HYDRO ENGINEERING & CONSULTING PTY LTD

# REPORT

# Tahmoor Mine
# Extraction Plan LW W3-W4
# Surface Water Technical Report

Prepared for: Tahmoor Coal

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# TABLE OF CONTENTS

## TABLE OF CONTENTS (Continued)

# TABLE OF CONTENTS (Continued)



## LIST OF TABLES

# LIST OF FIGURES

# 1.0 INTRODUCTION

## 1.1 EXTRACTION PLAN STUDY AREA

Tahmoor Coal Mine (Tahmoor Mine) is an underground coal mine located approximately 80 kilometres (km) south-west of Sydney between the towns of Tahmoor and Bargo, New South Wales (NSW). Tahmoor Mine produces up to three million tonnes of Run of Mine (ROM) coal per annum from the Bulli Coal Seam. A primary hard coking coal product and a secondary higher ash coking coal product are produced and are used predominantly for coke manufacture for steel production. Product coal is transported via rail to Port Kembla and Newcastle for Australian domestic customers and export customers.

Tahmoor Mine has been operated by Tahmoor Coal Pty Ltd (Tahmoor Coal) since commencement in 1979. Board and pillar mining methods were adopted until 1987 when longwall mining methods commenced. Tahmoor Coal is a wholly owned subsidiary within the SIMEC Mining Division (SIMEC) of the GFG Alliance (GFG) group.

Tahmoor Coal has previously mined 33 longwalls to the north and west of Tahmoor Mine's current pit top location. The current mining area, the 'Western Domain', is located north-west of the Main Southern Rail between the townships of Thirlmere and Picton (refer to Figure 1). The Western Domain is located within the Tahmoor North mining area and is within Mining Lease (ML) 1376 and ML 1539.

The mine plan for the Western Domain includes four longwalls - Longwalls West 1 to West 4 (refer to Figure 1). An Extraction Plan for the first two longwalls in the Western Domain, Longwalls West 1 and West 2 (LW W1-W2), was approved by the NSW Department of Planning, Industry and Environment (DPIE) on 8 November 2019. Longwall West 1 (LW W1) was the first longwall to be extracted in the Western Domain and was completed on 6 November 2020. Extraction of Longwall West 2 (LW W2) commenced on 7 December 2020. The proposed Longwalls West 3 and West 4 (LW W3-W4) are an extension of LW W1-W2 and will be the focus of the Tahmoor Mine Longwalls W3–W4 Extraction Plan.

Hydro Engineering & Consulting Pty Ltd (HEC) was commissioned by Tahmoor Coal to complete a Surface Water Technical Report (SWTR) which will inform the Water Management Plan for the Tahmoor Coal Mine Longwalls W3–W4 Extraction Plan (the Extraction Plan). The purpose of the SWTR is to assess the potential impacts to surface water resources associated with mining LW W3-W4 and to describe the proposed monitoring, mitigation and management strategies to be adopted.

The SWTR for the Extraction Plan covers a Study Area for LW W1 to LW W4 that includes both the predicted 20 mm Total Subsidence Contour and the 35° Angle of Draw Line (refer Figure 1).

## 1.2 STRUCTURE OF THIS DOCUMENT

The SWTR is structured as follows:

Section 2: Outlines the statutory requirements applicable to the SWTR.

Section 3: Describes the existing environment of the Study Area with respect to surface water.

Section 4: Details the predicted subsidence impacts and potential impacts to surface water resources within the Study Area.

Section 5: Describes the monitoring, mitigation and management plan for the Study Area.

Section 6: Details the Trigger Action Response Plans (TARPs) and adaptive management measures.


**Figure 1 Water Management Plan Study Area**

# 2.0 STATUTORY REQUIREMENTS

## 2.1 PROJECT APPROVAL

Under Condition 13H of the Development Consent (DA 67/98), an Extraction Plan is required for all second workings from LW W1 and subsequent longwalls. The majority of the Western Domain is covered by ML 1376, having received development consent in 1994 from the Land and Environment Court (DA57/93). The mine sections beneath urban areas and the railway line are covered by ML 1539, having received development consent in 1999 from the Minister for Urban Affairs and Planning (DA67/98).

Under Development Consent (DA 67/98), a Water Management Plan (WMP) is to be prepared for LW W3–W4 in consultation with the NSW Environment Protection Authority (EPA); DPIE - Water; Department of Regional NSW (DRN) - Resources Regulator; WaterNSW; Wollondilly Shire Council; and NSW State Emergency Services (SES). Consultation was also completed with Natural Resources Access Regulator (NRAR), Dams Safety Committee (DSC), and DPIE – Environment, Energy and Science (EES) Group during the preparation of the WMP.

The WMP is to provide for the management of potential impacts and environmental consequences of the proposed underground workings on watercourses and aquifers. This SWTR addresses the specific requirements of the WMP detailed in DA 67/98, as listed in Table 1.

**Table 1 DA67/98 WMP Requirements**

| Requirement | Where Addressed or Why not Addressed |
|---|---|
| Detailed baseline data on surface water flows and quality in watercourses and/or water bodies that could be affected by subsidence. | Section 3.0 |
| Surface water impact assessment criteria, including trigger levels for investigating any potentially adverse impacts on water resources or water quality. | Section 6.2 |
| A surface water monitoring program to monitor and report on:<br>• stream flows and quality;<br>• stream and riparian vegetation health; and<br>• channel and bank stability. | Section 5.0 and *Aquatic Biodiversity Technical Report Tahmoor North* (Niche, 2021) |
| A flood management protocol to:<br>• identify secondary access routes for those properties that could potentially be adversely impacted by 1% AEP flood events;<br>• regularly consult with landowners that would not have either a primary or secondary access route during 1% AEP flood events;<br>• provide up-to-date information (including subsidence and flooding predictions) to the State Emergency Service and Council regarding privately-owned residences that could be adversely affected by lack of access during 1% AEP flood events; and<br>• work with landowners, State Emergency Service and Council to develop evacuation plans to ensure landowners know what to do in the event of emergency as a result of a 1% AEP flood event. | Section 5.3 |
| A description of any adaptive management practices implemented to guide future mining activities in the event of greater than predicted impacts on aquatic habitat. | Section 6.1 |
| A program to validate the surface water models for the development, and compare monitoring results with modelled predictions. | Not applicable |
| A plan to respond to any exceedances of the surface water criteria. | Section 6.3 |

## 2.2 SUBSIDENCE PERFORMANCE MEASURES

In accordance with the Extraction Plan for Longwalls W3–W4 conditions of approval, Tahmoor Coal must ensure that the development does not cause any exceedances of the performance measures listed in Table 2.

**Table 2 Subsidence Impact Performance Measures – Natural Features**

| Feature | Performance Measures |
|---|---|
| Stonequarry Creek, Cedar Creek and Matthews Creek | No subsidence impact or environmental consequence greater than minor* |
| | No connective cracking between the surface, or the base of the alluvium, and the underground workings |

* minor is defined as *not very large, important or serious*

## 2.3 RELEVANT LEGISLATION

### *2.3.1 Water Management Act 2000*

The NSW DPIE – Water develops, assesses and recommends changes to water sharing / water resources plans and water management rules for regional water in NSW in accordance with the *Water Management Act 2000*. A primary objective of DPIE – Water is the sustainable management and use of water resources, balancing environmental, social and economic considerations. DPIE – Water has developed Water Sharing Plans (WSPs) for much of the State and these establish rules for sharing and trading water between the environment, town water supplies, basic landholder rights and commercial uses. NRAR is an independent regulatory body established by DPIE – Water and is responsible for compliance with and enforcement of the regulatory framework. The Study Area is located within the Upper Nepean River Water Source which is regulated by the *Water Sharing Plan for Greater Metropolitan Region Unregulated River Water Sources*.

Water used in existing and on-going mining and coal processing operations will continue to be sourced from the underground operations (groundwater ingress and recycling of supply for mining operations) and from water captured within the existing pit top water management system – principally at the coal handling and processing plant and rejects emplacement area, which are located approximately 8 km south of the Study Area. Some water is also supplied under agreement with Sydney Water.

### *2.3.2 Protection of the Environment Operations Act 1997*

Environment Protection Licence (EPL) 1389 includes licensed discharge points for surface water. The conditions of EPL 1389 would not be affected by on-going mining and coal processing operations related to LW W1 and subsequent longwalls in the Western Domain.

## 2.4 CONSULTATION

This SWTR has been prepared in consultation with the EPA, DPIE - Water, NRAR, Resources Regulator, Wollondilly Shire Council, WaterNSW, DSC, EES and SES. Table 3 presents each stakeholder comment relating to the WMP and Tahmoor Coal response.

**Table 3 Surface Water Management Consultation Outcomes**

| Stakeholder | Stakeholder Comment | Tahmoor Coal Response |
|---|---|---|
| NSW Department of Planning, Industry and Environment – Environment, Energy and Science (EES) Group | EES noted that their primary concern relates to subsidence impacts to watercourses including an appropriate water monitoring program and remediation plans that have appropriate measures and objectives to assess remediation success. | Potential subsidence impacts on watercourses are discussed in Section 4.0 of this report.<br><br>Proposed monitoring, mitigation and management strategies are presented in Section 5.0 of this report. |
| NSW Infrastructure - Land & Water - Natural Resources Access Regulator – East (NRAR) | NRAR requested details of water take and appropriate water licencing within the Water Management Plan. | Details of water take and appropriate water licensing are discussed in Section 4.4.4.6 of this report. |
| Wollondilly Shire Council | Modelling and data analysis to obtain an accurate scientific based assessment of the setbacks required for the longwalls to avoid impacts to third order water streams or above (in a catchment context). | The current mine plan is a revision of the 2014 SMP Application mine plan, which was reviewed based on feedback received from the community and NSW Government agencies, as well as updated knowledge on geotechnical, operational and mining conditions. The updated mine design was re-oriented to avoid mining directly under higher order streams (Matthews Creek, Cedar Creek and Stonequarry Creek).<br><br>Tahmoor Coal considers that the subsidence predictions for the current mine plan to be acceptable and that the current mine plan appropriately balances the requirements of resource recovery, mitigation of environmental impact and consideration of community and Government agency concerns.<br><br>An Adaptive Management Strategy has been developed to respond to any observed impacts to creeks from subsidence as a result of LW W2 and, if required, will inform the modification of the commencing end of LW W3 to avoid potential impacts to Stonequarry Creek.<br><br>An assessment of the potential impacts to ephemeral drainage lines and surface water systems within the Study Area based on subsidence and baseflow loss predictions and with consideration of surface water impacts associated with mining previously undertaken in the region is provided in Section 4.0 of this report. |

**Table 3 (Cont.) Surface Water Management Consultation Outcomes**

| Stakeholder | Stakeholder Comment | Tahmoor Coal Response |
|---|---|---|
| Wollondilly Shire Council | A detailed assessment of potential impacts of mining operations on the ecological health of waterways in a catchment context that includes aquatic ecology. | Potential impacts to aquatic ecology from the mining of LW W3-W4 are discussed in Section 4.4.7 and in the Aquatic Biodiversity Technical Report (Appendix B of the Biodiversity Management Plan [BMP]) and summarised in Section 4.1 of the WMP. |
| | A detailed groundwater and geological model that would allow for an accurate scientific based understanding of identification of potential impacts associated with the proposal on both surface and groundwaters. | The detailed groundwater model and potential impacts associated with the mining of LW W3-W4 are addressed in the Groundwater Technical Report (Section 3.2 and Section 4.2 of the WMP) and summarised in Section 4.4.4 of this report. |
| | A Water Management Plan detailing intended water quality monitoring that includes triggers based on ecological health parameters and monitoring for the presence of any re-emergence of water to the surface from mine induced fractures. | A detailed water quality monitoring program and associated TARP is documented in Section 5.0 of this report.<br><br>The water quality monitoring program and TARP consider learnings from the monitoring and TARP assessments undertaken for LW W1-W2. The water quality monitoring program and TARP have been developed with consideration to ecological health parameters as guided by the aquatic ecology assessment and Aquatic Biodiversity Technical Report (Appendix B of the BMP).<br><br>The 'Impact to pool level, natural drainage behaviour or overland connected flow' TARP includes a trigger stating that if impacts are observed at the monitoring sites, a visual inspection of downstream reaches will be undertaken, and if re-emergence is identified, water quality monitoring will be implemented at the re-emergence location/s. |
| | Any first or second order watercourse within the Study Area is to be subject to a detailed assessment of likely subsidence induced impacts prior to the commencement of any extraction activity. | Section 4.0 of this report addresses potential impacts to ephemeral drainage lines and surface water systems within the Study Area based on subsidence and baseflow loss predictions and with consideration to surface water impacts associated with mining previously undertaken in the region. |

# 3.0 EXISTING ENVIRONMENT

## 3.1 SURFACE WATER RESOURCES WITHIN THE CATCHMENT

The Study Area is located in the Stonequarry Creek Catchment with the relevant natural waterway features comprising Matthews Creek, Cedar Creek, Stonequarry Creek and Redbank Creek, as shown in Figure 1. Redbank Creek flows from west to east adjacent to but outside of the southern boundary of the Study Area. A topographic ridgeline straddles the Study Area, with the south-east portion of the area draining via tributaries to Redbank Creek. The south-west portion of the area drains to Matthews Creek, while the north-northwest portion of the area drains to Cedar Creek and Stonequarry Creek. A portion of Stonequarry Creek traverses the northern boundary of the Study Area, while Matthews Creek, Cedar Creek and Redbank Creek are located outside of the Study Area.

Matthews Creek and Cedar Creek rise in low hills to the west of the Study Area, with their junction approximately 850 m west of LW W3. Stonequarry Creek also rises to the west and flows to the east, joining Cedar Creek approximately 370 m north west of LW W3, before flowing east and south through the town of Picton. Redbank Creek rises to the west and flows into Stonequarry Creek towards the south-east of the Study Area. Redbank Creek is located approximately 600 m south of the edge of LW W4 at its closest point. Downstream of the confluence with Redbank Creek, Stonequarry Creek continues to flow south-east, joining the Nepean River near Maldon.

The Nepean River rises in the Great Dividing Range to the west of the Study Area, although its headwaters also lie in the coastal ranges to the east of the Study Area. Flows in the upper reaches of the Nepean River are highly regulated by the Upper Nepean Water Supply Scheme, operated by WaterNSW, which incorporates four major water supply dams on the Cataract, Cordeaux, Avon and Nepean Rivers. Flows in the Nepean River near and downstream of the Study Area are not part of a WaterNSW Drinking Water Catchment Area.

The surface water resources within the Study Area are regulated by the *Water Sharing Plan for Greater Metropolitan Region Unregulated River Water Sources* which specifically addresses the Stonequarry Creek Management Zone of the Upper Nepean and Upstream Warragamba Water Source. Section 3.1.5 provides detail of the Water Access Licences (WALs) and water usage for Stonequarry Creek Management Zone within the vicinity of the Study Area.

### *3.1.1 Matthews Creek*

Matthews Creek is a fourth order stream[1] where it flows within the vicinity of the Study Area (refer Figure 2). The creek runs adjacent to the western boundary of the Study Area, running near parallel to the Picton Mittagong Loop Line before flowing into Cedar Creek. The catchment area of Matthews Creek to its confluence with Cedar Creek is estimated at 8.1 km$^2$.

The headwaters of Matthews Creek lie within the residential area of Thirlmere, with the condition of the creek significantly affected by residential development. Adjacent to the Study Area, the creek channel is relatively incised in Hawkesbury Sandstone, with a steep sided valley and isolated vertical scarps (GeoTerra, 2014).

[1] Strahler stream order classification scheme (Strahler, 1952).

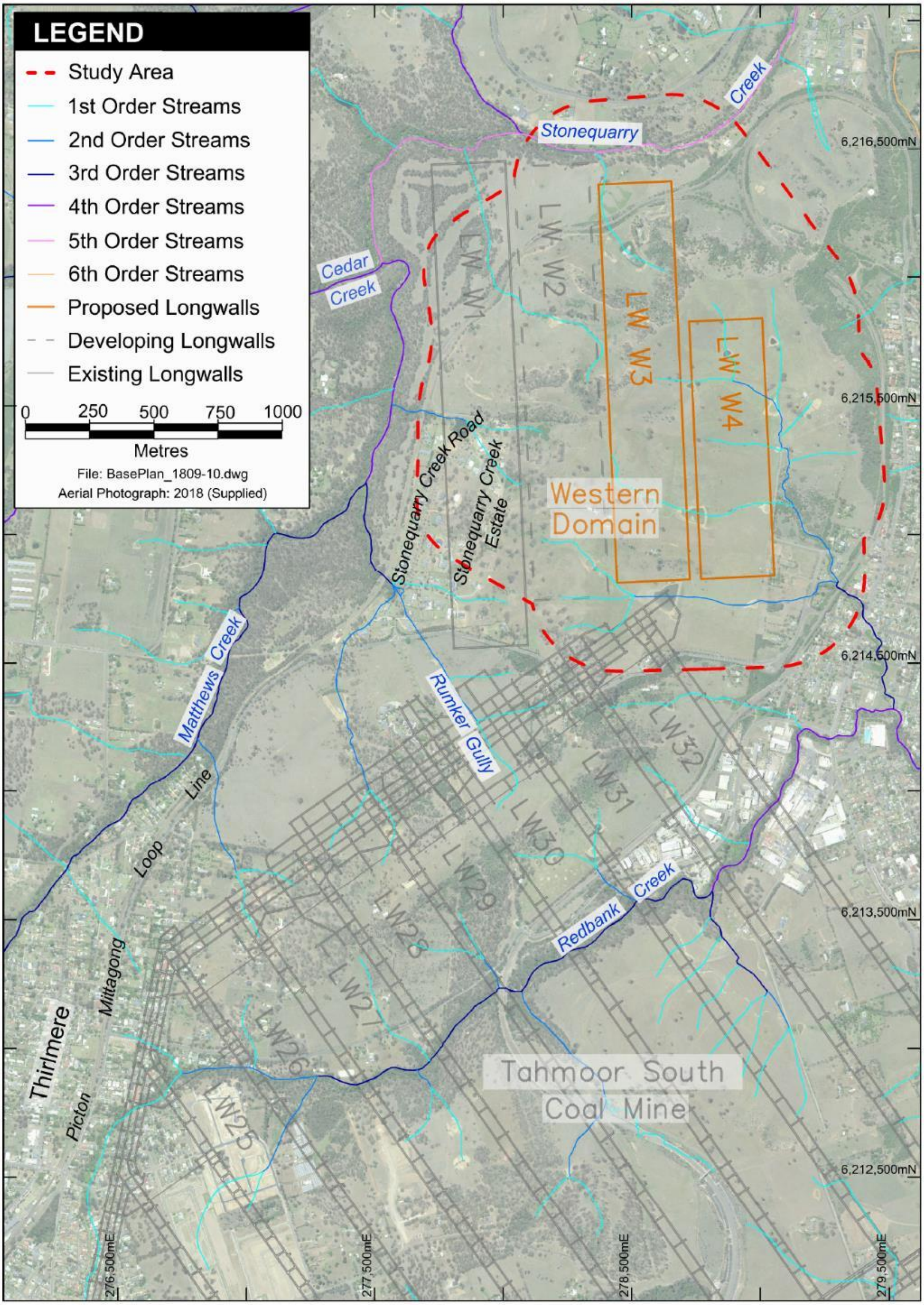


**Figure 2 Stream Order Delineation**

The eastern tributaries of Matthews Creek within the Study Area are first and second order ephemeral streams. The first and second order tributaries flow beneath Stonequarry Creek Road and a residential area along this road known as “Stonequarry Estate” located to the east of the Picton Mittagong Loop Line. Surface water runoff from these tributaries has been partially diverted by urban drainage associated with “Stonequarry Estate” and flows through stormwater detention basins / dams and culverts under the rail line, with runoff from the tributaries likely to contribute to flow in Matthews Creek during periods of extended or significant rainfall only. The tributaries of Matthews Creek traverse LW W1 and LW W2 but do not traverse LW W3 or LW W4.

Downstream of the Picton Mittagong Loop Line, Rumker Gully flows over predominately Hawkesbury Sandstone bedrock. Some sections of the tributary are steeply incised with isolated vertical scarps and there are a number of channel constraints, including rockbars, boulders and rock shelves, which form standing pools along the alignment of the tributary (MSEC, 2019).

SLR (2021a) state that the reach of Matthews Creek within the Study Area prior to mining LW W1-W2 was inferred to be losing to the groundwater system at upstream monitoring sites (MA and MB) and gaining from the groundwater system at sites further downstream in Matthews Creek (refer Figure 3 for monitoring site locations).

A visual inspection of pools on Matthews Creek was undertaken by GeoTerra in 2019 prior to commencement of mining of LW W1. The pool locations and corresponding monitoring sites (refer Section 3.2) are shown in Figure 3 and the pool description provided in Table 4. A total of 46 rockbar, boulder and rock shelf constrained pools were identified on Matthews Creek.

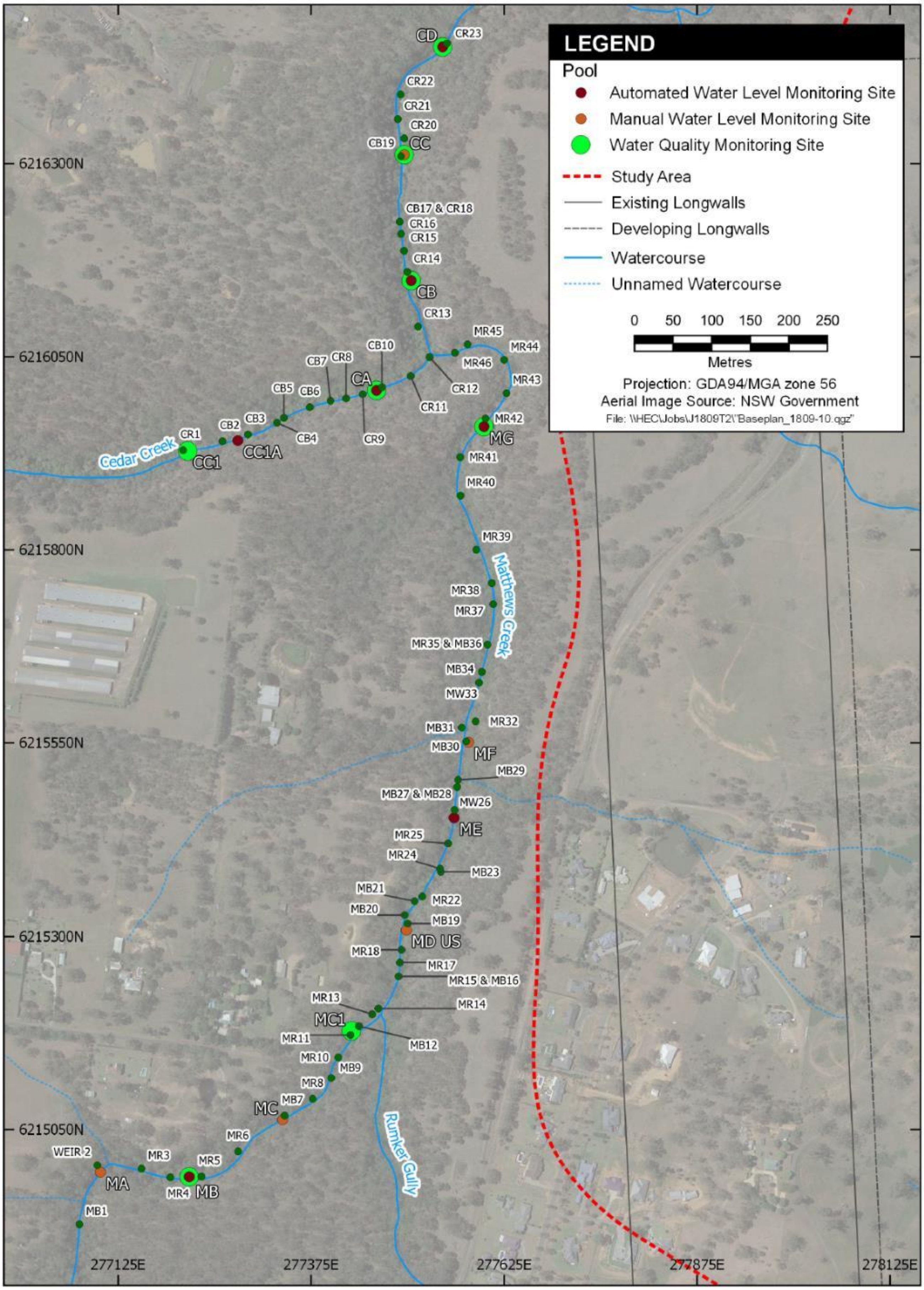


Figure 3 Matthews Creek and Cedar Creek Pool Locations

### Table 4 Matthews Creek Pool Descriptions

| Pool / Monitoring Site | Description |
|---|---|
| MB1 | Boulder constrained pool |
| Weir 2 / MA | Concrete weir constrained pool |
| MR3 | Rock / boulder constrained long pool |
| MR4 | Rockbar constrained pool |
| MR5 / MB | Rockbar constrained pool; start of large outcrop overhang on right hand side looking downstream |
| MR6 | Long shallow boulder constrained pool with large outcrop overhang on left hand side looking upstream |
| MB7 / MC | Narrow boulder constrained pool |
| MR8 | Long boulder race |
| MB9 | Long boulder constrained pool |
| MB10 | Wider boulder constrained pool |
| MR11 | Boulder constrained pool |
| MB12 / MC1 | Rock shelf and boulder constrained pool |
| MR13 | Moderate size long pool with Rumker Gully entering from east |
| MR14 | Boulder race |
| MR15 & MB16 | Boulder race |
| MR17 | Boulder race |
| MR18 | Boulder race |
| MB19 / MD US | Narrow pool with sandstone overhang |
| MB20 | Large pool with sandstone overhang |
| MB21 | Large boulder constrained pool |
| MR22 | Series of dry pools in stepped dipping sandstone |
| MB23 | Rockbar constrained wide pool |
| MR24 | First notable standing water in boulder / rockbar constrained pool |
| MR25 | Series of pools in stepped dipping sandstone |
| MW26 / ME | Series of pools in stepped dipping sandstone |
| MB27 & MB28 | Large pool boulder / rockbar constrained |
| MB29 | Small boulder constrained pool with side creek entering |
| MB30 / MF | Medium sized boulder / rockbar constrained pool |
| MB31 | Small boulder constrained pool |
| MR32 | Small boulder constrained pool |
| MW33 | Upstream waterfall (<2 m high) and downstream pools in sandstone race |
| MB34 | Medium sized boulder / rockbar constrained pool |
| MR35 & MB36 | Small pool and sandstone race |
| MR37 | Boulder race |
| MR38 | Boulder race |
| MR39 | Wide long rockbar constrained pool |
| MR40 | Medium sized pool with rockbar control |
| MR41 | Boulder race with small pools |
| MR42 / MG | Deep pool around bend in creek with outcrop overhang on left hand side looking downstream |

**Table 4 (Cont.) Matthews Creek Pool Descriptions**

| Pool / Monitoring Site | Description |
|---|---|
| MR43 | Significant decline in streambed elevation with outcrop overhang on both sides from pools MR42 - MR45 |
| MR44 | Pond on outcrop shelf within steep outcrop overhang |
| MR45 | Pond on outcrop shelf within steep outcrop overhang |
| MR46 | Pond on outcrop shelf within steep outcrop overhang |

### *3.1.2 Cedar Creek*

Cedar Creek flows from south-west to north-east adjacent to the western boundary of the Study Area. Cedar Creek joins with Stonequarry Creek approximately 370 m north-west of LW W3 and has an estimated catchment area of 27 $km^2$. At the confluence with Stonequarry Creek, Cedar Creek is a fifth order stream (refer Figure 2). The catchment area of Cedar Creek contains rural properties including a number of poultry farms, while the upper reaches are timbered and the head of the catchment lies within the Nattai National Park.

The minor tributary of Cedar Creek within the Study Area is a first order, ephemeral stream and likely only flows during periods of extended or high rainfall. Surface water runoff from the headwater of this tributary is predominately captured by a farm dam with runoff from the tributary likely to contribute to flow in Cedar Creek during periods of extended or significant rainfall only. Flow in the tributary passes through a culvert under the Picton Mittagong Loop Line before discharging to Cedar Creek. The tributary of Cedar Creek traverses LW W1 and LW W2 but does not traverse LW W3 or LW W4.

Adjacent to the Study Area, the channel of Cedar Creek is incised in Hawkesbury Sandstone, with a steep sided valley and exposed sandstone base in some parts. Rockbar, boulder and rock shelf constrained pools are prominent in the portion of creek traversing the Study Area. The bed and banks are well vegetated and show little evidence of erosion or bank instability (GeoTerra, 2014). Groundwater seepage has been observed to occur at the junction of Cedar Creek and Matthews Creek based on high iron hydroxide precipitation within this reach (Niche, 2019a).

Prior to the commencement of mining LW W1 and LW W2, the reach of Cedar Creek from monitoring site CA to CG (refer Figure 3 for site locations) was inferred to be dominantly gaining from the groundwater system, although losing conditions were predominant at monitoring site CC1A and CF (SLR, 2021a). These inferences are supported by the water level records for Cedar Creek (refer Section 3.3.1) and estimated streamflow rates at monitoring sites CC1A, CE and CG (refer Section 3.3.2.2).

A visual inspection of pools on Cedar Creek was undertaken by GeoTerra in 2019 prior to commencement of mining of LW W1. The pool locations and corresponding monitoring sites (refer Section 3.2) are shown in Figure 3 and a summary of the visual inspection is presented in Table 5. A total of 32 rockbar, boulder and rock shelf constrained pools were identified on Cedar Creek.

### Table 5 Cedar Creek Pool Description

| Pool / Monitoring Site | Description |
|---|---|
| CR1 / CC1 | - |
| CB2 | Deep, wide large pool with steep / high sandstone sides |
| CB3 / CC1A | Shallow wide pool with downstream boulder control |
| CB4 | Boulder race |
| CB5 | Shallow boulder constrained pool which divides into two channels downstream |
| CB6 | Large, wide boulder constrained pool |
| CB7 | Narrow boulder constrained medium sized pool |
| CR8 | Rockbar constrained long narrow pools, with outcrop overhang on left hand side |
| CR9 | Right hand side not visible, left hand side flowing under short outcrop overhang |
| CB10 / CA | Large wide boulder constrained pool |
| CR11 | Large wide pool upstream of rockbar at confluence with Matthews Creek |
| CR12 | Large wide pool upstream of rockbar at confluence with Matthews Creek |
| CR13 | Wide long rock shelf constrained pool with large outcrop overhang on right hand side |
| CR14 / CB | Large / wide stepped sandstone shelf with pools |
| CR15 | Boulder constrained medium sized pool |
| CR16 | Small pool with small waterfall |
| CB17 & CR18 | Stepped rock shelf with shallow pools |
| CB19 / CC | Shallow narrow boulder controlled pool |
| CR20 | Long pool with shallow rockbar constrained pool |
| CR21 | Small / medium sized pool, boulder / rockbar constrained |
| CR22 | Long shallow sandstone shelf with flow diverted to one side |
| CR23 / CD | Shallow pools on sandstone shelf |
| CR24 | Long pool, flowing around a rockbar / boulder constrained |
| CR25 / CE | Wide, medium long pool |
| CR26 / CF | Small / medium sized pool with large outcrop overhang on the bend, rock shelf control |
| CR27 | Wide shallow pool |
| CR28 | Wide medium sized pool |
| CR29 | Small / medium sized pool |
| CB30 | Medium sized pool |
| CR31 / CG | Series of small long pools in sand |
| CR32 | Long stretch of narrow pools in sand / some boulders, upstream of confluence with Stonequarry Creek |

### 3.1.3 Stonequarry Creek

Stonequarry Creek flows within the northern boundary of the Study Area and has an estimated catchment area of 44 $km^2$ to the downstream boundary of the Study Area. Within the Study Area, the creek is a fifth order stream (refer Figure 2). A minor tributary of Stonequarry Creek flows from south-east to north-west across the northern section of LW W3. Stonequarry Creek then flows eastwards outside boundary of the Study Area, through the town of Picton, joining the Nepean River near Maldon. The catchment area of Stonequarry Creek upstream of the Study Area comprises mainly rural properties and farmland with localised housing development.

The minor tributary of Stonequarry Creek within the Study Area is a first order, ephemeral stream which likely only flows during periods of extended or high rainfall. Surface water runoff from the headwater of the tributary is predominately captured by a farm dam with runoff from the tributary likely to contribute to flow in Stonequarry Creek during periods of extended or significant rainfall only. Flow in the tributary passes through a culvert under the Picton Mittagong Loop Line before discharging to Stonequarry Creek.

In the Study Area, the creek bed has a low gradient and predominately consists of a long pool, SR17, which extends from monitoring site SC2 (upstream) to monitoring site SB (downstream) (refer Figure 6). The pool is approximately 670 m long and flow appears to be perennial in nature, with trickle flow observed over the rockbar during a period of prolonged low rainfall in 2019. The deepest section of pool SR17 is approximately 4 metres below the surface of rockbar SR17 (MSEC, 2021). Signs of natural erosion and weathering are present on the surface of rockbar SR17. Flute holes and natural fracturing are prevalent in some areas of the rockbar (MSEC, 2021).

Downstream of the rockbar SR17 lies a series of connected pools, located on a large sandstone rock shelf and constrained by rockbars. Ground levels downstream of rockbar SR17 exceed the base elevation of pool SR17 for a length of approximately 170 m downstream of the pool (MSEC, 2021). The bed and banks within the section of Stonequarry Creek traversing the Study Area are well vegetated and show little evidence of erosion or bank instability (GeoTerra, 2014).

Prior to the commencement of mining LW W1 and W2, the upstream reach of Stonequarry Creek from monitoring site SG to SE (refer Figure 6 for site locations) was inferred to be spatially varying between gaining and losing conditions from the groundwater system (SLR, 2021a). Further downstream at pool SR17 (monitoring site SB), there is potential that the base of the pool is in connection with the Hawkesbury Sandstone, with the Hawkesbury Sandstone supporting baseflow to Stonequarry Creek. However, the relative influence of the shallow colluvium present at this location in comparison with the contribution of baseflow from the Hawkesbury Sandstone is uncertain (SLR, 2021a). Losing conditions are inferred to prevail at monitoring sites SC, SD and SF further downstream in Stonequarry Creek (SLR, 2021a). These inferences are supported by water level records for Stonequarry Creek (refer Section 3.3.1) and estimated streamflow rates at monitoring site SA and SD (refer Section 3.3.2.3).

A visual inspection of pools on Stonequarry Creek was undertaken by GeoTerra in 2019 prior to commencement of mining of LW W1. The pool locations and corresponding monitoring sites (refer Section 3.2) are shown in Figure 4 and a summary of the visual inspection is presented in Table 6. A total of 22 rockbar, boulder and rock shelf constrained pools were identified on Stonequarry Creek.

## Table 6 Stonequarry Creek Pool Description

| Pool / Monitoring Site | Description |
|---|---|
| SC1 | Isolated pool on rock shelf |
| SG2 / SG | Long pool with weeds / reeds and heavily vegetated banks |
| SG3 | Long pool with weeds / reeds and heavily vegetated banks controlled by willow tree |
| ST4 | Large wide pool on bend in creek |
| SR5 / SE | Long pool with rockbar control |
| SB6 | Medium sized pool with rockbar / willow tree control |
| SR7 | Medium sized pool with rockbar control |
| SG8 | Small pool with rockbar control and sandstone overhang |
| SG9 | Small pool with rockbar / boulder / willow tree control |
| SR10 | Large pool with willow tree / rockbar control |
| SB11 & ST12 | Long pool with willow tree / rockbar control |
| SB13 | Shallow wide pool |
| SB14 | Long pool with sandstone overhang |
| SB15 | Long narrow pool |
| SR16 / SA | Long narrow pool |
| SR17 / SC2 (upstream) & SB (downstream) | Long, deep pool with flow over a large sandstone rock shelf |
| SR18 | Series of connected pools on a large sandstone rock shelf |
| SR19 | Series of connected pools on a large sandstone rock shelf |
| SR20 | Series of connected pools on a large sandstone rock shelf |
| SR21 / SC | Series of connected pools on a large sandstone rock shelf |
| SR22 | Series of connected pools on a large sandstone rock shelf |

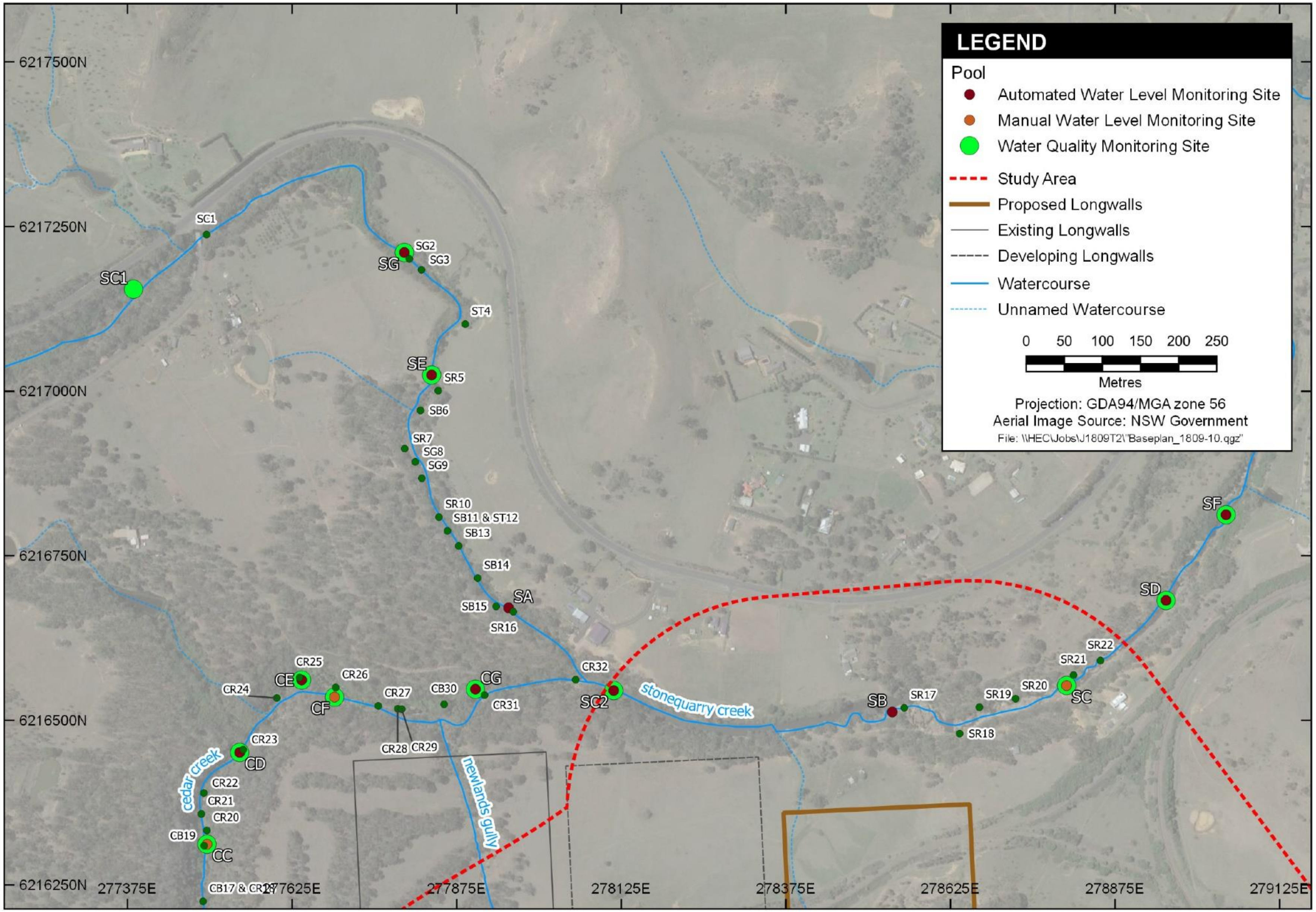


Figure 4 Stonequarry Creek Pool Locations

### 3.1.4 Redbank Creek

Redbank Creek is a fourth order stream within the vicinity of the Study Area. The Redbank Creek thalweg / centreline is approximately 600 m south-east of the finishing end of LW W4 at its closest point. Redbank Creek flows towards the east where it joins Stonequarry Creek approximately 1.5 km east of the eastern boundary of Tahmoor LW32. The catchment area of Redbank Creek to its confluence with Stonequarry Creek is estimated at 7.8 $km^2$.

The main channel of Redbank Creek is aligned north-east from the town of Thirlmere to its confluence with Stonequarry Creek, flowing above the previously mined LW24B to LW32. The upper and middle reaches near Thirlmere are located in residential and semi-rural residential areas, while the downstream portion near LW32 contains mostly industrial development near the southern end of Picton.

In the developed areas, Redbank Creek is predominantly in poor condition, containing a prevalence of weeds and rubbish (GeoTerra, 2014). However, the stream bed and banks are well vegetated with little evidence of erosion or bank instability (GeoTerra, 2014). In the reach of LW24B to LW32, the creek comprises a sequence of rockbar, boulder and rock shelf constrained pools. Redbank Creek flows over predominantly Hawkesbury Sandstone bedrock in its middle and lower reaches, with natural iron-rich seepage resulting in red colouration of the banks and pools (MSEC, 2014).

A third order tributary connects with Redbank Creek approximately 700 m downstream of LW32 (referred to herein as the main tributary of Redbank Creek). The first and second order reaches of this tributary traverse and run adjacent to LW W2, W3 and W4.

The catchment area of the main tributary of Redbank Creek is approximately 1.75 $km^2$, a large portion of which overlies LW W2 and LW W3 and the entirety of LW W4. The catchment area is predominately zoned as rural landscape with the third order reach of the tributary traversing low density residential areas (NSW Government, 2020).

The first and second order reaches of the main tributary predominately present as discontinuous, scoured drainage lines at topographical low points in the landscape. The third order reach to the confluence with Redbank Creek has a moderate longitudinal gradient of approximately 1.7%. In some sections, the channel is incised and well-defined with relatively dense riparian vegetation. Although well vegetated, the prevalence of weeds and rubbish is evident in some sections of the channel. Other sections of the third order reach have been heavily modified by residential development, including diversion through road culverts. The main tributary, including the third order reach, is not known to contain any noteworthy surface water features (i.e. rockbars, pools and aquatic habitat).

The tributaries of Redbank Creek within the Study Area, including the main tributary of Redbank Creek, are ephemeral and likely only flow during periods of extended, moderate or high rainfall. SLR (2021a) indicate that there is limited baseflow contribution from the outcropping Wianamatta Group to the main tributary of Redbank Creek. Two large farm dams and a number of smaller farm dams are located within the catchment area. Surface water runoff from the headwaters of the tributaries is predominately captured by these farm dams with runoff from the tributaries likely to contribute to flow in Redbank Creek during periods of extended or significant rainfall only.

### 3.1.5 Water Access Licences

The surface water resources within the Study Area are regulated by the *Water Sharing Plan for Greater Metropolitan Region Unregulated River Water Sources* which specifically addresses the Stonequarry Creek Management Zone of the Upper Nepean and Upstream Warragamba Water

Source.  The NSW Water Register[2] indicates that there are 22 Water Access Licence (WAL) - Water Supply Works and Water Use Approvals for the Stonequarry Creek Management Zone with a total share component of 680.3 ML for the period July 2020 to June 2021 (inclusive).

Seven WALs, associated with fourteen lots, are located in the vicinity of the Study Area (refer Figure 5 for lot locations - hatch colour indicates different WALs).  The WALs pertain to diversion works from the Stonequarry Creek Management Zone via direct extraction (pumping) and / or through collection and storage for irrigation and / or farming purposes.

The closest lots with a WAL for direct extraction (pumping) from Cedar Creek and Matthews Creek are located upstream of the Study Area.  One WAL for extraction from the Stonequarry Creek Management Zone is allocated to both lots which are located within the Study Area and overlie a portion of LW W1, W2 and W3.  Although the property bounds sections of Matthews Creek and Cedar Creek, it is inferred, based on reports from visual inspections (pers. comm. Tahmoor Coal), that direct extraction (pumping) is undertaken from Stonequarry Creek.  A landholder pump is located in pool SR17 on Stonequarry Creek within the bounds of the property assigned a WAL.  Two farm dams are also located within these lots, with one located in the Rumker Gully catchment (a tributary of Matthews Creek) and one located on a tributary of Cedar Creek.

Three lots, with one WAL, overlie a portion of LW W3 and W4 with the WAL associated with collection and storage of runoff in farm dams which are located on minor tributaries of Redbank Creek.  Downstream of the Study Area, two lots with two WALs are located on Stonequarry Creek adjacent to the confluence with Redbank Creek.  The WAL for these lots is associated with direct extraction (pumping) from Stonequarry Creek.

Tahmoor Coal also hold a WAL of 16 ML under the authority of the *Water Management Act 2000* for incidental surface water take from the Stonequarry Creek Management Zone (SLR, 2021a).

### 3.2 STRUCTURAL FEATURE OF INTEREST

The major structural feature of interest in the vicinity of the Study Area is the Nepean Fault.  As stated in SIMEC (2019), 'The Nepean Fault encountered at Tahmoor Mine is part of the regional Nepean Fault system. This system is the southern extension of the Lapstone Monocline, and at Tahmoor Mine, it consists of closely spaced sub-vertical en-echelon faults in a zone up to 400 m wide.'  SIMEC (2019) also note that the Nepean Fault zone is the only hydraulically charged geological structure which has been encountered during the period of mining at Tahmoor Mine to date.

SLR (2021a) note that the significant high angle structural feature is known to be transmissive and, as such, mine workings that intersect this zone may produce more water and increased groundwater depressurisation in overlying strata may occur.  SCT (2020a) conducted a detailed investigation of the Nepean Fault system to map features and estimate the distance of the Nepean Fault system to the LW W3-W4 panels.  SCT (2020a) identified that, at the north-eastern corner of the panel, LW W3 is located 250 m west of the nearest mapped fault trace and in the south-eastern corner of the panel, LW W3 is located 570 m west of the nearest mapped fault trace.  LW W4, in the north-eastern corner of the panel, is located 20 m west of the nearest mapped surface trace and 245 m in the south-eastern corner of the panel.

Further detail on the Nepean Fault system and potential associated impacts relating to mining of LW W3-W4 are provided in SCT (2020a) and the Groundwater Technical Report (SLR, 2021a; Appendix D of the WMP).

[2] https://waterregister.waternsw.com.au accessed October 2020.

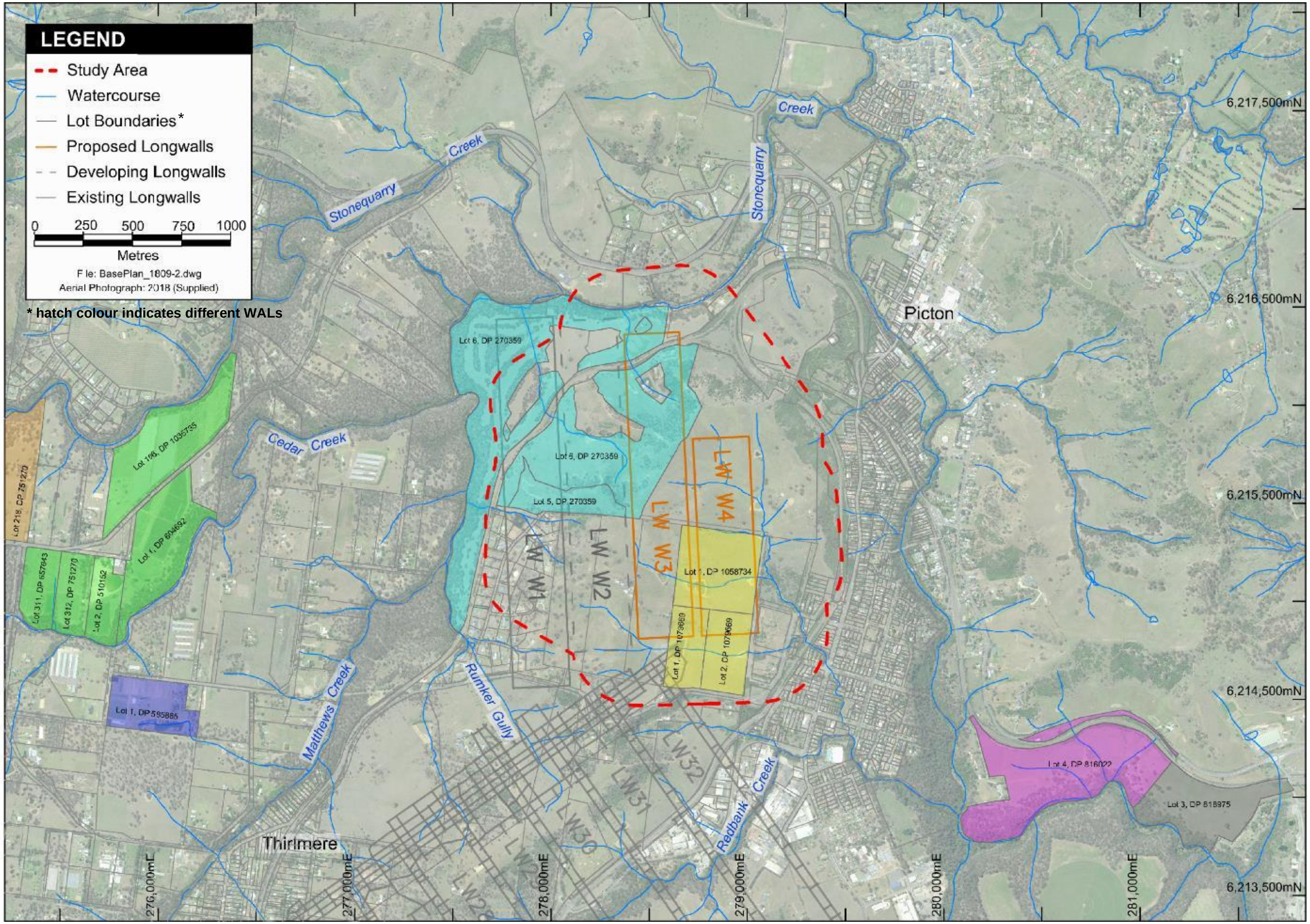


**Figure 5** Water Supply Works and Water Use Approvals

## 3.3 SURFACE WATER MONITORING

Pool water level and surface water quality data has been recorded at sites in Matthews Creek, Cedar Creek and Stonequarry Creek at the locations shown in Figure 6. Water quality monitoring of Redbank Creek has been conducted by routine sampling and laboratory analyses at select sites since February 2005 (refer Figure 7 for site locations). Laboratory water quality monitoring was discontinued in late 2020 although monthly field water quality monitoring has continued at select sites. Appendix A presents the tabulated Tahmoor Coal monitoring sites, type of monitoring and period of record presented in this SWTR.

The surface water monitoring programme implemented by Tahmoor Coal adopted a Before-After-Control-Impact (BACI) framework. The monitoring program aimed to develop a baseline (before) dataset for a range of surface water features and to assess operational and post-mining (after) impacts through the monitoring of reference (control) and performance measure (impact) sites. The monitoring sites have been categorised as follows:

Control / Reference site: a site which is to provide control / reference data against which future Project impacts could be compared; or

Baseline / Impact site: a site which is to be used to compare conditions before, during and after the Project.

Note that 'the Project' relates to potential cumulative impacts associated with mining of LW W1-W4.

### *3.3.1 Surface Water Level Monitoring*

Surface water level data has been collected by Tahmoor Coal at the monitoring sites on Matthews Creek, Cedar Creek and Stonequarry Creek as shown in Figure 6. Continuous surface water level data has been recorded at three pool monitoring sites on Matthews Creek, eight monitoring sites on Cedar Creek and seven monitoring sites on Stonequarry Creek. The surface water level data has been recorded hourly using water level sensors.

Manual water level measurements have also been collected monthly by Tahmoor Coal at the sites shown in Figure 6. Appendix B provides charts of the water level data for all monitoring sites. Note that the cease to flow (CTF) level shown on the automated water level plots refers to the point at which surface water ceases to flow over the streamflow control i.e. the lowest point on a controlling rockbar or boulder field. In the event that streamflow over the rockbar or boulder field ceases, there may still be streamflow around or under the rockbar / boulder field control which reports downstream of the control. Table 7 presents a summary of the water level monitoring for each pool in which a water level sensor is installed.

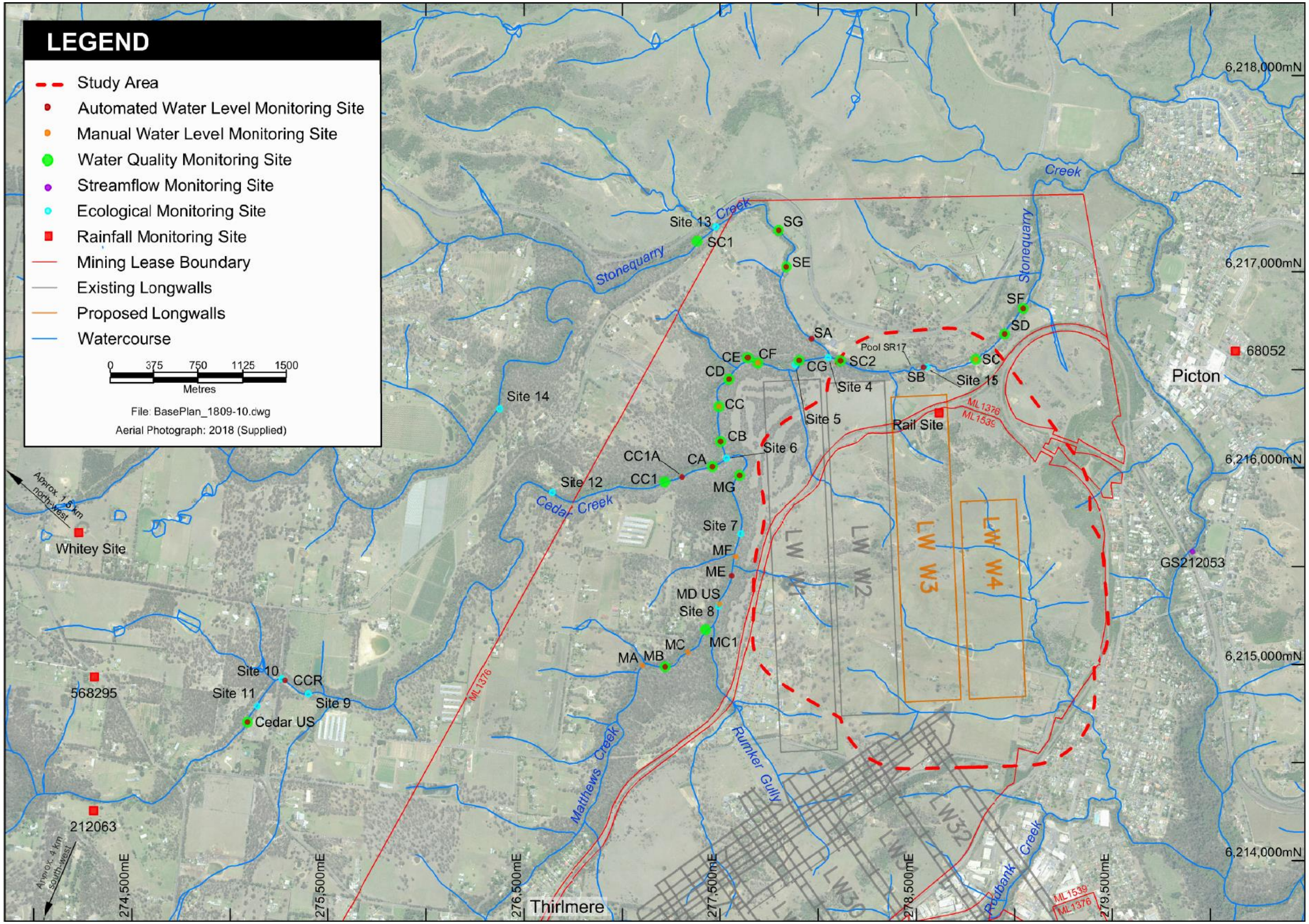


**Figure 6** Rainfall, Surface Water and Ecological Monitoring Locations

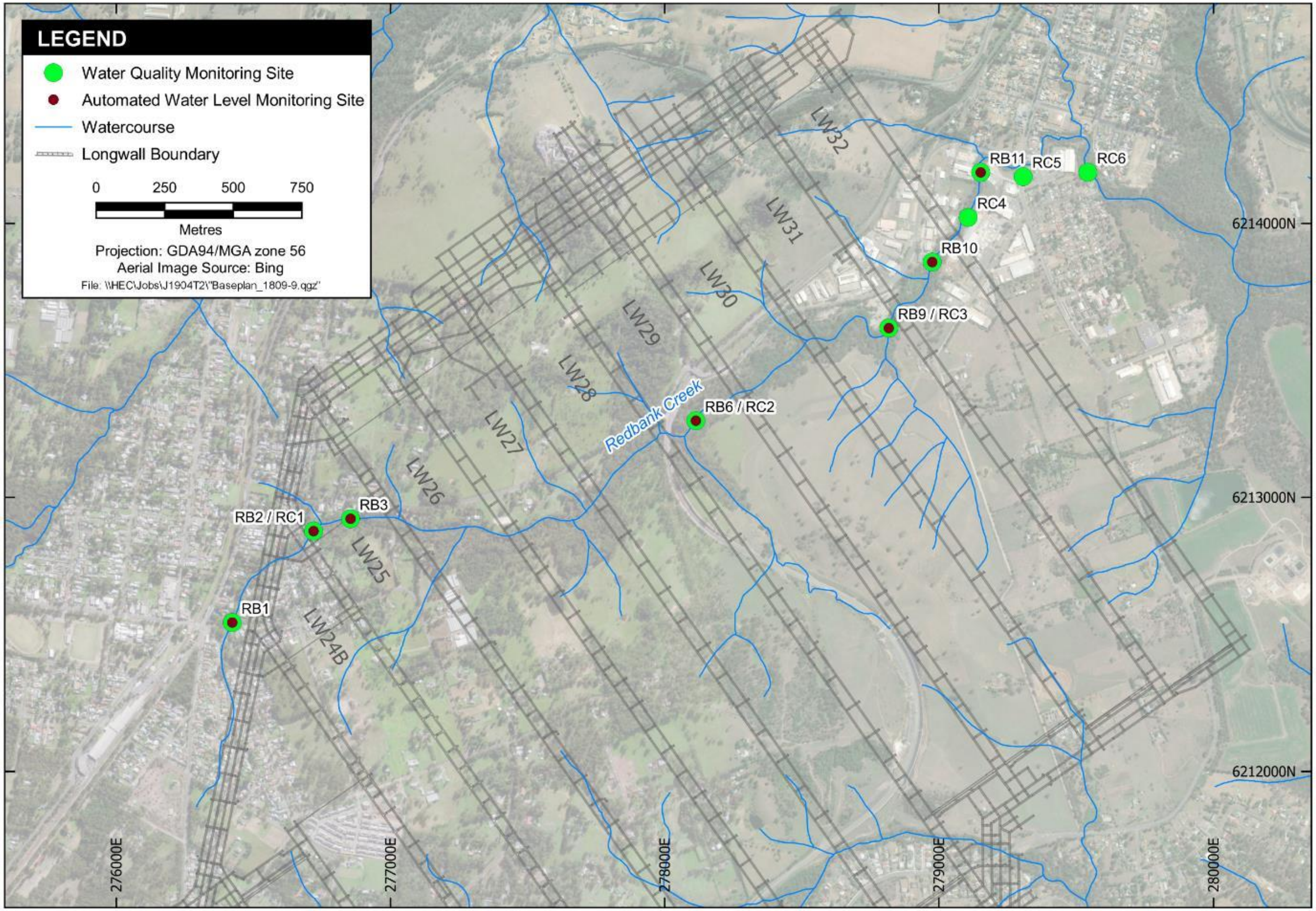


**Figure 7** **Redbank Creek Surface Water Monitoring Locations**

### Table 7 Summary of Water Level Monitoring

| Monitoring Site | Natural Control Characteristics | Recorded Water Level to February 2021 |
|---|---|---|
| *Matthews Creek* | | |
| MB<br>(Pool MR5)<br><br>Reference Site | Rockbar constrained | Between December 2018 and July 2019, the water level at site MB was predominantly near the cease to flow (CTF) level except during and shortly following rainfall events when rises in water level were recorded. Following an extended period of low rainfall, the water level declined below the CTF level from the end of July 2019 until late September 2019 and again from mid-October 2019 until mid-January 2020. Following substantial rainfall in early 2020, the water level remained predominately above the CTF level and above the previously recorded minimum for the remainder of the monitoring period. Water level rises were recorded in response to rainfall events, consistent with baseline (pre-mining LW W1) conditions (Chart B2, Appendix B). |
| ME<br>(Pool MR25)<br><br>Potential Impact Site | Boulder / rockbar constrained | Prior to mid-January 2020, the water level recorded at monitoring site ME was predominantly below the CTF level except for short periods during and shortly following rainfall events between November 2018 and April 2019 and again in September 2019. Following an extended low rainfall period in late 2019, the water level declined and the pool was dry until mid-January 2020. Following substantial rainfall in early 2020, the water level remained predominately above the CTF level and above the previously recorded minimum for the remainder of the monitoring period. Water level rises were recorded in response to rainfall events, consistent with baseline (pre-mining LW W1) conditions (Chart B5, Appendix B). |
| MG<br>(Pool MR42)<br><br>Potential Impact Site | Boulder constrained | Prior to mid-January 2020, the water level at monitoring site MG was predominantly below the CTF level except for short periods during and shortly following rainfall events between November 2018 and April 2019. Following an extended low rainfall period in late 2019, the water level declined and the pool was dry until mid-January 2020. Following substantial rainfall in early 2020 the water level remained above the CTF level for the remainder of the review period except for short periods in October and December, consistent with baseline conditions. Between mid-January 2020 and January 2021, the water level did not decline below the baseline minimum water level (Chart B7, Appendix B). |
| *Cedar Creek* | | |
| CCR<br><br>Reference Site | Weir | The water level records for monitoring site CCR are influenced by backwater effects from a large weir downstream during high rainfall periods (Chart B8, Appendix B). As such, the water level records for monitoring site CCR are not necessarily reflective of natural water level conditions during these periods. Subsequently, a monitoring site was commissioned upstream of CCR – referred to as Cedar US (refer Figure 6). Automated water level monitoring commenced at this site in December 2020 with the records included in Appendix B (Chart B9, Appendix B). |
| CC1A<br>(Pool CB3)<br><br>Reference Site | Boulder / rockbar constrained | The water level recorded at CC1A was relatively consistent for the period May to December 2019, with subdued small peaks in water level recorded in response to rainfall events. Following an extended low rainfall period in late 2019, the water level declined and the pool was dry until mid-January 2020. Following substantial rainfall in early 2020, the water level rose and remained above the previously recorded minimum for the remainder of the monitoring period. A water level decline occurred in early to mid-December 2020 and appeared inconsistent with baseline (pre-mining LW W1) conditions at this site, however, was consistent with a water level decline which occurred at other monitoring sites during the same period (Chart B10, Appendix B). Refer Section 4.3.1.4 for further detail. |

**Table 7 (Cont.) Summary of Water Level Monitoring**

| Monitoring Site | Natural Control Characteristics | Recorded Water Level to February 2021 |
|---|---|---|
| *Cedar Creek* | | |
| CA<br>(Pool CB10)<br><br>Potential Impact Site | Boulder constrained | Prior to commencement of mining LW W1, the water level at site CA remained above the CTF level for the majority of the monitoring period except for a short period in March 2019 following low rainfall. Subdued small peaks in water level were recorded during rainfall periods. Following an extended low rainfall period in late 2019 the water level fell below the CTF level for an extended period of time before substantial rainfall in early 2020 resulted in water level rise above the CTF level. From mid-January to December 2020, the water level remained predominately above the CTF level. Two sharp and notable periods of water level decline were recorded at this site in December 2020 and again in January 2021. The water level behaviour during these periods was atypical and inconsistent with baseline conditions. However, the water level did not decline below the previously recorded minimum water level during these periods (Chart B11, Appendix B). Refer Section 4.3.1.4 for further detail. |
| CB<br>(Pool CR14)<br><br>Potential Impact Site | Rockbar constrained | Prior to commencement of mining LW W1, the water level at site CB remained above the CTF level for the duration of the monitoring period. Subdued small peaks in water level were recorded during rainfall periods. During an extended low rainfall period in 2019, the water level remained relatively consistent and did not decline below the CTF level. Following substantial rainfall in mid-January and February 2020, the water level rose and remained above the CTF level until late June 2020. From June to early October 2020 the water level fluctuated around the CTF level, with a slight decline below the baseline minimum occurring in July 2020 and rises in water level occurring in response to rainfall events. From October 2020 to January 2021, the water level characteristics at this site were atypical and inconsistent with baseline conditions. The water level fell slightly below the previous minimum in September and October 2020 and notably below the previous minimum in December 2020 and January 2021 (Chart B12, Appendix B). Pool CR14 (monitoring site CB) has likely been impacted by mining LW W1/W2 and a detailed investigation has been undertaken. Refer Section 4.3.1.4 for further detail. |
| CD<br>(Pool CR23)<br><br>Potential Impact Site | Rockbar / boulder constrained | Prior to commencement of mining LW W1, the water level at site CD remained above the CTF level for the duration of the monitoring period, including during an extended low rainfall period in 2019. Following substantial rainfall in early 2020, the water level remained elevated until May 2020. Between May and October 2020, the water level remained above the CTF level, rising in response to rainfall events. The water level declined slightly below the CTF level and the baseline minimum for a short period in October 2020, December 2020 and January 2021 (Chart B14, Appendix B). Refer Section 4.3.1.4 for further detail. |
| CE<br>(Pool CR25)<br><br>Potential Impact Site | Rockbar / boulder constrained | The water level at site CE remained above the CTF level for the duration of the monitoring period. Peaks in water level were recorded during rainfall periods and a small gradual rise in water level was recorded from April to September 2019 in the absence of notable rainfall suggesting potential groundwater recharge. The water level following commencement of mining LW W1 did not decline below the baseline water level recorded prior to commencement of mining LW W1 (Chart B15, Appendix B). |

**Table 7 (Cont.) Summary of Water Level Monitoring**

| Monitoring Site | Natural Control Characteristics | Recorded Water Level to February 2021 |
|---|---|---|
| *Cedar Creek* | | |
| CG<br>(Pool CR31)<br><br>Potential Impact Site | Rock shelf constrained | The water level at site CG remained above the CTF level for the duration of the monitoring period. Peaks in water level were recorded during rainfall periods and a small gradual rise in water level was recorded from July to August 2019 in the absence of notable rainfall suggesting potential groundwater recharge. The water level declined slightly below the baseline minimum for a short period in late January 2021 (Chart B17, Appendix B). Refer Section 4.3.1.4 for further detail. |
| *Stonequarry Creek* | | |
| SG<br>(Pool SG2)<br><br>Reference Site | Rock shelf constrained | Automated water level monitoring commenced at monitoring site SF in August 2020. The water level records for this site are consistent with that of other monitoring sites in Stonequarry Creek upstream of the Study Area with steep rises in water level occurring during rainfall events and relatively steady water level during low rainfall periods (Chart B18, Appendix B). |
| SE<br>(Pool SR5)<br><br>Reference Site | Rockbar constrained | Automated water level monitoring commenced at monitoring site SE in April 2020. The water level records for this site are consistent with that of other monitoring sites in Stonequarry Creek upstream of the Study Area with steep rises in water level occurring during rainfall events and relatively steady water level during low rainfall periods (Chart B19, Appendix B). |
| SA<br>(Pool SR16)<br><br>Potential Impact Site | Rockbar / boulder constrained | Prior to commencement of mining LW W1, the water level at monitoring site SA remained above the CTF level between November 2018 and July 2019 except for one week in March 2019 when the water level declined below the CTF level. Following an extended period of low rainfall, the water level declined below the CTF level for the duration of July, for a short period in September and from the beginning of October 2019 until early 2020. Following substantial rainfall in early 2020, the water level remained above the CTF level and above the previously recorded minimum for the remainder of the monitoring period. Water level rises were recorded in response to rainfall events, consistent with baseline (pre-mining LW W1) conditions (Chart B20, Appendix B). |
| SC2<br>(Pool SR17)<br><br>Potential Impact Site | Rockbar constrained | Monitoring site SC2 is located upstream of monitoring site SB, both of which are located in pool SR17. Automated water level monitoring commenced at monitoring site SC2 in April 2020 with the water level records consistent with that recorded at monitoring site SB (Chart B21, Appendix B). |
| SB<br>(Pool SR17)<br><br>Potential Impact Site | Rockbar constrained | Manual water levels have been recorded from November 2018 at monitoring site SB with automated water level monitoring commencing in June 2020. The automated water level records appear consistent with baseline conditions, with peaks in water level occurring during rainfall events. The water level records indicate that the water level post commencement of mining LW W1 has not declined below the baseline mining recorded prior to the commencement of mining LW W1 (Chart B22, Appendix B). |

**Table 7 (Cont.) Summary of Water Level Monitoring**

| Monitoring Site | Natural Control Characteristics | Recorded Water Level to February 2021 |
|---|---|---|
| *Stonequarry Creek* | | |
| SD<br><br>Potential Impact Site | Rockbar constrained | Prior to commencement of mining LW W1, the water level records for monitoring site SD indicate rapid responses to rainfall events followed by steep recessions. The water level remained above the CTF level until late October 2019. From late-October 2019, the water level declined below the CTF level except for a short period in November 2019 during a rainfall event. Between 11 November 2019 and 15 January 2020, the pool at monitoring site SD was dry. Following substantial rainfall in mid-January and February 2020, the water level remained above the CTF level and above the previously recorded minimum for the remainder of the monitoring period. The water level records for the period post commencement of mining LW W1 are consistent with baseline conditions (Chart B24, Appendix B). |
| SF<br><br>Potential Impact Site | Rockbar constrained | Automated water level monitoring commenced at monitoring site SF in April 2020. The water level records for this site are generally consistent with monitoring site SD in Stonequarry Creek with steep rises in water level occurring during rainfall events and rapid recessions in water level occurring during low rainfall periods (Chart B25, Appendix B). |

### *3.3.2 Streamflow Monitoring*

Flow rating relationships have been derived for three monitoring sites on Matthews Creek, three monitoring sites on Cedar Creek and two monitoring sites on Stonequarry Creek (refer Figure 8 for site locations). The flow rating relationships allow for estimation of the streamflow rate derived from the water level monitoring data recorded at each pool for the period January 2019 to January 2021. Flow rating relationships have only been derived for monitoring sites with a suitable streamflow control that facilitates manual streamflow measurements and hydraulic modelling.

The flow rating relationships have been developed through detailed survey of the pool control and one dimensional (1D) hydraulic modelling calibrated to manual measurements of streamflow. Critical review of the flow rating relationships has been undertaken based on additional manual streamflow measurements recorded since initial model calibration. Where there was a distinct deviation in the manual streamflow measurements and the theoretical rating relationship derived from 1D hydraulic modelling, the theoretical rating relationship was revised through polynomial regression applied to the manual streamflow measurements.

As indicated in Table 7, the water level of some pools declined below the CTF level during the monitoring period. The theoretical rating relationships are derived only for flow over the pool control and may not include pool natural subsurface flow or flow that is diverted around the pool control. As such, the estimated streamflow rates are indicative only.

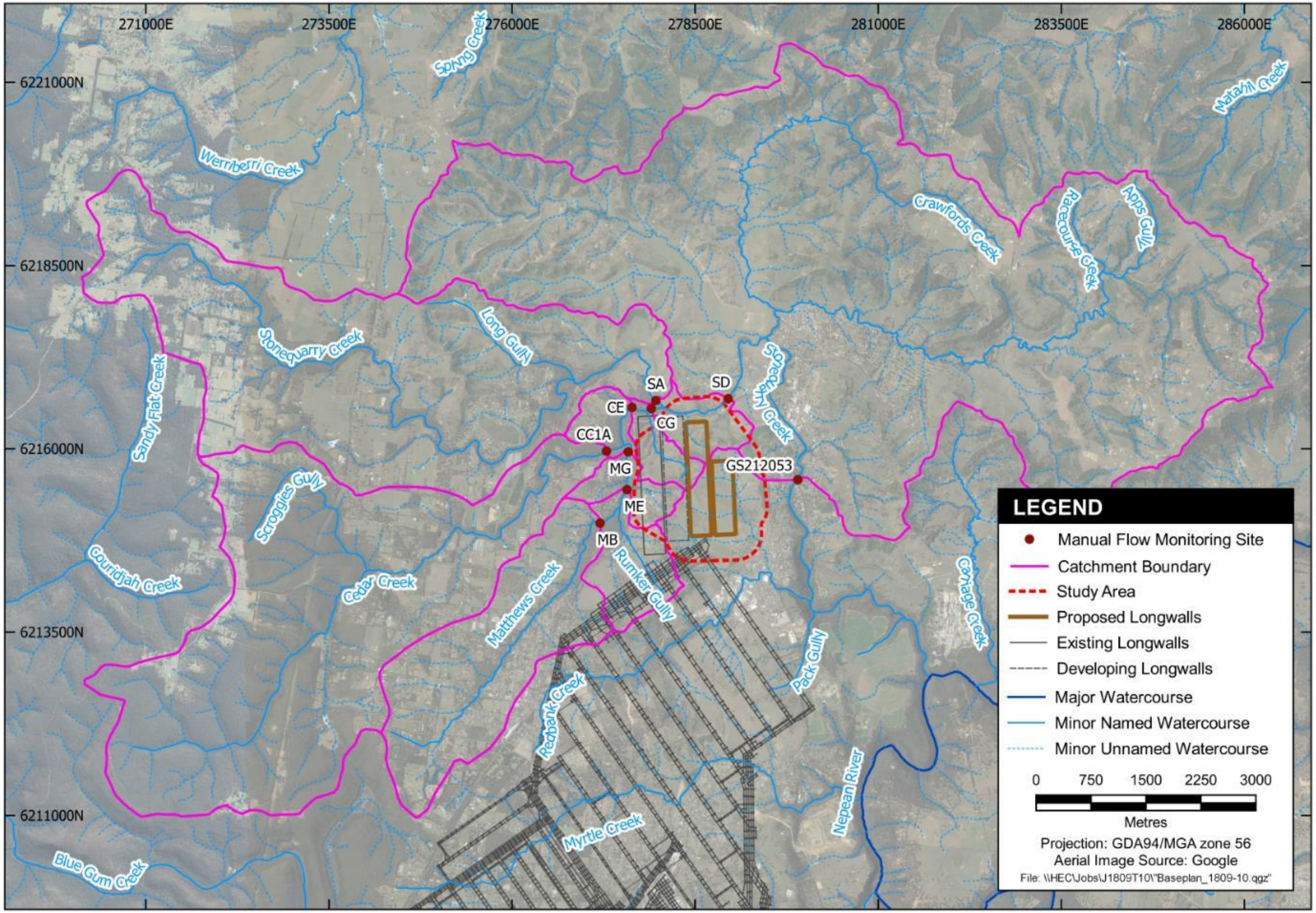


**Figure 8** **Manual Streamflow Monitoring Locations and Catchments**

Table 8 presents the estimated catchment areas, as illustrated in Figure 8. A summary of the estimated streamflow rate at each site is provided in the following sections.

**Table 8 Manual Streamflow Monitoring Site Catchment Areas**

| Surface Water System | Monitoring Site | Catchment Area ($km^2$) |
|---|---|---|
| Matthews Creek | MB | 5.9 |
| | ME | 7.3 |
| | MG | 8.1 |
| Cedar Creek | CC1A | 17.5 |
| | CE | 26.2 |
| | CG | 26.8 |
| Stonequarry Creek | SA | 16.4 |
| | SD | 44.1 |

### 3.3.2.1 Matthews Creek

Figure 9 presents the estimated flow duration curves[3] for flow over the control at monitoring sites MB, ME and MG on Matthews Creek, derived from water level records for January 2019 to January 2021. The estimated rate of streamflow is expressed in ML/d per square kilometre ($km^2$) of catchment (or mm/day) to enable direct comparison between sites.

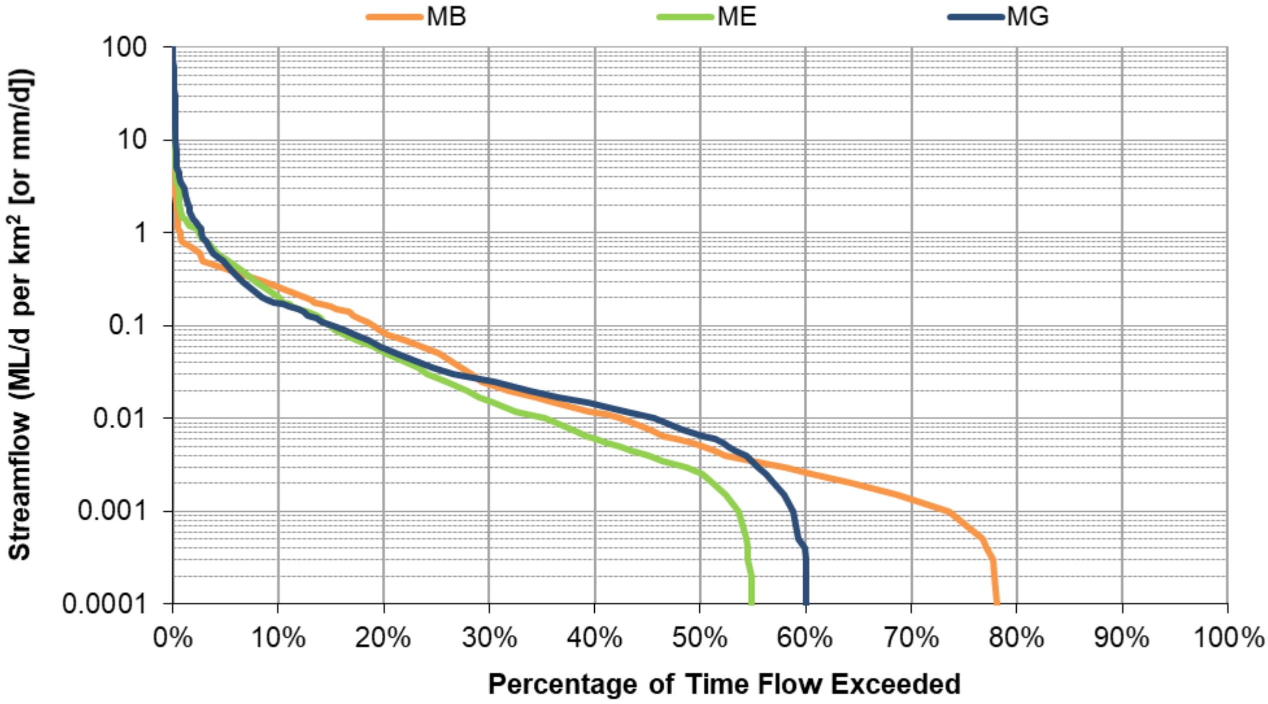


**Figure 9 Matthews Creek Monitoring Sites Estimated Flow Duration Curve**

Figure 9 illustrates that flow over the control at monitoring sites MB, ME and MG occurs intermittently (55 to 78% of the time). The estimated streamflow characteristics for monitoring sites MB and MG are similar for moderate (greater than 0.005 mm/d) to high flows (greater than 0.3 mm/d), with 0.005 mm/d exceeded at MB approximately 50% of the time and at MG approximately 53% of the

[3] A Flow Duration Curve is a plot of the proportion of time (days) flow is greater than a given flow rate based on a long period of record. In this report it has been calculated using daily flows over the entire modelled period. The flow duration curves produced in this report have been plotted on logarithmic scale to accentuate low flows.

time, in comparison with approximately 42% of the time at monitoring site ME. The estimated streamflow rates indicate a median flow rate of approximately 0.03 ML/d (0.005 mm/d) at monitoring site MB, 0.02 ML/d (0.003 mm/d) at monitoring site ME and 0.05 ML/d (0.007 mm/d) at monitoring site MG.

### 3.3.2.2 Cedar Creek

Figure 10 presents the flow duration curves for flow over the control at monitoring sites CA, CE, CG and CC1 on Cedar Creek, derived from water level records for January 2019 to January 2021.

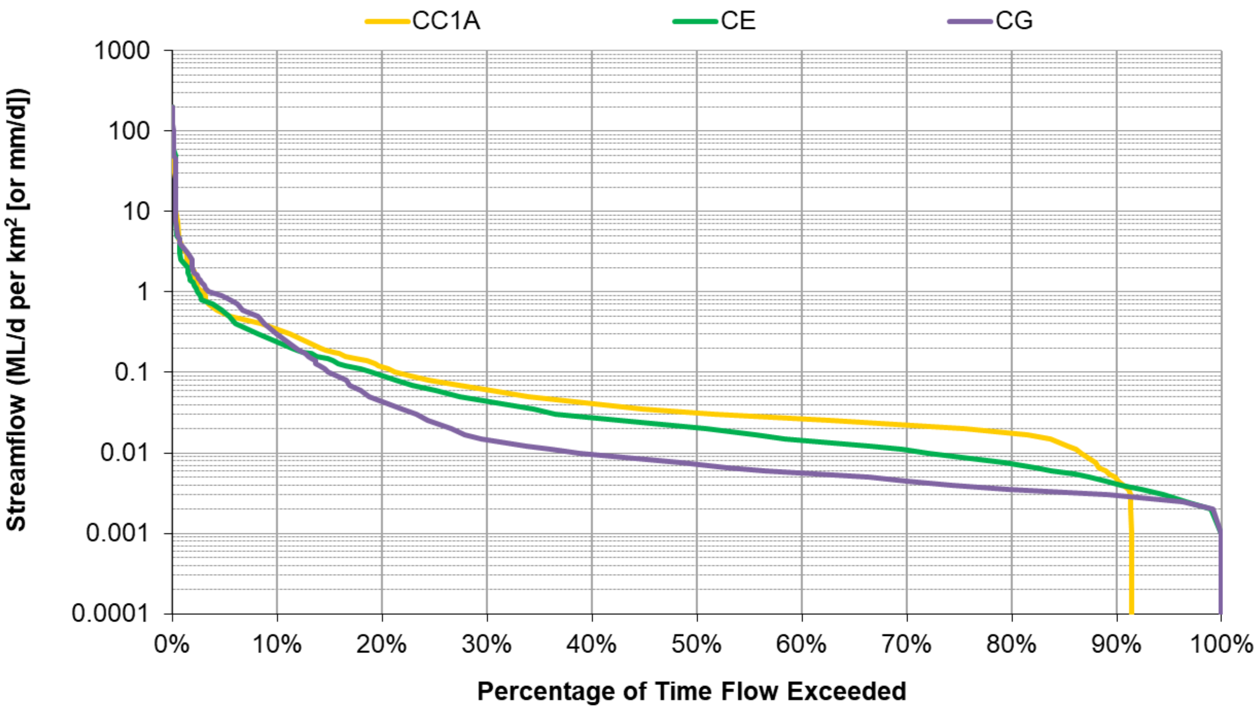


**Figure 10 Cedar Creek Monitoring Sites Estimated Flow Duration Curve**

Figure 10 illustrates that flow over the control at monitoring sites CC1A and CE is near perennial (flowing more than 90% of time) while flow over the control at monitoring site CG is perennial. The estimated streamflow characteristics for monitoring sites CC1A, CE and CG are similar for high flows (0.5 mm/d occurring approximately 5%, 8% and 5% of the time respectively), while moderate flows (greater than 0.01 mm/d) were estimated to occur more frequently at monitoring site CC1A and CE and low flows were estimated to occur more frequently at monitoring sites CE and CG. The estimated streamflow rates indicate a median flow rate of approximately 0.53 ML/d (0.02 mm/d) at monitoring site CE, 0.19 ML/d (0.007 mm/d) at monitoring site CG and 0.55 ML/d (0.03 mm/d) at monitoring site CC1A.

### 3.3.2.3 Stonequarry Creek within Study Area

Figure 11 presents the flow duration curves for flow over the control at monitoring sites SA and SD on Stonequarry Creek, derived from water level records for January 2019 to January 2021.

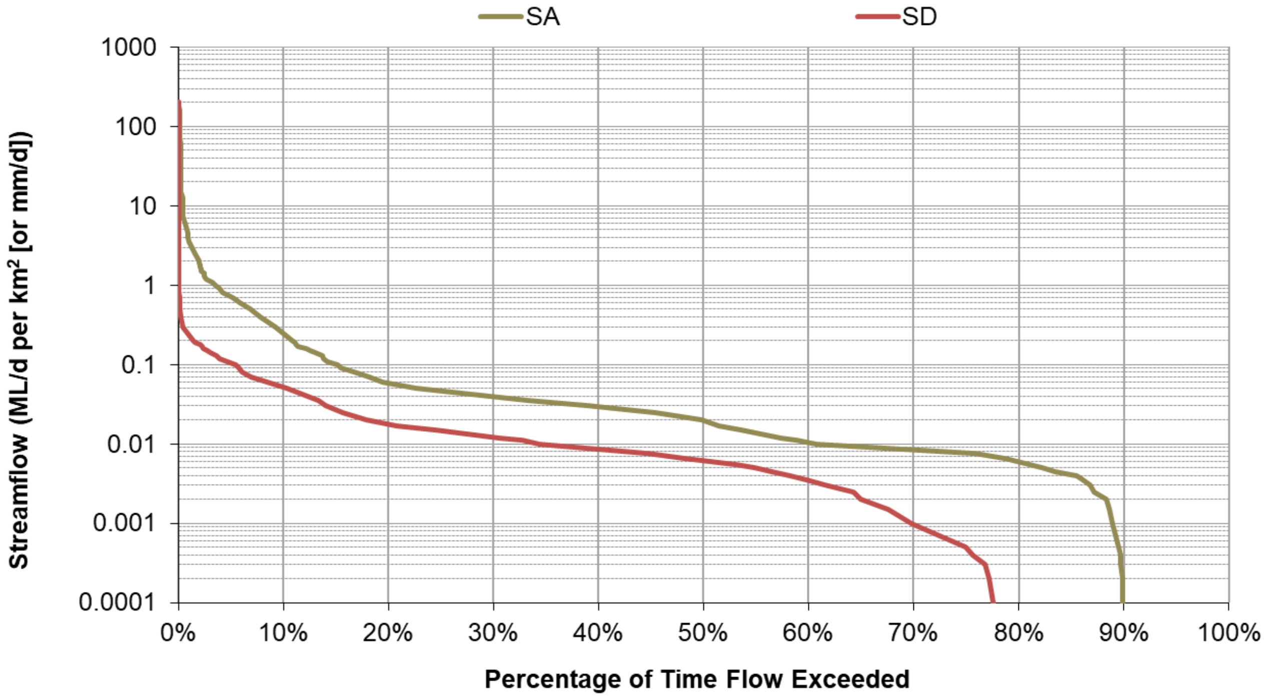


**Figure 11 Stonequarry Creek Monitoring Sites Estimated Flow Duration Curve**

Figure 11 illustrates that flow over the control at monitoring site SA and SD is intermittent with a flow rate of than 0.001 mm/d recorded approximately 89% of the time at monitoring site SA and approximately 70% of the time at monitoring site SD. It should be noted that the streamflow control at monitoring site SD is a wide, flat rockbar and, as such, monitoring of low flow rates is unable to be accurately undertaken at this site. The accuracy of low flow records will influence the percentage of time in which low flow rates are inferred to occur at monitoring site SD. There is also potential that the stream reach between pool SR17 (monitoring site SB) and monitoring site SD is sustained by baseflow discharge (i.e. the stream section is losing to the groundwater system) to a lesser degree than the reach upstream of monitoring site SD (refer Section 3.1.3). The estimated streamflow rates indicate a median flow rate of approximately 0.32 ML/d (0.02 mm/d) at monitoring site SA and 0.27 ML/d (0.006 mm/d) at monitoring site SD.

#### 3.3.2.4 Redbank Creek

Figure 12 presents the flow duration curve for flow over the control at monitoring site RB11 on Redbank Creek, recorded between December 2009 and June 2020 (refer Figure 7 for site location). The estimated catchment area of monitoring site RB11 is 5.2 $km^2$. In Figure 12, flow rate is again presented on a per unit catchment area basis.

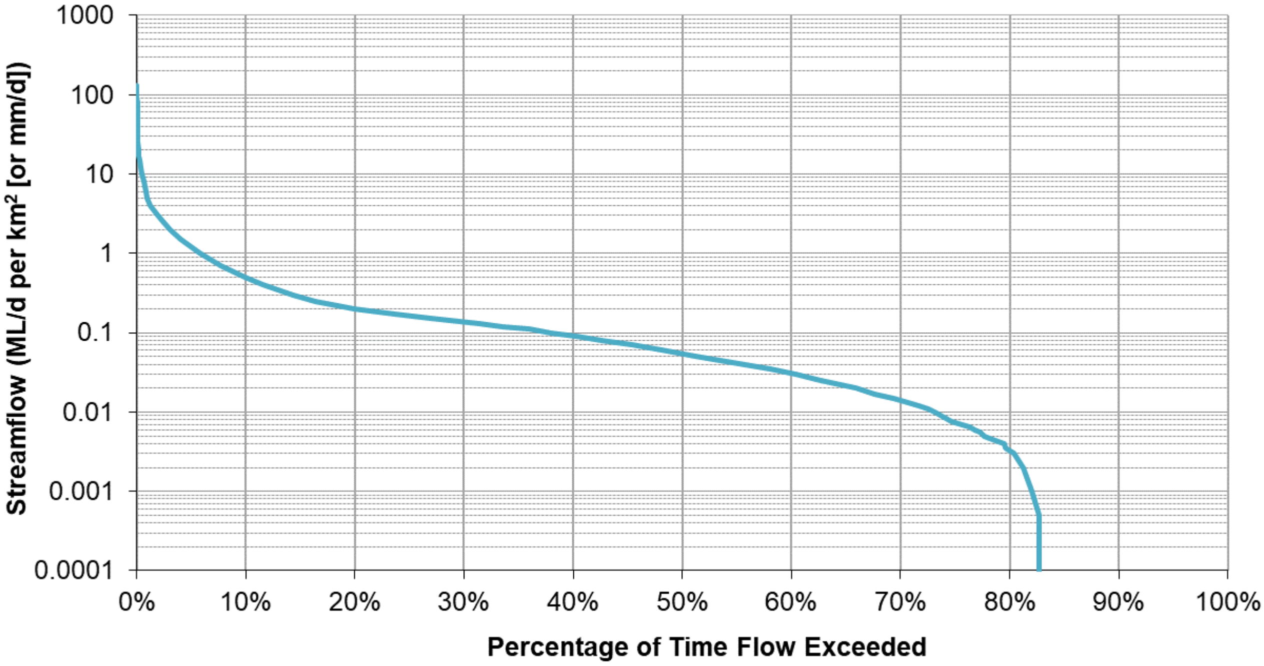


**Figure 12 Redbank Creek RB11 Flow Duration Curve**

Figure 12 illustrates that flow over the control at monitoring site RB11 is intermittent (flowing less than 83% of the time). The median recorded flow rate is 0.28 ML/d, equivalent to 0.054 mm/d.

#### 3.3.2.5 Stonequarry Creek at Picton

In addition to the monitoring within the Study Area undertaken by Tahmoor Coal, recorded streamflow data is available from a WaterNSW gauging station located on Stonequarry Creek at Picton (GS 212053), approximately 5 km downstream of the confluence with Cedar Creek, as shown in Figure 8. The estimated catchment area to the streamflow gauging station is 83 $km^2$. It is noteworthy that a significant tributary (Racecourse Creek) contributes additional flow to the creek at this point, downstream of the Study Area.

As discussed in Section 3.1.5, extraction of water from Stonequarry Creek Management Zone is licenced through WALs. Extraction of water from Stonequarry Creek catchment will influence the streamflow records for Stonequarry Creek at Picton (GS 212053). In addition to surface water extraction, changes in streamflow rating at Stonequarry Creek at Picton (GS 212053) have occurred due to the mobile nature of the stream bed and major flooding in the Stonequarry Creek catchment, notably the 2016 Picton flood. Licensed groundwater extraction in the Stonequarry Creek catchment also has the potential to influence streamflow characteristics at this site due to changes in baseflow characteristics and baseflow contribution.

WaterNSW complete regular review and revision of the streamflow rating for Stonequarry Creek at Picton (GS 212053), with the most recent review conducted in July 2020 (WaterNSW, 2020). As such, the streamflow rates for this site are subject to change.

Figure 13 presents the flow duration curve for Stonequarry Creek at Picton based on the recorded streamflow data for November 1990 to November 2020 (30 years). In Figure 13, flow rate is again presented on a per unit catchment area basis.

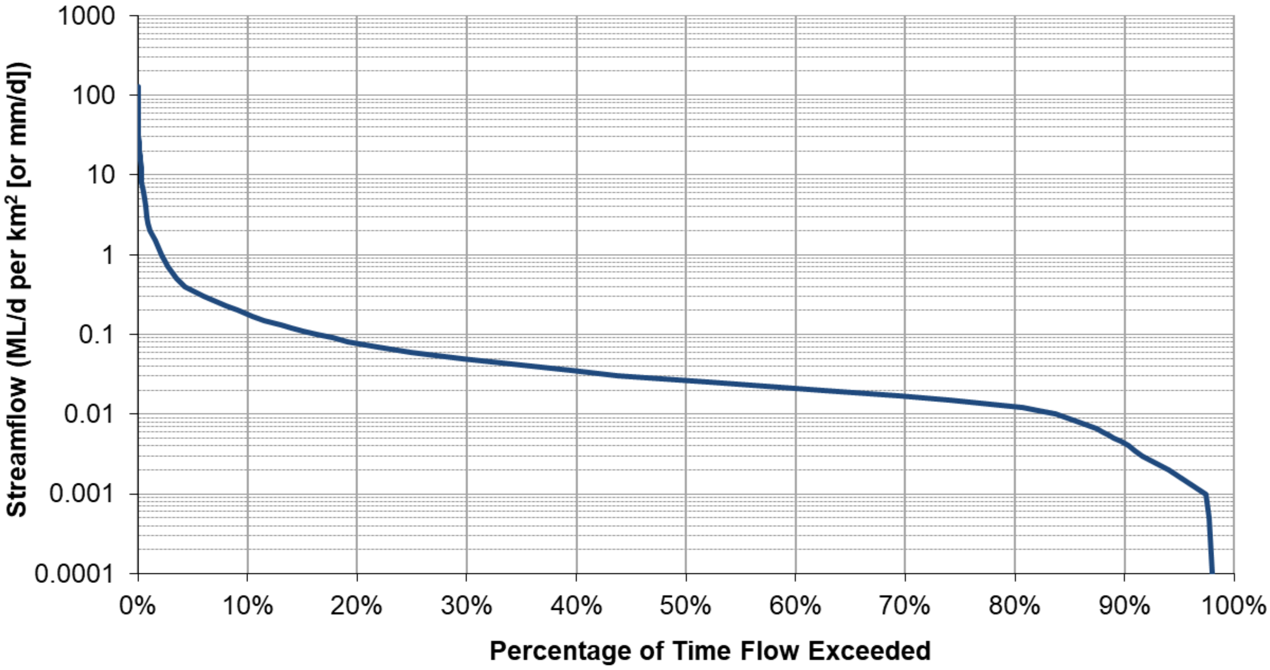


**Figure 13 Stonequarry Creek at Picton (GS 212053) Flow Duration Curve**

Figure 13 illustrates that Stonequarry Creek at Picton (GS 212053) is near perennial with a non-zero streamflow rate recorded 98.4% of the time. The median flow rate is 2.2 ML/d equivalent to 0.026 mm/d. A mean annual flow volume of 5,627 ML was recorded at Stonequarry Creek at Picton (GS 212053) for the period of November 1990 to November 2020.

## 3.4 WATER QUALITY DATA

Water quality monitoring was undertaken at sites on Matthews Creek, Cedar Creek and Stonequarry Creek since 2014. Water quality monitoring was undertaken by GeoTerra in November 2014 (GeoTerra, 2014) and by Niche in October 2014, November 2017, May 2018, November 2018, May 2019 and December 2019 (Niche, 2014; Niche, 2019b; Niche, 2021).

A programme of water quality monitoring was commenced by Tahmoor Coal in January 2019 and is planned to continue through and beyond the period of mining of the Western Domain (refer Section 5.0). Appendix A presents the tabulated Tahmoor Coal monitoring sites, type of monitoring and period of record presented in this SWTR. The water quality data for the period January 2019 to March 2021 is summarised in Section 3.4.1.1 to Section 3.4.1.3 below for Matthews Creek, Cedar Creek and Stonequarry Creek. This period includes mining of LW W1 (commenced in November 2019) and commencement of mining LW W2 (commenced in December 2020). The locations of the monitoring sites are shown in Figure 6.

Water quality monitoring of Redbank Creek has been undertaken by Tahmoor Coal since 2005 at some sites. Appendix A presents the tabulated Tahmoor Coal monitoring sites, type of monitoring and period of record discussed in this SWTR. The water quality data for the period February 2005 to March 2021 is summarised in Section 3.4.1.4 below. This period includes mining of LW24B (commenced in October 2006) to LW32 (completed in September 2019). The locations of the monitoring sites are shown in Figure 7.

The revised Water Quality Management Framework detailed in the ANZG (2018) Guidelines states that where locally relevant water quality guideline values are not yet available, the default guideline values should be adopted. However, updated default guideline values are yet to be published under the ANZG (2018) Guidelines for physicochemical constituents and, as such, adoption of the ANZECC

& ARMCANZ (2000) Guideline default values are recommended. Updated default guideline values for toxicants have been published by ANZG (2018) and are adopted in the assessment of water quality data presented in the following sections.

In NSW, the level of protection applied to most waterways is that for 'slightly to moderately disturbed' ecosystems, for which ANZG (2018) recommends adoption of the default guideline values for aquatic ecosystems at the 95% protection level. The water quality data for physicochemical constituents has been assessed against the ANZECC & ARMCANZ (2000) default guideline values for the protection of slightly disturbed aquatic ecosystems in south-east Australian Upland Rivers. Upland streams are defined as those above 150 m) altitude. The water quality default guideline values used in the assessment are summarised in Table 9 below.

**Table 9 Water Quality Default Guideline Values Adopted in Water Quality Assessment**

| Parameter | ANZECC (2000) & ANZG (2018) Water Quality Default Guideline Values | | |
|---|---|---|---|
| | Aquatic Ecosystems (95%ile level of species protection) † | Upland Rivers (NSW) ‡ | Recreational Use‡ |
| pH (pH units) | - | 6.5 - 8 | 6.5 - 8.5 |
| EC (µS/cm) and TDS (mg/L) | - | EC 350 | TDS 1,000 |
| Total Alkalinity as $CaCO_3$ (mg/L) | - | - | 500 |
| Sulphate (mg/L) | - | - | 400 |
| Sodium (mg/L) | - | - | 300 |
| Aluminium (mg/L) pH > 6.5 | 0.055 | - | - |
| Arsenic (mg/L) (As III) | 0.024 | - | - |
| Barium (mg/L) | - | - | 1 |
| Cadmium (mg/L) | 0.0002 | - | - |
| Copper (mg/L) | 0.0014 | - | 1 |
| Iron (mg/L) | - | - | 0.3 |
| Lead (mg/L) | 0.0034 | - | 0.05 |
| Manganese (mg/L) | 1.9 | | 0.1 |
| Nickel (mg/L) | 0.011 | - | - |
| Selenium (mg/L) | 0.011 | - | 0.01 |
| Zinc (mg/L) | 0.008 | - | 5 |
| NOx (mg/L) | - | 0.015 | - |
| Total Phosphorous (mg/L) | 0.02 | - | - |
| Total Nitrogen (mg/L) | 0.25 | - | - |

Note: EC = Electrical Conductivity; TDS = Total Dissolved Solids; - no relevant trigger value; † ANZG (2018); ‡ ANZECC & ARMCANZ (2000)

The water quality default guideline values listed in Table 9 have been used as a basis for interpretation of the water quality data in the following sections. Water quality summary tables for each monitoring site are included in Appendix C and plots of water quality records are presented in Appendix D for key constituents. Where multiple default guideline values are specified for a parameter, the most conservative value has been adopted for comparison. Where laboratory results have been recorded at below the limit of detection the result has been analysed assuming the concentration was equal to the limit of detection.

### 3.4.1.1 Matthews Creek

Monitoring site MC1 was dry between August 2019 and February 2020, while monitoring site MB was dry in December 2019 and January 2020. The pH (laboratory and field) records for monitoring sites in Matthews Creek indicate slightly acidic to near neutral conditions for the majority of the monitoring period. Substantially higher field pH values, inconsistent with baseline (pre-mining) conditions, were recorded between February and April 2020 at all monitoring sites on Matthews Creek. The field pH values recorded during this period were identified as potentially erroneous and the field pH meter replaced. Following replacement of the field pH meter, the recorded values have been consistent with baseline values.

The EC values recorded at monitoring sites in Matthews Creek indicate that EC is naturally elevated in Matthews Creek with a declining trend in EC values occurring from upstream (monitoring site MB) to downstream (monitoring site MG) on Matthews Creek. An increasing trend in EC values was recorded at monitoring site MB between April and November 2019 during an extended period of low rainfall. Following considerable rainfall in February 2020, the EC level reduced at all sites and has remained below 500 µS/cm for the remainder of the monitoring period.

Total alkalinity recorded at all sites was generally low (median concentration equal to or less than 38 mg/L) indicating a low capacity for buffering against changes in pH arising from natural or anthropogenic influences.

Concentrations of total arsenic, barium, lead, nickel and selenium recorded at all monitoring sites in Matthews Creek have been consistently below the ANZG (2018) default guideline values for the duration of monitoring.

Aluminium concentrations are naturally elevated in Matthews Creek, with median total aluminium concentrations exceeding the ANZG (2018) default guideline value (0.055 mg/L) at all sites including monitoring site MB (reference site). Dissolved aluminium at each monitoring site was generally low for the period post-commencement of mining of LW W1 and W2 (equal to or less than 0.05 mg/L) and lower than or consistent with baseline values. Some elevated concentrations were recorded in periods prior to or during rainfall events although no clear trend in dissolved aluminium concentrations is evident in the record and concentrations were also elevated at the reference site upstream of mining influences (monitoring site MB in Matthews Creek). It should be noted that the dissolved aluminium is unlikely to be highly soluble at the prevalent surface water pH levels and concentrations are most likely due to dissolution of very fine clay which has occurred during the analysis process.

Copper concentrations are also naturally elevated in Matthews Creek at times with exceedances of the ANZG (2018) default guideline value for total copper (0.0014 mg/L) recorded for 24% of samples collected at monitoring site MB (reference site), 23% of samples collected at monitoring site MG and 10% of samples collected at monitoring site MC1. However, the median concentration of total copper recorded at all sites was less than the limit of detection (0.001 mg/L).

Dissolved iron concentrations have been variable at all sites, with an elevated concentration of 13.7 mg/L dissolved iron recorded at monitoring site MB (reference site) following the onset of rainfall in early 2020 after a low rainfall period. An elevated dissolved iron concentration was also recorded at monitoring site MG (3.5 mg/L) and MC1 (4.54 mg/L) in February 2020 following the onset of substantial rainfall. High iron hydroxide precipitation has been recorded historically at monitoring site MG (Niche, 2019).

An increasing trend in dissolved manganese concentration was recorded at all monitoring sites in Matthews Creek during an extended low rainfall period from April 2019 to January 2020. Following substantial rainfall from mid-January to February 2020, the dissolved manganese concentrations reduced and have remained below 0.5 mg/L at all sites since this time.

Historically elevated sulphate concentrations were recorded at all monitoring sites in Matthews Creek including at MB (reference site) in November 2020. Sulphate concentrations ranged between 18 mg/L and 23 mg/L at Matthews Creek monitoring sites on this date. The sulphate concentrations recorded since November 2020 have been consistent with baseline concentrations.

Variable zinc concentrations have been recorded at all sites in Matthews Creek, particularly during the extended low rainfall period of April 2019 to January 2020. Zinc concentrations are naturally elevated in Matthews Creek at times with exceedances of the ANZG (2018) default guideline value for total zinc (0.008 mg/L) recorded for 52% of samples collected at monitoring site MB (reference site), 50% of samples collected at monitoring site MG and 14% of samples collected at monitoring site MC1. Following substantial rainfall in early 2020, the total zinc concentrations recorded in Matthews Creek have been generally less variable with concentrations of less than 0.013 mg/L recorded at all sites.

To date, there has been negligible evidence of an influence of mining LW W1 or LW W2 on surface water quality in Matthews Creek. The water quality characteristics of monitoring sites following commencement of mining LW W1 have been consistent with baseline conditions and / or consistent with reference site conditions (monitoring site MB).

#### 3.4.1.2 Cedar Creek

Water quality records for monitoring sites CC, CD, CE and CF are available for three samples only and are therefore not included in the tables presented in Appendix C although are included in the plots in Appendix D. Despite an extended low rainfall period in 2019, the monitoring sites on Cedar Creek continuously held water during this period.

The pH (laboratory and field) records for monitoring sites in Cedar Creek indicate slightly acidic to near neutral conditions for the majority of the monitoring period. Substantially higher field pH values, inconsistent with baseline conditions, were recorded in March and April 2020 at all monitoring sites on Cedar Creek. The field pH values recorded during this period were identified as potentially erroneous and the field pH meter replaced. Following replacement of the field pH meter, the recorded values have been consistent with baseline values.

Total alkalinity recorded at all sites was generally low (median concentration equal to or less than 12 mg/L) indicating a low capacity for buffering against changes in pH arising from natural or anthropogenic influences.

The monthly field EC values recorded at monitoring sites in Cedar Creek between January 2019 and January 2021 indicate that EC is naturally elevated in Cedar Creek (maximum 1,086 µS/cm recorded at monitoring site CC1 in August 2019) with generally consistent EC values recorded for upstream (monitoring site CC1) and downstream sites (monitoring site CG). From August 2019 to January 2020 during an extended period of low rainfall, EC values exceeded 1,000 µS/cm at some sites. Following substantial rainfall in early 2020, the EC levels reduced at all sites and records were less than 1,000 µS/cm for the remainder of the monitoring period.

Concentrations of total arsenic, barium, lead and selenium recorded at all monitoring sites in Cedar Creek have been consistently below the ANZG (2018) default guideline values for the duration of monitoring period.

At monitoring site CC1 (reference site) dissolved aluminium concentrations ranged between 0.1 mg/L and 0.32 mg/L from January to November 2019, indicating that dissolved aluminium concentrations are naturally elevated in Cedar Creek. From April 2020 to March 2021, dissolved aluminium concentrations recorded at all monitoring sites in Cedar Creek were typically low (equal to or below 0.06 mg/L) relative to previous records.

Total copper concentrations have predominately been recorded below the limit of detection (0.001 mg/L) at monitoring sites in Cedar Creek. The ANZG (2018) default guideline value for total copper (0.0014 mg/L) was exceeded in 19% of samples recorded at monitoring site CC1 (reference site), 15% of samples recorded at monitoring site CB and 11% of samples recorded at monitoring site CG. The total copper concentrations recorded at monitoring sites CA did not exceed the ANZG (2018) default guideline value.

Iron concentration records for each site have been variable with the highest concentrations generally recorded immediately prior to or following the onset of substantial rainfall in early 2020 which occurred after an extended low rainfall period. Monitoring sites CA and CB recorded higher concentrations of dissolved and total iron in January 2020 when compared with concentrations recorded at the reference site CC1. Site CA recorded 6.34 mg/L dissolved iron and 10.5 mg/L total iron while CB recorded 4.52 mg/L dissolved iron and 6.11 mg/L total iron in January 2020. In comparison, 0.84 mg/L dissolved iron and 2.8 mg/L total iron was recorded at reference site CC1 in January 2020. Following substantial rainfall in February 2020, dissolved and total iron concentrations reduced at all sites to within baseline concentrations. The high concentrations of dissolved and total iron recorded at monitoring sites CA and CB in January 2020 were likely due to groundwater seepage which has been observed historically at the junction of Cedar Creek and Matthews Creek based on high iron hydroxide precipitation within this reach (GeoTerra, 2019).

An increasing trend in dissolved manganese concentration was recorded at all sites in Cedar Creek during an extended low rainfall period from April 2019 to January 2020. Following substantial rainfall from mid-January to February 2020, the dissolved manganese concentrations reduced at all sites. Dissolved manganese concentrations remained below 1.3 mg/L at all monitoring sites in Cedar Creek between March 2020 and March 2021.

An increasing trend in nickel concentrations was recorded at sites CC1 and CB during an extended low rainfall period from April 2019 to January 2020. Following substantial rainfall in early 2020, the dissolved and total nickel concentrations reduced to below the ANZG (2018) default guideline value (0.011 mg/L) at all sites in Cedar Creek.

Zinc concentrations are naturally elevated in Cedar Creek with exceedances of the ANZG (2018) default guideline value for total zinc (0.008 mg/L) recorded for 89% of samples collected at monitoring site CC1 (reference site), 91% at monitoring site CA, 93% at monitoring site CB and 70% at monitoring site CG. Historically elevated concentrations of dissolved zinc were recorded at monitoring sites CA and CB on Cedar Creek (0.045 mg/L and 0.059 mg/L respectively) in July 2020. The dissolved zinc concentrations declined following subsequent rainfall events and have remained relatively low since this period.

The monitoring data collected for additional water quality monitoring sites CC, CD, CE and CF in Cedar Creek (from January to March 2021) indicates that the constituent levels for all parameters recorded at these sites were consistent with that of other sites which have records for the pre- and post-commencement of mining LW W1 and W2 periods.

To date, there has been negligible evidence of an influence of mining LW W1 and LW W2 on surface water quality in Cedar Creek. The water quality characteristics of monitoring sites following commencement of mining LW W1 have been consistent with baseline conditions and / or consistent with reference site conditions (monitoring site CC1).

#### 3.4.1.3 Stonequarry Creek

Monitoring site SC1 was dry in March 2019 and between May 2019 and February 2020, while monitoring site SD was dry in December 2019 and January 2020. All other monitoring sites retained water for the duration of the monitoring period.

The pH (laboratory and field) records for monitoring sites in Stonequarry Creek indicate slightly acidic to near slightly alkaline conditions. The EC values recorded at monitoring sites in Stonequarry Creek indicate that EC in Stonequarry Creek is naturally elevated (generally less than 1,100 µS/cm). An increasing trend in EC values was recorded at SC, SC2 and SD between October and January 2020. During this time EC recordings at monitoring site SC were historically high with a measurement of 3,240 µS/cm recorded in January 2020. Following substantial rainfall in February 2020, EC levels reduced at all sites and remained below 900 µS/cm for the remainder of the monitoring period.

Concentrations of total arsenic, barium, lead and selenium recorded at all monitoring sites in Stonequarry Creek have been consistently below the ANZG (2018) default guideline values for the duration of monitoring.

Dissolved aluminium concentrations recorded in Stonequarry Creek have typically been low (below 0.03 mg/L) except following substantial rainfall events where spikes in aluminium concentrations have been recorded. Nevertheless, aluminium concentrations are relatively low in Stonequarry Creek, with the median total aluminium concentrations exceeding the ANZG (2018) default guideline value (0.055 mg/L) at only one monitoring site – SC1 (reference site).

Copper concentrations are naturally low in Stonequarry Creek with the median concentration recorded at all sites equal to or less than the limit of detection (0.001 mg/L).

Iron concentration records for each site have been variable with the highest concentrations generally recorded immediately prior to or following the onset of substantial rainfall in early 2020 which occurred after an extended low rainfall period. An elevated concentration of 5.62 mg/L dissolved iron was recorded a monitoring site SC1 (reference site) following the onset of substantial rainfall in early 2020. Historically elevated dissolved iron concentrations of 3.26 mg/L and 4.92 mg/L were recorded in May and June 2020 respectively at monitoring site SC2 on Stonequarry Creek. The dissolved iron concentrations subsequently declined and have remained relatively consistent with baseline concentrations following this period.

Prior to commencement of mining LW W1 in November 2019, an elevated dissolved manganese concentration of 20.7 mg/L, 5.56 mg/L dissolved iron and 0.03 mg/L dissolved nickel were recorded at monitoring site SD. The sulphate concentration recorded on the same day was also elevated at 87 mg/L.

Nickel concentrations have generally been low at all sites in Stonequarry Creek, with a higher median concentration of total nickel recorded the reference site SC1 in comparison with potential impact sites. Following substantial rainfall in early 2020, the dissolved and total nickel concentrations at all sites reduced to below the ANZG (2018) default guideline value (0.011 mg/L) and have remained below this level since.

Variable zinc concentrations have been recorded at all sites in Stonequarry Creek, particularly during low rainfall periods. Zinc concentrations are naturally elevated in Stonequarry Creek at times with exceedances of the ANZG (2018) default guideline value for total zinc (0.008 mg/L) recorded for 59% of samples collected at monitoring site SC1 (reference site), 33% of samples collected at monitoring site SE (reference site), 14% of samples collected at monitoring site SG (reference site), 30% of samples collected at monitoring site SC2, 12% of samples collected at monitoring site SC, 33% of samples collected at monitoring site SD and 27% of samples collected at monitoring site SF.

To date, there has been negligible evidence of an influence of mining LW W1 and LW W2 on surface water quality in Stonequarry Creek. The water quality characteristics of monitoring sites following commencement of mining LW W1 have been consistent with baseline conditions and / or consistent with reference site conditions (monitoring site SC1, SE and SG).

#### 3.4.1.4 Redbank Creek

Water quality monitoring of Redbank Creek has been conducted by routine sampling and laboratory analyses at select sites over the period February 2005 to late 2020. Monthly field water quality monitoring has continued at select sites (refer Appendix A for site locations, type of monitoring and period of record). During the period October 2006 to September 2019, LW24B to LW32 were mined. Monitoring sites RB2/RC1 to RB10 were progressively influenced by mining-induced subsidence, with subsidence induced cracking of site flow controls (e.g. rock bars) leading to leakage, underflow and re-emergence of flow further downstream of impacted sites (refer Section 4.3.2 for further detail). Key water quality indicators for this period were recorded and observations have been made following assessment of the data.

The pH (laboratory and field) records for monitoring sites in Redbank Creek indicate slightly acidic to near neutral conditions for the majority of the monitoring period. Substantially higher field pH values, inconsistent with baseline conditions, were recorded in March 2020 at monitoring sites in Redbank Creek. The field pH values recorded during this period were identified as potentially erroneous and the field pH meter replaced. Following replacement of the field pH meter, the recorded values have been consistent with baseline values. Some field pH measurements recorded at monitoring site RB6/RC2 prior to the commencement of mining LW24B and at RC3 during the period of mining indicated increasing acidic conditions (less than pH 5), however, these pH values were not persistent.

The EC values recorded at monitoring site RB6/RC2 increased between 2013 and 2015 as mining progressed, with elevated EC values also recorded at monitoring sites RB9/RC3 and RC6 (downstream of LW32) between late 2014 and early 2018. Recorded EC values generally declined in 2018 and increased in 2019 during an extended low rainfall period. Recorded EC levels have since declined at all sites during and following the cessation of mining LW32.

Concentrations of total arsenic and barium recorded at all sites have been consistently below the ANZG (2018) default guideline values for the duration of monitoring with low concentrations of dissolved lead recorded at all sites for the duration of monitoring.

Dissolved barium recorded at monitoring site RB6/RC2 increased between 2011 and 2015 as mining progressed, with elevated dissolved barium concentrations also recorded at monitoring sites RB9/RC3 and RC4 (downstream of LW32) between late 2014 and early 2018. Some elevated concentrations of dissolved barium were recorded at monitoring site RC6 (downstream of LW32) in 2020 following cessation of mining and substantial rainfall in early 2020. However, the concentrations did not exceed the ANZG (2018) default guideline value for total barium (1 mg/L) at any site during the period of monitoring.

Dissolved aluminium concentrations recorded in Redbank Creek have typically been low (below 0.05 mg/L) except following substantial rainfall events where spikes in aluminium concentrations have been recorded. The data records indicate that copper concentrations may be naturally elevated in Redbank Creek with elevated dissolved copper concentrations recorded at monitoring site RC5 (downstream of LW32) in 2007 and early 2008, during mining of LW24B, although prior to the occurrence of mining impacts in Redbank Creek.

Iron concentrations recorded at monitoring site RB6/RC2 significantly increased during the mining of LW26 to LW32 (2012 to 2016), with isolated elevated concentrations also recorded at monitoring site

RC4, RC5 and RC6 (downstream of LW32) between 2015 and 2019. Elevated dissolved iron concentrations were recorded at monitoring site RB1 (upstream of LW24B) in early to mid-2020 following substantial rainfall which occurred after a prolonged low rainfall period. The same trend was recorded at monitoring site RC5 downstream of LW32, however, the dissolved iron concentrations recorded at monitoring site RC5 were less elevated than at monitoring site RB1. From mid-2020, dissolved iron concentrations have substantially declined at all sites. The elevated dissolved iron concentrations recorded at monitoring sites RB6/RC2 and RC4, RC5 and RC6 (downstream of LW32) during the period of mining suggest that longwall mining and the reported cracking of bedrock resulted in periodic increases in iron, however, the effects at downstream monitoring sites were largely isolated and appear to have diminished with time.

Elevated dissolved manganese concentrations were recorded at monitoring site RB6/RC2 prior to and during the period of mining. Elevated dissolved manganese concentrations were also recorded periodically at monitoring sites RB9/RC3, RC4 and RC5 over the period of mining, however, only slight increases in dissolved manganese concentrations were recorded further downstream at monitoring site RC6 during corresponding periods. Towards the end of and following completion of mining LW32, the dissolved manganese concentrations were generally below the ANZG (2018) default guideline value of 1.9 mg/L except at monitoring site RB10 and RC6 following substantial rainfall in early 2020.

Periodic elevated dissolved nickel concentrations were recorded at monitoring sites RB6/RC2, RB9/RC3, RB10, RC4 and RC5 during the period of mining, particularly from 2014 to 2018. Following the cessation of mining, dissolved nickel concentrations remained below the ANZG (2018) default guideline value of 0.011 mg/L at all sites except monitoring site RC6 where isolated elevated concentrations of dissolved nickel were recorded following substantial rainfall in early 2020. This suggests a temporary increase in dissolved nickel concentrations during the period of mining.

Slightly elevated dissolved zinc concentrations were recorded at monitoring site RB6/RC2 and monitoring site RC5 during the period of mining although concentrations have declined following cessation of mining. The pattern in recorded zinc concentrations is similar to the pattern in iron concentrations and suggests that longwall mining and the reported cracking of bedrock has resulted in periodic increases in zinc concentrations, although this has decreased with time.

### *3.4.2 Baseline Aquatic Habitat and Stream Health*

Baseline monitoring of aquatic ecology within the Study Area was undertaken in October 2014, November 2017, April 2018, November 2018 and May 2019 (Niche, 2014; Niche, 2019a and Niche, 2019b).

The baseline monitoring identified that Matthews Creek, Stonequarry Creek and Cedar Creek were in moderate to good condition with the best habitat located within gorges along Matthews Creek and Cedar Creek. Aquatic habitat within the Study Area and at control sites consisted predominately of pools with little to no riffles present. The streams were found to be controlled by the sandstone geology, with bedrock present in numerous locations and stream benthos dominated by finer sand/silt sized sediment where bedrock does not occur. Most sites had moderate to good riparian and channel health (Niche, 2019b).

Macrophyte occurrence varied between sites with generally low abundance and diversity recorded at upstream sites (Site 6 – 8 in Matthews Creek and Cedar Creek; refer Figure 6 for locations) and more diverse and abundant further downstream at Site 4 in Stonequarry Creek (Niche, 2019b).

Stonequarry Creek at the confluence with Cedar Creek was considered to be in moderate stream health condition with well vegetated streambanks and riparian corridor (Niche, 2014). Significant macrophyte beds were observed at the confluence of Stonequarry Creek and Cedar Creek consisting primarily of submerged species. Upstream of the Stonequarry Creek confluence, Cedar Creek was assessed as being in moderate-good condition. The streambanks were well vegetated and macrophytes were present in 10% of the reach. Most of the benthos and aquatic vegetation was covered in filamentous algae at this location.

Cedar Creek at the confluence with Matthews Creek was assessed as being in good condition (Niche, 2019b). The streambanks were well vegetated, providing moderate to high shading of the stream although no macrophytes were present at this location. Two additional locations monitored on Matthews Creek were assessed as having similar conditions with well vegetated streambanks and no macrophytes present.

In general, the 2017 - 2019 aquatic habitat survey found that the riparian and channel condition of Cedar Creek, Matthews Creek and Stonequarry Creek was similar to that observed during the 2014 survey (Niche, 2019b). The stream condition / aquatic habitat of Matthew Creek, Stonequarry Creek and Cedar Creek was found to be in moderate to good stream / riparian condition, although sections of the creeks with low flow rate were identified as placing natural stress on the aquatic environment and the availability and quality of aquatic habitat (Niche, 2019b). The fauna that are present in these habitats are adapted to the resulting stress of natural fluctuations in hydrology, habitat availability and water quality. Iron staining was observed at two locations in Cedar Creek, Site 6 and Site 12, and may indicate groundwater contribution influencing benthic habitat at these locations.

Pollution sensitive macroinvertebrates were present in Cedar Creek, Matthews Creek and Stonequarry Creek indicating that the streams are unlikely to be severely affected by pollution. All creeks were mapped as 'key fish habitat' and classed as either having highly sensitive or moderately sensitive aquatic habitat in 2014. Few fish were observed as part of the fish surveys in 2017 - 2019, with introduced Mosquito Fish (*Gambusia holbrooki)* observed in Cedar Creek, Matthews Creek and Stonequarry Creek, Mountain Galaxid (*Galaxias olidus*) observed in upstream Cedar Creek on one occasion, and Cox's Gudgeon (*Gobiomorphus coxii*) in Matthews Creek on one occasion. No aquatic threatened species were found to occur or have habitat within the Study Area.

Specific pools in Matthews Creek, Cedar Creek and Stonequarry Creek are shown in Photo 1 to Photo 4 below. It is noteworthy that sections of Matthews Creek are devoid of flow in between reaches which are flowing – this is illustrated in Photo 2.

**Photo 1 Matthews Creek Site 7 (Upstream of Cedar Creek Confluence) - Pool with Boulder Field Control (Source: Niche, 2019b; photo dated Spring 2018)**

**Photo 2 Matthews Creek Site 8 (Upstream Matthews Creek) - Typical Reach with No Flow (Source: Niche, 2019b; photo dated Spring 2018)**

**Photo 3** **Cedar Creek Site 6 (Confluence of Matthews Creek and Cedar Creek) - Pool with Rock Shelf and Pre-Mining Iron Staining (Source: Niche, 2019b; photo dated Spring 2018)**

**Photo 4** **Stonequarry Creek Site 4 (Confluence of Cedar Creek Stonequarry Creek) – Pool with Alluvium / Colluvium Base Material (Source: Niche, 2019b; photo dated Spring 2018)**

# 4.0 PREDICTED SUBSIDENCE IMPACTS AND CONSEQUENCES ON SURFACE WATER RESOURCES

## 4.1 POTENTIAL SUBSIDENCE IMPACTS

Longwall mining results in subsidence movements at the surface above and adjacent to longwall mining activities. The types of subsidence effects that can cause impacts and environmental consequences to surface water resources have been identified as follows:

- Vertical (downward) and horizontal displacements of the surface which are referred to as vertical subsidence and horizontal subsidence.
- Changes in surface slope, which is referred to as tilt.
- The rate of change of tilt, which is referred to as curvature.
- Changes in the horizontal distance between two points on the surface which is referred to as tensile strain if the distance between the two points increases and compressive strain if the distance between the two points decreases.
- Horizontal shear deformation across monitoring lines can be described by various parameters including horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index.

In addition to the above systematic (or conventional) effects, there are also particular effects which occur when subsidence occurs in incised valleys and gorges typical of the Southern Coalfield which are referred to as non-systematic (or unconventional) effects. These include the following:

- Upsidence is the reduced downward subsidence or the relative uplift within a valley which results from the dilation or buckling of near surface strata at or near the base of the valley.
- Valley closure is the reduction in the horizontal distance between the valley sides.
- Compressive valley strains occur within the bases of valleys as the result of valley closure and upsidence movements. Tensile valley strains also occur at the tops of the valleys as the result of valley closure movements.

## 4.2 POTENTIAL SURFACE WATER IMPACTS

The potential impacts to surface waters can be divided into three principal types:

1. Impacts to flow rate or the quantity of flow;
2. Changes to the hydraulic characteristics and associated impacts to the physical stability of the watercourses; and
3. Impacts to the water quality characteristics of watercourses.

The potential impacts and the mechanisms or causes are summarised in the sub-sections below.

### *4.2.1 Flow Rate/Quantity*

The key potential impacts of subsidence on the flow rate and quantity of surface water resources are summarised as:

1. Regional groundwater depressurisation and associated reduction in baseflow contribution to surface water systems;
2. Capture of a proportion of low flows and the diversion of this water downstream via the created underground fracture network;
3. Re-emergence of surface flow downstream of the affected area;

4. Reduced frequency of pools overflowing and lower pool water levels during dry weather due to flow loss;
5. Changes to upstream ponding due to changes in stream gradient; and
6. Reduced and periodic loss of interconnection between pools (where this exists) during dry weather.

#### *4.2.2 Flow Characteristics and Stability*

The key potential impacts of subsidence on the flow characteristics and stability of surface water resources are summarised as:

1. Changes in flow velocity and bed shear stresses due to subsidence induced changes to the shape and profile of watercourses;
2. Reduced stability of bed and banks due to subsidence induced fracturing;
3. Reduced stability of bed and banks due to loss of riparian vegetation from lower soil moisture availability as a result of subsidence induced fracturing; and
4. Changes to flooding and flood regimes due to the effects of subsidence on the geometry of watercourses.

#### *4.2.3 Surface Water Quality*

The key potential impacts of subsidence on water quality are summarised as:

1. Localised and transient increases in iron concentration and other minerals due to flushing from freshly exposed fractures in the sandstone rocks which contain variable mineralisation;
2. Creation and/or enhancement of existing iron rich springs; and
3. Drainage of strata gas[4].

### 4.3 REVIEW OF LW W1 – W2 SUBSIDENCE IMPACTS ON SURFACE WATER RESOURCES

The potential subsidence related impacts to surface water resources have been identified based on consideration of mining LW W1 and LW W2 in the Western Domain and historical longwall mining at Tahmoor. The subsidence predictions and potential impacts to water resources specific to LW W3 and LW W4 are detailed in Section 4.4.

#### *4.3.1 Tahmoor Western Domain Subsidence Impacts*

In accordance with the LW W1-W2 WMP (SIMEC, 2020), Tahmoor Coal have committed to six monthly reporting of water level and water quality monitoring data recorded at sites within and adjacent to the Western Domain. The outcomes of this analysis are assessed against the performance indicators and performance measures defined in the Trigger Action Response Plan (TARP), which are reviewed on a monthly basis as mining progresses. The following sections summarise the predicted and measured surface water related TARP significance levels reported during mining of LW W1 and LW W2.

##### 4.3.1.1 Predicted and Measured Subsidence

MSEC (2021) have reported that subsidence levels during mining of LW W1, as measured through ground surveys, were substantially less than predicted. Negligible valley closure has been recorded in Stonequarry Creek, Cedar Creek and downstream Matthews Creek to date. Minor closure of 7 mm was recorded at rockbar MR32, downstream of monitoring site MF. Very minor closure, in the

[4] Release of methane rich gases from overburden sequences.

order of 5 mm, was measured at rockbar SR17 on Stonequarry Creek between November 2019 and late January 2020, although no measurable changes have occurred since this time. Minor tilt has been recorded at some locations, with ground levels falling towards LW W1 (MSEC, 2021).

Physical surveys carried out at multiple locations along Cedar Creek and Matthews Creek have measured changes in horizontal distances that are within survey tolerance. The results at Global Navigation Satellite System (GNSS) 17 show that Cedar Creek likely experienced mining-induced horizontal and vertical movements when LW W1 was mined adjacent to GNSS 17, with the magnitude of the movements recorded at GNSS 17 (and at all GNSS sites) within subsidence predictions. GNSS 17 moved to the east and south during the mining of LW W1, with vertical subsidence of approximately 45 mm. The vertical movements occurred between February 2020 and September 2020, when LW W1 was mined adjacent to GNSS 17.

#### 4.3.1.2 Observed and Recorded Gas Emissions

Small although reasonably persistent gas bubbles were observed in pool MR45 in Matthews Creek during the creek visual inspections conducted in February to June, October, November and December 2020. This equated to a Level 3 TARP significance during these periods in accordance with the LW W1-W2 WMP (SIMEC, 2020).

Samples from pool MR45 were collected and analysed through gas chromatography. The results of the analysis indicated that the gas emissions were likely to be from the shallow Hawkesbury Sandstone and / or shallow anoxic, muddy alluvium and were not indicative of water discharged from the deep Hawkesbury Sandstone or deeper strata aquifers (GeoTerra, 2020a). The results of the gas chromatography analysis were insufficient to provide a direct linkage between mining related influences and the observed gas emissions, although a connection was considered probable (GeoTerra, 2020a).

Methane is naturally present in many natural shallow surface water and groundwater systems as a result of organic decomposition and redox-methanogenesis reactions (DoP, 2008). When sediments are disturbed by mining related subsidence effects, methane derived naturally may be released more rapidly in surface water systems (DoP, 2008). The generative fluxes and concentrations are generally low and inconsequential (DoP, 2008).

In areas where gas releases occur into the water column, there is insufficient time for substantial amounts of gas to dissolve into the water column (MSEC, 2019). Rare and isolated dieback of riparian vegetation has been reported in the Southern Coalfield due to release of gas emissions to the atmosphere (DoP, 2008). However, Niche (2021) have not reported evidence of vegetation dieback due to observed gas emissions in pool MR45 in Matthews Creek (refer Section 4.3.1.5).

#### 4.3.1.3 Water Quality TARP Triggers

Isolated occurrences of elevated water quality constituents, in excess of baseline conditions, were recorded at some monitoring sites on Matthews Creek, Cedar Creek and Stonequarry Creek following commencement of mining LW W1 (refer Section 3.3). The elevated levels of constituents were predominantly related to the extended low rainfall period of late 2019 to early 2020 or following the substantial rainfall which occurred in mid-January and February 2020 (refer water quality plots in Appendix D). Subsequent to the early 2020 rainfall events, isolated elevated levels of constituents were recorded at some sites as follows:

- Historically elevated dissolved iron concentrations of 3.26 mg/L and 4.92 mg/L were recorded on 6 May and 9 June 2020 respectively at monitoring site SC2 on Stonequarry Creek. The dissolved iron concentrations subsequently declined and have remained relatively consistent with baseline concentrations following this period.

- Historically elevated concentrations of dissolved zinc were recorded at monitoring sites CA and CB on Cedar Creek (0.045 mg/L and 0.059 mg/L respectively) on 15 July 2020. The dissolved zinc concentrations declined following subsequent rainfall events and have remained relatively low since this period.
- Historically elevated sulphate concentrations were recorded at all monitoring sites in Matthews Creek including at MB (reference site) on 3 November 2020. Sulphate concentrations ranged between 18 mg/L and 23 mg/L at Matthews Creek monitoring sites on this date. The sulphate concentrations recorded since 3 November 2020 have been consistent with baseline concentrations.

A water quality TARP significance above Level 2 has not been reported for any sites in Matthews Creek, Cedar Creek or Stonequarry Creek since commencement of mining LW W1 and W2.

#### 4.3.1.4 Water Level TARP Triggers

A summary of the surface water level TARP significance triggers during the period of mining LW W1 and W2 is presented in Table 10. A water level TARP significance above Level 1 has not been reported for any sites in Matthews Creek or Stonequarry Creek since commencement of mining LW W1 and W2.

SLR (2021a) identified that a change in interaction between groundwater and surface water in Matthews Creek, Cedar Creek and Stonequarry Creek is inferred to have occurred over the period of mining LW W1 and W2. The potential change in groundwater contribution to these surface water systems (resulting in transitions from gaining to weakly losing or losing at some sites) was driven by the decline in groundwater levels associated with mining induced regional groundwater depressurisation. While the potential change in groundwater contribution did not result in a notable influence on water levels recorded at monitoring sites in Matthews Creek and Stonequarry Creek, notable influences were recorded at monitoring sites in Cedar Creek.

Atypical surface water behaviour was recorded at monitoring site CB (pool CR14) from 8 October 2020 to late January 2021 and at monitoring site CA (pool CB10), which is located upstream of monitoring site CB (pool CR14) in Cedar Creek, from early December 2020 to late January 2021. A Level 4 TARP significance was triggered in relation to surface water level decline for the period 19 to 29 January 2021 at monitoring site CB (pool CR14) in Cedar Creek (refer Figure 6 for site location). Accordingly, a Subsidence Event Notification was submitted to the NSW Department of Planning, Industry and Environment (DPIE), NSW Infrastructure – Land and Water – Natural Resources Access Regulator (NRAR) and the Department of Regional NSW – Resources Regulator (Resources Regulator) on 23 February 2021 in relation to surface water level decline at monitoring site CB (pool CR14) in Cedar Creek.

Additional monitoring sites in Cedar Creek also recorded a water level decline below the pre-mining and / or baseline minimum following commencement of mining LW W1 and W2 as follows:

- Monitoring site CC1A (pool CB3) declined below the pre-mining minimum water level in parts of December 2020 (moderate decline) and January 2021 (slight decline);
- Monitoring site CD (pool CR23) declined below the baseline minimum water level in October 2020, December 2020 and January 2021 (slight decline);
- Monitoring site CC (pool CB19) declined below the baseline minimum water level in December 2020 (moderate decline) and monitoring site CF (pool CR26) declined below the baseline minimum in January 2021 (moderate decline); and

- Monitoring site CE (pool CR25) declined to the baseline minimum water level in January 2021 and monitoring site CG (pool CR31) declined below the baseline minimum water level in January 2021 (slight decline).

A detailed investigation of the surface water level decline at these sites identified that:

- There is evidence of a change in surface water characteristics in the reach of Cedar Creek within the LW W1 – W2 Investigative Area;
- Monitoring site CC1A, CA and CB experienced a notable change in water level recessionary behaviour in December 2020;
- Monitoring sites CA and CB also experienced a notable change in water level recessionary behaviour in January 2021;
- The pool water level decline is considered highly likely to be related to regional groundwater level decline associated with mining induced groundwater depressurisation, however further monitoring is required to confirm this; and
- Whilst not visible on the surface, it is likely that mining induced subsidence has mobilised existing fractures resulting in changes in water level recession rates in pools CB3 (monitoring site CC1A), CB10 (monitoring site CA) and CR14 (monitoring site CB). However, these effects only persisted at pool CB10 and pool CR14 and an additional period of monitoring data is required to confirm the longevity of these effects at these pools.

Despite evidence of mining related effects on the water level characteristics of pools in Cedar Creek, there has been no visible evidence of cracking, splitting or spalling of the creek rock bar controls and levels of iron oxy-hydroxide precipitation have not exceeded levels observed during the baseline (pre-mining) period.

In accordance with the LW W1-W2 WMP (SIMEC, 2020), the Subsidence Performance Measure for Stonequarry Creek, Cedar Creek and Matthews Creek is considered to be exceeded if mining-induced fracturing in a rockbar or stream bed results in a reduction in pool water level below the historically recorded minimum level for:

- More than 10% of pools within the Study Area; and / or
- Pool SR17.

Less than 10% of the pools within the Study Area have been impacted and no impacts to pool SR17 on Stonequarry Creek are evident. Consequently, there is negligible evidence to date of subsidence impacts with environmental consequences greater than minor associated with mining LW W1 and LW W2.

**Table 10 Surface Water Level TARP Significance for LW W1 and LW W2**

| Date | Location(s) | Comment | TARP Significance |
|---|---|---|---|
| 1-5 Jul; 7-17 Jul 2020 | Monitoring site CB (pool CR14) on Cedar Creek | Water level declined by 9 mm below baseline minimum | Level 2 |
| 19 - 26 Jul 2020 | | Water level declined by 11 mm below baseline minimum | Level 2 |
| 29 Sep – 1 Oct 2020 | | Water level declined by 12 mm below baseline minimum | Level 2 |
| 4 - 9 Oct 2020 | | Water level declined by 16 mm below baseline minimum | Level 2 |
| 8 Oct 2020 | | Recorded water level indicated atypical hydrological characteristics at monitoring site CB from 8 Oct 2020 to January 2021 (inclusive) | |
| 13 - 25 Oct 2020 | Monitoring site CD (pool CR23) on Cedar Creek | Water level declined by 14 mm below baseline minimum | Level 2 |
| 1 - 5 Dec 2020 | Monitoring site CA (pool CB10) on Cedar Creek | Atypical water level decline recorded at monitoring site CA below pre-mining minimum (111 mm) although not below baseline minimum | Level 2 |
| 1 - 5 Dec 2020 | Monitoring site CB (pool CR14) on Cedar Creek | Water level declined by 191 mm below baseline minimum | Level 3 |
| 1 - 4 Dec 2020 | Monitoring site CD (pool CR23) on Cedar Creek | Water level declined by 12 mm below baseline minimum | Level 2 |
| 9 - 17 Dec 2020 | Monitoring site CA (pool CB10) on Cedar Creek | Atypical water level decline recorded at monitoring site CA below pre-mining minimum (423 mm) although not below baseline minimum | Level 2 |
| 7 - 18 Dec 2020 | Monitoring site CB (pool CR14) on Cedar Creek | Water level declined by at least 307 mm below baseline minimum (water level below sensor level from 12 - 18 December 2020) | Level 3 |
| 7 Dec 2020 | Monitoring site CC (pool CB19) on Cedar Creek | Water level declined by 175 mm below baseline minimum | |
| 11 - 18 Dec 2020 | Reference site CC1A (pool CB3) on Cedar Creek | Atypical water level decline below pre-mining minimum (121 mm) although not below baseline minimum | |

**Table 10 (Cont.)** **Surface Water Level TARP Significance for LW W1 and LW W2**

| Date | Location(s) | Comment | TARP Significance |
|---|---|---|---|
| 17 - 29 Jan 2021 | Monitoring site CA (pool CB10) on Cedar Creek | Atypical water level decline recorded at monitoring site CA below pre-mining minimum (438 mm) although not below baseline minimum | Level 3 |
| 12 - 29 Jan 2021 | Monitoring site CB (pool CR14) on Cedar Creek | Water level declined by minimum of 331 mm below baseline minimum from 12 – 29 January 2021 (water level below sensor level from 20 - 29 January 2021) | Level 4 |
| 16 - 26 Jan 2021 | Monitoring site CD (pool CR23) on Cedar Creek | Water level declined by 16 mm below baseline minimum | Level 2 |
| 21 - 26 Jan 2021 | Monitoring site CG (pool CR31) on Cedar Creek | Water level declined by 12 mm below baseline minimum | Level 2 |
| 20 Jan 2021 | Monitoring site CF (pool CR26) on Cedar Creek | Water level declined by 69 mm below baseline minimum | Level 2 |
| 20 - 26 Jan 2021 | Reference site CC1A (pool CB3) on Cedar Creek | Atypical water level decline recorded at monitoring site CC1A below pre-mining minimum (33 mm) although not below baseline minimum | |
| 19 Jan 2021 | Pools CB10 - CR15 | Pools CB10 - CR15 were observed to have low water levels, no overland interconnecting flow and strong iron precipitation | Level 4 - pool CR14<br>Level 3 - pools CB10, CR12, CR13 and CR15 |
| 19 Jan 2021 | Pools MR45 and MR46 | Pools MR45 and MR46 were observed to have low water levels, no overland interconnecting flow and strong iron precipitation | Level 3 |
| 11 - 12 Feb 2021 | Monitoring site CB (pool CR14) on Cedar Creek | Water level declined by 11 mm below baseline minimum | Level 2 |

#### 4.3.1.5 Aquatic Ecology TARP Triggers

Three aquatic ecology monitoring programs have been conducted by Niche since commencement of mining LW W1 and LW W2 – Autumn 2020, Spring 2020 and Autumn 2021 (preliminary). During the Autumn 2020 monitoring program, which occurred following a period of considerably higher rainfall than the previous years, it was observed that all sites had similar riparian and channel condition to baseline conditions, however, there was more aquatic habitat available and less iron flocculation observed in Cedar Creek (Niche, 2021). AUSRIVAS scores with either comparable to previous results or higher than any scores observed during the baseline period and the number of taxa were above or within the range of pre-mining results. Macroinvertebrate assemblages indicated spatial and temporal variability with evidence that differences observed between the Spring 2019 and Autumn 2020 surveys were driven by a reduction in common macroinvertebrate families. However, this was observed at both control sites and potential impact sites and therefore is unlikely to be a result of subsidence related influences (Niche, 2021).

During the Spring 2020 monitoring, no change in stream morphology or condition was observed, the water quality was comparable with control sites, AUSRIVAS scores were either comparable to or higher than scores observed pre-mining and number of taxa were above or within the range of pre-mining results (Niche, 2021).

Niche (2021) concluded that, based on the Spring and Autumn 2020 aquatic monitoring programs, the creeks within the Study Area were at Level 1 TARP significance (normal conditions) and that mining of LW W1 had not resulted in a measurable impact on aquatic ecology in Autumn and Spring 2020.

The preliminary AUSRIVAS results from the Autumn 2021 monitoring program identified that AUSRIVAS scores were within the range of, or above, pre-mining AURIVAS scores and natural variability (Niche, 2021). No water quality or stream morphological changes were observed that could be related to potential subsidence impacts from LW W1 and LW W2 (Niche, 2021). The preliminary Autumn 2021 monitoring results confirmed that all sites were considered to be 'normal' according to the TARPs for aquatic ecology (macroinvertebrate indicators and aquatic habitat) and that no TARP triggers had been exceeded (Niche, 2021).

#### 4.3.1.6 Farm Dam TARP Triggers

Geotechnical inspection of farm dams within the active subsidence zone was undertaken monthly by Douglas Partners during the period of mining LW W1 and W2. Douglas Partners advise that mining of LW W1 and W2 (to date) has not resulted in a measurable impact on farm dams and that there were no exceedances of the Level 1 TARP significance (normal conditions) for farm dams.

### *4.3.2 Subsidence Impacts of the Tahmoor Mine on Redbank Creek and Myrtle Creek*

Mining of LW22 to LW32 by Tahmoor Coal resulted in subsidence impacts in Redbank Creek and Myrtle Creek. Examination of the past effects of mining on this creek provides a basis for assessing the potential impacts to watercourses within the Study Area. However, it should be noted that Redbank Creek and Myrtle Creek were directly undermined whereas the longwall layout in the Study Area has been designed in order to avoid mining directly beneath the main surface water resources within the area.

Observations of subsidence impacts to Redbank Creek associated with LW24B to LW32, shown in Figure 7, have been reported in the *Redbank Creek – Corrective Management Action Plan* (Tahmoor Coal, 2018). Further detail on the observed subsidence impacts and visual inspection findings are presented in GeoTerra (2007 to 2020b) and the End of Panel reports (MSEC, 2007 to 2020).

Mining related impacts to surface water features of Redbank Creek, occurring during mining of LW25 to LW32, are summarised as follows:

- Sandstone streambed and rockbar cracking in isolated locations with reduced flow over the rockbar;
- Reduction in pool water holding capacity during periods of low flow and the re-emergence of diverted flow further downstream in Redbank Creek; and
- Intermittent increases in salinity, iron, manganese, zinc and nickel at monitoring sites within and downstream of the subsidence zone (refer Section 3.3 for further detail).

Mining related impacts to surface water features of Myrtle Creek, occurring during mining of LW22 to LW28, are summarised as follows:

- Sandstone stream bed cracking and isolated exposed sandstone underflow[5] at specific locations;
- Pool cracking and significant to total pool water holding capacity reduction at isolated locations; and
- Re-emergence of diverted flow further downstream in Myrtle Creek.

## 4.4 SUBSIDENCE PREDICTIONS AND POTENTIAL IMPACTS ON SURFACE WATER RESOURCES ASSOCIATED WITH LW W3-W4

### *4.4.1 Proposed Longwall Layout*

LW W3 and LW W4 will be mined sequentially, with longwall mining occurring from north to south of each panel. The proposed Western Domain longwall layout underlies minor tributaries of Matthews Creek, Cedar Creek, Stonequarry Creek and Redbank Creek. Additionally, a number of small farm dams and stormwater culverts overlie the predicted subsidence impact area.

The Western Domain longwall layout has been designed to achieve no more than 200 mm of predicted valley closure for Matthews Creek, Cedar Creek, Stonequarry Creek and Redbank Creek. The longwall layout has been designed in order to avoid mining directly beneath Stonequarry Creek, with LW W3 setback 100 m from rockbar SR17 - a further 50 metres from Stonequarry Creek than previously planned in order to reduce the potential for adverse impacts on rockbar SR17.

The potential impacts to these surface water systems and infrastructure are addressed in the sections below.

### *4.4.2 Predicted Subsidence Related Impacts to Watercourses*

Table 11 provides specific predictions of subsidence related impacts to watercourses in the Study Area summarised from MSEC (2021). The maximum predicted total subsidence following mining of LW W4 and the incremental change after mining of LW W2 is presented. Redbank Creek is located outside of the predicted 20 mm total subsidence contour and hence subsidence predictions are not presented for Redbank Creek itself although subsidence predictions are presented for Tributary 1 (main tributary) of Redbank Creek which runs adjacent to LW W4. The profiles of predicted subsidence, upsidence and valley closure along the potentially affected reaches of local streams within the Study Area are presented in MSEC (2021). The potential impacts to water resources based on the predicted subsidence impacts are discussed in subsequent sections.

[5] Note that 'underflow' is referred to as 'through-flow' in the End of Panel reports.

### Table 11 Subsidence, Upsidence and Valley Closure Predictions

| Creek | Longwall | Maximum Predicted Total Subsidence / Maximum Incremental Change after LW W2 (mm) | Maximum Predicted Total Upsidence / Maximum Incremental Change (mm) | Maximum Predicted Total Closure / Maximum Incremental Change (mm) |
|---|---|---|---|---|
| Matthews Creek | After LW W2 | 90 | 90 | 170 |
| | After LW W3 | 100 / <20 | 100 / <20 | 190 / 30 |
| | After LW W4 | 100 / <20 | 100 / <20 | 200 / 40 |
| Cedar Creek | After LW W2 | 60 | 160 | 180 |
| | After LW W3 | 70 / <20 | 170 / <20 | 200 / 20 |
| | After LW W4 | 70 / <20 | 170 / <20 | 200 / 20 |
| Stonequarry Creek | After LW W2 | 50 | 90 | 60 |
| | After LW W3 | 70 / 35 | 120 / 60 | 80 / 45 |
| | After LW W4 | 70 / 35 | 120 / 60 | 80 / 45 |
| Rockbar SR17 | After LW W2 | <20 | 20 | 20 |
| | After LW W3 | 30 / 10 | 70 / 50 | 60 / 40 |
| | After LW W4 | 40 / 20 | 70 / 50 | 70 / 50 |
| Tributary 1 (main tributary) of Redbank Creek | After LW W2 | 75 | 60 | 120 |
| | After LW W3 | 525 / 450 | 200 / 140 | 325 / 205 |
| | After LW W4 | 850 / 775 | 375 / 315 | 500 / 380 |

Source: MSEC (2020)

Table 11 shows that Cedar Creek and Stonequarry Creek are predicted to experience 70 mm maximum vertical subsidence after mining LW W3 and LW W4, while Matthews Creek is predicted to experience 100 mm maximum vertical subsidence. Matthews Creek and Cedar Creek are predicted to experience maximum total valley-related closure of 200 mm after mining LW W3 and LW W4, while Stonequarry Creek is predicted to experience 80 mm maximum total valley-related closure. The majority of the predicted movements along Matthews Creek and Cedar Creek are expected to occur due to extraction of LW W1 and LW W2 (MSEC, 2021).

The predicted maximum additional movements associated with extraction of LW W3-W4 represent approximately 10 – 15% of the total maximum predicted movements associated with mining of LW W1-W4 (MSEC, 2021). The proposed extraction of LW W3-W4 is predicted to result in minor additional increases in the occurrence of subsidence, valley closure and upsidence along the reach of Stonequarry Creek within the Study Area (MSEC, 2021). Despite the potential for low levels of vertical subsidence to occur in Stonequarry Creek, the creek is not expected to experience measurable conventional tilts, curvature or strains (MSEC, 2021).

RockbarSR17 is located approximately 100 m from the commencing end of LW W3. Table 11 shows that rockbar SR17 is predicted to experience maximum total subsidence of 40 mm, maximum total upsidence of 70 mm and maximum total closure of 70 mm following mining of LW W3 and LW W4. Due to the proximity of pool SR17 to LW W3, rockbar SR17 and downstream of rockbar SR17 are predicted to experience greater movements associated with extraction of LW W3 than occurred, or will occur, due to extraction of LW W1-W2 (MSEC, 2021).

The main tributary of Redbank Creek (Tributary 1) is predicted to experience maximum total valley-related closure of 500 mm directly adjacent to LW W3 and LW W4.

### *4.4.3 Predicted Subsidence Related Impacts to Farm Dams*

A total of 20 medium to large sized dams are located within or adjacent to the Study Area for LW W3 and W4, of which six medium to large sized dams are directly overlying LW W3 and W4. Note that FD-5 (refer Figure 14) appears to be a stormwater detention basin within the Stonequarry Creek Estate. FD-9 to FD-11 were previously assessed for LW W1-W2 (HEC, 2020), however, are outside the Study Area of LW W3-W4 and have therefore not been included in this assessment.

Table 12 provides predictions of subsidence related impacts to these dams and the detention basin as summarised from MSEC (2021).

**Table 12 Subsidence Predictions for Dams**

| Dam* | Predicted Total Subsidence after LW W3 (mm) | Predicted Total Subsidence after LW W4 (mm) | Predicted Total Tilt after LW W3 (mm/m) | Predicted Total Tilt after LW W4 (mm/m) | Predicted Change in Freeboard after LW W3 (mm) | Predicted Change in Freeboard after LW W4 (mm) |
|---|---|---|---|---|---|---|
| FD-1 | 150 | 200 | 1.5 | 2 | < 50 | < 50 |
| FD-2 | 300 | 350 | 3 | 3.5 | < 50 | < 50 |
| FD-3 | 425 | 775 | 4.5 | 3.5 | 150 | 300 |
| FD-4 | 700 | 975 | 5 | 3.5 | < 50 | < 50 |
| FD-5 | 675 | 700 | 4 | 4 | 150 | 150 |
| FD-6 | 950 | 975 | 2.5 | 2.5 | < 50 | < 50 |
| FD-7 | 725 | 775 | 5 | 5 | 50 | 50 |
| FD-8 | 200 | 675 | 1.5 | 1.5 | < 50 | < 50 |
| FD-12 | 700 | 750 | 4.5 | 5 | 150 | 150 |
| FD-13 | 40 | 250 | < 0.5 | 2.5 | < 50 | < 50 |
| FD-14 | 50 | 375 | < 0.5 | 4.5 | < 50 | 100 |
| FD-15 | 40 | 100 | < 0.5 | 1 | < 50 | < 50 |
| FD-16 | 80 | 500 | < 0.5 | 3.5 | < 50 | 50 |
| FD-17 | < 20 | 80 | < 0.5 | < 0.5 | < 50 | < 50 |
| FD-18 | < 20 | 60 | < 0.5 | < 0.5 | < 50 | < 50 |
| FD-19 | < 20 | < 20 | < 0.5 | < 0.5 | < 50 | < 50 |
| FD-20 | 60 | 70 | 0.5 | 0.5 | < 50 | < 50 |

* FD-9 to FD-11 were previously assessed for LW W1-W2, however, are outside the Study Area of LW W3-W4 and have therefore not been included in this assessment.

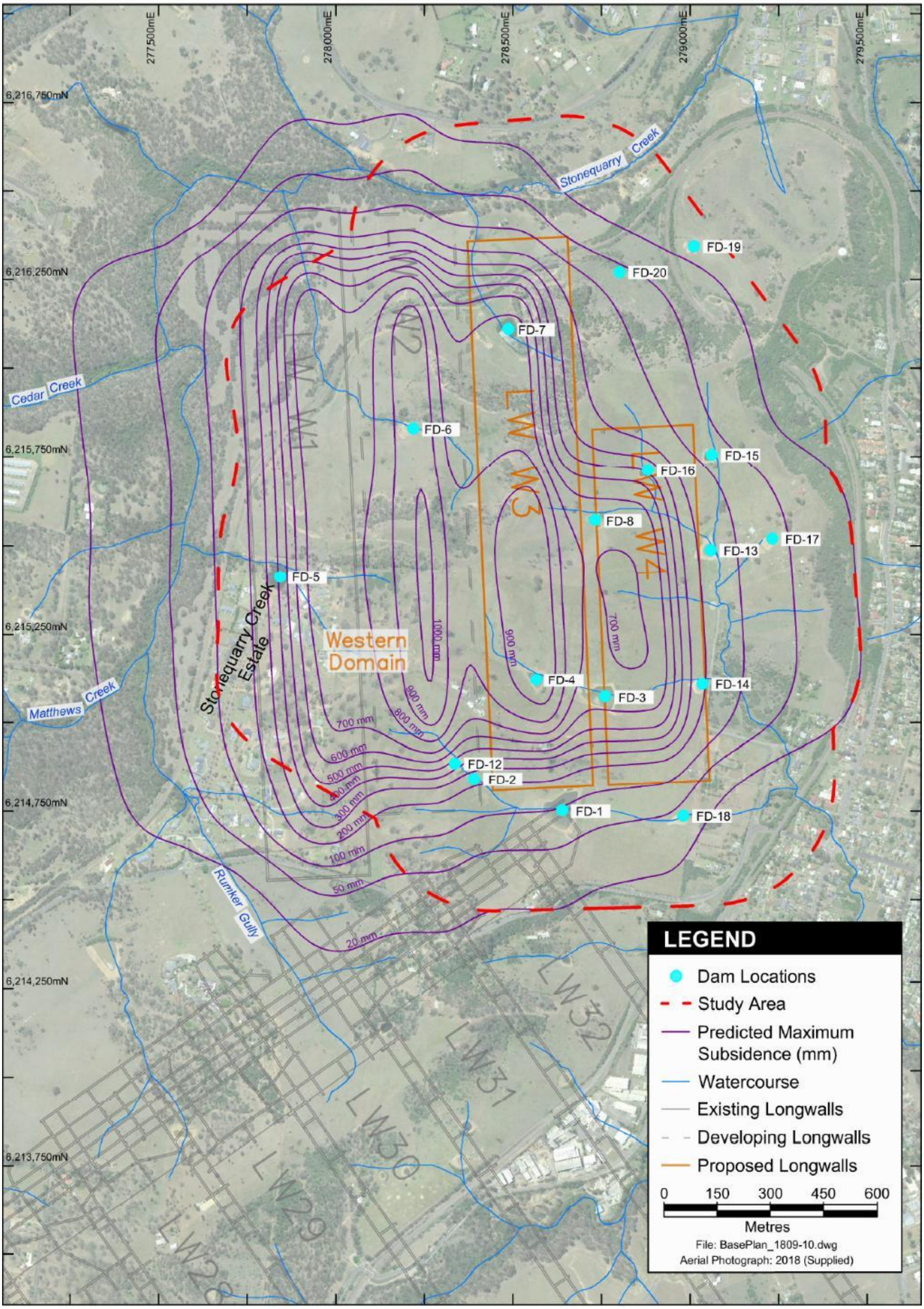


**Figure 14 Locations of Dams and Predicted Maximum Subsidence**

### 4.4.4 Potential Impacts to Water Quantity

Potential water quantity impacts associated with mining of LW W3-W4, as addressed in the following sections, include:

- Changes in pool water level and streamflow characteristics due to subsidence induced fracturing and tilt;
- Reduction in baseflow rates and change in low flow regime;
- Change in flood regime of watercourses and local tributary gullies;
- Change in overland flow behaviour; and
- Reduction in water supply to downstream surface water users.

#### 4.4.4.1 Potential Impacts to Pool Water Level and Streamflow Flow Due to Subsidence Induced Fracturing and Tilt

MSEC (2021) indicate that fracturing may occur at locations along Matthews Creek, Cedar Creek and Stonequarry Creek within the Study Area due to valley-related compressive strains. Using the rockbar impact model developed for the Southern Coalfield (Barbato et al., 2014), MSEC (2021) have assessed the potential for Type 3 impacts to occur along Matthews Creek, Cedar Creek and Stonequarry Creek. A Type 3 impact is defined as 'fracturing in a rockbar or upstream pool resulting in reduction in standing water level based on current rainfall and surface water flow' (MSEC, 2021). The proportion of rockbars within Matthews Creek and Cedar Creek that may experience a Type 3 impact is predicted at less than 10% based on a maximum predicted total closure of 200 mm due to the extraction of LW W1-W4.

The predicted rate of impact for rockbar SR17 is assessed to be less than 5% based on a maximum total closure of 80 mm predicted for Stonequarry Creek and total closure of 60 mm at rockbar SR17 following extraction of LW W1-W4 (MSEC, 2021). It is possible that mining-induced fractures could occur at rockbar SR17 due to the extraction of LW W3. As the rockbar is thinly bedded in places and natural fractures are present at isolated locations, it is possible that subsidence induced fracturing could result in surface water flow diversion within the rockbar. However, the likelihood of this occurring is assessed to be less than 5% (MSEC, 2021).

The pool SR17 extent and overall length is expected to change only slightly due to the extraction of LW W3-W4, although the central portion of pool SR17 is predicted to experience slightly more subsidence than rockbar SR17 resulting in this section of the pool increasing in depth by approximately 40 mm (MSEC, 2021). Monitoring site SC2 is located adjacent to the section of pool SR17 which is predicted to experience slightly more subsidence than rockbar SR17 and, as such, the water level measurements recorded at monitoring site SC2 may indicate minor changes in water level during and following extraction of LW W3 – W4 (MSEC, 2021).

After extraction of LW W3, no further mining will be conducted near rockbar SR17. LW W4 is setback substantially from Stonequarry Creek to reduce potential impacts to Stonequarry Creek and the Picton Railway Tunnel (MSEC, 2021).

SLR (2021a) note that near-surface fracturing may occur due to horizontal tension at the edges of a subsidence trough, with the depth of cracking from surface typically less than 20 m. McNally and Evans (2007) identified that near-surface fracturing is typically, although not always, transitory. If near-surface fracturing occurs, water diverted to the fracture zone is unlikely to continue downwards towards the goaf, with majority of the diverted surface water flow re-emerging further downstream in the surface water system (SLR, 2021a). This has previously occurred in Redbank Creek and Myrtle Creek during mining of LW22 to LW32 (refer Section 4.3.2).

As Stonequarry Creek, Matthews Creek, Cedar Creek and Redbank Creek will not be directly mined beneath, the subsidence related impacts to streamflow are likely to be less than that observed previously in Redbank Creek and Myrtle Creek due to mining of LW22 to LW32 directly beneath the creek. Nevertheless, monitoring of pool water level and catchment streamflow is proposed (refer Section 5.0) and TARPs have been developed to manage impacts should they occur (refer Section 6.0). In the event that impacts occur to rockbar SR17 or other rockbars / pools, remediation will be implemented as discussed in Section 5.3.

Predicted tensile and compressive strains associated with mining of LW W3-W4 may result in fracturing of bedrock in minor tributaries (MSEC, 2021). Fracturing is likely to occur predominantly where the tributaries directly overly LW W3-W4, although may occur at distances up to approximately 400 m beyond the extent of the longwall. Mining-induced compression due to valley closure effects may also result in dilation and the development of bed separation in the upper strata underlying the tributaries (MSEC, 2021). Additionally, compression may result in buckling of the topmost bedrock resulting in heaving in the overlying surface soils (MSEC, 2021).

Minor tributaries are likely to only flow during periods of high or extended rainfall and, as such, potential impacts of mining are unlikely to have discernible impacts on these surface water resources and ecosystems. The majority of minor tributary gullies are predicted to experience negligible change in gradient and as such it is unlikely that there will be a change in ponding upstream of the gullies or increased potential for scour and erosion (MSEC, 2021).

The main tributary of Redbank Creek (Tributary 1) is predicted to experience maximum total valley-related closure of 500 mm directly adjacent to LW W3 and LW W4 and therefore dilation and the development of bed separation in the upper strata underlying the tributary may occur. Further downstream, the majority of this tributary is predicted to experience less than 150 mm of vertical subsidence, with minor changes in grade that are generally less than 1 mm/m (MSEC, 2021).

As stated in Section 3.1.4, the third order reach of Tributary 1 has been heavily modified by residential development, including diversion through road culverts. The main tributary, including the third order reach, is not known to contain any noteworthy surface water features (i.e. rockbars, pools and aquatic habitat). As such, potential impacts of mining on Tributary 1 of Redbank Creek are unlikely to have discernible impact with respect to surface water resources and ecosystems.

Section 4.4.4.3 addresses the potential impacts to water levels due to the predicted subsidence and change in gradient of the tributary gullies.

#### 4.4.4.2 Potential Impacts to Baseflow and Low Flow Regime

SLR (2021a) describe baseflow reduction as '…the process of inducing leakage from a creek or river into the aquifer via a downward gradient or weakening an upward gradient from the aquifer into the watercourse and thereby reducing the rate at which baseflow occurs'.

As noted in Section 4.3.1.4, groundwater drawdown and depressurisation as a result of mining LW W1 has resulted in a reduction in baseflow and a change from gaining to losing conditions in some sections of the surface water systems within the Study Area. The reduction in baseflow contribution, potentially combined with subsurface fracturing, has led to pool water levels declining to below the baseline minimum or CTF level during periods of 2020 and early 2021 (refer Section 4.3.1.4 for further detail).

SLR (2021a) note that, given the similarity in proximity of LW W1 to Matthews Creek and Cedar Creek and the proximity of LW W3 to Stonequarry Creek, empirically there is potential that groundwater level decline and associated baseflow reduction may influence pool water levels in Stonequarry Creek. Mining of LW W3 (and to a lesser degree LW W4) may result in groundwater depressurisation and enhanced losing conditions at surface water monitoring site SB and further downstream in Stonequarry Creek. This may potentially result in a disconnection between the surface water system and groundwater system, thereby increasing the frequency of creek / pool water level decline in the reach of Stonequarry Creek within the Study Area (SLR, 2021a).

SLR (2021b) have made predictions of baseflow reductions for watercourses within the Study Area. The range of baseflow loss predictions were derived from groundwater modelling scenarios with varying degrees of fracturing and dilation simulated for the Hawkesbury Sandstone and low, medium and high hydraulic conductivities along the Nepean Fault system, which is in close proximity to LW W4 (SLR, 2021b).

Longitudinal and vertical connection between the goaf of LW W4 and Stonequarry Creek is considered the primary risk pathway in terms of impacts to the surface water system (SLR, 2021a). The permeability within the Nepean Fault zone in the vicinity of LW W4 would govern the longitudinal movement of groundwater along the fault zone, however, the permeability along the Nepean Fault zone is uncertain. As such, SLR (2021b) conducted uncertainty and sensitivity scenarios in relation to the permeability of the Nepean Fault zone which is reflected in the minimum, mean, likely and maximum baseflow reduction predictions for the surface water systems within the Study Area presented in Table 13 below.

**Table 13 Predicted Watercourse Baseflow Reduction**

| Watercourse | Baseflow Reduction Associated with LW W3-W4 (ML/year) | | | |
|---|---|---|---|---|
| | Minimum | Mean | Likely | Maximum |
| Cedar Creek to confluence with Stonequarry Creek | 1 | 1 | 5 | 5 |
| Matthews Creek to confluence with Cedar Creek | 0 | 2 | 3 | 4 |
| Stonequarry Creek at monitoring site SD | 10 | 27 | 45 | 45 |
| Main tributary of Redbank Creek | 0 | 1 | 2 | 2 |
| Redbank Creek to confluence with Stonequarry Creek | 1 | 4 | 7 | 7 |

As indicated in Table 13, there is a large amount of uncertainty (range) in the baseflow reduction predictions largely due to the proximity of LW W3-W4 to the Nepean Fault system. Further detail on the Nepean Fault system and range of uncertainty is provided in SLR (2021a).

Baseflow reduction is expected to be most noticeable during periods of low flow which would normally be dominated by baseflow. The effect on low flows can be seen by comparing the flow duration curves generated for the pre-mining and post-mining scenarios.

As noted in Section 4.4.4.1, although there may be some temporary, localised loss of flow (diversion) from the surface water systems in the event of fracturing or dilation, the flow diversion is likely to re-emerge in the surface water system further downstream (SLR, 2021a). As such, the influence of the baseflow reduction predictions on streamflow rates in Matthews Creek, Cedar Creek and Stonequarry Creek is a conservative estimate.

Figure 15 shows the impact of the range of predicted baseflow reduction rates due to mining of LW3-W4 on flows in Cedar Creek at monitoring site CG.

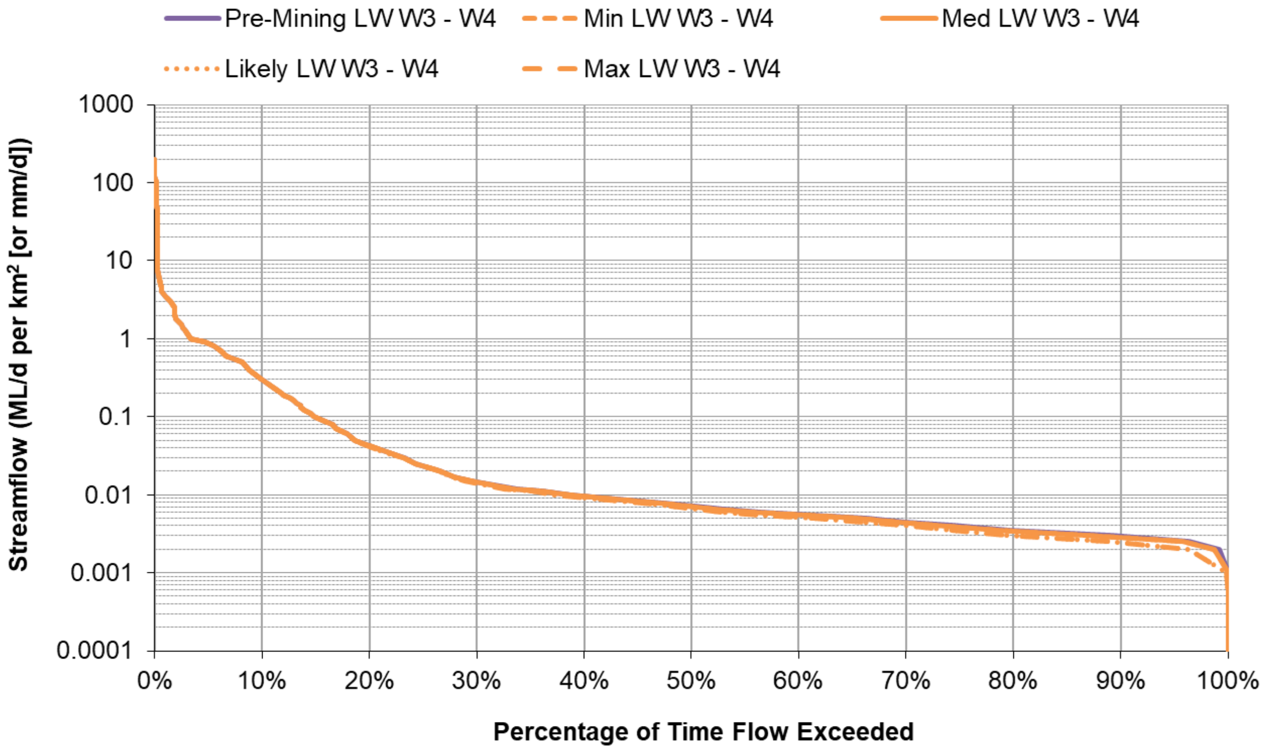


**Figure 15 Flow Duration Curve – Cedar Creek (Monitoring Site CG) Predicted Baseflow Reduction Impact**

Figure 15 shows that baseflow reduction associated with mining LW W3-W4 may result in effects on flows in Cedar Creek when flow rates are less than approximately 0.01 mm/d (0.27 ML/d). The probability that flow would be greater than 0.003 mm/d (0.08 ML/d) would reduce from 89% to between 87% and 79% of days based on the predicted minimum and maximum baseflow reduction rates associated with mining LW W3-W4. This level of change would be low and unlikely to be distinguishable from natural variability in catchment conditions.

Figure 16 shows the impact of the range of predicted baseflow reduction rates due to mining of LW3-W4 on flows in Matthews Creek at monitoring site MG.

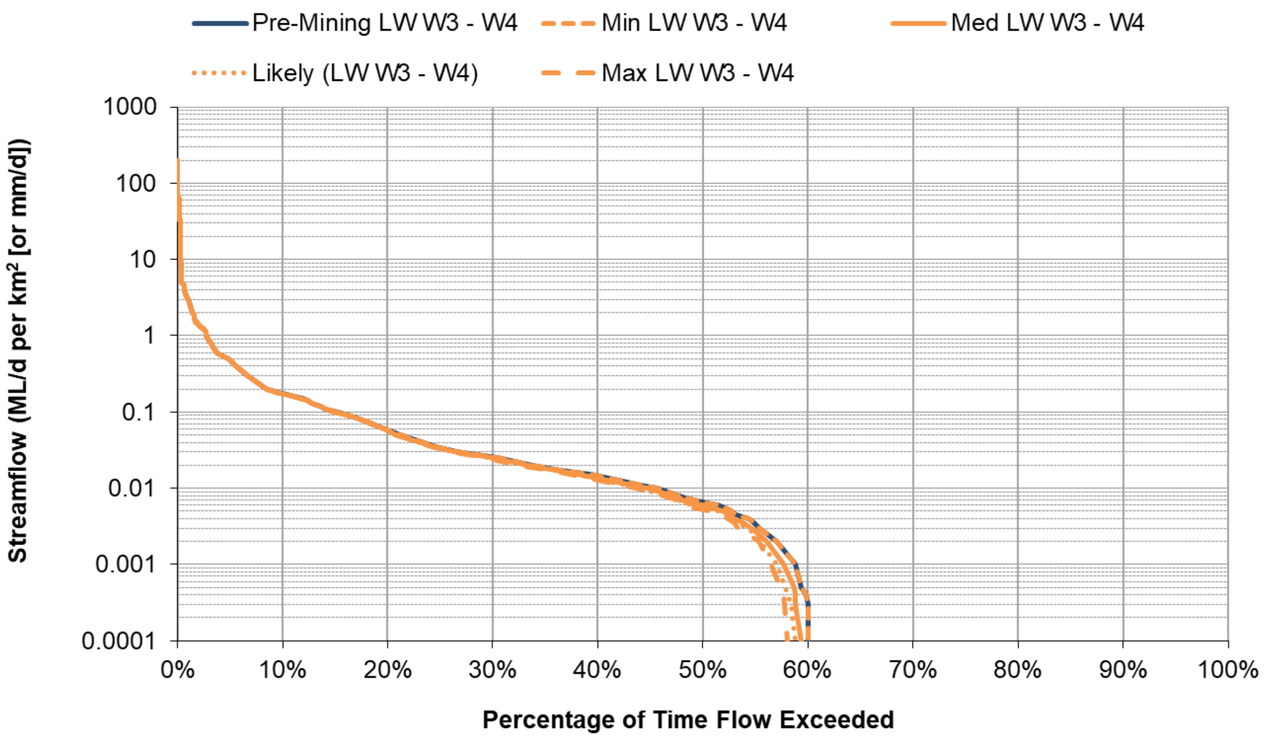


**Figure 16 Flow Duration Curve – Matthews Creek (Monitoring Site MG) Predicted Baseflow Reduction Impact**

Figure 16 shows that baseflow reduction associated with mining LW W3-W4 may result in effects for flows in Matthews Creek when flow rates are less than approximately 0.015 mm/d (0.12 ML/d). The probability that flow would be greater than 0.001 mm/d (0.008 ML/d) would reduce from 59% to 56% of days based on the predicted maximum baseflow reduction rates associated with mining LW W3-W4. This level of change would be indistinguishable from natural variability in catchment conditions.

Figure 17 shows the impact of the range of predicted baseflow reduction rates due to mining of LW3-W4 on flows in Stonequarry Creek at monitoring site SD.

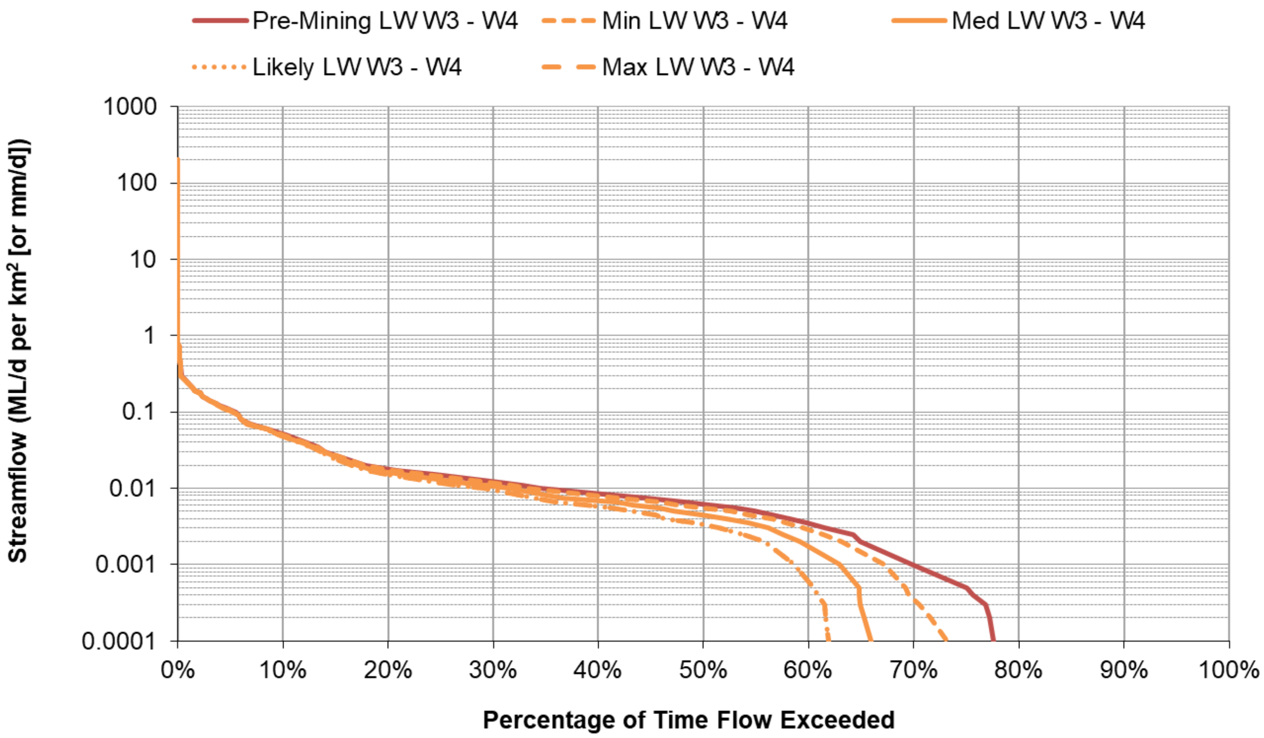


**Figure 17 Flow Duration Curve – Stonequarry Creek (Monitoring Site SD) Predicted Baseflow Reduction Impact**

Figure 17 shows that there is no apparent effect on flows in Stonequarry Creek at monitoring site SD for flows greater than approximately 0.05 mm/d (2.2 ML/d). The probability that flow would be greater than 0.001 mm/d (0.04 ML/d) would reduce from 70% to between 67% and 59% of days based on the predicted minimum and maximum baseflow reduction rates associated with mining LW W3-W4. This level of change may be detectable during normal periods of low flow and distinguishable from natural variability in catchment conditions.

As noted in Section 3.3.2.3, the streamflow control at monitoring site SD is a wide, flat rockbar and, as such, monitoring of low flow rates is unable to be accurately undertaken. As such, the potential reduction in streamflow rates presented in Figure 17 are indicative only.

Figure 18 shows the impact of the range of predicted baseflow reduction rates due to mining of LW3-W4 on flows in Redbank Creek at monitoring site RB11.

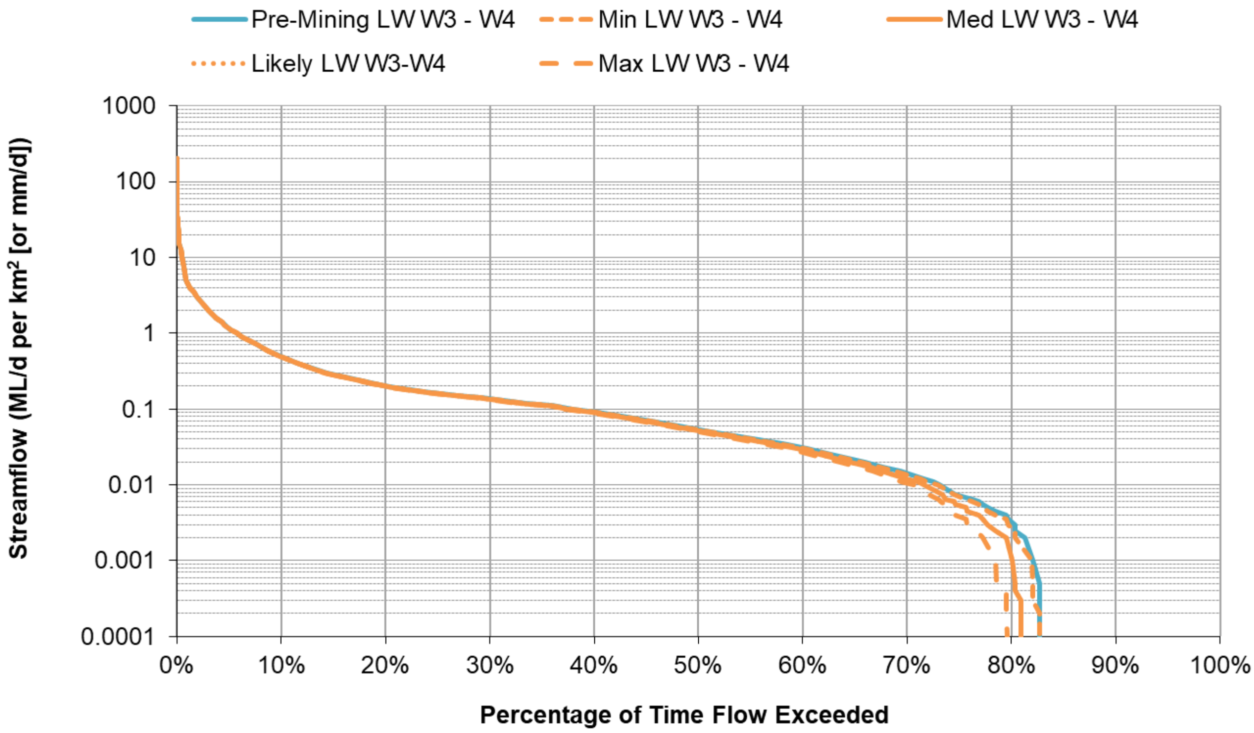


**Figure 18 Flow Duration Curve – Redbank Creek at Monitoring Site RB11 Predicted Baseflow Reduction Impact**

Figure 18 shows that baseflow reduction associated with mining LW W3-W4 may result in effects for flows less than approximately 0.06 mm/d (0.31 ML/d). The probability that flow would be greater than 0.001 mm/d (0.005 ML/d) would reduce from 82% to 78% of days based on the predicted maximum baseflow reduction rates associated with cumulative mining of LW W3-W4. This level of change would be low compared to natural variability in catchment conditions.

#### 4.4.4.3 Predicted Impact to Flood Regime – Local Tributary Gullies

Several tributaries of Matthews Creek, Cedar Creek, Stonequarry Creek and Redbank Creek overlie the proposed LW W3-W4. A hydraulic (surface flow) model was developed for each tributary and associated culverts as shown in Figure 19. The hydraulic model was used to assess the change in flood level for the 50% Annual Exceedance Probability (AEP) (representative of frequently occurring flows) and 1% AEP (representing rare events) peak flow rates based on the subsidence predictions for the Study Area.

The 50% AEP and 1% AEP peak flow rates for each tributary were estimated using the two-dimensional numerical hydraulic model TUFLOW. TUFLOW is a commonly used flood modelling software system which produces predictions of flood levels, flow velocities and other hydraulic parameters in two-dimensional space using finite difference simulation methods.

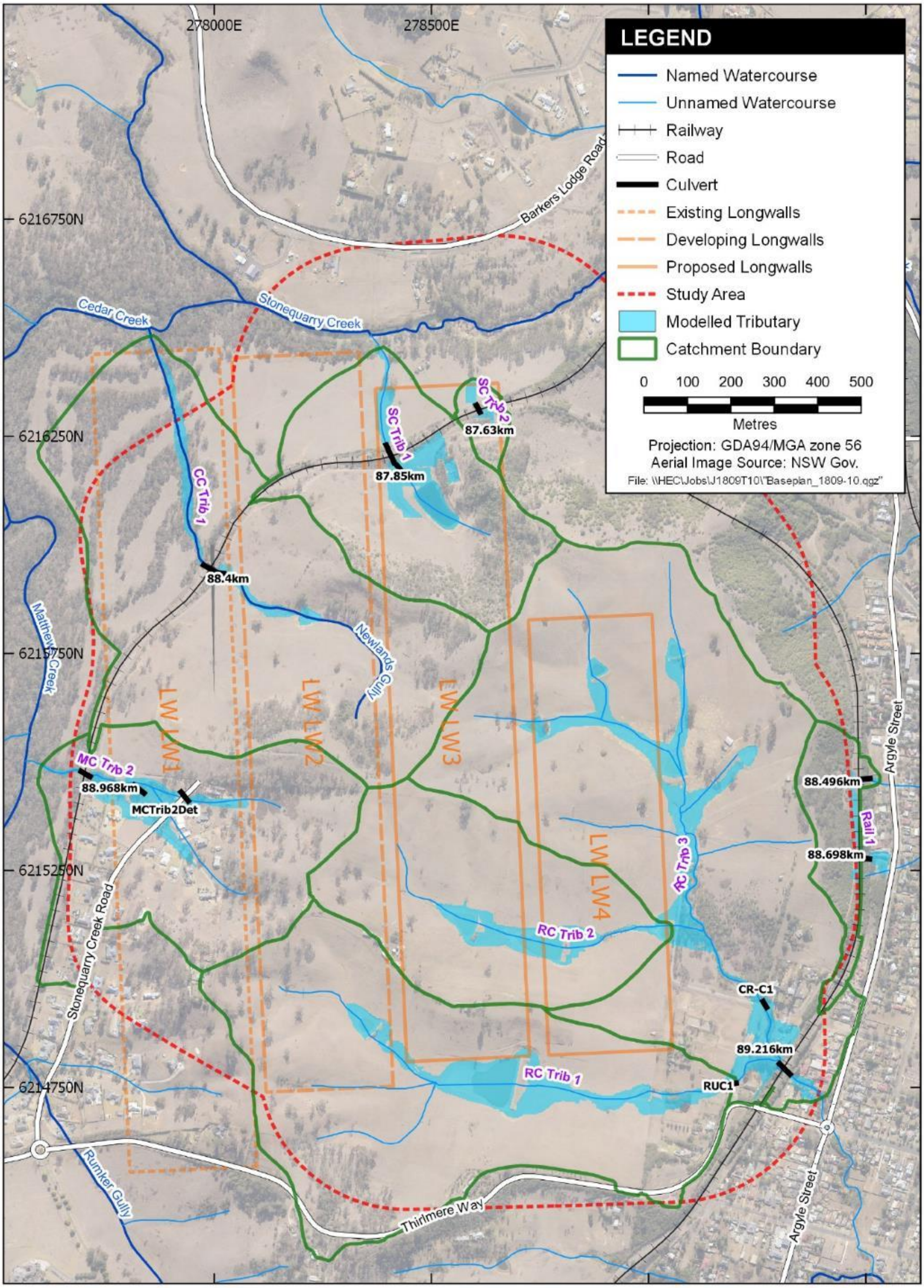


**Figure 19 Flood Assessment Tributary Locations, Catchment and Culvert Alignments**

Input information to the hydraulic model comprised:

- Digital elevation models (DEM) of the ground surface in the modelled area for both the pre and post subsidence case, obtained from MSEC.
- Estimates of channel or natural creek roughness/friction factors. The estimates for this study were obtained from interpretation of aerial and terrestrial photographs and literature guidelines. A uniform Manning's n roughness factor of 0.04 was assumed across the modelled area, except for road surfaces which were assigned a factor of 0.016.
- Rainfall excess hydrographs based on the initial loss/continuing loss model, using guideline values from ARR 2019 (Ball et al, 2019).
- An estimated normal depth was applied for the downstream boundaries where the flood slope was assumed equal to the stream bed slope which was estimated from the DEM. Any backwater effects from concurrent flow in downstream creeks have been ignored.
- Culvert details obtained from SIMEC (2018), JMA (2019a), JMA (2019b), MSEC (2014) and through visual inspection/photographic record.

Table 14 presents the estimated 50% AEP and 1% AEP peak flow rates at the downstream end of each tributary catchment. The change in longitudinal gradient for each tributary is also given (from subsidence predictions by MSEC for LW W3 and W4), with a positive change indicating an increase in gradient based on subsidence predictions and a negative change indicating a decrease in gradient.

**Table 14 Predicted Tributary Flow Rate and Change in Gradient**

| Ultimate Catchment | Tributary | Railway Chainage (km) | Peak flow rate ($m^3/s$) | | Maximum Predicted Reduction in Ground Level (mm) | Average Change in Tributary Gradient (%) |
|---|---|---|---|---|---|---|
| | | | 50% AEP | 1% AEP | | |
| Matthews Creek | MC Trib 2 | 88.968 | 1.79 | 9.36 | 799 | -0.14 |
| Cedar Creek | CC Trib 1 | 88.4 | 5.23 | 18.73 | 978 | -0.10 |
| Stonequarry Creek | SC Trib 1 | 87.85 | 2.31 | 7.43 | 763 | -0.15 |
| | SC Trib 2 | 87.63 | 0.23 | 0.85 | 163 | -0.06 |
| | Rail 1 | 88.496 | 0.48 | 2.78 | 20 | 0 |
| Redbank Creek | RC Trib 1 | n/a | 0.85 | 7.46 | 789 | -0.07 |
| | RC Trib 2 | n/a | 0.40 | 3.75 | 974 | -0.12 |
| | RC Trib 3 | 89.216 | 1.62 | 18.37 | 646 | -0.05 |

Maps illustrating the 50% AEP and 1% AEP pre-mining modelled velocity and depth and post-mining modelled velocity and depth increase for each tributary are presented in Appendix E. The results are summarised as follows:

Stonequarry Creek Tributaries

- Along the reach of SC Trib 1, SC Trib 2 and Rail 1 tributary, a negligible change in average water depth and velocity is predicted to occur post-mining for both the 50% and 1% AEP events (refer Figure E1 to Figure E8, Appendix E).
- In localised areas of SC Trib 1, SC Trib 2 and Rail 1 tributary, minor increases in depth (up to 0.043 m) and velocity (up to 0.24 m/s) may occur, however, these increases are predicted to occur in low risk areas (undeveloped areas with limited infrastructure).

- Post-mining, a negligible increase in depth is predicted to occur at the inlet of the 87.85 km railway culvert for both the 50% and 1% AEP events (refer Figure E2 and Figure E4, Appendix E).
- Changes in the depth profile of FD-7 are predicted to occur as a result of subsidence induced tilting (predicted tilt of 5 mm/m, refer Table 12).
- At the inlet of railway culverts 88.496 km and 88.698 km, the change in depth post-mining is predicted to be negligible for both the 1% AEP and 50% AEP events (refer Figure E28 and Figure E26, Appendix E).

Matthews Creek and Cedar Creek Tributaries

- Within the reach of MC Trib 2, the water depth is predicted to increase by a maximum of 0.074 m for a 1% AEP event post-mining LW W3-W4 (refer Figure E12, Appendix E). The depth increase is not predicted to result in the 1% AEP event flood extent reaching the residential buildings in this area.
- At the inlet of the Stonequarry Creek Road culverts (SC-C2 and SC-C3), slight increases in depth (up to 0.05 m) are predicted to occur for both the 50% AEP and 1% AEP events (refer Figure E10 and Figure E12, Appendix E). The slight increase in depth may result in water ponding at the inlet of the culverts for a short duration of time, however, will not result in a notable increase in flow depth over Stonequarry Creek Road.
- Across Stonequarry Creek Road, negligible changes in depth and velocity are predicted to occur for either the 50% or 1% AEP events (refer Figure E10, Figure E12, Figure E14 and Figure E16, Appendix E).
- Changes in the depth profile of detention basin FD-5 and farm dam FD-6 (refer Figure E10 and Figure E12, Appendix E) are predicted to occur as a result of subsidence induced tilting (refer Table 12 for predicted tilt levels).
- At the inlet of railway culvert 88.968 km, negligible increases in depth are predicted to occur for either the 50% or 1% AEP events (refer Figure E10 and Figure E12, Appendix E).
- At the inlet of railway culvert 88.4 km, the depth is predicted to decrease by 0.024 m for a 1% AEP event and a negligible change in depth is predicted for the 50% AEP event (refer Figure E10 and Figure E12, Appendix E).

Redbank Creek Tributaries

- Along the reach of RC Trib 1, RC Trib 2 and RC Trib 3, the change in average water depth and velocity is predicted to be negligible for both the 1% AEP and 50% AEP events (Refer Figure E17 to Figure E24, Appendix E).
- Changes in the depth profile of FD-1 to FD-4, FD-8 and FD-12 to FD-18 are predicted to occur as a result of subsidence induced tilting (refer Table 12 for predicted tilt levels).
- Increases in velocity are predicted to occur at the outlet of farm dams which are located along RC Trib 1, RC Trib 2 and RC Trib 3. The predicted increase in velocity may result in some increased scouring at the outlet of the dam during flood events. These dams will be visually inspected following flood events as detailed in Douglas Partners (2021).
- Upstream of railway culvert 89.216 km, the depth is predicted to increase by 0.032 m for a 1% AEP event and decrease by 0.07 m for a 50% AEP event due to changes in the flood characteristics of the upstream tributaries (refer Figure E20 and Figure E18, Appendix E). The slight depth increase predicted for a 1% AEP event may result in water ponding against the railway embankment for a short duration of time, however, will not exceed the height of the railway embankment.

- Negligible changes in depth and velocity across Star Street, Rumker Gully and Connellan Crescent are predicted to occur for either the 50% or 1% AEP events (Refer Figure E17 to Figure E24, Appendix E).
- Three residential buildings, downstream of CR-C1, on lots 1, 2 and 3 of plan DP1057554 are predicted to be within the existing inundation extent of the 1% AEP event associated with RC Trib 3 (Refer Figure E19, Appendix E). The maximum depth increases for flood water abutting these buildings during a 1% AEP event is predicted at 0.038 m, 0.039 m and 0.037 m for lots 1, 2 and 3 respectively (Refer Figure E20, Appendix E). This represents an increase in depth of 3%, 5% and 3% respectively in comparison with the predicted pre-mining 1% AEP depth.
- The maximum velocity increase for flood water abutting these buildings during a 1% AEP event is predicted at 0.027 m/s, 0.031 m/s and 0.039 m/s for lots 1, 2 and 3 respectively (Refer Figure E24, Appendix E). This represents an increase in velocity of 1%, 10% and 12% respectively in comparison with the predicted pre-mining 1% AEP velocity.

#### 4.4.4.4 Predicted Impact to Flood Regime – Matthews, Cedar and Stonequarry Creeks

A flood study has been undertaken to assess the impacts to flooding due to predicted subsidence within the Study Area. Hydrologic and hydraulic modelling was undertaken to assess the cumulative impacts of longwall panels LW W1 and LW W4 on peak flood levels in the three creeks for the 1% Annual Exceedance Probability (AEP) and Probable Maximum Flood (PMF) events. The modelling assessment and predictions are detailed in WRM (2020), which is included as Appendix F.

Figure 20 presents the 1% AEP peak flood extent and change in water level and Figure 21 shows the PMF flood extent and change in water level.

Figure 20 illustrates that the 1% AEP flood extent will be contained within the main creek channels providing Barkers Lodge Road with a 1% AEP flood immunity. The peak flood level for a 1% AEP flood event is predicted to decrease by up to 0.11 m in localised areas within creek channels, although may increase by up to 0.05 m at other localised areas within creek channels (WRM, 2020). The peak flood velocity change is predicted to increase by up to 0.15 m/s in localised areas, although the predicted velocity increases in most areas are expected to be generally less than 0.05 m/s. The modelling predictions indicate a very similar flood extent in the existing and post-subsidence conditions. As such, the impacts due to the proposed subsidence associated with the Western Domain on the three creeks in 1% AEP flood conditions are predicted to be negligible.

Figure 21 illustrates that the PMF flood extent will also be contained the main channels of Matthews and Cedar creeks, however flood break out would occur from portions of Stonequarry Creek, resulting in flooding of Barkers Lodge Road during the PMF event under existing and post-subsidence conditions by up to 1.5 m. The peak flood level is predicted to decrease by 0.11 m and increase by up to 0.1 m in localised areas. The flood velocity is predicted to increase by up to 0.2 m/s in localised areas, although the predicted velocity is expected to increase by less than 0.1 m/s generally. The modelling predictions indicate a similar flood extent in the existing and post-subsidence conditions. As such, the impacts due to the proposed subsidence associated with the Western Domain on the three creeks in PMF conditions are predicted to be negligible.

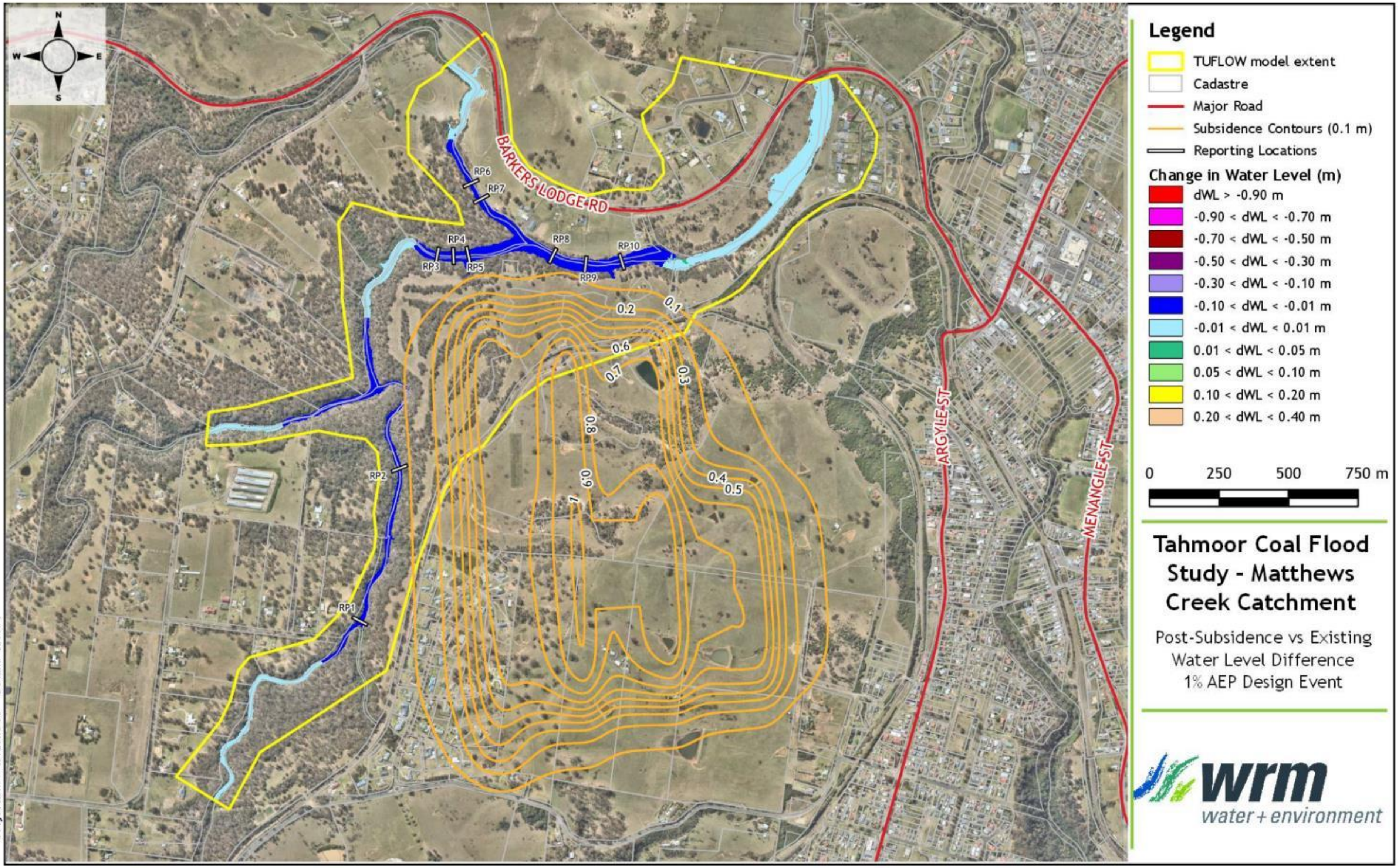


**Figure 20** Matthews, Cedar and Stonequarry Creeks 1% AEP Event – Change in Water Level (WRM, 2020)

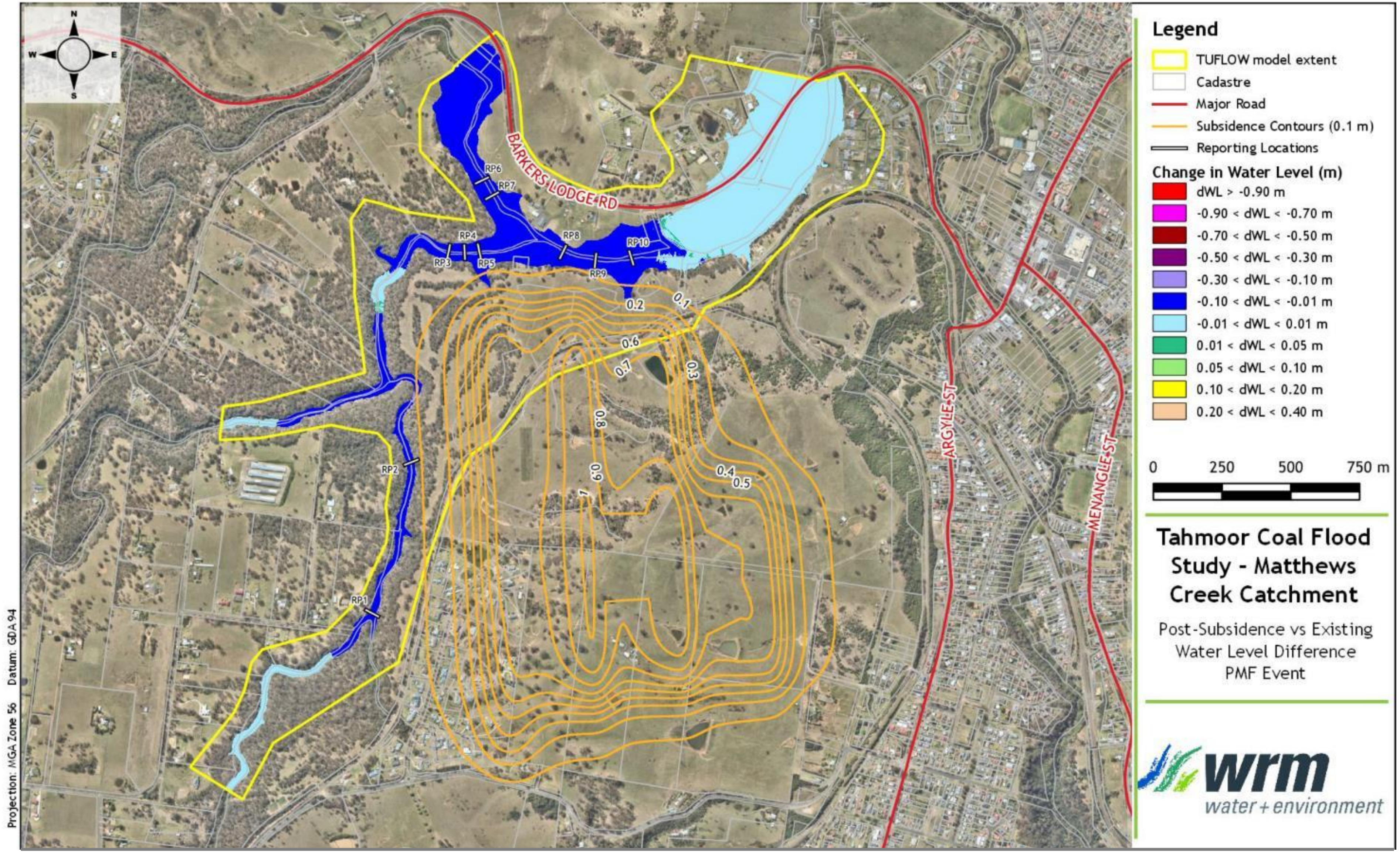


**Figure 21** Matthews, Cedar and Stonequarry Creeks PMF Event – Change in Water Level (WRM, 2020)

#### 4.4.4.5 Potential Impact to Overland Flow

The maximum predicted incremental tilt is 4.5 mm/m due to mining of LW W3 and LW W4 (MSEC, 2021). The minimum natural gradient overlying LW W3 is approximately 37 mm/m while the minimum natural gradient overlying LW W4 is approximately 47 mm/m. As the maximum predicted tilt is insignificant in comparison with the natural gradient, there are no locations in which the natural gradient will flatten or change direction. As such, while there may be some minor changes to the drainage pathways, remnant ponding in the landscape (excluding the watercourses) is unlikely to occur as a result of mining of LW W3 and W4.

#### 4.4.4.6 Potential Impact to Water Supply

As discussed in Section 3.1, there are six properties within the Study Area with a Water Supply Works and Water Use Approval. For the surface water systems in which pumping would occur, MSEC (2021) has predicted that less than 10% of pools are likely to experience fracturing and associated reduction in standing water level (refer Section 4.4.2). As such, while minor impacts to water supply may occur, the potential impacts to water supply should be manageable through implementation of monitoring, mitigation and management measures (refer Section 5.0) and through contingency planning (refer Section 6.0).

SLR (2021b) estimated a peak mean annual baseflow reduction associated with regional mining, including LW W3-W4, for the Stonequarry Creek Management Zone of approximately 50 ML/annum in 2023-2024 which is predicted to decline to approximately 25 ML/annum by approximately 2035. As stated in Section 3.3.2.5, the mean annual flow volume recorded at Stonequarry Creek at Picton (GS 212053) is 5,627 ML. The peak predicted baseflow reduction of 50 ML/annum equates to 0.9% of the mean annual flow at Stonequarry Creek at Picton (GS 212053) which is a small and likely indiscernible reduction in flow at this location.

A total of 680.3 share components (680.3 ML) is currently allocated as unregulated river access licences from the Stonequarry Creek Management Zone (WaterNSW, 2021). A peak mean annual baseflow reduction of 50 ML equates to 7.3% of the total issued share component of the Stonequarry Creek Management Zone for unregulated river access respectively. The predicted baseflow reduction would be mitigated by Tahmoor Coal purchasing sufficient water licences (WALs) for licensable surface water ‘take’ within the Stonequarry Creek Management Zone of the Upper Nepean and Upstream Warragamba Water Source.

As noted in Section 4.4.4.1, although there may be some temporary loss of flow (diversion) from the surface water systems in the event of fracturing or dilation, connectivity between the deep groundwater and surface water systems is not predicted to occur (SLR, 2021a). It is more likely that diverted flow will re-emerge further downstream of monitoring site SD on Stonequarry Creek. As such, the estimated baseflow reduction for Stonequarry Creek associated with mining LW W3-W4 is highly conservative as a portion of the diverted flow is likely to re-emerge further downstream.

### *4.4.5 Potential Impact to Surface Water Related Infrastructure*

Several stormwater culverts, stormwater detention basins and farm dams are present within the Study Area which may potentially be impacted by subsidence associated with mining in the Western Domain. The flood related impacts on culverts located within tributary gullies are assessed in Section 4.4.4.3.

The maximum predicted tilt for the farm dams within the predicted subsidence zone (refer Figure 14) is 5.0 mm/m (MSEC, 2021). Mining induced tilts may potentially reduce the storage capacity of farm dams, with the dam freeboard increasing on one side and decreasing on the other. Additionally, tilt may potentially affect the stability of the dam embankments. The predicted changes in freeboard, associated with subsidence induced tilting, for the farm dams within the Study Area are small, varying from less than 20 mm to 150 mm and as such, it is unlikely that the dams would experience adverse impacts to storage capacity (MSEC, 2021).

The dams have typically been constructed along the alignment of streams and as such, may experience valley related effects due to the extraction of LW W3-W4. The valley heights at the dams are small and it is therefore expected that the predicted valley related upsidence and closure movements at the dam embankments would not be substantial (MSEC, 2021).

The farm dams located directly above LW W3-W4 may experience cracking of the base of embankments due to the mining-induced curvatures and strains (MSEC, 2021). The impact of subsidence on a dam embankment is dependent on the specific nature of ground movement and cracking, the embankment construction materials, methods and quality of foundation preparation and construction, the embankment size, the location of the embankment with respect to the longwall panel and the surface geology and foundation characteristics (GeoTerra, 2014). Embankments which overlie the highest strain location of the longwalls (i.e. near the longwall ribs) are more likely to be impacted while embankments located in the centre of an extracted longwall are less likely to be impacted (GeoTerra, 2014).

The majority of dam embankments overlying previously mined LW22 to LW32 have not been observed, or reported by landowners, to have been affected by subsidence, excepting three dams overlying LW 26 which reported a loss of water holding capacity (GeoTerra, 2014). The maximum observed subsidence following mining of LW 26 was 1,382 mm with the three impacted dams overlying the longwall ribline zones.

The greatest subsidence at existing dams is predicted to occur at FD-4 and FD-6 (refer Table 12). The maximum total subsidence predicted for FD-4, which overlies LW W3, and FD-6, which overlies LW W2, is 975 mm following mining of LW W4 (refer Figure 14). As the maximum predicted total subsidence is significantly less than that experienced following mining of LW 26, it is anticipated that impacts to these dams will be less than those experienced following mining of LW 26.

The potential impacts on the structural integrity of the dam embankments are addressed further in the Geotechnical Assessment (Douglas Partners, 2020). Douglas Partners (2020) note that the farm dams are constructed with clay material, which can absorb conventional cracking, although localised cracking and deformations may occur. Farm dams FD1 – FD8, FD12 and FD16 may potentially experience cracking due to mining induced subsidence, which may cause loss of water storage capacity and require remediation (Douglas Partners, 2020).

The monitoring program developed for LW W1-W2 will continue to be implemented and will be expanded to include additional farm dams overlying or adjacent to LW W3-W4 as required. The monitoring program includes assessment of the dam embankment integrity and water level prior to secondary extraction within the Western Domain, during operations and post mining as detailed in Section 5.0. Should impacts be reported, a remediation program will be implemented in accordance with the TARP for landscape features (Douglas Partners, 2020).

### *4.4.6 Potential Impact to Water Quality*

Isolated, episodic pulses in salinity, iron, manganese, zinc and nickel may occur in Stonequarry Creek, Matthews Creek and Cedar Creek due to subsidence induced changes in surface water runoff, throughflow and baseflow discharging to these surface water systems. Localised and periodic increases in electrical conductivity and concentrations of dissolved iron, manganese, zinc, sulphate and nickel were recorded at monitoring sites in Redbank Creek overlying and downstream of LW24B to LW32 during and shortly following mining. While there were some periodic increases in constituents recorded at locations downstream of mining impacts, potentially due to re-emergence of upstream diverted flow, the increases were found to be temporary and decreased to baseline levels with time (refer Section 3.4.1.4). However, because Stonequarry Creek, Matthews Creek and Cedar Creek will not be directly mined beneath, the subsidence related impacts to water quality are likely to be less than that recorded previously in Redbank Creek following mining of LW25 to LW32. As stated in Section 3.3, to date there has been negligible evidence of an influence of mining LW W1 or LW W2 on surface water quality in Matthews Creek, Cedar Creek or Stonequarry Creek.

Groundwater seepage has been observed at the junction of Cedar Creek and Matthews Creek based on high iron hydroxide precipitation within this reach (GeoTerra, 2014). As such, subsidence related impacts to water quality may be more pronounced at this location. Ferruginous deposition is prevalent in Cedar Creek and may be exacerbated by subsidence induced emergence of ferruginous springs.

Water quality monitoring upstream and downstream of mine areas is planned (refer Section 5.0) and TARPs have been developed to assess the need for a response which may include remediation. Stream remediation measures (see Section 5.1) would be conducted on stream reaches of second order and above where subsidence results in fracturing of the stream bed or controlling rockbars.

#### *4.4.7 Potential Impact to Aquatic Habitat*

MSEC (2021) has predicted that less than 10% of pools along Stonequarry Creek, Matthews Creek and Cedar Creek are likely to experience fracturing and associated reduction in standing water level based on the predicted total valley closure. As such, there is likely to be less than 10% reduction in overall pool aquatic habitat in Stonequarry Creek, Matthews Creek and Cedar Creek (Niche, 2021). In the event of cracking, potential localised reduction in available habitat and macroinvertebrate biomass may occur as a result of reduced water levels. Additionally, temporal reduction in fish passage during low flow periods may occur (Niche, 2021). For invertebrates, while total biomass will likely be reduced, it is unlikely that a sub-catchment to catchment scale change in overall assemblage and family richness will be measurable. The majority of the stream biota observed in the Study Area are able to adapt to drying conditions and have the potential to recruit back to pools once the water holding capacity is re-established. For pools which experience long-term reduction in water holding capacity, this could lead to permanent changes to stream biota within the affected pools and restrict the recovery of biota that require stream connectivity e.g. fish (Niche, 2021).

The liberation of contaminants from subsidence induced fracturing in watercourses, with resulting localised and transient water quality impacts, has the potential to impact aquatic biota. This is particularly the case where increased iron precipitation occurs. Streams that are acidic and have low alkalinity are more likely to be impacted as these surface water systems have less buffering capacity against changes to pH (Niche, 2021). Section 3.4 illustrates that the surface water systems within the Study Area typically have low alkalinity and acidic to neutral pH conditions. As such, changes to pH will have greater impact on these surface water systems and associated aquatic biota.

Where localised and transient pulses in metals are observed, the impacts to stream fauna are similarly expected to be localised, with fauna likely to recover from transient spikes in concentrations. Localised long-term changes to fauna may occur if metal concentrations are elevated for prolonged periods of time (Niche, 2021).

As stated in Section 4.3.1.2, small although reasonably persistent gas bubbles were observed in pool MR45 in Matthews Creek during the creek visual inspections conducted in February to June, October, November and December 2020. The results of gas chromatography analysis were insufficient to provide a direct linkage between mining related influences and the observed gas emissions, although a connection was considered probable (GeoTerra, 2020a). Niche (2021) have not reported evidence of vegetation dieback due to observed gas emissions in pool MR45 in Matthews Creek. The watercourses will continue to be visually inspected for gas emissions and any evidence of vegetation dieback.

# 5.0 MONITORING, MITIGATION AND MANAGEMENT

## 5.1 MONITORING PLAN

Management and mitigation measures will be critically dependent on appropriate monitoring. The surface water monitoring sites for LW W3-W4 are shown in Figure 22, with the surface water monitoring program summarised in Table 15. The program, as it relates to surface water has been / will be undertaken in phases: prior to mining (secondary extraction), during secondary extraction and subsidence and following the end of mining and cessation of subsidence.

The monitoring program relates specifically to Matthews Creek, Cedar Creek and Stonequarry Creek. As Redbank Creek is located outside of the predicted 20 mm total subsidence contour, additional monitoring is not proposed to be undertaken in Redbank Creek. Monitoring of surface water quality and water level is ongoing at a number of sites in Redbank Creek as part of mining and post-mining monitoring for LW32 and previous longwalls. This includes site RC6 which is located downstream of the main tributary of Redbank Creek.

The establishment of monitoring locations in the main tributary of Redbank Creek is problematic due to the ephemeral nature of flow and poor establishment of this watercourse. A monitoring location on the boundary of the 20 mm subsidence contour was investigated as a potential site for monitoring, however, a suitable flow control was not identified and the tributary was dry despite rainfall occurring in the catchment just prior to the site being inspected. Further downstream, the main tributary of Redbank Creek is heavily modified by residential development, including diversion through road culverts. As such, monitoring of this tributary is not proposed to be undertaken.

As discussed in Section 3.2, a BACI framework has been implemented, where feasible, for surface water and groundwater monitoring and has been incorporated in the design of the TARP triggers (Section 6.2). The monitoring program is aimed to develop a baseline (before) dataset for a range of surface water and groundwater features and to assess operational and post-mining (after) impacts through the monitoring of reference (control) and performance measure (impact) sites. The TARP triggers have been designed to enable identification of potential impacts based on the before and after monitoring at reference and performance measure sites.

Quality assurance and quality control (QA/QC) for water quality monitoring is and will continue to be undertaken in accordance with the *Australian and New Zealand Guidelines for Fresh & Marine Water Quality* (ANZG, 2018). Both field and laboratory analyses are and will continue to be undertaken for some physico-chemical constituents and the values compared and queried if there are inconsistencies. The sample collection is and will continue to be undertaken by an experienced field technician, the sample analysis undertaken by a National Association of Testing Authorities (NATA) accredited laboratory and the data analysis undertaken by a specialist consultant. Where a data record is identified as potentially erroneous by the specialist consultant, the value is and would be queried with and reviewed by the field technician. The same process is and would be undertaken for pool water level records, with the records also verified through comparison of the manual field measurements and automatic water level logger records.

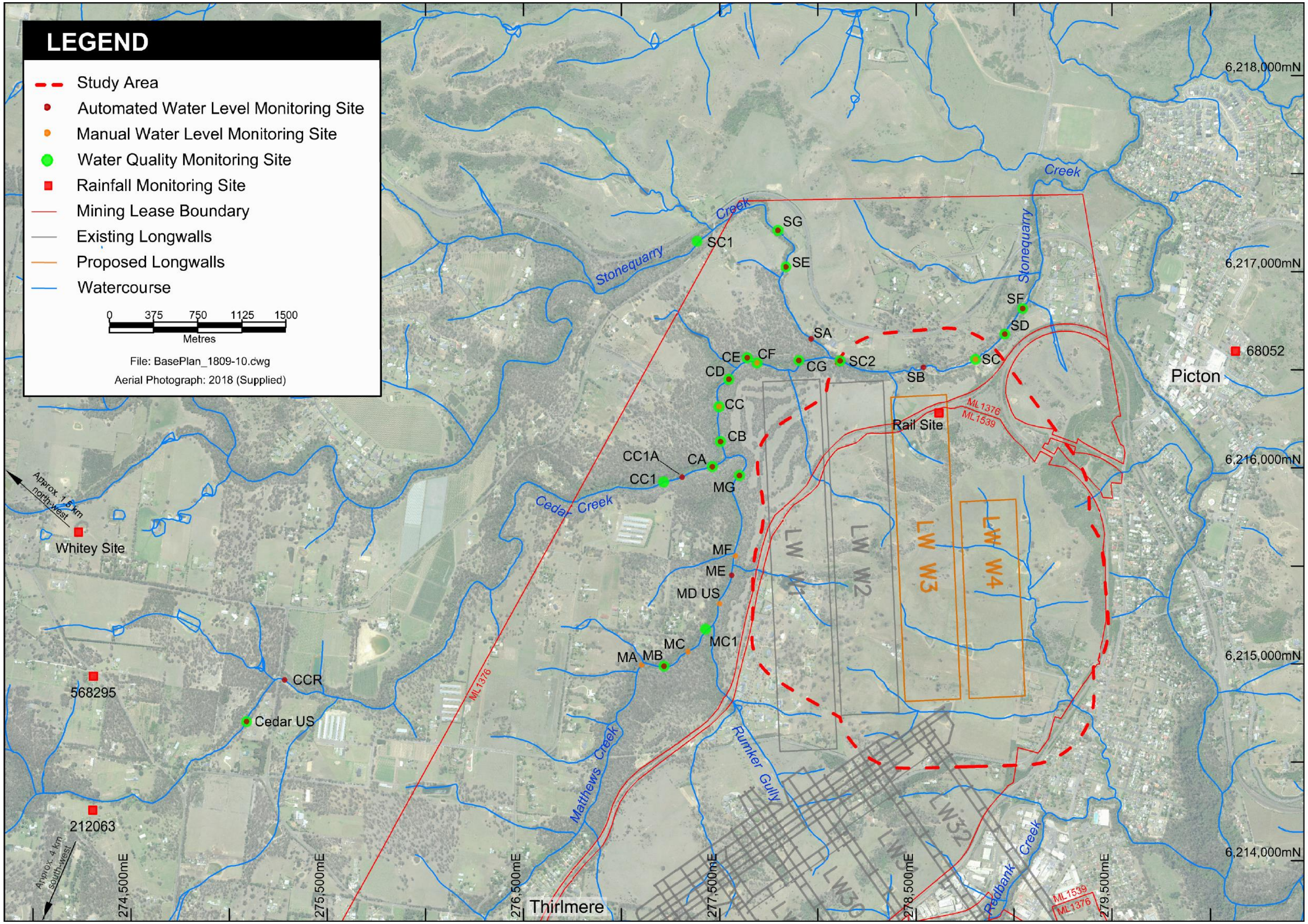


**Figure 22 Surface Water Monitoring Sites – LW W3-W4**

### Table 15 LW W3-W4 Monitoring Plan

| Feature | Locations | Monitoring | | |
|---|---|---|---|---|
| | | Prior to Mining | During Mining | Post Mining |
| Daily rainfall | • WaterNSW stations 568296 (Thurns Road) and 212063 (Lake Nerrigorang at Thirlmere Lakes)[1]<br>• Automatic rainfall stations at the Rail Site and Whiteys Site[2] | Data recorded daily and downloaded monthly. | Data recorded daily and downloaded monthly. | Data recorded daily and downloaded monthly for 12 months following the completion of LW W4. This period may be extended as per decision by the Environmental Response Group. |
| Automated pool water level | Tahmoor Coal automated pool level sites:<br>Baseline / Impact Site:<br>Cedar Creek (CA, CB, CD, CE, CG)<br>Matthews Creek (ME, MG)<br>Stonequarry Creek (SA, SB, SC2, SD, SF)<br>Reference / Control Site:<br>Cedar Creek (Cedar US, CCR, CC1A)<br>Matthews Creek (MB)<br>Stonequarry Creek (SE SG) | Continuous record. Data downloaded monthly. Baseline data recorded since October 2018 at majority of sites (refer Appendix A for monitoring dates). | Continuous record. Data downloaded monthly. | Continuous record. Data downloaded monthly for 12 months following the completion of LW W4. This period may be extended as per decision by the Environmental Response Group. |
| Manual pool water level | Tahmoor Coal manual pool water level sites:<br>Baseline / Impact Site:<br>Cedar Creek (CC, CF)<br>Matthews Creek (MC, MD US, MF, pool MR45, pool MR46)<br>Stonequarry Creek (SC)<br>Reference / Control Site:<br>Cedar Creek (Cedar US, CCR, CC1A)<br>Matthews Creek (MA, MB)<br>Stonequarry Creek (SG, SE) | Monthly manual level reading. Visual inspection of natural drainage behaviour using photo points. Baseline data recorded since October 2018 at majority of sites (refer Appendix A for monitoring dates). | Monthly manual level reading at all sites. Visual inspection of natural drainage behaviour using photo points. | Monthly manual level reading. Visual inspection of natural drainage behaviour using photo points 12 months following the completion of LW W4. This period may be extended as per decision by the Environmental Response Group. |

[1] Refer https://realtimedata.waternsw.com.au/
[2] Refer Figure 22

**Table 15 (Cont.) LW W3-W4 Monitoring Plan**

| Feature | Locations | Monitoring | | |
|---|---|---|---|---|
| | | Prior to Mining | During Mining | Post Mining |
| Stream Water Quality | Tahmoor Coal water quality sites:<br>Baseline / Impact Site:<br>• Cedar Creek (CA, CB, CC, CD, CE, CF, CG)<br>• Matthews Creek (MC1, MG)<br>• Stonequarry Creek (SC2, SC, SD, SF)<br>Reference / Control Site:<br>• Cedar Creek (Cedar US, CC1)<br>• Matthews Creek (MB)<br>• Stonequarry Creek (SC1, SE, SG) | Monthly sampling and analysis for 12 months prior to secondary extraction. Baseline data recorded since January 2019 at majority of sites (refer Appendix A for monitoring dates). | Monthly sampling and analysis. | Monthly sampling and analysis for 12 months following the completion of LW W4. This period may be extended as per decision by the Environmental Response Group. |
| | | *Parameters*:<br>Field analysis: pH, EC and DO, temperature and ORP.<br>Laboratory analysis for: pH, EC, TDS, alkalinity, sulphate, chloride, calcium, magnesium, sodium, potassium, fluoride, nitrate+nitrite, kjeldahl nitrogen, phosphorus, dissolved metals: aluminium, arsenic, barium, copper, lead, lithium, manganese, nickel, selenium, strontium, zinc and iron; and total metals: manganese, zinc and iron. | | |
| Physical features and natural behaviour of pools | Baseline / Impact Site:<br>Stream reaches of Cedar Creek, Matthews Creek and Stonequarry Creek within the Study Area.<br>Reference / Control Site:<br>Stream reaches of Cedar Creek, Matthews Creek and Stonequarry Creek outside of the Study Area. | Observations prior to mining using fixed location photo points. Baseline inspection first undertaken in 2014, and in November 2019 prior to mining LW W1. | Observations every month during the active subsidence period (after 200 m of secondary extraction of LW W1-W4), for sites within and adjacent to active subsidence zone[3], by Tahmoor Coal using fixed location photo points. Reduce frequency of observations to 2-monthly after 1,000 m of extraction of LW W3-W4 for sections of valleys that are located behind the active subsidence zone unless continuing adverse changes are observed. | Observations 3 monthly for 12 months following the completion of LW W4. This period may be extended as per decision by the Environmental Response Group. |
| Stream and Riparian Vegetation | As per Biodiversity Management Plan | Completed as part of baseline monitoring. | Bi-annually (Spring and Autumn). | Bi-annually (Spring and Autumn) for 12 months following the completion of LW W4. This period may be extended as per decision by the Environmental Response Group. |

[3] Survey area to include upstream pools (beyond mining effects) where a potential Level 4 TARP trigger has occurred at an impact site(s)

### Table 15 (Cont.) LW W3-W4 Monitoring Plan

| Feature | Locations | Monitoring | | |
|---|---|---|---|---|
| | | Prior to Mining | During Mining | Post Mining |
| Flood levels[4] | All dwellings within the 1% AEP flood extent. | Pre-mining modelling (using surveyed pre-mining topography) to establish 1% AEP flood levels and extents in areas potentially impacted by subsidence (complete). Pre-mining modelling was completed in May 2019. | Subsidence surveys to be conducted along local roads and the railway as defined in the Subsidence Monitoring Program. | Post-mine modelling (using surveyed post-mine topography) to estimate 1% AEP flood levels and extents in areas potentially impacted by subsidence. |
| First and Second Order Tributaries | Subsidence survey marks as defined in the Subsidence Monitoring Program. | Prior to mining of each longwall as defined in the Subsidence Monitoring Program. | As defined in the Subsidence Monitoring Program. | As defined in the Subsidence Monitoring Program. |

[4] Potential impact to flood levels assessed based on monitored subsidence and/or revised subsidence predictions

## 5.2 POTENTIAL STREAM REMEDIATION MEASURES

Various techniques have been adopted to successfully reduce subsidence impacts to streams associated with longwall mining at Tahmoor Coal and other operations in the Southern Coalfield. The remediation trial at Pool 23 rockbar on Myrtle Creek comprised injection of polyurethane into the fracture network in order to restore the pool holding capacity (SCT, 2020b). Aesthetic values have improved following remediation and the water level has remained elevated for a period in excess of 11 months (SCT, 2020b). Similar trials are currently being undertaken for pools in Redbank Creek with remediation progress continuously assessed.

A summary of remediation methods, possible application to different situations and limitations is provided in Table 16.

**Table 16 Proposed Stream Remediation Techniques**

| Restoration Technique | Description | Applications and Limitations |
|---|---|---|
| Hand grouting | Sealing of cracks exposed on the surface using hand applicators. A variety of sealants can be used including sealants that can be applied under water. | Limited to surface cracks which can be accessed using hand held application equipment. |
| Shallow pattern grouting | Drilling shallow holes using small hand held drilling equipment and low pressure injection of a grout using a portable pump.<br>Grouts used successfully on the Georges River (by Illawarra Coal) incorporated a cement mix that can be used with or without additives (e.g. bentonite). | • Used to seal shallow fractures in rockbars and pools.<br>• Applicable to sensitive areas where access for larger equipment is problematic.<br>• Improved results can be obtained if the target fractures are dewatered. |
| Deep pattern or curtain grouting | Drilling deeper holes using traditional air and or reverse circulation drilling rigs. Higher pressure grouting techniques can also be used. Grouts used successfully on the Georges River incorporated a cement-bentonite mix. | • Used to seal fracture networks at greater depths.<br>• Can seal larger and deeper fractures.<br>• Larger equipment may necessitate constructing access tracks.<br>• Less suitable for remote or difficult access sites. |
| Deep angle hole cement grouting | Remote directional drilling techniques can be used to access otherwise inaccessible sites. The same grouting methods as deep pattern/curtain grouting outlined above can be used. | Specialised technique which can be used in situations where drill access is available close to target site. |
| Polyurethane (PUR) grouting | Use of expanding PUR grouts to seal fracture networks. PUR, which is a rapid setting grout that sets under water, is pumped into closely spaced drill holes (pattern drilling) and fractures filled systematically from the "bottom up". | • Technique used successfully in Myrtle Creek by Tahmoor Coal and Waratah Rivulet by Helensburgh Coal Pty Ltd.<br>• Can be used under water and under low flow conditions.<br>• Can be used to fill large aperture fractures in stages. |

The range of available techniques would be considered by Tahmoor Coal in the design of any future stream restoration programs should these be required.

Prior to the implementation of remediation, the following preparatory work would be undertaken:

- obtaining required regulatory approvals;

- planning and securing land access agreements;
- preparing relevant management plans and protocols;
- preparing high resolution detailed pool and rockbar mapping;
- drilling of investigation bores to characterise sub-surface conditions (if grouting is the chosen remediation option);
- remediation using one or more of the techniques in Table 16; and
- on-going monitoring to evaluate success (refer Section 5.1).

### 5.3 FLOOD MANAGEMENT PROTOCOL

The flood assessment detailed in Section 4.4.4 has predicted that the peak 1% AEP flood extent will be contained within Matthews Creek, Cedar Creek and Stonequarry Creek meaning that Barkers Lodge Road has at least a 1% AEP flood immunity. The modelling indicates that the peak flood level for a 1% AEP flood event is predicted to decrease by up to 0.11 m in localised areas within creek channels, although may increase by up to 0.05 m at other localised areas within creek channels (WRM, 2020). The predicted increase is within the bounds of model accuracy and is considered to be negligible.

As discussed in Section 4.4.4.3, negligible changes in depth and velocity across Stonequarry Creek Road, Star Street, Rumker Gully and Connellan Crescent are predicted to occur for either the 50% or 1% AEP events. As such, it is not anticipated that access to Stonequarry Creek Road, Star Street, Rumker Gully or Connellan Crescent will be measurably impacted as a result of mining LW W3-W4.

Should subsidence predictions be updated, or observed subsidence be in excess of that predicted, modelling will be revised and up-to-date information (including subsidence and flooding predictions) will be provided to the State Emergency Service and Council regarding privately-owned residences that could be adversely affected by lack of access during 1% AEP flood events. Tahmoor Coal will work with landowners, State Emergency Service and Council to develop evacuation plans to ensure landowners are informed as to the appropriate course of action in the event of emergency as a result of a 1% AEP flood event.

# 6.0 CONTINGENCY PLAN

## 6.1 ADAPTIVE MANAGEMENT

In the event that the subsidence performance measures in relation to surface water resources are considered to have been exceeded or are likely to be exceeded, response and management will be undertaken.

Tahmoor Coal has designed the layout of LW W1-W4 to avoid mining directly beneath Matthews Creek, Cedar Creek and Stonequarry Creek in order to substantially reduce the severity and extent of impacts on these surface water resources. Tahmoor Coal has committed to implementing a detailed monitoring program to measure and record mining-induced movements and impacts on the surface water systems during the mining of LW W3-W4 (refer Section 5.0). Details of the proposed adaptive management plan are given in the LW W3-W4 Water Management Plan.

## 6.2 TRIGGER ACTION RESPONSE PLAN

TARPs are used to set out response measures for unpredicted subsidence impacts and have been developed for potential impacts to streamflow rate, pool water level, natural drainage behaviour, stream water quality, aquatic habitat, dams and flood levels. The monitoring results will be used to assess the impacts of mining in the Western Domain against the performance indicators and performance measures using the TARPs.

The frequency of assessment, impact assessment triggers and proposed action and response plans are detailed in Table 17. In Table 17, trigger level 1 nominally equates to “normal” conditions, trigger level 2 nominally equates to “within prediction” conditions, trigger level 3 nominally equates to “approaching exceedance” conditions and trigger level 4 nominally equates to “exceeds prediction” conditions.

**Table 17 Surface Water Trigger Action Response Plan**

| Feature | Methodology and relevant monitoring | Management | | |
|---|---|---|---|---|
| | | Trigger | Action | Response |
| Impact to pool water level | <u>AUTOMATED POOL WATER LEVEL</u><br>LOCATIONS (refer Figure 22):<br>Baseline / Impact site:<br>• Cedar Creek (CA, CB, CD, CE, CG)<br>• Matthews Creek (ME, MG)<br>• Stonequarry Creek (SA, SB, SC2, SD, SF)<br>Reference / Control site:<br>• Cedar Creek (Cedar US, CCR, CC1A)<br>• Matthews Creek (MB)<br>• Stonequarry Creek (SG SE)<br><br>PRE-MINING – Continuous record, data downloaded monthly. Baseline data recorded since October 2018 at the majority of Western Domain sites.<br>DURING - Continuous record, data downloaded monthly.<br>POST-MINING - Continuous record, data downloaded monthly for 12 months following the completion of LW W4. This period may be extended as per a decision by the Environmental Response Group. | Level 1 | | |
| | | • The recorded water level has not declined below the recorded baseline minimum level (in one 24 hour period for automated pool water level)<br>OR<br>• The recorded water level has declined below the recorded baseline minimum level (for more than one 24 hour period for automated pool water level) but the decline is due to a monitoring or sensor error or the magnitude of the decline (below the recorded baseline minimum level) is within the range of sensor accuracy | • Continue monitoring as per monitoring program<br>• Continue monthly review of data | • No response required |
| | | Level 2 | | |
| | | • The recorded water level has declined below the recorded baseline minimum level (for more than one 24 hour period for automated pool water level)<br>AND<br>• The above has occurred at one of the upstream pools (beyond mining effects) | • Continue monitoring as per monitoring program<br>• Continue monthly review of data<br>• Convene Tahmoor Coal Environmental Response Group to review response | • As defined by Environmental Response Group |
| | | Level 3 | | |
| | | • The recorded water level has declined, although not atypically^, below the recorded baseline minimum level (for more than one 24 hour period for automated pool water level)<br>AND<br>• The above has not occurred at one of the upstream pools (beyond mining effects) | • Continue monitoring as per monitoring program<br>• Continue monthly review of data<br>• Convene Tahmoor Coal Environmental Response Group to review response | • As defined by Environmental Response Group<br>• Consider increasing download and review of data frequency to fortnightly for sites where Level 3 has been reached<br>• Review manual water level measurements for additional monitoring sites to identify potential spatial trends in water level decline |
| | | Level 4 | | |
| | | • The recorded water level has declined atypically^ below the recorded baseline minimum level (for more than one 24 hour period for automated pool water level)<br>AND<br>• Similar behaviour has not occurred at one of the upstream pools (beyond mining effects) | • Increase download and review of data frequency to fortnightly for sites where Level 4 has been reached<br>• Continue monthly download and review of data for all other sites<br>• Convene Tahmoor Coal Environmental Response Group to undertake an investigation to assess if the change in behaviour is related to LW W3-W4 mining effects, other catchment changes or the prevailing climate | • Report to DPIE and relevant government agencies within 7 days of initial investigation completion<br>• Conduct detailed investigation of surface water level decline<br>• Review manual water level measurements for additional monitoring sites to identify potential spatial trends in water level decline<br>• If it is concluded that there has been a mining-related impact then implement a corrective action management plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the Resources Regulator |

^ 'Atypical' surface water characteristics relate to a notable and / or rapid water level decline or change in the slope of the falling limb of the hydrograph or the water level recessionary behaviour below the CTF level which is inconsistent with baseline conditions and cannot be attributed to climatic conditions

**Table 17 (Cont.) Surface Water Trigger Action Response Plan**

<table>
<tr><th rowspan="2">Feature</th><th rowspan="2">Methodology and relevant monitoring</th><th colspan="3">Management</th></tr>
<tr><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td rowspan="8">Impact to physical features and natural behaviour of pools</td><td rowspan="8"><u>VISUAL INSPECTIONS</u><br>LOCATIONS:<br>Baseline / Impact site:<br>Stream reaches of Cedar Creek, Matthews Creek and Stonequarry Creek within the Study Area.<br>Reference / Control site:<br>Stream reaches of Cedar Creek, Matthews Creek and Stonequarry Creek outside of the Study Area.<br><br>PRE-MINING - Observations prior to mining using fixed location photo points. Baseline data first recorded in 2014, and in November 2019 prior to mining.<br>DURING MINING - Observations every month during active subsidence period (after 200 m of secondary extraction of LW W3-W4), for sites within and adjacent to active subsidence zone*, by Tahmoor Coal using fixed location photo points. Reduce frequency of observations to 2-monthly after 1,000 m of extraction of LW W3-W4 for sections of valleys that are located behind the active subsidence zone unless continuing adverse changes are observed.<br>POST-MINING - Observations 3-monthly for 12 months following the completion of LW W4. This period may be extended as per a decision by the Environmental Response Group.</td><td colspan="3">Level 1</td></tr>
<tr><td>• No observed impacts to pool level, drainage or overland connected flow</td><td>• Continue monthly monitoring<br>• Continue monthly review of data</td><td>• No response required</td></tr>
<tr><td colspan="3">Level 2</td></tr>
<tr><td>• Visually observed reduction in pool level, drainage or overland connected flow<br>AND<br>• The above has occurred at one of the upstream pools (beyond mining effects)<br>OR<br>• Visual monitoring of pools has not noted any mining related impacts¥</td><td>• Continue monitoring as per monitoring program<br>• Continue monthly review of data<br>• Convene Tahmoor Coal Environmental Response Group to review response</td><td>• As defined by Environmental Response Group</td></tr>
<tr><td colspan="3">Level 3</td></tr>
<tr><td>• Rockbar and/or stream base cracking, gas release or iron precipitation noted during visual inspection (in excess of baseline conditions)<br>AND<br>• No reduction in pool water level, drainage or overland connected flow, taking into account climatic conditions and observations during baseline monitoring period</td><td>• Continue monitoring as per monitoring program<br>• Continue monthly review of data<br>• Convene Tahmoor Coal Environmental Response Group to undertake an investigation to assess if the change in behaviour is related to LW W3-W4 mining effects, other catchment changes or the prevailing climate</td><td>• As defined by Environmental Response Group<br>• Consider increasing inspection and review of data frequency to fortnightly for sites where Level 3 has been reached</td></tr>
<tr><td colspan="3">Level 4</td></tr>
<tr><td>• Visually observed reduction in pool water level, drainage or overland connected flow taking into account climatic conditions and observations during baseline monitoring period<br>AND<br>• The above change has not occurred at one of the upstream pools (beyond mining effects)</td><td>• Increase inspection and review of data frequency to fortnightly for sites where Level 4 has been reached<br>• Continue monthly download and review of data for all other sites<br>• Convene Tahmoor Coal Environmental Response Group to undertake an investigation to assess if the change in behaviour is related to LW W3-W4 mining effects, other catchment changes or the prevailing climate<br>• Conduct visual inspection of downstream reaches beyond mining effects to identify if flow re-emergence is occurring<br>• If flow re-emergence sites are located, implement water quality monitoring at these location(s)</td><td>• Report to DPIE and relevant agencies within 7 days of initial investigation completion<br>• Conduct detailed investigation of visually inspected impacts<br>• If it is concluded that there has been a mining-related impact then implement a corrective action management plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the NSW DPIE Resources Regulator</td></tr>
</table>

* Survey area to include upstream pools (beyond mining effects) where a potential Level 4 TARP trigger has occurred at an impact site(s)

¥ Rockbar and/or stream base cracking, or gas release, or iron precipitation in excess of baseline conditions

**Table 17 (Cont.)  Surface Water Trigger Action Response Plan**

| Feature | Methodology and relevant monitoring | Management – Trigger | Management – Action | Management – Response |
|---|---|---|---|---|
| Stream water quality impact | STREAM WATER QUALITY<br>LOCATIONS:<br>Baseline / Impact Site:<br>• Cedar Creek (CA, CB, CC, CD, CE, CF, CG)<br>• Matthews Creek (MC1, MG)<br>• Stonequarry Creek (SC2, SC, SD, SF)<br>Reference / Control Site:<br>• Cedar Creek (Cedar US, CC1)<br>• Matthews Creek (MB)<br>• Stonequarry Creek (SC1, SE, SG)<br><br>PRE-MINING - Monthly sampling for 12 months prior to secondary extraction. Baseline data was recorded monthly at the majority of sites from January 2019.<br>DURING MINING - Monthly sampling and analysis.<br>POST-MINING - Monthly sampling and analysis for 12 months following the completion of LW W4. This period may be extended as per a decision by the Environmental Response Group. | **Level 1** | | |
| | | • The triggers for pH, EC and dissolved metals defined below do not occur and there is no visual evidence of increased iron staining that was not observed in the baseline period | • Continue monitoring as per monitoring program<br>• Continue monthly review of data | • No response required |
| | | **Level 2** | | |
| | | • The trigger for pH, EC or dissolved metals defined below occurs in one month and there is no visual evidence of increased iron staining that was not observed in the baseline period | • Continue monitoring as per monitoring program<br>• Continue monthly review of data including analysis of water quality trend along creek (upstream to downstream) to identify spatial changes<br>• Convene Tahmoor Coal Environmental Response Group to review response | • As defined by Environmental Response Group |
| | | **Level 3** | | |
| | | • The trigger for pH, EC or dissolved metals defined below occurs in one month and there is visual evidence of increased iron staining that was not observed in the baseline period | • Continue monitoring as per monitoring program<br>• Continue monthly review of data to assess if the trigger was exceeded during the baseline period prior to commencement of mining and undertake analysis of water quality trend along creek (upstream to downstream) to identify spatial changes<br>• Convene Tahmoor Coal Environmental Response Group to review response | • As defined by Environmental Response Group<br>• Consider increasing monitoring and review of data frequency to fortnightly at sites where Level 3 has been reached |
| | | **Level 4** | | |
| | | Any of the following:<br>• pH: the value* falls below the corresponding control (upstream) site(s) mean minus two standard deviations or the site-specific baseline mean minus two standard deviations (i.e. the sample becomes more acidic) for more than two consecutive months OR the value rises above the corresponding control (upstream) site(s) mean plus two standard deviations or the site-specific baseline mean plus two standard deviations (i.e. the sample becomes more alkaline) for more than two consecutive months<br>• EC: the value* rises above the corresponding control (upstream) site(s) mean plus two standard deviations or the site-specific baseline mean plus two standard deviations for more than two consecutive months<br>• Dissolved metals: a specific metal or metals laboratory value/s rises above the corresponding control (upstream) site(s) mean plus two standard deviations or the site-specific baseline mean plus two standard deviations for more than two consecutive months | • Increase monitoring and review of data frequency to fortnightly for sites where Level 4 has been reached<br>• Continue monthly monitoring and review of data for all other sites<br>• Convene Tahmoor Coal Environmental Response Group to undertake an investigation to assess if the change in behaviour is related to LW W3-W4 mining effects, other catchment changes or the prevailing climate<br>• Immediately undertake additional water quality sampling and analysis of the site where the trigger has occurred and relevant control sites to confirm results and that the trigger exceedance is continuing<br>• Undertake an investigation to assess if the change in behaviour is related to LW W3-W4 mining effects (e.g. whether there has been subsidence induced cracking upstream), other catchment changes, unrelated pollution or the prevailing climate | • Report to DPIE and relevant government agencies within 7 days of initial investigation completion<br>• Conduct detailed investigation of water quality changes<br>• If it is concluded that there has been a mining-related impact then implement a corrective action management plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the Resources Regulator |

* Field and laboratory records of pH and EC are collected for quality assurance purposes. The field values will be used in the TARP assessment unless erroneous values are identified in which the laboratory values will be adopted in the assessment.

‡ Log transformations (i.e. base 10 logs of the water quality concentrations) will be used to calculate the arithmetic means and standard deviations. Log transformations are commonly applied to concentrations as part of statistical analyses in water resources studies as is evidenced by the following statement from a US Geological Survey publication regarding such analyses: "In order to make an asymmetric distribution become more symmetric, the data can be transformed or re-expressed into new units. These new units alter the distances between observations on a line plot. The effect is to either expand or contract the distances to extreme observations on one side of the median, making it look more like the other side. The most commonly-used transformation in water resources is the logarithm. Logs of water discharge, hydraulic conductivity, or concentration are often taken before statistical analyses are performed." (Helsel and Hirsch, 2002).

**Table 17 (Cont.) Surface Water Trigger Action Response Plan**

| Feature | Methodology and relevant monitoring | Management | | |
|---|---|---|---|---|
| | | Trigger | Action | Response |
| Impact to flood levels | FLOOD LEVELS<br>LOCATIONS - All dwellings within the 1% AEP flood extent<br>PRE-MINING - Pre-mining modelling (using surveyed pre-mining topography) to estimate 1% AEP flood levels and extents in areas potentially impacted by subsidence. Pre-mining modelling was completed in May 2019.<br>POST-MINING AND SUBSIDENCE - Post-mining modelling (using surveyed post-mine topography) to estimate 1% AEP flood levels and extents in areas potentially impacted by subsidence. | Level 1 | | |
| | | • No dwellings that were outside the pre-mining 1% AEP flood extent are within the post-mining 1% AEP flood extent | • No action required. | • No response required. |
| | | Level 4 | | |
| | | • Subsidence results in the post-mining 1% AEP flood level being above the floor level of one or more dwellings | • Provide up-to-date predicted flood information (including actual subsidence and flooding predictions) to the State Emergency Service, Council and landowners. | • Negotiate remediation or compensation with landowners |

## 6.3 POTENTIAL CONTINGENCY MEASURES

Potential contingency measures in the event of unforeseen impacts or impacts in excess of those predicted would include:

- the conduct of additional monitoring (e.g. increase in monitoring frequency or additional sampling) to inform the proposed contingency measures;
- the implementation of stream and/or dam remediation measures to reduce the extent and effect of subsidence fracturing (refer Section 5.3);
- the provision of a suitable offset(s) to compensate for the reduction in the quantity of water resources/flow;
- make good provisions, to be negotiated with the landholder, in the event that water supply from a surface water system (as designated by a Water Supply Works and Water Use Approval) is impacted; and/or
- the implementation of adaptive management measures – e.g. reducing the thickness of the coal seam extracted, narrowing of the longwall panels and/or increasing the setback of the longwalls from the affected area.

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# APPENDIX A – SURFACE WATER MONITORING PROGRAM

| Site | Weir / Pool | Type of Monitoring | Site Category | Period of Record* |
|---|---|---|---|---|
| *Matthews Creek* | | | | |
| MA | Weir 2 | Monthly manual water level | Control / Reference | October 2018 – March 2021 |
| MB | MR5 | Monthly manual water level | Control / Reference | October 2018 – March 2021 |
| | | Automated water level | | November 2018 – March 2021 |
| | | Monthly field and laboratory water quality | | January 2019 – March 2021 |
| MC | MB7 | Monthly manual water level | Baseline / Impact | October 2018 – March 2021 |
| MC1 | MB12 | Monthly field and laboratory water quality | Baseline / Impact | January 2019 – March 2021 |
| MD US | MB19 | Monthly manual water level | Baseline / Impact | April 2019 – March 2021 |
| ME | MW26 | Monthly manual water level | Baseline / Impact | October 2018 – March 2021 |
| | | Automated water level | | |
| MF | MB30 | Monthly manual water level | Baseline / Impact | October 2018 – March 2021 |
| MG | MR42 | Monthly manual water level | Baseline / Impact | October 2018 – March 2021 |
| | | Automated water level | | October 2018 – March 2021 |
| | | Monthly field and laboratory water quality | | January 2019 – March 2021 |
| - | MR45** | Monthly manual water level | Baseline / Impact | March 2021 |
| - | MR46** | Monthly manual water level | Baseline / Impact | March 2021 |
| *Cedar Creek* | | | | |
| CCR | - | Monthly manual water level | Control / Reference | October 2018 – March 2021 |
| | | Automated water level | | November 2018 – March 2021 |
| CC1 | CB2 | Monthly field and laboratory water quality | Control / Reference | January 2019 – March 2021 |
| CC1A | CB3 | Monthly manual water level | Control / Reference | May 2019 – March 2021 |
| | | Automated water level | | May 2019 – March 2021 |
| CA | CB10 | Monthly manual water level | Baseline / Impact | October 2018 – March 2021 |
| | | Automated water level | | November 2018 – March 2021 |
| | | Monthly field and laboratory water quality | | April 2019 – March 2021 |

* presented in the SWTR
** data has not been presented in the SWTR as only two values were available

| Site | Weir / Pool | Type of Monitoring | Site Category | Period of Record* |
|---|---|---|---|---|
| *Cedar Creek* | | | | |
| CB | CR14 | Monthly manual water level | Baseline / Impact | October 2018 – March 2021 |
| | | Automated water level | | November 2018 – March 2021 |
| | | Monthly field and laboratory water quality | | January 2019 – March 2021 |
| CC | CB19 | Monthly manual water level | Baseline / Impact | October 2018 – March 2021 |
| | | Monthly field and laboratory water quality | | January 2021 – March 2021 |
| CD | CR23 | Monthly manual water level | Baseline / Impact | October 2018 – March 2021 |
| | | Automated water level | | October 2018 – March 2021 |
| | | Monthly field and laboratory water quality | | January 2021 – March 2021 |
| CE | CR25 | Monthly manual water level | Baseline / Impact | October 2018 – March 2021 |
| | | Automated water level | | October 2018 – March 2021 |
| | | Monthly field and laboratory water quality | | January 2021 – March 2021 |
| CF | CR26 | Monthly manual water level | Baseline / Impact | October 2018 – March 2021 |
| | | Monthly field and laboratory water quality | | January 2021 – March 2021 |
| CG | CR31 | Monthly manual water level | Baseline / Impact | October 2018 – March 2021 |
| | | Automated water level | | November 2018 – March 2021 |
| | | Monthly field and laboratory water quality | | January 2019 – March 2021 |
| *Stonequarry Creek* | | | | |
| SC1 | - | Monthly field and laboratory water quality | Control / Reference | January 2019 – March 2021 |
| SA | SR16 | Monthly manual water level | Baseline / Impact | October 2018 – March 2021 |
| | | Automated water level | | November 2018 – March 2021 |
| SC2 | SR17 | Monthly manual water level | Baseline / Impact | April 2020 – March 2021 |
| | | Automated water level | | April 2020 – March 2021 |
| | | Monthly field and laboratory water quality | | January 2019 – March 2021 |

* presented in the SWTR

| Site | Weir / Pool | Type of Monitoring | Site Category | Period of Record* |
|---|---|---|---|---|
| *Stonequarry Creek* | | | | |
| SB | SR17 | Monthly manual water level | Baseline / Impact | October 2018 – March 2021 |
| | | Automated water level | | June 2020 – March 2021 |
| SC | SR21 | Monthly manual water level | Baseline / Impact | October 2018 – March 2021 |
| | | Monthly field and laboratory water quality | | January 2019 – March 2021 |
| SD | - | Monthly manual water level | Baseline / Impact | October 2018 – March 2021 |
| | | Automated water level | | October 2018 – March 2021 |
| | | Monthly field and laboratory water quality | | January 2019 – March 2021 |
| SE | SR5 | Monthly manual water level | Control / Reference | April 2020 – March 2021 |
| | | Automated water level | | April 2020 – March 2021 |
| | | Monthly field and laboratory water quality | | April 2020 – March 2021 |
| SF | - | Monthly manual water level | Baseline / Impact | April 2020 – March 2021 |
| | | Automated water level | | April 2020 – March 2021 |
| | | Monthly field and laboratory water quality | | May 2020 – March 2021 |
| SG | SG2 | Monthly manual water level | Control / Reference | September 2020 – March 2021 |
| | | Automated water level | | August 2020 – March 2021 |
| | | Monthly field and laboratory water quality | | September 2020 – March 2021 |

* presented in the SWTR

| Site | Type of Monitoring | Site Category | Period of Record* |
|---|---|---|---|
| *Redbank Creek* | | | |
| RB1 | Monthly laboratory water quality | Control / Reference | February 2019 – September 2020** |
| | Monthly field water quality | | February 2019 – March 2021 |
| RB2 / RC1 | Laboratory water quality (variable periods) | Baseline / Impact | February 2005 – September 2020** |
| | Field water quality (variable periods) | | February 2005 - March 2021 |
| RB3 | Laboratory water quality | Baseline / Impact | February 2019 – August 2020** |
| | | | February 2019 - March 2021 |
| RB6 / RC2 | Field and laboratory water quality (variable periods) | Baseline / Impact | February 2005 – January 2019** |
| RB9 / RC3 | Laboratory water quality (variable periods) | Baseline / Impact | October 2014 – September 2020** |
| | Field water quality (variable periods) | | October 2014 - March 2021 |
| RB10 | Monthly laboratory water quality | Baseline / Impact | February 2019 – September 2020** |
| | Monthly field water quality | | February 2019 - March 2021 |
| RC4 | Field and laboratory water quality (variable periods) | Baseline / Impact | October 2014 – January 2019** |
| RB11 | Monthly laboratory water quality | Baseline / Impact | February 2019 – October 2020** |
| | Monthly field water quality | | February 2019 - March 2021 |
| RC5 | Field and laboratory water quality (variable periods) | Baseline / Impact | February 2005 – October 2020** |
| RC6 | Field and laboratory water quality (variable periods) | Baseline / Impact | October 2014 – October 2020** |

* presented in the SWTR
** laboratory water quality monitoring has been discontinued at this site

# APPENDIX B – MONITORED WATER LEVEL PLOTS

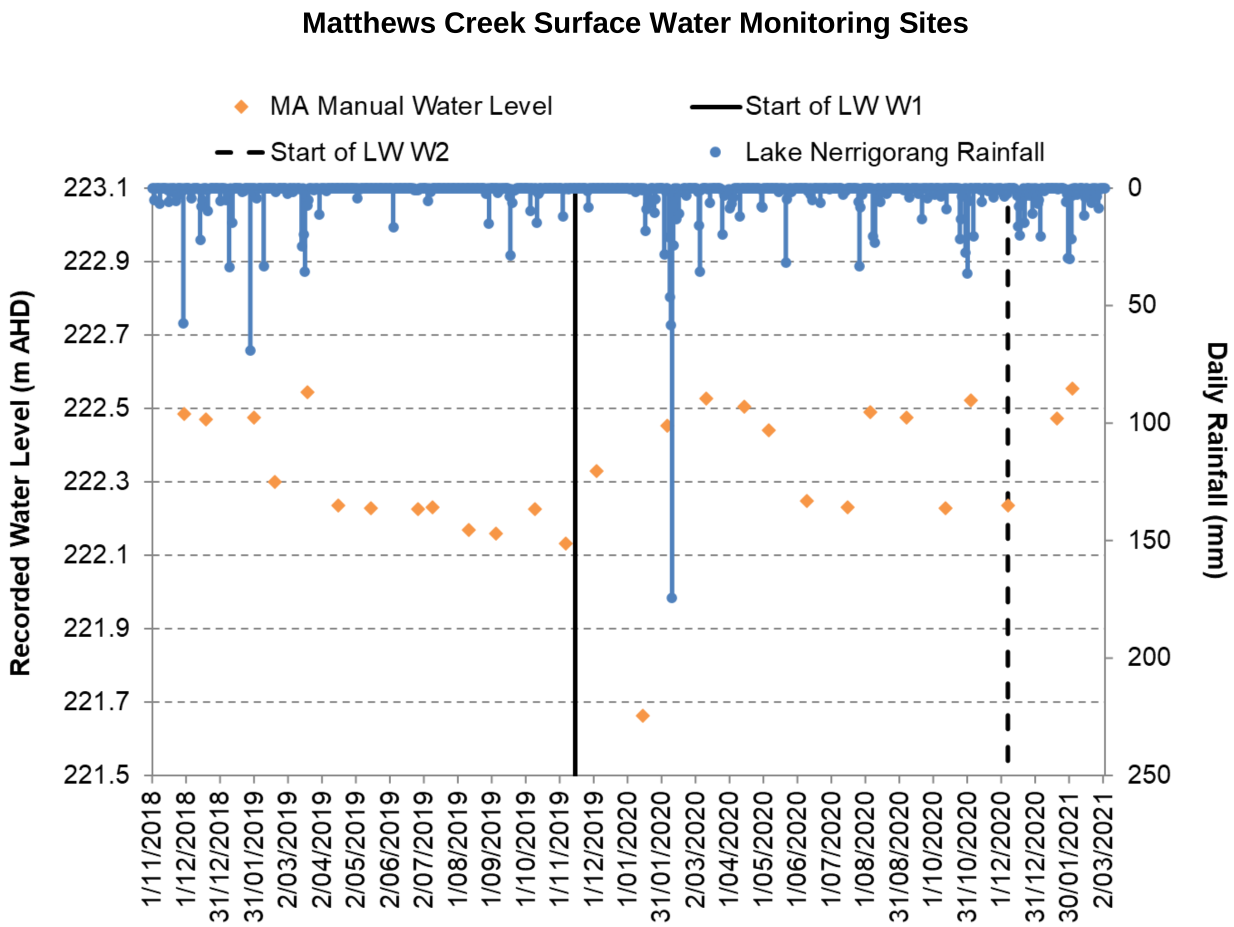



**Figure B1 Monitoring Site MA Water Level Records**

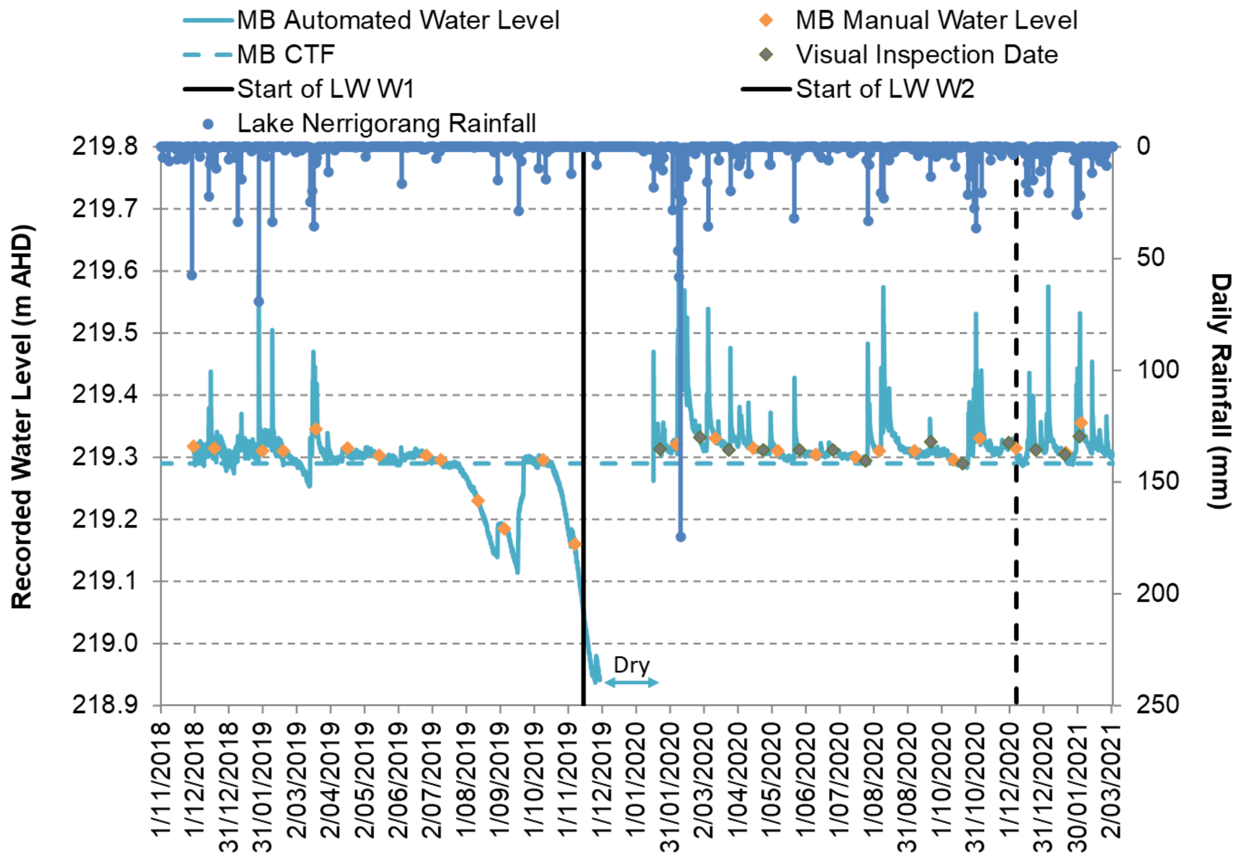



**Figure B2** Monitoring Site MB Water Level Records

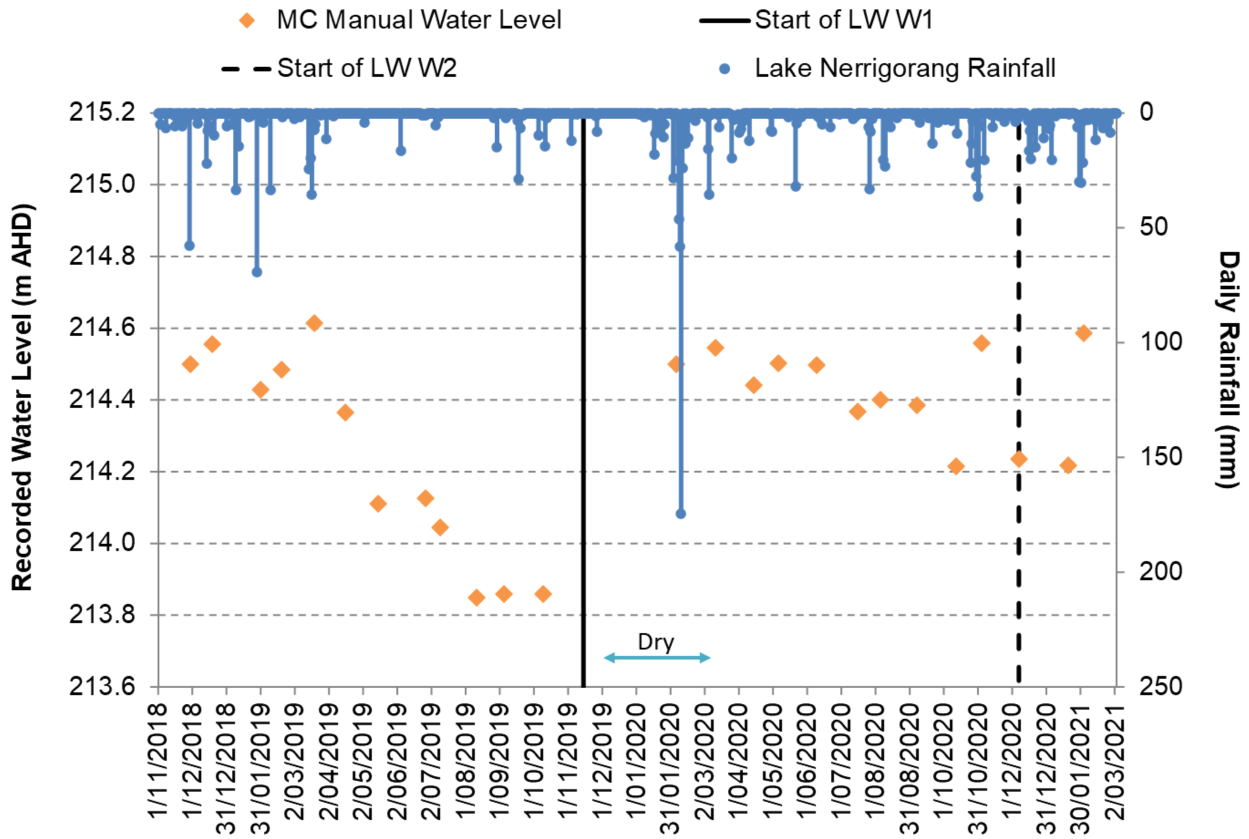



**Figure B3** Monitoring Site MC Water Level Records

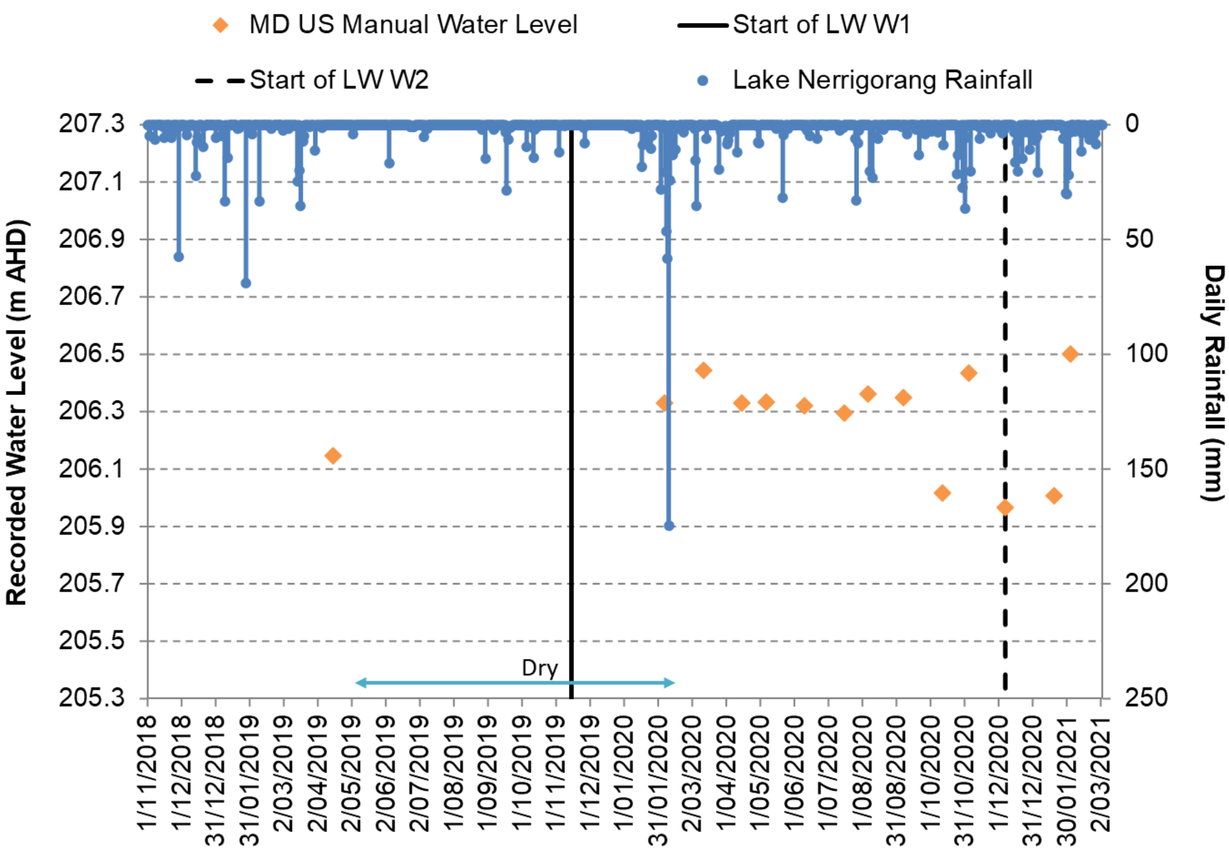



**Figure B4 Monitoring Site MD US Water Level Records**

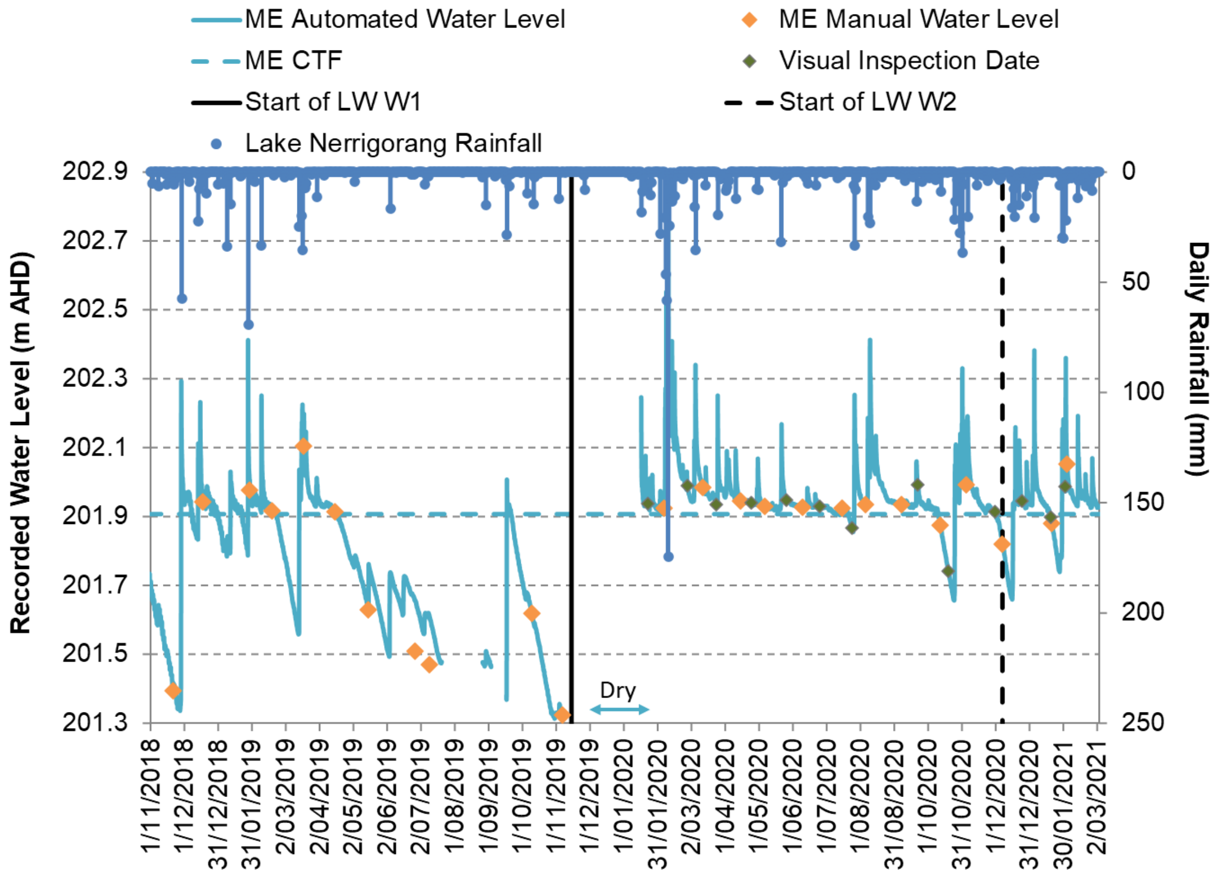



**Figure B5 Monitoring Site ME Water Level Records**

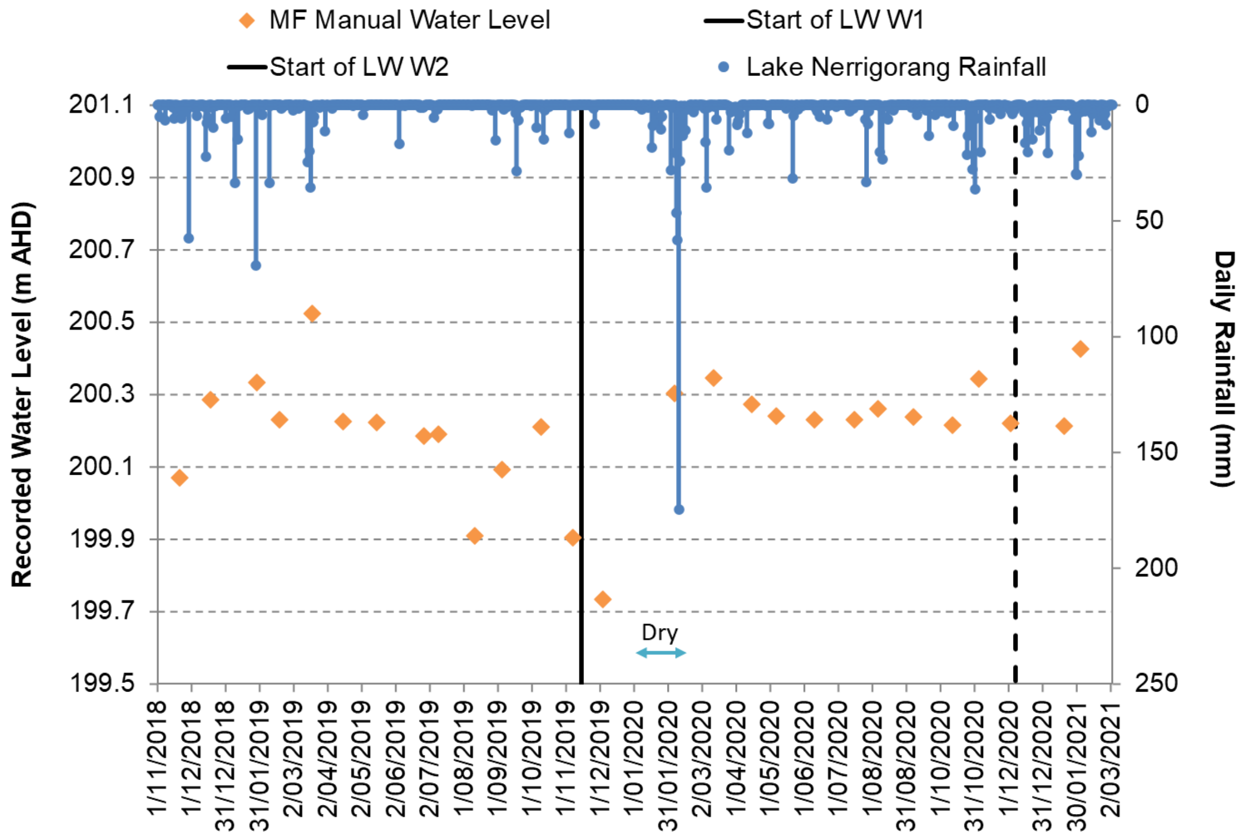



**Figure B6 Monitoring Site MF Water Level Records**

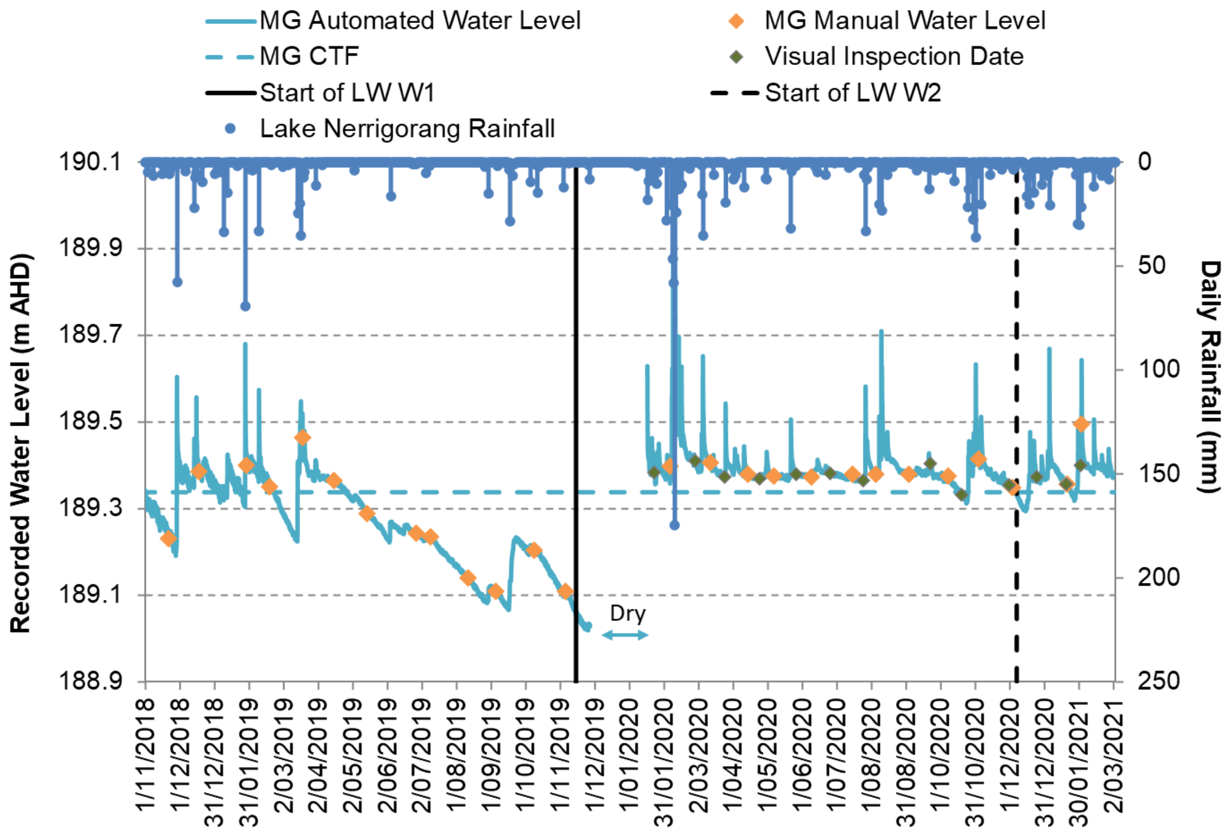



**Figure B7 Monitoring Site MG Water Level Records**

## Cedar Creek Surface Water Monitoring Sites

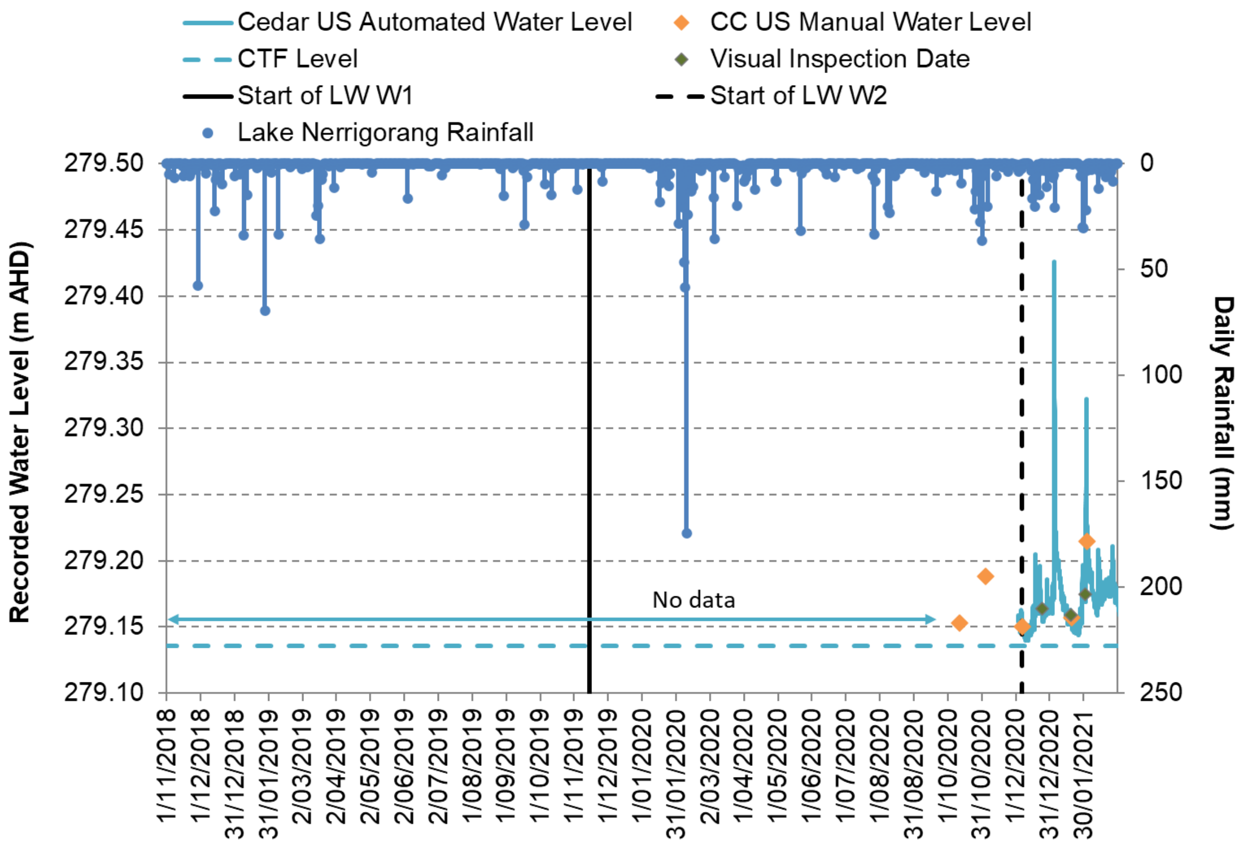



**Figure B8 Monitoring Site Cedar US Water Level Records**

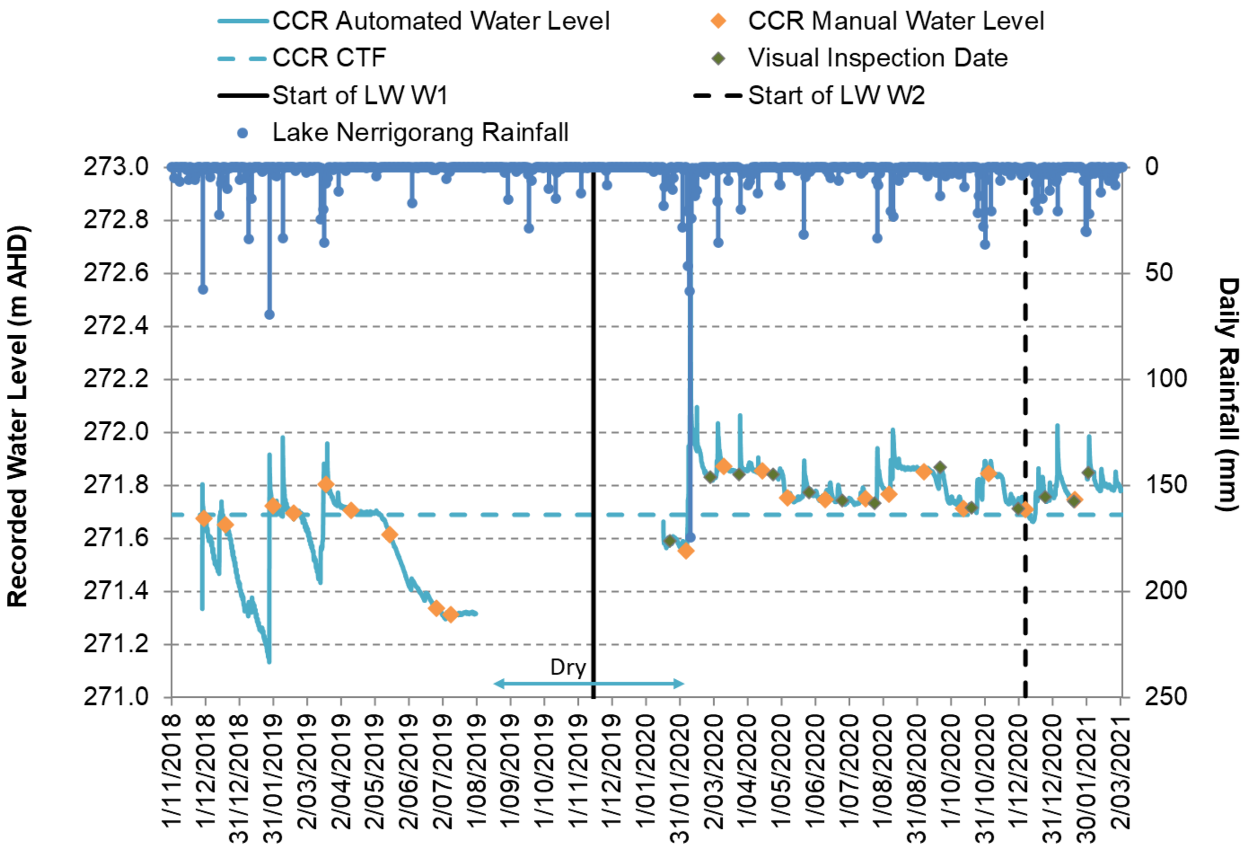



**Figure B9 Monitoring Site CCR Water Level Records**

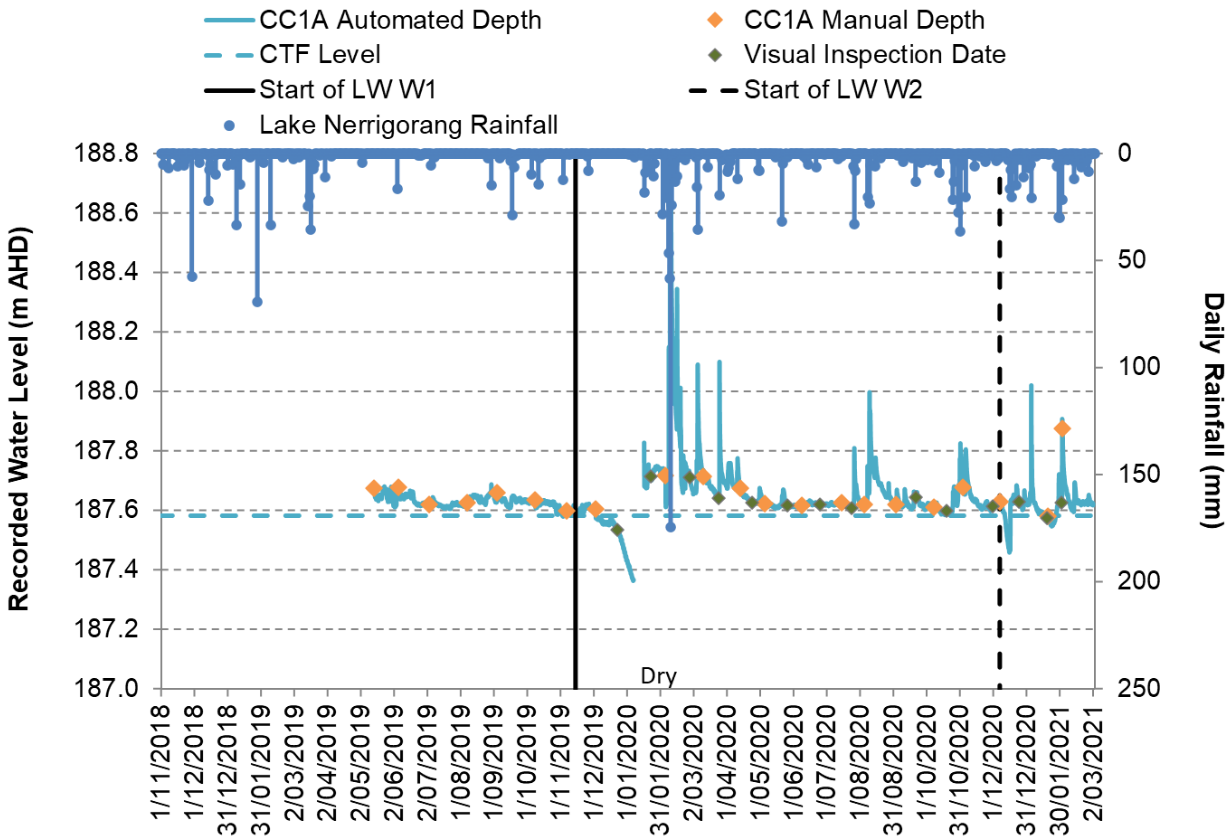



**Figure B10 Monitoring Site CC1A Water Level Records**

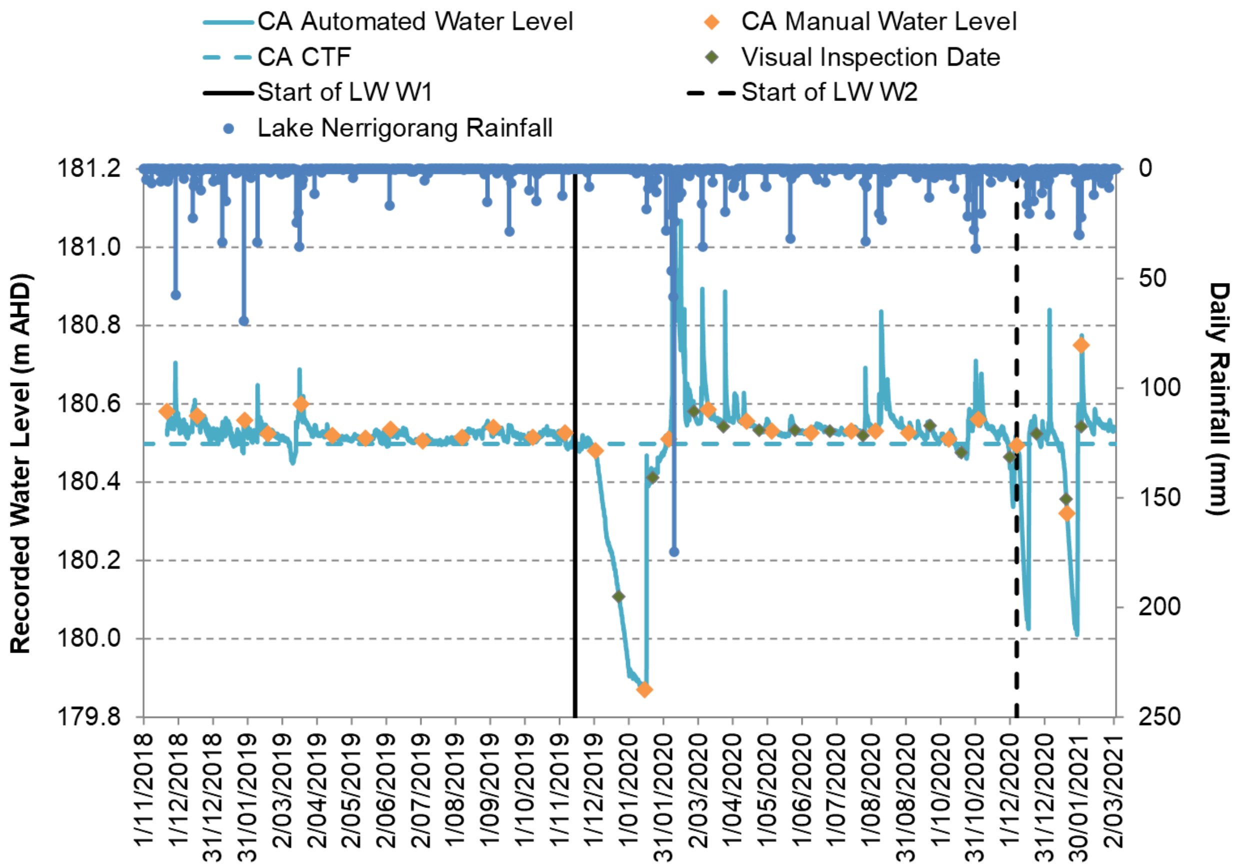



**Figure B11 Monitoring Site CA Water Level Records**

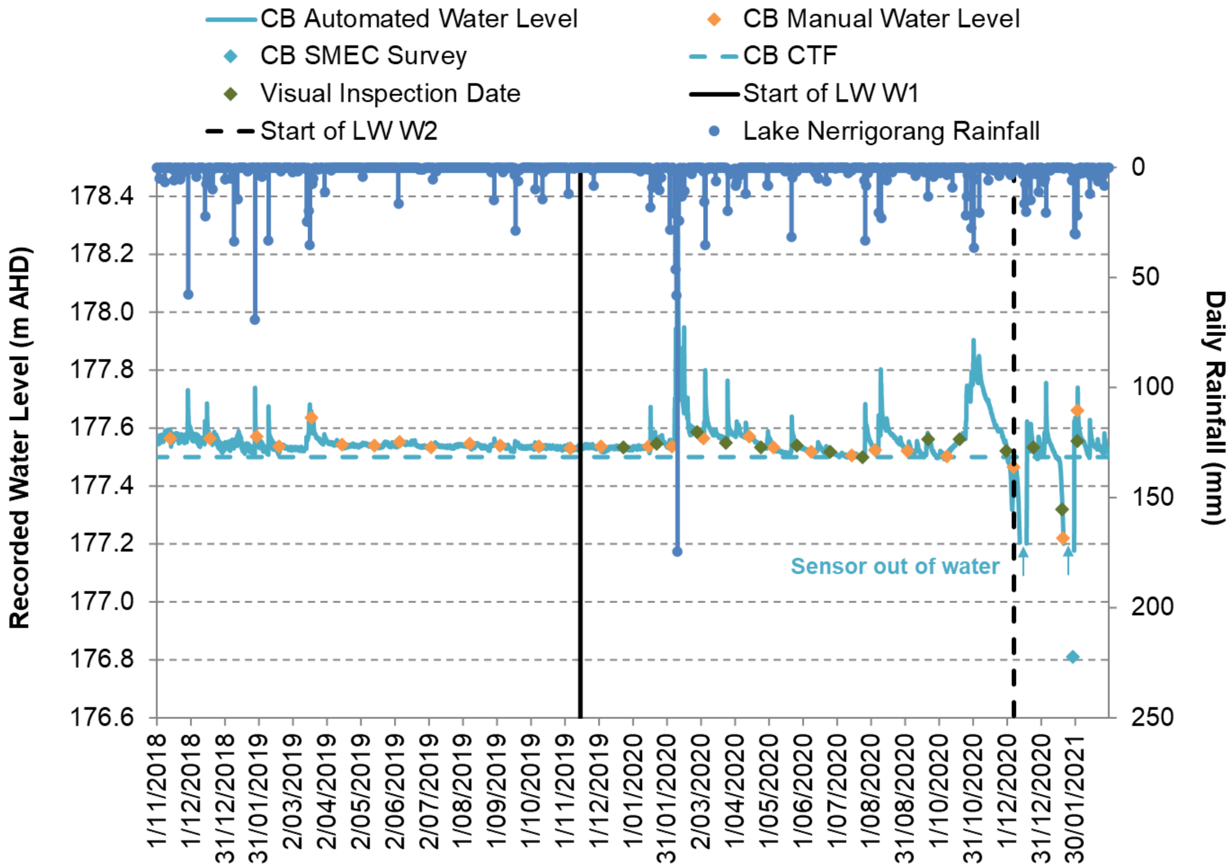



Figure B12 Monitoring Site CB Water Level Records

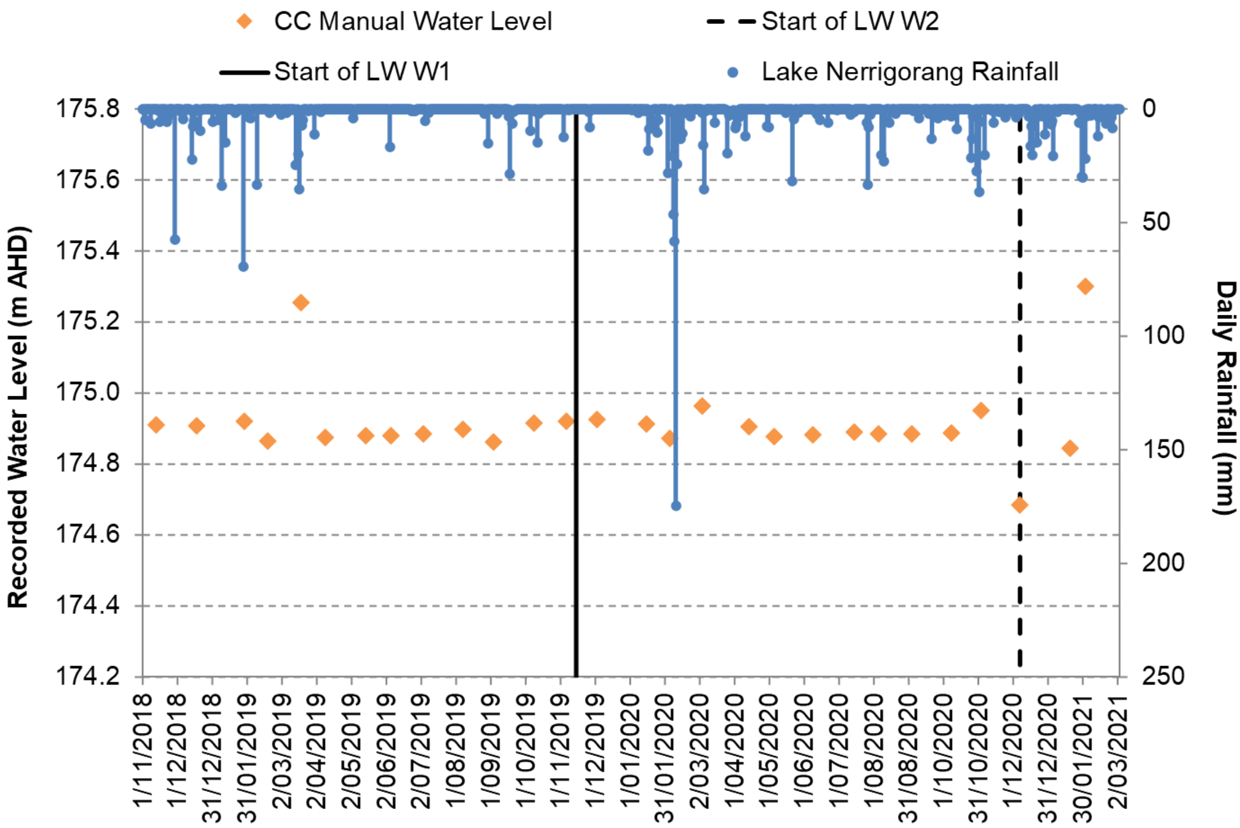



Figure B13 Monitoring Site CC Water Level Records

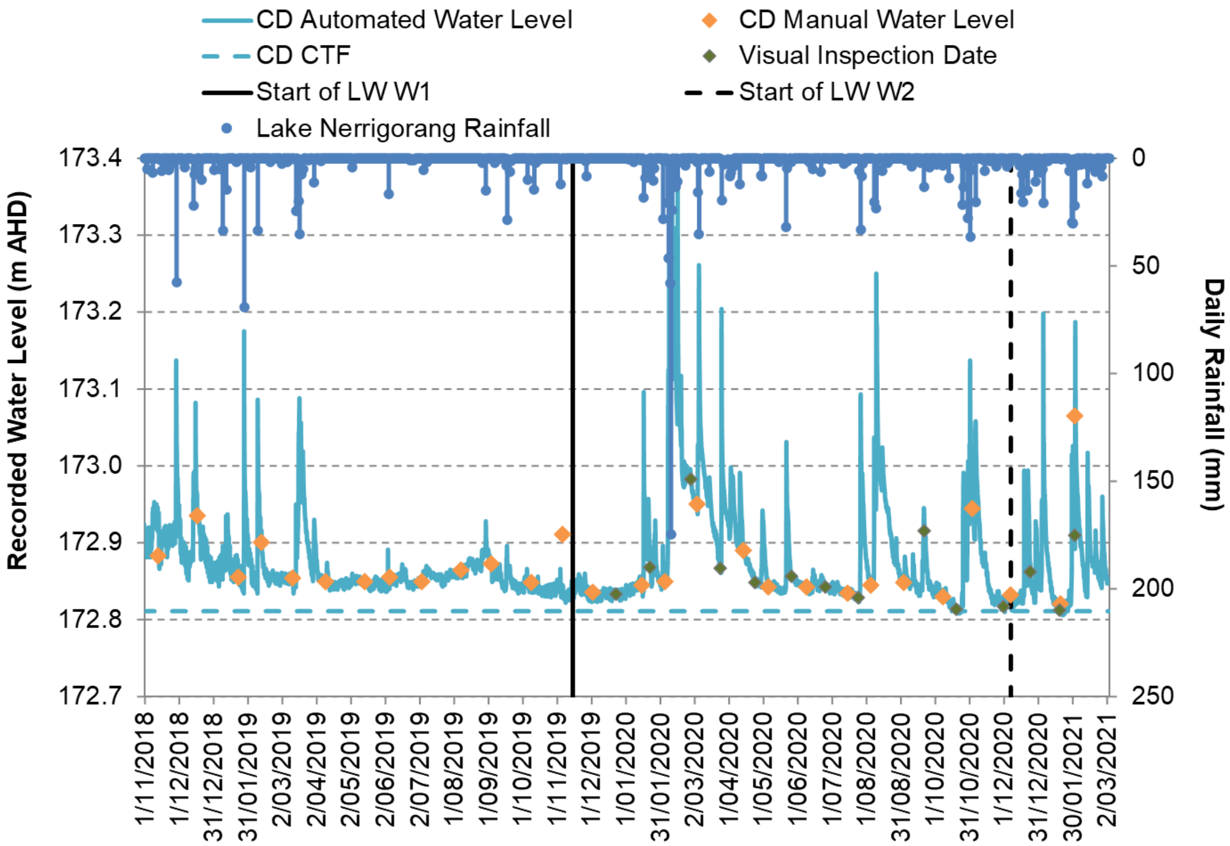



**Figure B14 Monitoring Site CD Water Level Records**

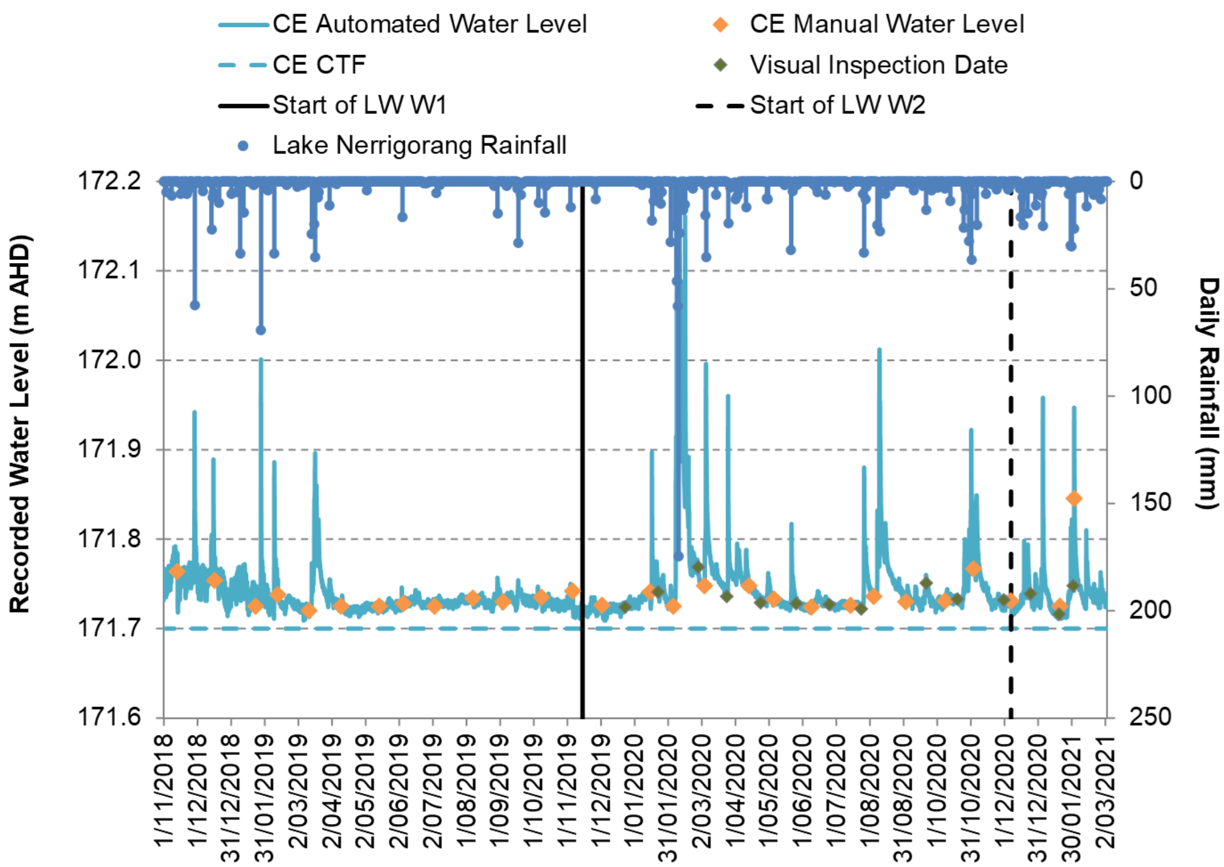



**Figure B15 Monitoring Site CE Water Level Records**

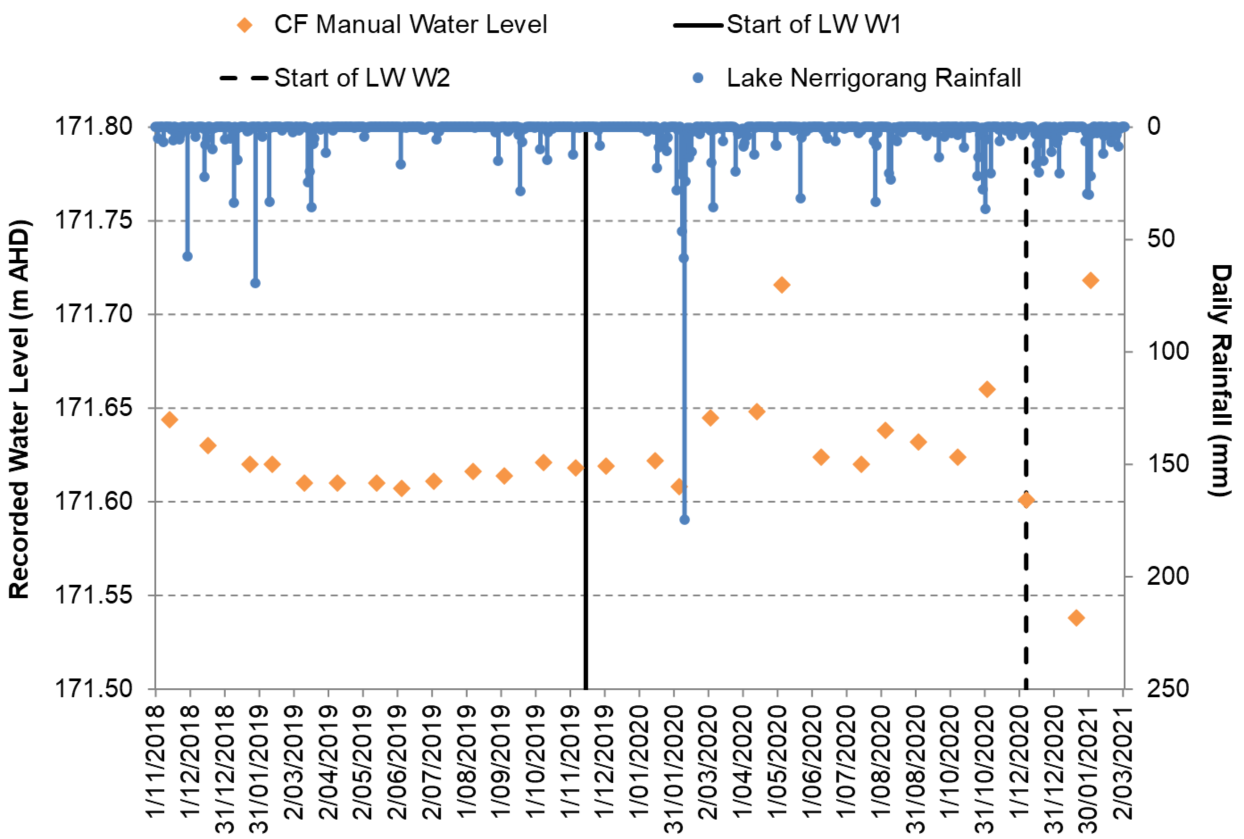



**Figure B16 Monitoring Site CF Water Level Records**

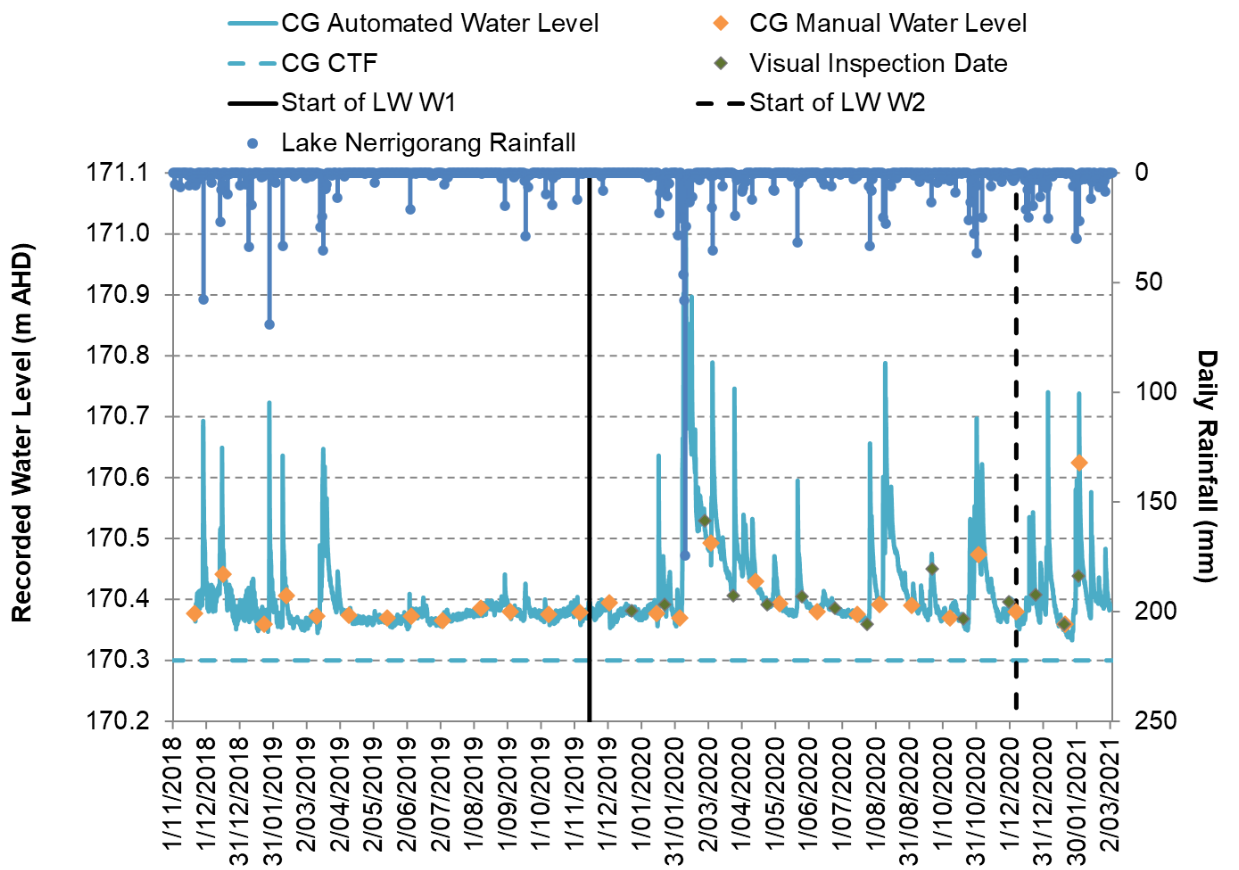



**Figure B17 Monitoring Site CG Water Level Records**

## Stonequarry Creek Surface Water Monitoring Sites

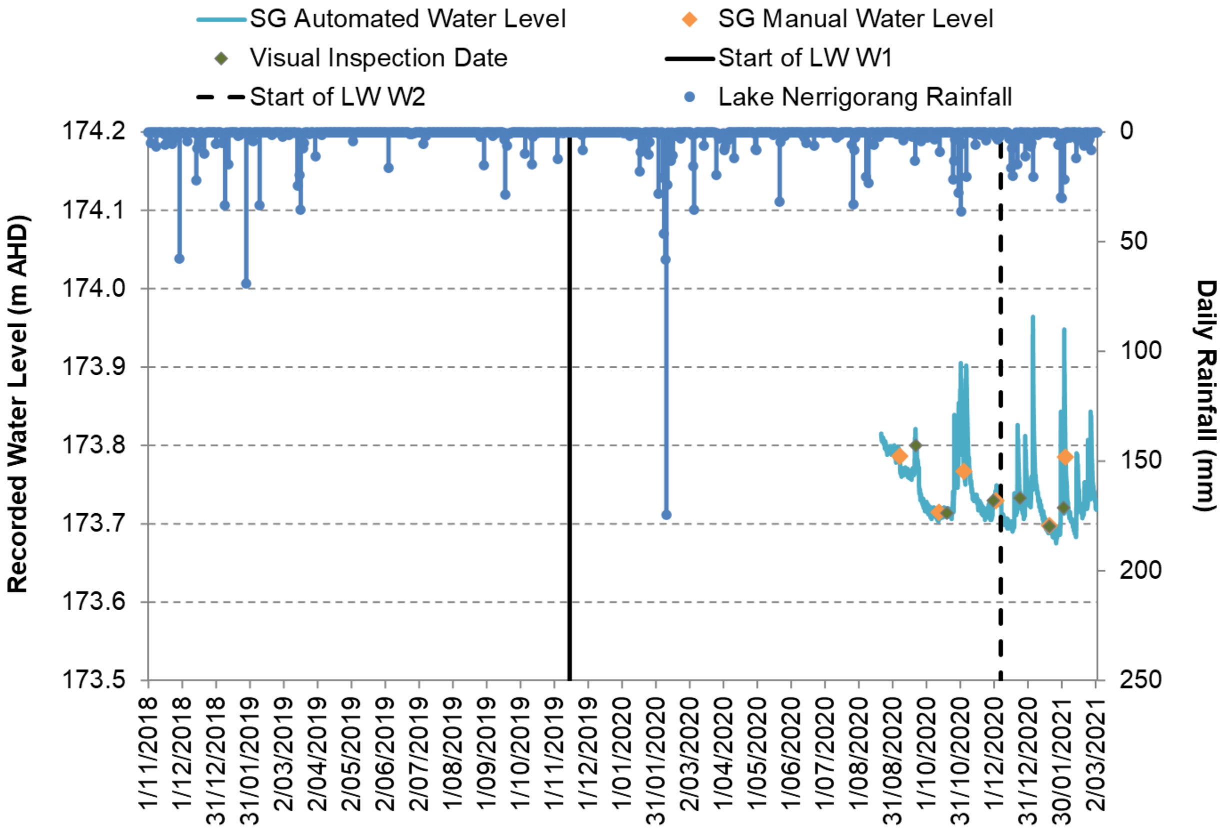



**Figure B18 Monitoring Site SG Water Level Records**

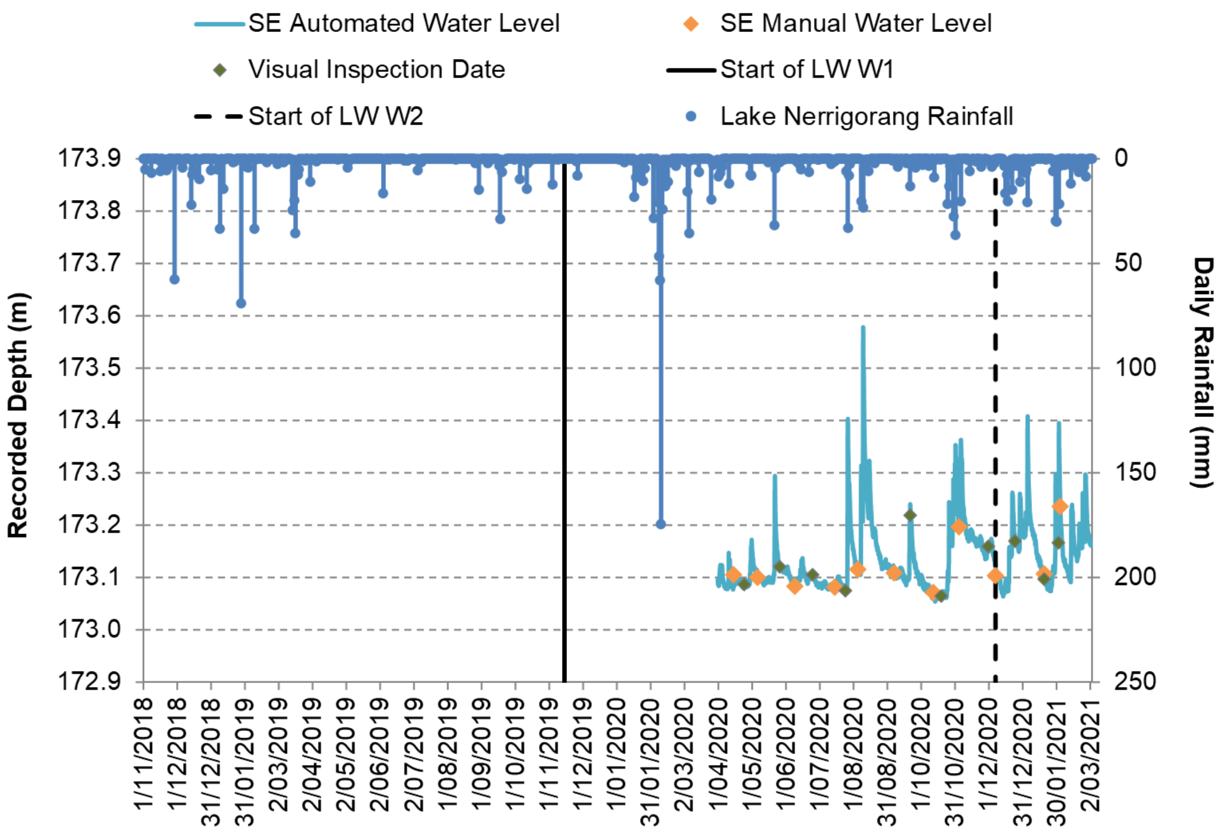



**Figure B19 Monitoring Site SE Water Level Records**

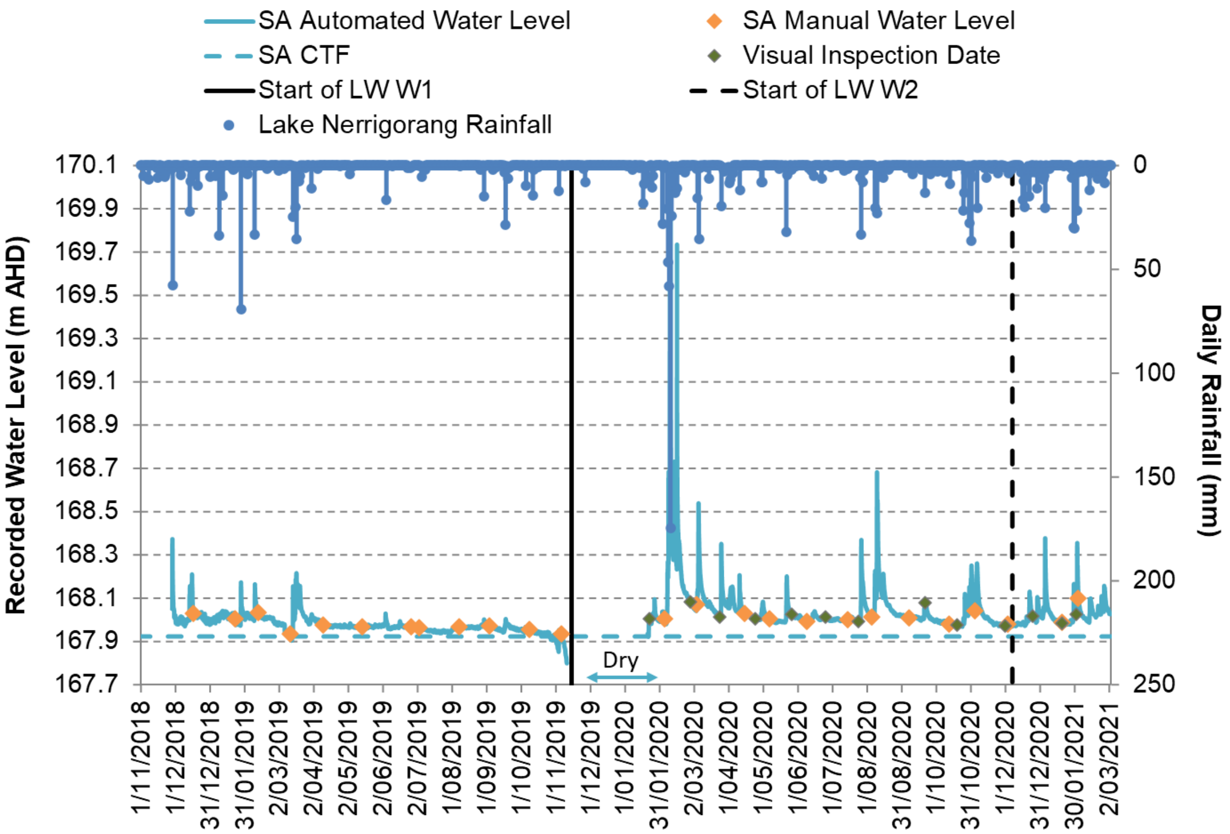



**Figure B20 Monitoring Site SA Water Level Records**

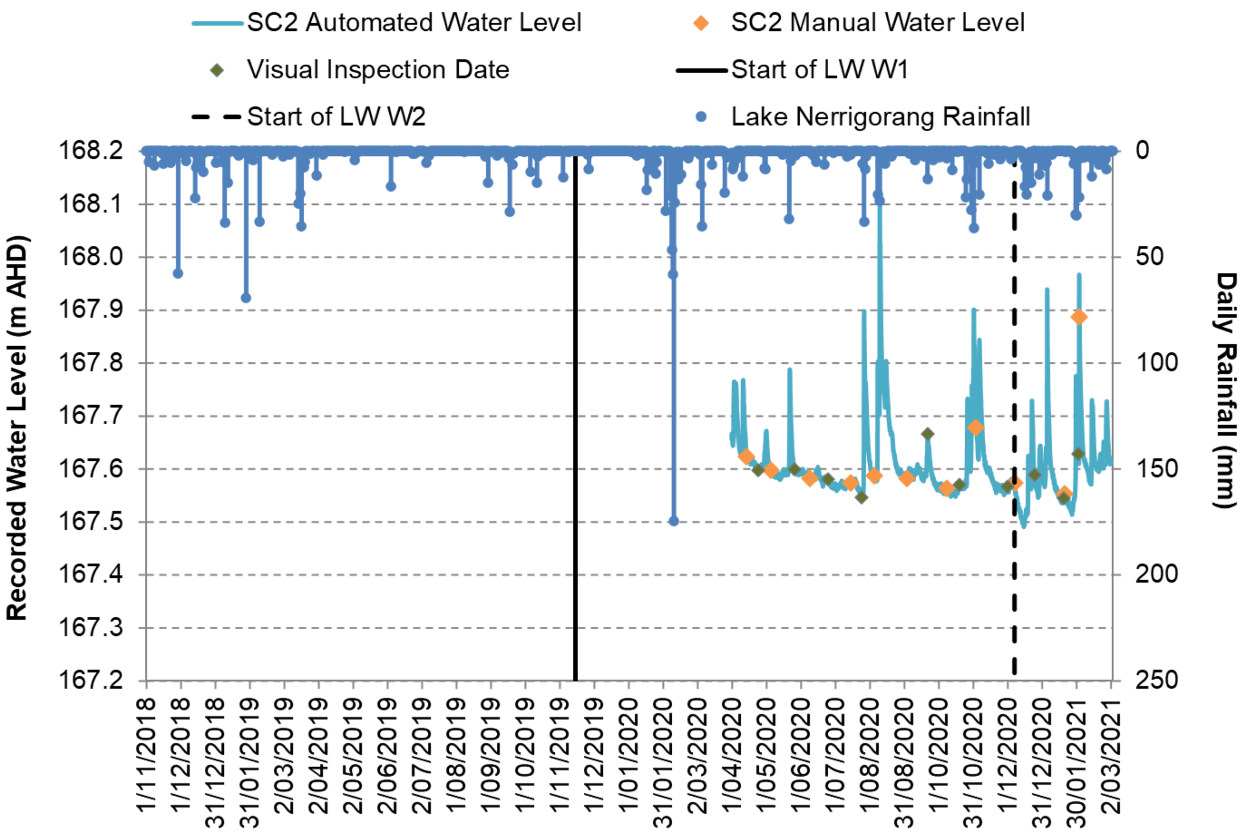



**Figure B21 Monitoring Site SC2 Water Level Records**

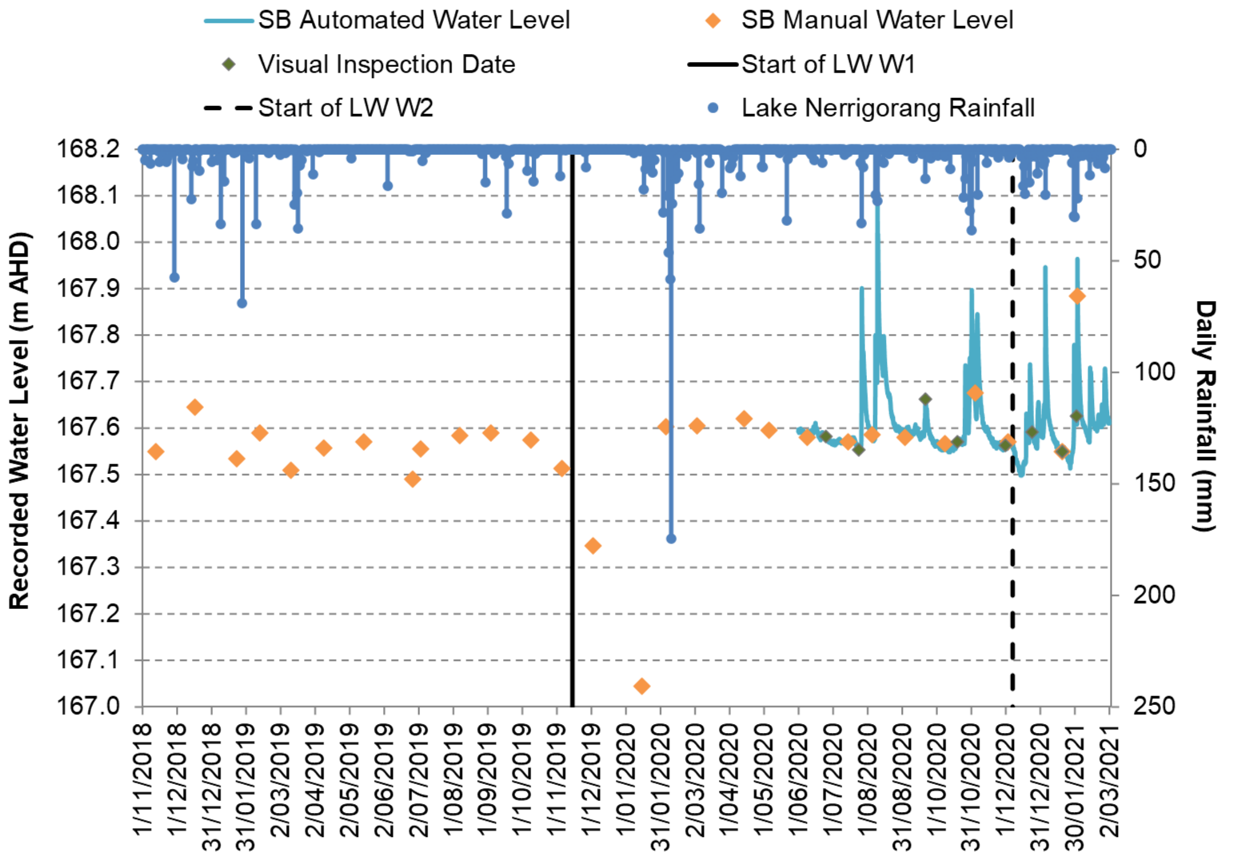



**Figure B22 Monitoring Site SB Water Level Records**

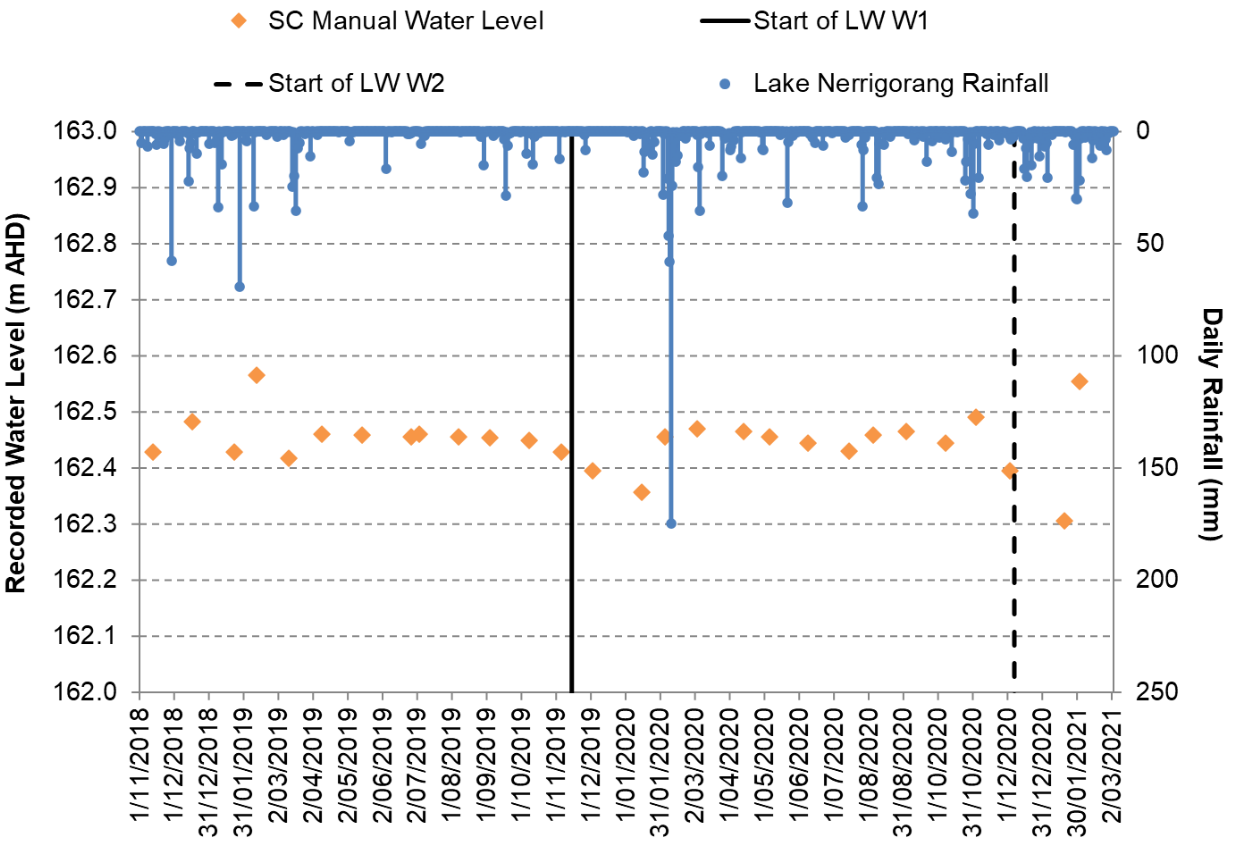



**Figure B23 Monitoring Site SC Water Level Records**

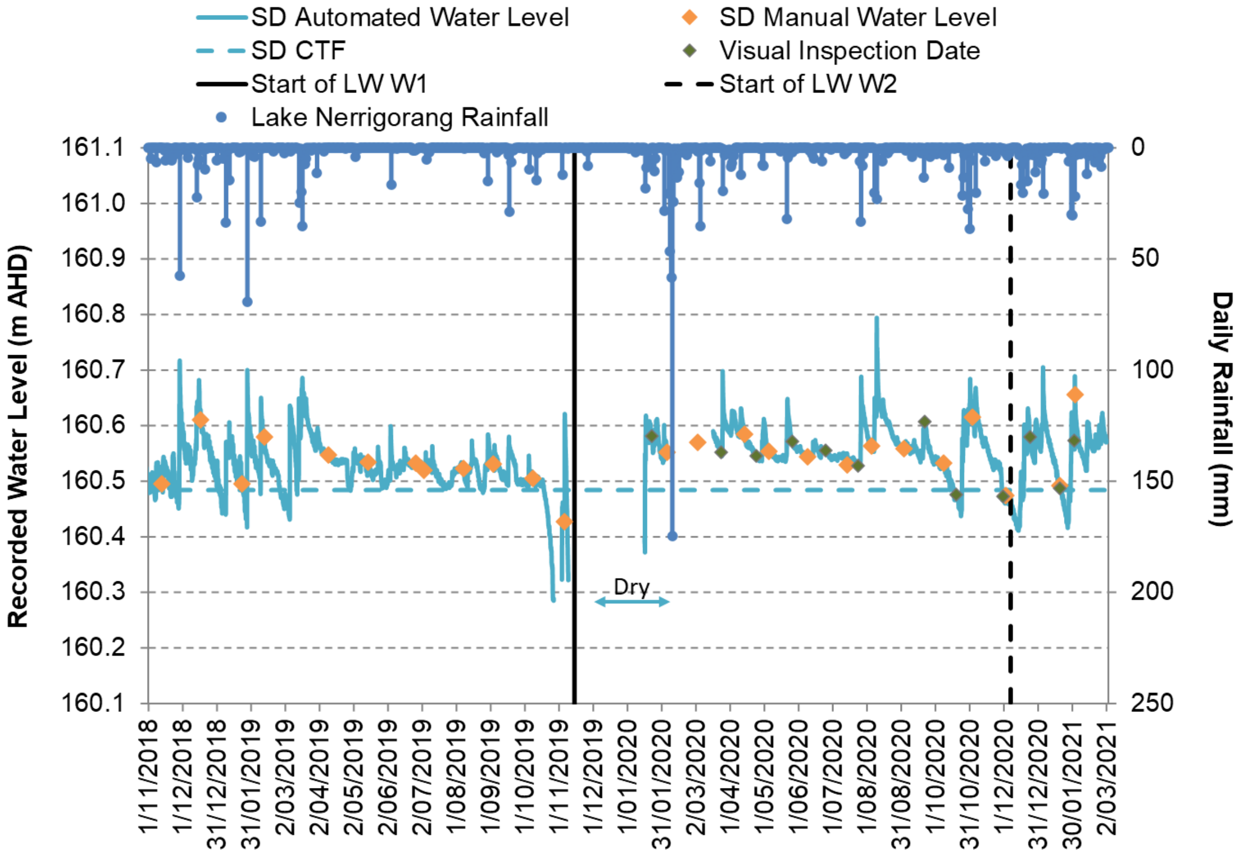



**Figure B24 Monitoring Site SD Water Level Records**

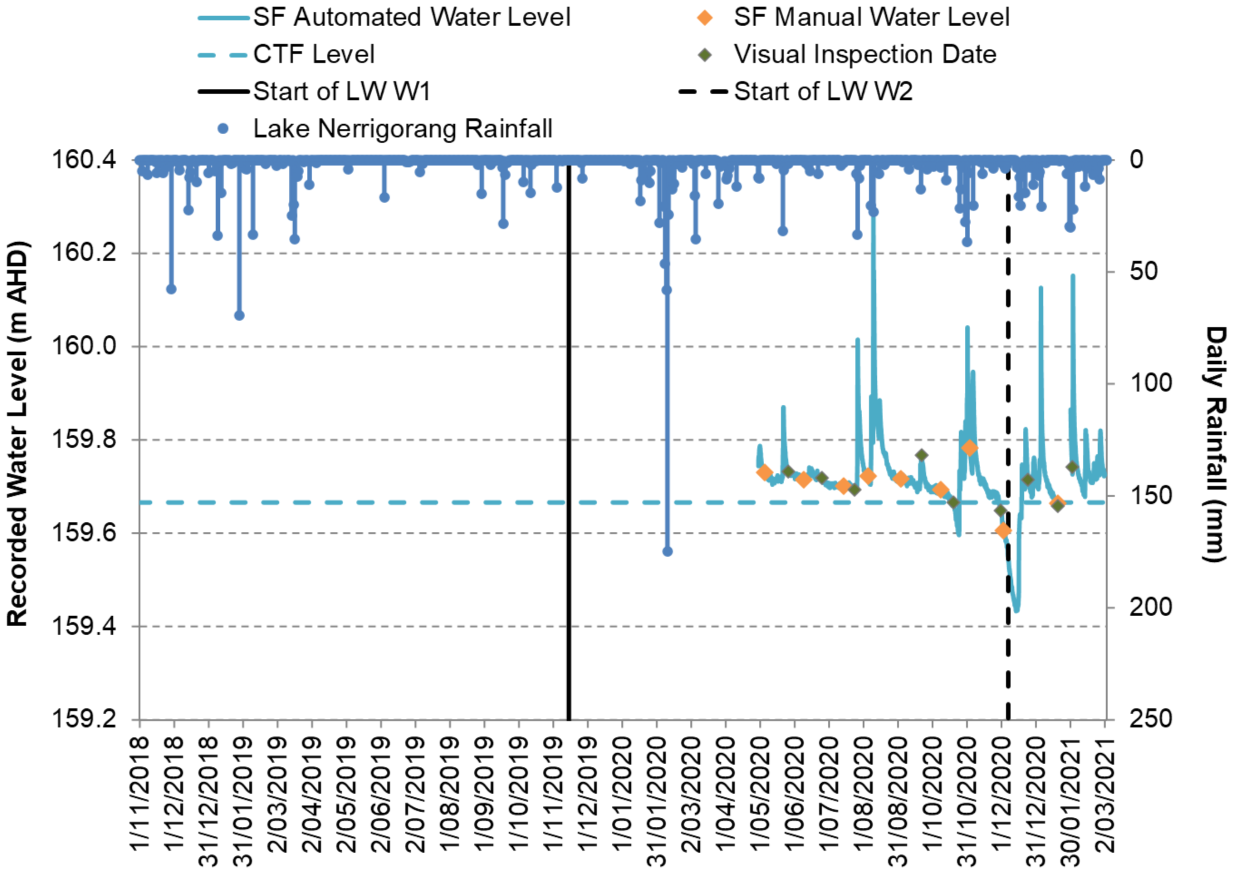



**Figure B25 Monitoring Site SF Water Level Records**

# APPENDIX C – SURFACE WATER QUALITY MONITORING SUMMARY TABLES

## Matthews Creek Water Quality Summary – Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | MC1 | | | | | MG | | | | | MB | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Lab pH | 6.5 - 8‡ | 19 | 6.32 | 6.79 | 7.28 | 16% | 25 | 6.10 | 6.72 | 7.38 | 24% | 24 | 6.38 | 6.92 | 7.29 | 17% |
| Lab EC (µS/cm) | 350‡ | 20 | 250 | 363.5 | 528 | 60% | 25 | 197 | 329 | 431 | 40% | 24 | 258 | 386 | 1090 | 67% |
| Field pH | 6.5 - 8‡ | 20 | 5.75 | 6.96 | 9.51 | 30% | 25 | 6.06 | 7.29 | 8.83 | 24% | 24 | 5.63 | 6.92 | 9.75 | 29% |
| Field EC (µS/cm) | 350‡ | 20 | 270 | 373 | 568 | 55% | 25 | 194 | 326 | 381 | 28% | 24 | 275 | 392.5 | 958 | 63% |
| Field DO | - | 20 | 0.90 | 7.83 | 12.9 | - | 25 | 0.32 | 5.69 | 11.38 | - | 24 | 0.34 | 5.35 | 12.2 | - |
| Total Alkalinity as $CaCO_3$ | 500* | 21 | 8 | 36 | 111 | 0% | 26 | 15 | 36.5 | 60 | 0% | 25 | 9 | 38 | 122 | 0% |
| Dissolved Calcium | - | 21 | 7 | 10 | 25 | - | 26 | 7 | 9 | 13 | - | 25 | 7 | 11 | 23 | - |
| Dissolved Magnesium | - | 21 | 6 | 8 | 25 | - | 26 | 5 | 8 | 10 | - | 25 | 6 | 9 | 24 | - |
| Dissolved Potassium | - | 21 | 7 | 9 | 40 | - | 26 | 7 | 9 | 14 | - | 25 | 7 | 10 | 16 | - |
| Dissolved Sodium | 300* | 21 | 8 | 39 | 70 | 0% | 26 | 18 | 34 | 41 | 0% | 25 | 26 | 42 | 125 | 0% |
| Sulfate as Turbidimetric $SO_4$ | 400* | 21 | <4 | 13 | 23 | 0% | 26 | <1 | 10 | 18 | 0% | 25 | <1 | 10 | 21 | 0% |
| Nitrogen Oxides | 0.015‡ | 14 | <0.01 | 0.07 | 0.85 | 93% | 26 | <0.01 | 0.045 | 1.79 | 69% | 25 | <0.01 | 0.09 | 2.33 | 80% |
| Total Nitrogen | 0.25‡ | 20 | 0.40 | 0.65 | 2.9 | 100% | 26 | 0.40 | 0.75 | 2.5 | 100% | 25 | 0.40 | 0.90 | 3.7 | 100% |
| Total Phosphorus | 0.02‡ | 21 | <0.01 | 0.03 | 1.20 | 62% | 26 | <0.01 | 0.03 | 0.41 | 54% | 25 | <0.01 | 0.03 | 0.6 | 68% |
| Dissolved Aluminium | 0.055† | 21 | <0.01 | 0.03 | 0.26 | 29% | 26 | <0.01 | 0.02 | 0.27 | 19% | 25 | <0.01 | <0.01 | 0.27 | 24% |
| Dissolved Arsenic | 0.024† | 21 | <0.001 | <0.001 | 0.002 | 0% | 26 | <0.001 | <0.001 | <0.001 | 0% | 24 | <0.001 | <0.001 | 0.003 | 0% |
| Dissolved Barium | 1* | 21 | 0.02 | 0.03 | 0.1 | 0% | 26 | 0.02 | 0.03 | 0.05 | 0% | 25 | 0.02 | 0.04 | 0.16 | 0% |
| Dissolved Copper | 0.0014† | 21 | <0.001 | <0.001 | 0.002 | 14% | 26 | <0.001 | <0.001 | 0.008 | 19% | 25 | <0.001 | <0.001 | 0.01 | 16% |
| Dissolved Iron | 0.3* | 20 | 0.28 | 0.94 | 4.54 | 95% | 26 | 0.15 | 0.58 | 3.5 | 88% | 25 | 0.18 | 0.7 | 13.7 | 72% |
| Dissolved Lead | 0.0034† | 21 | <0.001 | <0.001 | <0.001 | 0% | 26 | <0.001 | <0.001 | <0.001 | 0% | 25 | <0.001 | <0.001 | <0.001 | 0% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Matthews Creek Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | MC1 | | | | | MG | | | | | MB | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Dissolved Lithium | - | 12 | <0.001 | <0.001 | <0.001 | - | 18 | <0.001 | <0.001 | <0.001 | - | 17 | <0.001 | <0.001 | <0.001 | - |
| Dissolved Manganese | 1.9† | 21 | 0.02 | 0.14 | 4.41 | 5% | 26 | 0.01 | 0.05 | 0.73 | 0% | 25 | 0.02 | 0.24 | 6.21 | 4% |
| Dissolved Nickel | 0.011† | 21 | <0.001 | <0.001 | 0.004 | 0% | 26 | <0.001 | <0.001 | 0.003 | 0% | 25 | <0.001 | <0.001 | 0.003 | 0% |
| Dissolved Selenium | 0.011† | 21 | <0.01 | <0.01 | <0.01 | 0% | 26 | <0.01 | <0.01 | <0.01 | 0% | 25 | <0.01 | <0.01 | <0.01 | 0% |
| Dissolved Strontium | - | 21 | 0.05 | 0.07 | 0.17 | - | 26 | 0.05 | 0.06 | 0.11 | - | 25 | 0.05 | 0.07 | 0.19 | - |
| Dissolved Zinc | 0.008† | 21 | <0.005 | <0.005 | 0.011 | 5% | 26 | <0.005 | 0.006 | 0.016 | 19% | 25 | <0.005 | 0.007 | 0.027 | 40% |
| Total Aluminium | 0.055† | 21 | 0.04 | 0.08 | 0.34 | 81% | 26 | <0.01 | 0.06 | 0.45 | 54% | 25 | <0.01 | 0.06 | 0.61 | 52% |
| Total Arsenic | 0.024† | 21 | <0.001 | <0.001 | 0.002 | 0% | 26 | <0.001 | <0.001 | <0.001 | 0% | 25 | <0.001 | <0.001 | 0.004 | 0% |
| Total Barium | 1* | 21 | 0.02 | 0.04 | 0.12 | 0% | 26 | 0.02 | 0.03 | 0.07 | 0% | 25 | 0.02 | 0.04 | 0.21 | 0% |
| Total Copper | 0.0014† | 21 | <0.001 | <0.001 | 0.002 | 10% | 26 | <0.001 | <0.001 | 0.009 | 23% | 25 | <0.001 | <0.001 | 0.004 | 24% |
| Total Iron | 0.3* | 20 | 0.75 | 1.84 | 7.77 | 100% | 26 | 0.26 | 0.91 | 4.72 | 96% | 25 | 0.88 | 1.9 | 18.8 | 100% |
| Total Lead | 0.0034† | 21 | <0.001 | <0.001 | <0.001 | 0% | 26 | <0.001 | <0.001 | <0.001 | 0% | 25 | <0.001 | <0.001 | <0.001 | 0% |
| Total Lithium | - | 21 | <0.001 | <0.001 | <0.001 | - | 25 | <0.001 | <0.001 | <0.001 | - | 25 | <0.001 | <0.001 | <0.001 | - |
| Total Manganese | 1.9† | 21 | 0.02 | 0.15 | 4.57 | 5% | 26 | 0.01 | 0.06 | 0.66 | 0% | 25 | 0.03 | 0.26 | 5.91 | 4% |
| Total Nickel | 0.011† | 21 | <0.001 | <0.001 | 0.004 | 0% | 26 | <0.001 | <0.001 | 0.002 | 0% | 25 | <0.001 | <0.001 | 0.004 | 0% |
| Total Selenium | 0.011† | 21 | <0.01 | <0.01 | <0.01 | 0% | 26 | <0.01 | <0.01 | <0.01 | 0% | 25 | <0.01 | <0.01 | <0.01 | 0% |
| Total Strontium | - | 21 | 0.05 | 0.07 | 0.18 | - | 25 | 0.05 | 0.07 | 0.12 | - | 25 | 0.05 | 0.07 | 0.2 | - |
| Total Zinc | 0.008† | 21 | <0.005 | 0.006 | 0.01 | 14% | 26 | <0.005 | 0.0085 | 0.023 | 50% | 25 | <0.005 | 0.009 | 0.04 | 52% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Cedar Creek (CA and CB) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | CA | | | | | CB | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Lab pH | 6.5 - 8‡ | 21 | 5.02 | 6.06 | 7.16 | 76% | 23 | 4.52 | 6.3 | 7.07 | 70% |
| Lab EC (µS/cm) | 350‡ | 21 | 296 | 574 | 1170 | 95% | 26 | 280 | 549.5 | 1100 | 88% |
| Field pH | 6.5 - 8‡ | 22 | 4.46 | 6.28 | 10.32 | 73% | 26 | 3.66 | 6.52 | 8.3 | 50% |
| Field EC (µS/cm) | 350‡ | 22 | 247 | 578.5 | 1017 | 95% | 26 | 293 | 555.5 | 943 | 81% |
| Field DO | - | 22 | 1.46 | 6.6 | 11.92 | - | 26 | 3.06 | 6.275 | 12.27 | - |
| Total Alkalinity as $CaCO_3$ | 500* | 22 | <1 | 5 | 22 | 0% | 27 | <1 | 6 | 28 | 0% |
| Dissolved Calcium | - | 22 | 4 | 7 | 12 | - | 27 | 5 | 7 | 10 | - |
| Dissolved Magnesium | - | 22 | 7 | 15 | 32 | - | 27 | 7 | 14 | 30 | - |
| Dissolved Potassium | - | 22 | 4 | 6 | 12 | - | 27 | 4 | 6 | 11 | - |
| Dissolved Sodium | 300* | 22 | 32 | 63 | 137 | 0% | 27 | 31 | 64 | 125 | 0% |
| Sulfate as Turbidimetric $SO_4$ | 400* | 22 | <2 | 6 | 14 | 0% | 27 | <3 | 7 | 16 | 0% |
| Nitrogen Oxides | 0.015‡ | 22 | <0.01 | 0.13 | 1.25 | 95% | 27 | <0.01 | 0.07 | 1.33 | 74% |
| Total Nitrogen | 0.25‡ | 22 | <0.10 | 0.40 | 13.6 | 73% | 27 | <0.10 | 0.3 | 2 | 67% |
| Total Phosphorus | 0.02‡ | 22 | <0.01 | <0.01 | 0.08 | 14% | 27 | <0.01 | <0.01 | 0.37 | 15% |
| Dissolved Aluminium | 0.055† | 22 | <0.01 | 0.02 | 0.16 | 18% | 27 | <0.01 | 0.02 | 0.24 | 11% |
| Dissolved Arsenic | 0.024† | 22 | <0.001 | <0.001 | <0.001 | 0% | 27 | <0.001 | <0.001 | <0.001 | 0% |
| Dissolved Barium | 1* | 22 | 0.02 | 0.06 | 0.19 | 0% | 27 | 0.02 | 0.08 | 0.15 | 0% |
| Dissolved Copper | 0.0014† | 22 | <0.001 | <0.001 | <0.001 | 0% | 27 | <0.001 | <0.001 | 0.003 | 7% |
| Dissolved Iron | 0.3* | 22 | <0.05 | 0.56 | 6.34 | 59% | 27 | <0.05 | 1.08 | 5.08 | 85% |
| Dissolved Lead | 0.0034† | 22 | <0.001 | <0.001 | <0.001 | 0% | 27 | <0.001 | <0.001 | <0.001 | 0% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Cedar Creek (CA and CB) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | CA | | | | | CB | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Dissolved Lithium | - | 14 | 0.002 | 0.004 | 0.009 | - | 19 | <0.001 | 0.01 | 0.018 | - |
| Dissolved Manganese | 1.9† | 22 | 0.07 | 0.67 | 5.47 | 27% | 27 | 0.03 | 0.606 | 3.41 | 37% |
| Dissolved Nickel | 0.011† | 22 | <0.001 | 0.003 | 0.014 | 5% | 27 | <0.001 | 0.005 | 0.015 | 22% |
| Dissolved Selenium | 0.011† | 22 | <0.01 | <0.01 | <0.01 | 0% | 27 | <0.01 | <0.01 | <0.01 | 0% |
| Dissolved Strontium | - | 22 | 0.03 | 0.05 | 0.11 | - | 27 | 0.04 | 0.06 | 0.08 | - |
| Dissolved Zinc | 0.008† | 22 | <0.005 | 0.017 | 0.045 | 91% | 27 | <0.005 | 0.018 | 0.059 | 78% |
| Total Aluminium | 0.055† | 22 | <0.01 | 0.04 | 0.34 | 0% | 27 | 0.02 | 0.04 | 0.38 | 30% |
| Total Arsenic | 0.024† | 22 | <0.001 | <0.001 | <0.001 | 0% | 27 | <0.001 | <0.001 | <0.001 | 0% |
| Total Barium | 1* | 22 | 0.03 | 0.06 | 0.19 | 0% | 27 | 0.03 | 0.09 | 0.2 | 0% |
| Total Copper | 0.0014† | 22 | <0.001 | <0.001 | <0.001 | 0% | 27 | <0.001 | <0.001 | 0.01 | 15% |
| Total Iron | 0.3* | 22 | 0.38 | 1.6 | 10.5 | 100% | 27 | 0.61 | 3.07 | 8.40 | 100% |
| Total Lead | 0.0034† | 22 | <0.001 | <0.001 | 0.002 | 0% | 27 | <0.001 | <0.001 | <0.001 | 0% |
| Total Lithium | - | 21 | <0.001 | 0.003 | 0.01 | - | 26 | <0.001 | 0.004 | 0.022 | - |
| Total Manganese | 1.9† | 22 | 0.08 | 0.71 | 5.06 | 27% | 27 | 0.04 | 0.628 | 5.95 | 41% |
| Total Nickel | 0.011† | 22 | 0.002 | 0.004 | 0.013 | 9% | 27 | <0.001 | 0.006 | 0.02 | 33% |
| Total Selenium | 0.011† | 22 | <0.01 | <0.01 | <0.01 | 0% | 27 | <0.01 | <0.01 | <0.01 | 0% |
| Total Strontium | - | 21 | 0.04 | 0.05 | 0.12 | - | 26 | 0.04 | 0.06 | 0.1 | - |
| Total Zinc | 0.008† | 22 | <0.005 | 0.0195 | 0.053 | 91% | 27 | <0.005 | 0.018 | 0.062 | 93% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Cedar Creek (CC1 and CG) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | CC1 | | | | | CG | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Lab pH | 6.5 - 8‡ | 26 | 4.10 | 5.49 | 6.89 | 88% | 26 | 5.08 | 6.43 | 7.17 | 58% |
| Lab EC (µS/cm) | 350‡ | 26 | 297 | 632 | 1260 | 96% | 26 | 302 | 551 | 1140 | 85% |
| Field pH | 6.5 - 8‡ | 26 | 3.68 | 6.3 | 10.22 | 69% | 26 | 4.96 | 6.61 | 8.31 | 50% |
| Field EC (µS/cm) | 350‡ | 26 | 253 | 685 | 1086 | 96% | 26 | 298 | 622.5 | 1019 | 88% |
| Field DO | - | 26 | 2.67 | 7.56 | 12.3 | - | 26 | 0.90 | 6.84 | 12 | - |
| Total Alkalinity as $CaCO_3$ | 500* | 27 | <1 | <1 | 22 | 0% | 27 | <1 | 12 | 36 | 0% |
| Dissolved Calcium | - | 27 | 4 | 7 | 12 | - | 27 | 5 | 8 | 12 | - |
| Dissolved Magnesium | - | 27 | 7 | 16 | 33 | - | 27 | 7 | 17 | 34 | - |
| Dissolved Potassium | - | 27 | 5 | 7 | 11 | - | 27 | 5 | 6 | 11 | - |
| Dissolved Sodium | 300* | 27 | 33 | 76 | 142 | 0% | 27 | 32 | 71 | 129 | 0% |
| Sulfate as Turbidimetric $SO_4$ | 400* | 27 | <2 | 6 | 14 | 0% | 27 | <1 | <5 | 15 | 0% |
| Nitrogen Oxides | 0.015‡ | 27 | <0.01 | 0.08 | 1.27 | 93% | 27 | <0.01 | 0.03 | 0.88 | 63% |
| Total Nitrogen | 0.25‡ | 27 | <0.10 | 0.4 | 2 | 67% | 27 | <0.10 | 0.4 | 1.5 | 63% |
| Total Phosphorus | 0.02‡ | 27 | <0.01 | <0.01 | 0.29 | 11% | 26 | <0.01 | <0.01 | 0.05 | 8% |
| Dissolved Aluminium | 0.055† | 27 | <0.01 | 0.04 | 0.32 | 44% | 27 | <0.01 | <0.01 | 0.06 | 4% |
| Dissolved Arsenic | 0.024† | 27 | <0.001 | <0.001 | <0.001 | 0% | 27 | <0.001 | <0.001 | <0.001 | 0% |
| Dissolved Barium | 1* | 27 | 0.02 | 0.09 | 0.23 | 0% | 27 | 0.02 | 0.06 | 0.16 | 0% |
| Dissolved Copper | 0.0014† | 27 | <0.001 | <0.001 | <0.001 | 0% | 27 | <0.001 | <0.001 | 0.006 | 7% |
| Dissolved Iron | 0.3* | 27 | <0.05 | 0.48 | 2.90 | 56% | 27 | <0.05 | 0.68 | 2.15 | 67% |
| Dissolved Lead | 0.0034† | 27 | <0.001 | <0.001 | <0.001 | 0% | 27 | <0.001 | <0.001 | <0.001 | 0% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Cedar Creek (CC1 and CG) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | CC1 | | | | | CG | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Dissolved Lithium | - | 19 | <0.001 | 0.006 | 0.012 | - | 19 | <0.001 | 0.009 | 0.017 | - |
| Dissolved Manganese | 1.9† | 27 | 0.07 | 1.19 | 5.86 | 41% | 27 | 0.04 | 0.89 | 4.62 | 26% |
| Dissolved Nickel | 0.011† | 27 | <0.001 | 0.007 | 0.019 | 19% | 27 | <0.001 | 0.002 | 0.013 | 4% |
| Dissolved Selenium | 0.011† | 27 | <0.01 | <0.01 | <0.01 | 0% | 27 | <0.01 | <0.01 | <0.01 | 0% |
| Dissolved Strontium | - | 27 | 0.03 | 0.06 | 0.11 | - | 27 | 0.04 | 0.06 | 0.11 | - |
| Dissolved Zinc | 0.008† | 27 | <0.005 | 0.025 | 0.058 | 93% | 27 | <0.005 | 0.01 | 0.066 | 59% |
| Total Aluminium | 0.055† | 27 | 0.02 | 0.09 | 0.34 | 59% | 27 | <0.01 | 0.02 | 0.32 | 22% |
| Total Arsenic | 0.024† | 27 | <0.001 | <0.001 | <0.001 | 0% | 27 | <0.001 | <0.001 | <0.001 | 0% |
| Total Barium | 1* | 27 | 0.03 | 0.1 | 0.23 | 0% | 27 | 0.02 | 0.07 | 0.17 | 0% |
| Total Copper | 0.0014† | 27 | <0.001 | <0.001 | 0.008 | 19% | 27 | <0.001 | <0.001 | 0.008 | 11% |
| Total Iron | 0.3* | 27 | 0.43 | 1.48 | 4.69 | 100% | 26 | 0.32 | 1.67 | 6.45 | 100% |
| Total Lead | 0.0034† | 27 | <0.001 | <0.001 | <0.001 | 0% | 27 | <0.001 | <0.001 | <0.001 | 0% |
| Total Lithium | - | 26 | <0.001 | 0.0045 | 0.013 | - | 26 | <0.001 | 0.006 | 0.018 | - |
| Total Manganese | 1.9† | 27 | 0.08 | 1.23 | 6.19 | 44% | 27 | 0.05 | 0.98 | 5.03 | 33% |
| Total Nickel | 0.011† | 27 | <0.001 | 0.007 | 0.02 | 22% | 27 | <0.001 | 0.003 | 0.011 | 0% |
| Total Selenium | 0.011† | 27 | <0.01 | <0.01 | <0.01 | 0% | 27 | <0.01 | <0.01 | <0.01 | 0% |
| Total Strontium | - | 26 | 0.04 | 0.06 | 0.12 | - | 26 | 0.05 | 0.07 | 0.12 | - |
| Total Zinc | 0.008† | 27 | <0.005 | 0.027 | 0.06 | 89% | 27 | <0.005 | 0.013 | 0.097 | 70% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Stonequarry Creek (SC1, SC2 and SC) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | SC1 | | | | | SC2 | | | | | SC | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Lab pH | 6.5 - 8‡ | 15 | 6.00 | 6.96 | 7.30 | 20% | 26 | 6.40 | 6.95 | 7.36 | 8% | 25 | 6.61 | 7.16 | 8.36 | 12% |
| Lab EC (µS/cm) | 350‡ | 16 | 433 | 650 | 923 | 100% | 26 | 286 | 618 | 1130 | 92% | 25 | 300 | 641 | 3240 | 96% |
| Field pH | 6.5 - 8‡ | 16 | 5.74 | 6.89 | 8.2 | 38% | 26 | 5.72 | 6.95 | 8.63 | 27% | 24 | 5.92 | 7.5 | 9.50 | 25% |
| Field EC (µS/cm) | 350‡ | 16 | 440 | 640.5 | 1041 | 100% | 26 | 301 | 629 | 1015 | 92% | 24 | 295 | 667.5 | 2920 | 96% |
| Field DO | - | 16 | 1.04 | 6.955 | 11.97 | - | 26 | 0.35 | 6.345 | 11.53 | - | 24 | 3.98 | 8.32 | 13.16 | - |
| Total Alkalinity as $CaCO_3$ | 500* | 17 | 9 | 24 | 36 | 0% | 27 | 11 | 31 | 57 | 0% | 26 | 29 | 40 | 543 | 4% |
| Dissolved Calcium | - | 17 | 7 | 9 | 19 | - | 27 | 8 | 11 | 18 | - | 26 | 8 | 13.5 | 47 | - |
| Dissolved Magnesium | - | 17 | 12 | 17 | 36 | - | 27 | 8 | 18 | 39 | - | 26 | 9 | 21 | 167 | - |
| Dissolved Potassium | - | 17 | 5 | 6 | 117 | - | 27 | 5 | 6 | 79 | - | 26 | 6 | 7 | 16 | - |
| Dissolved Sodium | 300* | 17 | 8 | 70 | 119 | 0% | 27 | 7 | 62 | 134 | 0% | 26 | 32 | 67 | 394 | 4% |
| Sulfate as Turbidimetric $SO_4$ | 400* | 17 | <5 | 10 | 25 | 0% | 27 | <2 | 9 | 20 | 0% | 26 | 6 | 12 | 19 | 0% |
| Nitrogen Oxides | 0.015‡ | 15 | <0.01 | 0.09 | 0.24 | 73% | 24 | <0.01 | 0.03 | 4.06 | 75% | 26 | <0.01 | 0.035 | 0.4 | 69% |
| Total Nitrogen | 0.25‡ | 16 | 0.3 | 0.6 | 0.8 | 100% | 26 | <0.10 | 0.60 | 4.90 | 73% | 26 | 0.2 | 0.4 | 5.2 | 85% |
| Total Phosphorus | 0.02‡ | 17 | <0.01 | 0.02 | 0.11 | 41% | 27 | <0.01 | 0.02 | 0.17 | 33% | 26 | <0.01 | <0.01 | 0.11 | 19% |
| Dissolved Aluminium | 0.055† | 17 | <0.01 | 0.03 | 0.08 | 12% | 27 | <0.01 | <0.01 | 0.15 | 4% | 26 | <0.01 | <0.01 | 0.06 | 12% |
| Dissolved Arsenic | 0.024† | 17 | <0.001 | <0.001 | <0.001 | 0% | 27 | <0.001 | <0.001 | <0.001 | 0% | 26 | <0.001 | <0.001 | 0.002 | 0% |
| Dissolved Barium | 1* | 17 | 0.03 | 0.05 | 0.14 | 0% | 27 | 0.03 | 0.06 | 0.09 | 0% | 26 | 0.03 | 0.05 | 0.33 | 0% |
| Dissolved Copper | 0.0014† | 17 | <0.001 | <0.001 | 0.002 | 18% | 27 | <0.001 | <0.001 | <0.001 | 0% | 26 | <0.001 | <0.001 | 0.002 | 8% |
| Dissolved Iron | 0.3* | 16 | <0.05 | 0.82 | 5.62 | 69% | 26 | 0.07 | 0.56 | 4.92 | 69% | 26 | 0.06 | 0.235 | 1.78 | 46% |
| Dissolved Lead | 0.0034† | 17 | <0.001 | <0.001 | <0.001 | 0% | 27 | <0.001 | <0.001 | <0.001 | 0% | 26 | <0.001 | <0.001 | <0.001 | 0% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Stonequarry Creek (SC1, SC2 and SC) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | SC1 | | | | | SC2 | | | | | SC | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Dissolved Lithium | - | 8 | 0.003 | 0.0045 | 0.011 | - | 17 | 0.002 | 0.008 | 0.011 | - | 18 | 0.002 | 0.009 | 0.093 | - |
| Dissolved Manganese | 1.9† | 17 | 0.04 | 0.19 | 1.43 | 0% | 27 | 0.10 | 0.28 | 1.58 | 0% | 26 | 0.01 | 0.13 | 0.86 | 0% |
| Dissolved Nickel | 0.011† | 17 | <0.001 | 0.003 | 0.018 | 12% | 27 | <0.001 | 0.002 | 0.003 | 0% | 26 | <0.001 | <0.001 | 0.004 | 0% |
| Dissolved Selenium | 0.011† | 17 | <0.01 | <0.01 | <0.01 | 0% | 27 | <0.01 | <0.01 | <0.01 | 0% | 26 | <0.01 | <0.01 | <0.01 | 0% |
| Dissolved Strontium | - | 17 | 0.06 | 0.08 | 0.16 | - | 27 | 0.05 | 0.10 | 0.17 | - | 26 | 0.05 | 0.11 | 0.41 | - |
| Dissolved Zinc | 0.008† | 17 | <0.005 | 0.007 | 0.045 | 41% | 27 | <0.005 | <0.005 | 0.021 | 4% | 26 | <0.005 | <0.005 | 0.006 | 0% |
| Total Aluminium | 0.055† | 17 | 0.02 | 0.06 | 1.10 | 65% | 27 | <0.01 | 0.03 | 0.38 | 33% | 26 | <0.01 | 0.045 | 0.42 | 38% |
| Total Arsenic | 0.024† | 17 | <0.001 | <0.001 | <0.001 | 0% | 27 | <0.001 | <0.001 | <0.001 | 0% | 26 | <0.001 | <0.001 | 0.002 | 0% |
| Total Barium | 1* | 17 | 0.03 | 0.06 | 0.17 | 0% | 27 | 0.03 | 0.06 | 0.10 | 0% | 26 | 0.03 | 0.05 | 0.37 | 0% |
| Total Copper | 0.0014† | 17 | <0.001 | <0.001 | 0.010 | 29% | 27 | <0.001 | <0.001 | 0.005 | 19% | 26 | <0.001 | <0.001 | 0.015 | 15% |
| Total Iron | 0.3* | 16 | 0.72 | 1.81 | 7.81 | 100% | 26 | 0.16 | 1.555 | 4.8 | 96% | 26 | 0.14 | 0.61 | 2.60 | 69% |
| Total Lead | 0.0034† | 17 | <0.001 | <0.001 | <0.001 | 0% | 27 | <0.001 | <0.001 | <0.001 | 0% | 26 | <0.001 | <0.001 | <0.001 | 0% |
| Total Lithium | - | 17 | <0.001 | 0.004 | 0.012 | - | 27 | <0.001 | 0.006 | 0.011 | - | 25 | <0.001 | 0.006 | 0.124 | - |
| Total Manganese | 1.9† | 17 | 0.04 | 0.20 | 1.30 | 0% | 27 | 0.04 | 0.32 | 1.68 | 0% | 26 | 0.02 | 0.17 | 0.77 | 0% |
| Total Nickel | 0.011† | 17 | <0.001 | 0.004 | 0.018 | 12% | 27 | <0.001 | 0.002 | 0.008 | 0% | 26 | <0.001 | 0.002 | 0.004 | 0% |
| Total Selenium | 0.011† | 17 | <0.01 | <0.01 | <0.01 | 0% | 27 | <0.01 | <0.01 | <0.01 | 0% | 26 | <0.01 | <0.01 | <0.01 | 0% |
| Total Strontium | - | 17 | 0.06 | 0.08 | 0.17 | - | 27 | 0.05 | 0.10 | 0.18 | - | 25 | 0.06 | 0.12 | 0.43 | - |
| Total Zinc | 0.008† | 17 | <0.005 | 0.01 | 0.060 | 59% | 27 | <0.005 | 0.007 | 0.029 | 30% | 26 | <0.005 | <0.005 | 0.021 | 12% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Stonequarry Creek (SD and SE) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | SD | | | | | SE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Lab pH | 6.5 - 8‡ | 23 | 6.62 | 7.26 | 7.85 | 0% | 12 | 6.56 | 7.08 | 7.42 | 0% |
| Lab EC (µS/cm) | 350‡ | 23 | 301 | 632 | 1780 | 96% | 12 | 464 | 653 | 851 | 100% |
| Field pH | 6.5 - 8‡ | 23 | 6.22 | 7.63 | 8.11 | 22% | 11 | 6.87 | 7.31 | 8.01 | 9% |
| Field EC (µS/cm) | 350‡ | 23 | 297 | 616 | 1610 | 96% | 11 | 452 | 683 | 861 | 100% |
| Field DO | - | 23 | 0.64 | 9.40 | 12.79 | - | 11 | 2.8 | 7.93 | 12.06 | - |
| Total Alkalinity as $CaCO_3$ | 500* | 24 | 28 | 40.5 | 217 | 0% | 12 | 10 | 44.5 | 88 | 0% |
| Dissolved Calcium | - | 24 | 7 | 14 | 44 | - | 12 | 9 | 12 | 20 | - |
| Dissolved Magnesium | - | 24 | 9 | 20 | 65 | - | 12 | 12 | 21 | 32 | - |
| Dissolved Potassium | - | 24 | 6 | 7 | 17 | - | 12 | 5 | 6 | 7 | - |
| Dissolved Sodium | 300* | 24 | 33 | 66.5 | 146 | 0% | 12 | 53 | 71 | 98 | 0% |
| Sulfate as Turbidimetric $SO_4$ | 400* | 24 | 6 | 12 | 87 | 0% | 12 | 6 | 13 | 17 | 0% |
| Nitrogen Oxides | 0.015‡ | 24 | <0.01 | 0.025 | 0.48 | 67% | 12 | <0.01 | 0.07 | 0.34 | 83% |
| Total Nitrogen | 0.25‡ | 24 | 0.20 | 0.55 | 10.60 | 96% | 12 | 0.30 | 0.6 | 1.00 | 100% |
| Total Phosphorus | 0.02‡ | 24 | <0.01 | <0.01 | 0.27 | 33% | 12 | <0.01 | 0.02 | 0.06 | 33% |
| Dissolved Aluminium | 0.055† | 24 | <0.01 | <0.01 | 0.06 | 4% | 12 | <0.01 | <0.01 | 0.03 | 0% |
| Dissolved Arsenic | 0.024† | 24 | <0.001 | <0.001 | 0.004 | 0% | 12 | <0.001 | <0.001 | <0.001 | 0% |
| Dissolved Barium | 1* | 24 | 0.03 | 0.05 | 0.43 | 0% | 12 | 0.04 | 0.06 | 0.11 | 0% |
| Dissolved Copper | 0.0014† | 24 | <0.001 | <0.001 | 0.006 | 8% | 12 | <0.001 | <0.001 | 0.002 | 8% |
| Dissolved Iron | 0.3* | 24 | 0.07 | 0.32 | 5.56 | 54% | 12 | <0.05 | 0.45 | 1.86 | 58% |
| Dissolved Lead | 0.0034† | 24 | <0.001 | <0.001 | <0.001 | 0% | 12 | <0.001 | <0.001 | <0.001 | 0% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Stonequarry Creek (SD and SE) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | SD | | | | | SE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Dissolved Lithium | - | 16 | 0.002 | 0.008 | 0.022 | - | 4 | 0.003 | - | 0.011 | - |
| Dissolved Manganese | 1.9† | 24 | 0.005 | 0.090 | 20.700 | 4% | 12 | 0.08 | 0.12 | 1.67 | 0% |
| Dissolved Nickel | 0.011† | 24 | <0.001 | <0.001 | 0.030 | 4% | 12 | <0.001 | 0.002 | 0.002 | 0% |
| Dissolved Selenium | 0.011† | 24 | <0.01 | <0.01 | <0.01 | 0% | 12 | <0.01 | <0.01 | <0.01 | 0% |
| Dissolved Strontium | - | 24 | 0.053 | 0.10 | 0.33 | - | 12 | 0.068 | 0.11 | 0.18 | - |
| Dissolved Zinc | 0.008† | 24 | <0.005 | <0.005 | 0.017 | 13% | 12 | <0.005 | <0.005 | 0.012 | 17% |
| Total Aluminium | 0.055† | 24 | <0.01 | 0.03 | 0.31 | 25% | 12 | <0.01 | 0.03 | 0.19 | 33% |
| Total Arsenic | 0.024† | 24 | <0.001 | <0.001 | 0.004 | 0% | 12 | <0.001 | <0.001 | <0.001 | 0% |
| Total Barium | 1* | 24 | 0.03 | 0.05 | 0.49 | 0% | 12 | 0.04 | 0.06 | 0.11 | 0% |
| Total Copper | 0.0014† | 24 | <0.001 | <0.001 | 0.017 | 13% | 12 | <0.001 | <0.001 | 0.002 | 33% |
| Total Iron | 0.3* | 24 | 0.15 | 0.60 | 6.38 | 71% | 12 | 0.38 | 1.585 | 2.65 | 100% |
| Total Lead | 0.0034† | 24 | <0.001 | <0.001 | 0.002 | 0% | 12 | <0.001 | <0.001 | <0.001 | 0% |
| Total Lithium | - | 24 | <0.001 | 0.006 | 0.024 | - | 12 | 0.002 | 0.007 | 0.013 | - |
| Total Manganese | 1.9† | 24 | 0.009 | 0.099 | 22.100 | 4% | 12 | 0.10 | 0.13 | 1.80 | 0% |
| Total Nickel | 0.011† | 24 | <0.001 | 0.0015 | 0.032 | 4% | 12 | <0.001 | 0.002 | 0.002 | 0% |
| Total Selenium | 0.011† | 24 | <0.01 | <0.01 | <0.01 | 0% | 12 | <0.01 | <0.01 | <0.01 | 0% |
| Total Strontium | - | 24 | 0.06 | 0.11 | 0.34 | - | 12 | 0.08 | 0.11 | 0.171 | - |
| Total Zinc | 0.008† | 24 | <0.005 | <0.005 | 0.016 | 33% | 12 | <0.005 | 0.008 | 0.019 | 33% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Stonequarry Creek (SF and SG) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | SF | | | | | SG | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Lab pH | 6.5 - 8‡ | 11 | 6.62 | 6.9 | 7.47 | 0% | 7 | 6.5 | 6.97 | 7.23 | 0% |
| Lab EC (µS/cm) | 350‡ | 11 | 305 | 535 | 660 | 91% | 7 | 492 | 696 | 951 | 100% |
| Field pH | 6.5 - 8‡ | 10 | 6.99 | 7.395 | 7.66 | 0% | 6 | 6.87 | 7.185 | 7.41 | 0% |
| Field EC (µS/cm) | 350‡ | 10 | 301 | 528 | 806 | 90% | 6 | 468 | 723 | 898 | 100% |
| Field DO | - | 10 | 2.8 | 9.465 | 12.23 | - | 6 | 4.42 | 8.535 | 10.91 | - |
| Total Alkalinity as $CaCO_3$ | 500* | 11 | 35 | 43 | 78 | 0% | 7 | 37 | 42 | 107 | 0% |
| Dissolved Calcium | - | 11 | 8 | 11 | 14 | - | 7 | 9 | 13 | 25 | - |
| Dissolved Magnesium | - | 11 | 9 | 17 | 23 | - | 7 | 13 | 22 | 35 | - |
| Dissolved Potassium | - | 11 | 5 | 6 | 8 | - | 7 | 5 | 6 | 7 | - |
| Dissolved Sodium | 300* | 11 | 33 | 57 | 79 | 0% | 7 | 55 | 73 | 89 | 0% |
| Sulfate as Turbidimetric $SO_4$ | 400* | 11 | 6 | 11 | 14 | 0% | 7 | 6 | 12 | 16 | 0% |
| Nitrogen Oxides | 0.015‡ | 11 | <0.01 | 0.04 | 0.41 | 64% | 7 | <0.01 | 0.04 | 0.15 | 71% |
| Total Nitrogen | 0.25‡ | 11 | 0.30 | 0.5 | 1.1 | 100% | 7 | 0.30 | 0.40 | 0.7 | 100% |
| Total Phosphorus | 0.02‡ | 11 | <0.01 | 0.02 | 0.07 | 36% | 7 | <0.01 | <0.01 | 0.03 | 14% |
| Dissolved Aluminium | 0.055† | 11 | <0.01 | <0.01 | 0.06 | 9% | 7 | <0.01 | <0.01 | 0.04 | 0% |
| Dissolved Arsenic | 0.024† | 11 | <0.001 | <0.001 | <0.001 | 0% | 7 | <0.001 | <0.001 | <0.001 | 0% |
| Dissolved Barium | 1* | 11 | 0.03 | 0.05 | 0.07 | 0% | 7 | 0.035 | 0.066 | 0.121 | 0% |
| Dissolved Copper | 0.0014† | 11 | <0.001 | <0.001 | <0.001 | 0% | 7 | <0.001 | <0.001 | <0.001 | 0% |
| Dissolved Iron | 0.3* | 11 | 0.18 | 0.6 | 1.05 | 91% | 7 | <0.05 | 0.24 | 1.32 | 43% |
| Dissolved Lead | 0.0034† | 11 | <0.001 | <0.001 | <0.001 | 0% | 7 | <0.001 | <0.001 | <0.001 | 0% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Stonequarry Creek (SF and SG) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | SF | | | | | SG | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Dissolved Lithium | - | 4 | 0.002 | - | 0.004 | - | 4 | 0.003 | - | 0.016 | - |
| Dissolved Manganese | 1.9† | 11 | 0.04 | 0.13 | 0.65 | 0% | 7 | 0.06 | 0.23 | 0.858 | 0% |
| Dissolved Nickel | 0.011† | 11 | <0.001 | <0.001 | 0.002 | 0% | 7 | <0.001 | 0.002 | 0.002 | 0% |
| Dissolved Selenium | 0.011† | 11 | <0.01 | <0.01 | <0.01 | 0% | 7 | <0.01 | <0.01 | <0.01 | 0% |
| Dissolved Strontium | - | 11 | 0.05 | 0.09 | 0.12 | - | 7 | 0.066 | 0.116 | 0.213 | - |
| Dissolved Zinc | 0.008† | 11 | <0.005 | <0.005 | 0.007 | 0% | 7 | <0.005 | <0.005 | <0.005 | 0% |
| Total Aluminium | 0.055† | 11 | <0.01 | 0.03 | 0.31 | 36% | 7 | <0.01 | 0.03 | 0.14 | 29% |
| Total Arsenic | 0.024† | 11 | <0.001 | <0.001 | <0.001 | 0% | 7 | <0.001 | <0.001 | <0.001 | 0% |
| Total Barium | 1* | 11 | 0.03 | 0.05 | 0.07 | 0% | 7 | 0.041 | 0.062 | 0.12 | 0% |
| Total Copper | 0.0014† | 11 | <0.001 | <0.001 | 0.02 | 18% | 7 | <0.001 | <0.001 | 0.003 | 14% |
| Total Iron | 0.3* | 11 | 0.65 | 1.25 | 1.8 | 100% | 7 | 1.08 | 1.87 | 2.3 | 100% |
| Total Lead | 0.0034† | 11 | <0.001 | <0.001 | <0.001 | 0% | 7 | <0.001 | <0.001 | <0.001 | 0% |
| Total Lithium | - | 11 | <0.001 | 0.004 | 0.006 | - | 7 | 0.003 | 0.007 | 0.016 | - |
| Total Manganese | 1.9† | 11 | 0.05 | 0.14 | 0.65 | 0% | 7 | 0.068 | 0.235 | 0.9 | 0% |
| Total Nickel | 0.011† | 11 | <0.001 | 0.002 | 0.003 | 0% | 7 | <0.001 | 0.002 | 0.002 | 0% |
| Total Selenium | 0.011† | 11 | <0.01 | <0.01 | <0.01 | 0% | 7 | <0.01 | <0.01 | <0.01 | 0% |
| Total Strontium | - | 11 | 0.06 | 0.10 | 0.12 | - | 7 | 0.07 | 0.111 | 0.206 | - |
| Total Zinc | 0.008† | 11 | <0.005 | 0.006 | 0.014 | 27% | 7 | <0.005 | <0.005 | 0.013 | 14% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Redbank Creek (RB1, RB2/RC1 and RC3) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | RB1 | | | | | RB2/RC1 | | | | | RC3 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Lab pH | 6.5 - 8‡ | 10 | 6.59 | 6.84 | 7.18 | 0% | 12 | 6.79 | 7.005 | 7.49 | 0% | 4 | 6.81 | - | 7.4 | 0% |
| Lab EC (µS/cm) | 350‡ | 11 | 166 | 362 | 512 | 55% | 12 | 180 | 366.5 | 489 | 58% | 4 | 170 | - | 460 | 50% |
| Field pH | 6.5 - 8‡ | 17 | 6.03 | 6.79 | 8.54 | 29% | 23 | 5.80 | 6.90 | 7.83 | 26% | 8 | 6.59 | 7.06 | 7.53 | 0% |
| Field EC (µS/cm) | 350‡ | 17 | 167 | 342 | 512 | 47% | 67 | 22 | 343 | 694 | 48% | 8 | 169 | 339.5 | 449 | 50% |
| Field DO | - | 17 | 0.41 | 4.10 | 7.73 | - | 39 | 0.19 | 5.8 | 13.2 | - | 8 | 6.12 | 7.87 | 10.7 | - |
| Total Alkalinity as $CaCO_3$ | 500* | 0 | - | - | - | - | 0 | - | - | - | - | 0 | - | - | - | - |
| Dissolved Calcium | - | 11 | 12 | 28 | 40 | - | 34 | 6.4 | 22 | 54 | - | 4 | 10 | - | 28 | - |
| Dissolved Magnesium | - | 11 | 2 | 6 | 9 | - | 12 | 3 | 7 | 9 | - | 4 | 3 | - | 8 | - |
| Dissolved Potassium | - | 11 | 3 | 4 | 6 | - | 12 | 2 | 4 | 6 | - | 4 | 3 | - | 6 | - |
| Dissolved Sodium | 300* | 11 | 17 | 31 | 50 | 0% | 12 | 16 | 35 | 48 | 0% | 4 | 16 | - | 44 | 0% |
| Sulfate as Turbidimetric $SO_4$ | 400* | 11 | <1 | 14 | 70 | 0% | 34 | <1 | 14 | 60 | 0% | 4 | 13 | - | 43 | 0% |
| Nitrogen Oxides | 0.015‡ | 11 | <0.01 | 0.06 | 0.97 | 73% | 12 | <0.01 | 0.03 | 0.88 | 67% | 4 | 0.05 | - | 0.97 | 100% |
| Total Nitrogen | 0.25‡ | 11 | 0.400 | 0.90 | 4.40 | 100% | 38 | 0.2 | 1.00 | 7.60 | 89% | 4 | 0.2 | - | 1.40 | 75% |
| Total Phosphorus | 0.02‡ | 11 | <0.01 | 0.06 | 0.69 | 73% | 39 | <0.01 | 0.05 | 0.39 | 77% | 4 | <0.01 | - | 0.09 | 25% |
| Dissolved Aluminium | 0.055† | 11 | <0.01 | 0.03 | 0.46 | 45% | 18 | <0.01 | 0.02 | 0.32 | 11% | 4 | <0.01 | - | 0.2 | 50% |
| Dissolved Arsenic | 0.024† | 11 | <0.001 | <0.001 | 0.005 | 0% | 35 | <0.001 | 0.01 | 0.01 | 0% | 4 | <0.001 | - | <0.001 | 0% |
| Dissolved Barium | 1* | 11 | 0.01 | 0.03 | 0.06 | 0% | 35 | 0.00 | 0.03 | 0.11 | 0% | 4 | 0.02 | - | 0.04 | 0% |
| Dissolved Copper | 0.0014† | 11 | <0.001 | <0.001 | 0.004 | 27% | 39 | <0.001 | 0.002 | 0.007 | 54% | 4 | <0.001 | - | 0.002 | 75% |
| Dissolved Iron | 0.3* | 11 | 0.31 | 5.73 | 13.30 | 100% | 39 | <0.02 | 0.28 | 17 | 41% | 4 | <0.05 | - | 0.23 | 0% |
| Dissolved Lead | 0.0034† | 11 | <0.001 | <0.001 | <0.001 | 0% | 27 | <0.001 | <0.001 | <0.001 | 0% | 4 | <0.001 | - | <0.001 | 0% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Redbank Creek (RB1, RB2/RC1 and RC3) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | RB1 | | | | | RB2/RC1 | | | | | RC3 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Dissolved Lithium | - | 0 | - | - | - | - | 16 | <0.001 | 0.002 | 0.11 | - | 0 | - | - | - | - |
| Dissolved Manganese | 1.9† | 11 | 0.00 | 0.46 | 1.90 | - | 39 | 0.003 | 0.01 | 0.708 | - | 4 | 0.00 | - | 0.014 | - |
| Dissolved Nickel | 0.011† | 11 | <0.001 | <0.001 | 0.003 | 0% | 36 | <0.001 | 0.010 | 0.01 | 0% | 4 | <0.001 | - | <0.001 | 0% |
| Dissolved Selenium | 0.011† | 11 | <0.01 | <0.01 | <0.01 | 0% | 15 | <0.01 | <0.01 | <0.01 | 0% | 4 | <0.01 | - | <0.01 | 0% |
| Dissolved Strontium | - | 11 | 0.05 | 0.11 | 0.16 | - | 37 | 0.02 | 0.09 | 0.17 | - | 4 | 0.04 | - | 0.11 | - |
| Dissolved Zinc | 0.008† | 11 | <0.005 | 0.006 | 0.01 | 9% | 37 | <0.001 | 0.009 | 0.029 | 51% | 4 | <0.005 | - | 0.021 | 50% |
| Total Aluminium | 0.055† | 11 | 0.05 | 0.16 | 1.08 | 91% | 12 | 0.05 | 0.07 | 0.56 | 83% | 4 | 0.05 | - | 0.28 | 75% |
| Total Arsenic | 0.024† | 11 | <0.001 | <0.001 | 0.012 | 0% | 12 | <0.001 | <0.001 | 0.002 | 0% | 4 | <0.001 | - | <0.001 | 0% |
| Total Barium | 1* | 11 | 0.02 | 0.04 | 0.08 | 0% | 12 | 0.02 | 0.03 | 0.05 | 0% | 4 | 0.02 | - | 0.04 | 0% |
| Total Copper | 0.0014† | 11 | <0.001 | 0.002 | 0.007 | 64% | 12 | <0.001 | 0.002 | 0.005 | 58% | 4 | <0.001 | - | 0.004 | 50% |
| Total Iron | 0.3* | 11 | 0.65 | 8.38 | 126 | 100% | 39 | 0.16 | 1.10 | 64.00 | 92% | 4 | 0.1 | - | 0.26 | 0% |
| Total Lead | 0.0034† | 11 | <0.001 | <0.001 | 0.007 | 18% | 12 | <0.001 | <0.001 | 0.002 | 0% | 4 | <0.001 | - | <0.001 | 0% |
| Total Lithium | - | 11 | <0.001 | <0.001 | <0.001 | - | 12 | <0.001 | <0.001 | <0.001 | - | 4 | <0.001 | - | <0.001 | - |
| Total Manganese | 1.9† | 11 | 0.01 | 0.43 | 2.24 | 9% | 19 | 0.00 | 0.05 | 0.742 | 0% | 4 | 0.00 | - | 0.016 | 0% |
| Total Nickel | 0.011† | 11 | <0.001 | <0.001 | 0.004 | 0% | 12 | <0.001 | <0.001 | <0.001 | 0% | 4 | <0.001 | - | <0.001 | 0% |
| Total Selenium | 0.011† | 11 | <0.01 | <0.01 | <0.01 | 0% | 12 | <0.01 | <0.01 | <0.01 | 0% | 4 | <0.01 | - | <0.01 | 0% |
| Total Strontium | - | 11 | 0.05 | 0.11 | 0.17 | - | 12 | 0.04 | 0.09 | 0.13 | - | 4 | 0.05 | - | 0.12 | - |
| Total Zinc | 0.008† | 11 | <0.005 | 0.008 | 0.034 | 45% | 12 | <0.005 | 0.0175 | 0.035 | 83% | 4 | 0.006 | - | 0.018 | 50% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Redbank Creek (RB1, RB2/RC1 and RC3) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | RB6/RC2 | | | | | RB9/RC3 | | | | | RB10 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Lab pH | 6.5 - 8‡ | 0 | - | - | - | - | 6 | 6.77 | 7.04 | 7.34 | 0% | 12 | 5.91 | 6.86 | 7.5 | 17% |
| Lab EC (µS/cm) | 350‡ | 0 | - | - | - | - | 6 | 447 | 806.5 | 1060 | 100% | 12 | 214 | 698.5 | 1860 | 92% |
| Field pH | 6.5 - 8‡ | 18 | 3.1 | 6.555 | 7.45 | 44% | 28 | 4.14 | 6.255 | 7.16 | 61% | 15 | 5.15 | 6.55 | 8.08 | 47% |
| Field EC (µS/cm) | 350‡ | 60 | 155 | 852.5 | 3290 | 82% | 28 | 352 | 1191.5 | 2100 | 100% | 15 | 181 | 638 | 1800 | 93% |
| Field DO | - | 37 | 0.50 | 4.45 | 11.16 | - | 20 | 0.92 | 6.335 | 11.33 | - | 15 | 0.82 | 2.73 | 9.53 | - |
| Total Alkalinity as $CaCO_3$ | 500* | 0 | - | - | - | - | 0 | - | - | - | - | 0 | - | - | - | - |
| Dissolved Calcium | - | 25 | 7.4 | 17 | 75 | - | 7 | 14 | 19 | 24 | - | 12 | 9 | 17.5 | 23 | - |
| Dissolved Magnesium | - | 0 | - | - | - | - | 6 | 12 | 28 | 36 | - | 12 | 6 | 20.5 | 58 | - |
| Dissolved Potassium | - | 0 | - | - | - | - | 6 | 5 | 6 | 8 | - | 12 | 4 | 4.5 | 7 | - |
| Dissolved Sodium | 300* | 0 | - | - | - | - | 6 | 45 | 100 | 128 | 0% | 12 | 14 | 81 | 214 | 0% |
| Sulfate as Turbidimetric $SO_4$ | 400* | 25 | <2 | 12 | 30 | 0% | 7 | 15 | 28 | 42 | 0% | 12 | <1 | 21.5 | 139 | 0% |
| Nitrogen Oxides | 0.015‡ | 0 | - | - | - | - | 6 | <0.01 | 0.62 | 1.59 | 83% | 12 | <0.01 | 0.04 | 0.99 | 58% |
| Total Nitrogen | 0.25‡ | 24 | <0.10 | 0.4 | 7.70 | 67% | 18 | <0.10 | 0.35 | 2.30 | 56% | 12 | 0.3 | 0.4 | 1.50 | 100% |
| Total Phosphorus | 0.02‡ | 24 | <0.01 | 0.03 | 0.34 | 54% | 18 | <0.01 | <0.01 | 0.13 | 22% | 11 | <0.01 | 0.02 | 0.16 | 45% |
| Dissolved Aluminium | 0.055† | 0 | - | - | - | - | 17 | <0.01 | <0.01 | 0.06 | 6% | 12 | <0.01 | <0.01 | 0.08 | 8% |
| Dissolved Arsenic | 0.024† | 16 | 0.01 | 0.01 | 0.01 | 0% | 18 | <0.001 | 0.01 | 0.01 | 0% | 12 | <0.001 | <0.001 | <0.001 | 0% |
| Dissolved Barium | 1* | 22 | 0.001 | 0.15 | 0.45 | 0% | 18 | 0.038 | 0.25 | 0.41 | 0% | 12 | 0.039 | 0.08 | 0.20 | 0% |
| Dissolved Copper | 0.0014† | 24 | <0.001 | <0.001 | 0.005 | 38% | 18 | <0.001 | <0.001 | 0.007 | 44% | 12 | <0.001 | <0.001 | 0.002 | 8% |
| Dissolved Iron | 0.3* | 24 | <0.01 | 1.4 | 42 | 83% | 18 | <0.01 | 0.1 | 2.2 | 28% | 12 | <0.05 | 0.28 | 6.31 | 42% |
| Dissolved Lead | 0.0034† | 12 | <0.001 | <0.001 | 0.003 | 0% | 17 | <0.001 | <0.001 | 0.002 | 0% | 12 | <0.001 | <0.001 | <0.001 | 0% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Redbank Creek (RB1, RB2/RC1 and RC3) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | RB6/RC2 | | | | | RB9/RC3 | | | | | RB10 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Dissolved Lithium | - | 22 | <0.001 | 0.0275 | 0.14 | - | 1 | 0.06 | - | 0.06 | - | 0 | - | - | - | - |
| Dissolved Manganese | 1.9† | 24 | 0.01 | 2.05 | 4.40 | - | 18 | 0.04 | 2.10 | 5.30 | - | 12 | 0.07 | 0.96 | 2.59 | - |
| Dissolved Nickel | 0.011† | 23 | 0.01 | 0.01 | 0.07 | 26% | 18 | 0.002 | 0.02 | 0.06 | 56% | 12 | <0.001 | 0.007 | 0.024 | 17% |
| Dissolved Selenium | 0.011† | 3 | <0.01 | - | <0.01 | 0% | 6 | <0.01 | <0.01 | <0.01 | 0% | 12 | <0.01 | <0.01 | <0.01 | 0% |
| Dissolved Strontium | - | 22 | 0.03 | 0.12 | 0.26 | - | 18 | 0.07 | 0.14 | 0.21 | - | 12 | 0.07 | 0.10 | 0.20 | - |
| Dissolved Zinc | 0.008† | 24 | <0.001 | 0.0385 | 0.2 | 88% | 18 | 0.01 | 0.041 | 0.087 | 100% | 12 | 0.006 | 0.012 | 0.108 | 83% |
| Total Aluminium | 0.055† | 0 | - | - | - | - | 6 | 0.03 | 0.105 | 0.79 | 50% | 12 | <0.01 | 0.07 | 0.79 | 58% |
| Total Arsenic | 0.024† | 0 | - | - | - | - | 6 | <0.001 | <0.001 | <0.001 | 0% | 12 | <0.001 | <0.001 | <0.001 | 0% |
| Total Barium | 1* | 0 | - | - | - | - | 6 | 0.04 | 0.08 | 0.11 | 0% | 12 | 0.04 | 0.09 | 0.21 | 0% |
| Total Copper | 0.0014† | 0 | - | - | - | - | 6 | <0.001 | 0.002 | 0.003 | 50% | 12 | <0.001 | <0.001 | 0.004 | 25% |
| Total Iron | 0.3* | 24 | 0.82 | 12.50 | 82 | 100% | 18 | 0.33 | 1.57 | 96 | 100% | 12 | 0.24 | 2.02 | 7.25 | 92% |
| Total Lead | 0.0034† | 0 | - | - | - | - | 6 | <0.001 | <0.001 | <0.001 | 0% | 12 | <0.001 | <0.001 | 0.004 | 8% |
| Total Lithium | - | 0 | - | - | - | - | 6 | 0.003 | 0.01 | 0.018 | - | 12 | <0.001 | 0.01 | 0.033 | - |
| Total Manganese | 1.9† | 13 | 0.02 | 2.90 | 4.60 | 69% | 7 | 0.04 | 0.50 | 3.20 | 14% | 12 | 0.08 | 1.05 | 2.59 | 33% |
| Total Nickel | 0.011† | 0 | - | - | - | - | 6 | 0.003 | 0.008 | 0.012 | 33% | 12 | <0.001 | 0.009 | 0.028 | 17% |
| Total Selenium | 0.011† | 0 | - | - | - | - | 6 | <0.01 | <0.01 | <0.01 | 0% | 12 | <0.01 | <0.01 | <0.01 | 0% |
| Total Strontium | - | 0 | - | - | - | - | 6 | 0.07 | 0.13 | 0.15 | - | 12 | 0.08 | 0.11 | 0.22 | - |
| Total Zinc | 0.008† | 0 | - | - | - | - | 6 | 0.012 | 0.0305 | 0.048 | 100% | 12 | 0.008 | 0.0155 | 0.109 | 92% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Redbank Creek (RC4 and RC11) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | RC4 | | | | | RC11 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Lab pH | 6.5 - 8‡ | 0 | - | - | - | - | 19 | 6.74 | 7.23 | 7.84 | 0% |
| Lab EC (µS/cm) | 350‡ | 0 | - | - | - | - | 20 | 353 | 614 | 1480 | 100% |
| Field pH | 6.5 - 8‡ | 2 | 6.56 | - | 6.58 | 0% | 25 | 6.13 | 7.23 | 7.95 | 12% |
| Field EC (µS/cm) | 350‡ | 14 | 442 | 1307.5 | 2060 | 100% | 25 | 294 | 577 | 1630 | 96% |
| Field DO | - | 5 | 2.74 | 4.82 | 5.42 | - | 25 | 0.55 | 2.46 | 9.07 | - |
| Total Alkalinity as $CaCO_3$ | 500* | 0 | - | - | - | - | 0 | - | - | - | - |
| Dissolved Calcium | - | 1 | 19 | - | 19 | - | 20 | 10 | 18.5 | 28 | - |
| Dissolved Magnesium | - | 0 | - | - | - | - | 20 | 10 | 18 | 48 | - |
| Dissolved Potassium | - | 0 | - | - | - | - | 20 | 2 | 4 | 7 | - |
| Dissolved Sodium | 300* | 0 | - | - | - | - | 20 | 31 | 74 | 192 | 0% |
| Sulfate as Turbidimetric $SO_4$ | 400* | 1 | 23 | - | 23 | 0% | 20 | <1 | 12 | 34 | 0% |
| Nitrogen Oxides | 0.015‡ | 0 | - | - | - | - | 20 | <0.01 | 0.015 | 1.87 | 50% |
| Total Nitrogen | 0.25‡ | 10 | <0.10 | 0.65 | 15.00 | 80% | 20 | 0.2 | 0.40 | 2.70 | 90% |
| Total Phosphorus | 0.02‡ | 12 | <0.01 | 0.065 | 1.1 | 75% | 20 | <0.01 | 0.02 | 0.17 | 45% |
| Dissolved Aluminium | 0.055† | 11 | <0.01 | 0.02 | 0.04 | 0% | 20 | <0.01 | <0.01 | 0.11 | 10% |
| Dissolved Arsenic | 0.024† | 12 | 0.01 | 0.01 | 0.01 | 0% | 20 | <0.001 | <0.001 | <0.001 | 0% |
| Dissolved Barium | 1* | 12 | 0.08 | 0.22 | 0.43 | 0% | 20 | 0.05 | 0.08 | 0.16 | 0% |
| Dissolved Copper | 0.0014† | 12 | <0.001 | <0.001 | 0.013 | 42% | 20 | <0.001 | <0.001 | <0.001 | 0% |
| Dissolved Iron | 0.3* | 12 | <0.01 | 0.75 | 48.00 | 50% | 20 | 0.07 | 0.28 | 4.14 | 45% |
| Dissolved Lead | 0.0034† | 11 | <0.001 | <0.001 | 0.002 | 0% | 20 | <0.001 | <0.001 | <0.001 | 0% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Redbank Creek (RC4 and RC11) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | RC4 | | | | | RC11 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Dissolved Lithium | - | 19 | <0.001 | 0.006 | 0.012 | - | 19 | <0.001 | 0.009 | 0.017 | - |
| Dissolved Manganese | 1.9† | 27 | 0.07 | 1.19 | 5.86 | 41% | 27 | 0.04 | 0.89 | 4.62 | 26% |
| Dissolved Nickel | 0.011† | 27 | <0.001 | 0.007 | 0.019 | 19% | 27 | <0.001 | 0.002 | 0.013 | 4% |
| Dissolved Selenium | 0.011† | 27 | <0.01 | <0.01 | <0.01 | 0% | 27 | <0.01 | <0.01 | <0.01 | 0% |
| Dissolved Strontium | - | 27 | 0.03 | 0.06 | 0.11 | - | 27 | 0.04 | 0.06 | 0.11 | - |
| Dissolved Zinc | 0.008† | 27 | <0.005 | 0.025 | 0.058 | 93% | 27 | <0.005 | 0.01 | 0.066 | 59% |
| Total Aluminium | 0.055† | 27 | 0.02 | 0.09 | 0.34 | 59% | 27 | <0.01 | 0.02 | 0.32 | 22% |
| Total Arsenic | 0.024† | 27 | <0.001 | <0.001 | <0.001 | 0% | 27 | <0.001 | <0.001 | <0.001 | 0% |
| Total Barium | 1* | 27 | 0.03 | 0.10 | 0.23 | 0% | 27 | 0.02 | 0.07 | 0.17 | 0% |
| Total Copper | 0.0014† | 27 | <0.001 | <0.001 | 0.008 | 19% | 27 | <0.001 | <0.001 | 0.008 | 11% |
| Total Iron | 0.3* | 27 | 0.43 | 1.48 | 4.69 | 100% | 26 | 0.32 | 1.67 | 6.45 | 100% |
| Total Lead | 0.0034† | 27 | <0.001 | <0.001 | <0.001 | 0% | 27 | <0.001 | <0.001 | <0.001 | 0% |
| Total Lithium | - | 26 | <0.001 | 0.0045 | 0.013 | - | 26 | <0.001 | 0.006 | 0.018 | - |
| Total Manganese | 1.9† | 27 | 0.08 | 1.23 | 6.19 | 44% | 27 | 0.05 | 0.98 | 5.03 | 33% |
| Total Nickel | 0.011† | 27 | <0.001 | 0.007 | 0.02 | 22% | 27 | <0.001 | 0.003 | 0.011 | 0% |
| Total Selenium | 0.011† | 27 | <0.01 | <0.01 | <0.01 | 0% | 27 | <0.01 | <0.01 | <0.01 | 0% |
| Total Strontium | - | 26 | 0.04 | 0.06 | 0.12 | - | 26 | 0.05 | 0.07 | 0.12 | - |
| Total Zinc | 0.008† | 27 | <0.005 | 0.027 | 0.060 | 89% | 27 | <0.005 | 0.013 | 0.097 | 70% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Redbank Creek (RC5 and RC6) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | RC5 | | | | | RC6 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Lab pH | 6.5 - 8‡ | 14 | 6.98 | 7.155 | 7.87 | 0% | 13 | 6.89 | 7.14 | 7.57 | 0% |
| Lab EC (µS/cm) | 350‡ | 14 | 220 | 393 | 722 | 64% | 13 | 223 | 506 | 2690 | 69% |
| Field pH | 6.5 - 8‡ | 18 | 4.19 | 6.92 | 7.38 | 28% | 2 | 6.77 | - | 6.82 | 0% |
| Field EC (µS/cm) | 350‡ | 75 | 163 | 498 | 2790 | 72% | 21 | 361 | 933 | 1850 | 100% |
| Field DO | - | 44 | 1.3 | 6.315 | 10.65 | - | 11 | 2.26 | 5.6 | 11.50 | - |
| Total Alkalinity as $CaCO_3$ | 500* | 0 | - | - | - | - | 0 | - | - | - | - |
| Dissolved Calcium | - | 36 | 6.7 | 23.5 | 32 | - | 14 | 13 | 21 | 50 | - |
| Dissolved Magnesium | - | 14 | 5 | 10 | 19 | - | 13 | 5 | 9 | 18 | - |
| Dissolved Potassium | - | 14 | 2 | 3.5 | 7 | - | 13 | 2 | 4 | 9 | - |
| Dissolved Sodium | 300* | 14 | 19 | 35.5 | 79 | 0% | 13 | 20 | 53 | 466 | 8% |
| Sulfate as Turbidimetric $SO_4$ | 400* | 36 | <1 | 11.5 | 34 | 0% | 14 | <1 | 17.5 | 87 | 0% |
| Nitrogen Oxides | 0.015‡ | 14 | 0.02 | 0.07 | 0.88 | 100% | 13 | <0.01 | 0.13 | 2.09 | 85% |
| Total Nitrogen | 0.25‡ | 46 | 0.3 | 0.65 | 2.70 | 100% | 26 | 0.2 | 0.8 | 3.10 | 92% |
| Total Phosphorus | 0.02‡ | 47 | <0.01 | 0.04 | 0.25 | 68% | 27 | <0.01 | 0.05 | 13.5 | 67% |
| Dissolved Aluminium | 0.055† | 26 | <0.01 | 0.02 | 0.1 | 4% | 26 | <0.01 | <0.01 | 0.06 | 4% |
| Dissolved Arsenic | 0.024† | 40 | <0.001 | 0.01 | 0.01 | 0% | 26 | <0.001 | 0.0055 | 0.01 | 0% |
| Dissolved Barium | 1* | 44 | 0.02 | 0.07 | 0.63 | 0% | 27 | 0.028 | 0.08 | 0.44 | 0% |
| Dissolved Copper | 0.0014† | 47 | <0.001 | <0.001 | 0.006 | 30% | 27 | <0.001 | <0.001 | 0.003 | 19% |
| Dissolved Iron | 0.3* | 47 | <0.01 | 0.32 | 36 | 51% | 27 | <0.02 | 0.4 | 21 | 52% |
| Dissolved Lead | 0.0034† | 34 | <0.001 | <0.001 | 0.003 | 0% | 26 | <0.001 | <0.001 | 0.002 | 0% |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

## Redbank Creek (RC5 and RC6) Water Quality Summary - Full Period of Record

| Parameter (mg/L unless otherwise stated) | Guideline Value | RC5 | | | | | RC6 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. Samples | Min | Median | Max | % Exceedance | No. Samples | Min | Median | Max | % Exceedance |
| Dissolved Lithium | - | 17 | <0.001 | 0.01 | 0.06 | - | 1 | 0.04 | - | 0.04 | - |
| Dissolved Manganese | 1.9† | 47 | 0.01 | 0.226 | 6.6 | - | 27 | 0.01 | 0.68 | 6.90 | - |
| Dissolved Nickel | 0.011† | 47 | <0.001 | 0.01 | 0.07 | 13% | 26 | <0.001 | 0.0075 | 0.05 | 8% |
| Dissolved Selenium | 0.011† | 17 | <0.01 | <0.01 | <0.01 | 0% | 13 | <0.01 | <0.01 | <0.01 | 0% |
| Dissolved Strontium | - | 45 | 0.01 | 0.13 | 0.24 | - | 27 | 0.06 | 0.12 | 0.20 | - |
| Dissolved Zinc | 0.008† | 46 | <0.001 | 0.010 | 0.22 | 59% | 26 | <0.002 | 0.01 | 1 | 62% |
| Total Aluminium | 0.055† | 14 | 0.06 | 0.095 | 1.32 | 100% | 13 | 0.02 | 0.09 | 0.21 | 77% |
| Total Arsenic | 0.024† | 14 | <0.001 | <0.001 | 0.002 | 0% | 13 | <0.001 | <0.001 | <0.001 | 0% |
| Total Barium | 1* | 14 | 0.04 | 0.06 | 0.09 | 0% | 13 | 0.03 | 0.06 | 0.12 | 0% |
| Total Copper | 0.0014† | 14 | <0.001 | <0.001 | 0.012 | 43% | 13 | <0.001 | 0.002 | 0.01 | 54% |
| Total Iron | 0.3* | 47 | 0.15 | 1.6 | 185.00 | 98% | 27 | 0.3 | 1.50 | 85 | 96% |
| Total Lead | 0.0034† | 14 | <0.001 | <0.001 | 0.002 | 0% | 13 | <0.001 | <0.001 | <0.001 | 0% |
| Total Lithium | - | 14 | <0.001 | 0.003 | 0.012 | - | 13 | <0.001 | <0.001 | 0.004 | - |
| Total Manganese | 1.9† | 0 | - | - | - | - | 0 | - | - | - | - |
| Total Nickel | 0.011† | 24 | 0.03 | 0.535 | 5 | 4% | 13 | 0.26 | 0.69 | 1.82 | 0% |
| Total Selenium | 0.011† | 14 | <0.001 | 0.002 | 0.007 | 0% | 13 | <0.001 | 0.002 | 0.005 | 0% |
| Total Strontium | - | 14 | <0.01 | <0.01 | <0.01 | 0% | 13 | <0.01 | <0.01 | <0.01 | 0% |
| Total Zinc | 0.008† | 14 | 0.08 | 0.13 | 0.16 | - | 13 | 0.06 | 0.10 | 0.14 | - |

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

# APPENDIX D – SURFACE WATER QUALITY MONITORING PLOTS

## Matthews Creek, Cedar Creek and Stonequarry Creek

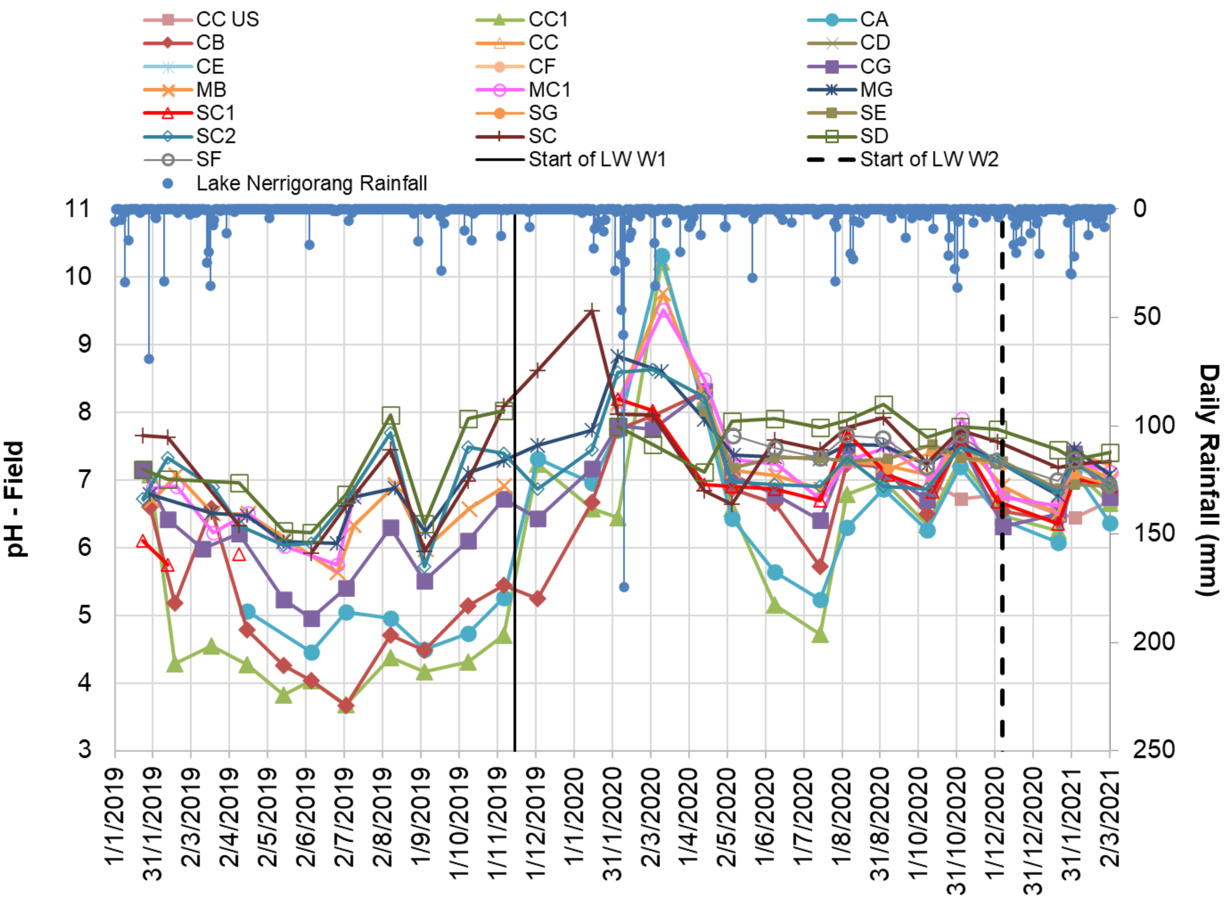
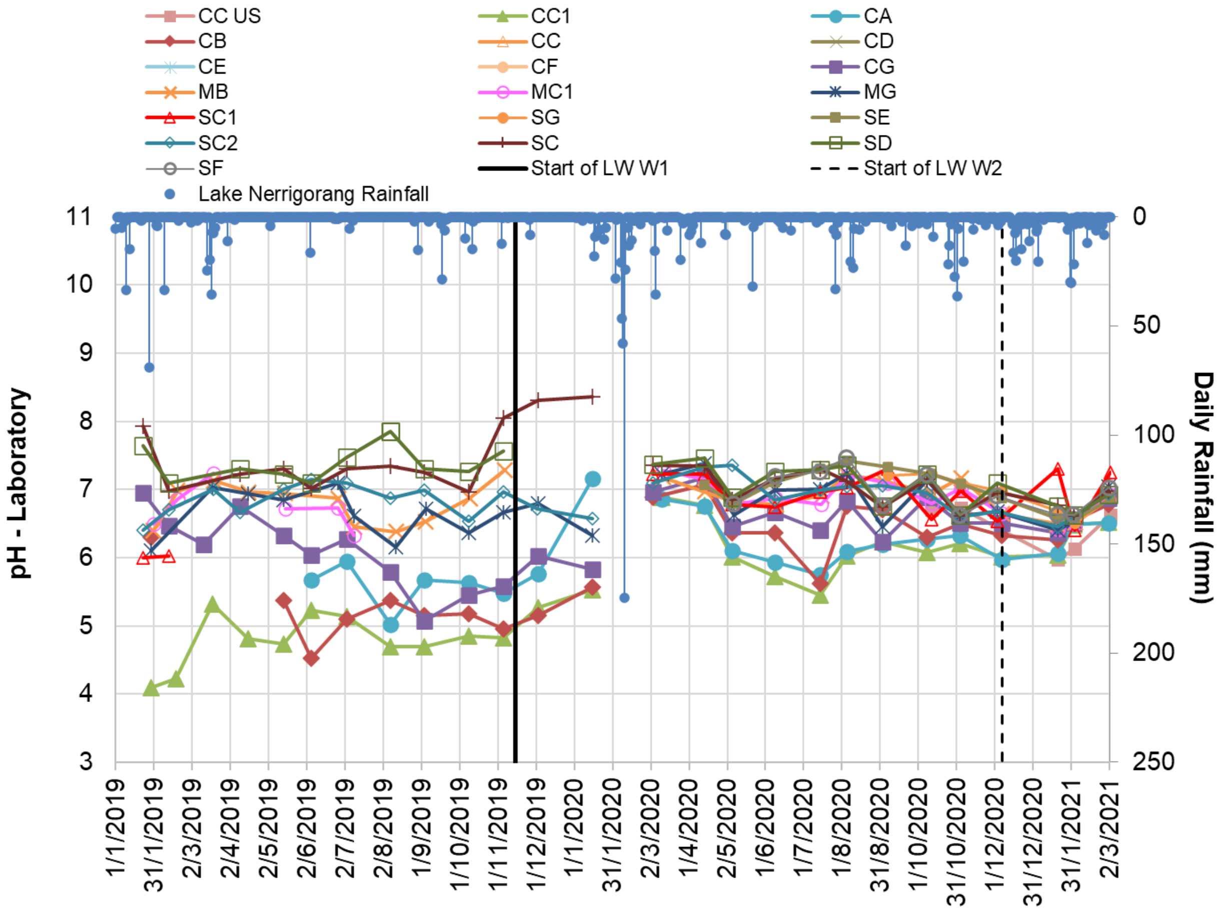
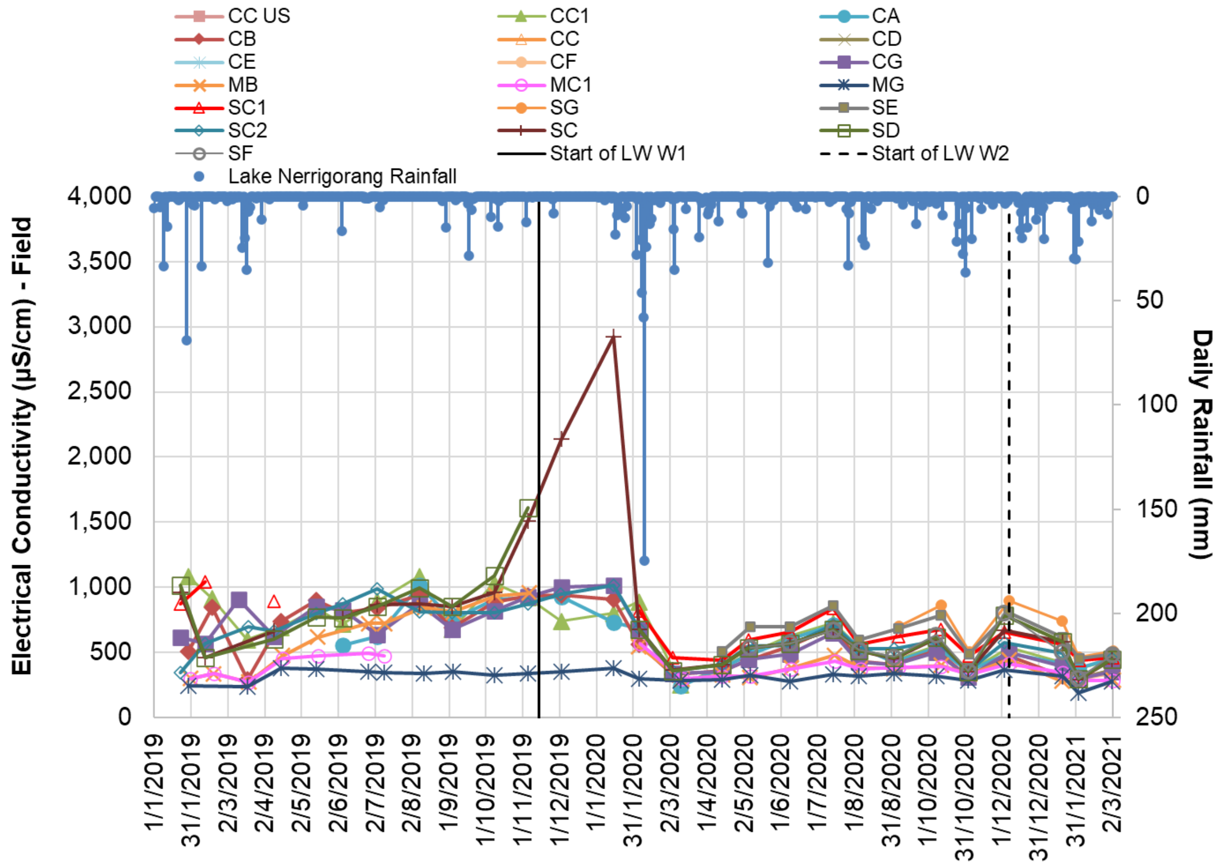



**Figure D1 Field pH Records**




## Figure D2 Laboratory pH Records




## Figure D3 Field Electrical Conductivity Records

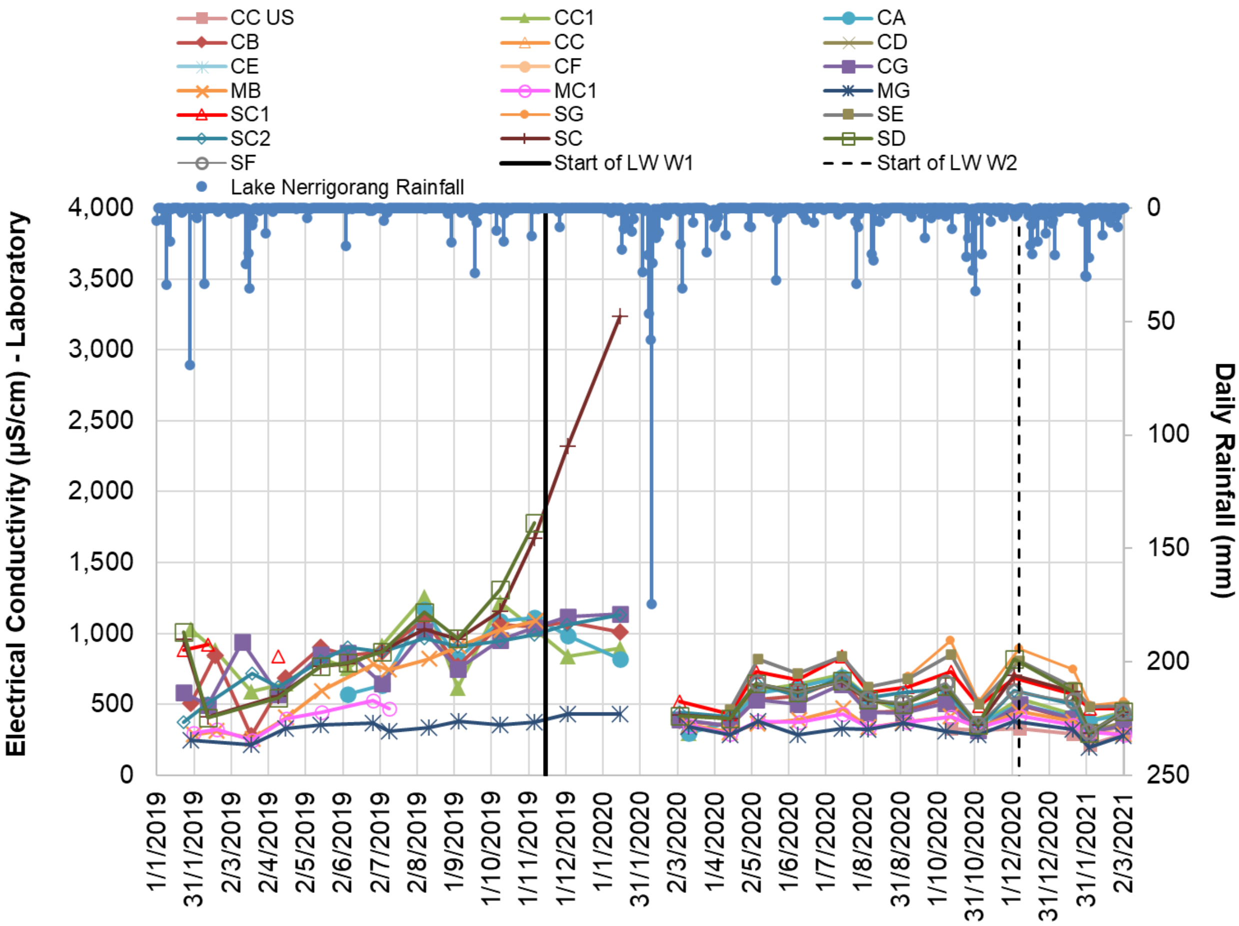



**Figure D4 Laboratory Electrical Conductivity Records**

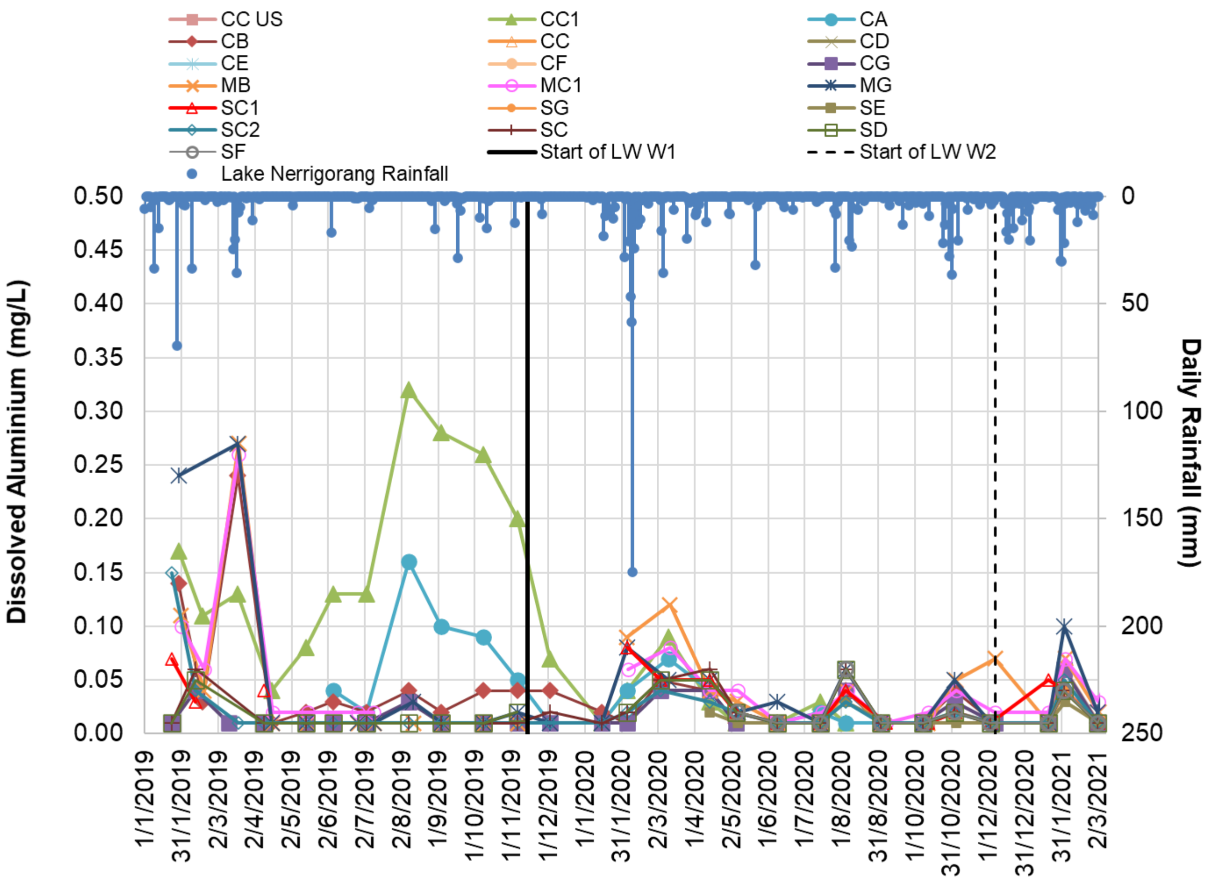
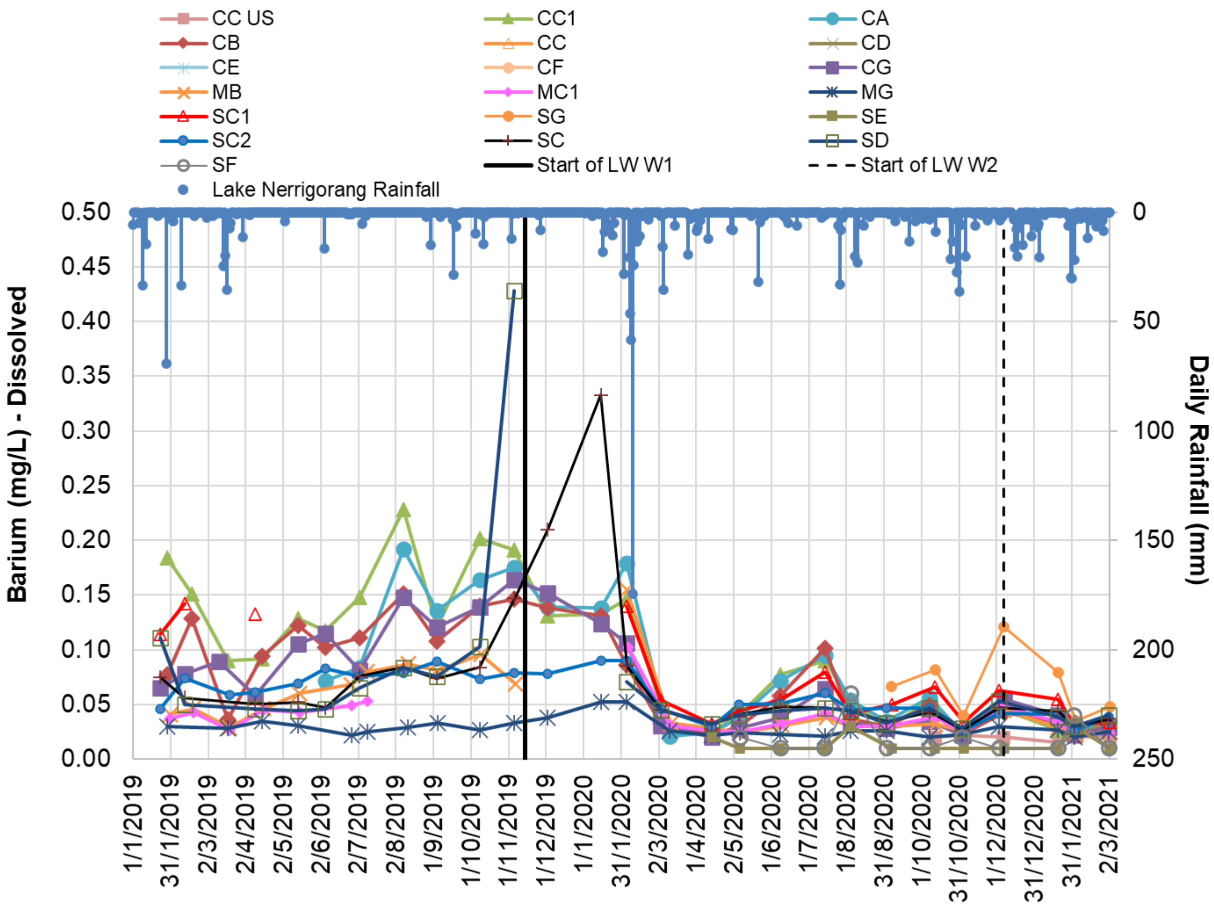
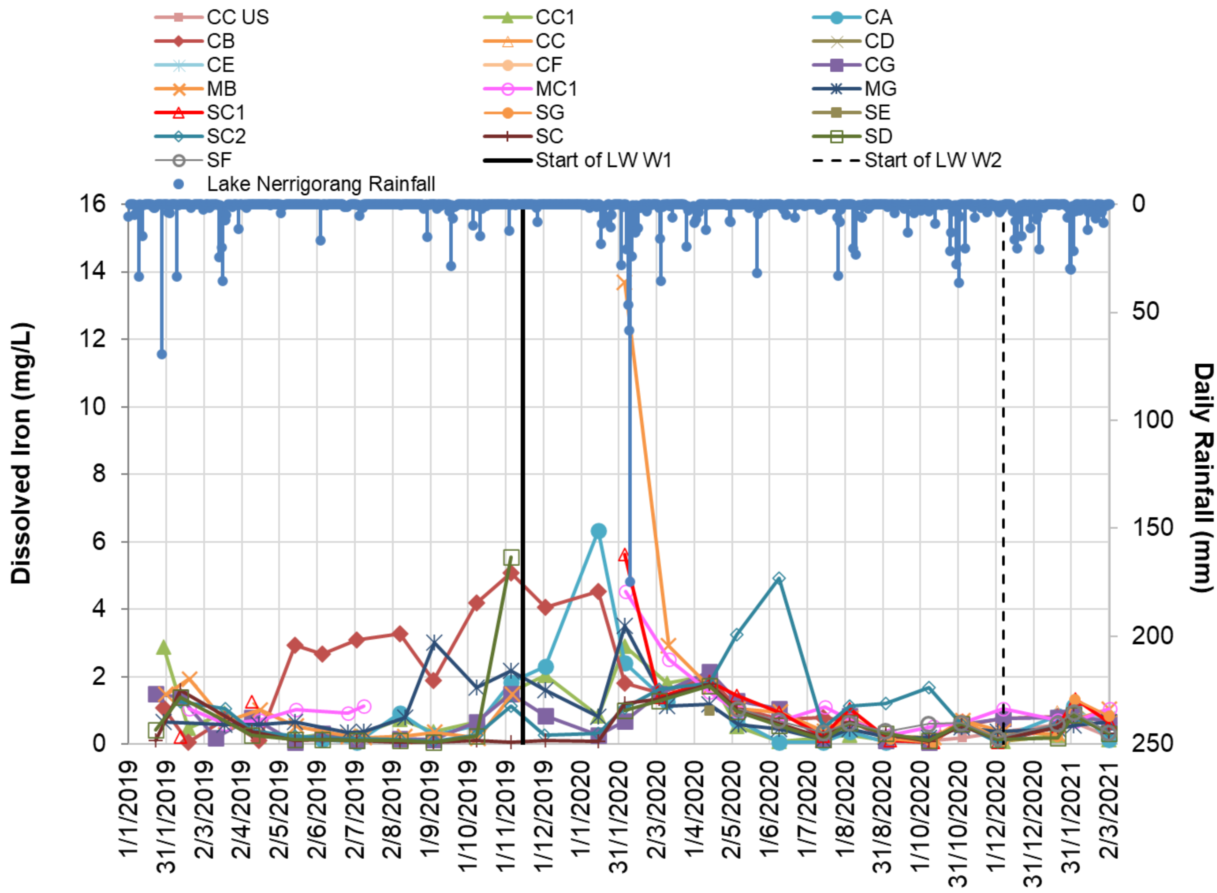



**Figure D5 Dissolved Aluminium Records**




## Figure D6 Dissolved Barium Records




## Figure D7 Dissolved Iron Records

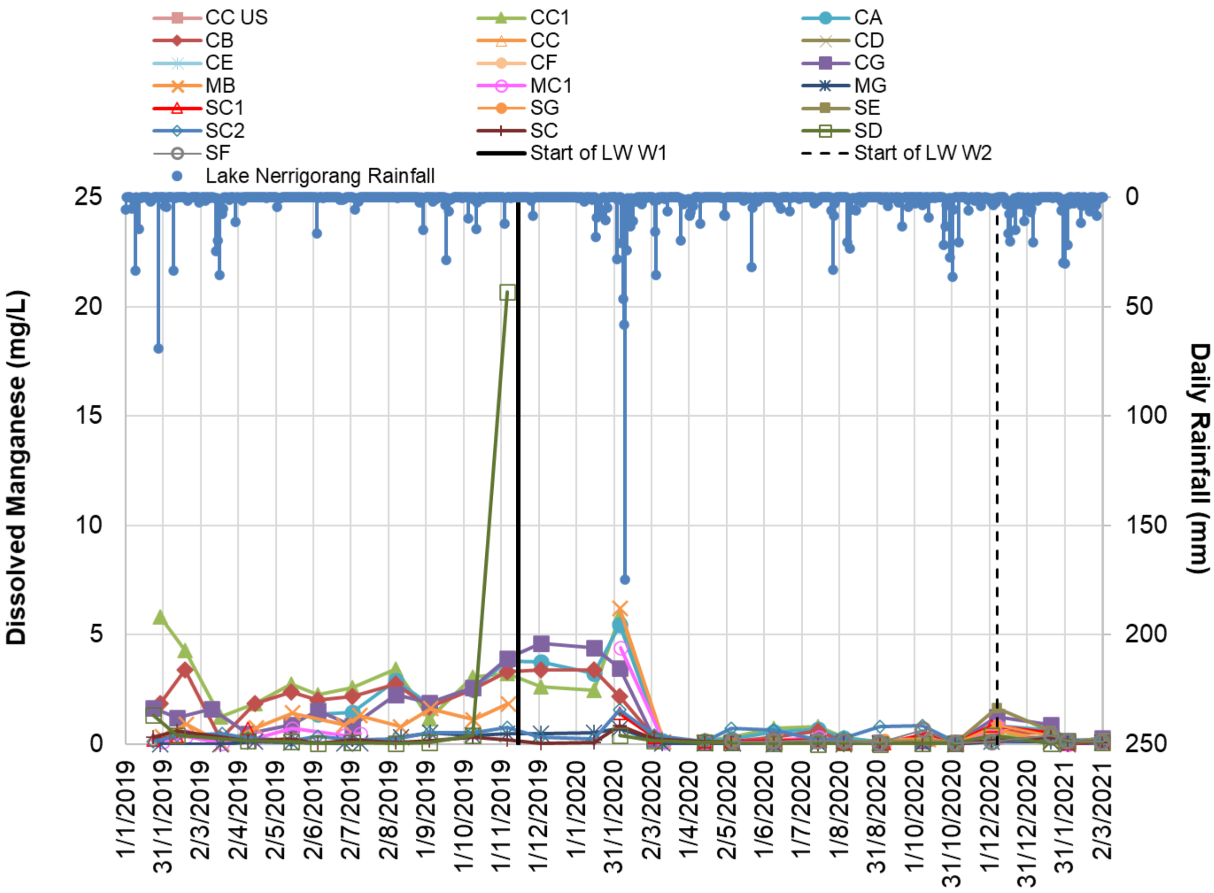



**Figure D8 Dissolved Manganese Records**

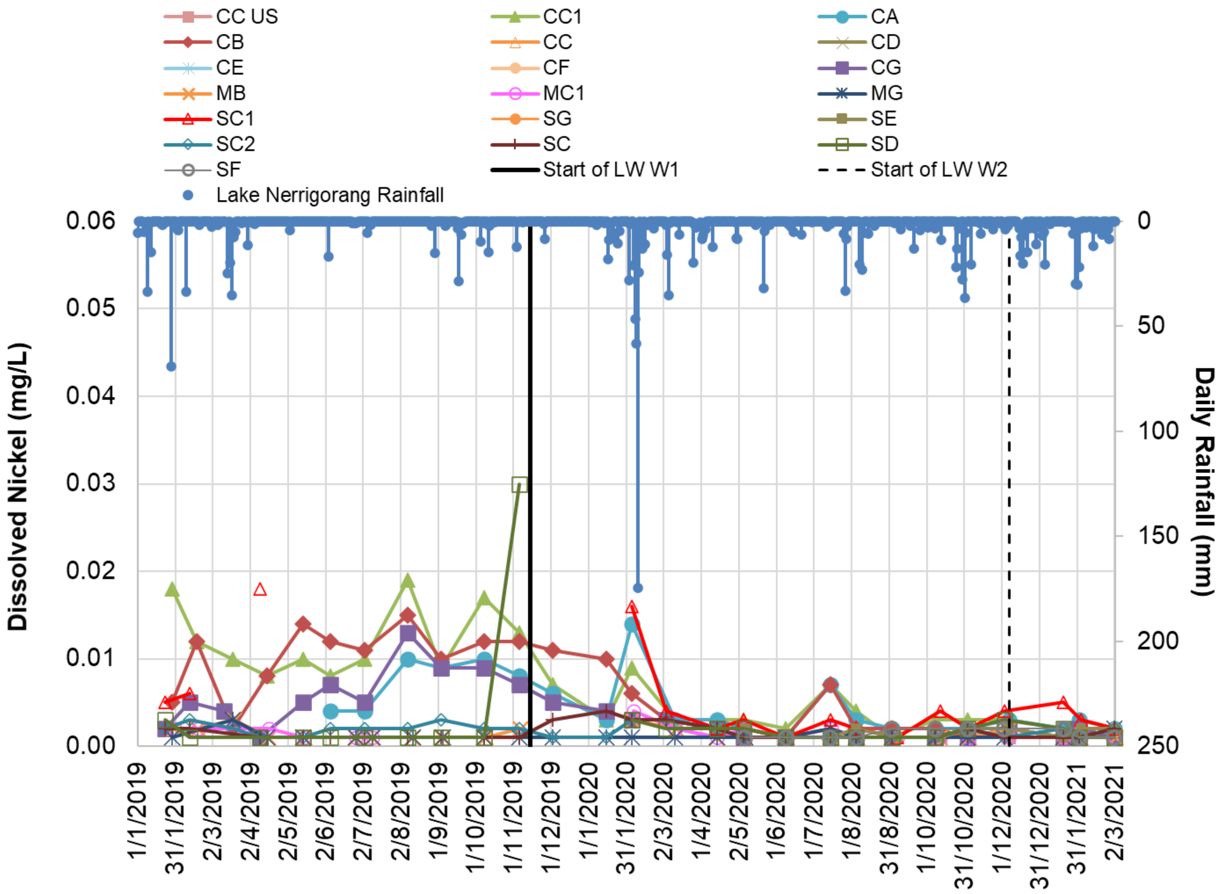



**Figure D9 Dissolved Nickel Records**

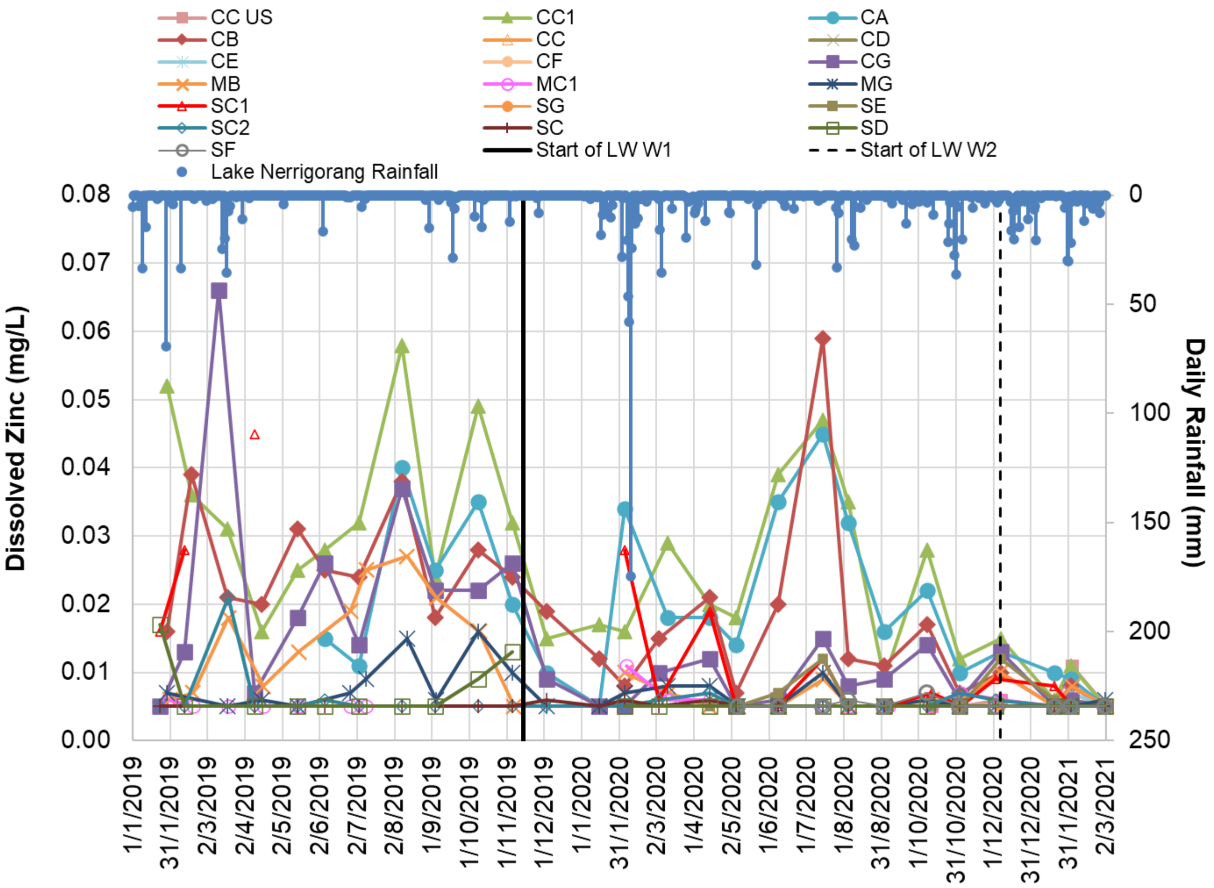



**Figure D10 Dissolved Zinc Records**

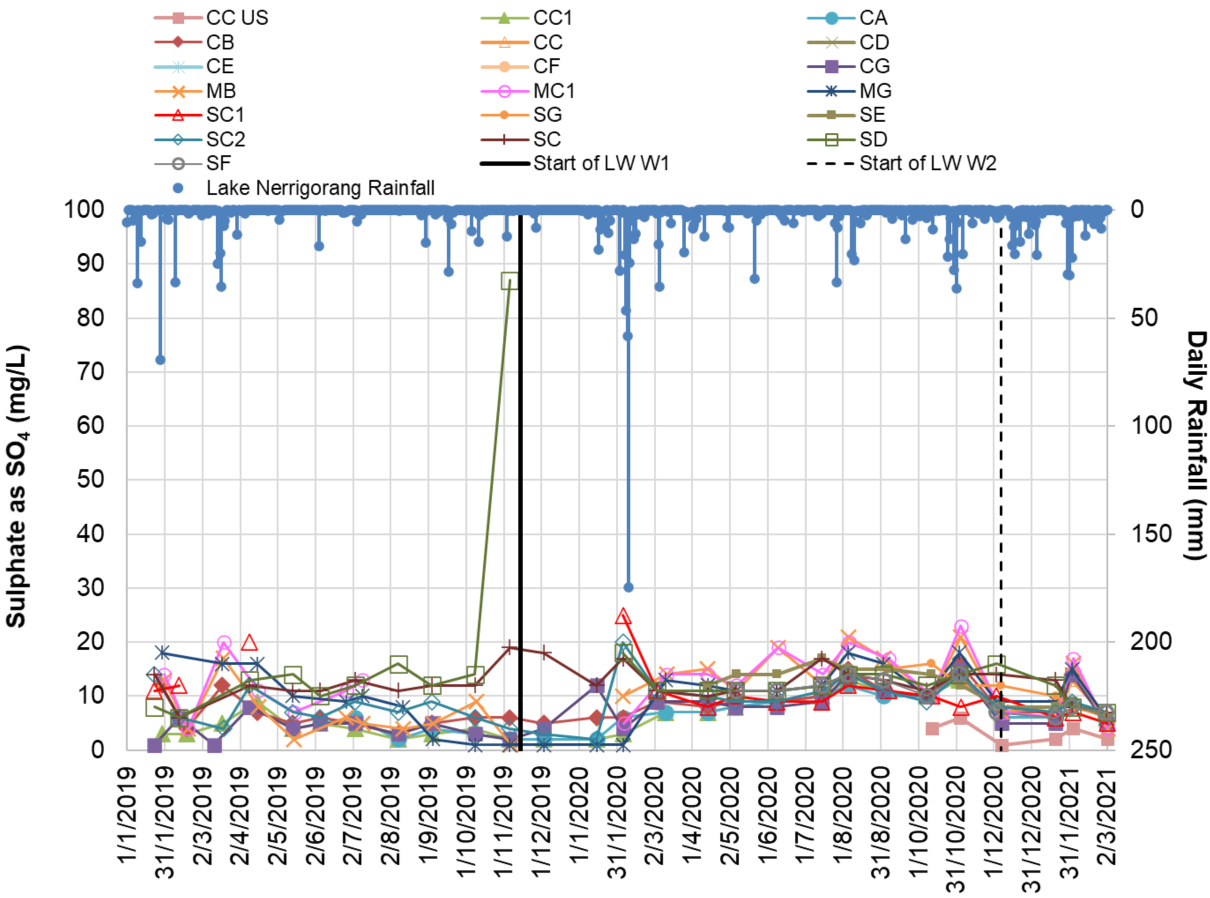



**Figure D11 Sulphate Records**

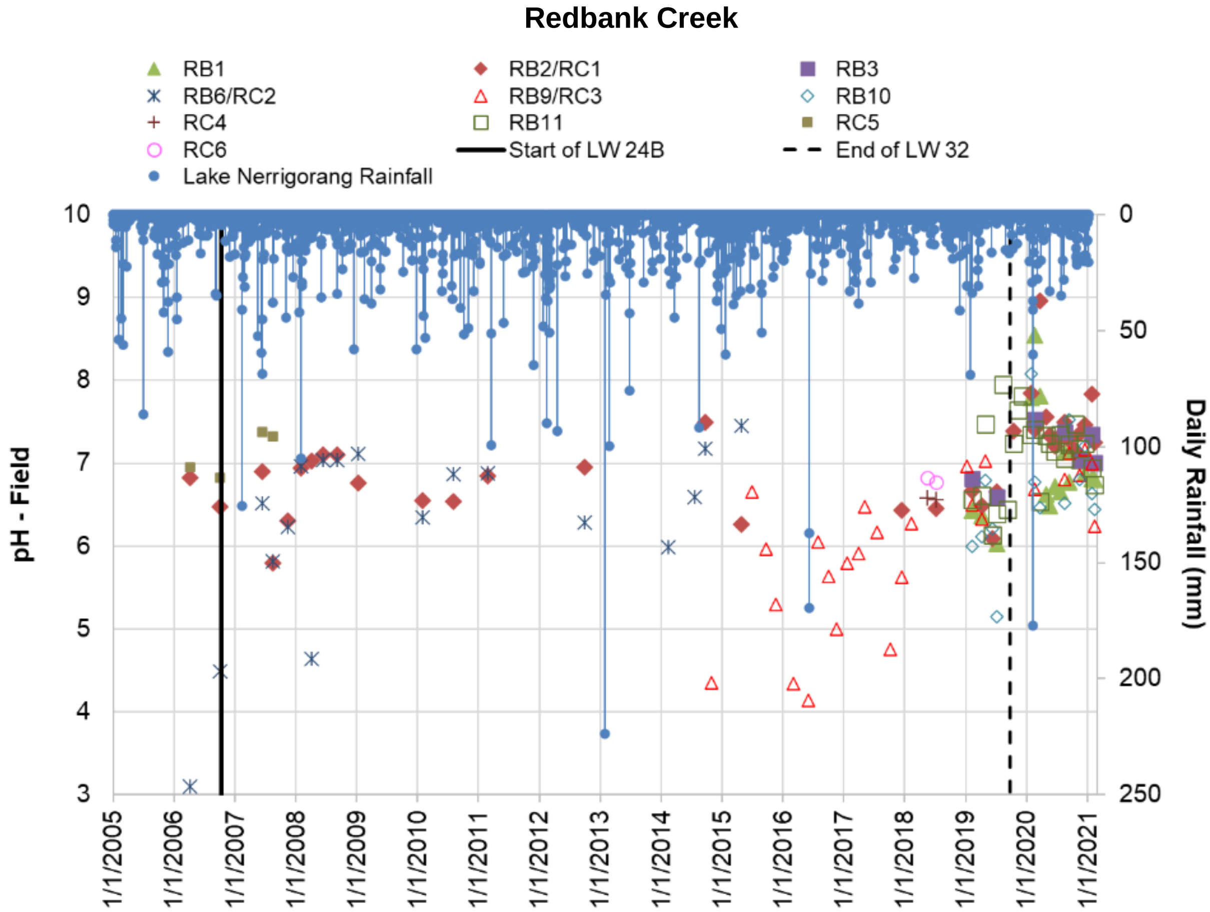



**Figure D12 Field pH Records**

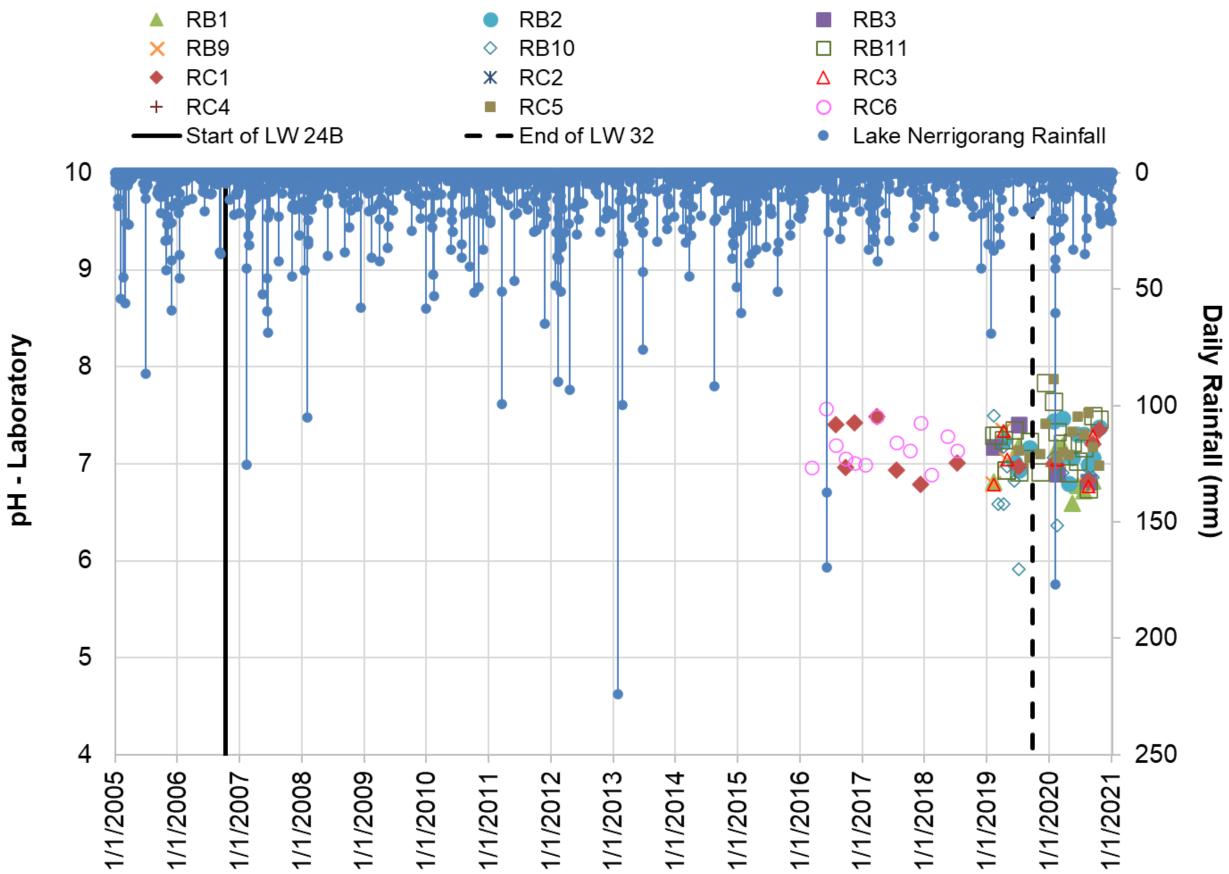



**Figure D13 Laboratory pH Records**

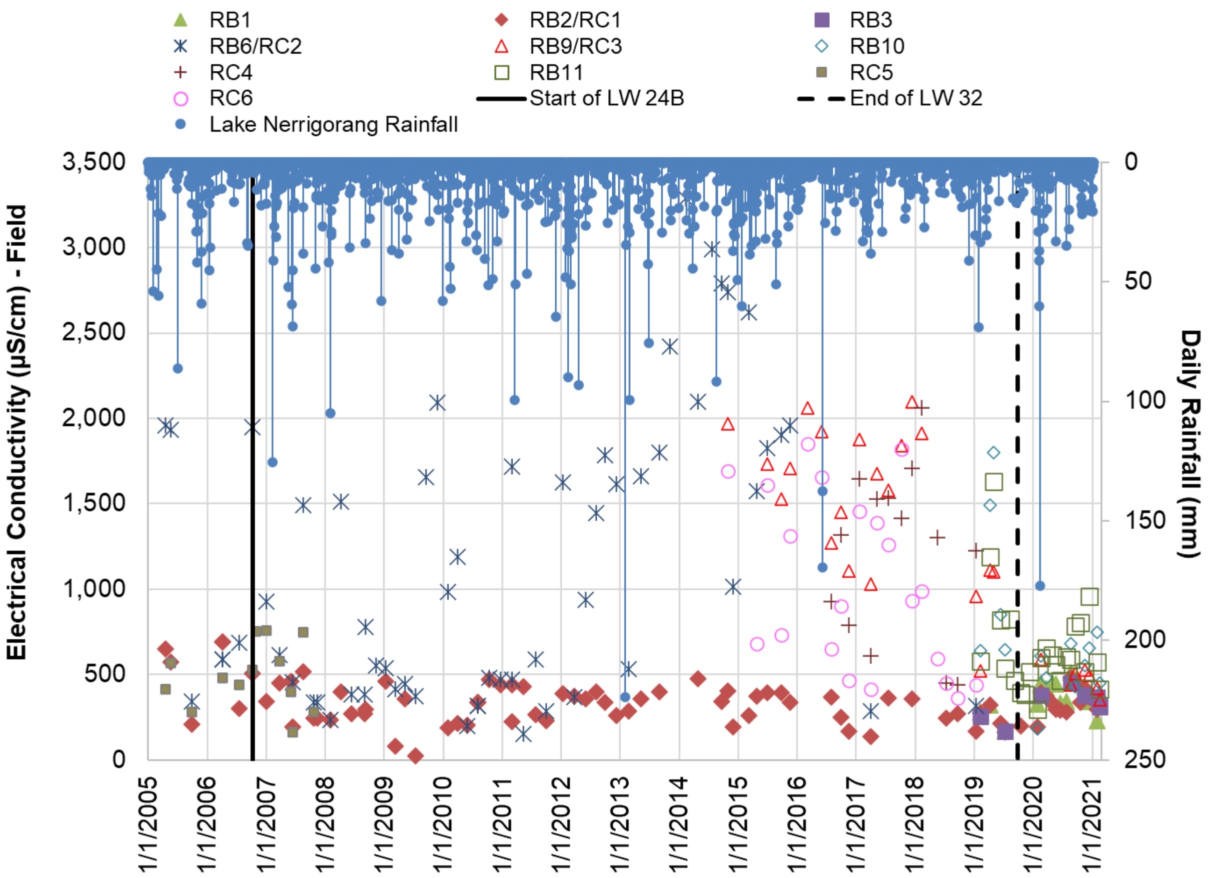



**Figure D14 Field Electrical Conductivity Records**

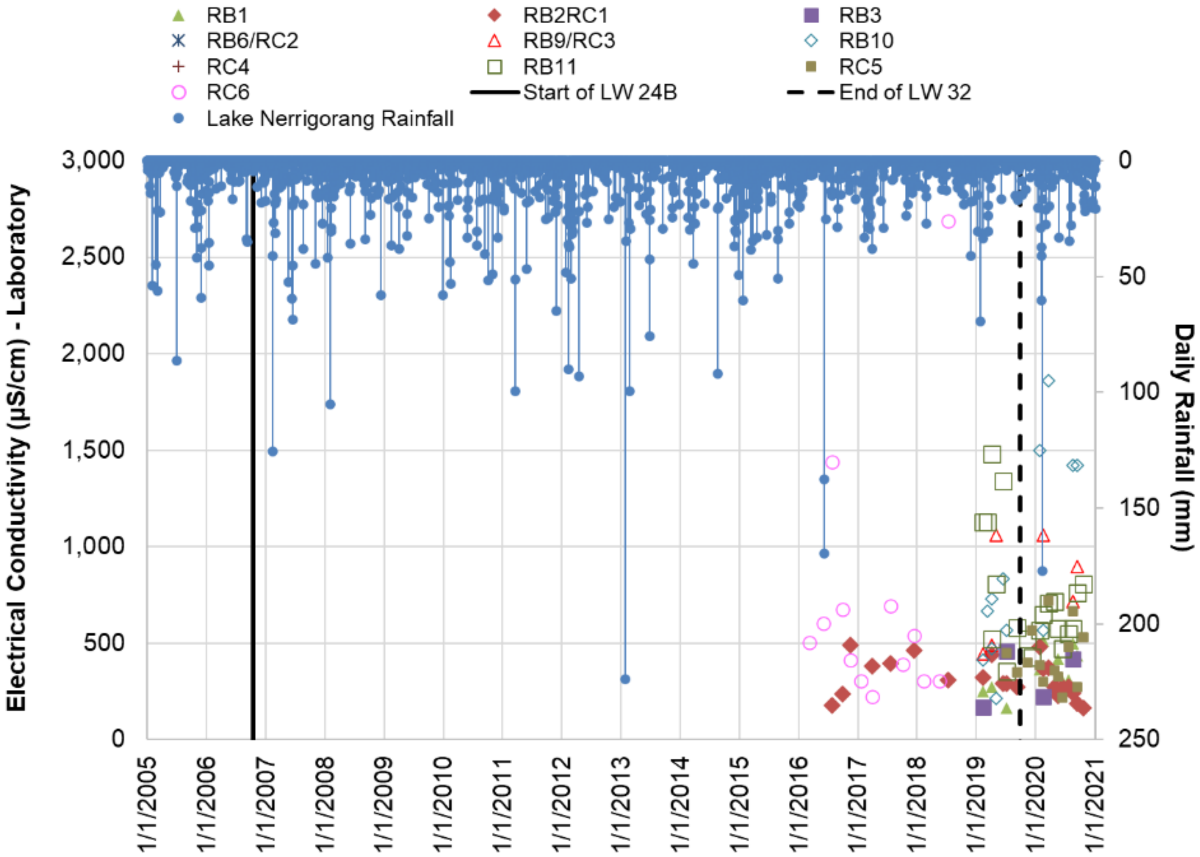



**Figure D15 Laboratory Electrical Conductivity Records**

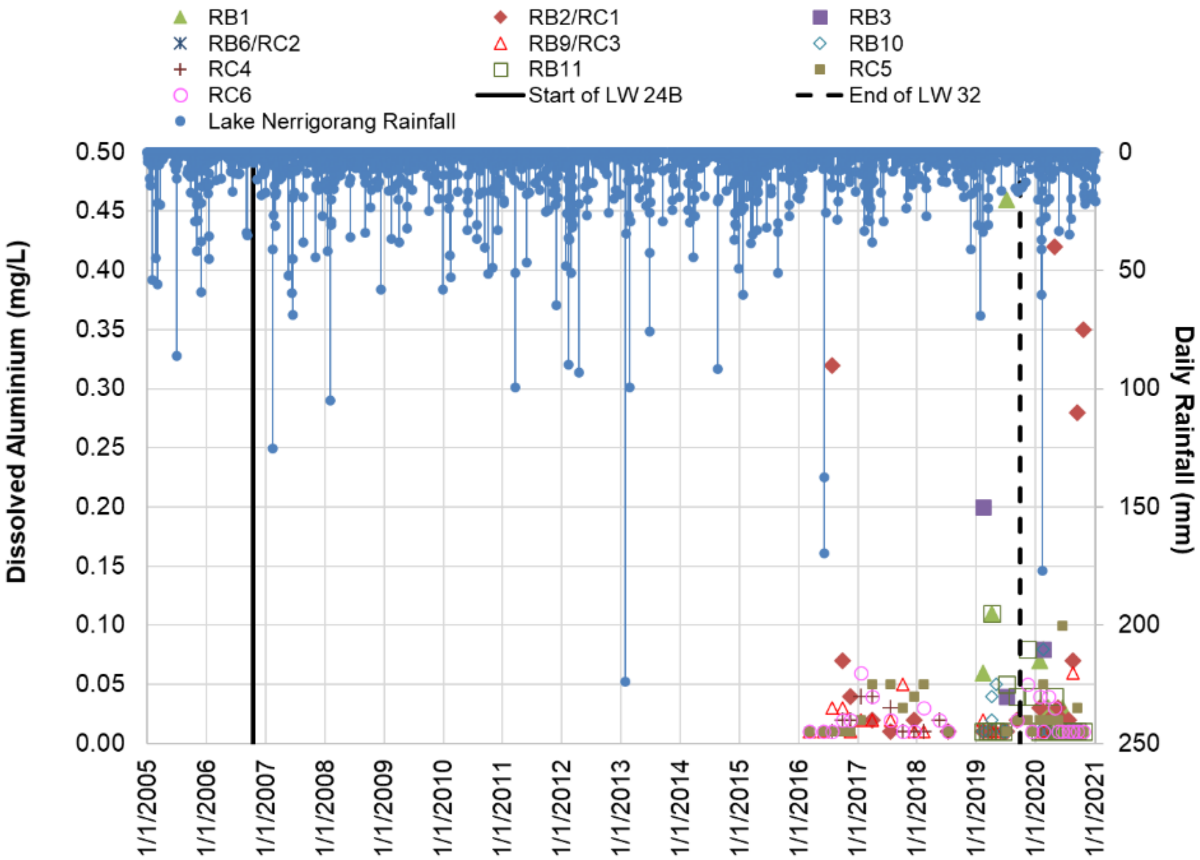
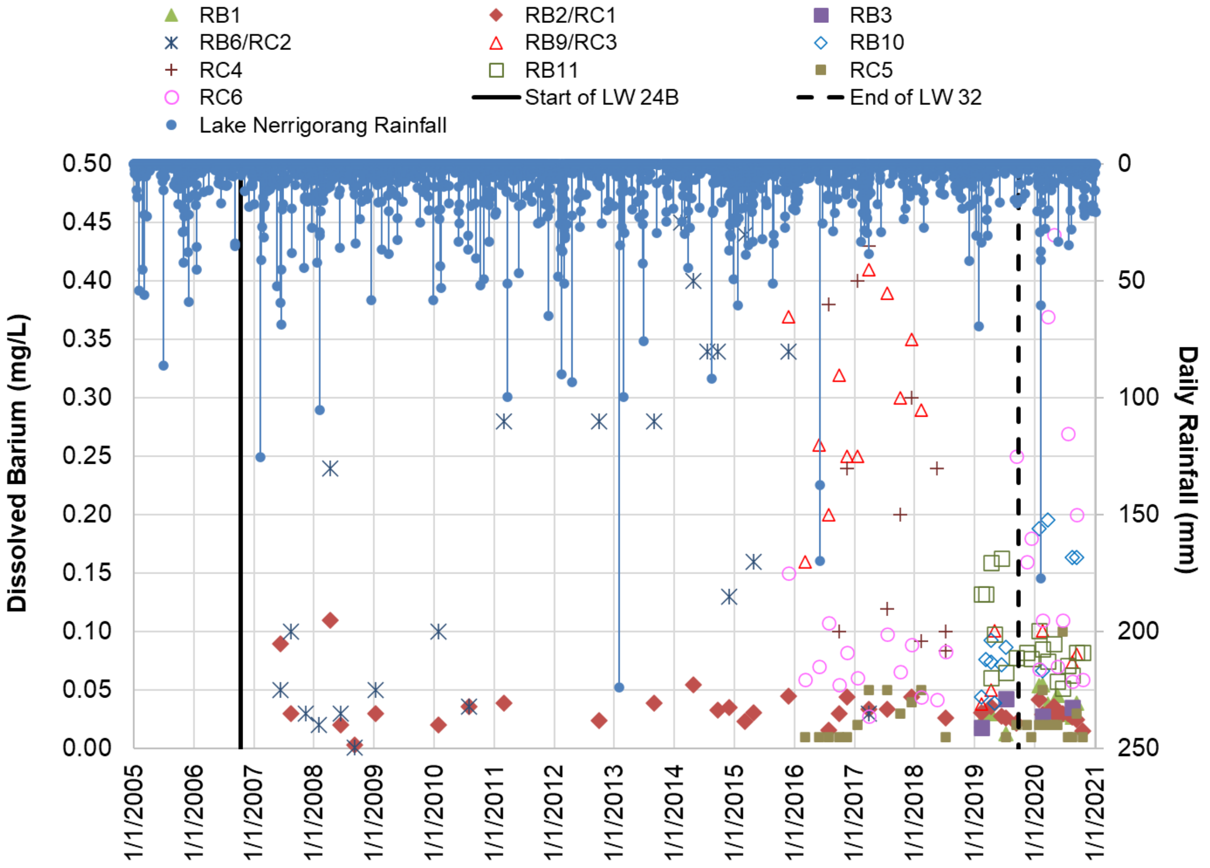
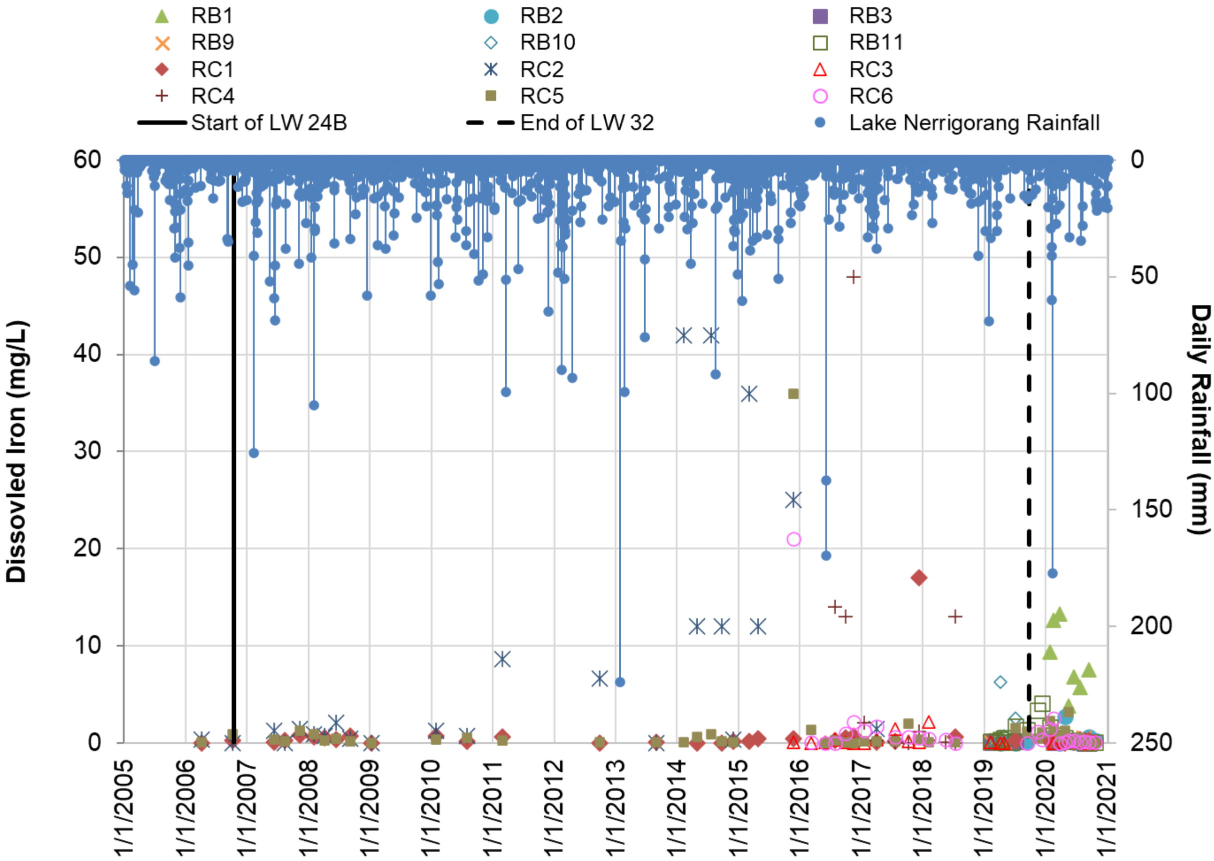


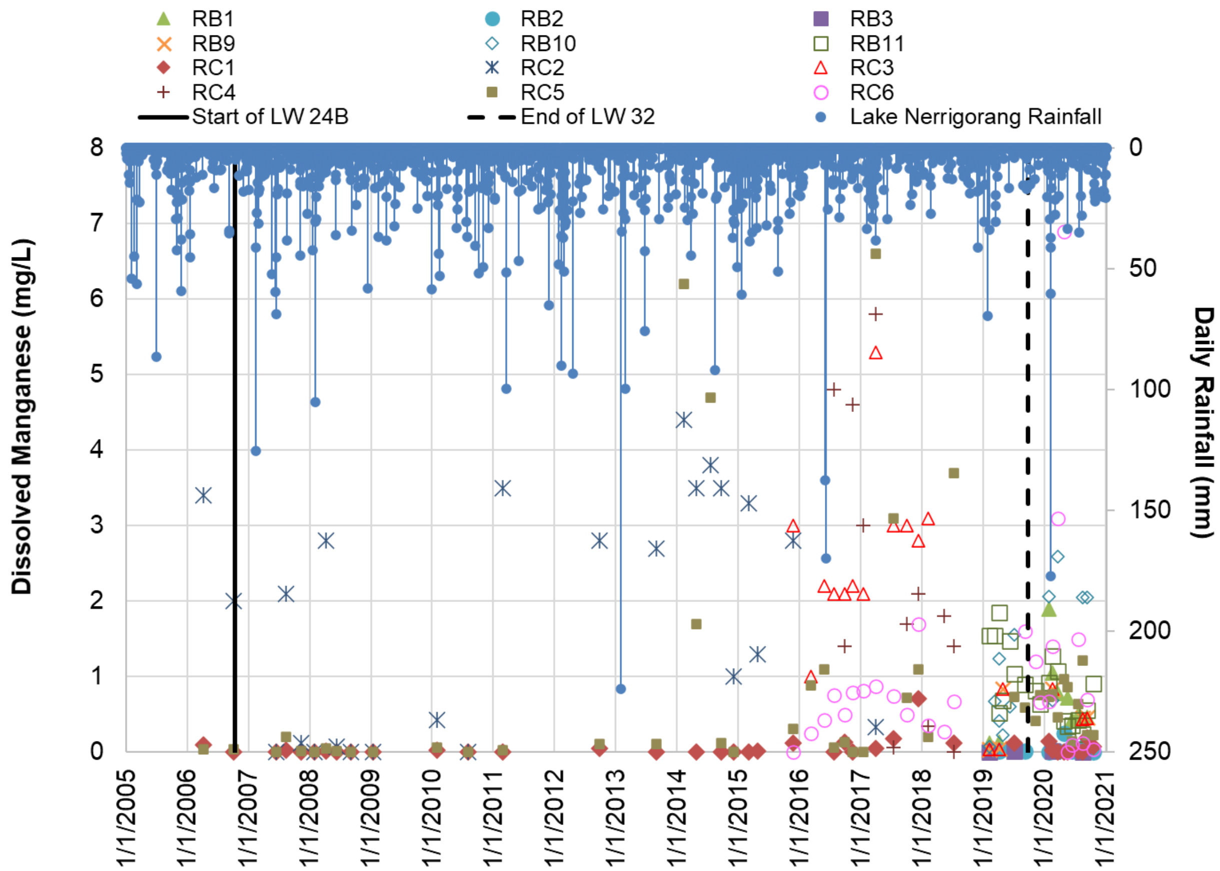

**Figure D16 Dissolved Aluminium Records**



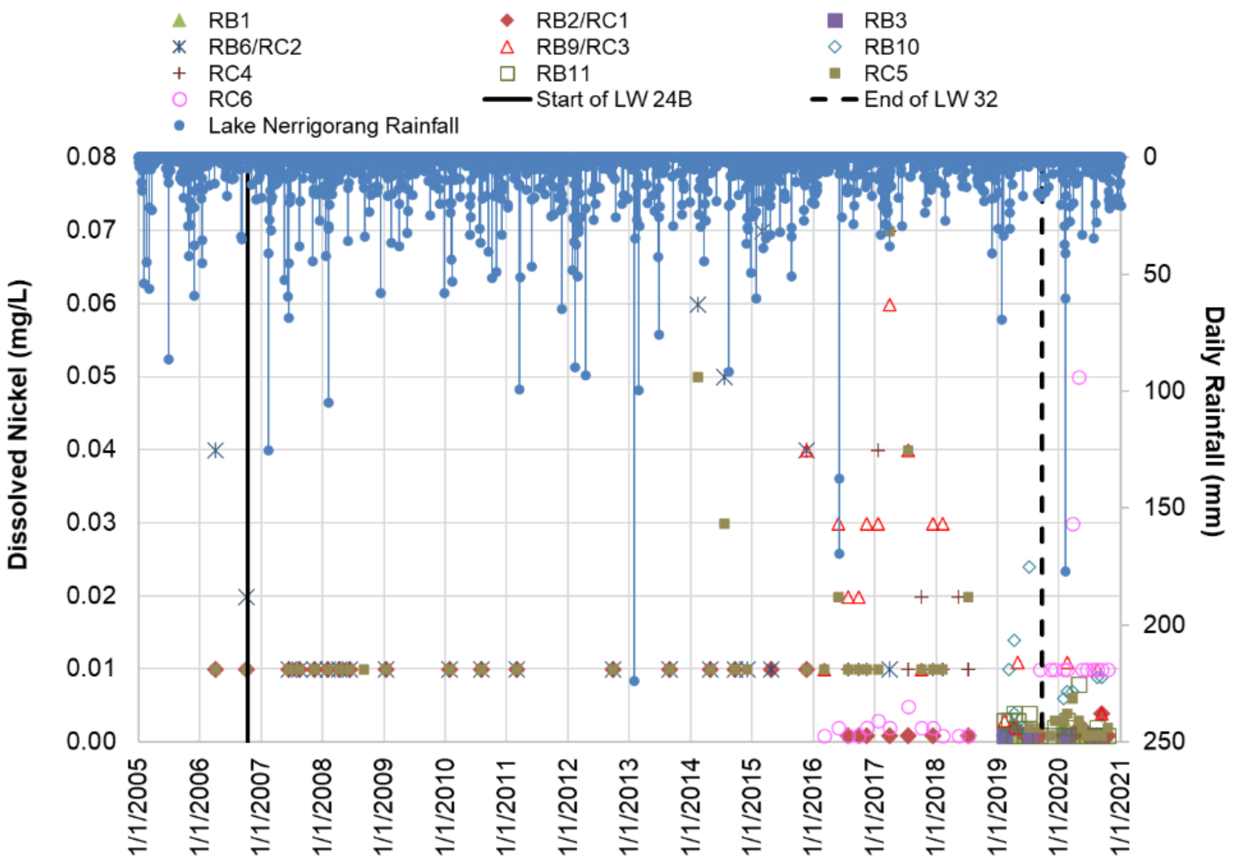

## Figure D17 Dissolved Barium Records



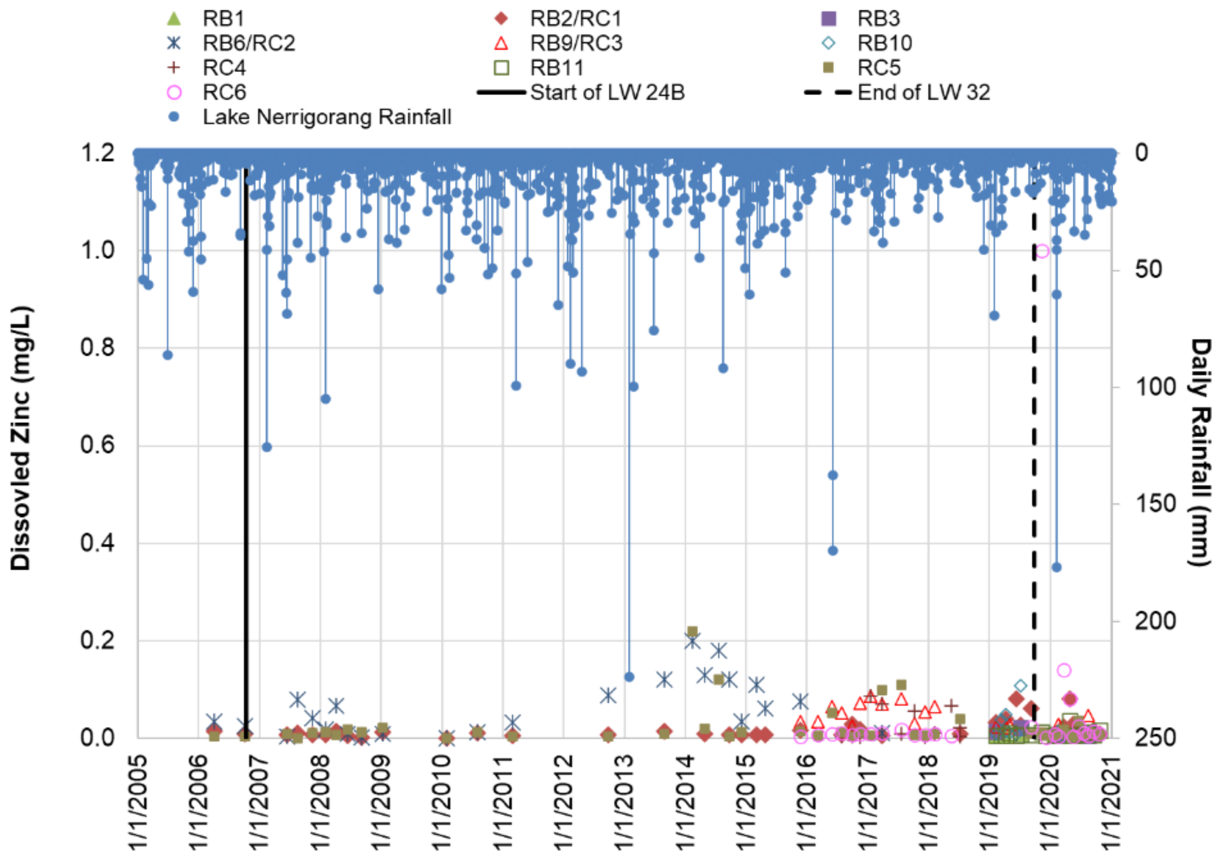

## Figure D18 Dissolved Iron Records



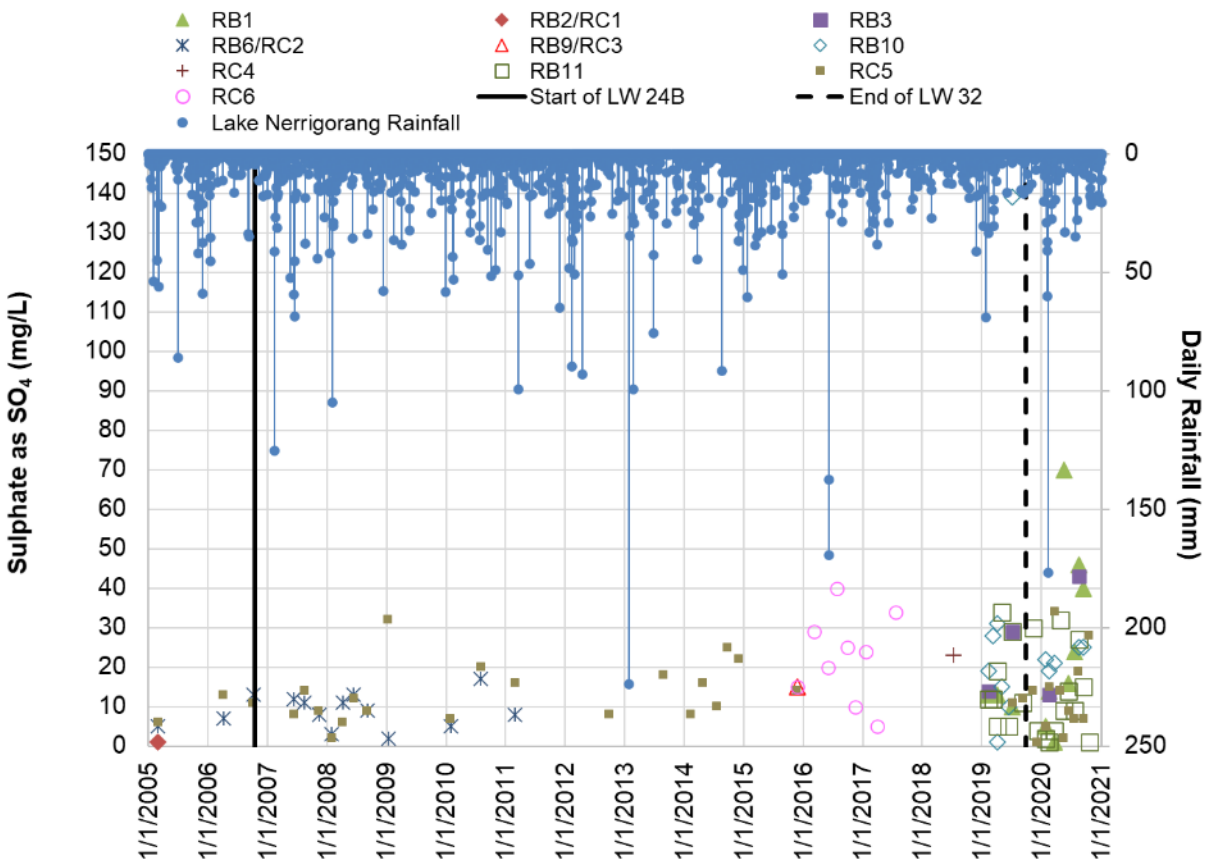

## Figure D19 Dissolved Manganese Records




## Figure D20 Dissolved Nickel Records




## Figure D21 Dissolved Zinc Records




## Figure D22 Sulphate Records

# APPENDIX E – LOCAL TRIBUTARY FLOOD REGIME FIGURES

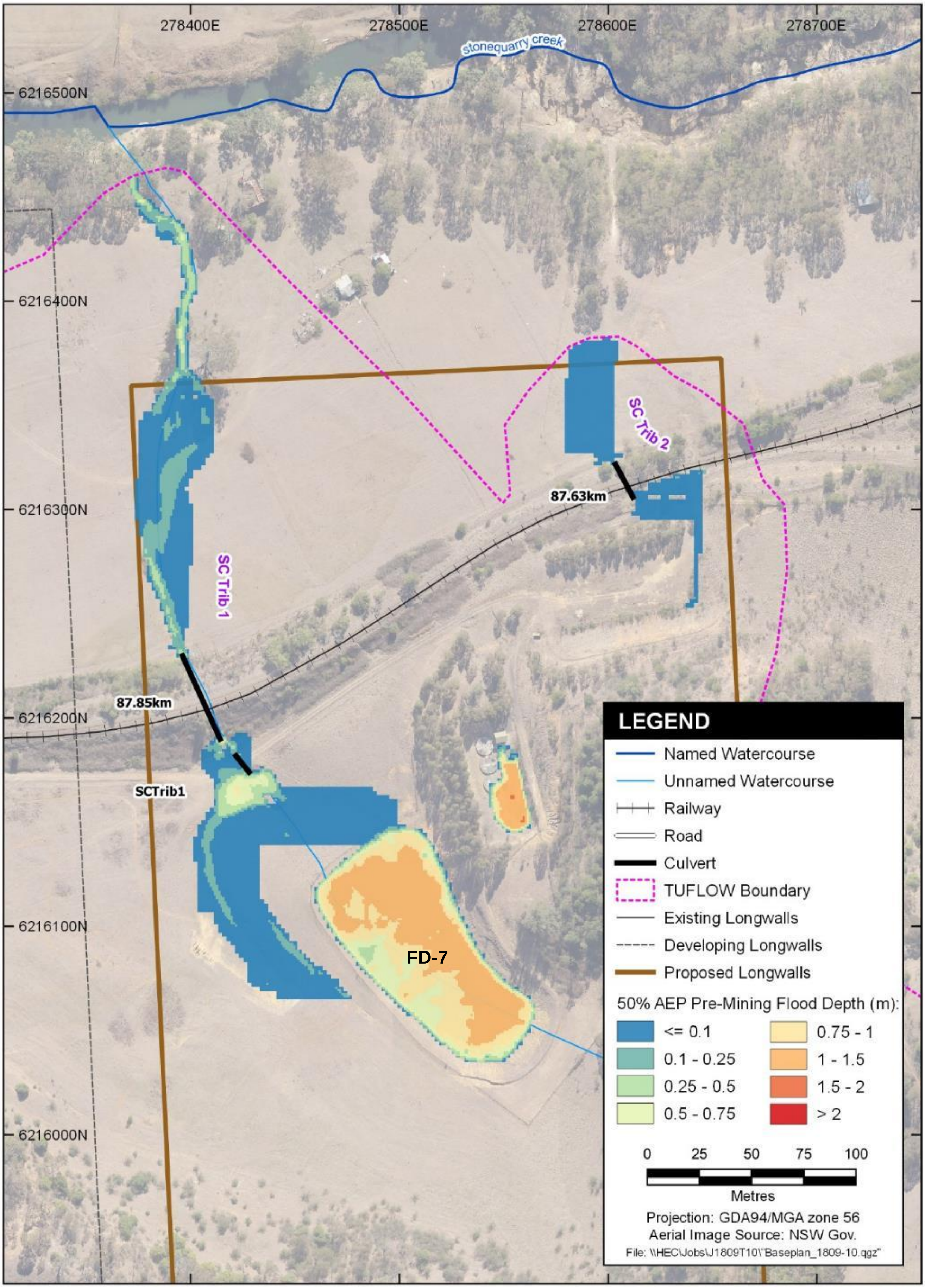



**Figure E1 50% AEP Pre-Mining Modelled Flood Depth – SC Trib 1 and SC Trib 2**

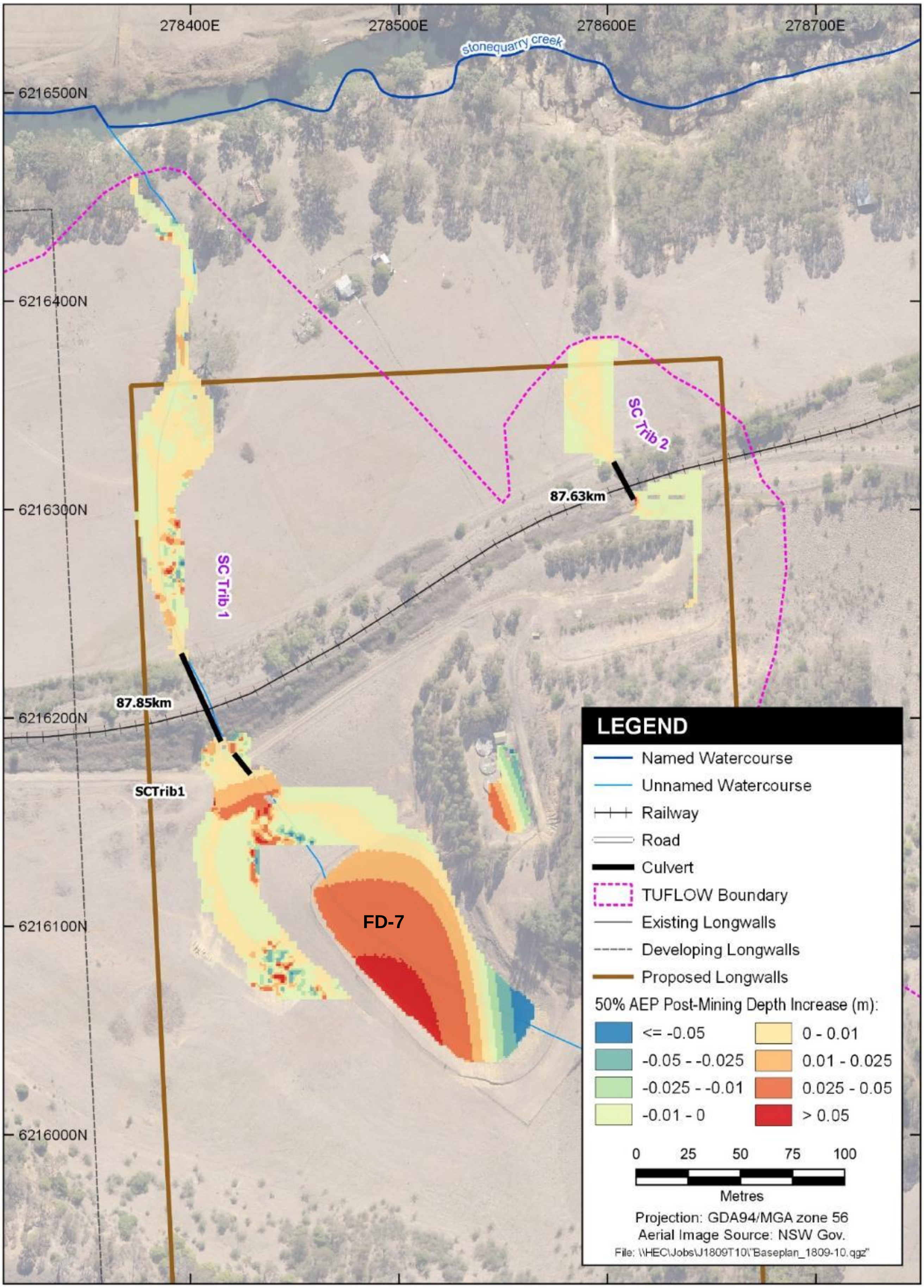



**Figure E2 50% AEP Post-Mining Modelled Flood Depth Increase – SC Trib 1 and SC Trib 2**

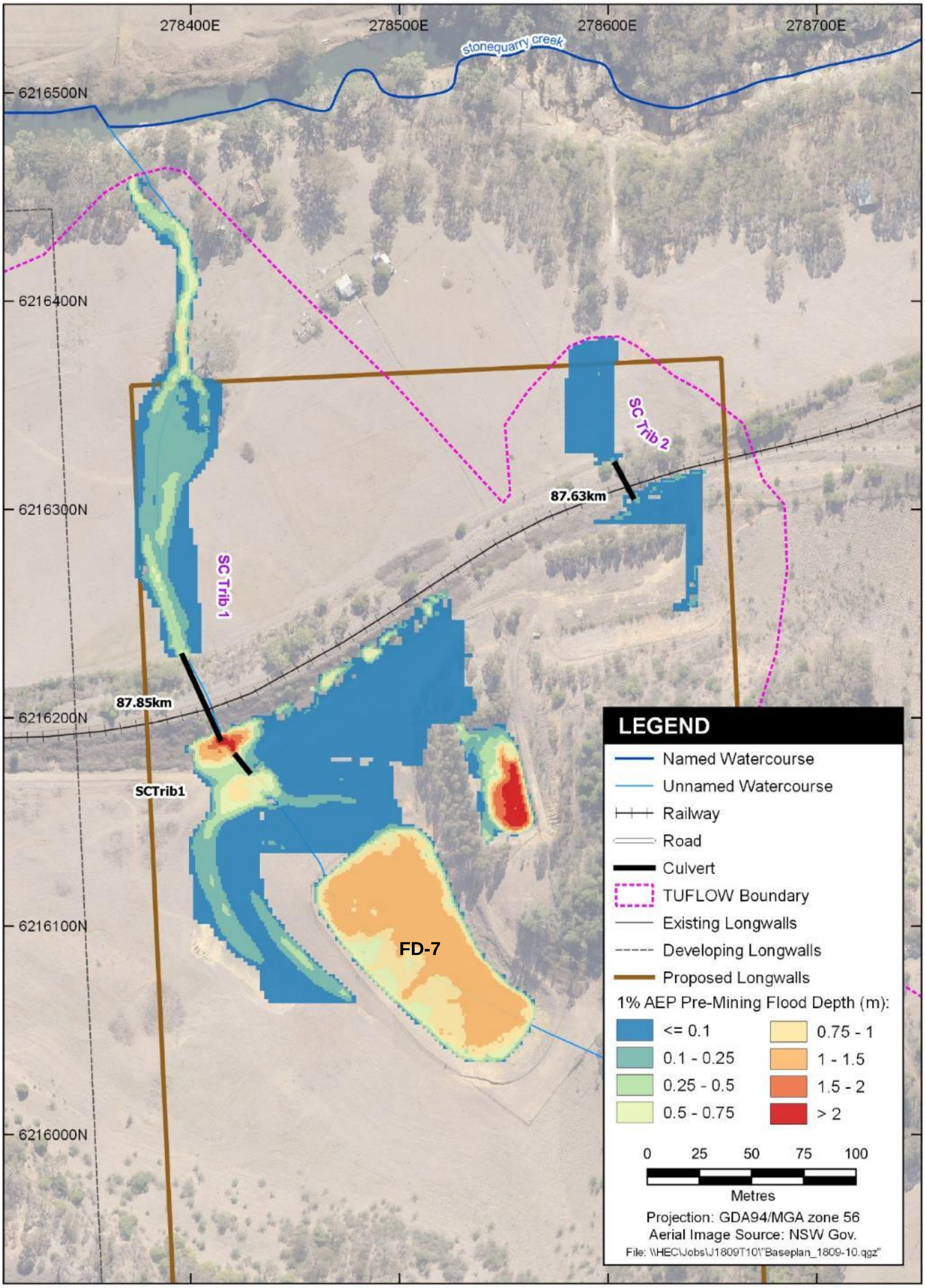



**Figure E3 1% AEP Pre-Mining Modelled Flood Depth – SC Trib 1 and SC Trib 2**

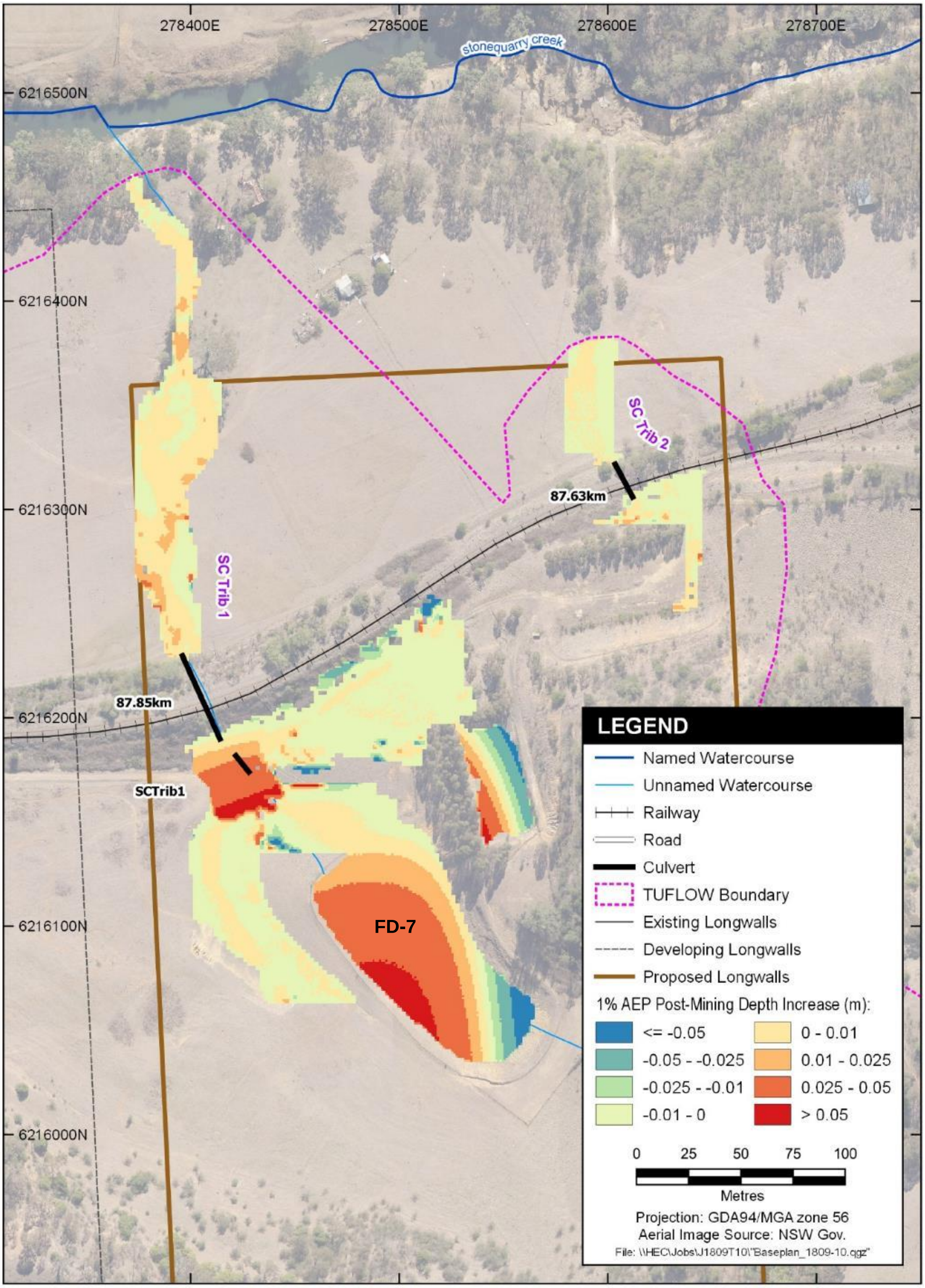



**Figure E4 1% AEP Post-Mining Modelled Flood Depth Increase – SC Trib 1 and SC Trib 2**

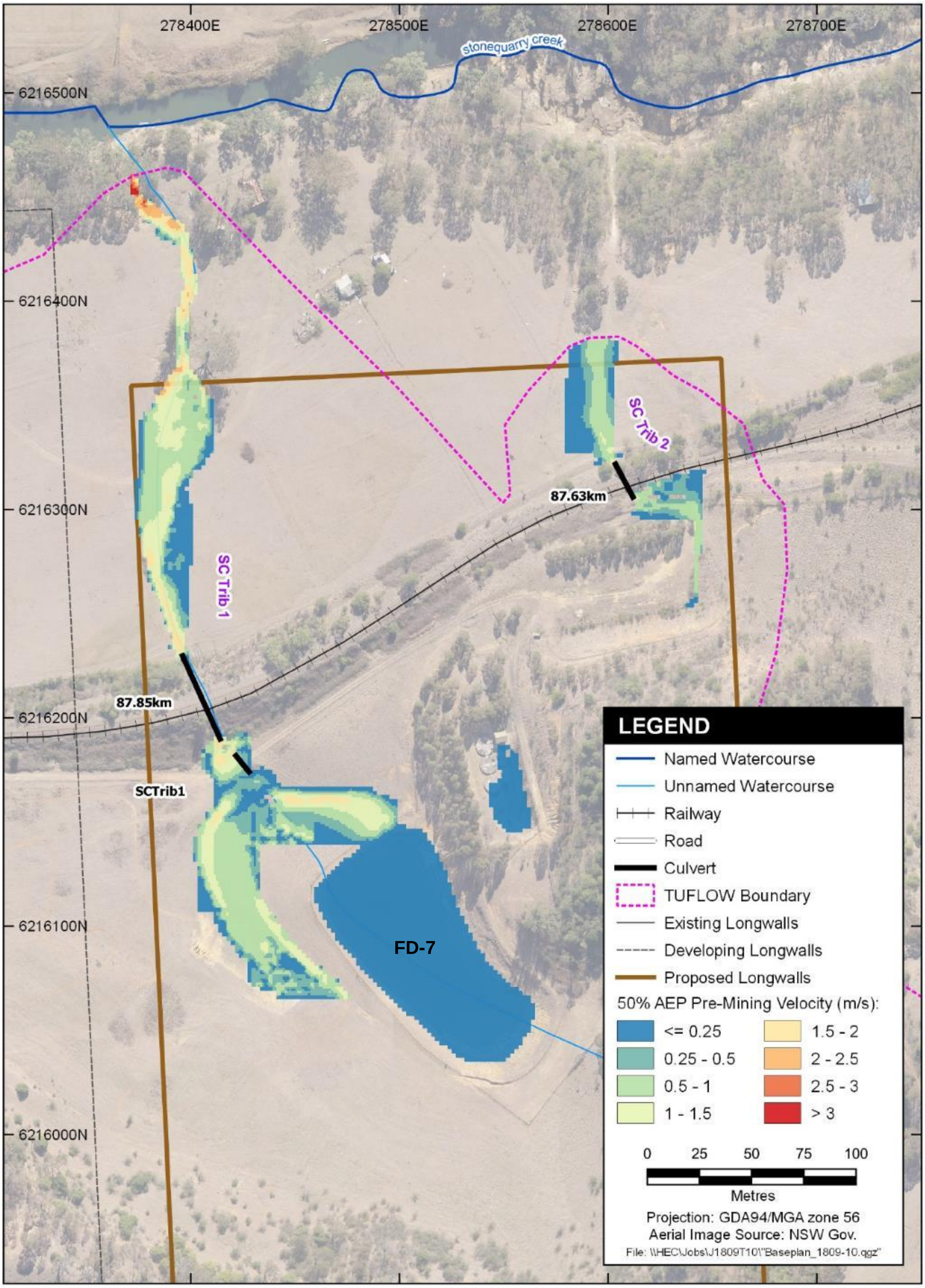



**Figure E5 50% AEP Pre-Mining Modelled Velocity - SC Trib 1 and SC Trib 2**

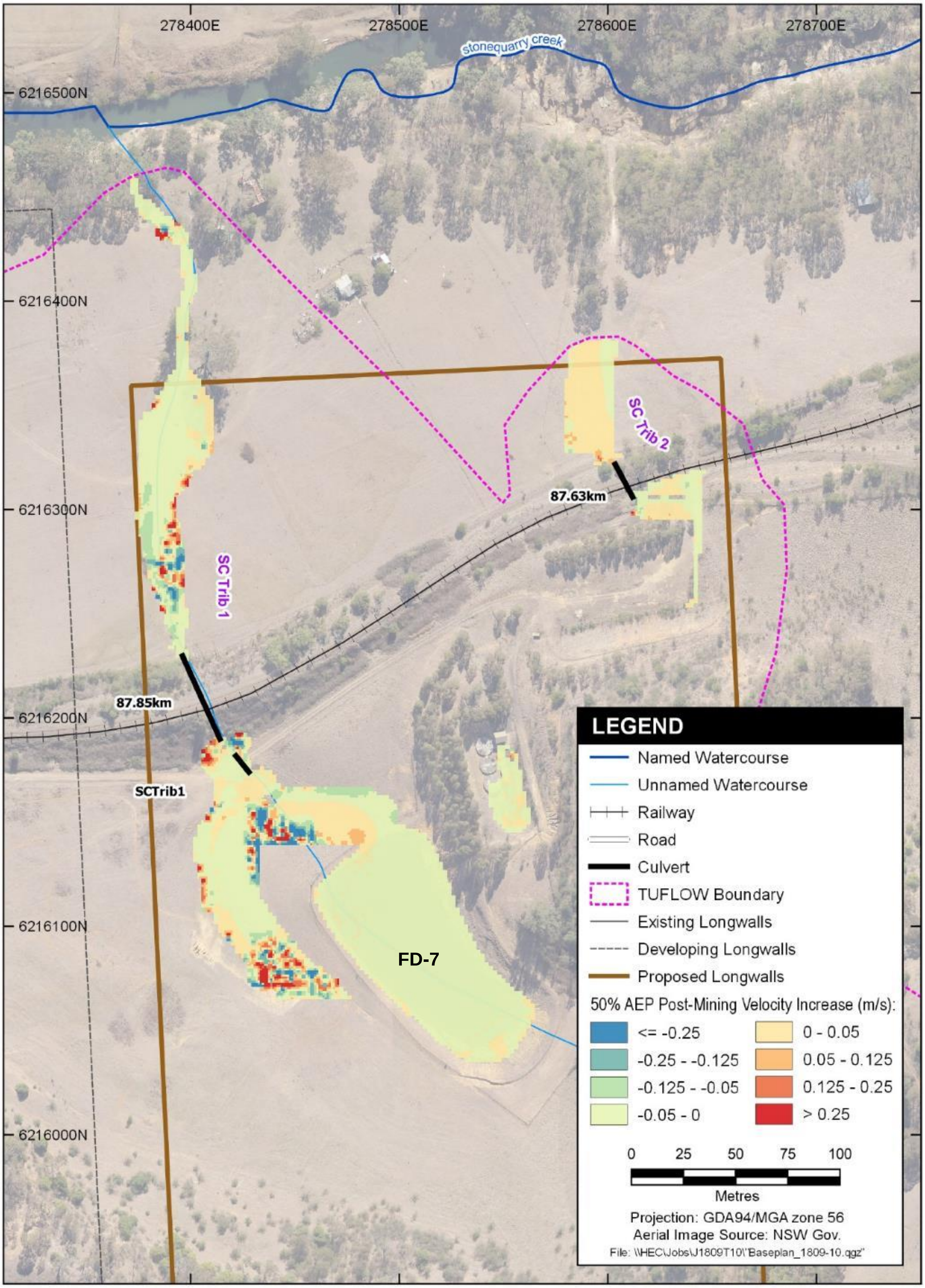



**Figure E6 50% AEP Post-Mining Modelled Velocity Increase – SC Trib 1 and SC Trib 2**

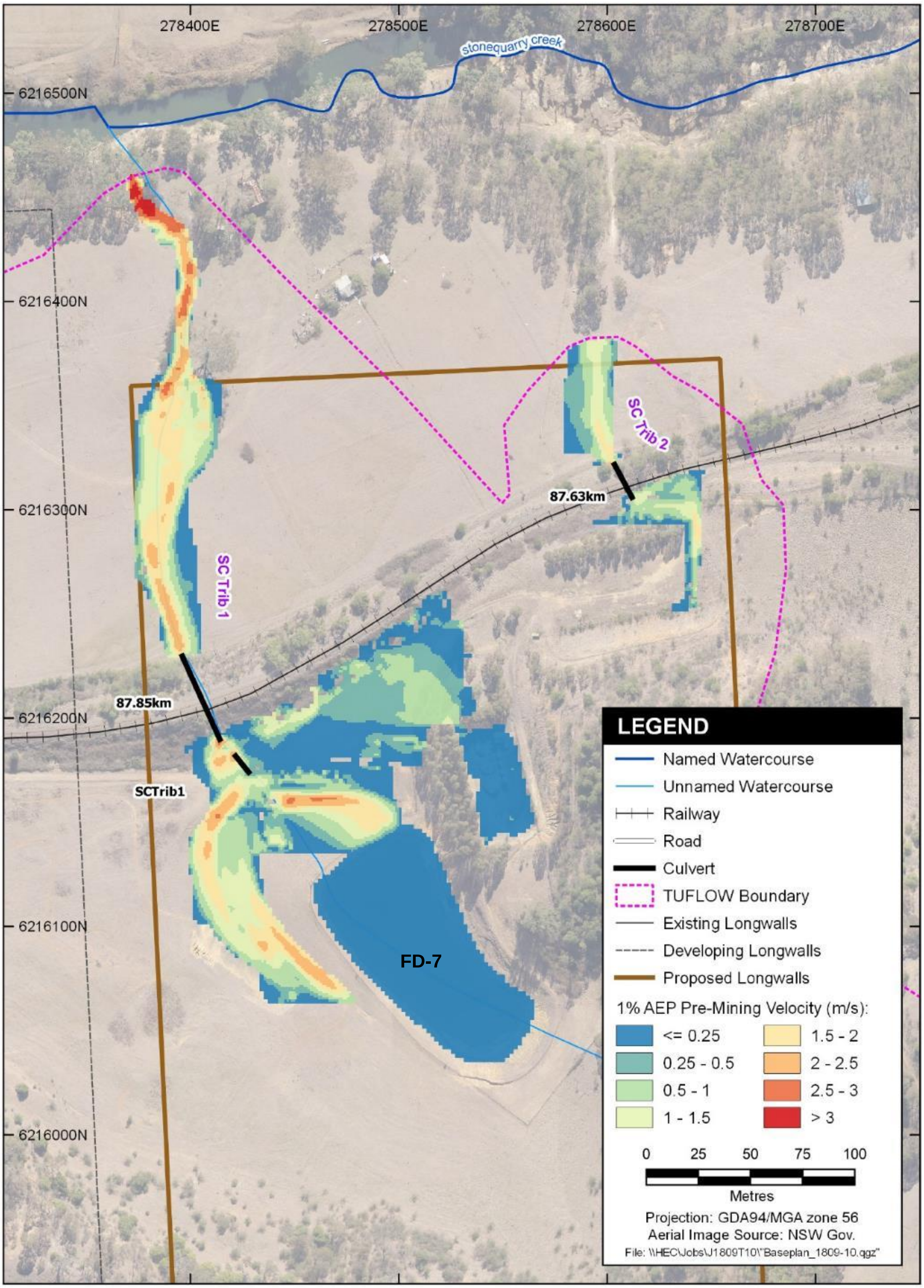



**Figure E7 1% AEP Pre-Mining Modelled Velocity – SC Trib 1 and SC Trib 2**

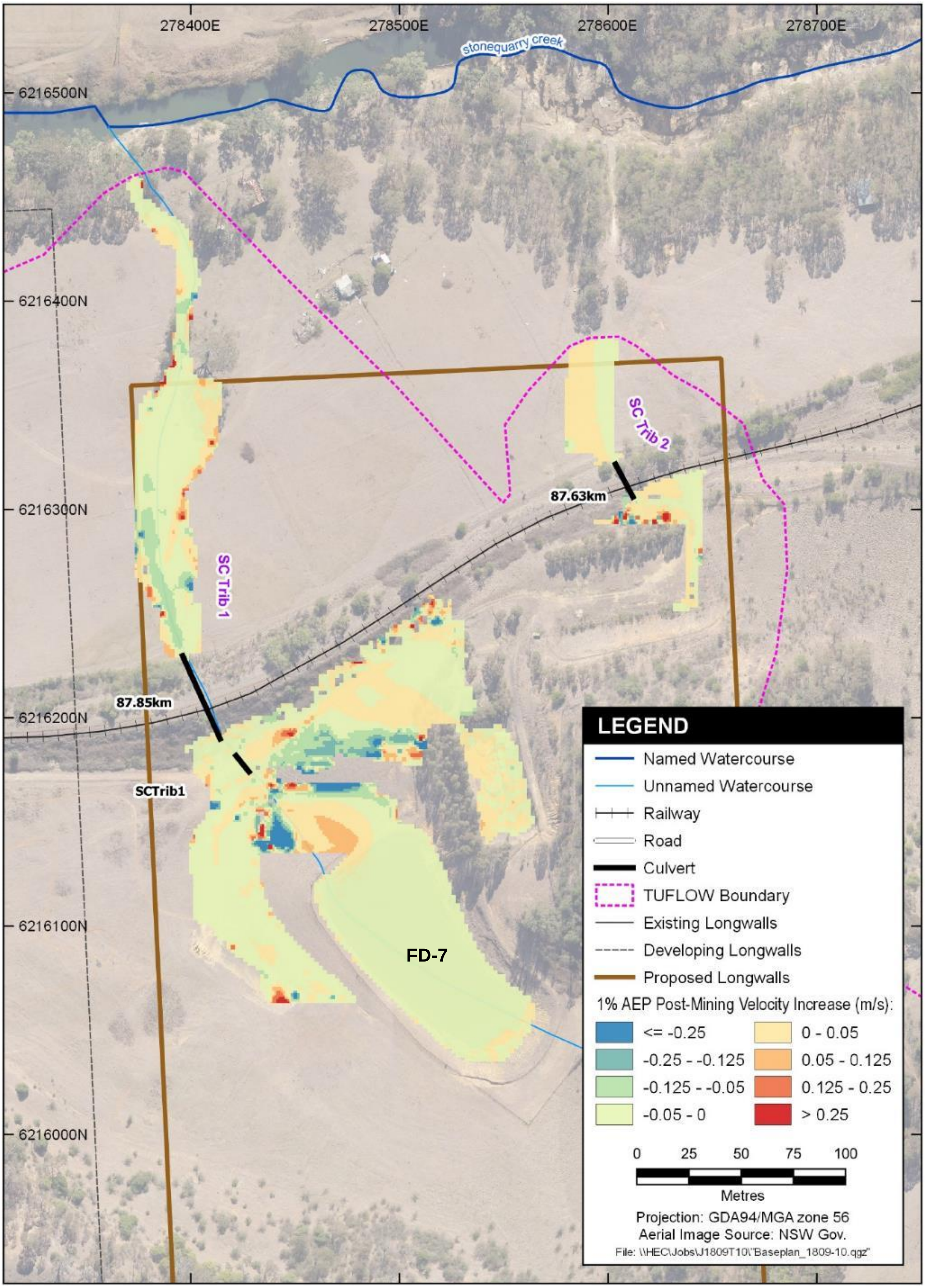



**Figure E8 1% AEP Pre-Mining Modelled Velocity Increase – SC Trib 1 and SC Trib 2**

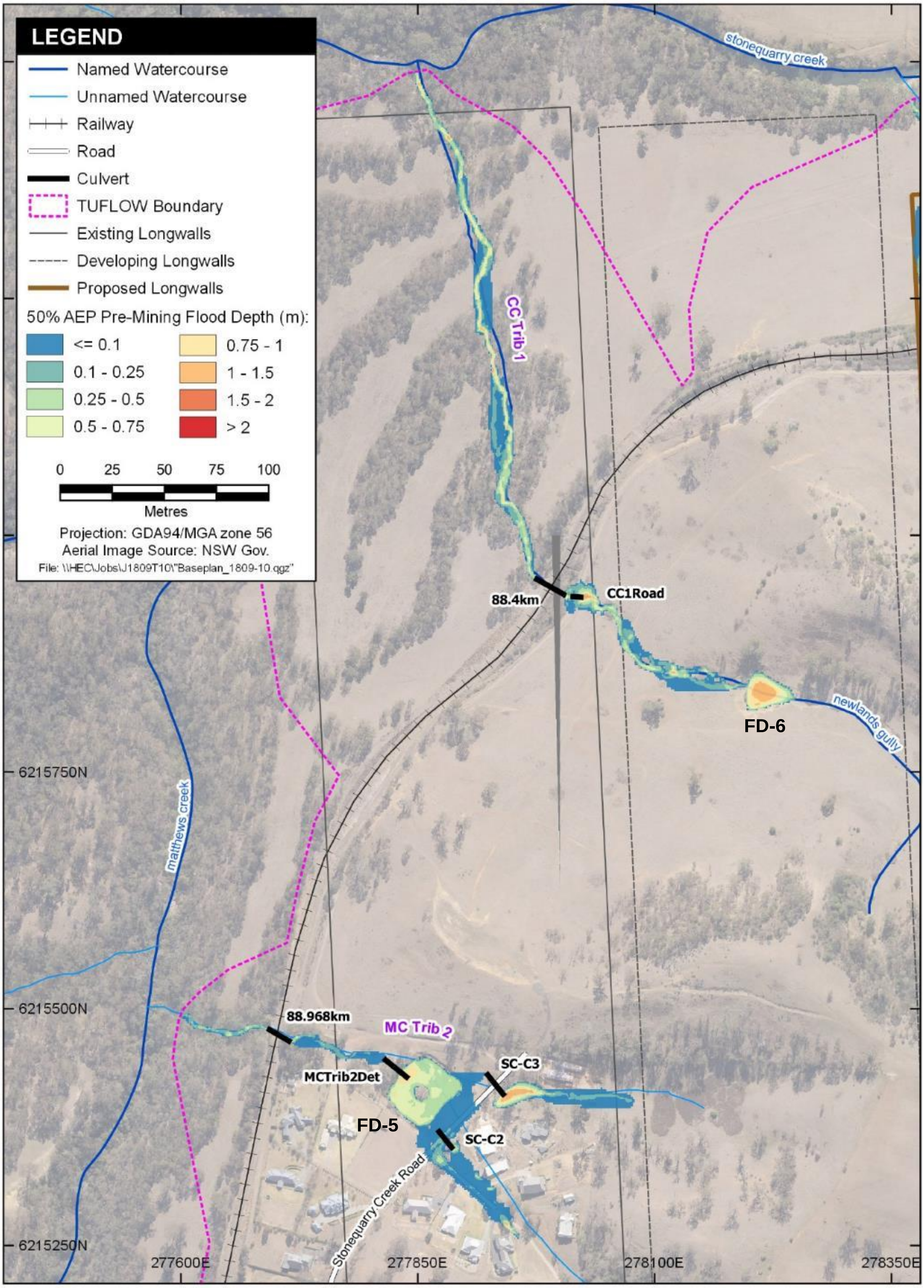



**Figure E9 50% AEP Pre-Mining Modelled Flood Depth – MC Trib 2 and CC Trib 1**

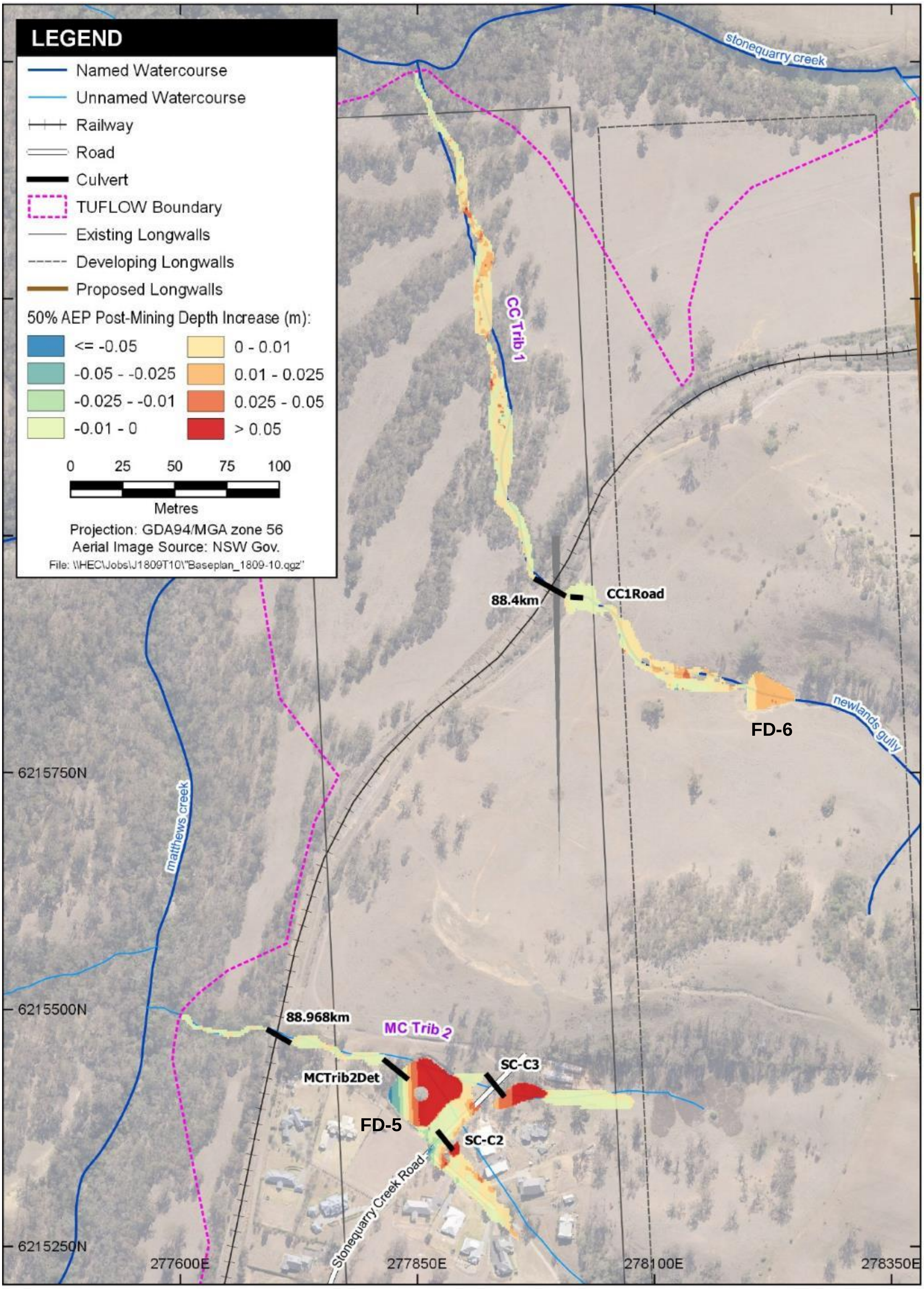



**Figure E10 50% AEP Post-Mining Modelled Flood Depth Increase – MC Trib 2 and CC Trib 1**

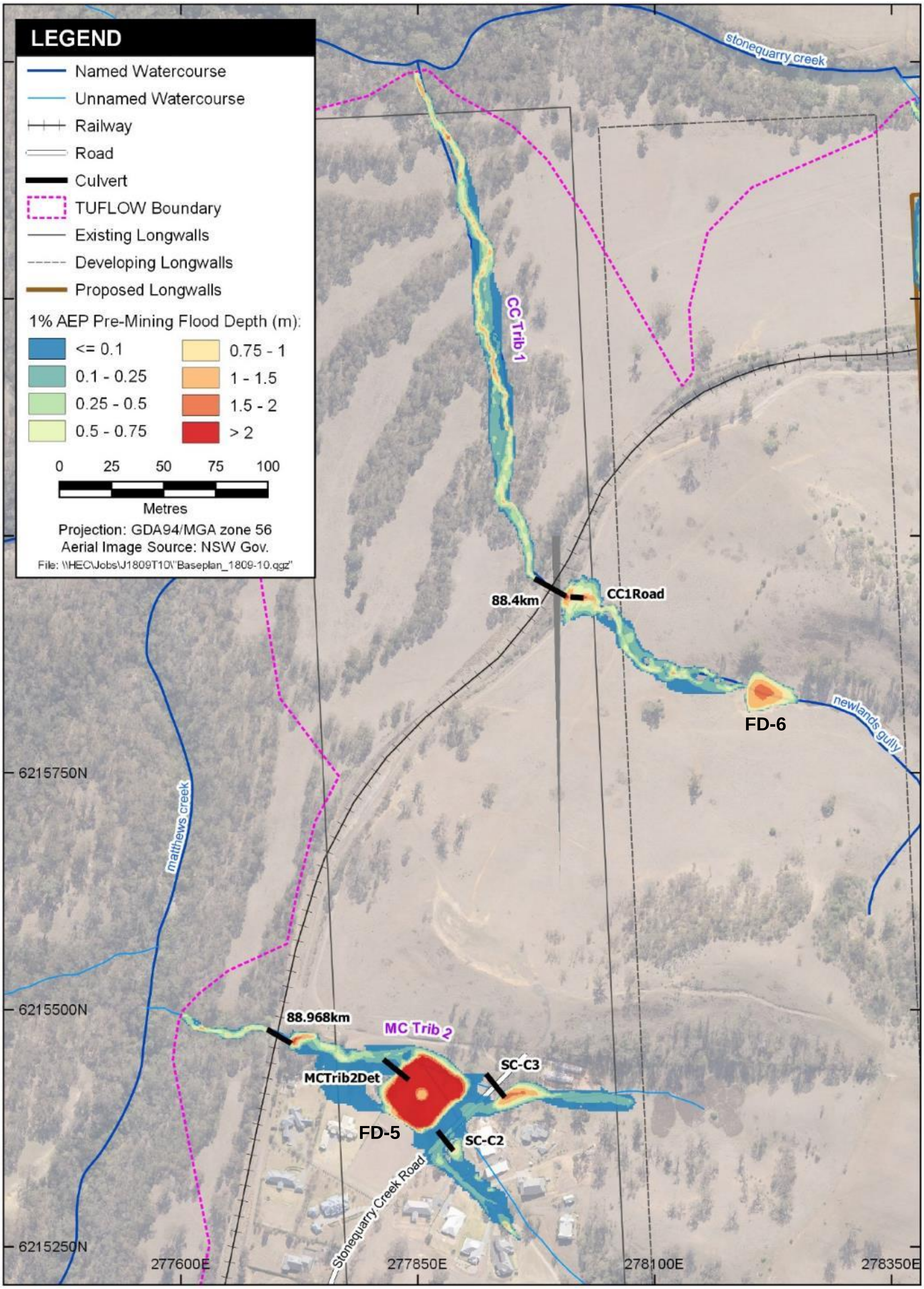



**Figure E11 1% AEP Pre-Mining Modelled Flood Depth – MC Trib 2 and CC Trib 1**

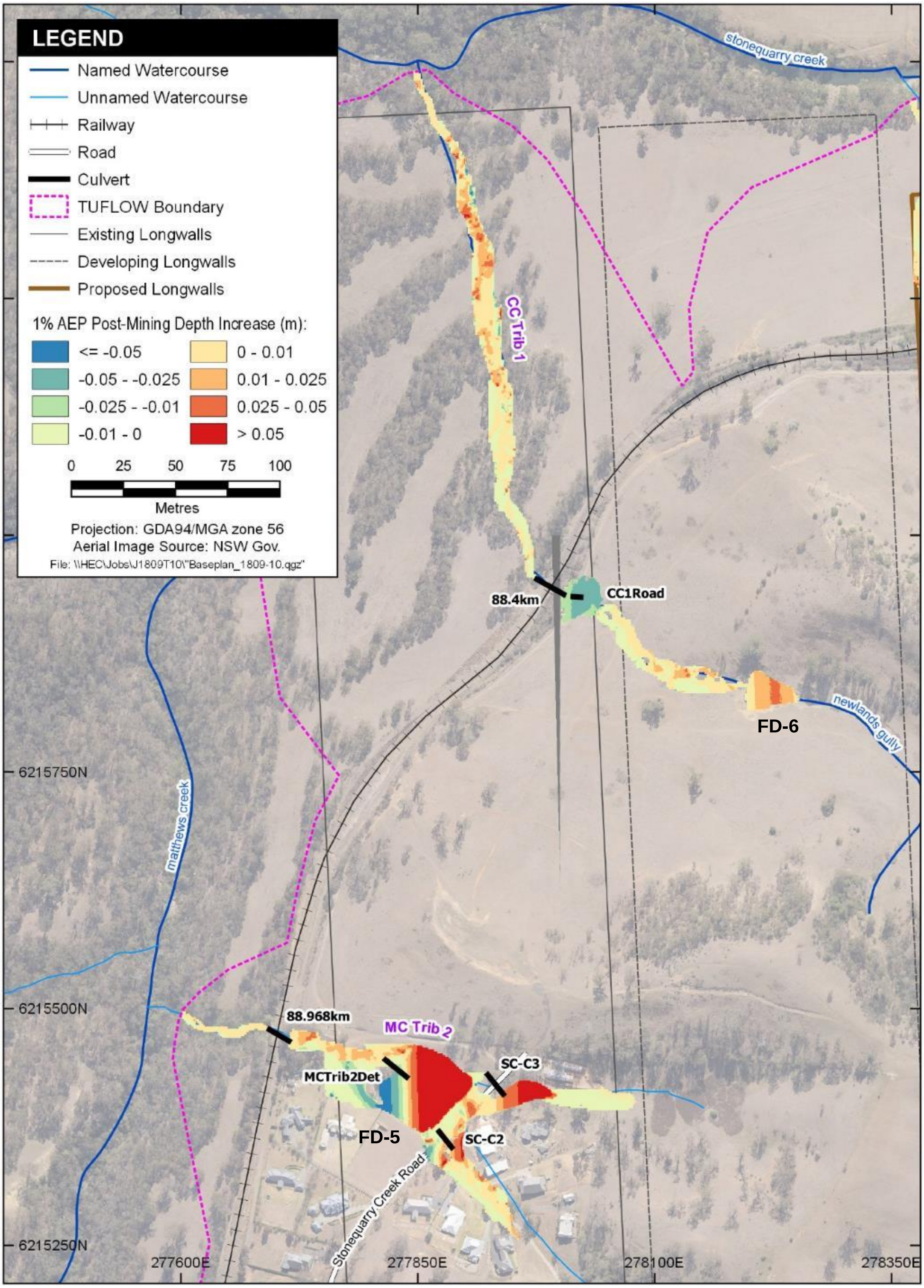



**Figure E12 1% AEP Post-Mining Modelled Flood Depth Increase – MC Trib 2 and CC Trib 1**

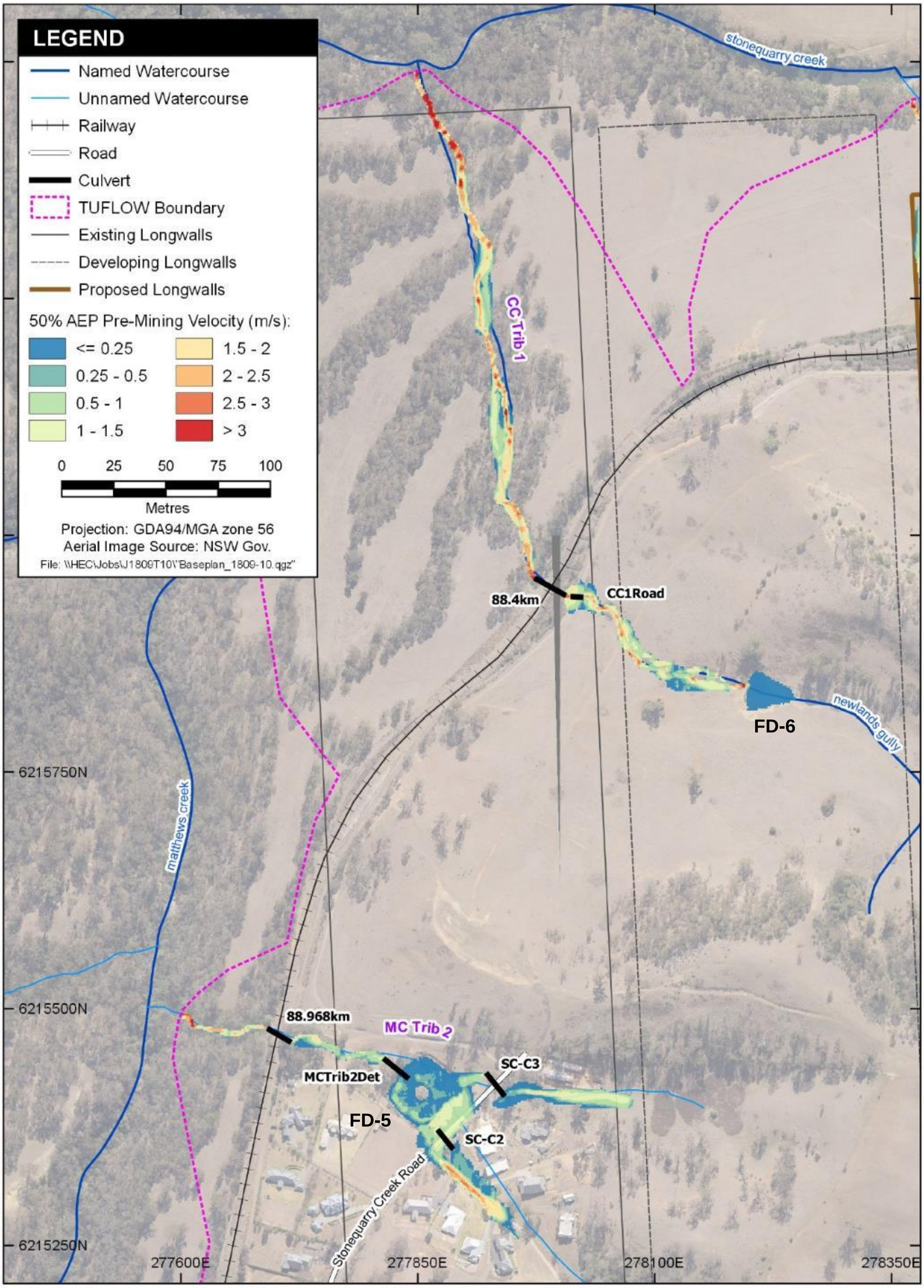



**Figure E13 50% AEP Pre-Mining Modelled Velocity - MC Trib 2 and CC Trib 1**

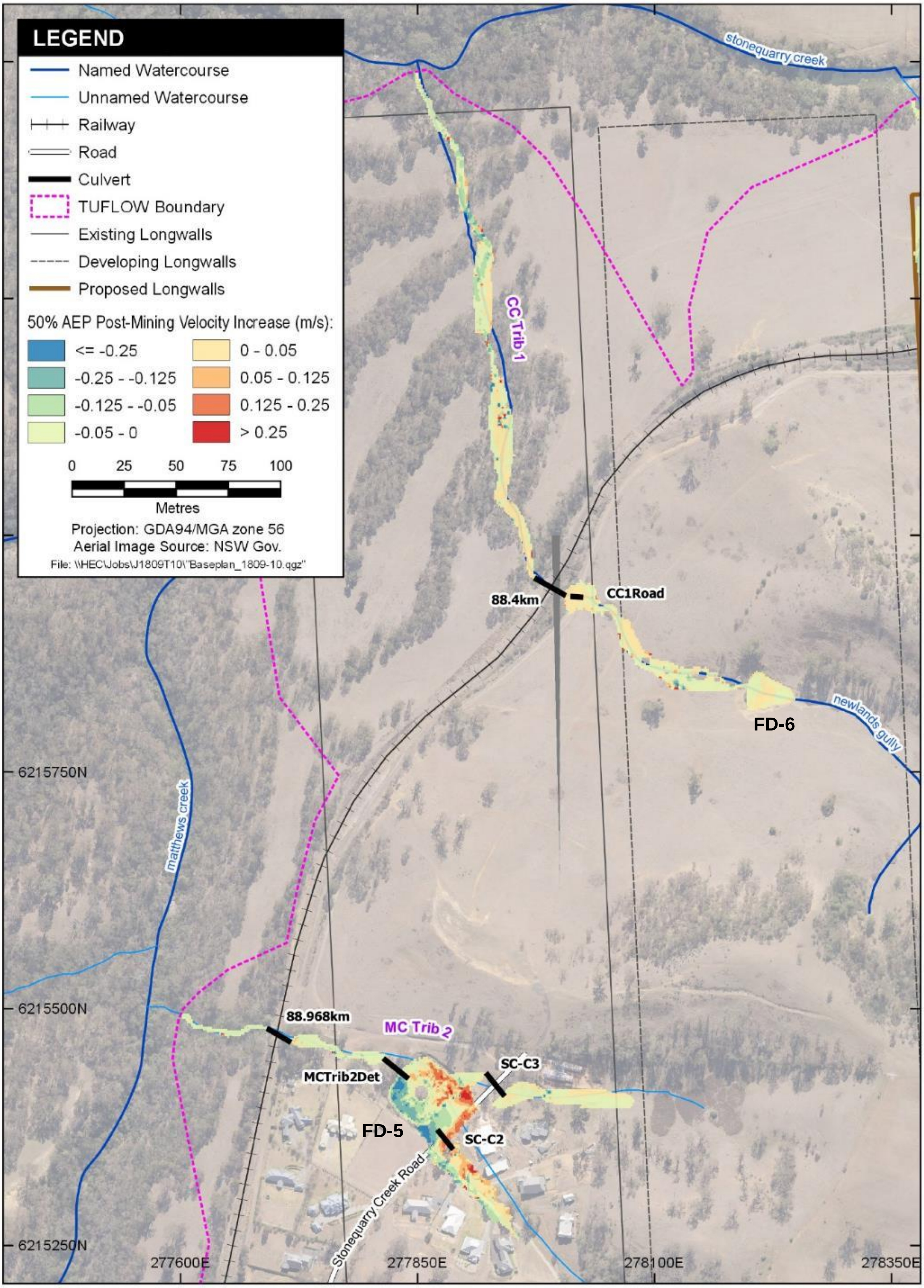



**Figure E14 50% AEP Post-Mining Modelled Velocity Increase – MC Trib 2 and CC Trib 1**

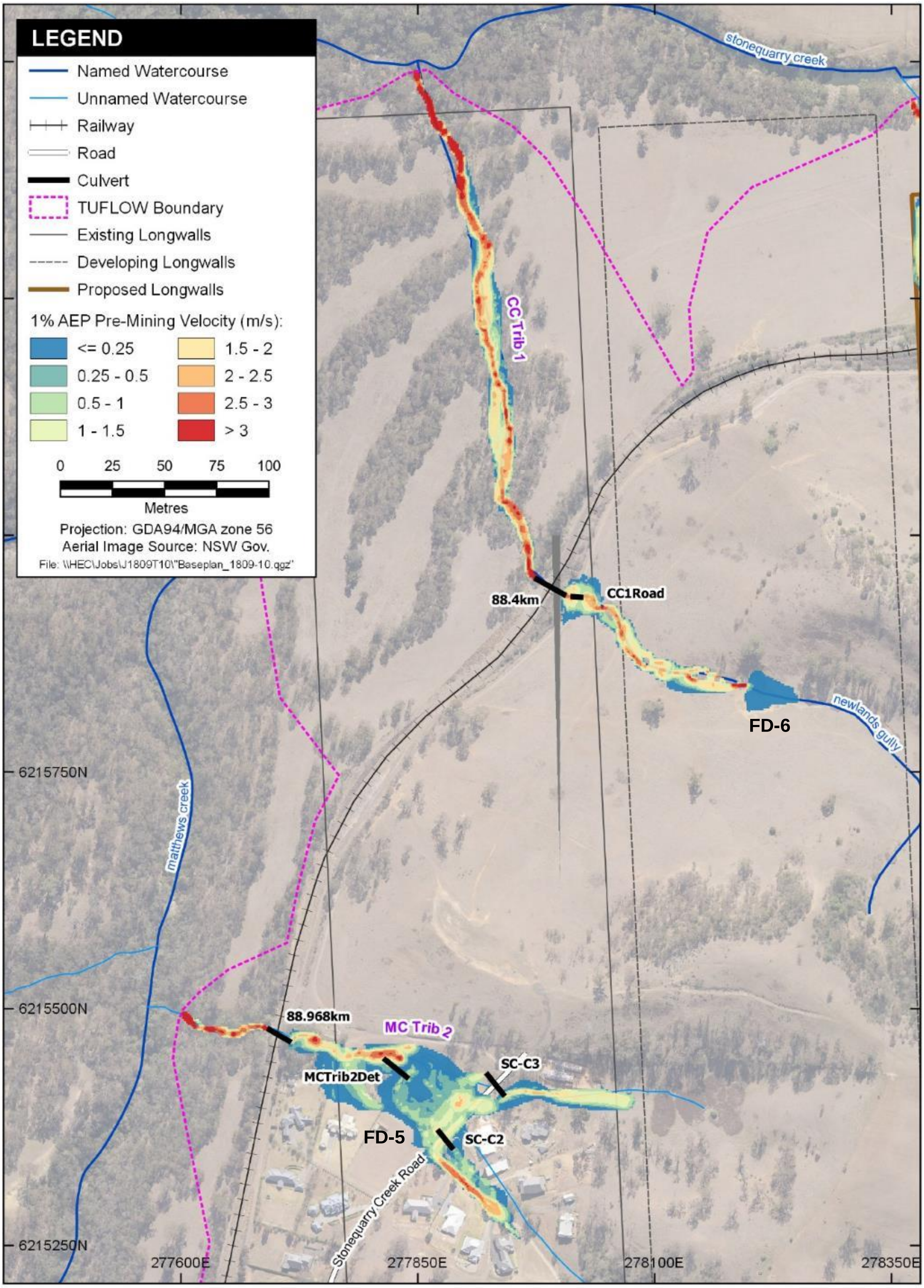



**Figure E15 1% AEP Pre-Mining Modelled Velocity – MC Trib 2 and CC Trib 1**

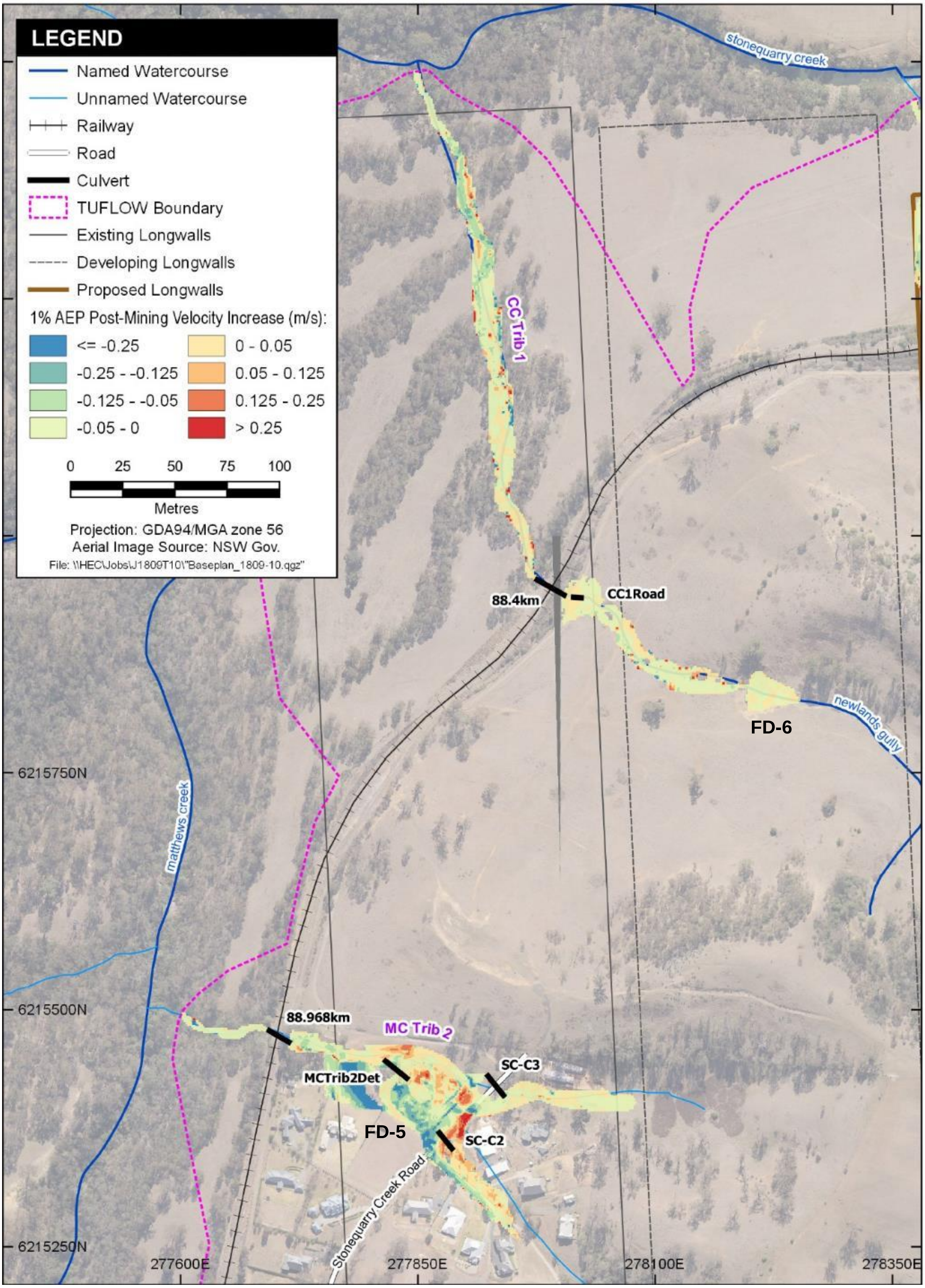



**Figure E16 1% AEP Pre-Mining Modelled Velocity Increase – MC Trib 2 and CC Trib 1**

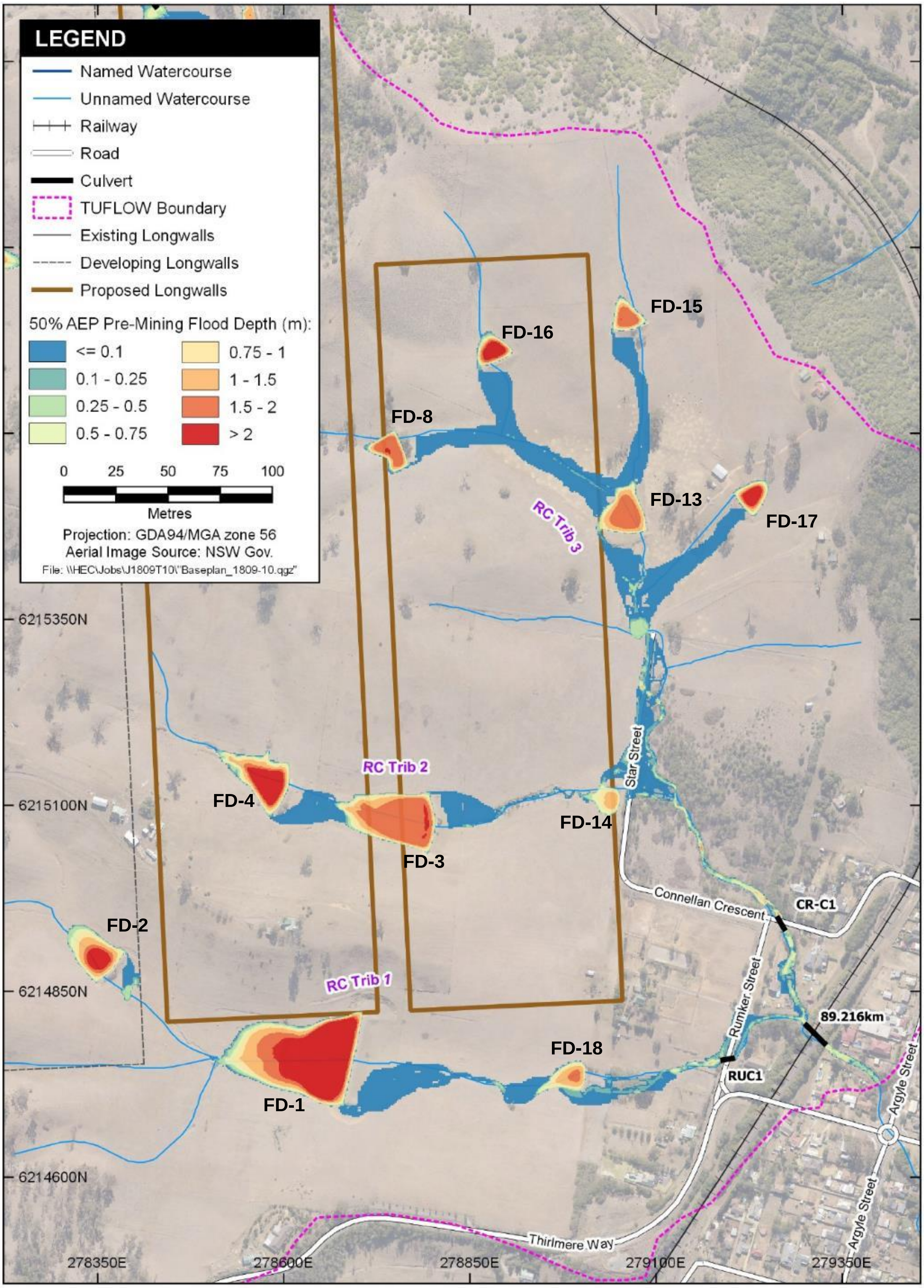



**Figure E17 50% AEP Pre-Mining Modelled Flood Depth – RC Trib 1, RC Trib 2 and RC Trib 3**

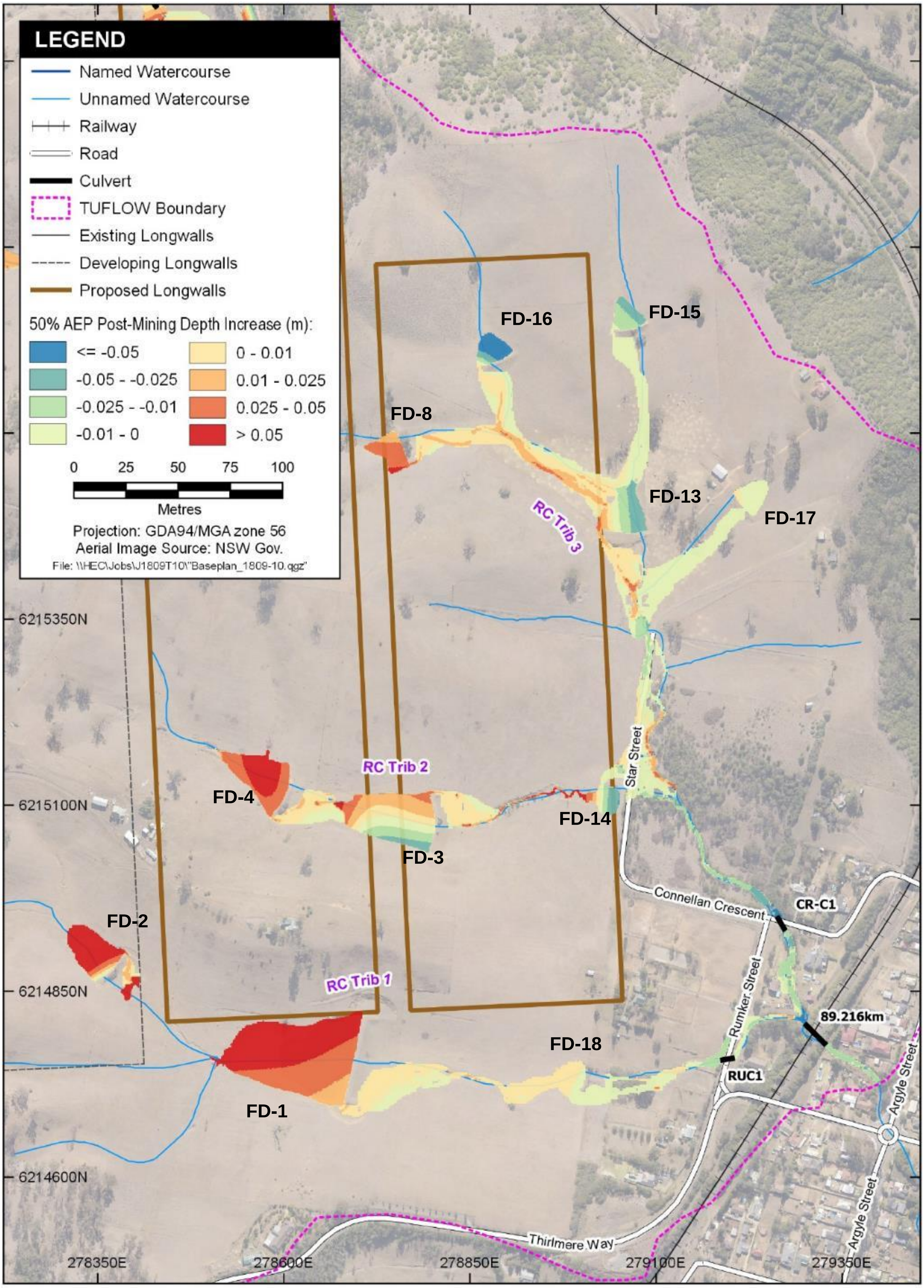



**Figure E18** 50% AEP Post-Mining Modelled Flood Depth Increase – RC Trib 1, RC Trib 2 and RC Trib 3

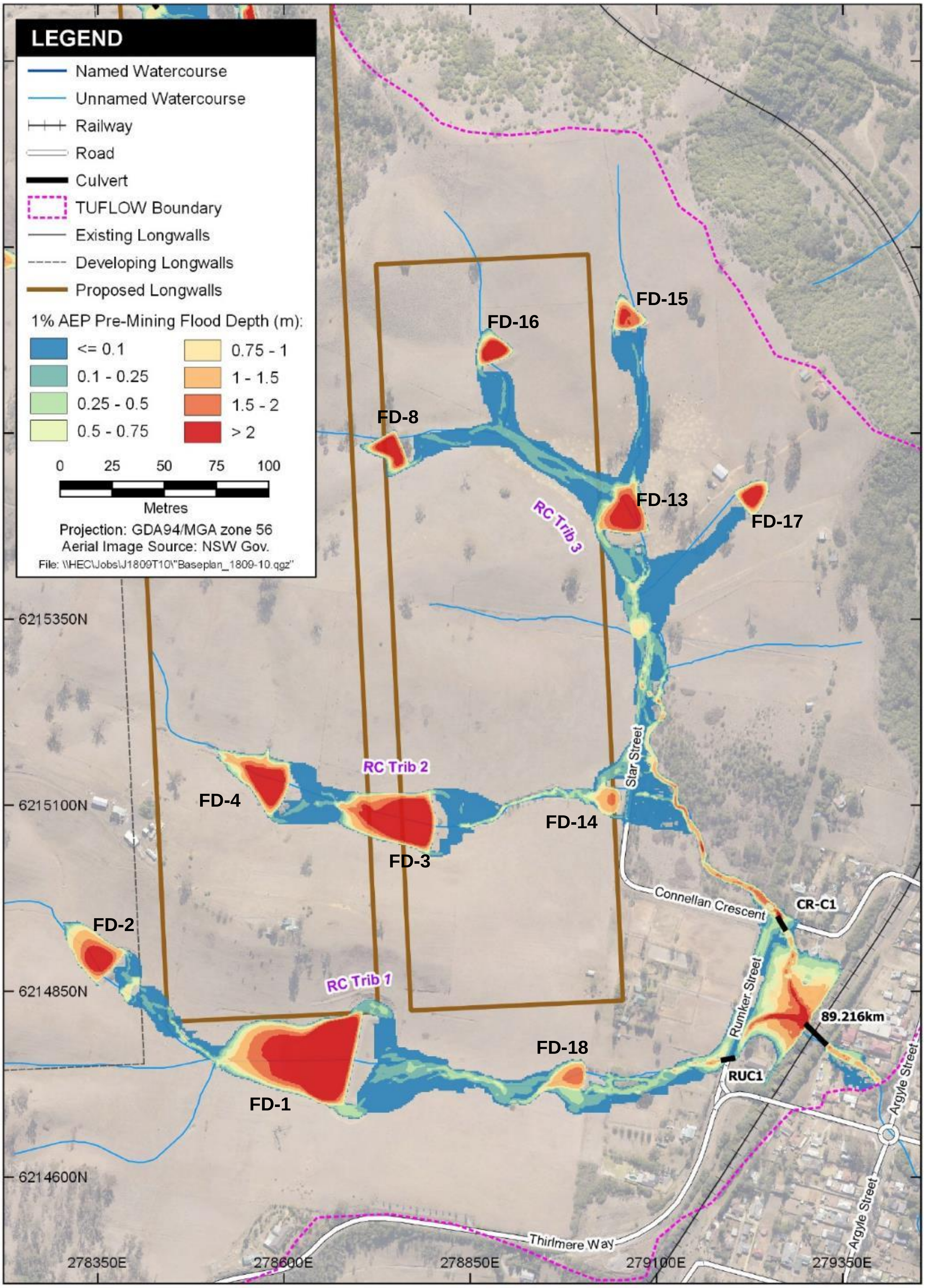



**Figure E19 1% AEP Pre-Mining Modelled Flood Depth – RC Trib 1, RC Trib 2 and RC Trib 3**

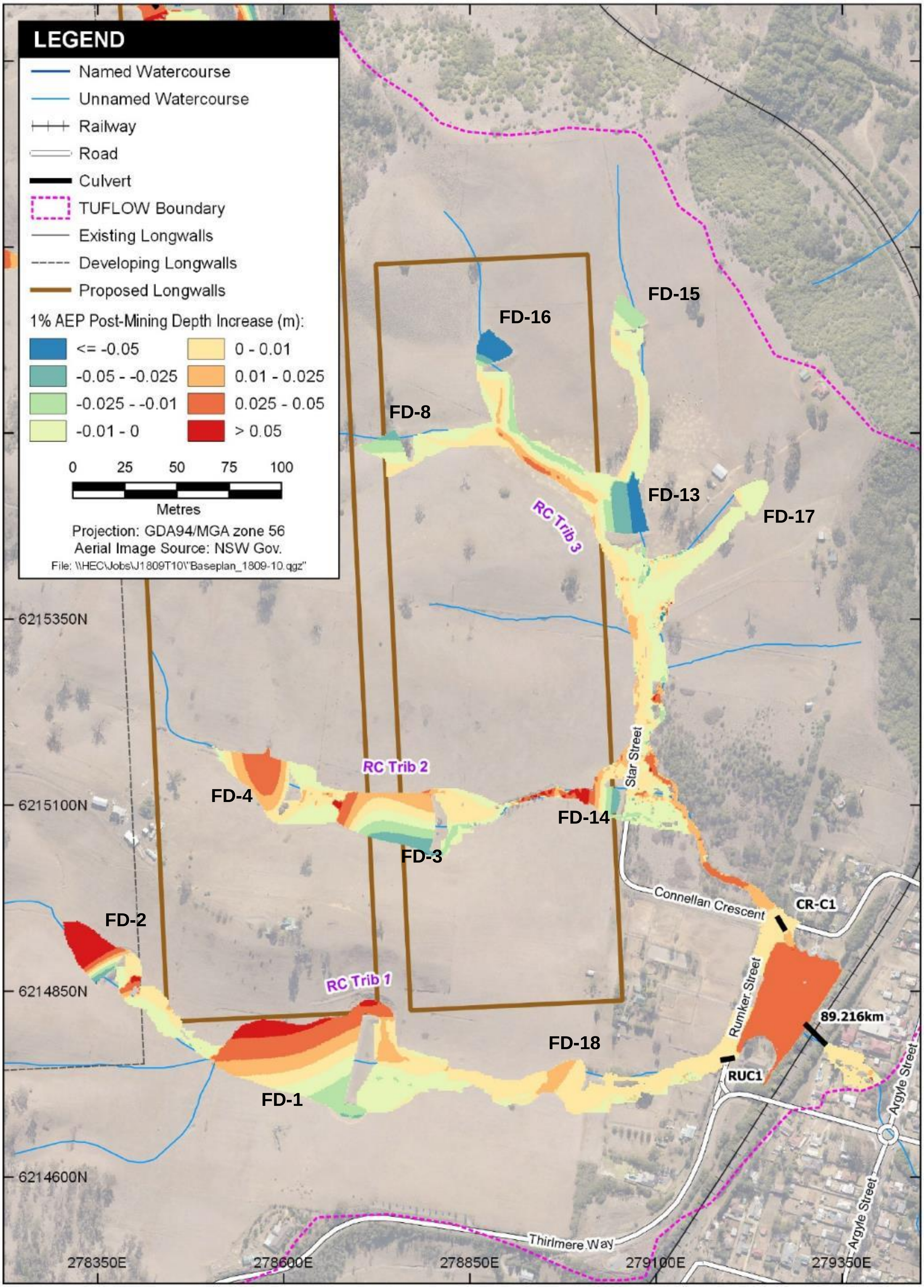



**Figure E20** 1% AEP Post-Mining Modelled Flood Depth Increase – RC Trib 1, RC Trib 2 and RC Trib 3

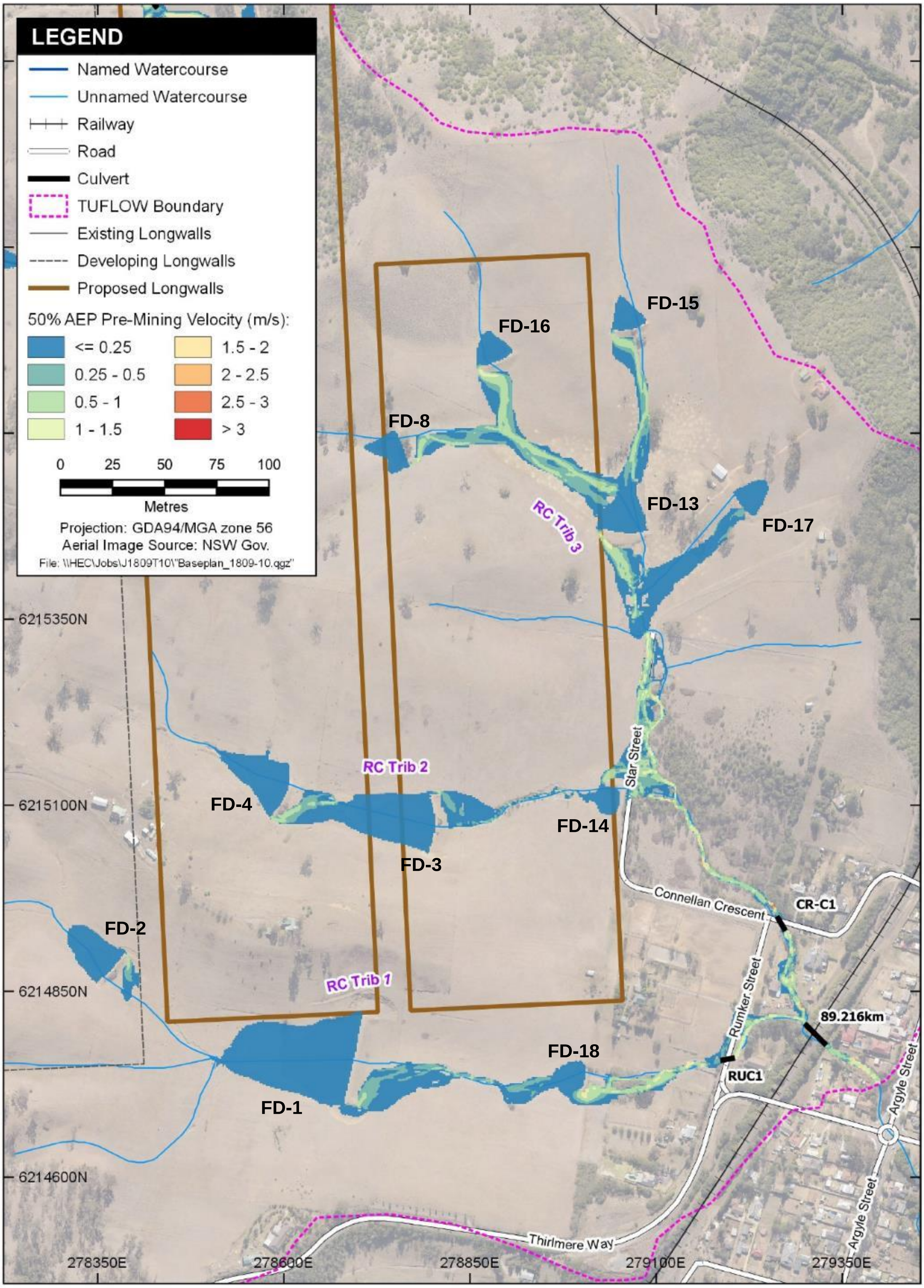



**Figure E21 50% AEP Pre-Mining Modelled Velocity – RC Trib 1, RC Trib 2 and RC Trib 3**

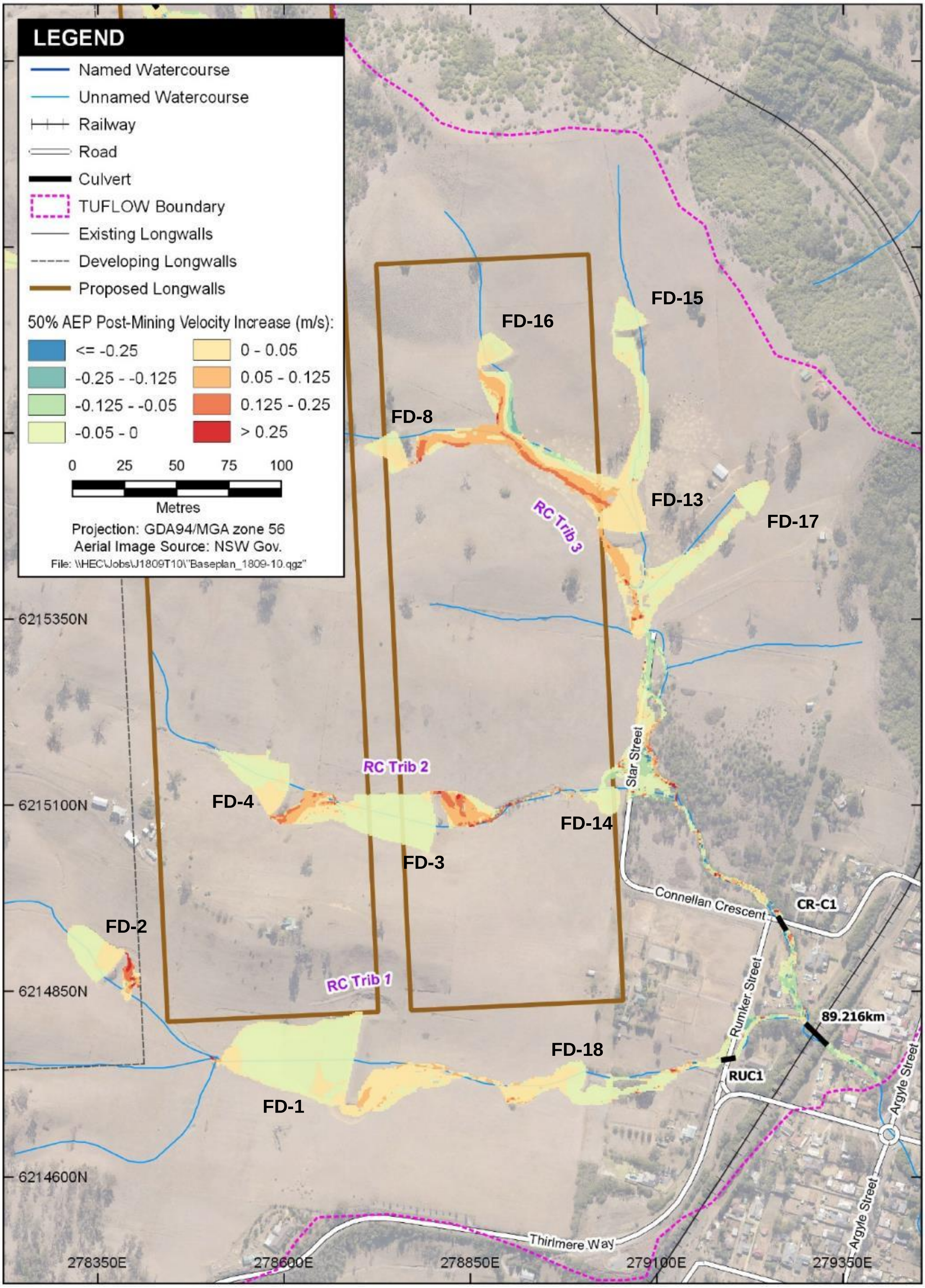



**Figure E22 50% AEP Post-Mining Modelled Velocity Increase – RC Trib 1, RC Trib 3 and RC Trib 3**

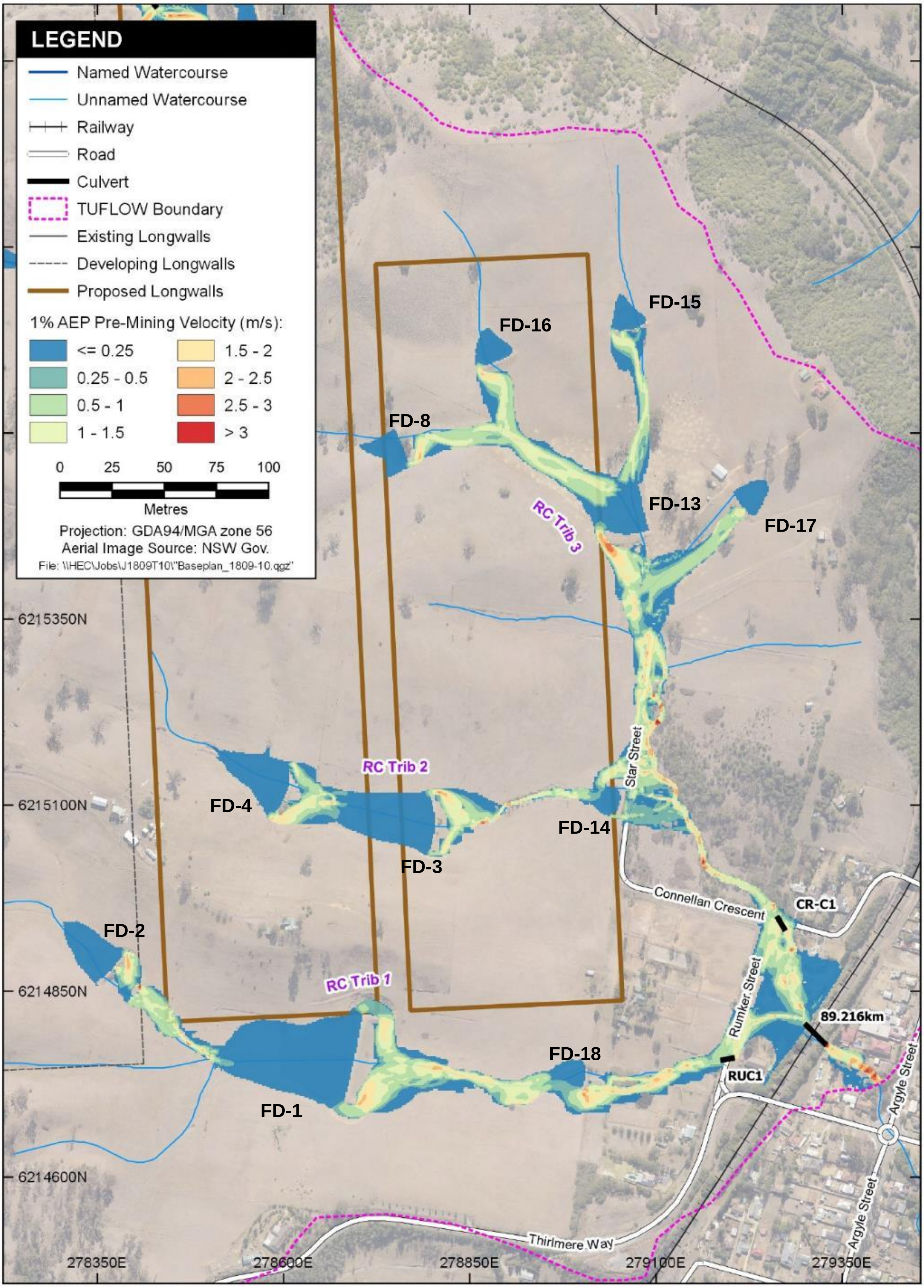



**Figure E23 1% AEP Pre-Mining Modelled Velocity – RC Trib 1, RC Trib 2 and RC Trib 3**

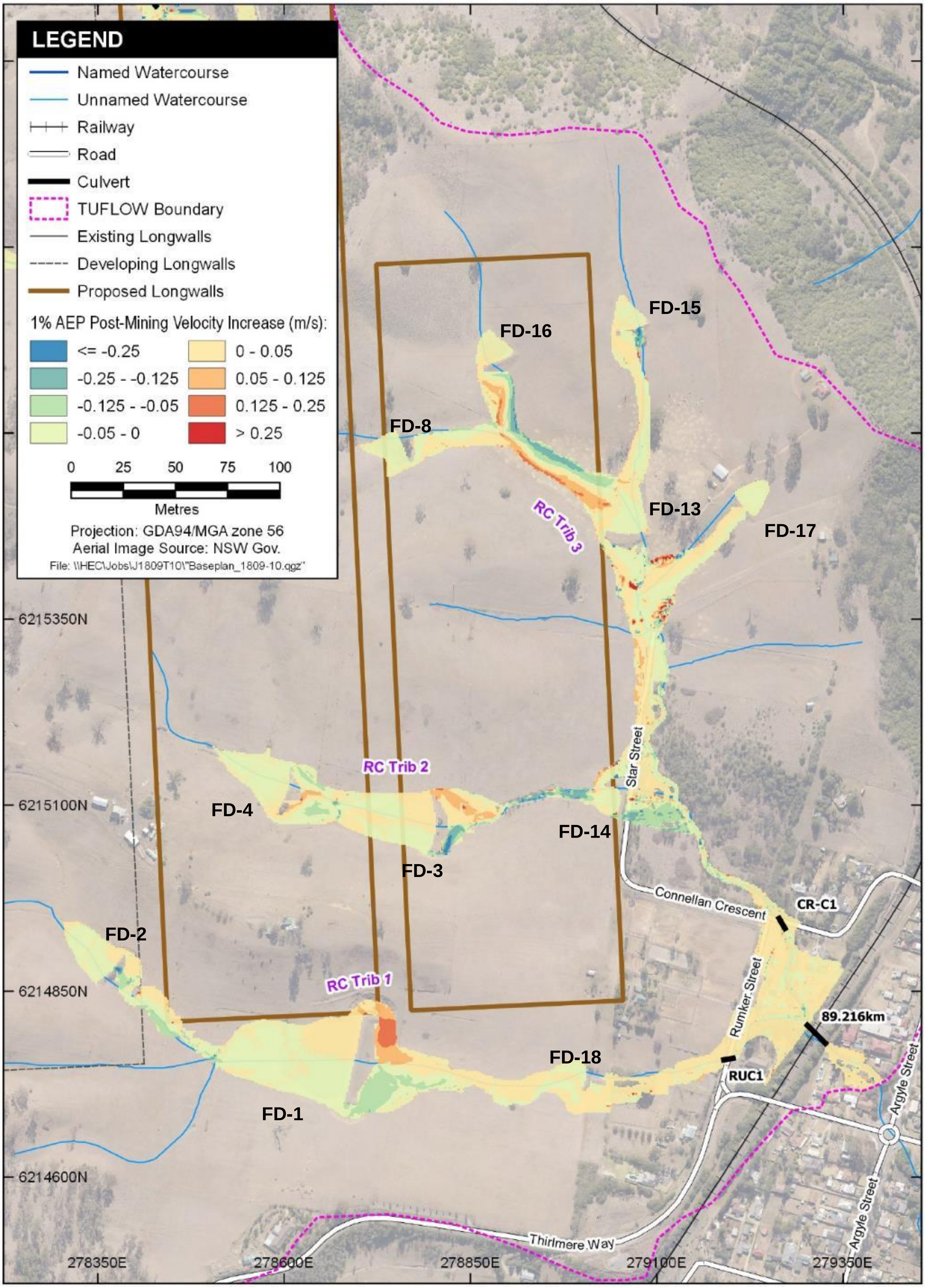



**Figure E24 1% AEP Pre-Mining Modelled Velocity Increase – RC Trib 1, RC Trib 2 and RC Trib 3**

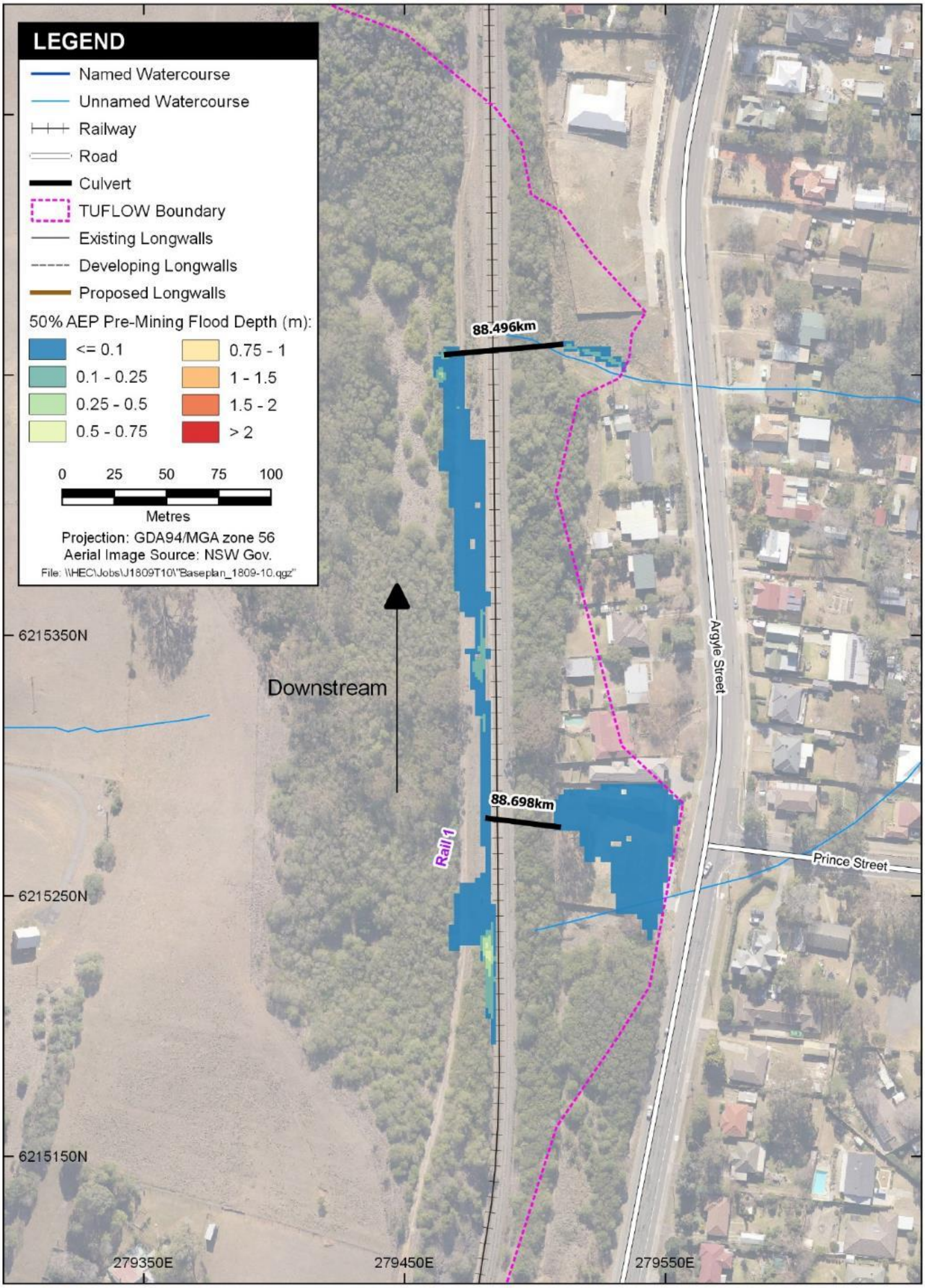



**Figure E25 50% AEP Pre-Mining Modelled Flood Depth – Rail 1**

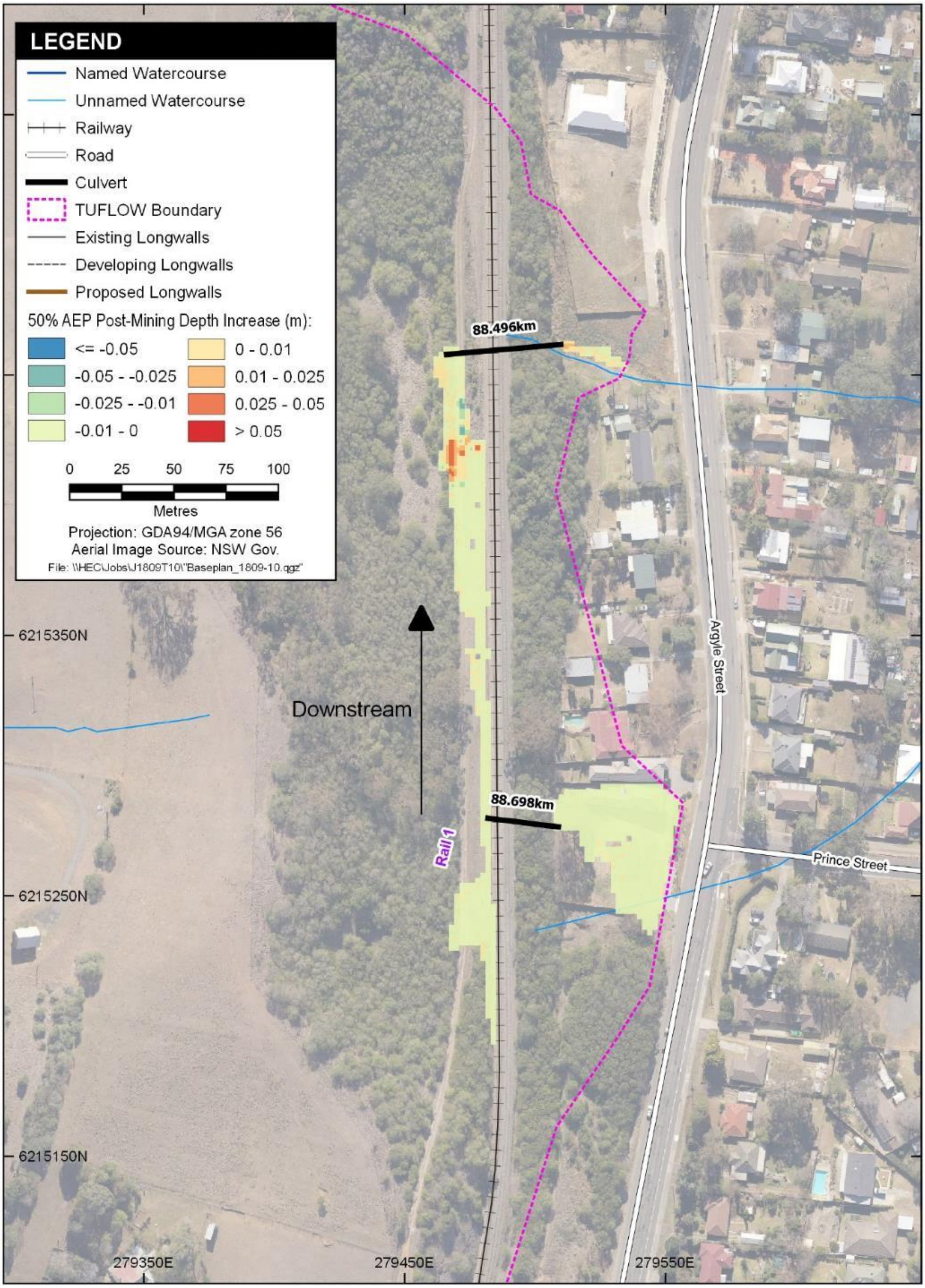



**Figure E26 50% AEP Post-Mining Modelled Flood Depth Increase – Rail 1**

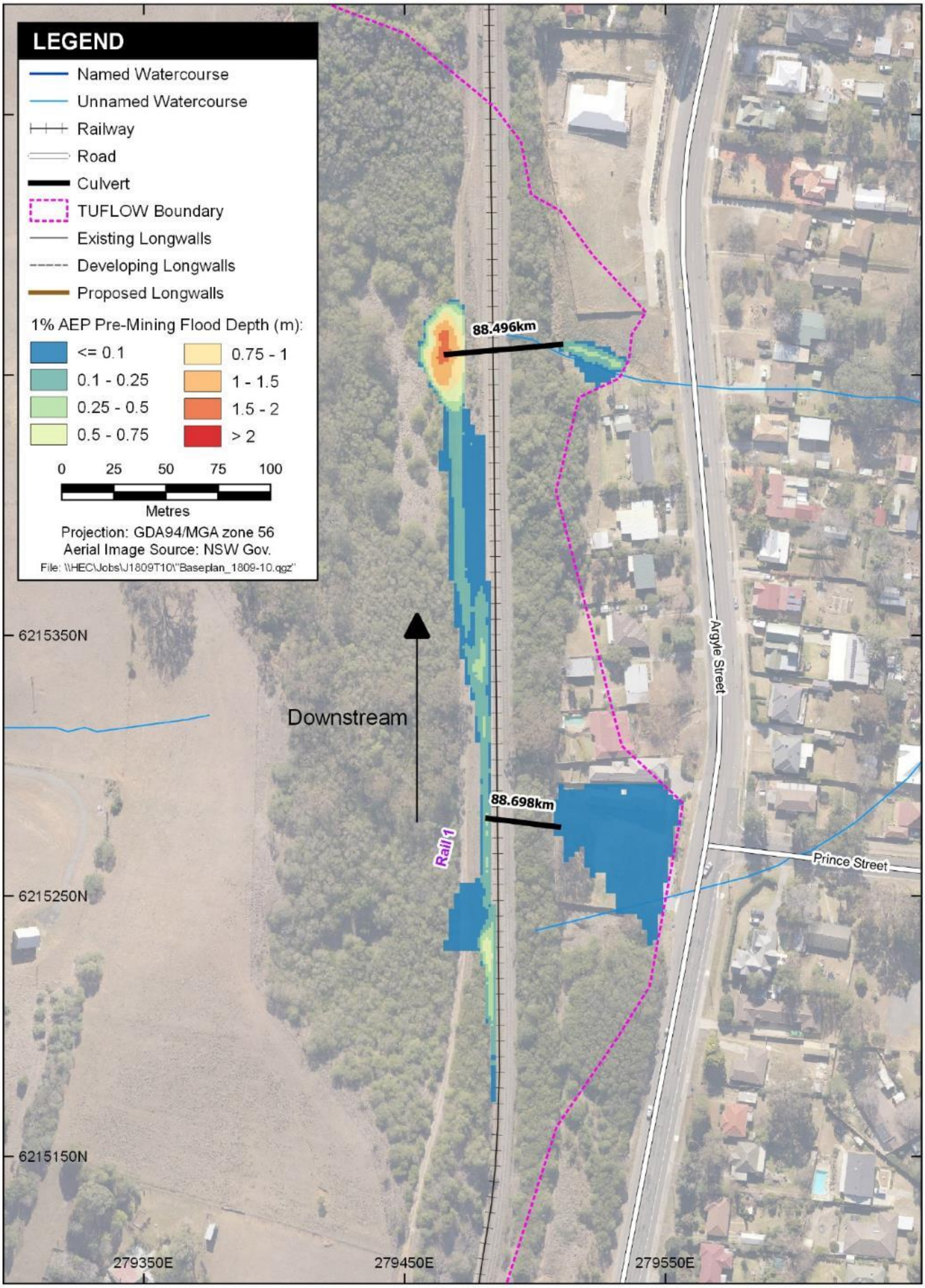



**Figure E27 1% AEP Pre-Mining Modelled Flood Depth – Rail 1**

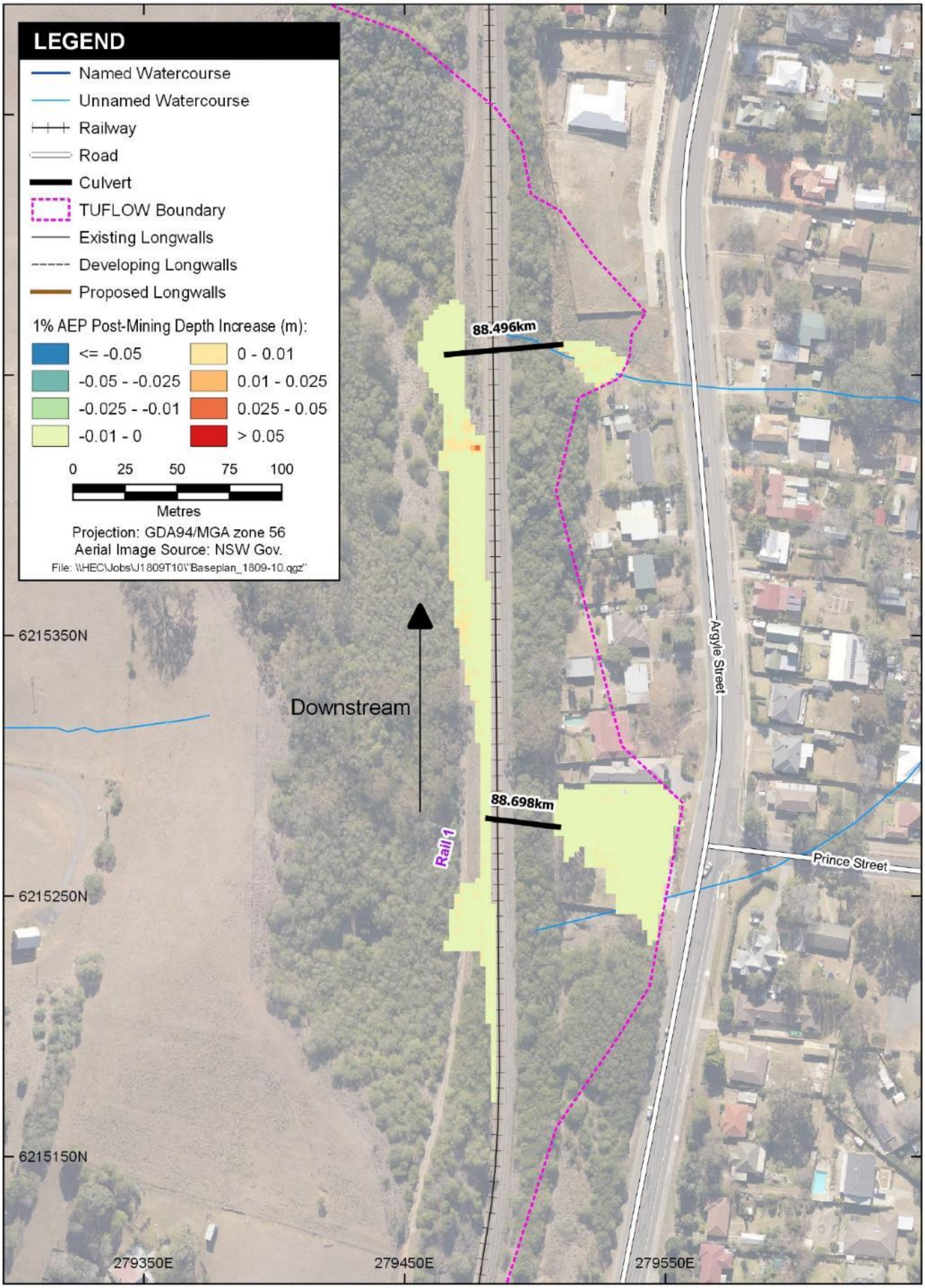



Figure E28 1% AEP Post-Mining Modelled Flood Depth Increase – Rail 1

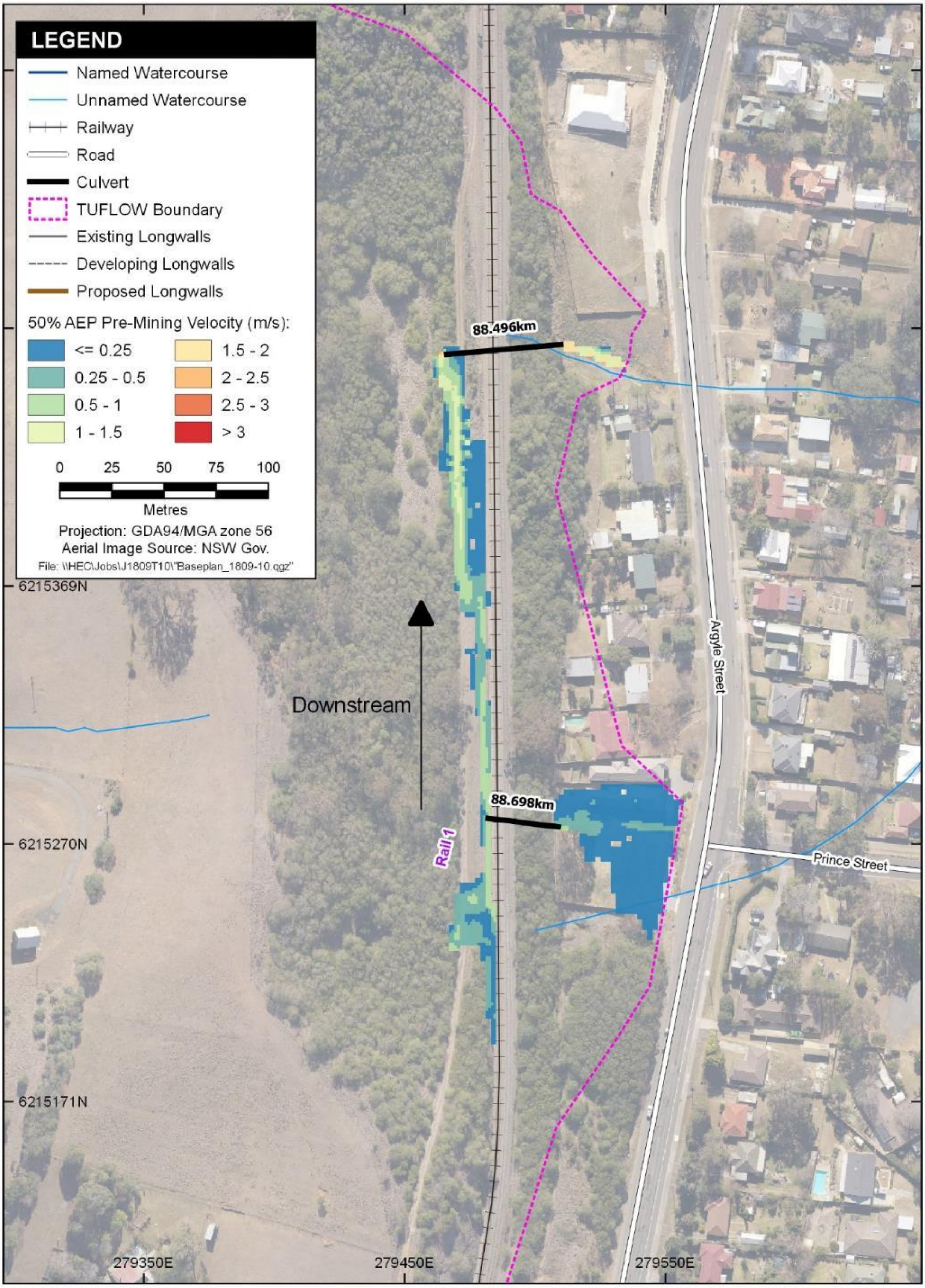



**Figure E29 50% AEP Pre-Mining Modelled Velocity – Rail 1**

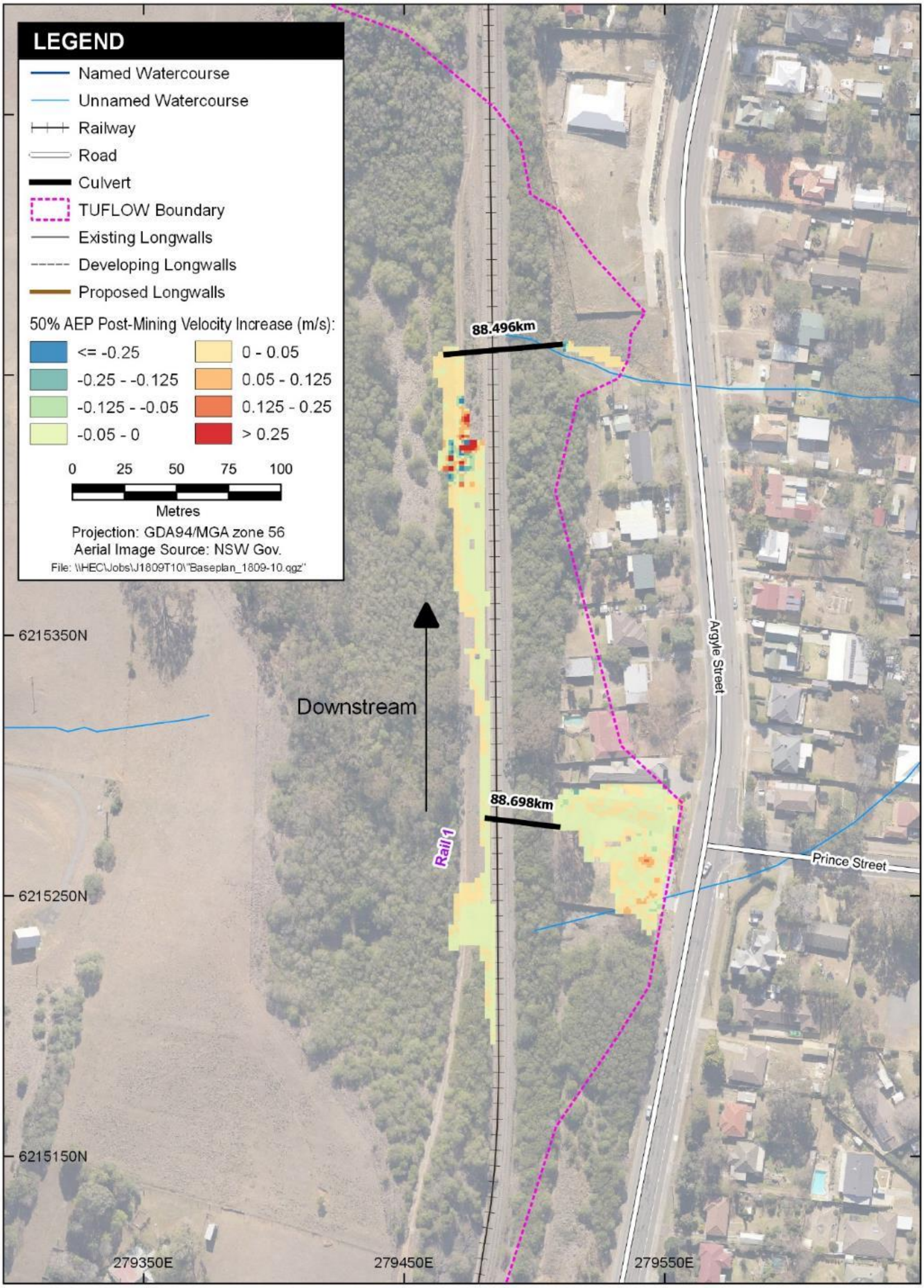



**Figure E30 50% AEP Post-Mining Modelled Velocity Increase – Rail 1**

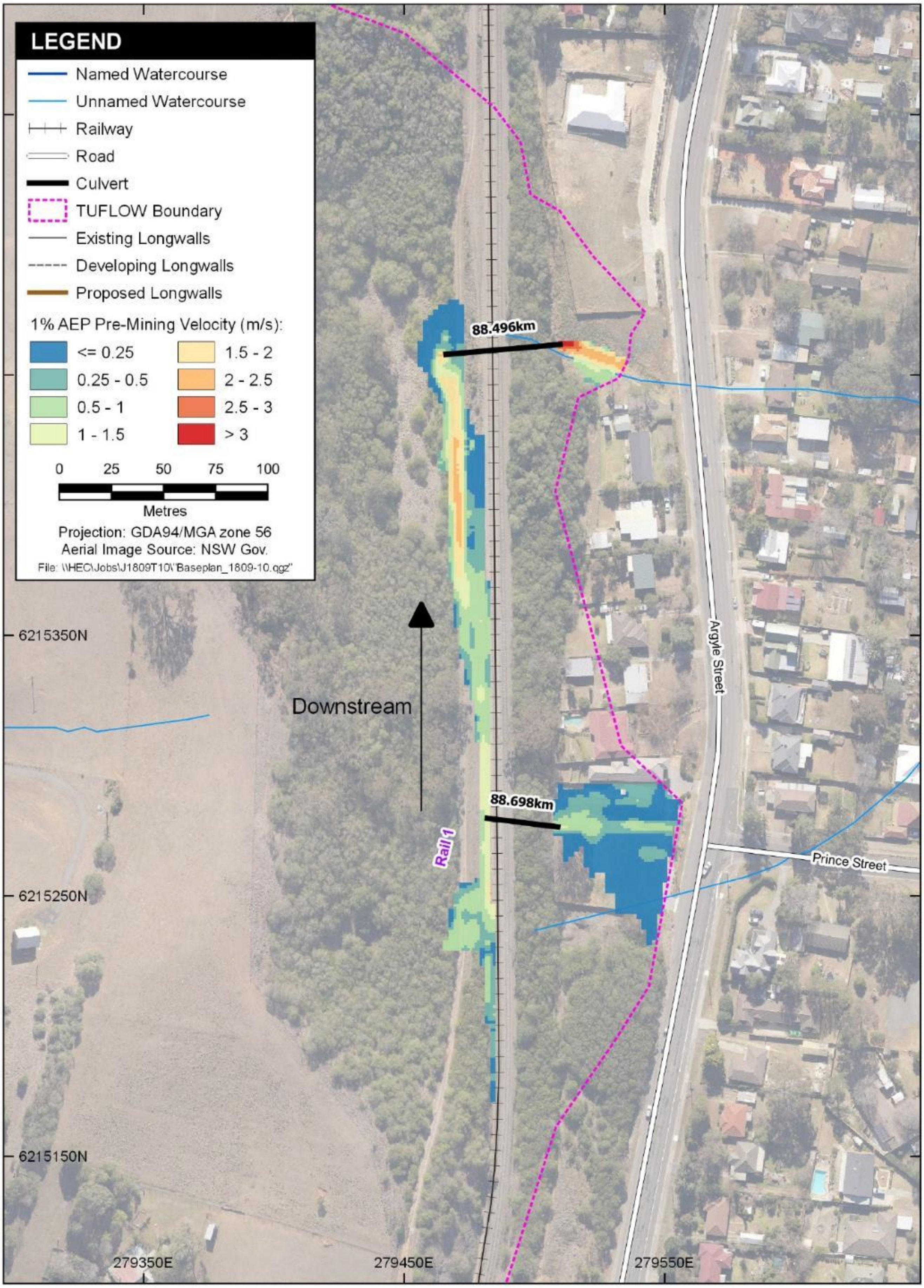



**Figure E31 1% AEP Pre-Mining Modelled Velocity – Rail 1**

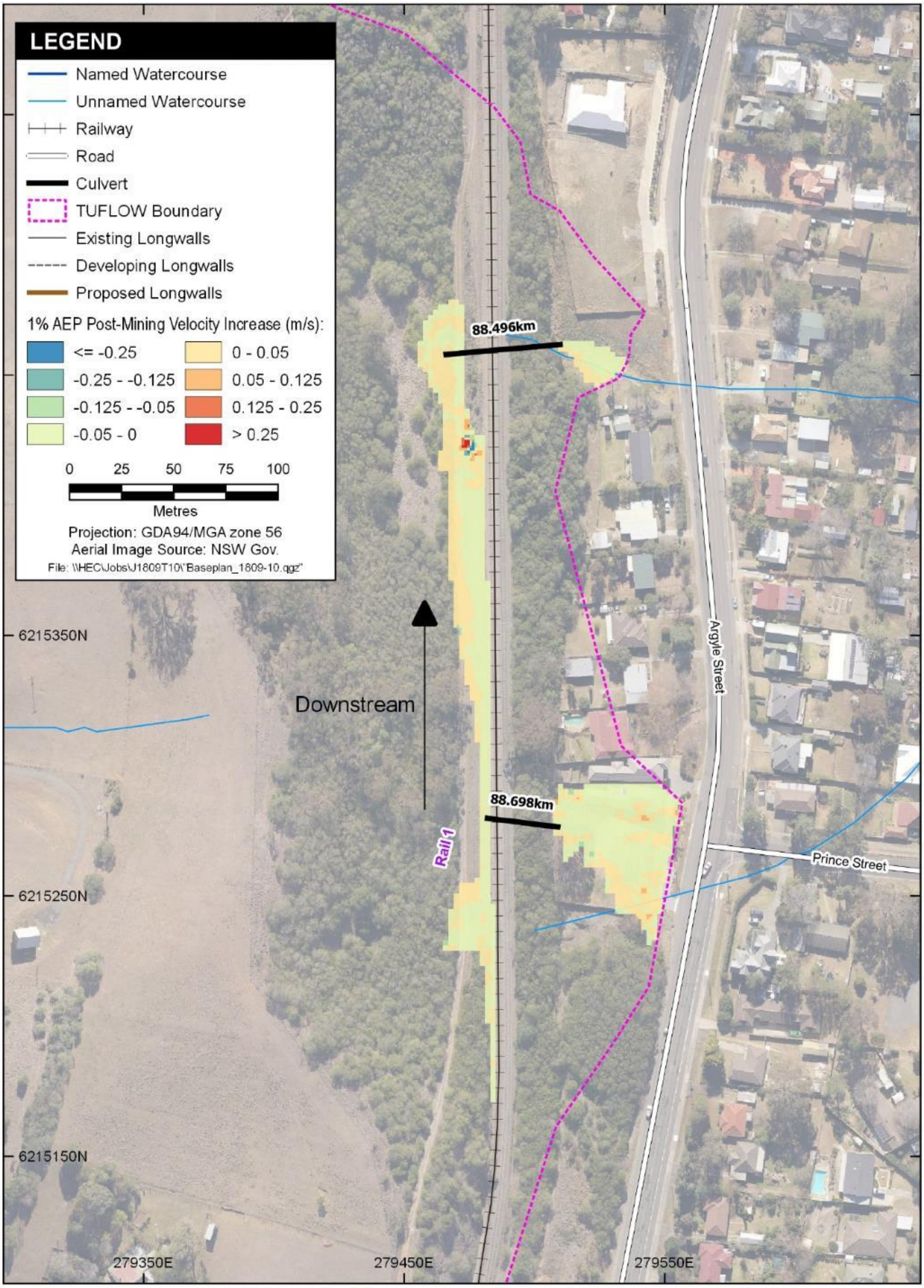



**Figure E32 1% AEP Pre-Mining Modelled Velocity Increase – Rail 1**

# APPENDIX F – FLOOD IMPACT STUDY

# Matthews Creek Catchment Flood Impact Study for LW W1-W4

## Tahmoor NSW

Tahmoor Coal Pty Ltd

1072-06-B1, 31 January 2020

For and on behalf of WRM Water & Environment Pty Ltd
Level 9, 135 Wickham Tce, Spring Hill
PO Box 10703 Brisbane Adelaide St Qld 4000
Tel 07 3225 0200

**WRM Water & Environment Pty Ltd**

**David Newton**

**Director**

NOTE: This report has been prepared on the assumption that all information, data and reports provided to us by our client, on behalf of our client, or by third parties (e.g. government agencies) is complete and accurate and on the basis that such other assumptions we have identified (whether or not those assumptions have been identified in this advice) are correct. You must inform us if any of the assumptions are not complete or accurate. We retain ownership of all copyright in this report. Except where you obtain our prior written consent, this report may only be used by our client for the purpose for which it has been provided by us.

# Contents



# List of Figures

## List of Tables

# 1 Introduction

Tahmoor Coal Pty Ltd (Tahmoor Coal) operates an underground coal mine located near the townships of Tahmoor and Picton in the Wollondilly Local Government Area of New South Wales (NSW). WRM Water & Environment Pty Ltd (WRM) has previously completed a flood impact study of Matthews Creek catchment, for LW W1 and LW W2 as documented in our previous report *Matthew Creek Catchment Flood Impact Study for LW W1-W2* (WRM, 2019).

Tahmoor Coal has revised the proposed western domain extraction plan to include Longwall West 3 (LW W3) and Longwall West 4 (LW W4) which are potentially impacted by the Matthews Creek catchment. The Matthews Creek catchment includes Mathews Creek which flows northeast before joining Cedar Creek and then Stonequarry Creek. The locations of LW W1 to LW W4 are shown in **Error! Reference source not found.**.

WRM was commissioned by Tahmoor Coal to update the previous flood impact assessment undertaken for LW W1 and LW W2 to include LW W3 and LW W4 for the 1% annual exceedance probability (AEP) and the Probable Maximum Flood (PMF) events. The methodology and results of the assessment are presented in this report.

# 2 Method of analysis

The hydrological (XP-RAFTS) and hydraulic (TUFLOW) models updated for the previous study (WRM, 2019) were used to assess the impacts of the revised longwall panels on flood levels and velocities in the Matthews Creek catchment.

The TUFLOW model was updated with the revised design surface elevations for the proposed subsidence of LW W1 to LW W4 provided by Mine Subsidence Engineering Consultants (MSEC).

The 1% AEP and PMF event design discharges from the previous study were adopted to assess the revised post-subsidence conditions for LW W1 to LW W4.

It was assumed for this study that the PMF is equivalent to the Probable Maximum Precipitation (PMP) design flood event. Estimation of PMF discharges and flood levels was undertaken in the following three steps:

- Estimation of PMP using the Generalised Short Duration Method (GSDM) for the Matthews Creek catchment;
- Estimation of PMF flood discharges using the XP-RAFTS model; and
- Estimation of PMF design flood levels using the TUFLOW model.

Flood levels and velocities were assessed for two scenarios:

- Existing conditions; and
- Post-subsidence conditions following the subsidence of LW W1 to LW W4.

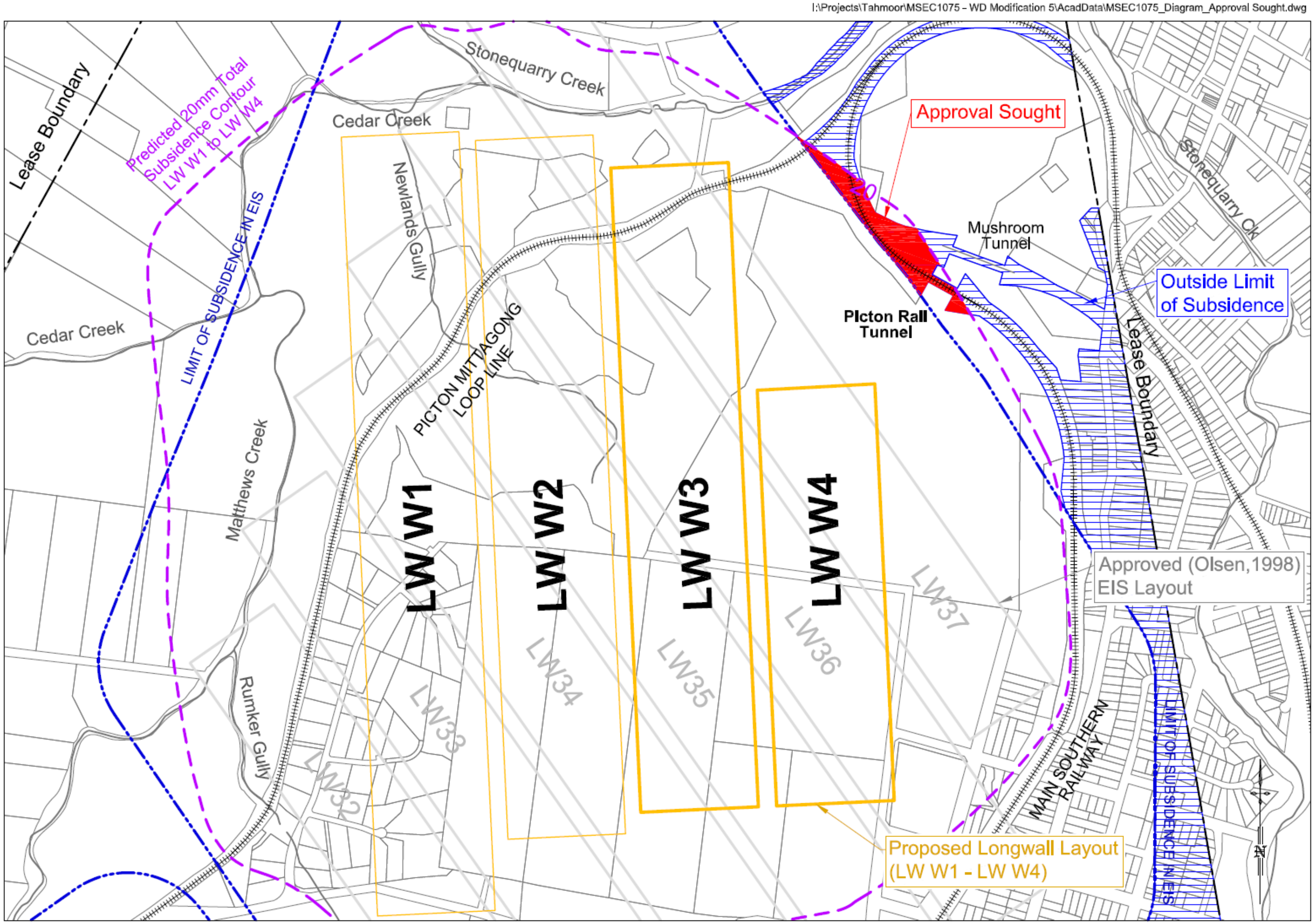



**Figure 2.1 – Locations of LW W1 to LW W4**

# 3 PMP rainfall depths

PMP rainfalls for the Matthews Creek catchment were estimated using the Generalised Short Duration Method (GSDM) (BOM, 2003a). The GSDM is suitable for application to small catchments (up to 1,000km$^2$) for short durations (up to 6 hours). The design spatial distribution of PMP was also applied, which resulted in four spatial zones (A, B, C and D). The rainfall distribution across the spatial zones decreased from zone A (centre of the catchment) through to spatial zone D. The spatial rainfall depths determined by the GSDM design spatial distribution were applied to the XP-RAFTS subcatchments. The subcatchments located in each spatial zone are shown in Figure 3.1.

Table 3.1 shows the estimated PMP rainfall depths for the Matthews Creek catchment spatial zones based on the GSDM method. The parameters used in the study include:

- Total catchment area of 42.6 km$^2$;
- Located in the coastal zone;
- The terrain was assumed rough (R = 1);
- Elevation Adjustment Factor (AEF = 1);
- Moistures Adjustment Factor (MAF = 0.69);
- The spatial zones include:
    - Zone A, full ellipse (2.6 km$^2$);
    - Zone B, full ellipse (13.4 km$^2$);
    - Zone C, partial ellipse (23 km$^2$); and
    - Zone D, partial ellipse (3.6 km$^2$).

**Table 3.1 - PMP rainfall depth estimates for the Matthews Creek catchment spatial zones**

| | Spatial Zone A | Spatial Zone B | Spatial Zone C | Spatial Zone D |
|---|---|---|---|---|
| Duration (hr) | Rainfall depth (mm) | | | |
| 0.25 | 160 | 137 | 54 | 90 |
| 0.50 | 232 | 203 | 78 | 131 |
| 0.75 | 293 | 259 | 97 | 166 |
| 1.00 | 340 | 304 | 124 | 200 |
| 1.50 | 439 | 389 | 157 | 255 |
| 2.00 | 513 | 454 | 181 | 297 |
| 2.50 | 566 | 501 | 205 | 331 |
| 3.00 | 622 | 547 | 220 | 359 |
| 4.00 | 711 | 625 | 246 | 407 |
| 5.00 | 783 | 687 | 272 | 449 |
| 6.00 | 828 | 732 | 287 | 476 |

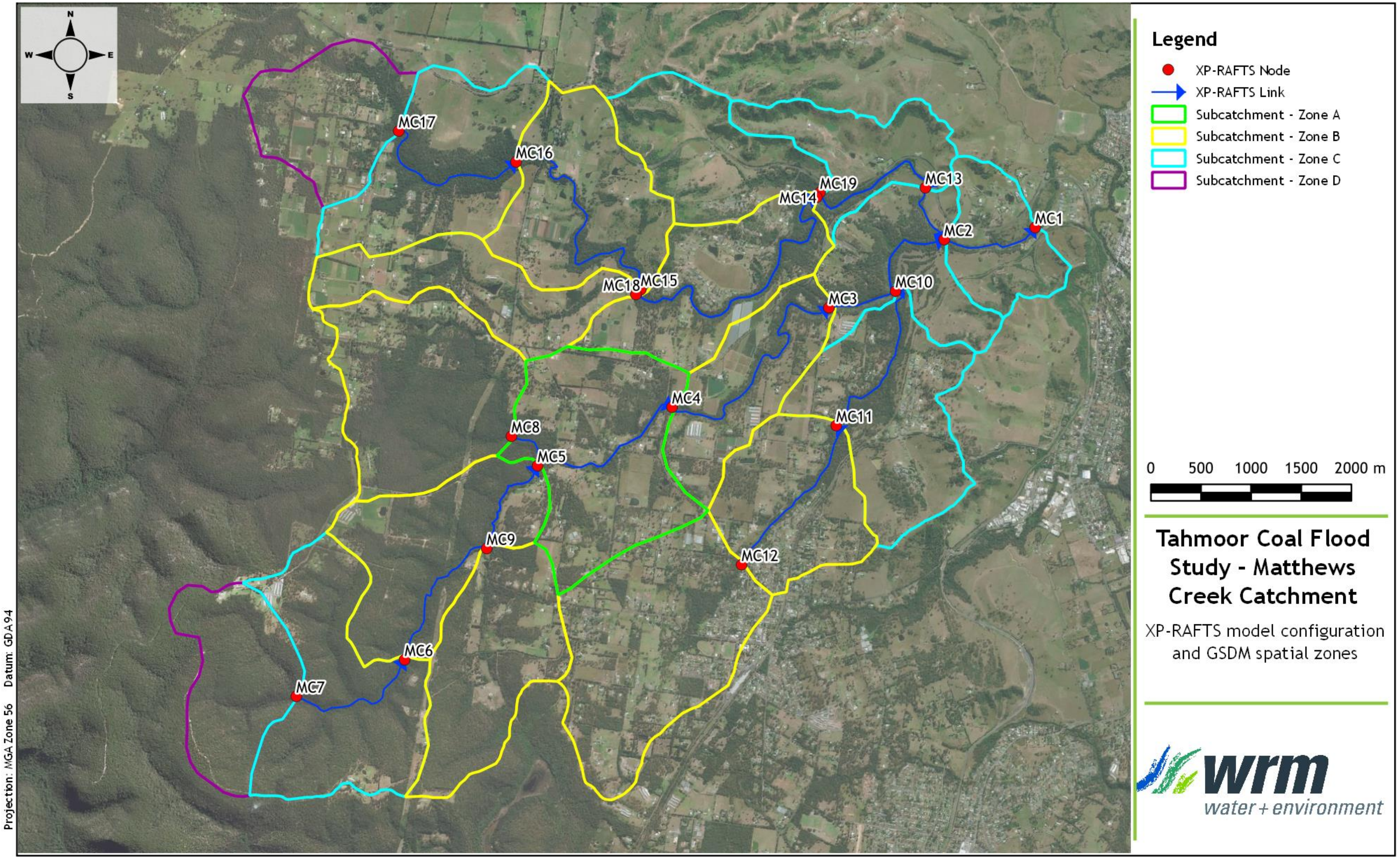



**Figure 3.1 – XP-RAFTS subcatchments and spatial zones**

# 4 Peak discharges

## 4.1 PEAK DISCHARGES FOR THE 1% AEP EVENT

The 1% AEP event discharges adopted from the previous study (WRM, 2014) calculated a critical storm duration of 6 hours and a peak discharge at the catchment outlet of 319 $m^3/s$.

## 4.2 PEAK DISCHARGES FOR THE PMF EVENT

The XP-RAFTS model was used to estimate discharges to determine the critical storm duration for the PMF event. Design rainfall depths and temporal and spatial rainfall distributions for the Matthews Creek catchment were derived using specified procedures for the GSDM (BOM, 2003a).

Figure 4.1 shows the PMF event discharges estimated by the XP-RAFTS model at the downstream boundary of the Matthews Creek catchment. The XP-RAFTS outputs were adopted as the hydraulic model inputs and modelled as inflows in the TUFLOW model. Storm durations of 1 hour to 6 hours were modelled. The critical storm duration was 2.5 hours and the peak discharge at the catchment outlet was calculated to be 1,836 $m^3/s$. Only the critical storm duration determined using the XP-RAFTS model was simulated in the TUFLOW model.

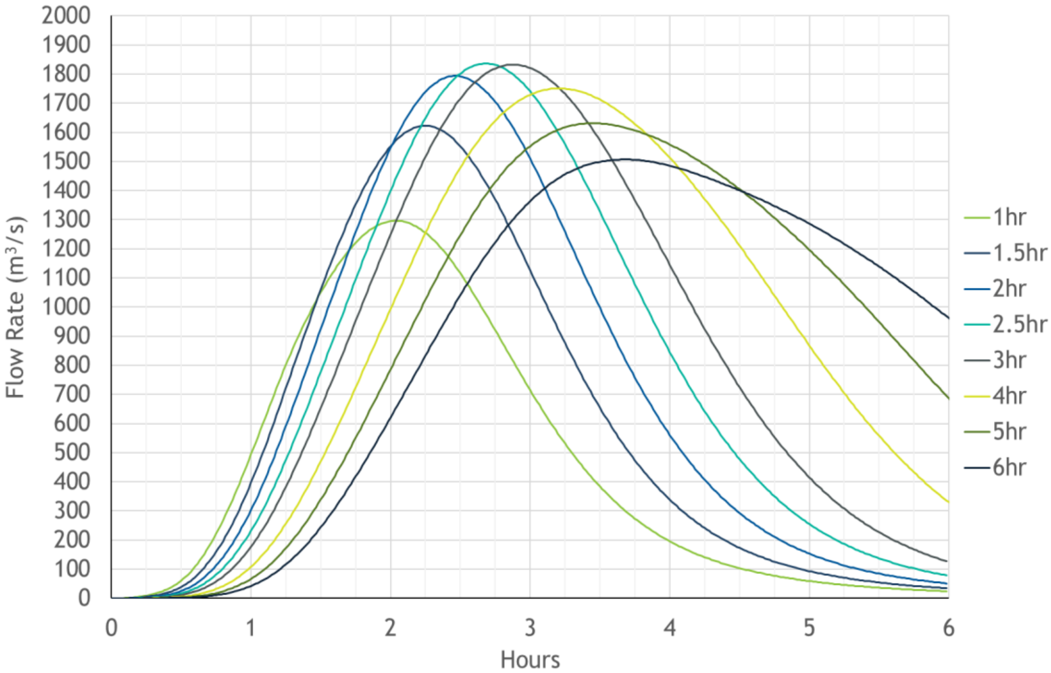



**Figure 4.1 - PMP discharges at the XP-RAFTS downstream boundary of Matthews Creek catchment**

# 5 Design flood levels

## 5.1 OVERVIEW

The TUFLOW model was run for the 1% AEP and PMF events for both the existing and post-subsidence conditions. The impacts of LW W1 to LW W4 were assessed by comparing the peak flood levels of the post-subsidence conditions with the peak flood levels of the existing conditions.

The post-subsidence contours of LW W1 to LW W4 shown in Figure 5.1 to Figure 5.4 indicate a change in ground surface elevations of up to 1 m in the vicinity of Matthews Creek, Cedar Creek and Stonequarry Creek. However, the proposed subsidence directly adjacent to the watercourses only changes ground elevations by up to 0.1 m.

## 5.2 PEAK FLOOD IMPACTS FOR THE 1% AEP EVENT

The impacts on peak water levels and peak velocities in Matthews Creek catchment for the 1% AEP event are shown in Figure 5.1 and Figure 5.2 respectively. The results for the peak water levels and peak velocities at reporting locations along Matthews Creek, Cedar Creek and Stonequarry Creek for the 1% AEP event are summarised in Table 5.1 and Table 5.2. The following is of note for the 1% AEP event:

- Within the TUFLOW model extent, Barkers Lodge Road has a 1% AEP flood immunity;
- The peak flood level is predicted to decrease by up to 0.11 m and at localised areas within creek channels the peak flood level is predicted to increase by up to 0.05 m;
- The peak flood velocity is predicted to increase by up to 0.15 m/s at localised areas within creek channels, however, velocity increases are generally less than 0.05 m/s; and
- These increases in peak flood levels and peak velocities are considered negligible.

The peak flood level maps for the 1% AEP event are provided in Appendix A. The existing conditions peak flood depths and peak velocities are shown in Figure A.1 and Figure A.2 respectively. The post-subsidence conditions peak flood depths and peak velocities are shown in Figure A.3 and Figure A.4 respectively.

**Table 5.1 - Comparison of peak flood levels for the 1% AEP event, Matthews Creek catchment**

| Reporting location | Existing Conditions (mAHD) | Post-Subsidence Conditions (mAHD) | Difference (m) |
|---|---|---|---|
| RP1 | 211.37 | 211.33 | -0.04 |
| RP2 | 196.48 | 196.40 | -0.08 |
| RP3 | 174.30 | 174.24 | -0.06 |
| RP4 | 174.10 | 174.02 | -0.08 |
| RP5 | 173.89 | 173.84 | -0.05 |
| RP6 | 174.15 | 174.12 | -0.03 |
| RP7 | 173.83 | 173.78 | -0.05 |
| RP8 | 172.89 | 172.82 | -0.06 |
| RP9 | 172.60 | 172.55 | -0.05 |
| RP10 | 171.68 | 171.65 | -0.03 |

**Table 5.2 – Comparison of peak velocities for the 1% AEP event, Matthews Creek catchment**

| Reporting location | Existing Conditions (m/s) | Post-Subsidence Conditions (m/s) | Difference (m/s) |
|---|---|---|---|
| RP1 | 2.94 | 2.94 | - |
| RP2 | 3.23 | 3.23 | - |
| RP3 | 3.25 | 3.28 | 0.03 |
| RP4 | 2.07 | 2.08 | 0.01 |
| RP5 | 1.77 | 1.77 | - |
| RP6 | 2.01 | 2.03 | 0.02 |
| RP7 | 1.84 | 1.87 | 0.03 |
| RP8 | 2.98 | 2.97 | -0.01 |
| RP9 | 2.59 | 2.58 | -0.01 |
| RP10 | 3.75 | 3.74 | -0.01 |

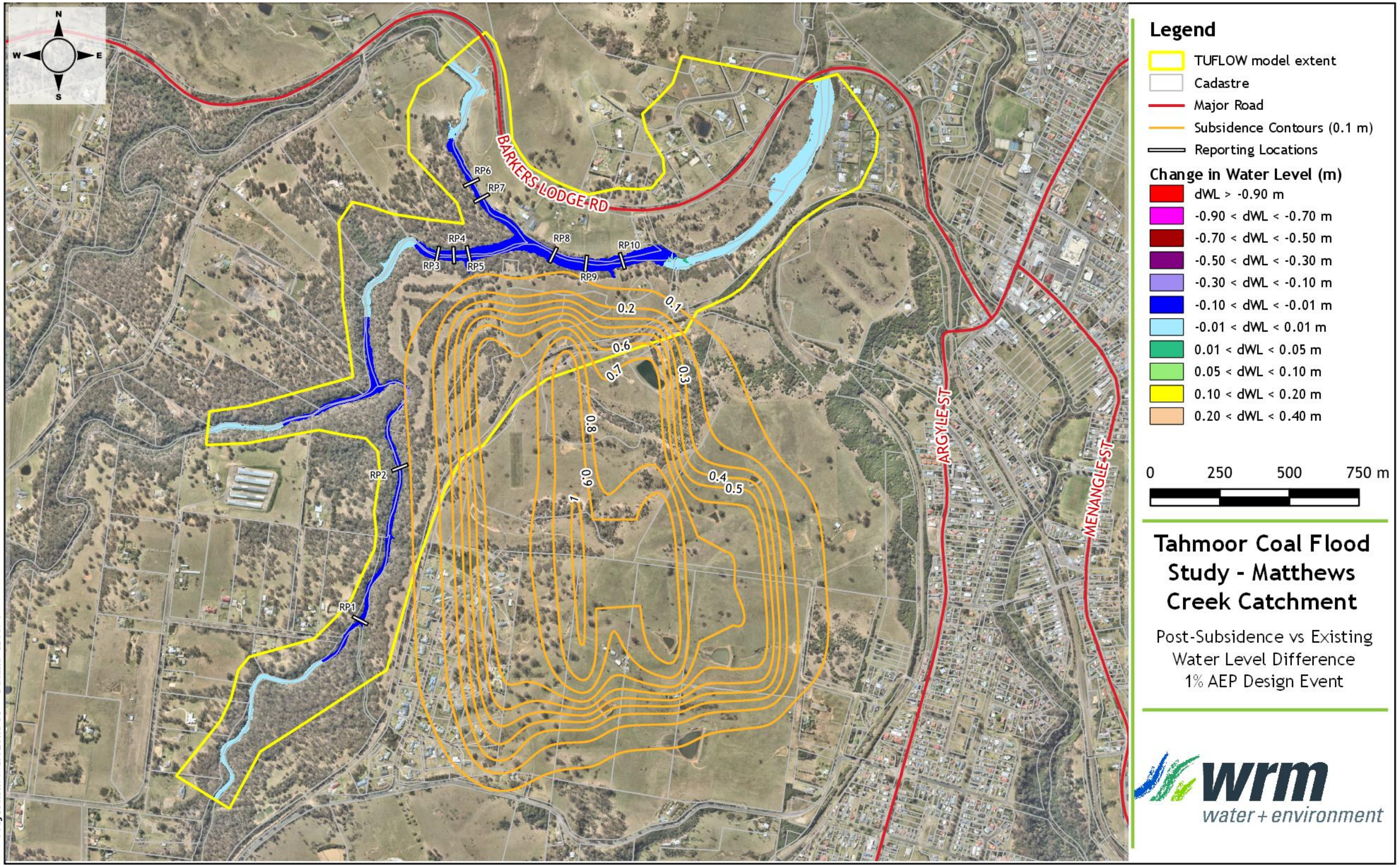



**Figure 5.1 – Matthews Creek catchment 1% AEP event impact – change in water level**

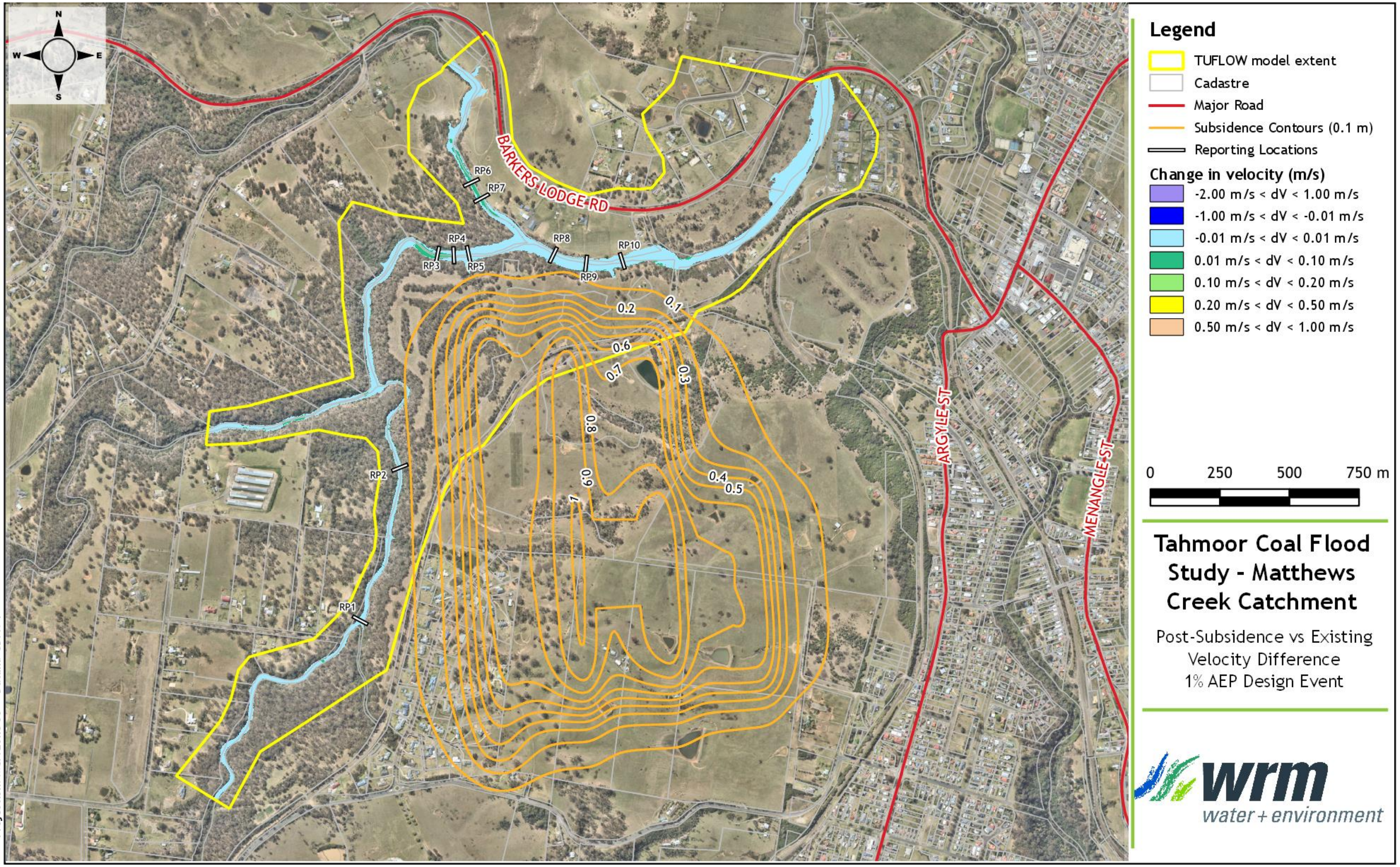



**Figure 5.2 – Matthews Creek catchment 1% AEP event impact – change in velocity**

## 5.3 PEAK FLOOD IMPACTS FOR THE PMF EVENT

The impacts on peak water levels and peak velocities in Matthews Creek catchment for the PMF event are shown in Figure 5.3 and Figure 5.4 respectively. The results for the peak water levels and peak velocities at reporting locations along Matthews Creek, Cedar Creek and Stonequarry Creek for the PMF event are summarised in Table 5.3 and Table 5.4. The following is of note for the PMF event:

- The crest of Barkers Lodge Road is overtopped during the PMF event under existing and post-subsidence conditions by up to 1.5 m;
- The peak flood level is predicted to decrease by up to 0.11 m and at localised areas within creek channels the peak flood level is predicted to increase by up to 0.1 m;
- The peak flood velocity is predicted to increase by up to 0.2 m/s at localised areas within creek channels, however, velocity increases are generally less than 0.1 m/s; and
- These increases in peak flood levels and peak velocities are considered negligible.

The peak flood level maps for the PMF event are provided in Appendix B. The existing conditions peak flood depths and peak velocities are shown in Figure B.1 and Figure B.2 respectively. The post-subsidence conditions peak flood depths and peak velocities are shown in Figure B.3 and Figure B.4 respectively.

**Table 5.3 – Comparison of peak flood levels for the PMF event, Matthews Creek catchment**

| Reporting location | Existing Conditions (mAHD) | Post-Subsidence Conditions (mAHD) | Difference (m) |
|---|---|---|---|
| RP1 | 214.52 | 214.48 | -0.04 |
| RP2 | 200.12 | 200.04 | -0.08 |
| RP3 | 180.16 | 180.09 | -0.07 |
| RP4 | 179.83 | 179.77 | -0.06 |
| RP5 | 179.82 | 179.75 | -0.07 |
| RP6 | 179.69 | 179.63 | -0.06 |
| RP7 | 179.60 | 179.53 | -0.07 |
| RP8 | 178.00 | 177.95 | -0.05 |
| RP9 | 176.81 | 176.76 | -0.03 |
| RP10 | 176.31 | 176.25 | -0.06 |

**Table 5.4 – Comparison of peak velocities for the PMF event, Matthews Creek catchment**

| Reporting location | Existing Conditions (m/s) | Post-Subsidence Conditions (m/s) | Difference (m/s) |
|---|---|---|---|
| RP1 | 5.82 | 5.82 | - |
| RP2 | 4.82 | 4.81 | -0.01 |
| RP3 | 5.18 | 5.21 | 0.03 |
| RP4 | 4.13 | 4.15 | 0.02 |
| RP5 | 3.45 | 3.46 | 0.01 |
| RP6 | 2.57 | 2.60 | 0.03 |
| RP7 | 2.47 | 2.49 | 0.02 |
| RP8 | 5.51 | 5.51 | - |
| RP9 | 5.72 | 5.70 | -0.02 |
| RP10 | 6.10 | 6.08 | -0.02 |

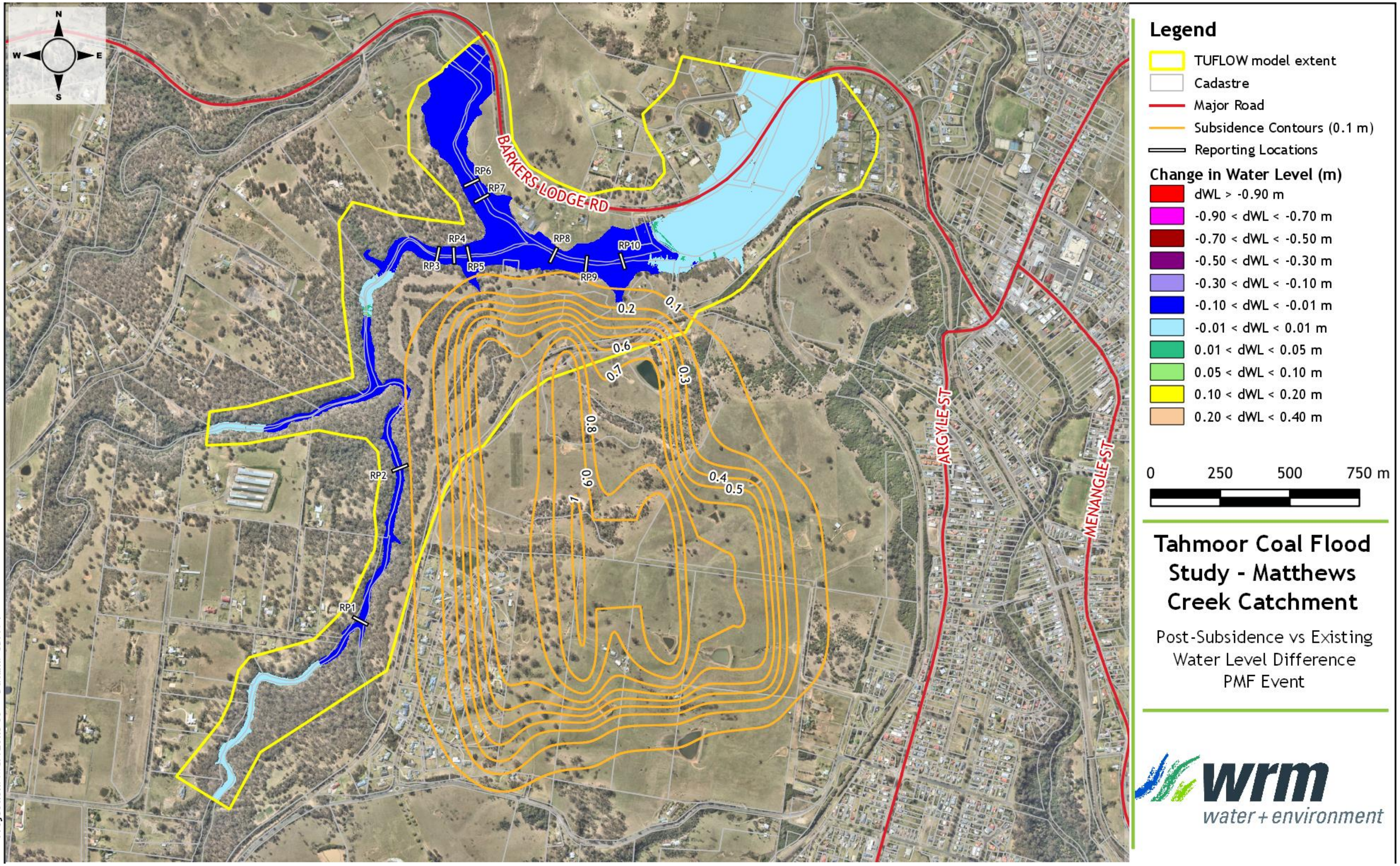



**Figure 5.3 – Matthews Creek catchment PMF event impact – change in water level**

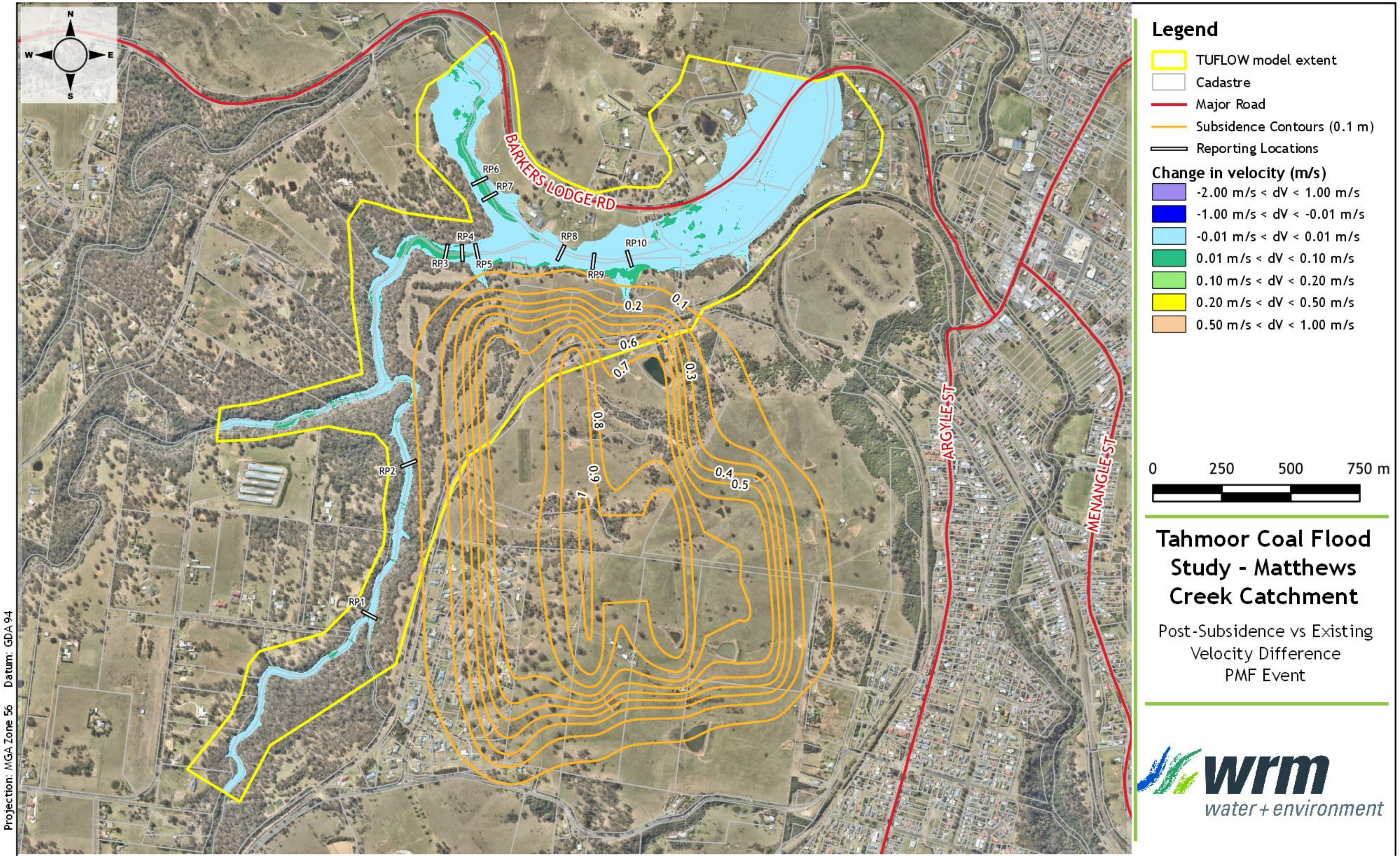



**Figure 5.4 – Matthews Creek catchment PMF event impact – change in velocity**

# 6 Summary

Hydrologic (XP-RAFTS) and hydraulic (TUFLOW) models were used to assess the impacts of the revised longwall panels LW W1 to LW W4 on peak flood levels in Matthews Creek, Cedar Creek and Stonequarry Creek for the 1% AEP and PMF events. The impact assessment found that the proposed subsidence from LW W1 to LW W4 will have negligible impacts on peak water levels and velocities.

For the 1% AEP event (see Figure 5.1 and Figure 5.2):

- Within the TUFLOW model extent, Barkers Lodge Road has a 1% AEP flood immunity;
- The peak flood level is predicted to decrease by up to 0.11 m and increase by up to 0.05 m;
- The peak flood velocity is predicted to increase by up to 0.15 m/s at localised areas within creek channels, however increases are generally less 0.05 m/s;
- Results indicate a similar flood extent in the existing and post-subsidence conditions; and
- Impacts due to the proposed subsidence are negligible.

For the PMF event (see Figure 5.3 and Figure 5.4):

- The crest of Barkers Lodge Road is overtopped during the PMF event under existing and post-subsidence conditions by up to 1.5 m;
- The peak flood level is predicted to decrease by up to 0.11 m and increase by up to 0.1 m;
- The peak flood velocity is predicted to increase by up to 0.2 m/s at localised areas within creek channels, however increases are generally less 0.1 m/s;
- Results indicate a similar flood extent in the existing and post-subsidence conditions; and
- Impacts due to the proposed subsidence are negligible.

# 7 References


| | |
|---|---|
| BOM (2003a) | The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method. Prepared by the Hydrometeorological Advisory Service Australian Government Bureau of Meteorology June 2003. Accessed from http://www.bom.gov.au/hydro/has/pmp.shtml on 11 October 2007 |
| BOM (2003b) | Guide to the Estimation of Probable Maximum Precipitation: Generalised Tropical Storm Method. Report and accompanying CD prepared by the Hydrometeorological Advisory Service Australian Government Bureau of Meteorology November 2003 |
| IEAUST (1999) | Australian Rainfall and Runoff. A Guide to Flood Estimation. Institution of Engineers Australia (1999) |
| WRM (2014) | Tahmoor Coal Flood Impact Study: LW31-37, WRM Water and Environment, 3 December 2014, reference 1072-02-B |
| WRM (2019) | Matthew Creek Catchment Flood Impact Study for LW W1-W2, WRM Water and Environment, 3 May 2019, reference 1072-05-B1 |

# Appendix A - 1% AEP event model results

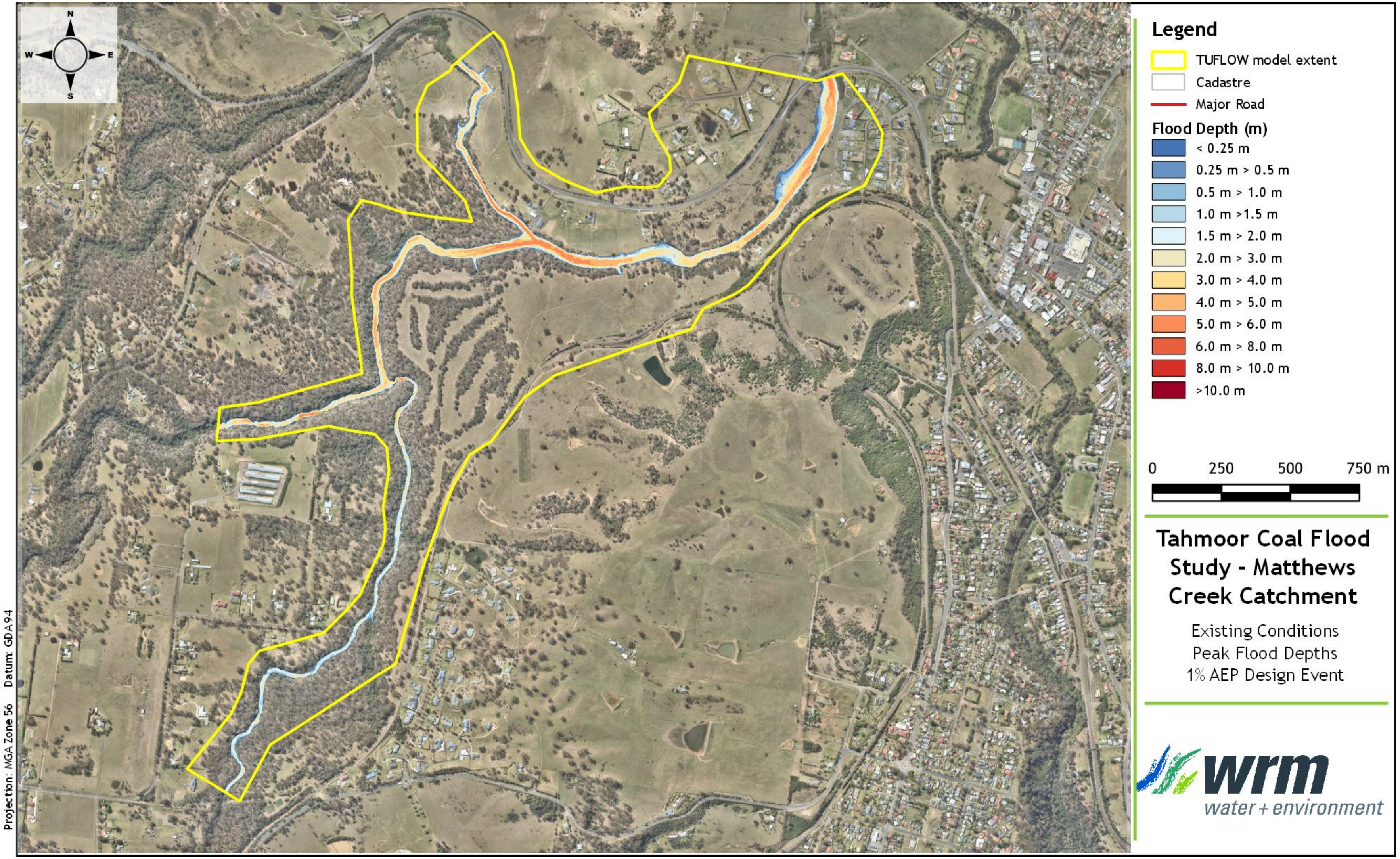



**Figure A.1 – Matthews Creek catchment existing conditions – 1% AEP event peak flood depths**

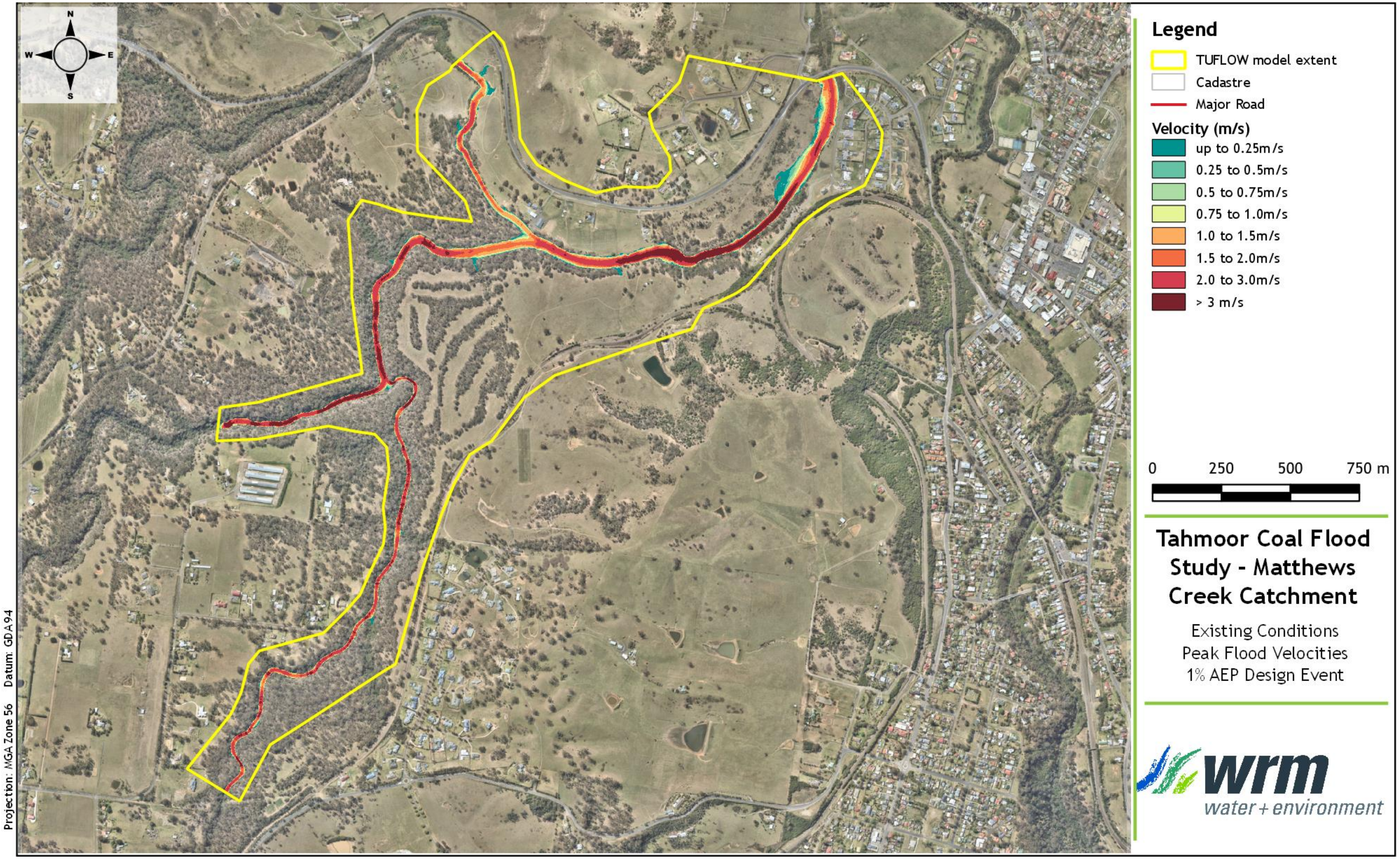



**Figure A.2 – Matthews Creek catchment existing conditions - 1% AEP event peak flood velocities**

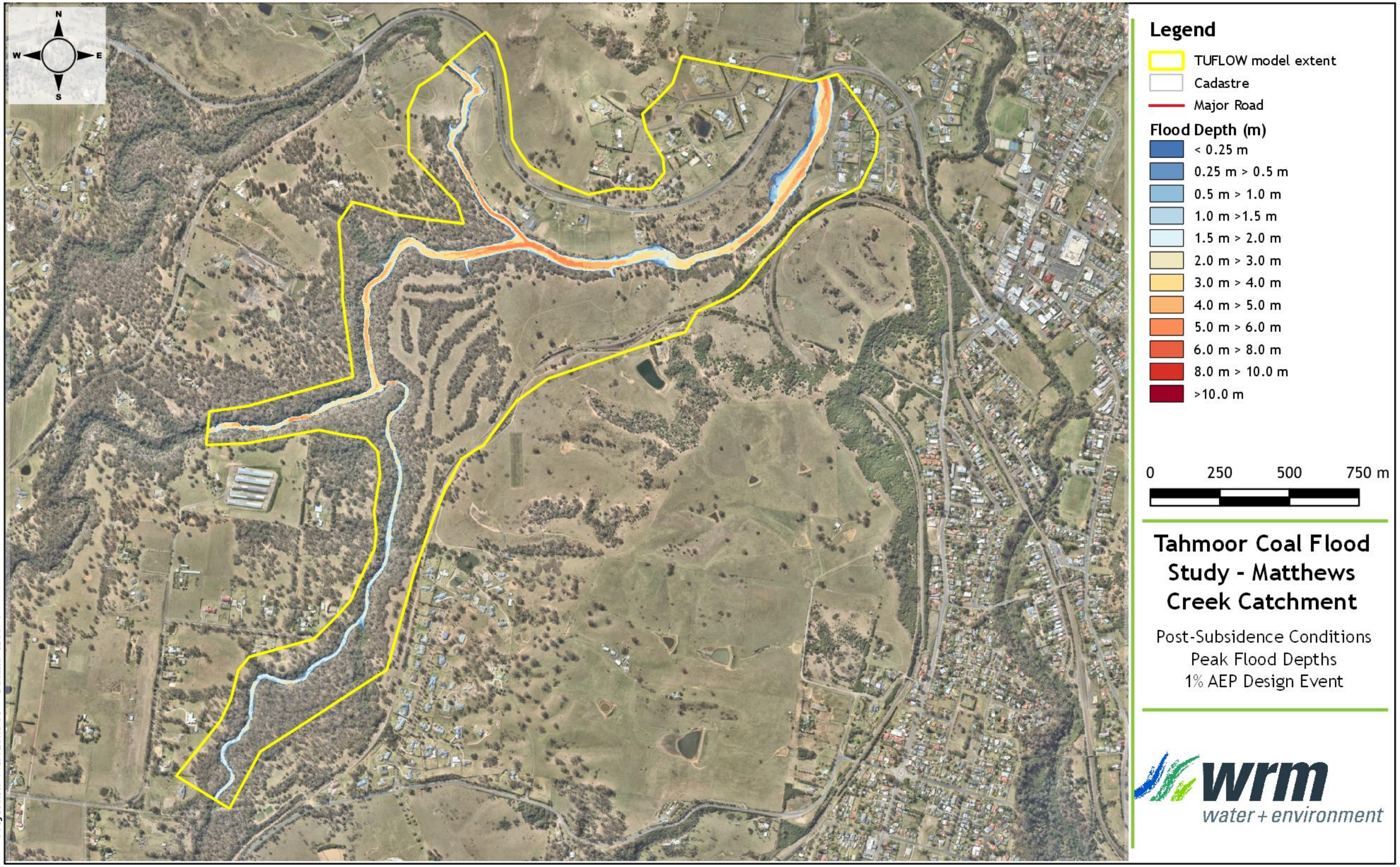



**Figure A.3 – Matthews Creek catchment post-subsidence conditions – 1% AEP event peak flood depths**

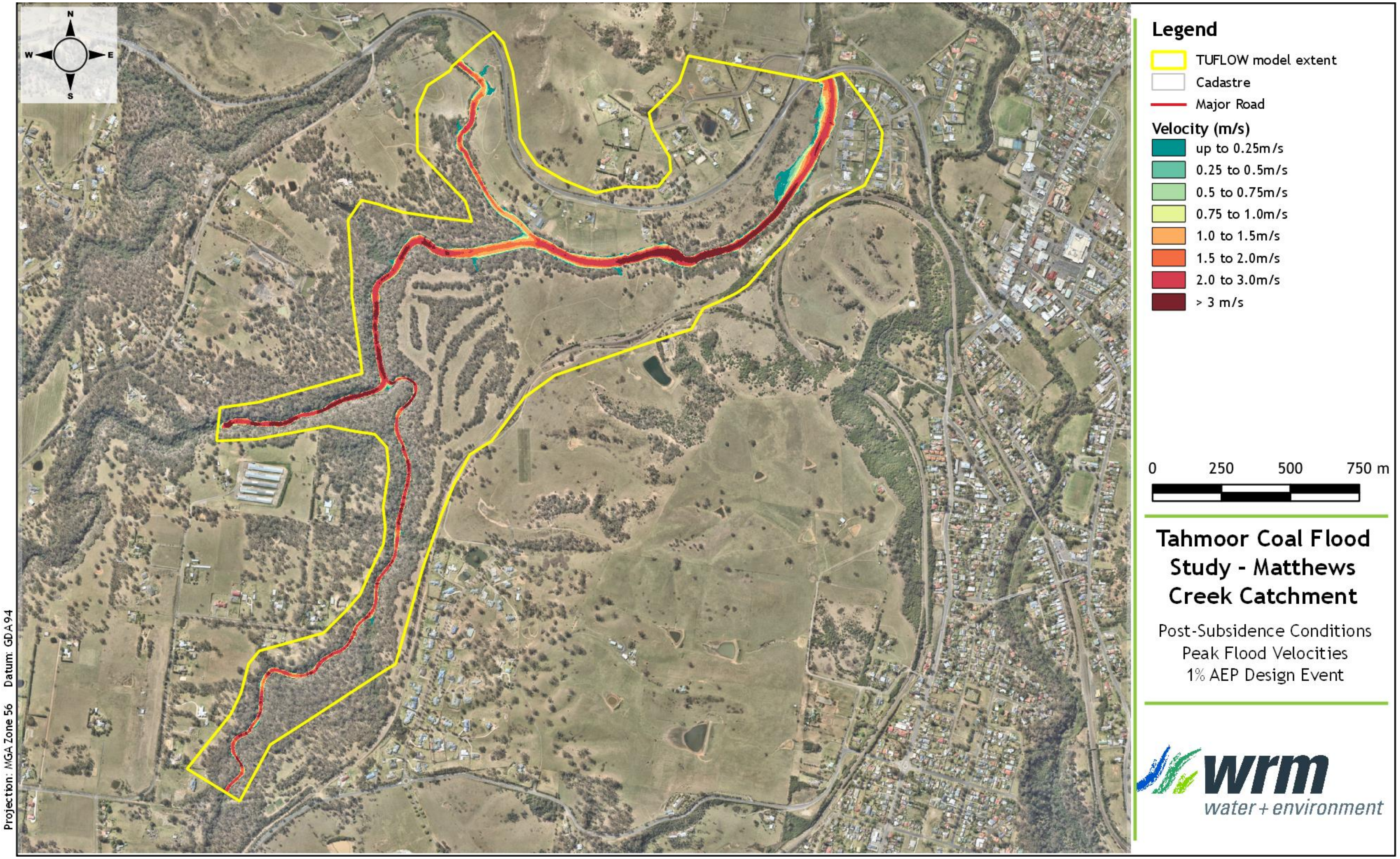



**Figure A.4 – Matthews Creek catchment post-subsidence conditions – 1% AEP event peak flood velocities**

# Appendix B - PMF event model results

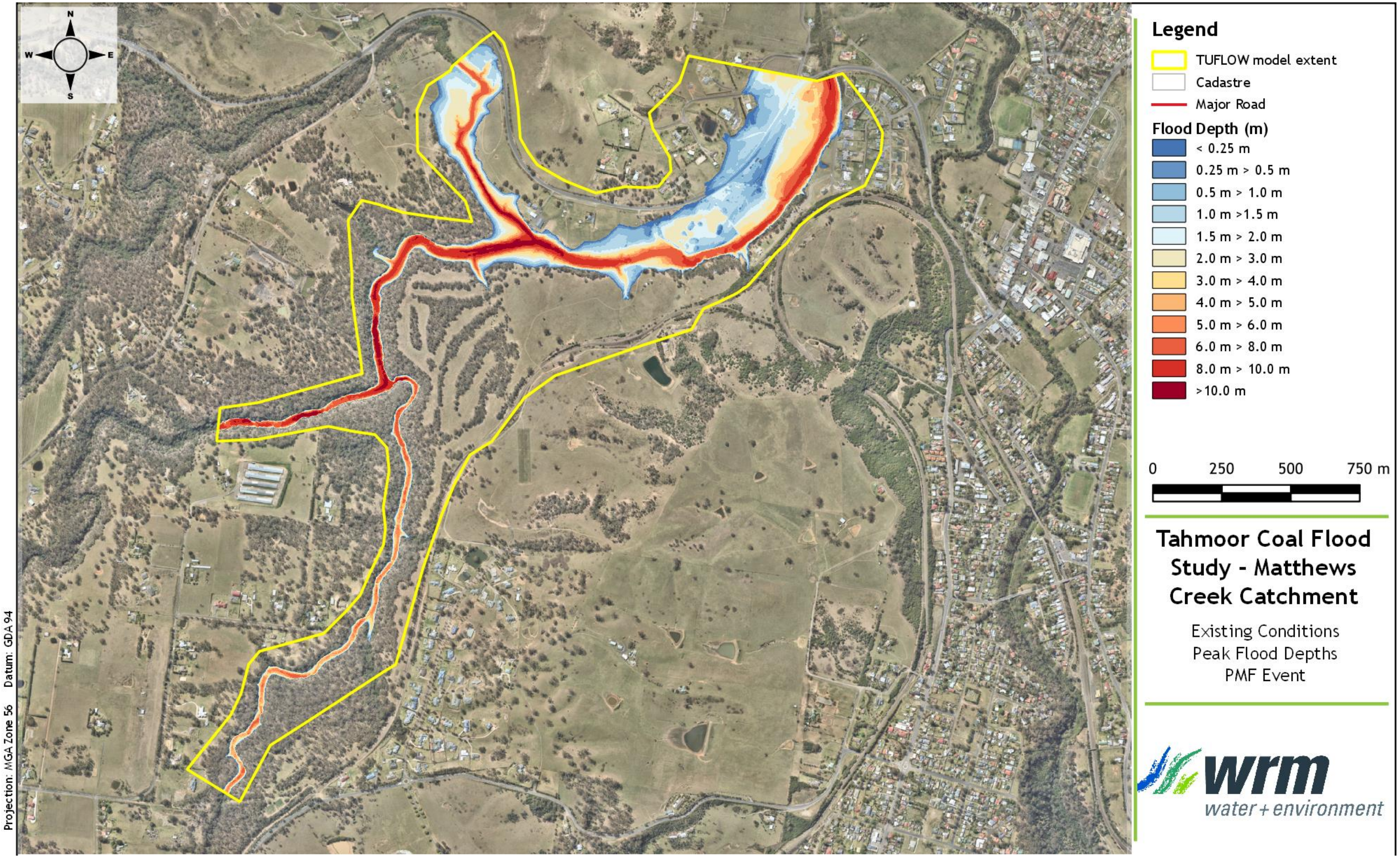



**Figure B.1 – Matthews Creek catchment existing conditions – PMF event peak flood depths**

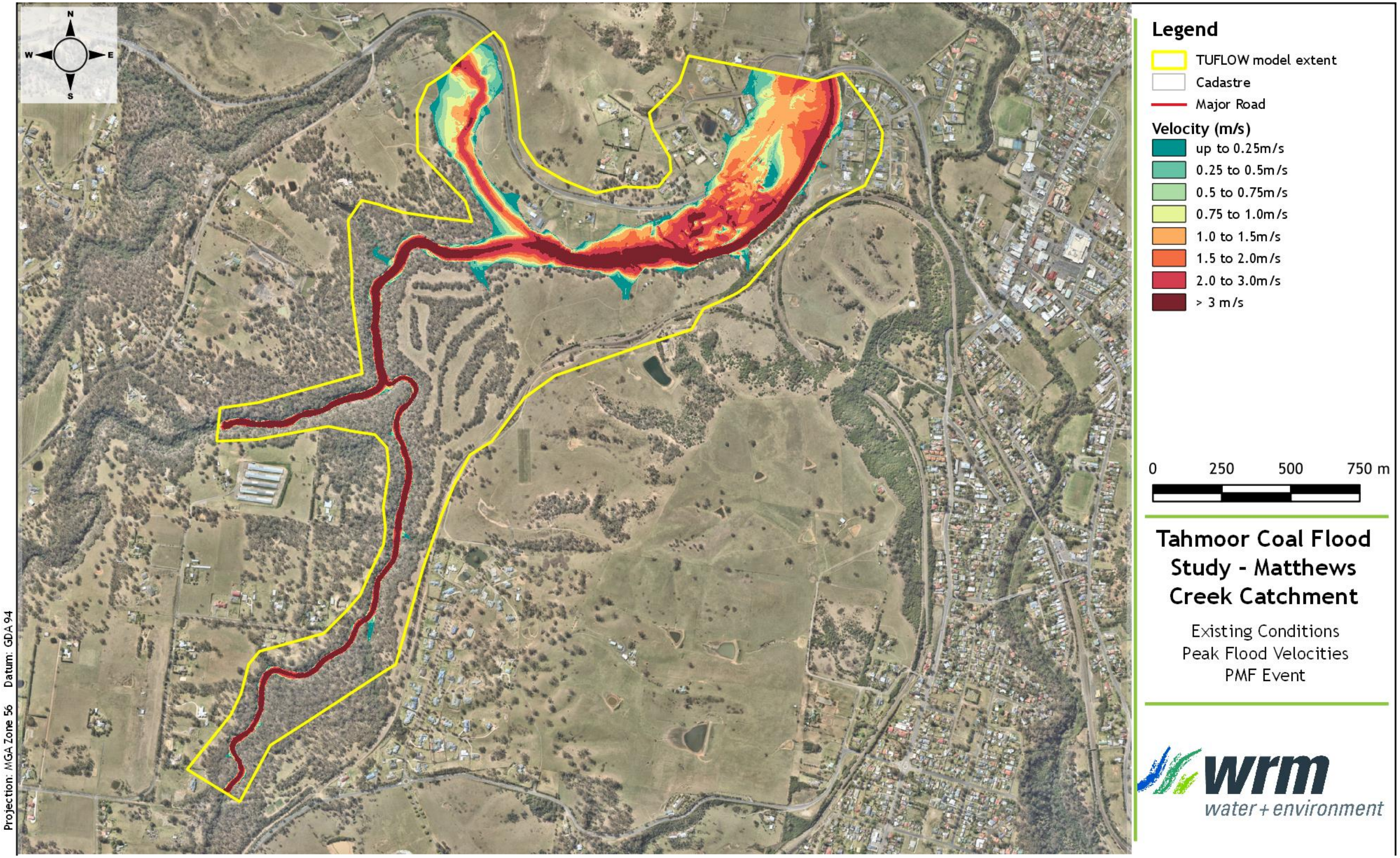



**Figure B.2 – Matthews Creek catchment existing conditions – PMF event peak flood velocities**

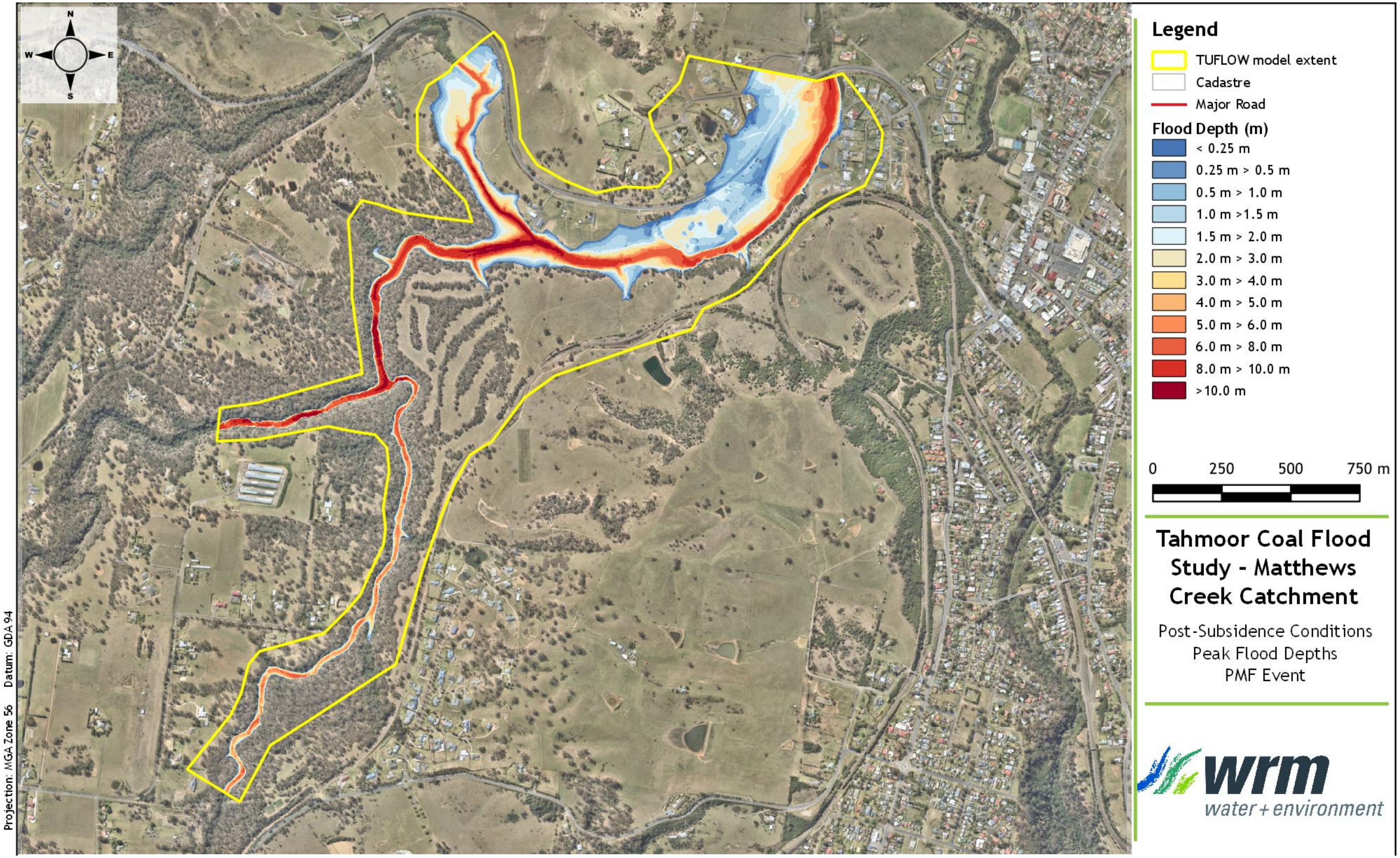



**Figure B.3 – Matthews Creek catchment post-subsidence conditions – PMF event peak flood depths**

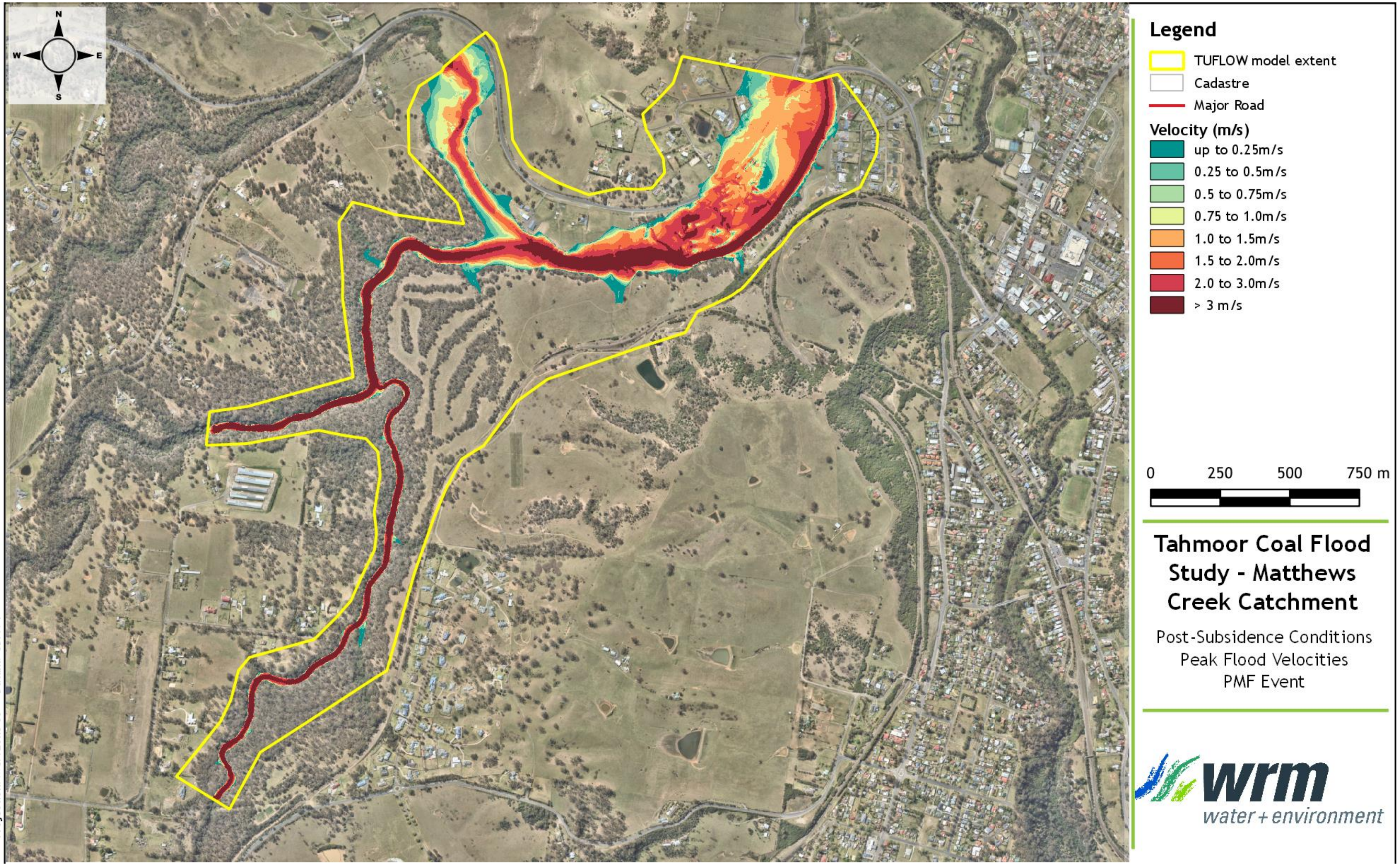



**Figure B.4 – Matthews Creek catchment post-subsidence conditions – PMF event peak flood velocities**