# WAMBO COAL PTY LIMITED

## SOUTH BATES EXTENSION UNDERGROUND MINE

# EXTRACTION PLAN
# LONGWALLS 24 TO 26

## REPORT 2
GROUNDWATER ASSESSMENT REVIEW

Peabody

# TECHNICAL REPORT 2 - GROUNDWATER ASSESSMENT REVIEW

**Longwalls 24-26 Extraction Plan**
**Groundwater Technical Report**

**Prepared for:**

Wambo Coal Pty Ltd
PMB1 Singleton
NSW, 2330

**SLR Ref: 665.10008.01915-R01**
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# BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Wambo Coal Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

# DOCUMENT CONTROL

| Reference | Date | Prepared | Checked | Authorised |
|---|---|---|---|---|
| 665.10008.01915-R01-v2.0 | 25 May 2023 | Sharon Hulbert and Adam Skorulis | Adam Skorulis | Brian Rask |
| 665.10008.01915-R01-v1.0 | 17 April 2023 | Sharon Hulbert and Adam Skorulis | Adam Skorulis | Brian Rask |

# EXECUTIVE SUMMARY

Wambo Coal Mine (Wambo) is located approximately 15 kilometres west of Singleton, near the village of Warkworth, New South Wales (NSW). Wambo is owned and operated by Wambo Coal Pty Limited (WCPL), a subsidiary of Peabody Energy Australia Pty Ltd.

Wambo is operated under Development Consent (DA 305-7-2003). Underground mining operations are currently being undertaken in the approved South Bates Extension (SBX) Underground Mine (Whybrow seam). Mining is currently being undertaken in Longwall (LW) 23 under an approved Extraction Plan (EP).

An application to modify Development Consent (DA 305-7-2003) was submitted by WCPL to include the re-orientation of SBX LWs 24 and 25 and the addition of LW 26 (Modification 19). Modification 19 was approved by the Department of Planning and Environment on 25 January 2023. In accordance with the development consent conditions, an Extraction Plan (EP) is required to be prepared prior to commencement of mining of these longwalls. WCPL is in the process of preparing an EP for the re-oriented series of longwalls at SBX (i.e. LWs 24-26) (the LW24-26 EP).

SLR Consulting Australia Pty Ltd (SLR) has been engaged by WCPL to complete a technical review of the predicted groundwater impacts for LW24-26. This groundwater technical review has been conducted with reference to the work done for the recent Modification 19 Groundwater Assessment (SLR, 2022). Previous studies have identified potential anthropogenic and environmental users of groundwater in the Wambo area. Potential impacts to registered bores on private land and potential groundwater dependent ecosystems (GDEs) near Wambo operations are a consideration of this review.

The assessment of potential groundwater-related impacts of SBX LW24-26 have been undertaken using numerical groundwater modelling. The groundwater modelling carried out for the EP has used the model developed for the Modification 19 Groundwater Assessment (SLR, 2022) using MODFLOW-USG software. The (SLR, 2022) model used was developed consistent with relevant NSW Government and Commonwealth Government requirements and was peer reviewed as part of the groundwater assessment.

The evaluation of incremental groundwater impacts of SBX LW24-26 has required the running of a model scerario that includes all approved and forseeable Wambo mining without SBX LW24-26. As there has been no significant change to the layout of approved Wambo mining including SBX LW24-26 since the completion of the Modification 19 Groundwater Assessment (SLR, 2022), the evaluation of cumulative impacts of all approved Wambo mining including SBX LW24-26 has used predictions from existing modelling.

This groundwater technical review has considered:

- Recent relevant environmental monitoring data.
- Relevant information obtained since the completion of the SLR (2022) groundwater assessment (e.g. Groundwater Dependant Ecosystem (GDE) studies), and information from recently installed environmental monitoring sites.
- Predicted groundwater impacts due to the extraction of LW24-26 (incremental impacts).
- Groundwater impacts predicted in SLR (2022) – the *Longwalls 24-26 Groundwater Assessment* (cumulative impacts).

As there has been no significant change to the layout of approved Wambo mining including SBX LW24-26 since the completion of the Modification 19 Groundwater Assessment (SLR, 2022), the predicted impacts of approved Wambo mining including SBX LW24-26 are the same as the predicted cumulative impacts presented in that assessment.

# EXECUTIVE SUMMARY

The key findings of this groundwater technical review are:

- The hydrogeological conceptual model developed for the Modification 19 Groundwater Assessment (SLR, 2022) is not materially changed by the installation of additional monitoring locations or the collection of recent data. Recent data and additional monitoring locations that have improved the understanding of the hydrogeological system near SBX LW24-26 include:
    - The regional water table is unlikely to be shallow enough to interact with the Waterfall Creek high potential GDE.
    - A perched groundwater system may exist near the north end of SBX LW25. This may be spatially and geologically limited as the same perching is not observed west of SBX LW26.
- WCPL holds sufficient groundwater licences for currently predicted groundwater interception in the *Lower Wollombi Brook Alluvial Water Source* and *North Coast Fractured and Porous Rock Groundwater Sources*. This is not influenced by LW24-26 extraction.
- There are no registered bores above the SBX footprint that are used for irrigation, domestic or stock use. There are no private registered bores that are likely to be affected by 2 m drawdown or more due to LW24 to 26 extraction.
- Site monitoring bores have the potential to be impacted during mining, therefore review of the condition of the monitoring network will be undertaken during each sampling event, and bores remediated/replaced as required, to maintain a long-term monitoring network.
- The extraction of SBX LW24-26 would result in drawdown at the water table and within the Whybrow Seam above and to the north of LW24-26. This drawdown is predicted to have some impact to alluvium, surface water, and GDEs identified in this study. The predicted impact of approved Wambo mining including SBX LW24-26 is the same as the predicted cumulative impacts presented in the Modification 19 Groundwater Assessment (SLR, 2022).
- Extraction of LW24 to 26 would not have a significant impact on water levels in the Permian coal measures from a regional perspective due to the regional zone of depressurisation within the Permian coal measures created by historical and ongoing open cut and underground mining.

An additional groundwater monitoring location is recommended to be installed at Waterfall Creek, north of the modified Longwalls 24 to 26 and adjacent to the mapped potential GDE on Waterfall Creek. This paired monitoring bore would target shallow unconsolidated and weathered strata and would aim to improve the understanding of the nature and saturation level of unconsolidated material, any potential interaction with the underlying groundwater system, or potential interaction with the nearby high potential GDE. Data collected at the recently installed VWPs north and west of the modified Longwalls 24 to 26 should continue to be monitored to validate conceptual model assumptions and numerical model predictions.

The groundwater data analysis, based on currently available records, has shown that there are no observed material impacts from longwall mining beyond what was foreseen for the cumulative impacts described in the Modification 19 Groundwater Assessment (SLR, 2022).

No additional groundwater impact mitigation measures are proposed for the Modification. Groundwater levels and quality should continue to be monitored at Wambo in accordance with the GWMP approved under the Development Consent.

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## APPENDICES

# 1 Introduction

## 1.1 Overview

Wambo Coal Mine (Wambo) is located approximately 15 kilometres (km) west of Singleton, near the village of Warkworth, New South Wales (NSW). Wambo is owned and operated by Wambo Coal Pty Ltd (WCPL), a subsidiary of Peabody Energy Australia Pty Ltd.

Wambo is operated under Development Consent (DA 305-7-2003). The location of all existing and approved underground mining activities are presented in **Figure 1-1**. Mining is currently being undertaken in Longwalls (LWs) 21 to 23 under an approved EP.

An application to modify Development Consent (DA 305-7-2003) was submitted by WCPL to include the re-orientation of South Bates Extension (SBX) Longwalls (LW) 24 and 25 and the addition of LW 26 (Modification 19). Modification 19 was approved by the Department of Planning and Environment on 25 January 2023. In accordance with the development consent conditions, an Extraction Plan (EP) is required to be prepared prior to commencement of mining of these longwalls. WCPL is in the process of preparing an EP for the re-oriented series of longwalls at SBX (i.e. LWs 24-26) (the SBX LW24-26 EP).

SLR Consulting Australia Pty Ltd (SLR) has been engaged by WCPL to complete a technical review of the predicted groundwater impacts for LW24-26. The area encompassing LW24-26 is referred to as the study area throughout this report (**Figure 1-2**).

## 1.2 Approved Wambo Coal Mine

Wambo is operated in accordance with Development Consent (DA 305-7-2003) which was granted in February 2004. Both open cut and underground mining operations under Development Consent (DA 305-7-2003) commenced in 2004. In November 2014, Glencore and Peabody Energy Australia Pty Limited agreed to form a 50:50 Joint Venture to develop an open cut coal mine project that combined the extraction and exploration rights for a number of mining tenements held by United Collieries Pty Limited (United) (a subsidiary of Glencore) and WCPL. The Joint Venture proposed that United would manage the combined open cut mining operations utilising Wambo's existing infrastructure. WCPL would continue to operate its underground mining operations, the coal handling and preparation plant (CHPP) and rail loading facilities.

Development associated with DA 305-7-2003 and SSD-7142 will be staged. From 1 December 2020, Wambo transitioned into Phase 2 operations which includes underground mining and coal handling and processing. Development Consent (DA 305-7-2003) covers the following mining operations at Wambo (see **Figure 1-1**):

- Underground mining operations in the approved North Wambo Underground Mine (Wambo seam) (completed).
- Underground mining operations in the approved South Bates Underground Mine (Wambo and Whybrow seams) (completed).
- Underground mining operations in the approved SBX Underground Mine (Whybrow seam) (in progress).
- Underground mining operations in the approved South Wambo Underground Mine (Woodlands Hill and Arrowfield Seams) (future operation).

- Ongoing operation of the CHPP and processing of coal from the underground mining operation and the UWOCP, with up to 14.7 million tonnes per annum of run-of-mine coal processed at the CHPP in any calendar year.

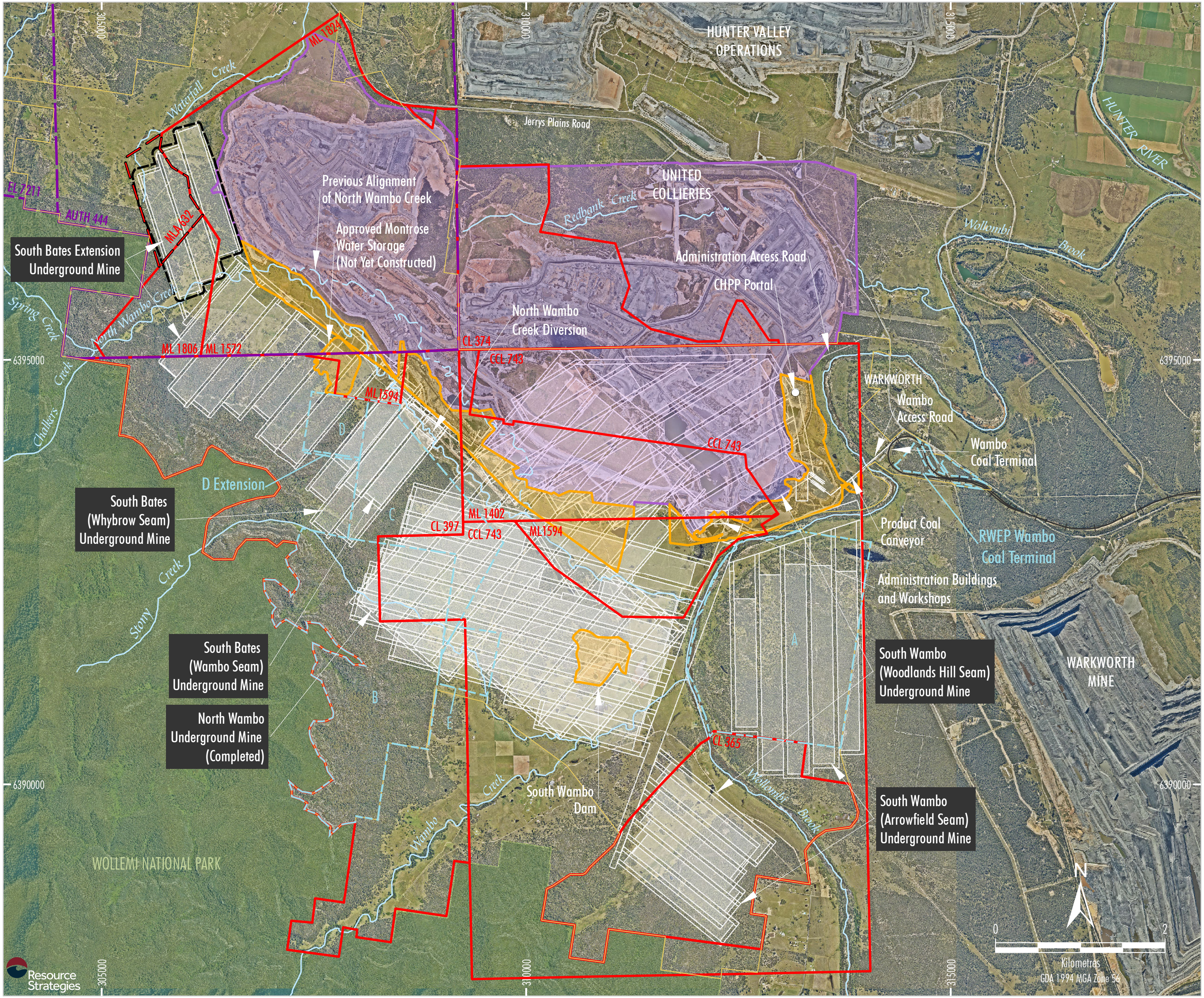
## 1.3 Extraction Plan objectives

An EP outlines the proposed management, mitigation, monitoring and reporting of potential subsidence impacts and environmental consequences from the secondary extraction of approved longwalls. This groundwater technical review contributing the LW24-26 EP comprises two parts, a description of the existing hydrogeological environment relevant to the study area, and an assessment of the potential groundwater related impacts due to LW24-26 extraction.

The most recent groundwater predictions were provided in the groundwater assessment conducted by SLR (2022) for Modification 19. The model utilised in this groundwater assessment was rebuilt from previous Wambo groundwater models (e.g. HydroSimulations, 2019), the United Wambo Open Cut numerical model (Australasian Groundwater and Environmental Consultants Pty Ltd [AGE] 2016) and site and regional geological models using current best practice modelling techniques.

This groundwater technical review presents and discusses the following:

- Recent relevant environmental monitoring data.
- Groundwater impacts predicted in SLR (2022) – the *Longwalls 24-26 Groundwater Assessment*.
- Relevant information obtained since the completion of the SLR (2022) groundwater assessment (e.g. Groundwater Dependant Ecosystem [GDE] studies, or information from recently installed environmental monitoring sites).
- Predicted groundwater impacts due to the extraction of SBX LW24-26.
- As there has been no significant change to the layout of approved Wambo mining including SBX LW24-26 since the completion of the Modification 19 Groundwater Assessment (SLR, 2022), the predicted impacts of approved Wambo mining including SBX LW24-26 are the same as the predicted cumulative impacts presented in that assessment.




LEGEND

- National Park
- SSD 7142 Operational Area #
- WCPL Owned Land

Wambo Coal Mine

- Exploration Licence Boundary (AUTH, EL)
- Mining and Coal Lease Boundary (ML, CL, CCL)
- Mining Lease Application Boundary (MLA)
- Remnant Woodland Enhancement Program (RWEP) Area
- Existing/Approved Wambo Coal Mine Surface Development Area
- Existing/Approved Underground Development
- Extraction Plan Application Area

# Under Phase 2 of mining at Wambo Coal Mine (commenced 1 December 2020), this area is operated by United Colleries Pty Ltd under the United Wambo Joint Venture Project.

*Source: WCPL (2023); MSEC (2023); NSW Spatial Services (2023)*
*Orthophoto: WCPL (Nov-May 2022)*

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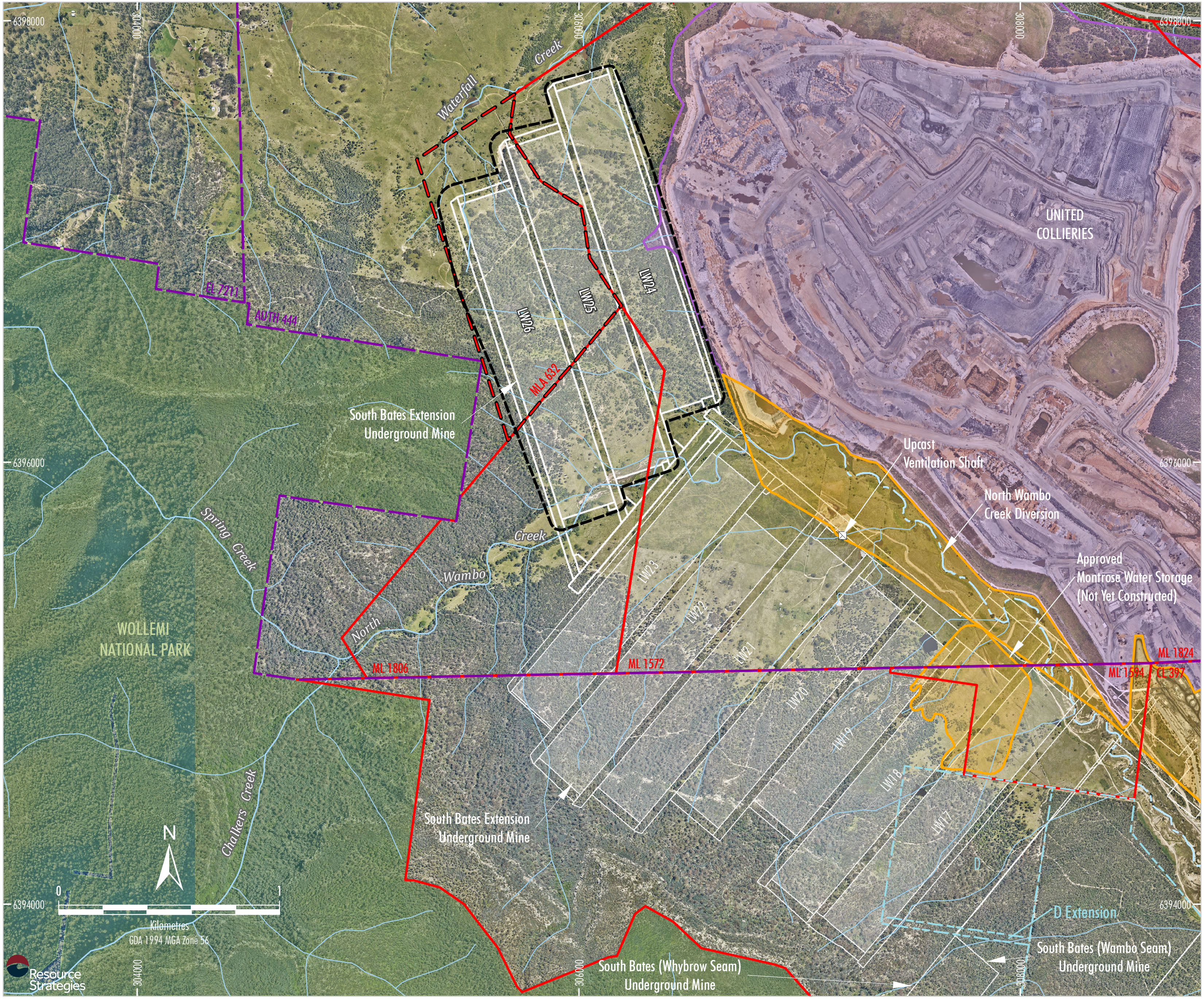
WAMBO COAL MINE

**Approved Wambo Coal Mine layout**
**Figure 1-1**

WAM-09-15_SBX Mod LW24-26_EP_PSMP_201A




# Under Phase 2 of mining at Wambo Coal Mine (commenced 1 December 2020), this area is operated by United Colleries Pty Ltd under the United Wambo Joint Venture Project.

*Source: WCPL (2023); MSEC (2023); NSW Spatial Services (2023)*
*Orthophoto: WCPL (Nov 2022)*

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Aerial photograph of Longwalls 24 - 26
Figure 1-2

WAM-09-15_SBX Mod LW24-26_EP_MT_203C

## 1.4 Information sources

The following information sources have been relied upon for the development of this groundwater technical review:

- Indicative approved and modified Wambo mine plan information in Geographic Information System (GIS) format.
- Wambo groundwater and surface water monitoring database (from 2003 to December 2022).
- Previous Wambo groundwater, surface water and ecological reporting and associated information/datasets.
- Previous Wambo numerical modelling reporting and associated information/datasets.
- Publicly available information:
  - Bureau of Meteorology (BoM) (2021) GDE Atlas.
  - Water NSW real time data registered bore database.

Condition B7, Schedule 2 of the Development Consent requires the Extraction Plan to "*…provide updated predictions of the potential subsidence effects, subsidence impacts and environmental consequences of the proposed mining covered by the Extraction Plan, incorporating any relevant information obtained since this consent;…*"

Since the completion of the groundwater assessment for Modification 19 (SLR,2022) the following additional studies have been completed and information has been obtained with relevance to the LW24-26 study area:

- Installation of vibrating wire piezometers (VWPs) at three locations north and west of the study area to better understand overburden groundwater conditions near LW24-26, including the potential for interaction between the regional water table and Waterfall Creek.
- The collection of surface and groundwater observation data across the site since the Modification 19 Groundwater Assessment.
- Completion of the Biodiversity Development Assessment Report (Hunter Eco, 2022), which includes the identification and assessment of potential impacts to groundwater dependant vegetation within and adjacent to the study area.

# 2 Existing Environment

## 2.1 Climate

The temperate climate of the Wambo area is characterised by hot summers and mild dry winters. Locally, daily rainfall has been recorded at Bulga (South Wambo) (BoM Station 061191) from 01 January 1959 to 1 April 2023. **Table 2-1** provides the long term historical monthly average rainfall for WCPL compared to recent (since 2019) monthly rainfall data.

### Table 2-1 Average and recent rainfall (mm)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Monthly Average** | **87.2** | **83.2** | **68** | **45.6** | **39.7** | **43.8** | **30.3** | **34.2** | **38.5** | **54.3** | **62** | **71.7** | **658.6** |
| 2019 | 59.6 | 21 | 145.6 | 3.4 | 11.8 | 6.4 | 13.4 | 21.8 | 21.4 | 4.4 | 30.8 | 0.2 | 339.8 |
| 2020 | 65.4 | 197.6 | 130.6 | 43 | 16.6 | 30.6 | 66.2 | 42.4 | 45.8 | 96.6 | 43.4 | 192 | 778.2 |
| 2021 | 132.4 | 96.4 | 256.3 | 19.8 | 5.5 | 67.6 | 30.8 | 46 | 24.8 | 78.5 | 229 | 96.2 | 987.1 |
| 2022 | 74.9 | 62.2 | 340.6 | 38.5 | 55.6 | 9.6 | 203.6 | 61.4 | 67.3 | 112.6 | 121.2 | 16 | 1147.5 |
| 2023 | 62.4 | 75.4 | 111.8 | | | | | | | | | | - |

Bulga (South Wambo) rainfall data was also used to generate a cumulative rainfall deficit (CRD) plot (**Figure 2-1**). A CRD plot is provided as a comparative tool to illustrate long term climate trends and their influence on groundwater in the Wambo area. The CRD graphically shows trends in recorded rainfall compared to long-term averages and provides a historical record of relatively wet and dry periods. A rising trend in slope in the CRD graph indicates periods of above average rainfall, whilst a declining slope indicates periods when rainfall is below average. A level slope indicates average rainfall conditions.

Recently, the Wambo area experienced below average rainfall from 2017 to early 2020, followed by above average rainfall from January 2020 through to early 2023.

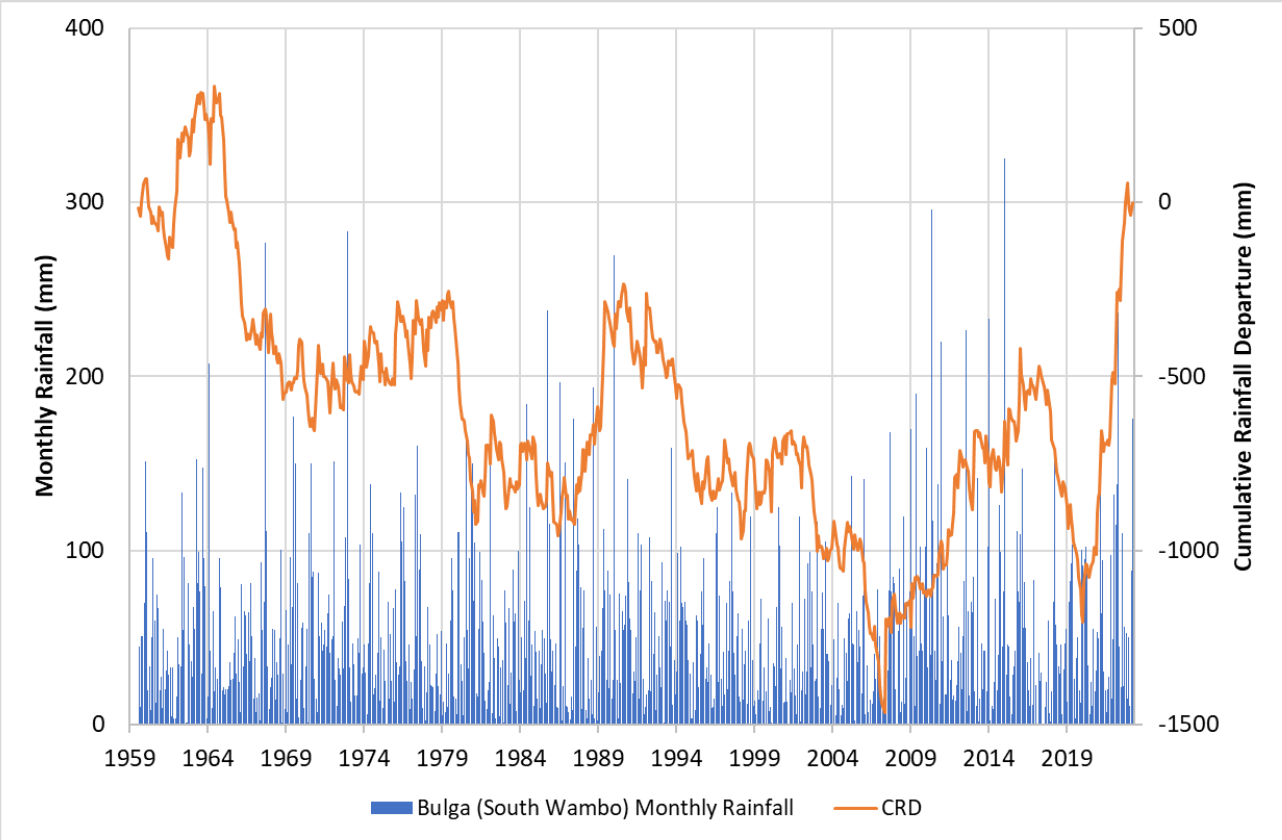


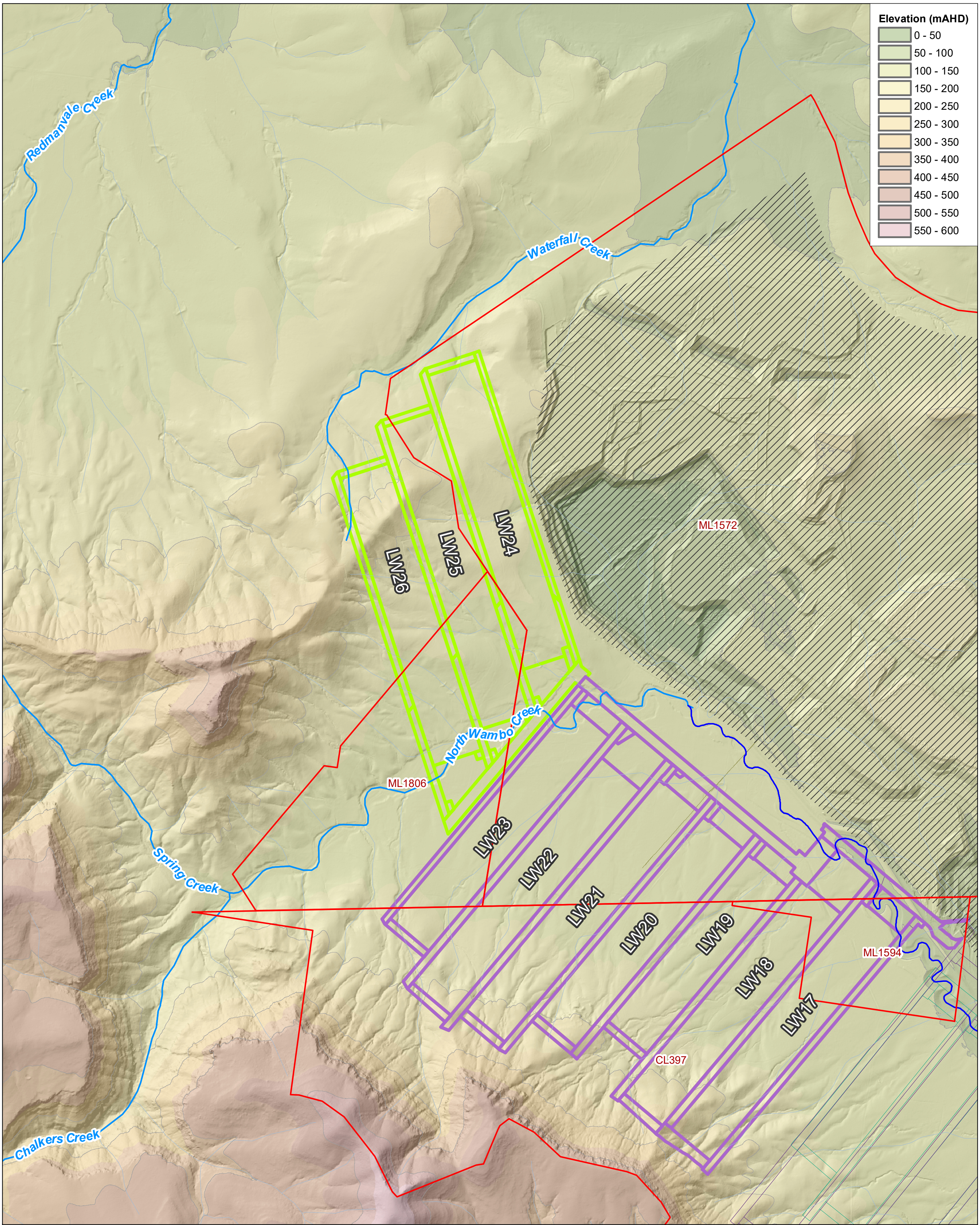

**Figure 2-1 Bulga (South Wambo) long-term monthly rainfall and CRD**

## 2.2 Topography, land use and drainage

Wambo is located in the Upper Hunter Valley region where landforms are characterised by gently sloping floodplains associated with the Hunter River and the undulating foothills, to the ridges and escarpments of the Mount Royal Range and Great Dividing Range. Elevations in the vicinity of Wambo range from approximately 60 metres Australian Height Datum (mAHD) at Wollombi Brook to approximately 650 mAHD within the Wollemi National Park to the west of Wambo (WCPL, 2003). Topographic data available for the site includes site LIDAR with <1 metres (m) refinement (used for key water courses and site features); publicly available data with 1 to 2 m refinement (used where available); and SRTM (satellite) Digital Elevation Model (DEM) with 1 to approximately 30 m refinement (used for the remaining model domain).

Due to historical farming and mining, the majority of the Wambo area is cleared of vegetation. Wollemi National Park, to the west (**Figure 1-1**), is densely vegetated with various plant communities, including open forests dominated by eucalypt species (AGE, 2016).

**Figure 2-2** shows local topography and drainage features in the SBX area. The primary drainage features of this area are the perennial Hunter River to the north and ephemeral North Wambo Creek and Waterfall Creek to the south and north of SBX LW24-26 respectively. North Wambo Creek drains into Wollombi Brook while Waterfall Creek drains into the Hunter River.






| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 56 |
| Scale: | 1:25,000 at A4 |
| Project Number: | 665.10008.01915 |
| Date: | 13-Apr-2023 |
| Drawn by: | NT |

South Bates Extension (LW17-23)
South Bates Extension (LW24-26)
Named Watercourse
NWC Diversion
Mining Lease
Approved Open Cut Mining

**Wambo Underground Mine Area**
South Bates - Whybrow Seam
South Bates - Wambo Seam

Data Source: NSW SS 2020

SLR

**WAMBO COAL MINE**
**LW24-26 EXTRACTION PLAN**
**GROUNDWATER TECHNICAL REVIEW**

**Topography and drainage**

**FIGURE 2-2**

### 2.2.1 Ephemeral creeks

Within the vicinity of Wambo Coal Mine, the following creeks are ephemeral in nature (see **Figure 2-2**):

- North Wambo and Wambo Creeks, which drain into Wollombi Brook;
- Stony Creek, which drains into Wambo Creek prior to its confluence with Wollombi Brook; and
- Waterfall Creek, which drains into the Hunter River.

Of the ephemeral creeks, North Wambo Creek and Waterfall Creek are the most relevant to this Groundwater Technical Report. North Wambo Creek and Waterfall Creek overlie or are near SBX LW24-26. Description on ephemeral creeks not discussed in the following section is provided in SLR (2022), which focused on the broader Wambo underground mine complex.

#### 2.2.1.1 North Wambo Creek

North Wambo Creek traverses from west to south-east, through the centre of the Wambo area and flows into Wollombi Brook. At its upstream end it drains to the north-east across the southern ends of SBX LW24-26 and the northern edge of SBX LW23. Recent installation of monitoring bores has shown the alluvium along North Wambo Creek to be 4 to 10 m deep comprising mainly sands, silts, and gravels, overlying weathered sandstones (regolith). Most of the south-west draining channel section of North Wambo Creek is an artificial realignment as open cut operations to the west mined out the natural channel.

North Wambo Creek is usually dry and only flows in response to heavy rainfall events. During peak flow events, conditions are likely to be losing (surface water leaking to the underlying aquifer). However, if rainfall and surface water flow sufficiently recharge the North Wambo Creek alluvium, gaining conditions may occur (groundwater discharging to surface water). Stage height from North Wambo Creek flow monitoring site FM1 is presented against nearby shallow groundwater level observations in **Section 4.3.5**.

Alluvium Consulting (2020) compared the antecedent precipitation index (API) from the Bulga (South Wambo) rainfall gauge (BoM Station 061191) with available data from the FM1 flow station on North Wambo Creek and found that the onset of surface flow generally occurs when API exceeds a value of 100 millimetres (mm). It is conceptualised that flow events on North Wambo Creek contribute to the saturation of its alluvial aquifer, and that incorporation of this API-flow relationship into the numerical model has enabled simulation of likely flow events not captured in the incomplete monitoring dataset.

#### 2.2.1.2 Waterfall Creek

Waterfall Creek is located in a catchment to the north of North Wambo Creek, and generally flows in a north easterly direction to the Hunter River. The UWOCP Surface Water Management Plan (United, 2022) describes Waterfall Creek as "*ephemeral and frequently dry. Its channel is generally shallow and poorly defined along its length as its catchment is predominantly drained by overland sheet flow. As such, Waterfall Creek's riparian zone is also poorly defined*."

The northern end of modified Longwalls 24 and 25 extend to within 100 to 300 m of Waterfall Creek, while modified Longwall 26 underlies the first and second order drainage lines that form the headwaters of Waterfall Creek (**Figure 2-2**). A review of Aerial imagery and the DEM shows that just north of modified SBX Underground Mine footprint, the channel is either poorly defined or not discernible along the floor of a reasonably steep sided valley in this location, with a floor elevation approximately 50 m lower than the valley sides. A farm dam has been constructed on the upper reach of the creek, which holds water, and a small pond is present within the valley just north of modified Longwall 24.

There is currently no data on the frequency and duration of flows, creek bed material, surface water – groundwater interactions, and or the presence of alluvium along Waterfall Creek. It is noted, however, that the presence of surface water flow within Waterfall Creek is infrequently encountered in routine and rain event surface water monitoring. Five events from 52 attempts (9.6%) at midstream Waterfall Creek (SW39) and 13 events from 52 attempts (25%) at downstream Waterfall Creek (SW41) encountered flow from October 2019 to December 2022, noting that three (at SW36) and seven (at SW41) sampling events were successful in 2022 with above average rainfall conditions. Infrequent flows monitored at Waterfall Creek, despite recent above average rainfall conditions is consistent with the ephemeral and frequently dry description above (United, 2022).

### 2.2.2 Wollombi Brook

Wollombi Brook flows north to north-easterly before meeting the Hunter River and is located approximately 6.5 km south-east of the SBX LW24-26. Alluvium along Wollombi Brook comprises up to 10 to 20 m of unconsolidated sediment including gravel, sand, silt, and clay (Mackie Environmental Research [MER], 2009). Stream flow analysis was undertaken by AGE (2016) to assess the contribution of baseflow in Wollombi Brook with results showing flow is largely a function of rainfall. AGE (2016) estimated that groundwater contributes up to 70 megalitres[1] per day (ML/day) to the flow in the Wollombi Brook. Although Wollombi Brook is predominantly a gaining environment (receiving groundwater) there are also areas where the Wollombi Brook recharges the underlying alluvium (losing environment), particularly in high flow events.

Monitoring of Wollombi Brook occurs at two key gauging stations, Wollombi Brook at Bulga (ID: 210028) and Wollombi Brook at Warkworth (ID: 210004) (**Table 2-2**). **Figure 2-3** presents stage height at the two gauges alongside the Wambo (SILO) CRD data to the end of the numerical model calibration period (December 2020 – see **Section 5.1**).

**Table 2-2 Wollombi Brook gauging stations**

| Station | WaterNSW ID | Easting | Northing | Zero Stage Elevation (mAHD) |
|---|---|---|---|---|
| Wollombi Brook at Bulga | 210028 | 314360 | 6385900 | 65.7 |
| Wollombi Brook at Warkworth | 210004 | 314228 | 6395064 | 49.4 |

[1] Note one megalitre is one million litres (1,000,000 L)

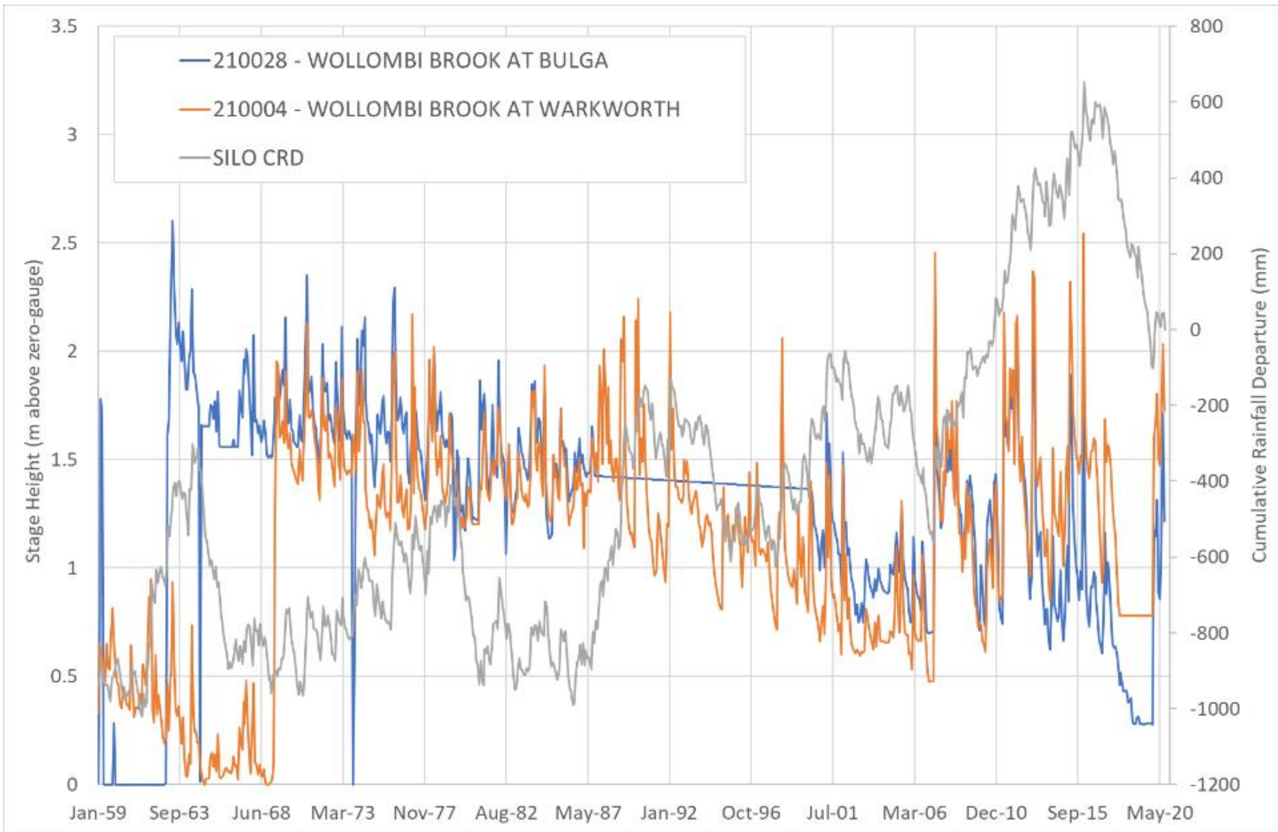



**Figure 2-3 Wollombi Brook stage height (above zero-gauge level) and Wambo (SILO) CRD plot**

### 2.2.3 Hunter River

Within the Wambo area, the Hunter River is around 20 to 50 m wide and flows in a south to south-easterly direction. The Hunter River is approximately 2.5 km north north-east of SBX LW24. The surface water is used for industrial and agricultural purposes, as well as town water supplies. Flowing perennially, daily flows generally range between 100 ML/day and 1,000 ML/day (from WaterNSW gauging station data). Flood events, recorded in May 2001, June 2007, September 2008, June 2011, and March 2013, experience daily flows of over 2,000 ML/day. Monitoring of gauging stations occurs via the Hunter Integrated Telemetry System operated by WaterNSW, with gauging stations relevant to the development of the SLR (2022) numerical model presented in **Table 2-3.**

**Table 2-3 Hunter River gauging stations**

| Station | WaterNSW ID | Easting | Northing | Zero Stage Elevation (mAHD) |
|---|---|---|---|---|
| Hunter River at Liddell | 210083 | 304903 | 6403439 | 177.2 |
| Hunter River u/s Foy Bk | 210126 | 316688 | 6404138 | 67.1 |
| Hunter River u/s Glennies Ck | 210127 | 317946 | 6402556 | 66.0 |
| Hunter River at Mason Dieu | 210128 | 316729 | 6401337 | 58.4 |

Gauging station data (stage height) is presented against the Wambo (SILO) CRD in **Figure 2-4** and illustrates that water levels within the Hunter River varied by ± 0.5 m between 2001 and 2020 (end of current model calibration period – **Section 5.1**). These levels remained relatively stable due to regulated releases from Glenbawn Dam.

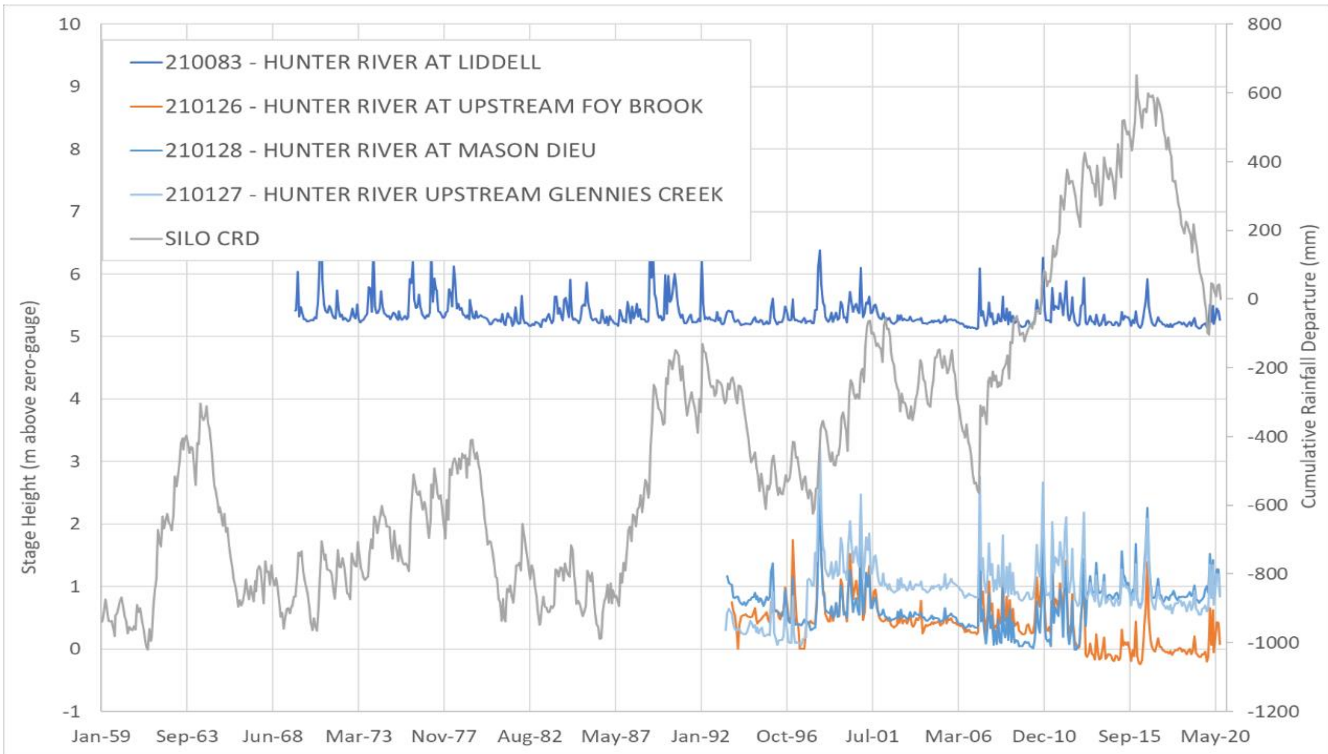



**Figure 2-4 Hunter River stage height and Wambo (SILO) CRD**

Baseflow separation completed by AGE (2016) indicates that surface water flow within Hunter River is largely a function of rainfall. However, it is estimated that groundwater contributes up to 231 ML/day to the Hunter River. The baseflow in the Hunter River is likely to be less than estimated due to releases from the Glenbawn Dam that maintains a permanent flow for downstream users. Although the Hunter River is predominantly a gaining environment (receiving groundwater) there are also areas where the river recharges the underlying alluvium (losing environment), particularly in high flow events.

## 2.3 Mining

Historically coal mining in the region has been undertaken via both open cut and underground mining techniques. Currently, mining is still occurring via both mechanisms undertaken by several operators. **Table 2-4** summarises the mine activities in the area, with those operational shown in bold.

**Table 2-4 Summary of mine activities (those in bold currently operational)**

| Operator | Mine Name | Seam(s) Mined | Date Operational | Mine Type |
|---|---|---|---|---|
| WCPL | Homestead Underground | Whybrow | 1969 – 1977 | Underground |
| | Wollemi Underground | Whybrow | 1997 – 2002 | Underground |
| | Ridge Underground | Whybrow | 1973 – 1983 | Underground |
| | Wombat Pit | Whybrow to Whynot | 1969 – 2009 | Open Cut |
| | Hunter Pit | Whybrow to Whynot | 1969 – 2011 | Open Cut |
| | Bates / Bates South Pit | Whybrow to Whynot | 1986 – 2016 | Open cut |
| | Glen Munro Pit | Glen Munro | 2016 – 2017 | Open Cut |
| | South Bates Underground | Whybrow<br>Wambo | 2016 – 2019 | Underground |
| | **SBX** | Whybrow | 2018 – 2023 | Underground |
| | Montrose Pit | Whybrow to Whynot | 2013 – 2020 | Open Cut |
| | Homestead Pit | Whybrow to Whynot | 1969 – 2009 | Open Cut |
| | North Wambo Underground | Wambo | 2007 – 2016 | Underground |
| | South Wambo Underground (Approved) | Arrowfield<br>Bowfield | To 2042 | Underground |
| | SBX – Longwalls 24-26 Modification (the Modification) | Whybrow | 2023 – 2025 | Underground |
| United Colliery | United Open Cut | Wambo to Whynot | 1989 – 1992 | Open Cut |
| | United Underground | Arrowfield | 1992 – 2010 | Underground |
| United Wambo Joint Venture | **UWOCP** | Whynot to Vaux | 2020 – 2039 | Open Cut |
| Hunter Valley Operations | **Hunter Valley Operations (HVO) North** | Mt Arthur<br>Bayswater | 1979 – 2025 | Open Cut |
| | **HVO South** | Arrowfield to Bayswater | 1997 – 2030 | Open Cut |
| | Lemington Underground | Mt Arthur Seam | 1971 – 1992 | Underground |
| | North Lemington | Mt Arthur to Vaux | 1971 – 1999 | Open Cut |
| Mount Thorley Operations Pty Ltd and Warkworth Mining Ltd | **Mount Thorley Warkworth (MTW)** | Woodlands Hill to Bayswater | 1981 – 2035 | Open Cut |

The SBX longwalls considered in this EP target the Whybrow Seam and will use the existing infrastructure at the SBX underground mine. A summary of the timing and geometry of LW24-26 is presented in **Table 2-5**.

### Table 2-5 LW24 – 26 proposed timing

| Longwall Panel | Proposed Start Date | Proposed Completion Date | Duration (days) | Panel Length (m) | Panel Width (m) |
|---|---|---|---|---|---|
| LW 24 | 12/15/2023 | 9/15/2024 | 275 | 1540 | 250 |
| LW 25 | 10/15/2024 | 8/15/2025 | 304 | 1575 | 250 |
| LW 26 | 9/15/2025 | 6/15/2026 | 273 | 1495 | 250 |

# 3 Geological setting

### 3.1.1 Regional stratigraphic setting

Wambo is situated within the Hunter Coalfield subdivision of the Sydney Basin, which makes up the southern part of the Sydney-Gunnedah-Bowen Basin. The basin was formed during the Late Carboniferous to Early Permian as a result of continental rifting processes and deposition of Permian and Triassic sediments (AGE, 2016). Regionally, the geological stratigraphic profile is characterised by surficial alluvium, overlying shallow bedrock (regolith), Jurassic Volcanics (intrusions), Triassic Sandstone and Permian coal measures (including the target seams for regional mining activities). A summary of the stratigraphic profile is provided in **Table 3-1**. The outcrop geology and geological structure relevant to SBX LW24-26 is presented in **Figure 3-1**.

**Table 3-1 Regional stratigraphic profile**

<table>
<tr><th colspan="2">Era</th><th colspan="3">Stratigraphic unit</th><th>Description</th></tr>
<tr><td colspan="2">Quaternary</td><td colspan="3">Quaternary alluvium (Qha/Qhb)</td><td>Shallow sequences of clay, silty sand, and sand (Qhb) and Basal sands and gravels along major watercourses (i.e. Hunter River) (Qha)</td></tr>
<tr><td colspan="2" rowspan="4">Tertiary</td><td colspan="3">Tertiary alluvium (Cza)</td><td>Alluvial terraces – Silt, sand, and gravel</td></tr>
<tr><td colspan="3">Aeolian Dunes (Czb)</td><td>Sand</td></tr>
<tr><td colspan="3">Silicified Weathering Profile (Czas)</td><td>Silcrete</td></tr>
<tr><td colspan="3">Alluvial Terraces (Cza)</td><td>Silt sand and gravel</td></tr>
<tr><td colspan="2">Jurassic</td><td colspan="3">Volcanics (Jv)</td><td>Flows, sills, and dykes</td></tr>
<tr><td colspan="2">Triassic</td><td colspan="3">Narrabeen Group (Rn)</td><td>Sandstone, interbedded sandstone, siltstone, and claystone. Localised at Wollemi National Park.</td></tr>
<tr><td rowspan="7">Permian</td><td rowspan="6">Late</td><td rowspan="6">Singleton Supergroup</td><td>Newcastle Coal Measures (Psl)</td><td>Glen Gallic Sub-group, Doyles Creek Sub-group, Horseshoe Creek Sub-group, Apple Tree Flat Sub-group</td><td>Coal seams, claystone (tuffaceous), siltstone, sandstone, and conglomerate.</td></tr>
<tr><td colspan="2">Watts Sandstone</td><td>Medium to coarse grained sandstone</td></tr>
<tr><td rowspan="4">Wittingham Coal Measures</td><td>Jerrys Plains Subgroup (Pswj)</td><td>Interbedded coal measures with siltstone, sandstone, and shale. Coal seams include Whybrow, Redbank Creek, Wambo, Whynot, Blakefield, Glen Munro, Woodlands Hill, Arrowfield, Bowfield, Warkworth, Mt Arthur, Piercefield, Vaux, Broonie and Bayswater.</td></tr>
<tr><td>Archerfield Sandstone (Psws)</td><td>Massive coarse-grained lithic sandstone.</td></tr>
<tr><td>Vane Subgroup (Pswv)</td><td>Interbedded coal measures with siltstone, sandstone, and shale. Coal seams include Lemington, Pikes Gully, Arties, Lidell, Barrett, and Hebden.</td></tr>
<tr><td>Saltwater Creek Formation (Pswc)</td><td>Sandstone and siltstone, minor coaly bands, marine siltstones intercalated towards base.</td></tr>
<tr><td>Middle</td><td>Maitland Group</td><td colspan="2">Mulbring Siltstone (Pmm)</td><td>Dark grey shale and siltstone, bioturbated and fossiliferous.</td></tr>
</table>

### 3.1.2 Local geology

#### 3.1.2.1 Alluvium

The alluvial deposits in the Wambo area unconformably overlie Triassic and Permian erosion surfaces and are associated with the perennial and ephemeral watercourses (**Section 2.2**), including:

- Hunter River Alluvium – alluvium along the Hunter Reiver comprises 10 to 20 m of unconsolidated sediments including gravel, sand, silt, and clay (MER, 2009). Within the Hunter River flood plains, the surficial alluvium is commonly underlain by basal sands and gravels. The basal sands and gravels are not present within the Wambo site. The alluvium unconformably overlies the Permian coal measures (AGE, 2016).
- North Wambo Creek Alluvium – alluvium along the upper reaches of North Wambo Creek is between 4 and 10 m thick according to monitoring bore installation logs.
  - The alluvium generally comprises sand and gravel, overlying weathered sandstones (regolith). The North Wambo Creek alluvium is outside of mapped areas of Highly Productive Groundwater (HydroSimulations, 2017); however, the coarser material encountered in drilling may be consistent with coarser 'highly productive' material along Wollombi Brook.
  - The current extent of alluvium along North Wambo Creek in the vicinity of the SBX LW14-26 is limited by the footprint of Montrose Pit. The alluvium within and adjacent to the Longwalls 24 to 26 has been disconnected from the regional alluvial system due to the removal of alluvium downstream across the full width of the channel by the approved open cut mining operations (and associated construction of the North Wambo Creek Diversion) (HydroSimulations, 2017).
- Waterfall Creek Alluvium – it is likely that any alluvial material associated with Waterfall Creek will be limited in extent, due to the small catchment size when compared with other ephemeral watercourses in the Wambo area and the relatively confined valley in which it is located. However, a review of aerial imagery from 2014-2021 and the DEM has identified the following features on Waterfall Creek that may indicate the presence of permeable and saturated shallow strata north of the modified SBX Underground Mine footprint:
  - A small pond is present within the Waterfall Creek valley 100 m north of modified Longwall 24. This pond appears to hold water persistently and may intersect a shallow water-table.
  - The creek channel is observed to disappear within the valley north of modified Longwall 24. Flow would not be able to dissipate laterally within the valley, and it is possible that permeable strata exist within the valley that can transport flow from upstream below ground surface.
- Wollombi Brook Alluvium – alluvium along Wollombi Brook comprises 10 to 20 m of unconsolidated sediments including gravel, sand, silt, and clay (MER, 2009). Within the Wollombi Brook floodplain, basal sands and gravels are typically between 7 to 20 m thick (AGE, 2016).
- Wambo Creek Alluvium – alluvium along Wambo Creek is approximately 4 to 7 m thick and comprises clayey to sandy, brown silt with areas of localised fine to medium grained sand (HLA-Envirosciences, 1999). There are also indications that the alluvial aquifer is discontinuous, probably due to bedrock highs (HLA-Envirosciences, 1999).

#### 3.1.2.2 Sediment and weathered bedrock (regolith)

Sediment and weathered shallow bedrock are present outside of areas of alluvium and form the regolith. The regolith consists of sandy or silty-clayey lithology where some coal seams outcrop/sub-crop, with a sandier lithology associated with the inter-seam units and some coal seams. The regolith thickness map developed by CSIRO (2015) indicates the regolith in the vicinity of the Wambo area has a variable thickness ranging from less than 1 to 11 m outside of the mapped alluvium extents. At higher elevation areas the regolith was found to be thin and is generally thicker in areas of lower elevation.

#### 3.1.2.3 Volcanics

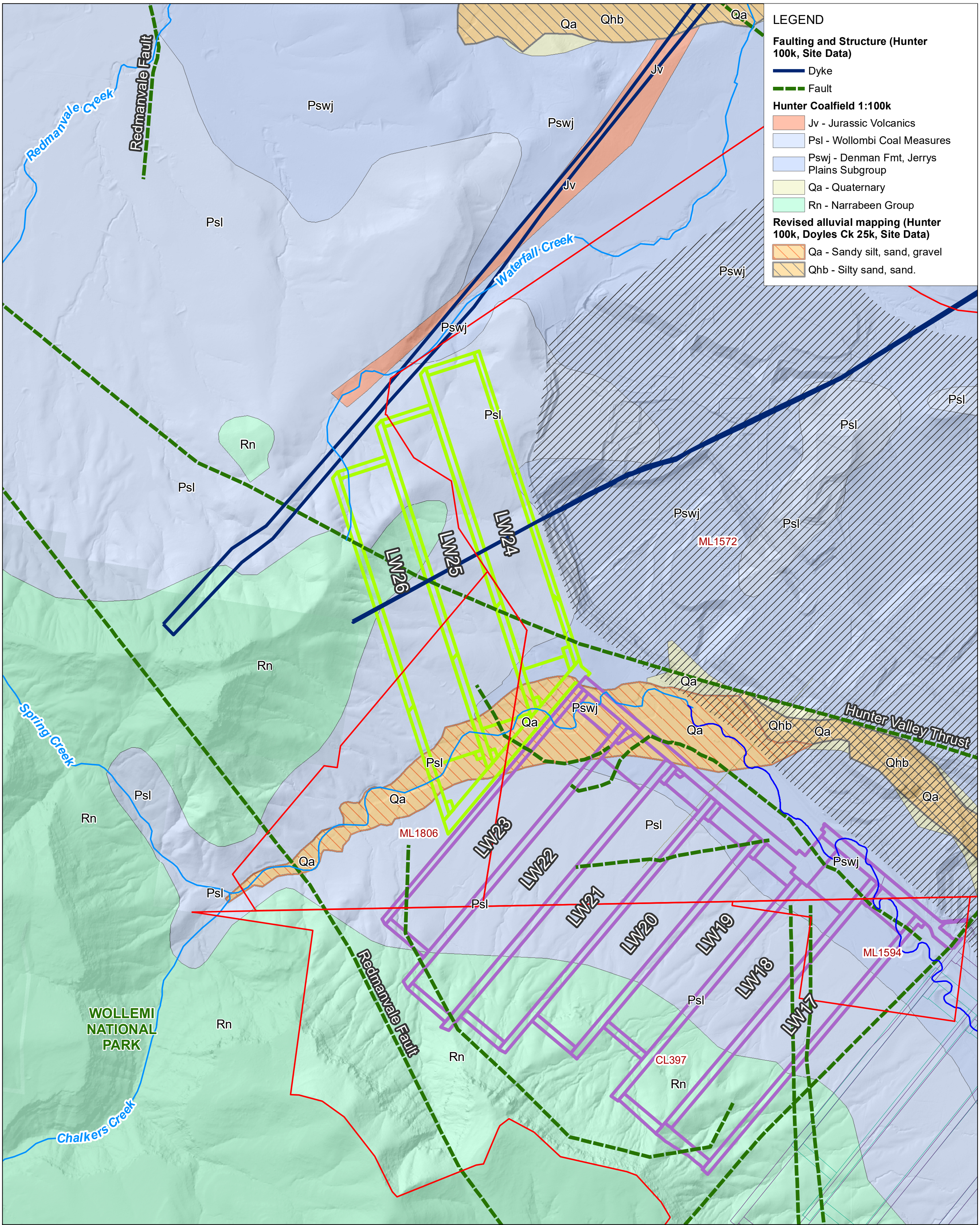
Jurassic volcanics have been observed at outcrops to the north and northeast of the Wambo area and have been encountered by many mining operations. The unit is comprised of Volcanic sills and dykes at surface and sub-surface and are likely recharged from rainfall recharge and surface water flow.

#### 3.1.2.4 Triassic Narrabeen Group

The Triassic Narrabeen Group forms the prominent escarpment on elevated areas to the west of SBX LW24-26 and unconformably overlies the Permian coal measures. The unit comprises mainly interbedded sandstone, with some siltstone and claystone.

#### 3.1.2.5 Permian coal measures

The coal measures are Permian age sediments which contain numerous coal seams and associated splits. These are separated by interburden comprising interbedded sandstones and laminated mudstones and siltstones. The Permian coal measures are regionally extensive and occur at surface and unconformably underlie Quaternary alluvium. The coal measures can also underlie and be intruded with volcanic sills in localised areas. Surficial geology at SBX LW24-26 is predominantly mapped as the Newcastle Coal Measures (**Figure 3-1**), which is underlain by the Wittingham Coal Measure that contain the economic coal seams within the Wambo area.




| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 56 |
| Scale: | 1:25,000 at A4 |
| Project Number: | 665.10008.01915 |
| Date: | 11-Apr-2023 |
| Drawn by: | NT |

SLR

Data Source: NSW SS 2020

**WAMBO COAL MINE**
**LW24-26 EXTRACTION PLAN**
**GROUNDWATER TECHNICAL REVIEW**

**Outcrop geology and geological structure**

**FIGURE 3-1**

H:\Projects-SLR\660-SrvWOL\660-WOL\665.10008 Wambo Groundwater Study\06 SLR Data\01 CADGIS\ArcGIS\SLR665100080 1915_LW24_26EP_2_3_OutcropStructuralGeology.mxd

### 3.1.3 Structural geology

**Figure 3-1** shows the structural geology of the Wambo area overlain on the regional geological mapping. The Permian coal measures generally dip at approximately three degrees to the south-west with structure complicated by some local variations in seam dip and direction. Coal seams generally have consistent thicknesses and interburden intervals (SLR, 2020). There are several northeast to southwest trending faults in the area. The major fault structures in the area include the Redmanvale fault and Hunter Valley Thrust Faults, which occur to west of and within the SBX LW24-26 area respectively. Drill logs indicate that the Hunter Valley Cross fault has a maximum displacement of approximately 10 m (AGE, 2016). There are several other north-east to south-west minor fault structures in the area; these have been mapped indicating up to 5 m displacement within the Permian coal measures (AGE, 2016).

Several dykes and intrusions occur within the Permian strata across the Wambo area. A dyke is mapped directly north of SBX LW24-26 and may be having some control on the alignment of Waterfall Creek (**Figure 3-1**).

# 4 Hydrogeology

This section presents a summary of the groundwater monitoring network near SBX and LW24-26 and discussion on groundwater level and quality trends in this area.

## 4.1 Groundwater monitoring

Groundwater monitoring at the site is undertaken in accordance with the Groundwater Management Plan (GWMP) (WCPL, 2021b) and the UWOCP and Wambo Water Monitoring Program (WMonProg) (WCPL, 2021a). The purpose of the network is to monitor groundwater quality and levels to detect potential impacts on surrounding groundwater users, consumptive or environmental, and assess the performance of the Wambo and UWOCP against the performance indicators.

The monitoring network near SBX is provided in **Table 4-1** and shown in **Figure 4-1**. This includes the combined network, Wambo-only, and UWOCP-only monitoring bores as categorised in the WMonProg (WCPL, 2021a), as well as recently installed monitoring sites not yet in the WMP. The current groundwater monitoring network around SBX that has water level or water quality data includes:

- Standpipe monitoring bores including:
    - Alluvial monitoring bores screened within alluvium associated with the Hunter River or North Wambo Creek.
    - Permian Coal Measures monitoring bores screened within the Permian coal measures within and adjacent to active and historical areas of mining.
- VWP locations with sensors screened within the Permian Coal Measures surrounding areas of mining.

As identified in the MSEC (2023) subsidence study, surface cracking and subsidence is predicted over Longwalls 24 to 26. This has the potential to impact on the condition of the site monitoring network. Review of the condition of the monitoring network should be undertaken during each sampling event, and bores remediated/replaced as required, to maintain a long-term monitoring network.

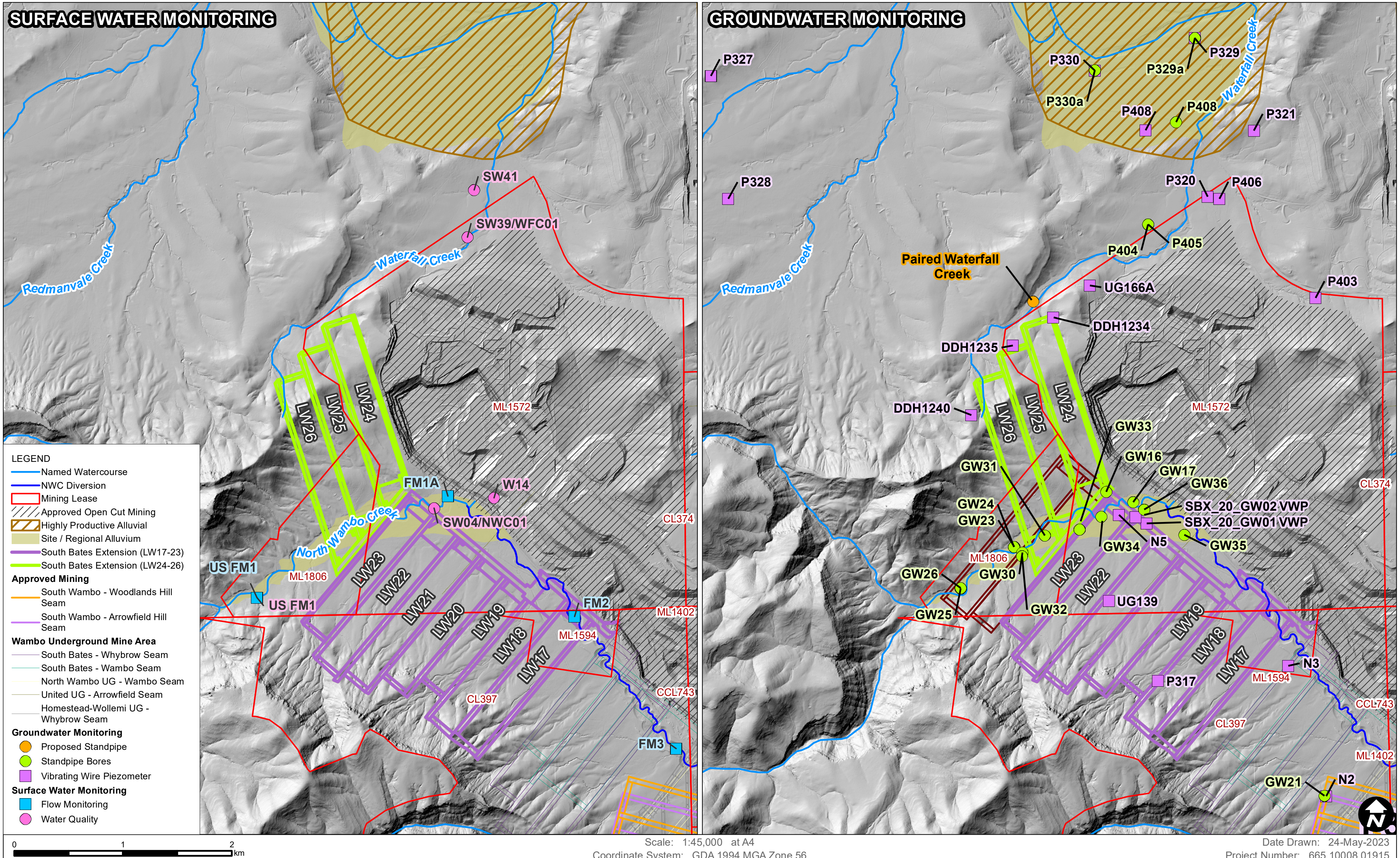
## Table 4-1 Groundwater monitoring network near South Bates Extension Underground Mine

| Bore ID | Type | Easting | Northing | Screened Interval/ Sensor Depth (mbgl) | Lithology |
|---|---|---|---|---|---|
| GW16 | MB | 306639 | 6396174 | 6.15 – 12.15 | Alluvium, Regolith |
| GW17 | MB | 306886 | 6396096 | 11 – 14 | Regolith |
| GW23 | MB | 305789 | 6395670 | 5.2 – 8.2 | North Wambo Creek Alluvium |
| GW24 | MB | 305791 | 6395668 | 11.7 – 13.2 | North Wambo Creek Weathered Rock |
| GW25 | MB | 305299 | 6395288 | 2.6 – 5.6 | North Wambo Creek Alluvium |
| GW26 | MB | 305299 | 6395668 | 11.7 – 13.2 | North Wambo Creek Weathered Rock |
| GW30 | MB | 306076 | 6395716 | 5.5 – 8.5 | North Wambo Creek Alluvium |
| GW31 | MB | 305877 | 6395582 | 7 – 10 | North Wambo Creek Alluvium |
| GW32 | MB | 306394 | 6395829 | 4 – 7 | North Wambo Creek Alluvium |
| GW33 | MB | 306592 | 6395946 | 4 – 7 | North Wambo Creek Alluvium |
| GW34 | MB | 307357 | 6395779 | 2.5 – 4 | North Wambo Creek Alluvium |
| GW35 | MB | 306988 | 6396012 | 6 – 9 | North Wambo Creek Alluvium |
| GW36a | MB | 306248 | 6395901 | 5 – 8 | North Wambo Creek Alluvium (Channel) |
| GW36b | MB | 306247 | 6395907 | 14 – 17 | North Wambo Creek Weathered Sandstone |
| N3 | VWP | 308314 | 6394575 | 30 | Permian Overburden |
| | | | | 55 | Permian Overburden |
| | | | | 75 | Permian Overburden |
| | | | | 108.5 | **Whybrow Seam** |
| | | | | 142 | Interburden |
| | | | | 190 | Wambo Seam |
| N5 | VWP | 306755 | 6395963 | 30 | Permian Overburden |
| | | | | 73 | **Whybrow Seam** |
| | | | | 89.5 | Interburden |
| | | | | 133 | Wambo Seam |
| P317 | VWP | 307115 | 6394439 | 35 | Regolith |
| | | | | 100 | Overburden |
| | | | | 174 | **Whybrow Seam** |
| | | | | 213 | Wambo Rider Seam |
| | | | | 248.5 | Wambo Seam |
| P320 | VWP | 307573 | 6398890 | 92 | Warkworth Seam |
| | | | | 191 | Vaux Seam |
| | | | | 217.5 | Bayswater Seam |
| | | | | 263 | Pikes Gully Seam |
| | | | | 305 | Lower Arties Seam |
| | | | | 344 | Middle Barrett Seam |
| P321 | VWP | 307573 | 6398890 | 31.8 | Arrowfield Seam |
| | | | | 72.1 | Warkworth Seam |

| Bore ID | Type | Easting | Northing | Screened Interval/ Sensor Depth (mbgl) | Lithology |
|---|---|---|---|---|---|
| P321 cont. | | | | 161.15 | Vaux Seam |
| | | | | 187.82 | Bayswater Seam |
| P327 | VWP | 302941 | 6399995 | 65.25 | Overburden |
| | | | | 228.25 | **Whybrow Seam** |
| | | | | 301.05 | Wambo Seam |
| | | | | 332.45 | Whynot Seam |
| P328 | VWP | 303160 | 6398870 | 43 | Overburden |
| | | | | 275 | **Whybrow Seam** |
| | | | | 350 | Wambo Seam |
| | | | | 388 | Whynot Seam |
| P329 | VWP | 307454 | 6400351 | 67.6 | Vaux Seam 1 |
| | | | | 87.4 | Vaux Seam 2/3 |
| | | | | 117.5 | Bayswater Seam |
| | | | | 150.5 | Pikes Gully Seam |
| P329a | MB | 307456 | 6400352 | 10 – 16 | Hunter Alluvium |
| P330 | VWP | 306533 | 6400050 | 67 | Vaux Seam 1 |
| | | | | 137.25 | Bayswater Seam |
| | | | | 201.5 | Pike Gully Seam |
| P330a | MB | 306533 | 6400052 | 10 – 13 | Hunter Alluvium |
| P403 | VWP | 308565 | 6397958 | TBC | Overburden & Coal Seams – Arrowfield, Warkworth & Vaux |
| P404 | TBC | 307023 | 6398634 | | Overburden |
| P405 | TBC | 307025 | 6398634 | | Arrowfield Seam |
| P406 | VWP | 307681 | 6398872 | TBC | Overburden |
| P408 | VWP | 307000 | 6399500 | 138.75 | Vaux Seam |
| | | | | 187 | Bayswater Seam |
| | | | | 223.75 | Pikes Gully Seam |
| P408 Standpipe | MB | 307282 | 6399576 | 11.6 – 14.6 | Hunter River Alluvium |
| SBX GW01 | VWP | 307010 | 6395886 | | Whybrow Seam Overburden |
| SBX GW02 | VWP | 306911 | 6395943 | 53.7 | Whybrow Seam Overburden |
| | | | | 61.7 | Whybrow Overburden |
| | | | | 65.8 | **Whybrow Seam** |
| SBX20 GW02a | MB | 306905 | 6395946 | 20 | base of weathering |
| DDH1234_LW 24 | VWP | 306153 | 6397780 | 22 | Shallow overburden |
| | | | | 39 | Near-seam overburden |
| | | | | 54 | **Whybrow Seam** |
| DDH1235_LW 25 | VWP | 305779 | 6397521 | 40 | Shallow overburden |
| | | | | 80 | Whybrow overburden |
| | | | | 114 | **Whybrow Seam** |

| Bore ID | Type | Easting | Northing | Screened Interval/ Sensor Depth (mbgl) | Lithology |
|---|---|---|---|---|---|
| DDH1240_SBXX_20_ST07 | VWP | 305397 | 6396881 | 50 | Narrabeen Group/ Overburden |
| | | | | 118 | Overburden 1 |
| | | | | 218.5 | Overburden 2 |
| | | | | 260.5 | **Whybrow Seam** |
| UG139 | VWP | 306665 | 6395173 | 263 | Unnamed D Seam |
| | | | | 281 | Unnamed E Seam |
| | | | | 319 | interburden Glen Munro – Unnamed E Seams |
| | | | | 329 | Glen Munro Seam |
| | | | | 375 | interburden Arrowfield – Glen Munro Seam |
| | | | | 382 | Arrowfield Seam |
| | | | | 402 | interburden Warkworth – Bowfield Seams |
| UG166A | VWP | 306488 | 6398076 | 130 | Unnamed D Seam |
| | | | | 153 | Unnamed E Seam |
| | | | | 183 | Blakefield Seam |
| | | | | 200 | Glen Munro Seam |
| | | | | 238 | Arrowfield Seam |
| | | | | 254 | Bowfield Seam |
| | | | | 260 | Bowfield Seam |

***Note:*** *Coordinates in GDA94 Zone 56* *mAHD – metres Australian Height Datum*
*Mbgl – metres below ground level*




Scale: 1:45,000 at A4
Coordinate System: GDA 1994 MGA Zone 56

Date Drawn: 24-May-2023
Project Number: 665.10008.01915

Data Source: Base data supplied by NSW SS

SLR

**WAMBO COAL MINE**
**LW24-26 EXTRACTION PLAN**

**Surface water and groundwater monitoring network**

**FIGURE 4-1**

H:\Projects-SLR\660-SrvWOL\660-WOL\665.10008 Wambo Groundwater Study\06 SLR Data\01 CADGIS\ArcGIS\SLR6651000801915_LW24_26EP_4_1_MonitoringNetwork.mxd

### 4.1.1 Data availability

**Table 4-2** and **Table 4-3** provide a summary of the groundwater level monitoring records for the main hydrostratigraphic units in the vicinity of the modified SBX Underground Mine area, based on the information currently held by SLR.

**Table 4-2 Standpipe groundwater level data availability summary**

| Screened Geological Unit | Catchment/ area | Bores with Manual Dip Data | Bores with Logger Data[1] | Currently actively bores | Record date range | Historical Monitoring Frequency |
|---|---|---|---|---|---|---|
| North Wambo Creek Alluvium | North Wambo Creek/ SBX | 10 | 2 | 10 (Manual) incl. 2 (Logger) | January 2010 to present (GW16)<br>Other sites from ~2018/19 to present | At least bi-monthly |
| Waterfall Creek Alluvium/ Colluvium | Waterfall Creek | 0 | 0 | 0 | n/a | n/a |
| Hunter Alluvium | Hunter | 3 | 0 | 2 (P408 unknown) | Nov 2020 to present | Bi-monthly |
| Permian Coal Measures (incl. regolith/ weathered) | North Wambo Creek | 5 | 2 | 5 (Manual) incl. 2 logger | January 2010 to present (GW17)<br>Other sites from Feb 2019 onwards | At least bi-monthly |
| | Waterfall Creek | 0 | 0 | 0 | n/a | n/a |
| | Redmanvale Creek (~3-4 km north) | 0 | 0 | 0 | n/a | n/a |
| **Total** | | **19** | **4** | **18** | - | - |

[1]GW36a, GW36b, GW35 and SBX- GW02 have been monitored with dataloggers since mid-2020.

**Table 4-3 VWP groundwater level data availability summary**

| Screened Geological Unit | Catchment/ area | Bores | Active Bores | Strata targeted |
|---|---|---|---|---|
| Permian Coal Measures | North Wambo Creek/ SBX | N5, SBX20_GW02, SBX20_GW01, P317, UG139, N3, DDH1234, DDH1235, DDH1240[1] | N5, SBX20_GW02, DDH1234, DDH1235, DDH1240 | Wambo Seam, Whybrow Seam, Overburden |
| | Waterfall Creek | UG166A, P321 | UG166A, P320 | Below Whynot Seam |
| | Redmanvale Creek (~3-4 km north) | P328a, P327 | P328a, P327 | Wambo Seam, Whybrow Whynot, Wambo and Whybrow Seams, Overburden |
| | Hunter River | P408, P329, P330 | P408, P329, P330 | Vaux to Pikes Gully Seams |

[1]DDH1234, DDH1235 and DDH1240 have been installed in Q1/ Q2 2022.

Groundwater data availability is considered sufficient to monitoring groundwater conditions and identify groundwater impacts due to SBXLW24-26 within shallow and deep Permian strata and the North Wambo Creek alluvium. As recommended in SLR (2022), an additional paired standpipe monitoring site at Waterfall Creek, north of Longwalls 24 to 26 and adjacent to the mapped potential GDE on Waterfall Creek (see proposed location on **Figure 4-1**), would provide more clarity on local shallow groundwater conditions.

## 4.2 Hydraulic properties

Extensive hydraulic testing has historically been undertaken across the Hunter Valley using a variety of methods including packer testing, slug testing, pumping tests, and laboratory core testing. Much of this data was compiled in MER (2009) and has been used to inform previous Wambo and UWOCP groundwater assessments (HydroSimulations, 2017; AGE, 2016). Data from surrounding sites (AGE (2003, 2010, 2014, 2016)) has also been used to inform appropriate model parameters.

Additional detail on hydraulic conductivity and storage parameters in the Hunter Valley that have informed groundwater system conceptualisation and numerical modelling is provided in SLR (2022). No additional hydraulic testing has been undertaken at Wambo since the SLR (2022) groundwater assessment.

## 4.3 Groundwater levels, distribution, flow, recharge, and discharge

Hydrogeological characteristics of aquifer units near SBX, including the nature of aquifer material, recharge and discharge mechanisms are presented in the following sections. Groundwater level trends, and responses to climatic and anthropogenic influences are also discussed for aquifer units near SBX LW24-26. Hydrogeological characteristics across the broader Wambo mine complex are discussed in SLR (2022).

### 4.3.1 North Wambo Creek alluvium

#### 4.3.1.1 Distribution and flow

The alluvium along the upper reaches of North Wambo Creek is approximately 4 to 10 m thick (SLR (2017), AGE (2019a, b) and SLR (2020)) and generally comprises sand, silt, and gravel, overlying weathered sandstones (regolith). 0.6 $km^2$ of North Wambo Creek alluvium is mapped to underlie the current SBX footprint including LW 24 to 26. Outside of high rainfall and flow events, alluvial bores in this area can be unsaturated with shallow saturation and flow occurring primarily within the underlying regolith (SLR, 2020). Recharge to the alluvium is observed in response to rainfall events of sufficient magnitude to induce flow on the alluvial flats and upstream confined valley of North Wambo Creek, with alluvial saturation observed near ground surface, indicating the potential for baseflow to North Wambo Creek.

#### 4.3.1.2 Recharge and discharge

Recharge to the North Wambo Creek alluvium occurs via diffuse infiltration from rainfall events of sufficient intensity or flow within the ephemeral North Wambo Creek. The creek is characterised as dominantly having losing conditions, with limited baseflow, consequently acting as a recharge mechanism for the North Wambo Creek alluvium in periods of flow (SLR, 2020). The alluvium does not sustain peak levels of saturation for long periods of time following rainfall/ flow events, with water percolating laterally or through to the underlying regolith.

#### 4.3.1.3 Groundwater level trends

Upstream of the North Wambo Creek Diversion, historical groundwater level data within the alluvium has been collected since alluvial bores were installed over the period 2017 to mid-2020. Data loggers are installed in two alluvial bores (GW35 and GW36b), upstream of the North Wambo Creek Diversion to assist in the assessment of groundwater levels.

Upstream bores in the North Wambo Creek alluvium (GW23, GW25, GW27 - **Figure 4-2** generally show increasing groundwater levels with recent higher-than-average rainfall (2020 to 2022) and fluctuate between 1 to 3 m in response to rainfall events to the end of 2022. It is likely that the highest groundwater levels recorded over this period reflect close to maximum levels at these locations, with creek discharge being a control.

Alluvial bores closer to the North Wambo Creek Diversion and Montrose Open Cut (GW28, GW30, GW31, GW32, GW33, GW34, GW35 and GW36b), show large rises and falls in groundwater level (4 to 7 m) in response to the high rainfall events during 2020, 2021 and 2022 (**Figure 4-2**). The rapid groundwater level response to high rainfall events appears closely linked to flow and flow recession in North Wambo Creek (refer to **Section 2.2.1.1**).

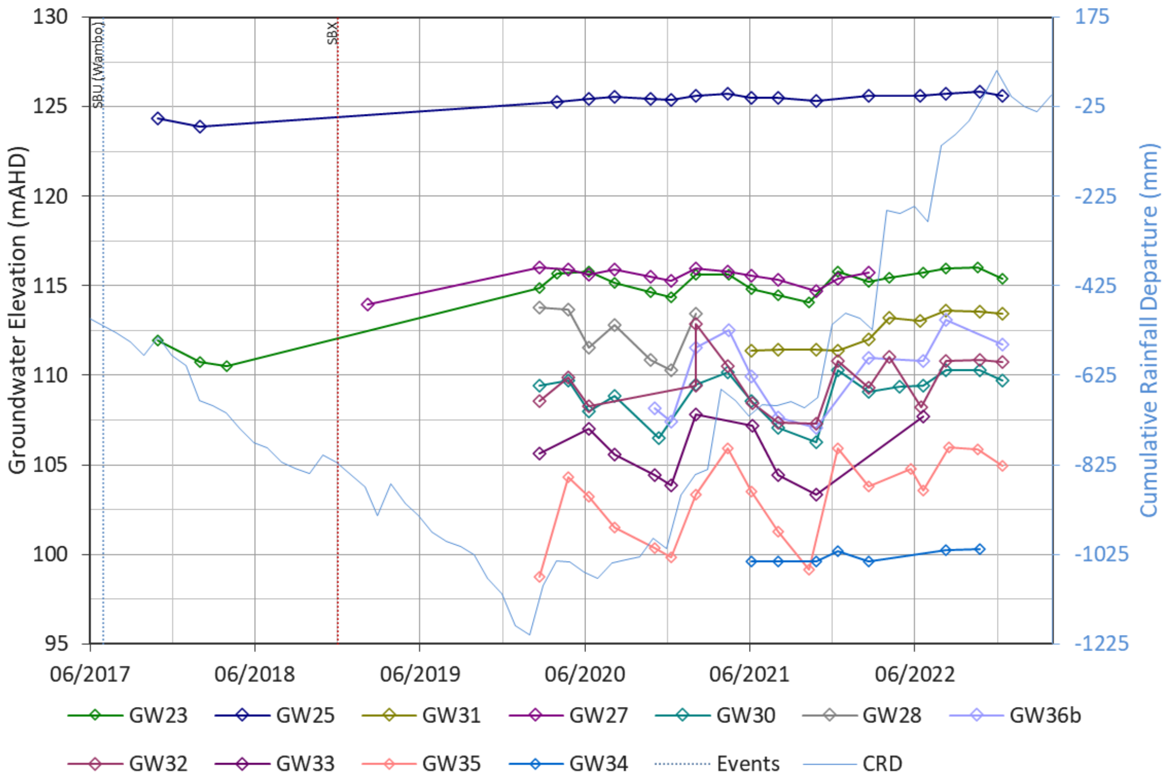



Figure 4-2 North Wambo Creek alluvium hydrographs

### 4.3.2 Hunter River alluvium

The Hunter River alluvium comprises surficial silts and clays overlying basal sands and gravels. The main aquifer has been found to occur within the basal gravel sequence (MER, 2009). The Hunter River alluvium is considered unconfined, and flow direction typically mimics topography in areas away from mining.

#### 4.3.2.1 Recharge and discharge

Recharge to the Hunter River alluvium occurs via two primary mechanisms, diffuse recharge, and focussed recharge. Diffuse recharge occurs via rainfall infiltration where there are no substantial clay barriers in the shallow sub-surface. Focussed recharge, interpreted to be the primary mechanism (AGE, 2016), occurs via stream losses from regulated streamflow or flooding. The Hunter River alluvium may gain water from the underlying Permian coal measures, or where mining has resulted in depressurisation of the Permian coal measures, the Hunter River alluvium will discharge to the coal measures (AGE, 2016). In some areas, groundwater levels compared to stream gauge levels indicate the Hunter River is receiving baseflow from the alluvium providing another pathway for groundwater discharge.

#### 4.3.2.2 Groundwater level trends

Groundwater level data for Hunter River alluvium monitoring bores P329a and P330a is presented in **Figure 4-3**. For the monitoring data available since 2020, fluctuations in groundwater levels up to 1 m have been observed in response to rainfall events generally in accordance with CRD.

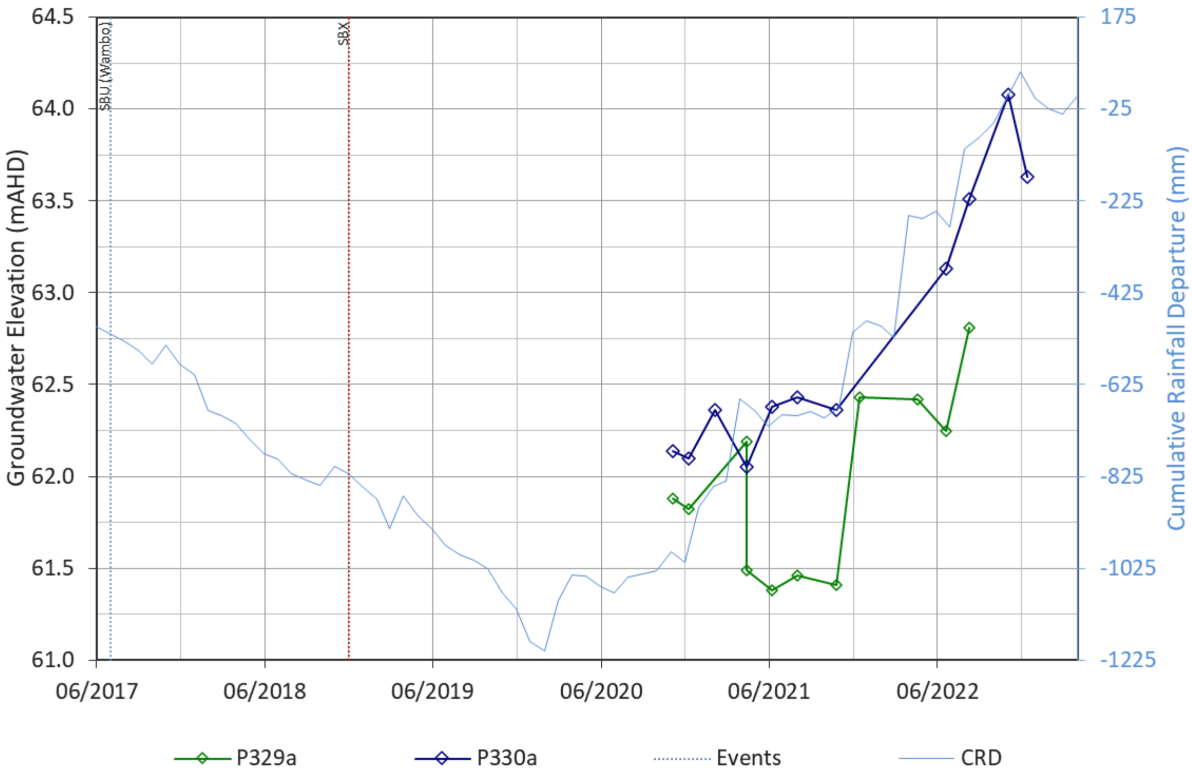



**Figure 4-3 Hydrograph – Hunter River alluvium**

### 4.3.3 Shallow weathered bedrock/ residual sediment (regolith)

#### 4.3.3.1 Distribution and flow

The regolith is generally saturated, with groundwater occurring between 4 to 12 m below ground surface. The regolith thickness map developed by CSIRO (2015) indicates the regolith in the vicinity of SBX and LW24-26 is variable in thickness ranging from less than 1 m up to 11 m outside the mapped alluvium extents. At higher elevations, the regolith was found to be thin and is generally thicker in areas of lower elevation.

#### 4.3.3.2 Recharge and discharge

The regolith may also host the regional water table and is the conduit for the main source of recharge to the underlying rock. In some locations a transient short-term perched groundwater system may form within the regolith in periods of significant rainfall when recharge rates exceed the ability of the underlying rock to receive the overlying recharge. The regolith likely contains localised areas of increased recharge associated with its weathered nature. Coal seams that weather to finer material will have limited ability to transmit groundwater, while the sandier units offer increased potential for groundwater recharge.

#### 4.3.3.3 Groundwater level trends

Groundwater levels in shallow/ weathered Permian strata (regolith) near North Wambo Creek are monitored upstream of the North Wambo Creek diversion at bores GW24, GW26, GW36a, GW16, GW17 and SBX-GW02 (**Figure 4-4**). Data loggers were installed in two of these regolith bores (SBX-GW02 and GW36a).

Despite relatively shallow construction depths (less than 20 m), and nearby mining and the drought conditions from 2017 to 2020, the bores upstream of the North Wambo Creek Diversion maintained saturation and provide useful baseline data prior to undermining in the future.

Groundwater levels illustrated in **Figure 4-4** indicate large fluctuations in groundwater levels up to 8 m in response to rainfall events. The rapid groundwater level response to high rainfall events appears similar to the North Wambo Creek alluvium and is closely linked to flow and flow recession in North Wambo Creek (refer to **Section 2.2.1.1**).

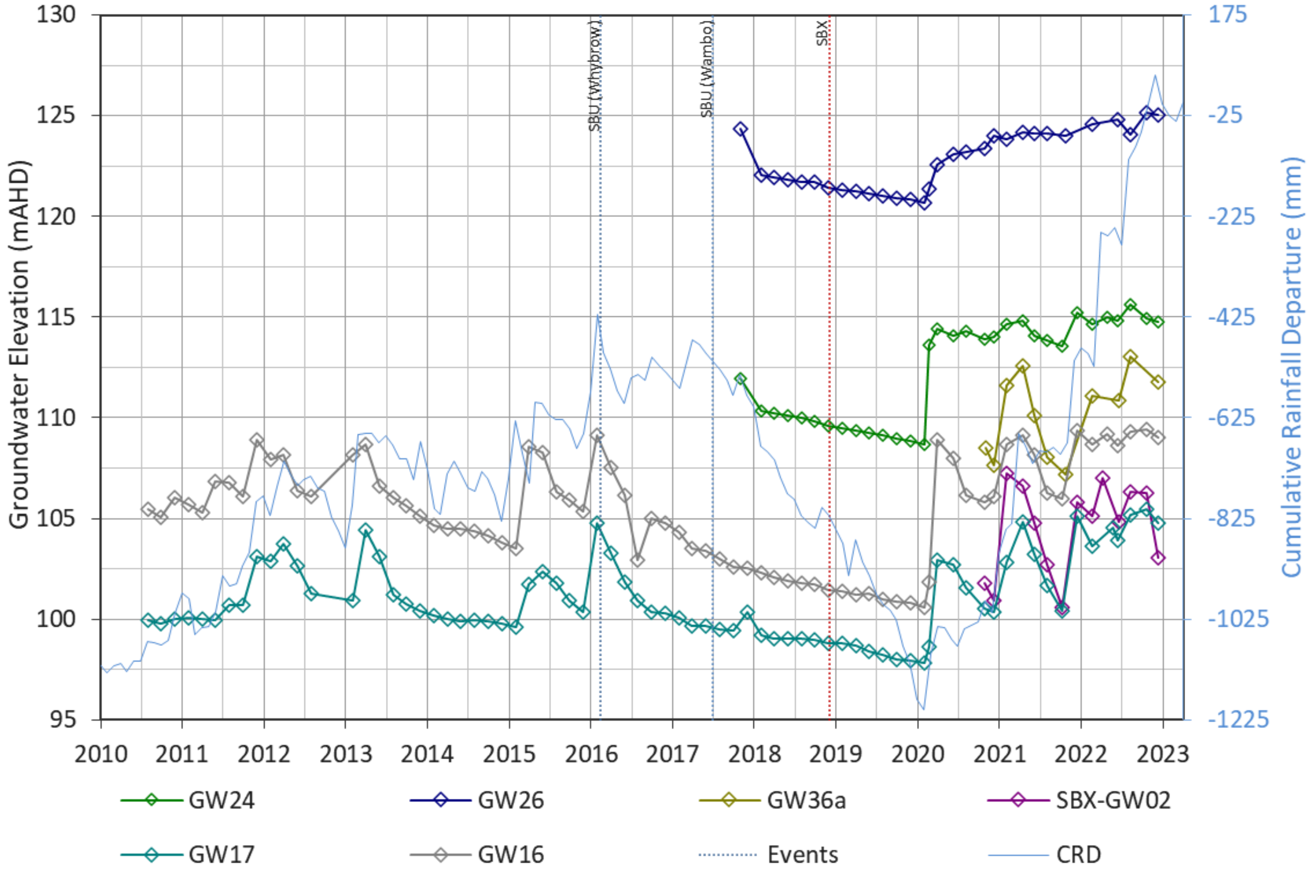



**Figure 4-4 Hydrograph – regolith**

### 4.3.4 Permian coal measures

#### 4.3.4.1 Distribution and flow

The Permian coal measures comprise stratified sequences of sandstone, siltstone, and claystone (interburden) and coal. The coal seams are generally identified as the groundwater bearing units, with the low permeability interburden generally confining the individual seams.

Hydraulic conductivity of the coal decreases slightly with depth due to increasing overburden pressure reducing the aperture of fractures (SLR, 2022). Vertical movement of groundwater (including recharge) is limited by the confining interburden layers, meaning that groundwater flow is primarily horizontal through the seams with recharge primarily occurring at sub-crop.

Groundwater flow largely follows the regional topography, flowing in a north-easterly direction and is likely host to the water table in elevated areas away from incised drainage lines and watercourses. Localised drawdown nearby active mining is apparent.

#### 4.3.4.2 Recharge and discharge

The Permian coal measures are recharged from rainfall primarily occurring at sub-crops, from downward seepage, and site water storage. Where mining is occurring, the actively mined coal seams are depressurised, and groundwater levels are significantly lower than groundwater levels in the overlying strata resulting in no upward leakage.

Groundwater discharge occurs as discharge to active mining and abstraction bores, and in localised areas outside the extent of mining influence, potential upward seepage to the Quaternary alluvium where hydraulic gradients enable this (AGE, 2016).

#### 4.3.4.3 Groundwater level trends

Extensive historical open cut and underground mining in the district has generated a regional zone of depressurisation within the Permian coal sequences. Groundwater levels in the in Permian strata near SBX LW24-26 (**Figure 4-1**) are monitored at Wambo multi-sensor VWPs P328, N5 and SBX_GW02. Hydrographs at these sites are displayed in **Appendix A**.

Hydrographs for recently installed VWPs DDH1234_LW24, DDH1235_LW25, DDH1240_SBXX_20_ST07 located north and west of LW24-26 are presented and discussed in the following section.

VWP sensors in the overburden above the Whybrow seam generally show water levels near the top of the unit, with a downward gradient from overlying weathered strata and alluvium (SBX-GW02) and are frequently observed to decline with the approach of mining (N5). Similar trends are observed within sensors in the Whybrow seam. Recent observations at N5 have shown increases in all sensors. Diffuse rainfall recharge may be influencing the overburden sensor, while saturation of the backfill in the adjacent Montrose open cut (which has mined to the deeper Whynot Seam) may be driving the increases in the lower sensors.

The following points summarise groundwater trends from the recently installed VWPs north and west of SBX LW24-26:

- Three sensors were installed at DDH1234, which is located on the north-east corner of LW24 to a maximum depth of 54 mbgl (103 mAHD) (see **Table 4-1** for detail on all sensors):
  - Pressures at all sensors are currently below the sensor elevation, indicating the depth to the regional water table is likely greater than 54 mbgl at this location (less than 103 mAHD) (**Figure 4-5**).
  - Waterfall Creek directly north of DDH1234 and LW24 is at an elevation of approximately 130 mAHD. Based on observations from DDH1234, Waterfall Creek is not likely to be directly interacting with the regional water table north of LW24.
- Three sensors were installed at DDH1235, which is located on the northern edge of LW25 to a maximum depth of 114 mbgl (53 mAHD) (see **Table 4-1** for detail on all sensors):
  - Pressures at the uppermost sensor (40 mbgl) appear to be showing some response to the rainfall trend and may show perched groundwater that is separate from the regional water table. The observed groundwater elevation at the upper sensor in March 2023 is 144 mAHD, while Waterfall Creek 200 m north of LW25 is approximately 135-140 mAHD, indicating there may be some potential for interaction between surface and groundwater.
  - The middle sensor (80 mbgl) is dry.

- The lower sensor (114 mbgl) at DDH1235 shows a reasonably stable groundwater level with approximately 20 m of head (**Figure 4-6**).

- Four sensors were installed at DDH1240, which is located 150 m west of LW26 to a maximum depth of 260.5 mbgl (16 mAHD) (see **Table 4-1** for detail on all sensors):
  - A datalogger has only recently been installed so only two points on consecutive days are available.
  - Pressures at the uppermost sensor (50 mbgl) are dry.
  - The second sensor (118 mbgl) has approximately 3 m of head.
  - There appears to be an upward gradient from the lowest (260.5 mbgl) to the second lowest sensor (218.5 mbgl).

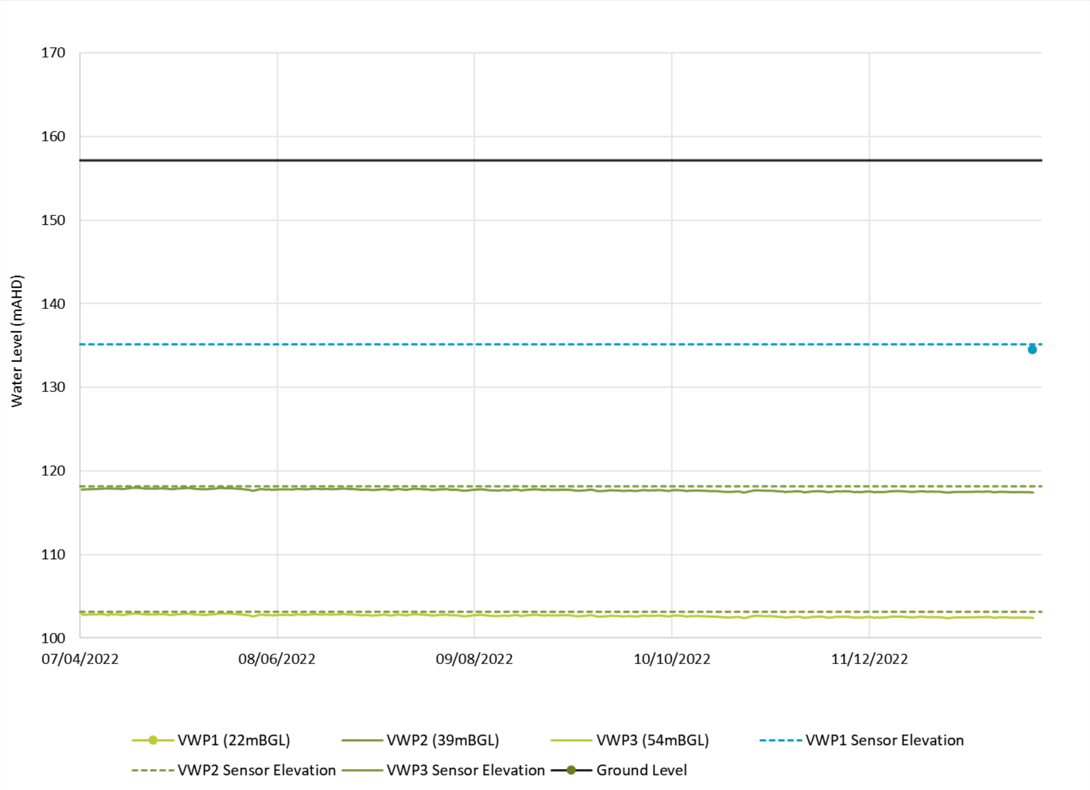
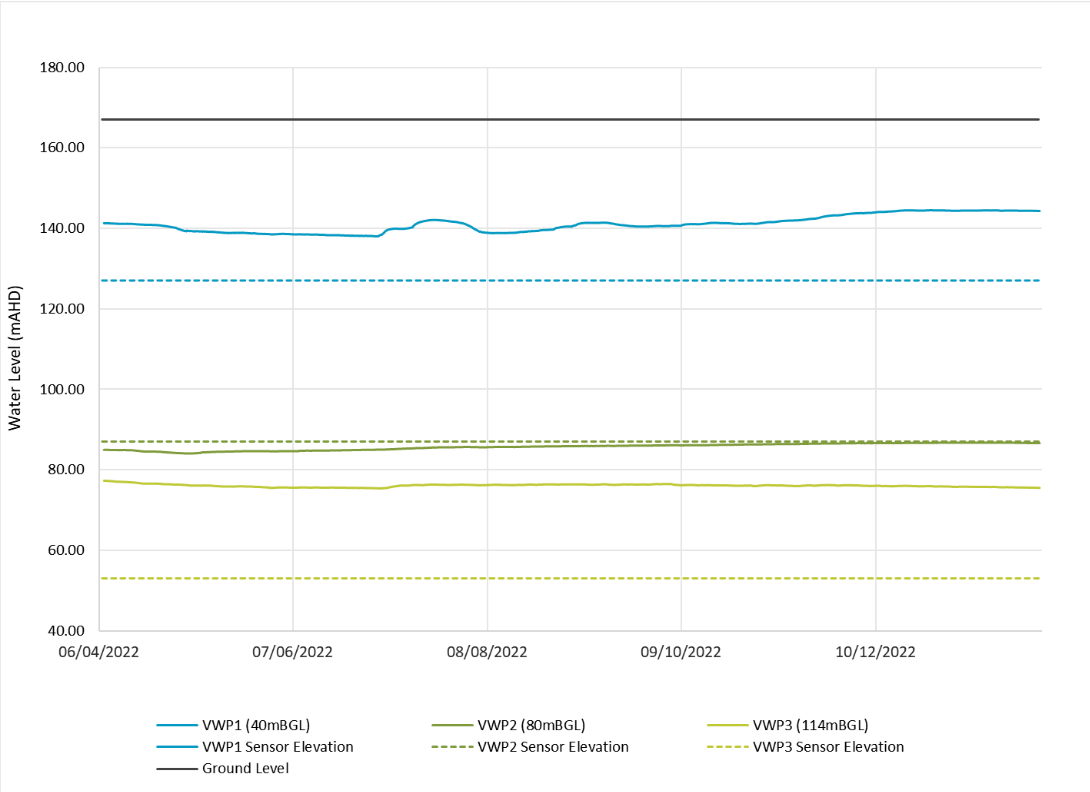
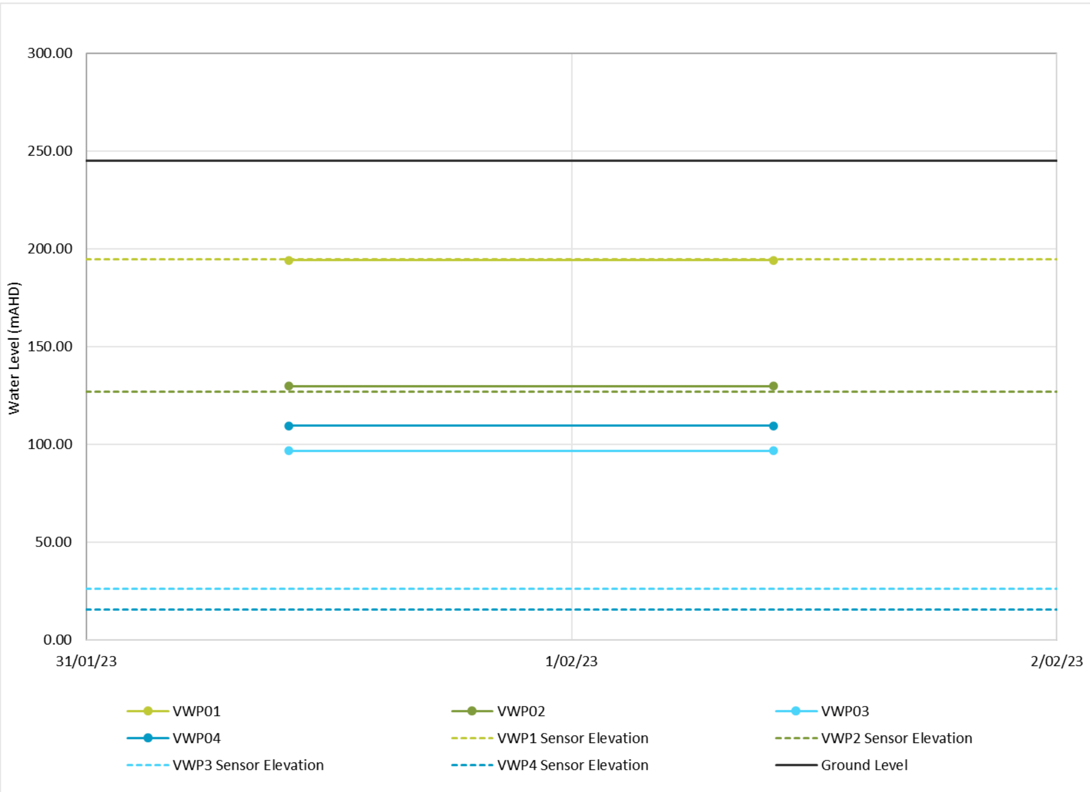



**Figure 4-5 DDH1234 groundwater elevation**




## Figure 4-6 DDH1235 groundwater elevation




## Figure 4-7 DDH1240 groundwater elevation

### 4.3.5 Groundwater interaction with watercourses

Surface water associated with larger drainage features is likely to be connected with any associated alluvium, and groundwater within the alluvium will discharge to the stream channels in some areas (HydroSimulations, 2017). This relationship is supported by the baseflow estimates undertaken for the Hunter River and Wollombi Brook (AGE, 2016) (see **Section 2.2**) which identifies groundwater may contribute 231 ML/day and 70 ML/day respectively to surface water flow.

A comparison of stream stage height with nearby groundwater elevations in both alluvial and shallow Permian aquifers has enabled an assessment of surface water-groundwater interaction for North Wambo Creek near the SBX Underground Mine including LW24-26 (**Figure 4-8** and **Figure 4-9**).

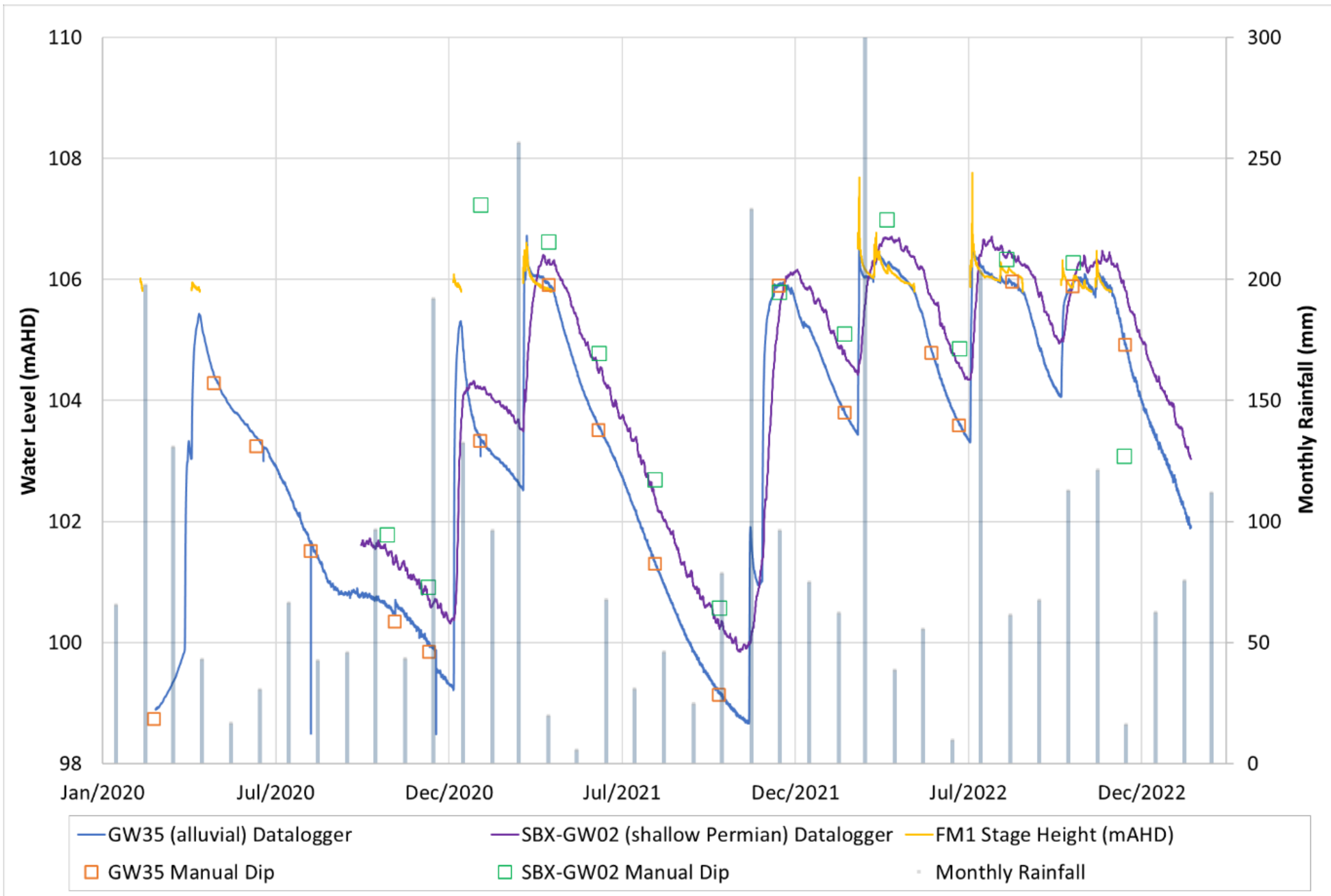



**Figure 4-8 GW35 (Alluvial) and SBX-GW02_Standpipe (shallow Permian) comparison with FM1**

**Figure 4-8** shows logger data from alluvial monitoring bore GW35 with North Wambo Creek stage height at the FM1 monitoring site (approximately 125 m northeast of GW35), monthly rainfall, and shallow Permian groundwater levels in nearby SBX_GW02_Standpipe (approximately 100 m southwest of GW35). These surface and groundwater monitoring sites are located near the confluence of North Wambo Creek and the North Wambo Creek Diversion (**Figure 4-1**).

A reference elevation for FM1 has been inferred using available LiDAR data, enabling a preliminary assessment of periods when baseflow or leakage is occurring. It is also noted that the surface and groundwater sites are spread over approximately 200 m, meaning a direct comparison of vertical gradients cannot be made.

Flow events at FM1BU in April 2020 and January 2021 appear to be leakage only, with observed groundwater levels not reaching the inferred North Wambo Creek stage height, while there is likely a period of baseflow following the April 2021 flow event, and flow events observed in 2022, inferred from the longer duration of flow and the observed groundwater elevation at GW35 receding slower than above the inferred FM1BU elevation.

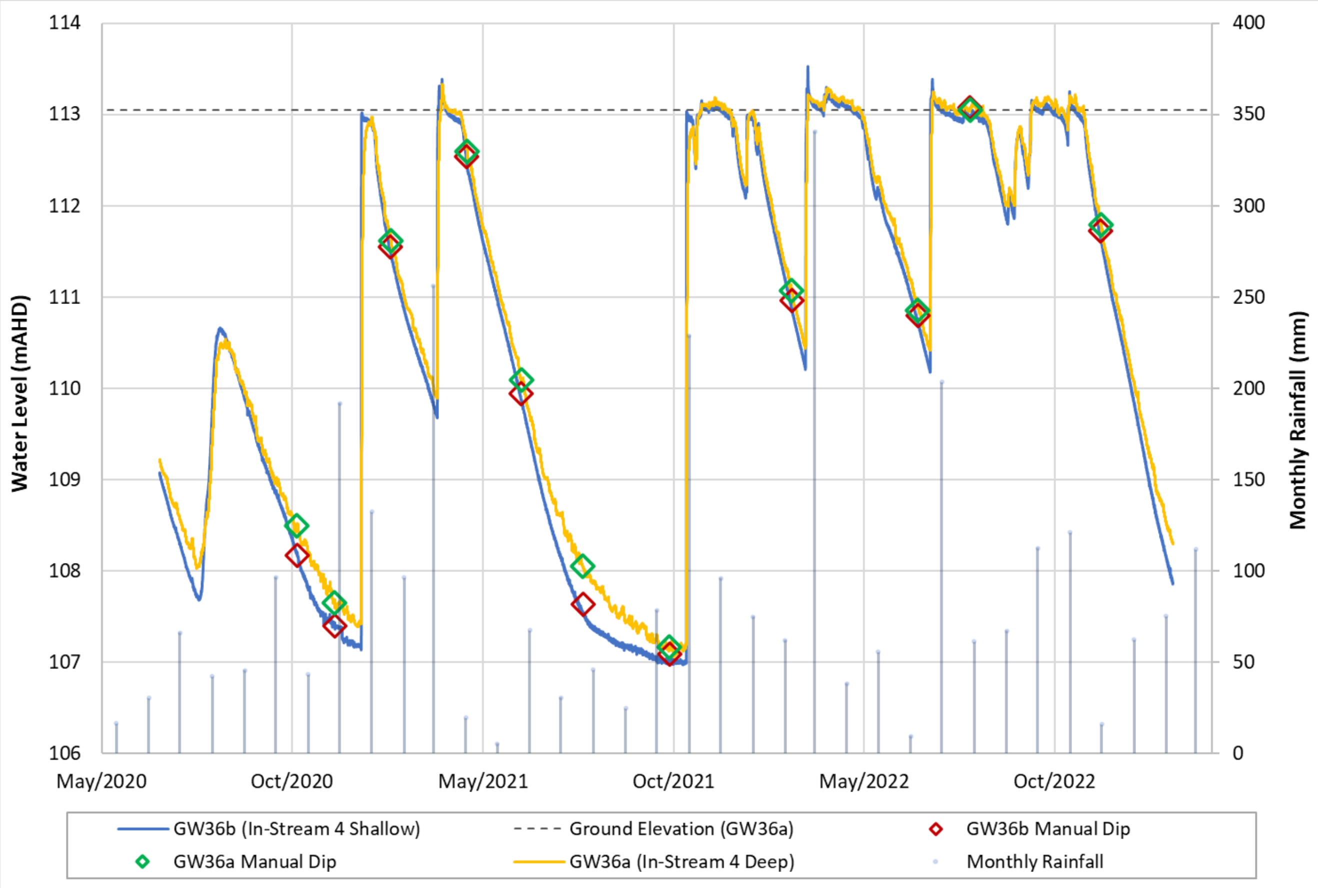



**Figure 4-9 GW36a and GW36b groundwater trends**

**Figure 4-9** shows logger and dip data from paired standpipes GW36a (regolith/weathered) and GW36b (alluvium) compared to GW36a ground elevation and monthly rainfall. Both monitoring sites show groundwater level fluctuations of up to 6 m in response to rainfall and flow events. The shallow site (GW36b) shows higher peak water levels then the deeper regolith site (GW36a), but the deeper site declines at a slower rate, and shows an upward gradient into the alluvium outside of flow periods and high water levels. Groundwater elevations at both standpipes are above the GW36a ground elevation during high rainfall periods, which is likely indicating periods of flow in North Wambo Creek and full saturation of the underlying alluvium and regolith.

The relationship between surface water and alluvial groundwater at this reach of North Wambo Creek is consistent with the HydroSimulations (2017) and SLR (2022) conceptualisation, with **Figure 4-8** and **Figure 4-9** also indicating that high rainfall events resulting in flow in North Wambo Creek are likely to be an important recharge mechanism for its alluvium and underlying weathered strata.

## 4.4 Groundwater quality

This section discusses the chemical characteristics and possible beneficial uses of groundwater within the various geological units near SBX and LW24-26. Water quality results for surface water (North Wambo Creek) are also discussed below.

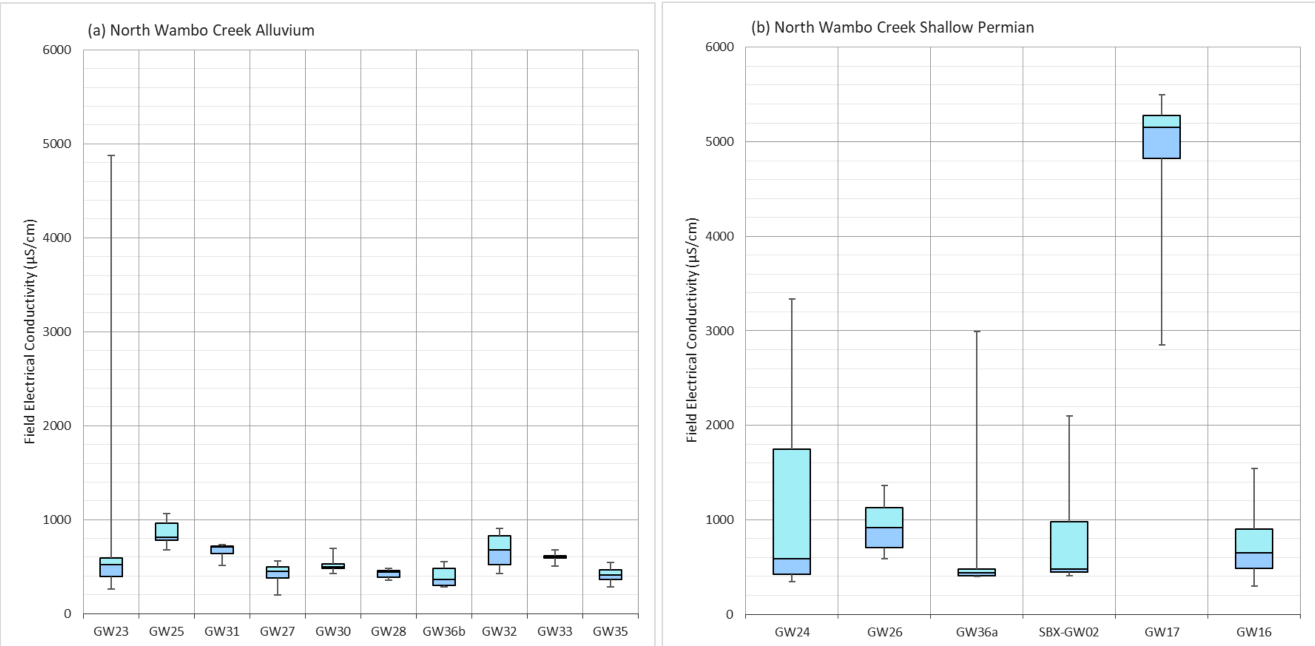
### 4.4.1 Salinity

Salinity is a key constraint to groundwater use and can be described by the EC of a water sample. **Figure 4-10** presents box and whisker plots of the EC data for monitoring bores near the SBX Underground Mine, while **Figure 4-11** and **Figure 4-12** present available time-series EC data at the same sites against the rainfall trend. Surface water EC for North Wambo Creek and Waterfall Creek surface water monitoring sites is shown in **Figure 4-13**.

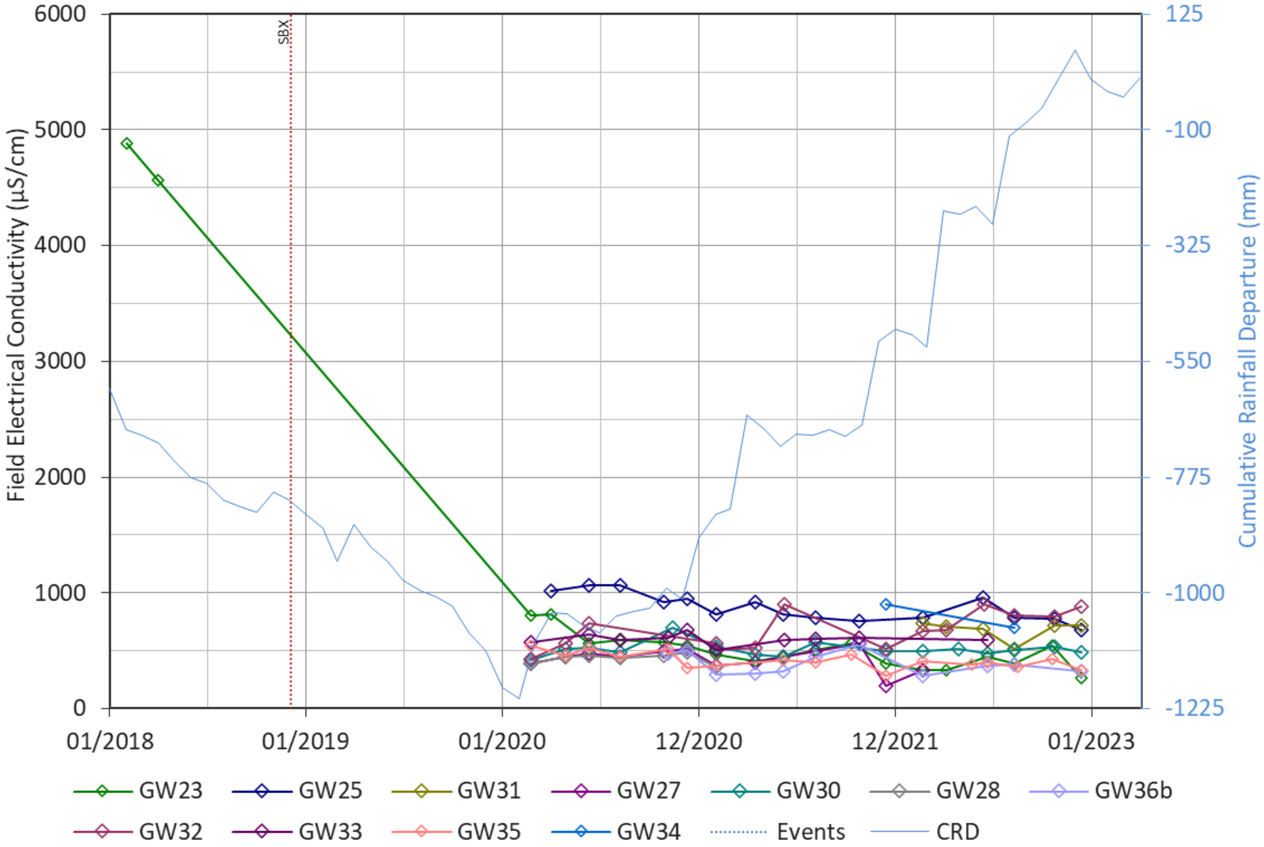
EC observations for surface water at Waterfall Creek are fresh (<200 MicroSiemens/cm [µS/cm]), but due to the highly ephemeral nature of Waterfall Creek, collection of water quality data is limited to periods shortly after a rain event sufficient to generate flow (**Figure 4-13**). As discussed previously, there are no groundwater monitoring sites near Waterfall Creek.

The charts show that groundwater within the North Wambo Creek alluvium is fresh, with EC generally 350 to 1000 µS/cm (**Figure 4-10** and **Figure 4-11**). These alluvial EC observations are also generally consistent with surface water quality observations for North Wambo Creek. Higher surface water EC observed at surface water monitoring site, US FM1, may be indicative of groundwater discharge (baseflow) from Narrabeen Group or Newcastle Coal Measures aquifers. This appears to be the main source of flow at US FM1 outside of periods of high rainfall and runoff, and is likely influencing EC observations at GW25, the furthest upstream alluvial monitoring site.

The upper limits of EC observations at shallow Permian monitoring bores are generally more saline than overlying alluvial sites (**Figure 4-10** and **Figure 4-12**), with EC values prior to 2020 from 1000 to 3000 µS/cm at most sites, and approximately 5000 µS/cm at GW17. However, following above average rainfall conditions through 2020, 2021, and 2022, EC has declined at most shallow Permian sites to values consistent with those observed in the alluvium. This indicates downward leakage from the alluvium is a recharge source for shallow Permian strata during periods of above average rainfall and saturation within the alluvium. Outside of wet climatic periods, up-flow or lateral flow through Permian strata is the likely recharge mechanism at these sites. This is indicated by the higher EC observations prior to 2020, and the increase in EC observed at sites such as SBX-GW02 during average rainfall conditions in early 2022 (**Figure 4-12**).




## Figure 4-10 Box plots of groundwater salinity near North Wambo Creek




## Figure 4-11 Time-series EC at North Wambo Creek alluvium bores

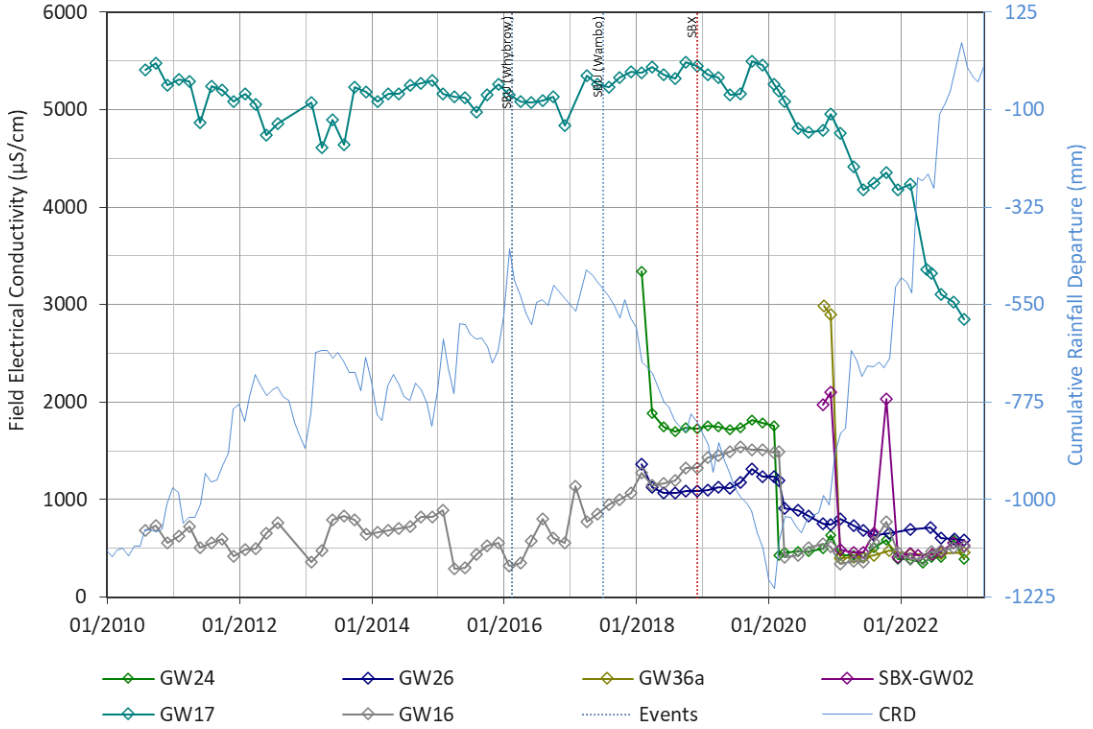



**Figure 4-12 Time-series EC at shallow Permian (weathered) bores near North Wambo Creek**

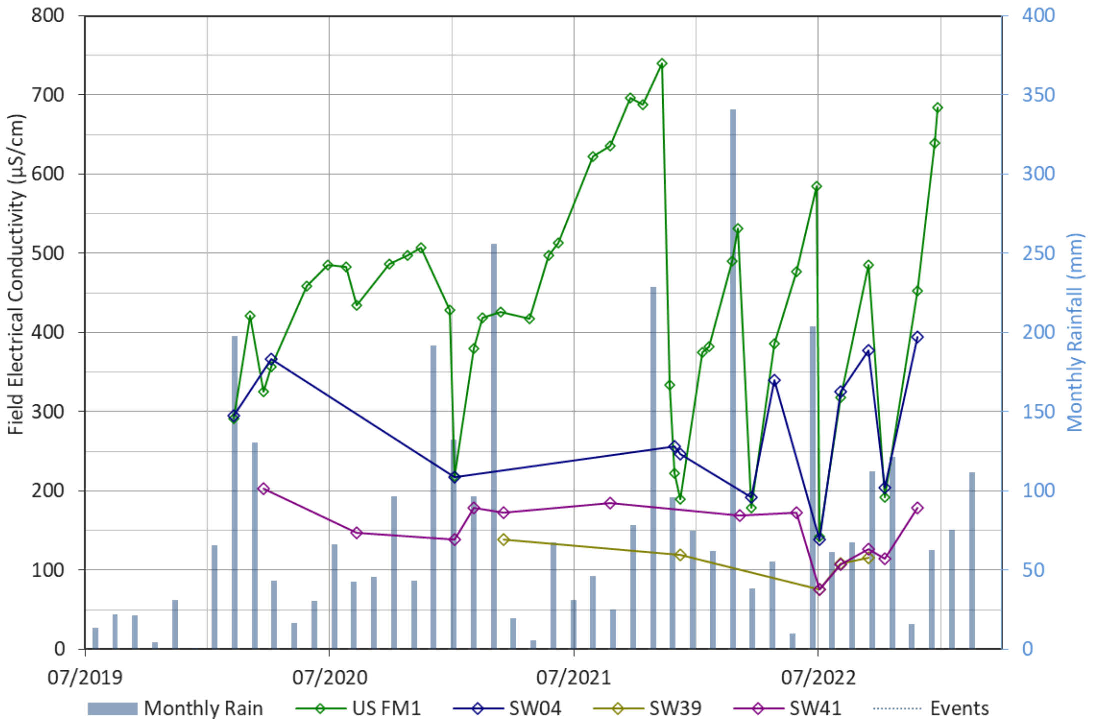



**Figure 4-13 Surface water EC at North Wambo and Waterfall Creeks**

## 4.5 Groundwater use and receptors

### 4.5.1 Anthropogenic users

A search of the NSW Bore Database was undertaken by WCPL in 2020 to supplement bore census findings reported by HydroSimulations (2014) and AGE (2016). The search identified 122 bores within a 4 km radius of Wambo and the UWOCP.

A majority of the existing bores (41) are registered as monitoring/test bores and located within WCPL tenement boundaries (namely ML1402, CL743, and ML1594). 15 bores were identified as mining/ dewatering/ exploration bores and 16 bores were of unknown use. 27 of the bores are registered for irrigation, domestic and/or stock use. The remainder of identified bores were noted as abandoned or destroyed (23). Bore details (including bore use and current status) are outlined in **Table 4-4** for all registered bores, excluding monitoring bores and bores that have been abandoned and destroyed (62 bores). The approximate locations of bores registered for irrigation, domestic and/or stock use, or have an unknown use near to SBX and LW24-26 are shown in **Figure 4-14**.

There are no metered records available for abstraction from registered bores near Wambo, although significant groundwater use is considered unlikely. AGE (2016) and WCPL (in 2021c, 2022) consultation with landholders indicates dated pumping hardware and generally infrequent use of private bores (**Table 4-4**).

Of the registered bores presented in **Table 4-4** and presented on **Figure 4-14**, those identified to be located on private, non-mine owned land have been focussed on in additional detail for this groundwater technical review. The bores are GW043225, GW064382, GW078477, GW078574, GW078575, GW078576, and GW078577. Cumulative impacts to all nearby registered bores are considered and presented in Appendix D of SLR (2022) the *Groundwater Modelling Technical Report*, which includes SBX LW24-26 mining.

## Table 4-4 Registered groundwater bores

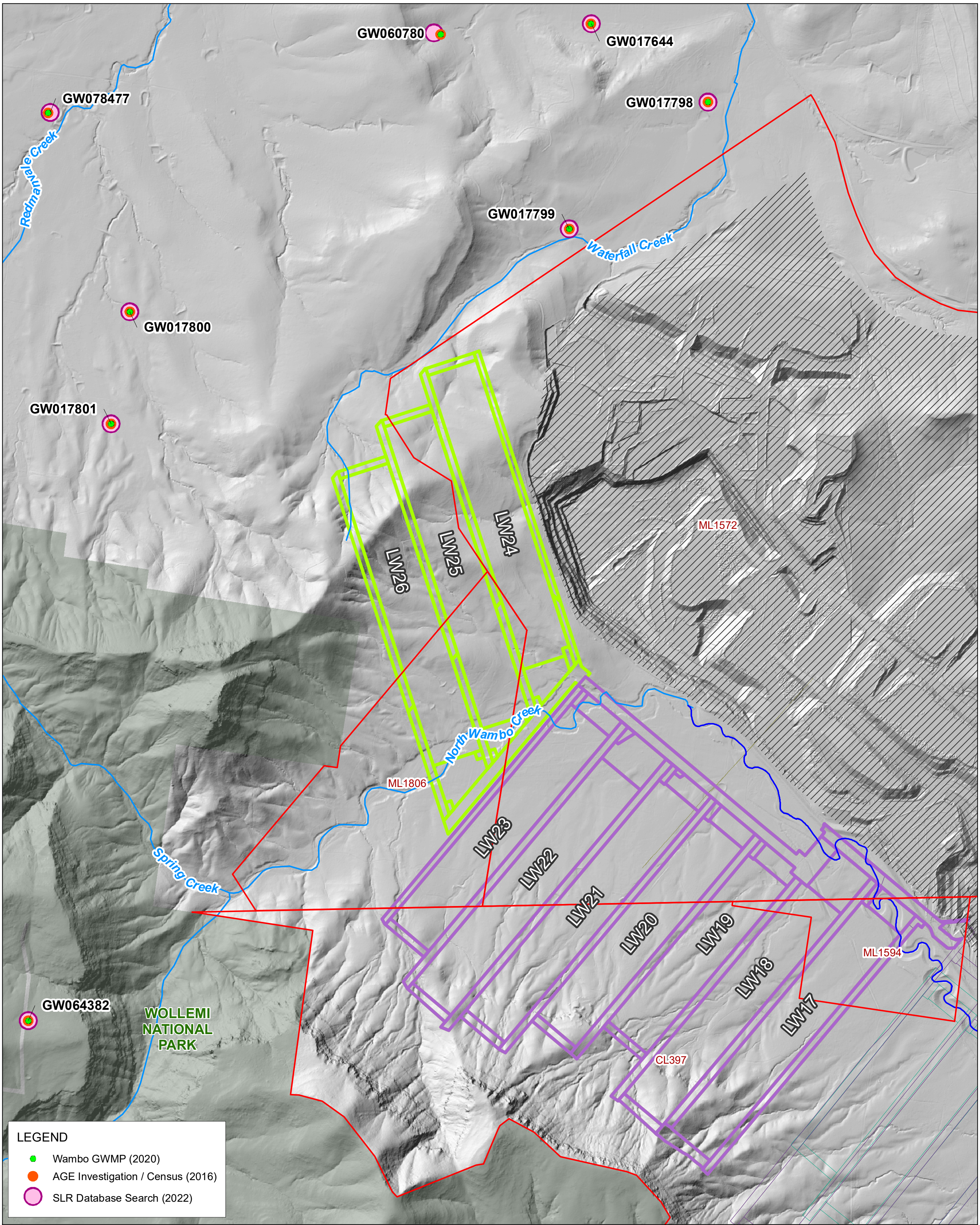
| Bore No. | Location | | Licence No. | Elevation (mAHD) | SWL (mbgl) | EC | Yield (L/s) | Bore Depth (mbgl) | Aquifer | Status | Bore Use | Comment (from AGE, 2016) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10010974 | 316585 | 6394626 | - | 67.89 | - | - | - | - | Alluvium | Unknown/ AD | Unknown | HVO land – Lemington South |
| 10011156 | 306219 | 6400469 | - | 66.03 | - | - | - | - | Alluvium | Unknown | Unknown | Access restrictions, bore not assessed. |
| GW005327 | 314683 | 6394498 | 20BL009540 | 59.92 | 6.1* | Excellent | 0.13* | 10.4 | Alluvium | EX | Stock | Located in township of Warkworth. |
| GW017462 | 315339 | 6391460 | 20BL008224 | - | - | - | - | 0 | - | - | Farming | - |
| GW017644 | 306708 | 6399431 | - | 75.3 | - | salty* | - | 11.6* | Weathered Permian | EX | Irrigation | Inspected by SLR May 2022 – missing. Located on WCPL owned land |
| GW017646 | 306937 | 6399774 | - | 72.7 | - | 3,001-7,000* | - | 11* | Alluvium | Unknown | Unknown | Located on WCPL owned land |
| GW017647 | 307326 | 6399905 | - | 72 | - | 7,001-10,000* | - | 9.1* | Weathered Permian | EX | Unknown | Located on WCPL owned land |
| GW017648 | 307397 | 6400276 | - | 70.3 | - | 3,001-7,000* | 25.26* | 12.8* | Alluvium | Unknown | Irrigation | Located on WCPL owned land |
| GW017798 | 307290 | 6399042 | - | 86.6 | - | 1,001-3,000* | - | 12.2* | Weathered Permian | EX | Unknown | Inspected by SLR April 2022 – missing. Located on WCPL owned land |
| GW017799 | 306598 | 6398412 | - | 108.7 | - | Salty* | - | 12.2* | Weathered Permian | EX | Unknown | Inspected by SLR April 2022 – missing. Located on WCPL owned land |
| GW017800 | 304413 | 6398000 | - | 133.2 | - | - | - | 27.4* | Triassic Narrabeen | Unknown | Unknown | Inspected by SLR May 2022 – dry/ blocked at 2.67 mbgl |
| GW017801 | 304320 | 6397443 | - | 149 | - | - | - | 42.7* | Triassic Narrabeen | EX | Stock | Inspected by SLR May 2022 – missing. |
| GW018045 | 302941 | 6398556 | - | 0 | - | - | - | 27.4* | Newcastle CM | Unknown | Unknown | Inspected by SLR May 2022 – missing, possibly damaged due to farming |
| GW018046 | 303013 | 6398866 | - | 0 | - | - | - | 18.3* | Newcastle CM | Unknown | Unknown | Inspected by SLR May 2022 – missing, possibly damaged due to farming |
| GW018047 | 302620 | 6398920 | - | 145.31 | 26.08 | - | - | 32 | Newcastle CM | PRP | Unknown | Inspected by SLR May 2022 |
| GW022685 | 309088 | 6401184 | - | 75 | 10.67 | 1022 | Continuous use | 14.6 | Alluvium | EX | Stock | Concrete well with pump infrastructure in place. Continuously used for stock and domestic supply. Water quality sample taken. |
| GW027120 | 309501 | 6401185 | - | 77 | 10.75 | 822 | 25.26* | 13.4 | Alluvium | AU | Irrigation | Concrete well at surface with metal lid. Currently disused. |
| GW030731 | 316680 | 6397640 | - | 63 | 13.33 | 2460 | No Pump | 17.02 | Alluvium | AU | - | Steel bore with marker post, disused. Water quality sample taken. |
| GW037184 | 309685 | 6393911 | - | 0 | - | - | - | 21* | Sandstone | - | Exploration | Located on WCPL owned land |
| GW037734 | 309553 | 6401502 | - | 83 | 11.36 | 1022 | 15.16* | 13.4 | Alluvium | AU | Irrigation | Concrete well structure in paddock. No pump infrastructure present, appears disused. |
| GW037998 | 311589 | 6392530 | - | 62.38 | - | - | - | 10.9* | Alluvium | - | Irrigation | Located on WCPL owned land |
| GW037999 | 311482 | 6392713 | - | 64.01 | - | - | - | 13.7* | Shale | - | Irrigation | Located on WCPL owned land |
| GW038000 | 311457 | 6392620 | - | 63.59 | - | - | - | 9.4* | Shale | - | Irrigation | Located on WCPL owned land |
| GW038579 | 309738 | 6393882 | - | 0 | - | - | - | 20.9* | Weathered Permian | - | Exploration | Located on WCPL owned land |
| GW042364 | 316824 | 6397645 | - | 63 | 12.77 | 1077 | - | 13.3 | Alluvium | AU | Unknown | Steel bore with marker post, was used for irrigation but hasn't been used for some time. |
| GW043225 | 303653 | 6398949 | - | 116 | 15.08 | - | - | 24.7 | Sandstone | EX | Irrigation | Inspected by WCPL May 2022. Bore viable but not currently utilised. Water described as 'black and saline'. |
| GW043673 | 311486 | 6392467 | - | 63.11 | - | - | - | 9.4* | Shale | - | Exploration | Located on WCPL owned land |

| Bore No. | Location | | Licence No. | Elevation (mAHD) | SWL (mbgl) | EC | Yield (L/s) | Bore Depth (mbgl) | Aquifer | Status | Bore Use | Comment (from AGE, 2016) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GW043674 | 311303 | 6392525 | - | 64.6 | - | - | - | 8.2* | Alluvium | - | Exploration | Located on WCPL owned land |
| GW043675 | 311433 | 6392527 | - | 63.73 | - | - | - | 8.5* | Alluvium | - | Exploration | Located on WCPL owned land |
| GW043676 | 311480 | 6392805 | - | 64.24 | - | - | - | 10.6* | Shale | - | Exploration | Located on WCPL owned land |
| GW053123 | 309631 | 6402062 | - | 78 | 12.55 | 993 | - | 13.1 | Alluvium | AU | Irrigation | Concrete well structure, disused. |
| GW053173 | 309101 | 640317 | - | 76 | 13.38 | 967 | 10.1* | 14.8 | Alluvium | AU | Irrigation and stock | Concrete well with old pump infrastructure present but appears disused. |
| GW053292 | 317670 | 6398097 | - | 53.3 | - | - | - | 10* | Alluvium | EX | Irrigation | Bore not visited, located on east side of Hunter River. |
| GW060326 | 314104 | 6393348 | - | - | 6.7 | - | - | 9.8 | | - | Mining | - |
| GW060327 | 314181 | 6393442 | - | - | 6.7 | 0-500 | - | 9.8 | - | - | Mining | - |
| GW060328 | 314205 | 6393534 | - | - | 7 | - | - | 10 | - | - | Mining | - |
| GW060329 | 311904 | 6392474 | - | - | - | - | - | 6.4 | - | - | Mining | - |
| GW060330 | 311727 | 6392163 | - | - | 3.8 | 0-500 | - | 6.2 | - | - | Mining | - |
| GW060750 | 314310 | 6394923 | 20BL132130 | 59 | - | - | - | 24.4* | Weathered Permian | Unknown | Domestic | Bore not visited, located in township of Warkworth. |
| GW060780 | 305961 | 6399379 | - | 104.1 | 18.62 | 1552 | No Pump | 25.5 | Weathered Permian | AU | Stock and domestic | Steep bore within vegetation. Uncapped and appears disused (no pump infrastructure present). |
| GW064382 | 303908 | 6394477 | - | 414.4 | - | - | - | 60* | Sandstone | - | Stock and domestic | Access restrictions, bore not assessed. |
| GW065014 | 305777 | 6400368 | - | 85 | - | - | - | 14.5* | Weathered Permian | Unknown | HUSE | Located on Wambo owned land |
| GW065117 | 311154 | 6390735 | - | - | - | - | - | 6 | - | - | Irrigation | - |
| GW066606 | 311207 | 6390674 | - | - | - | - | - | 2.5 | - | - | Domestic | - |
| GW078055 | 310105 | 6390490 | - | - | - | 1660 | 3-5 L/s | 198.5 | | - | Test | - |
| GW078477 | 304007 | 6398988 | - | 109.8 | 11.05 | 3630* | - | 102.5* | Sandstone | EX | Domestic | Private bore, bore in use with water licence 20BL167575. 150 mm diameter PVC casing. Grundfos pump installed to 29 m depth, used approximately every 3 months, and yields 3 L/s. |
| GW078574 | 309174 | 6390605 | 20BL167170 | - | - | - | - | 12 | - | - | Farming | - |
| GW078575 | 309505 | 6389687 | 20BL167171 | - | - | - | - | 12 | - | - | Farming | - |
| GW078576 | 309764 | 6389784 | 20BL167172 | - | - | - | - | 7 | Gravel, coal measures | - | Farming | - |
| GW078577 | 309969 | 6389973 | 20WA208559 | - | - | - | - | 10 | | - | Domestic | - |
| GW079060 | 314596 | 6394852 | - | - | - | - | - | 14.6 | | - | Unknown | - |
| GW080502 | 308897 | 6390160 | 20BL168017 | - | 105 | - | - | 250 | Coarse Sand | - | Mining | - |
| GW080519 | 313622 | 6394161 | 20BL168885 | 57.98 | 7.42* | 6490* | - | 10.5* | Alluvium | - | Unknown | Located on WCPL owned land |
| GW080951 | 314619 | 6394878 | - | 55 | - | - | - | 3.14* | Alluvium | Unknown | - | Bore not visited, located in township of Warkworth. |
| GW080952 | 314643 | 6394904 | - | 54 | - | - | - | 1.59* | Alluvium (sandy clay) | EX | - | Bore not visited, located in township of Warkworth. |
| GW200361 | 311833 | 6392209 | 20BL170638 | 60.97 | 3.12 | - | - | - | Alluvium | - | Test | Located on WCPL owned land |
| GW200624 | 310166 | 6392650 | 20BL168939 | - | 6 | - | - | 260 | | - | Dewatering | |
| GW200625 | 310901 | 6393375 | 20BL168940 | - | - | - | - | 270 | | - | Mining | - |
| GW200942 | 312325 | 6395750 | 20BL167947 | - | 32 | - | - | 37 | | - | Test | - |

| Bore No. | Location | | Licence No. | Elevation (mAHD) | SWL (mbgl) | EC | Yield (L/s) | Bore Depth (mbgl) | Aquifer | Status | Bore Use | Comment (from AGE, 2016) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GW200943 | 312332 | 6395760 | 20BL167947 | - | 27 | - | - | 30 | | - | Test | - |
| GW203459 | 311820 | 6392560 | - | 0 | - | - | - | 55 | Jerrys Plains SG | EX | Dewatering | |
| Unregistered bore (near GW029155) | 305430 | 6401656 | - | 76 | 8.2 | - | - | 9.8 | Alluvium | EX | Stock | Private bore, well at least 50 years old, 1 m concrete well, casing 0.6 m above surface. Windmill in place and pumps at rate of 2.4 L/minute. Used for stock water supply year-round. |

Status: AU – Abandoned but useable AD – Abandoned EX – Existing

* - value derived from NSW Bore Database/ Pinneena




0 0.25 0.5 km

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| Coordinate System: | GDA 1994 MGA Zone 56 |
| Scale: | 1:25,000 at A4 |
| Project Number: | 665.10008.01915 |
| Date: | 13-Apr-2023 |
| Drawn by: | NT |

South Bates Extension (LW17-23)
South Bates Extension (LW24-26)
Named Watercourse
NWC Diversion
Mining Lease
Approved Open Cut Mining
NPWS Reserve

**Wambo Underground Mine**
South Bates - Whybrow Seam
South Bates - Wambo Seam

**WAMBO COAL MINE**
**LW24-26 EXTRACTION PLAN**
**GROUNDWATER TECHNICAL REVIEW**

**Registered bores**

SLR

Data Source: NSW SS 2020

**FIGURE 4-14**

H:\Projects-SLR\660-SrvWOL\660-WOL\665.10008 Wambo Groundwater Study\06 SLR Data\01 CADGIS\ArcGIS\SLR665100080 1915_LW24_26EP_2_x_RegisteredBores.mxd

### 4.5.2 Groundwater Dependent Ecosystems

A GDE can be a plant (vegetation) and/or animal community (i.e. stygofauna) that is dependent on the availability of groundwater to maintain its structure and function. A review of relevant data sources was undertaken as part of this groundwater assessment with details on the occurrence of potential GDEs in the vicinity of modified SBX Underground Mine is provided below.

The GDE Atlas (BoM, 2021) was developed as a national dataset of Australian GDEs to inform groundwater planning and management. The GDE Atlas uses the following categories for mapping the likelihood of terrestrial GDEs:

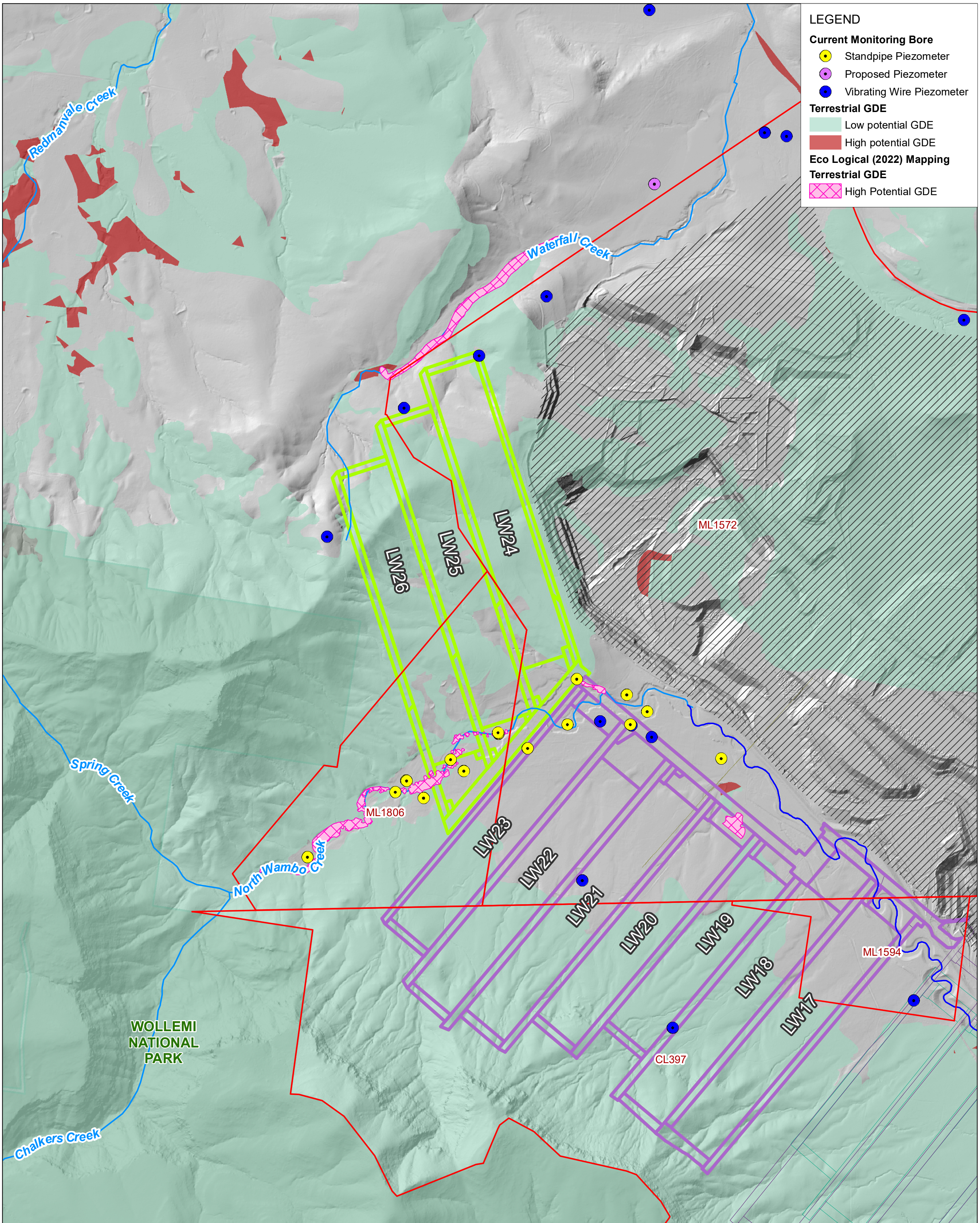
- High potential for groundwater interaction.
- Moderate potential for groundwater interaction.
- Low potential for groundwater interaction.

The term ‘potential’ is used to reflect the uncertainty inherent in identifying ecosystems as groundwater dependent using desktop methods.

**Figure 4-15** shows GDE Atlas mapping of the SBX Underground Mine area. Areas mapped as high potential terrestrial GDEs include areas mapped around Redmanvale Creek and the Hunter River (located northwest and north of SBX LW24-26), and small areas around Waterfall Creek and North Wambo Creek (located northeast and southeast of modified Longwalls 24 to 26). The mapping also identifies the Hunter River (located north of SBX LW24-26) as a high potential Aquatic GDE. **Figure 4-15** also shows high potential GDEs identified in ecological and biodiversity studies near SBX and LW24-26 (Hunter Eco, 2019 and Eco Logical, 2022) including sites at North Wambo Creek, Waterfall Creek and adjacent to SBX LW20.

Hunter Eco (2022) completed a Biodiversity Development Assessment Report (BDAR) for Modificaiton 19. Key findings relating to potential groundwater dependant vegetaion include:

- the Modification would decrease the impact to named watercourses because approximately 2 km of North Wambo Creek would no longer be undermined or subject to subsidence; and
- the Modification would materially reduce subsidence to vegetation that may use groundwater as approximately 91% (4.2 ha) of high potential GDE along North Wambo Creek would no longer be undermined or subject to subsidence.

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| Coordinate System: | GDA 1994 MGA Zone 56 |
| Scale: | 1:25,000 at A4 |
| Project Number: | 665.10008.01915 |
| Date: | 11-Apr-2023 |
| Drawn by: | NT |

Data Source: NSW SS 2020
Groundwater Dependent Ecosystems Atlas

**WAMBO COAL MINE**
**LW24-26 EXTRACTION PLAN**
**GROUNDWATER TECHNICAL REVIEW**

**Potential Groundwater Dependent Ecosystems (GDEs)**

**FIGURE 4-15**

H:\Projects-SLR\660-SrvWOL\660-WOL\665.10008 Wambo Groundwater Study\06 SLR Data\01 CADGIS\ArcGIS\SLR665100080 1915_LW24_26EP_2_x_GDEs.mxd

SLR (2022) assessed potential groundwater impacts to GDEs identified from Hunter Eco (2019), Eco Logical (2022) and BOM GDE Atlas Sources. The following points provide a summary of the work completed for the GDE study and in subsequent investigations and groundwater assessments:

- Groundwater observation data from March 2020 to present (March 2023) indicate areas of the North Wambo Creek alluvium saturate near to and above ground level (**Section 4.3.5**). This is observed following high magnitude rainfall events that resulted in flow in North Wambo Creek. Groundwater levels are observed to decline rapidly following these events.
- Modelling undertaken for this groundwater technical review and SLR (2022) simulates flow events in North Wambo Creek based on a rainfall event – stream flow relationship (**Section 2.2**). Model results using this relationship were consistent with observed data.
- SLR (2022) did not predict saturation of the alluvium/ regolith in model layer 1 at the Waterfall Creek high potential GDE. The water table elevation was predicted to be 53 mbgl for the model scenario that consider cumulative impacts of Wambo complex mining, including SBX LW24-26 and was assessed as not likely accessible by vegetation.
- SLR (2022) predicted 1 m drawdown within the North Wambo Creek alluvium for the eastern-most extent (a 120 m reach) of the high potential GDE along North Wambo Creek due to Wambo area underground and open cut operations cumulative impact. Approximately 5 – 7.5 m drawdown is predicted for the water table underlying the entire vegetation community identified by Hunter Eco (2019) as likely to be groundwater dependent and the broader SBX Underground Mine area.
- SLR (2022) predicted 1 m drawdown within the alluvium/ regolith of model layer 1 for the north-eastern 20% (approximately 0.15 Ha) of the additional high potential GDE due to Wambo complex mining since 2003 (including SBX LW24-26). Approximately 10 – 30 m drawdown is predicted for the water table underlying the entire additional high potential GDE due to Wambo complex mining since 2003. This is likely due to nearby open cut and underground mining.
- There is no drawdown predicted in the alluvium/ regolith (model layer 1) by SLR (2022) for areas mapped as high potential terrestrial GDEs from the BoM GDE Atlas. Up to 3 m of drawdown is predicted at the water table for some high potential terrestrial GDEs from the BoM GDE Atlas, however, the water table elevation at these locations was predicted to be too deep to be accessed by vegetation.

Based on groundwater level observations within the approved SBX Underground Mine area, the high potential GDE vegetation community identified by Hunter Eco (2019) is likely to have periodic access to groundwater. This periodic saturation of the alluvium is associated with high rainfall and flow events in North Wambo Creek and is captured within contemporary groundwater modelling. The monitoring network near this vegetation community is sufficient to observe changes in groundwater behaviour associated with the SBX Underground Mine including LW24-26.

Observations from the recently installed VWPs north and west of SBX LW24-26 appear to be consistent with SLR (2022), which predicts the regional water table elevation is too deep to be accessed by vegetation (DDH1234 – **Section 4.3.4**). The potential perched water table at DDH1235 (**Section 4.3.4**), is not captured within the current numerical model.

## 4.6 Conceptual model

Based on the data reviewed in the previous sections, the hydrogeological conceptual model developed for the Modification 19 Groundwater Assessment (SLR, 2022) is not materially changed by the installation of additional monitoring locations or the collection of recent data. Key findings from recent data and additional monitoring locations that have improved the understanding of the hydrogeological system near SBX LW24-26 include:

- The regional water table is unlikely to be shallow enough to interact with the Waterfall Creek high potential GDE. See DDH1234 data in **Section 4.3.4**.
- A perched groundwater system may exist near the north end of SBX LW25 (see DDH1235 data in **Section 4.3.4**). This may be spatially and geologically limited as the same perching is not observed at DDH1240.

# 5 Groundwater Simulation Model

## 5.1 Model details

The contemporary numerical model for Wambo was completed for the Modification 19 Groundwater Assessment (SLR, 2022). The model was rebuilt and recalibrated utilising previous Wambo groundwater models (e.g. HydroSimulations, 2019), the United Wambo Open Cut numerical model (AGE, 2016) and site and regional geological models using current best practice modelling techniques. Key features of the updated model include:

- *Algomesh* software was used to generate the model grid using Voronoi polygons, enabling progressive refinement of the model grid near key mining and environmental features.
- MODFLOW-USG used as model code.
- Update of alluvial geometry, representation of flow in ephemeral watercourses, and use of the Australian Landscape Water Balance Model (AWRA-L) to better capture observed groundwater levels in shallow strata.
- The model is calibrated to observed groundwater levels to the end of December 2020.

The rebuilt model was then recalibrated and underwent peer review (Appendix E of SLR (2022) – HydroAlgorithmics, 2022) as part of the approvals process for MOD19. The peer review (HydroAlgorithmics, 2022) found the model to be fit for purpose where the model's purpose was defined by the objectives stated in SLR (2022):

- "*assess the groundwater inflow to the mine workings as a function of mine position and timing;*
- *simulate and predict the extent of dewatering due to the Project and the level and rate of drawdown at specific locations;*
- *identify areas of potential risk, where groundwater impact mitigation/control measures may be necessary;*
- *estimate direct and indirect water take; and*
- *estimate post-mining recovery conditions*."

The following sections provide the model objectives and scenarios used in the groundwater technical review for the SBX LW24-26 EP only. Full details of the numerical groundwater model are included within the *Wambo Coal Mine Longwalls 24-26 Modification Groundwater Modelling Technical Report* (Appendix D of SLR (2022)).

## 5.2 Model objectives

Numerical modelling was undertaken in support of the groundwater review for the LW24-26 EP to evaluate the potential incremental impacts of LW24-26 on the local groundwater regime. The objectives of the predictive modelling were to:

- Assess the groundwater inflow to the mine workings as a function of mine position and timing as a result of LW24-26 extraction.
- Simulate and predict the extent and area of influence of dewatering, and the level and rate of drawdown at specific locations and in specific strata as a result of LW24-26 extraction.
- Identify areas of potential risk, where groundwater impact mitigation/control measures may be necessary as a result of LW24-26 extraction.
- Estimate direct and indirect water take as a result of LW24-26 extraction.

## 5.3 Model predictions

Transient predictive modelling was undertaken to simulate both the mining at Wambo and surrounding mines from January 2021 to December 2041. The model timing used quarterly stress period durations as mining progressed into the future. Three numerical model scenarios have been utilised:

1. **Null Run** – No Wambo/United Collieries/UWOCP mining after 2003 (i.e. when Development Consent (DA305-7-2003) was issued). This scenario does include mining at other approved mining operations outside of the Wambo/United Collieries/UWOCP mining complex. *No change to this scenario from SLR (2022).*
2. **No Longwalls 24-26** – Approved mining at Wambo (i.e. in accordance with Development Consent (DA305-7-2003) without the extraction of SBX LW24-26, and mining at other approved mining operations around Wambo. No changes are made to the timing of Approved mining at Wambo in this scenario. *This scenario has been developed for this EP in order to calculate incremental impacts.*
3. **Modification 19** – Approved mining at Wambo (i.e. in accordance with Development Consent [DA305-7-2003]) and mining at other approved mining operations around Wambo. This was considered the 'Modification' scenario in SLR (2022). *No change to this scenario from SLR (2022).*

The following differential comparisons were made on groundwater level and groundwater flux outputs to evaluate incremental impacts due to the Modification, and cumulative impacts due to Wambo including the Modification:

- *Modification 19 Scenario* compared to the *No Longwalls 24-26 Scenario* – to **evaluate the incremental impacts** of SBX LW24-26.
- *Modification Scenario* compared to the *Null Run* – **to evaluate cumulative impacts** due to modified Wambo (i.e. including Longwalls 24 to 26) and the United Collieries/UWOCP operations.

The only change made to the numerical model for this groundwater technical review is the creation of *the No Longwall 24-26* scenario to assess incremental impacts required for this EP. This involved changing the number of longwalls simulated for extraction at SBX Underground Mine only. Cumulative impacts presented in this groundwater technical review are consistent with the Modification 19 Groundwater Assessment (SLR, 2022). Incremental impacts presented in this groundwater technical review will show the predicted impacts of SBX LW24-26 extraction compared to SBX if mining was completed at LW23.

### 5.3.1 Environmental assumptions

**Table 5-1** provides an overview of how environmental inputs were simulated during the quarterly stress periods of the predictive modelling, and the annual, decadal and century length stress periods of the recovery modelling.

**Table 5-1 Summary of environmental assumptions during predictive modelling**

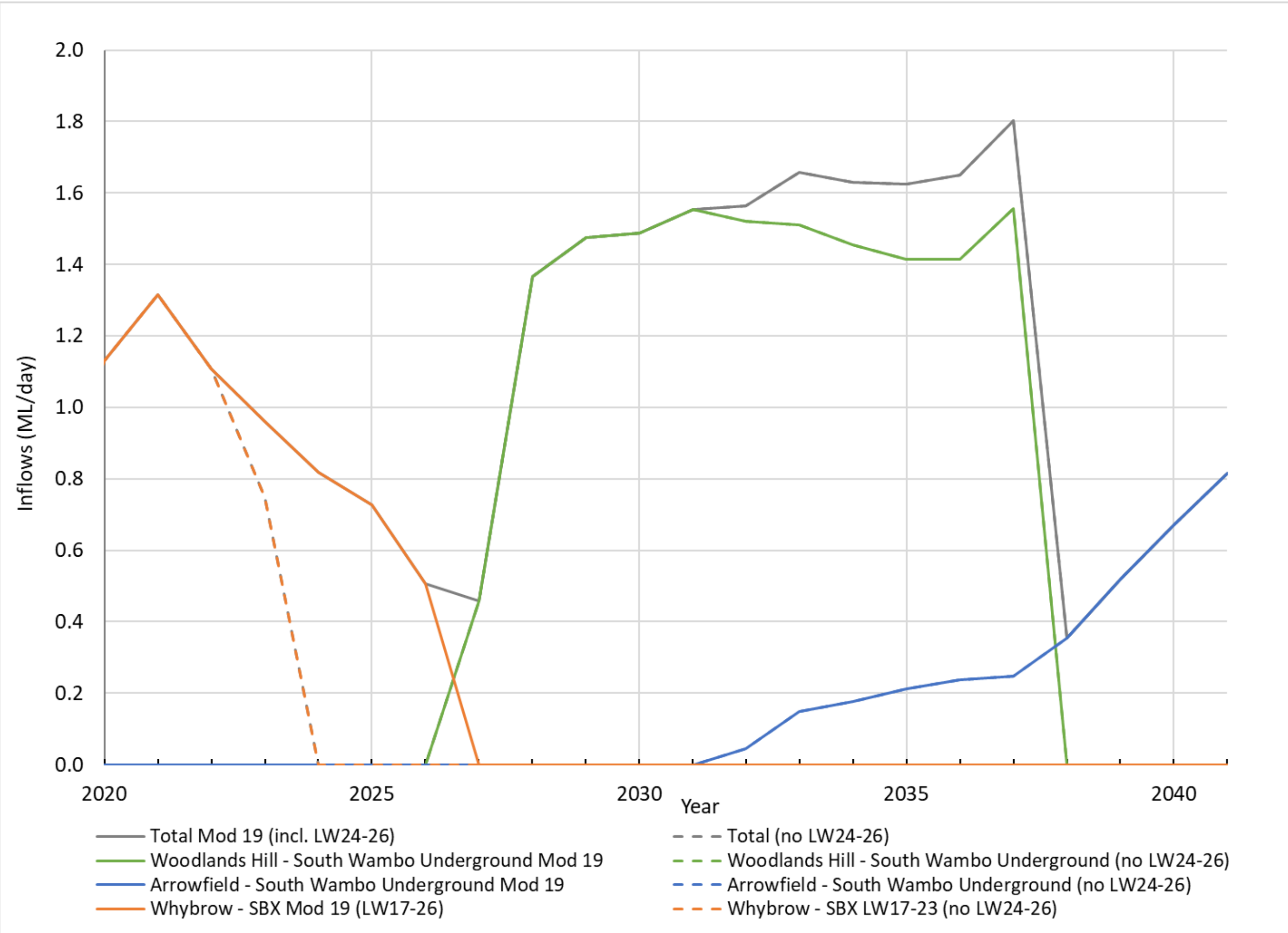
| Environmental Process | Reach/ Zone | Predictive assumption | Recovery assumptions |
|---|---|---|---|
| **Stream stage** | Hunter River | Seasonality simulated using long-term average stage height per quarter. | No seasonality. Long-term annual average stage height. |
| | Wollombi Brook | Seasonality simulated using long-term average stage height per quarter. | No seasonality. Long-term annual average stage height. |
| | Ephemeral watercourses | Timing of recharge episodes not predictable. No stage height simulated for ephemeral steams in the predictive modelling (e.g. Wambo Creek, North Wambo Creek, Stony Creek). | No stage height simulated for ephemeral steams in the recovery modelling. |
| **Rainfall Recharge** | Recharge zones as per calibration including a time variant zone for spoil/ backfill. | No seasonality. Long-term annual average rate applied after modification with calibrated multipliers. | No seasonality. Long-term annual average rate applied after modification with calibrated multipliers. |
| **Evapotranspiration** | ET zones as per calibration including a time variant zone for spoil and final voids. | Seasonality simulated using long-term average rate per quarter. | No seasonality. Long-term annual average rate applied. |

## 5.4 Predicted groundwater interception

The predicted groundwater inflows for underground mines at Wambo, and the total underground mine inflows with and without SBX LW24-26 are presented in **Figure 5-1**. SBX inflows only, with and without LW24-26 are presented in **Figure 5-2**.

No change to maximum inflows are predicted for the SBX Underground Mine due to LW24-26 extraction, with inflow predicted to reach a maximum annual inflow of 480.45 ML (1.32 ML/day) in 2021. No change to maximum inflows are predicted for the remaining life of approved underground mining at Wambo due to LW24-26 extraction, with a maximum total inflow of 657.45 ML (1.8 ML/day) is predicted for 2037 in both scenarios (**Figure 5-1**).

**Figure 5-2** shows the extraction of LW24-26 will result in up to 299.51 ML (0.82 ML/day) of groundwater inflows, which is predicted to peak in 2024. There is no increase in maximum predicted groundwater inflow for the SBX Underground Mine due to LW24-26. The extended SBX mine including LW24-26 results in a longer period of groundwater interception.




Note: South Wambo Underground (Arrowfield and Woodlands Hill Seam mining) was approved under Modification 12. However, South Wambo Underground mine scheduling was updated to incorporate SBX LW24-26 as part of Modification 19.

**Figure 5-1 Predicted Wambo underground mine groundwater inflows**

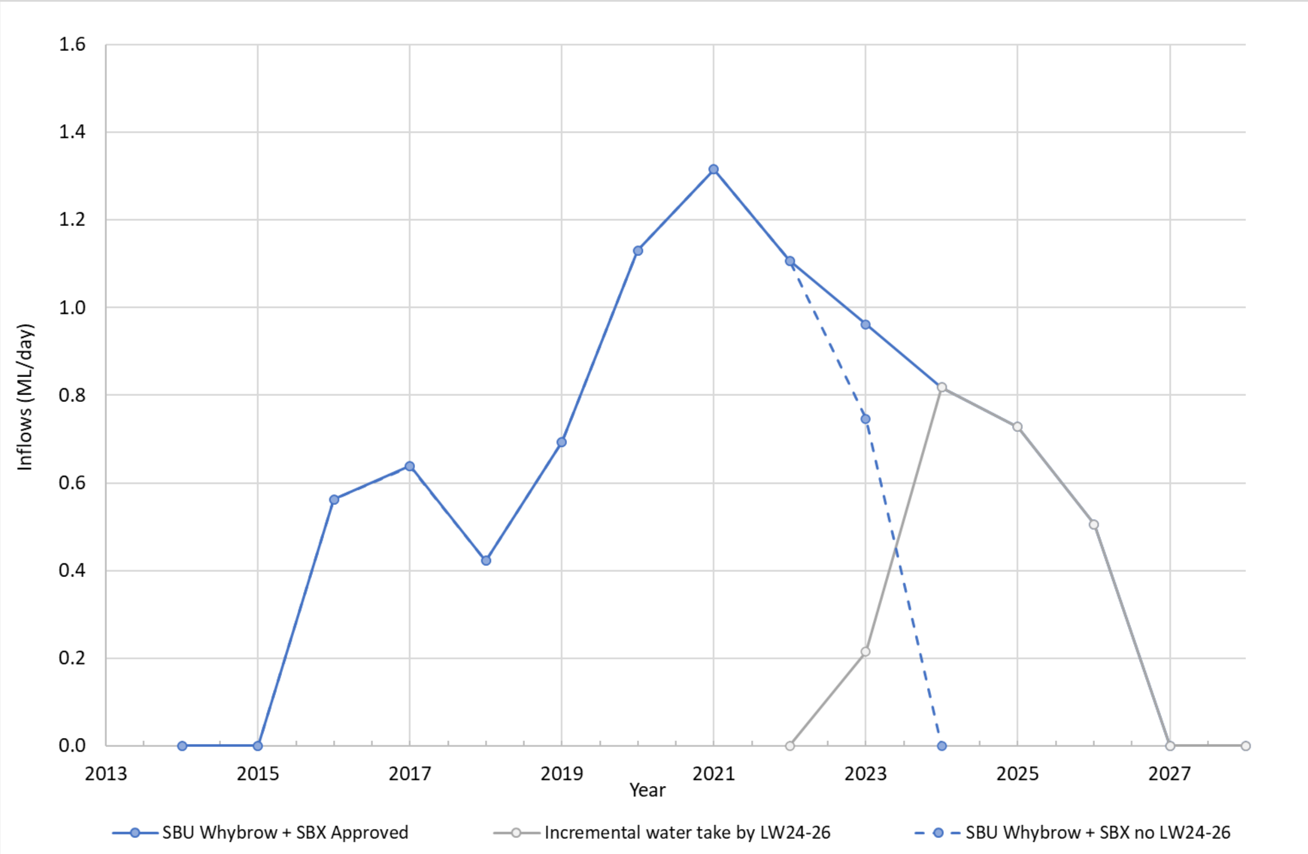



**Figure 5-2 South Bates Extension underground mine groundwater inflows**

WCPL currently has licence entitlements of 1,647 ML/year for groundwater derived from the Porous Rock source (WCPL, 2021b). Sufficient licence is currently available for the *North Coast Fractured and Porous Rock Groundwater Sources* for peak predicted mine inflow for approved Wambo underground mining. Peak inflow is not influenced by LW24-26 extraction and is predicted to occur during South Wambo mining.

## 5.5 Predicted maximum drawdowns

The process of mining reduces water levels in surrounding groundwater units due to the interception of groundwater in the mined geology. The extent of the zone affected is dependent on the properties of the aquifers/aquitards and is referred to as the zone of drawdown. Aquifer drawdown is greatest at the working coal-face, and generally, gradually decreases with distance from the mining operations.

Incremental drawdown due to LW24-26 extraction is obtained by comparing the difference in groundwater levels for different aquifers between the *Modification 19* and *No Longwall 24-26* scenarios. The maximum drawdown is a combination of the maximum drawdown values recorded at each model cell at any time over the duration of the predictive model. Predicted drawdown figures (**Figure 5-3** to **Figure 5-5)** show where maximum incremental drawdown impacts are predicted to exceed 1 m in key hydrogeological units.

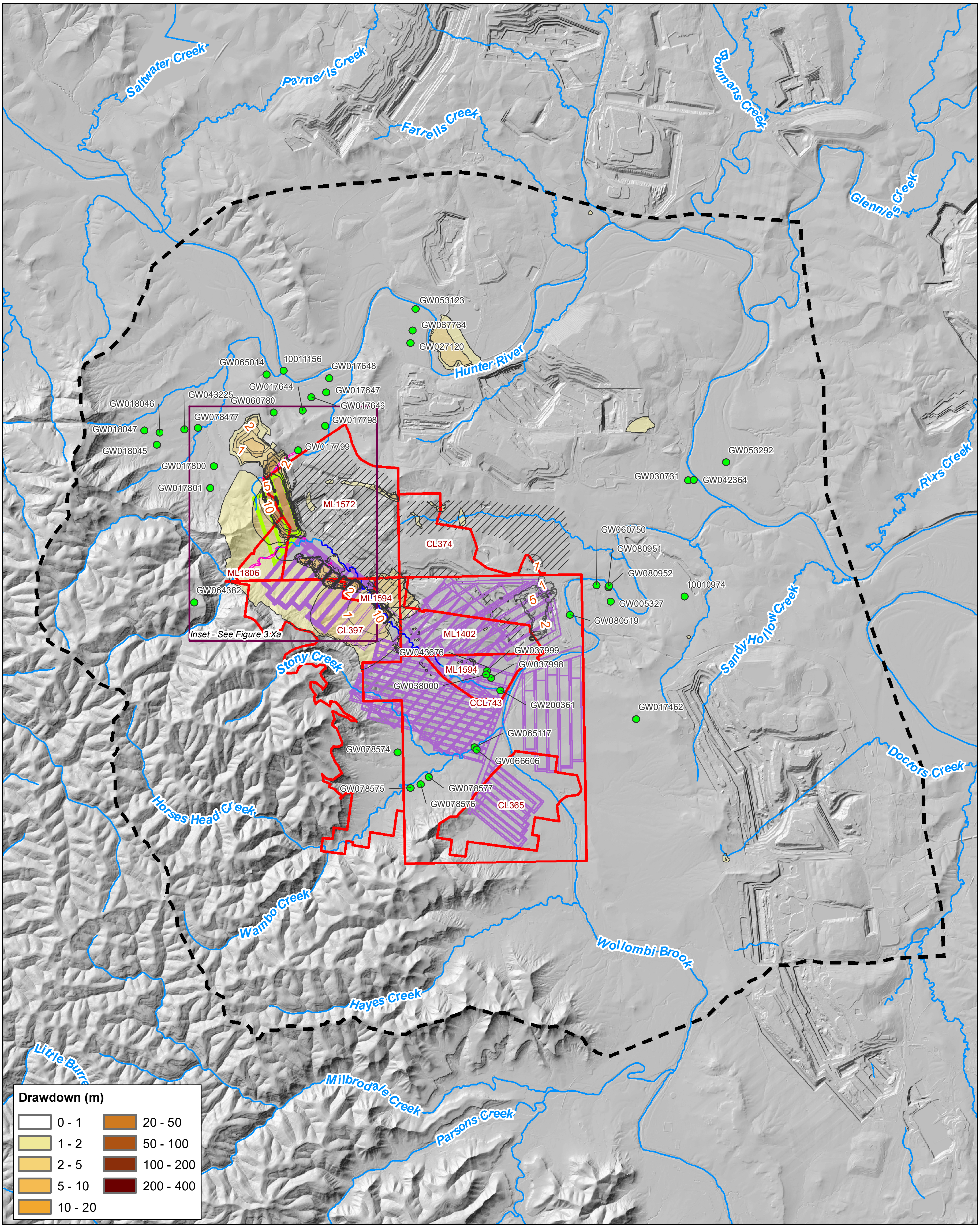
Several higher resolution versions of key spatial figures have also been developed to help identify the location and magnitude of predicted incremental drawdowns. The inset extent, where relevant, is displayed on the full extent figure.[2]

Maximum incremental drawdown to the water table is shown in **Figure 5-3** and **Figure 5-3 a**. Incremental drawdown to the water table of approximately 20 m is predicted above the modified Longwalls 24 to 26, with the 1 m drawdown contour extending up to 1.6 km north and 1 km west of Longwalls 24 to 26. Some drawdown impacts to the water table are predicted above the south-eastern panels of SBX Underground Mine (LW17-23), particularly where there are shallower depths of cover above the longwalls. This is due to the extended life of SBX mining and extended period of depressurisation with the inclusion of LW24-26.

No incremental drawdown impacts are predicted for the alluvium as a result of the LW24-26 (**Figure 5-4** and **Figure 5-4 a**). Conceptually, impacts to the North Wambo Creek alluvium are expected to be less if SBX LW24-26 were not extracted, with a smaller area of alluvium directly undermined by the modified SBX Underground Mine compared to the approved SBX Underground Mine. Other alluvial zones associated with larger watercourses (Wambo Creek, Wollombi Brook, Hunter River) are distant enough from the modified SBX Underground Mine that no incremental drawdowns are predicted. This prediction is consistent with HydroSimulations (2017) modelling.

The maximum predicted incremental drawdown associated with the Modification within the target Whybrow Seam is shown in **Figure 5-5** and **Figure 5-5 a**. The drawdown extent within the Whybrow Seam (Layer 7) is influenced by unit structure and is confined to unit extents, meaning that drawdown does not extend east, where the Whybrow Seam has outcropped. The 1 m drawdown influence is predicted to extend up to 3.5 km north-west of the Modification.

[2] Note: Inset figure numbers are only referenced in the first instance. Relevant figures will display inset extent.

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| Scale: | 1:130,000 at A4 |
| Project Number: | 665.10008.01915 |
| Date: | 13-Apr-2023 |
| Drawn by: | NT |

SLR

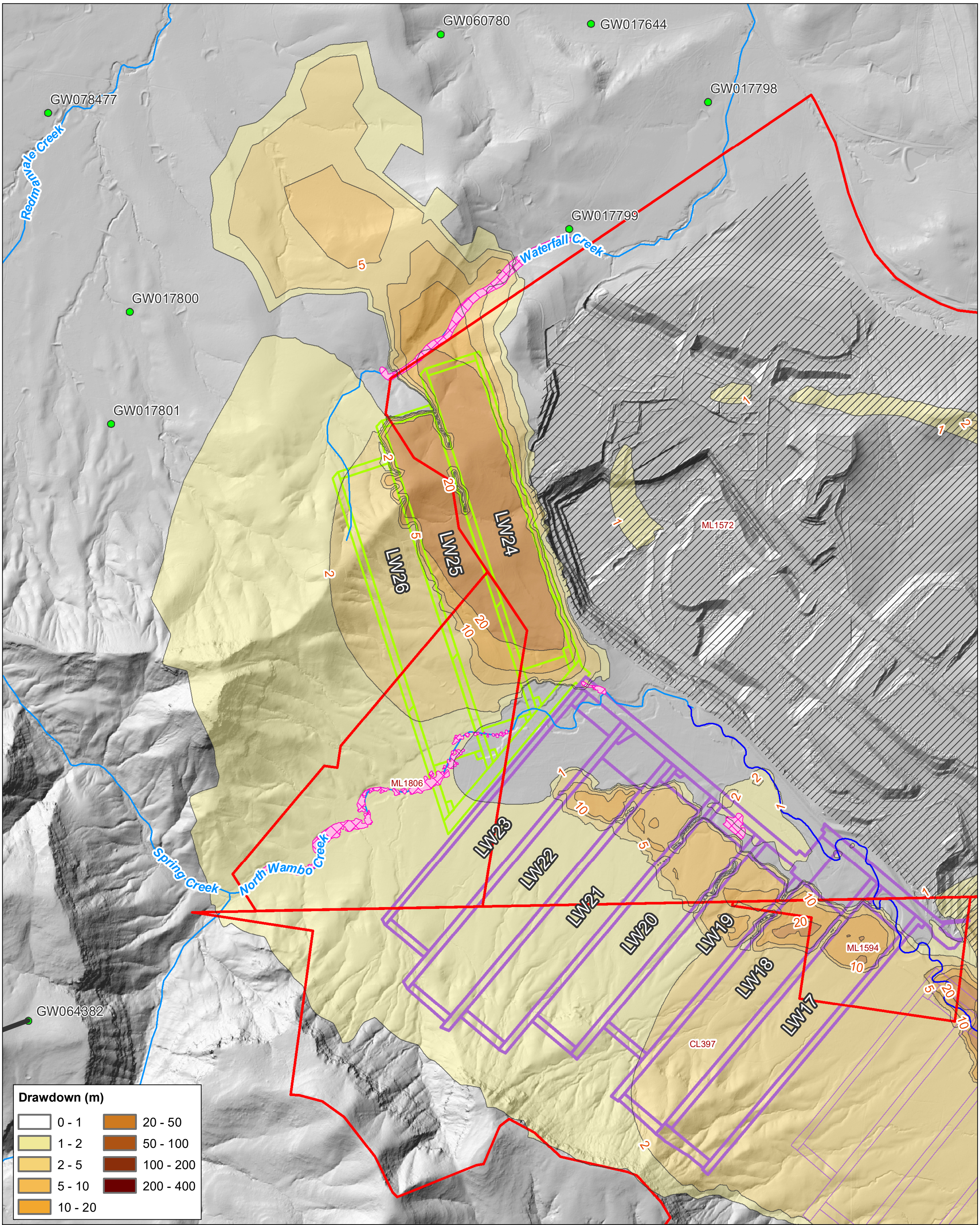
- Wambo GWMP (2020)
- New Wambo Model Boundary
- Named Watercourse
- NWC Diversion
- High Potential GDE
- Mining Lease
- Existing/Approved Underground Development
- Approved Open Cut Mining
- South Bates Extension (LW17-23)
- South Bates Extension (LW24-26)

Data Source: NSW SS 2020

**WAMBO COAL MINE**
**LW24-26 EXTRACTION PLAN**
**GROUNDWATER TECHNICAL REVIEW**

**Maximum incremental drawdown at the water table**

**FIGURE 5-3**




0 0.25 0.5 km

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| Coordinate System: | GDA 1994 MGA Zone 56 |
| Scale: | 1:25,000 at A4 |
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SLR

- Wambo GWMP (2020)
- New Wambo Model Boundary
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- South Bates Extension (LW17-23)
- South Bates Extension (LW24-26)

Data Source: NSW SS 2020

**WAMBO COAL MINE**
**LW24-26 EXTRACTION PLAN**
**GROUNDWATER TECHNICAL REVIEW**

**Maximum incremental drawdown at the water table - Inset**

**FIGURE 5-3a**

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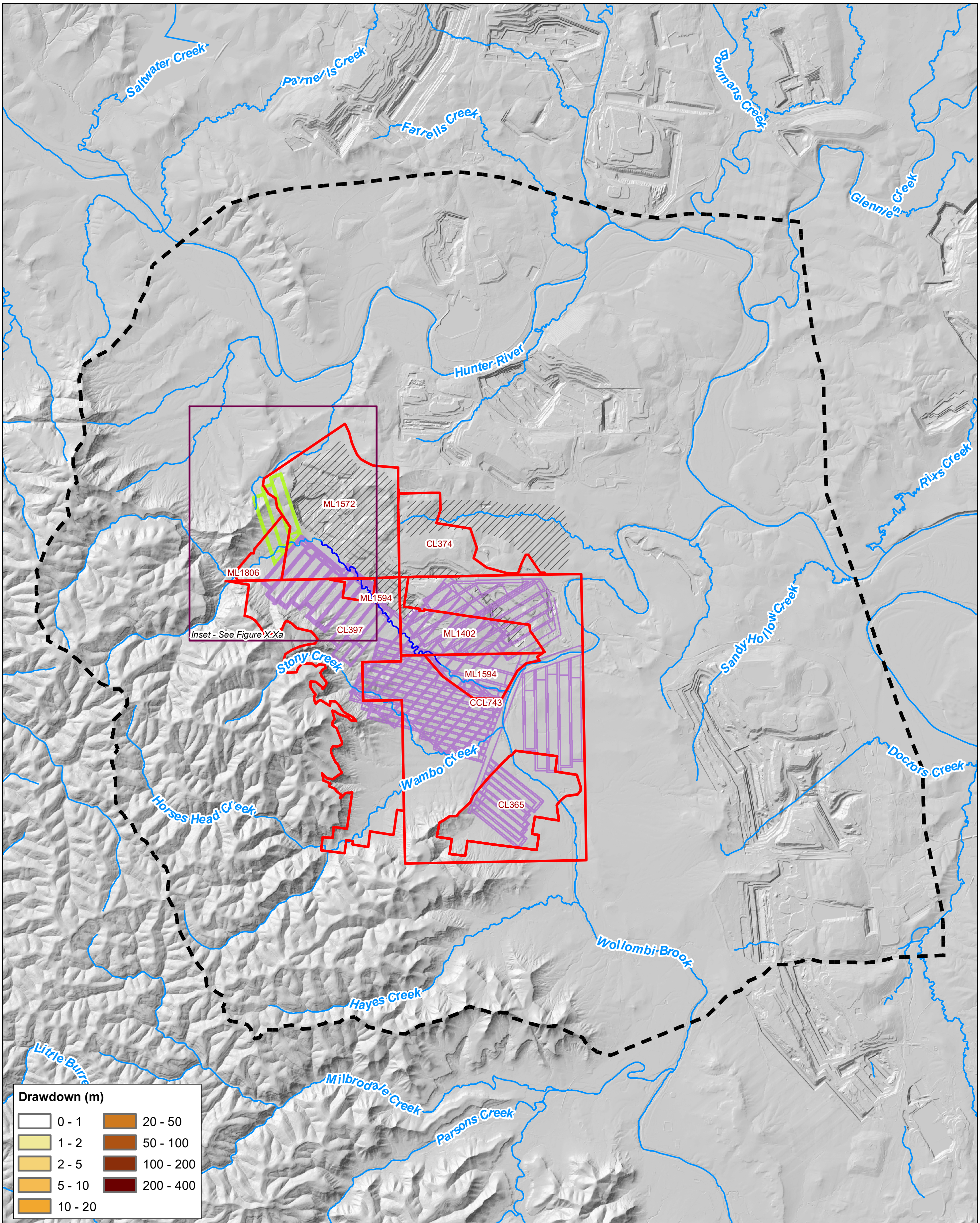


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| Coordinate System: | GDA 1994 MGA Zone 56 |
| Scale: | 1:130,000 at A4 |
| Project Number: | 665.10008.01915 |
| Date: | 11-Apr-2023 |
| Drawn by: | ANP |

New Wambo Model Boundary

Named Watercourse

NWC Diversion

Mining Lease

Existing/Approved Underground Development

Approved Open Cut Mining

South Bates Extension (LW17-23)

South Bates Extension (LW24-26)

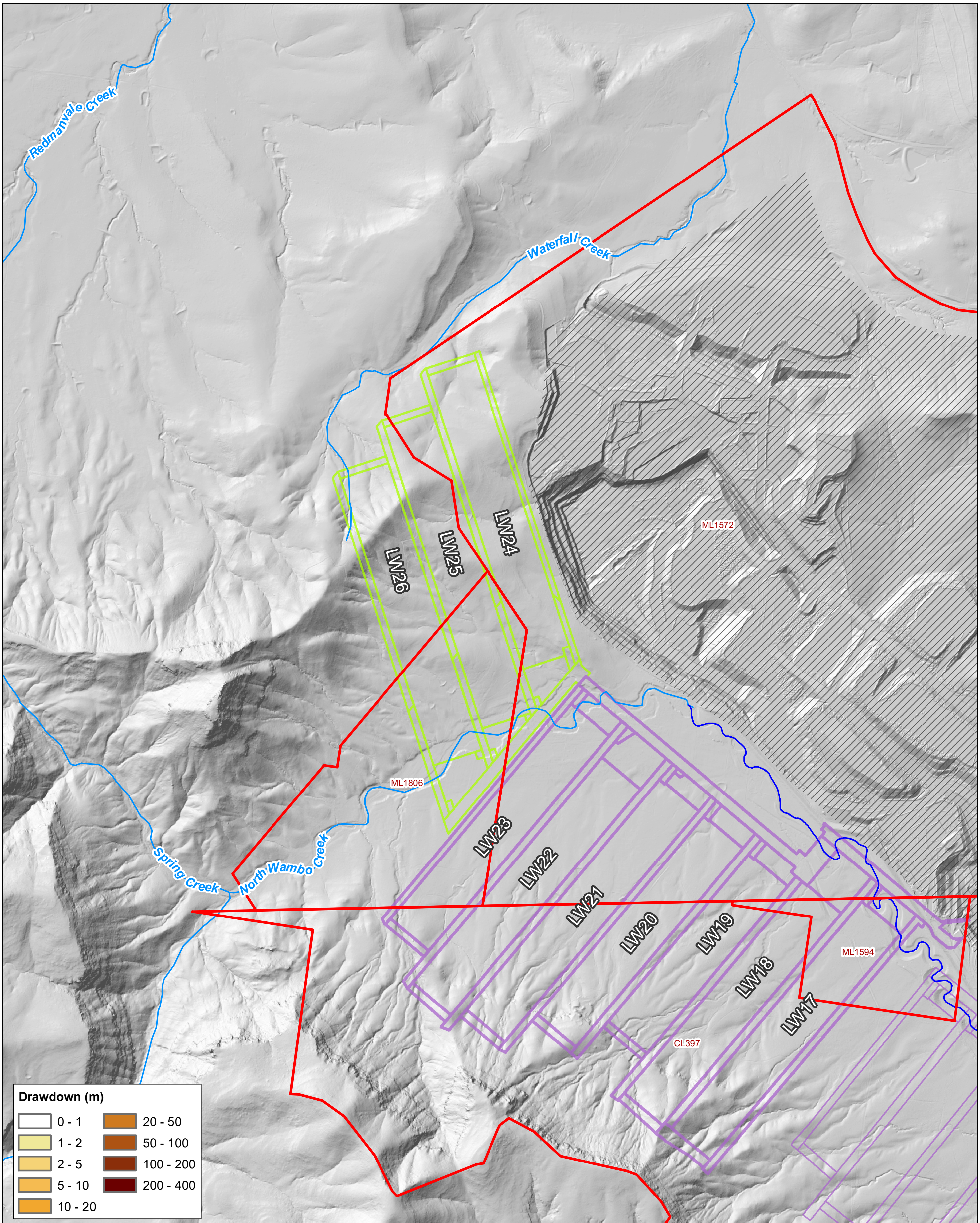
**WAMBO COAL MINE**
**LW24-26 EXTRACTION PLAN**
**GROUNDWATER TECHNICAL REVIEW**

**Maximum incremental drawdown in alluvium and regolith (layer 1)**

Data Source: NSW SS 2020

**FIGURE 5-4**

H:\Projects-SLR\660-SrvWOL\660-WOL\665.10008 Wambo Groundwater Study\06 SLR Data\01 CADGIS\ArcGIS\SLR665100080 1915_LW24_26EP_X_x_Max_IncrementalDD_Layer_1.mxd

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|---|---|
| Coordinate System: | GDA 1994 MGA Zone 56 |
| Scale: | 1:25,000 at A4 |
| Project Number: | 665.10008.01915 |
| Date: | 11-Apr-2023 |
| Drawn by: | ANP |

SLR

New Wambo Model Boundary
Named Watercourse
NWC Diversion
Mining Lease
Existing/Approved Underground Development
Approved Open Cut Mining

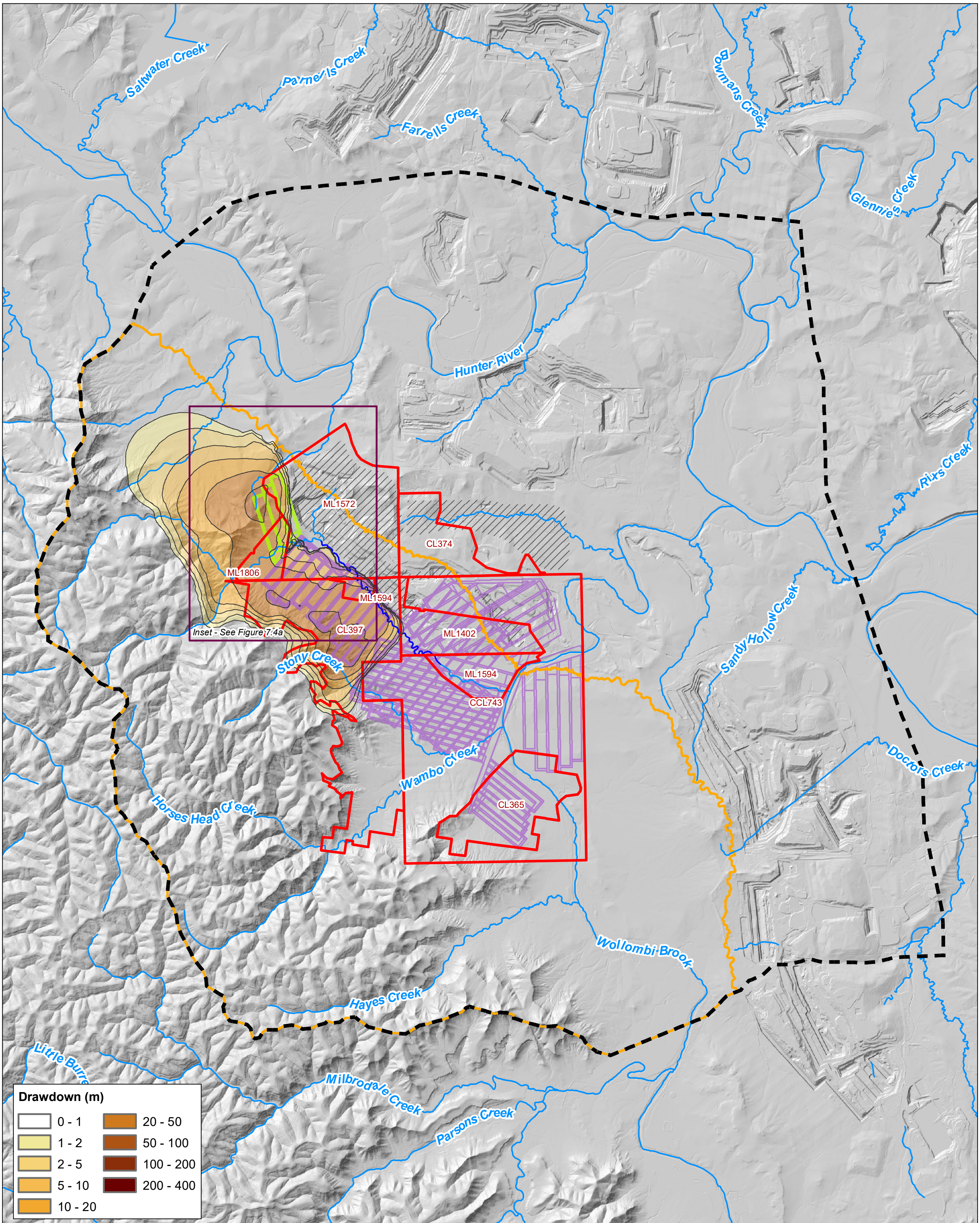
Data Source: NSW SS 2020

**WAMBO COAL MINE**
**LW24-26 EXTRACTION PLAN**
**GROUNDWATER TECHNICAL REVIEW**

**Maximum incremental drawdown in alluvium and regolith (layer 1) - Inset**

**FIGURE 5-4a**

H:\Projects-SLR\660-SrvWOL\660-WOL\665.10008 Wambo Groundwater Study\06 SLR Data\01 CADGIS\ArcGIS\SLR665100080 1915_LW24_26EP_X_xa_Max_IncrementalDD_Layer_1.mxd




0 2 4 km

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| Coordinate System: | GDA 1994 MGA Zone 56 |
| Scale: | 1:130,000 at A4 |
| Project Number: | 665.10008.01915 |
| Date: | 13-Apr-2023 |
| Drawn by: | ANP |

SLR

- New Wambo Model Boundary
- Named Watercourse
- NWC Diversion
- Mining Lease
- Whybrow Seam Extent (Layer 7)
- Existing/Approved Underground Development
- Approved Open Cut Mining
- South Bates Extension (LW17-23)
- South Bates Extension (LW24-26)

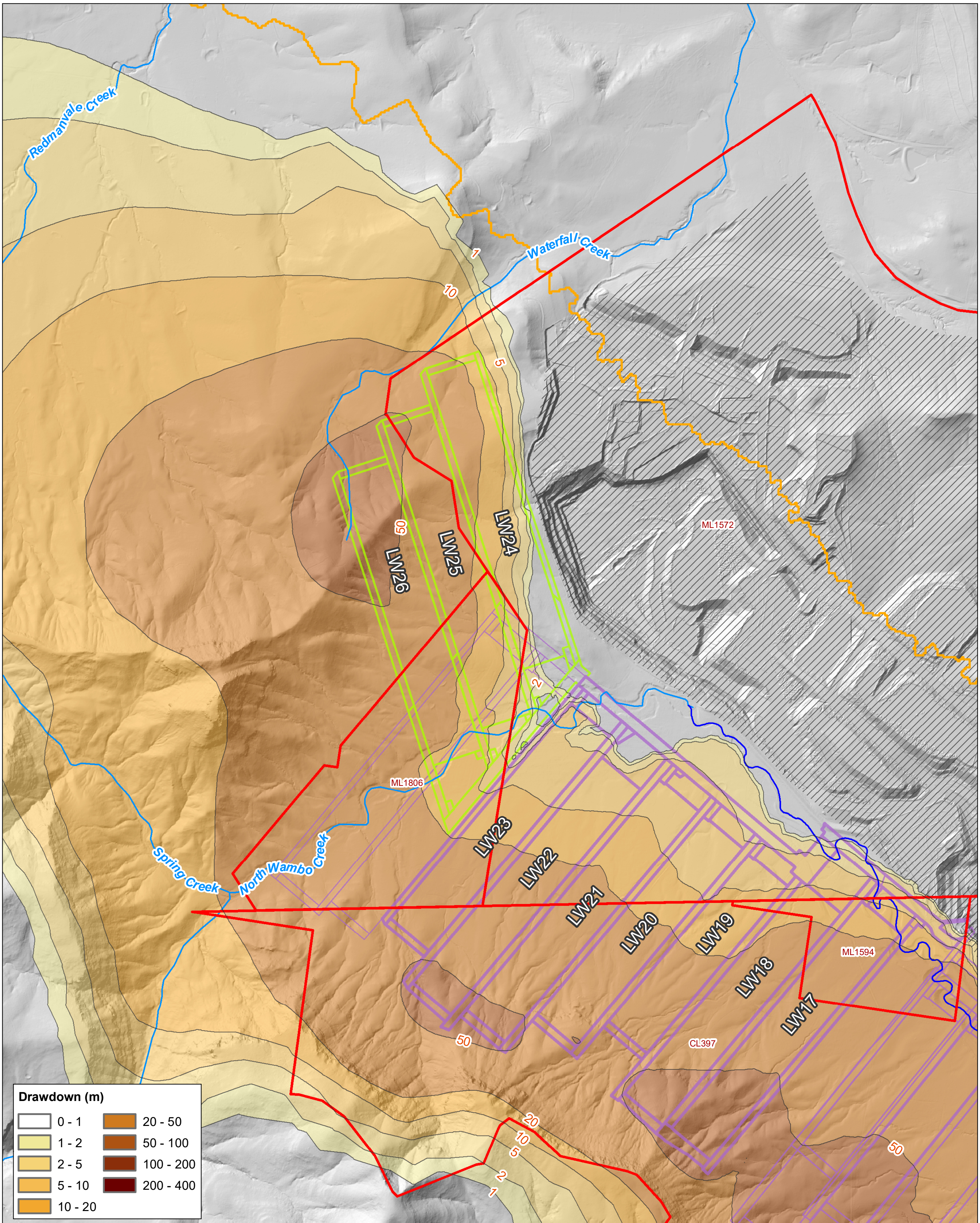
Data Source: NSW SS 2020

**WAMBO COAL MINE**
**LW24-26 EXTRACTION PLAN**
**GROUNDWATER TECHNICAL REVIEW**

**Maximum incremental drawdown in Whybrow Seam (layer 7)**

**FIGURE 5-5**

H:\Projects-SLR\660-SrvWOL\660-WOL\665.10008 Wambo Groundwater Study\06 SLR Data\01 CADGIS\ArcGIS\SLR665100080915_LW24_26EP_X_x_Max_IncrementalDD_Layer_7.mxd




0 0.25 0.5 km

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| Coordinate System: | GDA 1994 MGA Zone 56 |
| Scale: | 1:25,000 at A4 |
| Project Number: | 665.10008.01915 |
| Date: | 13-Apr-2023 |
| Drawn by: | ANP |

SLR

New Wambo Model Boundary

Named Watercourse

NWC Diversion

Mining Lease

Whybrow Seam Extent (Layer 7)

Existing/Approved Underground Development

Approved Open Cut Mining

South Bates Extension (LW17-23)

South Bates Extension (LW24-26)

Data Source: NSW SS 2020

**WAMBO COAL MINE**
**LW24-26 EXTRACTION PLAN**
**GROUNDWATER TECHNICAL REVIEW**

**Maximum incremental drawdown in Whybrow Seam (layer 7)- Inset**

**FIGURE 5-5a**

H:\Projects-SLR\660-SrvWOL\660-WOL\665.10008 Wambo Groundwater Study\06 SLR Data\01 CADGIS\ArcGIS\SLR665100080191 5_LW24_26EP_X_xa_Max_IncrementalDD_Layer_7.mxd

## 5.6 Incidental water impacts

### 5.6.1 Influence on alluvium

There is no direct interception of the alluvium, including that associated with North Wambo Creek, by the SBX Underground Mine operations including LW24-26. Any predicted interference of alluvial groundwater therefore largely relates to the depressurisation of the underlying Permian coal measures resulting in the potential for increased leakage from the alluvium to the Permian coal measures, or decreased flow from the Permian coal measures to the alluvium.

It is conceptualised for there to be an increase in mining induced flux change in North Wambo Creek alluvium upstream of the creek diversion due to the extraction of LW24-26, with the SBX LW24-26 directly underlying a larger area of North Wambo Creek alluvium than the SBX Underground Mine footprint to LW23 only. North Wambo Creek downstream of the diversion, Wambo Creek, Wollombi Brook and the Hunter River alluvium are conceptualised to show minor, temporary incremental differences between the *Modification 19* and *No Longwalls 24-26* scenarios due to the extended life of SBX mining with LW24-26 extraction.

Over the extent of alluvium near Wambo, the model predicts a low magnitude, short-term increase in leakage of water (more impact) from the North Wambo Creek, Wambo Creek and Wollombi Brook alluvium due to SBX LKW24-26 (from 2027, peaking 2031-2036), before this effect declines toward the end of Wambo mining (**Figure 5-6**). There is negligible effect predicted for the Hunter River alluvium due to the Modification.

A maximum increase of approximately 5.6 cubic metres per day ($m^3$/day) (2.0 ML/yr.) mining induced baseflow change (loss) is predicted in the Wambo Creek alluvium due to LW24-26 relative to SBX mining to LW23 only. Maximum increases of 2.0 $m^3$/day and 0.5 $m^3$/day are predicted for Wollombi Brook alluvium (0.75 ML/yr.) and North Wambo Creek alluvium (0.18 ML/yr.), respectively.

It is noted that the maximum increases occur after SBX L24-26 extraction (**Figure 5-6**), during South Wambo Underground Mine extraction in the Woodlands Hill and Arrowfield Seams. The following points evaluate the drivers of this predicted mining induced baseflow change to alluvium:

- The maximum decrease occurs in the Wambo Creek alluvium, which is 6 km from SBX LW24-26, but overlies the South Wambo Underground mine footprint. The extraction of LW24-26 alone is not likely driving the predicted baseflow change to the alluvium.
- The timing of South Wambo Underground mining does not change between the '*No Longwalls 24-26*' and '*Modification 19*' model scenarios, meaning that there is a 3.5-year gap between the end of SBX mining and the start of South Wambo Underground mining in the '*No Longwalls 24-26*' scenario.
- Groundwater recovery is predicted to occur at South Bates underground mine areas between the end of SBX LW23 and start of South Wambo Underground extraction (in the '*No Longwalls 24-26*' scenario). Some of this recovered groundwater will supplement South Wambo Underground mine inflows and reduce the magnitude of mining induced baseflow decreases compared to the '*Modification 19*' model scenario where there is no recovery between SBX and South Wambo Underground mining.

There is no alluvium mapped at Waterfall Creek, and the model predicts Layer 1 representing alluvium and regolith to be unsaturated at Waterfall Creek near the modified Longwalls 24 to 26. No flux changes due to the Modification are therefore predicted for the surficial groundwater system at Waterfall Creek.

WCPL currently has licence entitlements of 420 ML/year for the Lower Wollombi Brook Water Source. The current groundwater licence for the *Lower Wollombi Brook Water Source* is sufficient to cover the predicted water extraction from alluvium for all approved Wambo operations including SBX LW24-26.

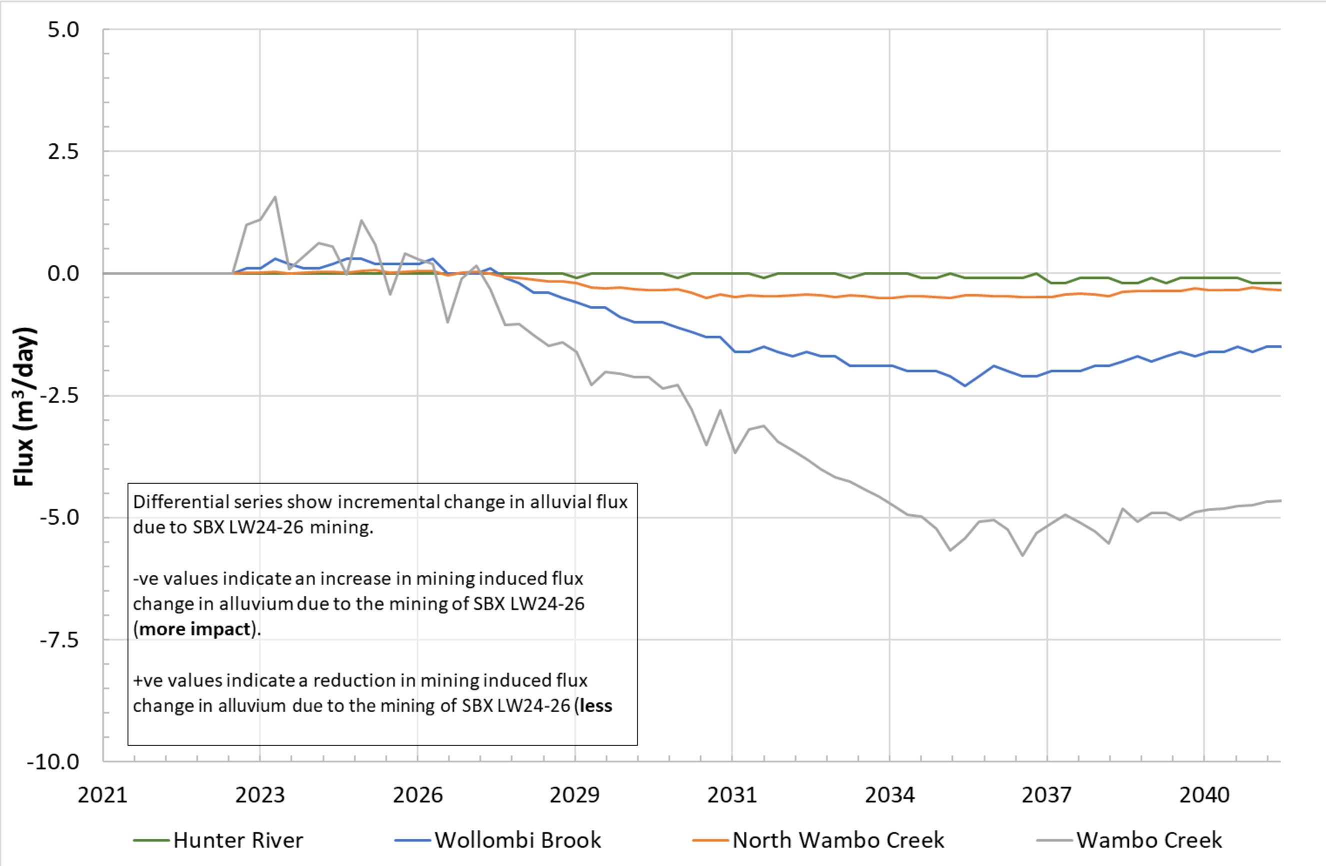



**Figure 5-6 Incremental alluvial flux change**

### 5.6.2 Influence on baseflow

The predicted change in water levels induced by mining could increase the hydraulic gradient between surface water flow in nearby watercourses and the underlying alluvium. As outlined within (**Section 2.2** and **Section 4.3.5**), ephemeral watercourses near Wambo (North Wambo Creek and Wambo Creek) may be losing systems during peak flow periods and gaining systems following these peak flow events when there is sufficient alluvial saturation. Semi-perennial (Wollombi Brook) and perennial (Hunter River) watercourse are predominantly gaining systems (receiving groundwater) (see **Section 2.2**), although there are also areas where the river recharges the underlying alluvium (losing environment), particularly in high flow events.

As described in **Section 5.3.1**, the predictive modelling does not simulate episodic periods of flow in ephemeral watercourses and will only report gaining conditions including Waterfall Creek and North Wambo Creek. Wollombi Brook and the Hunter River utilise long-term quarterly average stage heights throughout the prediction period.

**Figure 5-7** provides incremental flux change at watercourses near Wambo due to the Modification. This is calculated by taking the difference in net flux from the MODFLOW RIV package between the *Modification 19* and *No Longwalls 24-26* scenarios. It is noted that the model predicts no interaction between the surface water and groundwater system at Waterfall Creek for any model scenario, and therefore has not been included in **Figure 5-7**. Similar to predictions for alluvial fluxes (see **Section 5.6.1**), the extraction of LW24-26 is predicted to decrease baseflow to, or increase leakage from watercourses near Wambo compared to SBX only extracted to LW23. A decrease in net flux is predicted for Wambo Creek, Wollombi Brook and the Hunter River, with the decrease predicted to be a reduction in baseflow or increase in leakage (more impact). As discussed in **Section 5.6.1** this temporary reduction in predicted impacts is likely driven by the longer life of mine for SBX with LW24-26 extraction and shorter gap between SBX completion start of South Wambo Underground Mine in the Modification 19 scenario.

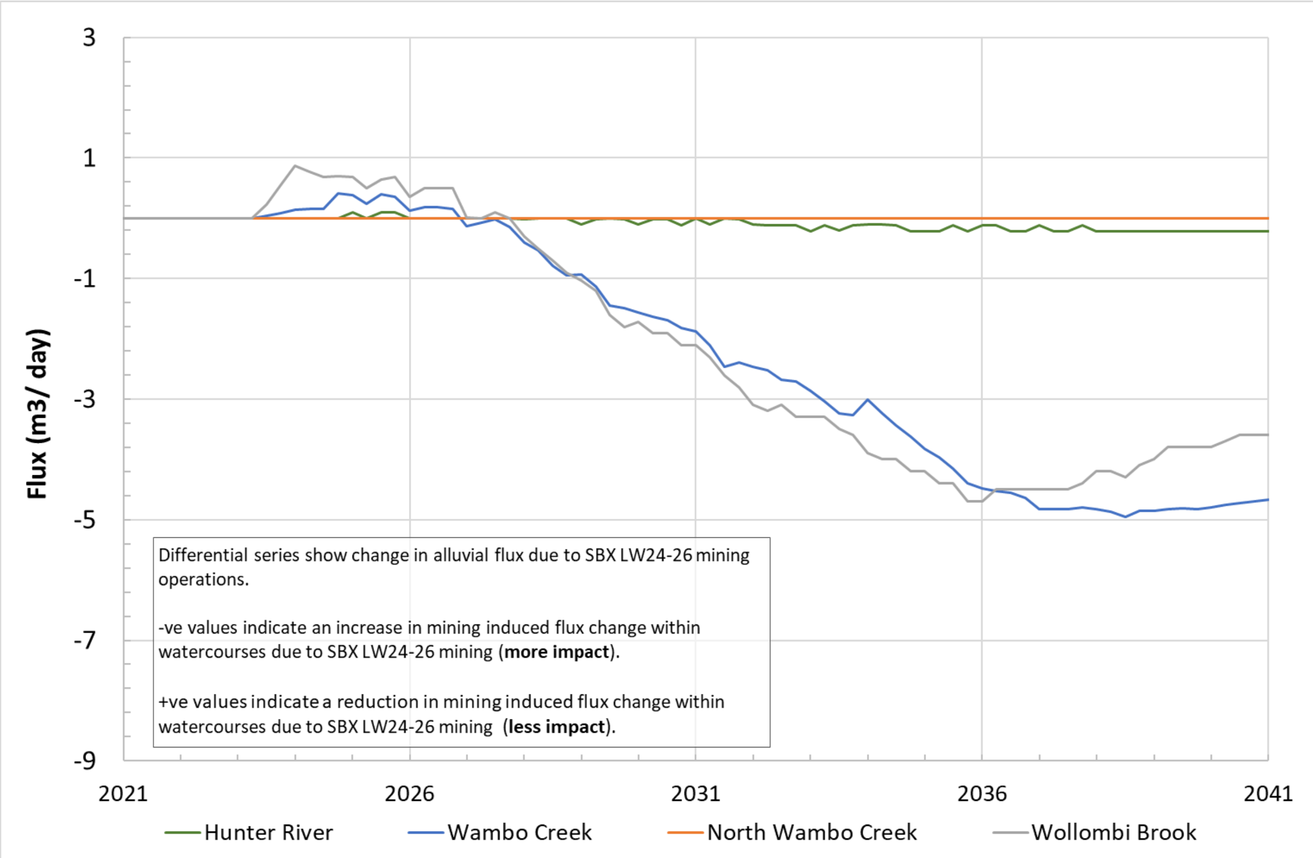



**Figure 5-7 Incremental RIV flux change**

SLR (2022) assessed model outputs to evaluate effect of approved Wambo operations (Modification 19) on the groundwater-surface water flow between the watercourses and their underlying alluvium/ regolith. The component of flow between watercourses and their alluvium to be considered for surface water licensing is an increased leakage from surface water to underlying alluvium/ regolith induced by Wambo. Reduction in groundwater flow to watercourses (baseflow) has not been considered a component of surface water licensing.

There is no licensable surface water take predicted for the approved Wambo operations (cumulative impact). Any change in net flux to/from watercourses due to Wambo is predicted to be a baseflow reduction, and licensable as extraction from an alluvial water source. Any reduction in impact to the groundwater system by removing SBX LW24-26 does not influence surface water licencing requirements.

## 5.7 Cumulative impacts

Cumulative impacts associated with approved Wambo operations (including Modification 19) and approved and foreseeable open cut and underground coal mines in the Wambo area were modelled in accordance with IESC requirements (refer IESC, 2018) for SLR (2022). The simulated cumulative drawdown predictions due to Wambo and UWOCP mining presented in this section show the impacts on different aquifers due to the existing approved works and entitlements within the model domain. As described in **Section 5.3**, cumulative impacts are evaluated by comparing the *Modification 19* and *Null* predictive modelling scenarios.

The simulated cumulative drawdown predictions also show whether the zone of impact from the approved Wambo is predicted to interact with the zone of impact from the Modification in the different aquifers. **Figure 5-8** to **Figure 5-10** show the maximum cumulative drawdown for key stratigraphic units, with cumulative drawdown estimated by comparing the Modification model scenario with the Null scenario (i.e. no Wambo/Untied Collieries/UWOCP mining from 2003).

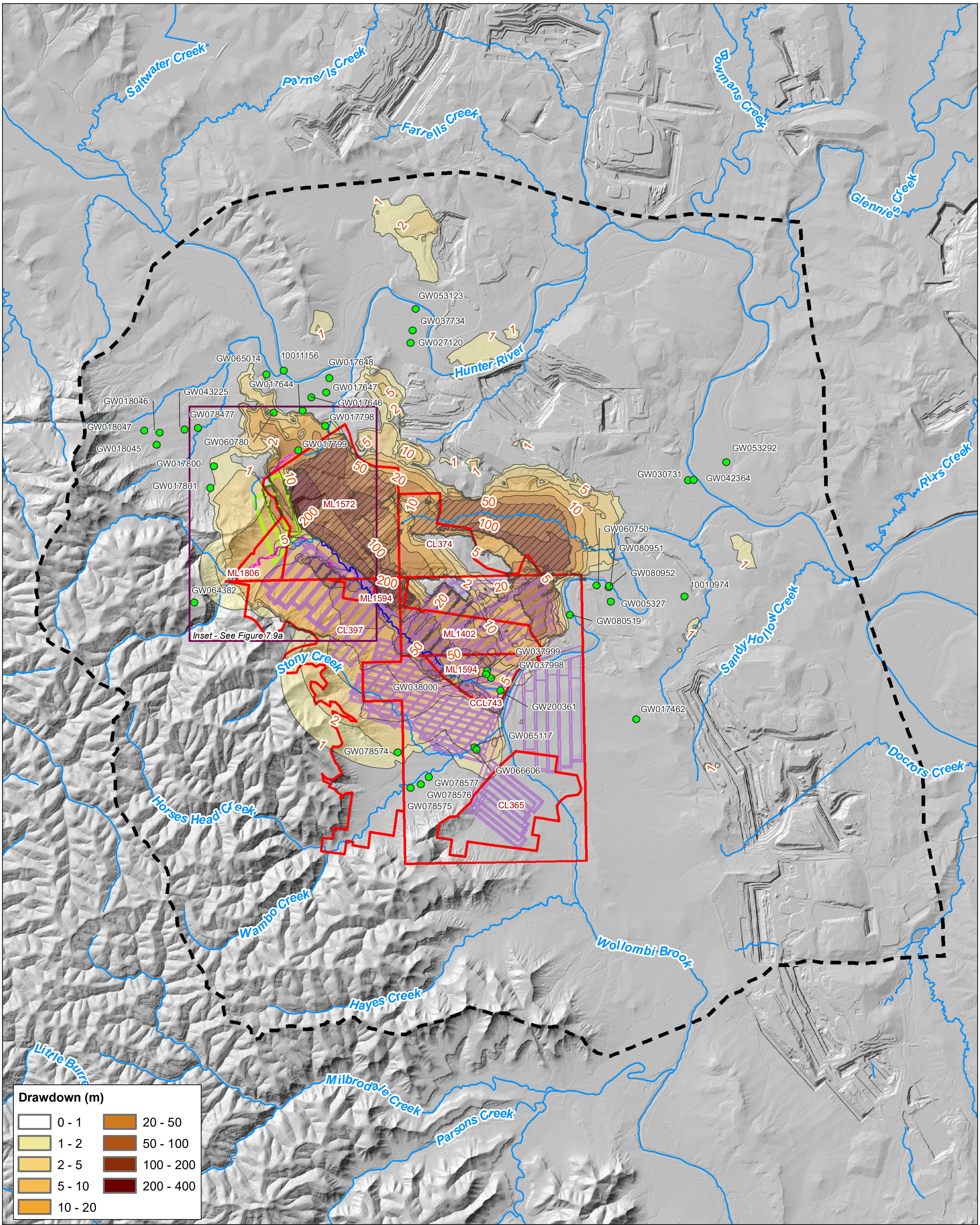
Several higher resolution versions of key spatial figures have also been developed to help identify the location and magnitude of predicted cumulative drawdowns. The inset extent, where relevant, is displayed on the full extent figure.[3]

**Figure 5-8** and **Figure 5-8 a** show predicted cumulative maximum water table drawdown. Depending on the depth to water table across the model domain, this drawdown may be experienced in surficial (layer 1) or shallow weathered strata (layer 2), or within the Permian coal measures in more elevated areas away from drainage lines. The largest water table drawdowns are experienced in areas of open cut mining, and where there are shallower depths of cover above the longwalls and fracture height calculations (SLR,2022) indicate surficial strata may be intersected by subsidence related fracturing (e.g. the north-eastern ends of the approved SBX Underground Mine longwalls.

**Figure 5-9** and **Figure 5-9 a** show that maximum cumulative drawdown within mapped Quaternary alluvium extends along Wollombi Brook, and ephemeral creeks near Wambo. The most significant areas of modelled drawdown are within North Wambo Creek where it has been mined-out by the Montrose open cut, and the confluence of North Wambo Creek and Wollombi Brook.

**Figure 5-10** and **Figure 5-10 a** show maximum cumulative drawdown within the Whybrow Seam, the target seam of approved and modified SBX Underground Mine. The cumulative maximum drawdown in the Whybrow Seam is predicted to be 195 m and is focussed on the south-western ends of South Bates (Whybrow) Longwalls 11-13. As with drawdown due to the Project, cumulative drawdown extends northwest and southeast along the strike of the Whybrow Seam.

[3] Inset figure numbers are only referenced in the first instance. Relevant figures will display inset extent.




0 2 4 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 56 |
| Scale: | 1:130,000 at A4 |
| Project Number: | 665.10008.01915 |
| Date: | 13-Apr-2023 |
| Drawn by: | ANP |

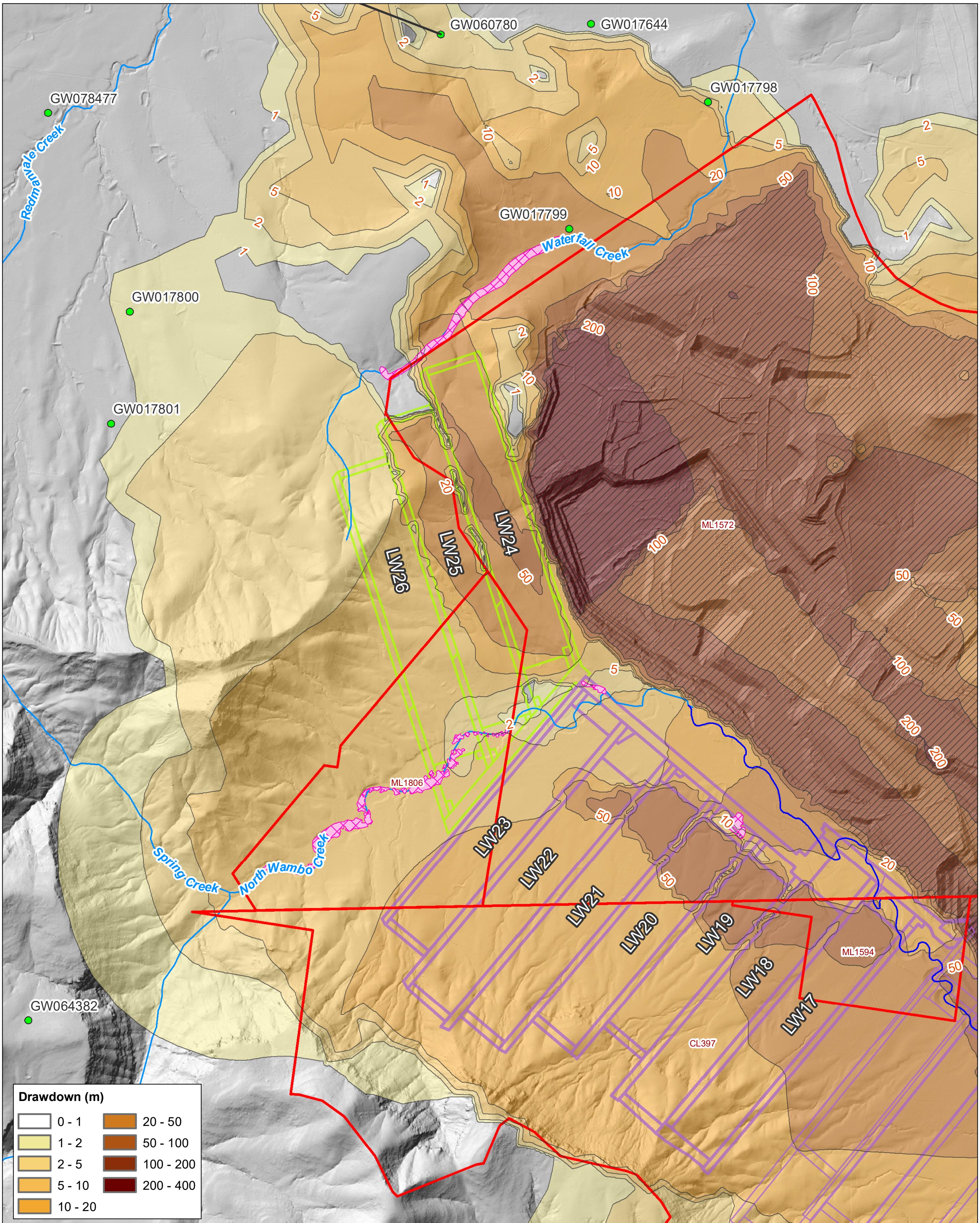
- Wambo GWMP (2020)
- New Wambo Model Boundary
- Named Watercourse
- NWC Diversion
- High Potential GDE
- Mining Lease
- Existing/Approved Underground Development
- Approved Open Cut Mining
- South Bates Extension (LW17-23)
- South Bates Extension (LW24-26)

Data Source: NSW SS 2020

**WAMBO COAL MINE**
**LW24-26 EXTRACTION PLAN**
**GROUNDWATER TECHNICAL REVIEW**

**Maximum cumulative drawdown at the water table**

**FIGURE 5-8**




0 0.25 0.5 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 56 |
| Scale: | 1:25,000 at A4 |
| Project Number: | 665.10008.01915 |
| Date: | 11-Apr-2023 |
| Drawn by: | ANP |

SLR

- Wambo GWMP (2020)
- New Wambo Model Boundary
- Named Watercourse
- NWC Diversion
- High Potential GDE
- Mining Lease
- Existing/Approved Underground Development
- Approved Open Cut Mining
- South Bates Extension (LW17-23)
- South Bates Extension (LW24-26)

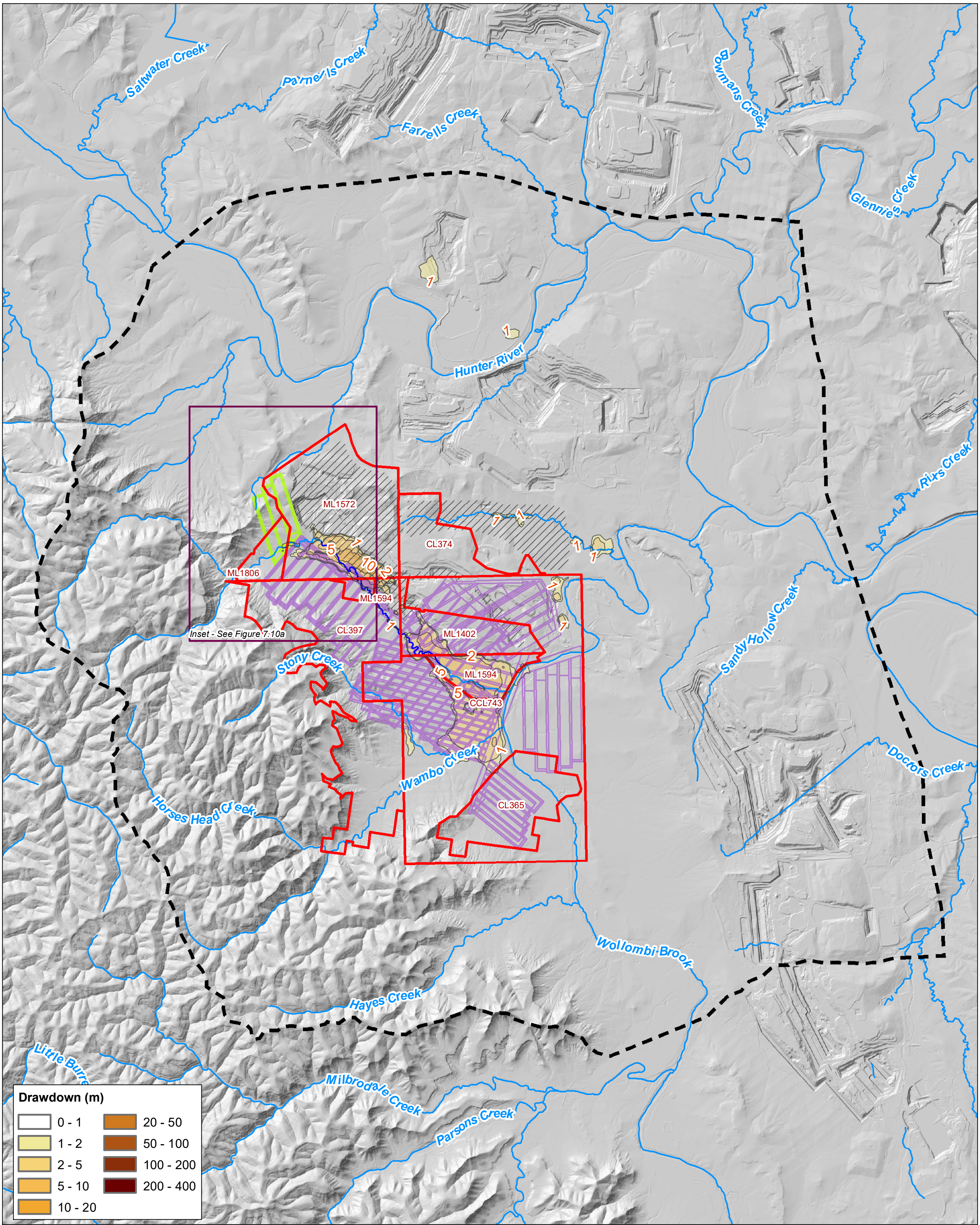
Data Source: NSW SS 2020

**WAMBO COAL MINE**
**LW24-26 EXTRACTION PLAN**
**GROUNDWATER TECHNICAL REVIEW**

**Maximum cumulative drawdown at the water table - Inset**

**FIGURE 5-8a**

H:\Projects-SLR\660-SrvWOL\660-WOL\665.10008 Wambo Groundwater Study\06 SLR Data\01 CADGIS\ArcGIS\SLR665100080 1915_LW24_26EP_X_xa_Max_CumulativeDD_at_WT.mxd




H:\Projects-SLR\660-SrvWOL\660-WOL\665.10008 Wambo Groundwater Study\06 SLR Data\01 CADGIS\ArcGIS\SLR665100080 1915_LW24_26EP_X_x_Max_CumulativeDD_Layer_1.mxd

N

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|---|---|
| Coordinate System: | GDA 1994 MGA Zone 56 |
| Scale: | 1:130,000 at A4 |
| Project Number: | 665.10008.01915 |
| Date: | 11-Apr-2023 |
| Drawn by: | NT |

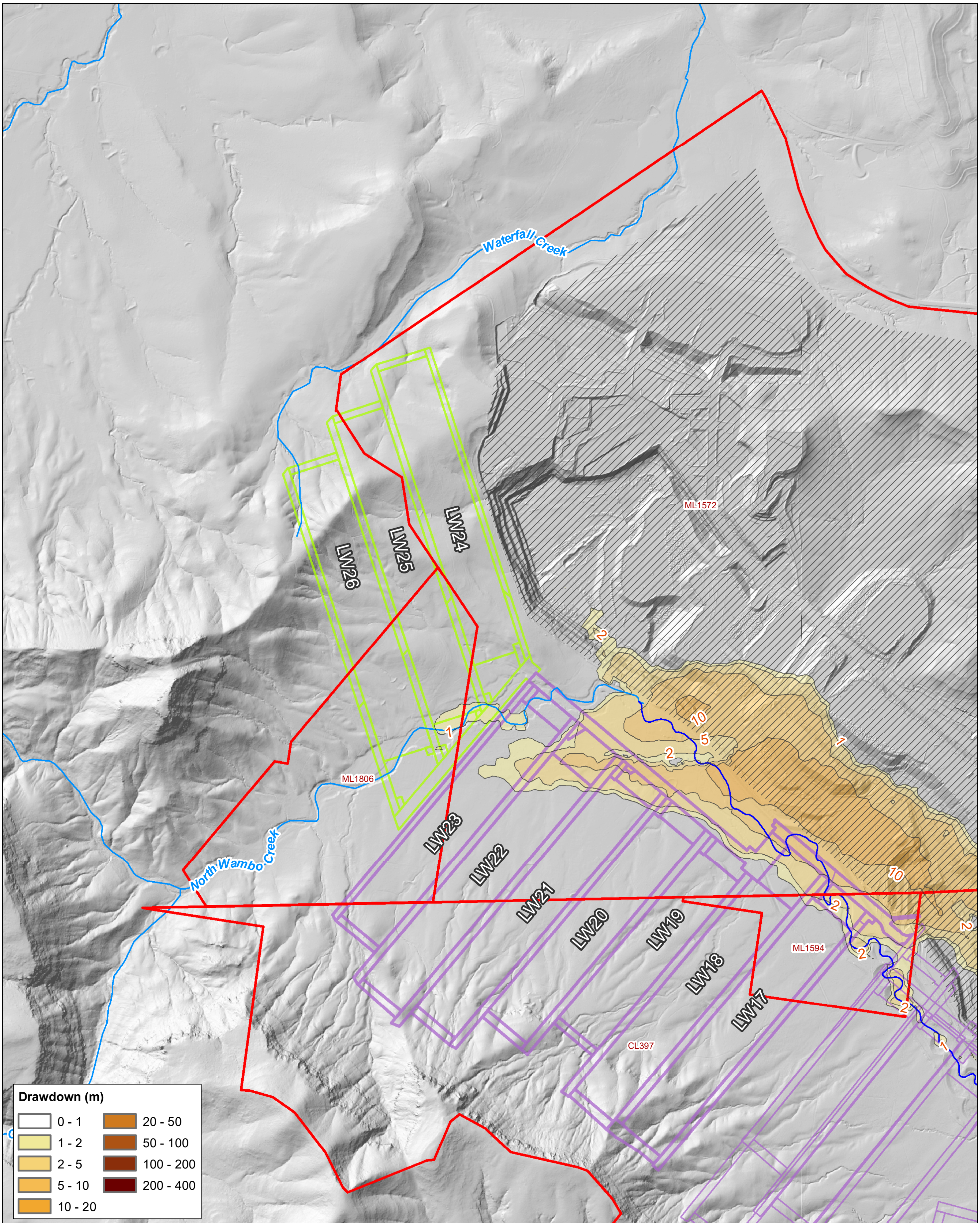
- New Wambo Model Boundary
- Named Watercourse
- NWC Diversion
- Mining Lease
- Existing/Approved Underground Development
- Approved Open Cut Mining
- South Bates Extension (LW17-23)
- South Bates Extension (LW24-26)

Data Source: NSW SS 2020

**WAMBO COAL MINE**
**LW24-26 EXTRACTION PLAN**
**GROUNDWATER TECHNICAL REVIEW**

**Maximum cumulative drawdown in alluvium and regolith (layer 1)**

**FIGURE 5-9**




0 0.25 0.5 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 56 |
| Scale: | 1:25,000 at A4 |
| Project Number: | 665.10008.01915 |
| Date: | 11-Apr-2023 |
| Drawn by: | ANP |

SLR

- New Wambo Model Boundary
- Named Watercourse
- NWC Diversion
- Mining Lease
- Existing/Approved Underground Development
- Approved Open Cut Mining
- South Bates Extension (LW17-23)
- South Bates Extension (LW24-26)

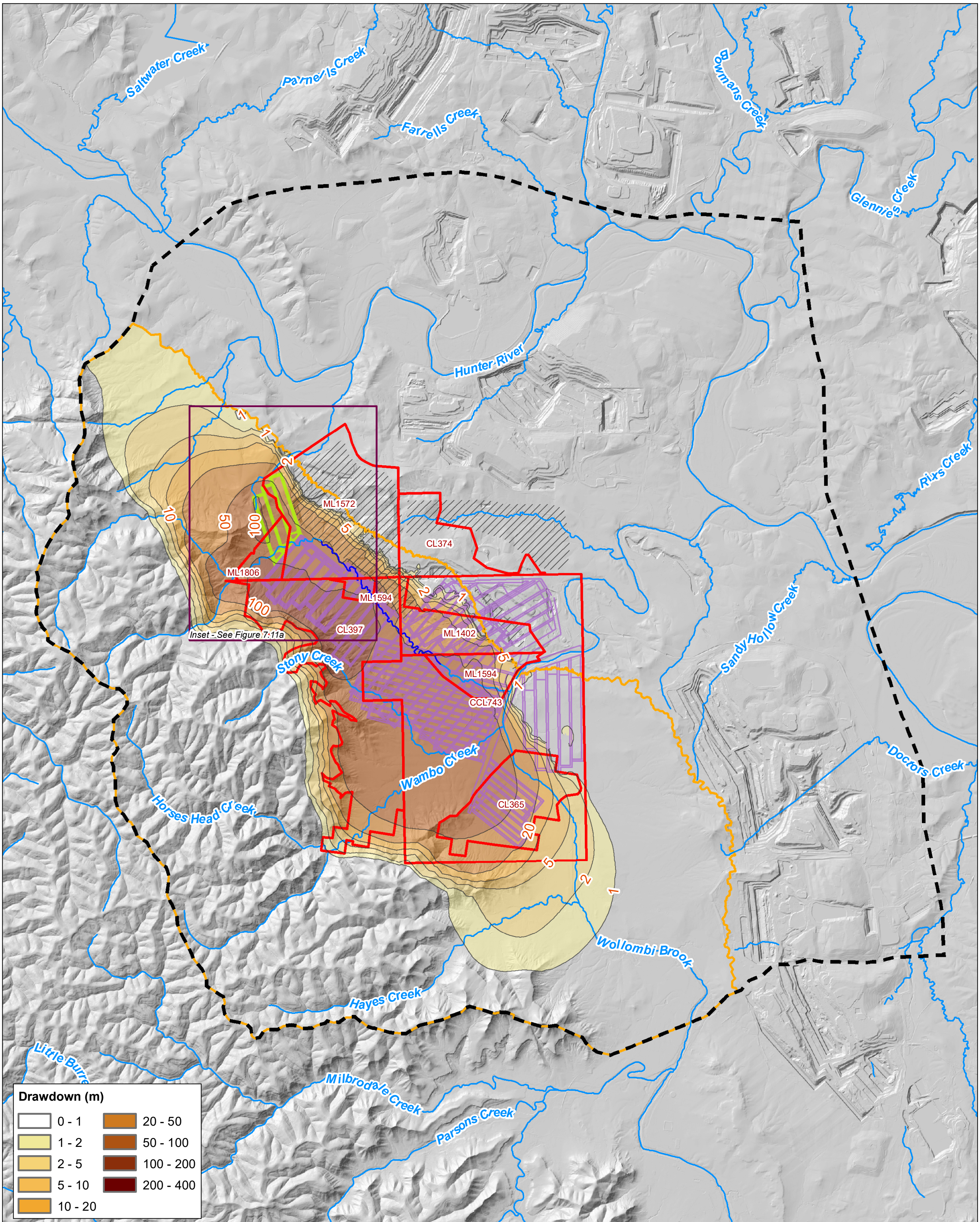
Data Source: NSW SS 2020

**WAMBO COAL MINE**
**LW24-26 EXTRACTION PLAN**
**GROUNDWATER TECHNICAL REVIEW**

**Maximum cumulative drawdown in alluvium and regolith (layer 1) - Inset**

**FIGURE 5-9a**

H:\Projects-SLR\660-SrvWOL\660-WOL\665.10008 Wambo Groundwater Study\06 SLR Data\01 CADGIS\ArcGIS\SLR6651000801915_LW24_26EP_X_xa_Max_CumulativeDD_Layer_1.mxd




H:\Projects-SLR\660-SrvWOL\660-WOL\665.10008 Wambo Groundwater Study\06 SLR Data\01 CADGIS\ArcGIS\SLR665100080 1915_LW24_26EP_X_x_Max_CumulativeDD_Layer_7.mxd

0 2 4 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 56 |
| Scale: | 1:130,000 at A4 |
| Project Number: | 665.10008.01915 |
| Date: | 11-Apr-2023 |
| Drawn by: | ANP |

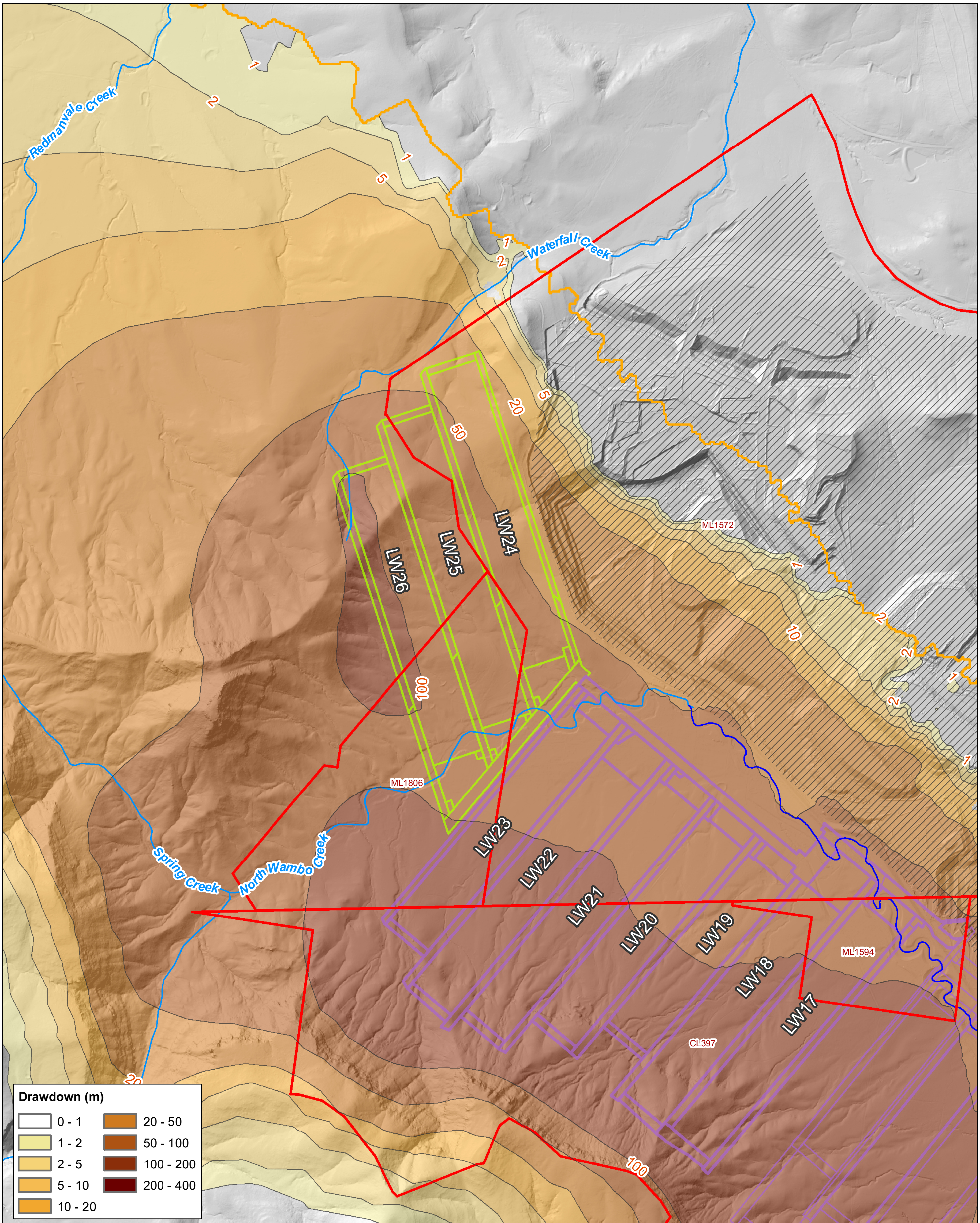
- New Wambo Model Boundary
- Named Watercourse
- NWC Diversion
- Mining Lease
- Whybrow Seam Extent (Layer 7)
- Existing/Approved Underground Development
- Approved Open Cut Mining
- South Bates Extension (LW17-23)
- South Bates Extension (LW24-26)

Data Source: NSW SS 2020

**WAMBO COAL MINE**
**LW24-26 EXTRACTION PLAN**
**GROUNDWATER TECHNICAL REVIEW**

**Maximum cumulative drawdown in Whybrow Seam (layer 7)**

**FIGURE 5-10**




0 0.25 0.5 km

| | |
|---|---|
| Coordinate System: | GDA 1994 MGA Zone 56 |
| Scale: | 1:25,000 at A4 |
| Project Number: | 665.10008.01915 |
| Date: | 11-Apr-2023 |
| Drawn by: | NT |

SLR

New Wambo Model Boundary
Named Watercourse
NWC Diversion
Mining Lease
Whybrow Seam Extent (Layer 7)
Existing/Approved Underground Development
Approved Open Cut Mining
South Bates Extension (LW17-23)
South Bates Extension (LW24-26)

Data Source: NSW SS 2020

**WAMBO COAL MINE**
**LW24-26 EXTRACTION PLAN**
**GROUNDWATER TECHNICAL REVIEW**

**Maximum cumulative drawdown in Whybrow Seam (layer 7) - Inset**

**FIGURE 5-10a**

H:\Projects-SLR\660-SrvWOL\660-WOL\665.10008 Wambo Groundwater Study\06 SLR Data\01 CADGIS\ArcGIS\SLR665100080 1915_LW24_26EP_X_xa_Max_CumulativeDD_Layer_7.mxd

### 5.7.1 Drawdown at privately owned registered bores

Locations of relevant privately owned registered bores in the vicinity of Wambo and the predicted incremental water table drawdown associated with SBX LW24-26 are presented in **Figure 5-3**.

**Figure 5-8** shows the cumulative water table drawdown associated with the Wambo (including the Modification) and relevant privately-owned registered bores.

**Table 5-2** presents a summary of relevant privately-owned registered bores near Wambo including predicted cumulative and incremental drawdown associated with the Modification. Of the private bores near Wambo, none are predicted to exceed a drawdown of 2 m. Predicted cumulative impacts (due to all approved Wambo mining and nearby UWOCP) at all relevant registered bores near Wambo are presented in the *Groundwater Modelling Technical Report* (Appendix D of SLR (2022)).

**Table 5-2 Predicted drawdown effects at privately owned registered bores**

| Work No. (bore ID) | Location (GDA94 z56) | | Use | Measured Depth to Water (mbgl) | Depth (mbgl) | Predicted Drawdown (m) | |
|---|---|---|---|---|---|---|---|
| | mE | mN | | | | Incremental[1] | Cumulative[2] |
| GW043225 | 303653 | 6398949 | Irrigation | 15.1 (2022) | 24.7 | 0.1 | 0.2 |
| GW064382 | 303908 | 6394477 | Stock/ domestic | | 60 | 0.2 | 0.6 |
| GW078477 | 304007 | 6398988 | Domestic | 11.05 (2015) | 102.5 | 0.2 | 0.4 |
| GW078574 | 309174 | 6390605 | Farming | | 12 | 0.0 | 1.3 |
| GW078575 | 309505 | 6389687 | Farming | | 12 | 0.0 | 0.4 |
| GW078576 | 309764 | 6389784 | Farming | | 7 | 0.0 | 0.0 |
| GW078577 | 309969 | 6389973 | Domestic | | 10 | 0.0 | 0.3 |

[1] Incremental drawdown is evaluated by comparing the *Modification 19* and *No Longwall 24-26* predictive model scenarios (**Section 5.3**)
[2]Cumulative drawdown is evaluated by comparing the *Modification 19* and *Null* predictive model scenarios (**Section 5.3**)

## 5.8 Ecological sites

A review of relevant data sources was undertaken as part of this groundwater technical review, with details on the occurrence of potential GDEs or other environmental groundwater receptors in the vicinity of the SBX Longwalls 24-26 provided in **Section 4.5.2**.

### 5.8.1 Waterfall Creek GDE

The high potential GDE along Waterfall Creek (Eco Logical, 2022) has been reviewed against predicted alluvium/ regolith (Layer 1), and water table impacts due to LW24-26 extraction only (incremental) and the impacts of approved mining at Wambo (i.e. in accordance with Development Consent [DA305-7-2003]) and mining at other approved mining operations around Wambo (cumulative).

No incremental drawdown is predicted in alluvium/ regolith (layer 1) at the high potential GDE at Waterfall Creek due to the SBX LW24-26 extraction (incremental impact - **Figure 5-4)**. Up to 20.5 m of incremental drawdown at the water table is predicted at the high potential GDE north of modified Longwall 24 due to SBX LW24-26 extraction (incremental impact-**Figure 5-3**).

No drawdown is predicted in alluvium/ regolith (layer 1) at the high potential GDE at Waterfall Creek due to Wambo area underground and open cut operations (cumulative impact - **Figure 5-9)**. Up to 26 m drawdown at the water table is predicted at the high potential GDE north of LW24 due to the Wambo area underground and open cut operations (cumulative impact -**Figure 5-8**).

### 5.8.2 North Wambo Creek GDEs

The high potential GDE characterised in the biodiversity review for the Modification (Eco Logical, 2022) is mapped to cover a 1.5 km reach along North Wambo Creek (**Figure 4-15**). 0.5 km of the reach is underlain by the SBX footprint including LW24-26, with 0.2 km of the reach directly overlying the southern end of Longwall 26.

MSEC (2023) predicts up to 1.95 m of total vertical subsidence above the eastern parts of LWs 24 to 26, potentially causing increased ponding of North Wambo Creek. HydroSimulations (2019) concluded that fracturing to the surface above longwalls, or temporary connection between surface cracks and subsurface fracturing may lead to periods of water transfer out of North Wambo Creek. However, it was also concluded that this occurrence may not reduce the long-term ability for the high potential GDE to temporarily access groundwater. The reduced surface area of high potential GDE subject to subsidence with the Modification mine plan will reduce likelihood of this facultative GDE being impacted by the SBX Underground Mine.

Key outputs from the groundwater modelling relating to the North Wambo Creek high potential GDE due to LW24-26 extraction only (incremental) and the impacts of approved mining at Wambo (i.e. in accordance with Development Consent [DA305-7-2003]) and mining at other approved mining operations around Wambo (cumulative):

- No incremental drawdown is predicted for the North Wambo Creek alluvium due to the SBX LW24-26 extraction (**Figure 5-4)** where the high potential GDE is located.
- The water table under localised areas of mapped high potential GDE (<50 m long near the southern end of Modification Longwall 24) is predicted to experience approximately 2 m of incremental drawdown due to SBX LW24-26 extraction (**Figure 5-3**). The rest of the mapped high potential GDE is predicted to experience 1-1.5 m drawdown.

- 1 m drawdown within the North Wambo Creek alluvium is predicted for the eastern-most extent (a 120 m reach) of the high potential GDE along North Wambo Creek due to Wambo area underground and open cut operations Cumulative impact (**Figure 5-9**). Approximately 5–7.5 m drawdown is predicted for the water table underlying the entire vegetation community identified by Hunter Eco (2019) as likely to be groundwater dependent and the broader SBX Underground Mine area (**Figure 5-8**).
- No incremental drawdown is predicted for the North Wambo Creek alluvium/ regolith (model layer 1) (**Figure 5-4**), and up to 1.7 m of drawdown is predicted at the water table due to SBX LW24-26 extraction (**Figure 5-3**) where the SBX LW20 high potential GDE (Eco Logical, 2022) is located.
- 1 m drawdown within the alluvium/ regolith (model layer 1) is predicted for the north-eastern 20% (approximately 0.15 Ha) of the SBX LW20 high potential GDE due to Wambo since 2003 (Cumulative impact -**Figure 5-9**). Approximately 10 – 30 m drawdown is predicted for the water table underlying the entire additional high potential GDE due to Wambo area underground and open cut operations. This is likely due to nearby open cut and underground mining (Cumulative impact **Figure 5-8**).

### 5.8.3 GDE Atlas high-potential GDEs

Areas mapped as high potential terrestrial GDEs from the BoM GDE Atlas (**Figure 4-15**), including areas mapped around Redmanvale Creek and the Hunter River (located northwest and north of LW24 – 26), and small areas around Waterfall Creek and North Wambo Creek (located northeast and southeast of LW24 – LW26) have been reviewed against predicted alluvium/ regolith (Layer 1 and Layer 2), and water table impacts due to the Modification and Wambo.

- There are no incremental drawdown impacts predicted due to SBX LW24-26 extraction in alluvium/ regolith (Layer 1) (**Figure 5-3**) at any mapped vegetation identified in the BoM GDE Atlas as a high potential terrestrial or aquatic GDE.
- Up to 5 m of drawdown is predicted due to SBX LW24-26 extraction at the water table (**Figure 5-4**) at three areas of terrestrial vegetation identified in the BoM GDE Atlas as a high potential GDE. These are adjacent to or north of SBX Underground Mine.
- There are no drawdown impacts predicted due to Wambo area underground and open cut operations in alluvium/ regolith (Layer 1) (**Figure 5-9**) at any mapped vegetation identified in the BoM GDE Atlas as a high potential terrestrial or aquatic GDE.
- Approximately 3 m of cumulative drawdown is predicted at the water table (**Figure 5-8**) over the south-western fifth of a mapped high potential terrestrial GDE on Waterfall Creek, 250 m north of the modified Longwall 25. The water table elevation at this location is predicted to be 42 metres below ground level (mbgl) and likely not accessible by vegetation.
- Approximately 1 m of cumulative drawdown is predicted at a small number of mapped high potential terrestrial GDEs near Redmanvale Creek. The water table elevation at this location is predicted to be 15 to25 mbgl and likely not accessible by vegetation.

# 6 Predicted subsidence

The Subsidence Assessment for LWs 24-26 (Mine Subsidence Engineering Consultants [MSEC], 2023) has been considered in this Groundwater Assessment and is summarised in **Table 6-1**.

### Table 6-1 Subsidence impacts relevant to the Extraction Plan

| Overview of predicted subsidence impacts for the modified SBX Underground Mine |
|---|
| • The maximum predicted subsidence effects of the longwalls are expected to be similar to those based on the Modification 19 layout – maximum predicted subsidence effects are 1,950 mm vertical subsidence (i.e., 65% of the maximum extraction height of 3.0 m), 75 mm/m tilt (i.e., 7.5% or 1 in 13) and greater than 3.0 $km^{-1}$ curvature (i.e., a minimum radius of curvature less than 0.3 km).<br>• North Wambo Creek is located above the mining area based on the Modification 19 layout. North Wambo Creek crosses directly above the finishing (i.e. southern) ends of LWs 25 and 26 for approximately 300 m. The predicted subsidence effects and the assessed impacts on North Wambo Creek, based on the extraction plan layout, are the same as those based on the Modification 19 layout.<br>• The upper reaches (i.e. first and second order sections) of Waterfall Creek are located above the northern end of the modified Longwall 26. The total length of Waterfall Creek above the mining area is 200 m. The predicted subsidence effects and assessed impacts on Waterfall Creek, based on the extraction plan layout, are the same as those based on the Modification 19 layout.<br>• Fracturing and compression heaving are expected to develop along the sections of watercourses located directly above the longwall panels. The impacts are expected to be similar to those observed along the streams above the previously extracted at the South Bates Underground Mine and the SBX Underground Mine.<br>• Compression and dilation are also expected to impact the upper 10 m to 20 m of bedrock (regolith), which has the potential to affect groundwater conditions within the regolith. Compression can also result in buckling of the upper bedrock resulting in heaving in the overlying surface soils. |

# 7 Environmental risk review

An Environmental Risk Assessment (ERA) was undertaken in March 2023. The scope of the risk assessment included:

- establishing the context including review of supporting information and objectives;
- identifying potential issues by review of the project description and similar issues from previous Wambo risk assessments;
- analysis of identified risks and nomination of key environmental issues; and
- ranking of the key issues and associated risks, including consideration of mitigation measures.

The ERA identifies environmental issues and ranks these issues in consideration of control measures. As part of the ERA, a risk review team identified the key environmental issues associated with the project, including those related to (Risk Mentor, 2023):

- impacts on North Wambo Creek and Waterfall Creek flow regime associated with subsidence resulting from the underground mine;
- impacts on shallow groundwater sources (i.e. regolith and alluvium) with subsidence resulting from the underground mine;
- impacts on groundwater users in the study area with groundwater loss, including private landholders and vegetation;
- incremental increases in subsidence induced ponding effects on areas of agricultural land;
- potential subsidence impacts on the groundwater monitoring network;
- potential subsidence impacts on cliffs and steep slopes; and
- potential subsidence impacts on items of Aboriginal heritage.

The review team risk ranked the key environmental issues and concluded that with the application of the identified controls, the subsidence related impacts over Longwalls 24 to 26 could be managed at a tolerable level of risk (Risk Mentor, 2023).

# 8 Conclusions

This groundwater technical review has considered:

- Recent relevant environmental monitoring data (**Section 2** and **Section 4**)
- Relevant information obtained since the completion of the SLR (2022) groundwater assessment (e.g. GDE studies, or information from recently installed environmental monitoring sites (**Section 4.5.2**).
- Predicted groundwater impacts due to the extraction of LW24-26 (incremental impacts – **Section 5**).
- Groundwater impacts predicted in SLR (2022) – the *Longwalls 24-26 Groundwater Assessment* (cumulative impacts - **Section 5**).

The key findings of this groundwater technical review are:

- The hydrogeological conceptual model developed for the Modification 19 Groundwater Assessment (SLR, 2022) is not materially changed by the installation of additional monitoring locations or the collection of recent data. Recent data and additional monitoring locations that have improved the understanding of the hydrogeological system near SBX LW24-26 include:
    - The regional water table is unlikely to be shallow enough to interact with the Waterfall Creek high potential GDE. See DDH1234 data in **Section 4.3.4**.
    - A perched groundwater system may exist near the north end of SBX LW25 (see DDH1235 data in **Section 4.3.4**). This may be spatially and geologically limited as the same perching is not observed at DDH1240.
- WCPL holds sufficient groundwater licences for currently predicted groundwater interception in the *Lower Wollombi Brook Alluvial Water Source* and *North Coast Fractured and Porous Rock Groundwater Sources*. This is not influenced by LW24-26 extraction.
- There are no registered bores above the SBX footprint that are used for irrigation, domestic or stock use. There are no private registered bores that would be likely to be affected by 2 m drawdown or more if Longwalls 24 to 26 were to occur in isolation.
- Site monitoring bores have the potential to be impacted during mining, therefore review of the condition of the monitoring network will be undertaken during each sampling event, and bores remediated/replaced as required, to maintain a long-term monitoring network.
- The extraction of SBX LW24-26 would result in drawdown at the water table and within the Whybrow Seam above and to the north of LW24-26. This drawdown is predicted to have some impact to alluvium, surface water, and GDEs identified in this study. These impacts are consistent within/ less than predicted cumulative impacts presented in the Modification 19 Groundwater Assessment (SLR, 2022).
- Extraction of Longwalls 24 to 26 would not have a significant impact on water levels in the Permian coal measures from a regional perspective due to the regional zone of depressurisation within the Permian coal measures created by historical and ongoing open cut and underground mining.

An additional groundwater monitoring location is recommended to be installed at Waterfall Creek, north of the modified Longwalls 24 to 26 and adjacent to the mapped potential GDE on Waterfall Creek (see proposed location on **Figure 4-1**). This paired monitoring bore would target shallow unconsolidated and weathered strata and would aim to improve the understanding of the nature and saturation level of unconsolidated material, and any potential interaction with the underlying groundwater system. Data collected at the recently installed VWPs north and west of the modified Longwalls 24 to 26 should continue to be monitored to validate conceptual model assumptions and numerical model predictions.

No additional groundwater impact mitigation measures are proposed for SBX LW24-26 extraction. Groundwater levels and quality should continue to be monitored at Wambo in accordance with the GWMP approved under the Development Consent.

Consistent with the currently approved GWMP (WCPL, 2021b), in the event that a groundwater quality or water level trigger level specified in the GWMP is exceeded, an investigation should be conducted in accordance with the Groundwater Management Plan. Consistent with the AIP, management measures that may be implemented as a result of the investigation described above could include a “make good” commitment or relinquishment of an equivalent portion of water access licences as a direct offset for potential groundwater inflows into the underground.

The groundwater data analysis, based on currently available records, has shown that there are no observed material impacts from longwall mining beyond what was foreseen for the cumulative impacts described in the Modification 19 Groundwater Assessment (SLR, 2022).

# 9 References

Australasian Groundwater and Environmental Consultants Pty Ltd, 2003. *Wambo Development Project Groundwater Impact Assessment.* Report prepared for Wambo Coal Pty Ltd. April 2003

Australasian Groundwater and Environmental Consultants Pty Ltd, 2010. *Warkworth Mine Extension Groundwater Impact Assessment*. Report prepared for Warkworth Mining Pty Ltd, April 2010.

Australasian Groundwater and Environmental Consultants Pty Ltd, 2014, *Warkworth Continuation 2014 Groundwater Assessment*. Report prepared for EMGAMM and Warkworth Mining Pty Ltd, May 2014.

Australasian Groundwater and Environmental Consultants Pty Ltd ,2016. *United Wambo Open-Cut Coal Mine Project – Groundwater Impact Assessment*, Prepared for Umwelt Australia, July 2016

Australasian Groundwater and Environmental Consultants Pty Ltd ,2019a. *Wambo Coal Mine Alluvial Drilling and Monitoring Bore Installation Report – Phase One*. Ref G1884C. Prepared for Wambo Coal Pty Ltd, January 2019

Australasian Groundwater and Environmental Consultants Pty Ltd ,2019b. *Wambo Coal Mine Alluvial Drilling and Monitoring Bore Installation Report – Phase Two*. Ref G1884C. Prepared for Wambo Coal Pty Ltd, July 2019

Alluvium Consulting, 2020. *Surface Water Technical Report for South Bates Extension Underground Mine*

Bureau of Meteorology (2021) *Groundwater Dependent Ecosystems Atlas*.

CSIRO, 2015. *AUS Soil and Landscape Grid National Soil Attribute Maps - Depth of Regolith (3" resolution) - Release 2*. Bioregional Assessment Source Dataset. Viewed 22 June 2021 - http://data.bioregionalassessments.gov.au/dataset/c28597e8-8cfc-4b4f-8777-c9934051cce2

Eco Logical Australia (2022). *Wambo MOD19 Biodiversity Review*. Prepared for Wambo Coal Pty Ltd.

HLA – Envirosciences Pty Ltd, 1999. *Effect of Longwall Panel 9 Missing on Surface and Groundwater Homestead Underground Mine Warkworth NSW.*

Hunter Eco, 2019. *South Bates Extension Groundwater Dependent Ecosystems Vegetative Assessment*. Report prepared for Wambo Coal Pty Ltd, April 2019.Hunter Eco (2022). *Wambo Coal Mine, Longwalls 24 to 26 Modification Biodiversity Development Assessment Report*. Report BAAS17004 prepared for Wambo Coal Pty Ltd.

HydroAlgorithmics, 2022. *Wambo Longwalls 24-26 Modification – Groundwater Peer Review.* Report HA2022/1a for Wambo Coal Pty Ltd. 30 July 2022.

HydroSimulations, 2014. *North Wambo Underground Mine Longwall 10A Modification Groundwater Assessment.* Report HS2014/20 prepared for Wambo Coal Pty Ltd, September 2014.

HydroSimulations, 2017. *South Bates Extension Modification Groundwater Assessment.* Report No. HS2016/51 for Wambo Coal Pty Ltd. March 2017.

HydroSimulations, 2019. *Groundwater Knowledge to Inform GDE Study*. Report HS2018-50 for Wambo Coal Pty Ltd. September 2019.

Independent Expert Scientific Committee (IESC), 2018. *Information guidelines for proponents preparing coal seam gas and large coal mining development proposals, Commonwealth of Australia, 2018*

Mackie Environmental Research (MER), 2009. *Hydrogeological Characterisation of coal measures and overview of impacts of coal mining on groundwater systems in the Upper Hunter Valley of NSW*, PhD thesis, Faculty of Science, University of Technology, Sydney.

Mine Subsidence Engineering Consultants Pty Limited (2023) *South Bates Extension Underground Mine Longwalls 24 to 26 Extraction Plan Subsidence Assessment.*

Risk Mentor (2023) *Wambo U/G South Bates Extension Underground Mine – Longwalls 24-26 – Extraction Plan Risk Assessment Report*.

SLR, 2017. *Wambo Drilling Program – Upper North Wambo Creek*. Report 631.12300-L01 for Peabody Energy, Wambo Coal Mine. 4 December 2017.

SLR, 2020. *South Bates Extension LW21-24 Groundwater Technical Review*. Report 665.10008-R02 For Wambo Coal Pty Ltd February 2020.

SLR, 2022. *Wambo Coal Mine – Longwalls 24-26 Modification Groundwater Assessment*. Report 665.10008.00815-v4.0-20220728 prepared for Wambo Coal Pty Ltd. July 2022.

United Wambo Open Cut Project, 2022. *Surface Water Management plan.*

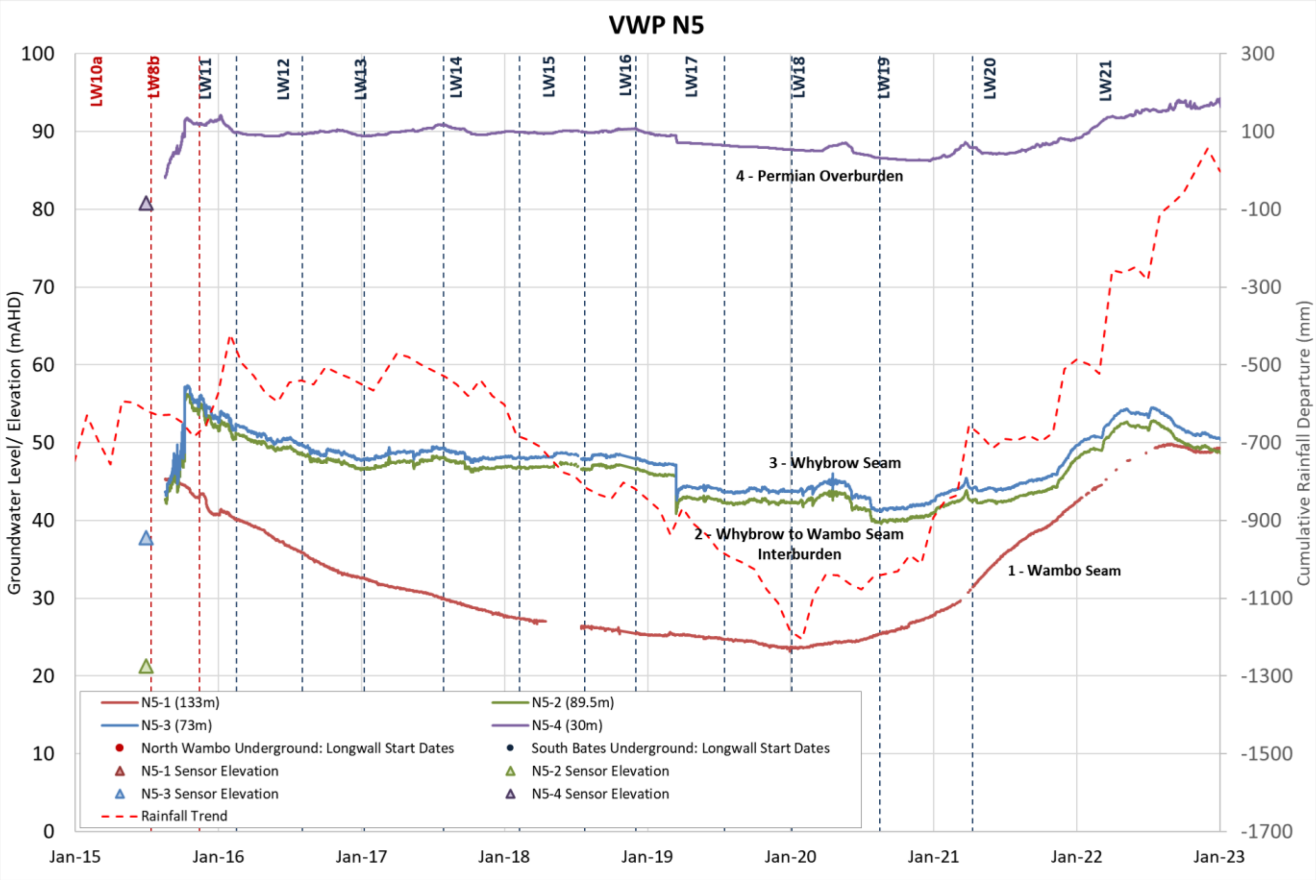
Wambo Coal Pty Ltd, 2003. *Wambo Development Project Environmental Impact Statement.*

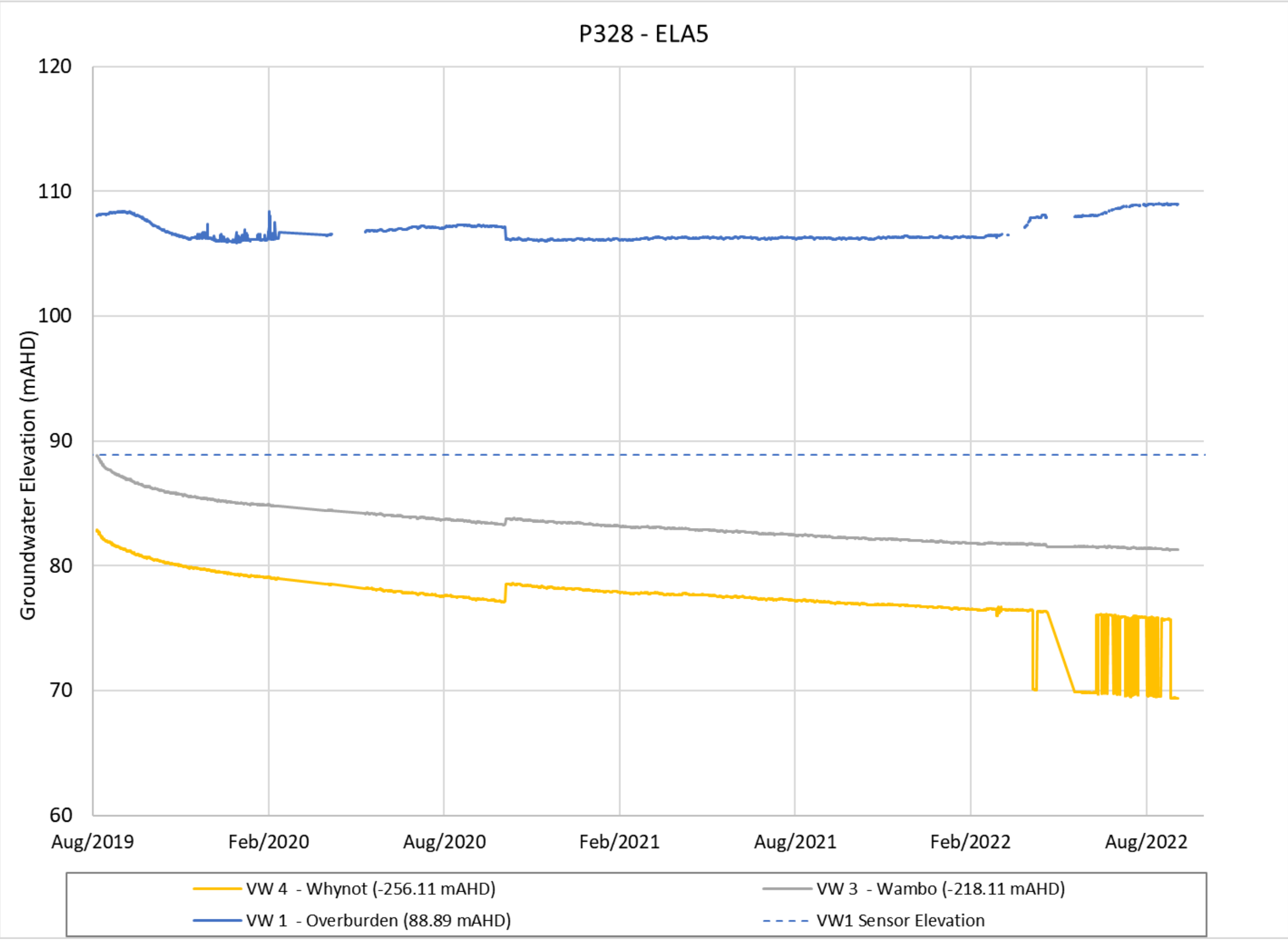
Wambo Coal Pty Ltd, 2021a. *United Wambo Open Cut and Wambo Water Monitoring Program* Document WA-ENV-MNP-509.8 December 2021

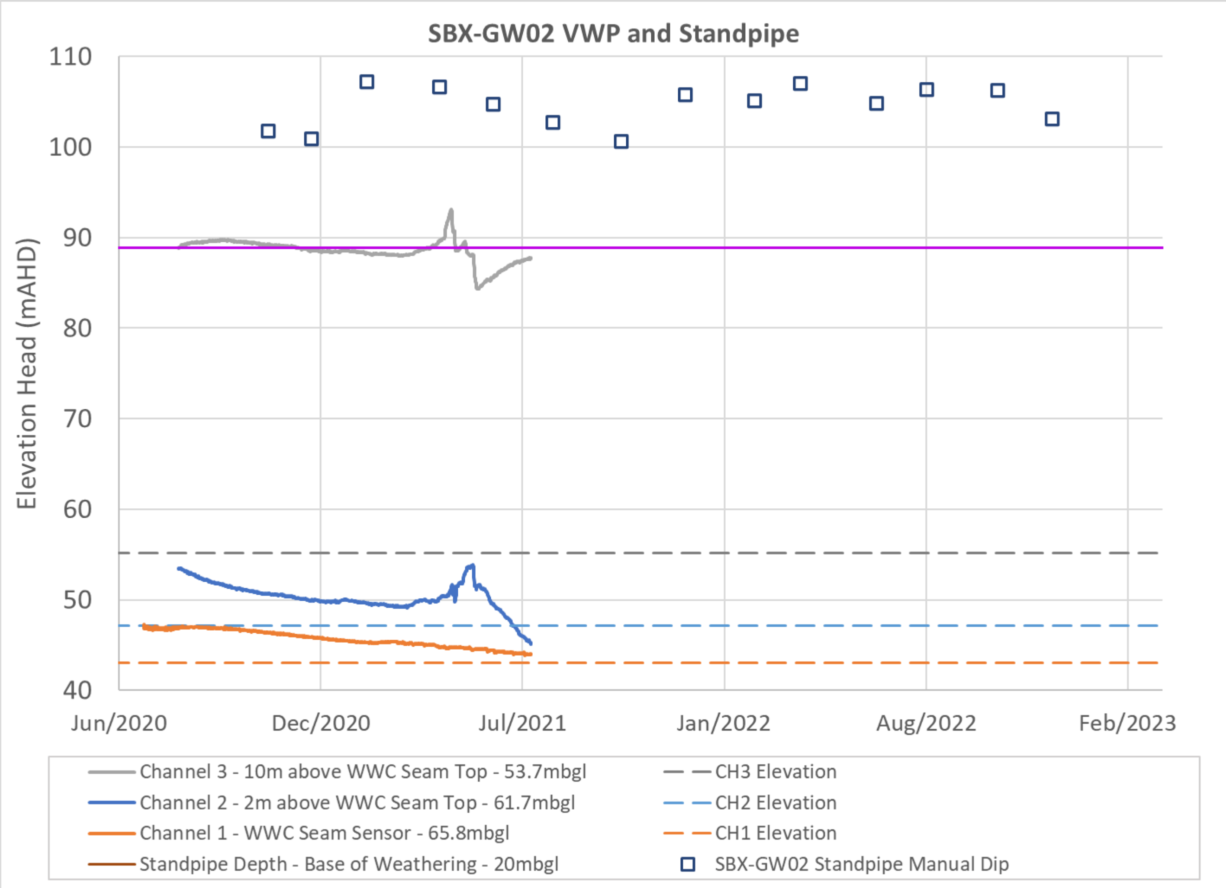
Wambo Coal Pty Ltd, 2021b. *Wambo Groundwater Management Plan* Document WA-ENV-MNP-509.1 November 2020

# Appendix A:

## Additional VWP hydrographs


VWP N5
LW10a
LW8b
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW20
LW21
4 - Permian Overburden
3 - Whybrow Seam
2 - Whybrow to Wambo Seam Interburden
1 - Wambo Seam
Groundwater Level/ Elevation (mAHD)
Cumulative Rainfall Departure (mm)
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
N5-1 (133m)
N5-2 (89.5m)
N5-3 (73m)
N5-4 (30m)
North Wambo Underground: Longwall Start Dates
South Bates Underground: Longwall Start Dates
N5-1 Sensor Elevation
N5-2 Sensor Elevation
N5-3 Sensor Elevation
N5-4 Sensor Elevation
Rainfall Trend


P328 - ELA5
Groundwater Elevation (mAHD)
Aug/2019
Feb/2020
Aug/2020
Feb/2021
Aug/2021
Feb/2022
Aug/2022
VW 4 - Whynot (-256.11 mAHD)
VW 3 - Wambo (-218.11 mAHD)
VW 1 - Overburden (88.89 mAHD)
VW1 Sensor Elevation


SBX-GW02 VWP and Standpipe
110
100
90
80
70
60
50
40
Elevation Head (mAHD)
Jun/2020
Dec/2020
Jul/2021
Jan/2022
Aug/2022
Feb/2023
Channel 3 - 10m above WWC Seam Top - 53.7mbgl
Channel 2 - 2m above WWC Seam Top - 61.7mbgl
Channel 1 - WWC Seam Sensor - 65.8mbgl
Standpipe Depth - Base of Weathering - 20mbgl
CH3 Elevation
CH2 Elevation
CH1 Elevation
SBX-GW02 Standpipe Manual Dip

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