Australasian Groundwater and
Environmental Consultants Pty Ltd

Report on

Yancoal Ashton Longwalls 205-208 Extraction Plan Surface and Groundwater Impact Assessment

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Report on

Yancoal Ashton Longwalls 205-208 Extraction Plan Surface and Groundwater Impact Assessment

1 Introduction

1.1 Background

The Ashton Coal Project (Ashton) is located 14 kilometres (km) northwest of Singleton in the Hunter Valley region of New South Wales (NSW). Ashton Coal Operations Ltd (ACOL) operates the mine and is wholly owned and operated by Yancoal Australia Limited (Yancoal).

Ashton was granted development consent on 11 October 2002 and commenced operations in 2003 at the former north-east open cut mine (NEOC). Coal was extracted from the Permian Foybrook Formation from eleven seams of varying thickness, down to and including the Lower Barrett seam (LB). Underground mine development commenced in July 2006 in an area located predominantly south of the New England Highway. Open cut mining subsequently ceased in 2011.

The general layout of the underground mine includes up to eight longwalls (LW) panels (LW1-LW4, LW5A, LW6A-LW6B, LW7A-LW7B and LW8). The Pike's Gully seam (PG) was mined from 2006 to 2012, followed by the Upper Liddell Seam (ULD) from 2012 to 2017. Mining is currently underway in the Upper Lower Liddell (ULLD) seam and extraction of ULLD panels is expected to be completed by late 2023.

Australasian Environmental and Groundwater Consultants Pty Ltd (AGE 2016a) previously reported on the impacts of the proposed extraction of longwalls panels 201-204 in the ULLD seam. From May 2021, ACOL is planned to continue mining the ULLD by extracting coal from panels LW205-LW208. The estimated groundwater impacts from proposed extraction of LW205-LW208 are presented in this report.

1.2 Objective

The objective of this assessment is to predict groundwater impacts from the proposed extraction of longwalls panels 5 to 8 in the Upper Lower Liddell seam (LW205, LW206A, LW206B, LW207A, LW207B and LW208) to the satisfaction of the NSW Government departments.

1.3 Scope

In order to achieve the above project objective, AGE undertook the following scope:

- describe the existing environment and assess how the groundwater system operates (system conceptualisation), focussing on the ULLD;
- update the mine plan and panel extraction dates in the AGE (2016b) groundwater model;
- review the potential impacts specifically related to the mining of LW205 to LW208 on groundwater levels (in the alluvium and fractured rock aquifers), groundwater quality, stream baseflow, groundwater dependent ecosystems (GDEs) and other groundwater users;
- review drawdown at the completion of LW208, on top of any cumulative impacts from proceeding or adjacent mining;

- analyse the sensitivity of key parameters affecting the model; and
- make recommendations resulting from the assessment, including suggested monitoring, mitigation and management strategies.

1.4 Regulatory framework

The planned mine progression requires consideration of the following NSW Government legislation, policies and guidelines for groundwater:

- *Water Act 1912,* included in the *Water Management Act 2000* as of 1 July 2016;
- *Water Management Act 2000* and the Water Sharing Plan for Hunter Regulated River Water Source and Hunter Unregulated and Alluvial Water Sources;
- Groundwater Quality Protection Policy;
- Groundwater Dependent Ecosystems Policy;
- Groundwater Quantity Management Policy; and
- Aquifer Interference Policy (2012).

A summary of the above legislation, policies and guidelines is provided in Appendix A.

1.5 Water licensing

Water licences held by ACOL are summarised in Table 1.1. ACOL has a combined total surface water and groundwater entitlement of 2271.5 ML/year assuming full allocation. It is noted that groundwater seepage from the alluvial groundwater source and from the surface water source is also accounted for under these entitlements.

Table 1.1 Ashton water licences

Licence No.	Reference	Category	Approved extraction (ML/year)
Surface water			
WAL 984	20AL201282	Glennies Creek (General Security)	9
WAL 15583	20AL204249	Glennies Creek (General Security)	354
WAL 997	20AL201311	Glennies Creek (High Security)	11
WAL 8404	20AL200491	Glennies Creek (High Security)	80
WAL 1358	20AL203056	Glennies Creek (Supplementary)	4
WAL 1121	20AL201625	Hunter River (General Security)	335
WAL 6346	20AL203106	Hunter River (Supplementary)	15.5
WAL 1120	20AL201624	Hunter River (High Security)	3
WAL 19510	20AL211015	Hunter River (High Security)	130
WAL 23912	20AL211423	Bowmans Creek (Unregulated River)	14
WAL36702	20AL212975	Bowmans Creek (Unregulated River)	116
WAL36703	20AL212976	Bowmans Creek (Unregulated River)	150
Groundwater			
WAL 29566	20AL212287	Bowmans Creek (Aquifer Access)	358
WAL 41501		Sydney Basin- North Coast Groundwater Source	100
WAL 41552		Sydney Basin- North Coast Groundwater Source	511
WAL 41553		Sydney Basin- North Coast Groundwater Source	81

2 Hydrogeological environment

2.1 Geology

The following main stratigraphic units occur at Ashton (from youngest to oldest):

- Quaternary alluvium; and
- Permian Wittingham Coal Measures, key units of interest include:
  - Regolith/weathered profile;
  - Conglomerate within the Lemington Seams ply profile (from here on referred to as the Lemington Conglomerate); and
  - Four main mining seams – PG, ULD, ULLD and LB.

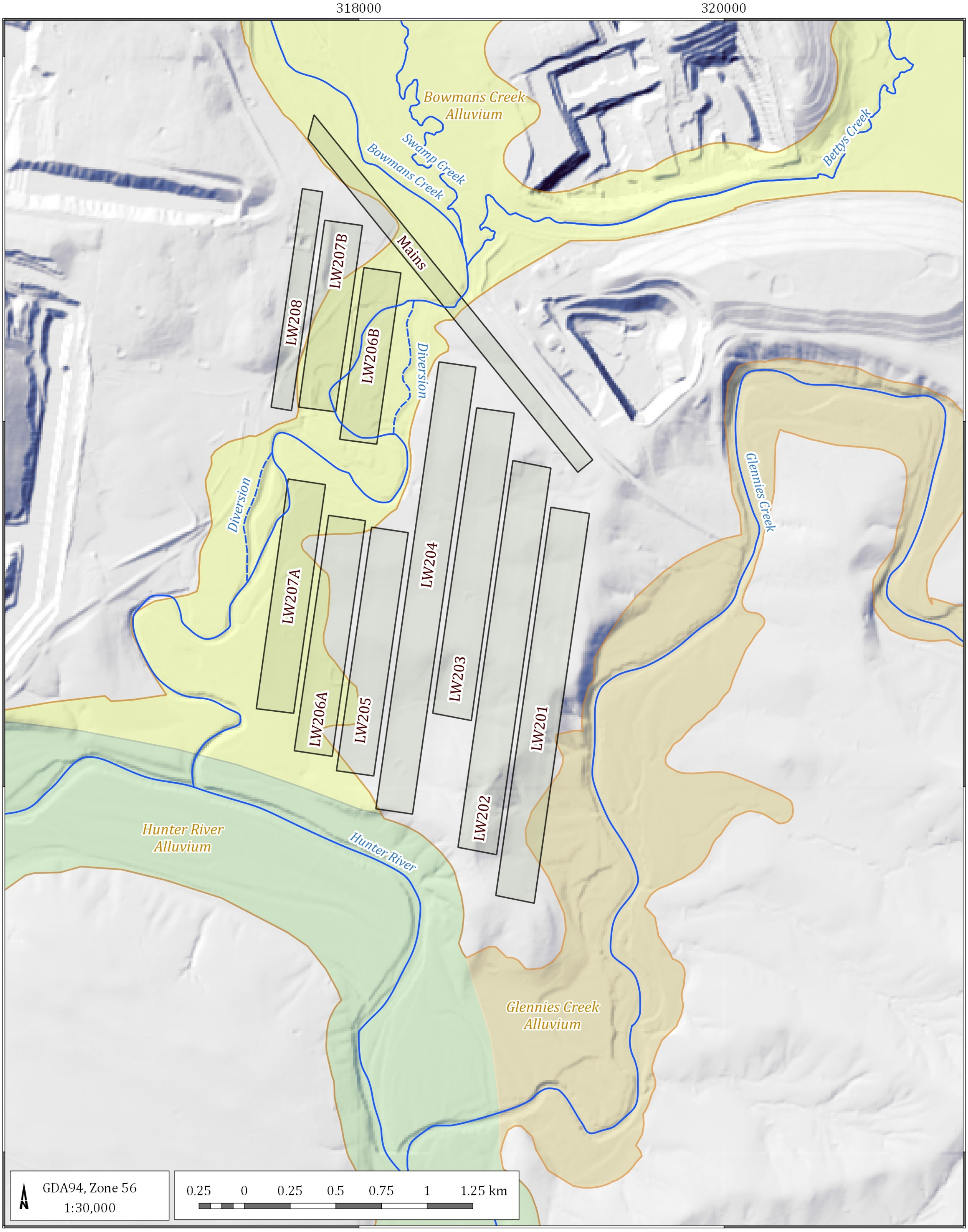
The Quaternary/recent aged alluvium is associated with the Hunter River, Glennies Creek and Bowmans Creek flood plains. The outline of the alluvial extents is shown on Figure 2.1. Along the drainage lines, the surficial alluvium is typically constrained to within 500 m of the creeks and is between 7 m to 15 m thick. The alluvium bodies have been divided into two main types: a coarser grained permeable alluvium and a fine grained low permeability colluvium (refer Figure 2.2).

The Wittingham Coal Measures comprise coal seams which occur with various splits and plies, with a coal thickness of between 2 m and 2.5 m. The coal measures are interbedded with units of siltstone, sandstone and shale, referred to as interburden in the mining context. The four target coal seams at Ashton are separated by approximately 30 m of interburden.

The Wittingham Coal Measures dip west south-west in the Ashton area, an orientation locally controlled by the Camberwell Anticline to the east of the mine and the Bayswater Syncline to the west. The top target seam at Ashton (PG) subcrops under the Glennies Creek alluvium (GCA) approximately 300 m east of the mine, while the lowest target seam (LB) subcrops under regolith approximately 2 km away from the east of the mine. In the western portion of the mining area, the overburden above the top target coal seam (PG) ranges in thickness between 100 m (north end of LW7) and 190 m (south end of LW7).

Groundwater occurs within the Quaternary Alluvium (in the Hunter River, Bowmans Creek and Glennies Creek) and the Permian Wittingham Coal Measures. Regional groundwater flow follows a west south-west direction imposed by the sedimentary beds in the area.

Locally, groundwater recharge occurs primarily via rainfall infiltration in the alluvium, direct infiltration in outcrop of the coal measures and indirect infiltration from the alluvium into the subcrop of the coal measures. The local hydraulic connectivity between the coal measures and the alluvium, however, is not well understood.



LEGEND

- Drainage
- Diversion
- Underground mine (Upper Lower Liddell Seam)
- Quaternary alluvium/colluvium
- Bowmans Creek Alluvium
- Glennies Creek Alluvium
- Hunter River Alluvium

Ashton Longwall 205-208 EP (G1922M)

Alluvium boundaries

DATE 27/04/2020

FIGURE No: **2.1**

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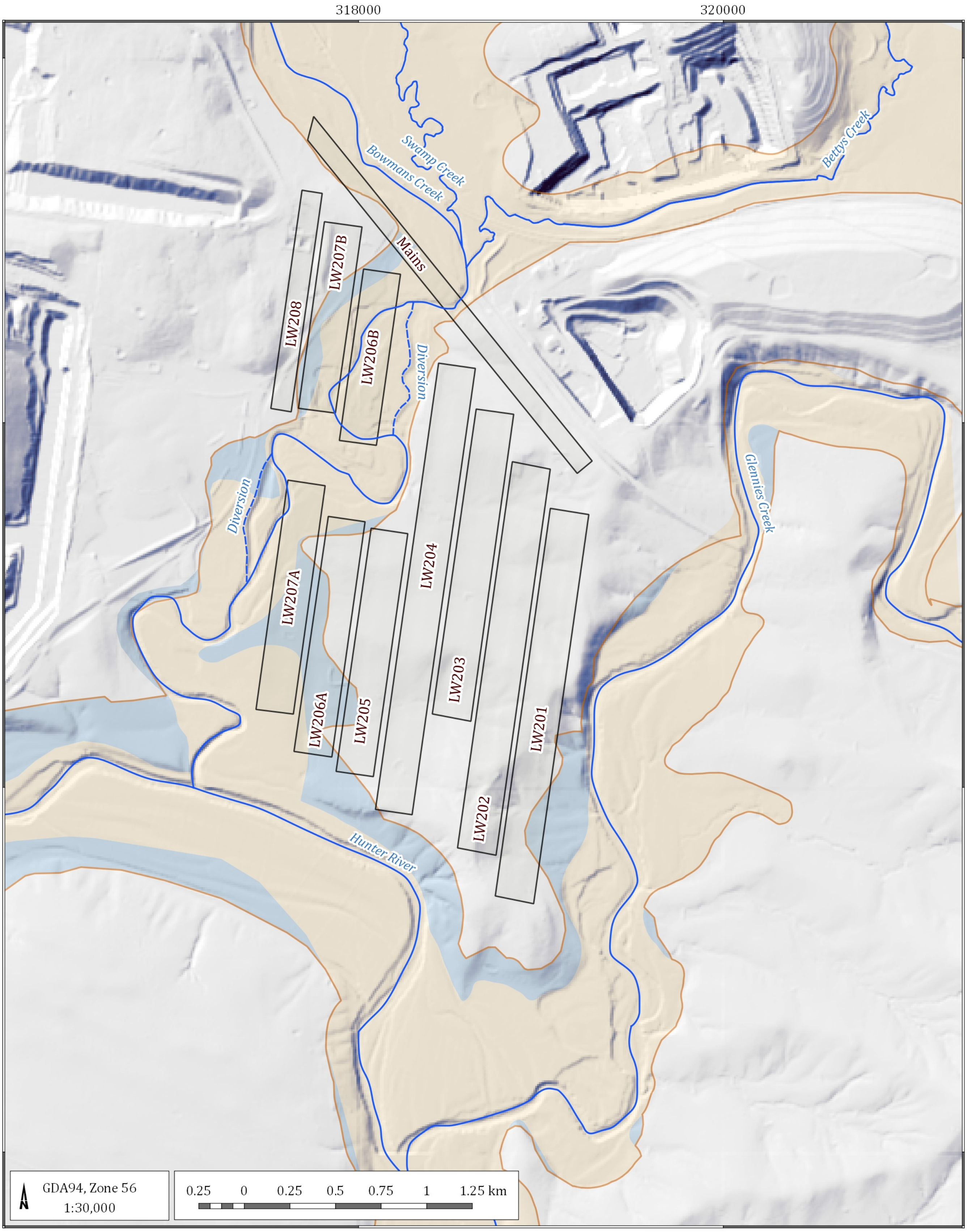

LEGEND

- Drainage
- Diversion
- Underground mine (Upper Lower Liddell seam)
- Quaternary alluvium/colluvium
- Coarse grained
- Fine grained

Ashton Longwall 205-208 EP (G1922M)

Alluvium properties and extents

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FIGURE No: **2.2**

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2.2 Groundwater/surface water interaction

The strata collapse process associated with longwalls coal mining has the ability to impact regional groundwater flow systems (Tammetta 2015). The assessment of the potential and actual effects on groundwater systems has been the subject of numerous publications.

Dawkins (1999) states "that there is generally no significant loss of stream flow for underground mines deeper than 100 m as surface cracking and goaf zones are unlikely to be hydraulically connected, yet surface water can still be transferred to the groundwater system". The depth of cover over particular sections of underground mining of the PG Seam at the Ashton is marginally greater than 100 m, allowing for the potential for surface waters to enter the groundwater system. That said, the impacts of subsidence at Ashton are likely to reach coarse grained/conglomeratic water bearing units high in the geological sequence. Dawkins (1999) also states that ribside cracks may develop along the axis of an extracted longwalls panel as the overburden falls in towards the subsidence trough. These cracks may not close up entirely, but may reduce in size as adjacent longwalls panels are extracted. Further, if these types of cracks permeate the ground surface, the rate of surface water drainage to the groundwater table will likely increase (i.e. increased surface water groundwater connectivity).

The occurrence of subsidence induced surface cracking above and surrounding the Ashton underground workings is well documented in various Strata Control Technology (SCT) reports (SCT 2006, SCT 2008) and suggests the potential for surface water groundwater connectivity. However, alluvium water levels have been observed to not be impacted significantly during and post mining, whilst the underlying Permian strata have been depressurised due to the effects of subsidence.

Figure 2.3 shows the historic water level trends in Bowman Creek Alluvium (BCA) bores over LW6B and LW7B (bore locations are shown on Figure B1 in Appendix B). Figure 2.4 shows the coal measures depressurising as a result of mining LW6B. The depressurisation extends above PG to the Lemington 15 seam (through depressurisation) and below PG to the Arties seam (possibly through an effect of unloading). Repressurisation of the Arties Seam is evident from May 2015. Other surface water bodies on site, such as agricultural dams, have not shown subsidence-related water loss.

The alluvium water trends match the cumulative rainfall departure (CRD) curve and are notably influenced by significant rainfall events. Underground inflows are relatively constant and independent of rainfall events. Groundwater abstraction from the underground is monitored and no correlation has been found between rainfall and changes to groundwater abstraction rates from the underground.

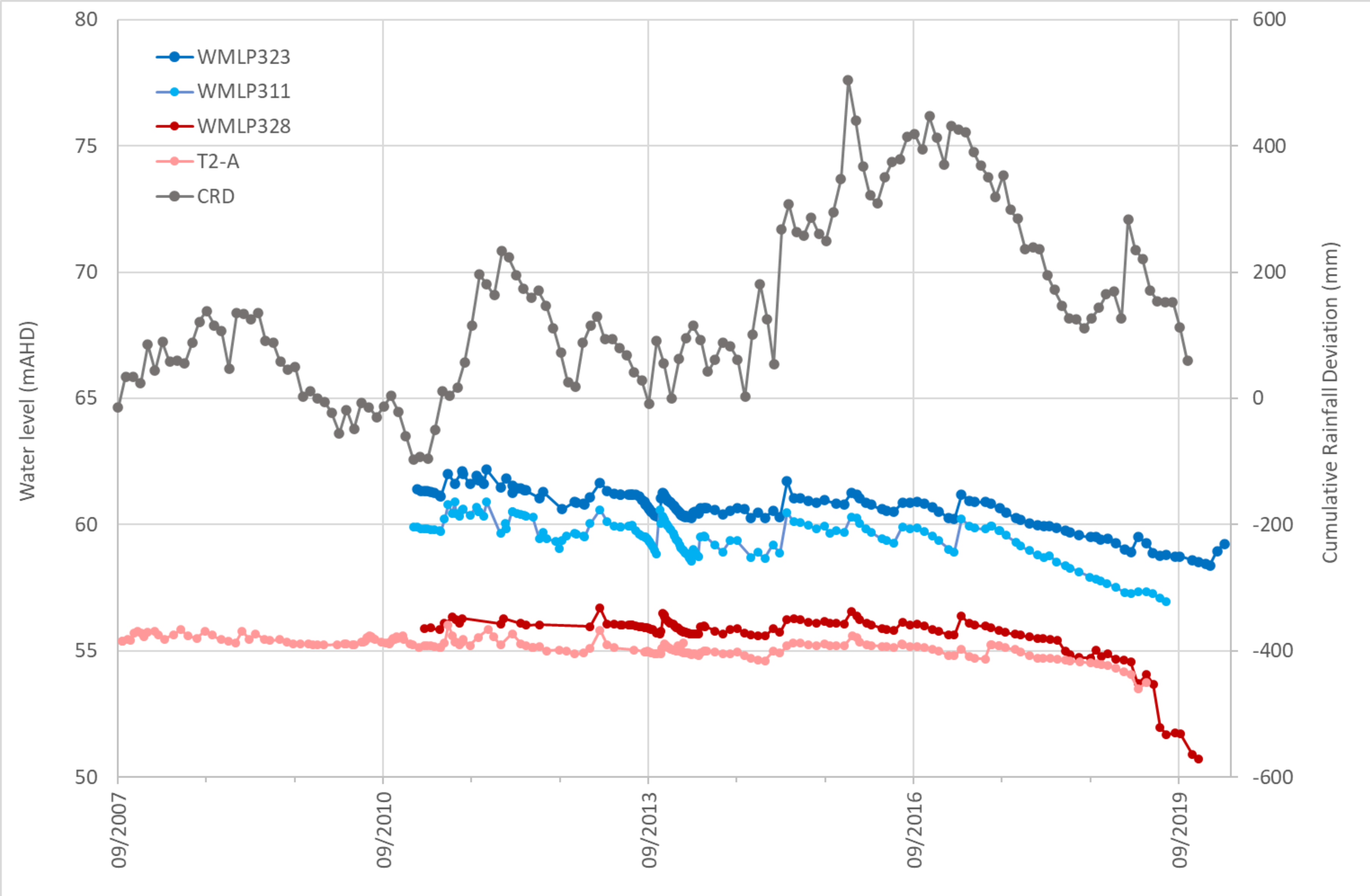


Figure 2.3 Bowmans Creek Alluvium water levels and Cumulative Rainfall Deviation

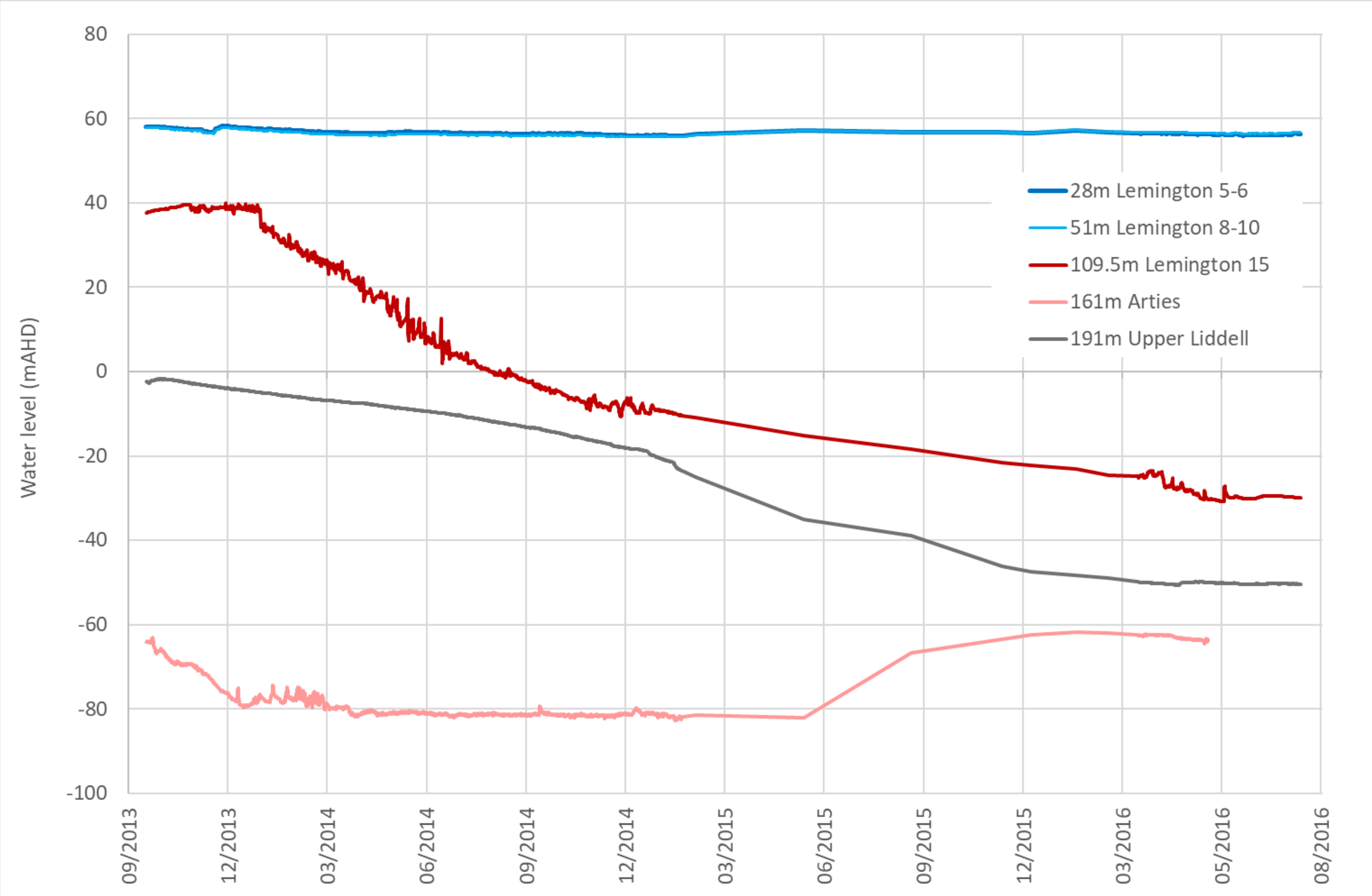


Figure 2.4 **WMLC361 Vibrating wire piezometer water level**

3 Groundwater model 2016

3.1 Background

Several groundwater studies including numerical models have been prepared for the Ashton project, including:

- 2001 - An initial groundwater model was developed by HLA Envirosciences (2001) for the mine approval environmental impact statement (EIS). This model was created using MODFLOW, and included 120 columns, 120 rows and 7 layers;
- 2009 - The 2001 model was updated by Aquaterra in 2009 for the Bowmans Creek Diversion environmental assessment (EA). MODFLOW-SURFACT v4 (a version of MODFLOW) was the code selected for the model. The updated model included 188 columns, 252 rows and 15 layers;
- 2014 - Another update was performed by RPS (formerly Aquaterra/RPS-Aquaterra) upon completion of mining the PG seam. For this update, MODFLOW-SURFACT v4 was also used, and the model geometry and domain remained unchanged; and
- 2016 – A new numerical groundwater flow model was developed by AGE in 2016 using MODFLOW-USG (Panday et al. 2015). MODFLOW-USG is the latest version of the MODFLOW code which uses unstructured grids instead of traditional rows and columns. This version of the model included 18 layers and 370468 total nodes.

MODFLOW-USG provides flexibility to a MODFLOW simulation by enabling use of triangular, rectangular or other polygon shaped geometries individually or in combination, to appropriately discretise the domain. This allows the model to have layers which pinch out, leading to layers with differing number of nodes. This feature also allows for an improved simulation of coal seams pinching out/sub-cropping beneath alluvium, a feature that was not available in other modelling software. For example, many of the model layers pinch out around the Camberwell Anticline, allowing nodes representing coal seams (layers 8, 11, 14 and 17) to be in direct contact with the alluvium and regolith units represented in layer 1.

The AGE (2016b) groundwater model was adopted for this extraction plan. This model was previously used for the extraction plan for LW panels 201-204 (AGE 2016a). The 2016 base model parameters and resulting calibration were unchanged. Minor model updates were required to contemporise the mine plan, mostly through adjusting panel extraction dates.

3.2 Model calibration

A satisfactory calibration was achieved in AGE (2016b) and steep head changes were adequately reproduced in the Permian strata. AGE (2016b) recalibrated this model for improved resolution around impacts to the alluvium while remaining statistically calibrated to the underlying aquifers.

3.3 Sensitivity analysis

The sensitivity analysis from AGE (2016b) was carried forward to this model. In AGE (2016b), the sensitivity analysis was carried out on parameters that were most likely to impact the interaction and predictions between the alluvium and shallow coal seam/coal seam subcrop.

Sensitivity assessments were carried out on key hydrogeological parameters:

- Hydrogeological parameters of the GCA – sensitivity of the model predictions to the horizontal and vertical conductivity, specific yield and storativity (storage) of the alluvium were carried out and showed some minor changes to take and mine inflows. The model was sensitive to changes in hydraulic conductivity, particularly with regards to drawdown; that is, lower conductivities caused less drawdown. Also, when reducing the vertical hydraulic conductivity to a very small value to attempt to replicate a low permeability liner on the GCA (as per the RPS model (2009)), the model did not converge;
- Permeability of shallow coal - a sensitivity analysis modifying the permeability of shallow coal and hence the interaction with regolith and alluvium, significantly changed the amount of recharge from the surface water body (river/creek) and the alluvium (particularly on predicted baseflow in Glennies Creek), mine inflows were also notably changed; and
- Recharge to GCA from Glennies Creek – the calibrated value for recharge of the GCA from the Glennies Creek surface water body needed to be reduced in light of the reduced hydraulic conductivity identified by the sensitivity analysis.

In summary, a sensitivity analysis modifying the permeability of shallow coal and hence the interaction with regolith and alluvium, significantly changed the amount of recharge from the surface water body (river/creek) and the alluvium (particularly on predicted baseflow in Glennies Creek), and mine inflows were also notably changed. The interaction was also dependent on the vertical hydraulic conductivity of the alluvium.

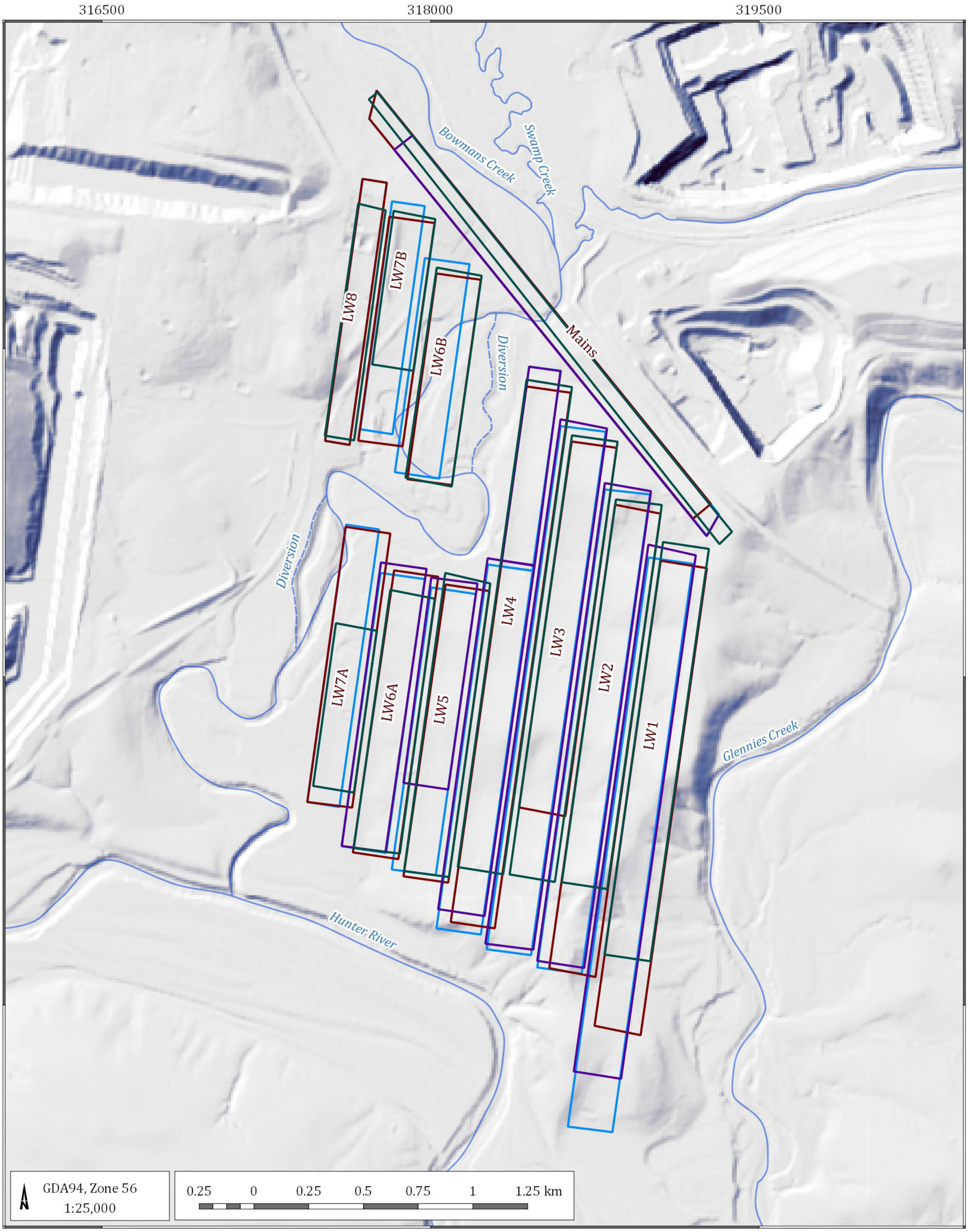
4 Upper Lower Liddell Mine Plan

The mining schedule utilised for the groundwater model is presented in Table 4.1. This schedule was provided by ACOL in December 2019. For reference, a mine plan diagram with panel names is presented in Figure 4.1.

Table 4.1 Ashton underground mine schedule

Seam	Longwalls panel	Start date	End date	Duration (months)
Pikes Gully (PG)	LW1	Mar-2007	Oct-2007	7
	LW2	Nov-2007	Jul-2008	8
	LW3	Aug-2008	Mar-2009	6
	LW4	Apr-2009	Oct-2009	6
	LW5	Jan-2010	Jun-2010	5
	LW6A	Jul-2010	Nov-2010	4
	LW6B	Jul-2013	Oct-2013	3
	LW7A	Mar-2011	Aug-2011	4
	LW7B	Oct-2011	Jan-2012	3
	LW8	Feb-2012	Jun-2012	3
Upper Liddell (ULD)	LW101	Aug-2012	Jun-2013	10
	LW102	Nov-2013	Aug-2014	9
	LW103	Aug-2014	Jun-2015	10
	LW104A	Jul-2015	Jan-2016	6
	LW104B	Feb-2016	Apr-2016	2
	LW105A	May-2016	Sep-2016	4
	LW106A	Oct-2016	Feb-2017	4
	LW106B	Not scheduled		N/A
	LW107A	Not scheduled		N/A
	LW107B	Not scheduled		N/A
Upper Lower Liddell (ULLD)	LW201	Jul-2017	Aug-2018	13
	LW202	Jun-2018	Aug-2019	14
	LW203	Oct-2019	May-2020	7
	LW204	Jun-2020	Apr-2021	10
	LW205	May-2021	Oct-2021	5
	LW206A	Nov-2021	Apr-2022	5
	LW206B	Jun-2022	Aug-2022	3
	LW207A	Sep-2022	Feb-2023	5
	LW207B	Feb-2023	May-2023	3
	LW208	Jun-2024	Oct-2023	4

Seam	Longwalls panel	Start date	End date	Duration (months)
Lower Barrett (LB)	LW301	Nov-2023	Oct-2024	11
	LW302	Sep-2024	Jul-2025	10
	LW303	Aug-2025	Apr-2026	8
	LW304A	May-2025	Oct-2026	5
	LW304B	Oct-2026	Feb-2027	4
	LW305	Mar-2027	Aug-2027	5
	LW306A	Aug-2027	Jan-2028	5
	LW306B	Feb-2028	Jun-2028	4
	LW307A	Jul-2028	Oct-2028	3
	LW307B	Nov-2028	Apr-2029	5
	LW308	May-2029	Sep-2029	4
Pikes Gully (PG)	Mains0_PG	Feb-2006	May-2008	27
Upper Liddell (ULD)	Mains1_ULD	Aug-2011	Jan-2016	53
Upper Lower Liddell (ULLD)	Mains2_ULLD	Oct-2016	Sep-2021	59
Lower Barrett (LB)	Mains3_LB	Apr-2022	Oct-2025	42



LEGEND

- Drainage
- Diversion
- Pike's Gully seam
- Upper Liddell seam
- Upper Lower Liddell seam
- Lower Barrett seam

Ashton Longwall 205-208 EP (G1922M)

Plan of Ashton underground longwall panels

DATE 15/04/2020

FIGURE No: **4.1**

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4.1 Interaction with other mines

Adjacent mines considered as part of this assessment are presented in Table 4.2. Data available in the public domain was used to replicate the schedule of adjacent mining.

Table 4.2 Summary of adjacent mining operations

Mine	Mining type	Seams targeted	Date from	Date to	Current Status
Ashton	Underground	Pikes Gully	2006	2012	Completed
Ashton	Underground	Upper Liddell	2011	2017	Completed
Ashton	Underground	Upper Lower Liddell	2016	2023	In progress
Ashton	Underground	Lower Barrett	2023	2029	Planned
Ashton NEOC	Open cut	Seams to Lower Barrett	2004	2010	Decommissioned Void being filled with rejects and tailings
Ravensworth	Underground	Pikes Gully	2007	2014	Care and maintenance (2014 to date)
Ravensworth - Narama	Open cut	Seams to Bayswater	1993	2015	Decommissioned# Void being backfilled
Ravensworth - South	Open cut	Seams to Bayswater	1989	2000	Decommissioned Void being backfilled
Ravensworth - No.2	Open cut	Seams to Bayswater	1970	1984	Decommissioned Void being backfilled
Integra	Open cut	Seams to Hebden	1992	1999	Decommissioned Void open
Glendell	Open cut	Seams to Lower Barrett	2009	2020#*	In progress Void being backfilled

Notes: *# as per publicly available data.*

** site operational. Void drain cells remain on to replicate pit remaining dry to end of mining LW205-LW208.*

5 Groundwater predictions

5.1 Approved impacts

Ashton has undertaken two relevant groundwater impact assessments as part of the approval process for the underground and open cut mines (2001 EIS and 2009 Bowmans Creek Diversion EA). As part of this process, Ashton undertook extensive groundwater investigations and modelling to assess the potential impacts to the groundwater and surface water system.

The following sections detail the predicted groundwater impacts, with a focus on impacts related to the extraction of coal from LW205 to LW208 in the ULLD. Simulated impacts were compared against the approved EIS (HLA, 2001) and Bowmans Creek Diversion EA (Aquaterra, 2009). A comparison of values from these two documents is presented in Table 5.1 below.

Table 5.1 2001 EIS and 2009 EA comparison values

Impact description	Location	2009 EA (End of mine life)	2001 EIS (End of mine life)
Drawdown	Bowmans Creek Alluvium (BCA)	< 3 m	No significant drawdown
	Glennies Creek Alluvium (GCA)	< 2 m	2.5 m
	Hunter River Alluvium (HRA)	< 1 m	No significant drawdown
Stream baseflow loss	BCA	0.13 ML/d	0.4-1.4 ML/day
	GCA	0.23 ML/d	0.6 ML/day
	HRA	0.06 ML/d	0.3 ML/day
Salinity	BCA	Likely decrease in salinity	Electrical Conductivity (EC): great variability - maximum increase of 70 µS/cm attributable to mining related impacts
	GCA	Likely decrease in salinity	Similar quality to pre-mining
	HRA	Likely decrease in salinity	N/A

5.2 Modelled impacts from ULLD LW205 to LW208

5.2.1 Groundwater impacts as drawdown

Modelled impacts to groundwater heads are determined by calculating the difference between a null or "no-mine" model run and a "mining" simulation that contains the additional activity from which impacts are sought. This process was further refined to isolate the impacts of mining at LW205 to LW208 from cumulative impacts by means of a comparison between the proposed mining as currently scheduled and the proposed mining without extraction of LW205- LW208. The modelled heads from the "no-mine" and "mining" simulations within the alluvium and mined seams (PG, ULD and ULLD) were compared at the start of mining in LW205 and at the end of mining in LW208. Predicted groundwater impacts (presented as drawdown) immediately prior to the commencement of LW205, upon completion of mining of LW208 and the drawdown attributable only to the mining of LW205 to LW208 are presented in Figure 5.1 to Figure 5.4.

Key predicted groundwater level impacts attributable to the mining of LW205 to LW208 are summarised herein.

In the BCA:

- The alluvial drawdown prior to the extraction of LW205 is around 1 m in the area surrounding the Bowmans Creek diversion (Figure 5.1a). Some very small, localised areas show drawdown to 5m along the edge of the alluvial boundary at the top of LW5.
- By the end of mining LW208, the area of 1 m alluvial drawdown has expanded toward the centre of LW6B (Figure 5.1b).
- The expansion of the area of 1 m drawdown is the result of drawdown propagating outward from previous panel extractions and cannot be attributed to the extraction of LW205-LW208 at Ashton. Figure 5.1c illustrates that drawdown in the BCA resulting directly from the extraction of LW205-208 is negligible.

In the GCA:

- In general, drawdown in the GCA is around 1 m in the coarse grained alluvium. The drawdown along the eastern margin of LW1 is increased as the model cells representing the fine grained alluvium become unsaturated (Figure 5.1a; Figure 5.1b).
- The extent of the area of coarse grained alluvium with 1m drawdown expands over time (Figure 5.1b), but as with drawdown in the Bowmans Creek alluvium, is the result of propagation of drawdown from previous mining.
- The drawdown resulting directly from the extraction of longwalls panels LW205-LW208 is negligible (Figure 5.1c).
- As Glennies Creek is a regulated stream, it is unlikely that drawdown impacts will be observed in monitoring bores as the creek recharges the alluvium.

In the HRA:

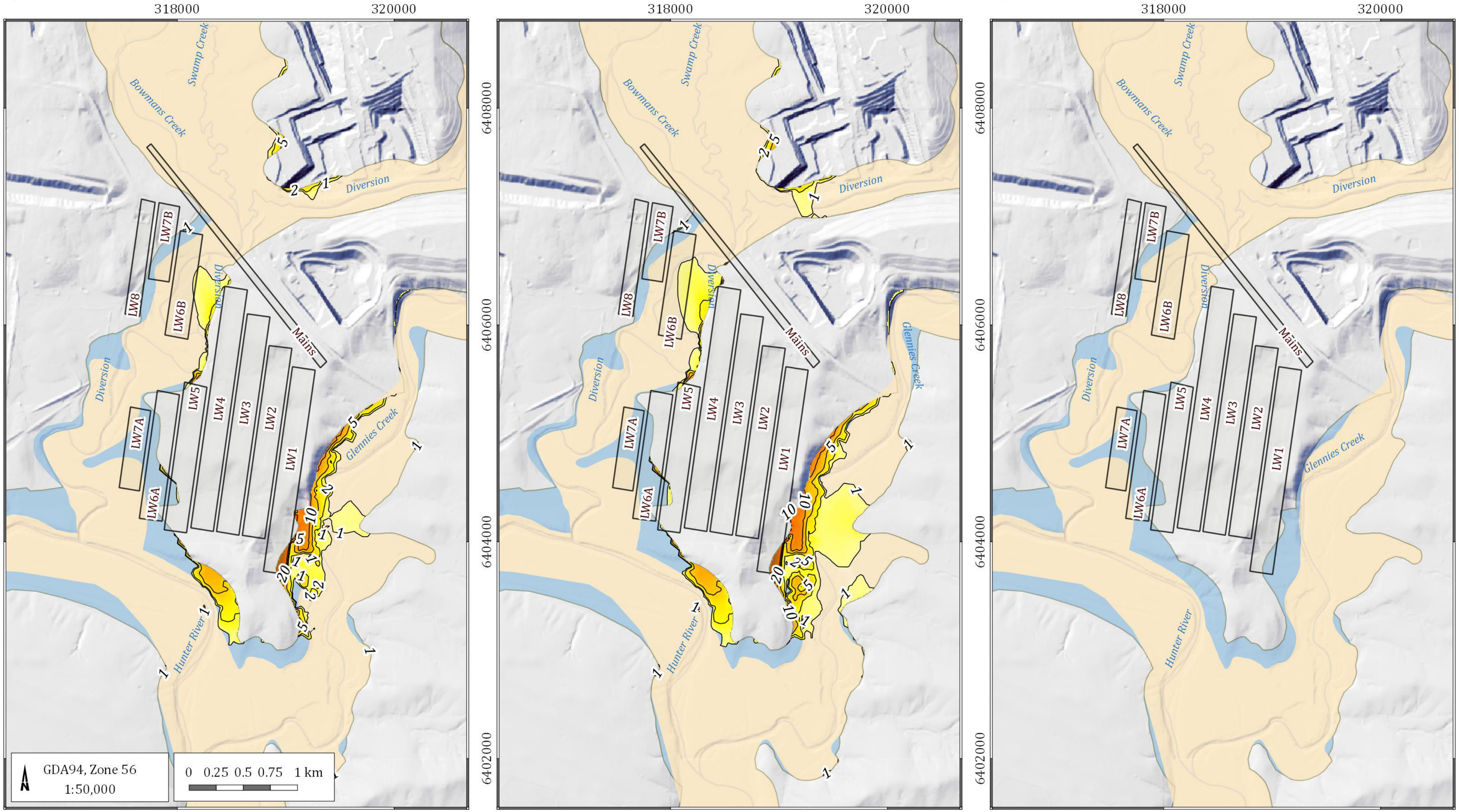
- No drawdown greater than 1m is predicted in the coarse grained alluvium (Figure 5.1b).
- A very small and localised area of increased drawdown is present in the fine grained alluvium to the south of panels LW3 and LW4 and this does not change significantly between the outputs presented in Figure 5.1a and Figure 5.1b.
- Drawdown resulting directly from the extraction of panels LW205-LW208 is negligible (Figure 5.1c).

In the underground mine:

- Additional drawdown in the Pike's Gully seam is minimal (Figure 5.2c), as most of the drawdown took place during previous mining and a dewatered state is maintained within the mine.
- Up to 20 m of additional drawdown occurs in the Upper Liddell seam, centered over panels LW206 and LW207 (Figure 5.3c). These panels were not mined in the Upper Liddell seam, so it was not in a completely dewatered state leading to predicted drawdown impacts from the dewatering of the ULLD seam below.
- There will be a maximum of 100m of drawdown at the start of panel LW205 in the Upper Lower Liddell Seam (Figure 5.4a). By the end of LW208, the cone of depression was steeper than previously reported on, with a maximum of 200 m drawdown along the southern boundary of the same panels (Figure 5.4b). Up to 100m of drawdown could be directly attributed to the extraction of panels LW205-LW208 (Figure 5.4c).

A comparison between the simulated impacts and approved impacts is presented in Section 5.3.

a) Start of LW205- April 2021 b) End of LW208- October 2023 c) Drawdown induced by LW205-208- October 2023



LEGEND

- Drainage
- Diversion
- Underground mine (Pike's Gully seam)
- Quaternary alluvium/colluvium

Alluvium properties boundary

- High permeability
- Low permeability

Drawdown (m)

- 0
- 1
- 2
- 5
- 10
- 20
- 50
- Drawdown contour (m)

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Ashton Longwall 205-208 EP (G1922M)

Predicted groundwater drawdown in alluvium

DATE
27/04/2020

FIGURE No:
5.1

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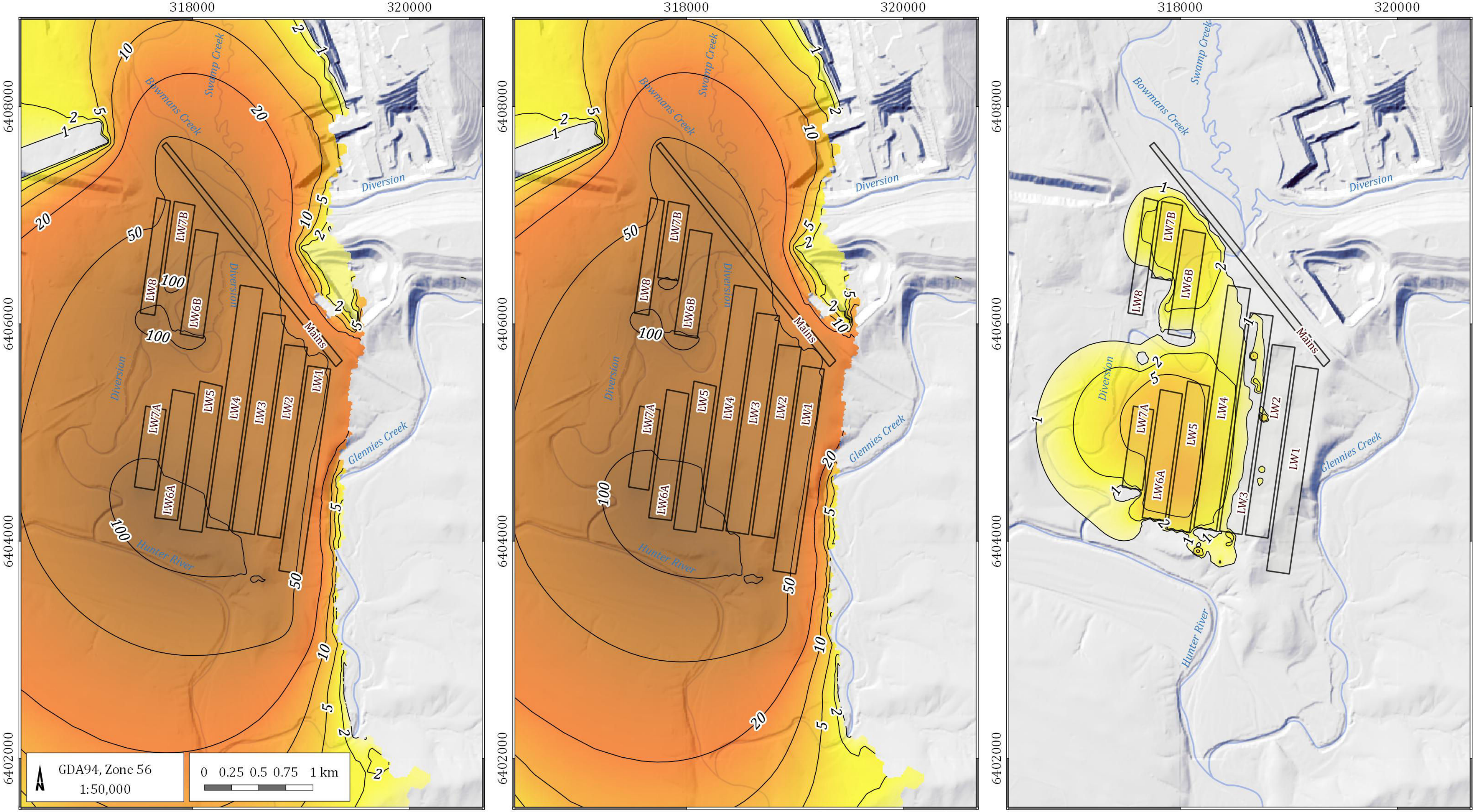
G:\Projects\G1922M.Ashton_Longwall_205-208_EP\3_GIS\Workspaces\001_Deliverable1\05.01_G1922M_Predicted groundwater drawdown in alluvium.qgs

a) Start of LW205 - April 2021

b) End of LW208 - October 2023

c) Drawdown induced by LW205-208- October 2023



LEGEND

- Drainage
- Diversion
- Drawdown contour (m)
- Underground mine (Pike's Gully seam)

Drawdown (m)

0
1
2
5
10
20
50
100

Ashton Longwall 205-208 EP (G1922M)

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Predicted groundwater drawdown in Pike's Gully seam

DATE
27/04/2020

FIGURE No:
5.2

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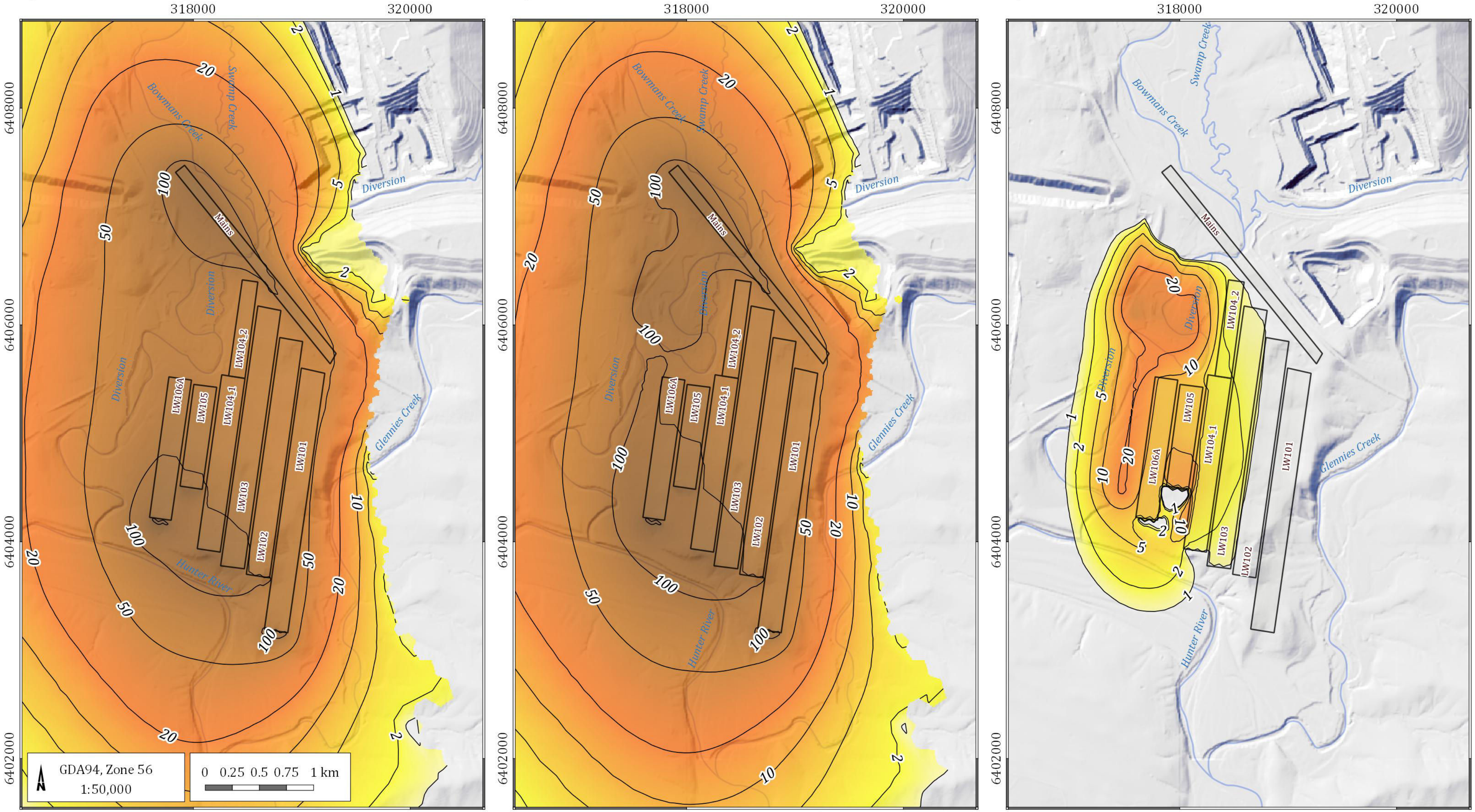
G:\Projects\G1922M.Ashton_Longwall_205-208_EP\3_GIS\Workspaces\001_Deliverable1\05.02_G1922M_Predicted groundwater drawdown in Pike's Gully seam.qgs

a) Start of LW205 - April 2021 | b) End of LW208 - October 2023 | c) Drawdown induced by LW205-208- October 2023



LEGEND

- Drainage
- Diversion
- Drawdown contour (m)
- Underground mine (Upper Liddell seam)

Drawdown (m)

0
1
2
5
10
20
50
100
200

Ashton Longwall 205-208 EP (G1922M)

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Predicted groundwater drawdown in Upper Liddell seam

DATE
27/04/2020

FIGURE No:
5.3

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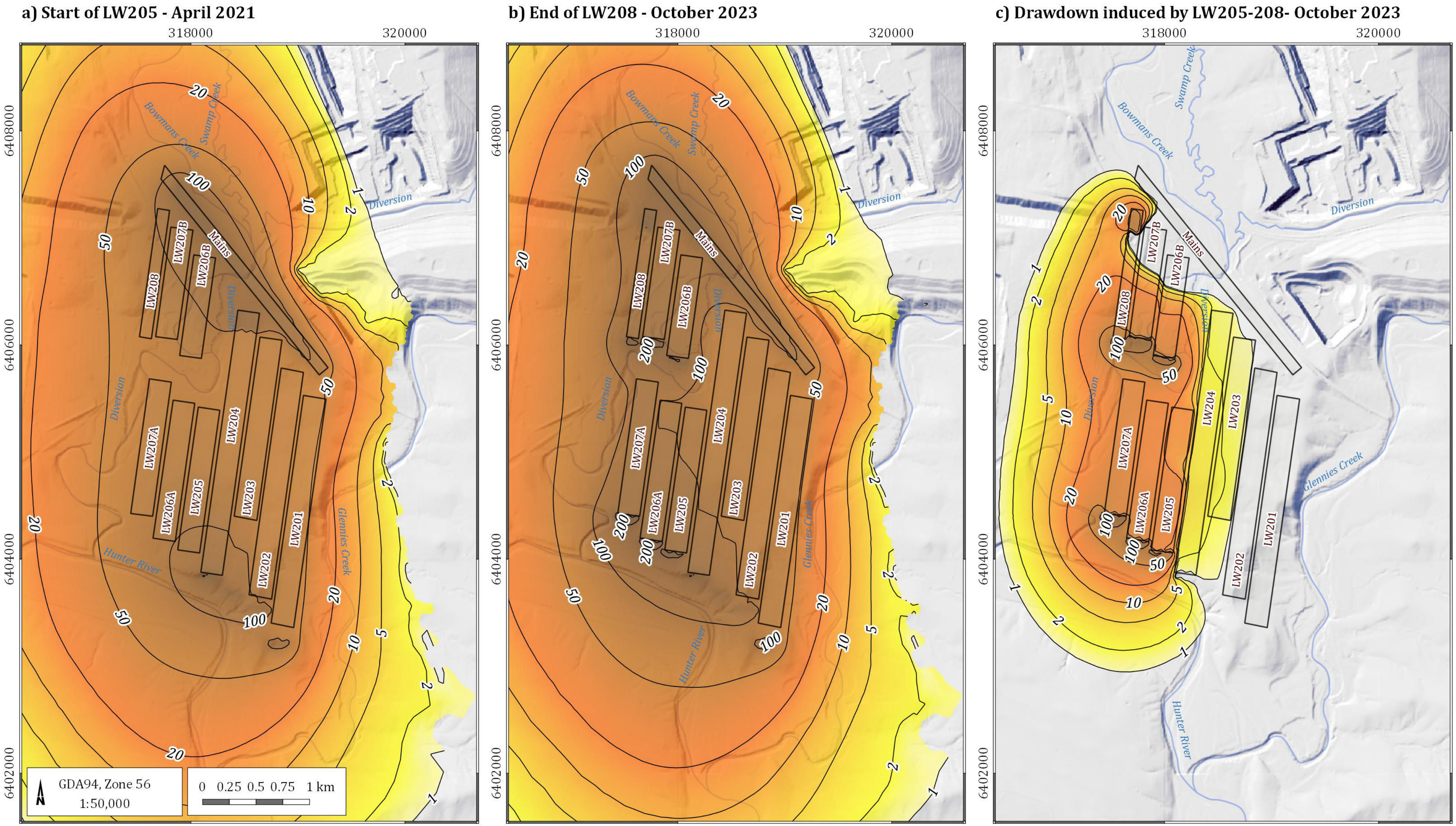
G:\Projects\G1922M.Ashton_Longwall_205-208_EP\3_GIS\Workspaces\001_Deliverable1\05.03_G1922M_Predicted groundwater drawdown in Upper Liddell seam.qgs



LEGEND

- Drainage
- Diversion
- Drawdown contour (m)
- Underground mine (Upper Lower Liddell seam)

Drawdown (m)

0
1
2
5
10
20
50
100
200

Ashton Longwall 205-208 EP (G1922M)

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Predicted groundwater drawdown in Upper Lower Liddell seam

DATE
27/04/2020

FIGURE No:
5.4

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G:\Projects\G1922M.Ashton_Longwall_205-208_EP\3_GIS\Workspaces\001_Deliverable1\05.04_G1922M_Predicted groundwater drawdown in Upper Lower Liddell seam.qgs

5.2.2 Baseflow impacts

Predicted impacts to stream baseflow in the Hunter River, Bowmans Creek and Glennies Creek in the model domain are displayed in Figure 5.5. The positive values for baseflow rate show that the Hunter River, Bowmans Creek and Glennies Creek were simulated in the model as gaining streams; whereby the aquifers are contributing water to the streams rather than the streams recharging the aquifers. The baseflow rates during mining were compared to a "no-mine" simulation in which the Ashton Underground mine was removed to provide a baseline condition (Figure 5.5). The reduction in baseflow was calculated by taking the difference between the mine and no-mine simulations(Figure 5.6). The modelled impact on baseflow can be summarised as follows:

Hunter River:

- In the no-mine simulation, the predicted baseflow for the simulated reach of the Hunter River was around 0.536 ML/day prior to the extraction of LW205 and 0.535 ML/day upon completion of LW208
- In the mining simulation, the change in baseflow between the start of panel LW205 and the end of panel LW208 was negligible (0.003 ML/day), with 0.514 ML/day of baseflow at the beginning of LW205 and 0.511 ML/day upon completion of LW208.

Bowmans Creek:

- In the no-mine simulation, the predicted baseflow for the simulated reach of Bowmans Creek was estimated to be 0.475 ML/day prior to the extraction of LW205 and 0.467 ML/day upon completion of LW208. The reduced rate over time, in the absence of the Ashton Underground mine, is considered to be the cumulative result of baseflow reduction induced by surrounding mining operations.
- In the mining simulation, the predicted baseflow reduced to 0.418ML/day prior to the extraction of LW205 and to 0.405 ML/day upon completion of LW208.
- The reduction of baseflow in Bowmans Creek predicted to occur during the mining of LW205-LW208 was estimated to be 0.013 ML/day.

Glennies Creek:

- In the no-mine simulation, the baseflow rate of the simulated reach of Glennies Creek was estimated to be 0.630 ML/day prior to the extraction of LW205 and 0.629 ML/day upon completion of LW208.
- In the mining simulation, the predicted baseflow was 0.575 ML/day prior to extraction of LW205 and 0.567 ML/day upon completion of LW208.
- The predicted reduction of baseflow in Glennies Creek that can be attributed to the mining of LW205-LW208 was 0.008 ML/day.

Overall impacts:

- Mining in the Ashton Underground mine results in a general decrease in the rate of baseflow over the life of the project. The simulated decrease in baseflow is within the range of approved impacts.

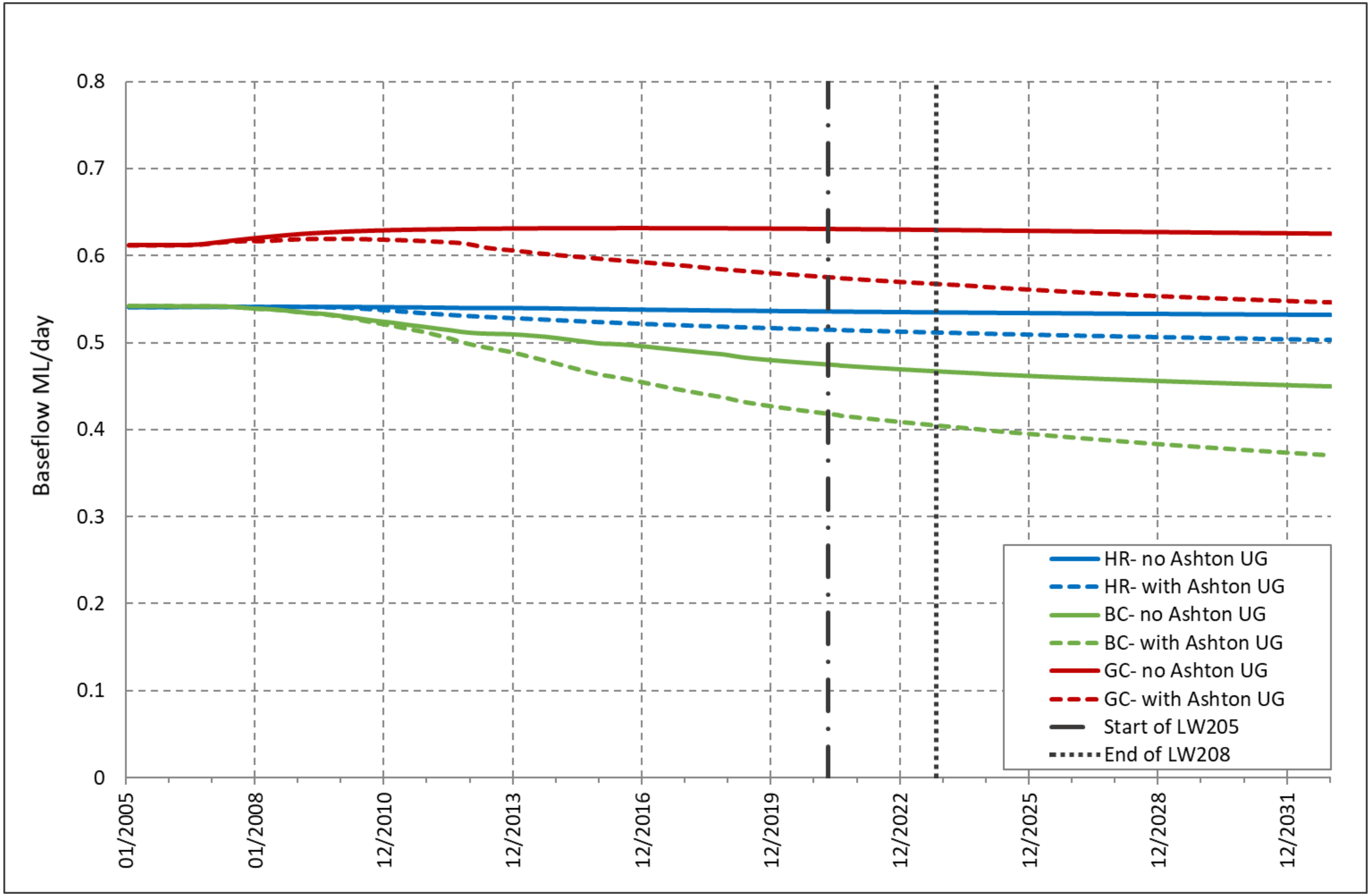


Figure 5.5 Simulated baseflow in watercourses surrounding Ashton

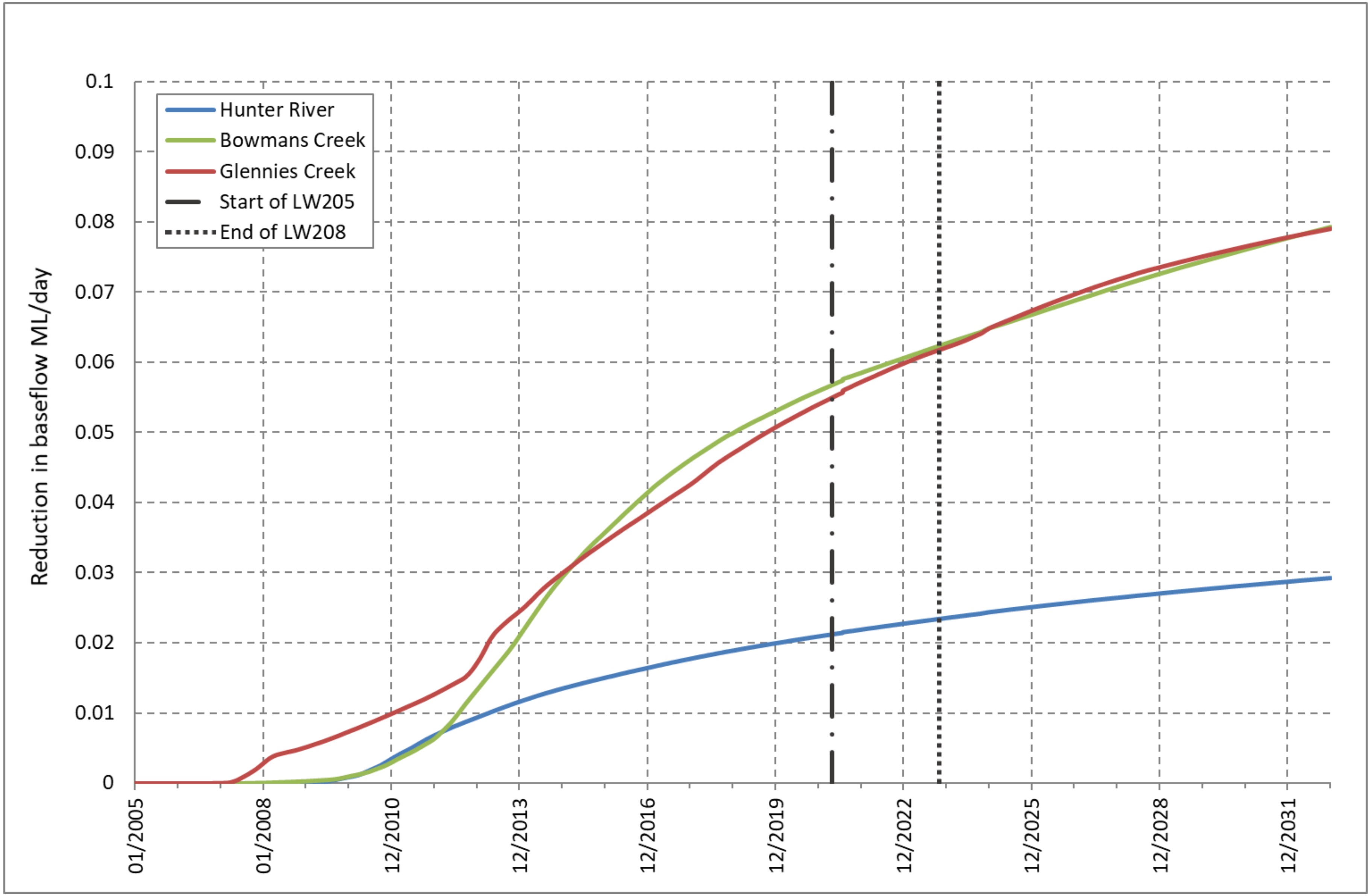


Figure 5.6 Simulated reduction in baseflow in watercourses surrounding Ashton

5.2.3 Mine inflows

The total predicted Ashton underground mine inflows were partitioned into the respective groundwater sources (Figure 5.7, Table 5.2). Over the period of mining LW205-LW208:

- total mine inflows range from ~ 410 ML/year (1.12 ML/day) in 2020-2021 and 2024-2025 to ~ 417 ML/year (1.14 ML/day) in 2022-2023;
- inflow from the Permian strata remains relatively stable before decreasing in 2024-2025;
- inflow from the GCA, Glennies Creek channel, Bowmans Creek channel and Hunter River channel increases;
- inflow from the BCA remains relatively constant; and
- inflow from the HRA decreases.

While the channel inflows increase slightly, the volumes of channel losses are minor in comparison to the total mine inflows, and as such the percentage contribution of each to the total inflows does not change over the period of interest. The total mine inflows are consistent with those presented in AGE (2016a) and within the limits of the approved impacts.

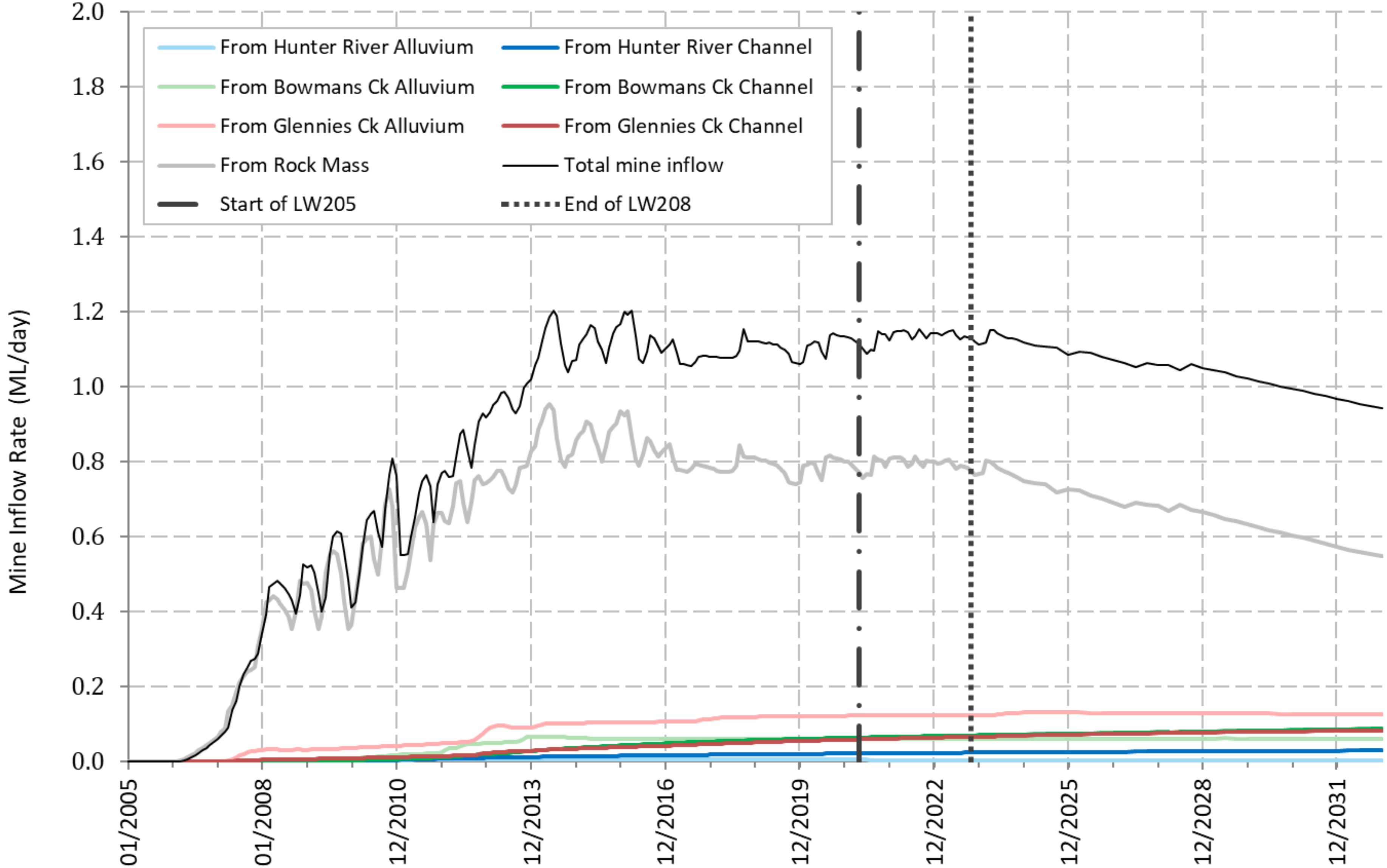


Figure 5.7 Predicted Ashton underground mine inflows

Table 5.2 Predicted Ashton underground mine inflows

	2020-2021	2021-2022	2022-2023	2023-2024	2024-2025
Mine Inflow (ML/yr)					
Total Mine Inflow (ML/yr)	409.99	415.22	416.76	413.28	409.51
From HRA	1.61	1.56	1.52	1.48	1.45
From Hunter River Channel	7.75	8.09	8.41	8.70	8.93
From BCA	21.97	21.93	22.01	22.09	22.18
From Bowmans Creek Channel	23.07	24.05	24.89	25.69	26.31
From GCA	44.57	44.89	45.01	45.13	47.36
From Glennies Creek Channel	21.30	22.43	23.42	24.28	25.22
From Permian strata	289.72	292.28	291.51	285.92	278.07
Mine Inflow (%)					
From HRA	0%	0%	0%	0%	0%
From Hunter River Channel	2%	2%	2%	2%	2%
From BCA	5%	5%	5%	5%	5%
From Bowmans Creek Channel	6%	6%	6%	6%	6%
From GCA	11%	11%	11%	11%	12%
From Glennies Creek Channel	5%	5%	6%	6%	6%
From Permian strata	71%	70%	70%	69%	68%

5.2.4 Potential impacts on water quality

Previous groundwater modelling predicted a risk of an increase in salinity due to potential mixing of fresher surface water and alluvium groundwater with the saline groundwater from the Permian strata (Aquaterra 2009). Based on the current conceptual model this is unlikely, due to the Permian strata being depressurised by subsidence.

Mining activities at Ashton promote a downward vertical hydraulic gradient due to underground dewatering and subsidence. This minimises the potential risk of saline groundwater from the Permian strata flowing into alluvium and creeks. Therefore, mining activities at Ashton are not expected to cause an increase in the groundwater salinity of creeks and alluvial aquifers; however, there may be a slight decrease in salinity due to the reduced discharge from the Permian strata.

Other risks to water quality, including acid forming potential and heavy metal precipitation, have not been observed as a potential issue for Ashton (HLA, 2001).

5.2.5 Potential impacts on groundwater dependent ecosystems

GDEs are defined by ARMCANZ/ANZECC (1996) as ecosystems which have their species composition and their natural ecological processes determined by groundwater.

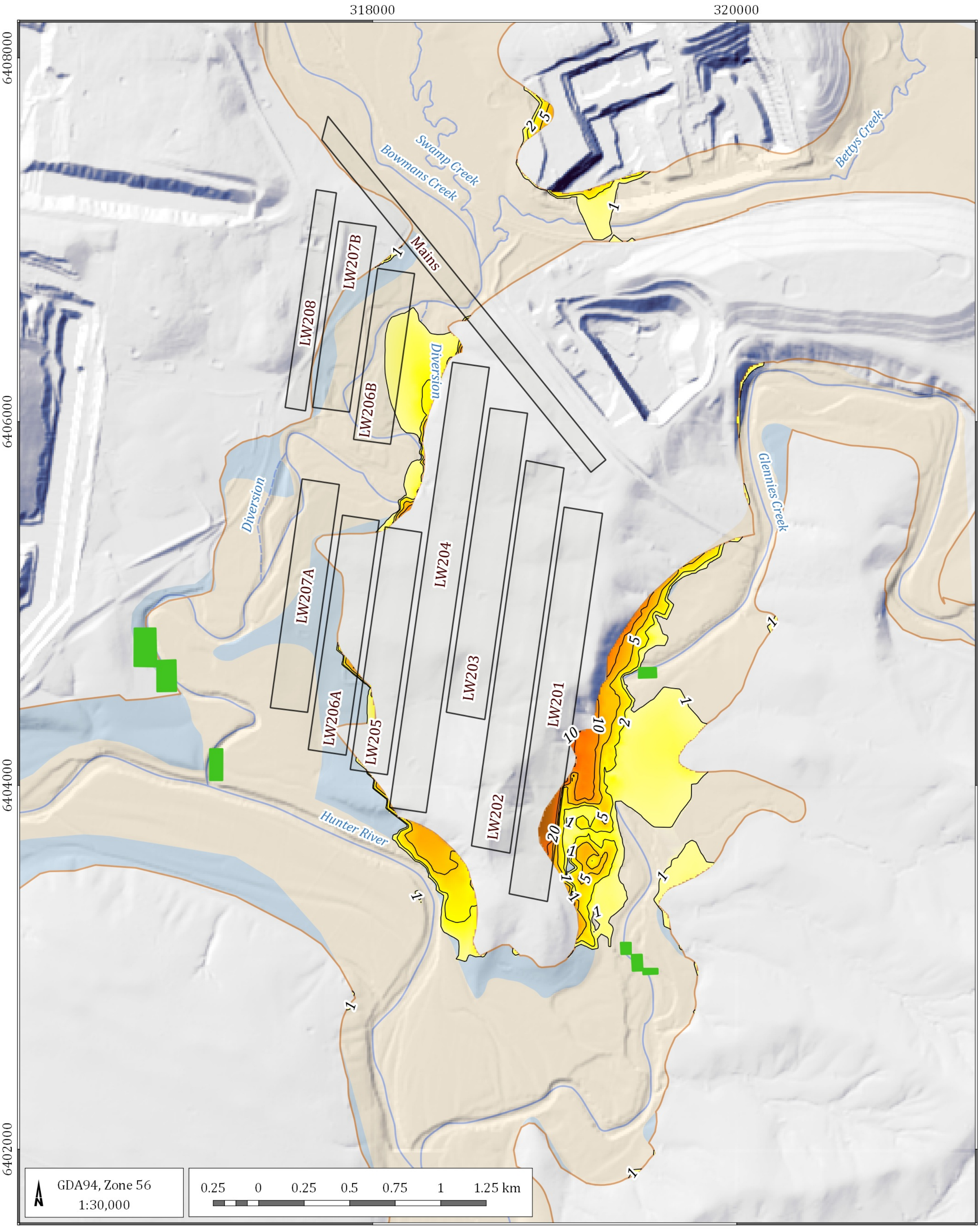
The River Red Gums (RRG) are the only identified GDEs in the vicinity of Ashton. Small stands of RRGs are located on the lower reaches of Bowmans Creek, within 1 km of the Hunter River confluence, and the lower reaches of Glennies Creek (Figure 5.8). These GDEs are likely to access shallow alluvial groundwater, supported by baseflow from creeks.

The predicted alluvial groundwater drawdown upon completion of LW208 does not extend to the known RRG stands (Figure 5.8), hence the RRG stands are not likely to be impacted by drawdown. Additionally, impact to the alluvial water level is likely to be mitigated by recharge from Glennies Creek, which is regulated by surface water discharge from Lake St Clair.

5.2.6 Potential impacts on existing groundwater users

There are no non-ACOL registered bores in surrounding areas that will be impacted by the underground mine. The reason for this is that most of the drawdown resulting from the underground mine occurs in close proximity to the mined area.

As simulated in previous and current versions of the Ashton groundwater model, drawdown generated by Ashton is not predicted to extend far enough to impact on private extraction bores in surrounding areas.



LEGEND

- Drainage
- Diversion
- Underground mine (Upper Lower Liddell seam)
- Quaternary alluvium/colluvium
- River Red Gum areas
- Coarse grained
- Fine grained

Drawdown (m)

- 0
- 1
- 2
- 5
- 10
- 20
- Drawdown contour (m)

Ashton Longwall 205-208 EP (G1922M)

Groundwater dependent ecosystems

DATE 27/04/2020

FIGURE No: **5.8**

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G:\Projects\G1922M.Ashton_Longwall_205-208_EP\3_GIS\Workspaces\001_Deliverable1\05.08_G1922M_Groundwater dependent ecosystems.qgs

5.3 Comparison of revised groundwater impacts to 2001 EIS and 2009 EA

A comparison of predicted groundwater impacts against the approved EIS (HLA, 2001) and EA (Aquaterra, 2009) is presented in Table 5.3. Since the EIS and the EA provide impact estimations for the life of the mine, these values were used as reference for the comparison; however, the 2009 EA represents the current mine footprint and is considered the most relevant.

Historical salinity monitoring can be found in the document "*Report on Yancoal Australia - Ashton Coal Project - End of Panel Report - LW104*" (G1758L Ashton End of Panel Report – LW104 - AGE 2016c).

Table 5.3 Comparison of impacts to 2001 EIS and 2009 EA

Impact description	Location	Observed	Current study	2009 EA	2001 EIS
		Impact to April 2020 (to mid LW203 ULLD)	Impact to end of LW208 - ULLD (October 2023)	Completed mine impact	Completed mine impact
Drawdown	BCA	No drawdown observed in WMP* bores (WMLP311, WMLP323, WMLP328, T2A)	< 1 m (>1m in a very small and localised area as model cells become unsaturated)	< 3 m	No significant drawdown
	GCA	No drawdown observed in WMP bores (WML120B, WML129, WML239)	< 1 m (>1m in a small and localised area as model cells become unsaturated)	< 2 m	2.5 m
	HRA	No drawdown observed in WMP bores (WMLP279, WMLP280, WMLP337)	< 1 m	< 1 m	No significant drawdown
Stream baseflow loss	Bowmans Creek	-	0.01 ML/day	0.13 ML/day	0.4-1.4 ML/day
	Glennies Creek	-	0.01 ML/day	0.23 ML/day	0.6 ML/day
	Hunter River	-	negligible	0.06 ML/day	0.3 ML/day
Salinity	Bowmans Creek	No mining related impact observed in WMP bores (WMLP311)	Likely decrease in salinity	Likely decrease in salinity	EC: great variability - maximum increase of 70 µS/cm attributable to mining related impacts
	Glennies Creek	No mining related impact observed in WMP bores (WML120B, WML239)	Likely decrease in salinity	Likely decrease in salinity	Similar quality to pre-mining
	Hunter River	No mining related impact observed in WMP bores (WMLP337)	Likely decrease in salinity	Likely decrease in salinity	N/A

Note: ** Water management plan (WMP)*

The following is a summary of the modelled impacts at the end of LW208 (Table 5.3):

- The predicted drawdown for the alluvial aquifers is within approved impacts; whilst the timing of the modelled impacts (to end of LW208) is not directly comparable to the approved impacts (to the end of mining the Lower Barrett), the results are consistent with previous modelling at the end of mining in the ULLD seam. On this basis, the 2009 EA approved impacts are not expected to be exceeded at the end of mining.
- With the exception of some localised drawdown at the limits of the alluvium, the predicted drawdown is more pronounced in areas where coal seams subcrop below the alluvium. The difference in predicted impacts between the current study (using the same model used in AGE, 2016b) and previous approval modelling is due to MODFLOW-USG providing for improved resolution around the seam subcrop / alluvium interaction.
- The predicted changes to stream baseflow are significantly smaller than the corresponding approved impacts.
- Mining related impacts on groundwater quality have not been observed to date. According to the conceptual understanding of the groundwater system and modelled directions of groundwater flow, future impacts to groundwater quality are not expected and salinity is likely to decrease.
- Mine inflow rates and volume predictions were compared to those predicted in the 2009 EA. Both the mine inflow rates and volumes are within the limits of previous predictions and approved impacts.

6 Recommendations, monitoring, management and mitigation

Ashton has developed and implemented a site WMP to monitor and manage potential mining related impacts to the groundwater regime. The protocols in the WMP ensure that Ashton complies with consent conditions and approved impacts.

The current groundwater monitoring program (Ashton 2018), is comprehensive and aims to identify potential mining related impacts to the groundwater regime. The WMP outlines the following:

- groundwater monitoring network, with bores targeting alluvium and Permian units;
- monitoring frequency for groundwater levels and quality;
- groundwater levels and quality triggers for early identification of potential adverse impacts to the groundwater regime; and
- monitoring of groundwater abstraction from the underground workings.

The groundwater monitoring program focusses primarily on monitoring for potential impacts to the alluvial aquifer, which is the prime sensitive receptor. The groundwater monitoring network and level/quality impact assessment criteria for the alluvium aquifer are considered sufficient and appropriate to monitor impacts predicted by the groundwater model.

Ashton prepares a number of reports to assess if the impacts to Glennies Creek, Bowmans Creek and the Hunter River (and connected alluvium) are within the approved predictions, including monitoring and compliance reporting. These reports are considered appropriate.

Groundwater flow into the underground has been estimated with the numerical model. Monitoring of groundwater abstraction (volume and quality) provides a good understanding of the mine inflow. Data collected will continue to be incorporated into future groundwater modelling.

7 References

Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) and Australian and New Zealand Environment and Conservation Council (ANZECC) (1996), *National Principles for the Provision of Water for Ecosystems,* ARMCANZ / ANZECC Occasional Paper No 3

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Strata Control Technology (2006), *Subsidence Assessment for Ashton Coal Mine Longwalls 1-4*, Report No. ASH3084B, August 2006

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Appendix A Relevant legislation, polices and guidelines

A1 Regulatory framework

The proposed modification requires consideration of the following NSW government legislation, policy and guidelines for groundwater:

- Water Act 1912, included in the Water Management Act 2000 as of 1 July 2016;
- Water Management Act 2000 and the Water Sharing Plan for Hunter Regulated River Water Source and Hunter Unregulated and Alluvial Water Sources;
- Groundwater Quality Protection Policy;
- Groundwater Dependent Ecosystems Policy;
- Groundwater Quantity Management Policy; and
- Aquifer Interference Policy (2012).

The following sections summarise the intent of the above legislation, policy and guidelines, and how they apply to the Extraction Plan.

A1.1 Water Act 1912

The Water Act 1912 regulates water sources including rivers, lakes and groundwater aquifers across the State. It also manages the trade of water licences and allocations. The Water Management Act 2000 is progressively replacing the Water Act 1912 in NSW. The Water Management Act 2000 has replaced the Water Act 1912 for the alluvial and surface water sources, and as of 1 July 2016, all groundwater outside the alluvial zones including the fractured rock aquifer. Prior to July 2016, seepage of groundwater to the mining areas from the Permian groundwater regime required an aquifer access licence under Part 5 of the Water Act 1912; subsequently, water take is licenced under the Water Management Act 2000 and the North Coast Fractured and Porous Rock Water Sharing Plan.

A1.2 Water Management Act 2000

The Water Management Act 2000 provides for the "protection, conservation and ecologically sustainable development of the water sources of the State". The Water Management Act 2000 provides clear arrangements for controlling land based activities that affect the quality and quantity of the State's water resources. It provides for three primary types of approval in Part 3:

- water use approval – which authorise the use of water at a specified location for a particular purpose, for up to 10 years;
- water management work approval; and
- controlled activity approval which includes an aquifer interference activity approval – which authorises the holder to conduct activities that affect an aquifer such as activities that intersect groundwater, other than water supply bores and may be issued for up to 10 years.

A1.3 Water sharing plans

NSW Water Sharing Plans (WSPs) establish rules for sharing water between the environmental needs of the river or aquifer and water users, and between different types of water use such as town supply, rural domestic supply, stock watering, industry and irrigation.

Department of Planning, Industry and Environment - Water (DPIE-Water, formerly NSW Office of Water) is progressively developing WSPs for rivers and groundwater systems across NSW following the introduction of the Water Management Act 2000. The purposes of these plans are to protect the health of rivers and groundwater, while also providing water users with perpetual access licences, equitable conditions, and increased opportunities to trade water through separation of land and water rights.

Three WSPs apply to the area of aquifers and surface waters which are affected by the proposed modification, including:

- Hunter Regulated River Water Source WSP 2003 (Hunter Regulated WSP) - The Hunter Regulated WSP covers the Hunter River surface water flows and highly connected alluvial bodies described in the plan. There are three relevant management zones within the Hunter Regulated WSP:
    - Management Zone 1 – all of the Hunter Regulated WSP upstream of the junction of the Hunter River and Glennies Creek;
    - Management Zone 2 – all of the Hunter Regulated WSP downstream of the junction of the Hunter River and Glennies Creek; and
    - Management Zone 3 – all of the Hunter Regulated WSP within the catchment of Glennies Creek.
- Hunter Unregulated and Alluvial Water Sources WSP 2009 (Hunter Unregulated and Alluvial WSP) - The Hunter Unregulated and Alluvial WSP includes the unregulated rivers and creeks within the Hunter River catchment, the highly connected alluvial groundwater (above the tidal limit), and the tidal pool areas. The Hunter Unregulated and Alluvial WSP is subdivided into water sources each with management zones, including:
    - There are two relevant Hunter Unregulated and Alluvial WSP management zones:
        - Management Zone 1 - Upstream Glennies Creek Management Zone; and
        - Management Zone 3 - Glennies Creek Management Zone.
    - Glennies Water Source; and
    - Jerrys Water Source – Jerrys Management Zone.
- North Coast Fractured and Porous Rock Groundwater Sources WSP 2016 (NCFPRGS WSP) – The NCFPRGS WSP commenced on 1st July 2016 and replaces licensing under the Water Act 1912, which covered seepage of groundwater from the Permian coal measures at the site, including groundwater hosted in the Permian coal seams, interburden and weathered profile. Ashton falls within the Sydney Basin – North Coast Groundwater Source of the NCFPRGS WSP.

The alluvium along the Hunter River, Glennies Creek and Bowmans Creek are classified as containing both "highly productive" and "less productive" groundwater sources by DPIE-Water, as discussed further under the Aquifer Interference Policy (AIP) section.

A1.4 Aquifer Interference Policy

The Water Management Act 2000 defines an aquifer interference activity as that which involves any of the following:

- penetration of an aquifer;
- interference with water in an aquifer;
- obstruction of the flow of water in an aquifer;
- taking of water from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations; and
- disposal of water taken from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations.

Examples of aquifer interference activities include mining, coal seam gas extraction, injection of water, and commercial, industrial, agricultural and residential activities that intercept the water table or interfere with aquifers.

The AIP (Department of Primary Industries 2012) states that: "*all water taken by aquifer interference activities, regardless of quality, needs to be accounted for within the extraction limits defined by the water sharing plans.*

A water licence is required under the WM Act (unless an exemption applies or water is being taken under a basic landholder right) where any act by a person carrying out an aquifer interference activity causes:

- *the removal of water from a water source;*
- *the movement of water from one part of an aquifer to another part of an aquifer; or*
- *the movement of water from one water source to another water source, such as:*
  - *from an aquifer to an adjacent aquifer; or*
  - *from an aquifer to a river/lake; or*
  - *from a river/lake to an aquifer. "*

Proponents of aquifer interference activities are required to provide predictions of the volume of water to be taken from a water source(s) as a result of the activity. These predictions need to be calculated prior to granting of development consent and these volumes need to be measured and reported annually. The water access licence must hold sufficient share component and water allocation to account for the take of water from the relevant water source at all times.

The AIP states that a water licence is required for the aquifer interference activity regardless of whether water is taken directly for consumptive use or incidentally. Activities may induce flow from adjacent groundwater sources or connected surface water. Flows induced from other water sources also constitute take of water. In all cases, separate access licences are required to account for the take from all individual water sources.

In addition to the volumetric water licensing considerations, the AIP requires details of potential:

- *"water level, quality or pressure drawdown impacts on nearby water users who are exercising their right to take water under a basic landholder right;*
- *water level, quality or pressure drawdown impacts on nearby licensed water users in connected groundwater and surface water sources;*
- *water level, quality or pressure drawdown impacts on groundwater dependent ecosystems;*
- *increased saline or contaminated water inflows to aquifers and highly connected river systems;*
- *to cause or enhance hydraulic connection between aquifers; and*
- *for river bank instability, or high wall instability or failure to occur."*

In particular, the AIP describes minimal impact considerations for aquifer interference activities based upon whether the water source is highly productive or less productive and whether the water source is alluvial or porous/fractured rock in nature.

A highly productive groundwater source is defined by the AIP as a groundwater source which has been declared in Regulations and datasets, based on the following criteria:

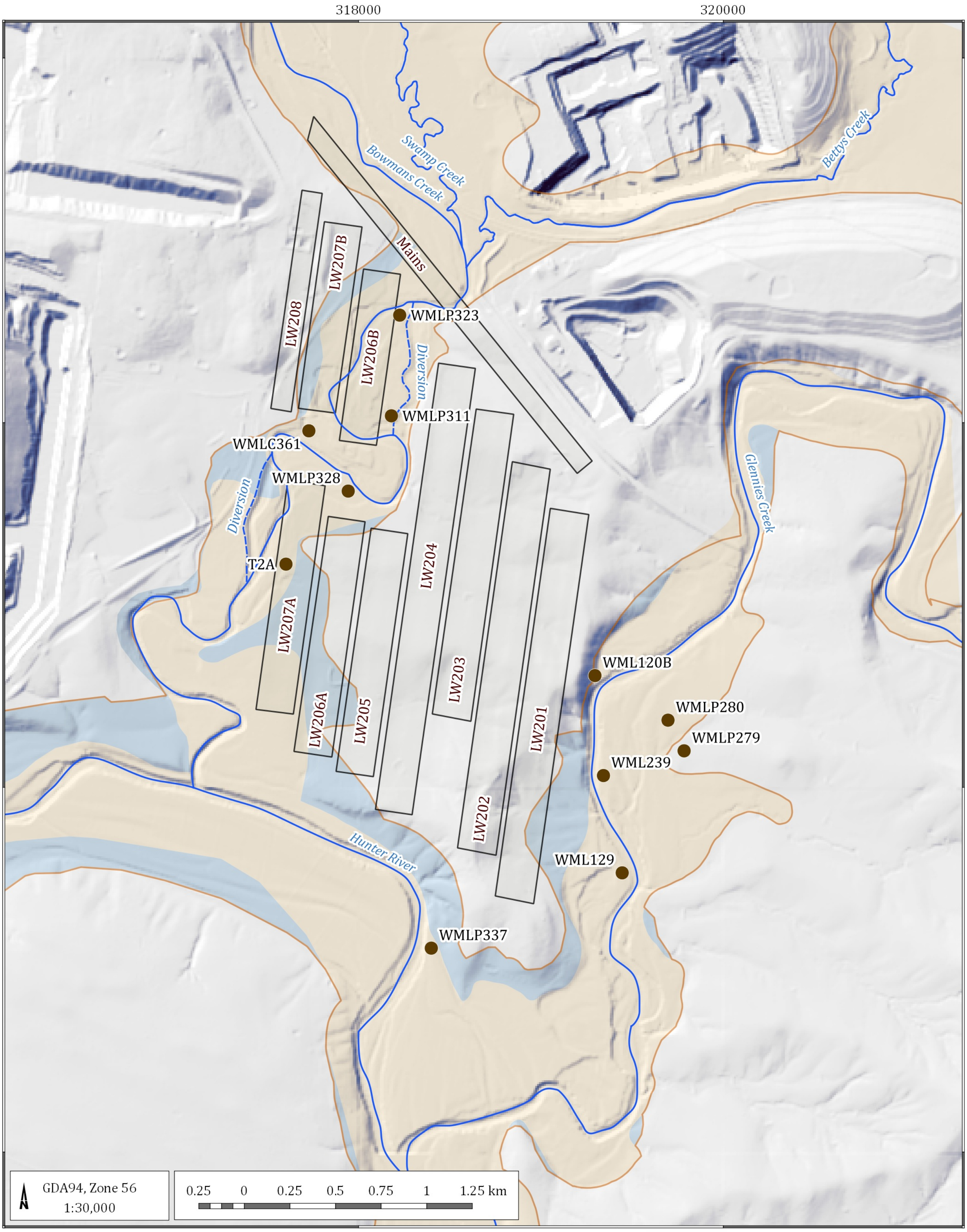
a) has a total dissolved solids (TDS) concentration less than 1,500 mg/L; and
b) contains water supply works that can yield water at a rate greater than 5 L/s.

"Highly productive" groundwater sources are further grouped by geology into alluvial, coastal sands, porous rock, and fractured rock. "Less productive" groundwater sources include aquifers that cannot be defined as "highly productive" according the yield and water quality criteria.

The alluvium along the Hunter River, Glennies Creek and Bowmans Creek meet the criteria of the "highly productive" and "less productive" alluvial water sources categories (Figure 2.2). The Permian coal measures (porous and fractured rock) are categorised as "less productive".

The activities at Ashton and the predicted impacts are approved under the Development consent (DA 309-11-2001) that was granted in October 2002.

Appendix B Bore location map



LEGEND

- Monitoring bores/VWPs
- Drainage
- Diversion
- Underground mine (Upper Lower Liddell seam)
- Quaternary alluvium/colluvium
- Coarse grained
- Fine grained

Ashton Longwall 205-208 EP (G1922M)

Figure B1 Bores and VWPs referenced in report text

AGE

DATE 27/04/2020

FIGURE No: **2.2**

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