# WAMBO COAL PTY LIMITED

## SOUTH BATES EXTENSION UNDERGROUND MINE

# EXTRACTION PLAN
# LONGWALLS 24 TO 26

## REPORT 3
SURFACE WATER ASSESSMENT REVIEW

Peabody

# Longwalls 24-26 – Extraction Plan -Surface Water

WAMBO COAL MINE

October 2024

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Alluvium recognises and acknowledges the unique relationship and deep connection to Country shared by Aboriginal and Torres Strait Islander people, as First Peoples and Traditional Owners of Australia. We pay our respects to their Cultures, Country and Elders past and present.

*Artwork by Vicki Golding. This piece was commissioned by Alluvium and has told our story of water across Country, from catchment to coast, with people from all cultures learning, understanding, sharing stories, walking to and talking at the meeting places as one nation.*


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# 1 Introduction

Wambo Coal Mine (Wambo) underground coal mining operation is located approximately 15 kilometres west of Singleton, near the village of Warkworth, New South Wales (NSW). Wambo is operated by Wambo Coal Pty Limited (WCPL), a subsidiary of Peabody Energy Australia Pty Limited. WCPL is currently seeking approval of an updated Extraction Plan for its longwall mining operation at South Bates Extension underground mine. The proposed update to the Extraction Plan will cover the mining of Longwalls (LW) 24 to 26, extracting coal from the Whybrow Seam.

Wambo is operated under Development Consent (DA 305-7-2003, as modified), which allows for the extraction of coal resources in the Whybrow Seam from Longwalls (LW) 17 to 26 at the South Bates Extension Underground Mine. WCPL submitted an Extraction Plan for the LW24-26 component of the South Bates Extension Underground Mine, which was subsequently approved by the Department of Planning, Housing and Infrastructure on 6 December 2023.

Since the approval of the Extraction Plan on 6 December 2023, WCPL has identified adverse geological conditions in the LW24-26 mining area, which will hinder the full development and extraction of LW24-26. WCPL proposes an alteration of the LW 24-26 underground mine layout (the revised mine layout) to avoid these adverse geological conditions.

One of the effects of underground longwall mining is that after coal is mined, the roof strata falls into the void (goaf) causing the natural ground surface to subside. The environments of Waterfall Creek, North Wambo Creek and the North Wambo Creek Diversion (NWCD), their adjacent floodplains, tributaries and hill slopes that exist over the area of the South Bates Extension underground mine plan that will be affected by subsidence are the subject of this report.

This technical report outlines the pre (pre LW21-26) and post subsidence environment for the revised mine layout (as shown in Figure 1-1), addresses potential impacts on surface water caused by subsidence, and proposes mitigation, monitoring and reporting. This report also provides commentary on the change in impact and mitigation measures between the current and revised layouts of LW24-26.

To effectively manage the impacts of subsidence this technical report consists of the following aspects:

- Measurement of pre-subsidence baseline data
- Predictive subsidence modelling and impact assessment
- Ongoing subsidence monitoring
- Pre-subsidence and post subsidence mitigation, reporting and maintenance.

## 1.1 Scope

This technical report covers surface water aspects that interface with the South Bates Extension and South Bates underground mine plan. This includes Waterfall Creek, North Wambo Creek, its diversion (NWCD), its tributaries and surrounding landscape.

The impact assessment of subsidence upon waterways and surface water generally is undertaken in the structure developed during the *Isaac River Cumulative Impact Assessment of Mine Developments* (Alluvium, 2008), a project jointly funded by Anglo American and BHP Billiton undertaken in collaboration with Queensland Government. Although not directly applicable to NSW regulation, the findings assisted the development of the *Watercourse Subsidence – Central Queensland Mining Industry* guideline (DERM, 2011). The framework for assessing impacts on watercourses by subsidence was developed into the following hierarchy, which has been adopted for this study:

- 1st order – direct physical effects of subsidence
- 2nd order – geomorphic response to subsidence
- 3rd order – changes to water quantity and quality
- 4th order – biological response

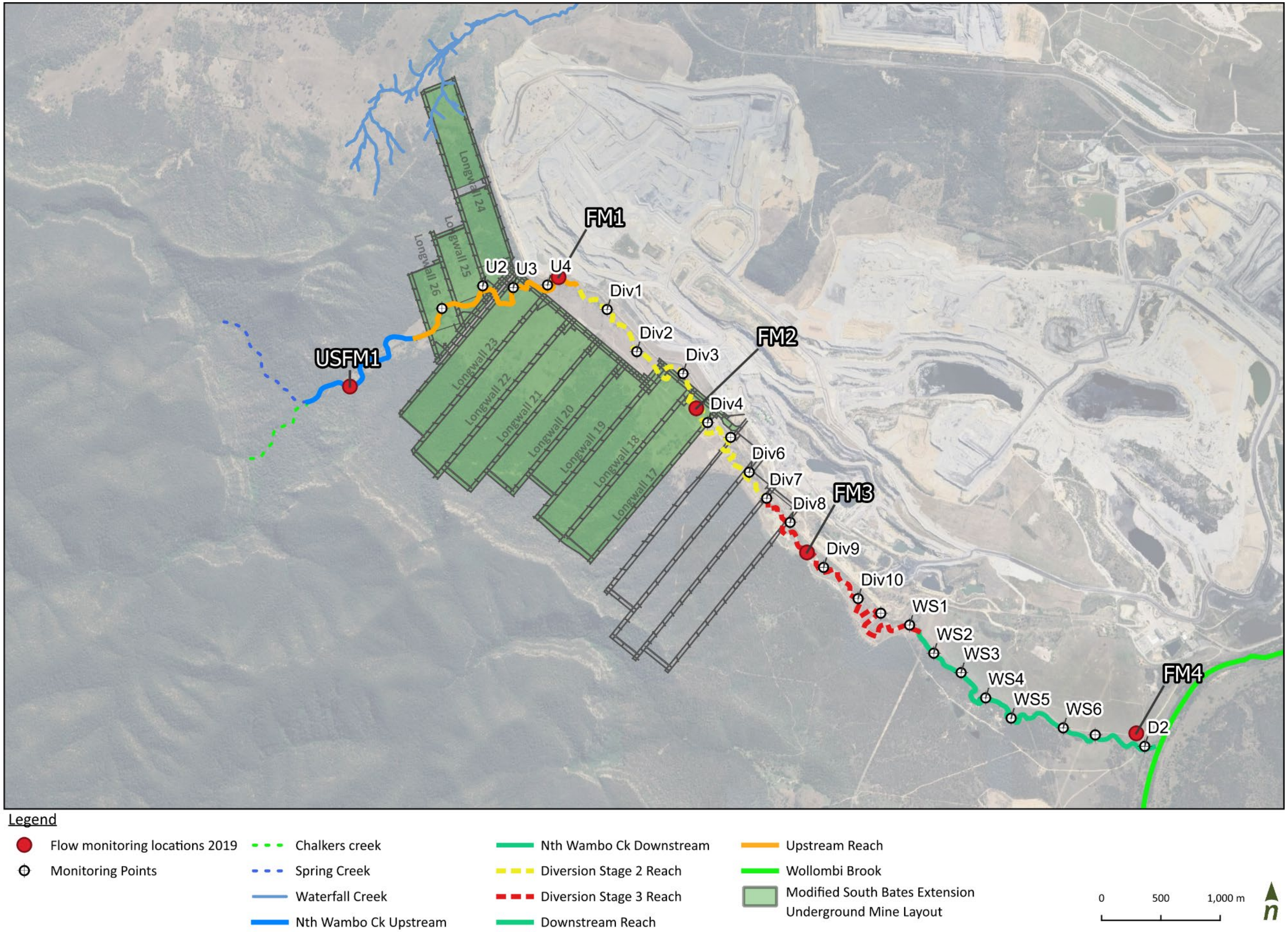


Figure 1-1. *Overview of Underground Mining – LW17 to LW26*

# 2 Description of Existing Surface Water Values

A snapshot of the condition of the landscape and surface water environments interacting with the South Bates Extension underground mine plan is provided to inform the impact assessment and any mitigation strategies that may be required. This snapshot is the existing condition based on several previous point in time condition assessments (2015-2022) and the NWCD monitoring from 2017-2023.

A monitoring program for NWCD was established in November 2017 in response to recommendations in the extraction plan for LW11 to LW16 (Alluvium, 2016) (see Section 4.3). The results of the monitoring program to date are detailed in Alluvium's report; *North Wambo Creek Diversion Operations Monitoring 2022* (Alluvium, 2023). Monitoring has also occurred in 2023 and 2024. Further baseline assessment of the upstream reaches of North Wambo Creek and its tributaries Spring and Chalkers Creeks was completed in February 2018. The results of that assessment are detailed in Alluvium's report; *North Wambo Creek – Baseline assessment geomorphic context statement* (Alluvium, 2018).

As well as the monitoring, information from the 2015 performance review of NWCD (Alluvium, 2016) and other historical information were used to inform this assessment.

LW11 to LW21 had been fully mined at the time of the 2022 monitoring. Of the panels LW18 to LW20 and LW21 to LW26, with the updated arrangement, only LW18 intercepts the NWCD, while LW23, LW25 and LW26 directly undermine North Wambo Creek upstream of NWCD. LW23 had subsided North Wambo Creek prior to the 2024 monitoring (report in prep.). The downstream extent of NWCD was subsided prior to construction. Downstream of NWCD, North Wambo Creek has also subsided by earlier underground mining operations.

## 2.1 Character, Behaviour and Condition of Waterways

### Upstream Reach

The 2018 baseline assessment of the upstream reach of North Wambo Creek extended to include its upstream tributaries, Spring and Chalkers Creeks (Alluvium, 2018). This reach is termed upstream as it was upstream of NWCD and any longwall operation. LW24-26 will mine beneath part of this reach. What is termed upstream will be moved to be upstream of any direct mining influence.

Spring and Chalkers Creek tributaries originate from the sandstone capped ranges to the west of the mine. These ranges have massive sandstone beds that form plateau on the crest with angle of repose slopes beneath. Consequently, these ranges can generate substantial quantities of sand as input to North Wambo Creek valley. Near the confluence, which forms North Wambo Creek, much of the sedimentary bedrock is conglomerate, providing cobbles and gravels as bedload to the waterway. Both these waterways have a steep gradient and are horizontally confined by bedrock in hillslopes with only minor floodplain pockets.

Downstream of the confluence of the confined Spring and Chalkers Creeks, North Wambo Creek becomes progressively less confined before becoming completely alluvial prior to the NWCD. The extents of North Wambo Creek assessed have been subject to a long period of adjustment in response to land clearing and domestic livestock grazing. The farming settlement of the valley appears to have comprised several smaller allotments and land use is likely to have been intensive. Grazing by domestic stock has ceased in recent time in the valley and along the subject reaches.

Prior to development of the mining operation, North Wambo Creek has undergone a number of adjustments. It is probable that the watercourse was a discontinuous alluvial channel with swamp like features, potentially a chain of ponds. With complete clearing of the valley floor it appears that a channel incised, widened and meandered in the sandy alluvials. There is no longer an active channel present for much of North Wambo Creek immediately upstream of the diversion, it has infilled and exhibits limited fluvial bed form activity. This section appears to be returning to a discontinuous alluvial form, inset below the former surface.

It is likely in this setting that much of the flow generated in the range to the west in lower intensity and magnitude rainfall events was as base flow in the alluvial sediments.  The current open cut operation adjacent to the offtake of NWCD alters the flow regime due to opening the alluvial aquifer to the pit void, this impacts North Wambo Creek, NWCD and downstream.

The location where North Wambo Creek will first be subsided moving from upstream is LW26.  This location coincides with a rapid change in cross sectional form.  Upstream of subsidence is relatively narrow, where North Wambo Creek will be first subsided by LW26 widens rapidly (see photos in Figure 2-1).  This geometry favours a shear stress gradient that has high capacity for transporting bed sediment.  The subsidence will increase that.

Riparian vegetation in the reach immediately upstream of NWCD is limited to ground cover, which has been sparse and dense across the period 2015-2022 in response to climatic conditions.  The reasons for limited regeneration of woody species in this reach are not known.  The reach appears no longer subject to cattle grazing however kangaroo numbers in the area are significant.  Changes in the saturation of alluvials due to a steeper hydraulic gradient to the open cut may also be a factor in limiting woody regeneration.


*Typical Spring Creek reach (2018 baseline)*


*Typical Chalkers Creek reach (2018 baseline)*


*Partly confined North Wambo Creek, downstream of confluence of Spring and Chalkers Creeks (2018)*


*Partly confined North Wambo Creek, downstream of confluence of Spring and Chalkers Creeks (2018)*

*Upstream view where NWC will steepen at subsidence of LW26. Section is relatively narrow*

*Downstream view where NWC will steepen at subsidence into LW26. Section widens rapidly from the upstream view.*

*Upstream view in fully alluvial reach (2019) at monitoring point US3*

*Upstream view in alluvial reach (2022) at US3 to contrast ground cover and 2 years of surface flow after >7 years dry years*

Figure 2-1. *North Wambo Creek Upstream reach photographs*

### NWCD Stage 2

The upstream half (approximately) of NWCD is known as Stage 2. This was constructed prior to Stage 3 which replaces the mined-out Stage 1. Stage 2 of the diversion is constructed initially in the floodplain of North Wambo Creek then gradually into foot slopes of the range to the west (transitioning from an alluvial setting to fully bedrock controlled). A low capacity low flow channel, typically 2-3 metres (m) deep and up to 10m top width has been cut into a constructed floodplain that decreases from around 80m wide to 30m wide moving downstream as depth of cut increases (to about 8m below natural ground surface at the interface with Stage 3).

At the upstream end of Stage 2, overland flow entry has been managed adequately and with a lower gradient and broader cross section the diversion is in similar condition to the upstream reach. Hydraulic energy conditions increase with the depth of cut and the narrower floodplain, moving downstream. This has resulted in deepening and widening of the low flow channel that is likely to continue in the alluvial/colluvial sediments present. This process is occurring in the zone over LW 11 to LW 17 and immediately upstream. Subsidence of LW16 and LW17 is now exacerbating this process and rehabilitation works are planned or underway.

With subsidence changing overland flow entry to the diversion from the west, a number of works such as rock chutes on diversion batters have been built 2020-22 to mitigate erosion on the batters. This work is continuing in 2023.

Stage 2 of the diversion is known to have had substantial rehabilitation effort in the form of revegetation largely with a pasture seed mix and some tube stock patches and other remedial works in 2011 and again in 2013. This work had limited success. A program of shallow ripping (including treatment of subsidence cracks) and seeding has progressed since early 2019. With wet conditions across 2020-22 (in 2021 the rainfall gauge at Bulga (South Wambo) experienced its wettest year on record), this program is showing signs of success with greatly improved vegetation coverage.

### NWCD Stage 3

Stage 3 is largely constructed in foot slopes with much of the channel boundaries being weathered sandstone and conglomerate bedrock. Where not bedrock, the weathered sediments are generally highly dispersive and prone to erosion on the surface and sub-surface.

This section of the diversion has been subject to considerable rehabilitation activities in recent years to address vegetation establishment and overland flow entry. These works are showing a positive condition trajectory (Alluvium, 2023).

Elevated energy conditions in Stage 3 and the limited finer sediment supplied to the reach under current sediment supply conditions means there is little prospect of deposition in the low flow channel and that any fine sediment topsoil in the channel is likely to be stripped in larger flow events. Combined, these conditions constrain longer term vegetation establishment potential from regeneration/self-seeding processes. With the shallow bedrock in the reach, vegetation is at further risk of removal due to potential barriers to root penetration where sandstone beds are massive.

The downstream extents of Stage 3 were constructed over terrain that was already subsided by earlier longwall mining.

NWCD Stage 2 and Stage 3 are shown on Figure 2-2.

*Substantial bank erosion following incision in response to subsidence between LW16 and LW17. Limited riparian vegetation providing poor resistance.*

*Head cut incision of channel bed in response to subsidence between LW16 and LW17*

*Substantial deposition within the subsided extent of LW16 from the erosion at upstream pillar. A new low flow channel will develop in this area.*

*Weak bedrock on the LW14-15 pillar at Div 7 is being mobilised in response to steepened grade dropping into LW14*

*Subsidence pool over LW14 providing increased aquatic habitat opportunity*

*Downstream view at Div9 highlighting positive condition trajectory of revegetation efforts*

*Upstream view at Div11 highlighting positive condition trajectory for revegetation efforts*

*Upstream view at Div11 in 2017 for comparison*

**Figure 2-2.** *North Wambo Creek Diversion Stage 2 and Stage 3*

### Downstream Reach

Downstream of NWCD through to the confluence with Wollombi Brook, the remaining alignment of North Wambo Creek has been subsided by five longwalls in the 2000's. This reach of North Wambo Creek is relatively low sinuosity and is increasingly incised as it cuts down to the level of Wollombi Brook. Channel migration is limited by consolidated Wollombi Brook terrace sediments. Bedrock controls are occasionally present in the channel bed.

Riparian vegetation remains minimally cleared for much of the reach, however clearing has occurred to the top of bank along the north eastern side for much of the reach. What remains, has exhibited clear signs of water stress during periods of lows rainfall and due to the reduction in flows from upstream reaches. Recovery during the wet period of 2020-22 is limited to date.

Subsidence pools are present in the reach, providing pool habitat that is otherwise not presently common in North Wambo Creek, although these were all found to be dry in Nov 2019. There has been limited erosion response in the reach, such as incision through pillars, to date.

A notable threat to the condition of the downstream reach exists in the form of a significant drop through culverts of a track crossing shortly upstream of the Wollombi Brook confluence. Sediment has accumulated upstream of the culverts and has been colonised by vegetation. Should the culverts fail through undermining or outflanking it is likely a considerable amount of deepening would occur through the accumulated sediments. Remedial works to mitigate the threat are being undertaken in 2024.

### Western Tributaries

Several tributaries flow from the sandstone escarpment of the range to the west into North Wambo Creek and NWCD are shown in Figure 2-3. These tributaries transition from steep deeply incised bedrock-controlled gullies to broad alluvial flood-outs with no defined channel progressing downstream before entry to North Wambo Creek and NWCD. These systems are all presently in dynamic equilibrium with relative stability. Riparian vegetation is near intact throughout the steeper upper reaches then cleared for grazing where they flood out onto the flatter valley base. There are small farm dams on some of these tributaries and the nature of their inflow to NWCD has been altered by works implemented with the diversion and subsidence.

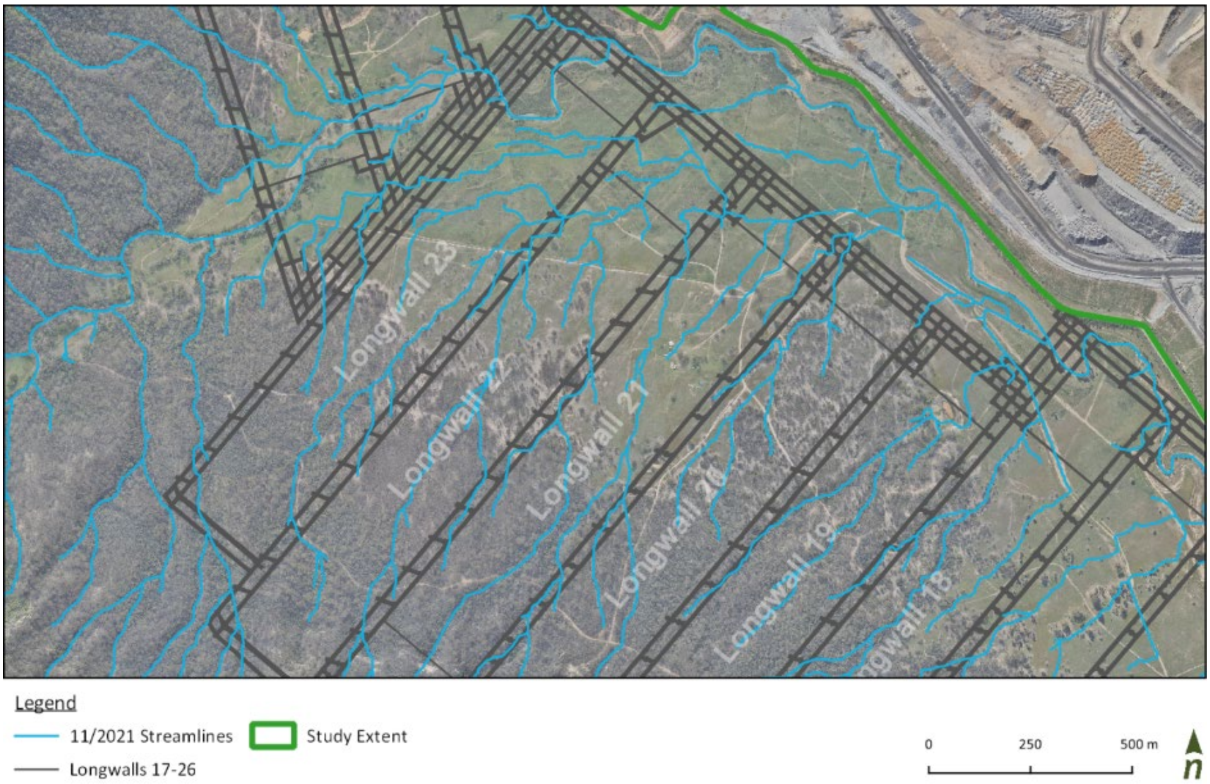


**Figure 2-3.** *Western tributaries of North Wambo Creek*

**Northern Tributaries**

To the north of North Wambo Creek several tributaries flow from the ridge towards the upstream reach of North Wambo Creek, some of which cross the footprint of proposed LW24-26. These tributaries have steep valley fills that have undergone some minor incision in places, otherwise remain intact. Riparian vegetation cover is generally diverse and dense throughout (Figure 2-4).

*Example of an intact valley fill on a moderately steep northern tributary to NWC*

*Valley fill that has been subject to incision in post land use change history*

**Figure 2-4.** *Northern tributaries of North Wambo Creek*

**Waterfall Creek**

Over the ridge from the Northern Tributaries the Waterfall Creek headwaters and tributaries are generally steep, with a range of bedrock controlled sections and alluvial/colluvial fill in valley floors (Figure 2-5). Waterfall Creek derives its name from a near vertical drop of approximately 25m over a semi circular scarp that is approximately 50m across. This scarp is interbedded thick and brittle layers of sandstone and conglomerate. Other tributaries with developed soil profiles have been subject to adjustment post clearing and some localised instabilities remain, though extents are limited by bedrock.

A farm dam downstream of LW24 has breached in recent high flow events and is likely to fail without intervention. This will have no consequence for subsidence related processes as a bedrock cascade is present shortly upstream at the margin of the mine plan.

*View across the broad scarp from which Waterfall Creek derives its name.*

*View from scarp looking downstream in Waterfall Creek*

*Waterfall Creek farm dam.*

*Waterfall Creek north of LW24 maintains an intact valley fill bedform despite clearing and grazing*

*Farm dam on tributary downstream of LW24*

*The embankment of the farm dam has already breached and may be subject to rapid failure in future flows.*

*Bedrock cascade on tributary above farm dam where it crosses out of LW24 would limit any potential adjustment should the dam embankment erode further*

*Existing erosion of valley fill where tributary crosses into LW24. Further erosion in response to subsidence likely.*

Figure 2-5. *Waterfall Creek and tributaries*

### Highwall Tributary

A small tributary stream that once contributed to NWC catchment has been truncated by the open cut highwall (Figure 2-6). It flows over the highwall at present. A headcut has eroded approximately 30m upstream from the highwall to a bedrock bar that halts its upstream progression. Further up this tributary a small dam is present on the edge of LW24that is likely to destabilise post subsidence.

*Existing erosion where tributary drops over highwall*

*Headcut migration upstream in response to drop over highwall with bedrock control limiting extent*

*Intact valley fill upstream of bedrock control*

*Small dam on edge of LW24that is likely to be destabilised by subsidence*

Figure 2-6. *Highwall tributary*

# 3 Impact Assessment

The impact assessment method and outcomes in this surface water component of the extraction plan are consistent with the impacts described in Surface Water Assessment for Modification 19 (Alluvium, 2022). The impact assessment in this report explores geomorphic and hydrological risk at a finer temporal and spatial scale than that which occurred in the Surface Water Assessment.

## 3.1 1st order – Direct Effects of Subsidence

### Subsidence Modelling

Mine Subsidence Engineering Consultants (MSEC) have provided updated subsidence predictions for the extraction of the South Bates Extension LW24 to LW26 (Figure 3-1). The LiDAR provided for this study was captured in November 2021 and is considered to have captured the majority of subsidence which has occurred between LW17 and LW20. Therefore, the predictions provided by MSEC have been adopted between LW21 and LW26. It should be noted that no material differences are present between the older and newer subsidence prediction between LW21 and LW25. For the latest update to the modelling, updated subsidence predictions for LW24-26 have been used in the 1D and 2D modelling.

The subsidence predictions are for maximum subsidence expressed at the surface of 1.8m with chain pillar subsidence of up to 0.2m.

The updated predicted subsidence depths across LW24 to LW26 is shown in Figure 3-2. Figure 3-3 shows 1m and 5m contours derived from the post-subsidence topography generated by subtracting the predicted subsidence depth from the LiDAR.

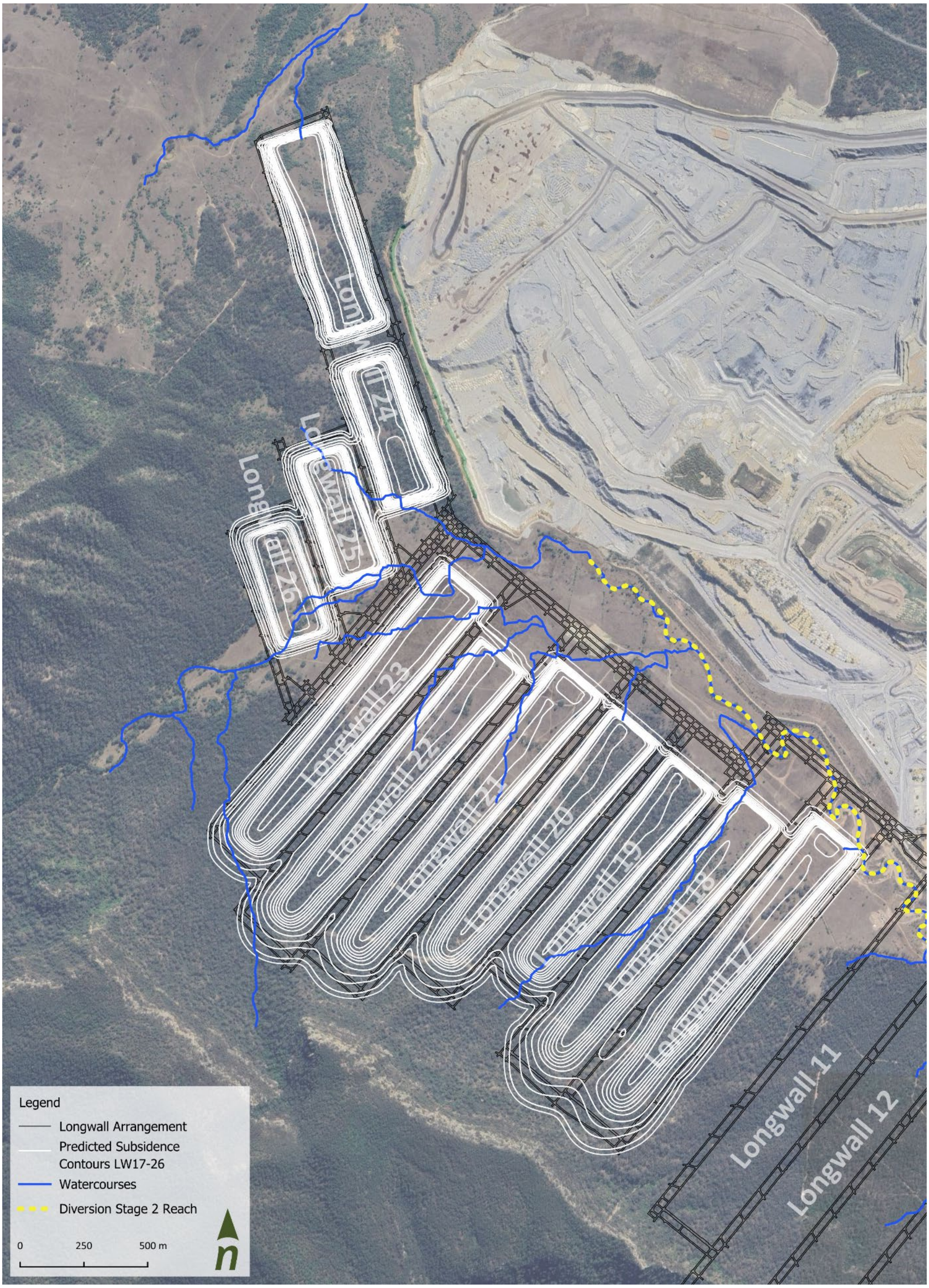


Figure 3-1. *Predicted post subsidence surface contours – LW21 to LW26*

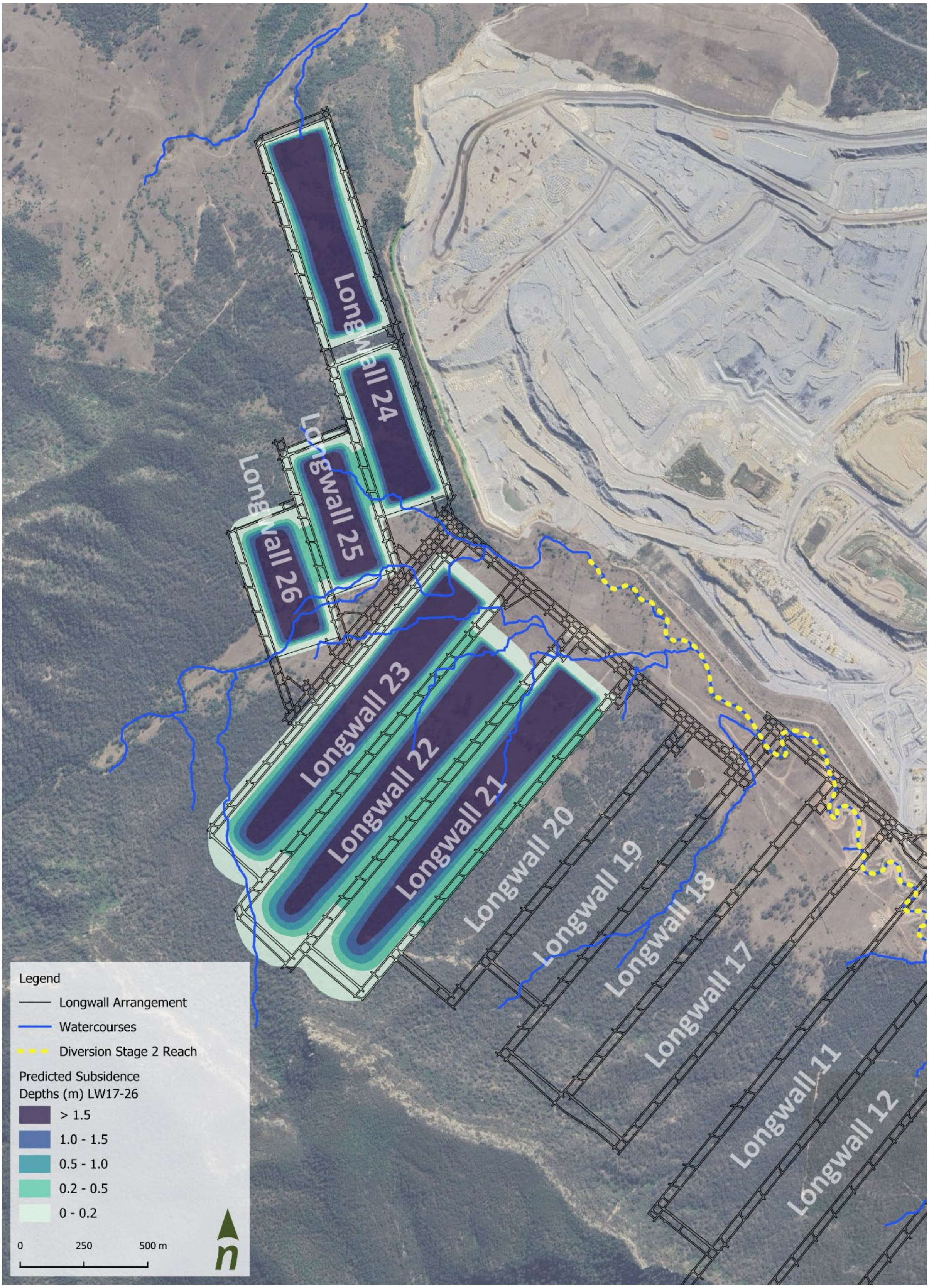


Figure 3-2. *Predicted Subsidence Depths LW21 to LW26*

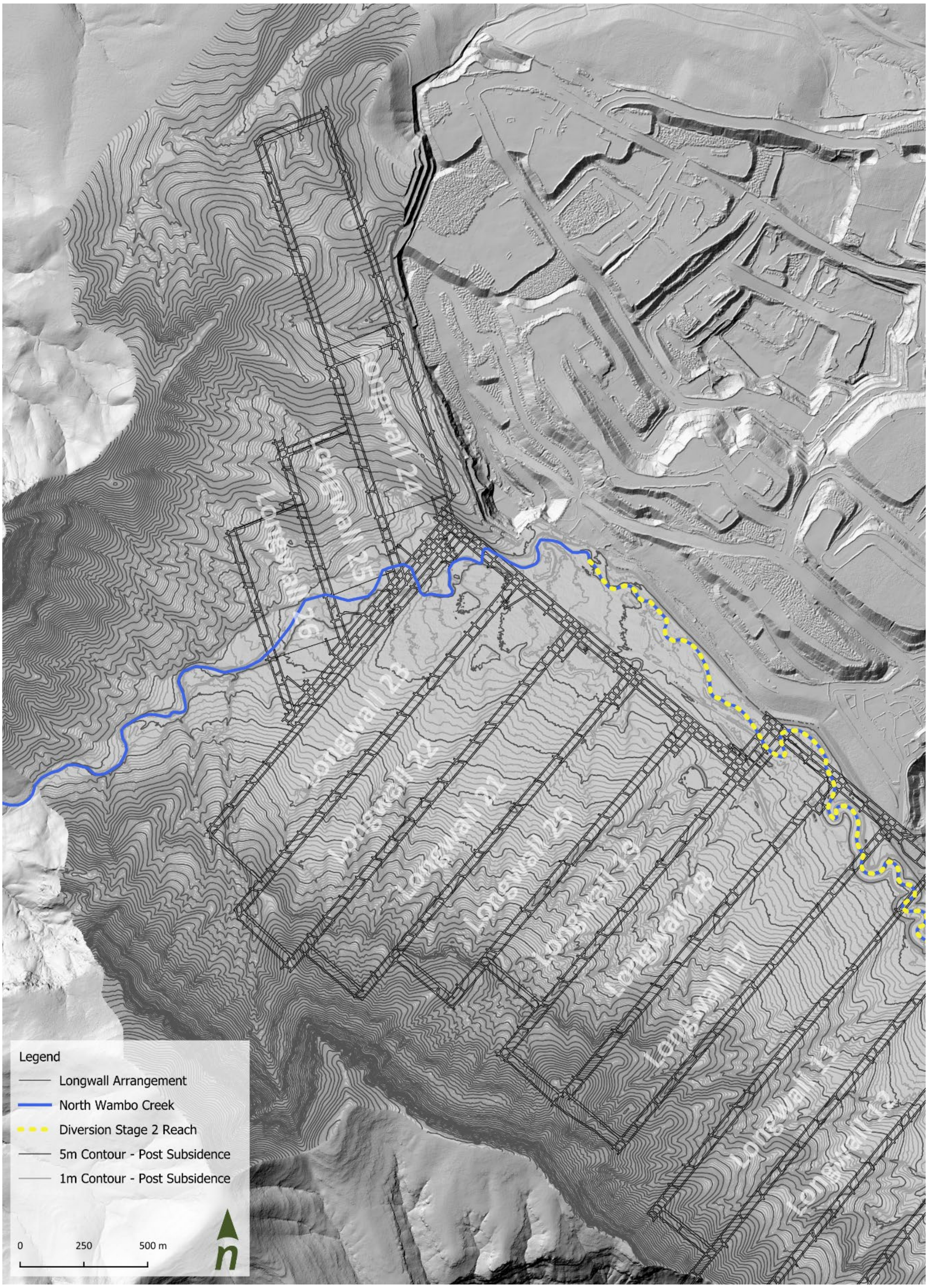


Figure 3-3. *Predicted (LW21-26) and actual post subsidence surface contours*

*Surface tensile cracking and compressional buckling*

Cracking has been observed above LW17 at the surface (Figure 3-4). As part of their subsidence assessment, MSEC have mapped the surface cracking across Wambo Mine for LW11-LW20 (Figure 3-5 and Figure 3-6). Where these cracks occur in colluvial and alluvial sediments, surficial and sub surface erosion response can be expected. The sediments across this terrain can be dispersive, which makes them prone to changes in rates of erosion with changes in landscape dynamics. No additional cracking was observed in the 2022-23 inspections however the increased ground cover made these features harder to identify.

The areas of greatest risk will be where cracks open in erodible sediments with an orientation down slope or where flow entry may be concentrated, or ponding occurs. These may be prone to enlargement should the volume of the crack be sufficient that local inputs of sediment don't infill it nor do the clays swell sufficiently to seal it. In these instances, some rill/gully erosion may develop. This had not been observed to the end of 2019 due to dry conditions. Inspections of surface cracking should be undertaken when safe to do so as cracks such as those shown in Figure 3-7 have the potential to undergo substantial enlargement due to runoff.

Where local ponding occurs in the same location as cracking, dispersive sediments are likely to flow down cracks with water, enlarging the crack at surface, which may develop into considerable tunnel erosion. An example of tunnel erosion can be seen below in Figure 3-8.

**Figure 3-4.** *Surface Cracking along the Access Tracks above LW17*

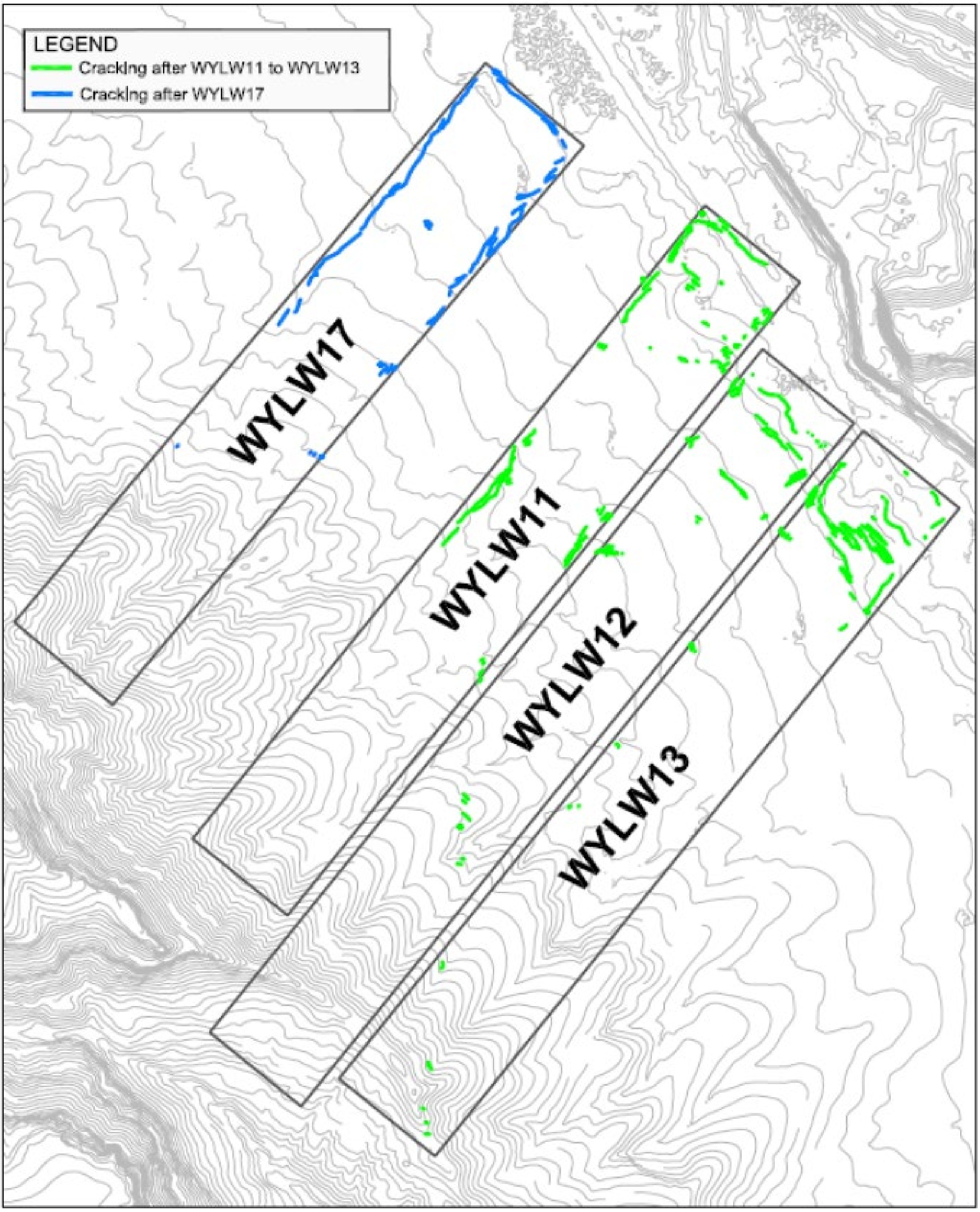


Figure 3-5. *Mapped surface cracking above LW11, LW12, LW13 and LW17 (MSEC, 2020)*

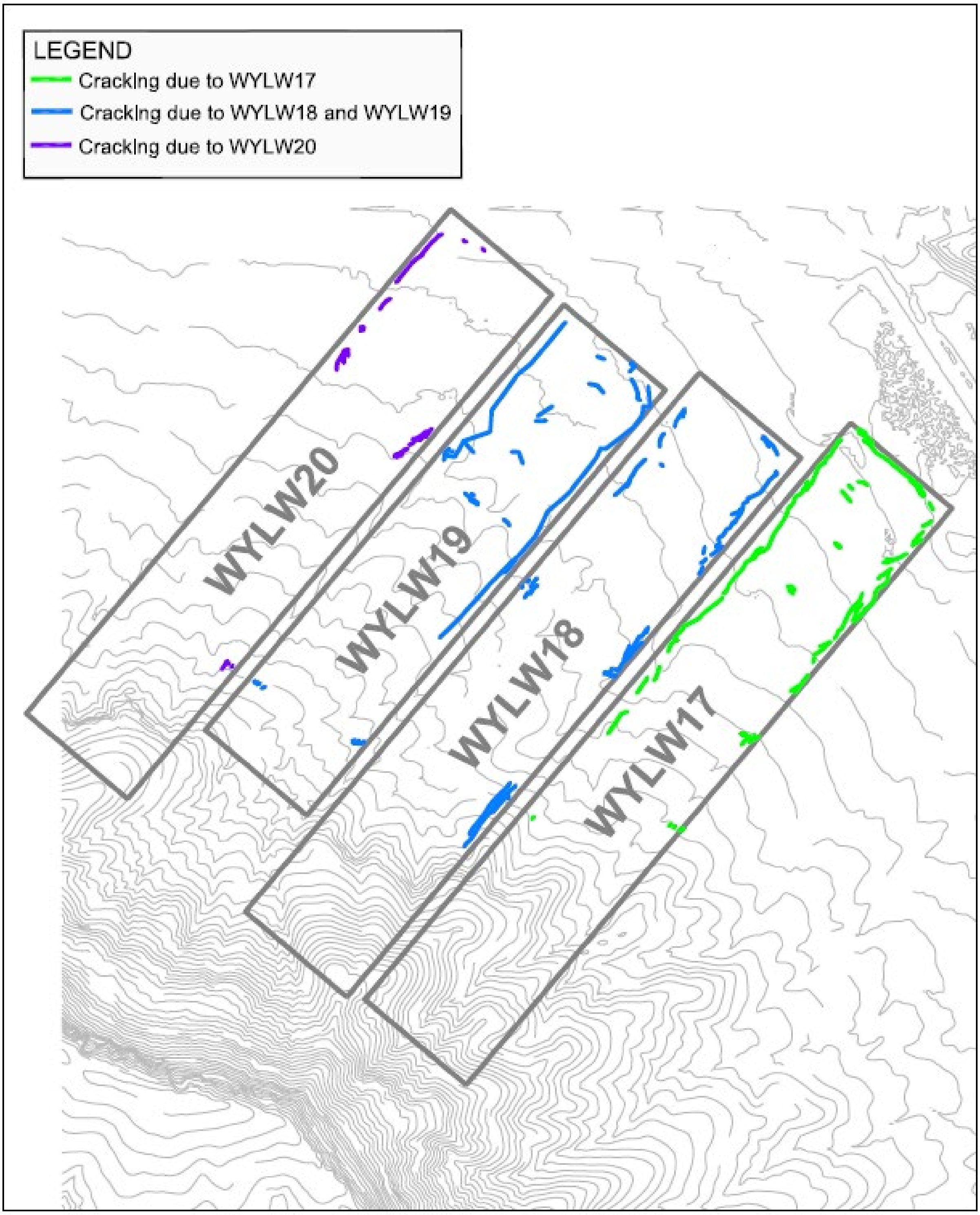

Figure 3-6. *Mapped Surface Cracking above LW 17 to LW 20 (MSEC, 2022)*

Figure 3-7. *Surface cracking near Dam d07 adjacent to the main gate of LW20*

Figure 3-8. *Tunnelling over LW12/15 on track adjacent NWCD associated with subsidence crack*

*Subsurface cracking of overburden strata*
An increase in hydraulic connectivity between the surface and the workings, particularly under waterways, is a considerable third order impact risk. Observations in the downstream extents of North Wambo Creek (downstream of where the panels LW1 to LW10 intercept the creek) indicate that flows reaching this part of the waterway are limited to high intensity rainfall events or following extended wet conditions. Base flow conditions are likely to have been altered because of underground mining, alluvial drawdown associated with open cut extraction, the removal of alluvium upstream for the construction of the NWCD and excision of catchment by the open cut. Observations of vegetation indicate that base flow conditions have been altered by a combination of the above factors, leading to death of aquatic plants and increasing colonisation by terrestrial vegetation. In the fully subsided sections of these longwalls, subsidence pools have developed over several panels. This may indicate that loss of base flow is most likely through tensile cracking along the boundaries of the pillars and not compression buckle cracks across the panel.

### Predicted Subsidence of Panel Catchments and Waterways
Details of the predicted maximum subsidence within North Wambo Creek and its catchment are shown in Table 3-1 below. A visual representation of the maximum subsidence depth for each longwall panel is shown in Figure 3-9. The maximum subsidence with the revised layout of LW26 increases the maximum depth of subsidence to 1.8m compared to 1.6m with the previous LW26 layout.

Table 3-1. Maximum predicted subsidence depth by longwall panel

| Longwall Panel | Panel Length (km) | Maximum Depth of Subsidence (m) | |
|---|---|---|---|
| | | Longwall Panel | North Wambo Creek channel |
| 22 | 1.47 | 1.85 | 0 |
| 23 | 1.67 | 1.85 | 1.8 |
| 24a | 0.86 | 1.85 | 0 |
| 24b | 0.64 | 1.85 | 0 |
| 25 | 0.58 | 1.85 | 0.2 |
| 26 | 0.59 | 1.85 | 1.8 |

The predicted subsidence void (or pool) volume estimates within the North Wambo Creek channel are summarised in Table 3-2. The longitudinal profile of the channel bed is shown on Figure 3-10 and Figure 3-9. These assume static channel boundaries (no erosion or deposition or management intervention), which will not be the case when flows occur that are capable of eroding the channel boundaries (2nd order response). Such response will change the pool volumes over time. Volumes are calculated from top of bank to top of bank of the macro channel, which includes the inset floodplain/bench and the low flow channel. The predicted subsidence void volume for LW23, LW25 and LW26 (LW24 does not overlap the North Wambo Creek channel) is 66,146 cubic metres ($m^3$) which is comparable to the predicted subsidence void volume of the previous panels (LW11 to LW16) subsiding NWCD which had a total subsidence void volume of 64,225$m^3$. This is also significantly lower than the original arrangement of LW24 where the panel was aligned almost in parallel with North Wambo Creek creating void volumes within this panel of over 89,000$m^3$.

Compared with the previous layout of LW26, the revised mine layout increases the subsidence void volume in North Wambo Creek by 15% as the revised mine layout extends further south-east into the North Wambo Creek channel.

Table 3-2. Subsidence void volumes

| Longwall Panel | Subsidence void volume ($m^3$) |
|---|---|
| 23 | 14,212 |
| 25 | 16,025 |
| 26 | 35,909 |
| **Total** | **66,146** |

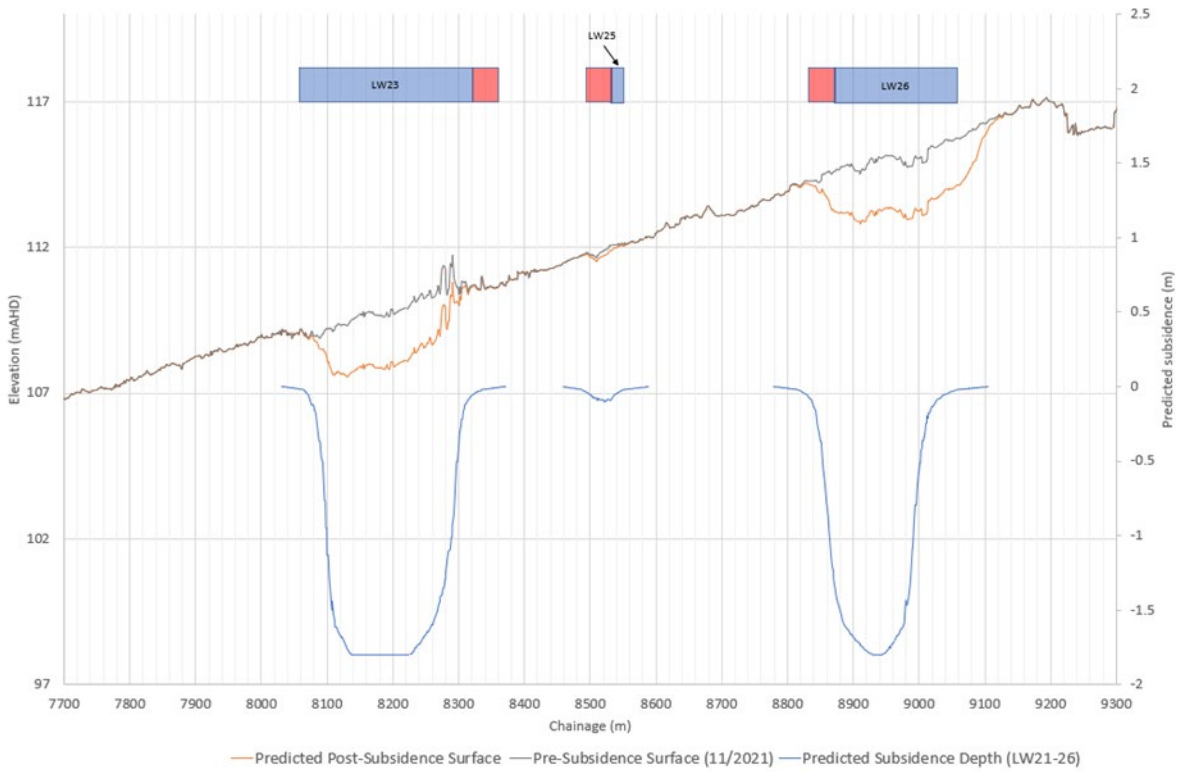


Figure 3-9. *Pre and post subsidence longitudinal profile of North Wambo Creek through LW23, LW25 & LW26*

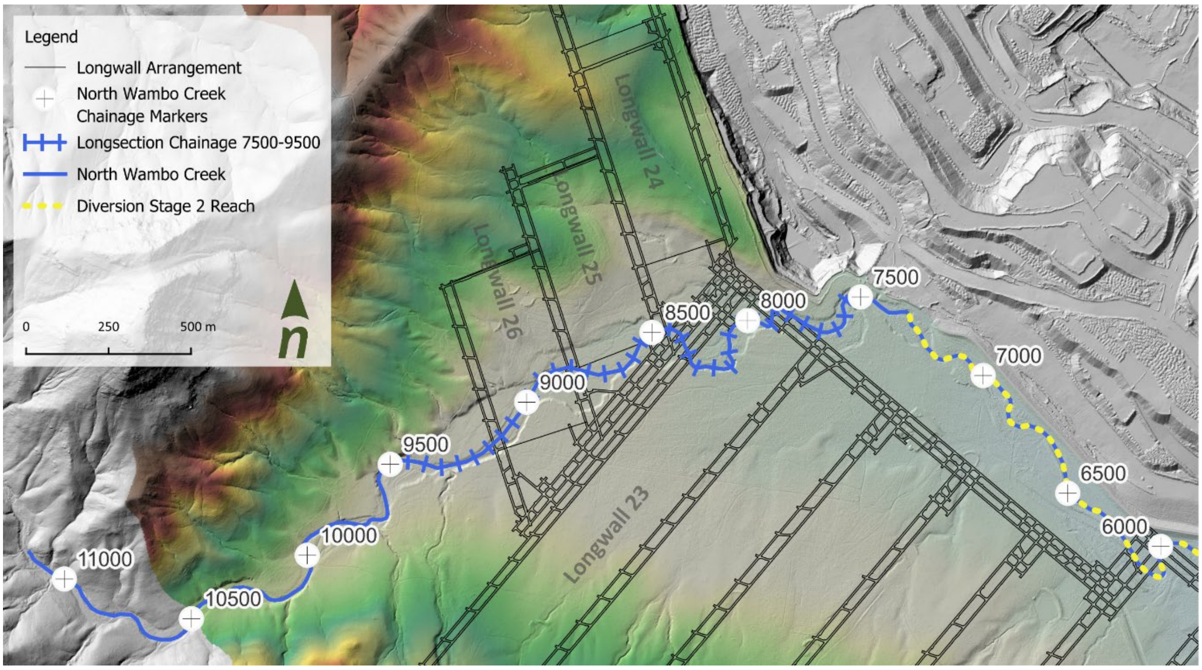


Figure 3-10. *Predicted post subsidence surface over LW23, LW24 and LW25. Note the extents of macro channel and orientation of the channel in relation to the LW23, LW24-5 panel alignment.*

## 3.2 2nd Order – Predicted Geomorphic Response of Surface Water Systems

### North Wambo Creek

Up to 1.8m of subsidence over approximately 220m of North Wambo Creek channel over LW23 has the potential to initiate erosion response upstream through the unconsolidated alluvial sediments in the channel over the extents of the main headings and the margins of LW25 should surface flows occur. This will be in the form of incision of the channel bed, followed by widening and potentially meander migration with the channel trying to reduce its grade. This incision has the potential to link with that in LW26 in the future. The erosion will serve to mobilise sediments into the LW23 subsidence void/pool, resulting in overall lowering of the stream bed locally. A full sediment supply and transport analysis would be required to determine the potential maximum depth and duration of such deepening. However, in the long term (dependent on timing of flows capable of mobilising sediment), sediment supply from upstream, which appears relatively high, hence the infilling of the previous post settlement incision, will overwhelm the subsidence void created by LW23 and LW26.

The upstream extent of subsidence of LW26 in North Wambo Creek is in a section where banks are weakly consolidated, weakened by animal burrows and the channel cross section rapidly expands from narrow upstream to broad downstream (see upstream and downstream photos in Figure 2-1). The combination of subsidence and cross section form is likely to initiate bank erosion following deepening of the channel bed.

In-channel one dimensional hydraulic assessment (Figure 3-11 to Figure 3-14) indicates that the reach impacted by LW21-26 is relatively low energy with stream power, shear stress and velocity typically below thresholds where erosion would be likely. Based on the assessment of the previous LW24-26 layout, there were some areas (particularly across the panels) where hydraulic parameters decrease and some areas (particularly across the pillars) where they extend within the range where instability for alluvial channel boundaries is expected and may require management. This is still the case with the revised mine layout as the updated to LW26 in particular has exposed more of the channel bed to deeper subsidence.

The capture of any bedload sediment transported to this point in North Wambo Creek, which is presently negligible, in LW23 and LW26 means that flows downstream of the panels are effectively clear and will look to mobilise material from the channel bed. Downstream within the NWCD where potential for deposition is already limited due to diversion configuration, surfaces are likely to remain as bare bedrock, limiting potential for vegetation establishment on lower channel boundaries.

The location of the end of the LW25 panel relative to the North Wambo Creek low flow channel means there is a high likelihood that the low flow channel will migrate to the north (between 50 and 80m), against the base of the terrace/hillslope. As the current low flow is largely infilled this is a small change in function of the watercourse and no management response is proposed other than monitoring. Figure 3-15 and Figure 3-16 highlight the likely change.

### NWCD

There is no predicted subsidence within NWCD caused by the extraction of LW24 to LW26. Increased geomorphic impacts are likely due to further starvation of bedload sediment transport into NWCD for a short period of time until the subsidence troughs infill, increasing erosion potential, should flow reach the diversion. The potential for flow to get to the diversion will be decreased by the volume within the subsided extent of LW23 and LW26 which will then likely report to shallow alluvials and eventually seep to open cut or into underground workings from the subsidence pool.

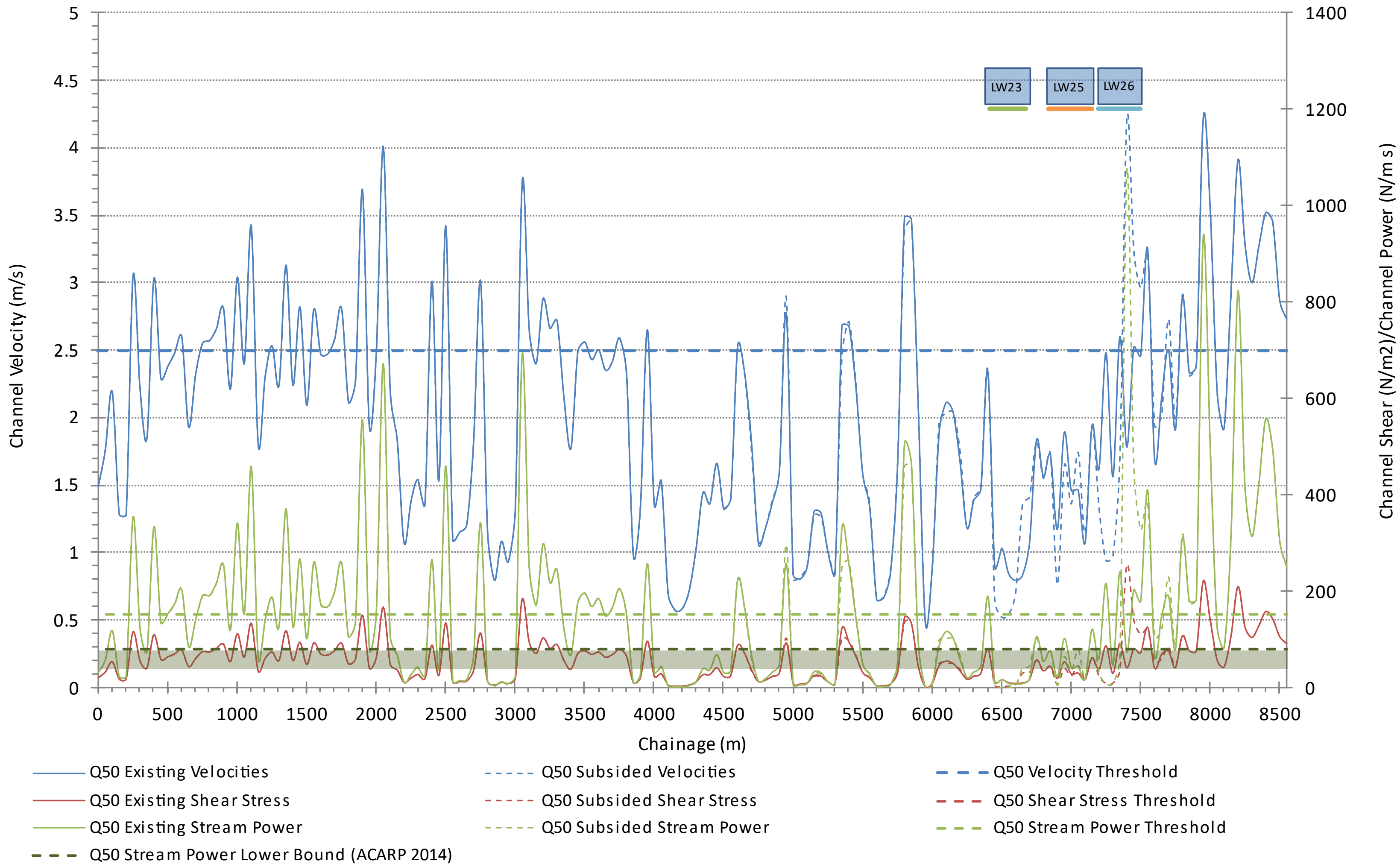


**Figure 3-11.** *Existing and post subsidence hydraulic conditions for 2% AEP*

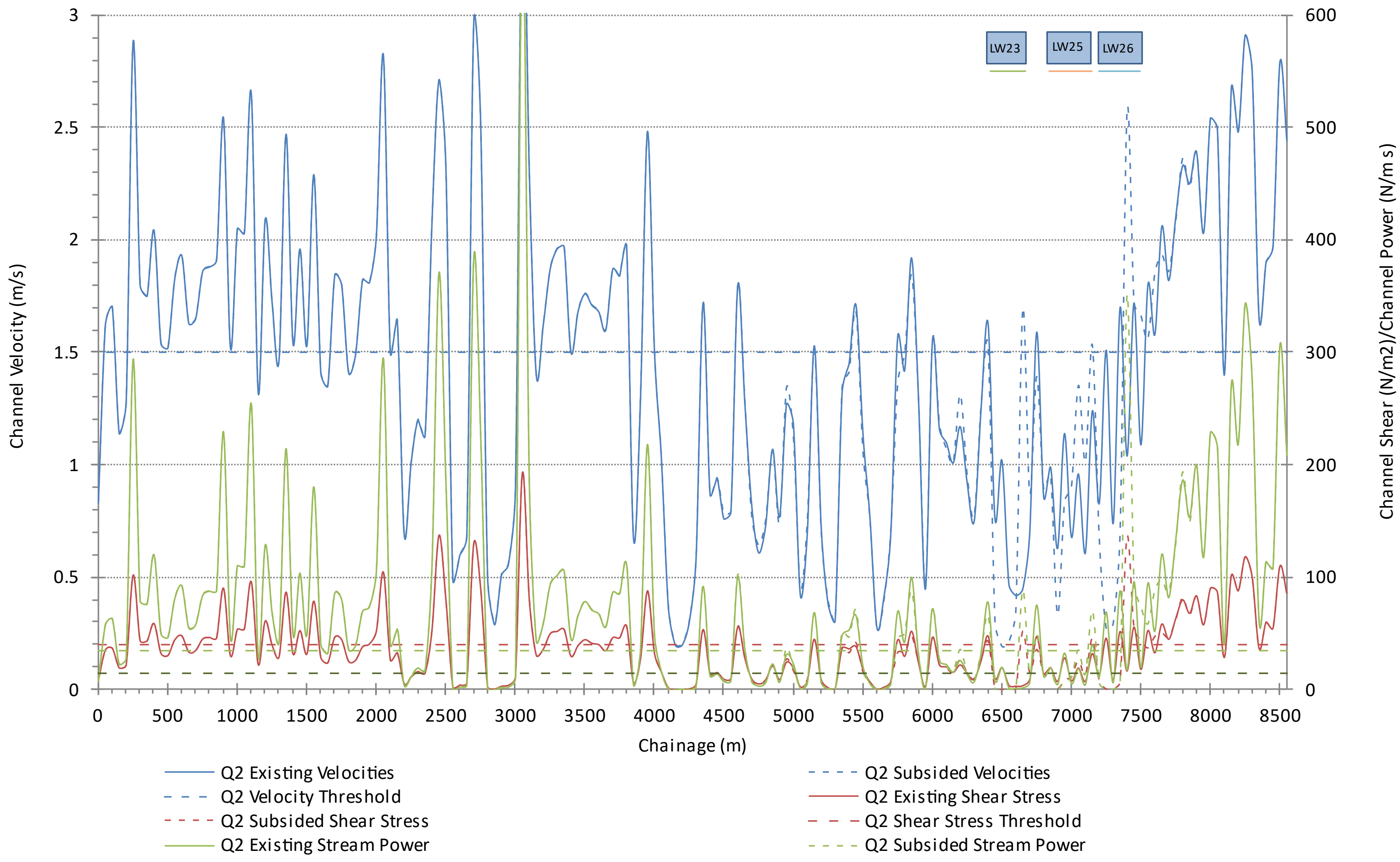


**Figure 3-12.** *Existing and post subsidence hydraulic conditions for 0.5EY Event (1 in 2 AEP)*

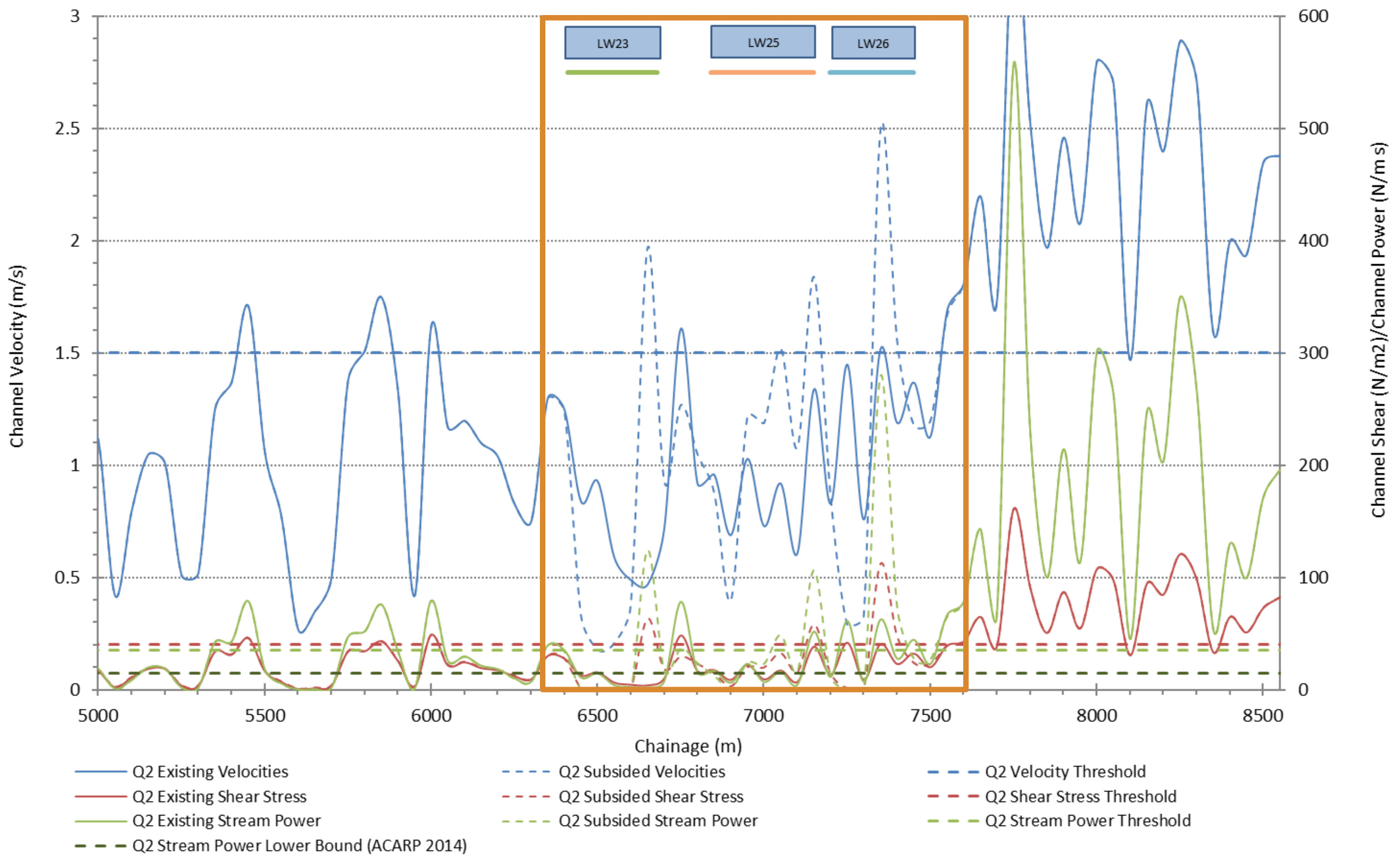


Figure 3-13. *Original Layout of LW 24-26:* *Existing and post subsidence hydraulic conditions for 0.5EY Event (1 in 2 AEP) zoomed in to area of interest*

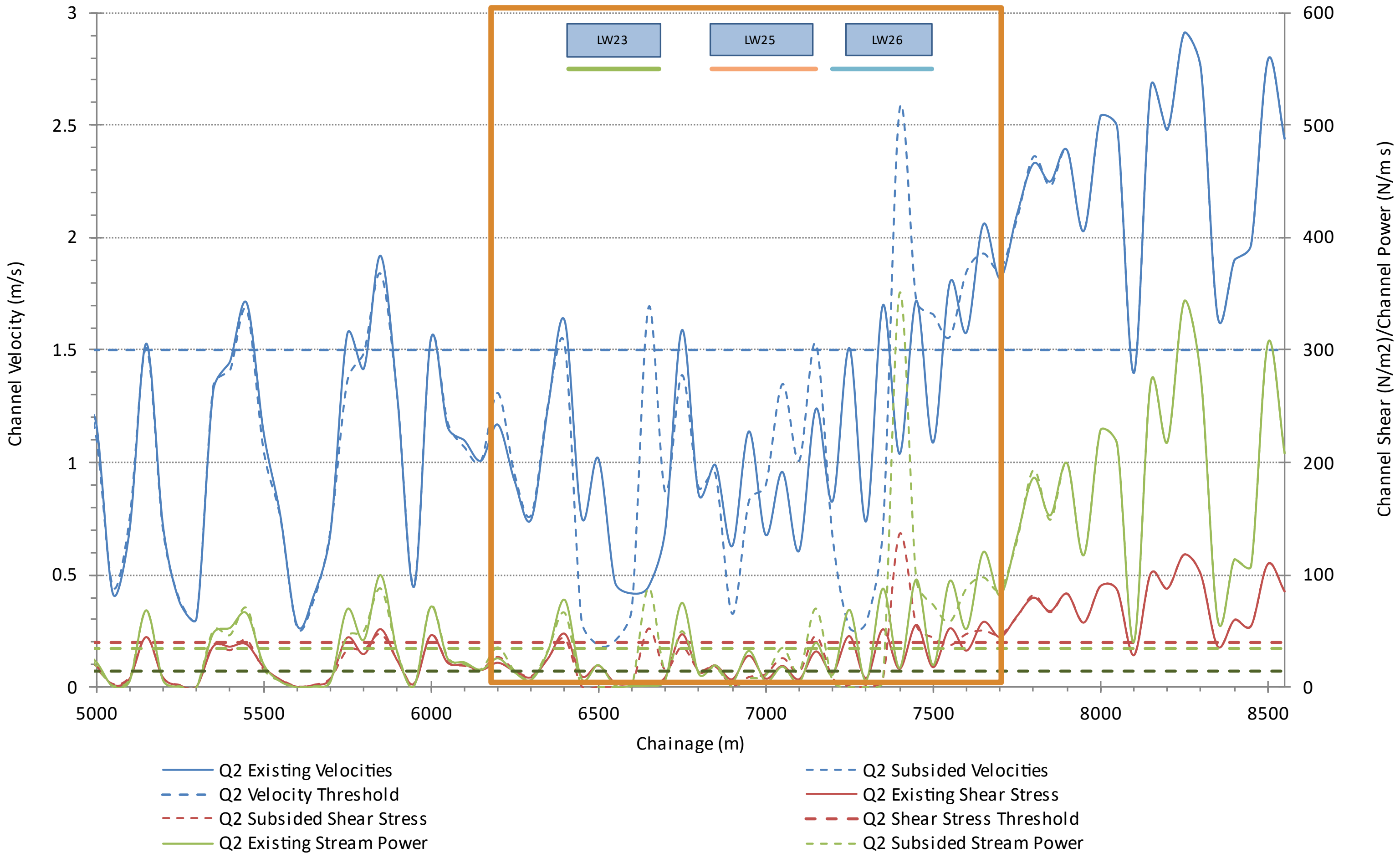


**Figure 3-14.** _Revised Mine Layout:_ Existing and post subsidence hydraulic conditions for 0.5EY Event (1 in 2 AEP) zoomed in to area of interest

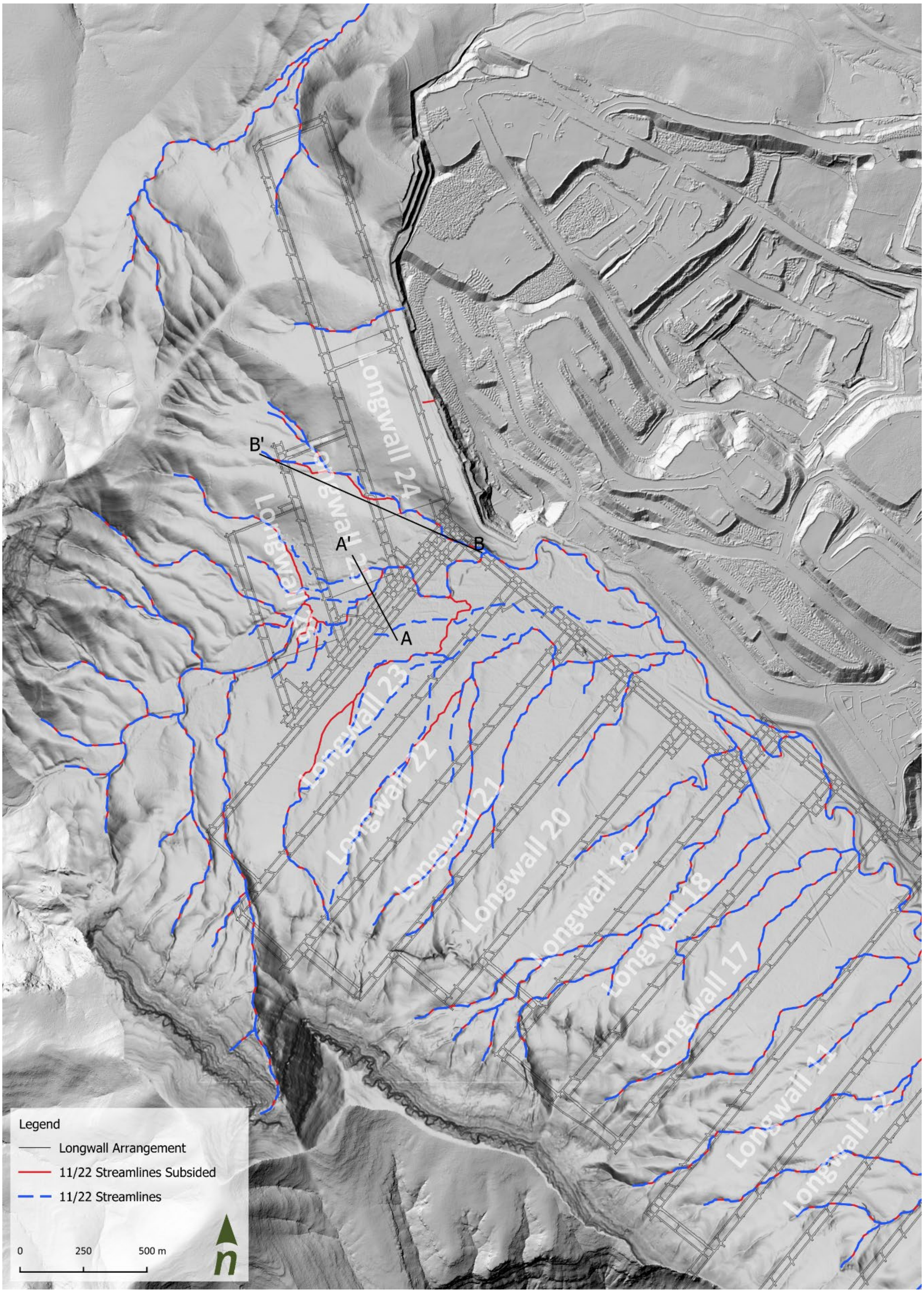


Figure 3-15. *Pre and post Subsidence flow paths (November 2022 LiDAR)*

**Figure 3-16**. *NWC low flow channel is likely to migrate to the north (right) to the base of hillslope/terrace in LW25*

### Northern Tributaries

The flow paths from the range to the north into North Wambo Creek are also likely to undergo change following subsidence of LW24 to LW26. This is due to the geometry of these flow paths relative to magnitude of subsidence.

The predicted changes in flow paths are presented in Figure 3-15. The streamlines shown are those predicted by the software CatchmentSIM using the existing and predicted subsidence digital terrain models (DTM). It is important to note that the predicted flow path changes are completely reliant on the accuracy of the DTM and subsidence predictions, particularly as changes in flow paths occur with relatively small changes in elevation.

The existing streamlines are shown as light blue dashed lines with the predicted post subsidence streamlines shown as solid red for full subsidence. Hence where a blue dashed streamline is shown on the map with no underlying red, that section of stream is abandoned post subsidence.

Over LW26, the major change for the existing streamlines following subsidence occur towards southern end of the panel where the subsidence interacts with North Wambo Creek, an effect still seen with the updated LW26 layout. The flow path is predicted to shift slightly further to the south, directing more flow paths within LW26 instead of flowing to LW25. This will result in some slight shortening of this tributary which will increase the grade and therefore lead to possible instabilities.

The steepness of the northern tributaries has meant the subsidence in LW24-26 hasn't resulted in significant changes to the flow paths overall. When these flow paths meet North Wambo Creek there has been some migration to parallel flow paths typically within 50m of the baseline. However, given alluvial/colluvial valley fills are the dominant stream form, some incision in response to any steepening of grade across pillars is possible.

LW25 and LW26 retain some storm volume within the subsided panel within North Wambo Creek just upstream of the pillars. These pillar locations should be monitored as they may lead to increased erosion of the pillars within North Wambo Creek.

This assessment does not include an evaluation of whether or not seepage into the sands that are dominant in the sediments allow for seepage to reduce the occurrence of overtopping from these subsidence troughs. Based on observations, this is likely for smaller runoff events.

### Waterfall Creek

The impact of subsidence of the flow paths in the Waterfall Creek catchment is predicted to be minor with only small changes in alignment, typically less than 10m, towards the centre of the panel. The small impacts are primarily due to the relatively smaller extent of the panels within the catchment and due to their position in the steeper upper catchment. LW25 and LW26 do not interact with this catchment in the revised mine layout.

Where soil profiles are present, particularly those that are sodic, erosion response to steepened grade is likely.

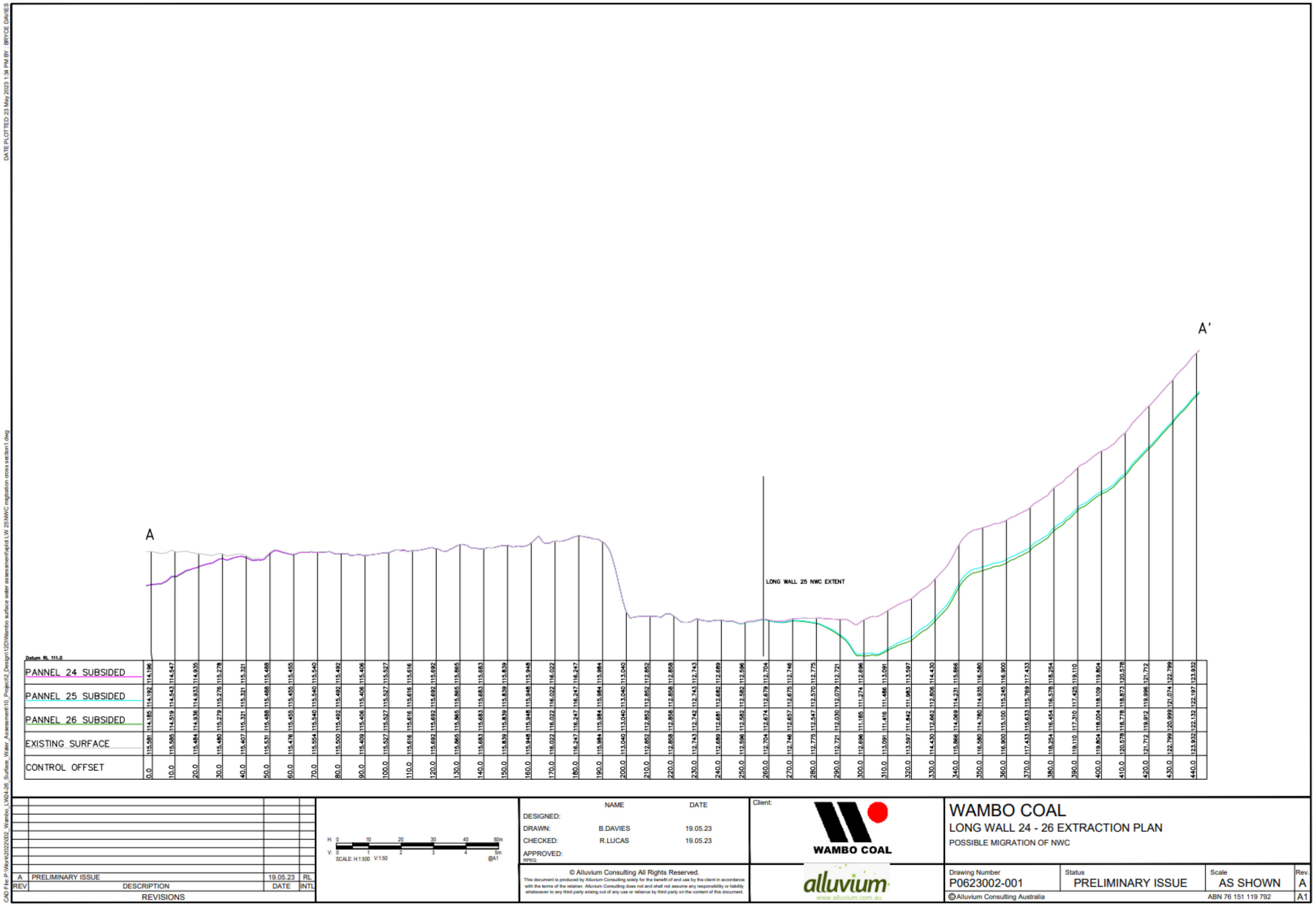


Figure 3-17. Section A-A' Likely North Wambo Creek migration

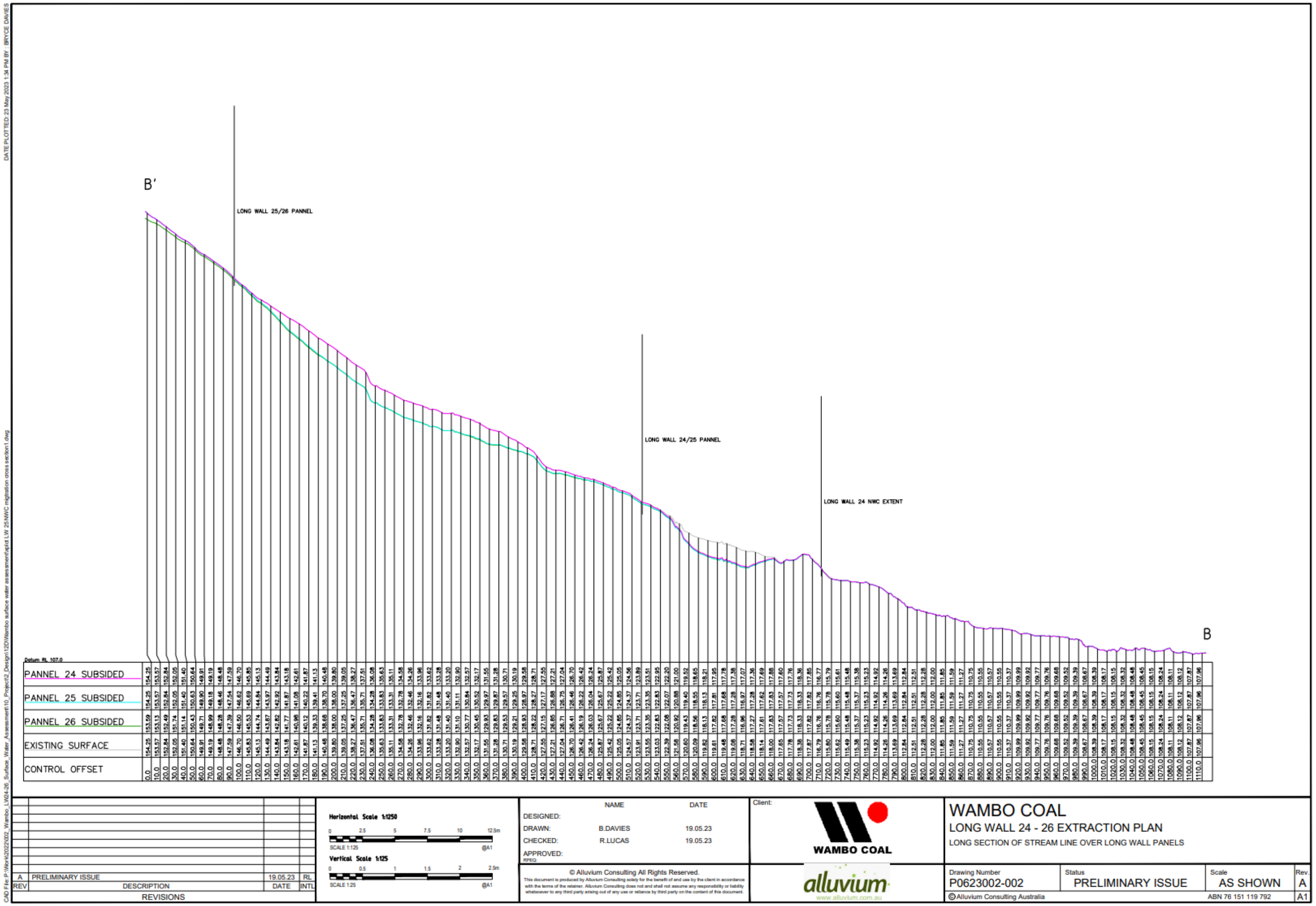


Figure 3-18. Section B-B' Stream Line Over Panels

## 3.3 3rd Order – Predicted Impacts to Water Quantity and Quality

**Changes to Water Quantity**

The impact of subsidence on flow rate and storage were assessed using 2D hydraulic modelling. The 2D model was used to determine how the subsidence from LW24 to 26 would impact on the stream and surface water flow passing through the site. The models were run longer than the duration of the storm events to determine the volume of water remaining ponded across the site.

The hydrology used in this project in North Wambo Creek built on the RORB hydrologic model developed to assess LW21-24 which was updated to meet the recent update to the 2019 Australian Rainfall and Runoff (ARR) (ARR, 2019).

Previous version of the hydrologic model built for this site in 2016, utilised 25 millimetres (mm) as the initial loss. Subsequent work in 2018 revised this with a higher loss of 65.9mm based on advice from 2017 and 2018 site visits. Following the 2016 ARR update the modelling for this report utilised the Australian Rainfall and Runoff Datahub's initial loss value of 50 mm and a continuing loss of 3.4mm. The continuing loss value was multiplied by a factor of 0.4 down to 1.36 millimetres per hour on advice provided by the ARR Data Hub. This advice suggested that flows estimated using the data hub losses were underpredicting design flows in NSW.

Table 3-3 shows the effect of these changes on the peak design flows across the four storm events.

**Table 3-3. RORB Peak Design Flows: 2016 estimates, 2018 estimates and 2022 estimates**

| | 2016 estimates | 2018 estimates | 2020 estimates |
|---|---|---|---|
| Upstream catchment ($km^2$) | 34 | 34 | 34 |
| Event | Peak Discharge ($m^3/s$) | Peak Discharge ($m^3/s$) | Peak Discharge ($m^3/s$) |
| 0.5EY | 43 | 10.5 | 21.6 |
| 2% AEP | 154 | 57.6 | 102.3 |
| 1% AEP | 180 | 75.4 | 119.6 |
| 0.1% AEP | 324 | 93 | 225.8 |

Note: AEP = Annual Exceedance Probability and EY = Exceedances per Year.

Subsidence of LW21-26 will increase in-channel storage by more than 12 times when compared to existing conditions (Table 3-4).

**Table 3-4. Residual Ponding Volume Estimates North Wambo Creek and Waterfall Creek (2% AEP)**

| Longwall | Existing ($m^3$) | Updated - Subsided ($m^3$) | Updated - Difference ($m^3$) | Previous Layout – Difference ($m^3$) |
|---|---|---|---|---|
| 21 | 645.2 | 645.5 | 0.2 | |
| 22 | 40.5 | 3,046.6 | 3,006.1 | |
| 23 | 134.9 | 5,326.0 | 5,191.2 | |
| 24* | 139.9 | 496.1 | 356.2 | 482.8 |
| 25* | 2.7 | 1,721.6 | 1,718.8 | 1,181.9 |
| 26* | 244.5 | 4,956.4 | 4,712.0 | 4,264.7 |
| TOTAL | 1,207.8 | 16,192.3 | 14,984.5 | |

* Denotes LW layout updated in this assessment

As well as increasing in-channel storage, the subsidence of LW21 to LW26 will result in ponding of water at the lower ends of the panels. The predicted ponding following subsidence is depicted in greater detail in Figure 3-19 and Figure 3-20, for the 2% AEP. It should be noted that the ponding due to subsidence occurs almost completely in North Wambo Creek. In Waterfall Creek no ponding is shown in the existing case and a ponding volume of 40m$^3$ in the subsided case in the 2% AEP.

While the impact to the amount of ponding is significant, these volumes are smaller in terms of the overall runoff volumes estimated in North Wambo Creek. Table 3-5 shows the largest change in volume is a reduction of 0.5EY event. The impact on volume decreases as the magnitude of the total design storm volume increases relative to the storage capacity of the subsided terrain. These estimates do not include seepage to the alluvial aquifer after an event.

Table 3-5. Predicted volume changes to North Wambo Creek stream flow post subsidence

| Event | Existing (m$^3$) | Subsided (m$^3$) after LW21-26 | Difference (%) |
|---|---|---|---|
| 0.5EY | 670,342 | 646,309 | -3.6% |
| 2% AEP | 1,218,112 | 1,202,587 | -1.3% |
| 1% AEP | 1,172,181 | 1,156,874 | -1.3% |
| 0.1% AEP | 3,250,392 | 3,234,552 | -0.5% |

Subsidence impacts on water quantity on Waterfall Creek were smaller again due to there being very little additional storage created by the subsidence in LW24 and that LW25 and LW26 no longer crosses the ridge into the Waterfall Creek catchment. Table 3-6 shows the overall impact on volumes.

Table 3-6. Predicted volume changes to Waterfall Creek stream flow post subsidence

| Event | Existing (m$^3$) | Subsided (m$^3$) after LW24-26 | Difference (%) |
|---|---|---|---|
| 0.5EY | 19,226 | 19,150 | -0.4% |
| 2% AEP | 31,536 | 31,443 | -0.3% |
| 1% AEP | 34,841 | 34,763 | -0.2% |
| 0.1% AEP | 51,535 | 51,468 | -0.1% |

The impacts of the subsidence on the design event hydrographs through North Wambo Creek are shown in Figure 3-21 to Figure 3-24. Figure 3-25 shows the volume impacts in the 2% AEP event.

It should be noted that this assessment has only considered the topographical impacts resulting from subsidence and has not assessed the potential for losses to the alluvial aquifer, losses to the underground workings or changes to topography by erosion/deposition or management intervention. It is likely that such losses will increase with ponding in these areas unless fine sediment decreases the hydraulic conductivity of the base of the pools or there is management intervention.

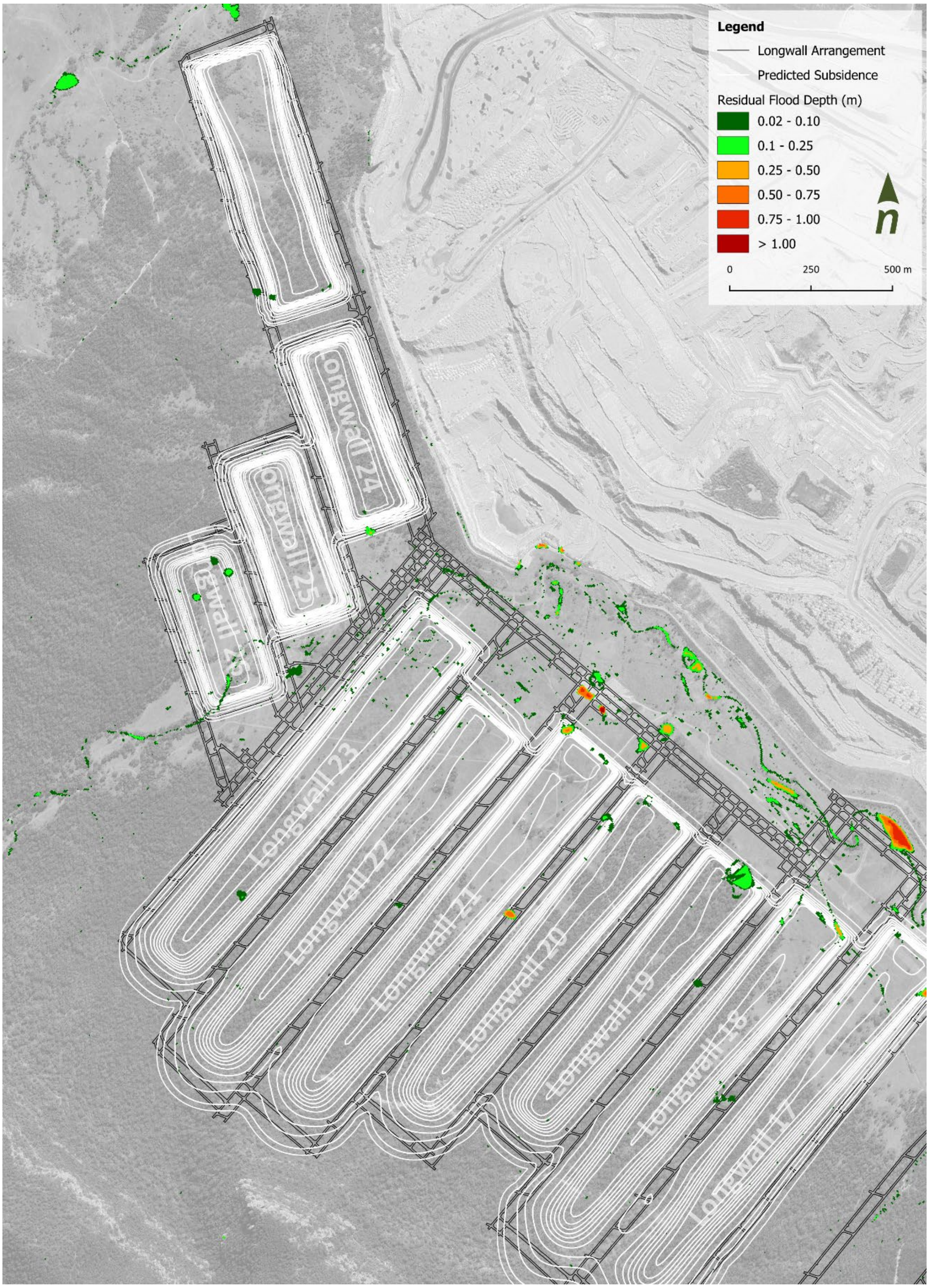


Figure 3-19. *2% AEP Residual Ponding – Existing Conditions*

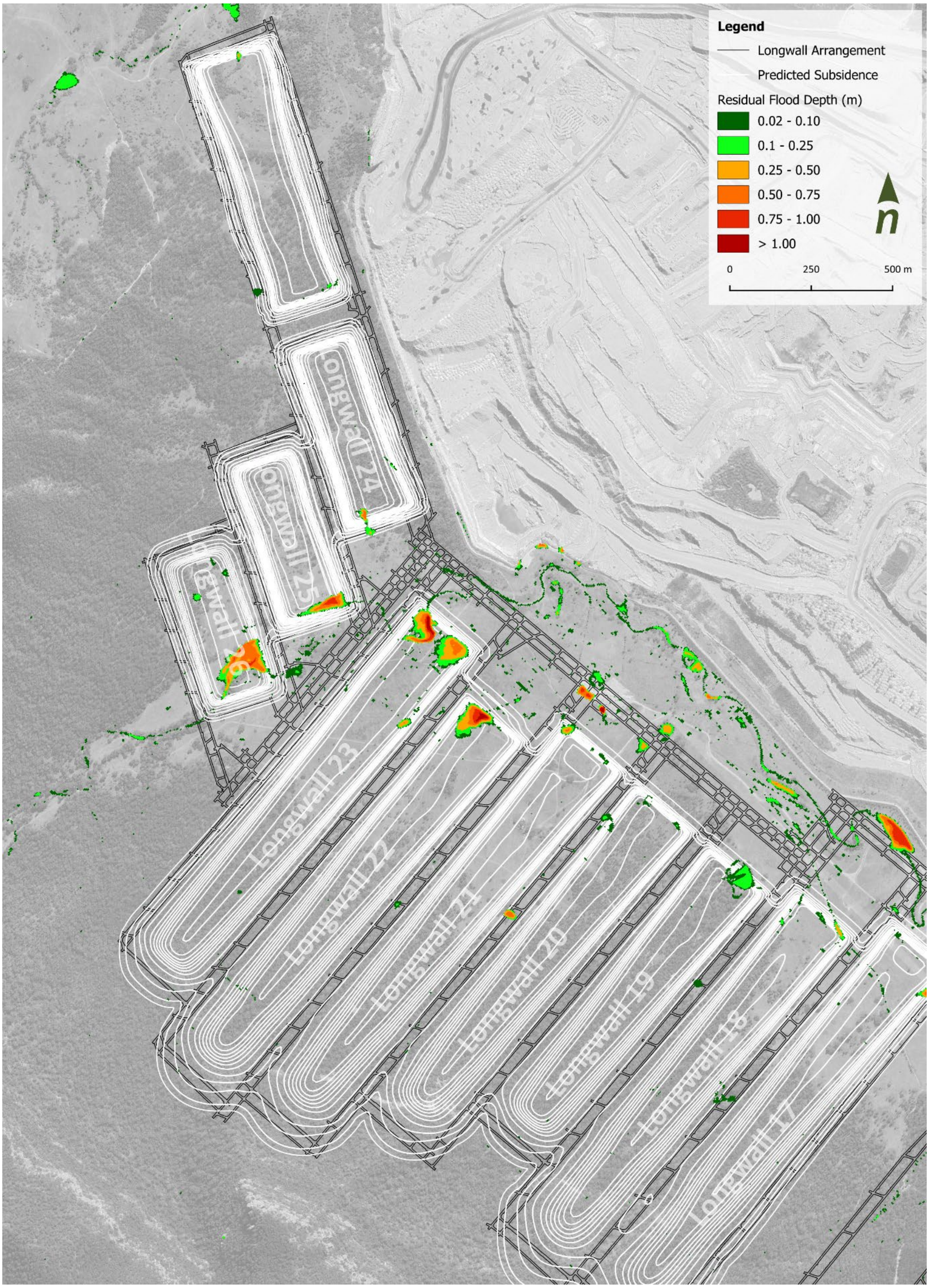


Figure 3-20. *2% AEP Residual Ponding – Longwall 24-26 Subsided Conditions*

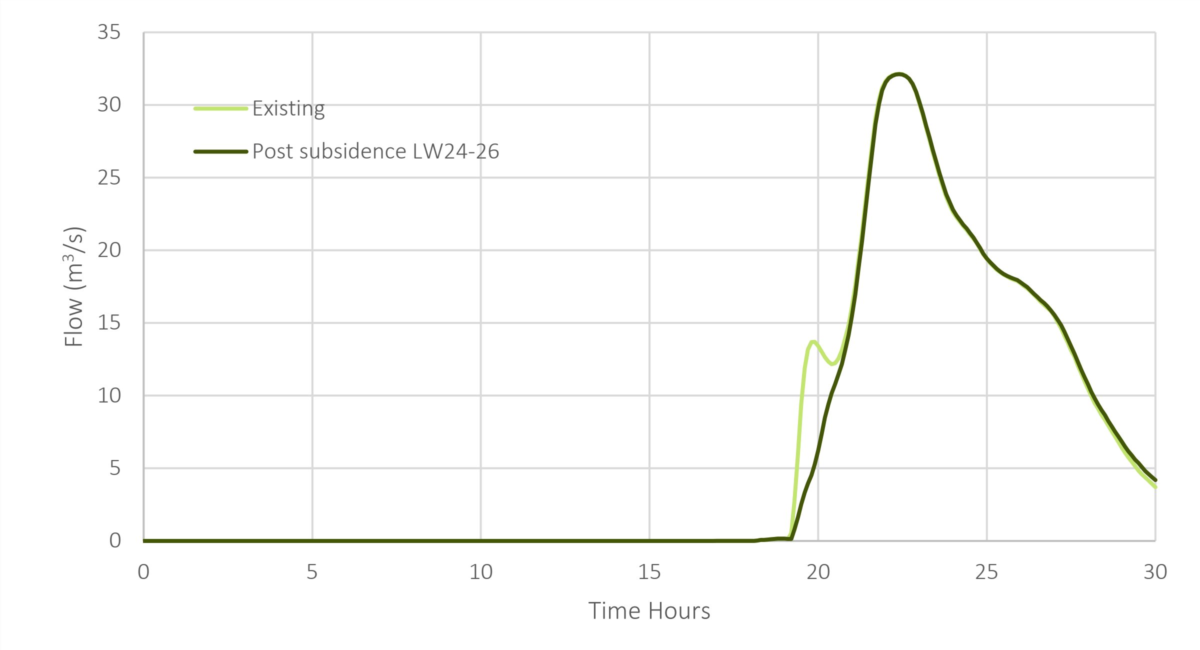


**Figure 3-21.** *North Wambo Creek Hydrograph at FM2 – Pre and post Subsidence (0.5EY Event)*

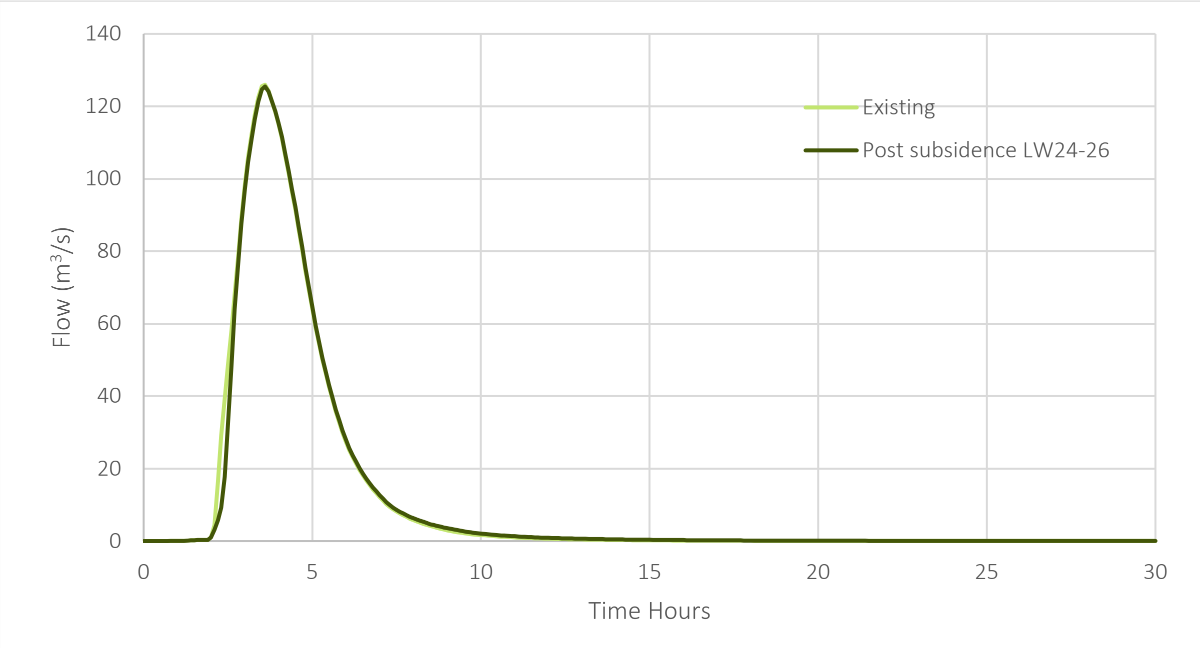


**Figure 3-22.** *North Wambo Creek Hydrograph at FM2 – Pre and post Subsidence (2% AEP Event)*

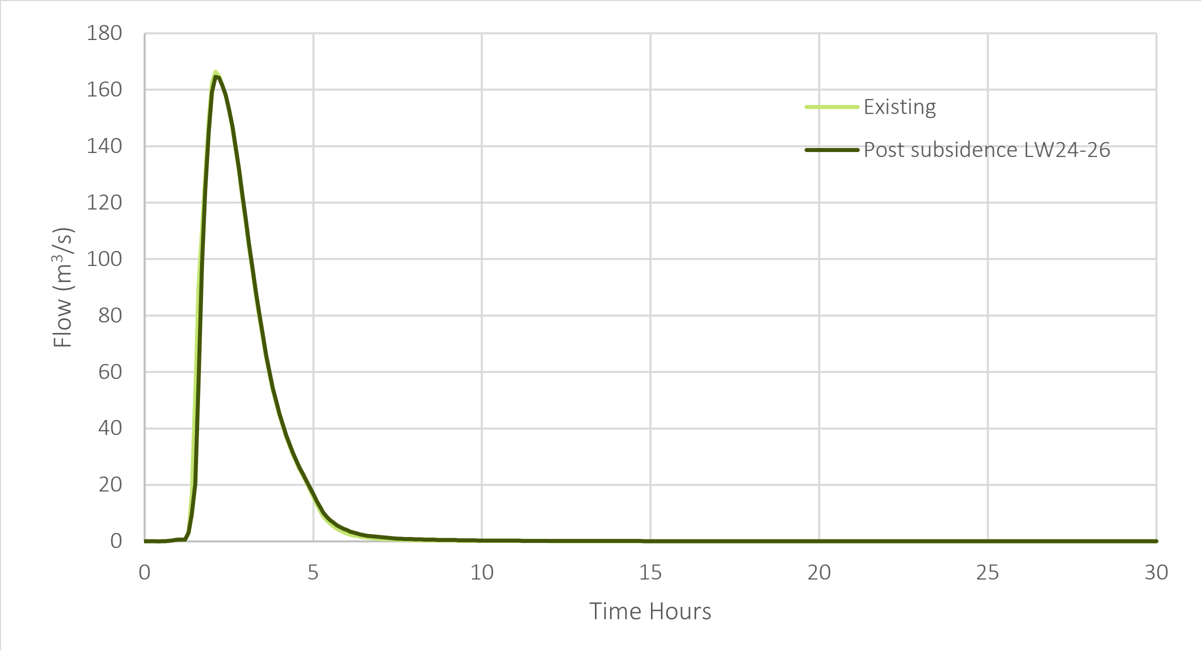


**Figure 3-23.** *North Wambo Creek Hydrograph at FM2 – Pre and post Subsidence (1% AEP Event)*

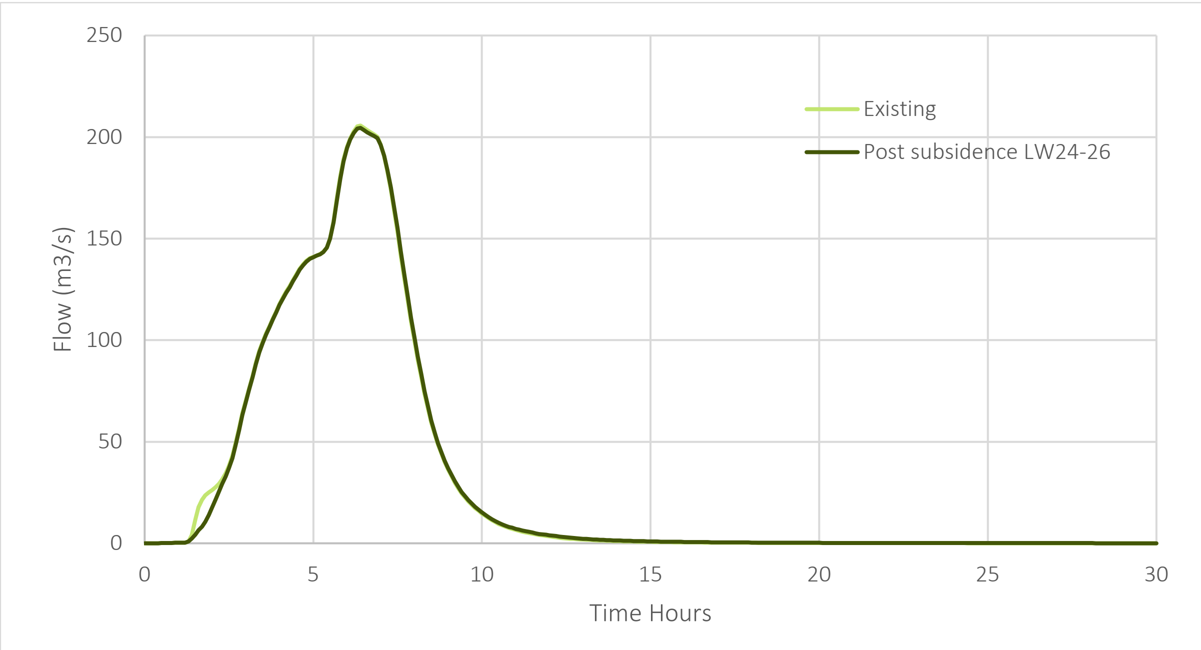


**Figure 3-24.** *North Wambo Creek Hydrograph at FM2 – Pre and post Subsidence (0.1% AEP Event)*

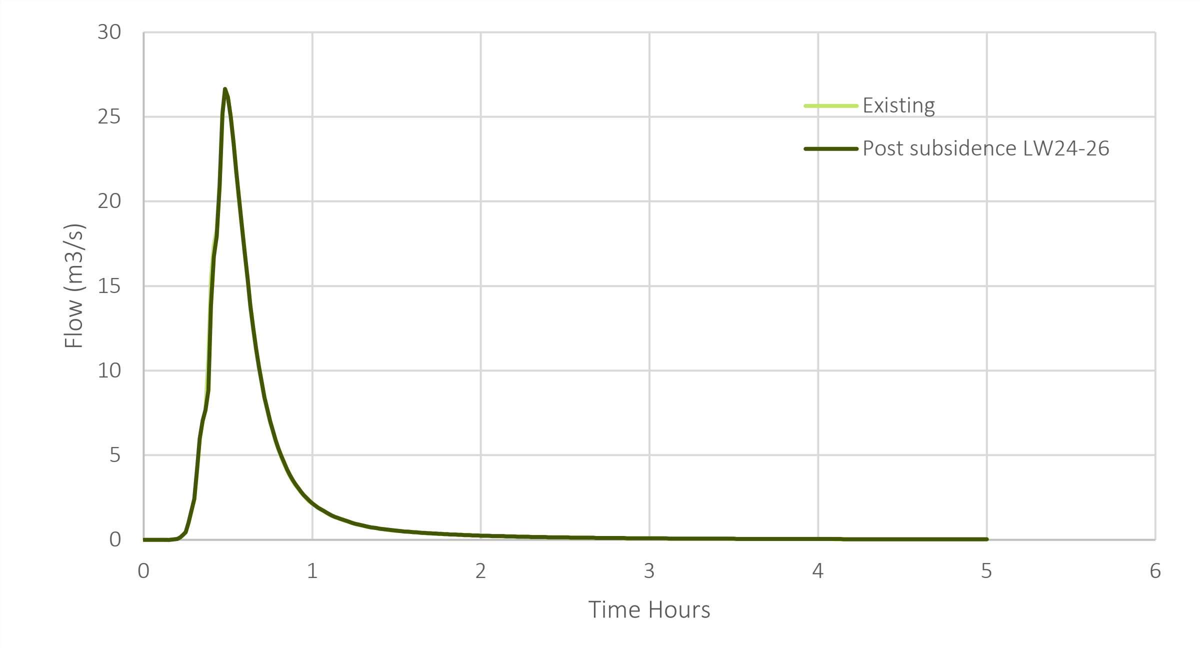


**Figure 3-25.** *Waterfall Creek Hydrograph at downstream of model extent – Pre and post Subsidence (2% AEP Event)*

#### Changes to Water Quality

An increase in suspended sediments in Waterfall Creek, North Wambo Creek and the NWCD is possible from increased erosion. Management measures can be put in place to mitigate the risk.

Due to a predicted decrease in flows (water quantity) through Waterfall Creek, North Wambo Creek and NWCD as a result of losses to alluvial aquifer, subsidence cracks and voids, it is possible that any negative impacts to water quality will be exacerbated as there will be less dilution occurring. However, reduced flows also mean reduced potential to transport sediments downstream of site, hence potential for off-site impacts to water quality is low.

## 3.4 4th Order – Predicted Impacts to Flora and Fauna

The consequences for ecology associated with impacts described above should be considered by WCPL's ecology specialists. The changes in behaviour of water in the landscape due to subsidence provide potential for both positive and negative impacts, depending on current ecological conditions and the extent of change. The primary change of note is alteration of flow paths in the western tributaries may alter the species composition along the zones that currently receive flows and similarly for those areas that will receive flows post subsidence. There is also the possibility of pools forming over LW21 to LW26 which may provide ecological habitat for some flora and fauna yet impact negatively on others.

# 4 Subsidence Management

Subsidence management involves monitoring the impacts of subsidence to identify issues or the need for mitigation activities. Monitoring involves establishing baseline data against which future monitoring can be compared. Monitoring of waterways intersected by the panels extends upstream and downstream of the mine footprint to determine if observed changes are the result of subsidence or other factors. The monitoring program implemented at North Wambo Creek is described below.

## 4.1 Monitoring and Evaluation

As part of the Extraction Plan for LW21 to 24 it was identified that up until 2016 the monitoring activities undertaken across NWCD, North Wambo Creek and South Bates underground mine subsidence area included:

- Streamflow monitoring
- Surface water quality monitoring
- Groundwater monitoring
- Riparian monitoring
- Freshwater Macroinvertebrate monitoring
- Bed and bank stability monitoring
- Landscape Function Analysis (LFA)
- Floristic and habitat monitoring sites.

While the extent and complexity of the monitoring satisfied regulatory conditions regarding mining operations, the information was not synthesised to evaluate the impact of subsidence on waterways or the condition of NWCD in relation to reaches of North Wambo Creek, upstream and downstream.

It was recommended that existing monitoring be integrated into a diversion and subsidence monitoring program based upon the “Monitoring and Evaluation Program for Bowen Basin River Diversions” (ID&A, 2001, ACARP project C9068), which was undertaken for the Australian Coal Association Research Program (ACARP). This monitoring program is considered best practice for diversions in the Australian mining industry at present. Despite the methodology being developed for diversions it is readily applicable to monitoring subsidence of a watercourse and it has been successfully implemented at several longwall mines over the past decade (some of which also subside diversions).

Adopting a consistent monitoring methodology for the upstream and downstream reaches of North Wambo Creek, NWCD (Stages 2 and 3) and the subsided reach, meant the results were comparable and able to provide an overall perspective on the creek’s response to subsidence and overall performance in relation to relinquishment in the longer term.

The current monitoring program implemented and developed as part of the Extraction Plans for LW21 to LW24 encompasses the entire diversion and all current and past longwalls, including the extents of the NWCD over LW17 to LW24. Now that mining is extending to LW24 to LW26, additional monitoring points are included on the pillar zones of LW25/26 (U1A – upstream 1A) and LW24 (U2A – upstream 2A) as well as additional points on flow paths entering Waterfall Creek where they will be affected by subsidence. Four new monitoring bores upstream of the predicted mining impact reach have also been installed.

A Baseflow Separation Analysis for North Wambo Creek (Alluvium, 2020) identified a data gap in the existing surface flow measuring system. This could be enhanced by the installation of rainfall gauges at the flow monitoring stations in the upper catchment to provide detailed data on precipitation depth and intensity. Evaluation of data now being collected is recommended to more accurately inform realistic performance criteria for NWCD.

## 4.2 Typical Monitoring Program Components

A typical monitoring package from baseline to approvals relinquishment comprises four components as shown in Table 4-1.

Table 4-1. Subsidence and diversion monitoring package components

| Monitoring components | Objective | Status |
|---|---|---|
| 1: Baseline monitoring | To establish a baseline data set that can be used for tracking condition trajectory. | The diversion is already constructed, as such the first-round operations monitoring (stage 3 below) would establish the baseline. Baseline monitoring extended upstream of LW24-LW26 prior to mining of those panels. |
| 2: Construction / rehabilitation monitoring | Technical overview of construction and documentation of as constructed works including any amendments from design (new or rehabilitation). | The diversion is already constructed, as such the first-round operations monitoring (stage 3 below) would establish the baseline. |
| 3: Operations monitoring | To assess the performance of the NWCD and North Wambo Creek following subsidence to maintain or improve channel condition and reduce risk to mining infrastructure and the environment. | First round completed by Alluvium in November 2017, continued annually since. |
| 4: Relinquishment monitoring | To demonstrate North Wambo Creek through the area of subsidence and the NWCD is operating as a waterway in equilibrium with and not adversely impacting on adjoining reaches. | To be completed following relinquishment of mine. |

## 4.3 The Monitoring Program

In 2020 Alluvium began implementation of the monitoring program that was recommended as part of the previous extraction plan for LW21 to LW24 by completing baseline monitoring.

### Baseline Monitoring

The baseline data provides a reference to evaluate the condition of all reaches of North Wambo Creek over time.

As the NWCD is already constructed, the first round of operations monitoring completed in 2017 established the baseline and considered:

- Index of Diversion Condition (IDC) (including establishment of reaches and monitoring points) collected in the first round of operational monitoring
- Assessment of performance against risks identified in the Extraction Plan by expert fluvial geomorphic assessment
- Aerial photography analysis of changes relative to subsidence in the monitoring period
- Vegetation of geomorphic features in the monitoring area (referencing previous LFA monitoring)
- Analysis of flow event information for frequency and duration
- Analysis of long and cross-section survey for future comparison
- Summary of baseline condition and recommendations for mitigation of risks

A series of upstream, diversion and downstream monitoring transects were completed for North Wambo Creek and NWCD. The current monitoring sites for subsidence are shown in Figure 4-1.

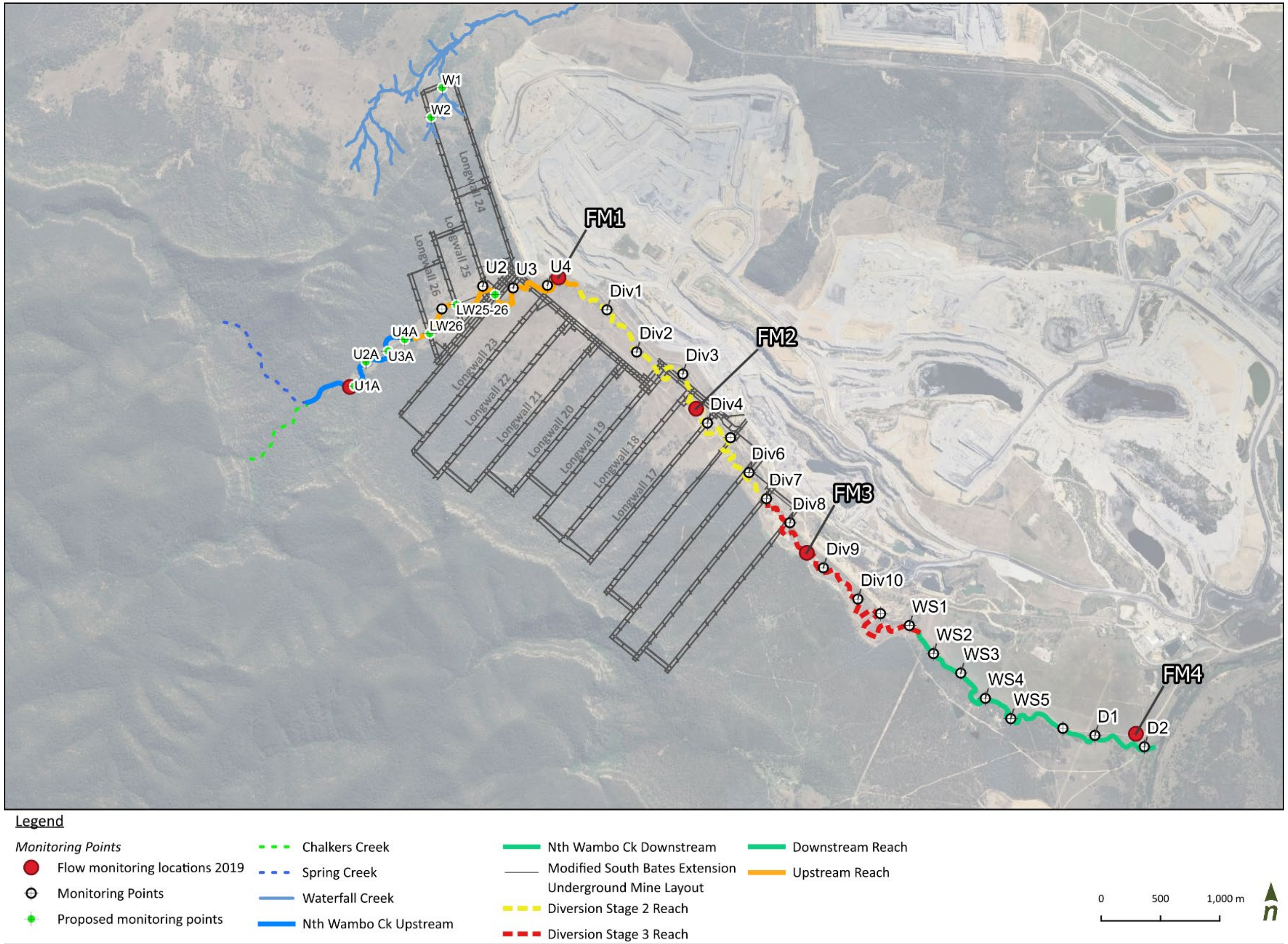


Figure 4-1. *Monitoring locations for Diversion and Subsidence Monitoring Program including proposed monitoring points*

### Operations Monitoring – Index of Diversion Condition Transects

The IDC provides a rapid assessment of the diversion and adjoining reaches of interest along the watercourse(s) and is designed to flag potential management issues rather than provide a detailed scientific assessment of the waterway. It is an integrated suite of indicators that measures the geomorphic and riparian condition of a diversion (Geomorphic Index and Riparian Index, respectively) and its upstream and downstream reaches. Observations are recorded at monitoring points, spaced at regular intervals, within each reach to determine an average score for the reach. To provide a consistent approach at each monitoring point, observations are recorded within a limited area known as a transect. IDC monitoring locations are established in Wambo's Surface Water Monitoring Program.

For details on the most recent round of monitoring at Wambo refer *North Wambo Creek Diversion Operations Monitoring 2023* (Alluvium, 2024).

### Operations Monitoring – Hydrology

Analysis of 2022 rainfall and flow data from the monitoring stations across the site (Figure 4-1), provides context for possible changes in the system. In 2022 there were two large flow events in March and July, observable at all monitoring stations, that could have influenced any changes observed. For each monitoring station there is a backup (BU) station in place, it is assumed they are in place in the same or similar locations to the primary sensor. Peak theoretical flows in North Wambo Creek ranged from 22 cubic metres per second ($m^3/s$) to $120m^3/s$ at most monitoring stations, however the peak flows at FM4 and FM4BU are more than five times larger (Table 4-2). For the March event both the primary and backup (BU) station recorded these unusually high flows and in the July event, the backup recorded a flow of $9{,}200m^3/s$ which was far higher than any other flow recorded. This could possibly be explained by the location of the FM4 and FM4BU stations as they are near the confluence of North Wambo Creek and Wollombi Brook, which is a larger watercourse to the east of the site. Because of this, the stations could have been influenced by the tailwater from Wollombi Brook which could inflate the height and therefore the flow recordings at the gauge.

The flows recorded at the stations along the diversion, namely FM2BU, FM3 and FM3BU, are at the most risk of being affected by subsidence and cracking. These stations could experience lower flows than expected, especially during low rainfall periods due to the 1$^{st}$ order effects of subsidence detailed in Section 3.1.

**Table 4-2. Peak theoretical flows for March and July flow events**

| Station | Peak Flow – March Event ($m^3/s$) | Peak Flow – July Event ($m^3/s$) |
|---|---|---|
| USFM1 | 56 | 30 |
| FM1 | 110 | 120 |
| FM2BU | 59 | 52 |
| FM3 | 22 | 22 |
| FM3BU | 22 | 22 |
| FM4 | 660 | - |
| FM4BU | 680 | 9,200 |

*Note: data from FM1BU and FM2 was unavailable for 2022. FM4 data was missing from June to October hence the absence of any July event data.

The total rainfall for 2022 was 1,192.6mm, almost half of which fell within the months of March and July, which is 491.8mm higher than the annual mean of 700.8mm. The monthly rainfall totals for 2022 are generally similar to the historic total monthly rainfall averages (Figure 4-2) apart from the months of March and July where the site experienced unusually high rainfall (historic data taken from the Bureau of Meteorology at Bulga). These high rainfall events could influence the condition at monitoring, encourage higher levels of sediment transport or cause channel erosion.

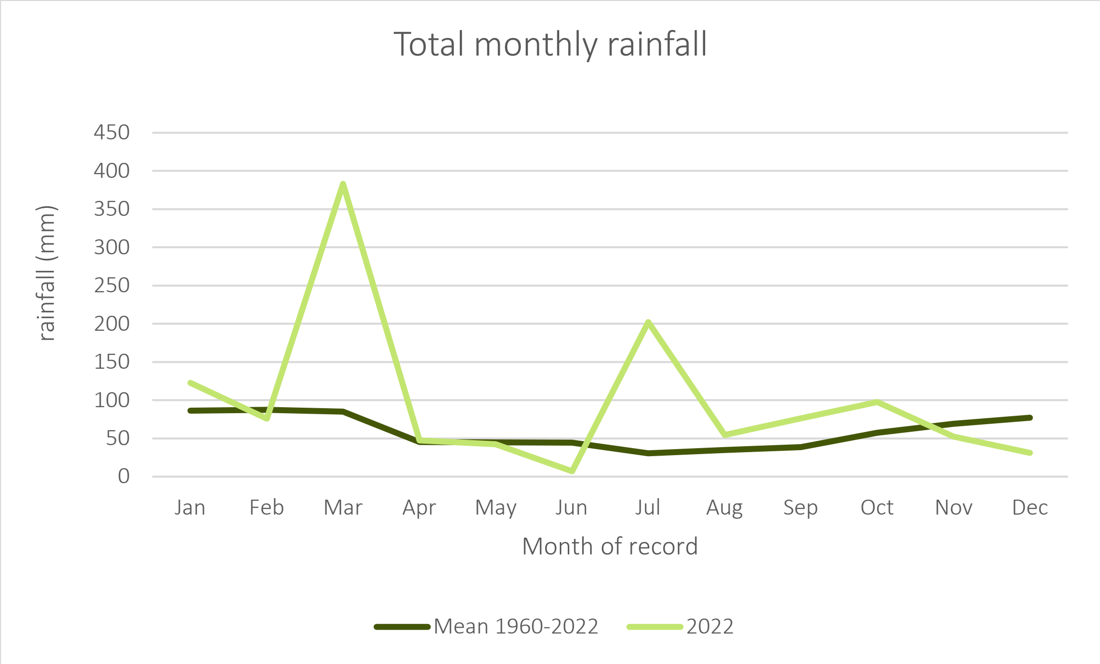


**Figure 4-2.** *Total monthly rainfall comparison*

## 4.4 Recommendations for Mitigation Works

Locations where erosion response is likely and a management response of monitor or mitigation for North Wambo Creek, Waterfall Creek and their tributaries associated with the subsidence of LW24 to LW26 are shown on Figure 4-3. Based on the predicted subsidence and landscape response, a number of mitigation measures are proposed. These measures are indicative and purely relate to potential geomorphic response associated with surface water flows. Any mitigation works will need to be coordinated with any works associated with alluvial groundwater management that may be proposed as part of meeting rehabilitation targets for NWCD and NWC through to its confluence with Wollombi Brook.

It is important to note that all the mitigation works mentioned are based on predicted subsidence modelling and final mitigation works will be dependent on actual subsidence.

### North Wambo Creek

Instabilities are likely to develop at the drop into LW26 (and upstream) (see Figure 4-4) that will require mitigation (potentially temporary), a grade control rock chute is recommended. This is consistent with the mitigation suggested under the previous LW24-26 layout, however the location of the rock chute is slightly upstream due to the update to LW26. Local regrading and horizontal migration of the channel bed through the other panels will not instigate a negative erosion response, no mitigation works are recommended for those. Any changes in condition will be captured in annual monitoring, allowing for timely response should any unforeseen adjustments occur.

### Northern Tributaries

It is recommended that the northern tributaries be monitored across pillar zones and an assessment for potential grade control mitigation works made shortly after subsidence occurs. The changes in flow paths now show that there will not be tributaries crossing from LW26 to LW25 owing to the update to LW26. The focus should be on the pillars between LW25 and LW24. The location of in situ bedrock relative to changes in grade induced by subsidence are important features as they provide resistance to incision. Actual subsidence conditions will need to be observed to inform requirements for built grade control.

Modelling indicates that the overland flow entry location of some tributaries may change. Mitigation measures will depend on the actual location and severity of the erosion and could range from revegetation to channel realignment and lengthening or the construction of a rock chute.

**Waterfall Creek**

Fluvial instability is unlikely in Waterfall Creek in response to subsidence given the prevalence of bedrock. The change in mine plan means geotechnical instability of the bedrock scarp from cracking is not likely as it won't be subsided. Bedrock cracking may occur in the bed of the Waterfall Creek tributary where it crosses into LW24. Comparison of the modelled streamlines shows that large changes are not anticipated for the predicted subsidence in LW24 (LW25 and LW26 no longer impact the Waterfall Creek catchment following the revised mine layout). Mitigation measures may be required where gullies cross pillars. Where needed the mitigation measures may involve a combination of vegetation management and grade control rock chutes.

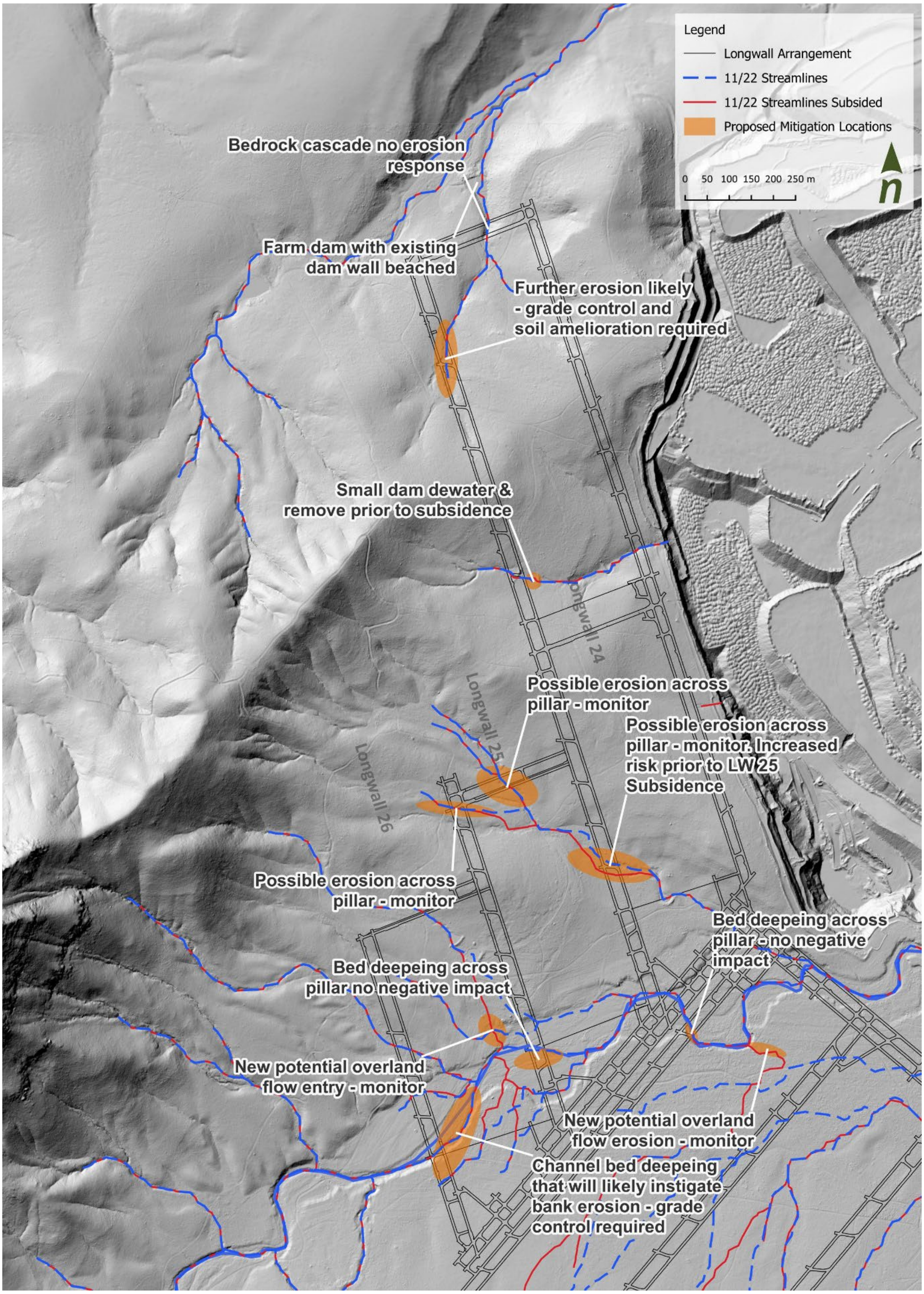


Figure 4-3. *Locations where mitigation measures are potentially required following subsidence*

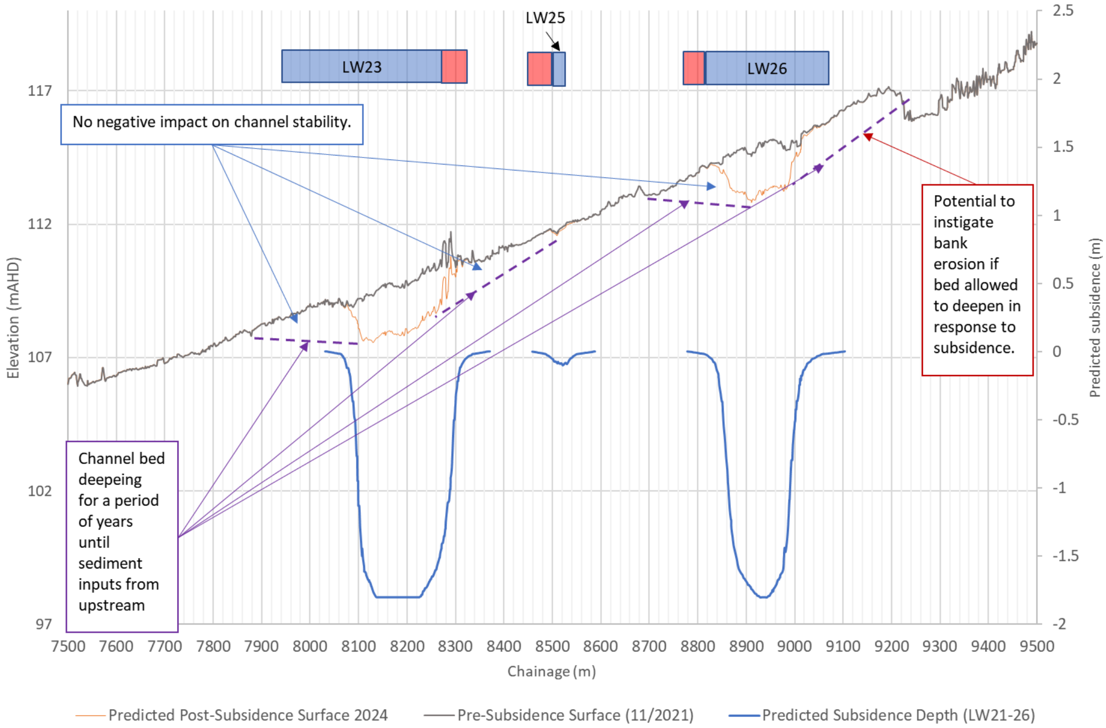


Figure 4-4. *Longitudinal profile of NWC following subsidence and likely bed level response in the short to medium term*

# 5 References


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# Attachment A. 1D Hydraulic Modelling Long Sections – North Wambo Creek Diversion

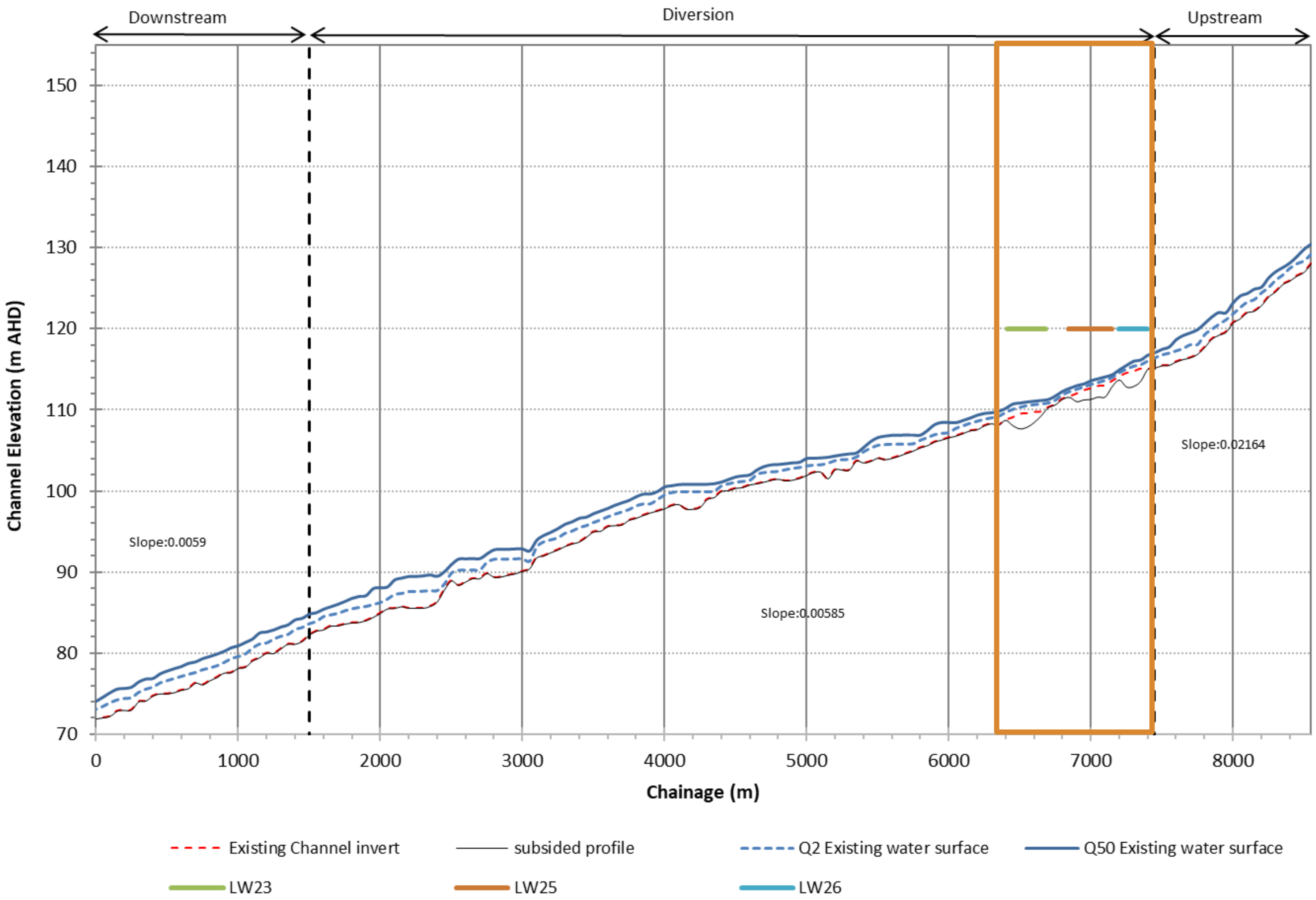
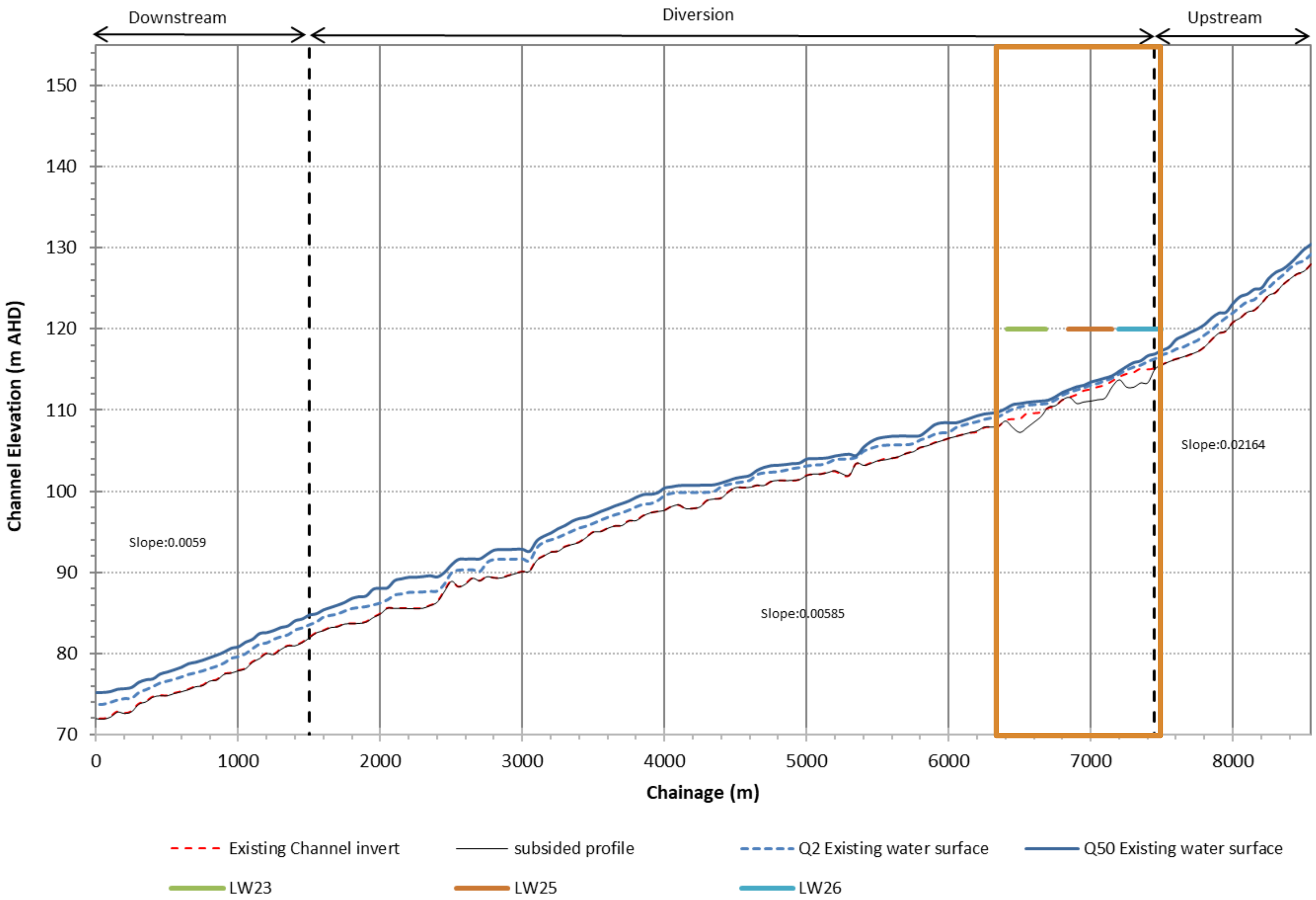



Figure A 1. North Wambo Creek – Pre and Post Subsidence bed levels and water surface elevations – 0.5EY and 2% AEP Event


Downstream
Diversion
Upstream
150
140
130
120
110
100
90
80
70
Channel Elevation (m AHD)
Slope:0.0059
Slope:0.00585
Slope:0.02164
0
1000
2000
3000
4000
5000
6000
7000
8000
Chainage (m)
Existing Channel invert
subsided profile
Q2 Existing water surface
Q50 Existing water surface
LW23
LW25
LW26

# Attachment B. Hydrologic Modelling Updates

# 1 Hydrologic Modelling of South Bates Extension Underground Mine LW21-26

Hydrologic modelling was undertaken to develop inflow for the hydraulic models developed for North Wambo Creek and Waterfall Creek. The hydraulic models were developed to assess the changes in flood behaviour in the area impacted by the planned longwall mining panels (LWs 21-26) at the Wambo Coal Mine. This includes the rearrangement of LW24-26 from their previously approved locations. The catchment, as defined for the study, covers an area of approximately 39.5km$^2$ and is shown in Figure B**1**-**1**

For North Wambo Creek, the hydrologic model used in this study is a RORB model and is based on the RORB model developed for the previous assessment of the South Bates Extension[1]. The hydrologic model has not been directly calibrated as no reliable long-term flow data was available on North Wambo Creek (short term data records have been used to further develop understanding of losses). Hydrologic outputs for the catchment have been derived at locations to facilitate the hydraulic modelling of existing mining operations.

In Waterfall Creek a direct rainfall approach has been adopted across the whole catchment area. The process of deriving IFDs has been described in this report but the application of the rainfall to the hydraulic model is covered in Attachment C discussing the hydraulic modelling.

For this study flow estimates have been generated for the 0.5EY, 2% AEP, 1% AEP and 0.1% AEP events.

## 1.1 RORB Model Description

The hydrologic modelling software used in this study is RORBWin version 6.45, a Windows version of the industry accepted RORB program (Laurenson et al 2007).

A RORB model represents the rainfall runoff process occurring in a catchment by:

- Conceptualising the catchment as a linked series of sub-catchments represented in the model by catchment storages and river reach storages;
- Applying rainfall excess (rainfall minus losses) to each sub-catchment (rainfalls are assumed to enter the sub-catchment at its centroid);
- Calculating the resulting runoff from each sub-catchment storage;
- Routing the runoff through the catchment system, combining flows at channel junctions; and
- Outputting flow hydrographs at points of interest in the catchment.

The model represents only the rapid flow or surface runoff component of stream flow, and the slow response or base flow component has not been included in the model.

Setting up the model comprises:

- Determining the catchment boundary and dividing the catchment into sub-catchments;
- Calculating the area of each sub-catchment;
- Placing model nodes at sub-catchment inflows and junctions;
- Placing reach storages between nodes; and
- Measuring the length of reach between adjacent nodes.

---

[1] Alluvium, (2020) *Surface Water Technical Report for South Bates Extension Underground Mine (Longwalls 21- 24)*

The RORB model requires four parameters to be specified which include $k_c$, m, initial loss (IL) and continuing loss (CL). The $k_c$ and m parameters are factors in the storage discharge relationship.

The storage discharge relationship for the reach storages in the model has the general form:

$$S = 3600k\,Q^m$$

Where:

S is the volume of water in storage ($m^3$);
k is related to travel time of a particular reach and the characteristics of the whole catchment;
Q is outflow rate from the reach storage; and

m is a dimensionless exponent representing the non-linearity of catchment response. m varies in the range 0.6 to 1.0 with a value of 1 representing a linear response. Many studies adopt a value of 0.8.

The relationship between k and $k_c$ is given by the equation:

$$k = k_{ri}\,k_c$$

Where:

$k_{ri}$ is the relative delay time of reach i; and
$k_c$ is an empirical coefficient applicable to the catchment and is a constant for the whole catchment.

The two rainfall loss parameters of initial loss and continuing loss are used in the generation of the rainfall excess hyetograph for the model. Initial loss is the rainfall at the start of a storm event which fills soil and groundwater storage, is intercepted by vegetation, or is lost by another process and does not contribute to runoff. Continuing loss is the ongoing portion of rainfall that falls after the initial loss that does not produce surface runoff. This could be due to deep soil storage, vegetation interception or evaporation. The loss parameters used in the model can be storm and catchment specific.

## 1.2 Catchment Delineation

The catchment delineation developed in the previous study has been carried over for this analysis. For inflows to the hydraulic model only the subcatchments upstream of the Spring Creek-Chalkers Creek confluence were required. These are considered to be sufficiently upstream of the area subject to the subsidence to warrant any review of the subcatchment delineation.

## 1.3 Model Parameters

Due to the lack of long-term stream flow data for the catchment, it was not possible to directly calibrate the hydrologic model. Therefore, it was necessary to investigate what options were available to develop the parameters required for modelling.

### Kleemola Regional Relationship Method

Australian Rainfall and Runoff (ARR) outlines, in section 3.6.2, the regional relationships developed to calculate $k_c$ for ungauged catchments. For eastern New South Wales, the relevant method was derived by Kleemola and takes the form:

$$k_c = 1.18*Area^{0.46}$$

Table B1-1, below, lists the Kleemola-derived $k_c$ value.

Table B1-1. Calculated Kleemola value

| Scenario | Catchment Area ($km^2$) | Kleemola $k_c$ Value* |
|---|---|---|
| Existing Conditions | 39.5 | 6.40 |

*Note, that the underlying assumption is that m = 0.8.

### Other modelling parameters

The initial loss-continuing loss (IL/CL) model was used. ARR 2019 provides regional estimates of loss parameters for whole storm loss and continuing losses. Initial losses were adjusted based on median pre-burst depths for events of varying AEP. The initial and continuing loss values for the 0.1% AEP were linearly interpolated using a log-log of losses versus AEP as described in Book 8 of ARR 16. The adopted loss values are presented in Table B1-2.

Table B1-2. Adopted model parameters for initial loss and continuing loss prior to pre-burst

| Parameter | 0.5EY to 0.5%AEP | 0.1% AEP |
|---|---|---|
| Initial Loss | 50 mm | 14.4 mm |
| Continuing Loss | 1.36 mm/hr* | 1.28 mm/hr |

* Note: For events up to the 1% AEP the data hub continuing loss of 3.4 mm/hr was multiplied by 0.4 as per recommendation for catchments in New South Wales where other catchment specific losses aren't available.

## 1.4 Design Rainfall

Design rainfall depths were generated for events up to the 0.1% AEP event for this study. The IFD table for the North Wambo Creek catchment is presented in Table B1-3 and the Waterfall Creek IFD is presented in Table B1-4. The design rainfalls were determined using the ARR method inbuilt in RORB (with site specific parameters determined from ARR (2019)).

Table B1-3. IFD Table for the North Wambo Creek catchment, total rainfall depth in mm (includes ARF)

| Event | 0.5EY | 2% AEP | 1% AEP | 0.1% AEP |
|---|---|---|---|---|
| 15 min | 11.5 | 23.9 | 27.1 | 37.9 |
| 30 min | 16.8 | 34.3 | 38.7 | 54.3 |
| 1 hour | 22.6 | 43.9 | 49.2 | 68.8 |
| 3 hours | 33.3 | 60.5 | 67 | 91.4 |
| 6 hours | 43 | 80.2 | 89.4 | 124.6 |
| 12 hours | 56.6 | 109.7 | 123.5 | 174 |
| 18 hours | 66.9 | 133.6 | 150.6 | 215.3 |
| 24 hours | 75.4 | 154.2 | 175.7 | 252.5 |
| 48 hours | 97.1 | 207.9 | 236.3 | 361.4 |

Table B1-4. IFD Table for the Waterfall Creek catchment, total rainfall depth in mm (includes ARF)

| Event | 0.5EY | 2% AEP | 1% AEP | 0.1% AEP |
|---|---|---|---|---|
| 15 min | 12.3 | 26.2 | 29.9 | 52 |
| 30 min | 17.7 | 36.8 | 41.7 | 69.5 |
| 1 hour | 23.3 | 46.4 | 52.1 | 84.3 |
| 3 hours | 33.7 | 62.6 | 69.6 | 110.1 |
| 6 hours | 42.7 | 80.9 | 90.5 | 136.4 |
| 12 hours | 55.1 | 108.2 | 122.3 | 178.5 |
| 18 hours | 63.8 | 129.6 | 146.9 | 212.6 |
| 24 hours | 70.9 | 147.5 | 168.2 | 241.7 |
| 48 hours | 89.1 | 194.4 | 221 | 331.7 |

### Temporal patterns

The temporal patterns were taken from the Datahub with the majority of data originating from the East Coast (South) region.

In Waterfall Creek the full set of temporal patterns were run TUFLOW model. From the processed outputs GIS techniques were used to determine the relevant temporal patterns for the area of interest.

For North Wambo Creek, the full set of temporal patterns were not run in the TUFLOW. Instead, the ensemble of temporal patterns was narrowed down to the most critical by the Storm Injector program. Storm Injector is a software product that can take a hydrologic model created in RORB and automatically create and analyse derivative versions of the model in accordance with ARR 2016.

The existing and diverted catchments of North Wambo creek catchment were analysed. Storm injector provided the critical durations and the temporal pattern that produced it. Table B1-5 summarises the AEP and temporal patterns selected for 2D hydrodynamic modelling.

Table B1-5. North Wambo Creek - AEP, duration and corresponding temporal patterns

| Durations (min) | Durations (hour) | AEP | | | |
|---|---|---|---|---|---|
| | | 0.5EY | 2% | 1% | 0.1% |
| 90 | 1.5 | | | 5 | |
| 180 | 3 | | 5 | | |
| 360 | 6 | | | | 1 |
| 1440 | 24 | 1 | | | |

## 1.5 RORB Model Output

The RORB model outputs for North Wambo Creek are presented in Table B1-6. The output locations are downstream of the predicted extent of subsidence from LW21-26 on North Wambo Creek. Note this is the located that was used to determine the critical storm duration but a different location to inflow point into the TUFLOW model (at the confluence of Spring Creek and Chalkers Creek). Downstream of the inflow point, direct rainfall is applied to the 2D model.

Note that the peak flow rates did not all coincide on the same duration storm event – overall the critical duration varied from as long as the 24 hour for the 0.5EY event to as short as the 1.5 hour for the 0.1%AEP event, depending on location within the catchment.

Table B1-6. Design flow estimates from RORB analysis

| | Downstream of LW-21-26 (Catchment 23) |
|---|---|
| Upstream catchment ($km^2$) | 28.8 |
| ARI/AEP | Peak Discharge ($m^3/s$) |
| 0.5EY | 29 |
| 2% | 113 |
| 1% | 143 |
| 0.1% | 230 |

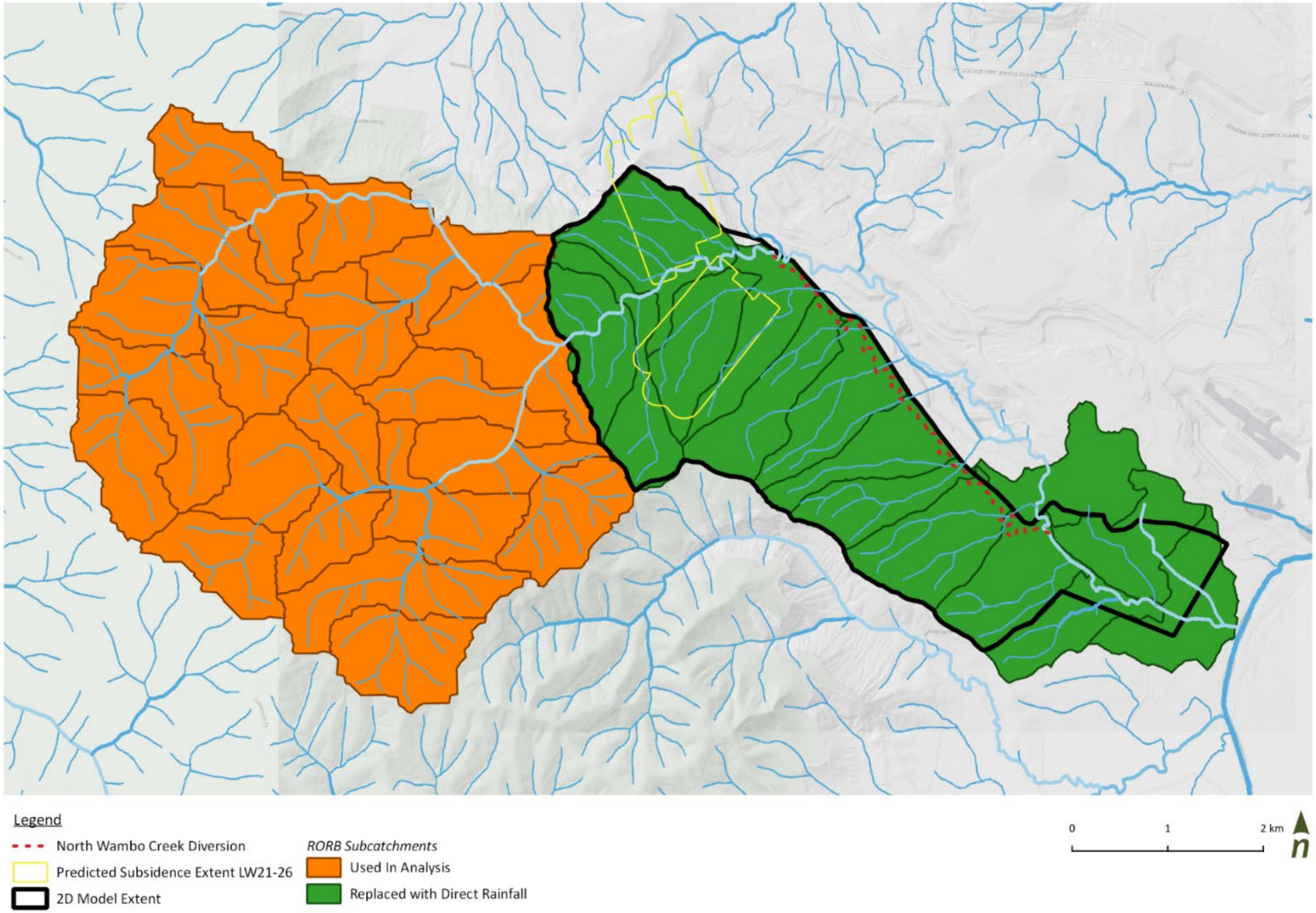



Figure B1-1. *RORB Model*

# Attachment C. 2D Hydraulic Modelling

# 1 Hydraulic Modelling of South Bates Extension Underground Mine LW21-26

Hydraulic modelling was undertaken to assess the changes in flood behaviour in the area impacted by the planned longwall mining panels (LWs 21-26) at the Wambo Coal Mine. This includes the rearrangement of LW24-26 from their previously approved locations.

## 1.1 Model Extent

A 2D hydraulic model of North Wambo Creek and Waterfall Creek catchments was developed in TUFLOW HPC (Build 2020-10-AC). The model has two separate 2D model domains; one for each watercourse.

The hydraulic model outfalls on North Wambo Creek, approximately 2km downstream of the North Wambo Creek diversion. The upstream model extent on North Wambo Creek is the confluence of Spring Creek and Chalkers Creek. In the Waterfall Creek model domain the entire catchment adjacent to the long walls has been modelled. The extent of the model is shown in Figure C1-1.

## 1.2 Topography

### LiDAR

Two LiDAR datasets were provided by Wambo Coal Pty Limited (WCPL). The limited metadata provided indicates the LiDAR was flown on the 15$^{th}$ of November 2021 and the 22$^{nd}$ of November 2022. The point data provided was triangulated into a TIN and exported to ASCII grid format with a 1m grid cell size for use in the TUFLOW model. The 2022 data takes precedence in the model with 2021 data being adopted where there is no coverage in the 2022 dataset.

Due to it being captured in November 2022 this dataset is considered to have captured actual subsidence up to the completion of LW21. Subsidence from LW22-26 will be represented in this study using the subsidence predictions provided.

### Subsidence Predictions

Updated subsidence predictions were provided by WCPL in March of 2023. The subsidence predictions were provided and DEM files covering the extents from LW17 to LW26 which covers the rearrangement of LW24-26.

In the model the updated subsidence predictions were clipped to only include LW22 to LW26 because the LiDAR has captured actual subsidence up to this point. Subsidence predictions along this cut line were modified slightly to prevent a sharp step in the topography which was considered unrealistic.

A final fully subsided surface was created by subtracting the predicted subsidence depths from the LiDAR discussed above.

## 1.3 Model Parameters

Both 2D domains adopted a 4m grid cell size. Running in TUFLOW HPC, the model has an adaptive timestep.

## 1.4 Roughness

Manning's n roughness coefficient for the model was set by assessing aerial imagery and site photographs. Depth-varying coefficients have been used where higher coefficients are adopted up to a depth of 30mm which transition to smaller coefficients at a depth of 100mm. Table C1-1 shows the depth-varying roughness coefficients applied in the North Wambo Creek and Waterfall Creek models.

Table C1-1. Manning's 'n' Coefficients

| Depth 1 | n1 | Depth 2 | n2 | Description |
|---|---|---|---|---|
| - | 0.02 | - | - | Water bodies |
| 0.03 | 0.03 | 0.1 | 0.03 | Unpaved roads |
| 0.03 | 0.03 | 0.1 | 0.035 | Waterway minimal vegetation |
| 0.03 | 0.03 | 0.1 | 0.06 | Moderate dense vegetation |
| 0.03 | 0.03 | 0.1 | 0.1 | Dense Vegetation |
| 0.03 | 0.03 | 0.1 | 0.04 | General Topography |

## 1.5 Boundary Conditions

**North Wambo Creek**

Inflow hydrographs were applied to the upstream model boundary and the confluence between Spring Creek and Chalkers Creek as shown in Figure C1-1. On North Wambo Creek rainfall was applied downstream of this confluence using a 2d_rf rainfall boundary. This approach allows for a better representation of the surface water flow paths on the mining panels allows for simple quantification of the impacts to these flow paths due to subsidence.

Two downstream boundaries were adopted on North Wambo Creek; one stage-discharge (HQ) boundary on the main channel of North Wambo Creek and a separate stage-discharge (HQ) boundary for the overbank flow on the left bank of North Wambo Creek.

**Waterfall Creek**

On Waterfall Creek rainfall was applied to the entire model domain using a 2d_rf rainfall boundary as shown in Figure C1-1. The downstream boundary applied in this domain is a stage-discharge (HQ) boundary applied using a 2d_bc layer.

## 1.6 Limitations

It should be noted that the TUFLOW does not simulate erosion and sediment transport. Dam and other embankment failure scenarios have not been modelled in this assessment and therefore results are based on stable topography over the full length of the modelled events – which is unlikely to occur during a large magnitude event.

It should also be noted that this assessment has focussed solely on the impact that the topographical changes resulting from subsidence have had on storage and flow in North Wambo Creek and Waterfall Creek. The assessment does not consider the potential for losses to cracking in the subsided surface in the vicinity of the longwall panels.

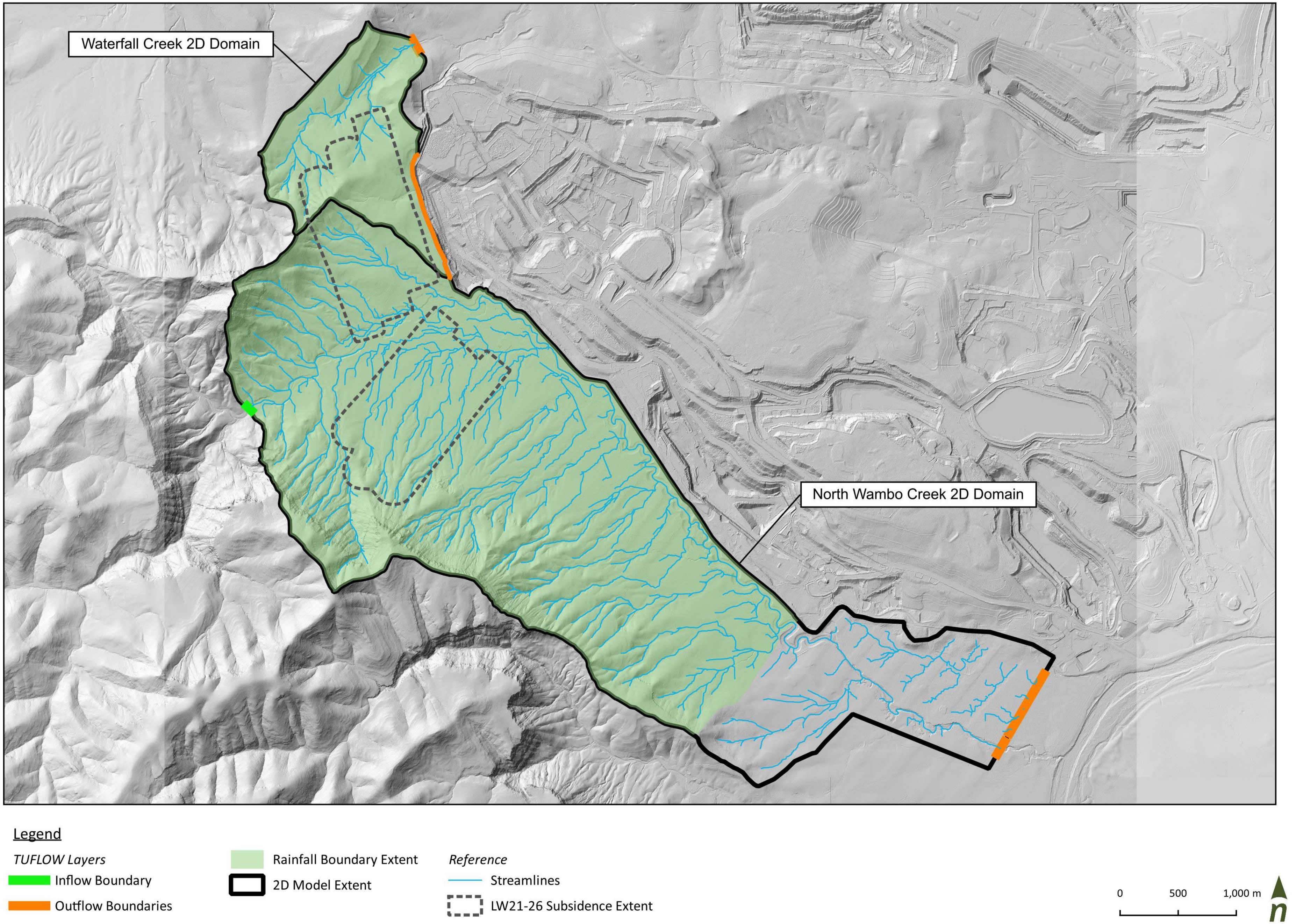


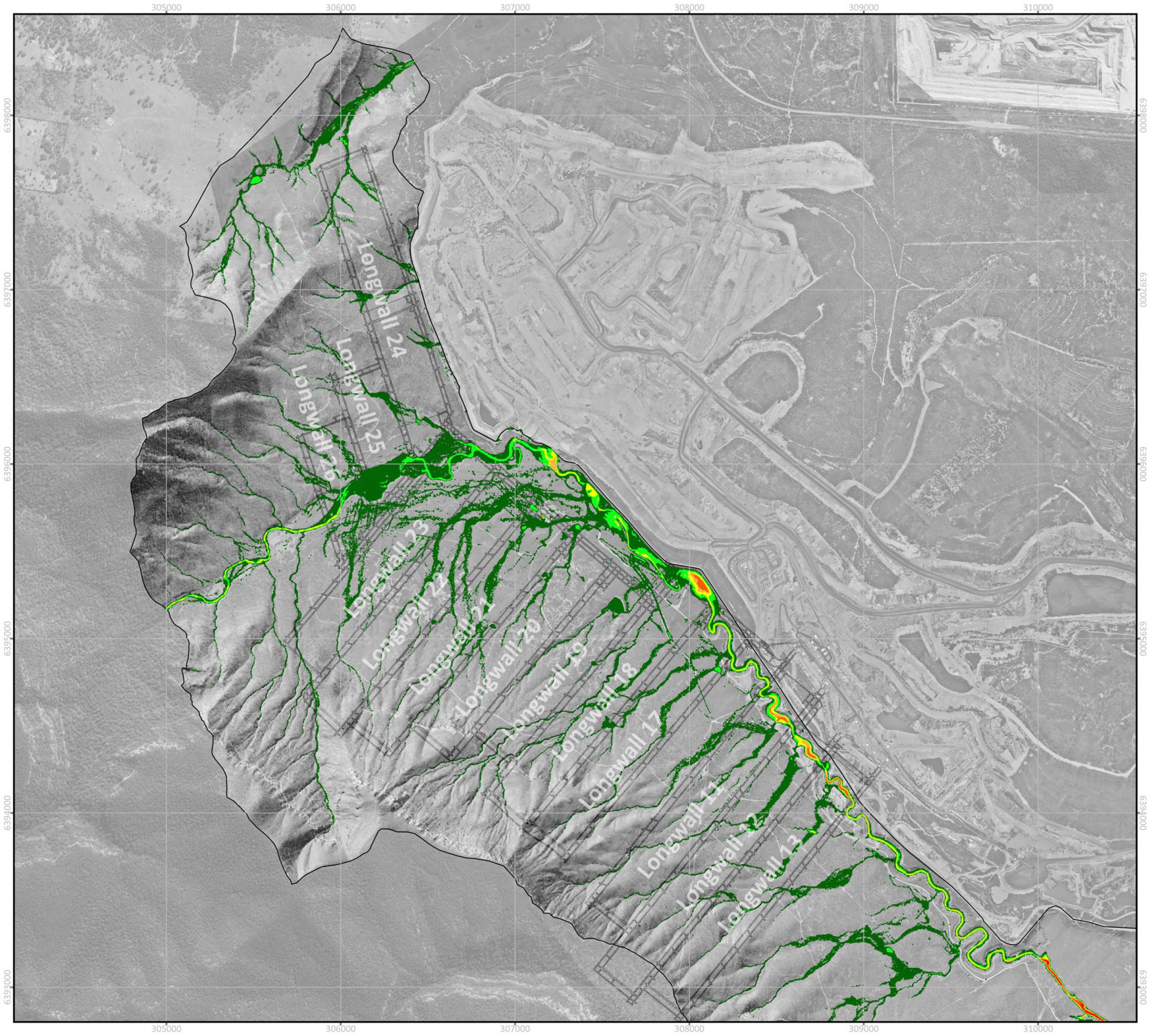

Figure C1-1. *TUFLOW Model Setup*

# 2 Modelling Results

The figures below are presented in the following order:

- Existing Flood Depth & Velocity (Figure C3 to Figure C8)
- Subsided LW21-24 Flood Depth & Velocity (Figure C9 to Figure C14)
- Subsided LW21-25 Flood Depth & Velocity (Figure C15 to Figure C20)
- Subsided LW21-26 Flood Depth & Velocity (Figure C21 to Figure C26)

Within each group, the figures are presented in order of design flood event; 0.5EY, 2% AEP and 0.1% AEP.




LEGEND

Longwall Arrangement

Model Boundary

Flood Depth (m)

- 0.00 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- > 3.00

0 0.5 1 km

**FIGURE C03**
**0.5 EY EVENT - FLOOD DEPTH**
**EXISTING SCENARIO**
**PROJECT:** 0623002 Wambo Longwall 24-26 Extraction Plan SW

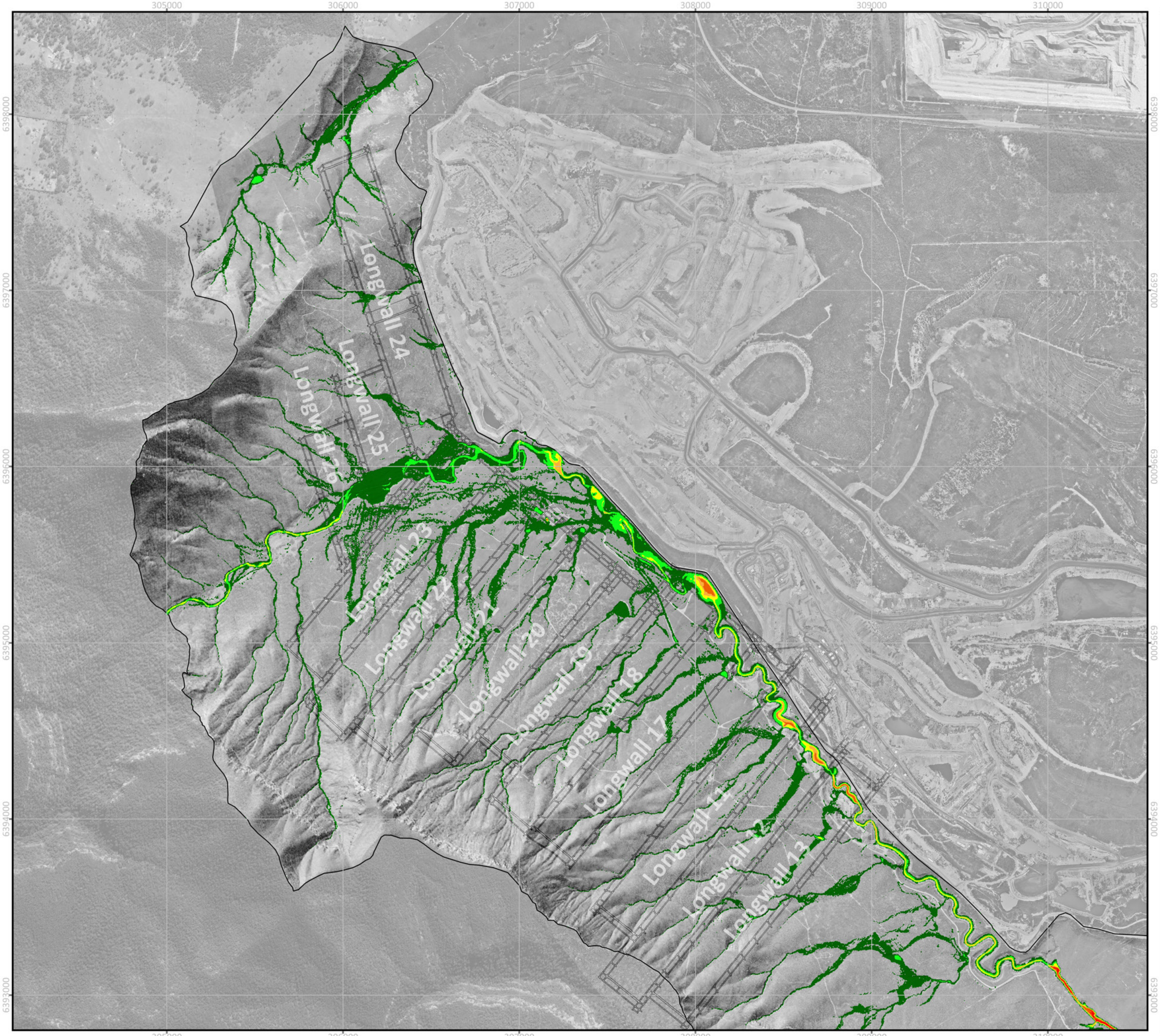
Data sources: Peabody, NSW Spatial Services, Wambo Aerial Imagery 23/11/2020 25cm, Google Aerial Basemap

n

alluvium

Coordinate System: GDA94 / MGA zone 56
Created: 27/09/2024
Scale: 1:20,000

Originator:HN
Checked: CB
Approved:NA




LEGEND

Longwall Arrangement

Model Boundary

Flood Depth (m)

- 0.00 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- > 3.00

0 | 0.5 | 1 km

**FIGURE C03**

**0.5 EY EVENT - FLOOD DEPTH**

**EXISTING SCENARIO**

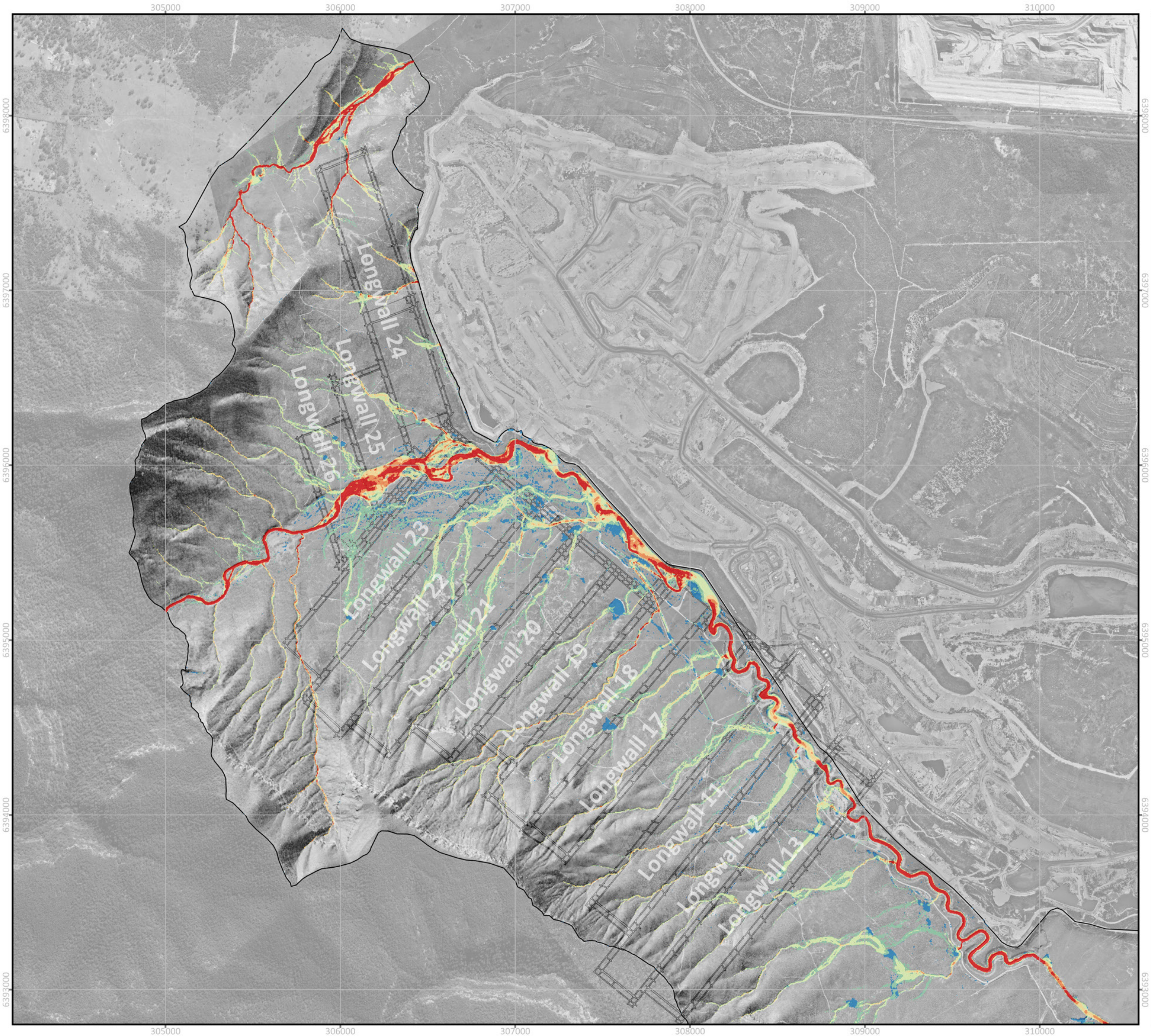
**PROJECT:** 0623002 Wambo Longwall 24-26 Extraction Plan SW

Data sources: Peabody, NSW Spatial Services, Wambo Aerial Imagery 23/11/2020 25cm, Google Aerial Basemap

alluvium

Coordinate System: GDA94 / MGA zone 56
Created: 27/09/2024
Scale: 1:20,000

Originator:HN
Checked: CB
Approved:NA




LEGEND

Longwall Arrangement

Model Boundary

Flood Velocity (m/s)

- 0.00 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00

0 0.5 1 km

**FIGURE C04**

**0.5 EY EVENT - FLOOD VELOCITY**

**EXISTING SCENARIO**

**PROJECT:** 0623002 Wambo Longwall 24-26 Extraction Plan SW

Data sources: Peabody, NSW Spatial Services, Wambo Aerial Imagery 23/11/2020 25cm, Google Aerial Basemap

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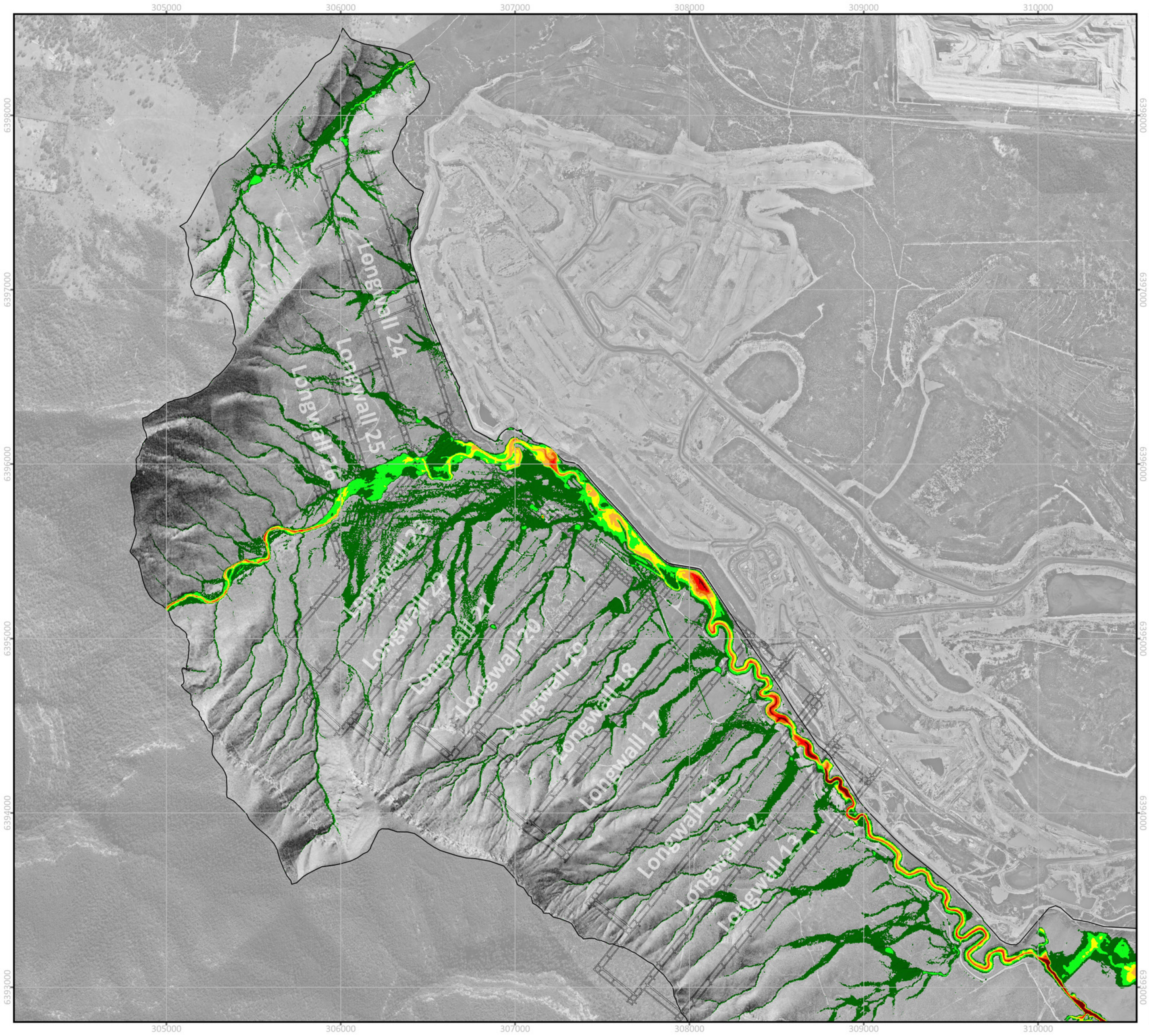
alluvium

Coordinate System: GDA94 / MGA zone 56
Created: 27/09/2024
Scale: 1:20,000

Originator:HN
Checked: CB
Approved:NA




LEGEND

- Longwall Arrangement
- Model Boundary

Flood Depth (m)

- 0.00 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- > 3.00

0 0.5 1 km

**FIGURE C05**

**2% AEP EVENT - FLOOD DEPTH**

**EXISTING SCENARIO**

**PROJECT:** 0623002 Wambo Longwall 24-26 Extraction Plan SW

Data sources: Peabody, NSW Spatial Services, Wambo Aerial Imagery 23/11/2020 25cm, Google Aerial Basemap

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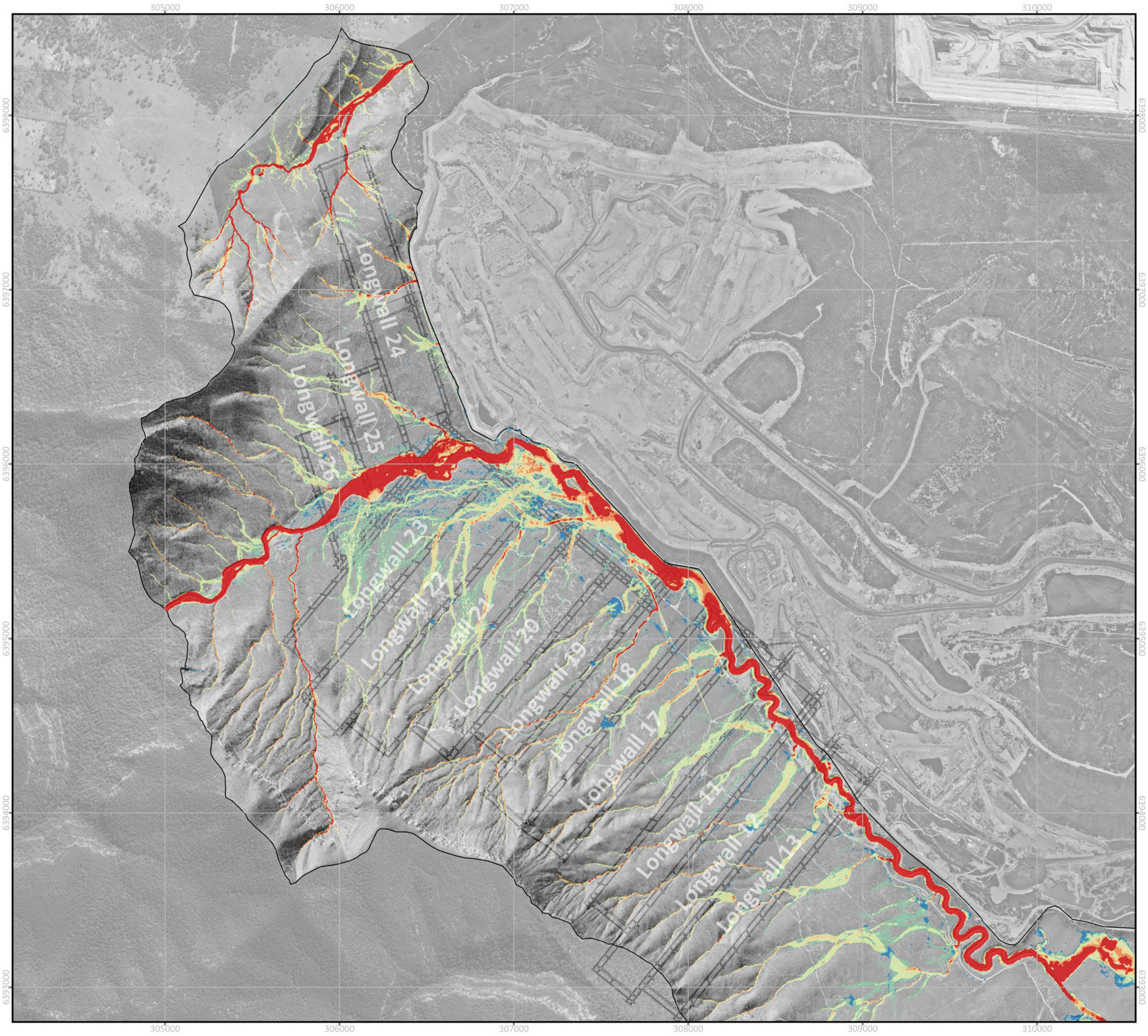
alluvium

Coordinate System: GDA94 / MGA zone 56
Created: 27/09/2024
Scale: 1:20,000

Originator:HN
Checked: CB
Approved:NA




LEGEND

Longwall Arrangement

Model Boundary

Flood Velocity (m/s)

- 0.00 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00

0 0.5 1 km

**FIGURE C06**

**2% AEP EVENT - FLOOD VELOCITY**

**EXISTING SCENARIO**

**PROJECT:** 0623002 Wambo Longwall 24-26 Extraction Plan SW

Data sources: Peabody, NSW Spatial Services, Wambo Aerial Imagery 23/11/2020 25cm, Google Aerial Basemap

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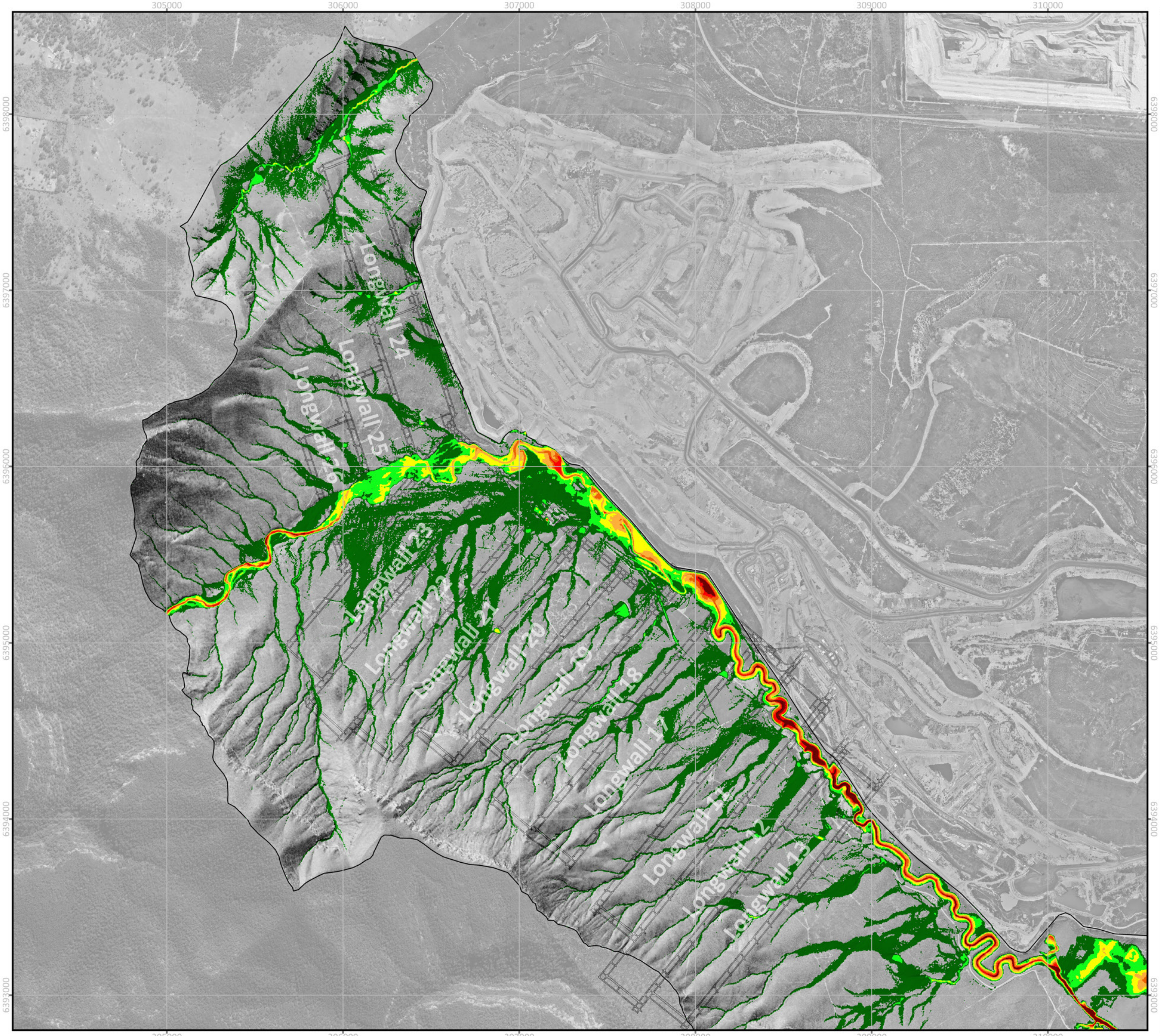
Coordinate System: GDA94 / MGA zone 56
Created: 27/09/2024
Scale: 1:20,000

Originator:HN
Checked: CB
Approved:NA




LEGEND

Longwall Arrangement

Model Boundary

Flood Depth (m)

- 0.00 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- > 3.00

0 0.5 1 km

**FIGURE C07**

**0.1% AEP EVENT - FLOOD DEPTH**

**EXISTING SCENARIO**

**PROJECT:** 0623002 Wambo Longwall 24-26 Extraction Plan SW

Data sources: Peabody, NSW Spatial Services, Wambo Aerial Imagery 23/11/2020 25cm, Google Aerial Basemap

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Coordinate System: GDA94 / MGA zone 56

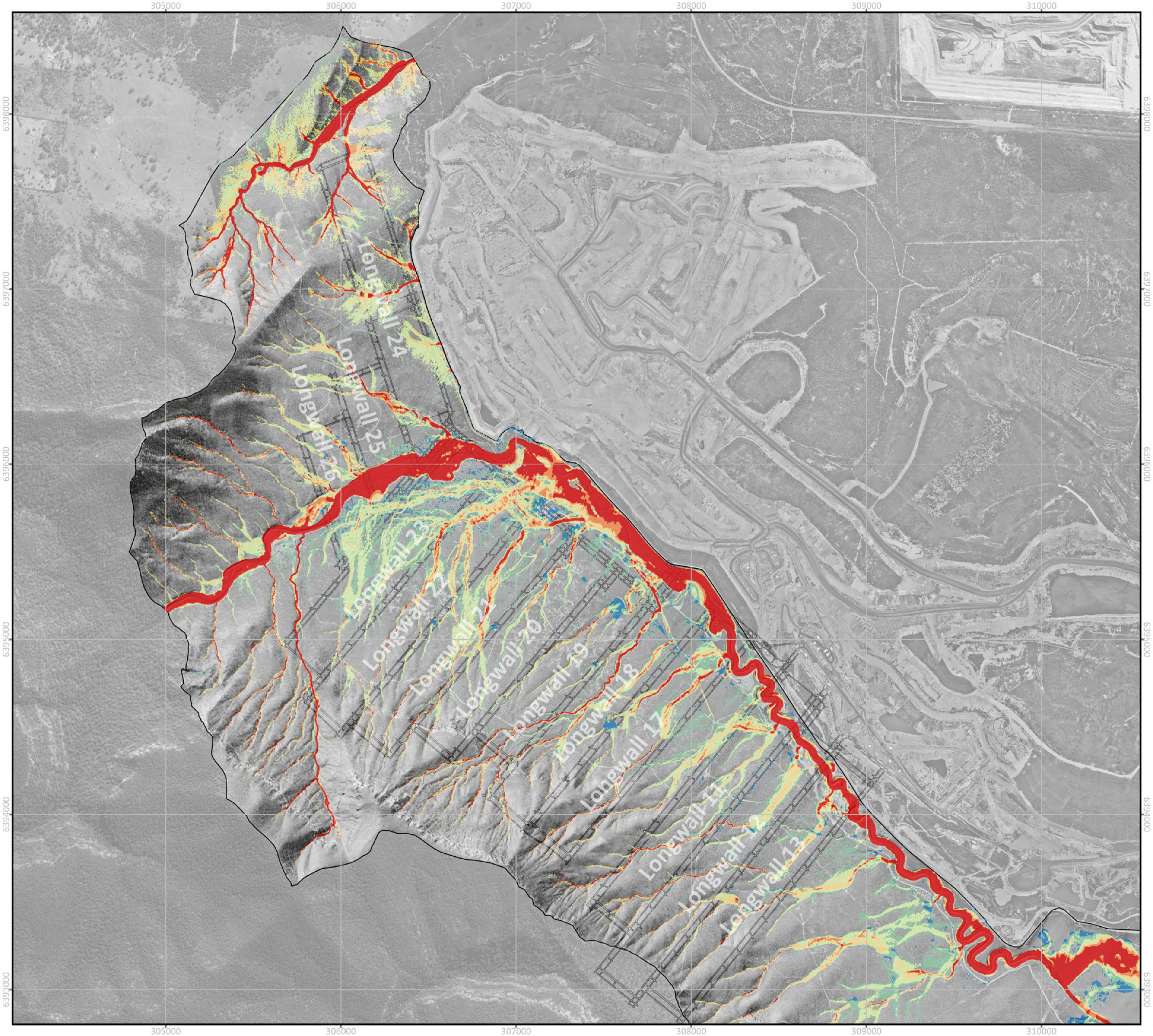
Created: 27/09/2024

Scale: 1:20,000

Originator:HN

Checked: CB

Approved:NA




LEGEND

Longwall Arrangement

Model Boundary

Flood Velocity (m/s)

- 0.00 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00

0 0.5 1 km

**FIGURE C08**

**0.1% AEP EVENT - FLOOD VELOCITY**

**EXISTING SCENARIO**

**PROJECT:** 0623002 Wambo Longwall 24-26 Extraction Plan SW

Data sources: Peabody, NSW Spatial Services, Wambo Aerial Imagery 23/11/2020 25cm, Google Aerial Basemap

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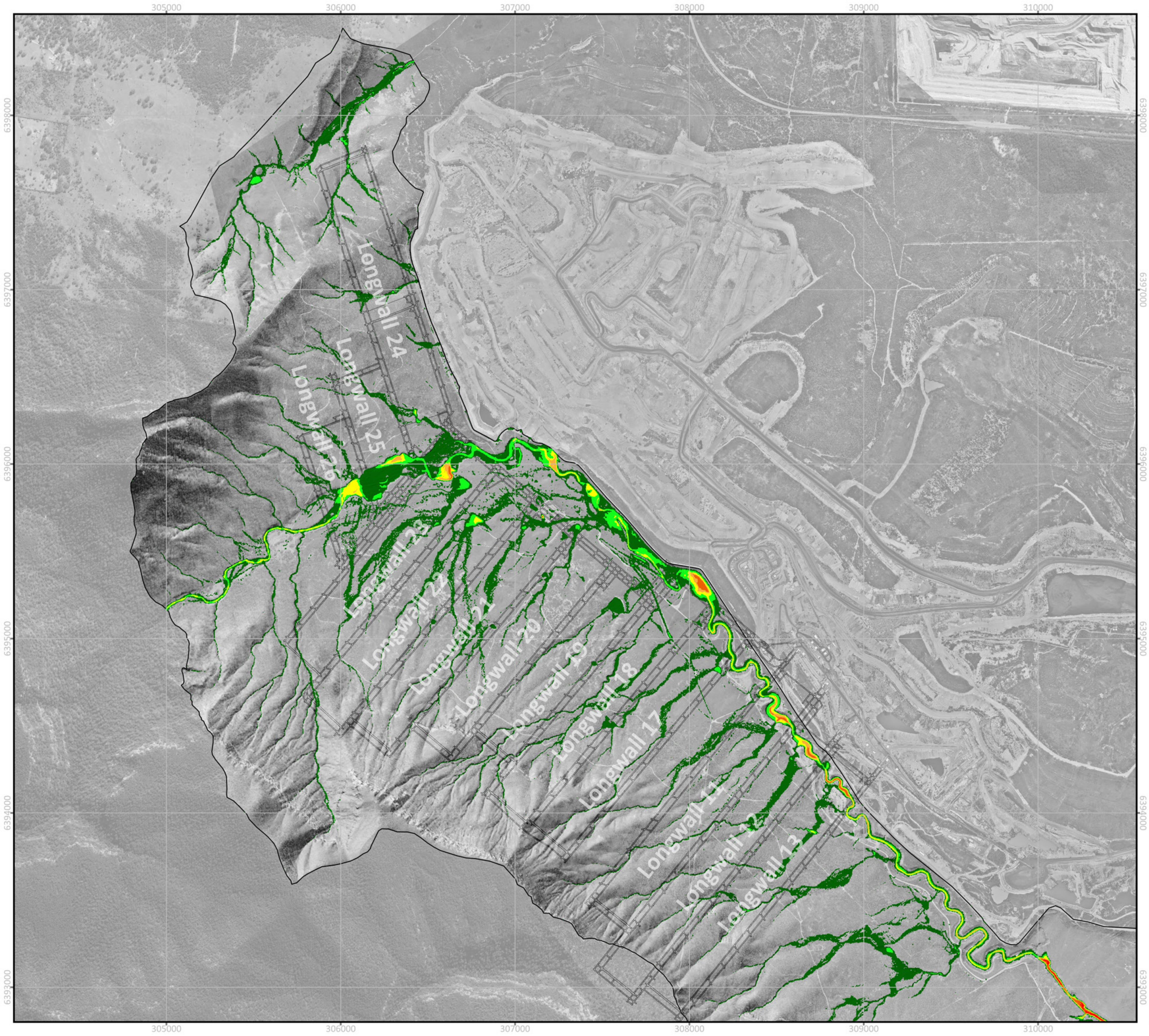
Coordinate System: GDA94 / MGA zone 56
Created: 27/09/2024
Scale: 1:20,000

Originator:HN
Checked: CB
Approved:NA




LEGEND

Longwall Arrangement

Model Boundary

Flood Depth (m)

- 0.00 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- > 3.00

0 0.5 1 km

**FIGURE C09**

**0.5 EY EVENT - FLOOD DEPTH**

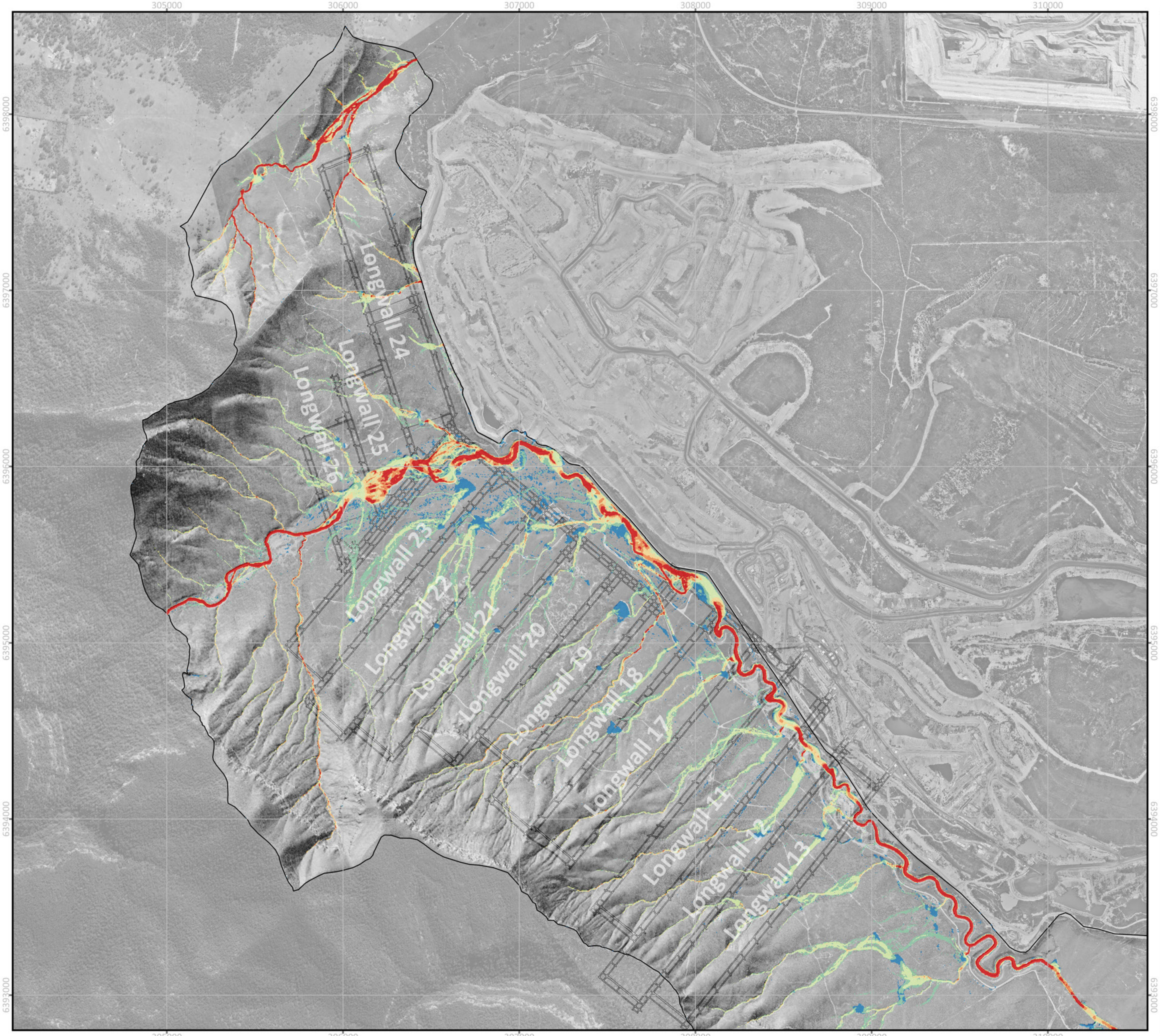
**SUBSIDED 17-26 SCENARIO**

**PROJECT:** 0623002 Wambo Longwall 24-26 Extraction Plan SW

Data sources: Peabody, NSW Spatial Services, Wambo Aerial Imagery 23/11/2020 25cm, Google Aerial Basemap

Coordinate System: GDA94 / MGA zone 56
Created: 27/09/2024
Scale: 1:20,000

Originator:HN
Checked: CB
Approved:NA




LEGEND

Longwall Arrangement

Model Boundary

Flood Velocity (m/s)

- 0.00 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00

0 0.5 1 km

**FIGURE C10**
**0.5 EY EVENT - FLOOD VELOCITY**
**SUBSIDED 17-26 SCENARIO**
**PROJECT:** 0623002 Wambo Longwall 24-26 Extraction Plan SW

Data sources: Peabody, NSW Spatial Services, Wambo Aerial Imagery 23/11/2020 25cm, Google Aerial Basemap

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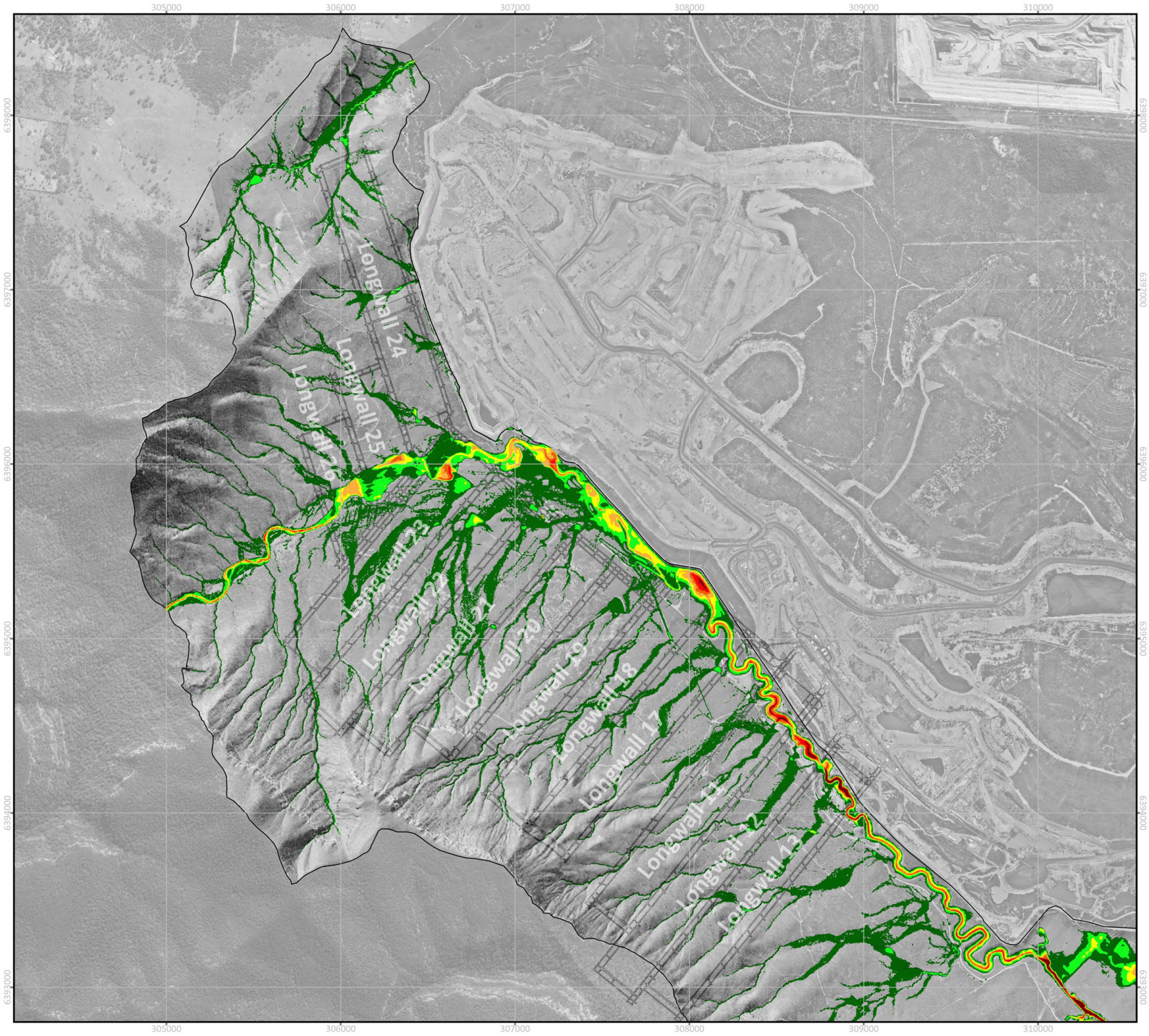
Coordinate System: GDA94 / MGA zone 56
Created: 27/09/2024
Scale: 1:20,000

Originator:HN
Checked: CB
Approved:NA




LEGEND

Longwall Arrangement

Model Boundary

Flood Depth (m)

- 0.00 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- > 3.00

0 0.5 1 km

**FIGURE C11**
**2% AEP EVENT - FLOOD DEPTH**
**SUBSIDED 17-26 SCENARIO**
**PROJECT:** 0623002 Wambo Longwall 24-26 Extraction Plan SW

Data sources: Peabody, NSW Spatial Services, Wambo Aerial Imagery 23/11/2020 25cm, Google Aerial Basemap

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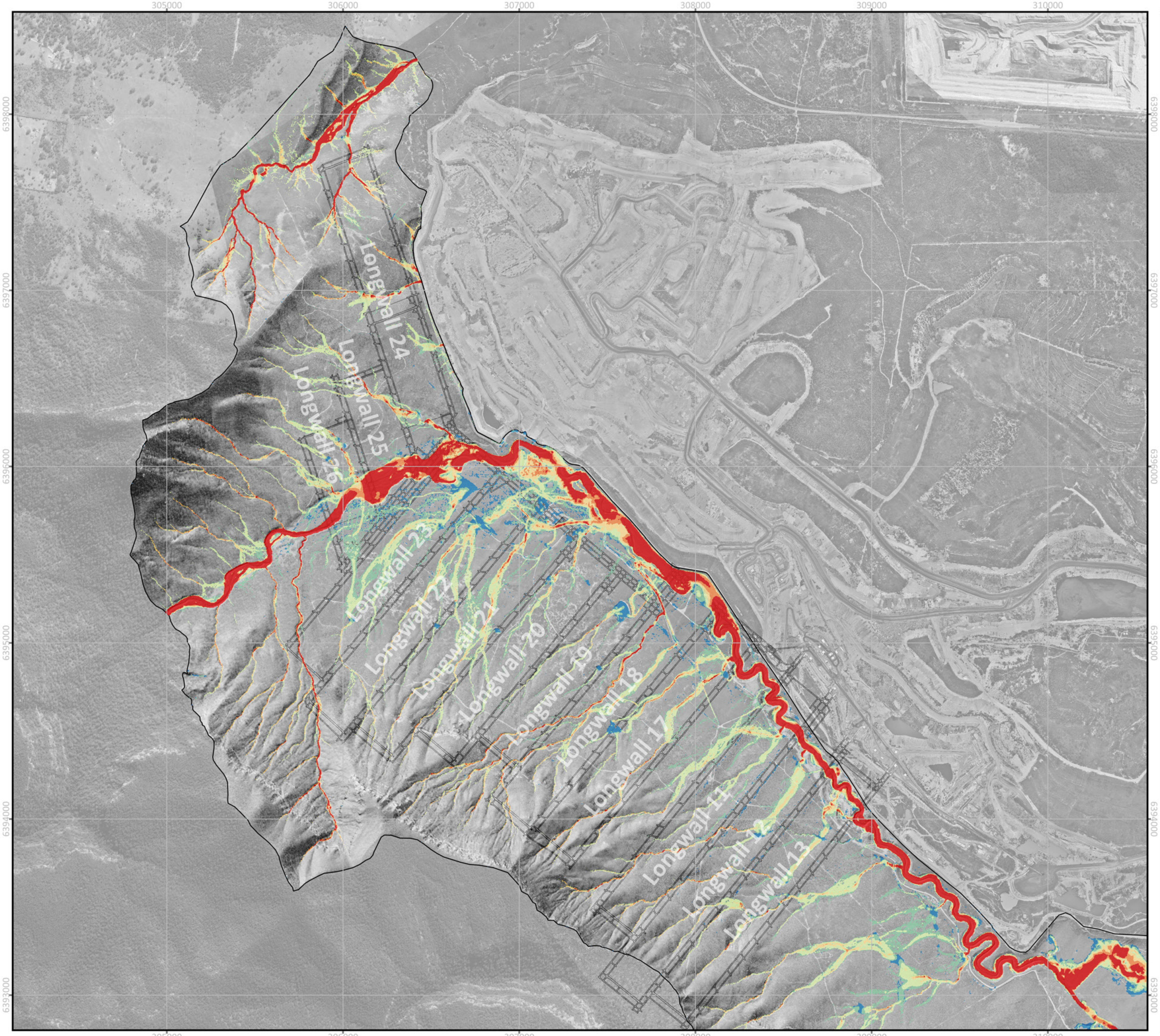
alluvium

Coordinate System: GDA94 / MGA zone 56
Created: 27/09/2024
Scale: 1:20,000

Originator:HN
Checked: CB
Approved:NA




LEGEND
Longwall Arrangement
Model Boundary

Flood Velocity (m/s)
0.00 - 0.10
0.10 - 0.25
0.25 - 0.50
0.50 - 0.75
0.75 - 1.00
> 1.00

0 0.5 1 km

**FIGURE C12**
**2% AEP EVENT - FLOOD VELOCITY**
**SUBSIDED 17-26 SCENARIO**
**PROJECT:** 0623002 Wambo Longwall 24-26 Extraction Plan SW

Data sources: Peabody, NSW Spatial Services, Wambo Aerial Imagery 23/11/2020 25cm, Google Aerial Basemap

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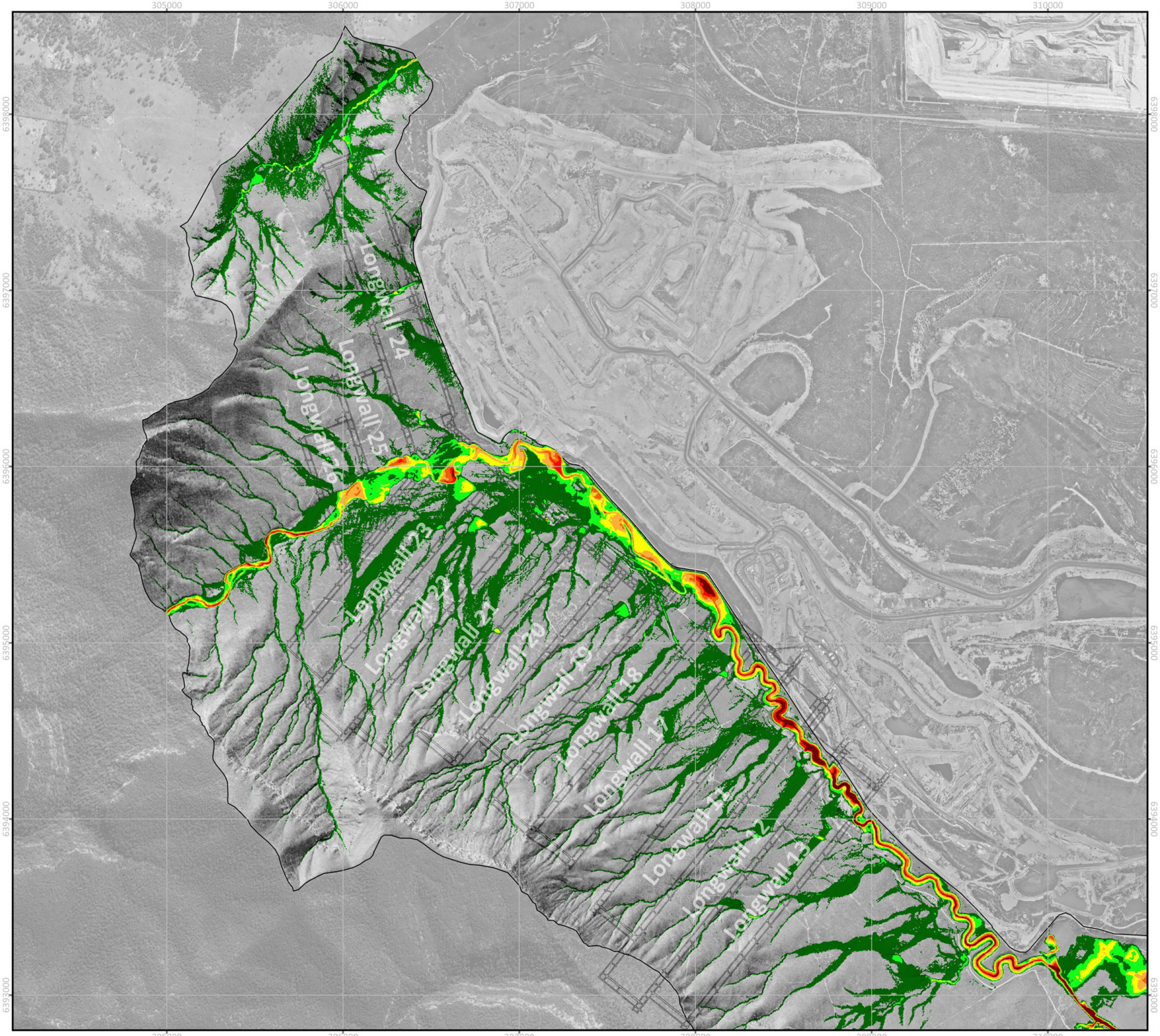
alluvium

Coordinate System: GDA94 / MGA zone 56
Created: 27/09/2024
Scale: 1:20,000

Originator:HN
Checked: CB
Approved:NA




LEGEND
Longwall Arrangement
Model Boundary

Flood Depth (m)

0.00 - 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 2.50
2.50 - 3.00
> 3.00

0 0.5 1 km

**FIGURE C13**
**0.1% AEP EVENT - FLOOD DEPTH**
**SUBSIDED 17-26 SCENARIO**
**PROJECT:** 0623002 Wambo Longwall 24-26 Extraction Plan SW

Data sources: Peabody, NSW Spatial Services, Wambo Aerial Imagery 23/11/2020 25cm, Google Aerial Basemap

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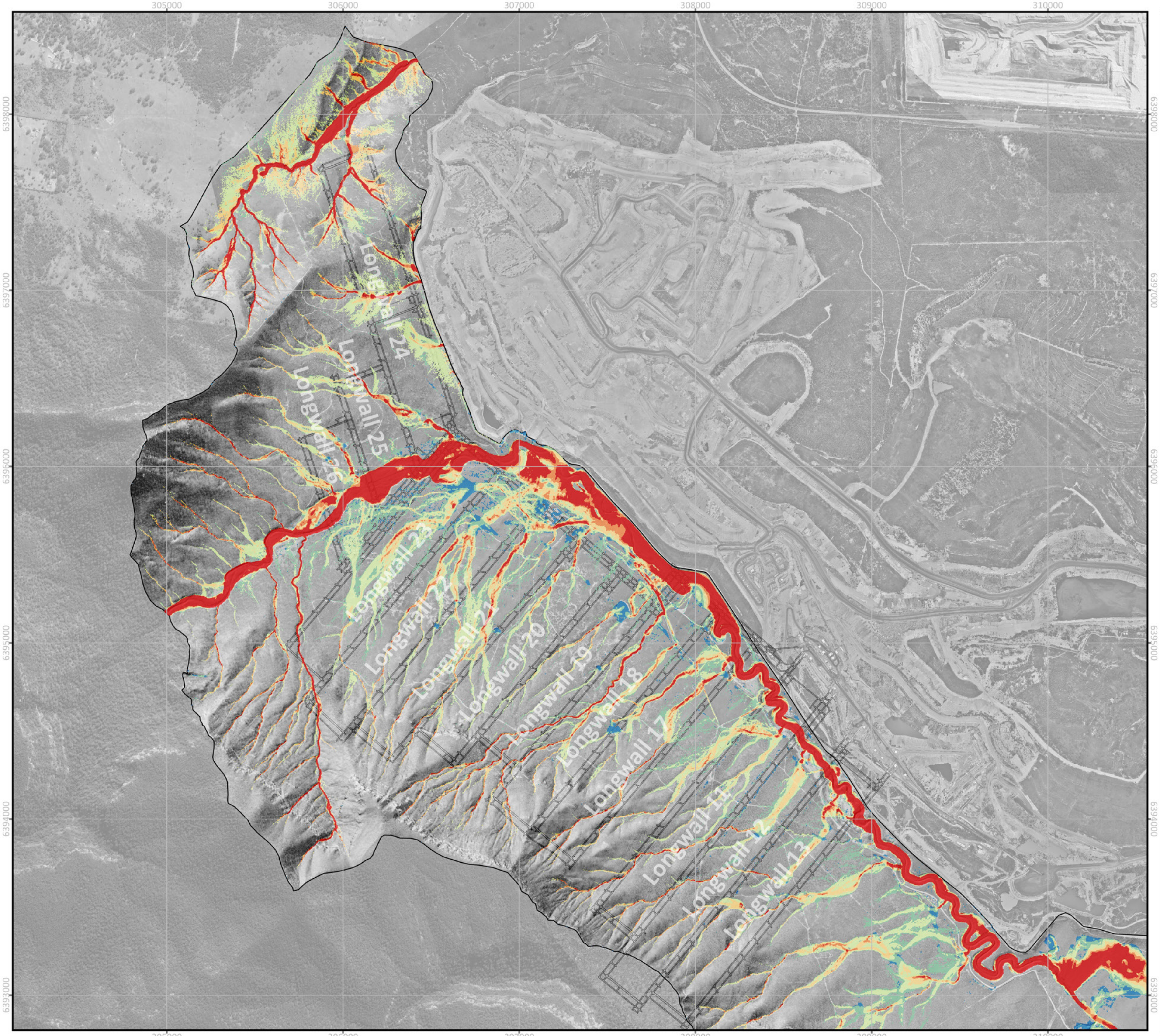
Coordinate System: GDA94 / MGA zone 56
Created: 27/09/2024
Scale: 1:20,000

Originator:HN
Checked: CB
Approved:NA




LEGEND

Longwall Arrangement

Model Boundary

Flood Velocity (m/s)

- 0.00 - 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- > 1.00

0 0.5 1 km

**FIGURE C14**
**0.1% AEP EVENT - FLOOD VELOCITY**
**SUBSIDED 17-26 SCENARIO**
**PROJECT:** 0623002 Wambo Longwall 24-26 Extraction Plan SW

Data sources: Peabody, NSW Spatial Services, Wambo Aerial Imagery 23/11/2020 25cm, Google Aerial Basemap

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alluvium

Coordinate System: GDA94 / MGA zone 56
Created: 27/09/2024
Scale: 1:20,000

Originator:HN
Checked: CB
Approved:NA