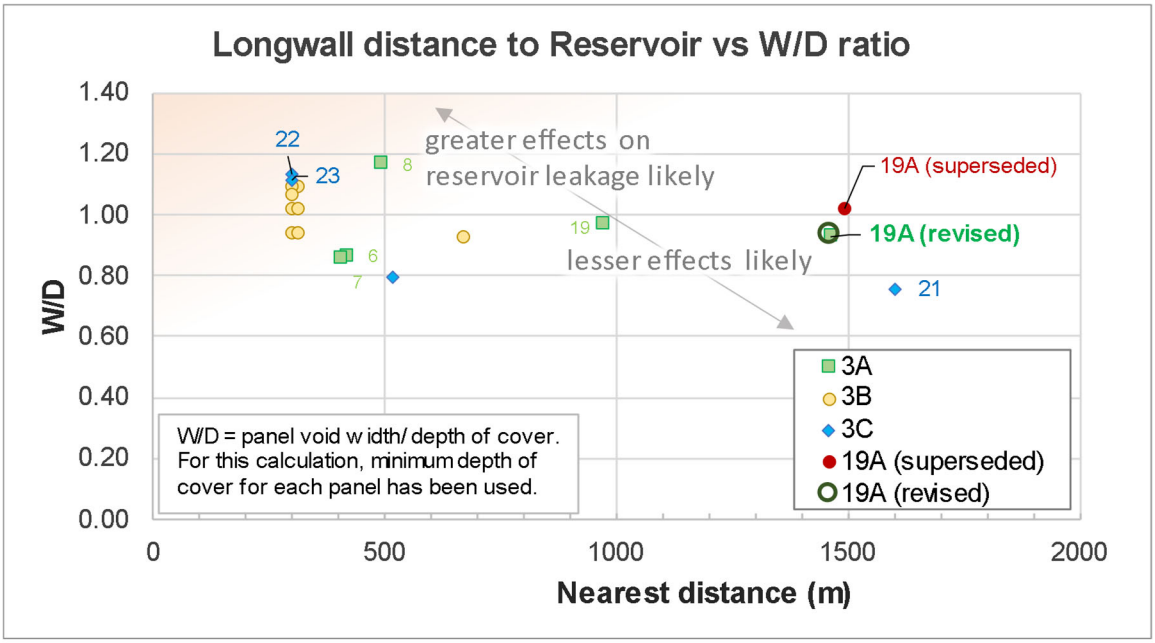


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Figure 3-3 Distance and risk of effects on adjacent reservoirs

Based on the mapping presented in Section 3.2.2, geological structures are not considered to be a pathway from or related to Longwall 19A.

3.3.2 Wongawilli Creek

Groundwater drawdown at Wongawilli Creek, reducing baseflow and leading to a reduction in surface water flow in the creek, which is likely to manifest itself as an increased duration or frequency of 'cease-to-flow' events in this creek, and extending the length of the creek that this effect occurs, noting that this effect was observed between Areas 3A and 3B during the significant drought periods in 2018-19.

For the superseded plan for Longwall 19A, the risk was relatively low compared to previous Area 3A longwalls. As a result of the revised layout (i.e. change to modelled void width) the risk has declined slightly (**Figure 3-4**), even though the distance from Wongawilli Creek is unchanged. In addition, the reduced void width means there the 'frontage' of the panel adjacent to Wongawilli Creek is slightly reduced.

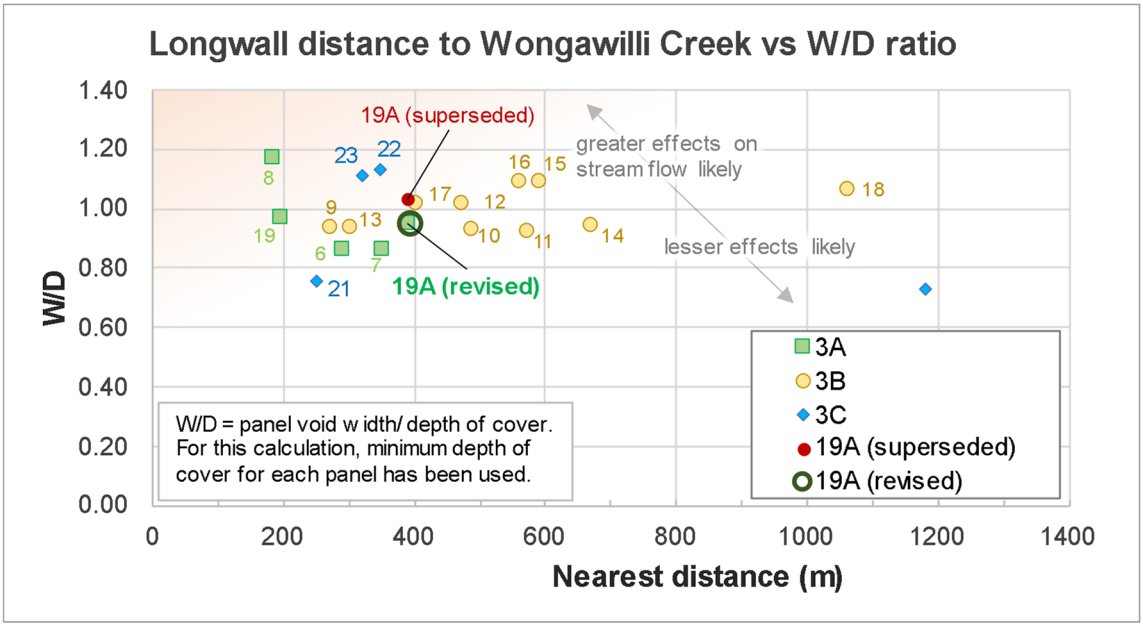

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Figure 3-4 **Distance and risk of effects on Wongawilli Creek**

Based on the mapping presented in Section 3.2.2, geological structures are not considered to be a pathway from or related to Longwall 19A.

3.3.3 Tributary SC10

Similar processes could affect tributary SC10, which is the main tributary to Sandy Creek. Because it is closer to Longwall 19A than Wongawilli Creek is, it is more likely that fracturing and water table decline would occur and affect this creek, with resultant effects of reduced flow (detected via changes to median flow) and increased low-flow and cease-to-flow frequency and duration.

Figure 3-5 shows that Longwall 19A has a relatively higher risk of impacting SC10 than Longwalls 6 and 7, but lower than Longwall 8 and the current Longwall 19.

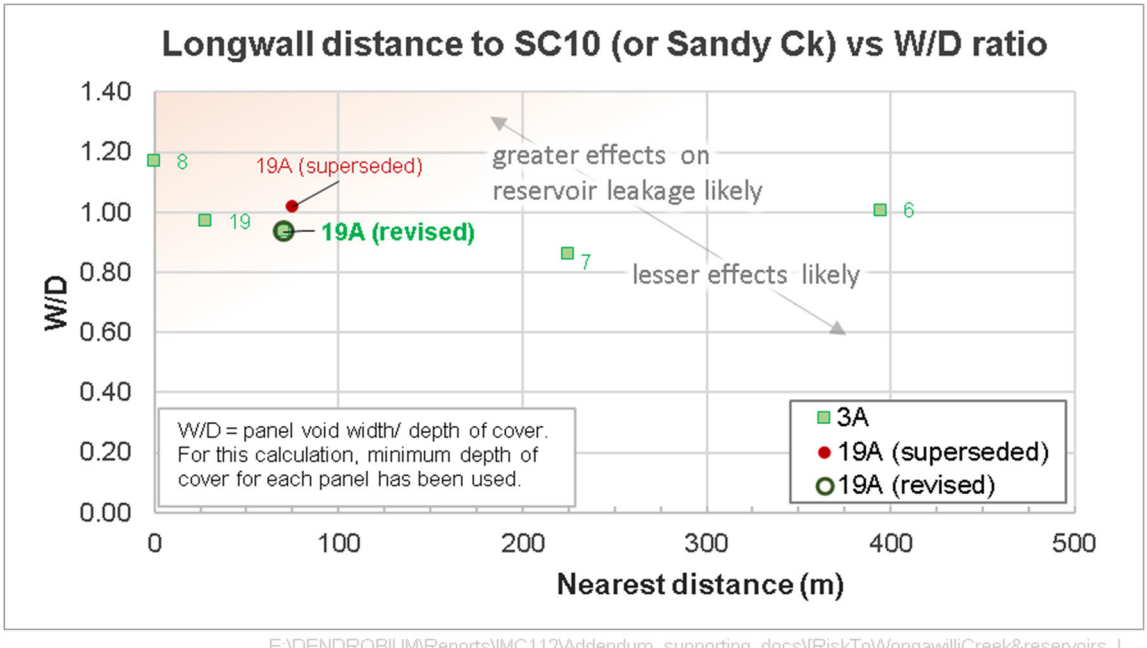

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Figure 3-5 **Distance and risk of effects on tributary SC10**

The revised layout will mean that Longwall 19A is slightly closer (which would increase the potential for surface cracking effects), but the revised void width is lower, which slightly reduces the risk or magnitude of impact related to the connected fracture zone (Section 3.3.4).

Based on the mapping presented in Section 3.2.2, geological structures are not considered to be a pathway from or related to Longwall 19A.

3.3.4 Seam-to-surface connectivity

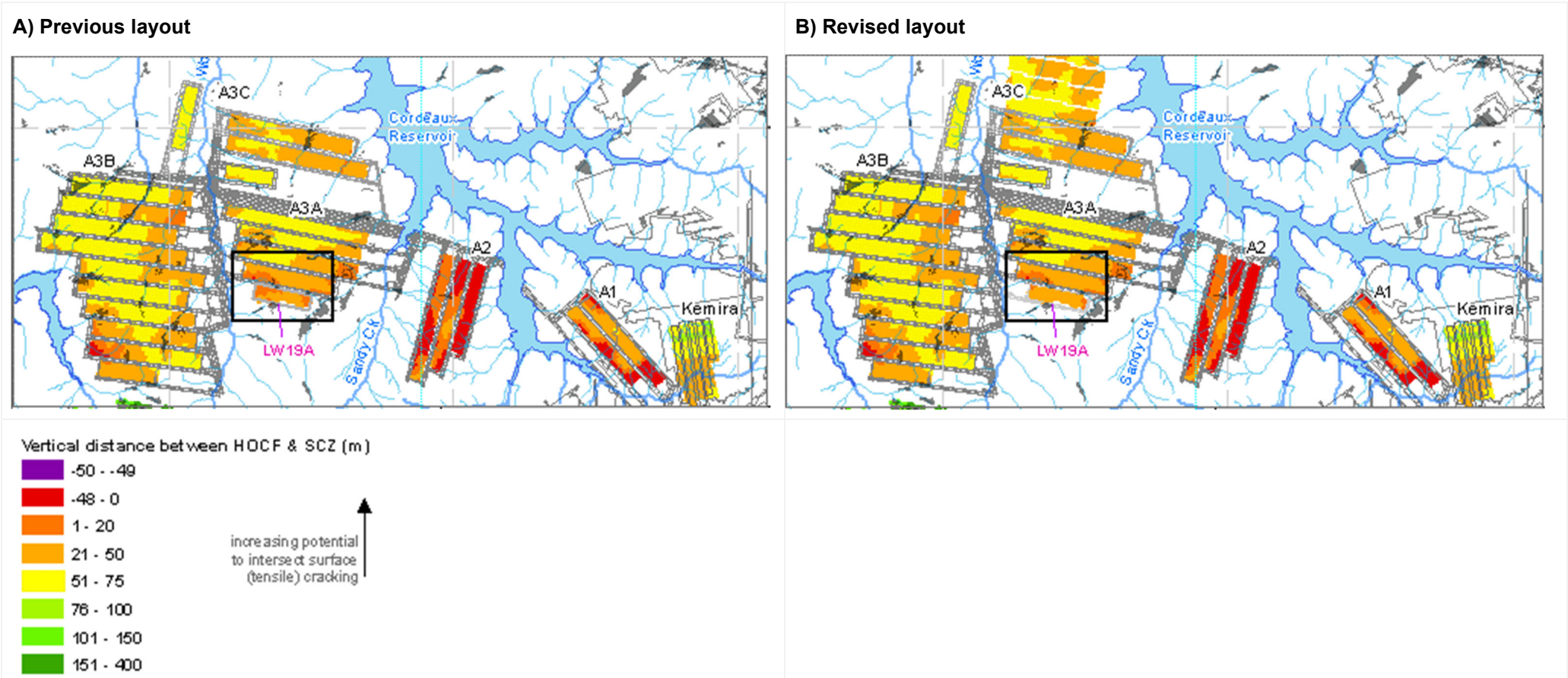
In areas where the connected fracture networks extending upward from the goaf intersect surface cracking extending downward from the surface, there is a risk of surface water being able to percolate downward and into the mine workings. The inflow record and water chemistry analysis indicate that this occurs in Area 2, where depth of cover is as low as 140-160 m above parts of Longwalls 3 and 4, compared to 290 m above Longwall 19A. A spatially distributed estimate of the connected fracture zone has been made using the relevant parameters at Dendrobium and at nearby longwall mines using the Ditton Geology Model A95 estimate (Ditton & Merrick, 2014). The justification for using this model has been presented in previous reporting - especially the Area 5 EIS Groundwater Assessment (Watershed HydroGeo, 2022a) - and discussions with DPE, WaterNSW, and IAPUM.

Figure 3-6 presents this in terms of the vertical separation between the top of the zone and the base of the surface cracking zone (SCZ), for A) previously reported longwall geometry and B) the revised Longwall 19A geometry. This figure is presented at a scale appropriate for comparison with other parts of Dendrobium Mine.

Two features of **Figure 3-6** are:

- The slight eastern extension of Longwall 19A in the **Figure 3-6B** (revised layout) compared to **Figure 3-6A** (previous layout).
- The slight increase in the separation between the height of connected fracturing (HOCF) and SCZ in **Figure 3-6B** (paler orange) compared to **Figure 3-6A** . This is related to the reduction in modelled void width from 305 m to 281 m.

This is consistent with the assessment of risk pathways re: Wongawilli Creek and SC10 (Sections 3.3.2 and 3.3.3) – the eastward extension of the revised layout means an increased risk to SC10, while the reduction in void width means a general reduction in the potential for connected fracturing extending upward through the strata compared to the previous layout for Longwall 19A.



HOCF = Height of connected fracturing. SCZ = surface cracking zone.

Figure 3-6 Spatial variation in height of connected fracturing (HOCF) at Dendrobium

4 Numerical modelling

The numerical groundwater model presented in Watershed (2022b) has been re-run for the purposes of this addendum to simulate the effects of the revised Longwall 19A mine plan. Most of the model scenarios run and reported in Watershed (2022b) are valid and used again here (**Table 4-1**), with a new version of Scenario D and one of the uncertainty analysis scenarios (highlighted in blue) to incorporate the revised Longwall 19A geometry.

Table 4-1 Summary of modelled mine development and uncertainty scenarios

Scenario	Run	Name	Dendrobium	Connected fracture zone method	Other Mines	Comment
B	DND6TR30B	Baseline	No Dendrobium	TVM	All	Baseline condition. Comparison against D isolates effects of Dendrobium.
C	DND6TR30C	Dendrobium, no LW19A	All Areas 1, 2, 3A, 3C (LW 20-23) and all 3B, except LW19A	TVM + Stacked Drains	All	Comparison against D isolates effects of LW 19A.
D	DND6TR030D	Full Development (with previous Longwall 19A)	All Areas 1, 2, 3A (including previous Longwall 19A), 3C (LW 20-23) and all 3B	TVM + Stacked Drains	All	This was compared with the Scenario C to estimate the effects of the previous Longwall 19 layout.
D	**DND6TR033D**	Full Development (with revised Longwall 19A)	All Areas 1, 2, 3A (including revised Longwall 19A), 3C (LW 20-23) and all 3B	TVM + Stacked Drains	All	This can be compared with the previous version of Scenario D to estimate the effects of the revised layout.
Deterministic uncertainty scenarios						
D	**DND6TR34D**	Full Development: Offgoaf 1 (revised 19A)	as for D (above)	as for D	as for D	Greater off-goaf permeability (Kh 6.0E-2 m/d), as per the previous assessment.

Of note is that the change in longwall dimensions means that one additional model cell is used to represent the increased length of Longwall 19A at its eastern end. Otherwise, the model is unchanged from that reported in Watershed (2022b) for reasons of consistency with the previous reporting, noting that the model is being updated in the near future.

The key results are presented in the following sub-sections.

4.1 Groundwater level and drawdown

In order to compare groundwater levels and drawdown a result of the two Longwall 19A layouts (superseded and revised), the groundwater level hydrographs presented in the previous Groundwater Assessment have been repeated here: once showing the previously modelled geometry, and once for the revised geometry.

These hydrographs are presented for three locations:

- At S1888, which was on the edge of the previous longwall panel footprint, and would be within the revised footprint. Essentially this shows effects 'above' the longwall. Modelled hydrographs for this site are shown in **Figure 4-1** and **Figure 4-2**.
- At a nominal location adjacent to Wongawilli Creek, at the point nearest to the western end of Longwall 19A. Modelled hydrographs are shown in **Figure 4-3** and **Figure 4-4**.
- At (or beneath) shallow piezometer 15a_06, which is in Swamp Den15a, near the eastern end of Longwall 19A. Modelled hydrographs are shown in **Figure 4-5** and **Figure 4-6**.

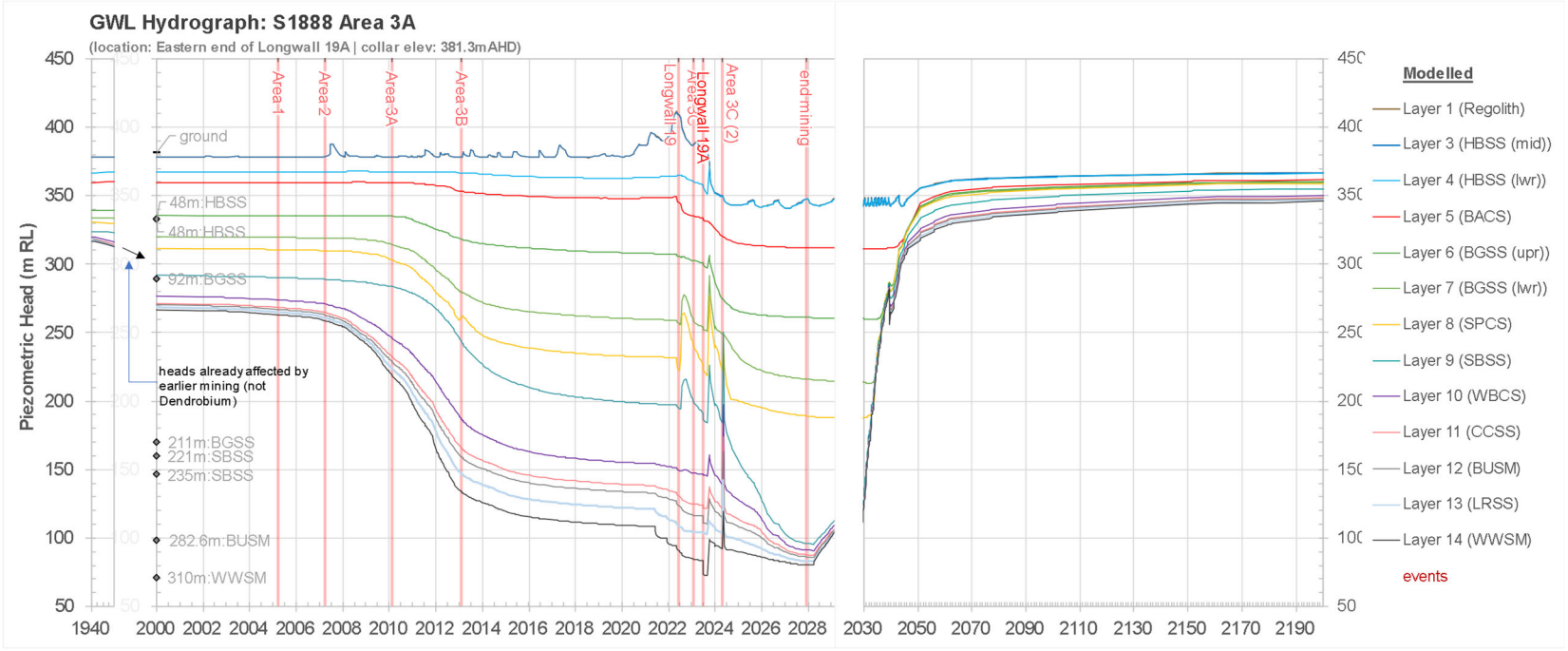


Figure 4-1 **Modelled groundwater levels at S1888 (Longwall 19A footprint) – previous layout**

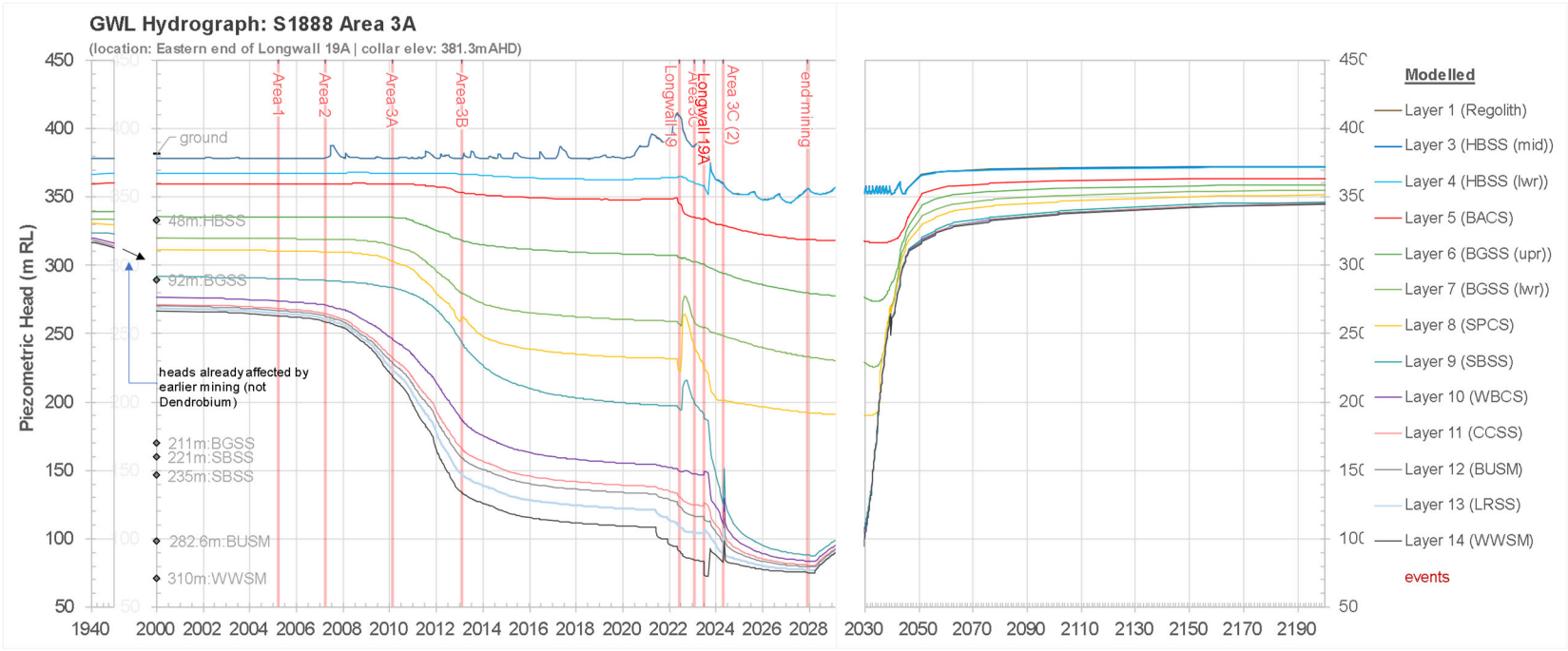


Figure4-2 **Modelled groundwater levels at S1888 (Longwall 19A footprint) – revised layout**

When comparing these modelled groundwater level hydrographs for site S1888 within the footprint (**Figure 4-1** and **Figure 4-2**), there is essentially no difference between the simulated post-mining groundwater levels and drawdown in the deeper units; Bald Hill Claystone (BACS) down to the Wongawilli Seam (WWSM). This is because, despite the change in void width, the connected fracturing would still result in significant depressurisation and even some horizons of zero or near-zero groundwater pressure.

The main difference is in the lower Hawkesbury Sandstone (HBSS lwr). The assessment of the previous layout (**Figure 4-1**) indicated drawdown from 367 mAHD down to 340 mAHD, i.e. 27 m drawdown, before recovering to 1 m below pre-mining levels (366 mAHD).

For the revised layout (**Figure 4-2**), groundwater levels in the HBSS-lwr are predicted to decline to 345 mAHD (i.e. 22 m drawdown), before recovering to 371 mAHD, i.e. above pre-mining levels.

This is expected with the slight reduction in void width.

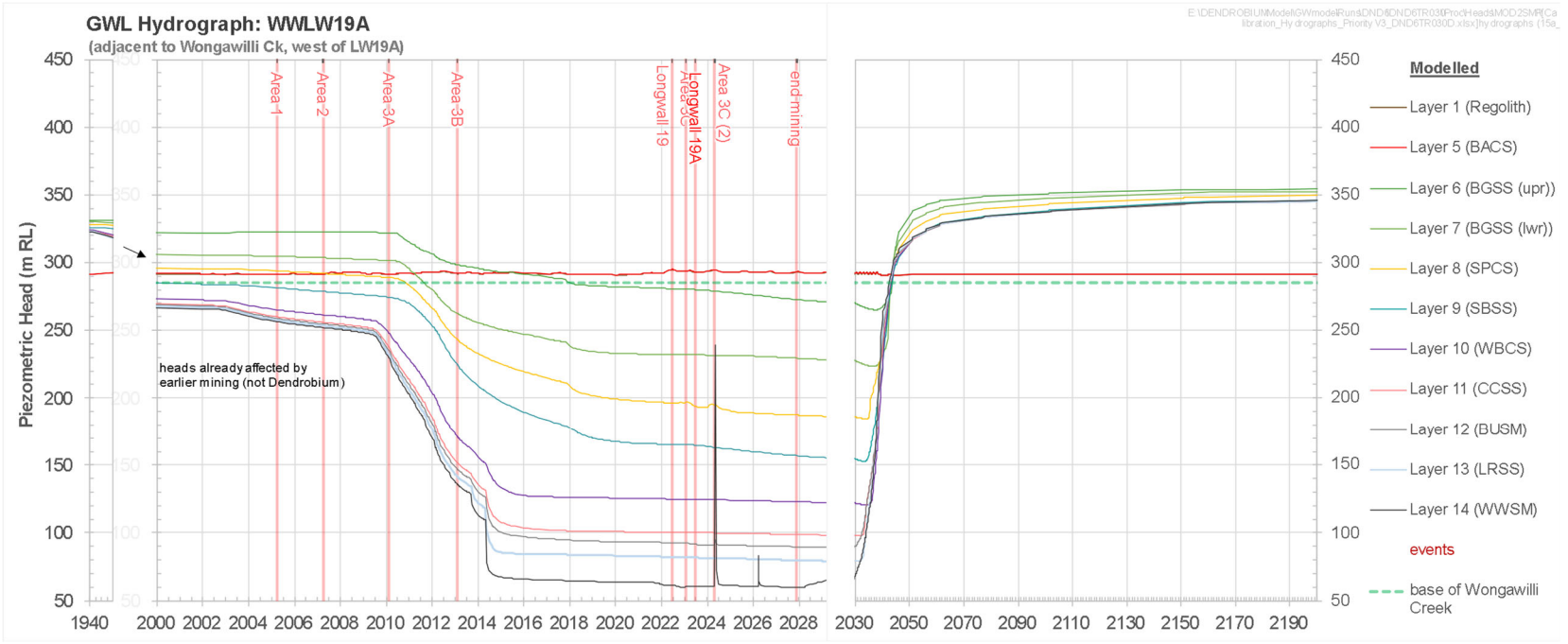


Figure 4-3 **Modelled groundwater levels adjacent to Wongawilli Creek – previous layout**

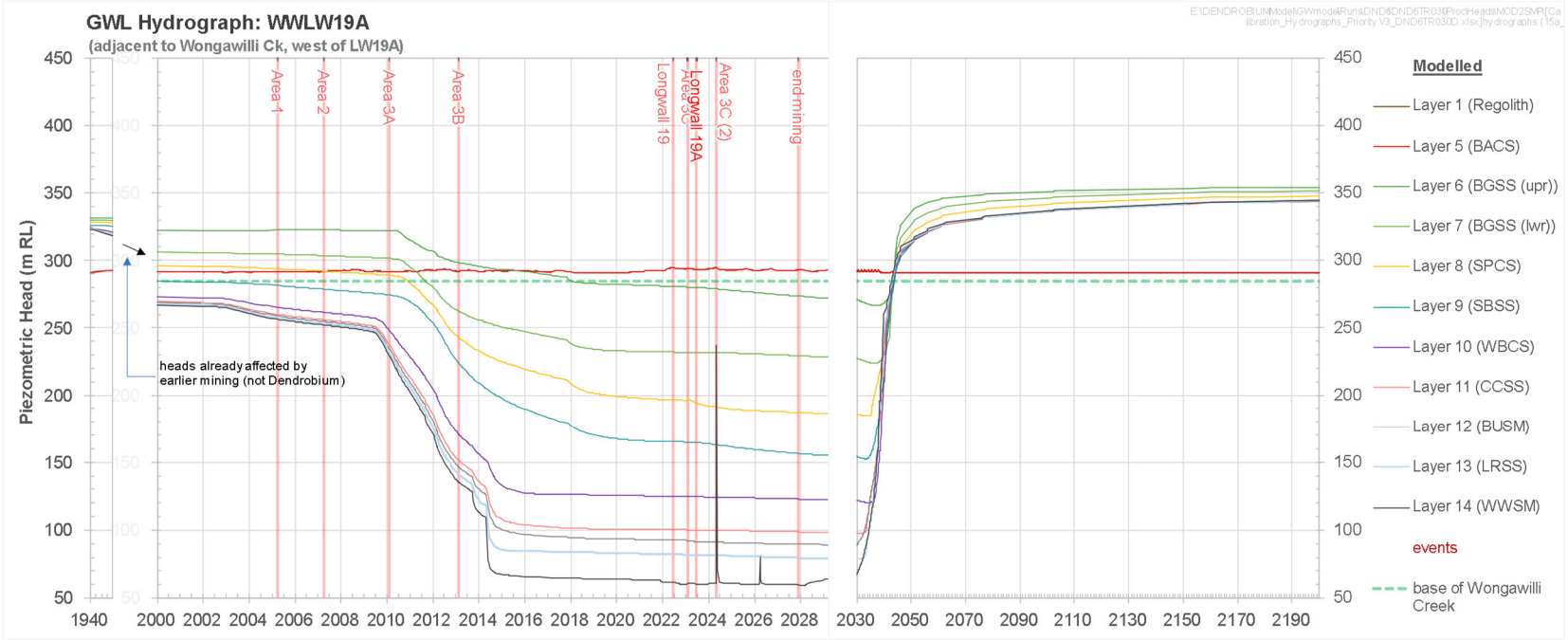


Figure4-4 **Modelled groundwater levels adjacent to Wongawilli Creek – revised layout**

When comparing these modelled groundwater level hydrographs for this site adjacent to Wongawilli Creek (**Figure 4-3** and **Figure 4-4**, there is essentially no difference between the simulated post-mining groundwater levels and drawdown in the deeper units; lower Bulgo Sandstone (BGSS-lwr) down to the Wongawilli Seam (WWSM). This is because, despite the change in void width, the connected fracturing would still result in significant depressurisation and even some horizons of zero or near-zero groundwater pressure.

The main difference, and even this is very minor, is in the upper Bulgo Sandstone (BGSS upr). The assessment of the previous layout (**Figure 4-3**) indicated drawdown from 322 mAHD down to 265 mAHD, i.e. 57 m drawdown, before recovering to 31 m above pre-mining levels (353 mAHD).

For the revised layout (**Figure 4-4**), groundwater levels in the HBSS-lwr are predicted to decline to 266 mAHD (i.e. 56 m drawdown), before recovering to the same level as in the previous assessment (353 mAHD), i.e. also above pre-mining levels.

This is expected with the slight reduction in void width.

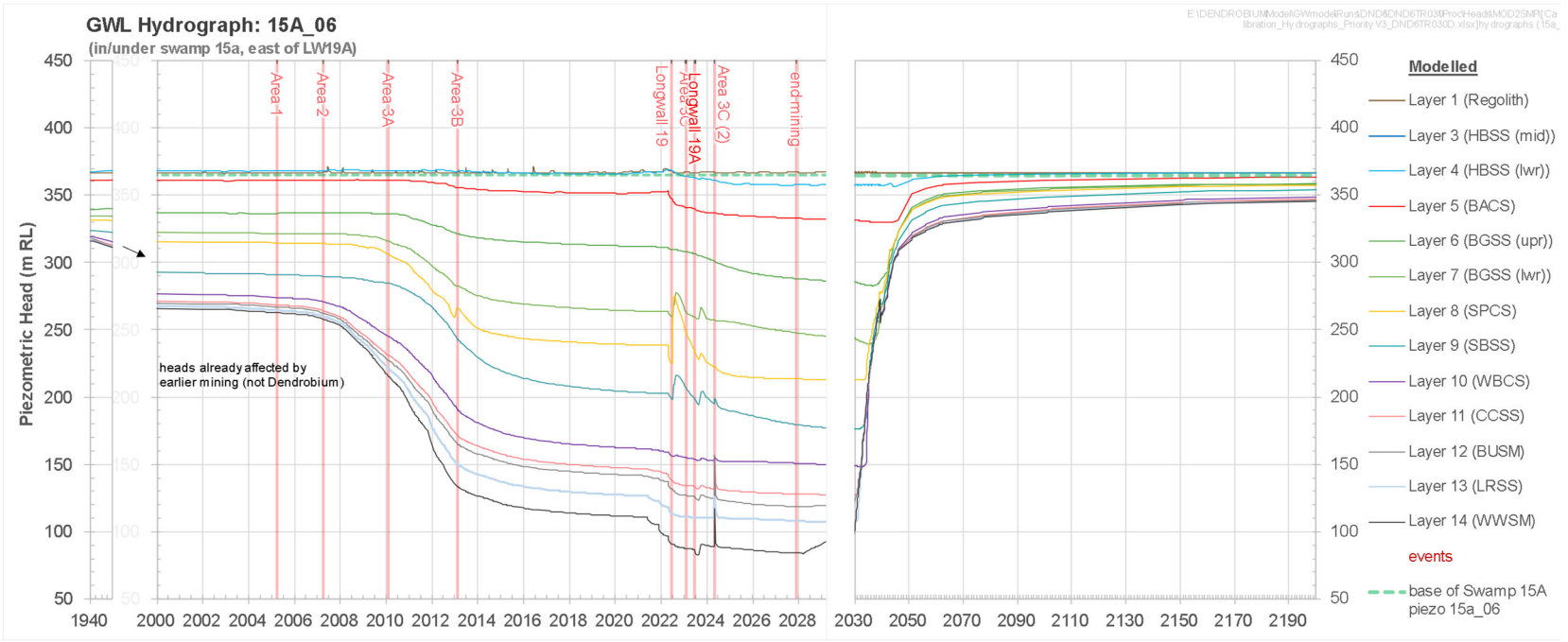


Figure 4-5 **Modelled groundwater levels near Swamp 15a – previous layout**

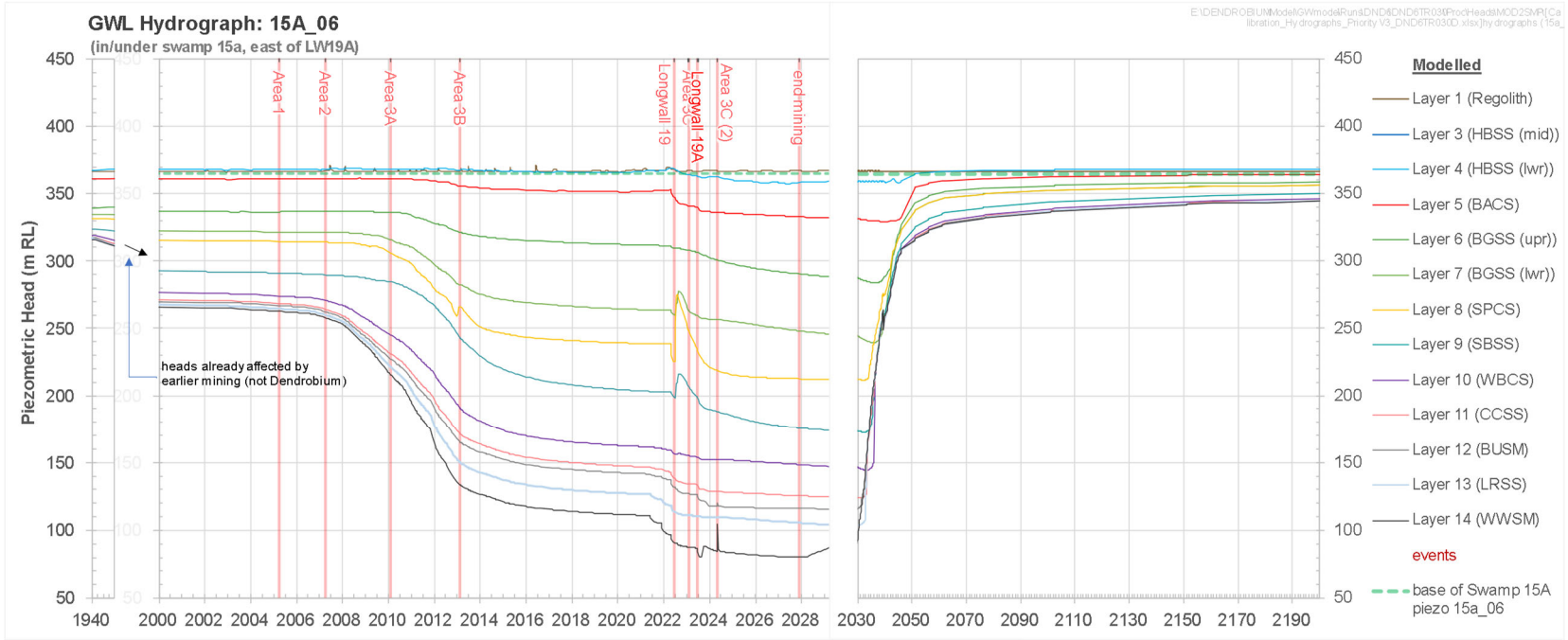


Figure4-6 **Modelled groundwater levels near Swamp 15a – revised layout**

When comparing these modelled groundwater level hydrographs for this site adjacent to Wongawilli Creek (**Figure 4-5** and **Figure 4-6**, there is a slight increase in the drawdown simulated in the deeper units; Bulgo Sandstone (BGSS) down to the Wongawilli Seam (WWSM). This is because of the increased panel length at its eastern end and despite the change in void width. Note however that the change in drawdown is not significant, given that drawdown is still 75-200 m and still resulting in some horizons of zero or near-zero groundwater pressure.

There is little difference in the simulated groundwater levels and drawdown in the Bald Hill Claystone (BACS).

In the shallower strata, the main difference, and even this is very minor, is in the lower Hawkesbury Sandstone (HBSS lwr). The assessment of the previous layout (**Figure 4-5**) indicated drawdown from 368 mAHD down to 356 mAHD, i.e. 12 m drawdown to below the local base of the swamp, before recovering to 2 m above the base of the swamp (366 mAHD).

For the revised layout (**Figure 4-6**), HBSS-lwr groundwater levels are predicted to decline to 358 mAHD (i.e. 10 m drawdown), before recovering to the pre-mining levels (368 mAHD), also above the base of the swamp.

4.2 Groundwater inflow

Groundwater inflow to Area 3A and to the mine as a whole has been compared from the model scenarios for the previous and revised layouts.

Figure 4-7 shows modelled (and observed) inflow to Area 3A.

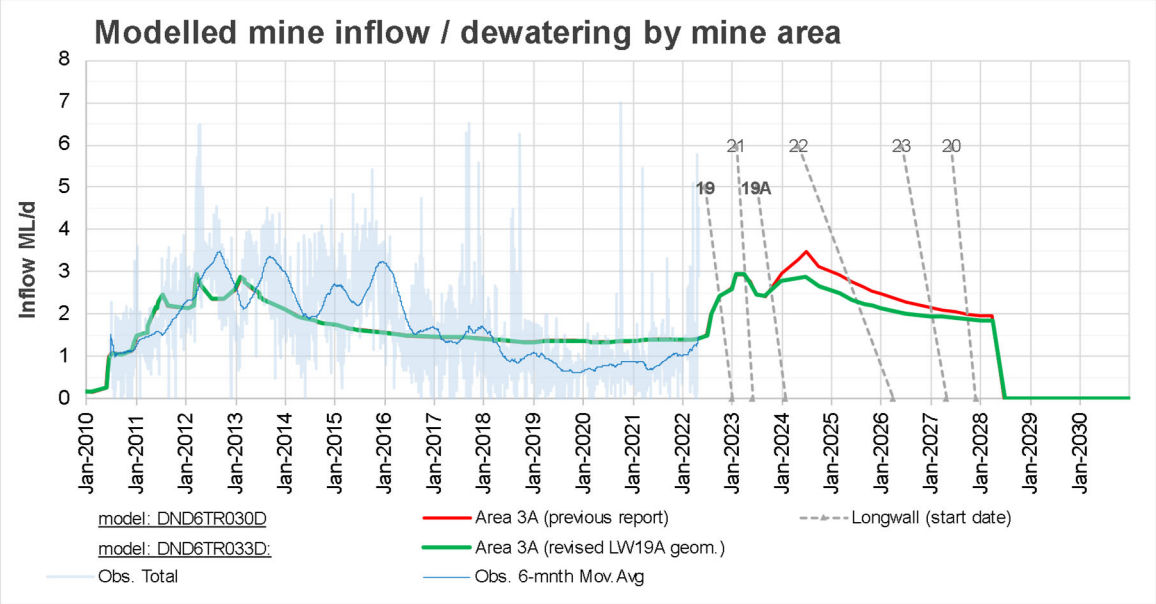


Figure 4-7 **Modelled total groundwater inflow to Area 3A**

The modelled revised geometry results in a slightly lower inflow to Area 3A than was previously reported (**Figure 4-7**). Peak inflow following extraction of Longwall 19A is simulated as being 2.9 ML/d, compared to 3.5 ML/d in the previously modelled layout. This is obviously despite the slightly longer panel, and mainly related to the reduced void width.

Figure 4-8 presents modelled inflow to the mine as a whole (Areas 1-3C).

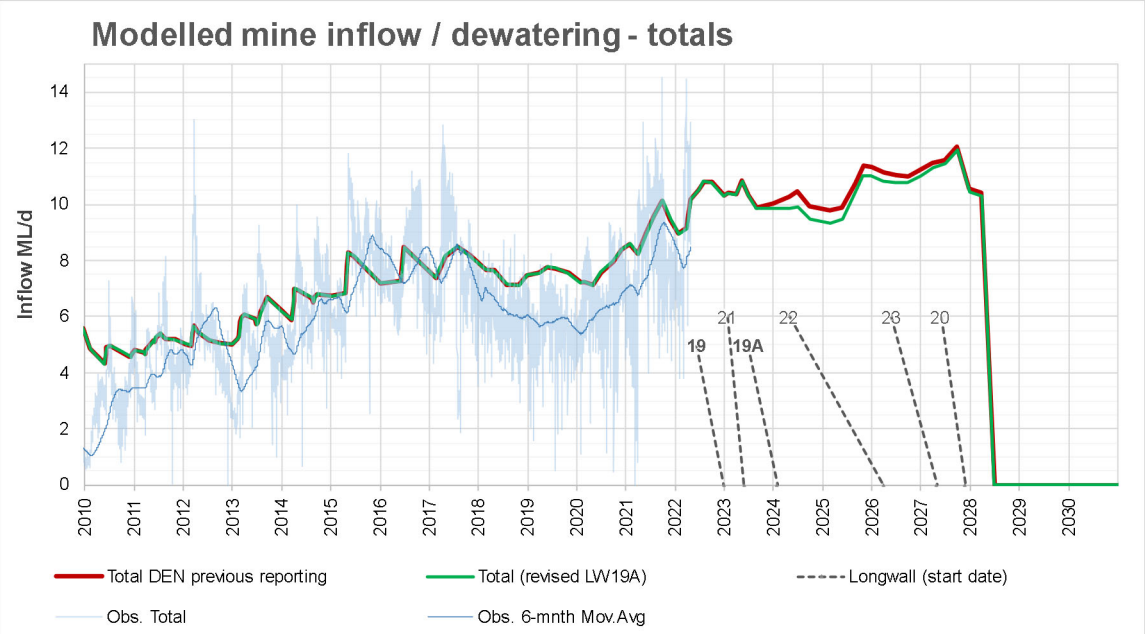


Figure 4-8 **Modelled total groundwater inflow to Areas 1-3C**

This shows a similar result to that for Area 3A, with the revised scenario simulating a peak reduction of 0.6 ML/d at the end of Longwall 19A, and an average reduction of 0.3 ML/d from the start of Longwall 19A to the simulated end of mining (2028).

4.3 Forecast discharge after closure

Longwall 19A as a whole was predicted to have less than 1% change in total discharge rate from the mine portals (Watershed HydroGeo, 2022b). Conceptually, and supported by the minimal difference in groundwater inflow modelled at mine closure (simulated as 2028) as shown in **Figure 4-7** and **Figure 4-8**, the effect of this change in geometry of Longwall 19A would have a negligible difference on post-closure discharge from the mine portal.

4.4 Simulated leakage from Water Supply Reservoirs

Modelling indicates that the change in Longwall 19A geometry would have a negligible effect on leakage from Cordeaux Reservoir as was reported for the previous layout (Watershed HydroGeo, 2022b). This is expected given the distance between the panel and the reservoir (Sections 3.1 and 3.3.1).

The Avon Reservoir is even further away, and would not be affected by Longwall 19A extraction.

4.5 Simulated 'Incidental Take' from Watercourses

For the purpose of this assessment, we have concentrated on the incremental effects of Longwall 19A on adjacent watercourses. This is summarised in Table 4-2 (Sandy Creek catchments) and Table 4-3 (Wongawilli Creek catchments), showing the incremental effect reported for the previous layout and the incremental effect modelled due to the revised Longwall 19A layout, and summarised for different periods during and after mining.

Red text highlights where the revised layout is predicted to cause a greater reduction in stream flow than in the previous assessment.

The tables show that in general there is a slight reduction in the take from adjacent watercourses as a result of the revised longwall geometry, although typically the reductions related to the change in longwall geometry are very small, on the order of 10-25%.

The watercourses where the modelling suggests that water take may increase are SC10A (during mining), SC10B, SC10 and Sandy Creek (all in the long-term) and (based on the uncertainty scenario). Again, the change is very small, e.g. -0.3 ML/d compared to -0.29 ML/d in SC10.

These changes are generally consistent with the conceptual model and the assessment of risk pathways in Section 3.3.

Table 4-2 Predicted annualised change in surface water flow (ML/d): Longwall 19A increment – Sandy Creek catchment

Period	Statistic	SC10A		SC10B		SC10		Sandy Ck (SCL)	
		Previous	Revised	Previous	Revised	Previous	Revised	Previous	Revised
Longwall 19A + 3yrs 2023-2028	Mean & Max (base case)	-0.007 to -0.01	-0.005 to -0.008	-0.002 to -0.004	-0.002 to -0.003	-0.012 to -0.018	-0.011 to -0.015	-0.012 to -0.018	-0.011 to -0.015
	Uncertainty Max	*-0.027*	*-0.03*	*-0.011*	*-0.011*	*-0.074*	*-0.07*	*-0.077*	*-0.07*
30yrs post-mining 2029-2060	Mean & Max (base case)	-0.003 to -0.009	-0.003 to -0.006	-0.003 to -0.008	-0.003 to -0.006	-0.010 to -0.017	-0.006 to -0.012	-0.011 to -0.017	-0.007 to -0.012
	Uncertainty Max	*-0.021*	*-0.019*	*-0.015*	*-0.015*	*-0.0915*	*-0.08*	*-0.096*	*-0.08*
Long-term 2060-2200	Mean (base case)	0.000	0.000	-0.007	-0.005	-0.009	-0.002	-0.008	-0.002
	Uncertainty Max	*-0.004*	*-0.003*	*-0.009*	*-0.011*	*-0.029*	*-0.03*	*-0.029*	*-0.03*

Negative value = reduction in surface water flow. Statistics reported are "MEAN" to "MAX" from the Base Case [calibrated] model, and *("UNCERTAINTY MAX")* from deterministic scenarios.
Red text shows where the revised mine plan predicted to cause greater reduction in surface water flow
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Table 4-3 Predicted annualised change in surface water flow (ML/d): Longwall 19A increment – Wongawilli Creek catchment

Period	Statistic	WC13		WC14		lower Wongawilli Creek (WWL)	
		Previous	Revised	Previous	Revised	Previous	Revised
Longwall 19A + 3yrs 2023-2028	Mean & Max (base case)	-0.010 to -0.014	-0.007 to -0.009	-0.003 to -0.003	-0.002 to -0.002	-0.012 to -0.018	-0.008 to -0.012
	Uncertainty Max	*-0.021*	*-0.021*	*-0.014*	*-0.011*	*-0.042*	*-0.04*
30yrs post-mining 2029-2060	Mean & Max (base case)	-0.010 to -0.014	-0.006 to -0.008	-0.002 to -0.003	-0.001 to -0.001	-0.010 to -0.022	-0.007 to -0.016
	Uncertainty Max	*-0.021*	*-0.021*	*-0.018*	*-0.012*	*-0.152*	*-0.14*
Long-term 2060-2200	Mean (base case)	0.000	0.000	0 to +0.001	+0.001	0 to +0.010	+0.010
	Uncertainty Max	*0*	*0*	*-0.002*	*0*	*0 to +0.01*	*+0.01*

Note: Red text shows where the revised mine plan predicted to cause greater reduction in surface water flow

5 Conclusions

The conceptual analysis and the numerical modelling indicate that the change to Longwall 19A geometry would have negligible to very minor effects on the behaviour of groundwater and connected surface water.

In shallower strata, groundwater drawdown is predicted to be slightly reduced for the revised layout compared to the previous assessment.

Groundwater inflow would decrease slightly, influenced by the reduction in the void width assessed in this addendum compared to in the previous Groundwater Assessment (Watershed HydroGeo, 2022b).

Most effects on watercourses would decline slightly (again related to the void width), with the main risk pathway being a greater chance of surface cracking on tributaries SC10B (due to being mined beneath by the revised layout) and SC10 (due to reduced distance from the panel footprint). This same effect would increase the likelihood of effects on Swamps Den15c and 15a, as discussed in the Addenda to the Subsidence Assessment (MSEC, 2023) and Surface Water Assessment (HGEO, 2023).

Due to the distances involved, effects on water supply reservoirs due to Longwall 19A would remain negligible.

Post-closure discharge of water from the portals would be unaffected by the revised layout of Longwall 19A.

5.1 Recommendations

Because of the very minor or negligible changes to predicted groundwater and surface water behaviour, no changes to the monitoring and analysis that was previously recommended (Watershed HydroGeo, 2022b) are necessary.

Your sincerely,

Will Minchin
will.minchin@watershedhg.com

6 References

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Watershed HydroGeo. (2022a). *Dendrobium Mine Extension Project: Groundwater Assessment* (No. R029c; Report for South32 Illawarra Metallurgical Coal, p. 437).

Watershed HydroGeo. (2022b). *Dendrobium Area 3A: Longwall 19A Groundwater assessment* (No. R042a; Report for South32 Illawarra Metallurgical Coal, p. 151).

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To:	Cody Brady (Illawarra Metallurgical Coal)	cc:
From:	Stuart Brown	
Subject:	**Assessment of surface water flow and shallow groundwater effects of proposed Dendrobium Longwall 19A: Revised longwall geometry**	
Date:	20 February 2023	**Ref:** D23208

1. Introduction

Since the completion of the Area 3A Longwall 19A SMP impact assessments, the dimensions for Longwall 19A have been revised by Illawarra Metallurgical Coal (IMC). In discussion with Department of Planning and Environment (DPE), a series of addenda to the specialist impact assessments were prepared outlining the change to the longwall geometry in comparison with the previously reported dimensions and assess the key changes that this update would have on predicted impacts.

This memorandum describes the changes with respect to predicted impacts to surface water and swamps, and is designed to be an Addendum to the existing Longwall 19A Surface water assessment (HGEO 2022). This revised assessment relies on estimates of ground subsidence, groundwater drawdown and surface water losses presented in reports by MSEC (2022) and Watershed (2023).

1.1 Summary of findings

The revised longwall panel extends 42 m further at its eastern end and is 6 m wider than the previously assessed Longwall 19A, having an area that is 1.3 Ha or 4.7% larger than the previously assessed panel. With respect to potential effects to surface water and shallow groundwater:

- there is expected to be no measurable difference in impacts on Wongawilli Creek and its tributaries between the revised and previous longwall geometries.
- it is unlikely that Sandy Creek Waterfall will experience adverse impacts due to the mining of Longwall 19A based on both the previous and revised geometries.
- the estimated number of cease-to-flow days per year at key gauging stations on Wongawilli Creek and Sandy Creek are not significantly different from previous estimates.
- the assessment of potential impacts to water quality impact remains unchanged from the previous assessment.
- no additional swamps are likely to be affected by subsidence associated with the revised longwall geometry and the overall assessment of potential shallow groundwater effects is unchanged; however, the revised longwall layout may result in impacts to a slightly larger area (0.04 Ha) of Swamp 148 than previously assessed. Effects within Swamp 15a are possible within 400 m of Longwall 19A.
- the geology of Longwall 19A and its surrounds was reassessed by IMC in February 2023. No significant faults or dykes are expected to intersect Longwall 19A. Underground mapping of the adjacent Longwall 19 indicates no anomalous groundwater inflow associated with intersected joints. Therefore, no additional impact to surface watercourses or swamps is expected due to faults and lineaments intersecting the revised longwall layout.

2. Revised mining geometry for Longwall 19A

The revised and previous mining geometries for Longwall 19A are summarised in Table 1. A comparison of previous and revised longwall outlines is shown in Figure 1.

Table 1. Revised mining geometry for Longwall 19A

Mine plan	Length (m)	Width (m)	Area (Ha)
2022 (Previous)	1009	275	27.8
2023 (Revised)	1051	281	29.1

The revised longwall panel extends 42 m further at its eastern end and is 6 m wider than the previously assessed Longwall 19A. The revised longwall panel has an area 1.3 Ha or 4.7% larger than the previously assessed panel.

The changes in geometry are negligible in the western part of the panel that overlaps Wongawilli Creek sub-catchments and there is expected to be no measurable difference in impacts between the revised and previous longwall geometries on Wongawilli Creek and its tributaries. The revised longwall geometry overlaps with a larger area of mapped swamp vegetation along its northern and eastern margins. Key map figures from the previous surface water and shallow groundwater assessment are reproduced in Figures 1 to 4 with the revised Longwall 19A geometry and associated distance buffers.

3. Impacts to surface water

3.1 Subsidence effects on drainage lines

MSEC (2022) assessed ground subsidence effects from Longwall 19A based on the previous and revised mining geometry. In relation to potential impacts to adjacent watercourses, MSEC concluded that "*the assessed levels of potential impact for SC10 and WC14, based on the [revised] layout, are the same as those based on the previous layout. The assessments and recommended management strategies for the drainage lines, therefore, are the same as those provided in Report No. MSEC1234 and the Extraction Plan Application.*". In relation to Sandy Creek and Sandy Creek Waterfall, MSEC concluded that "*it is unlikely that Sandy Creek Waterfall would experience adverse impacts due to the mining of LW19A based on both the previous and [revised] Layouts.*"

3.2 Surface water flow and duration

Assessment of the predicted impacts to surface water relies on estimates of groundwater drawdown and induced surface water losses by Watershed (2023). Predicted changes in surface flow in streams due to incremental (Longwall 19A only) and cumulative (whole of mine) modelled groundwater drawdown is presented in Tables 4-2 and 4-3 of the addendum memo by Watershed (2023). Those estimates of surface flow loss were applied to baseline flow-duration data to estimate changes in cease-to-flow days per year. Table 2 summarises estimates from the previous surface water assessment (HGEO 2022) and this revised assessment (in blue). Revised flow-duration curves are shown in Figure 5, Figure 6 and Figure 7.

Table 2. Predicted effects on stream flow characteristics.

No-flow days per year	Wongawilli Creek WWL		Sandy Creek SCL		Sandy Creek SC10S1	
	Previous	Revised	Previous	Revised	Previous	Revised
Baseline	**44**	**44**	**57**	**57**	**39**	**39**
Incremental Short term	47	46	60	60	42	41
Incremental Long term	46	44	59	57	41	40
Cumulative Short term	97	96	120	120	121	120
Cumulative Long term	44	44	72	70	56	52

Due to conservative assumptions used by Watershed (2022) in its assessment of the previous mine geometry, the revised estimates of surface flow loss (Watershed 2023) are unchanged or slightly less, than the previous estimates. As a result, estimates of the number of no-flow days per year at key gauging stations on Wongawilli Creek and Sandy Creek are slightly lower than, but not significantly different from, previous estimates.

3.3 Surface water quality

Longwall subsidence can result in fracturing of streambeds and this fracturing can lead to changes in stream water quality, primarily due to diversion of flow through shallow fractures and oxidation and dissolution of minerals in the freshly fractured bedrock. End of Panel assessments have noted localised effects, including transient or persistent increases in EC, increases (or decreases) in pH and increases in dissolved metal concentrations such as Fe, Mn, Al and Zn. Iron staining in creek beds is commonly associated with watercourses that have been directly mined beneath or are within the mining area of influence.

The previous assessment of Longwall 19 estimated that, based on previous observations, water quality influence due to mining would be minor in stream reaches within subsidence affected areas (SC10 and SC10B; upper reaches of WC14, WC13). Local discolouration of streambeds and rock faces by iron hydroxide precipitation could continue for a number of years but is a temporary impact. Water quality effects on stored waters of the reservoirs are expected to be negligible and undetectable. The revised layout of Longwall 19A does not intersect any additional watercourses and therefore the assessment of potential water quality impact remains unchanged. However, it is noted that the eastern end of Longwall 19A is closer to the main channel of SC10 (60 m with revised geometry; previously 90 m).

4. Impacts to shallow groundwater (swamps)

Assessment of the predicted impacts to shallow groundwater and areas of mapped swamp vegetation relies on estimates of ground subsidence (MSEC 2022) and studies of previous impacts to shallow groundwater beneath swamps in above and adjacent to Dendrobium Mine (Watershed HydroGeo 2021). The study by Watershed (2021) concluded that almost all shallow piezometers that are directly mined under by longwalls extracted in Dendrobium Area 3A and 3B show responses to mining. Changes in shallow groundwater levels or groundwater fluctuation characteristics are not evident in shallow piezometers located in swamp sediments more than 60 m from the extracted longwall margin.

Assessments of the likely impacts of future mining on shallow groundwater beneath swamps are based on those observations. It is assumed that areas of swamp vegetation that are within 60 m of the proposed longwall footprint are likely to experience changes in groundwater level and/or recession behaviour after mining. Furthermore, it is possible that areas of swamp vegetation located within 400 m of a longwall may be affected due to fracturing of the sandstone substrate, with the likelihood decreasing with distance away from the longwall (MSEC 2022). Table 3 summarises likely impacts to shallow groundwater underlying mapped swamp vegetation (an update of Table 13 from the previous assessment). Revised effect estimates are shown in blue and compared with previous (red).

Table 3. Summary of predicted impacts to Upland Swamps

Swamp	Veg. community	Total swamp area (Ha)	Area (Ha) within 60 m of longwall	Predicted vertical ground movement (mm; MSEC, 2023)		Likelihood of shallow groundwater effects
				Subsidence	Tilt (mm/m)	
Den12	Banksia Thicket	5.37	0	<20	<0.5	Previously mined under by Longwalls 7 and 8. Further effects unlikely.
Den15a	Banksia Thicket	8.57	0	30	<0.5	Previously within area of influence of Longwall 19. Effects from Longwall 19A possible where < 400 m from longwall
	Cyperoid Heath	4.40	0			
	Restioid Heath	2.49	0			
	Tea-Tree Thicket	2.56	0			
Den15b	Unvalidated	0.10	0	30	<0.5	Previously mined under by Longwalls 7 and 8. Further effects unlikely.
	Banksia Thicket	3.25	0			
	Cyperoid Heath	0.57	0			
	Tea-Tree Thicket	1.04	0			
Den 15c	Banksia Thicket	0.65	0.65 (100%)	1450 *[Previously 1400]*	25	Previously affected by Longwall 19. Effects from 19A Likely
Den34	Mallee Heath	1.90	1.02 (53.6%)	325	11	

Swamp	Veg. community	Total swamp area (Ha)	Area (Ha) within 60 m of longwall	Predicted vertical ground movement (mm; MSEC, 2023)		Likelihood of shallow groundwater effects
				Subsidence	Tilt (mm/m)	
			[unchanged]			Likely effects in area of Mallee Heath < 60 m from longwall. Possible elsewhere.
	Banksia Thicket	0.40	0			
	Tea-Tree Thicket	0.28	0			
Den96	Banksia Thicket	0.17	0	<20	<0.5	Unlikely
Den148	Banksia Thicket	0.86	0.53 (61.5%) *[Previously 0.49 Ha]*	3300 *[previously 3250]*	35	Previously mined beneath by Longwall 19. Likely further effects within 60 m of Longwall 19A

The revised assessment indicates that no additional swamps are likely to be affected by subsidence associated with the revised longwall geometry and the overall assessment of potential shallow groundwater effects is unchanged; However, a slightly larger area (0.04 Ha) of Swamp 148 is within 60 m of the revised longwall.

4.1 Influence of faults and lineaments

Observations at the Springvale Mine in the Western Coalfield show that hydrological impacts can occur in swamps overlying connected geological structures (faults or other lineaments) at distances greater than 1200 m from the longwall (Galvin *et al.* 2016). The same effect is not apparent at Dendrobium. Recent studies have identified no anomalous subsidence specifically related to mapped lineaments (MSEC 2019; SRK 2020), and no hydrological impacts at swamp piezometers located near mapped lineaments that are greater than 60 m from the goaf (Watershed Hydrogeo 2019; Watershed HydroGeo 2021). However, it is prudent to consider the possibility of distant impacts where swamps overlie mapped lineaments that intersect the mine footprint.

The geology of Longwall 19A was revised by IMC in early 2023, based on underground mapping of underground first workings, surface and underground drilling, surface geology and geophysical surveys (South32 2023). The report noted a prominent NW-SE joint orientation in MG19, consistent with the orientation of surface lineaments. However, the joints have no impact on roof conditions for mining and are not associated with anomalous water make. Based on recent underground mapping, no significant faults or dykes are expected to intersect Longwall 19A.

5. References

Galvin, J.R., Timms, W. and Mactaggart, B. 2016. *Springvale Mine Extension Project - Extraction Plan for Longwall 419*. Report for NSW Department of Planning and Environment.

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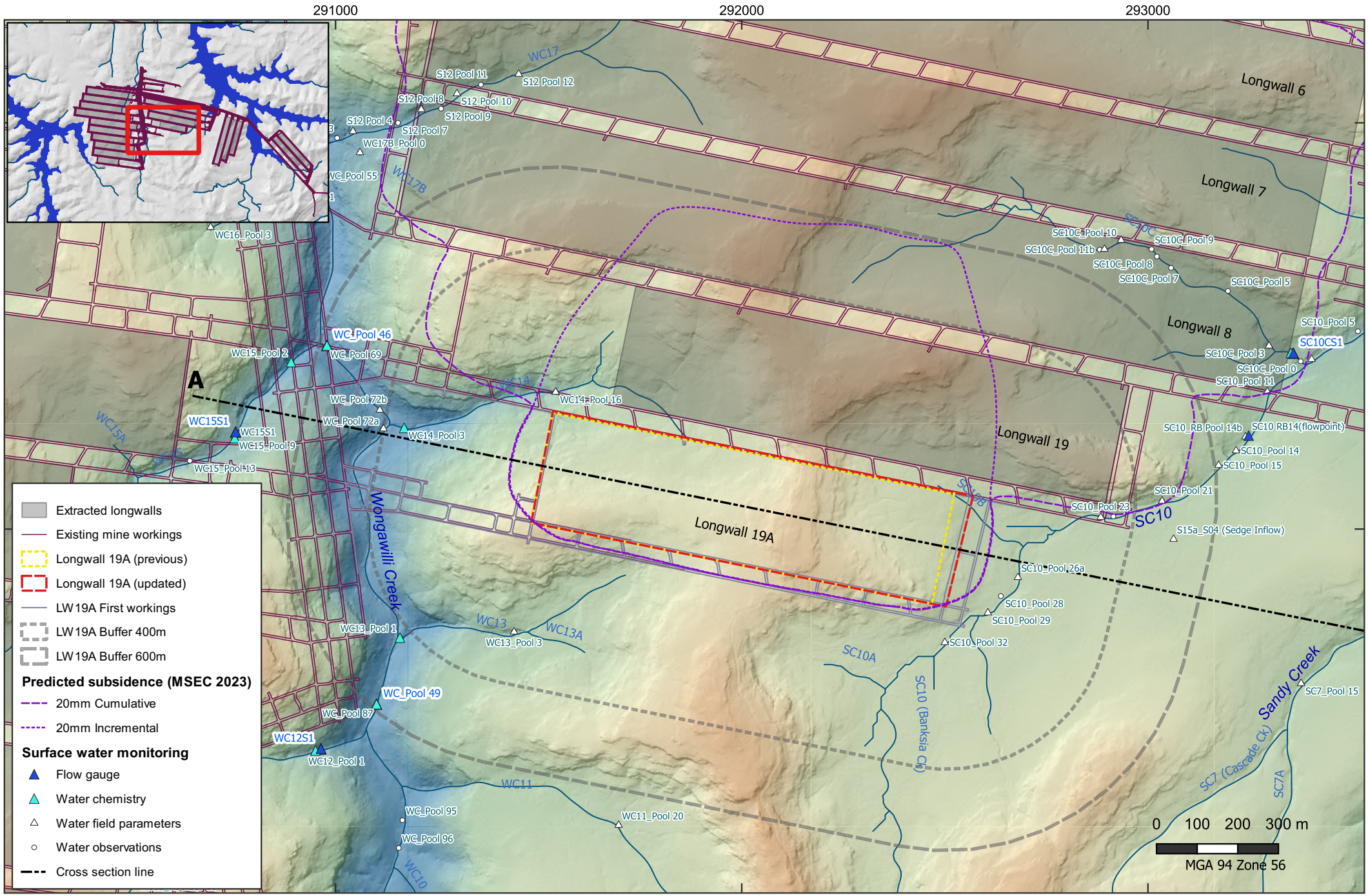
Watershed HydroGeo. 2023. *Addendum to Groundwater Assessment of Longwall 19A Re: Revised Longwall Geometry*. **IMC112–M049c**Report for South32 Illawarra Metallurgical Coal.

Document:
https://hgeocomau.sharepoint.com/sites/hgeo/shared documents/files/client_site/dendrobium/04_projects/j21533_lw19a_smp_surface_water/lw19a_update_2023/d23208_dendrobium_lw19a_sw_assessment_update_v01.docx



Dendrobium Longwall 19A Surface water assessment - Addendum

Location map and surface water monitoring sites

Figure 1

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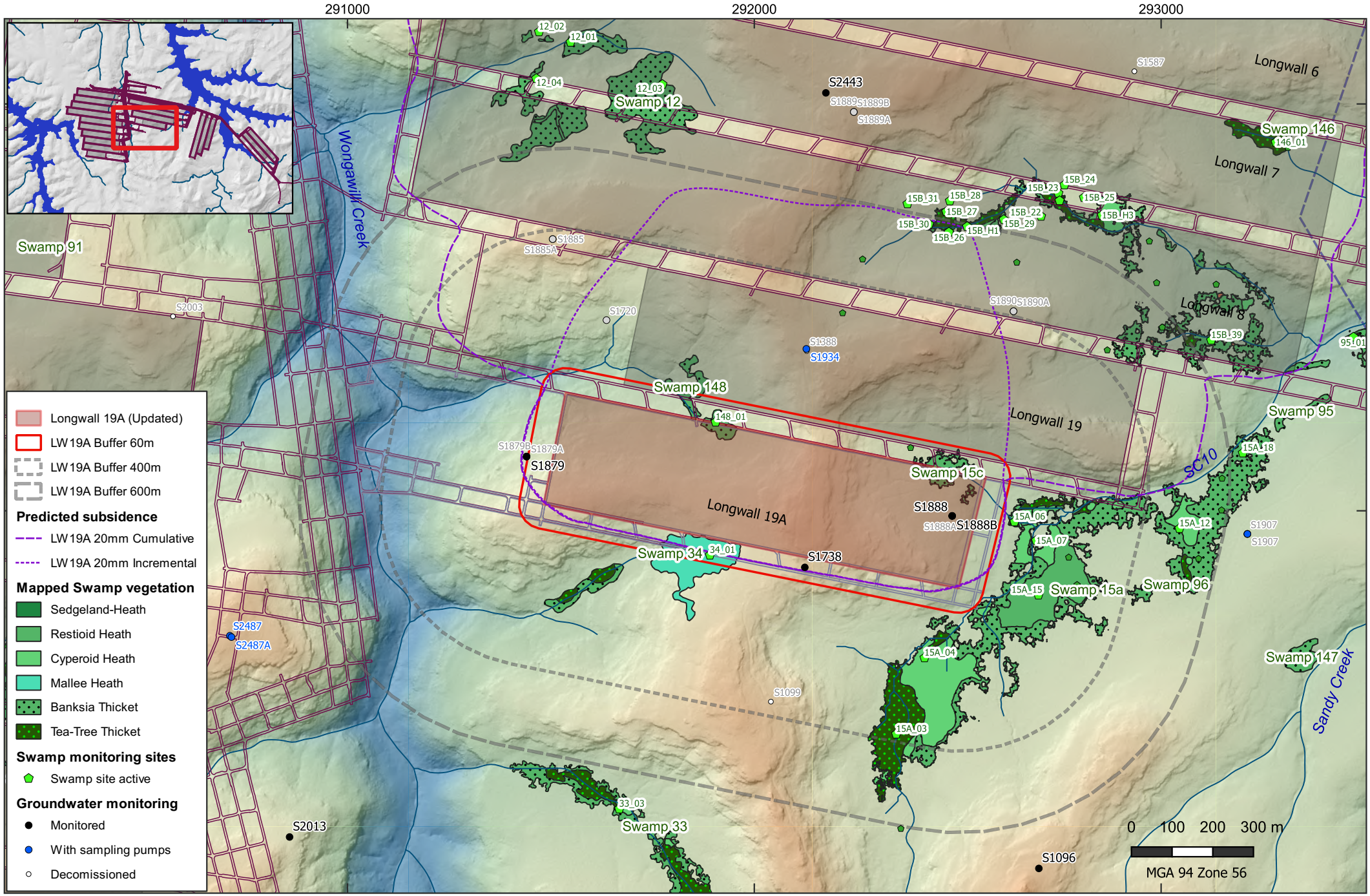

Dendrobium Longwall 19A Surface water assessment - Addendum

Coastal Upland Swamp vegetation and monitoring sites

Figure 2

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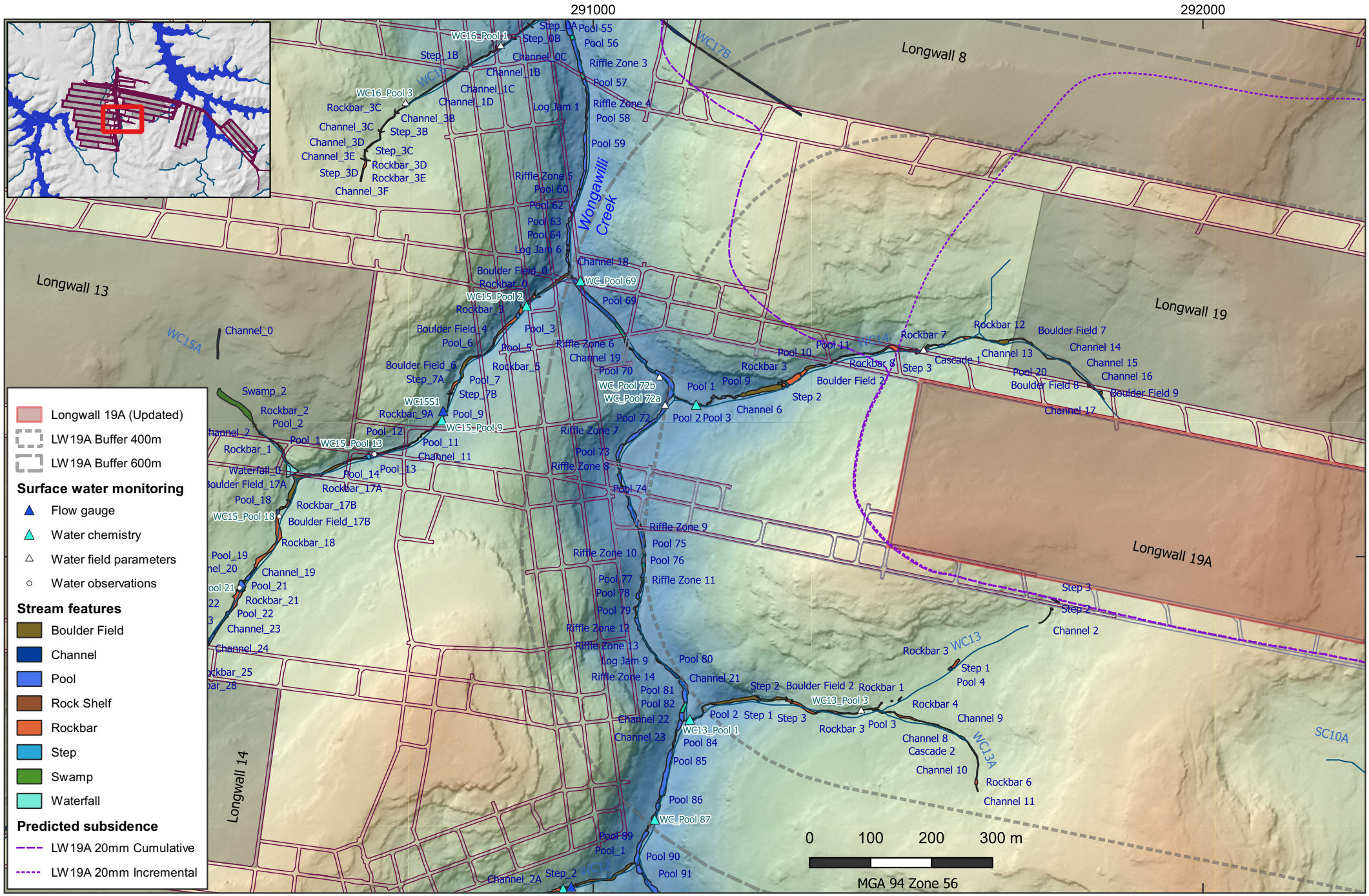

Dendrobium Longwall 19A Surface water assessment - Addendum

Stream morphological mapping within Study Area (Wongawilli Creek)

Figure 3

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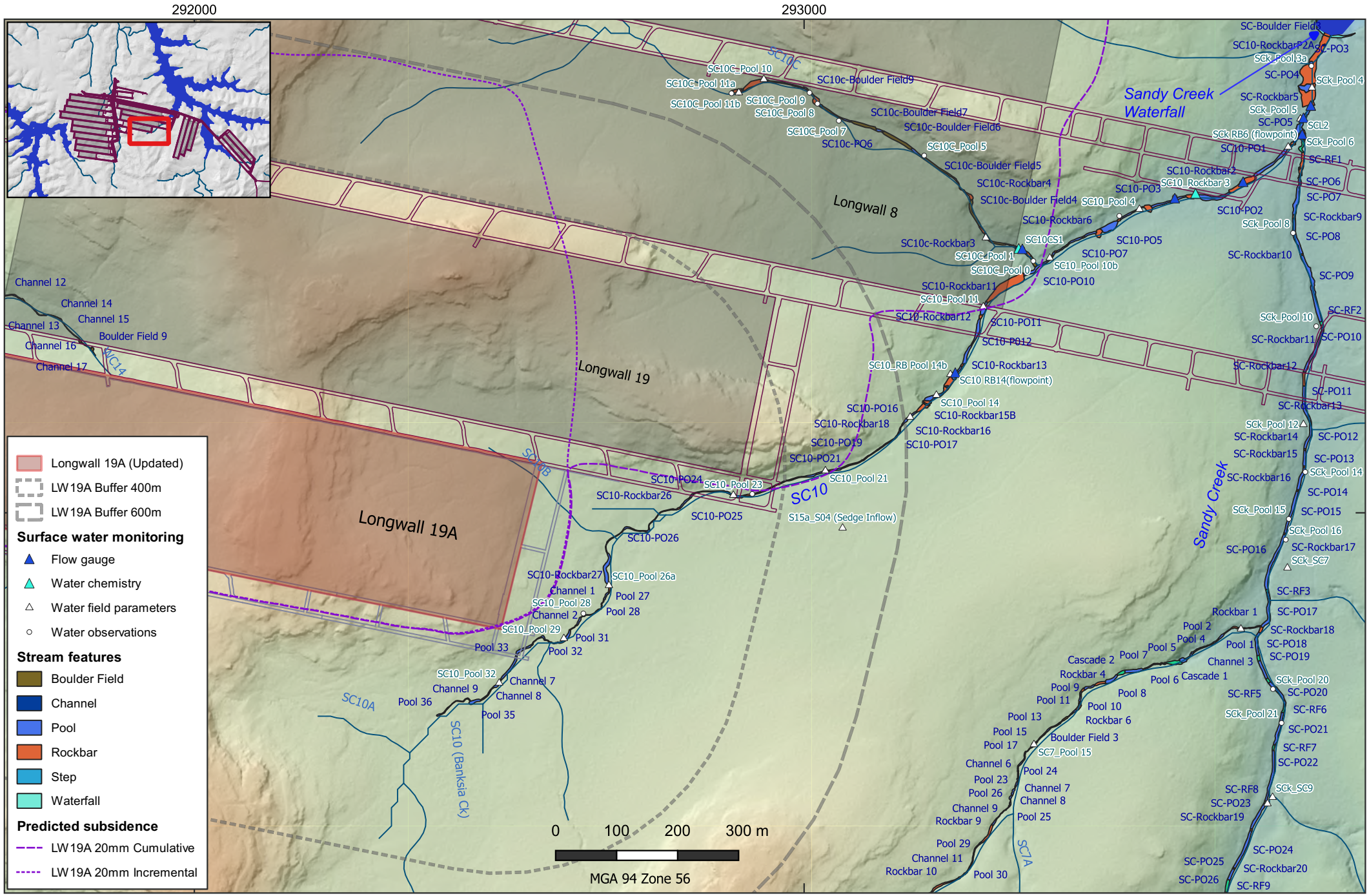

Dendrobium Longwall 19A Surface water assessment - Addendum

Stream morphological mapping within Study Area (Sandy Creek)

Figure 4

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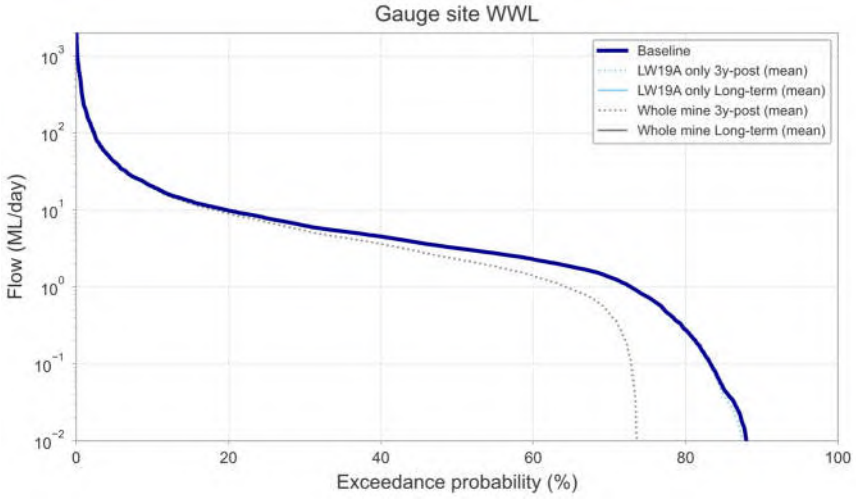

Figure 5. Baseline and forecast flow duration curve for WWL on Wongawilli Creek

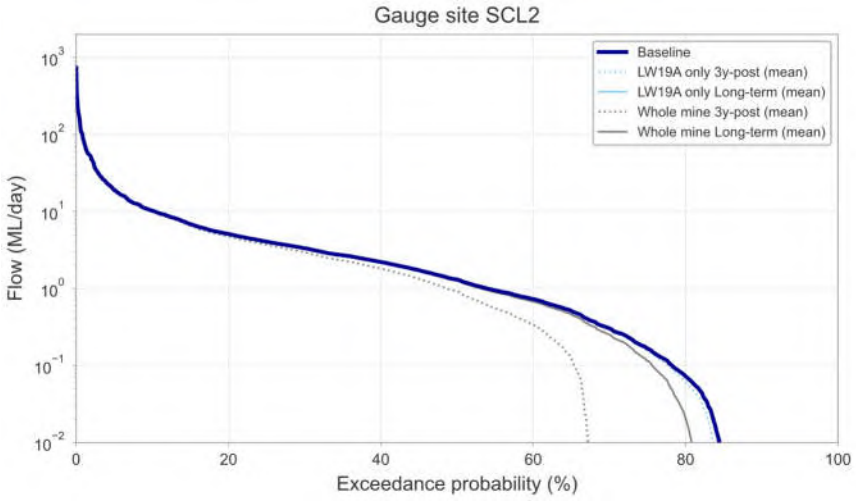

Figure 6. Baseline and forecast flow duration curve for SCL on Sandy Creek

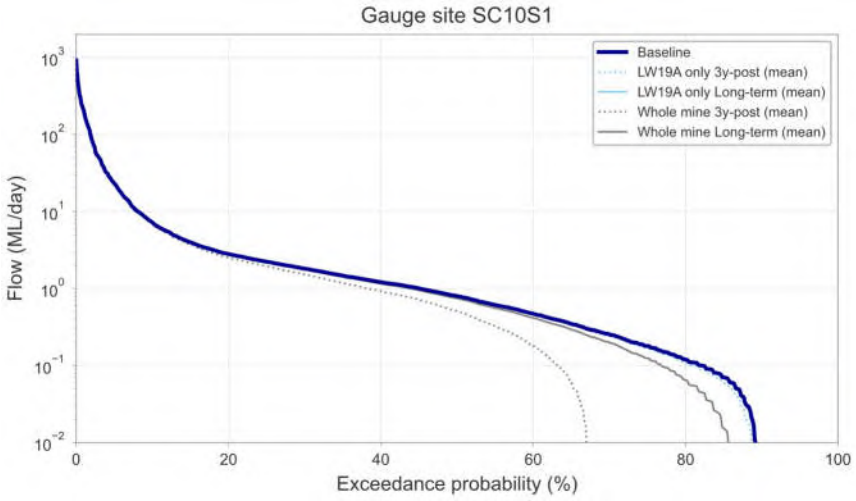

Figure 7. Baseline and forecast flow duration curve for SC10CS1 on tributary SC10

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Excellence in your environment

2 March 2023

Kai Whitaker
Experienced Consultant – Environmental Approvals
Niche Environment and Heritage
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Woonona NSW 2517

E: kwhitaker@niche-eh.com

Dear Kai,

Re: Dendrobium Area 3A Longwall 19A - Terrestrial Ecology Assessment Addendum (Niche ref 7167)

The Dendrobium Longwall (LW) 19A - Terrestrial Ecology Assessment was completed in September 2022 (Niche 2022). South32 Illawarra Metallurgical Coal (IMC) revised the LW19A dimensions during the assessment process and subsequently discovered that the dimensions utilised in the various specialist reports were not consistent, as follows:

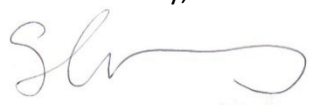
- Terrestrial Ecology Assessment (Niche 2022) and Subsidence Predictions and Impact Assessment Report (MSEC 2022) – revised LW19A dimensions
- Surface Water Assessment (HGeo 2022) and Groundwater Assessment (Watershed HydroGeo 2022) – previous LW19A dimensions.

In discussion with Department of Planning and Environment (DPE), a series of addenda to the specialist impact assessments have been prepared to outline the change to the longwall geometry in comparison with the previously reported dimensions and assess the key changes that this update would have on predicted impacts.

Niche was commissioned by IMC to provide an Addendum to the existing LW 19A Terrestrial Ecology Assessment (Niche 2022), which is provided below. In summary, there are no changes to the Niche (2022) impact assessment required as a result of the updated prediction of impacts provided in the Surface Water Assessment (HGeo 2022) and Groundwater Assessment (Watershed HydroGeo 2022).

I trust that the addendum provided below provides all the information you require for your assessment. Please do not hesitate to contact me if you require any further information.

Yours sincerely,



Sian Griffiths

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Dendrobium Area 3A Longwall 19A - Terrestrial Ecology Assessment Addendum

Table 1 below details the changes to the Terrestrial Ecological Assessment, with regards to the addendums to the Surface Water (HGeo 2023) and Groundwater Assessments (Watershed HydroGeo 2023).

In summary, there are no changes to the Niche (2022) impact assessment:

- No change to predicted impacts to Wongawilli Creek.
- No change to predicted impacts to Sandy Creek and Sandy Creek Waterfall.
- No change to predicted impacts to Wongawilli Creek and Sandy Creek tributaries.
- As the Niche (2022) assessment relied on MSEC (2022) for assessment of likely subsidence impacts to cliffs, rock outcrops and steep slopes, both of which referred to the revised LW19A layout, there is no change to the predicted impacts to cliffs, rock outcrops or steep slopes.
- No change to the predicted impacts to swamps.
- No change to predicted impacts to water quality or surface water.
- No change to predicted impacts to threatened flora and fauna and their habitats.

Table 1: Predicted LW19A subsidence impacts to natural features (Niche 2022) and revised assessment (MSEC 2022, HGeo 2023, Watershed HydroGeo 2023)

Feature	Niche (2022) predicted subsidence or surface water impact LW19A	Revised predicted subsidence or surface water impact LW19A
Wongawilli Creek	It is unlikely that there would be adverse changes in the potential for ponding, flooding, or scouring of the banks along the creek due to the mining-induced tilt. It is possible, however, that there could be some localised changes in the levels of ponding or flooding where the maximum changes in grade coincide with existing pools, steps or cascades along the creek. It is not anticipated that these changes would result in adverse impacts on the creek. It has been assessed that the likelihood of fracturing resulting in surface water flow diversions along Wongawilli Creek, due to the extraction of the proposed LW19A, is low. However, minor fracturing could still occur along the creek, at distances up to approximately 400 m from the proposed longwalls.	The revised surface water assessment (HGeo 2023) states: ''*The changes in geometry are negligible in the western part of the panel that overlaps Wongawilli Creek sub-catchments and there is expected to be no measurable difference in impacts between the revised and previous longwall geometries on Wongawilli Creek and its tributaries*.'' No change to predicted impacts to Wongawilli Creek from Niche (2022).
Sandy Creek and Sandy Creek Waterfall	It is unlikely that adverse impacts would occur along Sandy Creek due to the mining of LW19A. Sandy Creek Waterfall is located 1400 m north-east of the commencing end of LW19A. The predicted incremental closure for Sandy Creek Waterfall due to the mining of LW19 and LW19A are similar to the order of survey tolerance and environmental effects.	The revised surface water assessment states the following (HGeo 2023): • ''*It is unlikely that Sandy Creek Waterfall will experience adverse impacts due to the mining of Longwall 19A based on both the previous and revised geometries.* • *The estimated number of cease-to-flow days per year at key gauging stations on Sandy Creek are not significantly different from previous estimates.*'' No change to predicted impacts to Sandy Creek and Sandy Creek Waterfall from Niche (2022).
Drainage Lines	The drainage lines are located across the study area and, therefore, could experience the full range of predicted subsidence movements.	No change to predicted impacts to Wongawilli Creek tributaries from Niche (2022), as ''*there is expected to be no measurable difference in impacts between the revised*

Feature	Niche (2022) predicted subsidence or surface water impact LW19A	Revised predicted subsidence or surface water impact LW19A
	The potential impacts of increased ponding and scouring of the drainage lines due to tilt are expected to be minor and localised. Impacts resulting from changes in surface water flows due to tilt are expected to be small in comparison with those which occur during natural flooding conditions. It is expected that fracturing of the bedrock would occur along the sections of the drainage lines that are located directly above the proposed LW19A and the adjacent future LW19. Fracturing can also occur outside the extents of the longwalls, with minor and isolated fracturing occurring at distances up to approximately 400 m. Surface water flow diversions are likely to occur along the sections of drainage lines that are located directly above and adjacent to the longwalls.	*and previous longwall geometries on Wongawilli Creek and its tributaries*'' (HGeo 2023). Watershed HydroGeo (2023) found that under the revised layout, SC10 was closer to LW19A which would increase the potential for surface cracking effects, but the revised void width is lower, which slightly reduces the risk or magnitude of impact related to the connected fracture zone. Niche (2022) relied on the MSEC (2022) assessment of potential for surface cracking at SC10, therefore the above does not change the predicted impacts to Sandy Creek tributaries from Niche (2022).
Cliffs "*Continuous rock face, including overhangs, having a minimum length of 20 m, a minimum height of 10 m and a minimum slope of 2 to 1 (>63.4º)*"	While the cliffs could experience very low levels of vertical subsidence due to the mining of LW19A, they are not expected to experience measurable tilts, curvatures, or strains. Cliffs DA3-CF16 to DA3-CF18 and DA3-CF24 are situated within the valley of Wongawilli Creek. While the valleys where the cliffs are located could experience valley-related effects, the cliffs themselves are unlikely to experience upsidence or compressive strain due to valley closure, as they are located along the valley sides. Cliff DA3-CF7 is located above the eastern end of LW19 and DA3-CF17 is partially located above the western end of that LW. It is possible that isolated rock falls could occur at DA3-CF7 and DA3-CF17, due	As the Niche (2022) assessment relied on MSEC (2022) for assessment of likely subsidence impacts to cliffs, and both assessments referred to the revised layout, there is no change to the predicted impacts to cliffs from Niche (2022).

Feature	Niche (2022) predicted subsidence or surface water impact LW19A	Revised predicted subsidence or surface water impact LW19A
	to the mining of LW19A, where they are located above the previously mined area. Cliffs DA3-CF16 to DA3-CF18 and DA3-CF24 are located outside the mining area. It is unlikely that these cliffs would experience adverse impacts due to the mining of LW19A based on their distances from the longwall and the very low levels of predicted subsidence effects.	
Rock outcrops "Exposed rockfaces with heights of less than 10 m or slopes of less than 2 in 1." Steep slopes "*An area of land having a gradient between 1 in 3 (33% or 18.3º) and 2 in 1 (200% or 63.4º)*".	The rock outcrops and steep slopes are located across the study area and, therefore, are expected to experience the full range of predicted subsidence movements. It is likely that fracturing, and cracking would occur where these features are located directly above the proposed longwalls. The crack widths could be similar to those previously observed in LW1 and LW2.	As the Niche (2022) assessment relied on MSEC (2022) for assessment of likely subsidence impacts to rock outcrops and steep slopes, and both assessments referred to the revised layout, there is no change to the predicted impacts to rock outcrops or step slopes from Niche (2022).
Swamps, wetlands and water related ecosystems	While swamps Den12, Den15a, Den15b and Den96 could experience very low levels of vertical subsidence due to the mining of LW19A only, they are not expected to experience measurable tilts, curvatures, or strains. The maximum predicted incremental subsidence effects occur at Den148 and Den15c as they are partially located above the tailgate of LW19A. The predicted incremental subsidence effects for Den34 are lower since this swamp is generally located outside the mining area apart from its northern extent. It is considered unlikely that there would be adverse changes in the levels of ponding or scouring for the	Watershed HydroGeo (2023) states that there is a greater chance of surface cracking on Swamps Den15c and 15a due to reduced distance from the panel footprint under the revised layout of LW19A. HGeo (2023 states the following in relation to swamp impacts: ''*No additional swamps are likely to be affected by subsidence associated with the revised longwall geometry and the overall assessment of potential shallow groundwater effects is unchanged; however, the revised longwall layout may result in impacts to a slightly larger area (0.04 Ha) of Swamp 148 than previously assessed. Effects within Swamp 15a are possible within 400 m of Longwall 19A*.

Feature	Niche (2022) predicted subsidence or surface water impact LW19A	Revised predicted subsidence or surface water impact LW19A
	swamps within the study area based on the predicted vertical subsidence and tilt. Den34, Den148 and Den15c are partially located above the proposed LW19A and Den12, Den15b and Den148 are partially located above the existing LW7 and LW8. The valley-related effects for Den12 and Den15b occur predominately due to the existing LW7 and LW8, rather than the proposed LW19A. It is likely, therefore, that fracturing would occur in the bedrock beneath these swamps, predominately in areas located above and adjacent to the mining area. At Swamps Den15a and Den34, it is possible that a series of smaller fractures, rather than one single fracture, could develop in the bedrock. Fracturing or surface cracking due to mine subsidence are not anticipated at Den96 due to the mining of LW19A. Den12, Den15b, Den15c and Den148 are predicted to experience valley-related effects that could result in the dilation of the strata beneath these swamps, which could result in the diversion of some surface water flows beneath parts of these swamps where they are located directly above the mining area. The drainage lines upstream of these swamps flow during and shortly after rainfall events. Where there is no connective fracturing to any deeper storage, it is likely that surface water flows will re-emerge at the limits of fracturing and dilation. Den12 and Den15b are located directly above LW7 and LW8 and, therefore, the potential impacts predominately occur due to these existing longwalls, rather than the proposed LW19A.	*No additional impact to surface watercourses or swamps is expected due to faults and lineaments intersecting the revised longwall layout*.'' Niche (2022) relied on the MSEC (2022) assessment of potential for surface cracking at swamps, which utilised the revised LW layout of LW19A, rather than HGEO (2022) or Watershed HydroGeo (2022). Consequently, Niche (2022) assessed the revised area of impact to Swamp 148 and possible cracking within 400 m of LW 19A within Swamp 15a. Therefore the above does not change the predicted impacts to swamps from Niche (2022).

Feature	Niche (2022) predicted subsidence or surface water impact LW19A	Revised predicted subsidence or surface water impact LW19A
	Only small areas of Den148 and Den15c are located directly above the proposed LW19A.	
Water quality and surface water	Reduction to baseflow components of Wongawilli Creek and Sandy Creek would manifest as an increase in low-flow (and no-flow) days during prolonged dry periods. Water quality influence due to mining is expected to be minor in stream reaches within subsidence affected areas. Effects are likely to include temporary changes in water salinity, pH and iron content with local transient discolouration of streambeds and rock faces by iron hydroxide. Water quality effects on stored waters of the reservoirs are expected to be negligible and undetectable. Parts of Swamp Den15c and Den148 overlap with the proposed longwall footprint and Swamp Den34 extends within 60 m of the longwall. Based on previous experience at DA3B and subsidence predictions, shallow groundwater levels will likely be affected in Swamp Den15c, Den148 and Den34 that are within 60 m of the LW19A. Shallow groundwater impacts are possible in areas of Swamp 15a that are within 400 m of Longwall 19A. Areas of Swamps Den12, Den15b and Den148 were previously mined under (or were within 60 m of) Longwalls 7, 8 and 19. The remaining swamps are unlikely to be impacted since they are located more than 400 m from the proposed goaf and/or are predicted to experience negligible ground movement related to subsidence and valley closure.	The revised surface water assessment states the following (HGeo 2023): • *"The estimated number of cease-to-flow days per year at key gauging stations on Wongawilli Creek and Sandy Creek are not significantly different from previous estimates."* • *''The assessment of potential impacts to water quality impact remains unchanged from the previous assessment.''* The revised Groundwater assessment (Watershed HydroGeo 2023) states: • *"The change to Longwall 19A geometry would have negligible to very minor effects on the behaviour of groundwater and connected surface water.''* Therefore, there is no change to predicted impacts to water quality or surface water from Niche (2022). Watershed HydroGeo (2023) refer to an increased likelihood of surface cracking in drainage lines SC10 and SC10B and swamps 15a and 15c. However, Niche (2022) relied on the MSEC (2022) assessment of potential for surface cracking at drainage lines and swamps (which assessed the revised LW19A layout), rather than HGeo (2022) or Watershed HydroGeo (2022), therefore the above does not change the predicted impacts to Sandy Creek tributaries from Niche (2022).

Feature	Niche (2022) predicted subsidence or surface water impact LW19A	Revised predicted subsidence or surface water impact LW19A
Threatened Flora	Four threatened plant species (*Epacris purpurascens var. purpurascens, Pultenaea aristata, Cryptostylis hunteriana* and *Leucopogon exolasius)* were deemed to have habitat in the study area that may be potentially impacted by subsidence. Upland Swamps and creek line habitat may be impacted by subsidence mechanisms. Impacts for these species are likely to be minimal.	Given there are no changes to the predicted impacts on upland swamps and drainage lines from Niche (2022) (as detailed above), there are therefore no changes to the predicted impacts on threatened flora habitats.
Threatened Fauna	Nine threatened fauna species are considered to be potentially impacted by subsidence resulting from LW19A comprising: • Littlejohn's Tree Frog, Giant Burrowing Frog - Potential impacts include changes to flow regimes, loss of surface flow and water retention within breeding pools. Changes in Upland Swamps are likely to impact the species via influencing downstream pool availability or permanency or through changes in sheltering habitat within swamps. • Red-crowned Toadlet – changes in hydrology related to cracking of bedrock underlying streams providing habitat for the Red-crowned Toadlet have the potential to influence moisture levels and retention of moisture within small pools, soaks and leaf litter environments on which Red-crowned Toadlets rely to complete their lifecycle.	Given there are no changes to the predicted impacts on upland swamps, drainage lines, cliffs, rock outcrops and steep slopes from Niche (2022) (as detailed above), there are therefore no changes to the predicted impacts on threatened fauna habitats.

Feature	Niche (2022) predicted subsidence or surface water impact LW19A	Revised predicted subsidence or surface water impact LW19A
	• Reptiles: Broad-headed Snake, Rosenberg's Goanna - minimal impacts for these species • Large Bentwing Bat, Little Bentwing Bat, - Potential impacts include death or injury as result of rock fall or collapse, possible changes in availability of breeding and roosting habitat. • Southern Myotis: Potential impacts include death or injury as result of rock fall or collapse and impacts on prey availability due to drying of pools • Invertebrates: Giant Dragonfly - Potential impacts include loss of upland swamp habitat as a result of subsidence. From the above species, it is considered that potentially significant impacts could occur for the three frog species and the Giant Dragonfly.	

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3 March 2023

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Dear Kai,

LONGWALL 19A SMP AQUATIC ECOLOGY ASSESSMENT – ADDENDUM

INTRODUCTION

South32 – Illawarra Metallurgical Coal (IMC) is using longwall mining to extract coal from the Dendrobium Coal Mine, situated near Cordeaux approximately 20 kilometres (km) west of Wollongong. IMC are proposing to extract coal from Longwall 19A in Area 3A (the Project) and engaged Stantec (formerly Cardno and The Ecology Lab) to undertake the Aquatic Ecology Assessment (AEA) to support the Subsidence Management Plan (SMP) application for this longwall. The AEA (Cardno 2022) was delivered 30 September 2022 and included assessment of the potential impacts of the Project on aquatic ecology, including threatened species, and any cumulative impacts, in Wongawilli Creek, Sandy Creek and Lake Cordeaux and their tributaries that may experience impacts associated with potential mining subsidence due to Longwall 19A extraction. The impact assessment in the AEA was based on the Longwall 19A layout and predictions of mine subsidence (MSEC 2022) and associated predicted impacts to surface water and groundwater quality and availability in the surface water (WHG 2022) and groundwater assessment (HGeo 2022).

Following revision of the longwall layout assessed in WHG (2022) and HGeo (2022) for consistency with that assessed in Cardno (2022) and MSEC (2022), two addenda documents were prepared that described updates to the surface water (HGeo 2023) and groundwater (WHG 2023) assessments. IMC requested Stantec prepare an aquatic ecology addendum that described any associated changes to the aquatic ecology impact assessment following the revised surface water and groundwater predictions in HGeo (2023) and WHG (2023) respectively.

Specifically, the scope of the aquatic ecology assessment addenda includes:

- Review of revised surface water and groundwater specialist studies, particularly with respect to the revised longwall layout and associated changes to the predictions of potential impacts contained in each study.
- Revision of the aquatic ecology impact assessment based on the changes to impact assessment in each of the specialist studies.
- Preparation of a stand-alone addenda (this document) that describes any changes to the specialist studies with respect to aquatic ecology, and any updates to the aquatic ecology impact assessment. This would include descriptions of changes (if any) to the recommended monitoring program.

SUMMARY OF CHANGES

Longwall Layout

The previous surface water (WHG 2022) and groundwater assessment (HGeo 2022) were based on a longwall width of 275 m and 305 m, respectfully, and in both assessments a longwall length of 1,009 m. The revised longwall layout assessed in HGeo (2023), and which was originally assessed in Cardno (2022) and MSEC (2022),

was 281 m wide and 1,051 long. The revised layout represents an increase in longwall width of 6 m in the case of the surface water assessment, and a reduction in longwall width of 14 m in the case of the groundwater assessment. In each case, revised longwall layout extended 42 m farther to the east and closer to Lake Cordeaux and Sandy Creek tributaries SC10 and SC10B compared to the previous layout.

Surface Water

The changes to the surface water impact assessment in HGeo (2023) based on the updated longwall layout are summarised as:

- Due to conservative predictions in WHG (2022), revised predictions of reduced surface flow were unchanged or slightly smaller compared to the original longwall layout HGeo (2023) (**Table 1-1**).

Table 1-1 Predicted changes in number of annual zero flow days based on the original and updated Longwall 19A layout (HGeo 2023).

Scenario	Wongawilli Creek - WWL		Sandy Creek - SCL		Sandy Creek – SC10S1	
Baseline (background number of zero flow days per year)	44		57		39	
	Previous	**Revised**	**Previous**	**Revised**	**Previous**	**Revised**
Incremental short-term	47	46	57	57	39	39
Incremental long-term	47	44	59	57	41	40
Cumulative short-term	97	96	120	120	121	120
Cumulative long-term	44	44	72	70	56	52

- Due to the revised Longwall 19A layout not intersecting any additional watercourses, the predictions of potential water quality impacts are unchanged (i.e., minor in watercourses within subsidence affected areas). Predictions of water quality effects on stored waters of Lake Cordeaux remained unchanged and negligible.

Groundwater

The changes to the groundwater impact assessment in HGeo (2023b) based on the revised longwall layout are summarised as:

- Overall, the updated longwall layout is associated with a reduced magnitude of groundwater drawdown and reduced surface water flow compared to the original longwall layout. This is due the reduction in longwall width.
- The potential for groundwater drawdown to result in reduced surface water flow in Wongawilli Creek reduced slightly.
- Effects on Lake Cordeaux would be unchanged based on the updated longwall layout (i.e., negligible).

CONSEQUENCES FOR THE AQUATIC ECOLOGY IMPACT ASSESSMENT

Physical Impacts

As the subsidence predictions (MSEC 2022) and aquatic ecology impact assessment (Cardno 2022) were based on the revised longwall layout, there is no change to predictions of impacts to aquatic habitat and biota due to physical mining impacts, subsidence induced surface fracturing, flow diversions and pool drainage. The potential for significant impacts to Wongawilli Creek remain unchanged (i.e., are not expected.) and there is no change to the predicted potential reduction in aquatic habitat in first and second order tributaries that could occur following mining induced subsidence, fracturing and flow diversions. Although impacts to aquatic habitat and biota in these tributaries would be significant at the scale of individual pools and tributaries, in isolation, impacts associated with extraction of Longwall 19A would be minimal in the context of the upper Avon River and Cordeaux River catchments (Cardno 2022).

Water Availability and Quality

Previous surface and groundwater modelling (HGeo 2022; WHG 2022) indicated that the short-term (up to 6 years) and long-term (> 40 years) incremental reduction in flow along Wongawilli Creek due to extraction of Longwall 19A would be up to 0.02 ML/day (maximum reduction in the short-term). During drought periods, this was associated with a negligible increase in the duration and length over which cease-to-flow conditions would occur in Wongawilli Creek (HGeo 2022). Change in flow in Sandy Creek would was also predicted to be negligible (HGeo 2022). Associated impacts to aquatic habitat and biota due to groundwater depressurisation and reductions in surface water availability associated with Longwall 19A, in isolation, were therefore predicted to be negligible (Cardno 2022). The revised predictions of increase in the number of zero flow days in Wongawilli Creek, Sandy Creek and SC10 (**Table 1-1** and HGeo 2023) represent no-change or a reduction in the potential for zero-flow days to occur in these watercourses due to extraction of Longwall 19A. This was due to a reduced magnitude of groundwater drawdown associated with the revised longwall layout (WHG 2023). Thus, potential impacts for aquatic habitat and biota associated with the revised longwall layout would be no more severe, and most modelled scenarios less severe, than predicted in Cardno (2022).

The estimated incremental leakage losses from both reservoirs as a result of extraction of the revised Longwall 19A layout is estimated to be negligible (WHG 2023). This represents no change to the predictions of associated negligible impacts to aquatic habitat and biota in Cardno (2022). Similarly, the revised layout of Longwall 19A does not intersect any additional watercourses and the assessment of potential water quality impact remains unchanged (HGeo 2023). That is, minor water quality impacts in tributaries affected directly by subsidence and not detectable in watercourses that are not directly undermined (including Wongawilli Creek).

Cumulative Impacts

During periods of extended drought, cumulative impacts on surface water flows due to groundwater depressurisation following extraction of Area 3A, Area 3B and Area 3C will likely result in reduced flows and draining of some pools in Wongawilli Creek adjacent to these mine areas (Cardno 2022). Flow and pool water levels would recover following the return of substantial rainfall. Macquarie perch has not been identified in these areas, and so should not be affected. There would, however, be temporary (likely up to several months) reductions in aquatic habitat availability, including Type 1 – KFH, and connectivity. The revised Longwall 19A layout represents no change or a reduction in the potential for short-term and long-term cumulative increases in zero flow days in Wongawilli Creek, Sandy Creek and SC10 (**Table 1-1** and HGeo 2023). Thus, potential impacts for aquatic habitat and biota would be no more severe, and most modelled scenarios less severe, than predicted in Cardno (2022).

CONCLUSION

The revised Longwall 19A layout assessed in the updated surface water and groundwater assessments is associated with the same or less severe impacts to water availability and quality in nearby watercourses compared to the original assessments. This is due primarily to the reduction in longwall width and lower potential for groundwater drawdown and smaller predicted reductions in surface flows in watercourses. As a consequence, associated potential impacts to aquatic habitat and biota due to extraction of the revised Longwall 19A are no worse, and in some cases less severe, than predicted in Cardno (2022). Overall, the revised longwall layout represents slightly improved outcomes for aquatic ecology compared to the previous longwall layout. Therefore, no changes to the recommendations and monitoring plan outlined in Cardno (2022) are considered necessary.

Yours sincerely,

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