HYDRO ENGINEERING & CONSULTING PTY LTD

REPORT

Tahmoor Mine
Extraction Plan LW W1 – W2
Amended Surface Water
Technical Report

Prepared for: Tahmoor Coal

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1.0 INTRODUCTION

1.1 EXTRACTION PLAN STUDY AREA

The 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. Tahmoor Mine produces a primary hard coking coal product and a secondary higher ash coking coal product that 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.

The Tahmoor Mine has been operated by Tahmoor Coal Pty Ltd (Tahmoor Coal) since Tahmoor Mine commenced in 1979 using board and pillar mining methods and via longwall mining methods since 1987. Tahmoor Coal, trading as Tahmoor Coking Coal Operations (TCCO), is a wholly owned subsidiary within the SIMEC Mining Division (SIMEC) of the GFG Alliance (GFG).

Tahmoor Coal has previously mined 31 longwalls to the north and west of the Tahmoor Mine pit top location (refer to Figure 1). Tahmoor Coal is currently mining Longwall 32 in accordance with Development Consents and Subsidence Management Plan Approval.

Tahmoor Coal proposes to extend underground coal mining to the north-west of the Main Southern Railway (referred to as the 'Western Domain') which will include Longwalls West 1 (LW W1) to West 4 (LW W4) at Picton and Thirlmere. The first two longwalls to be mined are LW W1 and Longwall West 2 (LW W2) (collectively referred to as LW W1 - W2), which are the focus of this Extraction Plan. The location of these areas is shown in Figure 1.

The proposed LW W1 - W2 are located in the area referred to as the 'Western Domain' within Mining Lease (ML) 1376 and ML 1539. The location of the mining tenure is illustrated in part on Figure 1.

The Longwalls W1-W2 Extraction Plan was granted approval on 8 November 2019 by the NSW Government Department of Planning Industry and Environment (DPIE). Conditions were imposed on approval of the Extraction Plan as detailed in *Tahmoor Coal Mine Longwalls W1-W2 Extraction Plan: Reasons for Approval* (DPIE, 2019).

1.2 PURPOSE AND SCOPE

Hydro Engineering & Consulting Pty Ltd (HEC) was commissioned by Tahmoor Coal to complete a Surface Water Technical Report (SWTR) which informed the Water Management Plan (Tahmoor Coal, 2019) for the Tahmoor Mine Extraction Plan LW W1 - W2. The purpose of the SWTR (HEC, 2019) was to outline the management strategies, controls and monitoring programs to be implemented for the management of potential environmental impacts and consequences of the proposed underground workings on watercourses and surface drainage, in accordance with Condition 13H of the Development Consent.

Further conditions for management of surface water resources within and adjacent to LW W1 – W2 were imposed on approval of the Extraction Plan (DPIE, 2019). The conditions relate predominately to performance indicators necessary for managing and monitoring compliance with performance measures, revisions to the Trigger Action Response Plan and development of a detailed adaptive management strategy. The conditions are to be addressed in an updated version of the Water Management Plan to the satisfaction of the DPIE Secretary. Subsequently, to support revision of the Water Management Plan, this Amended SWTR has been revised to address the conditions imposed on approval of the Extraction Plan (DPIE, 2019) in relation to surface water management.

The Amended SWTR has also been revised to provide additional surface water baseline data which has been collated and analysed for the Western Domain since submission of the SWTR (HEC, 2019). The outcomes of the assessment of potential impacts to flood levels, flow depth and flow velocity for specific culverts and associated tributaries of Matthews Creek, Cedar Creek and Stonequarry Creek as a result of proposed modifications to the masonry structures is also presented.

The Amended SWTR for the Extraction Plan covers a Study Area for LW W1 and LW W2 that includes both the predicted 20 mm Total Subsidence Contour and the 35° Angle of Draw Line (refer Figure 1). A separate Extraction Plan will be prepared for future LW W3 and LW W4, which are included in a broader Investigative Area (refer Figure 1).

1.3 STRUCTURE OF THIS DOCUMENT

The Amended SWTR is structured as follows:

Section 2: Outlines the statutory requirements applicable to the Surface Water Technical Report.

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

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

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

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

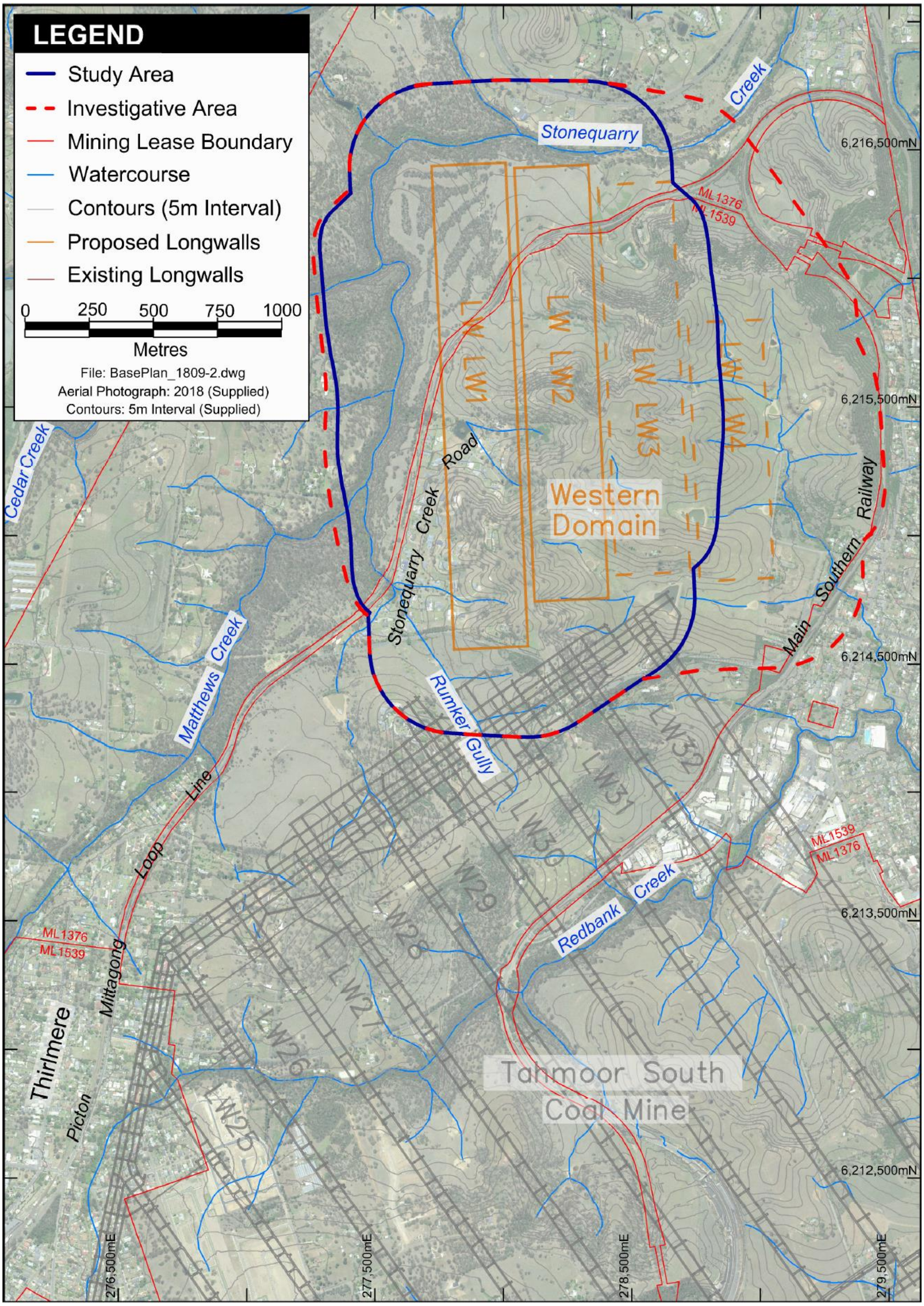

Figure 1 Water Management Plan Investigative Area

2.0 STATUTORY REQUIREMENTS

2.1 PROJECT APPROVAL

Under Condition 13H of the Development Consent (DA 67/98), an Extraction Plan was required for all second workings from LW W1 and subsequent longwalls. The majority of the Western Domain is covered by Mining Lease Number 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 Mining Lease Number 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 was prepared in consultation with the NSW Environment Protection Authority (EPA), Department of Planning, Industry & Environment (DPIE), Department of Planning & Environment (DPE) - Resources Regulator and WaterNSW to provide for the management of potential impacts and environmental consequences of the proposed underground workings on watercourses and aquifers. The specific requirements of the Water Management Plan with respect to surface water and the sections of the SWTR (HEC, 2019) which address each requirement are listed in Table 1.

Table 1 Development Consent (DA 67/98) Requirements of the Water Management Plan – Surface Water

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: • stream flows and quality; • stream and riparian vegetation health; and • channel and bank stability.	Section 5.0 and *Aquatic Biodiversity Technical Report Tahmoor North* (Niche, 2019a)
A flood management protocol to: • identify secondary access routes for those properties that could potentially be adversely impacted by 1% AEP flood events; • regularly consult with landowners that would not have either a primary or secondary access route during 1% AEP flood events; • 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 • 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 5.2
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 PROJECT APPROVAL CONDITIONS

Further conditions for management of surface water resources within and adjacent to LW W1 – W2 were imposed on approval of the Extraction Plan (DPIE, 2019). The conditions were addressed in an updated version of the Water Management Plan to the satisfaction of the DPIE Secretary. The specific conditions with respect to revision of the Water Management Plan and the sections of this Amended SWTR (HEC, 2019) which address each requirement are listed in Table 2.

Table 2 Project Approval Conditions – Surface Water

Requirement	Where Addressed or Why not Addressed
Include performance indicators capable of managing and monitoring compliance with the performance measures in Condition 1 of the Extraction Plan approval.	Performance indicators are addressed in the Trigger Action Response Plan –Table 33, Section 6.2.
Include suitable revisions to the Trigger Action Response Plan to include:	
• Level 1, 2 and 3, and exceeding prediction triggers to enable trends in data to be identified, actioned and reported as potential impacts escalate;	The Trigger Action Response Plan (Table 33, Section 6.2) has been revised to incorporate four trigger levels.
• Separation of actions and responses;	The Trigger Action Response Plan (Table 33, Section 6.2) has been revised to address actions and responses separately.
• Methodology and relevant monitoring stations;	The methodology and relevant monitoring stations are specified in the revised Trigger Action Response Plan (Table 33, Section 6.2).
• Higher frequency monitoring of pool water levels;	Additional pool water level monitoring sites have been implemented with baseline data provided in Section 3.0 and Appendix B.
• Justification of the proposed flow triggers; and	Justification of the proposed flow triggers is discussed in Section 6.2.
• Specific figures relevant to the baseline data.	Specific figures relevant to the baseline data are provided in Section 6.2.
Include a detailed adaptive management strategy that sets quantifiable assessment criteria and provides parameters for when additional setbacks from relevant watercourses should be implemented.	A detailed adaptive management strategy is addressed in the revised Water Management Plan.

Further comments pertaining to the revised Water Management Plan and Amended SWTR were provided by the DPIE and have been addressed in the second revision of the Water Management Plan and Amended SWTR (this report). The specific comments relevant to surface water and the sections of this revised Amended SWTR which address each requirement are listed in Table 2.

Table 3 Further Agency Comments – Surface Water

Organisation	Requirement	Where Addressed or Why not Addressed
Wollondilly Shire Council	Provide an updated overview of potential subsidence induced impacts based on current research including relevant parts of the Final Report by the Independent Panel for Mining in the Drinking (sic) Catchment.	An overview of potential subsidence induced impacts are provided in Section 4.2.1 and Section 4.2.2.
	Include a greater description of potential impacts resulting from re-emergence of water that enters mine induced fractures.	A description of potential impacts resulting from re-emergence of water that enters mine induced fractures is provided in Section 4.2.1 and Section 4.2.2.
	Duration of the post mining monitoring program be expanded from 12 months to a timeframe as recommended by current scientific research.	The monitoring program detailed in Section 5.0 and the Trigger Action Response Plan (TARP), Table 33 of Section 6.0, have been updated in relation to the duration of the post mining monitoring program.
	Update the Stream Water Quality Impact Feature to include inspections for the presence of any re-emergence of water to the surface from mine induced fractures and that any such identified re-emergence is monitored as part of the program.	The TARP for surface water quality presented in Table 33 of Section 6.0 has been updated to include inspections for the presence of any re-emergence of water to the surface from mine induced fractures.
DPIE - Environment, Energy and Science (EES) Division	Improvement of TARPs for flow, pool and ground water levels to demonstrate how an objective BACI assessment can be achieved given the monitoring sites/frequencies while also incorporating quality assurance/quality control (QA/QC) for data derived from the monitoring program. The TARPs also need to clearly and unambiguously identify important pools and levels of impacts for which remediation is required.	Section 3.2 and Section 5.0 have been updated to demonstrate adoption of a BACI approach to surface water monitoring. The QA/QC approach for data derived from the monitoring program is summarised in Section 5.0.
DPIE	Update Trigger Action Response Plan (TARP) with all identified reference sites for water quality, stream flows and pool depths.	Section 3.2 and the TARPs in Table 33 of Section 6.0 have been updated to specify control / reference monitoring sites and baseline / impact monitoring sites.

2.3 SUBSIDENCE PERFORMANCE MEASURES

In accordance with the conditions on approval of the Extraction Plan for Longwalls W1 – W2, the Applicant must ensure that the development does not cause any exceedances of the performance measures listed in Table 4.

Table 4 Subsidence Impact Performance Measures – Natural Features

Feature	Performance Measures	Exceedance Criteria
Stonequarry Creek, Cedar Creek and Matthews Creek	No subsidence impact or environmental consequence greater than minor*	This performance indicator will be considered to be exceeded if mining-induced fracturing in a rockbar or stream bed results in a reduction in pool water level below historically recorded water levels, taking into account rainfall and observations during the baseline monitoring period, for: • More than 10% of pools located within the 600 m Study Area for Natural Features; and/or • Pool SR17.
	No connective cracking between the surface, or the base of the alluvium, and the underground workings	This performance indicator will be considered to be exceeded if analysis of inflow data suggests high correlation to rainfall events and significant departure from recent groundwater model predictions. This would be supported by analysis of pre- and post-mining goaf centreline bore data.

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

2.4 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. The Natural Resources Access Regulator (NRAR) is an independent regulatory body established by DPIE – Water and is responsible for compliance with and enforcement of the regulatory framework. The Investigative 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 kilometres (km) south of the Study Area. Some water is also supplied under agreement with Sydney Water. None of the activities involve extraction of water or water sharing from sources covered by the WSP.

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.

2.5 CONSULTATION

This SWTR has been prepared in consultation with the EPA, DPIE - Water, NRAR, DPE Resources Regulator, WaterNSW, Dams Safety Committee (DSC), NSW Office of Environment and Heritage (OEH) and NSW State Emergency Services (SES). Table 5 presents a summary of the consultation outcomes with respect to surface water management for the Tahmoor Mine Extraction Plan LW W1 - W2.

Table 5 Surface Water Management Consultation Outcomes

Stakeholder	Stakeholder Comment	Tahmoor Coal Response
NSW Environment Protection Authority (EPA)	As the proposed activity does not include works that require modification of surface facilities or changes to the licence, the EPA has no comments to provide on the Extraction Plan.	Noted
Department of Planning, Industry & Environment - Water (DPIE - Water)	Refer to NRAR consultation.	
NSW Infrastructure - Land & Water - Natural Resources Access Regulator – East (NRAR)	NRAR did not raise any comments regarding surface water.	Noted
NSW Department of Planning & Environment – Resources Regulatory (Environment)	Consideration should be given to increase the stand-off distance from creek lines to avoid/minimise impacts or investigate other longwall layout configurations.	The SCT (2019) report supports the orientation of the current mine plan in the Western Domain in relation to the stand-off distances from creek lines.
	If the creeks in the Western Domain are likely to be impacted, demonstrated progress of remediation of Myrtle Creek and Redbank Creek would provide additional confidence that Tahmoor Coal can effectively remediate creek impacts.	Noted.
	Commence collecting baseline data for groundwater and surface water to help inform the subsidence monitoring program and the development of completion criteria for rehabilitation.	Surface water monitoring of creeks in the Western Domain commenced in December 2018 and groundwater monitoring in the Western Domain commenced in March 2019.
WaterNSW	As the Study Area is located outside the Sydney Drinking Water Catchment area, WaterNSW has no comments on the project.	Noted
Dams Safety Committee (DSC)	DSC stated that LW W1-W2 does not lie within the DSC Notification Area, and DSC has no requirements for the LW W1-W2 Extraction Plan.	Noted

Table 4 (Continued) Surface Water Management Consultation Outcomes

Stakeholder	Stakeholder Comment	Tahmoor Coal Response
NSW Office of Environment and Heritage (OEH)	OEH stated that the mine plan for LW W1-W2 was an improvement on the previous mine plan presented in the SMP for LW31-37, however there are still perceived issues due to the proximity (approximately 100 m) to Cedar Creek and Stonequarry Creeks. In particular, the proximity of the corner of LW W2 to Stonequarry Creek is perceived to be an issue. Pulling the longwalls back (e.g. 200 m) would reduce the effects of upsidence and valley closure to the creeks and would enable quicker approval of the Extraction Plan. The cost of remediation following mining may outweigh the profit of mining the start of the longwall that is in proximity to the creeks.	Tahmoor Coal advised that a review of subsidence impacts following the first 1,000 m of mining of LW W1 would be completed and appropriate adaptive management strategies (if required) would be implemented for LW W2. Tahmoor Coal acknowledges that the north-eastern corner of LW W2 is 250 m from the grinding groove site in Stonequarry Creek. Current subsidence predictions (MSEC, 2019) indicate that the performance measures will be met with negligible subsidence impacts to all Aboriginal heritage sites.
	OEH noted that adaptive management strategies following mining would be too late to mitigate impacts the influences of LW W1 on the creeks to the north of the longwall.	The SCT (2019) report supports the orientation of the current mine plan in the Western Domain in relation to the stand-off distances from creek lines.
	OEH noted that the justification behind mining in proximity to the creeks would need to be sound.	Tahmoor Coal confirmed justification would be provided in the Extraction Plan. The SCT (2019) report supports the orientation of the current mine plan in the Western Domain in relation to the stand-off distances from creek lines.
NSW State Emergency Services (SES)	SES requested provision of a copy of the Tahmoor Coal Emergency Management Plan for evacuations and vertical rescue.	A copy of the Emergency Management Plan (document TAH-HSEC-00168) for underground workings was provided. A flood impact assessment was completed by WRM (2019) for LW W1-W2 and determined that there would be a negligible increase in flood risk as a result of the proposed mining in the Western Domain.

3.0 EXISTING ENVIRONMENT

3.1 EXISTING SURFACE WATER RESOURCES WITHIN CATCHMENT

The Investigative Area is located in the Stonequarry Creek Catchment with the natural waterway features comprising Matthews Creek, Cedar Creek and Stonequarry Creek, as shown in Figure 1. Redbank Creek flows from west to east adjacent to, though outside of, the southern boundary of the Investigative Area. A topographic ridgeline straddles the Investigative Area, with the south-east portion of the area discharging via tributaries to Redbank Creek. The south-west portion of the area discharges to Matthews Creek, while the north-northwest portion of the area discharges to Cedar Creek and Stonequarry Creek.

Matthews Creek and Cedar Creek rise in low hills to the west of the Investigative Area, with their junction approximately 200 m west of LW W1. Stonequarry Creek also rises to the west and flows to the east along the northern boundary of the Investigative Area, joining Cedar Creek approximately 130 m north of LW W2, before flowing east and south through the town of Picton. Redbank Creek flows into Stonequarry Creek towards the south-east of the Investigative Area. 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 Investigative Area, although its headwaters also lie in the coastal ranges to the east of the Investigative 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 Investigative Area are not part of a WaterNSW Drinking Water Catchment Area.

The surface water resources within the Investigative Area are regulated by the *Water Sharing Plan for Greater Metropolitan Region Unregulated River Water Sources* which specifically addresses the Stonequarry Creek Management Zone. A review of the NSW Water Register[1] identified six properties within the Investigative Area with a Water Supply Works and Water Use Approval. The approvals pertain to diversion works from an adjacent surface water system (pumping) and/or through collection in a farm dam for irrigation purposes.

3.1.1 Redbank Creek

Redbank Creek is a fourth order stream[2] within the vicinity of the Investigative Area, with minor tributary gullies of Redbank Creek traversing the south-eastern portion of the Investigative Area. Redbank Creek flows towards the east where it joins Stonequarry Creek approximately 1.5 kilometres east of Longwall 32 (LW 32). The catchment area of Redbank Creek to its confluence with Stonequarry Creek is estimated at 7.8 square kilometres (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 LW 25 to LW 31 and LW 32 which is currently being mined. The upper and middle reaches near Thirlmere are located in residential and semi-rural residential areas, while the downstream portion near LW 32 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 Tahmoor Mine area, the creek comprises a sequence of rock bar, boulder and rock shelf constrained pools. Redbank Creek

[1] https://waterregister.waternsw.com.au

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

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).

The minor tributaries of Redbank Creek within the Investigative Area are ephemeral and likely only flow during periods of extended, moderate or high rainfall. Surface water runoff from the headwaters of these tributaries is predominately captured by farm dams with runoff from the tributaries likely to contribute to flow in Redbank Creek during periods of extended or significant rainfall only.

3.1.2 Matthews Creek

Matthews Creek is a fourth order stream where it flows within the vicinity of the Investigative Area. The Creek traverses the western boundary of the Investigative Area, running near parallel to the Picton Mittagong Loop Line before flowing into Cedar Creek. Eastern tributary gullies of Matthews Creek flow above the proposed LW W1 and LW W2. 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. Within the Investigative Area, the creek channel is relatively incised in Hawkesbury Sandstone, with a steep sided valley and isolated vertical scarps (GeoTerra, 2014).

The eastern tributaries of Matthews Creek within the Investigative Area are ephemeral. The tributaries are predominately first and second order streams, excepting a portion of Rumker Gully which is a third order stream from the Picton Mittagong Loop Line to the confluence with Matthews Creek (refer Figure 4). 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.

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 rock bars, boulders and rock shelves, which form standing pools along the alignment of the tributary (MSEC, 2019).

A visual inspection of pools on Matthews Creek was undertaken by GeoTerra in 2019 prior to commencement of mining of LW W1. The visual inspection identified that there were no connective overland water flows in Matthews Creek. Most pools were dry with a few pools holding water at low to medium levels.

The pool locations and corresponding monitoring sites (refer Section 3.2) are shown in Figure 2 and a summary of the visual inspection is presented in Table 6. Photographs of specific pools are provided in Appendix A. A total of 46 rock bar, boulder and rock shelf constrained pools were identified on Matthews Creek.

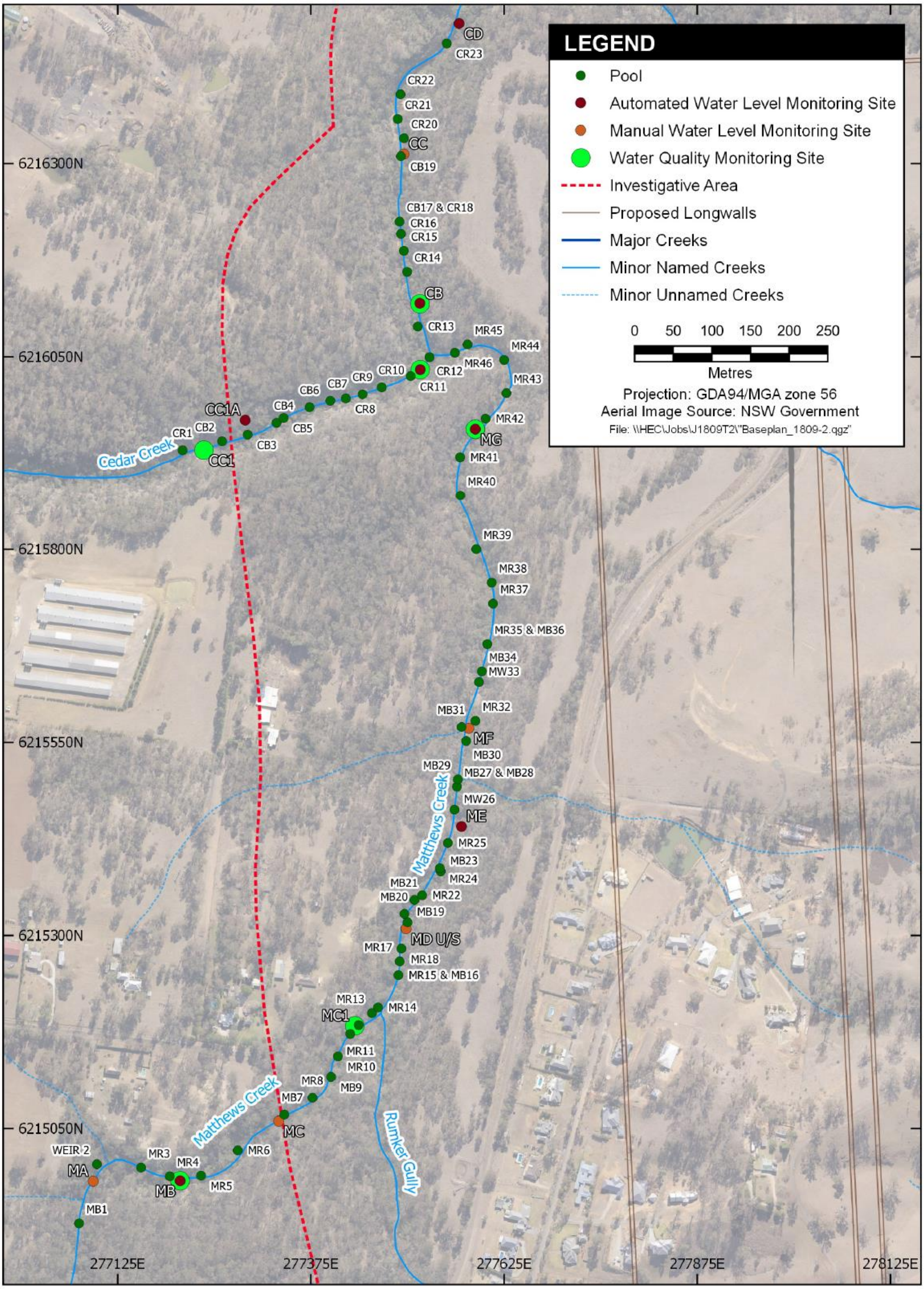

Figure 2 Matthews Creek and Cedar Creek Pool Locations

Table 6 Matthews Creek Pool Description

Pool	Description
MB1	Boulder constrained pool
Weir 2	Concrete weir constrained pool with dark brown / black water
MR3	Rock / boulder constrained long pool
MR4	Black water
MR5	Black water with large outcrop overhang on RHS looking DS
MR6	Long shallow boulder constrained pool with large outcrop overhang on LHS looking US
MB7	Narrow boulder constrained pool
MR8	Long boulder race
MB9	Long pool
MR10	Wider boulder constrained pool
MR11	Boulder constrained pool
MB12	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	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	Rock bar constrained wide pool
MR24	First notable standing water in boulder / rock bar constrained pool
MR25	Series of pools in stepped dipping sandstone
MW26	Series of pools in stepped dipping sandstone
MB27 & MB28	Large pool boulder / rock bar constrained
MB29	Small boulder constrained pool with side creek entering
MB30	Moderate boulder / rock bar constrained pool
MB31	Small boulder constrained pool
MR32	Small boulder constrained pool
MW33	<2 m high US waterfall and DS pools in sandstone race
MB34	Moderate boulder / rock bar constrained pool
MR35 & MB36	Small pool and sandstone race
MR37	Boulder race
MR38	Boulder race
MR39	Wide long rock bar constrained pool
MR40	Medium sized pool with rock bar control
MR41	Boulder race with small pools
MR42	Deep pool around bend in creek with outcrop overhang on LHS (looking DS)

Table 4 (Continued) Matthews Creek Pool Description

Pool	Description
MR43	Creek drops elevation significantly with outcrop overhang on both sides from sites 42 - 45
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

Note: LHS = left hand side, RHS = right hand side, US = upstream, DS = downstream

3.1.3 Cedar Creek

Cedar Creek flows from south-west to north-east adjacent to the northern boundary of the Investigative Area. A minor tributary gully of Cedar Creek flows from east to west over the northern portion of LW W1 and LW W2. Cedar Creek joins with Stonequarry Creek adjacent to the northern boundary of LW W2 and has an estimated catchment area of 27 km^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 Investigative Area is ephemeral 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 flowing to Cedar Creek. 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, 2019b).

In the Investigative Area, the channel of Cedar Creek is incised in Hawkesbury Sandstone, with a steep sided valley and exposed sandstone base in some parts. Rock bar, boulder and rock shelf constrained pools are prominent in the portion of creek traversing the Investigative Area. The bed and banks are well vegetated and show little evidence of erosion or bank instability (GeoTerra, 2014).

A visual inspection of pools on Cedar Creek was undertaken by GeoTerra in 2019 prior to commencement of mining of LW W1. During the visual inspection, GeoTerra recorded that no connective overland water flows were observed in Cedar Creek upstream of the confluence with Matthews Creek. Most pools were dry with a few pools holding water at low to medium levels. Downstream of Matthews Creek, pools in Cedar Creek were full with a trickle flow observed out of the majority of the pools. The sand substrate at the lower reaches of Cedar Creek near the confluence with Stonequarry Creek had no observable flow, though the stream would have been flowing into Stonequarry Creek through the sand. Pools in this section were either dry or at low levels.

The pool locations and corresponding monitoring sites (refer Section 3.2) are shown in Figure 2 and a summary of the visual inspection is presented in Table 7. Photographs of specific pools are provided in Appendix A. A total of 32 rock bar, boulder and rock shelf constrained pools were identified on Cedar Creek.

Table 7 Cedar Creek Pool Description

Pool	Description
CR1	-
CB2	Deep, wide large pool with steep / high sandstone sides
CB3	Shallow wide pool with DS boulder control
CB4	Boulder race
CB5	Shallow boulder constrained pool which divides into two channels DS
CB6	Large, wide boulder constrained pool
CB7	Narrow boulder constrained medium sized pool
CR8	Rock bar constrained long narrow pools, with outcrop overhang on LHS
CR9	RHS not visible, LHS flowing under short outcrop overhang
CR10	Large wide boulder constrained pool
CR11	Large wide pool US of rock bar at confluence with Matthews Ck
CR12	Large wide pool US of rock bar at confluence with Matthews Ck
CR13	Wide long rock shelf constrained pool with large outcrop overhang on RHS
CR14	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	Shallow narrow pool
CR20	Long pool with shallow rock bar constrained pool
CR21	Small / medium pool, boulder / rock bar constrained
CR22	Long shallow sandstone shelf with flow diverted to one side
CR23	Shallow pools on sandstone shelf
CR24	Long pool, flowing around a rock bar / boulder constrained
CR25	Wide, medium long pool
CR26	Small / med pool with large outcrop overhang on the bend, rock shelf control
CR27	Wide shallow pool
CR28	Wide medium sized pool
CR29	Small / medium pool
CB30	Medium sized pool
CR31	Series of small long pools in sand
CR32	Long stretch of narrow pools in sand / some boulders, US of Stonequarry Creek

Note: LHS = left hand side, RHS = right hand side, US = upstream, DS = downstream

3.1.4 Stonequarry Creek

Stonequarry Creek flows along the northern boundary of the Investigative Area and has an estimated catchment area of 44 km^2 to the downstream boundary of the Investigative Area. A minor tributary of Stonequarry Creek flows from south to north adjacent to the proposed LW W2. Stonequarry Creek then flows eastwards outside boundary of the Investigative Area, through the town of Picton, joining the Nepean River near Maldon. The catchment area of Stonequarry Creek upstream of the Investigative Area comprises mainly rural properties and farmland with localised housing development.

The minor tributary of Stonequarry Creek within the Investigative Area is ephemeral and 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 tributaries 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 flowing to Stonequarry Creek.

In the Investigative Area, the creek bed has a low gradient and contains rock bar, boulder and rock shelf constrained pools. The bed and banks are well vegetated and show little evidence of erosion or bank instability (GeoTerra, 2014).

A visual inspection of pools on Stonequarry Creek was undertaken by GeoTerra in 2019 prior to commencement of mining of LW W1. During the visual inspection, GeoTerra (2019) observed a trickle flow continuing over the rock bar which retains water levels in pool SC2. All pools were holding water at low to medium levels.

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 8. Photographs of specific pools are provided in Appendix A. A total of 22 rock bar, boulder and rock shelf constrained pools were identified on Stonequarry Creek.

Table 8 Stonequarry Creek Pool Description

Pool	Description
SC1	Isolated pool on rock shelf
SG2	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	Long pool with rock bar control
SB6	Medium pool with rock bar / willow tree control
SR7	Medium pool with rock bar control
SG8	Small pool with rock bar control and sandstone overhang
SG9	Small pool with rock bar / boulder / willow tree control
SR10	Large pool with willow tree / rock bar control
SB11 & ST12	Long pool with willow tree / rock bar control
SB13	Shallow wide pool
SB14	Long pool with sandstone overhang
SB15	Long narrow pool
SR16	Long narrow pool
SR17	End of pool where it flows over the large sandstone rock shelf
SR18	Series of connected pools on the large sandstone rock shelf
SR19	Series of connected pools on the large sandstone rock shelf
SR20	Series of connected pools on the large sandstone rock shelf
SR21	Series of connected pools on the large sandstone rock shelf
SR22	Series of connected pools on the large sandstone rock shelf

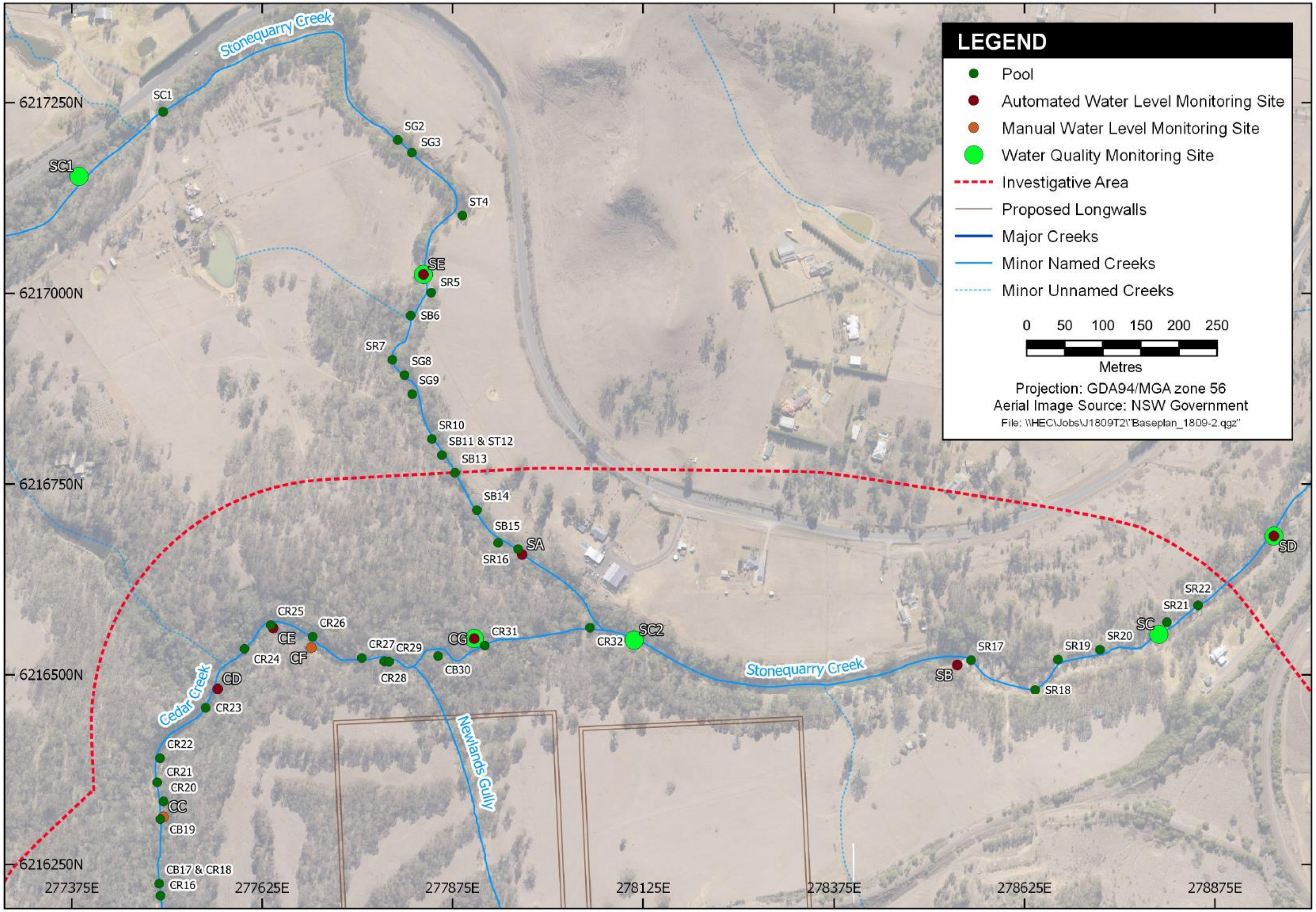

Figure 3 Stonequarry Creek Pool Locations

3.2 BASELINE MONITORING

Baseline pool water level and surface water quality data has been collected within and surrounding the Investigative Area at the locations shown in Figure 4. 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.

Table 9 summarises the Tahmoor Coal monitoring sites and the associated categories. Baseline data collection was undertaken until the commencement of second workings from LW W1 (November 2019). Monitoring sites SE and SF on Stonequarry Creek were installed following completion of the baseline data collection phase and, as such, data for these sites is not presented in the following sections.

Table 9 Summary of Surface Water Monitoring Sites

Site	Weir / Pool	Type of Monitoring	Site Category
Matthews Creek			
MA	Weir 2	Manual water level	Control / Reference
MB	MR4 and MR5	Automated water level Water quality monitoring	Control / Reference
MC	MB7	Manual water level	Baseline / Impact
MC1	MR11, MB12 and MR13	Water quality monitoring	Baseline / Impact
MD U/S	MB19	Manual water level	Baseline / Impact
ME	MR25 and MW26	Automated water level	Baseline / Impact
MF	MB30, MB31 and MR32	Manual water level	Baseline / Impact
MG	MR42	Automated water level Water quality monitoring	Baseline / Impact
Cedar Creek			
CCR	-	Automated water level	Control / Reference
CC1	CR1 and CB2	Water quality monitoring	Control / Reference
CC1A	CB3	Automated water level	Control / Reference
CA	CR11 and CR12	Automated water level Water quality monitoring	Baseline / Impact
CB	CR13	Automated water level Water quality monitoring	Baseline / Impact
CC	CB19	Manual water level	Baseline / Impact
CD	CR23	Automated water level	Baseline / Impact
CE	CB25	Automated water level	Baseline / Impact
CF	CR26	Manual water level	Baseline / Impact
CG	CR31	Automated water level Water quality monitoring	Baseline / Impact

Table 9 (Cont.) Summary of Surface Water Monitoring Sites

Site	Weir / Pool	Type of Monitoring	Site Category
Stonequarry Creek			
SC1	-	Water quality monitoring	Control / Reference
SE	SR5	Automated water level Water quality monitoring	Control / Reference
SA	SR16	Automated water level	Baseline / Impact
SC2	CR32	Water quality monitoring	Baseline / Impact
SB	SR17	Automated water level	Baseline / Impact
SC	SR21	Manual water level	Baseline / Impact
SD	-	Automated water level Water quality monitoring	Baseline / Impact
SF	-	Automated water level	Baseline / Impact

3.2.1 Baseline 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 4. Continuous surface water level data has been recorded at three pool monitoring sites on Matthews Creek, six monitoring sites on Cedar Creek and two monitoring sites on Stonequarry Creek. The surface water level data has been recorded hourly using water level sensors. The baseline monitoring period commenced in November 2018 for pools with water level sensors except for pool CC1A for which the monitoring period commenced in May 2019.

Manual water level measurements have also been collected monthly by Tahmoor Coal at the sites shown in Figure 4. Appendix B provides charts of the water level data for all pools. Table 10 presents a summary of the baseline water level monitoring for each pool in which a water level sensor is installed.

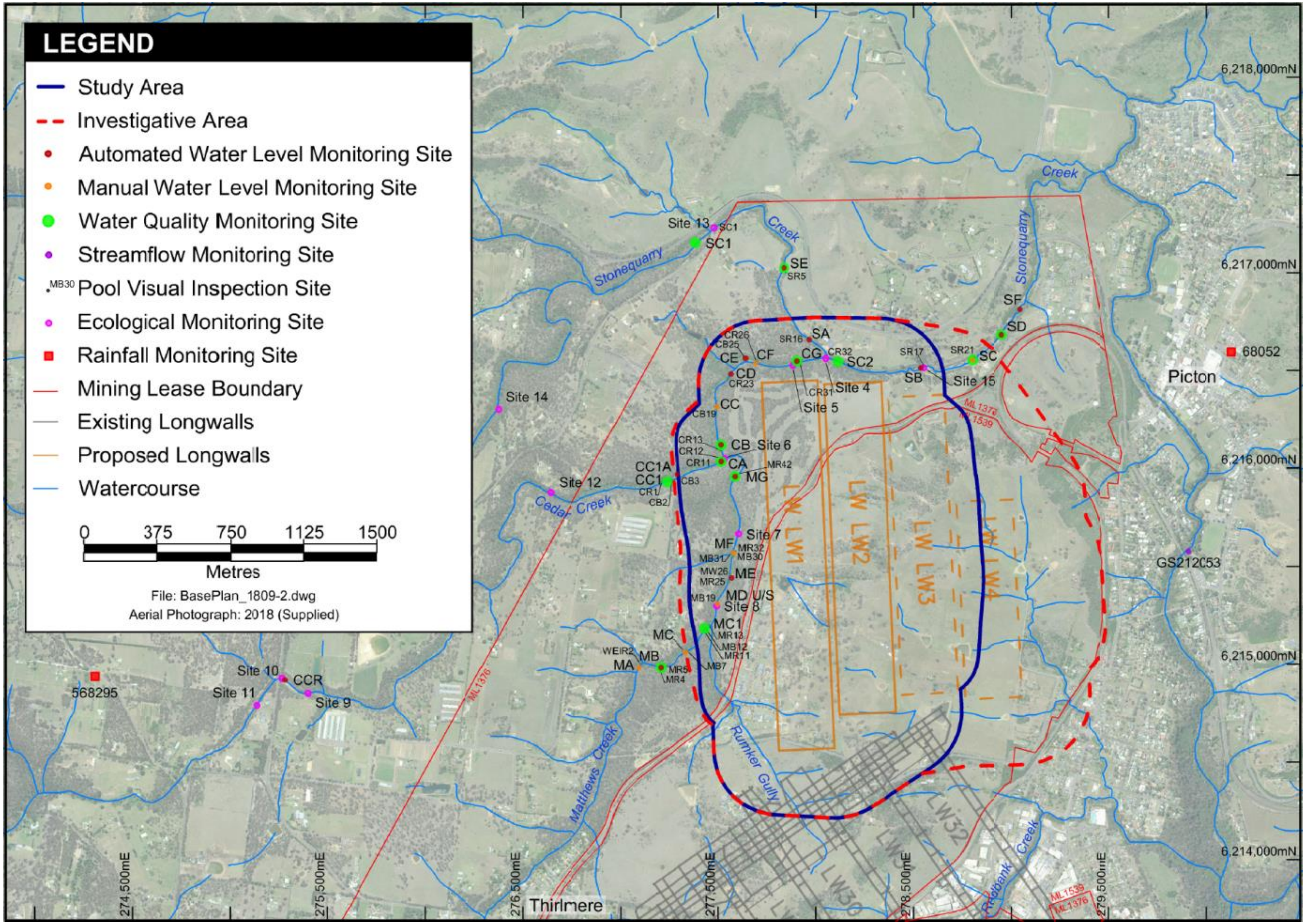

Figure 4 Rainfall, Surface Water and Ecological Monitoring Locations

Table 10 Summary of Water Level Monitoring

Monitoring Site	Natural Control Characteristics	Recorded Water Level During Baseline Period
Matthews Creek		
MB (Pool MR4 and Pool MR5)	Rock 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 spikes 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. The water level remained near the CTF level until mid-October 2019 before declining below the CTF level for the remainder of the monitoring period. The water level was at the minimum at the end of the monitoring period (Chart B2, Appendix B).
ME (Pool MR25 and MW26)	Boulder / rock bar constrained	The water level at site ME was predominately below the CTF level during the monitoring period except for short periods during and shortly following rainfall events between November 2018 and April 2019 and again in September 2019. The water level was at the minimum towards the end of the monitoring period (Chart B5, Appendix B).
MG (Pool MR42)	Boulder race with small pools	The water level at site MG was predominately below the CTF level during the monitoring period except for short periods during and shortly following rainfall events between November 2018 and April 2019. The water level was at the minimum at the end of the monitoring period (Chart B7, Appendix B).
Cedar Creek		
CCR	Alluvial bank	Sharp increases in water level were recorded at CCR (the most upstream site) during rainfall events followed by steep recessions. The water level was below the CTF level for the majority of the monitoring period. Two significant periods of water level above the CTF level occurred in late January to late February 2019 and again from mid-March to early May (Chart B8, Appendix B).
CC1A (Pool CB3)	N/A	Sharp increases in water level were recorded at CC1A during rainfall events followed by steep recessions (Chart B9, Appendix B).
CA (Pool CR11 & CR12)	Rock bar constrained	The water level at site CA remained above the CTF level for the majority of the monitoring period except for short periods in 2019 following low rainfall. Subdued small peaks in water level were recorded during rainfall periods (Chart B10, Appendix B).
CB (Pool CR13)	Sandstone shelf	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 (Chart B11, Appendix B).
CD (Pool CR23)	Rock bar / boulder constrained	The water level at site CD remained above the CTF level for the duration of the monitoring period. Small peaks in water level were recorded during rainfall periods (Chart B13, Appendix B).
CE (Pool CR25)	Rock bar / boulder constrained	The water level at site CE remained above the CTF level for the duration of the monitoring period. Small peaks in water level were recorded during rainfall periods (Chart B14, Appendix B). A small gradual rise in recorded water level was recorded in late autumn 2019 in the absence of rainfall.
CG (Pool CR32)	Rock shelf control	The water level at site CG remained above the CTF level for the duration of the monitoring period. Small peaks in water level were recorded during rainfall periods (Chart B16, Appendix B). A small gradual rise in recorded water level was recorded in winter 2019 in the absence of rainfall.

Table 8 (Cont.) Summary of Water Level Monitoring

Monitoring Site	Natural Control Characteristics	Recorded Water Level During Baseline Period
Stonequarry Creek		
SA (Pool SR16)	Rock bar / boulder constrained	The water level at site SA was 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. Peaks in water level were recorded during rainfall events. 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 to the end of the monitoring period. The water level was at the minimum at the end of the monitoring period (Chart B17, Appendix B).
SD	Sandstone rock shelf	The water level records for site SD indicate rapid responses to rainfall events followed by steep recessions. The water level was predominately above the CTF level except for short periods in November 2018 and in January to March 2019. From mid-October 2019, the water level declined below the CTF level except for a short period in November 2019 following a rainfall event (Chart B20, Appendix B).

3.2.2 Baseline Streamflow Monitoring

Preliminary flow rating relationships have been developed for three monitored pools on Matthews Creek, six monitoring sites on Cedar Creek and two monitoring sites on Stonequarry Creek (refer Figure 5). 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 December 2019. As indicated in Table 10, many of the pools dropped below their CTF levels during the baseline monitoring period and it should be noted that the rating relationships may not include pool natural subsurface flow. Table 11 presents the estimated catchment area, as illustrated in Figure 5, and period of water level record for each monitoring pool. A summary of the estimated streamflow rate at each pool is provided in the following sections.

Table 11 Streamflow Monitoring Sites

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
	CA	17.6
	CB	25.7
	CD	26.2
	CE	26.2
	CG	26.8
Stonequarry Creek	SA	16.4
	SD	44.1

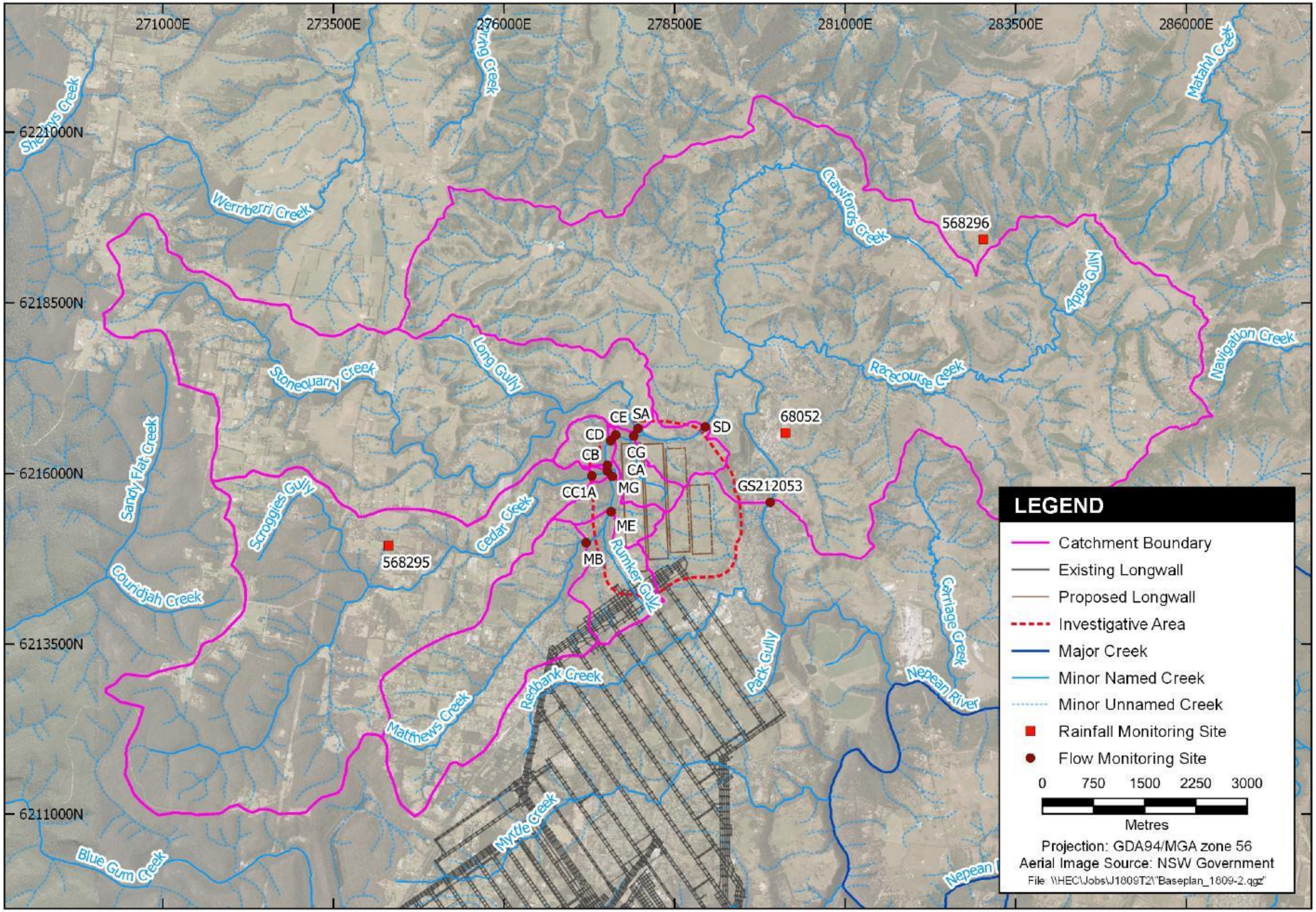

Figure 5 **Streamflow Monitoring Locations and Catchments**

3.2.2.1 Matthews Creek

Figure 6 presents the flow duration curves for the monitored pools on Matthews Creek. 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.

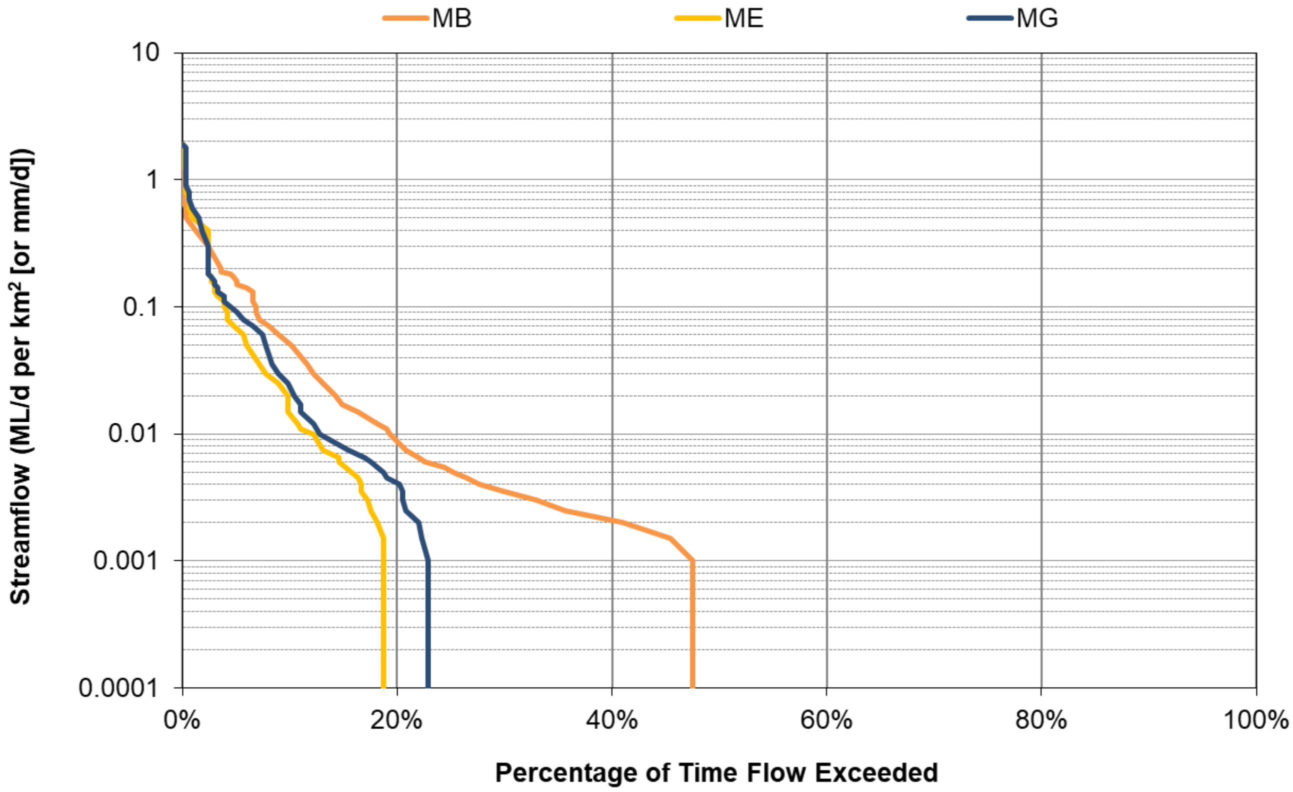

Figure 6 Matthews Creek Flow Duration Curve

Figure 6 illustrates that the streamflow characteristics for sites ME and MG are similar, with a non-negligible streamflow rate (greater than 0.001 mm/d) exceeded at ME approximately 19% of the time and at MG approximately 23% of the time. Streamflow at MB was recorded a higher percentage of time, with non-negligible flow recorded approximately 48% of the time.

3.2.2.2 Cedar Creek

Figure 7 presents the flow duration curves for the streamflow monitoring sites on Cedar Creek.

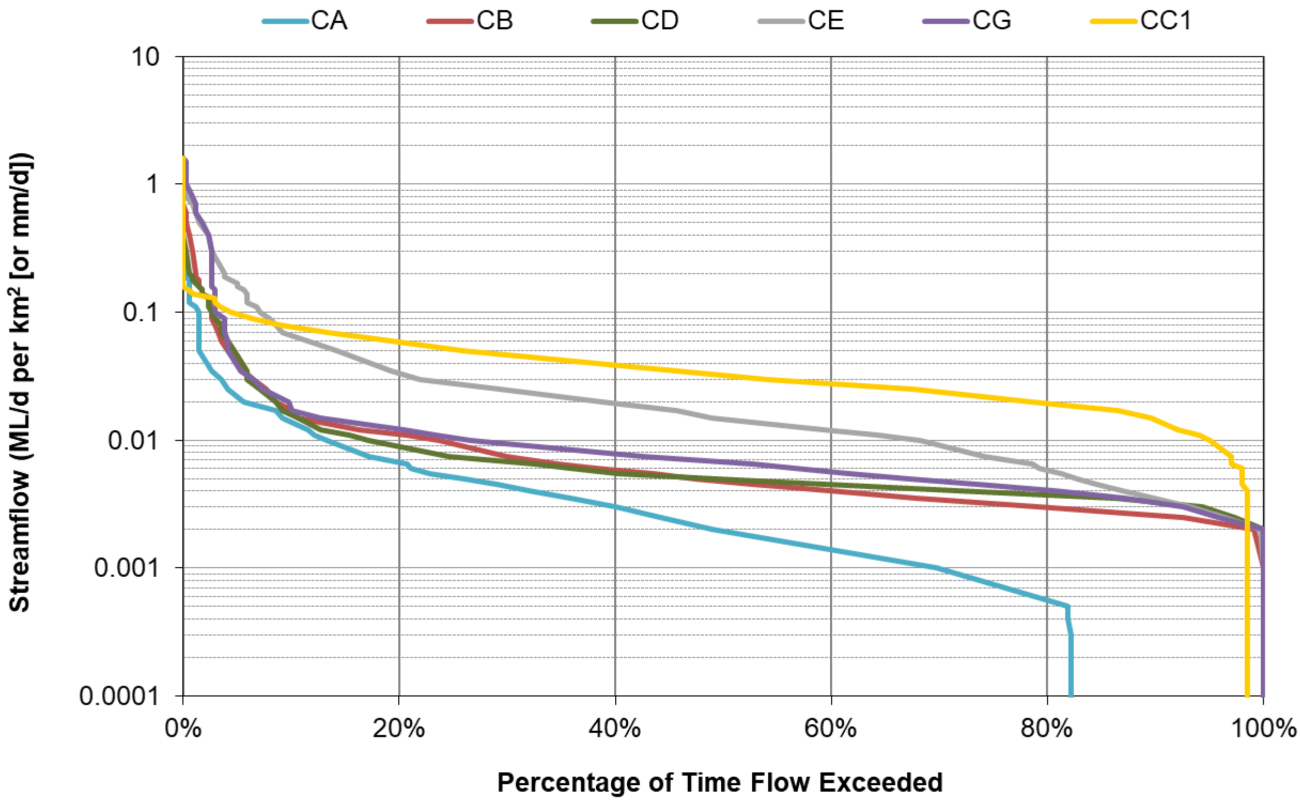

Figure 7 Cedar Creek Flow Duration Curve

Figure 7 illustrates that the streamflow characteristics for sites CB, CD and CG are similar while lower streamflow rates per unit area of catchment were recorded at CA and higher rates were recorded at CE and CC1. The flow rate at CB and CD exceeded 0.005 mm/d (0.12 and 0.13 ML/d respectively) approximately 50% of the time, while the flow rate at CG exceeded 0.007 mm/d (0.19 ML/d) approximately 50% of the time. The flow rate at CA exceeded 0.002 mm/d (0.03 ML/d) approximately 50% of the time, the flow rate at CE exceeded 0.015 mm/d (0.38 ML/d) approximately 50% of the time and the flow rate at CC1A exceeded 0.03 (0.57 ML/d) approximately 50% of the time.

3.2.2.3 Stonequarry Creek

Figure 8 presents the flow duration curves for the streamflow monitoring sites on Stonequarry Creek.

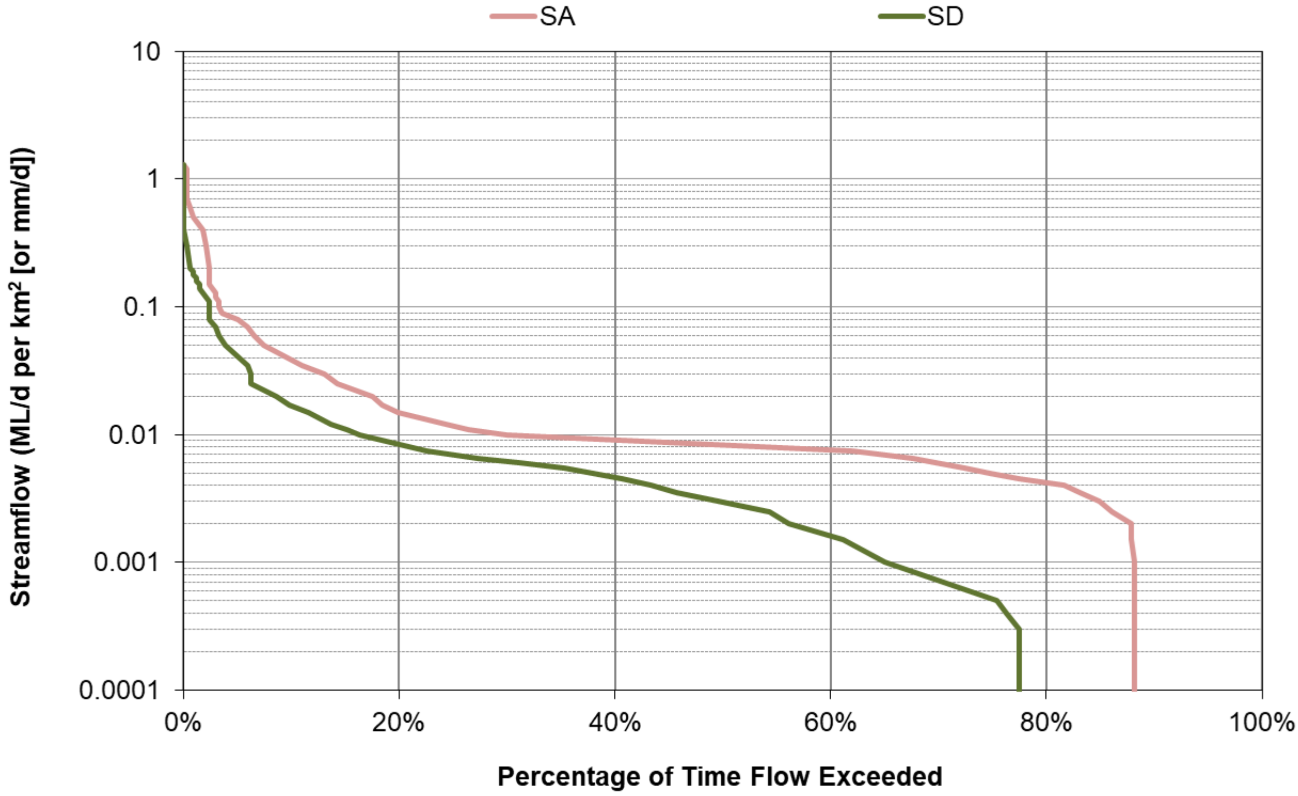

Figure 8 Stonequarry Creek Flow Duration Curve

Figure 8 illustrates higher streamflow rates per unit area for SA than for SD. The flow rate at SA exceeded 0.008 mm/d (0.14 ML/d) approximately 50% of the time, while the flow rate at SD exceeded 0.003 mm/d (0.13 ML/d) approximately 50% of the time.

In addition to the monitoring within the Investigative Area undertaken by Tahmoor Coal, recorded streamflow data is available from a WaterNSW station located on Stonequarry Creek at Picton (GS212053), approximately 5 km downstream of the confluence with Cedar Creek, as shown in Figure 5. 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 Investigative Area. Figure 9 presents the flow duration curve for Stonequarry Creek at Picton based on daily recorded streamflow from November 1990 to December 2019 (more than 28 years). In Figure 9, flow rate is again presented on a per unit catchment area basis.

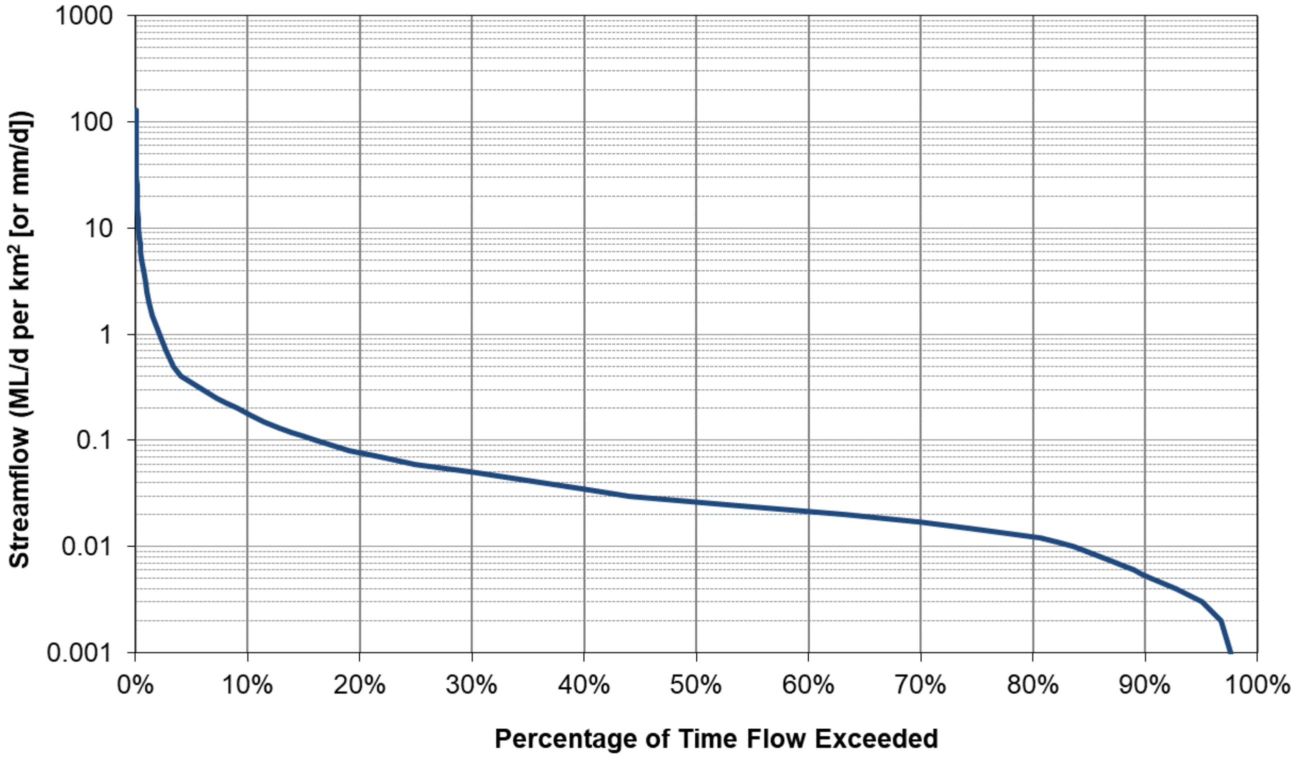

Figure 9 Stonequarry Creek at Picton (GS 212053) Flow Duration Curve

Figure 9 illustrates that Stonequarry Creek at Picton is near perennial with a non-zero streamflow rate recorded 98.4% of the time. The flow rate exceeds 0.03 millimetres per day (mm/d), equivalent to 2.2 Megalitres per day (ML/d), approximately 50% of the time.

3.3 CATCHMENT MODELLING OF STONEQUARRY CREEK AT PICTON

Catchment modelling has been undertaken for Stonequarry Creek at Picton using the Australian Water Balance Model (AWBM) (Boughton, 2004), which is a nationally-recognised catchment-scale water balance model for simulating surface runoff and baseflow processes on gauged and un-gauged catchments.

Streamflow records for Stonequarry Creek at Picton (GS 212053) for the period from the end of mining of LW25 (21 February 2011) to the commencement of secondary extraction from LW W1 (15 November 2019) have been used to calibrate the catchment model. LW25 was the first longwall with subsidence impacts just extending into the Matthews Creek catchment. The calibrated catchment model will be used to simulate the streamflow rate of Stonequarry Creek at Picton during mining of LW W1 and LW W2, which will then be compared with monitored data in order to trigger investigation of whether streamflow in Stonequarry Creek at Picton has been affected (refer Table 33, Section 6.2).

The AWBM is simulated on a daily basis using rainfall and evaporation data available for the Stonequarry Creek catchment. Rainfall data recorded at Picton Council Depot (Bureau of Meteorology Station 68052), Lakesland Road (Water NSW Station 568295) and Thurns Road (Water NSW Station 568296) and evaporation data for the catchment centroid, obtained from the SILO Data Drill[3], were adopted for model calibration.

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[3] The SILO Data Drill is a system which provides synthetic data sets for a specified point by interpolation between surrounding point records held by the Bureau of Meteorology – refer https://legacy.longpaddock.qld.gov.au/silo/datadrill/

The plots and metrics provided in the following sections were identified from the eWater CRC *Guidelines for Rainfall-Runoff Modelling: Towards Best Practice Model Application* (Vaze et al., 2011) as assessment techniques and measures for calibration of hydrological models.

The AWBM simulated and monitored flow for Stonequarry Creek at Picton are shown in Figure 10.

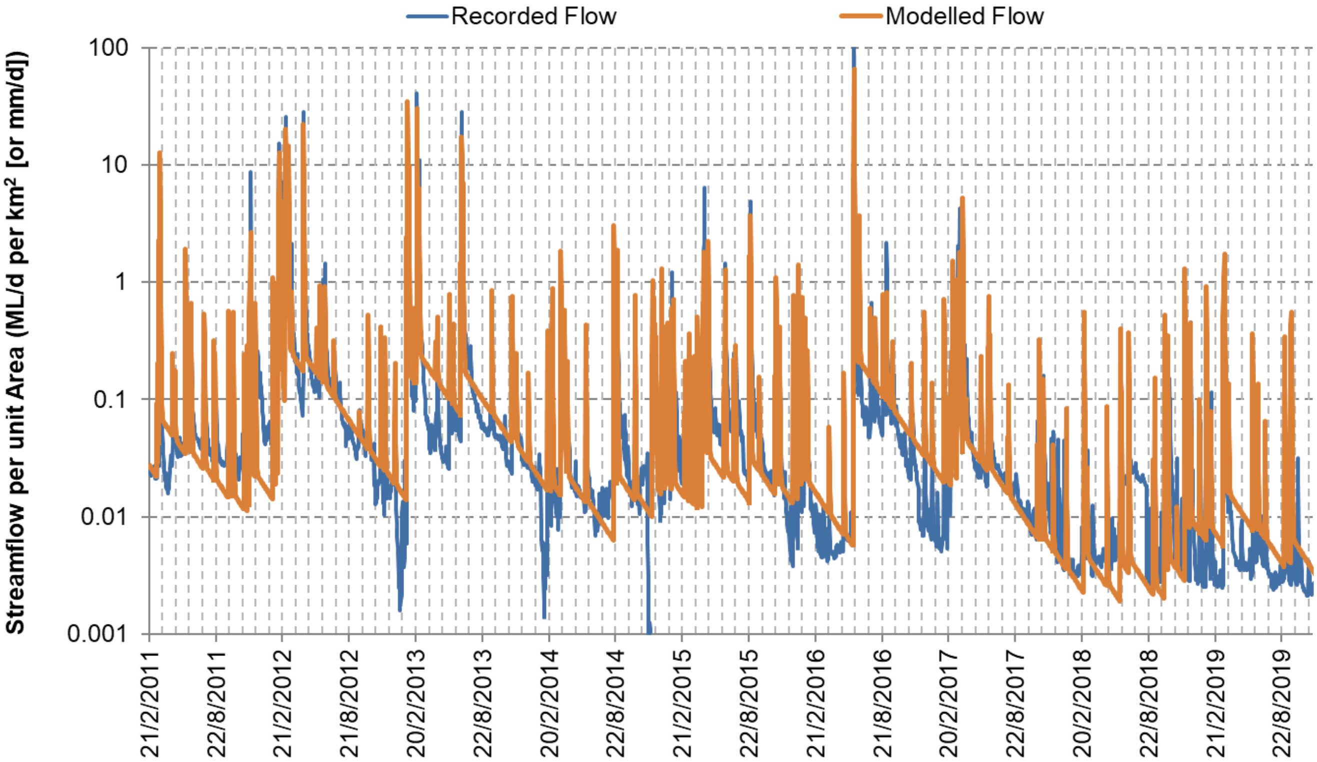

Figure 10 Recorded and Modelled Flows – Stonequarry Creek at Picton (GS 212053)

The match between modelled and recorded flows can be assessed by comparing the flow duration curves of recorded and modelled flows – refer Figure 11 which has been compiled for the calibration period.

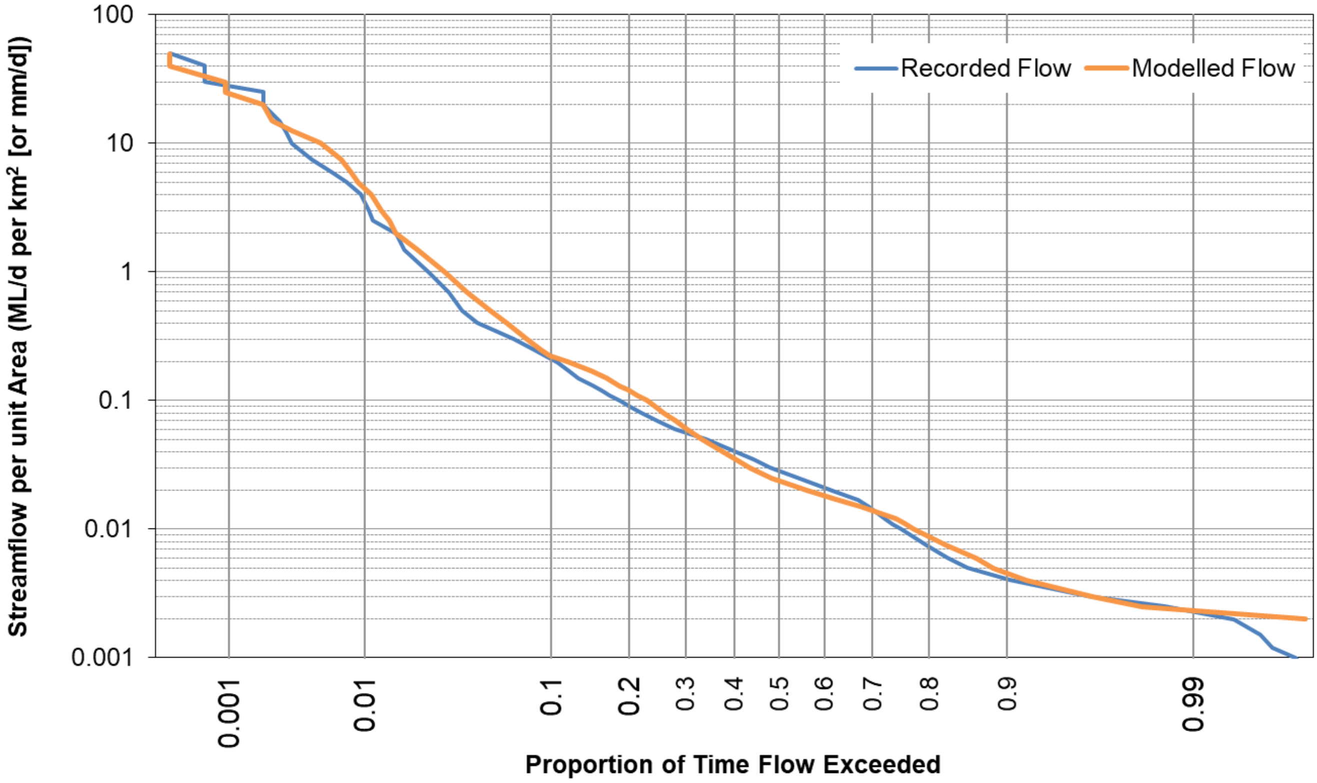

Figure 11 Modelled and Recorded Flow Duration Curves - Stonequarry Creek at Picton (GS 212053)

Table 12 summarises statistical parameters of model fit which have been identified from and calculated in accordance with Vaze et al. (2011).

Table 12 AWBM Statistical Metrics

Gauging Station	Ratio of Model to Recorded Streamflow	Coefficient of Determination on Monthly Flows (r^2)	Nash Sutcliffe Coefficient of Efficiency on Monthly Flows
Stonequarry Creek at Picton (GS 212053)	99.4%	0.954	0.948

Vaze et al. (2011) suggest that modelled and recorded streamflow volumes should match to within 5%. As shown in Table 12, modelled to recorded streamflow volumes match to within 0.6%. The Nash Sutcliffe coefficient of efficiency (NSE) is indicative of the predictive power or accuracy of the hydrological model. Moriasi et al. (2007) suggest that a NSE on monthly streamflows of 0.75 < NSE < 1.0 is a very good performance rating.

The coefficient of determination on monthly flows (r^2) quantifies the degree of correlation between recorded and modelled streamflow rates and is representative of the proportion of variance in the recorded data which is able to be replicated or explained by the model. The r^2 value in Table 12 indicates that the model explains 95.4% of the variance in the recorded data. Values of r^2 greater than 0.5 are generally considered acceptable (Moriasi et al., 2007).

3.4 BASELINE WATER QUALITY DATA

Baseline water quality monitoring has been 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 and May 2019 (Niche, 2014 and Niche, 2019a). Note that data from the Niche water quality monitoring programs undertaken in October 2014, November 2017 and May 2018 only were available at the time of preparation of this report. 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). The location of the monitoring sites for which data has been included in this report is shown in Figure 4.

The strategic framework for water quality improvement in the Hawkesbury-Nepean is provided by the water quality objectives (WQOs) determined by the NSW Healthy Rivers Commission inquiry into the Hawkesbury-Nepean system (HRC, 1998) and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC Guidelines) (ANZECC, 2000). The ANZECC Guidelines apply for all parameters excepting nutrients and chlorophyll-a. For nutrients and chlorophyll-a, the Healthy Rivers Commission (HRC, 1998) water quality triggers apply, as specified by the NSW Government in a Statement of Joint Intent (2001). In NSW, the level of protection applied to most waterways is that for ‘slightly to moderately disturbed’ ecosystems, for which the ANZECC Guidelines recommend adoption of the 95% protection level trigger values for aquatic ecosystems.

The baseline water quality data has been assessed against the ANZECC (2000) and ANZG (2018) default guideline trigger levels for the protection of aquatic ecosystems at the 95% level of protection and recreational use in accordance with the perceived principal beneficial uses of the surface water resources in the area. The guideline trigger levels used in the assessment are summarised in Table 13 below.

Table 13 Water Quality Guideline Trigger Values Used in Baseline Water Quality Assessment

Parameter	ANZECC (2000) & ANZG (2018) Water Quality Guidelines			HRC Guidelines
	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	-
Dissolved Oxygen (%)	-	90 - 110	-	-
Turbidity (NTU)	-	2 - 25	-	
Sulphate (mg/L)	-	-	400	-
Chloride (mg/L)	-	-	400	-
Sodium (mg/L)	-	-	300	-
Aluminium (mg/L)	-	-	0.2	-
Aluminium (mg/L) pH > 6.5	0.055	-	-	-
Arsenic (mg/L)	-	-	50	-
Arsenic (mg/L) (As III)	0.024	-	-	-
Barium (mg/L)	-	-	1	-
Boron (mg/L)	0.37	-	-	-
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	-
Silver (mg/L)	0.00005			
Sulphate (mg/L)	-	-	400	-
Zinc (mg/L)	0.008	-	5	-
NOx (mg/L)	-	0.015	-	-
Total Phosphorous (mg/L)	-	-	-	0.05
Total Nitrogen (mg/L)	-	-	-	0.7

Note: EC = Electrical Conductivity
TDS = Total Dissolved Solids
- No relevant trigger value

The water quality default guideline trigger values listed in Table 13 have been used as a basis for interpretation of the baseline water quality data in the following sections. Where multiple trigger values are specified for a parameter, the most conservative trigger value has been adopted for comparison, with exceedances of the trigger value shown in bold.

3.4.1.1 Matthews Creek

Water quality monitoring was undertaken by GeoTerra at one site on Matthews Creek in November 2014 (GeoTerra, 2014) and by Niche at two additional sites on Matthews Creek in October 2014 (Niche, 2014). The monitoring results are presented in Table 14.

Table 14 Matthews Creek Water Quality – Laboratory Analysis 2014

Parameter	Trigger Value	MC1	Site 7	Site 8
		Nov 14	Oct 14	Oct 14
pH (pH units)	6.5-8[1]	-	6.8	6.8
Dissolved Organic Carbon (mg/L)		12	-	-
EC (µS/cm)	350[2]	-	222	212
Turbidity (NTU)	2 - 25[2]	-	1.6	0.5
Total Dissolved Solids (mg/L)	1,000[3]	192	-	-
Suspended Solids (mg/L)		18	-	-
Dissolved Oxygen (% sat)	90 - 110[2]	-	**88**	90
Alkalinity (mg $CaCO_3$/L)		-	25	20
ORP (Oxidation Reduction Potential) (mV)		-	377	363
Sulphate as SO_4 (mg/L)	400[3]	3	-	-
Chloride (mg/L)	400[3]	86	-	-
Calcium (mg/L)		10.0	-	-
Magnesium (mg/L)		9.5	-	-
Sodium (mg/L)	300[3]	43	-	-
Potassium (mg/L)		7.3	-	-
Fluoride (mg/L)		<0.1	-	-
Total Nitrogen (mg/L)	0.7[4]	**1.2**	-	-
Total Phosphorus (mg/L)	0.05[2]	**0.08**	-	-
Dissolved Iron (mg/L)		2.6	-	-
Dissolved Manganese (mg/L)		3.2	-	-
Total Aluminium (mg/L)	0.055[1]	0.03	-	-
Total Arsenic (mg/L)	0.024[1]	<0.01	-	-
Total Barium (mg/L)	1[3]	0.06	-	-
Total Copper (mg/L)	0.0014[1]	<0.001	-	-
Total Iron (mg/L)	0.3[3]	**4.1**	-	-
Total Lead (mg/L)	0.0034[1]	<0.001	-	-
Total Lithium (mg/L)		0.002	-	-
Total Manganese (mg/L)	1.9[1]	**3.4**	-	-
Total Nickel (mg/L)	0.011[1]	<0.01	-	-
Total Strontium (mg/L)		0.074	-	-
Total Zinc (mg/L)	0.008[1]	0.005	-	-

[1] ANZECC (2000) default guideline trigger value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – guideline value relates to total concentration though can be compared to dissolved concentrations where total concentration is not available.

[2] ANZECC (2000) default guideline trigger value for Upland Rivers in NSW.

[3] ANZECC (2000) default guideline trigger value for recreational use.

[4] HRC (1998) water quality objective.

Table 14 indicates that near neutral conditions were recorded at Site 7 and Site 8 in 2014 with the pH value within the default guideline trigger range. Total nitrogen and total phosphorus exceeded the default trigger values at MC1. Total iron and total manganese concentrations exceeded the default trigger value at MC1.

Two additional sampling rounds were undertaken by Niche at the two Matthews Creek sites (Site 7 and Site 8) in November 2017 and April 2018. Note that Site 8 was dry in April 2019. The monitoring results are presented in Table 15.

Table 15 Matthews Creek Water Quality – Field Records 2017 and 2018

Parameter	Trigger Value	Site 7		Site 8	
		Nov 2017	Apr 2018	Nov 2017	Apr 2018
pH (pH units)	6.5-8[1]	7.1	7.6	7.6	-
EC (µS/cm)	350[2]	284	340	308	-
Turbidity (NTU)	2 - 25	3.7	**850**	13.2	-
Dissolved Oxygen (% sat)	90 - 110[2]	**28**	**62**	**22**	-
Alkalinity (mg $CaCO_3$/L)		30	60	30	-

[1] ANZECC (2000) default guideline trigger value for aquatic ecosystems (95%ile level of species protection for slightly to moderately disturbed ecosystems).

[2] ANZECC (2000) default guideline trigger value for Upland Rivers in NSW.

Table 15 illustrates that pH and EC records at Site 7 and Site 8 during the 2017 and 2018 sampling were consistent with that recorded in 2014. The turbidity concentration recorded at Site 7 in April 2018 was elevated. Dissolved Oxygen (DO) was significantly reduced at both Site 7 and Site 8 in comparison with concentrations recorded in 2014 and compared with the default trigger value.

Table 16 presents a summary of the monthly water quality data recorded by Tahmoor Coal at sites on Matthews Creek since January 2019 in comparison with the default water quality trigger values presented in Table 13. 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. The constituent values which exceed the lowest default water quality trigger value have been shown in bold. Charts of the monthly monitoring records for specific constituents are presented in Appendix C.

Table 16 Matthews Creek Water Quality Summary - 2019

Parameter	Trigger Value	MG				MB				MC1			
		No. of Samples	Min	Med	Max	No. of Samples	Min	Med	Max	No. of Samples	Min	Med	Max
pH Value – lab	6.5 – 8[1]	10	**6.1**	6.7	7.1	11	**6.4**	6.9	7.3	6	**6.3**	6.7	7.2
pH Value - field		10	**6.1**	6.6	7.3	11	**5.6**	6.5	7.1	7	**5.8**	6.5	6.9
Electrical Conductivity (µS/cm) – lab	350[2]	10	218	345	**384**	11	258	**744**	**1,090**	7	250	**400**	**528**
Electrical Conductivity (µS/cm) - field		10	235	343	**381**	11	275	**723**	**958**	7	270	**458**	**496**
Dissolved Oxygen (mg/L) - field		10	0.4	2.4	8.2	11	0.9	3.2	7.5	7	1.2	3.2	8.3
Total Alkalinity (mg/L)		10	15.0	25.5	52.0	11	9.0	22.0	48.0	7	8.0	25.0	41.0
Sulphate as SO_4 (mg/L)	400[3]	10	1.0	9.5	18.0	11	1.0	5.0	17.0	7	4.0	11.0	20.0
Chloride (mg/L)	400[3]	10	40.0	73.5	79.0	11	47.0	211.0	321.0	7	46.0	117.0	141.0
Calcium (mg/L)		10	7.0	9.0	12.0	11	9.0	15.0	20.0	7	8.0	10.0	11.0
Magnesium (mg/L)		10	5.0	8.0	9.0	11	6.0	17.0	24.0	7	6.0	11.0	13.0
Sodium (mg/L)	300[3]	10	23.0	37.0	38.0	11	26.0	79.0	125.0	7	8.0	52.0	56.0
Potassium (mg/L)		10	9.0	10.0	12.0	11	9.0	10.0	12.0	7	8.0	10.0	40.0
Fluoride (mg/L)		9	0.1	0.1	0.1	11	0.1	0.1	0.1	7	0.1	0.1	0.1
Total Nitrogen (mg/L)	0.7[4]	10	0.4	**0.9**	**2.2**	11	0.4	**0.9**	**3.0**	6	0.4	0.6	**2.9**
Total Phosphorus (mg/L)	0.05[2]	10	0.01	0.05	**0.41**	11	0.02	0.04	**0.17**	7	0.01	0.04	**1.20**
Dissolved Aluminium (mg/L)		10	0.01	0.01	0.27	11	0.01	0.01	0.27	7	0.02	0.02	0.26
Dissolved Arsenic (mg/L)		10	0.001	0.001	0.001	10	0.001	0.001	0.001	7	0.001	0.001	0.001
Dissolved Barium (mg/L)		10	0.022	0.030	0.035	11	0.029	0.068	0.096	7	0.027	0.043	0.053
Dissolved Copper (mg/L)		10	0.001	0.001	0.008	11	0.001	0.001	0.01	7	0.001	0.001	0.002
Dissolved Iron (mg/L)		10	0.34	0.66	3.01	11	0.18	0.53	1.94	6	0.62	0.97	1.12
Dissolved Lead (mg/L)		10	0.001	0.001	0.001	11	0.001	0.001	0.001	7	0.001	0.001	0.001

Table 14 (Continued) Matthews Creek Water Quality Summary - 2019

Parameter	Trigger Value	MG				MB				MC1			
		No. of Samples	Min	Med	Max	No. of Samples	Min	Med	Max	No. of Samples	Min	Med	Max
Dissolved Lithium (mg/L)		10	0.001	0.001	0.001	11	0.001	0.001	0.001	7	0.001	0.001	0.001
Dissolved Manganese (mg/L)		10	0.01	0.10	0.54	11	0.04	0.92	1.86	7	0.02	0.34	0.74
Dissolved Nickel (mg/L)		10	0.001	0.001	0.003	11	0.001	0.001	0.003	7	0.001	0.002	0.002
Dissolved Selenium (mg/L)		10	0.010	0.010	0.010	11	0.010	0.010	0.010	7	0.010	0.010	0.010
Dissolved Strontium (mg/L)		10	0.052	0.063	0.086	11	0.06	0.113	0.159	7	0.057	0.070	0.074
Dissolved Zinc (mg/L)		10	0.005	0.008	0.028	11	0.005	0.016	0.027	7	0.005	0.005	0.006
Total Aluminium (mg/L)	0.055[1]	10	0.01	0.025	**0.45**	11	0.01	0.03	**0.61**	7	0.05	**0.10**	**0.28**
Total Arsenic (mg/L)	0.024[1]	10	0.001	0.001	0.001	11	0.001	0.001	0.001	7	0.001	0.001	0.001
Total Barium (mg/L)	1[3]	10	0.025	0.031	0.038	11	0.031	0.079	0.103	7	0.03	0.05	0.06
Total Copper (mg/L)	0.0014[1]	10	0.001	0.001	**0.002**	11	0.001	0.001	**0.003**	7	0.001	0.001	**0.002**
Total Iron (mg/L)	0.3[3]	10	**0.55**	**1.04**	**3.45**	11	**0.88**	**2.24**	**6.07**	6	**0.75**	**2.32**	**5.46**
Total Lead (mg/L)	0.0034[1]	10	0.001	0.001	0.001	11	0.001	0.001	0.001	7	0.001	0.001	0.001
Total Lithium (mg/L)		10	0.001	0.001	0.001	11	0.001	0.001	0.001	7	0.001	0.001	0.001
Total Manganese (mg/L)	1.9[1]	10	0.0	0.1	0.5	11	0.0	1.0	1.8	7	0.0	0.4	0.9
Total Nickel (mg/L)	0.011[1]	10	0.001	0.001	0.002	11	0.001	0.001	0.002	7	0.001	0.001	0.003
Total Selenium (mg/L)	0.011[1]	10	0.010	0.010	0.010	11	0.010	0.010	0.010	7	0.010	0.010	0.010
Total Strontium (mg/L)		10	0.053	0.0665	0.087	11	0.057	0.123	0.159	7	0.053	0.073	0.095
Total Zinc (mg/L)	0.008[1]	10	0.005	**0.012**	**0.023**	11	0.008	**0.018**	**0.04**	7	0.005	0.005	**0.01**

[1] ANZECC (2000) default guideline trigger value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – guideline value relates to total concentration though can be compared to dissolved concentrations where total concentration is not available.

[2] ANZECC (2000) default guideline trigger value for Upland Rivers in NSW.

[3] ANZECC (2000) default guideline trigger value for recreational use.

[4] HRC (1998) water quality objective.

Table 16 shows slight variances in the field and laboratory pH values recorded at each site. Based on the laboratory records, slightly acidic to near neutral conditions were recorded at each site. The EC readings were generally consistent between field and laboratory analyses at all sites. The maximum value of EC recorded at MG slightly exceeded the ANZECC default guideline trigger value, while the median and maximum values of EC for both field and laboratory records at MB and MC1 exceeded the ANZECC default guideline trigger value.

The median and maximum concentrations of total nitrogen recorded at MB and MG, and the maximum concentration of total nitrogen recorded at MC1, exceeded the HRC guideline trigger value of 0.7 mg/L. The maximum concentration of total phosphorus exceeded the HRC guideline trigger value of 0.05 mg/L at all monitoring sites on Matthews Creek.

The maximum concentration of total copper was slightly elevated at all three sites in comparison with the default guideline trigger values of 0.0014 mg/L. The maximum concentration of total aluminium was elevated at MG and MB in comparison with the default guideline trigger value of 0.055 mg/L, while the median and maximum concentrations of total aluminium concentration recorded at MC1 exceeded the default guideline trigger value. The median and maximum concentrations of total zinc recorded at MG and MB exceeded the default guideline trigger value of 0.008 mg/L, while the maximum concentration of total zinc recorded at MC1 slightly exceeded the default guideline trigger value. The default trigger value for recreational use was exceeded at all sites based on measured iron concentrations.

3.4.1.2 Cedar Creek

Water quality monitoring was undertaken by GeoTerra at two sites on Cedar Creek in November 2014 (GeoTerra, 2014) and by Niche at two additional sites on Cedar Creek in October 2014 (Niche, 2014). The monitoring results are presented in Table 17.

Table 17 Cedar Creek Water Quality – Laboratory Analysis 2014

Parameter	Trigger Value	CC1	CB	Site 5	Site 6
		Nov 14	Nov 14	Oct 14	Oct 14
pH (pH units)	6.5-8[1]	-	-	**3.6**	6.6
Dissolved Organic Carbon (mg/L)		3	2	-	-
EC (µS/cm)	350[2]	-	-	**359**	237
Turbidity (NTU)	2 - 25[2]	-	-	-	3.7
Total Dissolved Solids (mg/L)	1,000[3]	350	156	-	-
Suspended Solids (mg/L)		2	6	-	-
Dissolved Oxygen (% sat)	90 - 110[2]	-	-	90	**80**
Alkalinity (mg $CaCO_3$/L)		-	-	10	15
ORP (mV)		-	-	301	201
Sulphate as SO_4 (mg/L)	400[3]	5	5	-	-
Chloride (mg/L)	400[3]	210	230	-	-
Calcium (mg/L)		8.6	9.9	-	-
Magnesium (mg/L)		21	23	-	-
Sodium (mg/L)	300[3]	89	97	-	-
Potassium (mg/L)		6.0	5.9	-	-
Fluoride (mg/L)		<0.1	<0.1	-	-
Total Nitrogen (mg/L)	0.7[4]	<0.1	<0.1	-	-
Total Phosphorus (mg/L)	0.05[2]	0.03	0.02	-	-
Dissolved Iron (mg/L)		0.76	2.5	-	-
Dissolved Manganese (mg/L)		1.7	1.9	-	-
Total Aluminium (mg/L)	0.055[1]	**0.11**	0.02	-	-
Total Arsenic (mg/L)	0.024[1]	<0.01	<0.01	-	-
Total Barium (mg/L)	1[3]	0.13	0.10	-	-
Total Copper (mg/L)	0.0014[1]	**0.003**	**0.004**	-	-
Total Iron (mg/L)	0.3[3]	**0.92**	**3.7**	-	-
Total Lead (mg/L)	0.0034[1]	<0.001	<0.001	-	-
Total Lithium (mg/L)		0.01	0.016	-	-
Total Manganese (mg/L)	1.9[1]	1.8	**2.0**	-	-
Total Nickel (mg/L)	0.011[1]	<0.01	<0.01	-	-
Total Strontium (mg/L)		0.072	0.075	-	-
Total Zinc (mg/L)	0.008[1]	**0.036**	**0.032**	-	-

[1] ANZECC (2000) guideline trigger value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – guideline value relates to total concentration though can be compared to dissolved concentrations where total concentration is not available.

[2] ANZECC (2000) guideline trigger value for Upland Rivers in NSW.

[3] ANZECC (2000) guideline trigger value for recreational use.

[4] HRC (1998) water quality objective.

Table 17 indicates that pH near neutral conditions were recorded at Site 6 in 2014 while acidic conditions were recorded at Site 5. Total nitrogen and total phosphorus concentrations were below the default guideline trigger values at CC1 and CB. Elevated concentrations of total aluminium, total copper, total iron and total zinc, as compared with the default guideline trigger values, were recorded at CC1 in 2014. Elevated concentrations of total copper, total iron, total manganese and total zinc, as compared with the default guideline trigger values were recorded at CB in 2014.

Two additional sampling rounds were undertaken by Niche at Cedar Creek sites in November 2017 and April 2018. The monitoring results are presented in Table 18 and Table 19. Note that Site 10 and Site 11 were dry in April 2018.

Table 18 Cedar Creek Upstream Water Quality – Field Records 2017 and 2018

Parameter	Trigger Value	Site 5		Site 6		Site 9		Site 12
		Nov 2017	Apr 2018	Nov 2017	Apr 2018	Nov 2017	Apr 2018	Apr 2018
pH (pH units)	6.5-8[1]	7.0	6.9	6.6	7.6	6.9	6.7	**5.1**
EC (µS/cm)	350[2]	**786**	**1,037**	**835**	271	**543**	340	**1,388**
Turbidity (NTU)	2 - 25[2]	1.7	2.7	**30**	**1,967**	**31**	24	600
Dissolved Oxygen (% sat)	90 - 110[2]	**37**	93	**22**	**32**	**45**	**60**	**48**
Alkalinity (mg $CaCO_3$/L)		10	20	10	60	20	20	20

[1] ANZECC (2000) guideline trigger value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems).

[2] ANZECC (2000) guideline trigger value for Upland Rivers in NSW.

Table 19 Cedar Creek Downstream Water Quality - Field Records 2017

Parameter	Trigger Value	Site 10	Site 11
		Nov 2017	Nov 2017
pH (pH units)	6.5-8[1]	6.5	6.5
EC (µS/cm)	350[2]	302	338
Turbidity (NTU)	2 - 25[2]	**60**	**101**
Dissolved Oxygen (% sat)	90 - 110[2]	**32**	**22**
Alkalinity (mg $CaCO_3$/L)		20	20

[1] ANZECC (2000) guideline trigger value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems).

[2] ANZECC (2000) guideline trigger value for Upland Rivers in NSW.

Table 18 and Table 19 illustrate that pH near neutral conditions were recorded at all sites on Cedar Creek during 2017 and 2018, excepting at Site 12. Elevated EC values were recorded at Site 5 in November 2017 and April 2018, at Site 6 and Site 9 in November 2017 and at Site 12 in April 2018. Dissolved oxygen was significantly reduced at all sites in November 2017 and at Site 6, Site 9 and Site 12 in April 2018, in comparison with concentrations recorded in 2014 and compared with the default guideline trigger value.

Table 20 and Table 21 present a summary of the water quality data recorded by Tahmoor Coal at sites on Cedar Creek since January 2019 in comparison with the default water quality trigger values presented in Table 13. 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. The constituent values which exceed the lowest default water quality trigger value are shown in bold. Charts of the monthly monitoring records for specific constituents are presented in Appendix C.

Table 20 Cedar Creek (CA and CB) Water Quality Summary - 2019

Parameter	Trigger Value	CA				CB			
		No. of Samples	Min	Med	Max	No. of Samples	Min	Med	Max
pH Value – lab	6.5 – 8[1]	6	**5.0**	**5.7**	**6.0**	8	**4.5**	**5.2**	**6.3**
pH Value - field		6	**4.5**	**4.8**	**5.3**	11	**3.7**	**4.8**	6.6
Electrical Conductivity (µS/cm) – lab	350[2]	6	**574**	**956**	**1,170**	11	280	**847**	**1,100**
Electrical Conductivity (µS/cm) - field		6	**553**	**828**	**1,017**	11	293	**843**	**939**
Dissolved Oxygen (mg/L) - field		6	3.3	4.7	8.3	11	4.7	6.3	8.2
Total Alkalinity (mg/L)		6	1.0	1.5	5.0	11	1.0	1.0	18.0
Sulphate as SO_4 (mg/L)	400[3]	6	2.0	3.5	6.0	11	3.0	6.0	12.0
Chloride (mg/L)	400[3]	6	175.0	282.5	343.0	11	63.0	266.0	321.0
Calcium (mg/L)		6	5.0	8.0	11.0	11	5.0	7.0	8.0
Magnesium (mg/L)		6	14.0	24.0	28.0	11	7.0	23.0	29.0
Sodium (mg/L)	300[3]	6	65.0	104.0	123.0	11	31.0	99.0	120.0
Potassium (mg/L)		6	6.0	6.5	8.0	11	4.0	5.0	8.0
Fluoride (mg/L)		6	0.1	0.1	0.1	10	0.1	0.1	0.1
Total Nitrogen (mg/L)	0.7[4]	6	0.2	0.4	**13.6**	11	0.1	0.3	**2.0**
Total Phosphorus (mg/L)	0.05[2]	6	0.01	0.01	**0.07**	11	0.01	0.01	0.04
Dissolved Aluminium (mg/L)		6	0.02	0.07	0.16	11	0.01	0.03	0.24
Dissolved Arsenic (mg/L)		6	0.001	0.001	0.001	11	0.001	0.001	0.001
Dissolved Barium (mg/L)		6	0.072	0.150	0.192	11	0.036	0.111	0.151
Dissolved Copper (mg/L)		6	0.001	0.001	0.001	11	0.001	0.001	0.003
Dissolved Iron (mg/L)		6	0.05	0.42	1.84	11	0.05	2.68	5.08
Dissolved Lead (mg/L)		6	0.001	0.001	0.001	11	0.001	0.001	0.001
Dissolved Lithium (mg/L)		6	0.003	0.005	0.006	11	0.001	0.011	0.018
Dissolved Manganese (mg/L)		6	1.4	2.2	3.8	11	0.3	2.2	3.4
Dissolved Nickel (mg/L)		6	0.004	0.009	0.010	11	0.002	0.012	0.015
Dissolved Selenium (mg/L)		6	0.010	0.010	0.010	11	0.010	0.010	0.010
Dissolved Strontium (mg/L)		6	0.045	0.079	0.102	11	0.052	0.064	0.075

Table 18 (Continued) Cedar Creek (CA and CB) Water Quality Summary - 2019

Parameter	Trigger Value	CA				CB			
		No. of Samples	Min	Med	Max	No. of Samples	Min	Med	Max
Dissolved Zinc (mg/L)		6	0.011	0.023	0.040	11	0.016	0.024	0.039
Total Aluminium (mg/L)	0.055[1]	6	0.03	**0.08**	**0.16**	11	0.02	0.05	**0.38**
Total Arsenic (mg/L)	0.024[1]	6	0.001	0.001	0.001	11	0.001	0.001	0.001
Total Barium (mg/L)	1[3]	6	0.076	0.159	0.187	11	0.04	0.136	0.203
Total Copper (mg/L)	0.0014[1]	6	0.001	0.001	0.001	11	0.001	0.001	**0.003**
Total Iron (mg/L)	0.3[3]	6	**0.87**	**1.545**	**2.71**	11	**0.98**	**5.23**	**6.66**
Total Lead (mg/L)	0.0034[1]	6	0.001	0.001	0.001	11	0.001	0.001	0.001
Total Lithium (mg/L)		6	0.003	0.006	0.008	11	0.002	0.013	0.017
Total Manganese (mg/L)	1.9[1]	6	1.4	**2.2**	**3.8**	11	0.3	**2.4**	**6.0**
Total Nickel (mg/L)	0.011[1]	6	0.005	0.010	**0.013**	11	0.005	**0.013**	**0.02**
Total Selenium (mg/L)	0.011[1]	6	0.010	0.010	0.010	11	0.010	0.010	0.010
Total Strontium (mg/L)		6	0.051	0.085	0.102	11	0.056	0.068	0.095
Total Zinc (mg/L)	0.008[1]	6	**0.013**	**0.0245**	**0.039**	11	**0.021**	**0.028**	**0.057**

[1] ANZECC (2000) default guideline trigger value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – guideline value relates to total concentration though can be compared to dissolved concentrations where total concentration is not available.

[2] ANZECC (2000) default guideline trigger value for Upland Rivers in NSW.

[3] ANZECC (2000) default guideline trigger value for recreational use.

[4] HRC (1998) water quality objective.

Table 21 Cedar Creek (CC1 and CG) Water Quality Summary - 2019

Parameter	Trigger Value	CC1				CG			
		No. of Samples	Min	Med	Max	No. of Samples	Min	Med	Max
pH Value – lab	6.5 – 8[1]	11	**4.1**	**4.8**	**5.3**	11	**5.1**	**6.2**	7.0
pH Value - field		11	**3.7**	**4.3**	7.1	11	**5.0**	**6.1**	7.2
Electrical Conductivity (µS/cm) – lab	350[2]	11	**588**	**886**	**1,260**	11	**497**	**850**	**1,040**
Electrical Conductivity (µS/cm) - field		11	**598**	**891**	**1,086**	11	**568**	**818**	**930**
Dissolved Oxygen (mg/L) - field		11	4.6	6.6	8.3	11	0.9	6.0	10.0
Total Alkalinity (mg/L)		11	1.0	1.0	3.0	11	1.0	2.0	24.0
Sulphate as SO_4 (mg/L)	400[3]	11	2.0	4.0	9.0	11	1.0	4.0	8.0
Chloride (mg/L)	400[3]	11	174.0	280.0	373.0	11	170.0	259.0	309.0
Calcium (mg/L)		11	5.0	8.0	12.0	11	6.0	8.0	10.0
Magnesium (mg/L)		11	14.0	24.0	31.0	11	15.0	25.0	30.0
Sodium (mg/L)	300[3]	11	67.0	103.0	133.0	11	67.0	99.0	117.0
Potassium (mg/L)		11	6.0	7.0	7.0	11	5.0	6.0	7.0
Fluoride (mg/L)		10	0.1	0.1	0.1	11	0.1	0.1	0.1
Total Nitrogen (mg/L)	0.7[4]	11	0.1	0.2	**1.0**	11	0.1	0.1	0.7
Total Phosphorus (mg/L)	0.05[2]	11	0.01	0.01	**0.29**	11	0.01	0.01	0.02
Dissolved Aluminium (mg/L)		11	0.04	0.13	0.32	11	0.01	0.01	0.04
Dissolved Arsenic (mg/L)		11	0.001	0.001	0.001	11	0.001	0.001	0.001
Dissolved Barium (mg/L)		11	0.09	0.148	0.228	11	0.058	0.105	0.164
Dissolved Copper (mg/L)		11	0.001	0.001	0.001	11	0.001	0.001	0.006
Dissolved Iron (mg/L)		11	0.18	0.48	2.88	11	0.05	0.32	1.5
Dissolved Lead (mg/L)		11	0.001	0.001	0.001	11	0.001	0.001	0.001
Dissolved Lithium (mg/L)		11	0.004	0.008	0.012	11	0.006	0.009	0.016
Dissolved Manganese (mg/L)		11	1.2	2.8	5.8	11	0.5	1.6	3.9
Dissolved Nickel (mg/L)		11	0.008	0.010	0.019	11	0.001	0.005	0.013
Dissolved Selenium (mg/L)		11	0.010	0.010	0.010	11	0.010	0.010	0.010
Dissolved Strontium (mg/L)		11	0.052	0.076	0.094	11	0.053	0.071	0.094

Table 19 (Continued) Cedar Creek (CC1 and CG) Water Quality Summary - 2019

Parameter	**Trigger Value**	**CC1**				**CG**			
		No. of Samples	**Min**	**Med**	**Max**	**No. of Samples**	**Min**	**Med**	**Max**
Dissolved Zinc (mg/L)		11	0.016	0.032	0.058	11	0.005	0.022	0.066
Total Aluminium (mg/L)	0.055[1]	11	**0.06**	**0.16**	**0.34**	11	0.01	0.02	**0.06**
Total Arsenic (mg/L)	0.024[1]	11	0.001	0.001	0.001	11	0.001	0.001	0.001
Total Barium (mg/L)	1[3]	11	0.092	0.154	0.227	11	0.066	0.121	0.167
Total Copper (mg/L)	0.0014[1]	11	0.001	0.001	**0.003**	11	0.001	0.001	**0.008**
Total Iron (mg/L)	0.3[3]	11	**0.43**	**1.37**	**4.14**	10	**0.32**	**1.095**	**2.99**
Total Lead (mg/L)	0.0034[1]	11	0.001	0.001	0.001	11	0.001	0.001	0.001
Total Lithium (mg/L)		11	0.004	0.008	0.013	11	0.006	0.012	0.016
Total Manganese (mg/L)	1.9[1]	11	1.2	**3.1**	**6.2**	11	0.6	**2.0**	**3.9**
Total Nickel (mg/L)	0.011[1]	11	0.007	**0.012**	**0.02**	11	0.003	0.006	0.011
Total Selenium (mg/L)	0.011[1]	11	0.010	0.010	0.010	11	0.010	0.010	0.010
Total Strontium (mg/L)		11	0.052	0.082	0.099	11	0.057	0.075	0.104
Total Zinc (mg/L)	0.008[1]	11	**0.017**	**0.035**	**0.060**	11	0.005	**0.023**	**0.097**

[1] ANZECC (2000) default guideline trigger value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – guideline value relates to total concentration though can be compared to dissolved concentrations where total concentration is not available.

[2] ANZECC (2000) default guideline trigger value for Upland Rivers in NSW.

[3] ANZECC (2000) default guideline trigger value for recreational use.

[4] HRC (1998) water quality objective.

Table 20 and Table 21 show slight variances in the field and laboratory pH values recorded at each site on Cedar Creek. Notwithstanding, the median laboratory and field values indicate acidic to near neutral conditions at all sites. The EC readings were generally consistent between field and laboratory analyses, with all samples exceeding the default guideline trigger value at CA, CC1 and CG and the median and maximum values exceeding the default guideline trigger value at CB.

The maximum concentration of total nitrogen recorded at CA, CB and CC1 on Cedar Creek exceeded the HRC guideline trigger value of 0.7 mg/L, while the maximum concentration of total phosphorus exceeded the HRC guideline trigger value of 0.05 mg/L at CA and CC1.

The median and maximum concentrations of total aluminium at CA, the maximum concentration of total aluminium at CB and CG and the total concentration of aluminium for all samples from CC1 exceeded the default guideline trigger value of 0.055 mg/L. The median and maximum concentrations of manganese exceeded the default guideline trigger value of 1.9 mg/L at all sites. The median and maximum concentrations of total nickel recorded at CB and CC1 and the maximum concentration of total nickel recorded at CA exceeded the default guideline trigger value of 0.011 mg/L. At CA, CB and CC1, the concentration of total zinc recorded for all samples exceeded the default guideline trigger value of 0.008 mg/L, while the median and maximum concentrations of total zinc recorded at CG exceeded the default guideline trigger value. The maximum concentration of total copper recorded at CB, CC1 and CG exceeded the default guideline trigger value of 0.0014 mg/L. The default guideline trigger value for recreational use was exceeded at all sites based on measured iron concentrations.

3.4.1.3 Stonequarry Creek

Water quality monitoring was undertaken by GeoTerra at three sites on Stonequarry Creek in November 2014 (GeoTerra, 2014) and by Niche at one additional site on Stonequarry Creek in October 2014 (Niche, 2014). The monitoring results are presented in Table 22.

Table 22 Stonequarry Creek Water Quality – Laboratory Analysis 2014

Parameter	Trigger Value	SC1	SC2	SC	Site 4
		Nov 14	Nov 14	Nov 14	Oct 14
pH (pH units)	6.5-8[1]	-	-	-	6.4
Dissolved Organic Carbon (mg/L)		3	5	7	-
EC (µS/cm)	350[2]	-	-	-	**354**
Turbidity (NTU)	2 - 25[2]	-	-	-	2.6
Total Dissolved Solids (mg/L)	1,000[3]	475	360	390	-
Suspended Solids (mg/L)		8	24	12	-
Dissolved Oxygen (% sat)	90 - 110[2]	-	-	-	**80**
Alkalinity (mg CaCO3/L)		-	-	-	10
ORP (mV)		-	-	-	294
Sulphate as SO_4 (mg/L)	400[3]	12	3	5	-
Chloride (mg/L)	400[3]	240	190	200	-
Calcium (mg/L)		24	15	17	-
Magnesium (mg/L)		36	22	26	-
Sodium (mg/L)	300[3]	98	80	86	-
Potassium (mg/L)		5.7	5.5	6.3	-
Fluoride (mg/L)		0.15	0.12	0.13	-
Total Nitrogen (mg/L)	0.7[4]	<0.1	<0.1	**1.0**	-
Total Phosphorus (mg/L)	0.05[2]	0.04	**0.06**	0.04	-
Dissolved Iron (mg/L)		0.29	0.31	0.06	-
Dissolved Manganese (mg/L)		0.74	0.41	0.16	-
Total Aluminium (mg/L)	0.055[1]	0.01	0.01	0.01	-
Total Arsenic (mg/L)	0.024[1]	<0.01	<0.01	<0.01	-
Total Barium (mg/L)	1[3]	0.14	0.06	0.05	-
Total Copper (mg/L)	0.0014[1]	0.001	<0.001	**0.002**	-
Total Iron (mg/L)	0.3[3]	**2.6**	**1.4**	0.2	-
Total Lead (mg/L)	0.0034[1]	<0.001	<0.001	<0.001	-
Total Lithium (mg/L)		0.033	0.016	0.019	-
Total Manganese (mg/L)	1.9[1]	0.82	0.68	0.18	-
Total Nickel (mg/L)	0.011[1]	<0.01	<0.01	<0.01	-
Total Strontium (mg/L)		0.22	0.14	0.17	-
Total Zinc (mg/L)	0.008[1]	0.004	0.005	**0.033**	-

[1] ANZECC (2000, 2018) default guideline trigger value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – guideline value relates to total concentration though can be compared to dissolved concentrations where total concentration is not available.

[2] ANZECC (2000, 2018) default guideline trigger value for Upland Rivers in NSW.

[3] ANZECC (2000, 2018) default guideline trigger value for recreational use.

[4] HRC (1998) water quality objective.

Table 22 indicates that pH near neutral conditions were recorded at Site 4 in 2014. The total nitrogen concentration at SC and total phosphorus concentration at SC2 exceeded the default guideline trigger value. A slightly elevated concentration of total copper was recorded at SC, with elevated concentrations of total iron recorded at SC1 and SC2 and an elevated concentration of total zinc recorded at SC in comparison with the default guideline trigger values.

Two additional sampling rounds were undertaken by Niche at Stonequarry Creek sites in November 2017 and April 2018. The monitoring results are presented in Table 23 and Table 24. Note that Site 13 was dry in April 2018.

Table 23 Stonequarry Creek Upstream Water Quality – Field Records 2017

Parameter	Trigger Value	Site 4	Site 13	Site 14	Site 15
pH (pH units)	6.5-8[1]	6.9	7.0	**6.4**	7.2
EC (µS/cm)	350[2]	**838**	**1,269**	**1,473**	**1,004**
Turbidity (NTU)	2 - 25[2]	3.5	**99.0**	6.7	18.6
Dissolved Oxygen (% sat)	90 - 110[2]	**27**	**24**	**33**	**42**
Alkalinity (mg $CaCO_3$/L)		40	50	10	20

[1] ANZECC (2000) guideline trigger value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems).

[2] ANZECC (2000) guideline trigger value for Upland Rivers in NSW.

Table 24 Stonequarry Creek Downstream Water Quality – Field Records 2018

Parameter	Trigger Value	Site 4	Site 14	Site 15
pH (pH units)	6.5-8[1]	7.3	6.6	7.6
EC (µS/cm)	350[2]	**1,075**	**1,308**	**1,071**
Turbidity (NTU)	2 - 25[2]	9.0	1.5	18.0
Dissolved Oxygen (% sat)	90 - 110[2]	**39**	**75**	**87**
Alkalinity (mg $CaCO_3$/L)		40	20	40

[1] ANZECC (2000) guideline trigger value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems).

[2] ANZECC (2000) guideline trigger value for Upland Rivers in NSW.

Table 23 and Table 24 illustrate that pH near neutral conditions were recorded at all sites on Stonequarry Creek during both sampling rounds. Elevated EC values were recorded at all sites during both sampling rounds. Dissolved oxygen was significantly reduced at all sites in November 2017, and at Site 4 in 2018, in comparison with the concentration recorded at Site 4 in 2014 and compared with the default guideline trigger value.

Table 25 and Table 26 present a summary of the water quality data recorded by Tahmoor Coal at sites on Stonequarry Creek since January 2019 in comparison with the default water quality trigger values presented in Table 13. 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. The constituent values which exceed the lowest default water quality trigger value are shown in bold. Charts of the monthly monitoring records for specific constituents are presented in Appendix C.

Table 25 Stonequarry Creek Water Quality Summary (SC1 and SC2) - 2019

Parameter	Trigger Value	SC1				SC2			
		No. of Samples	Min	Med	Max	No. of Samples	Min	Med	Max
pH Value – lab	6.5 – 8[1]	2	**6.0**	-	**6.0**	12	**6.4**	6.9	7.2
pH Value - field		3	**5.7**	**5.9**	**6.1**	11	**5.7**	6.7	7.7
Electrical Conductivity (µS/cm) – lab	350[2]	3	**840**	**886**	**923**	12	**374**	**886**	**1,060**
Electrical Conductivity (µS/cm) - field		3	**875**	**893**	**1,041**	11	347	**803**	**991**
Dissolved Oxygen (mg/L) - field		3	2.5	2.8	3.8	11	0.4	5.4	9.4
Total Alkalinity (mg/L)		3	9.0	9.0	9.0	12	11.0	23.0	36.0
Sulphate as SO_4 (mg/L)	400[3]	3	11.0	12.0	20.0	12	3.0	6.5	14.0
Chloride (mg/L)	400[3]	3	248.0	265.0	340.0	12	83.0	252.0	340.0
Calcium (mg/L)		3	13.0	15.0	15.0	12	8.0	12.5	15.0
Magnesium (mg/L)		3	26.0	26.0	30.0	12	11.0	27.0	33.0
Sodium (mg/L)	300[3]	3	8.0	101.0	102.0	12	7.0	93.5	122.0
Potassium (mg/L)		3	8.0	9.0	117.0	12	5.0	6.5	79.0
Fluoride (mg/L)		3	0.1	0.1	0.1	12	0.1	0.1	0.3
Total Nitrogen (mg/L)	0.7[4]	2	0.4	-	**0.8**	11	0.1	0.2	**4.9**
Total Phosphorus (mg/L)	0.05[2]	3	0.01	**0.10**	**0.11**	12	0.01	0.01	**0.08**
Dissolved Aluminium (mg/L)		3	0.03	0.04	0.07	12	0.01	0.01	0.15
Dissolved Arsenic (mg/L)		3	0.001	0.001	0.001	12	0.001	0.001	0.001
Dissolved Barium (mg/L)		3	0.114	0.133	0.142	12	0.046	0.075	0.089
Dissolved Copper (mg/L)		3	0.001	0.002	0.002	12	0.001	0.001	0.001
Dissolved Iron (mg/L)		2	0.21	-	1.26	11	0.09	0.26	1.26
Dissolved Lead (mg/L)		3	0.001	0.001	0.001	12	0.001	0.001	0.001
Dissolved Lithium (mg/L)		3	0.009	0.010	0.011	12	0.004	0.009	0.011
Dissolved Manganese (mg/L)		3	0.2	0.4	0.7	12	0.1	0.3	0.8
Dissolved Nickel (mg/L)		3	0.005	0.006	0.018	12	0.001	0.002	0.003
Dissolved Selenium (mg/L)		3	0.010	0.010	0.010	12	0.010	0.010	0.010
Dissolved Strontium (mg/L)		3	0.137	0.139	0.159	12	0.075	0.111	0.137

Table 23 (Continued) Stonequarry Creek Water Quality Summary (SC1 and SC2) - 2019

Parameter	Trigger Value	SC1				SC2			
		No. of Samples	Min	Med	Max	No. of Samples	Min	Med	Max
Dissolved Zinc (mg/L)		3	0.016	0.028	0.045	12	0.005	0.005	0.021
Total Aluminium (mg/L)	0.055[1]	3	**0.08**	**0.09**	**1.10**	12	0.01	0.015	**0.28**
Total Arsenic (mg/L)	0.024[1]	3	0.001	0.001	0.001	12	0.001	0.001	0.001
Total Barium (mg/L)	1[3]	3	0.129	0.142	0.167	12	0.055	0.078	0.1
Total Copper (mg/L)	0.0014[1]	3	**0.002**	**0.002**	**0.003**	12	0.001	0.001	**0.002**
Total Iron (mg/L)	0.3[3]	2	**0.72**	-	**3.52**	11	0.16	**0.62**	**1.98**
Total Lead (mg/L)	0.0034[1]	3	0.001	0.001	0.001	12	0.001	0.001	0.001
Total Lithium (mg/L)		3	0.01	0.011	0.012	12	0.007	0.010	0.011
Total Manganese (mg/L)	1.9[1]	3	0.2	0.8	1.0	12	0.2	0.4	0.9
Total Nickel (mg/L)	0.011[1]	3	0.006	0.010	**0.018**	12	0.001	**0.002**	**0.008**
Total Selenium (mg/L)	0.011[1]	3	0.010	0.010	0.010	12	0.010	0.010	0.010
Total Strontium (mg/L)		3	0.146	0.15	0.173	12	0.078	0.114	0.137
Total Zinc (mg/L)	0.008[1]	3	**0.023**	**0.049**	**0.060**	12	0.005	**0.009**	**0.029**

[1] ANZECC (2000) default guideline trigger value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – guideline value relates to total concentration though can be compared to dissolved concentrations where total concentration is not available.

[2] ANZECC (2000) default guideline trigger value for Upland Rivers in NSW.

[3] ANZECC (2000) default guideline trigger value for recreational use.

[4] HRC (1998) water quality objective.

Table 26 Stonequarry Creek Water Quality Summary (SC and SD) - 2019

Parameter	Trigger Value	SC				SD			
		No. of Samples	Min	Med	Max	No. of Samples	Min	Med	Max
pH Value – lab	6.5 – 8[1]	10	7.0	7.3	8.1	10	7.1	7.3	7.9
pH Value - field		9	**5.9**	7.0	8.1	10	**6.2**	7.0	8.0
Electrical Conductivity (µS/cm) – lab	350[2]	10	**411**	**920**	**1,670**	10	**406**	**917**	**1,780**
Electrical Conductivity (µS/cm) - field		9	**459**	**867**	**1,510**	10	161	**815**	**1,088**
Dissolved Oxygen (mg/L) - field		9	4.0	6.8	10.2	10	0.6	8.7	11.5
Total Alkalinity (mg/L)		10	29.0	51.5	307.0	10	28.0	56.0	217.0
Sulphate as SO_4 (mg/L)	400[3]	10	6.0	12.0	19.0	10	6.0	12.5	87.0
Chloride (mg/L)	400[3]	10	121.0	242.0	352.0	10	121.0	247.5	382.0
Calcium (mg/L)		10	10.0	18.0	47.0	10	10.0	17.0	44.0
Magnesium (mg/L)		10	14.0	29.0	70.0	10	15.0	29.0	65.0
Sodium (mg/L)	300[3]	10	53.0	91.0	156.0	10	54.0	95.0	146.0
Potassium (mg/L)		10	6.0	7.5	8.0	10	6.0	8.0	17.0
Fluoride (mg/L)		10	0.1	0.1	0.3	10	0.1	0.1	0.2
Total Nitrogen (mg/L)	0.7[4]	10	0.2	0.4	0.7	10	0.2	0.5	**10.6**
Total Phosphorus (mg/L)	0.05[2]	10	0.01	0.01	0.02	10	0.01	0.01	**0.27**
Dissolved Aluminium (mg/L)		10	0.01	0.01	0.06	10	0.01	0.01	0.05
Dissolved Arsenic (mg/L)		10	0.001	0.001	0.001	10	0.001	0.001	0.004
Dissolved Barium (mg/L)		10	0.047	0.075	0.147	10	0.044	0.071	0.428
Dissolved Copper (mg/L)		10	0.001	0.001	0.002	10	0.001	0.001	0.006
Dissolved Iron (mg/L)		10	0.06	0.105	1.61	10	0.07	0.19	5.56
Dissolved Lead (mg/L)		10	0.001	0.001	0.001	10	0.001	0.001	0.001
Dissolved Lithium (mg/L)		10	0.004	0.010	0.044	10	0.005	0.010	0.022
Dissolved Manganese (mg/L)		10	0.1	0.2	0.6	10	0.0	0.1	20.7
Dissolved Nickel (mg/L)		10	0.001	0.001	0.002	10	0.001	0.001	0.030
Dissolved Selenium (mg/L)		10	0.010	0.010	0.010	10	0.010	0.010	0.010
Dissolved Strontium (mg/L)		10	0.082	0.140	0.368	10	0.084	0.137	0.33

Table 24 (Continued) Stonequarry Creek Water Quality Summary (SC and SD) - 2019

Parameter	Trigger Value	SC				SD			
		No. of Samples	Min	Med	Max	No. of Samples	Min	Med	Max
Dissolved Zinc (mg/L)		10	0.005	0.005	0.005	10	0.005	0.005	0.017
Total Aluminium (mg/L)	0.055[1]	10	0.020	0.045	**0.080**	10	0.010	0.020	**0.080**
Total Arsenic (mg/L)	0.024[1]	10	0.001	0.001	0.001	10	0.001	0.001	0.004
Total Barium (mg/L)	1[3]	10	0.052	0.080	0.158	10	0.049	0.078	0.486
Total Copper (mg/L)	0.0014[1]	10	0.001	0.001	**0.002**	10	0.001	0.001	**0.007**
Total Iron (mg/L)	0.3[3]	10	0.14	0.27	**1.78**	10	0.15	**0.37**	**6.38**
Total Lead (mg/L)	0.0034[1]	10	0.001	0.001	0.001	10	0.001	0.001	0.001
Total Lithium (mg/L)		10	0.005	0.011	0.044	10	0.005	0.011	0.024
Total Manganese (mg/L)	1.9[1]	10	0.1	0.2	0.6	10	0.0	0.2	**22.1**
Total Nickel (mg/L)	0.011[1]	10	0.001	0.001	**0.002**	10	0.001	0.001	**0.032**
Total Selenium (mg/L)	0.011[1]	10	0.010	0.010	0.010	10	0.010	0.010	0.010
Total Strontium (mg/L)		10	0.085	0.1515	0.392	10	0.085	0.146	0.337
Total Zinc (mg/L)	0.008[1]	10	0.005	0.005	0.007	10	0.005	**0.011**	**0.016**

[1] ANZECC (2000) default guideline trigger value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – guideline value relates to total concentration though can be compared to dissolved concentrations where total concentration is not available.

[2] ANZECC (2000) default guideline trigger value for Upland Rivers in NSW.

[3] ANZECC (2000) default guideline trigger value for recreational use.

[4] HRC (1998) water quality objective.

Table 25 and Table 26 show slight variances in the field and laboratory pH values recorded at each site on Stonequarry Creek. The results of the laboratory analyses indicate slightly acidic conditions at SC1 and near neutral to slightly alkaline conditions at SC2, SC and SD. The EC records were generally consistent between field and laboratory analyses at SC1, SC2 and SC, though variances were noted at SD. Based on the laboratory analyses, all samples exceeded the default guideline trigger value of 350 µS/cm.

The maximum concentration of total nitrogen recorded at SC1, SC2 and SD on Stonequarry Creek exceeded the HRC guideline trigger value of 0.7 mg/L, the median and maximum concentrations of total phosphorus exceeded the HRC guideline trigger value of 0.05 mg/L at SC1 and the maximum concentration of total phosphorus exceeded the HRC guideline trigger value at SC2 and SD.

The maximum concentration of total aluminium at SC2, SC and SD and the total concentration of aluminium for all samples recorded at SC1 exceeded the default guideline trigger value of 0.055 mg/L. The maximum concentration of manganese exceeded the default guideline trigger value of 1.9 mg/L at SD during a period of no flow (as reported from visual inspection). The median and maximum concentrations of total nickel recorded at SC2 and the maximum concentration of total nickel recorded at SC1, SC and SD exceeded the default guideline trigger value of 0.011 mg/L. At SC2 and SD, the median concentration of total zinc exceeded the default guideline trigger value of 0.008 mg/L, while the concentrations of total zinc in all samples recorded at SC1 exceeded the default guideline trigger value. The maximum concentration of total copper recorded at SC2, SC and SD slightly exceeded the default guideline trigger value of 0.0014 mg/L while the concentrations of total copper in all samples recorded at SC1 slightly exceeded the default guideline trigger value. The median and maximum concentrations of total iron recorded at SC2 and SD, the maximum concentration recorded at SC and the total iron concentration recorded in both samples at SC1 exceeded the default guideline trigger value for recreational use of 0.3 mg/L.

Water quality data monitored by WaterNSW was provided for Stonequarry Creek at Picton (location N912 in Figure 4) for the period from 2014 to 2019. Table 27 presents the minimum, median and maximum water quality values for Stonequarry Creek at Picton. The total number of samples and percentage of exceedances against the default guideline trigger values are also presented where available.

Table 27 Stonequarry Creek at Picton Water Quality Summary – Laboratory Analysis 2014 to 2019

Parameter	Trigger Value	No. of Samples	Min	Median	Max	Percentage of Exceedances
pH (pH units)	6.5-8[1]	135	6.8	7.4	7.9	0
EC (µS/cm)	350[2]	134	9	**702**	**1,603**	99
Turbidity (NTU)	2 - 25[2]	136	2	8	**250**	19
Dissolved Oxygen (% sat)	90 - 110[2]	135	**13**	**71**	100	89
Alkalinity (mg $CaCO_3$/L)		10	0.11	0.15	0.16	
Total Nitrogen (mg/L)	0.7[4]	133	0.2	0.5	**4.5**	22
Total Phosphorus (mg/L)	0.05[2]	133	0.01	0.02	**0.24**	16
Calcium (mg/L)		21	18	32	38	
Potassium (mg/L)		21	3.8	4.5	5.4	
Sodium (mg/L)	300[3]	21	62	99	106	0
Arsenic (mg/L)	0.024[1]	21	0.0003	0.0005	0.0007	0
Barium (mg/L)	1[3]	21	0.09	0.18	0.23	0
Boron (mg/L)	0.37[1]	21	0.02	0.02	0.04	0
Molybdenum (mg/L)		21	0.0002	0.0002	0.0004	
Selenium (mg/L)	0.011[1]	21	<0.0002	<0.0002	<0.0002	0
Silver (mg/L)	0.00005[1]	21	<0.0001	<0.0001	<0.0001	0
Zinc (mg/L)	0.008[1]	21	0.002	0.004	**0.009**	5
Total Aluminium (mg/L)	0.055[1]	21	0.01	**0.08**	**0.35**	67
Total Antimony (mg/L)		21	<0.0003	<0.0003	<0.0003	
Total Beryllium (mg/L)		21	<0.0005	<0.0005	<0.0005	
Total Cadmium (mg/L)	0.0002[1]	21	<0.0001	<0.0001	<0.0001	0
Total Chromium (mg/L)		21	<0.0002	<0.0002	0.0005	
Total Cobalt (mg/L)		21	0.0003	0.0005	0.0013	
Total Copper (mg/L)	0.0014[1]	21	<0.0005	0.001	**0.0025**	19
Total Iron (mg/L)	0.3[3]	21	0.26	**0.68**	**1.41**	95
Total Lead (mg/L)	0.0034[1]	21	<0.0001	0.0002	0.0011	0
Total Lithium (mg/L)		21	0.0030	0.0050	0.0100	
Total Magnesium (mg/L)		17	17.3	28.9	32.7	
Total Manganese (mg/L)	1.9[1]	15	0.17	0.34	0.86	0
Total Nickel (mg/L)	0.011[1]	21	0.0003	0.0011	0.0015	0

[1] ANZECC (2000) default guideline trigger value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – guideline value relates to total concentration though can be compared to dissolved concentrations where total concentration is not available.

[2] ANZECC (2000) default guideline trigger value for Upland Rivers in NSW.

[3] ANZECC (2000) default guideline trigger value for recreational use.

[4] HRC (1998) water quality objective.

Table 27 illustrates that the water quality of Stonequarry Creek at Picton was near neutral during the period of data with pH values within the range of the default trigger guideline values. The median and maximum EC values were greater than the ANZECC default guideline trigger value (350 µS/cm), consistent with EC values recorded at other monitoring sites upstream on Stonequarry Creek. The total nitrogen and total phosphorus concentration exceeded the HRC guideline trigger values in 22% and 16% of the samples respectively. The guideline trigger value for zinc was exceeded in 5% of samples, total aluminium in 67% of samples, total copper in 19% of samples and total iron in 95% of samples.

3.4.2 Aquatic Habitat and Stream Health

The aquatic habitat in creeks within the Investigative Area consists primarily of pools with moderate riparian and channel health (Niche 2019b). The streams are 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.

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, 2014). The streambanks were well vegetated, providing moderate to high shading of the stream though 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 sites on Cedar Creek, Matthews Creek and Stonequarry Creek were in moderate to good condition with the highest rated habitat found in gorges along Matthews and Cedar Creeks. Typical pools on Matthews and Stonequarry Creeks are shown in Photo 1 and Photo 2 below. It is noteworthy that sections of Matthews Creek are devoid of flow in between reaches which are flowing – this is illustrated in Photo 3.

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 caught 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.

Photo 1 Matthews Creek Typical Pool with Boulder Field at Downstream End (Site 7 - refer Figure 4)

Photo 2 Stonequarry Creek Typical Pool with Rock Bar at Downstream End (Site SB - refer Figure 4)

Photo 3 Matthews Creek Typical Reach with No Flow (Downstream of Site MD – refer Figure 4)

4.0 PREDICTED SUBSIDENCE IMPACTS AND CONSEQUENCES ON SURFACE WATER RESOURCES

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.

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.

4.1 POTENTIAL SURFACE WATER IMPACTS

The potential subsidence related impacts to surface water resources have been identified based on consideration of coal extraction from the Western Domain, experience with historical longwall mining at Tahmoor and other similar longwall mining operations in the Southern Coalfields. The potential impacts and the mechanisms or causes are summarised in the sub-sections below. The subsidence predictions and potential impacts to water resources specific to the Western Domain are detailed in Section 4.4.

4.1.1 Flow Rate/Quantity

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

1. Capture of a proportion of low flows and the diversion of this water downstream via the created underground fracture network;
2. Re-emergence of surface flow downstream of the affected area;

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

4.1.2 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.

4.1.3 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].

4.2 REVIEW OF PAST SUBSIDENCE IMPACTS ON SURFACE WATER RESOURCES

Mining of LW 25 to LW 31 by Tahmoor Coal has resulted in subsidence in Redbank Creek. Examination of the past effects of mining on this creek provides a basis for assessing the potential impacts to watercourses within the Investigative Area. However, it should be noted that Redbank Creek was directly undermined whereas the longwall layout in the Investigative Area has been designed in order to avoid mining directly beneath the main surface water resources within the area.

4.2.1 Subsidence Impacts of the Tahmoor Colliery on Redbank Creek

Observations of subsidence impacts to Redbank Creek associated with LW 25 to LW 31, shown in Figure 1, have been reported in the *Redbank Creek – Corrective Management Action Plan* (Tahmoor Coal, 2018). LW 25 to LW 31 were all 283 m wide. Coal seam thickness varied from 1.8 to 2.2 m and cover (i.e. depth from top of seam to surface) varied from 395 m to 500 m. Maximum measured vertical subsidence was 1,240 mm and maximum valley closure measured in Redbank Creek was 179 mm.

LW 25 undermined a section of Redbank Creek near the northern end of the panel and sub-surface underflow (diversion) was reported in a 6 m long section of exposed sandstone in Redbank Creek overlying the longwall. The short-term flow diversion was reported to be in the absence of observable bed cracking. There was no change to streamflow or water quality at flow monitoring sites in Redbank Creek further downstream as a result of mining of LW 25 and no generation of ferruginous seepage was observed (GeoTerra, 2014; and Tahmoor Coal, 2018).

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

Following completion of LW 26, subsidence resulted in cracking of the streambed and underflow in isolated sections of Redbank Creek including a pool overlying LW 25. Pool desiccation was observed in clay incised sections of the creek containing cobbles. GeoTerra (2014) reported that overall, there was no adverse effect on stream bed stability, stream bank stability or water quality in Redbank Creek during the monitoring period. While localised loss of flow was observed at some sites in Redbank Creek, no overall loss of streamflow was reported (Tahmoor Coal, 2018).

Following mining of LW 27, cracking was observed at sites along Redbank Creek and pools were observed to drain at times of low flow, though diverted flow was observed to re-emerge downstream of LW 27. Increased salinity was recorded downstream of the subsidence zone and elevated levels of iron, manganese, zinc and nickel were recorded during the mining of LW 27.

During mining of LW 28, LW 29 and LW 30, additional subsidence effects were observed. Cracking was observed at sites along Redbank Creek and pools were observed to drain at times of low flow, though diverted flow was observed to re-emerge downstream of each longwall. Increased salinity was recorded downstream of the subsidence zone and elevated levels of iron, manganese, zinc and nickel were also recorded (Tahmoor Coal, 2018). Gas emissions have not been observed in streams or pools above mining at the Tahmoor Mine (Tahmoor Colliery, 2013).

No direct evidence of dam wall or floor cracking was observed following mining of LW 25 to LW 28. Associated adverse water level, water storage or water quality effects were not observed during site investigations, however, complaints were made by three landowners with respect to loss of water holding capacity in dams following mining of LW 26 (GeoTerra, 2014).

4.2.2 Summary of Previous Impacts on Flow and Water Quality in Streams in the Southern Coalfields

There have also been a number of watercourses in the Southern Coalfields more generally which have been affected by subsidence from longwall mining. The following sections provided a summary of the reported impacts to streamflow and surface water quality relating to subsidence-induced mining impacts in the Southern Coalfields.

4.2.2.1 Reported Impacts to Flow

Waratah Rivulet, a perennial surface water system overlying the longwall mining operations at the Metropolitan Coal Mine near Helensburgh, has experienced a loss of pool water levels and flowing water in some locations following direct undermining. Analysis of recorded flows at a downstream gauging station on Waratah Rivulet (located downstream of longwall mining) indicated that whilst there was localized impact, there was no net affect to catchment yield (Gilbert & Associates, 2008) and no discernible change to catchment flows downstream due to longwall mining post-1995. However, in the Eastern Tributary, a succession of pools experienced water losses due to subsidence-induced mining impacts that were not initially predicted (IEPMC, 2019). Metropolitan Coal has subsequently developed a rock bar remediation technique to rehabilitate sections of Waratah Rivulet and the Eastern Tributary where subsidence-induced mining impacts have occurred (Pitt and Sherry, 2018).

Stokes Creek overlies longwall mining which has taken place at the West Cliff Colliery, near Appin, with some 3.3 km of the creek being directly undermined. A comparative analysis of streamflow gauging station data upstream and downstream of the longwall mining indicated that there had been no change to the flow characteristics of Stokes Creek, including low flow characteristics, prior to and after the commencement of longwall mining (Gilbert & Associates, 2009).

4.2.2.2 Reported Impacts to Stream Water Quality

Analysis of water quality data collected on Waratah Rivulet (Gilbert & Associates, 2008) showed that water quality both within and downstream of reaches affected by subsidence was generally good with most water quality indicators being low relative to the default ANZECC (2000) guideline trigger values for the protection of aquatic ecosystems. The effects of subsidence were however evident as localized and transient spikes in iron, manganese and aluminium which could be linked in time to subsidence induced fracturing of the stream bed.

Assessments of subsidence impacts have been conducted by Illawarra Coal Holdings Pty Ltd on all recent (post 2005) longwall mining operations at their West Cliff, Dendrobium, Eloura, Tower and Appin Collieries. The following summary has been compiled from information published in the Bulli Seam EIS (Gilbert & Associates, 2009).

Appin Longwall 701 came within about 190 m (in plan location) of the Nepean River at its closest point. Two iron release zones were reported during mining which resulted in visible iron stains – one in the Nepean River and one in Elladale Creek – an adjacent tributary. The iron stain in Elladale Creek was believed to have been related to a reactivation (additional movement) of a previously goafed area. Four gas release zones were also observed in the Nepean River and one in Elladale Creek.

Mining of Longwalls 31 and 32 at West Cliff Colliery came within about 30 m (in plan) of the Georges River. The observed and monitored effects on water quality in the Georges River during and following completion of these longwalls is summarised as follows:

1. A small localised and isolated spike in manganese concentration was detected during mining of Longwall Panel 31a, however the concentration was low compared the default ANZECC (2000) guideline trigger values for the protection of aquatic ecosystems. The spike may not have been as a result of mining;
2. Nine minor observations of gas release were detected along the Georges River during mining of Longwall Panel 32; and
3. Two small iron stains were observed during and following completion of Longwall Panel 32.

The Cataract River, a perennial system, was undermined by Longwalls 3 to 16 of the Tower Colliery underground operations, with reported impacts on the Cataract River including:

1. Reduced dissolved oxygen concentration;
2. Increased turbidity;
3. Strata gas emissions which declined in magnitude and intensity over the monitored period;
4. Increased electrical conductivity (salinity); and
5. Minor pH fluctuations.

Appin Colliery Longwalls 301 and 302 were mined close to but not directly beneath the Cataract River. Reported impacts included gas releases and observations of iron staining along the adjacent reach of the Cataract River. Results of paired water quality sampling upstream and downstream of the area adjacent to the longwall panels were unable to provide any clear evidence of water quality effects. Water quality in this reach of Cataract River was dominated by periods of variable and at times significant releases of water from the upstream Cataract Dam during the monitoring period. Similar effects were noted from observations and monitoring during mining of Appin Colliery longwall 405 which was mined close to the Cataract River.

Stokes Creek was undermined by West Cliff Colliery Longwalls 17 to 24 with stream condition mapping and photographic reconnaissance of Stokes Creek in the affected reach revealing iron staining and flocs in pools. Mallaty Creek was undermined by West Cliff Colliery Longwalls 32 and

33, with monitoring revealing minor iron staining which was attributed to a groundwater spring possibly associated with subsidence movements. Extensive water quality monitoring along Mallaty Creek prior to mining confirmed the presence of a saline spring within the reach which was subsequently undermined by Longwall 32. During mining there was a localised and temporary increase in pH which was attributed to subsidence effects on the spring.

Longwalls 3 and 4 at the Dendrobium Mine are located within 250 m (in plan) at the closest point to the shoreline of the Cordeaux Reservoir. It was concluded from the analysis of water quality data that there were localised spikes in aluminium and iron recorded in one tributary creek which could be attributable to the effects of subsidence induced cracking. The peak concentrations measured were however low compared to the default ANZECC (2000) guideline trigger values for the protection of aquatic ecosystems and were not above levels in other creeks in the area.

Longwall mining under Kembla Creek and several of its tributaries has not resulted in reported changes in water quality that could be related to mining effects. Minor fracturing and pool water loss was however reported in tributary streams.

The headwaters of Wongawilli Creek and Native Dog Creek were undermined by Elouera Colliery Longwall Panels 1 to 6. An intense and widespread fire following the completion of mining had a major impact on vegetation in the area and resulted in erosion and redistribution of sediment in local drainages following subsequent intense rainfall events. Water quality monitoring revealed relatively low pH, dissolved oxygen concentrations and elevated aluminium and zinc in the creeks. These effects were attributed to longwall mining beneath these creeks and to the effects of drought. It was inferred from the data that these effects were ameliorating with time.

4.3 PROPOSED LONGWALL LAYOUT AND TIMING

The Western Domain longwalls will be mined sequentially from LW W1 to W4. Longwall mining will occur from north to south of each panel. The longwall layout has been designed in order to avoid mining directly beneath the main creeks within the Investigative Area, namely: Matthews Creek, Cedar Creek and Stonequarry Creek. The Western Domain longwall layout has been designed to achieve no more than 200 mm of predicted valley closure for these watercourses.

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

4.4 SUBSIDENCE PREDICTIONS AND POTENTIAL IMPACTS ON SURFACE WATER RESOURCES

Table 28 provides specific predictions of subsidence related impacts to watercourses in the Investigative Area summarised from MSEC (2019). The maximum predicted total subsidence following mining of LW 32, LW W1 and LW W2 and the incremental change after mining of LW 32 is presented. Redbank Creek, and third order tributaries of Redbank Creek, are located outside the predicted 20 mm total subsidence contour and hence are not presented. The profiles of predicted subsidence, upsidence and valley closure along the affected reaches of local streams within the Investigative Area compiled by MSEC (2019) are provided in Appendix A. The potential impacts to water resources based on the predicted subsidence impacts are discussed in subsequent sections.

Table 28 Subsidence, Upsidence and Valley Closure Predictions

Creek	Longwall	Maximum Predicted Total Subsidence / Incremental Change from LW 32 (mm)	Maximum Predicted Total Upsidence / Incremental Change from LW 32 (mm)	Maximum Predicted Total Closure / Incremental Change from LW 32 (mm)
Stonequarry Creek	After W1	<20 / 0	30 / 10	30 / 10
	After W2	60 / 40	90 / 70	60 / 40
Cedar Creek	After W1	40 / 20	90 / 70	130 / 90
	After W2	60 / 40	160 / 140	180 / 160
Matthews Creek	After W1	70 / 50	50 / 30	120 / 100
	After W2	90 / 70	90 / 70	170 / 150
First and Second Order section of Rumker Gully	After W1	325 / <20	350 / <20	200 / <20
	After W2	325 / <20	350 / <20	200 / <20
Third order section of Rumker Gully	After W1	30 / 10	30 / 10	60 / 40
	After W2	40 / 20	40 / 20	80 / 60

Table 28 illustrates that subsidence impacts are predicted to be relatively greater in the south, with Matthews Creek predicted to experience greater subsidence effects than Stonequarry Creek and Cedar Creek. While the creeks could experience low-levels of vertical subsidence, associated conventional tilts, curvatures or strains are predicted to be immeasurable (MSEC, 2019). However, compressive strains may occur due to valley related effects, with maximum predicted valley related closure for Matthews, Cedar and Stonequarry Creeks of 170 mm, 180 mm and 60 mm respectively. Fracturing may therefore occur along Matthews, Cedar and Stonequarry Creeks due to the valley closure compressive strains. However, the predicted rate of impact for pools along these creeks, with respect to fracturing and reduction in standing water level, is less than 10% (MSEC, 2019).

The upper reach of Rumker Gully is located partially above the existing LW30, with the maximum predicted subsidence parameters for the tributary, associated with LW22 to LW32, being 300 mm vertical subsidence, 350 mm upsidence and 200 mm closure (MSEC, 2019). Low-level additional movements are predicted due to the extraction of LW W1-W2 (less than 20 mm upsidence, subsidence and valley closure). The third order section of Rumker Gully is predicted to experience vertical subsidence of less than 20 mm and as such is not expected to experience measurable conventional tilts, curvatures or strains (MSEC, 2019).

Minor tributaries located directly above LW W1-W2 may experience the full range of predicted subsidence movements (MSEC, 2019). Mining-induced compression due to valley closure effects may result in dilation and the development of bed separation in the upper strata underlying the tributaries (MSEC, 2019).

There are twelve existing farm dams and detention basins within the predicted subsidence zone as illustrated in Figure 12. FD-5 and FD-10 on Figure 12 appear to be detention basins within the Stonequarry Creek Estate. There is one detention basin located directly above LW W1 (FD-5) and three dams located directly above LW W2 (FD-2, FD-6 and FD-12). Table 29 provides predictions of subsidence related impacts to these dams and detention basins as summarised from MSEC (2019).

Table 29 Subsidence Predictions for Dams

Dam	Predicted Total Subsidence after LW W1 (mm)	Predicted Total Subsidence after LW W2 (mm)	Predicted Total Tilt after LW W1 (mm/m)	Predicted Total Tilt after LW W2 (mm/m)
FD-1	20	40	<0.5	<0.5
FD-2	30	175	<0.5	2.5
FD-3	<20	50	<0.5	<0.5
FD-4	20	125	<0.5	0.5
FD-5	425	625	2.5	4.0
FD-6	70	750	<0.5	5.0
FD-7	30	125	<0.5	0.5
FD-8	<20	40	<0.5	<0.5
FD-9	30	30	<0.5	<0.5
FD-10	40	50	<0.5	<0.5
FD-11	40	50	<0.5	<0.5
FD-12	50	525	<0.5	4.5

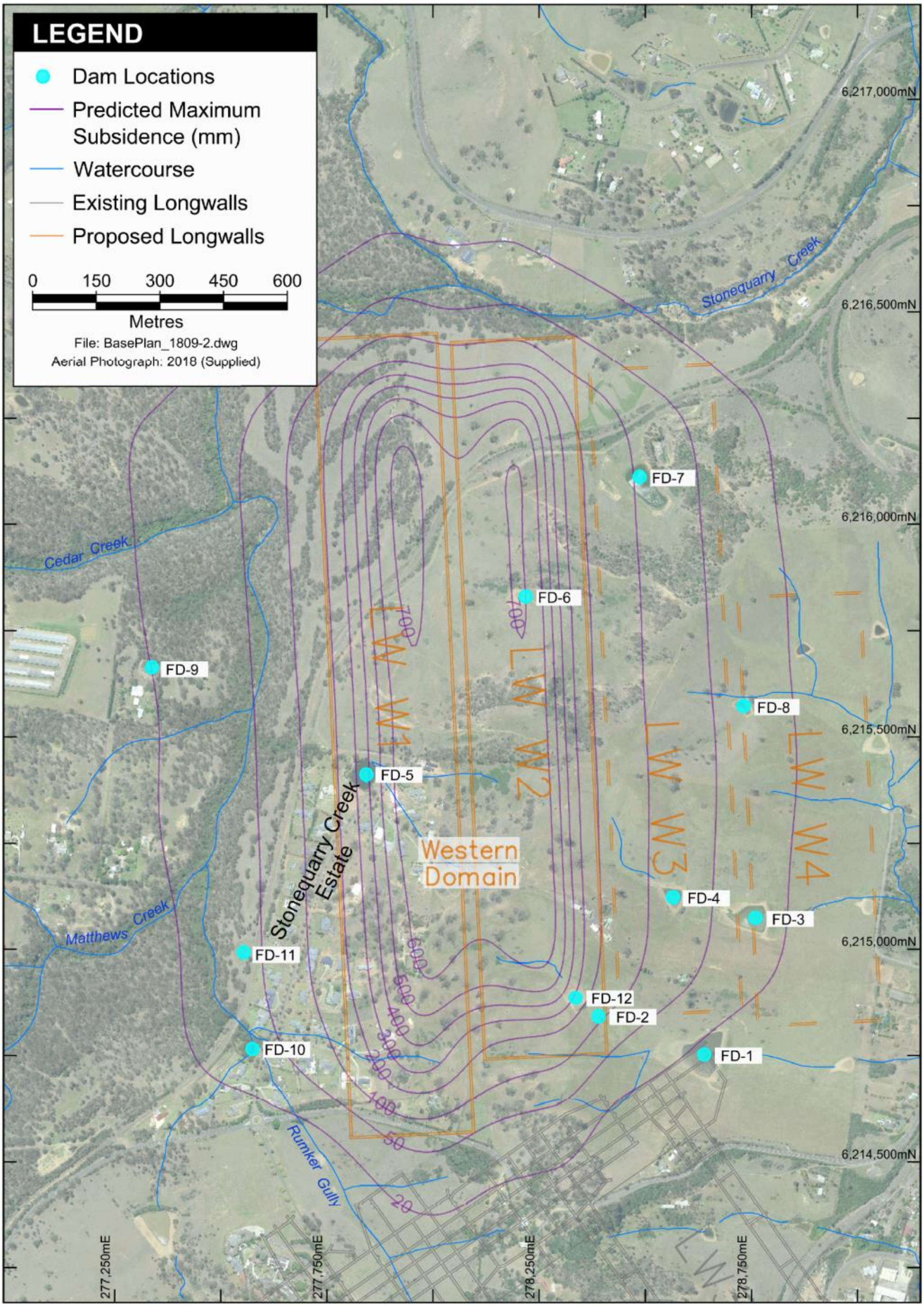

Figure 12 **Locations of Dams and Predicted Maximum Subsidence**

4.4.1 *Water Quantity*

Where mining occurs directly beneath surface water systems, there is potential for cracking of the stream bed and underlying strata with associated impacts to the flow regime and water holding capacity of the surface water system. Additionally, mining induced subsidence may result in changes in ground level and gradient and thereby impact water levels in watercourses within the subsidence impact zone.

4.4.1.1 Potential Impact to Low Flow Regime

MSEC (2019) 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 mining-induced changes in grade along these creeks are predicted to be negligible, it is unlikely that increased levels of ponding or scouring will be observed. Nevertheless monitoring of these creeks to assess impacts is proposed (refer Section 5.0) and trigger action response plans (TARPs) have been developed to manage impacts should they occur (refer Section 6.0).

The third order section of Rumker Gully is predicted to experience vertical subsidence of less than 20 mm and as such is not expected to experience measurable conventional tilts, curvatures or strains (MSEC, 2019). Due to the maximum predicted total compressive strain, the third order section of Rumker Gully may experience fracturing and associated reduction in standing water level. However, the maximum predicted total closure is 80 mm in this reach and as such less than 10% of pools are likely to experience impacts (MSEC, 2019).

A maximum total closure of 200 mm is predicted for the first and second order reaches of Rumker Gully, however, this is expected to occur following mining of LW 32 and minimal additional closure is predicted following mining of LW W1 and LW W2. In the first and second order sections of Rumker Gully, the tributary is ephemeral and has been heavily modified by the development of the Stonequarry Creek Estate. These sections of Rumker Gully do not contain any noteworthy surface water features (i.e. rock bars, pools and aquatic habitat). As such, potential impacts of mining on Rumker Gully are unlikely to have discernible impact with respect to surface water resources and ecosystems.

Minor tributaries located directly above LW W1-W2 may experience the full range of predicted subsidence movements (MSEC, 2019). Mining-induced compression due to valley closure effects may result in dilation and the development of bed separation in the upper strata underlying the tributaries (MSEC, 2019). These 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 minimal change in gradient and as such it is unlikely that there will be increased ponding upstream of the gullies or increased potential for scour and erosion (MSEC, 2019). Section 4.4.1.3 addresses the potential impacts to water levels due to the predicted subsidence and change in gradient of the tributary gullies.

The hydrogeological assessment predicts that the height of connected fracturing due to mining of LW W1 and W2 will not extend to the surface (HydroSimulations, 2019). As such, although there may be some temporary loss of flow (diversion) from the surface water systems in the event of cracking or dilation, connectivity between the groundwater and surface water systems is not predicted (HydroSimulations, 2019).

Flow diversion occurred in Redbank Creek following mining of Tahmoor North LW 25 to 32, however, the diverted flow was observed to re-emerge downstream of each longwall and no overall loss of streamflow was reported (Tahmoor Coal, 2018). As Stonequarry Creek, Matthews Creek and Cedar

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 because LW 25 to LW 32 directly mined 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).

4.4.1.2 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 Investigative Area. Hydrologic and hydraulic modelling was undertaken to assess the impacts of longwall panels LW W1 and LW W2 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 (2019), which is included as Appendix B[5]. Figure 13 presents the 1% AEP flood extent and change in water level and Figure 14 shows the PMF flood extent and change in water level.

Figure 13 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 is predicted to decrease by 0.01 m (RP10) to 0.07 m (RP2 and RP4) based on subsidence predictions for the Western Domain. There are no locations where the 1% AEP flood level is predicted to increase following mining. The flood velocity change is predicted to range between an increase of up to 0.02 m/s (RP3) and a decrease of up to 0.03 m/s (RP8). 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 14 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 1.4 m. The peak flood level is predicted to decrease by 0.02 m (RP9 and RP10) to 0.06 m (RP2) based on subsidence predictions for the Western Domain. There are no locations where the PMF event flood level is predicted to increase following mining. The flood velocity change is predicted to range between an increase of up to 0.02 m/s (RP3) and a decrease of up to 0.03 m/s (RP9). 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.

[5] Although the WRM (2019) report is entitled “Matthews Creek Flood Impact Study for LW W1-W2” and the titles of the maps included here as Figure 13 and Figure 14 purport to be for the “Matthews Creek Catchment”, the extent of modelling covers Matthews, Cedar and Stonequarry Creeks over and beyond the predicted extent of subsidence effects.

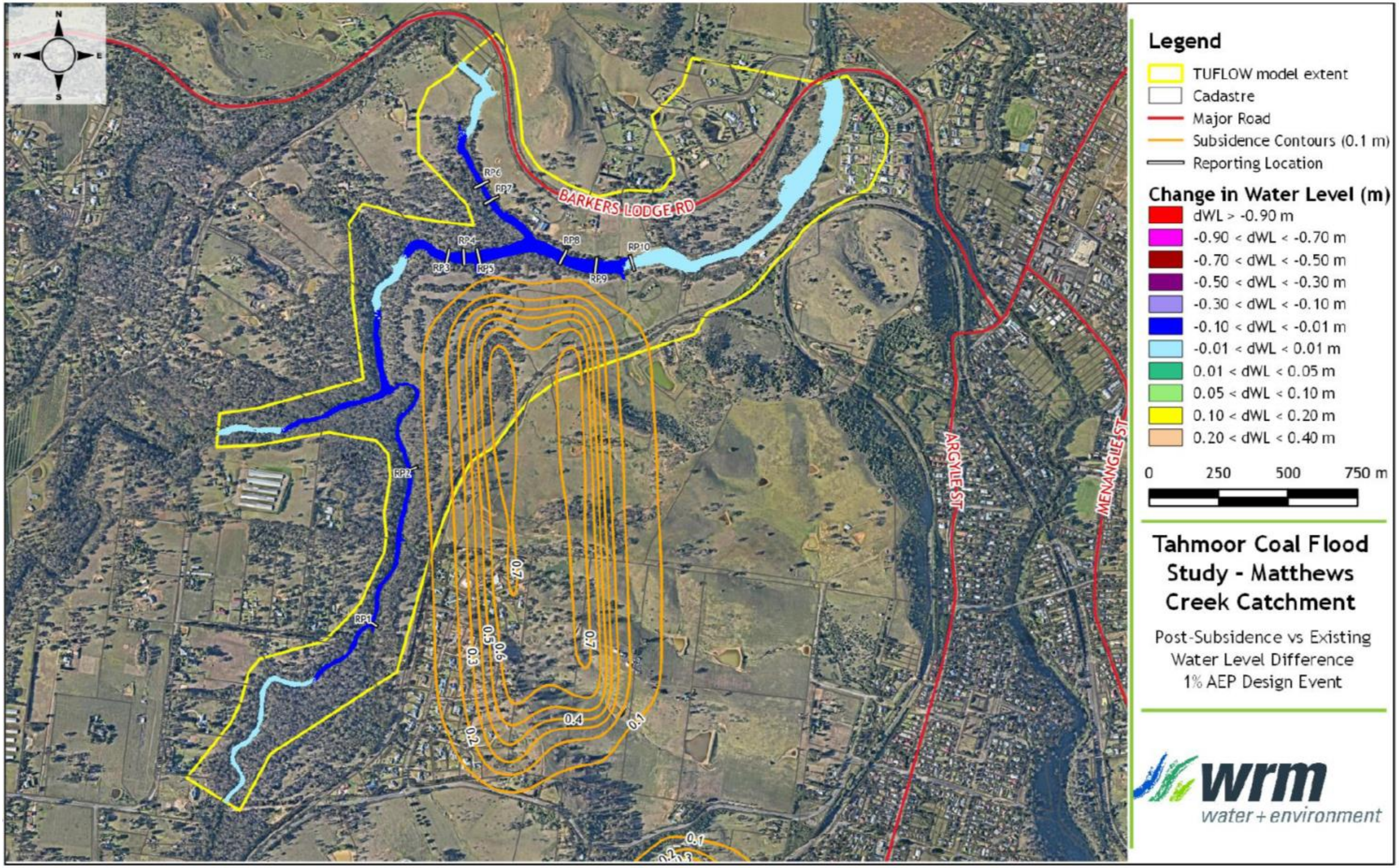

Figure 13 Matthews, Cedar and Stonequarry Creeks 1% AEP event impact – change in water level

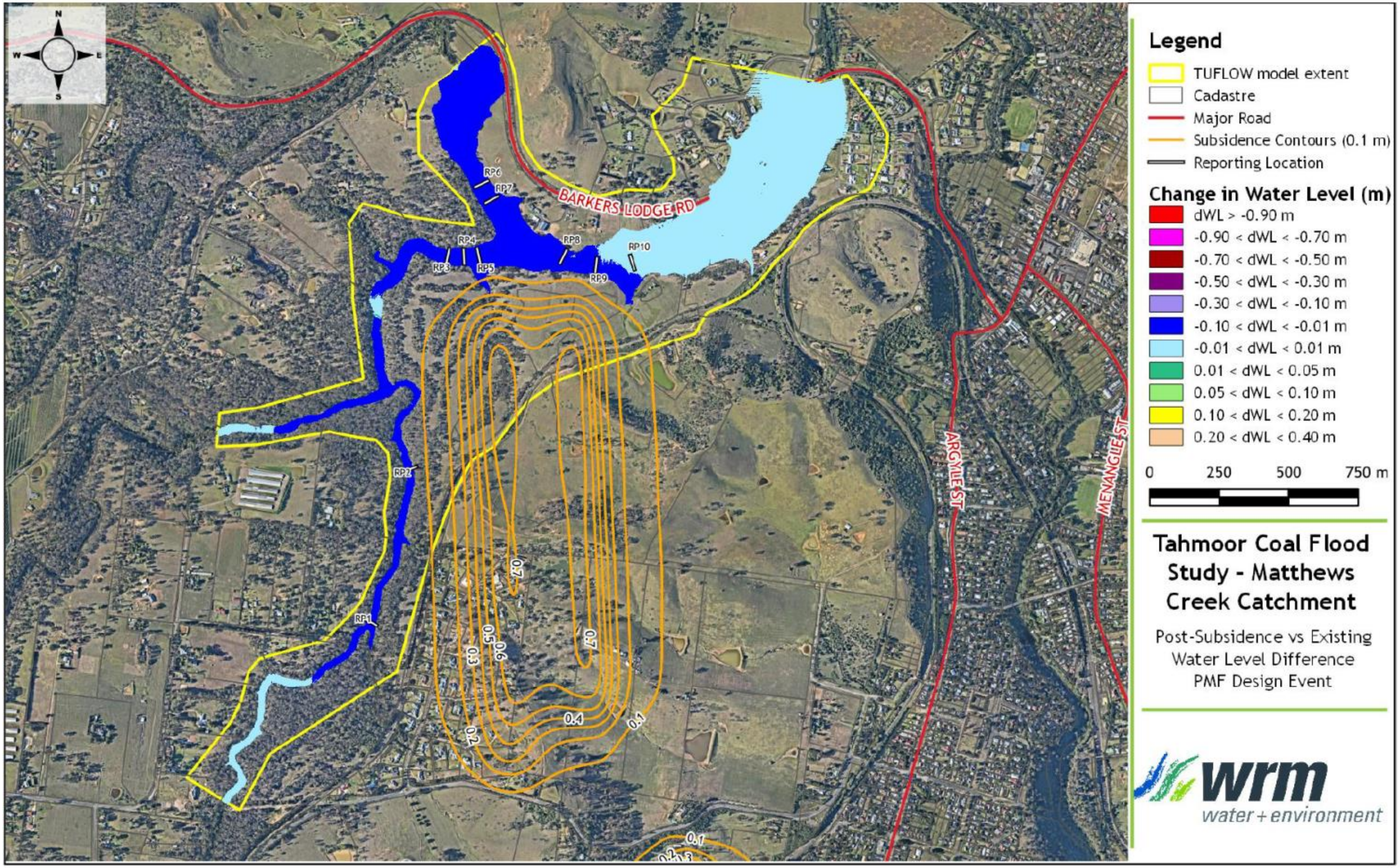

Figure 14 Matthews, Cedar and Stonequarry Creeks PMF event impact – change in water level

4.4.1.3 Predicted Impact to Flood Regime – Local Tributary Gullies

Several tributaries of Matthews Creek, Cedar Creek, Stonequarry Creek and Redbank Creek overlie the proposed LW W1 to LW W4. A flood study has been undertaken to assess the impacts to flood flows in these tributary gullies due to subsidence within the Investigative Area (WRM, 2019).

A 1-dimensional hydraulic (surface flow) model was developed for each tributary and culvert shown in Figure 15. The hydraulic model was used to assess the change in flood level during the 50% AEP (representative of frequently occurring flows) and 1% AEP (representing rare events) peak flow rates based on the subsidence predictions for the Investigative Area. The 50% AEP and 1% AEP peak flow rates for each tributary were estimated using the Regional Flood Frequency Estimation Model (ARR, 2016)[6].

Predicted subsidence contours, obtained from MSEC, were used to assess the change in longitudinal gradient of each tributary and culvert due to subsidence impacts. The catchment area and cross-sectional details of each tributary were estimated/obtained from digital elevation data obtained from MSEC. The cross-sectional characteristics and gradient of each tributary and culvert were then modified to reflect changes following predicted subsidence. Culvert details were obtained from SIMEC (2018), JMA (2019a) and through visual inspection/photographic record. Estimates of stream roughness were made from visual inspection of vegetation cover and literature recommended values.

Table 30 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, with a positive change indicating an increase in gradient based on subsidence predictions and a negative change indicating a decrease in gradient.

Table 30 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	Rumker Gully	89.629	1.7	19.3	27	-0.01
	Tributary 2 (MC Trib 2)	88.980	0.6	7.4	405	-0.10
	Tributary 2a (MC Trib 2a)	N/A	0.2	2.4	920	-0.16
Cedar Creek	Tributary 1 (CC Trib 1)	88.400	0.8	9.1	940	-0.06
Stonequarry Creek	Tributary 1 (SC Trib 1)	87.850	0.5	5.7	500	-0.02
	Tributary 2 (SC Trib 2)	87.330	0.04	0.5	190	+0.04
Redbank Creek	Tributary 1 (RC Trib 1)	N/A	0.3	3.6	80	-0.03
	Tributary 2 (RC Trib 2)	N/A	0.4	5.1	80	-0.06

[6] https://rffe.arr-software.org/

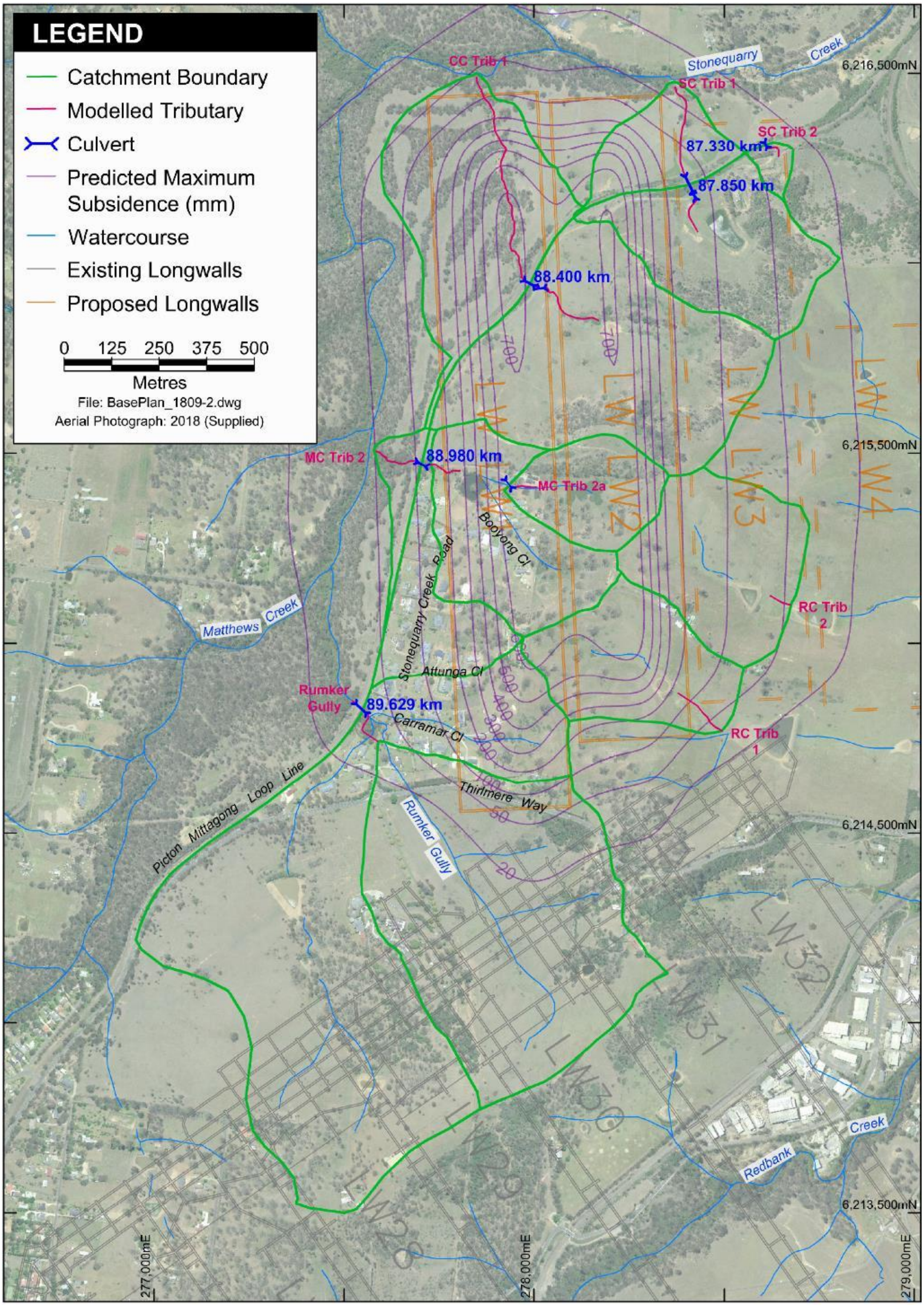

Figure 15 Flood Assessment Tributary Locations, Catchment and Culvert Alignments

Structural and geotechnical assessments undertaken by JMA (2019b) for the Tahmoor Mine Extraction Plan LW W1 – W2 have identified that the most cost-effective subsidence mitigation measure for sandstone railway culverts in the Investigative Area is to “sleeve” the masonry structures with concrete pipes. As such, Tahmoor Coking Coal Operations (TCCO) is proposing to place concrete pipes to “sleeve” culverts at railway chainages 88.980 km, 88.400 km, 87.850 km and 89.629 km (refer Figure 15) prior to undermining.

For the culverts at railway chainages 88.980 km, 88.400 km, 87.850 km and 89.629 km, an assessment has been undertaken to predict the potential impacts to flood levels, flow depth and flow velocity for the culverts and associated tributaries as a result of the proposed modifications to the masonry structures as well as the subsidence predictions for the Investigative Area. A hydraulic model has been developed to predict the tributary 50% AEP and 1% AEP peak flow flood levels, flow depth and flow velocity for three cases:

1. existing conditions (with existing culverts and pre-subsidence);
2. with concrete pipe sleeves in place and pre-subsidence; and
3. with concrete pipe sleeves in place and post-subsidence.

Figure 16 shows the pre and post-subsidence alignment of Rumker Gully, the railway and railway culvert. The pre and post-subsidence modelled flood levels for the 50% AEP and 1% AEP peak flow rates are also given. Note that modelling included the drain adjacent to (on the southern and western side of) the detention basin (Dam 3 on Figure 12) rather than the detention basin itself.

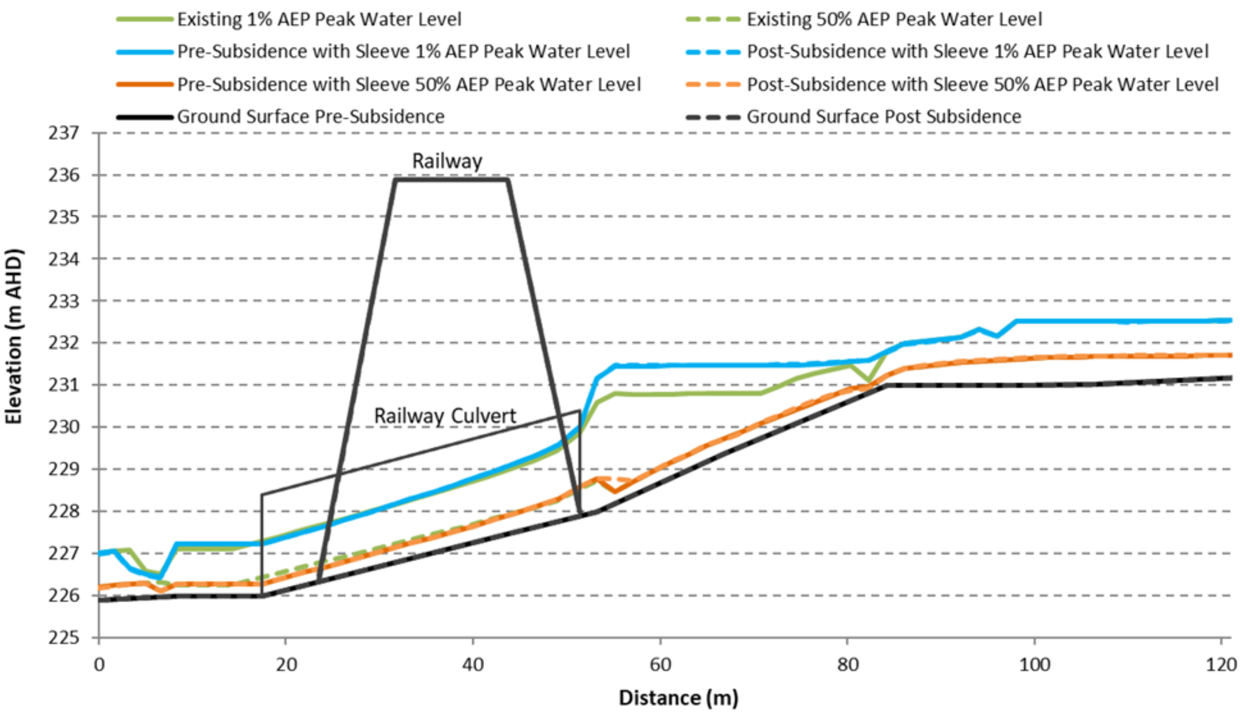

Figure 16 Rumker Gully Pre and Post-Subsidence Modelled Peak Flood Level

Figure 16 illustrates that reduction of the railway culvert diameter due to the installation of the concrete pipe sleeve will result in a maximum predicted increase in the 1% AEP flood level of 0.7 m upstream of the culvert. A negligible increase in flood level is predicted for the 50% AEP peak flow for this case.

The flow velocity is predicted to increase by a maximum of 0.3 m/s immediately upstream of the railway culvert and 1.1 m/s immediately downstream of the railway culvert for the 1% AEP peak flow due to the presence of the concrete pipe sleeve. For the 50% AEP peak flow, the velocity is predicted to increase by a maximum of 0.1 m/s immediately upstream of the railway culvert and 0.5 m/s immediately downstream of the railway culvert due to the presence of the concrete pipe sleeve. For the remainder of the tributary alignment, the difference in flow velocity between the existing and with concrete pipe sleeve (pre-subsidence) cases is predicted to be negligible.

A maximum increase in depth between pre and post-subsidence conditions (both with the concrete pipe sleeve in place) of 0.03 m is predicted for both the 50% AEP peak flow and the 1% AEP peak flow. The difference in flow velocity between the pre and post-subsidence cases is predicted to be negligible.

Figure 17 shows the pre and post-subsidence alignment of Matthews Creek Tributary 2 (MC Trib 2), the railway and railway culvert. The pre and post-subsidence modelled flood levels for the 50% AEP and 1% AEP peak flow rates are also given.

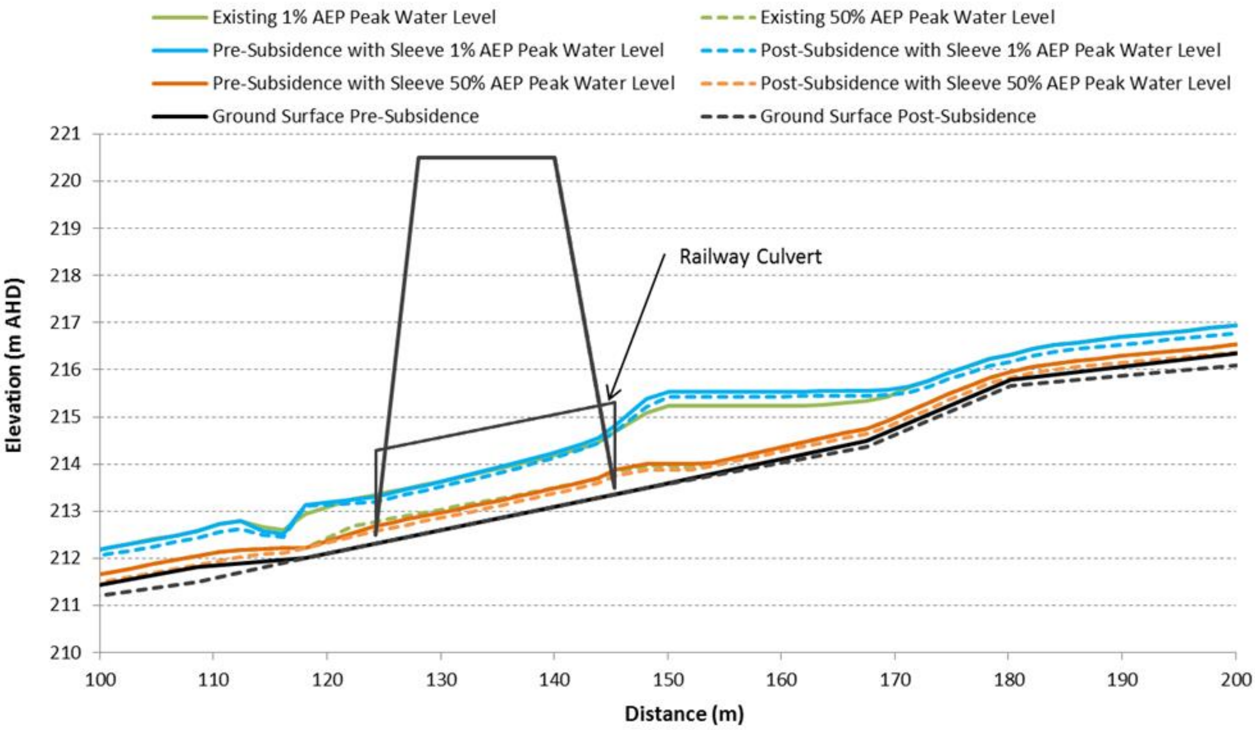

Figure 17 MC Trib 2 Pre and Post-Subsidence Modelled Peak Flood Level

Figure 17 illustrates that reduction of the railway culvert diameter due to the installation of the concrete pipe sleeve will result in a maximum predicted increase in the 1% AEP flood level of 0.3 m upstream of the culvert. A negligible increase in flood level is predicted for the 50% AEP peak flow for this case.

The flow velocity is predicted to increase by a maximum of 0.3 m/s immediately downstream of the railway culvert for both the 1% AEP peak flow and 50% AEP peak flow due to the presence of the concrete pipe sleeve. For the remainder of the tributary alignment, the difference in flow velocity between the existing and with concrete pipe sleeve (pre-subsidence) cases is predicted to be negligible.

Based on the predicted subsidence at MC Trib 2, the water level is then predicted to reduce by a maximum of 0.31 m and 0.27 m respectively for the 50% AEP and 1% AEP peak flow rates (both with the concrete pipe sleeve in place). A maximum increase in depth of 0.11 m is predicted for the 50% AEP peak flow and a maximum increase in depth of 0.16 m is predicted for the 1% AEP peak flow.

A maximum increase in flow velocity between the pre and post-subsidence conditions of 0.2 m/s for the 50% AEP peak flow and 0.3 m/s for the 1% AEP peak flow is predicted immediately upstream of the railway culvert. For the remainder of the tributary alignment, the difference in flow velocity between the pre and post-subsidence cases is predicted to be negligible.

Figure 18 shows the pre and post-subsidence alignment of Matthews Creek Tributary 2a (MC Trib 2a), the Stonequarry Creek Road and road culvert. The pre and post-subsidence modelled flood levels for the 50% AEP and 1% AEP peak flow rates are also given.

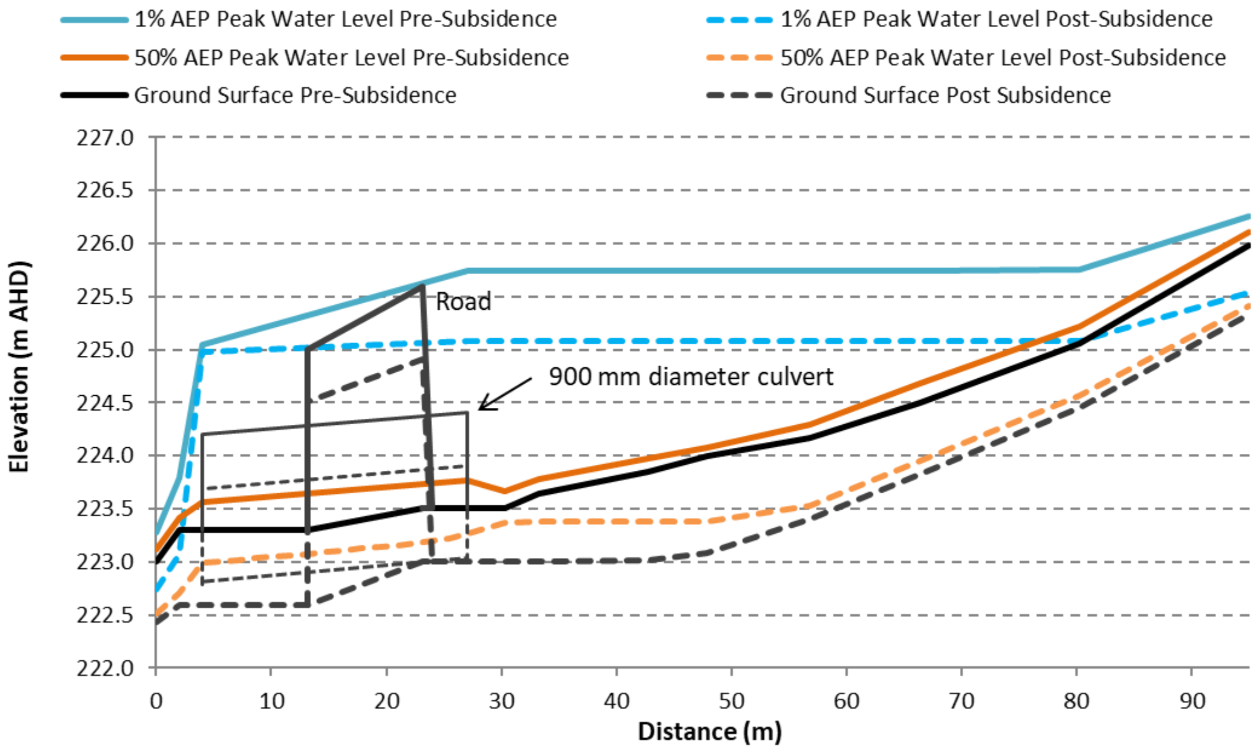

Figure 18 MC Trib 2a Pre and Post-Subsidence Water Level

MC Trib 2a is predicted to experience a significant subsidence impact with a reduced average longitudinal gradient of 0.16% and a maximum reduction in ground level of 920 mm. Figure 18 illustrates that, based on the predicted subsidence, the peak water level is predicted to reduce by a maximum of 0.77 m and 0.72 m respectively for the 50% AEP and 1% AEP peak flow rates. A maximum increase in depth of 0.23 m is predicted for the 50% AEP peak flow and a maximum increase in depth of 0.26 m is predicted for the 1% AEP peak flow. The maximum increase in depth is predicted to occur approximately 20 m upstream of the culvert where the maximum reduction in ground level is predicted. The flow depth over Stonequarry Creek Road is predicted to increase by a maximum of 0.04 m for the 1% AEP peak flow. A maximum increase in flow velocity of 0.1 m/s and 0.4 m/s is predicted for the 50% AEP and 1% AEP peak flow respectively at the most upstream section of the modelled profile.

Figure 19 shows the pre and post-subsidence alignment of Cedar Creek Tributary 1 (CC Trib 1), the road (track), road culvert, railway and railway culvert. The pre and post-subsidence modelled flood levels for the 50% AEP and 1% AEP peak flow rates are also given.

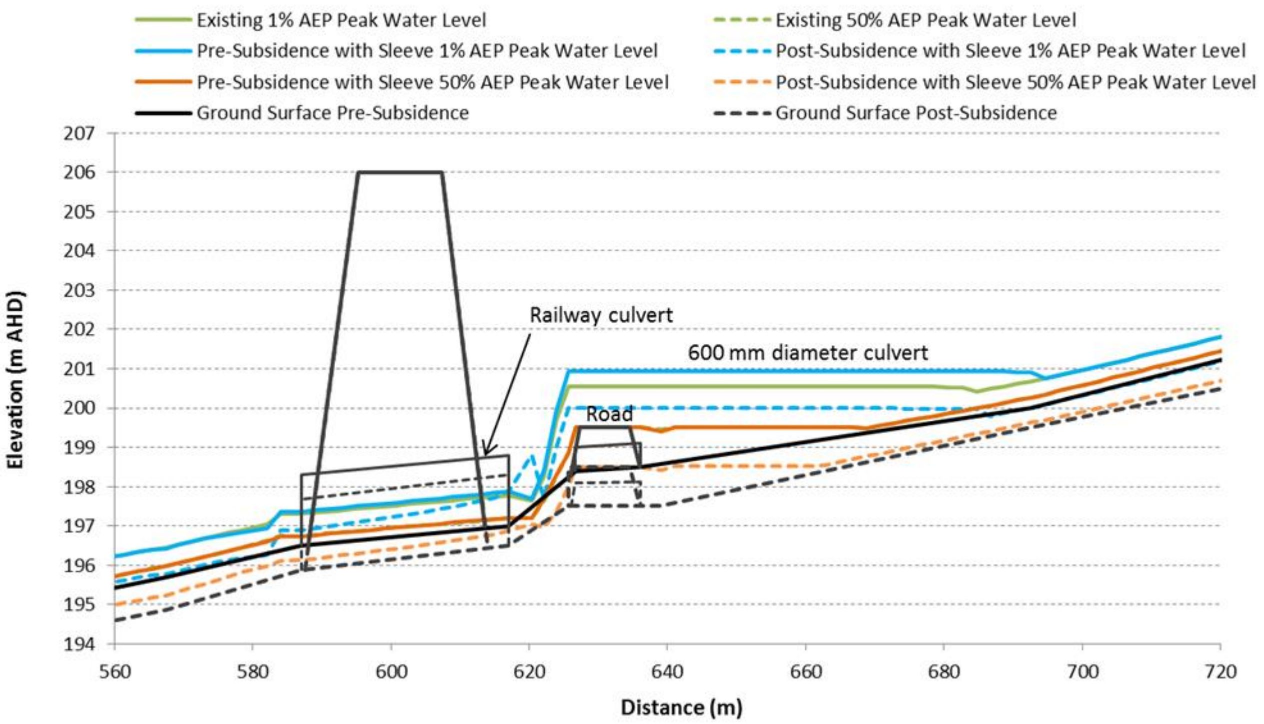

Figure 19 CC Trib 1 Pre and Post-Subsidence Water Level

Figure 19 illustrates that reduction of the railway culvert diameter due to the installation of the concrete pipe sleeve will result in a maximum predicted increase in the 1% AEP flood level of 0.5 m upstream of the railway culvert. A negligible increase in flood level is predicted for the 50% AEP peak flow for this case.

The flow velocity is predicted to increase by a maximum of 0.5 m/s immediately upstream of the railway culvert and 1.2 m/s immediately downstream of the railway culvert for the 1% AEP peak flow due to the presence of the concrete pipe sleeve. For the 50% AEP peak flow, the velocity is predicted to increase by a maximum of 0.4 m/s immediately upstream of the road culvert and 0.3 m/s immediately downstream of the railway culvert. For the remainder of the tributary alignment, the difference in flow velocity between the existing and with concrete pipe sleeve (pre-subsidence) cases is predicted to be negligible.

CC Trib 1 is predicted to experience a significant depth of subsidence with an average reduction in ground level of 940 mm. The change in longitudinal gradient is predicted to be negligible with an average reduction of 0.06% of the tributary gradient. Figure 19 illustrates that, based on the predicted subsidence and with the concrete pipe sleeve in place, the peak water level is predicted to reduce by a maximum of 1.0 m and 0.9 m for the 50% AEP and 1% AEP peak flow rates respectively. A maximum increase in depth for this case of 0.35 m is predicted for the 50% AEP peak flow and 1.6 m for the 1% AEP peak flow – localised just upstream of the railway culvert. This water level increase may result in a short duration of water ponding against the railway embankment (0.5 m above the top of the culvert) but is still more than 7 m below the top of the railway embankment. The maximum increase in depth for both the 50% AEP peak flow and 1% AEP flow rate is predicted to occur immediately upstream of the railway culvert.

A maximum increase in flow velocity between the pre and post-subsidence conditions of 0.2 m/s for the 50% AEP peak flow is predicted at distance 567 m along the tributary alignment (referring to the distance scale shown on Figure 19). For the 1% AEP peak flow, a maximum increase of 1.3 m/s for the 1% AEP peak flow is predicted at distance 685 m on Figure 19. For the remainder of the tributary alignment, the flow velocity is predicted to be predominately lower for the post-subsidence case in comparison with the pre-subsidence case.

Figure 20 shows the pre and post-subsidence alignment of Stonequarry Creek Tributary 1 (SC Trib 1), the road (track), road culvert, railway and railway culvert. The pre and post-subsidence modelled flood levels for the 50% AEP and 1% AEP peak flow rates are also given.

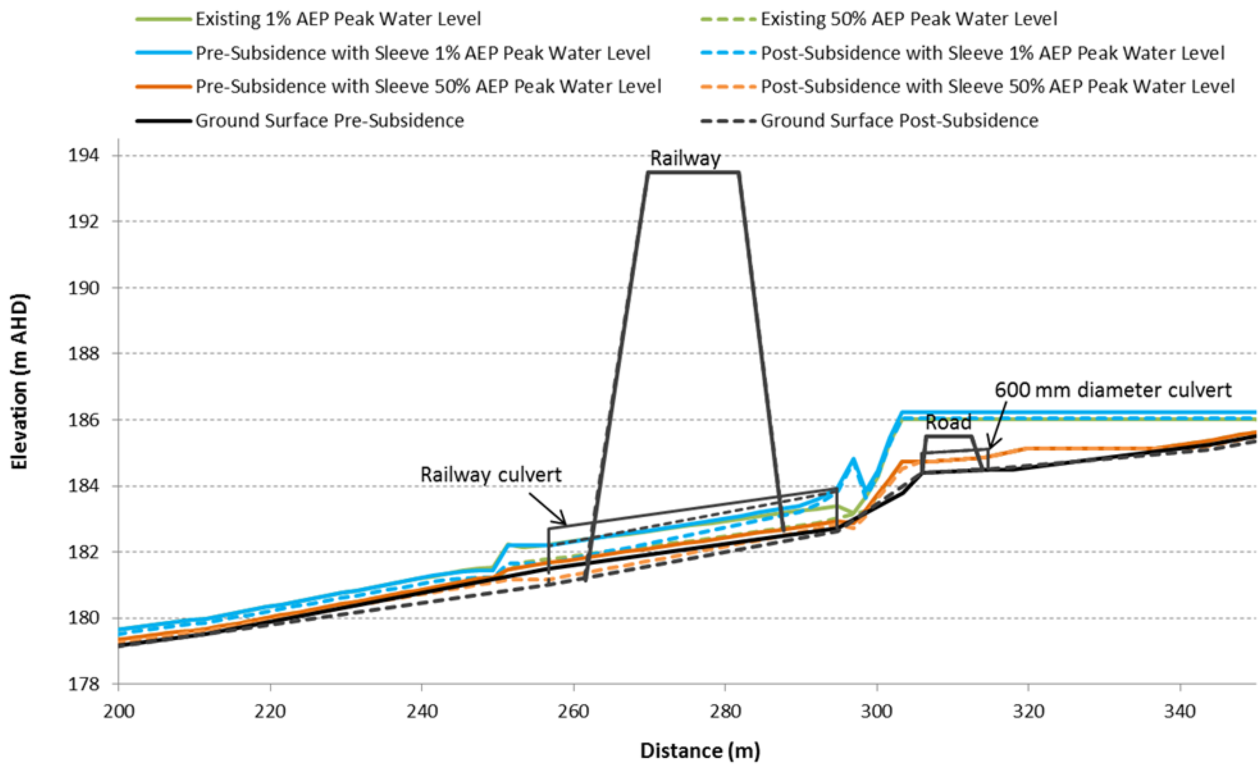

Figure 20 SC Trib 1 Pre and Post-Subsidence Water Level

Figure 20 illustrates that reduction of the railway culvert diameter due to the installation of the concrete pipe sleeve will result in a maximum predicted increase in the 1% AEP flood level of 1.7 m upstream of the railway culvert. This water level increase may result in a short duration of water ponding against the railway embankment (0.9 m above the top of the culvert) but is still more than 8.5 m below the top of the railway embankment. A negligible increase in flood level is predicted for the 50% AEP peak flow for this case.

The flow velocity is predicted to increase by a maximum of 2.7 m/s immediately upstream of the railway culvert for the 50% AEP peak flow due to the presence of the concrete pipe sleeve – however it should be noted that at a point less than 2 m further upstream, the velocity is predicted to remain virtually unchanged at a high velocity of approximately 3.5 m/s. At the same location, modelling indicates for a 1% AEP peak flow a velocity decrease of 4.7 m/s due to the presence of the concrete pipe sleeve. For the 1% AEP peak flow, the velocity is predicted to increase by a maximum of 0.3 m/s immediately downstream of the railway culvert due to the presence of the concrete pipe sleeve. For the remainder of the tributary alignment, the difference in flow velocity between the existing and with concrete pipe sleeve (pre-subsidence) cases is predicted to be negligible.

Based on the predicted subsidence at SC Trib 1 and with the concrete pipe sleeve in place, the peak water level is predicted to reduce by a maximum of 0.3 m for the 50% AEP and 0.5 m for the 1% AEP peak flow rates. A maximum increase in depth for this case of 0.05 m is predicted for the 50% AEP peak flow and a maximum increase in depth of 0.04 m is predicted for the 1% AEP peak flow.

A maximum increase in flow velocity between the pre and post-subsidence conditions of 0.5 m/s for the 50% AEP peak flow and 1.8 m/s for the 1% AEP peak flow is predicted immediately downstream of the railway culvert. For the remainder of the tributary alignment, the difference in flow velocity for the post-subsidence case in comparison with the pre-subsidence case is predicted to be negligible.

Figure 21 shows the pre and post-subsidence alignment of Stonequarry Creek Tributary 2 (SC Trib 2), the railway and railway culvert. The pre and post-subsidence modelled flood levels for the 50% AEP and 1% AEP peak flow rates are also given.

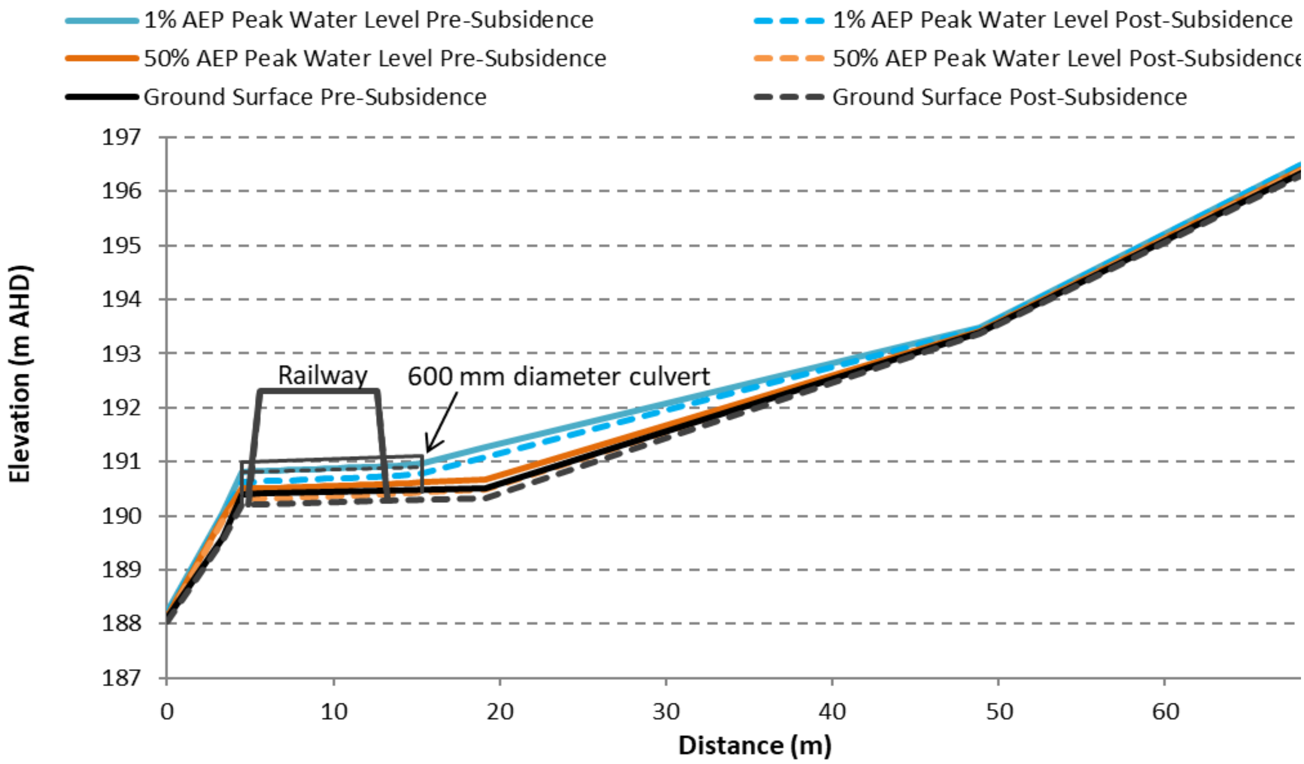

Figure 21 SC Trib 2 Pre and Post-Subsidence Water Level

Figure 21 illustrates that based on the predicted subsidence at SC Trib 2, the peak water level is predicted to reduce by a maximum of 0.2 m for both the 50% AEP and 1% AEP peak flow rates. A maximum increase in depth of 0.02 m is predicted for the 50% AEP peak flow and a maximum increase in depth of 0.01 m is predicted for the 1% AEP peak flow. A maximum increase in flow velocity of 0.16 m/s and 0.06 m/s is predicted for the 50% AEP and 1% AEP peak flow respectively.

Figure 22 shows the pre and post-subsidence alignment of Redbank Creek Tributary 1 (RC Trib 1), located on a reach between two farm dams. The pre and post-subsidence peak flood levels for the 50% AEP and 1% AEP flow rates are also given.

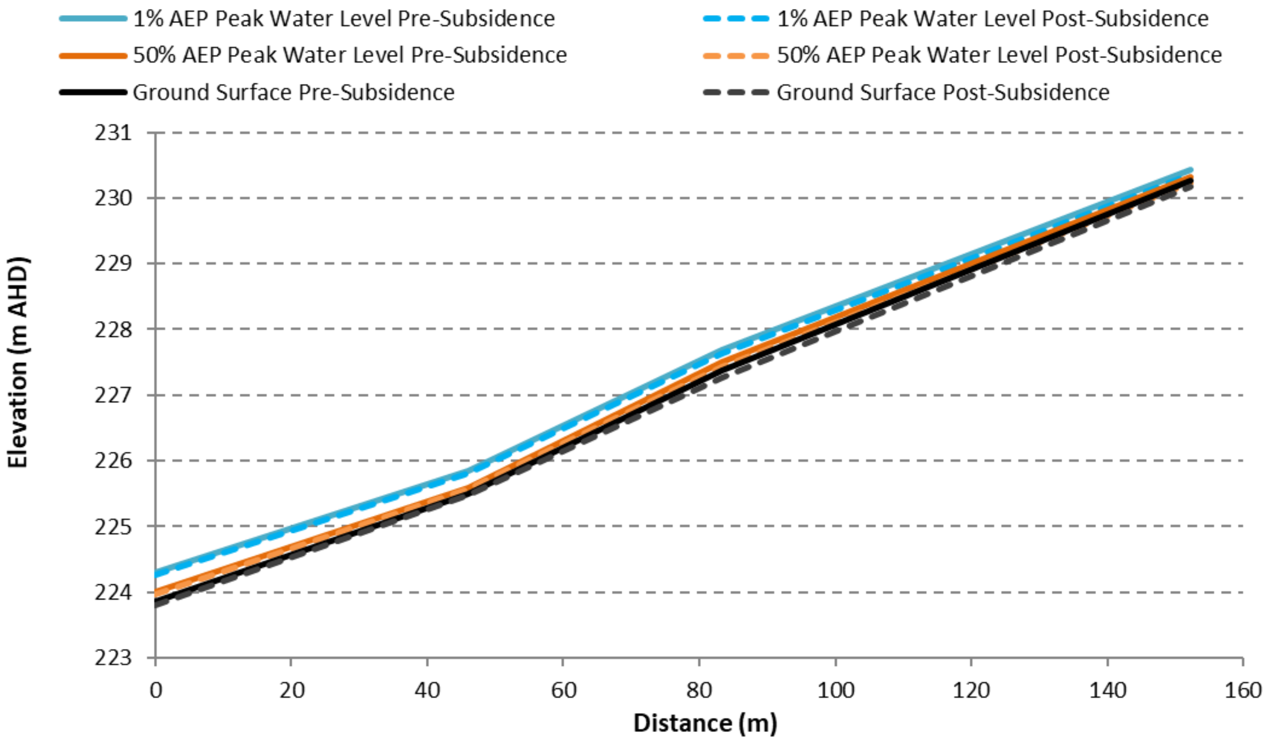

Figure 22 RC Trib 1 Pre and Post-Subsidence Water Level

Figure 22 illustrates that based on the predicted subsidence at RC Trib 1, the peak water level is predicted to reduce by a maximum of 0.09 m and 0.08 m respectively for the 50% AEP and 1% AEP peak flow rates. A maximum increase in depth of 0.01 m is predicted for the 50% AEP peak flow and a maximum increase in depth of 0.04 m is predicted for the 1% AEP peak flow. A maximum increase in flow velocity of 0.1 m/s is predicted for both the 50% AEP and 1% AEP peak flow.

Figure 23 shows the pre and post-subsidence alignment of Redbank Creek Tributary 2 (RC Trib 2), located on a reach between two farm dams. The pre and post-subsidence peak flood levels for the 50% AEP and 1% AEP rainfall events are also given.

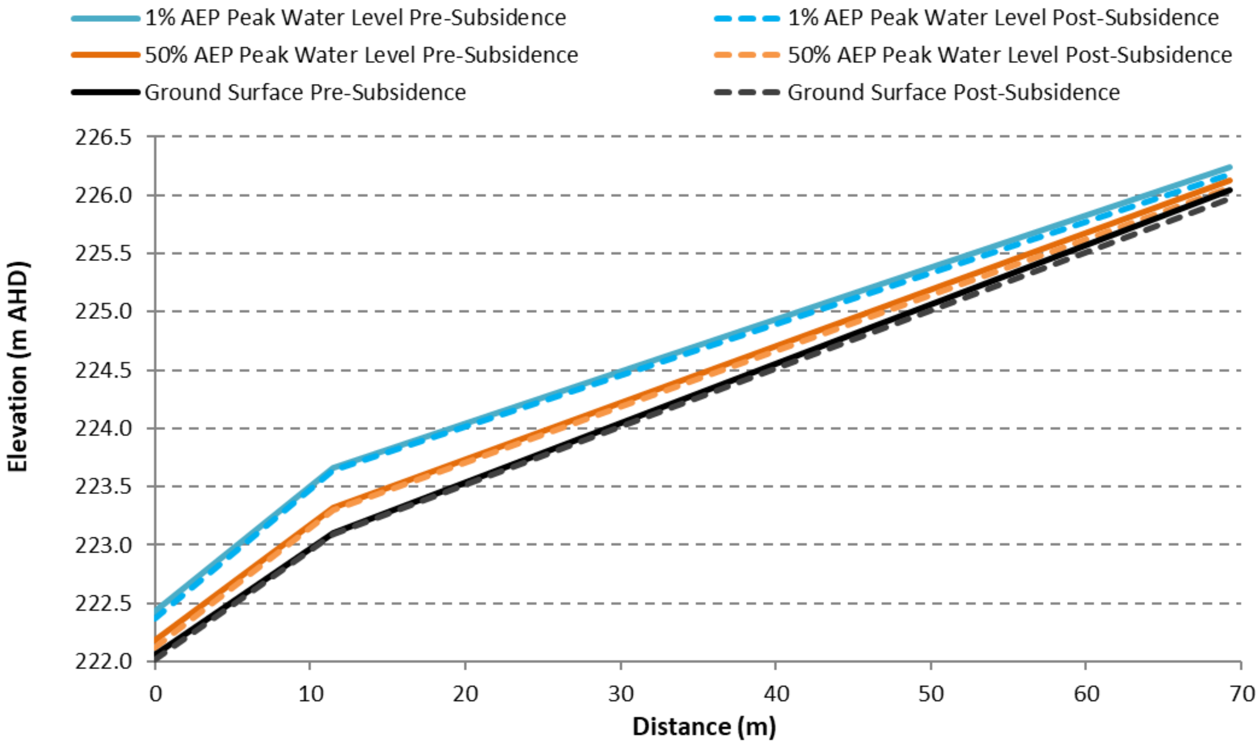

Figure 23 RC Trib 2 Pre and Post-Subsidence Water Level

Figure 23 illustrates that based on the predicted subsidence at RC Trib 2, the peak water level is predicted to reduce by a maximum of 0.07 m for both the 50% AEP and 1% AEP peak flow rates. An increase in depth is not predicted to occur for RC Trib 2. A maximum increase in flow velocity of 0.05 m/s and 0.09 m/s is predicted for the 50% AEP and 1% AEP peak flow respectively.

In summary, modelling of 50% AEP and 1% AEP peak flow rates for pre and post-subsidence conditions in MC Trib 2a, RC Trib 1 and RC Trib 2, indicates that peak flood levels should be lower, peak flood depths will increase by a maximum of 0.23 m for the 50% AEP and 0.26 m for the 1% AEP peak flow at MC Trib 2a, while peak flow velocities will increase by a maximum of 0.1 m/s for the 50% AEP and 0.4 m/s for the 1% AEP at MC Trib 2a.

The concrete sleeve culverts are predicted to result in a maximum increase in the 1% AEP flood level upstream of the railway of 0.7 m at Rumker Gully, 0.3 m at MC Trib 2, 0.5 m at CC Trib 1 and 1.6 m at SC Trib 1 immediately upstream of the railway culvert. Predicted increased water levels are all well below the top of the railway embankment.

A maximum increase in the 1% AEP peak flow velocity of 1.1 m/s is predicted for Rumker Gully, 0.3 m/s for MC Trib 2, 1.2 m/s for CC Trib 1 and 0.3 m/s for SC Trib 1 due to the presence of the concrete pipe sleeves. For the 50% AEP peak flow, the velocity is predicted to increase by a maximum of 0.5 m/s for Rumker Gully, 0.3 m/s for MC Trib 2, 0.4 m/s for CC Trib 1 and 2.7 m/s for SC Trib 1 due to the presence of the concrete pipe sleeves. However, it should be noted that the increase in velocity is predicted to occur immediately upstream or downstream of the railway culvert, while for the remainder of the tributary alignments, the difference in flow velocity between the existing and with concrete pipe sleeve (pre-subsidence) case is predicted to be negligible.

Based on the predicted subsidence associated with the Western Domain and with the concrete pipe sleeves in place, the 50% AEP and 1% AEP peak flood levels for each tributary are predicted to be lower, peak flood depths are predicted to increase by a maximum of 0.35 m for the 50% AEP and 1.6 m for the 1% AEP peak flow immediately upstream of the railway culvert at CC Trib 1. Predicted increased water levels are all well below the top of the railway embankment. Peak flow velocities are predicted to increase by a maximum of 0.5 m/s for the 50% AEP and 1.8 m/s for the 1% AEP immediately downstream of the railway culvert at SC Trib 1.

4.4.1.4 Potential Impact to Overland Flow

The maximum predicted incremental tilt is 3 mm/m due to mining of LW W1 and 5 mm/m due to mining of LW W2 (MSEC, 2019). The minimum natural gradient overlying LW W1 is 19 mm/m while the minimum natural gradient overlying LW W2 is approximately 29 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.

4.4.1.5 Potential Impact to Water Supply

As discussed in Section 3.1, there are six properties within the Investigative Area with a Water Supply Works and Water Use Approval. For the surface water systems in which pumping would occur, MSEC (2019) has predicted that less than 10% of pools are likely to experience fracturing and associated reduction in standing water level (refer Section 4.1.1.1). 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).

4.4.2 Surface Water Related Infrastructure

Several stormwater culverts, stormwater detention basins and farm dams are present within the Investigative 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 4.4.1.3.

The maximum predicted tilt for the farm dams within the predicted subsidence zone (refer Figure 12) is 5.0 mm/m (MSEC, 2019). 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 for the farm dams within the Study Area are small, varying from less than 20 mm to 140 mm and as such, it is unlikely that the dams would experience adverse impacts to storage capacity (MSEC, 2019).

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 W1 – W2. 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, 2019).

The four dams located directly above LW W1 – W2 may experience cracking of the base of embankments due to the mining-induced curvatures and strains (MSEC, 2019). 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 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 LW 22 to LW 28 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-5 and FD-6 (refer Table 29). The maximum total subsidence predicted for FD-5 which overlies LW W1 is 625 mm, while for FD-6 which overlies LW W2 it is 750 mm (refer Figure 12). 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 reduced.

The potential impacts on the structural integrity of the dam embankments is addressed further in the Geotechnical Assessment (Douglas Partners, 2019). As the farm dams are located in valleys, the likelihood of development of a flood wave due to topographical features is negligible. Cracking of the top surface may cause breaching of the dam embankment, however, it is unlikely that flooding of adjacent buildings will occur due to the higher elevation of the buildings relative to the dams (Douglas Partners, 2019).

A monitoring plan will be implemented to monitor 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 rehabilitation program will be implemented (refer MSEC, 2019).

4.4.3 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 LW 25 to 32 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 (HEC, 2020). 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 LW 25 to LW 32.

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 remediation. Stream remediation measures (see Section 5.1) would be conducted on stream reaches of second order and above where subsidence results in the draining of pools in stream sections between controlling rock bars, where the remediation measures are considered technically feasible. It should be noted that this is unlikely to occur in Stonequarry Creek, Matthews Creek and Cedar Creek as these surface water systems are not predicted to experience an increase valley closure of 200 mm or greater.

4.4.4 Aquatic Habitat

MSEC (2019) 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, 2019b). 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, 2019b). 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 Investigative 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, 2019b).

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, 2019b). Section 3.4 illustrates that the surface water systems within the Investigative 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, 2019b).

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, 2014). Rare and isolated dieback of riparian vegetation has been reported in the Southern Coalfields due to release of gas emissions to the atmosphere (DoP, 2008). However, gas emissions have not been observed in streams or pools above mining at Tahmoor Colliery (Tahmoor, 2013) and are not expected to be observed following mining of LW W1 - W2.

5.0 MONITORING, MITIGATION AND MANAGEMENT

5.1 MONITORING

Management and mitigation measures will be critically dependent on appropriate monitoring. The monitoring programme in relation to assessing the performance of the water management system as it relates to surface water is given in Table 31. The programme, as it relates to surface water is divided into three phases: prior to mining (secondary extraction), during secondary extraction and subsidence and following the end of mining and cessation of subsidence. The monitoring locations are shown in Figure 24 and Figure 25.

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 aims 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 undertaken in accordance with the *Australian and New Zealand Guidelines for Fresh & Marine Water quality* (ANZG, 2018). Both field and laboratory analyses are undertaken for some constituents and the values compared and queried if there are inconsistencies. The sample collection is 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 queried with and reviewed by the field technician. The same process is undertaken for pool water level records, with the records also verified through comparison of the manual field measurements and automatic water level logger records.

Table 31 Monitoring Plan

Feature	Locations	Monitoring		
		Prior to Mining	During Mining	Post Mining
Daily rainfall	• Bureau of Meteorology Station 68052 (Picton Council Depot)[1] • WaterNSW stations 568295 (Lakesland Road), 568296 (Thurns Road) and 212063 (Lake Nerrigorang at Thirlmere Lakes)[2] • Additional automatic rainfall stations to be installed (including Stonequarry Creek catchment, Picton to Mittagong rail corridor and additional locations depending on land owner access).	Data recorded daily and downloaded monthly (other than Stonequarry Creek catchment station).	Data recorded daily and downloaded monthly.	Data recorded daily and downloaded monthly for 12 months following the completion of LW W2. This period may be extended as per decision by the Environmental Response Group (refer Section 5.2 of the WMP).
Streamflow	Baseline / Impact Site: WaterNSW gauging station GS212053 (Stonequarry Creek at Picton)[2] Control / Reference Sites: Bargo River upstream (300061)[3] Hornes Creek (300062)[3]	Continuous record. Data downloaded at start of mining.	Continuous record. Data downloaded monthly.	Continuous record, data downloaded monthly for 12 months following the completion of LW W2. This period may be extended as per decision by the Environmental Response Group (refer Section 5.2 of the WMP).
Automated pool water level	Tahmoor Coal automated pool level sites: Baseline / Impact Site: Cedar Creek (CA, CB, CD, CE and CG) Matthews Creek (ME, MG) Stonequarry Creek (SA, SB, SC2) Reference / Control Site: Cedar Creek (CCR, CC1A) Matthews Creek (MB) Stonequarry Creek (SD, SE)	Continuous record. Data downloaded at start of mining. Baseline data recorded since October 2018 in the Western Domain (excluding SC2 and SB).	Continuous record. Data downloaded monthly.	Continuous record. Data downloaded monthly for 12 months following the completion of LW W2. This period may be extended as per decision by the Environmental Response Group (refer Section 5.2 of the WMP).

[1] Refer http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=&p_c=&p_stn_num=68052

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

[3] Refer Figure 25

Table 29 (Cont.) Monitoring Plan

Feature	Locations	Monitoring		
		Prior to Mining	**During Mining**	**Post Mining**
Manual pool water level	Tahmoor Coal manual pool water level sites: Baseline / Impact Site: Cedar Creek (CC, CF) Matthews Creek (MC, MD U/S (upstream), MF) Reference / Control Site: Matthews Creek (MA) Stonequarry Creek (SC)	Monthly manual level reading. Visual inspection of natural drainage behaviour using photo points. Baseline data recorded since October 2018 in the Western Domain.	Monthly manual level reading. 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 W2. This period may be extended as per decision by the Environmental Response Group (refer Section 5.2 of the WMP).
Stream Water Quality	Tahmoor Coal water quality sites: Baseline / Impact Site: • Cedar Creek (CA, CB, CG) • Matthews Creek (MC1, MG) • Stonequarry Creek (SC2, SC, SD) Reference / Control Site: • Cedar Creek (CC1) • Matthews Creek (MB) • Stonequarry Creek (SC1, SE)	Monthly sampling and analysis for 12 months prior to secondary extraction. Baseline data was recorded at some sites during 2014 and all sites since January 2019.	Monthly sampling and analysis.	Monthly sampling and analysis for 12 months following the completion of LW W2. This period may be extended as per decision by the Environmental Response Group (refer Section 5.2 of the WMP).
		Parameters: Field analysis: pH, EC and DO, temperature and ORP. Laboratory analysis for: pH, EC, TDS, alkalinity, sulphate, chloride, calcium, magnesium, sodium, potassium, fluoride, nitrate+nitrite, kjeldahl nitrogen, phosphorus and the following total and dissolved metals: aluminium, arsenic, barium, copper, lead, lithium, manganese, nickel, selenium, strontium, zinc and iron.		
Stream and Riparian Vegetation	As per Biodiversity Management Plan.	As per baseline monitoring.	Bi-annually (first occurring in Spring 2019).	Bi-annually (Spring and Autumn for 3-5 years).
Private Dams	Dam FD-1 to FD-12	Dam embankment integrity and water level observation every month for at least two months immediately prior to undermining using fixed location photo points. Pre-mining inspections commenced in November 2019.	Dam embankment integrity and water level observation every week by Tahmoor Coal and monthly by a Geotechnical Engineer during active subsidence period using fixed location photo points.	Dam embankment integrity and water level observation 3 monthly for 12 months following the completion of LW W2. This period may be extended as per decision by the Environmental Response Group (refer Section 5.2 of the WMP).

Table 29 (Cont.) Monitoring Plan

Feature	Locations	Monitoring		
		Prior to Mining	**During Mining**	**Post Mining**
Natural drainage behaviour	Baseline / Impact Site: Stream reaches of Cedar Creek, Matthews Creek and Stonequarry Creek within the Study Area. Reference / Control Site: 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 data first recorded in 2014, and in November 2019 prior to mining.	Observations every month during active subsidence period (after 200 m of secondary extraction of LW W1-W2) by Tahmoor Coal using fixed location photo points. Reduce frequency of observations to 2-monthly after 1000 m of extraction of LW W1-W2 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 W2. This period may be extended as per decision by the Environmental Response Group (refer Section 5.2 of the WMP).
Flood levels[4]	All dwellings within the 1% AEP flood extent.	Pre-mine modelling (using surveyed pre-mine topography) to establish 1% AEP flood levels and extents in areas potentially impacted by subsidence (complete). Pre-mining modelling was completed in May 2019.	None, though subsidence surveys will be conducted along local roads 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.

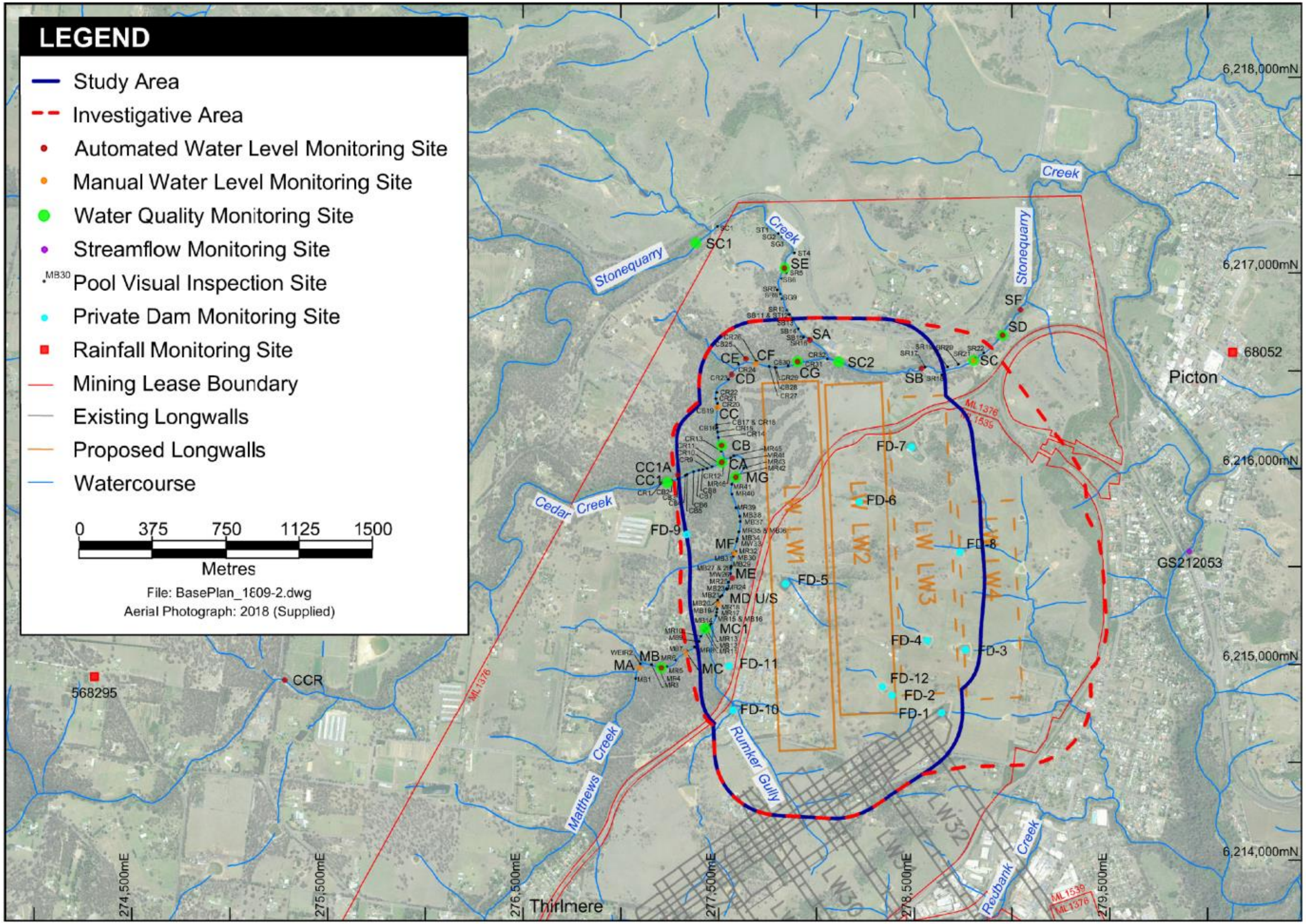

Figure 24 **LW W1 and LW W2 Surface Water Monitoring Sites**

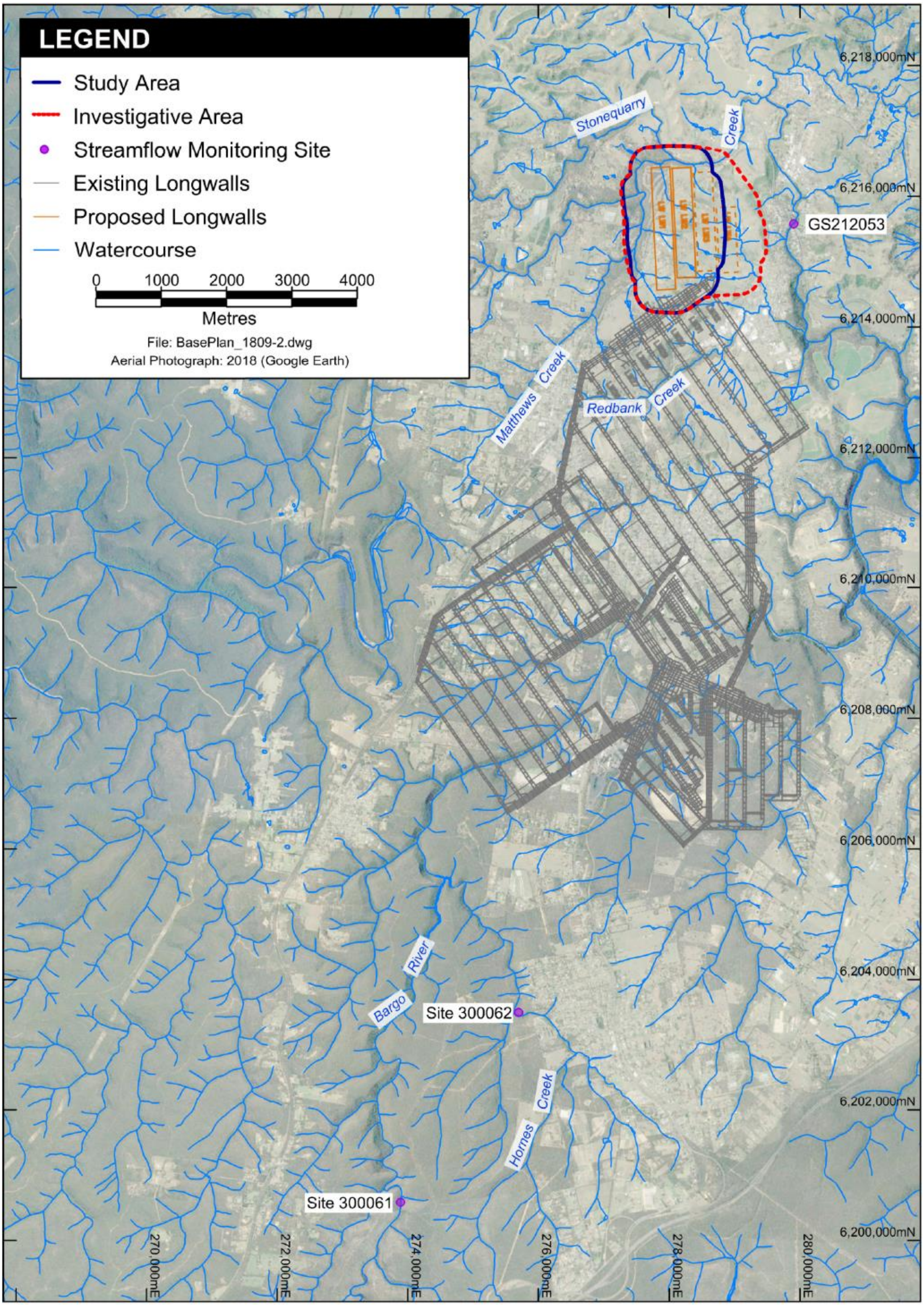

Figure 25 Regional Streamflow Monitoring Sites

5.2 STREAM REMEDIATION MEASURES

Various techniques have been previously adopted to successfully reduce subsidence impacts to streams associated with longwall mining at other operations in the Southern Coalfield. A summary of these methods, their possible application to different situations and their limitations is provided in Table 32.

Table 32 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. 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 rock bars and pools. Applicable to sensitive areas where access for larger equipment is problematic. Better 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. Can seal larger and deeper fractures. Larger equipment may necessitate constructing access tracks. 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 on Waratah Rivulet by Helensburgh Coal Pty Ltd. Can be used under water and under low flow conditions. Can be used to fill large aperture fractures in stages.

The full 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 rock bar 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 32; and
- on-going monitoring to evaluate success (refer Section 5.1).

5.3 FLOOD MANAGEMENT PROTOCOL

The flood assessment detailed in Section 4.4.1 has predicted that the peak 1% AEP flood extent will be contained within Matthews, Cedar and Stonequarry Creeks meaning that Barkers Lodge Road has at least a 1% AEP flood immunity. The modelling predictions indicate a virtually unchanged flood extent in the existing and post-subsidence conditions with no predicted increase in flood level. A maximum increase in flow depth over Stonequarry Creek Road of 0.04 m is predicted to occur for the 1% AEP flood event based on predicted post-subsidence conditions. The predicted increase is within the bounds of model accuracy and is considered to be negligible. As such, it is not anticipated that access to Stonequarry Creek Road will be measurably impacted during a 1% AEP flood event and access routes during a 1% AEP flood event are expected to be retained for pre and post-mine conditions.

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.

5.4 FUTURE MONITORING

To assist in the preparation of future Extraction Plans, surface water monitoring as outlined in Table 31 provide sufficient baseline data to assist the preparation of the Extraction Plan for LW W3-W4.

The Study Area of LW W3-W4 will be located within the Investigative Area as illustrated on Figure 1. As is shown on this figure, the waterways that will be affected by LW W3-W4 will primarily be Stonequarry Creek and tributaries of Redbank Creek.

A brief review of the adequacy of established water quality and flow monitoring sites to support the LW W3-W4 Extraction Plan was completed. With regards to Stonequarry Creek, it was identified that there are sufficient monitoring sites located upstream of potential impacts (e.g. SC1, CC1, MB), within the impact zone (e.g. SC2, SC), and downstream of potential impacts (e.g. SD, GS212053, N912) along Stonequarry Creek and the connecting creeks of Cedar Creek and Matthews Creek to provide an understanding of impacts to Stonewater quality and flow as a result of mining.

With regards to Redbank Creek, monitoring for surface water quality and water flow is ongoing along Redbank Creek at a number of sites as part of mining and post-mining monitoring for Longwalls 32 and previous longwalls. This includes site RC6 (coordinates 279542mE, 6214187mN in GDA94 Zone 56) which is located downstream of the confluence of an unnamed tributary (third order tributary flowing south from the Western Domain) and Redbank Creek. Site RC6 will provide a monitoring location downstream of LW W3-W4. However, as this site will be impacted from the Western Domain longwalls, urban development and previous longwall extraction, this site is not an ideal downstream site as it will be impacted by activities other than the extraction of LW W3-W4.

The establishment of monitoring locations along tributaries upstream of Redbank Creek in the Western Domain will be problematic due to their intermittent flow nature and poor establishment as watercourses. A monitoring location (coordinates 279420mE, 6214737mN in GDA94 Zone 56) downstream of the confluence of two tributaries and upstream of the majority of Picton urban development will be investigated for water level and water quality monitoring. However, it is noted that this site may not be suitable as a monitoring site due to the ephemeral nature of the tributaries.

6.0 CONTINGENCY PLAN

6.1 ADAPTIVE MANAGEMENT

In the event that the subsidence performance measures in relation to surface water resources, as summarised in Table 4, 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-W2 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 W1 (refer Section 5.0). If impacts to Matthews Creek, Cedar Creek and Stonequarry Creek are greater than anticipated following mining of LW W1, Tahmoor Coal will consider amending the commencing position of LW W2 to further reduce the potential for impact to Stonequarry Creek and specifically Pool SR17. A similar review will be undertaken during mining of LW W2 and prior to mining of LW W3. Details of the proposed adaptive management plan are given in the 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 33. In Table 33, 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 33 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">Downstream reduction in catchment flow rate in Stonequarry Creek at Picton Gauging Station (GS212053)</td><td rowspan="8">RAINFALL
LOCATIONS:
• Bureau of Meteorology (BoM) Station 68052 (Picton Council Depot)
• WaterNSW stations 568295 (Lakesland Road), 568296 (Thurns Road) and 212063 (Lake Nerrigorang at Thirlmere Lakes)
• Additional automatic rainfall stations to be installed (including Stonequarry Creek catchment, Picton to Mittagong rail corridor and additional locations depending on land owner access agreements)

PRE-MINING – Data recorded daily and downloaded monthly (other than Stonequarry Creek catchment station).
DURING - Data recorded daily and downloaded monthly and used in analysis as outlined in the methodology for streamflow below.
POST MINING - Data recorded daily and downloaded monthly for 12 months post mining. This period may be extended as per decision by the Environmental Response Group (refer Section 5.2 of the WMP).

STREAMFLOW
LOCATIONS:
Baseline / Impact site – WaterNSW gauging station GS212053 (Stonequarry Creek at Picton)
Reference / Control site - Bargo River (Site 300061) and Hornes Creek (Site 300062)

PRE-MINING – Continuous record, data downloaded at start of mining; data from the end of mining of LW25 (21/2/2011) has been used to calibrate a pre-mining streamflow model. The period from 21/2/2011 to the commencement of secondary extraction from LW W1 is the baseline data period.
DURING - Continuous record, data downloaded monthly and analysed six monthly to compare monitored to model predicted flows as follows:
1. Monitored flows will be filtered in order to assess only low flows (flows > 0.24 ML/d [mean flow] will be set to modelled flows);
2. Filtered monitored flows will be summed to give 14 day totals for comparison with corresponding 14 day totals of predicted flow from the catchment model.
The ratio of filtered, monitored flows divided by the modelled flows will be calculated at 14 day intervals commencing at the beginning of the baseline data period and advancing to the end of the assessment period. The median of the ratios will be analysed over a sliding window of 1 year.
POST MINING - Continuous record, data downloaded monthly for 12 months post mining and analysed as described above. This period may be extended as per decision by the Environmental Response Group (refer Section 5.2 of the WMP).</td><td colspan="3">Level 1</td></tr>
<tr><td>• The median of the ratios does not fall below the 40th percentile* of the baseline data at GS212053 (refer to Table 34 for baseline ratios).</td><td>• Continue monitoring as per monitoring program.
• Six monthly review and assessment of data.</td><td>• No response required.</td></tr>
<tr><td colspan="3">Level 2</td></tr>
<tr><td>• The median of the ratios falls below the 40th percentile but does not fall below the 20th percentile* of the baseline data at GS212053 (refer to Table 34 for baseline ratios).</td><td>• Continue monitoring as per monitoring program.
• Six monthly review and assessment of data.
• Convene Tahmoor Coal Environmental Response Group to review possible cause and response.</td><td>• As defined by Environmental Response Group.</td></tr>
<tr><td colspan="3">Level 3</td></tr>
<tr><td>• The median of the ratios falls below the 20th percentile* of the baseline data at GS212053 (refer to Table 34 for baseline ratios).
AND
• A similar trend has occurred at the control sites.</td><td>• Continue monitoring as per monitoring program.
• Six monthly review and assessment of data.
• Convene Tahmoor Coal Environmental Response Group to review possible cause and response.</td><td>• As defined by Environmental Response Group.
• Consider increasing review of data to monthly.
• Undertake the analysis of monitored flow rate versus modelled flow in control catchments. Filtered monitored flows at the control sites will be summed to give 14 day totals for comparison with corresponding 14 day totals of predicted flow from catchment models for these sites (calibrated for the baseline data period).</td></tr>
<tr><td colspan="3">Level 4</td></tr>
<tr><td>• The median of the ratios falls below the 20th percentile* of the baseline data at GS212053 (refer to Table 34 for baseline ratios).
AND
• A similar trend has not occurred at the control sites.</td><td>• Continue monitoring as per monitoring program.
• Increase review and assessment of data to monthly.
• Convene Tahmoor Coal Environmental Response Group to undertake an investigation to assess if the change in behaviour is related to LW W1-W2 mining effects, other catchment changes or the prevailing climate.</td><td>• Continue monitoring and monthly assessment (until assessment indicates that the trigger is no longer occurring or it can be established whether the effect is mining related).
• Report to DPIE within 7 days of investigation completion (according to Table 6-1 of the Extraction Plan Main Document).
• If it is concluded that there has been a mining-related impact then implement a corrective management action plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the NSW DPIE Resources Regulator (refer to Section 6.2.2 of the WMP).</td></tr>
</table>

Footnote: * The 40th and 20th percentiles of the baseline data have been adopted for each trigger level. The 20th percentile is an accepted metric of a significant variation from 'normal' conditions (e.g. ANZECC, 2000) while the 40th percentile represents a slight deviation from the median or 'normal' conditions. As such, the range between the 40th percentile and the 20th percentile represents a slight deviation from 'normal' conditions to a significant variation from 'normal' conditions. Refer to Table 34 for baseline ratios.

Table 31 (Continued) Trigger Action Response Plan

Feature	Methodology and relevant monitoring	Management: Trigger	Management: Action	Management: Response
Impact to pool water level	<u>AUTOMATED POOL WATER LEVEL</u> LOCATIONS: Baseline / Impact site: • Cedar Creek (CA, CB, CD, CE and CG) • Matthews Creek (ME, MG) • Stonequarry Creek (SA, SB, SC2) Reference / Control site: • Cedar Creek (CCR, CC1A) • Matthews Creek (MB) • Stonequarry Creek (SD, SE) PRE-MINING – Continuous record, data downloaded monthly. Baseline data recorded since October 2018 in the Western Domain (excluding SC2 and SB). DURING - Continuous record, data downloaded monthly. POST MINING - Continuous record, data downloaded monthly for 12 months following the completion of LW W2. This period may be extended as per a decision by the Environmental Response Group (refer to Section 5.2 of the WMP). <u>MANUAL POOL WATER LEVEL</u> LOCATIONS: Baseline / Impact site: • Cedar Creek (CC, CF) • Matthews Creek (MC, MD U/S (upstream), MF) Reference / Control site: • Matthews Creek (MA) • Stonequarry Creek (SC) PRE-MINING - Monthly manual level reading. Visual inspection of natural drainage behaviour using photo points. Baseline data recorded since October 2018 in the Western Domain. DURING MINING - Monthly manual level reading. Visual inspection of natural drainage behaviour using photo points. POST MINING - Monthly manual level reading. Visual inspection of natural drainage behaviour using photo points 12 months following the completion of LW W2. This period may be extended as per a decision by the Environmental Response Group (refer to Section 5.2 of the WMP).	**Level 1**		
		• The recorded water level has not dropped below the previously recorded minimum level (in one 24 hour period for automated pool water level) (refer to Table 35 for baseline minimum recorded water level).	• Continue monitoring as per monitoring program. • Six monthly review of data.	• No response required.
		Level 2		
		• The recorded water level has dropped below the previously recorded minimum level (for more than one 24 hour period for automated pool water level) (refer to Table 35 for baseline minimum recorded water level). AND • The above has occurred at one of the upstream pools (beyond mining effects). AND • Visual monitoring of pools has not noted any mining related impacts.	• Continue monitoring as per monitoring program. • Six monthly review of data. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by Environmental Response Group.
		Level 3		
		• The recorded water level has dropped below the previously recorded minimum level (for more than one 24 hour period for automated pool water level) (refer to Table 35 for baseline minimum recorded water level). AND • The above has occurred at one of the upstream pools (beyond mining effects). AND • Visual monitoring of pools has noted mining related impacts.	• Continue monitoring as per monitoring program. • Six monthly review of data. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by Environmental Response Group. • Consider increasing review of data to monthly.
		Level 4		
		• The recorded water level has dropped below the previously recorded minimum level (for more than one 24 hour period for automated pool water level) (refer to Table 35 for baseline minimum recorded water level). AND • Similar behaviour has not occurred at one of the upstream pools (beyond mining effects). AND • Visual monitoring of pools has noted mining related impacts.	• Continue monitoring as per monitoring program. • Increase review of data to monthly. • Convene Tahmoor Coal Environmental Response Group to undertake an investigation to assess if the change in behaviour is related to LW W1-W2 mining effects, other catchment changes or the prevailing climate.	• Report to DPIE within 7 days of investigation completion (according to Table 6-1 of the Extraction Plan Main Document). • If it is concluded that there has been a mining-related impact then implement a corrective management action plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the NSW DPIE Resources Regulator (refer to Section 6.2.2 of the WMP).

Table 31 (Continued) Trigger Action Response Plan

Feature	Methodology and relevant monitoring	Management		
		Trigger	Action	Response
Impact to pool level, natural drainage behaviour or overland connected flow	<u>VISUAL INSPECTIONS</u> LOCATIONS: Baseline / Impact site: Stream reaches of Cedar Creek, Matthews Creek and Stonequarry Creek within the Study Area. Reference / Control site: Stream reaches of Cedar Creek, Matthews Creek and Stonequarry Creek outside of the Study Area. PRE-MINING - Observations prior to mining using fixed location photo points. Baseline data first recorded in 2014, and in November 2019 prior to mining. DURING MINING - Observations every month during active subsidence period (after 200 m of secondary extraction of LW W1-W2) by Tahmoor Coal using fixed location photo points. Reduce frequency of observations to 2-monthly after 1000 m of extraction of LW W1-W2 for sections of valleys that are located behind the active subsidence zone unless continuing adverse changes are observed (refer to triggers in Level 4). POST MINING - Observations 3-monthly for 12 months following the completion of LW W2. This period may be extended as per a decision by the Environmental Response Group (refer to Section 5.2 of the WMP).	Level 1		
		• No observed impacts to pool level, drainage or overland connected flow.	• Continue monthly monitoring. • Continue monthly review of data.	• No response required.
		Level 2		
		• Visually observed reduction in pool level, drainage or overland connected flow. AND • The above has occurred at one of the upstream pools (beyond mining effects). AND • Visual monitoring of pools has not noted any mining related impacts.	• Continue monitoring as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by Environmental Response Group.
		Level 3		
		• Rock bar and/or stream base cracking, or gas release, or iron precipitation noted during visual inspection. AND • No reduction in pool water level, drainage or overland connected flow, taking into account climatic conditions and observations during baseline monitoring period.	• Continue monitoring as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to undertake an investigation to assess if the change in behaviour is related to LW W1-W2 mining effects, other catchment changes or the prevailing climate.	• As defined by Environmental Response Group. • Consider increasing inspection and reporting frequency to fortnightly for sites where Level 3 has been reached.
		Level 4		
		There appear to be impacts to natural drainage behaviour such that: • Visually observed reduction in pool water level, drainage or overland connected flow. AND • The above change has not occurred at one of the upstream pools (beyond mining effects).	• Continue monitoring as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to undertake an investigation to assess if the change in behaviour is related to LW W1-W2 mining effects, other catchment changes or the prevailing climate.	• Report to DPIE within 7 days of investigation completion (according to Table 6-1 of the Extraction Plan Main Document). • If it is concluded that there has been a mining-related impact then implement a corrective management action plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the NSW DPIE Resources Regulator (refer to Section 6.2.2 of the WMP).

Table 31 (Continued) Trigger Action Response Plan

Feature	Methodology and relevant monitoring	Management		
		Trigger	Action	Response
Impact to flood levels	<u>FLOOD LEVELS</u> LOCATIONS - All dwellings within the 1% AEP flood extent PRE-MINING - Pre-mine modelling (using surveyed pre-mine topography) to estimate 1% AEP flood levels and extents in areas potentially impacted by subsidence. Pre-mining modelling was completed in May 2019. POST MINING AND SUBSIDENCE - Post-mine 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-mine 1% AEP flood extent are within the post-mine 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.

Table 31 (Continued) Trigger Action Response Plan

Feature	Methodology and relevant monitoring	Management		
		Trigger	Action	Response
Impacts to dams	PRIVATE DAMS LOCATIONS - FD-1 to FD-12 PRE-MINING - Dam embankment integrity and water level observation every month for at least two months immediately prior to undermining using fixed location photo points. Pre-mining inspections commenced in November 2019. DURING MINING - Dam embankment integrity and water level observation every week by Tahmoor Coal and monthly by a Geotechnical Engineer during active subsidence period using fixed location photo points. POST MINING - Dam embankment integrity and water level observation 3-monthly for 12 months post mining using fixed location photo points. This period may be extended as per a decision by the Environmental Response Group (refer to Section 5.2 of the WMP).	Level 1		
		• No cracks develop within dam wall or floor (other than natural desiccation cracking).	• Continue weekly monitoring by Tahmoor Coal and monthly monitoring by geotechnical engineer during active subsidence period. • Continue monthly review of data.	• No response required.
		Level 2		
		• Development of small isolated cracks developed within dam wall or floor cracks <5 cm (other than natural desiccation cracking).	• Continue weekly monitoring by Tahmoor Coal and monthly monitoring by geotechnical engineer during active subsidence period. • Continue monthly review of data. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by Environmental Response Group.
		Level 3		
		• Development of cracking within dam wall or floor > 5 cm and isolated in nature.	• Continue weekly monitoring by Tahmoor Coal and monthly monitoring by geotechnical engineer during active subsidence period. • Continue monthly review of data. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by Environmental Response Group. • Consider increasing to weekly monitoring by geotechnical engineer during active subsidence period.
		Level 4		
		• Development of cracking within dam wall or floor > 5 cm and non-isolated in nature. • Reduction in water holding capacity compared to baseline, taking into account climatic conditions; or cracking causing embankment instability.	• Weekly monitoring by geotechnical engineer during active subsidence period. • Convene Tahmoor Coal Environmental Response Group to review response. • Erect warning signs where necessary. • Reduce dam water level by at least half dam volume, pending land access and land owner consent.	• Notify relevant Government Agencies and other stakeholders. • Repair cracks and embankment instability at the completion of the active subsidence period by excavation, grouting and re-compaction where practical.

Table 31 (Continued) Trigger Action Response Plan

Feature	Methodology and relevant monitoring	Management		
		Trigger	Action	Response
Stream water quality impact	<u>STREAM WATER QUALITY</u> LOCATIONS: Baseline / Impact site: • Cedar Creek (CA, CB, CG) • Matthews Creek (MC1, MG) • Stonequarry Creek (SC2, SC, SD) Reference / Control site: • Cedar Creek (CC1) • Matthews Creek (MB) • Stonequarry Creek (SC1, SE) PRE-MINING - Monthly sampling for 12 months prior to secondary extraction. Baseline data was recorded at some sites during 2014 and all sites since January 2019. DURING MINING - Monthly sampling and analysis. Analysis is to comprise comparison of pH, EC and specific dissolved metals: manganese, nickel, zinc and iron recorded at sites within mining effects and at control (upstream) sites. The value at a given site (within mining effects) is to be compared with the corresponding control (upstream) site(s) mean plus two standard deviations‡ using the full period of data for the control (upstream) sites. For each surface water system: • Matthews Creek MC1 and MG results are to be compared with results from MB; • Cedar Creek CB and CG results are to be compared with combined results from MB and CC1; and • Stonequarry Creek SC2, SC and SD are to be compared with combined results from MB, CC1 and SC1. POST MINING - Monthly sampling and analysis for 12 months post mining. This period may be extended as per a decision by the Environmental Response Group (refer to Section 5.2 of the WMP).	**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. • 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. • Continue monthly review of data including analysis of water quality trend along creek (upstream to downstream) to identify spatial changes. • 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. • 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. • Convene Tahmoor Coal Environmental Response Group to review response.	• As defined by Environmental Response Group. • Consider increasing monitoring to fortnightly at sites where Level 3 has been reached.
		Level 4		
		Any of the following: • pH: the value* falls below the corresponding control (upstream) site(s) mean minus two standard deviations or the site-specific historic 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 minus two standard deviations or the site-specific historic mean minus two standard deviations (i.e. the sample becomes more alkaline) for more than two consecutive months. • EC: the value* rises above the corresponding control (upstream) site(s) mean minus two standard deviations or the site-specific historic mean minus two standard deviations for more than two consecutive months. • Dissolved metals: a specific metal or metals laboratory value/s rises above the corresponding control (upstream) site(s) mean minus two standard deviations or the site-specific historic mean minus two standard deviations for more than two consecutive months.	• Continue monitoring as per monitoring program. • Convene Tahmoor Coal Environmental Response Group to undertake an investigation to assess if the change in behaviour is related to LW W1-W2 mining effects, other catchment changes or the prevailing climate. • 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. • Undertake an investigation to assess if the change in behaviour is related to LW W1-W2 mining effects (e.g. whether there has been subsidence induced cracking upstream), other catchment changes, unrelated pollution or the prevailing climate.	• Report to DPIE within 7 days of investigation completion (according to Table 6-1 of the Extraction Plan Main Document). • If it is concluded that there has been a mining-related impact then implement a corrective management action plan in accordance with a timeframe as recommended by the Environmental Response Group in consultation with the NSW DPIE Resources Regulator (refer to Section 6.2.2 of the WMP).

Footnotes:

* 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).

The baseline ratio of monitored to modelled flows for each trigger level proposed to assess the downstream reduction in catchment flow rate in Stonequarry Creek at Picton Gauging Station (GS212053) are presented Table 34. As specified in Table 33, the 40th and 20th percentiles of the baseline data have been adopted for each trigger level. The 20th percentile is an accepted metric of a significant variation from 'normal' conditions (ANZECC, 2000) while the 40th percentile represents a slight deviation from the median or 'normal' conditions. As such, the range between the 40th percentile and the 20th percentile represents a slight deviation from 'normal' conditions to a significant variation from 'normal' conditions.

Table 34 Baseline Ratio of Monitored to Modelled Flow

Surface Water System	Adjusted Baseline Ratio of Monitored to Modelled Flow	
Stonequarry Creek at Picton (GS212053)	20th Percentile	0.52
	40th Percentile	0.79

An impact to pool water level is to be assessed based on the minimum pool water level measured during the baseline period, as listed in Table 35.

Table 35 Baseline Minimum Recorded Water Level (Automated Monitoring)

Surface Water System	Monitoring Site	Minimum Recorded Water Level (m AHD)*
Matthews Creek	MB	219.048
	ME	201.313
	MG	189.057
Cedar Creek	CC1A	0.668 (m)
	CA	180.448
	CB	178.872
	CD	172.822
	CE	171.709
	CG	170.345
Stonequarry Creek	SA	167.799
	SD	160.285

* Subject to additional baseline data acquisition for the period prior to non-negligible subsidence from LW W1.

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 0);
- the implementation of revegetation measures to remediate impacts of vegetation loss due to subsidence;
- 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;
- the provision of an alternative water source until the completion of repairs in the event that a water storage dam 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.

7.0 REFERENCES

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APPENDIX A – POOL PHOTOGRAPHS (GEOTERRA, 2019)

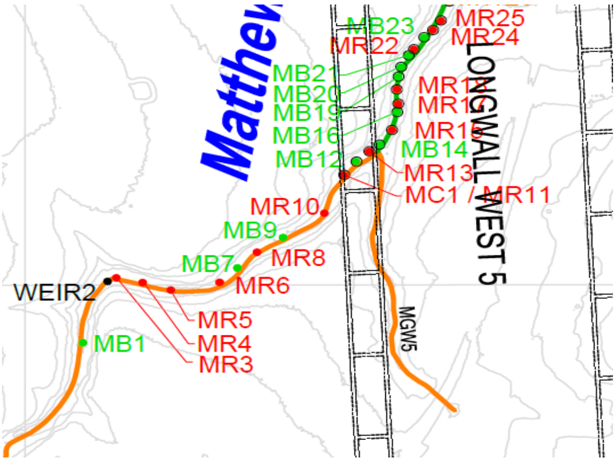
Matthews Creek – Pool MB1

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



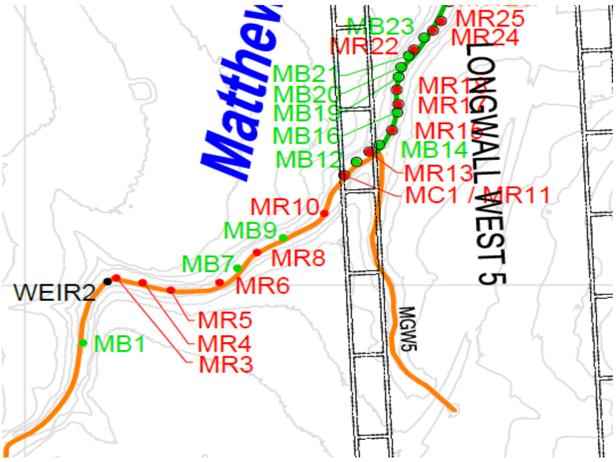
Map location

Matthews Creek – Weir 2

Photograph date:29/08/2019

Upstream

Downstream



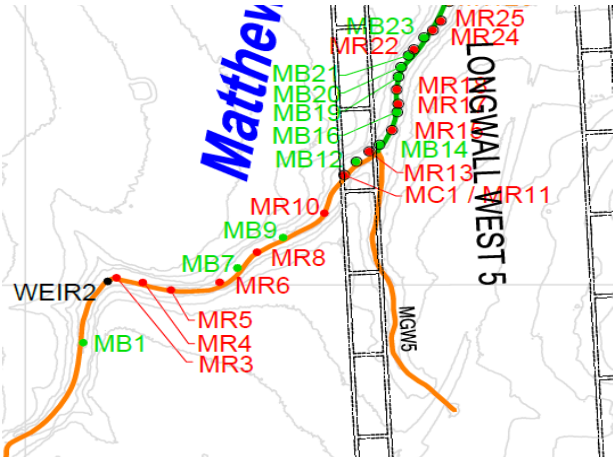
Map location

Matthews Creek – Pool MR3

Photograph date:29/08/2019

Upstream

Downstream



Map location

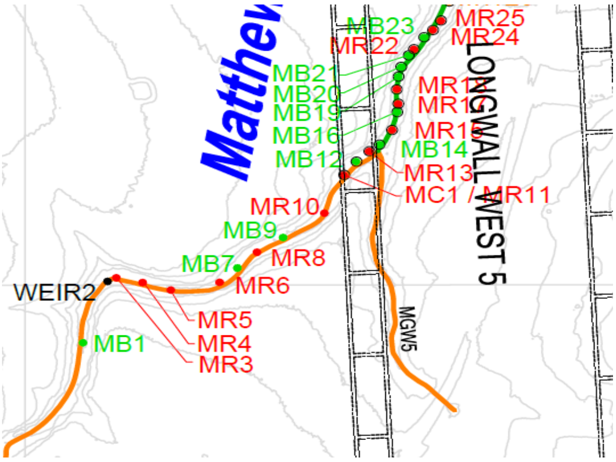
Matthews Creek – Pool MR4

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



Map location

Matthews Creek – Pool MR5

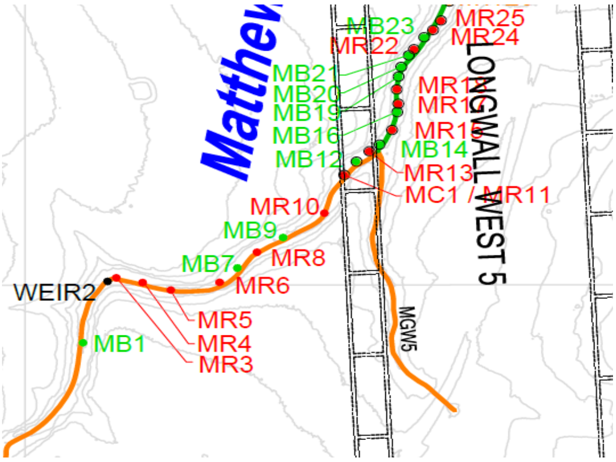
Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1

Additional Photo 2



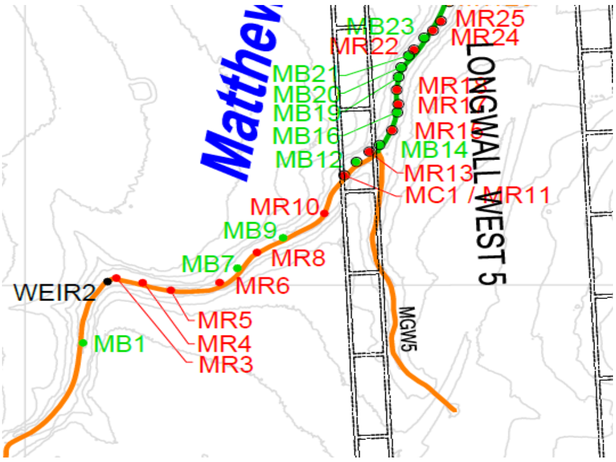
Map location

Matthews Creek – Pool MR6

Photograph date:29/08/2019

Upstream

Downstream



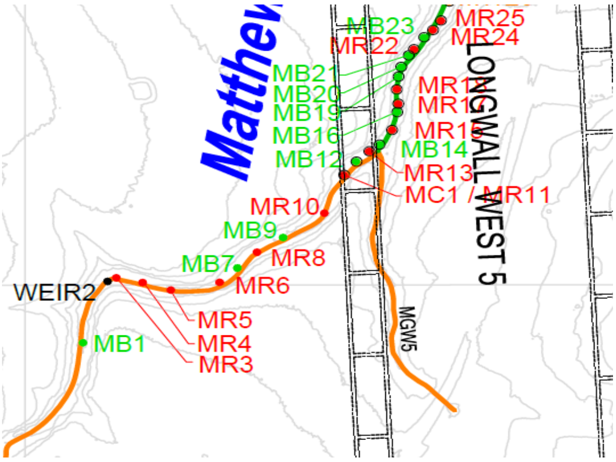
Map location

Matthews Creek – Pool MB7

Photograph date:29/08/2019

Upstream

Downstream



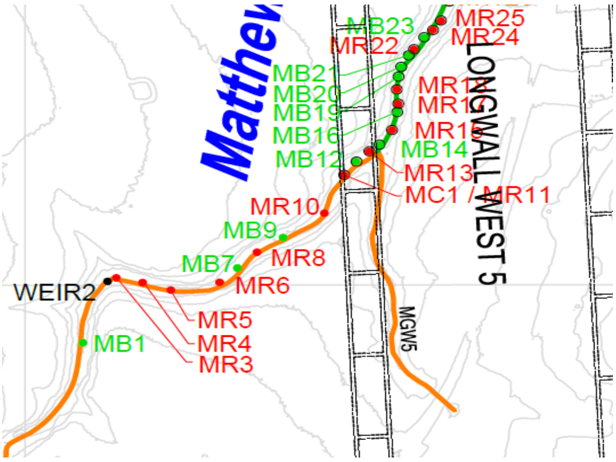
Map location

Matthews Creek – Pool MR8

Photograph date:29/08/2019

Upstream

Downstream



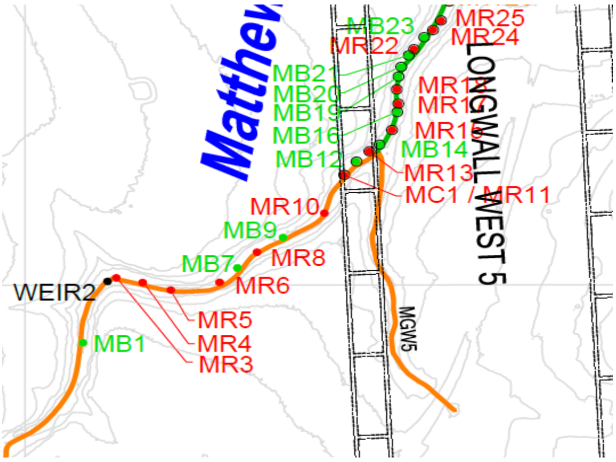
Map location

Matthews Creek – Pool MB9

Photograph date:29/08/2019

Upstream

Additional Photo 1



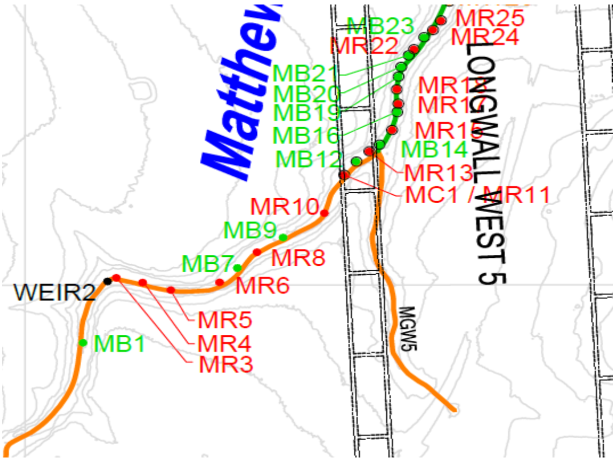
Map location

Matthews Creek – Pool MR10

Photograph date:29/08/2019

Upstream

Additional Photo 1



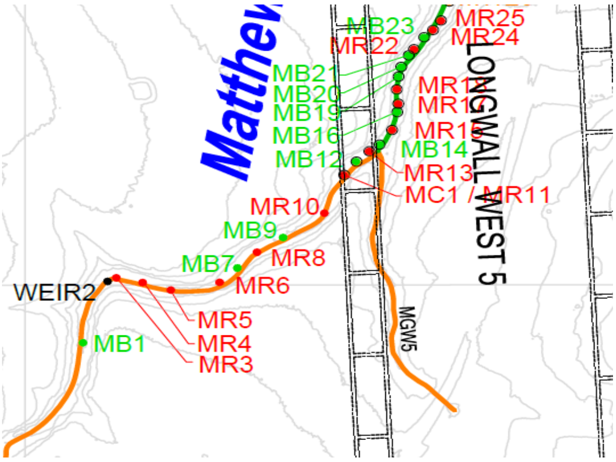
Map location

Matthews Creek – Pool MC1 / MR11

Photograph date:29/08/2019

Upstream

Downstream



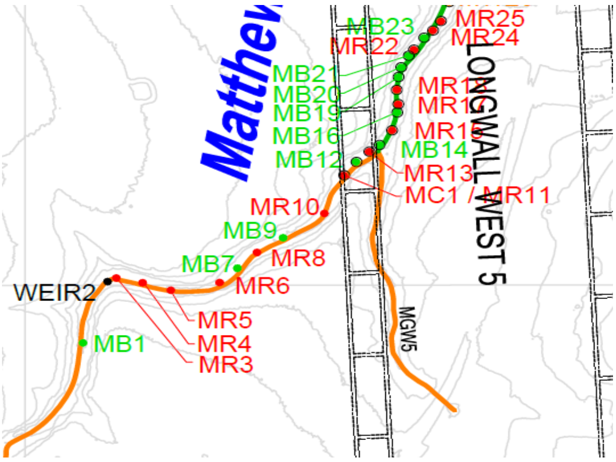
Map location

Matthews Creek – Pool MB12

Photograph date:29/08/2019

Upstream

Downstream



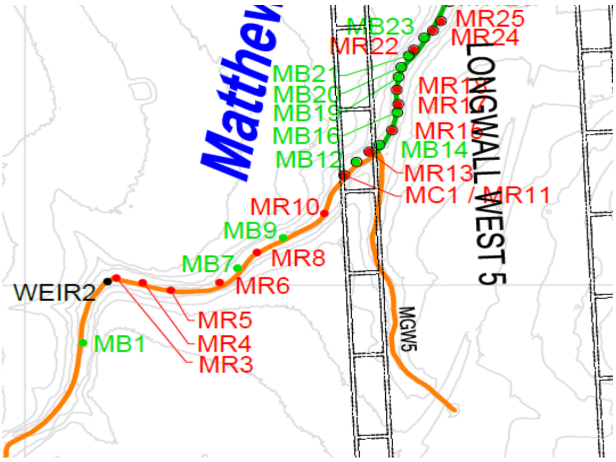
Map location

Matthews Creek – Pool MR13

Photograph date:29/08/2019

Upstream

Downstream



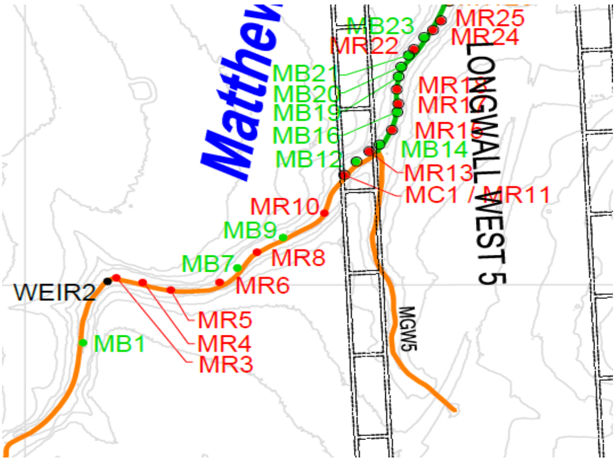
Map location

Matthews Creek – Pool MB14

Photograph date:29/08/2019

Upstream

Downstream



Map location

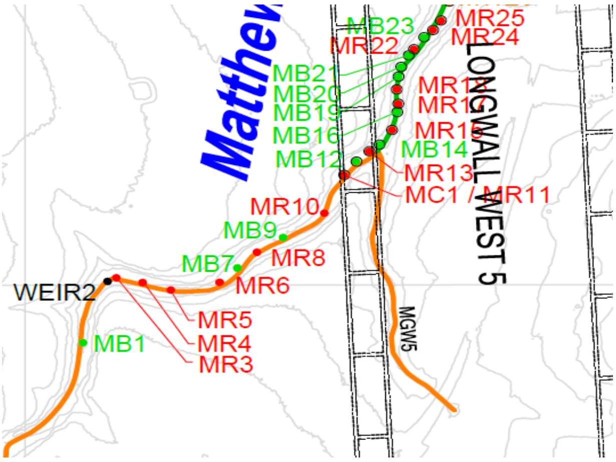
Matthews Creek – Pool MR15 / MB16

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



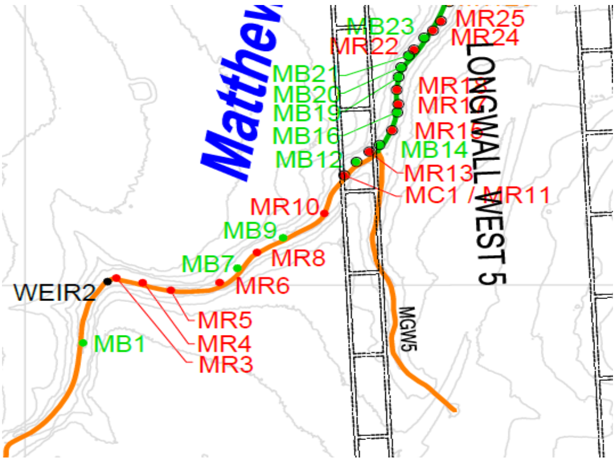
Map location

Matthews Creek – Pool MR17

Photograph date:29/08/2019

Upstream

Downstream



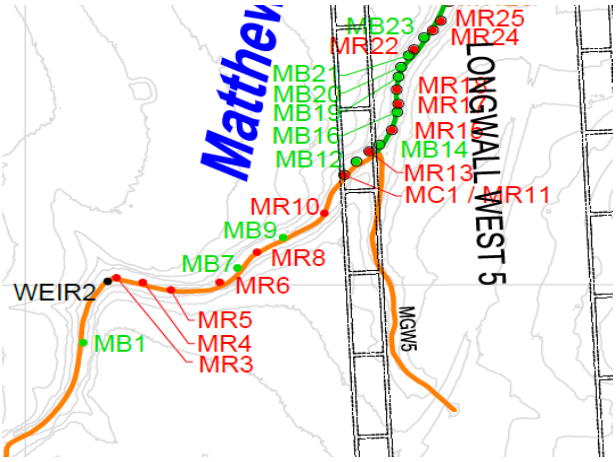
Map location

Matthews Creek – Pool MR18

Photograph date:29/08/2019

Upstream

Downstream



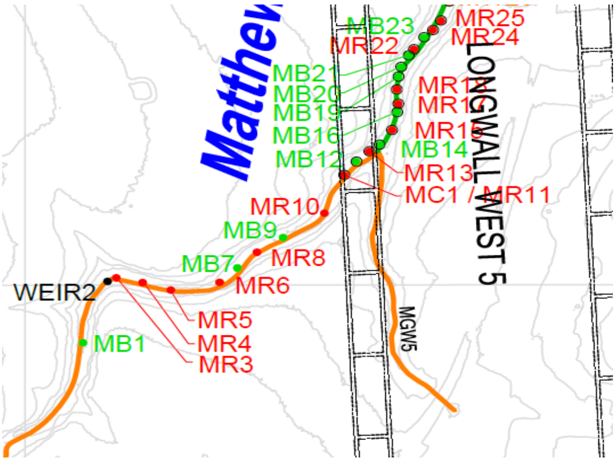
Map location

Matthews Creek – Pool MB19

Photograph date:29/08/2019

Upstream

Downstream



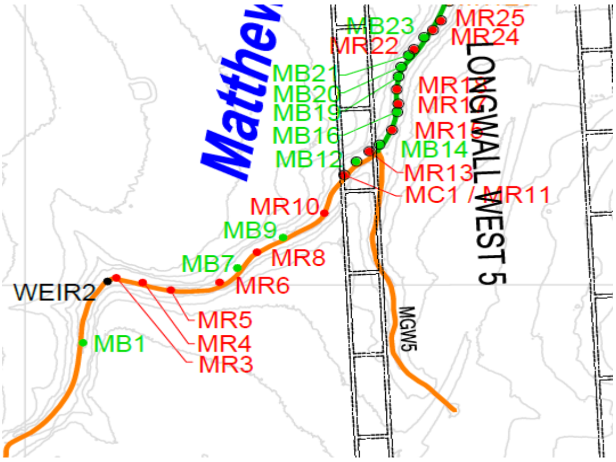
Map location

Matthews Creek – Pool MB20

Photograph date:29/08/2019

Upstream

Downstream



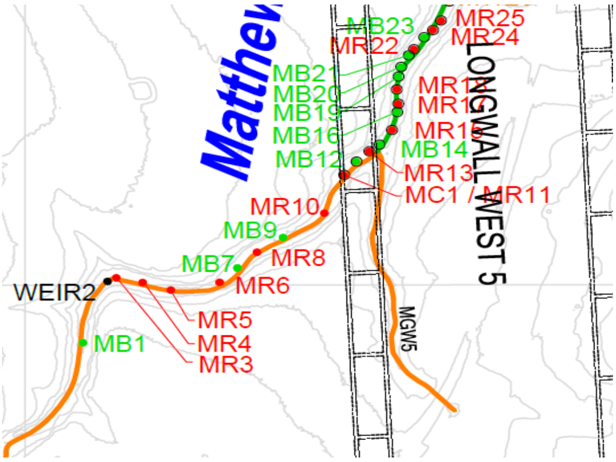
Map location

Matthews Creek – Pool MB21

Photograph date:29/08/2019

Upstream

Additional Photo 1



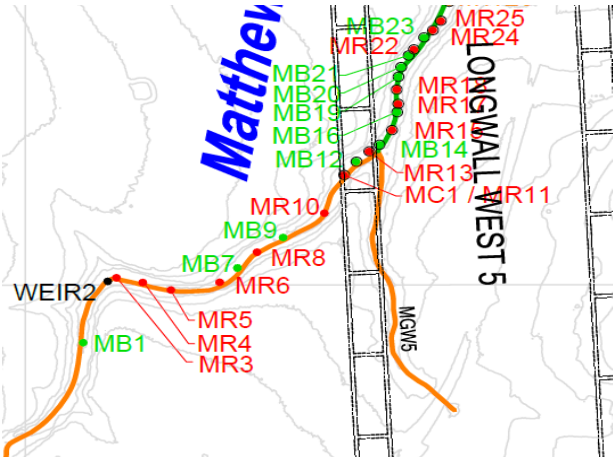
Map location

Matthews Creek – Pool MR22

Photograph date:29/08/2019

Upstream

Downstream



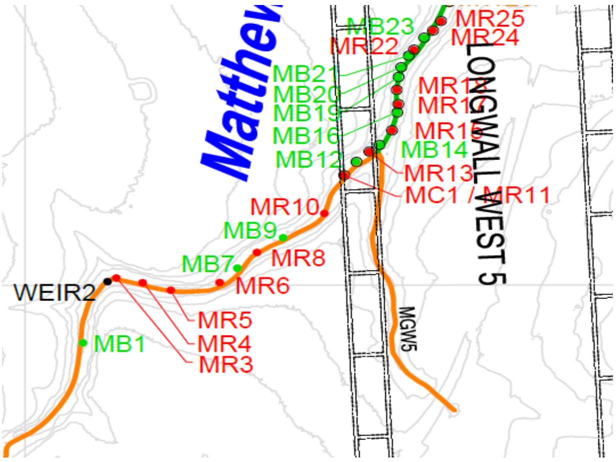
Map location

Matthews Creek – Pool MB23

Photograph date:29/08/2019

Upstream

Downstream



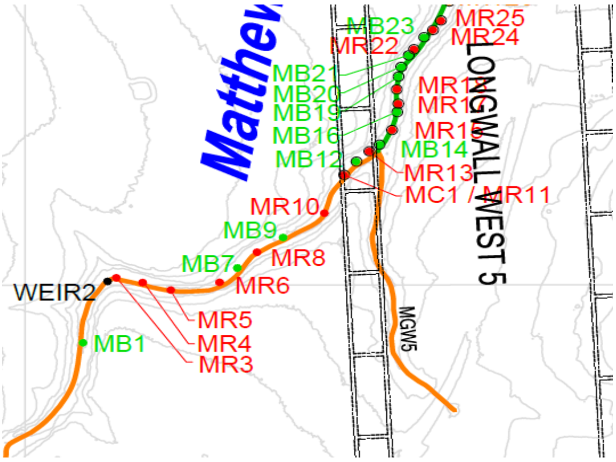
Map location

Matthews Creek – Pool MR24

Photograph date:29/08/2019

Upstream

Additional Photo 1



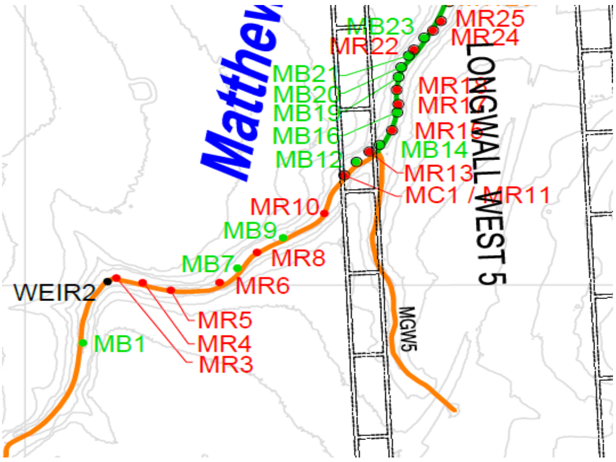
Map location

Matthews Creek – Pool MR25

Photograph date:29/08/2019

Upstream

Downstream



Map location

Matthews Creek – Pool MW26

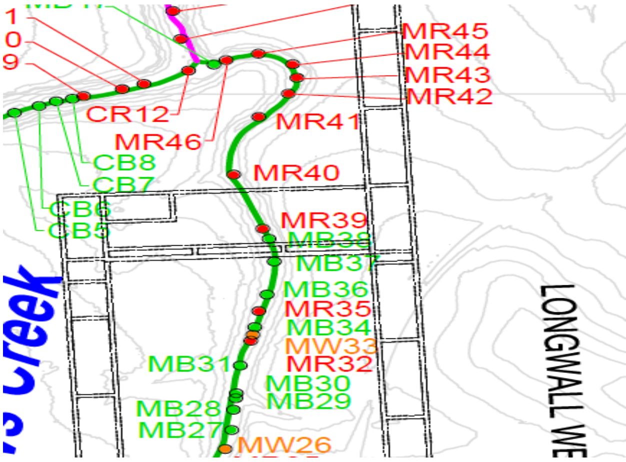
Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1

Additional Photo 2



Map location

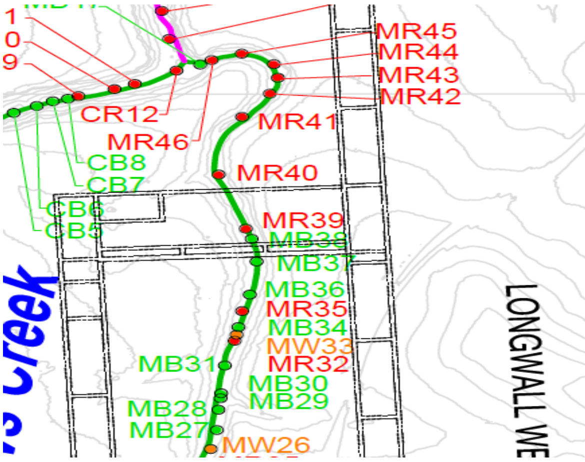
Matthews Creek – Pool MB27 / MB28

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



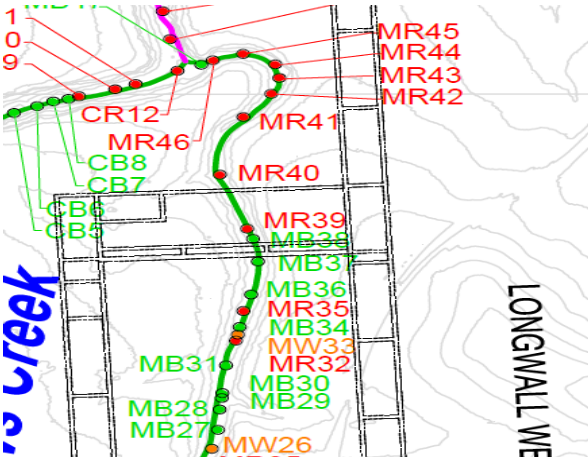
Map location

Matthews Creek – Pool MB29

Photograph date:29/08/2019

Upstream

Downstream



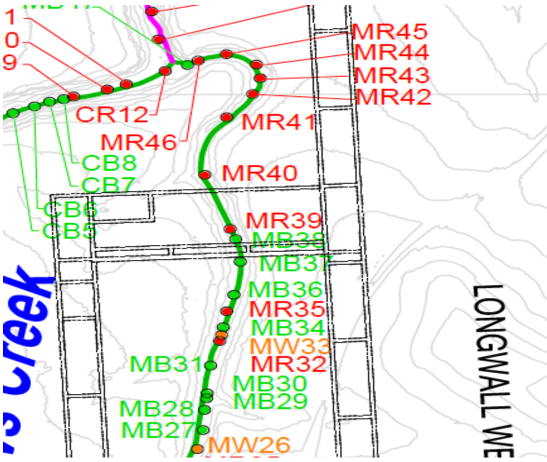
Map location

Matthews Creek – Pool MB30

Photograph date:29/08/2019

Upstream

Downstream



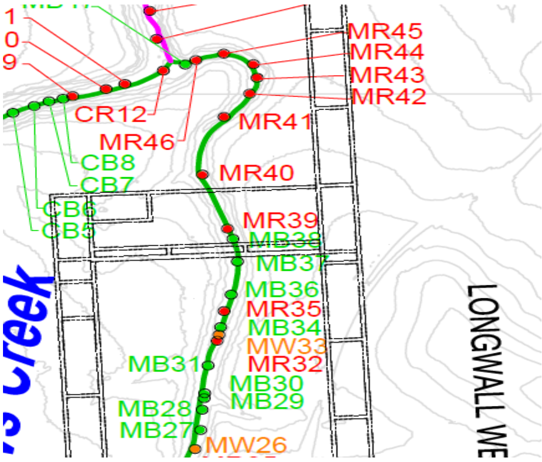
Map location

Matthews Creek – Pool MB31

Photograph date:29/08/2019

Upstream

Downstream



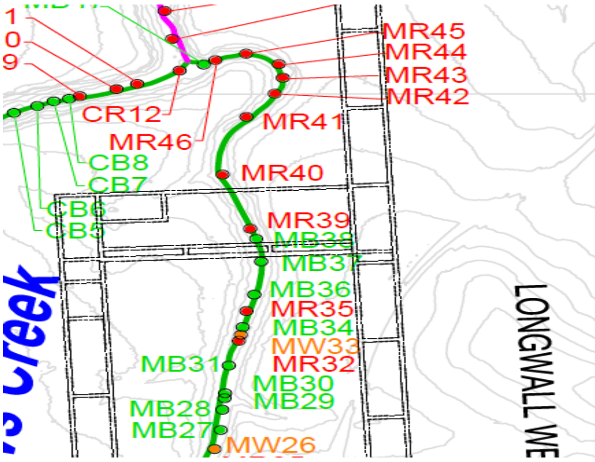
Map location

Matthews Creek – Pool MR32

Photograph date:29/08/2019

Upstream

Additional Photo 1



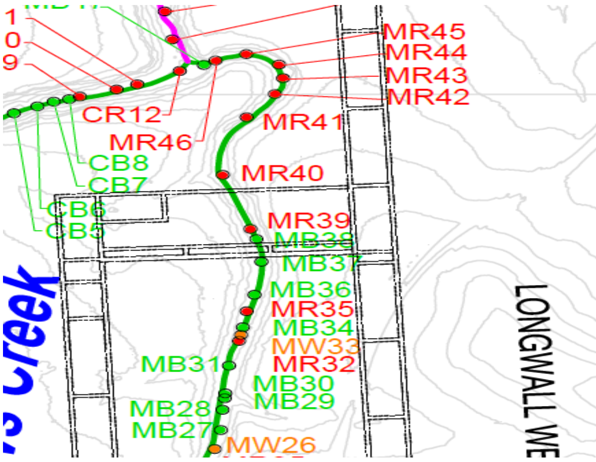
Map location

Matthews Creek – Pool MW33

Photograph date:29/08/2019

Upstream

Downstream



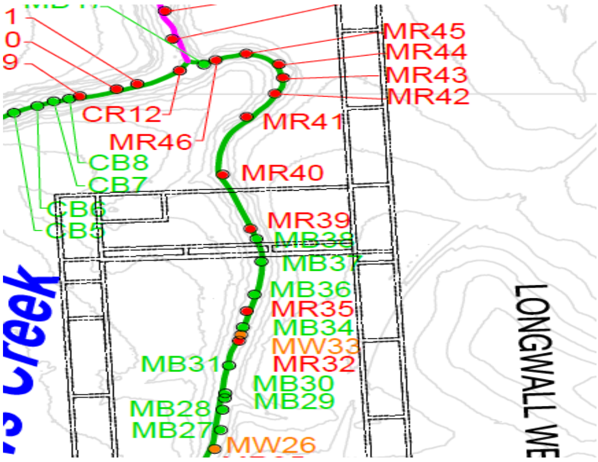
Map location

Matthews Creek – Pool MB34

Photograph date:29/08/2019

Upstream

Downstream



Map location

Matthews Creek – Pool MR35 / MB36

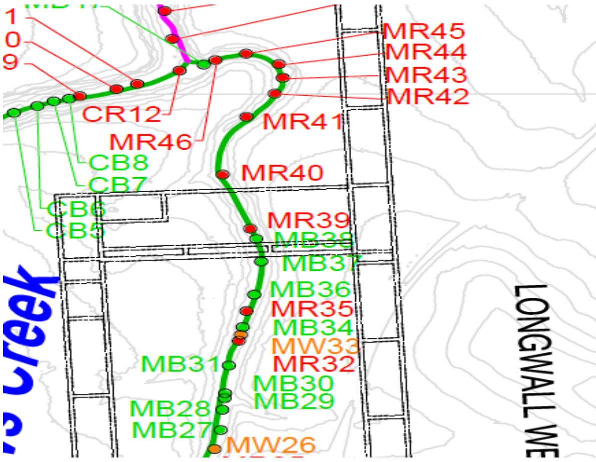
Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1

Additional Photo 2



Map location

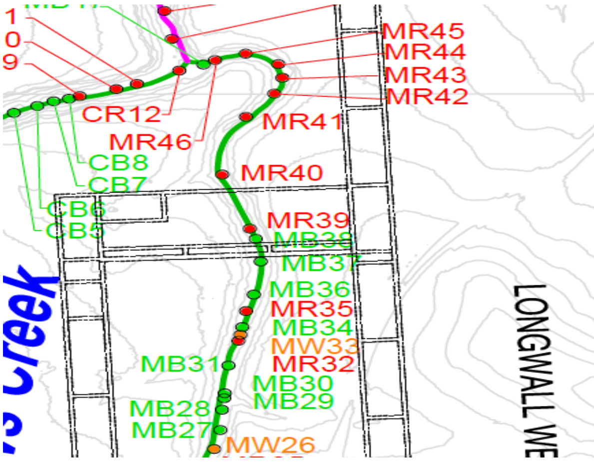
Matthews Creek – Pool MB37

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



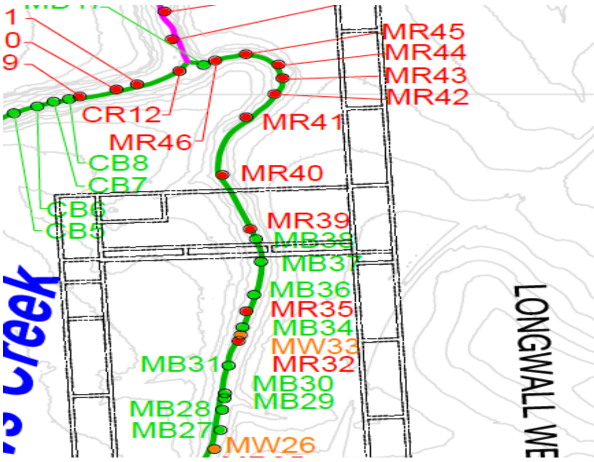
Map location

Matthews Creek – Pool MB38

Photograph date:29/08/2019

Upstream

Downstream



Map location

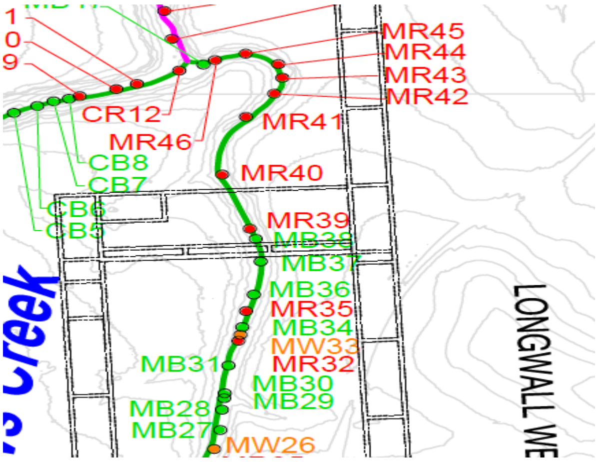
Matthews Creek – Pool MR39

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



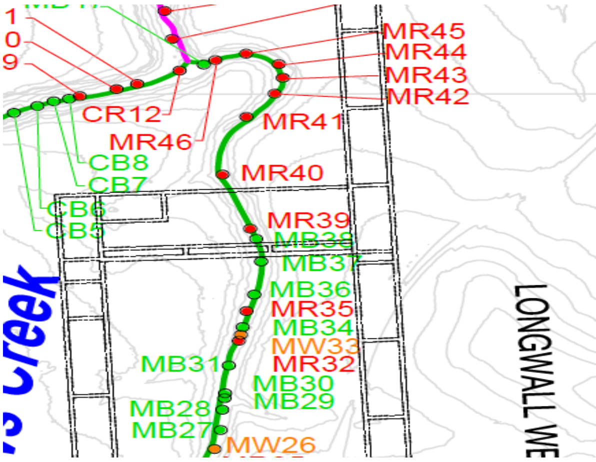
Map location

Matthews Creek – Pool MR40

Photograph date:29/08/2019

Downstream

Additional Photo 1



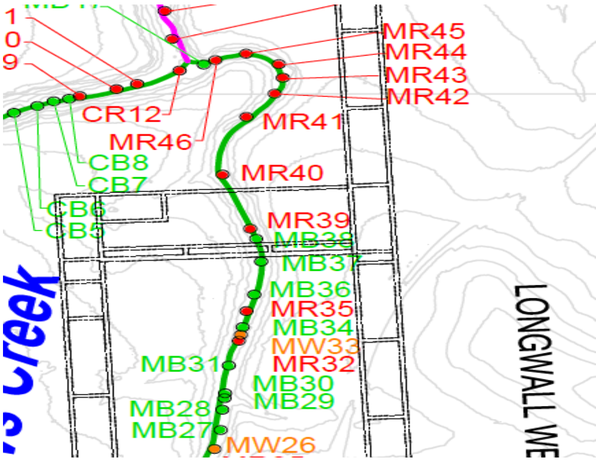
Map location

Matthews Creek – Pool MR41

Photograph date:29/08/2019

Downstream

Additional Photo 1



Map location

Matthews Creek – Pool MR42

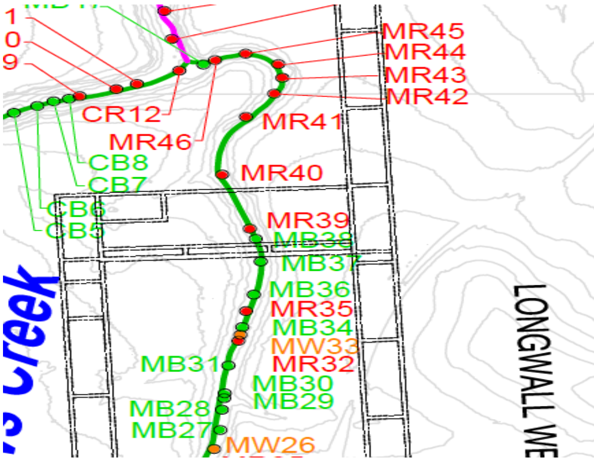
Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1

Additional Photo 2



Map location

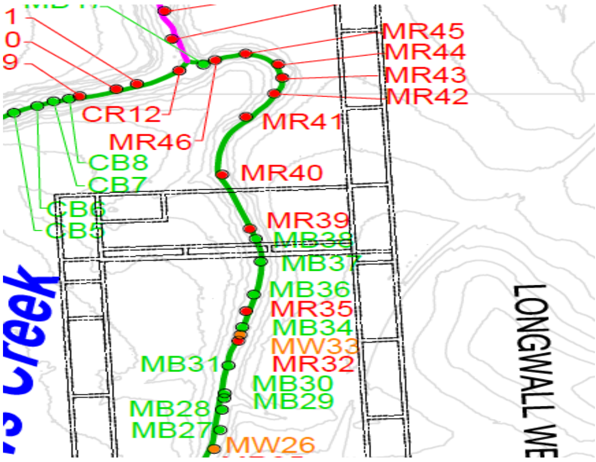
Matthews Creek – Pool MR43

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



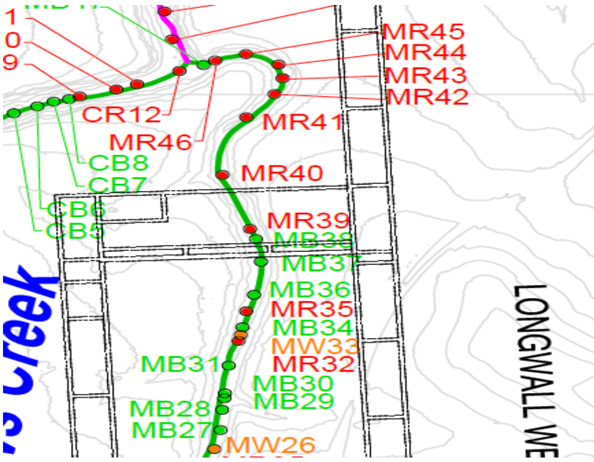
Map location

Matthews Creek – Pool MR44

Photograph date:29/08/2019

Upstream

Downstream



Map location

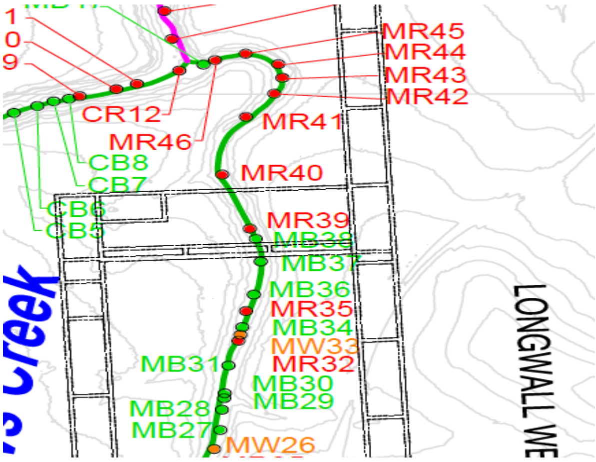
Matthews Creek – Pool MR45

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



Map location

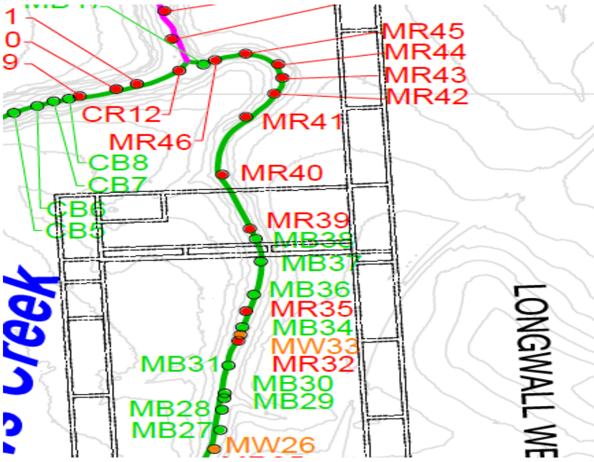
Matthews Creek – Pool MR46

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



Map location

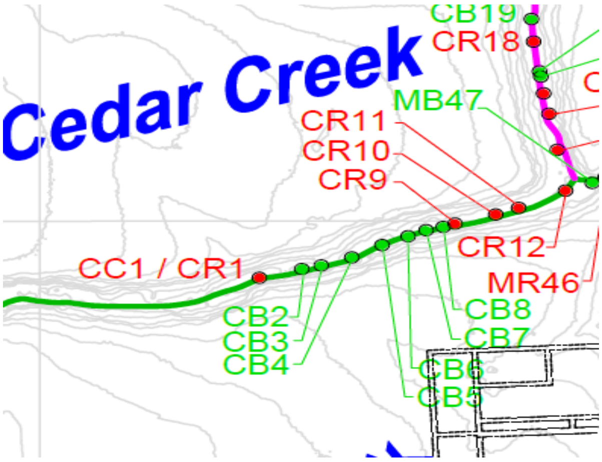
Cedar Creek – Pool CB2

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo



Map location

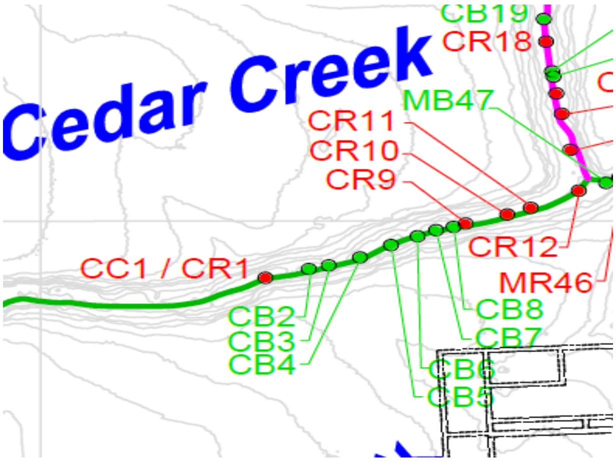
Cedar Creek – Pool CB3

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo



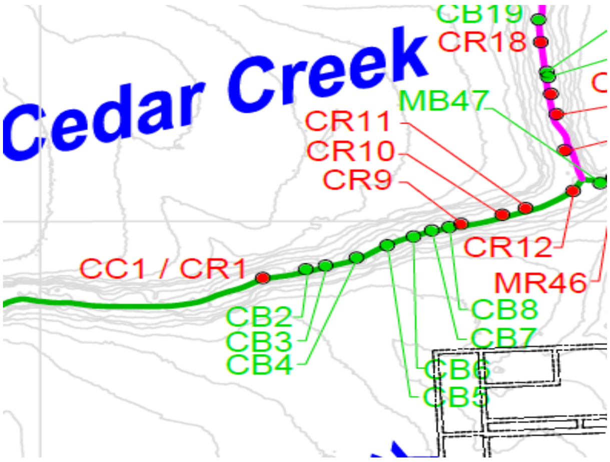
Map location

Cedar Creek – Pool CB4

Photograph date:29/08/2019

Upstream

Downstream



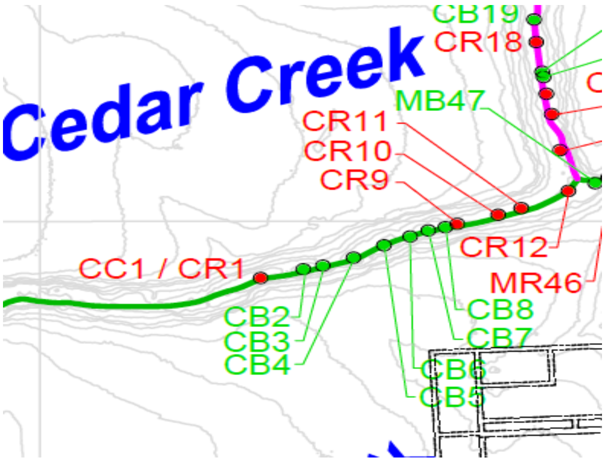
Map location

Cedar Creek – Pool CB5

Photograph date:29/08/2019

Upstream

Downstream



Map location

Cedar Creek – Pool CB6

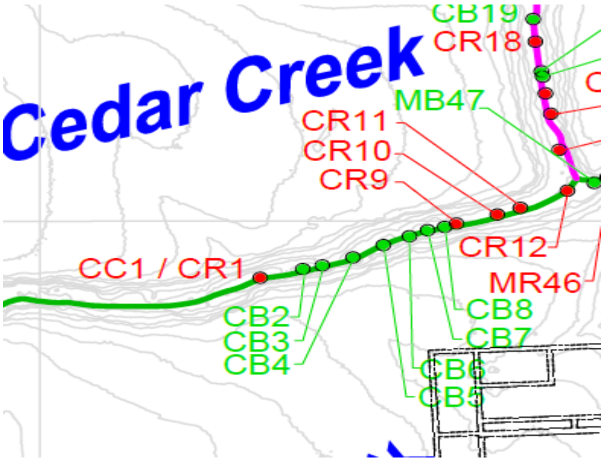
Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1

Additional Photo 2



Map location

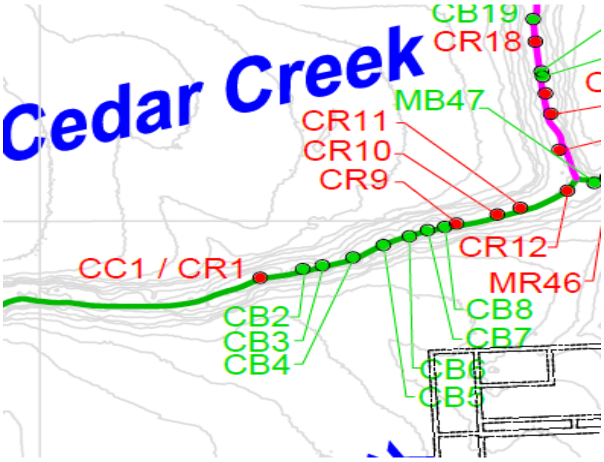
Cedar Creek – Pool CB7

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



Map location

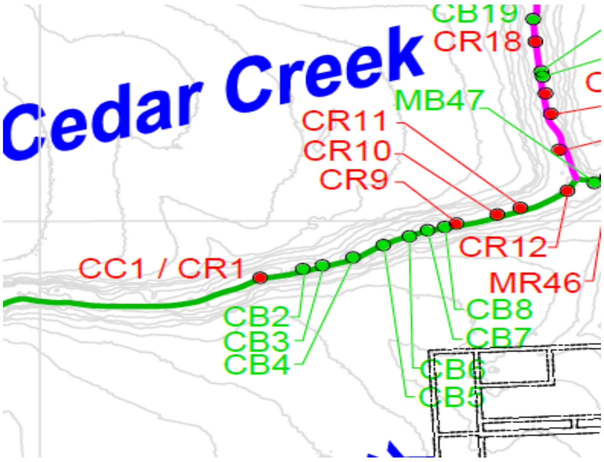
Cedar Creek – Pool CB8

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



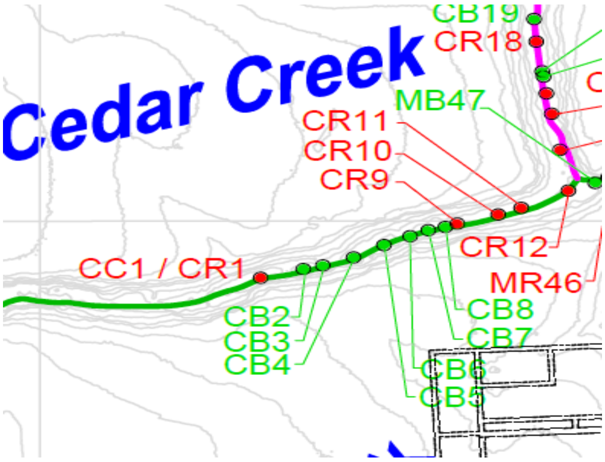
Map location

Cedar Creek – Pool CR9

Photograph date:29/08/2019

Upstream

Downstream



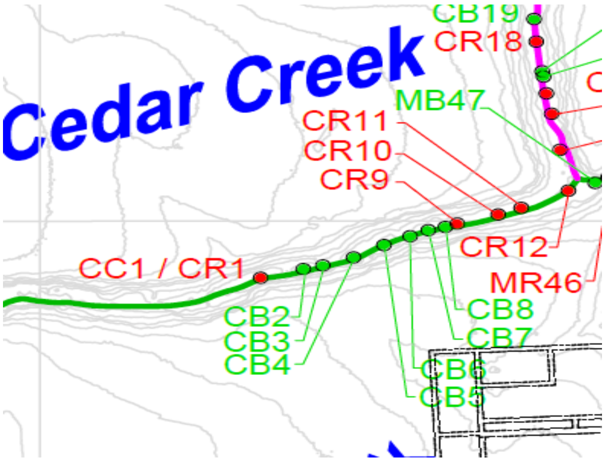
Map location

Cedar Creek – Pool CR10

Photograph date:29/08/2019

Upstream

Downstream



Map location

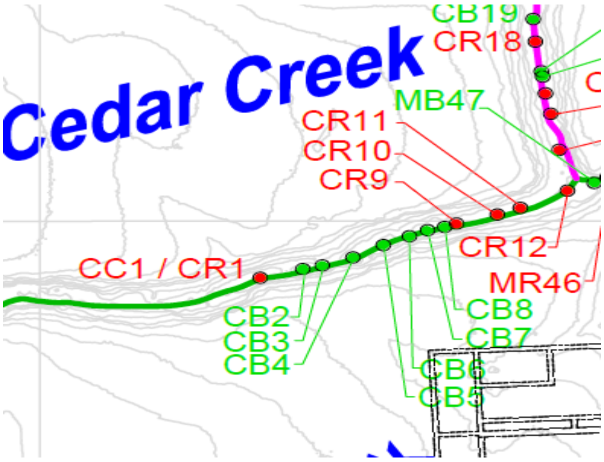
Cedar Creek – Pool CR11 / CR12

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



Map location

Cedar Creek – Pool CR13

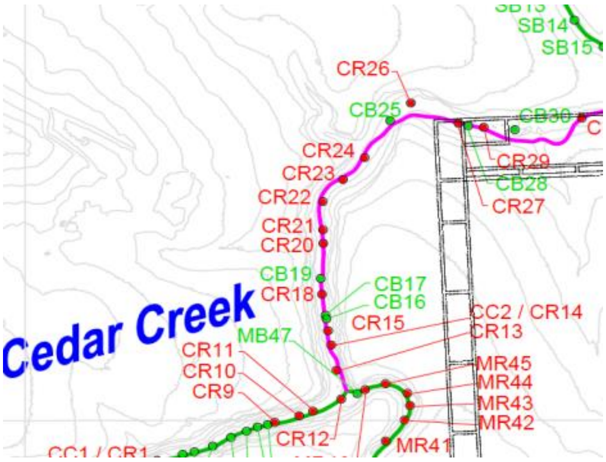
Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1

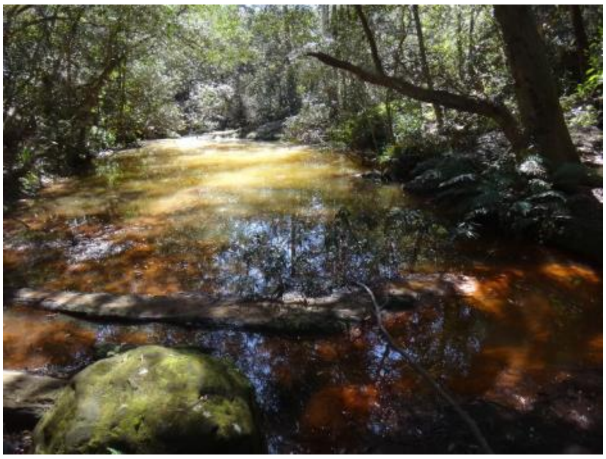
Additional Photo 2



Map location

Cedar Creek – Pool CR14

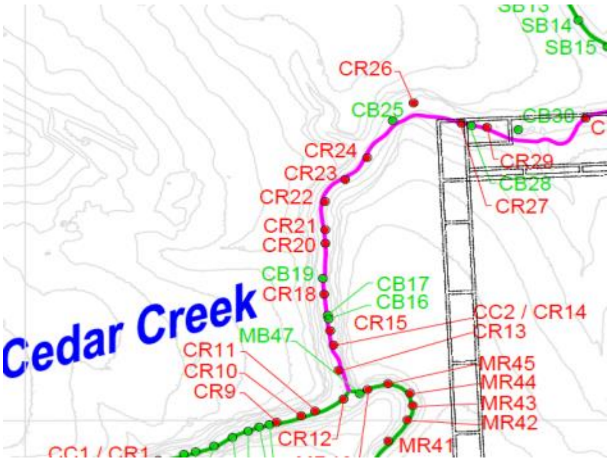
Photograph date:29/08/2019



Upstream

Downstream

Additional Photo 1



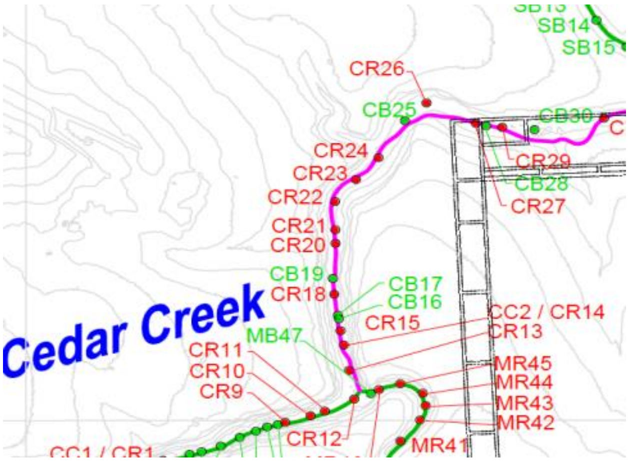
Map location

Cedar Creek – Pool CR15

Photograph date:29/08/2019

Upstream

Downstream



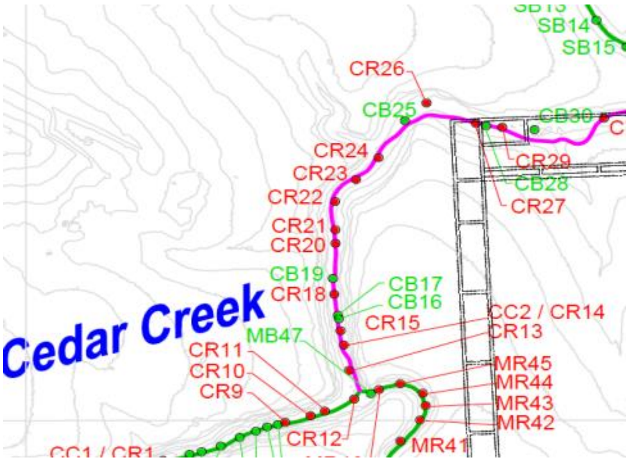
Map location

Cedar Creek – Pool CB16

Photograph date:29/08/2019

Upstream

Downstream



Map location

Cedar Creek – Pool CB17 / CR18

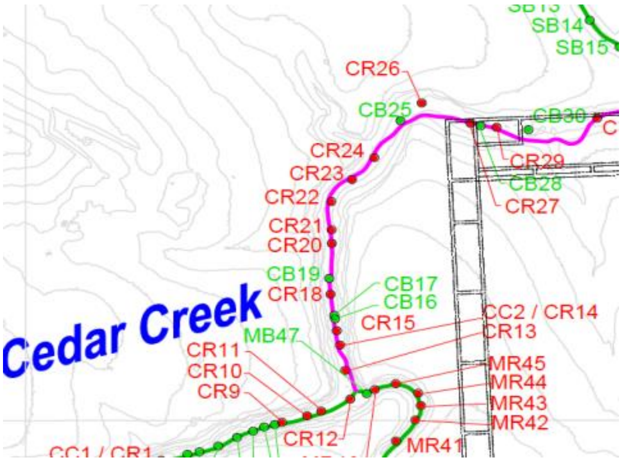
Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1

Additional Photo 2



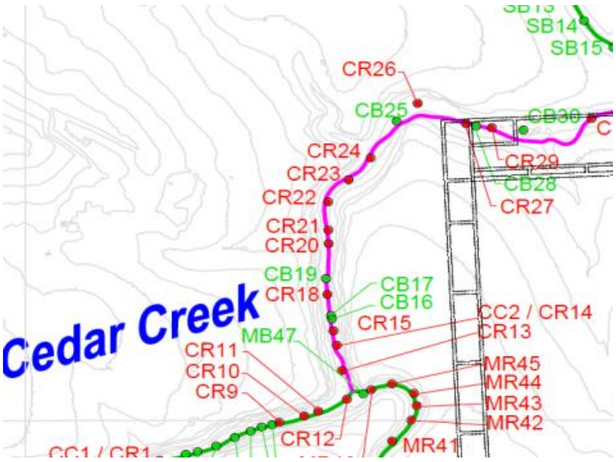
Map location

Cedar Creek – Pool CB19

Photograph date:29/08/2019

Upstream

Downstream



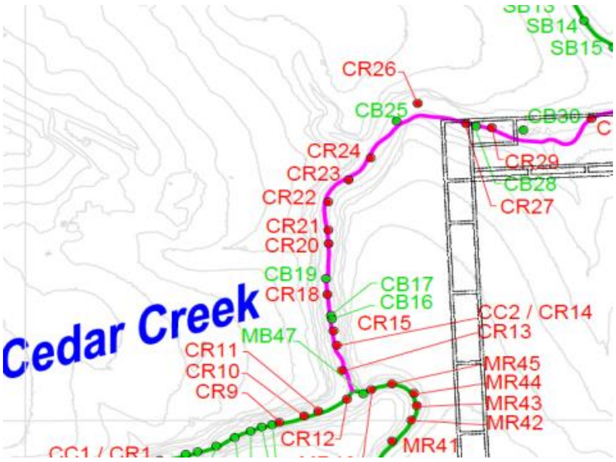
Map location

Cedar Creek – Pool CR20

Photograph date:29/08/2019

Upstream

Downstream



Map location

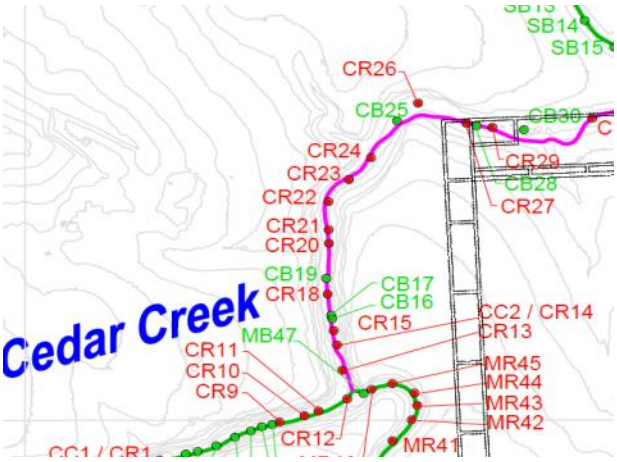
Cedar Creek – Pool CR21

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



Cedar Creek – Pool CR22

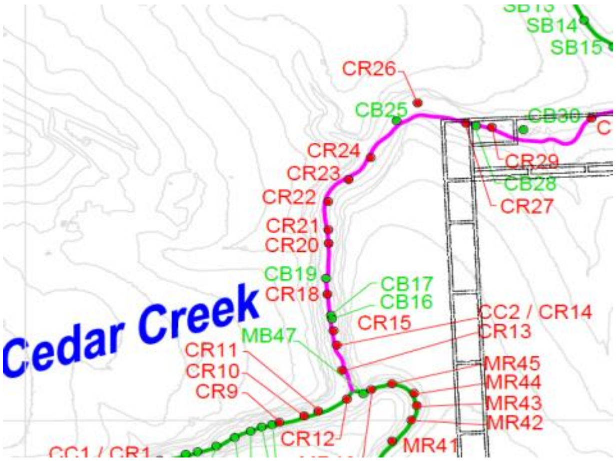
Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1

Additional Photo 2



Map location

Cedar Creek – Pool CR23

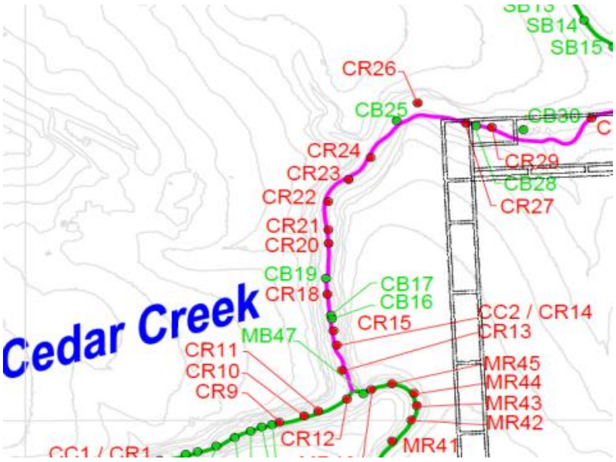
Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1

Additional Photo 2



Map location

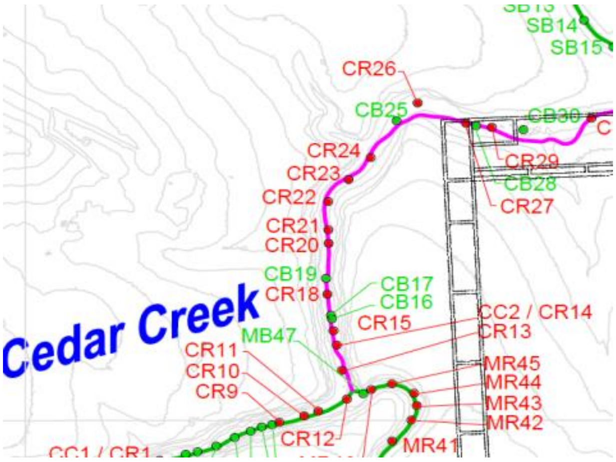
Cedar Creek – Pool CR24

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



Map location

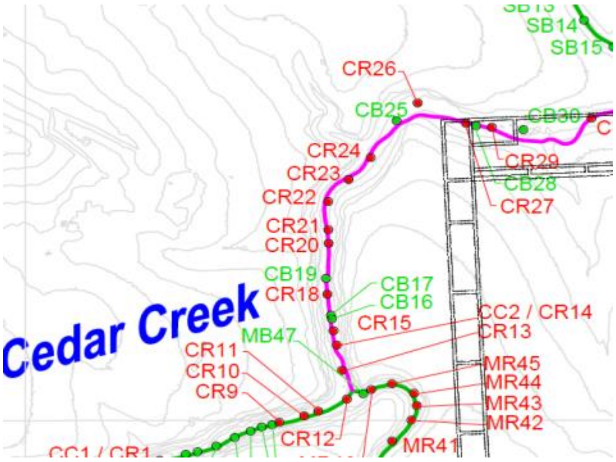
Cedar Creek – Pool CB25

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



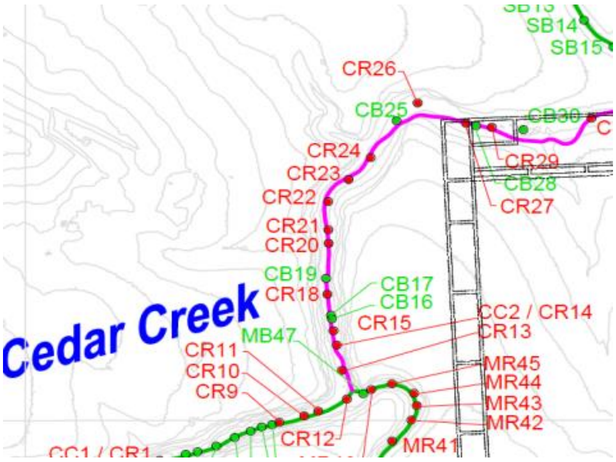
Map location

Cedar Creek – Pool CR26

Photograph date:29/08/2019

Upstream

Downstream



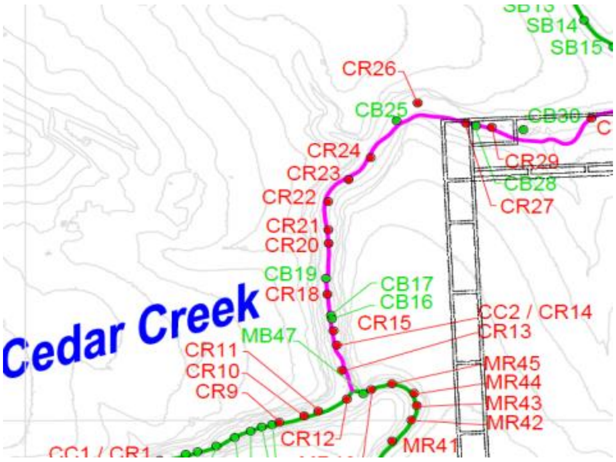
Map location

Cedar Creek – Pool CR27

Photograph date:29/08/2019

Upstream

Downstream



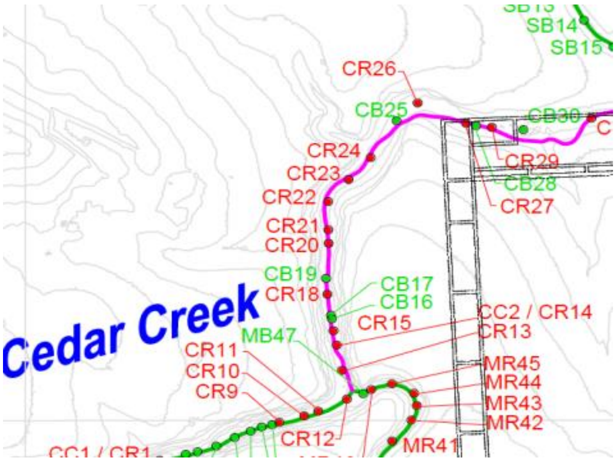
Map location

Cedar Creek – Pool CB28

Photograph date:29/08/2019

Upstream

Downstream



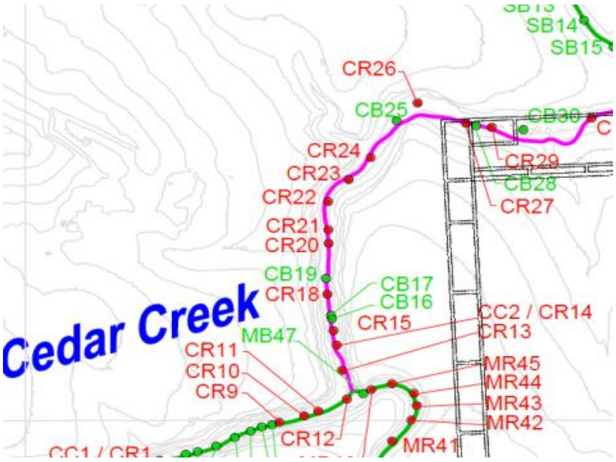
Map location

Cedar Creek – Pool CR29

Photograph date:29/08/2019

Upstream

Downstream



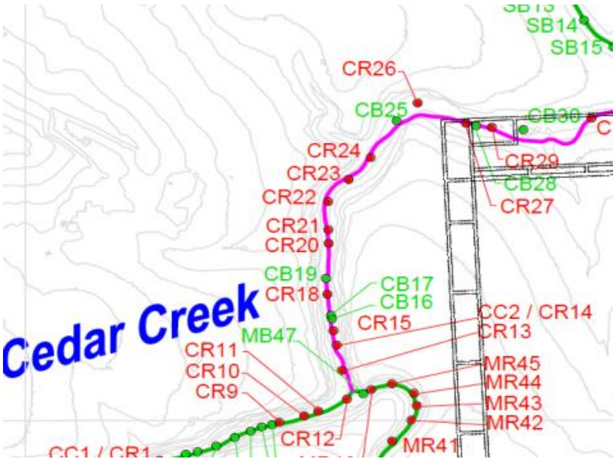
Map location

Cedar Creek – Pool CB30

Photograph date:29/08/2019

Upstream

Downstream



Map location

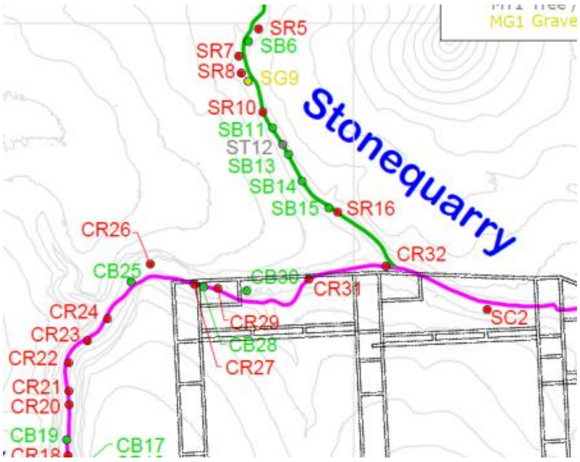
Cedar Creek – Pool CR31

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



Map location

Cedar Creek – Pool CR32

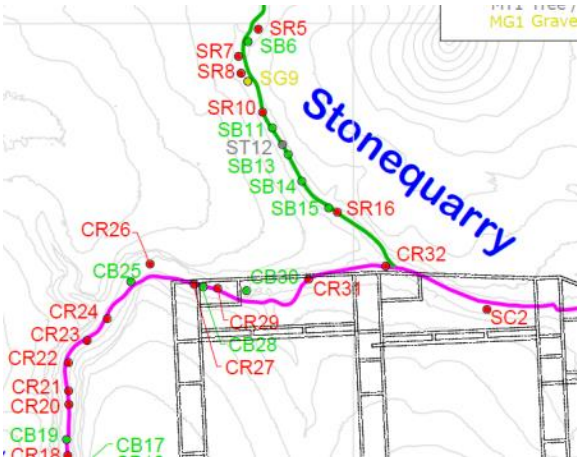
Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1

Additional Photo 2

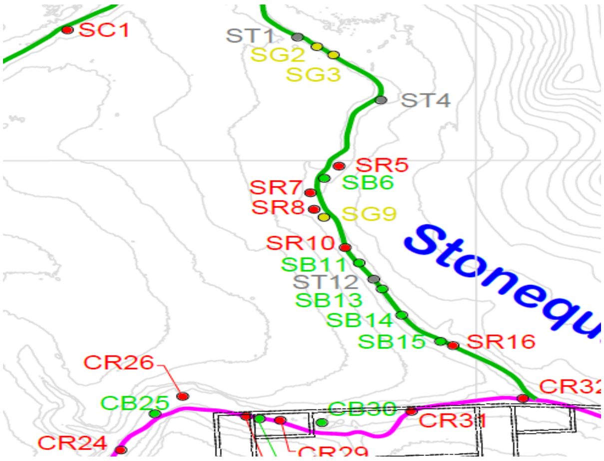


Map location

Stonequarry Creek – Pool SC1

Photograph date:29/08/2019

Downstream



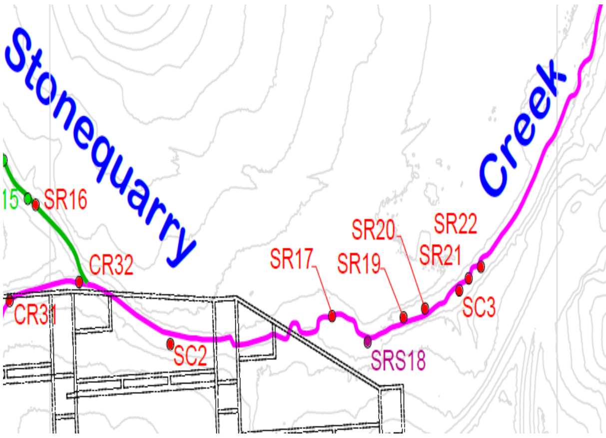
Map location

Stonequarry Creek – Pool SG2

Photograph date:29/08/2019

Downstream

Additional Photo 1



Map location

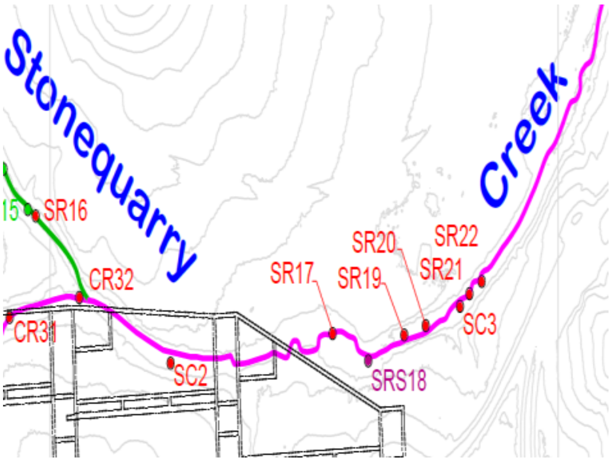
Stonequarry Creek – Pool SG3

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



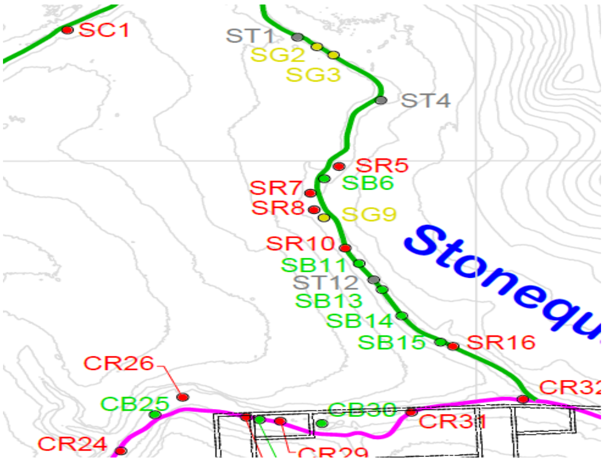
Map location

Stonequarry Creek – Pool ST4

Photograph date:29/08/2019

Downstream

Additional Photo 1



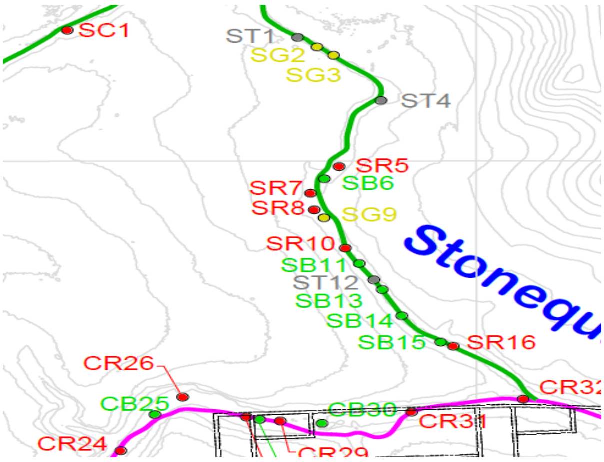
Map location

Stonequarry Creek – Pool SR5

Photograph date:29/08/2019

Downstream

Additional Photo 1



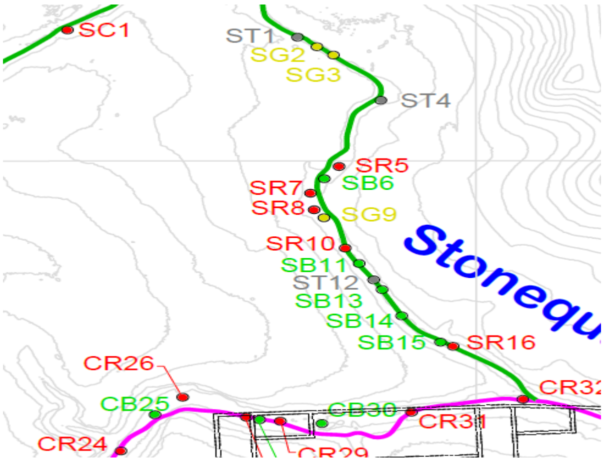
Map location

Stonequarry Creek – Pool SB6

Photograph date:29/08/2019

Downstream

Additional Photo 1



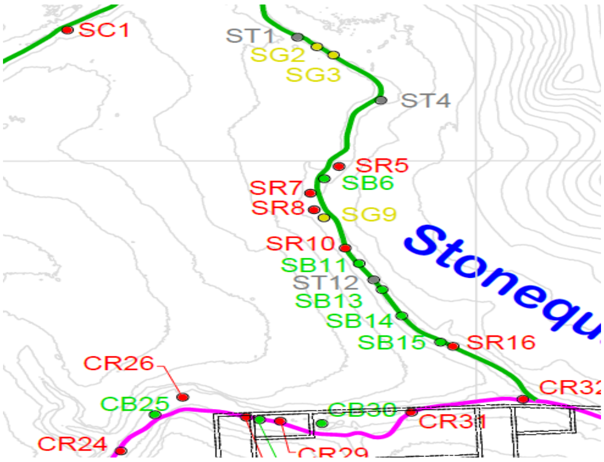
Map location

Stonequarry Creek – Pool SR7

Photograph date:29/08/2019

Downstream

Additional Photo 1



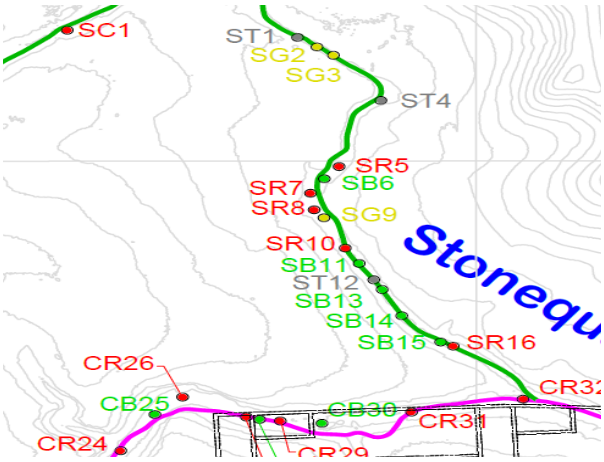
Map location

Stonequarry Creek – Pool SR8

Photograph date:29/08/2019

Upstream

Additional Photo 1



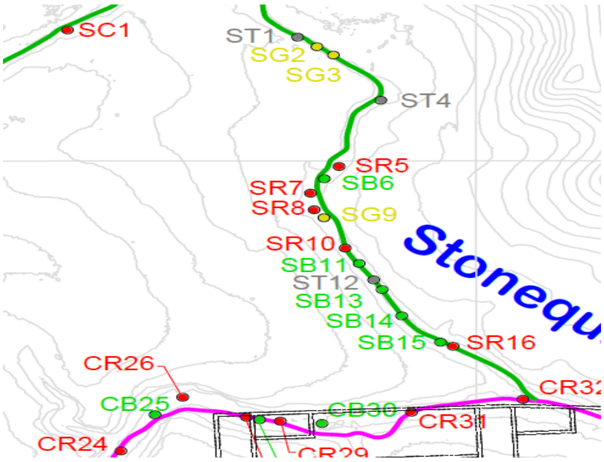
Map location

Stonequarry Creek – Pool SC9

Photograph date:29/08/2019

Downstream

Additional Photo 1



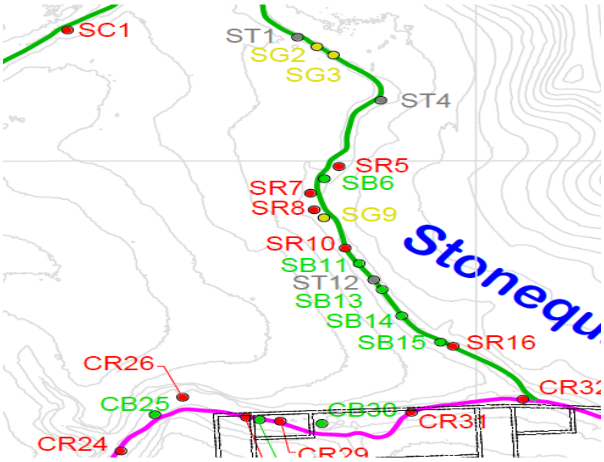
Map location

Stonequarry Creek – Pool SR10

Photograph date:29/08/2019

Downstream

Additional Photo 1



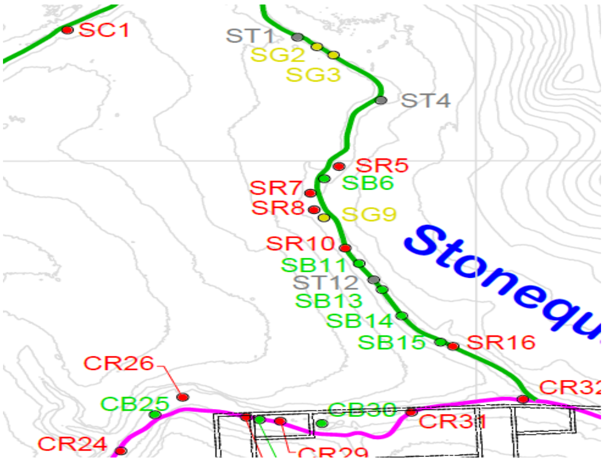
Map location

Stonequarry Creek – Pool SB11 / ST12

Photograph date:29/08/2019

Downstream

Additional Photo 1



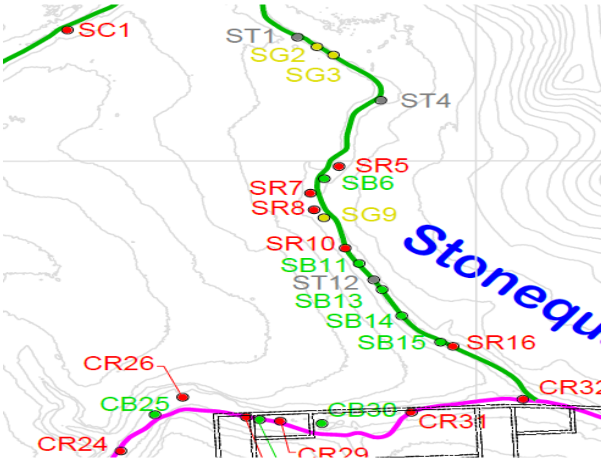
Map location

Stonequarry Creek – Pool SB13

Photograph date:29/08/2019

Upstream

Additional Photo 1



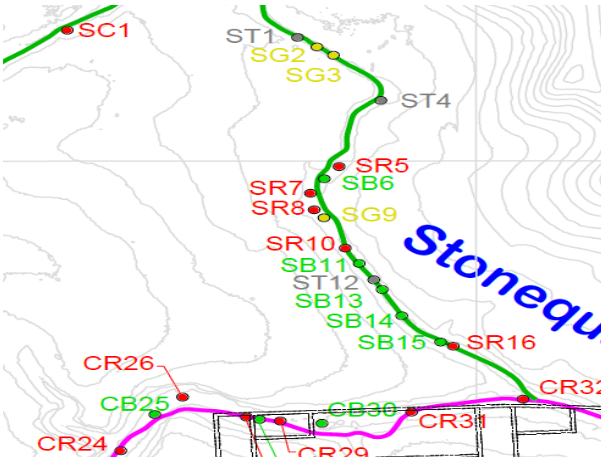
Map location

Stonequarry Creek – Pool SB14

Photograph date:29/08/2019

Upstream

Additional Photo 1



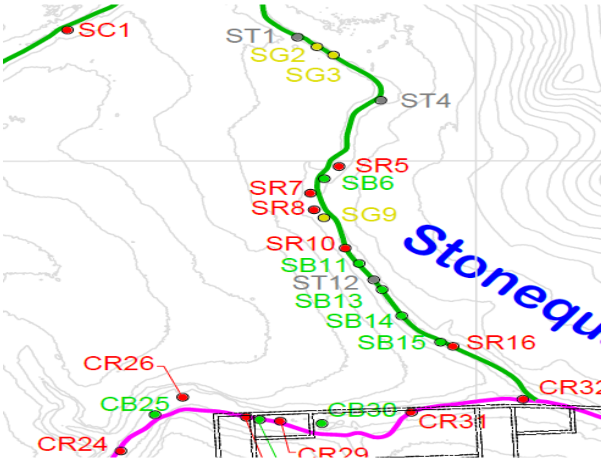
Map location

Stonequarry Creek – Pool SB15

Photograph date:29/08/2019

Upstream

Additional Photo 1



Map location

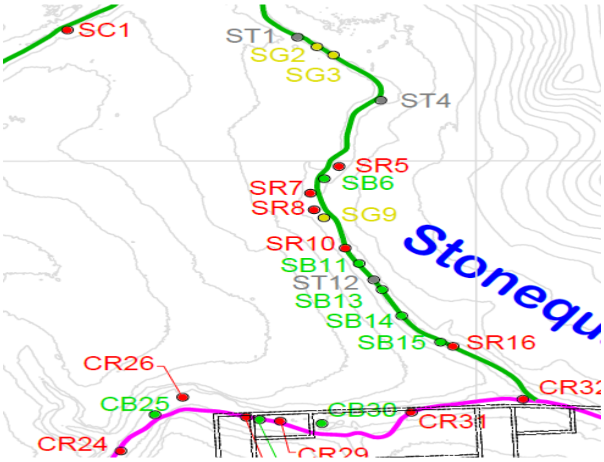
Stonequarry Creek – Pool SR16

Photograph date:29/08/2019

Downstream

Upstream

Additional Photo 1



Map location

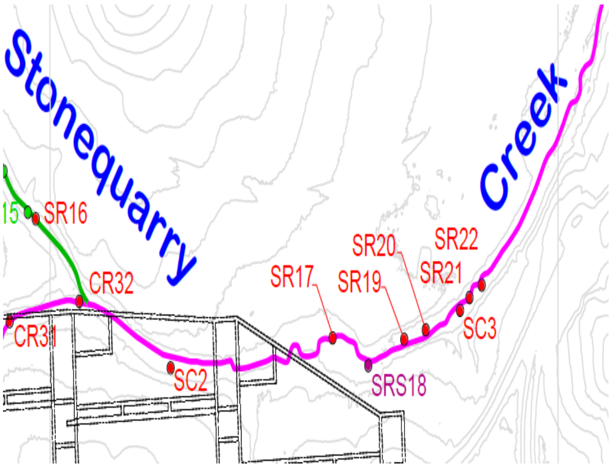
Stonequarry Creek – Pool SR17

Photograph date:29/08/2019

Downstream

Downstream

Additional Photo 1



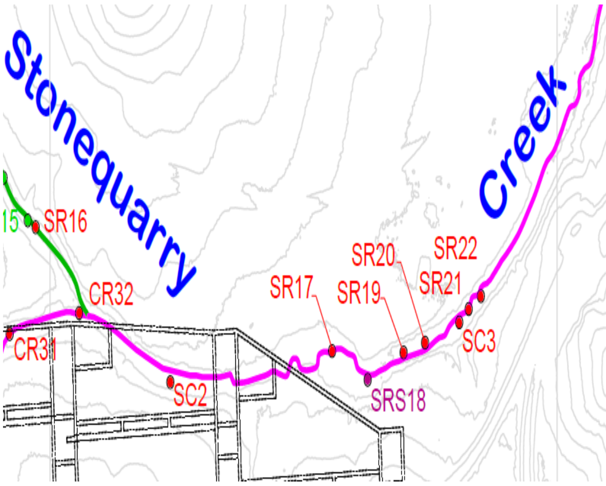
Map location

Stonequarry Creek – Pool SRS18

Photograph date:29/08/2019

Downstream

Additional Photo 1



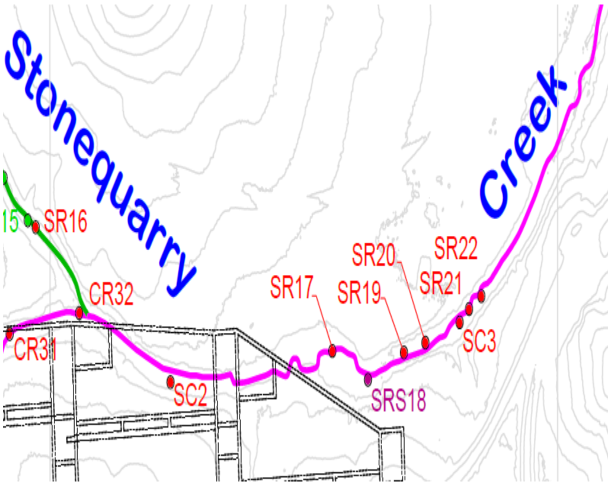
Map location

Stonequarry Creek – Pool SR19

Photograph date:29/08/2019

Downstream

Additional Photo 1



Map location

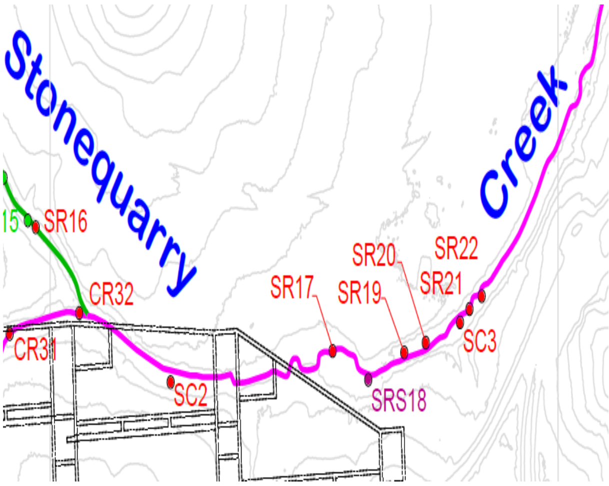
Stonequarry Creek – Pool SR20

Photograph date:29/08/2019

Upstream

Downstream

Additional Photo 1



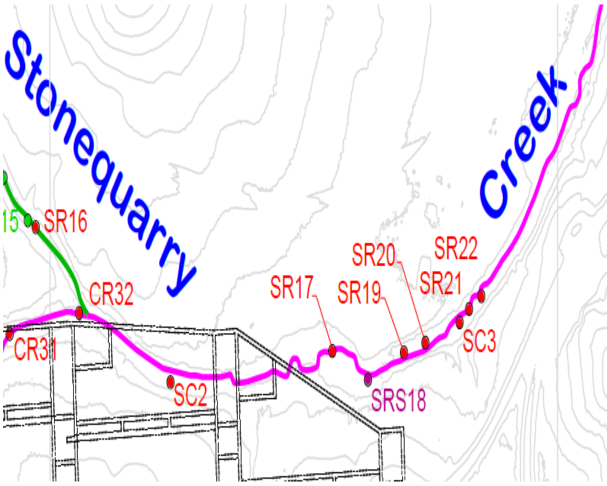
Map location

Stonequarry Creek – Pool SR22

Photograph date:29/08/2019

Downstream

Additional Photo 1



Map location

APPENDIX B – MONITORED WATER LEVEL HYDROGRAPHS

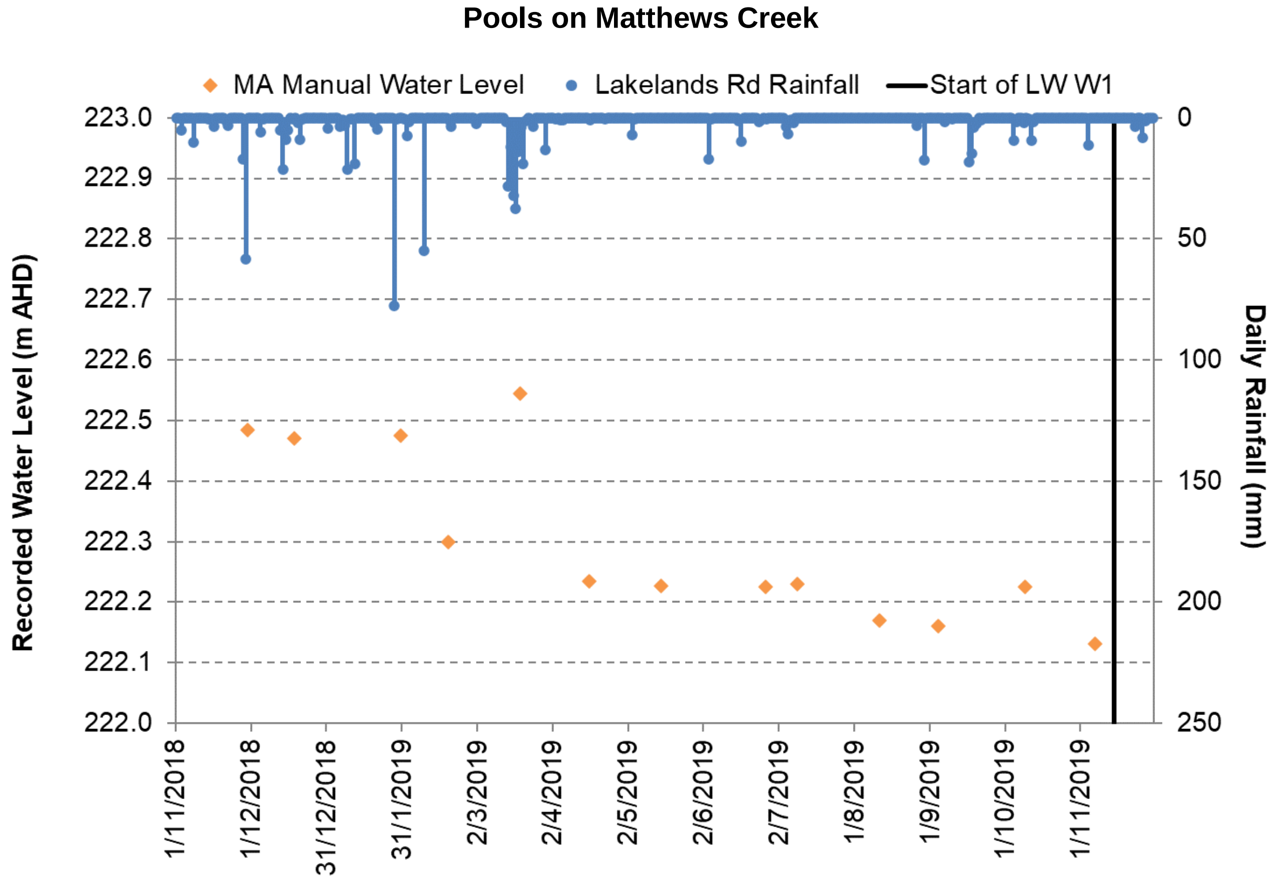
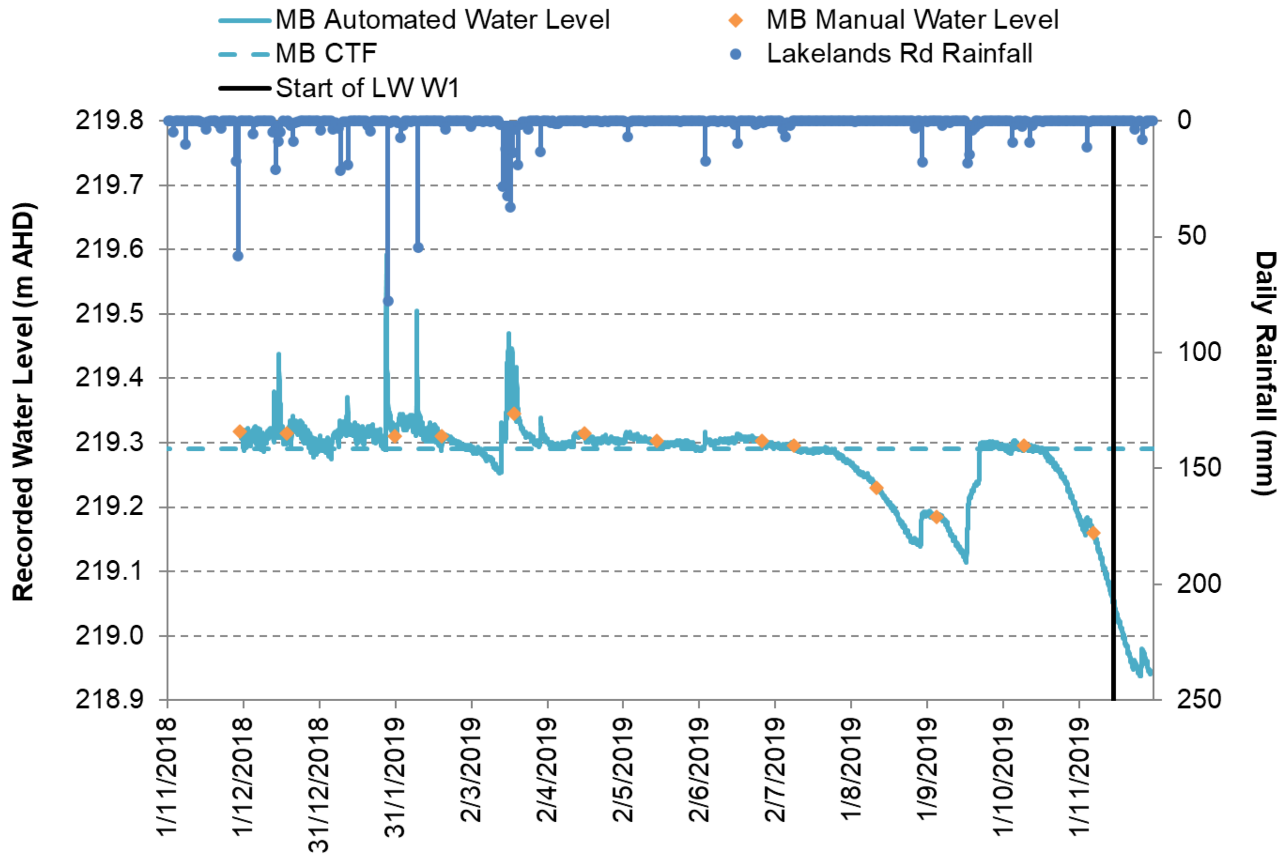


Chart B1 Matthews Creek MA Water Level



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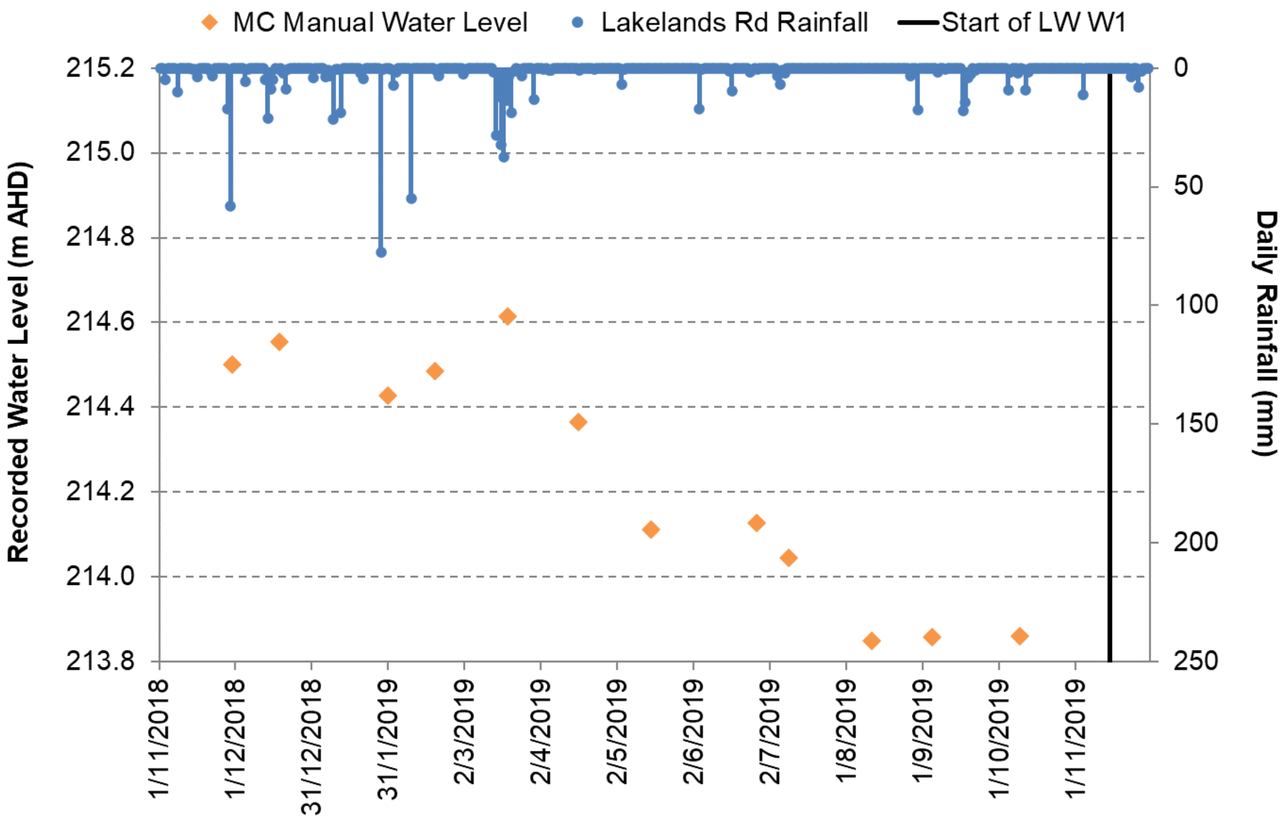


Chart B3 Matthews Creek MC Water Level

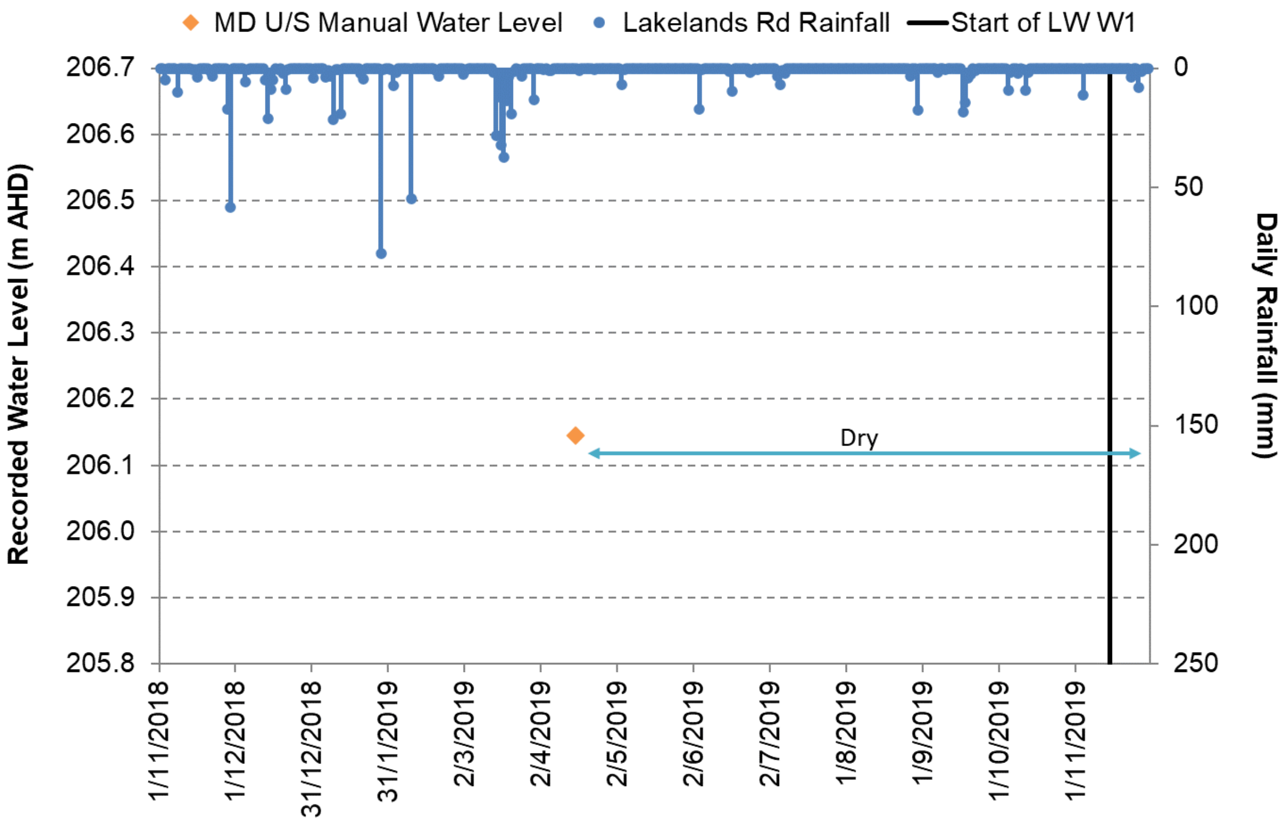


Chart B4 Matthews Creek MD Upstream (U/S) Water Level

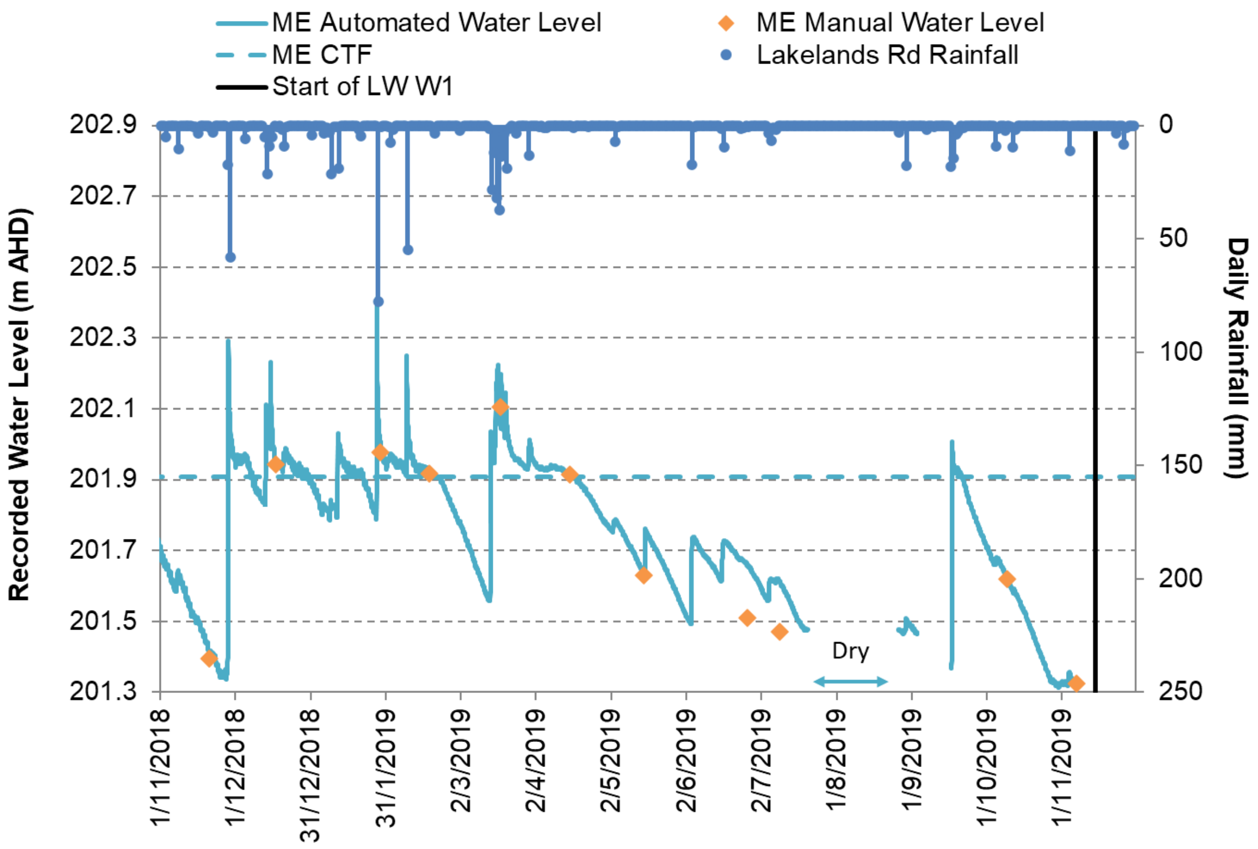


Chart B5 Matthews Creek ME Water Level

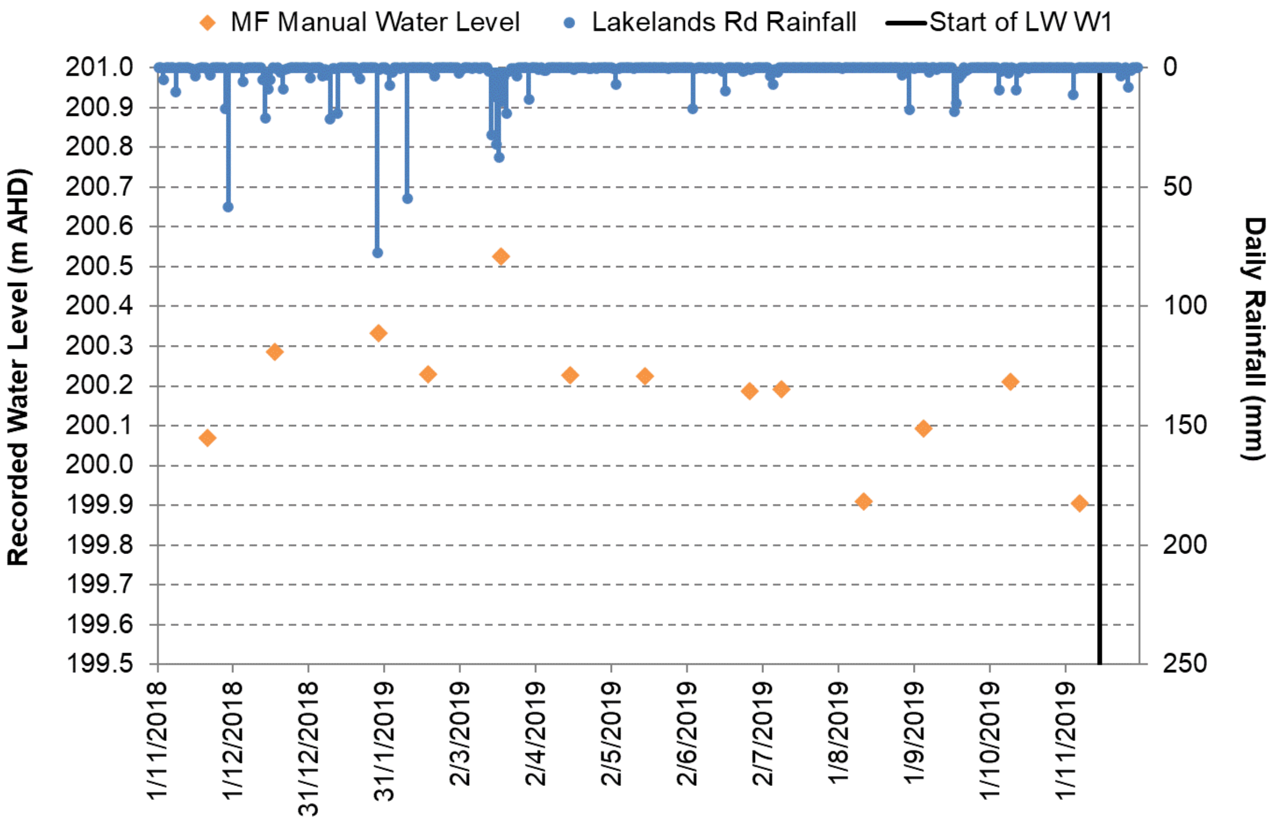


Chart B6 Matthews Creek MF Water Level

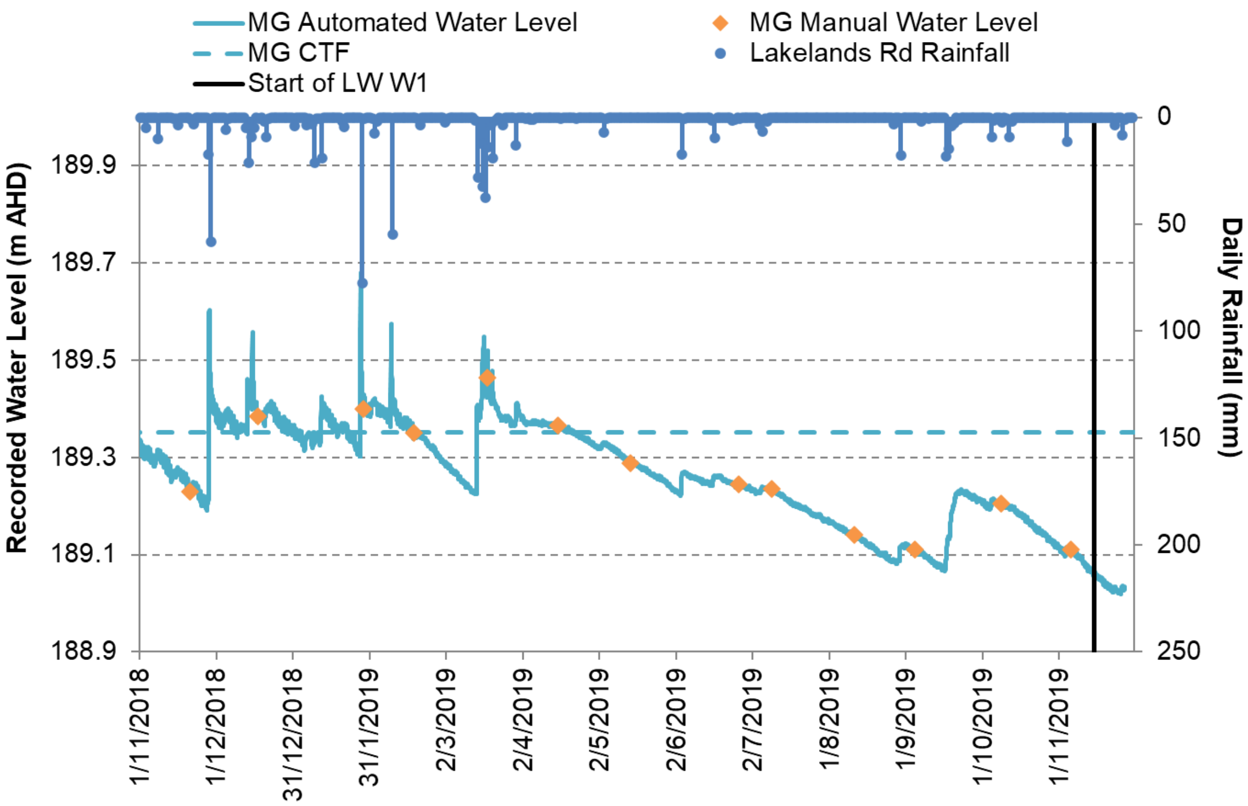


Chart B7 **Matthews Creek MG Water Level**

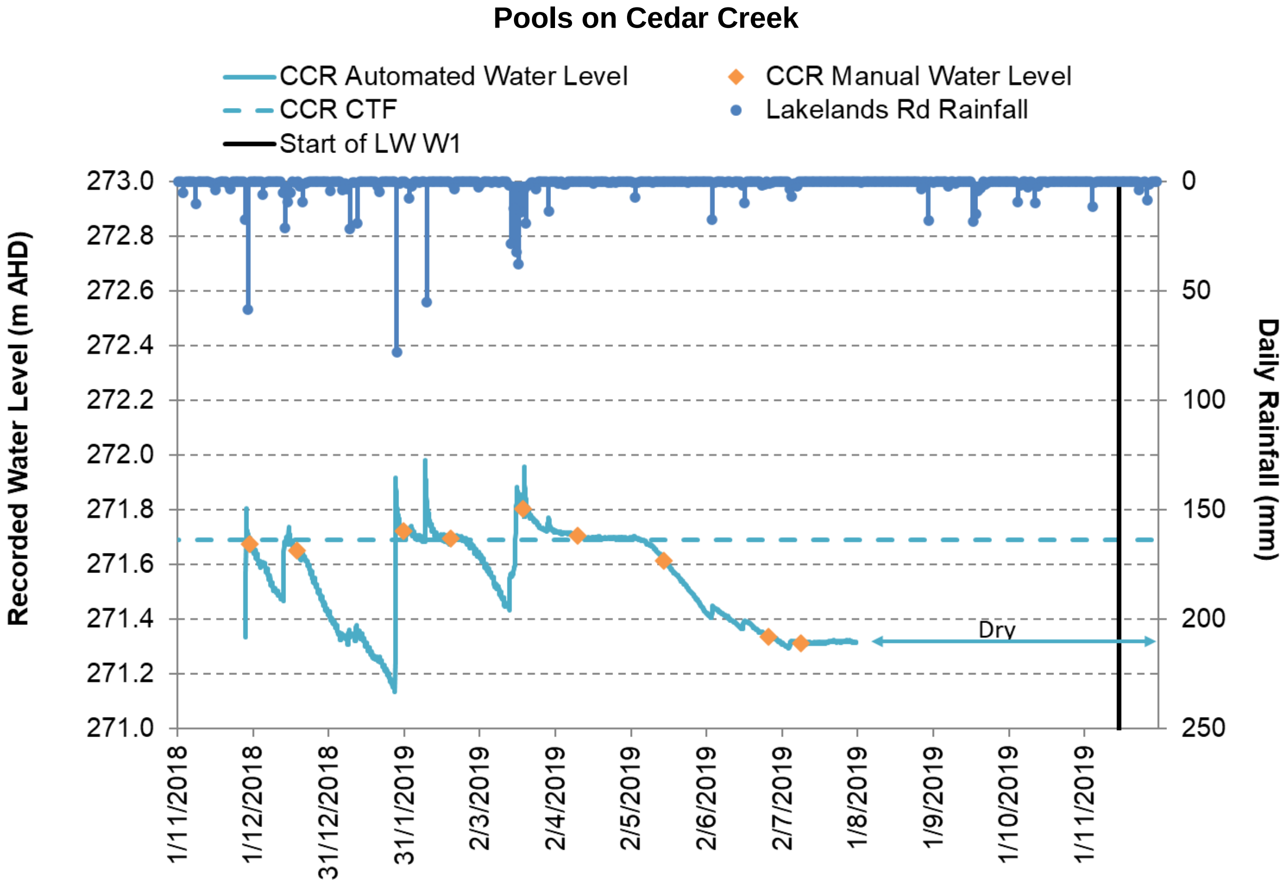


Chart B8 Cedar Creek CCR Water Level

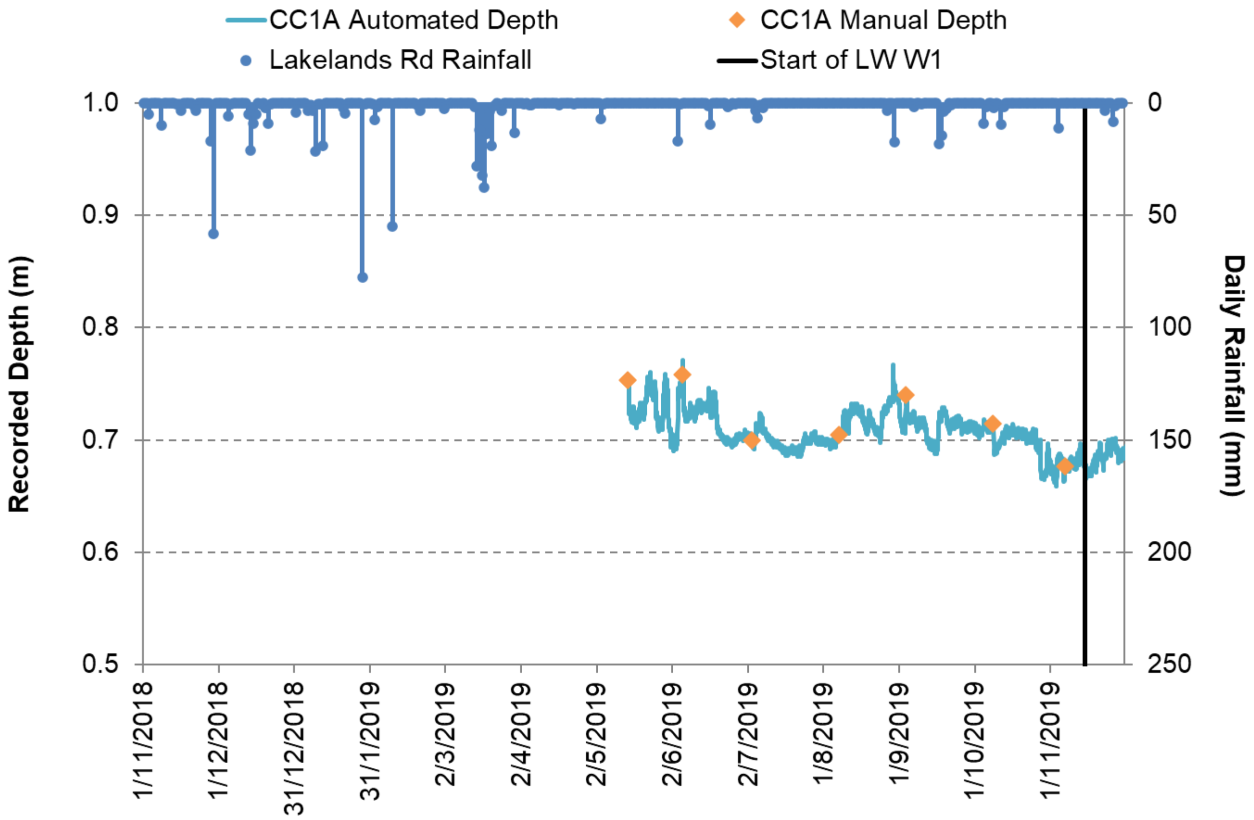


Chart B9 Cedar Creek CC1A Water Level

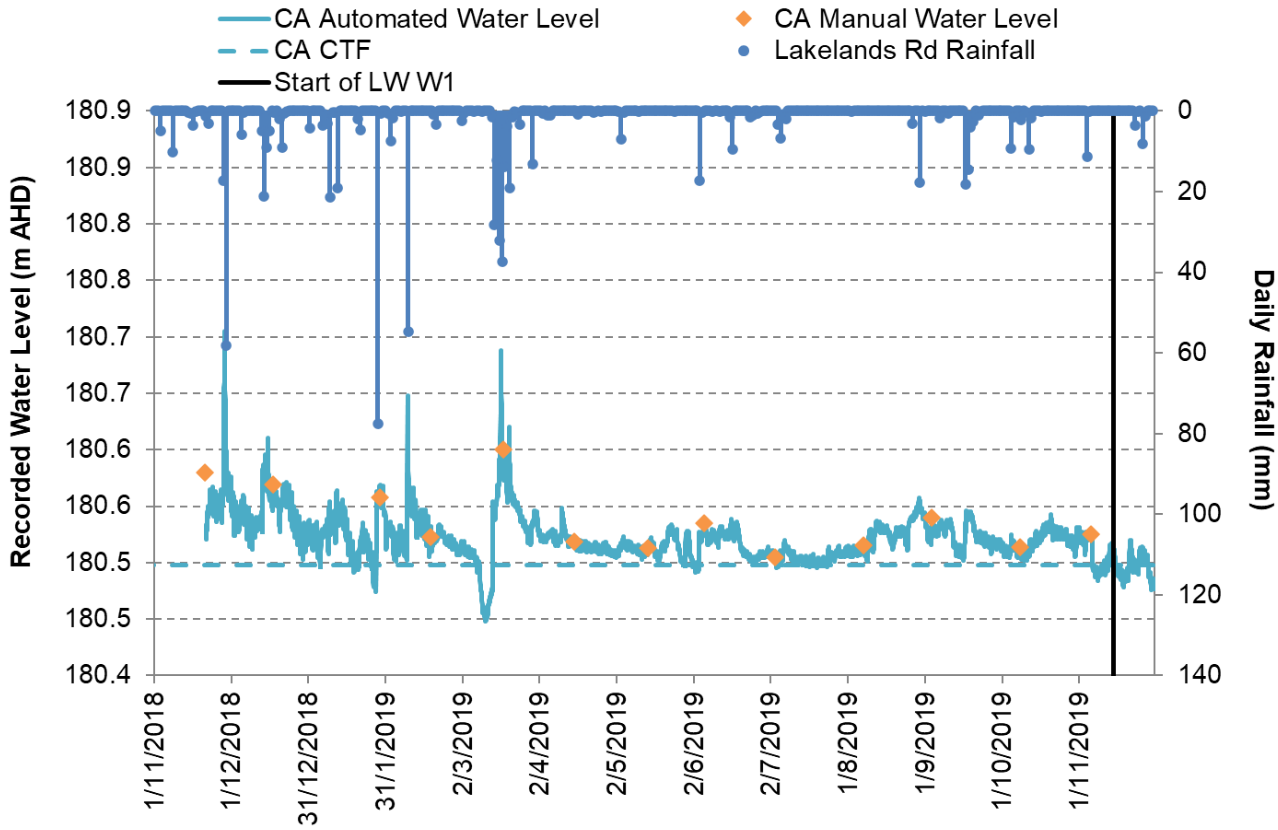


Chart B10 Cedar Creek CA Water Level

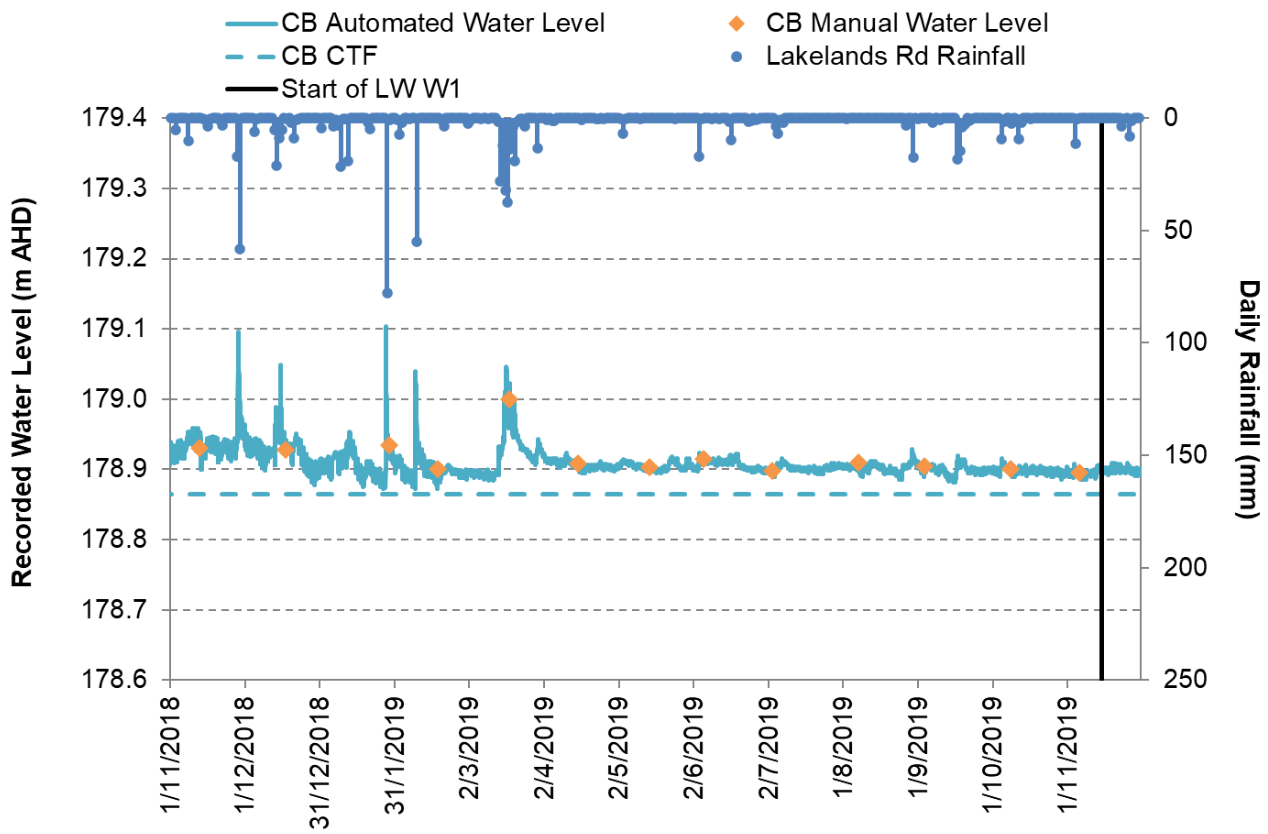


Chart B11 Cedar Creek CB Water Level

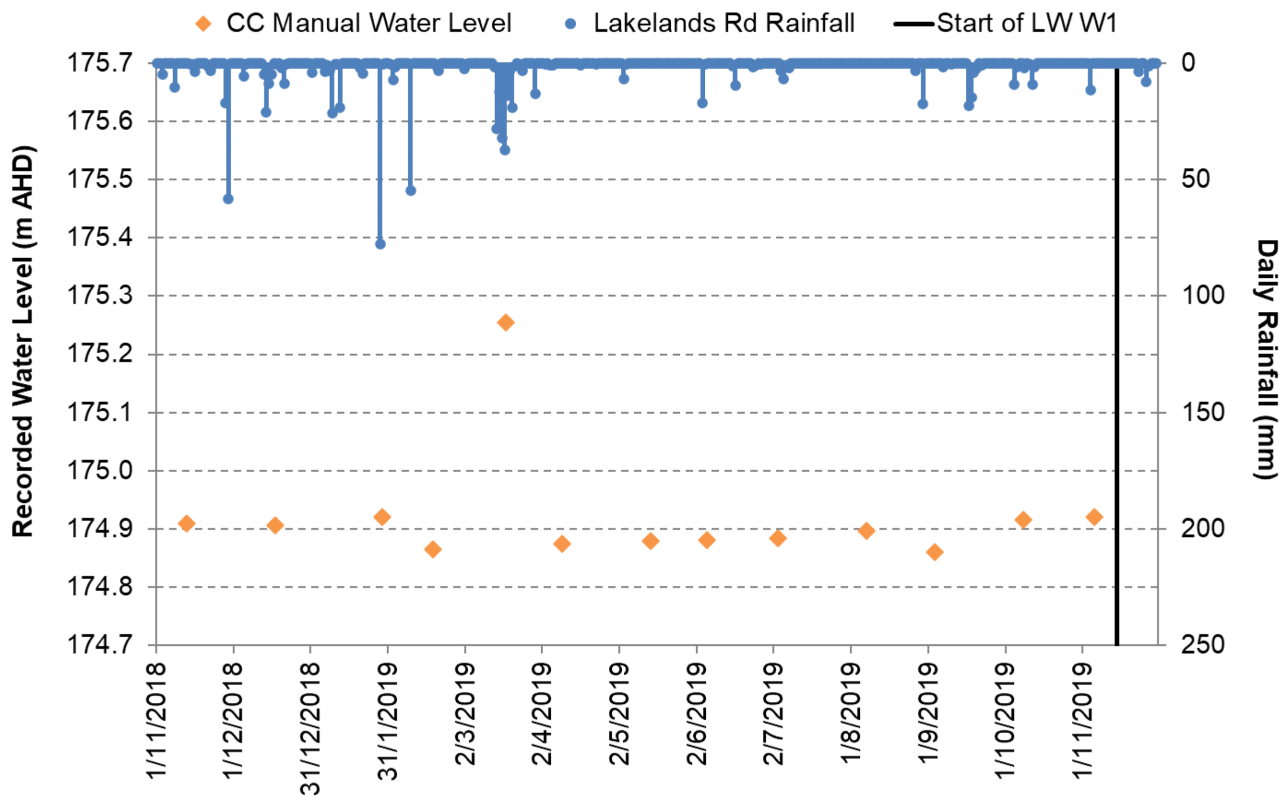


Chart B12 Cedar Creek CC Water Level

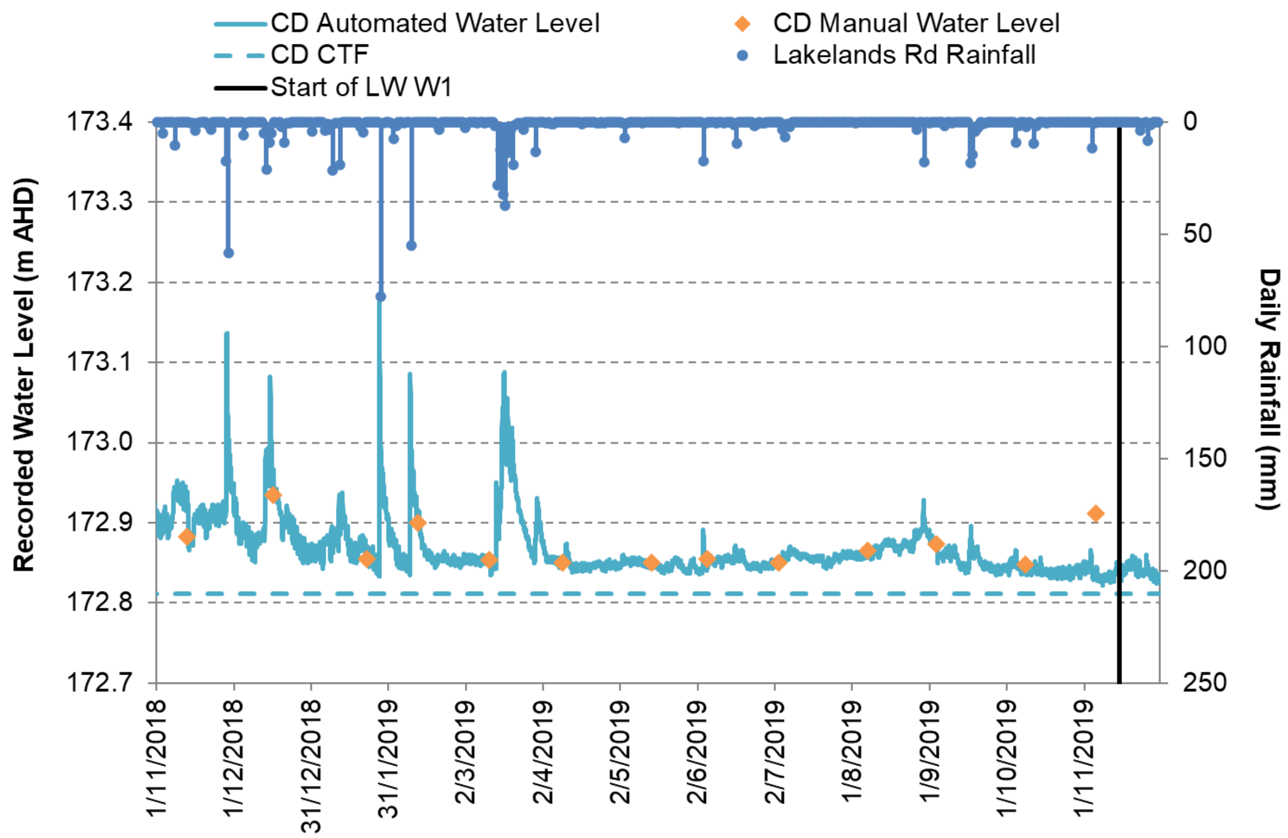


Chart B13 Cedar Creek CD Water Level

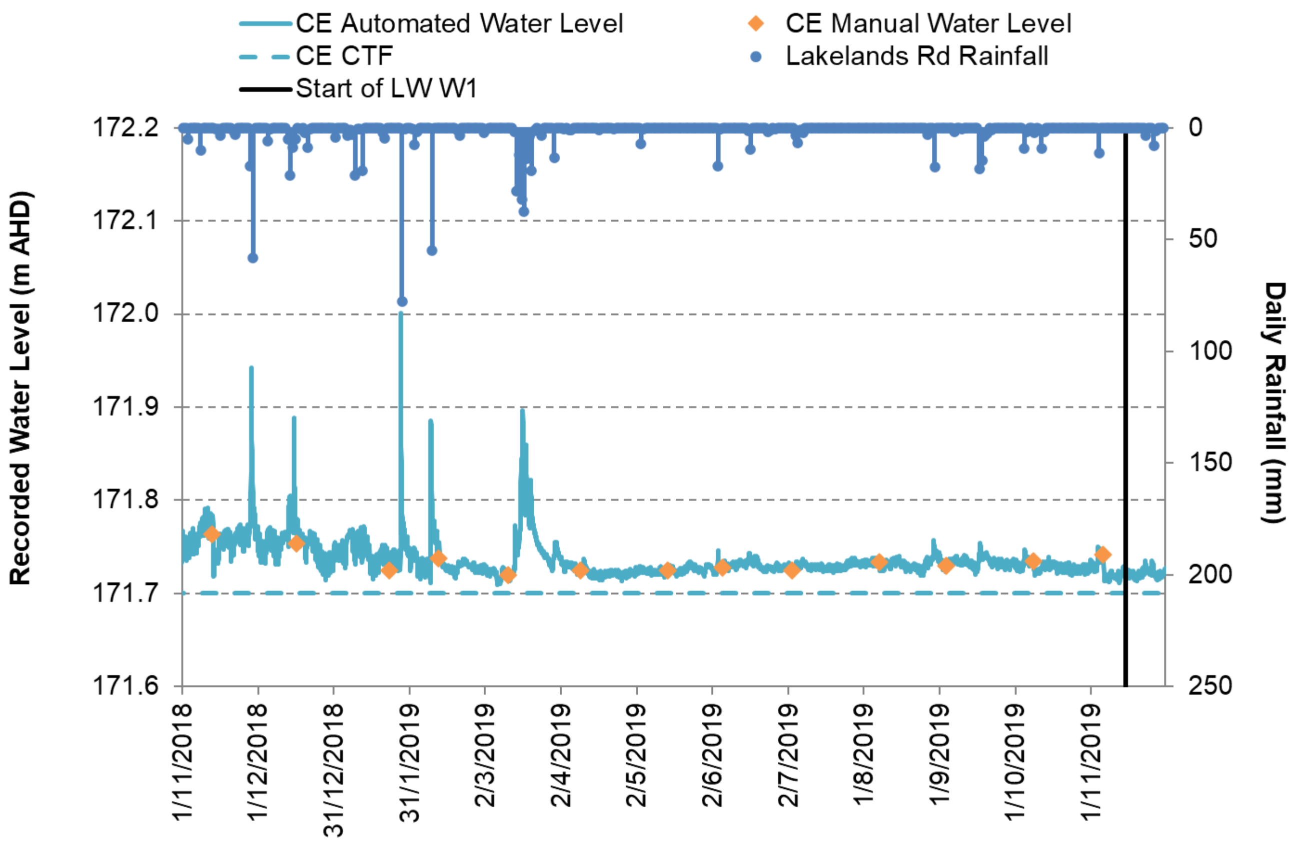


Chart B14 Cedar Creek CE Water Level

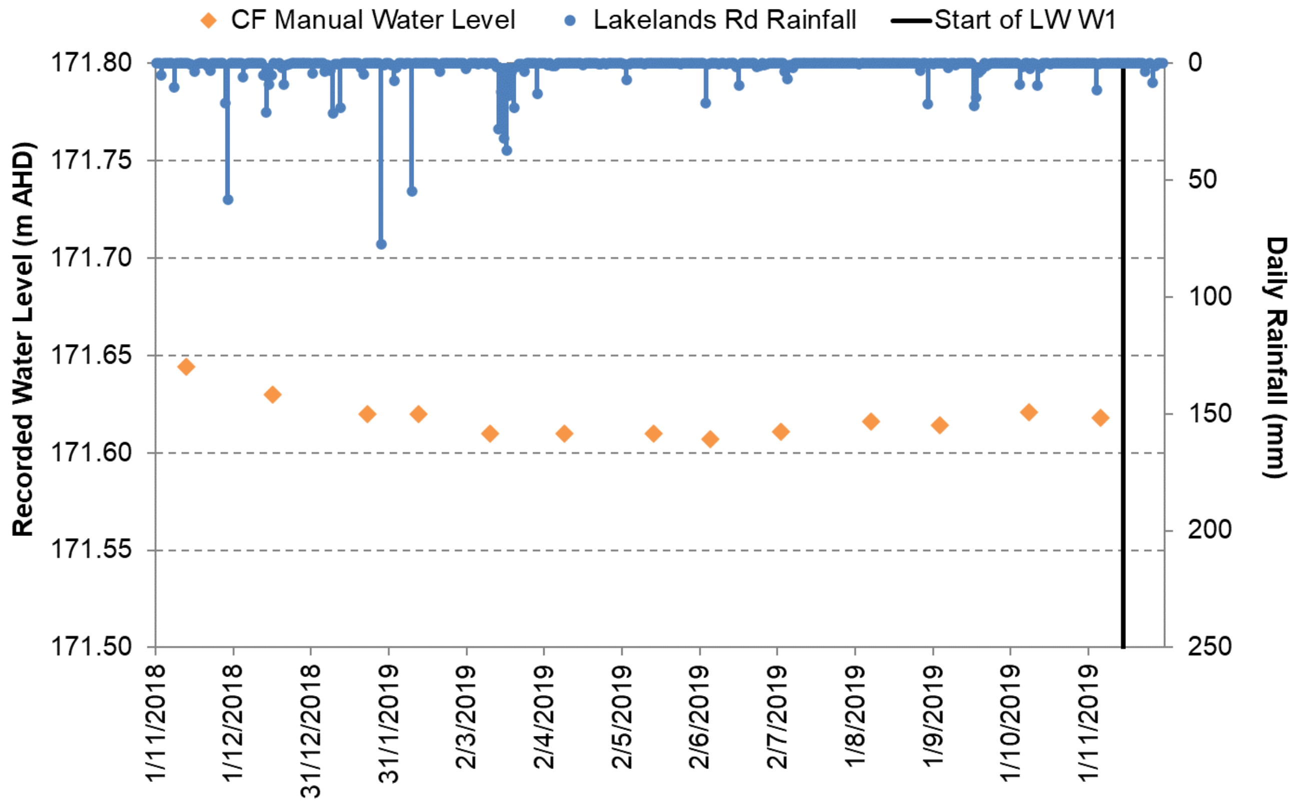


Chart B15 Cedar Creek CF Water Level

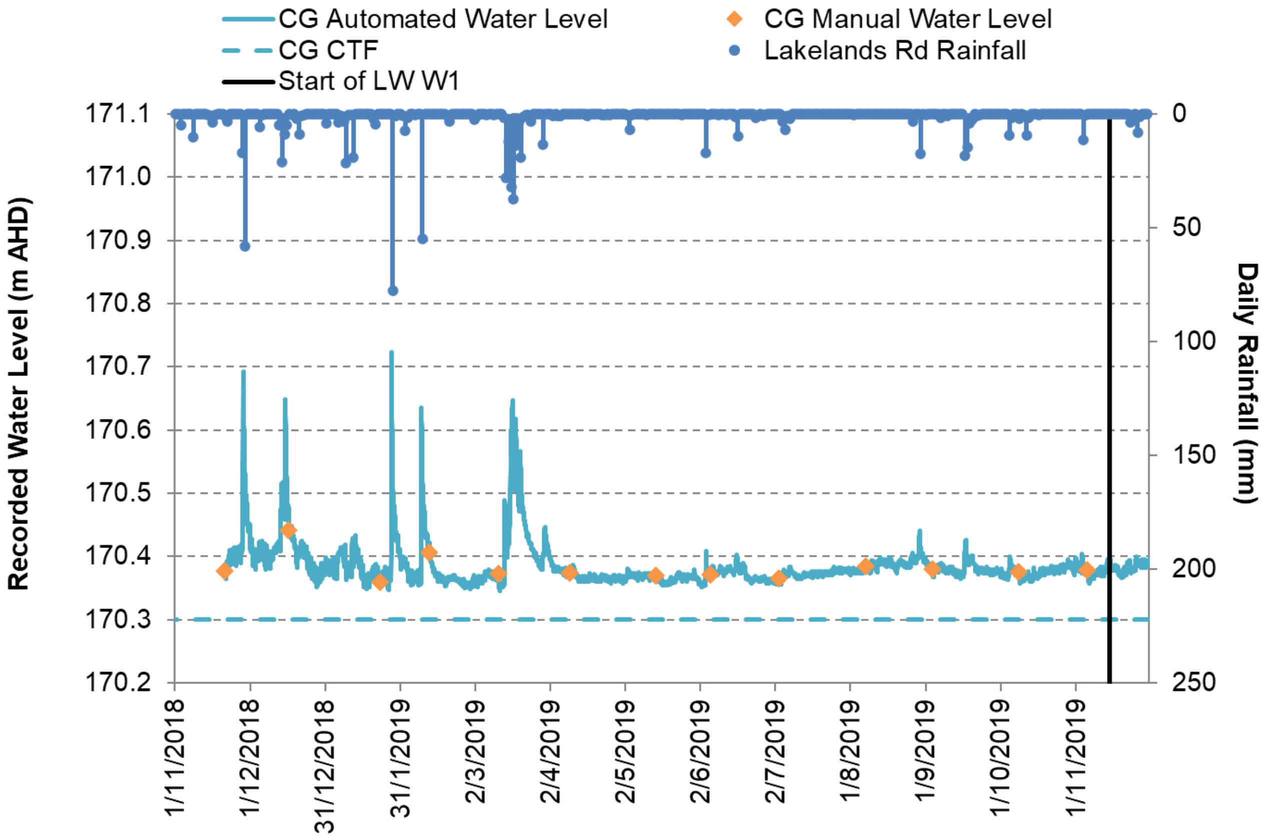


Chart B16 Cedar Creek CG Water Level

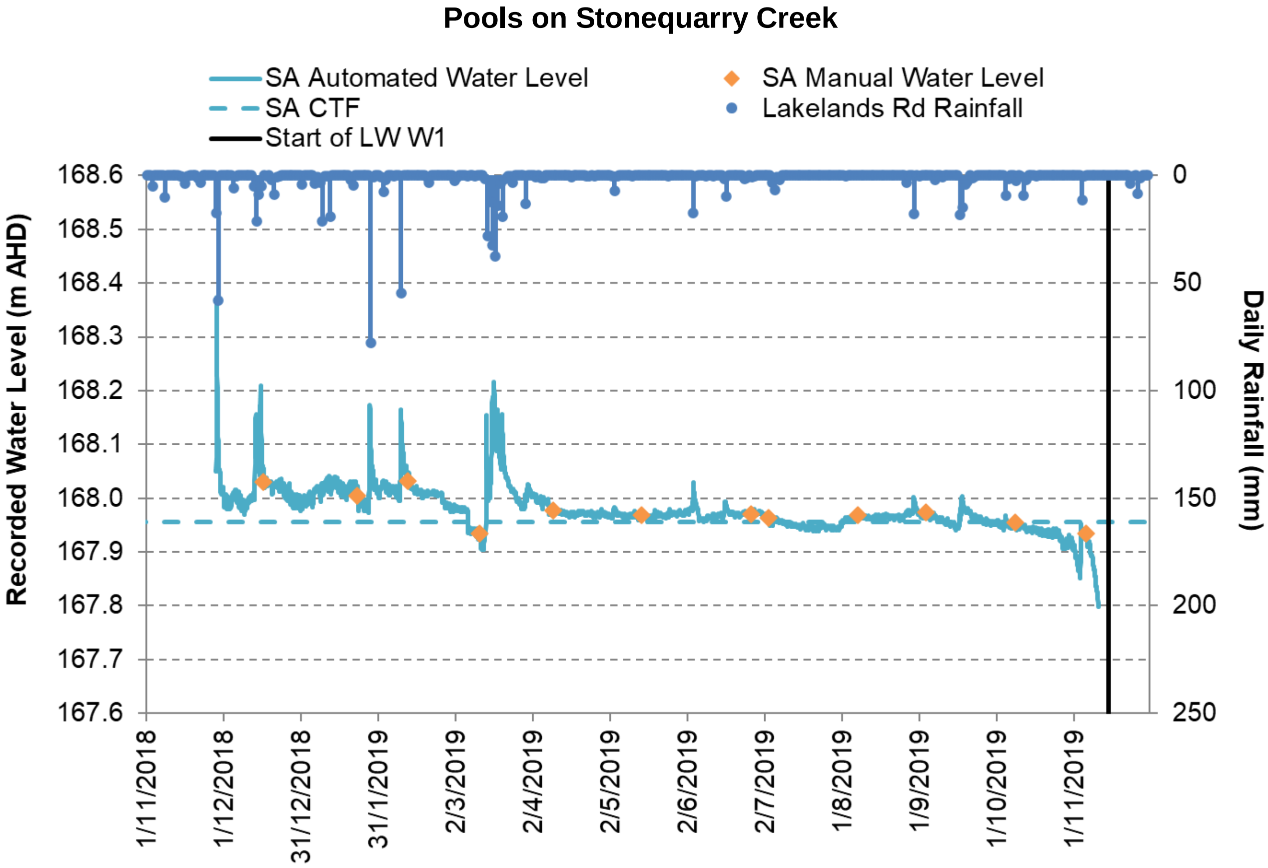


Chart B17 Stonequarry Creek SA Water Level

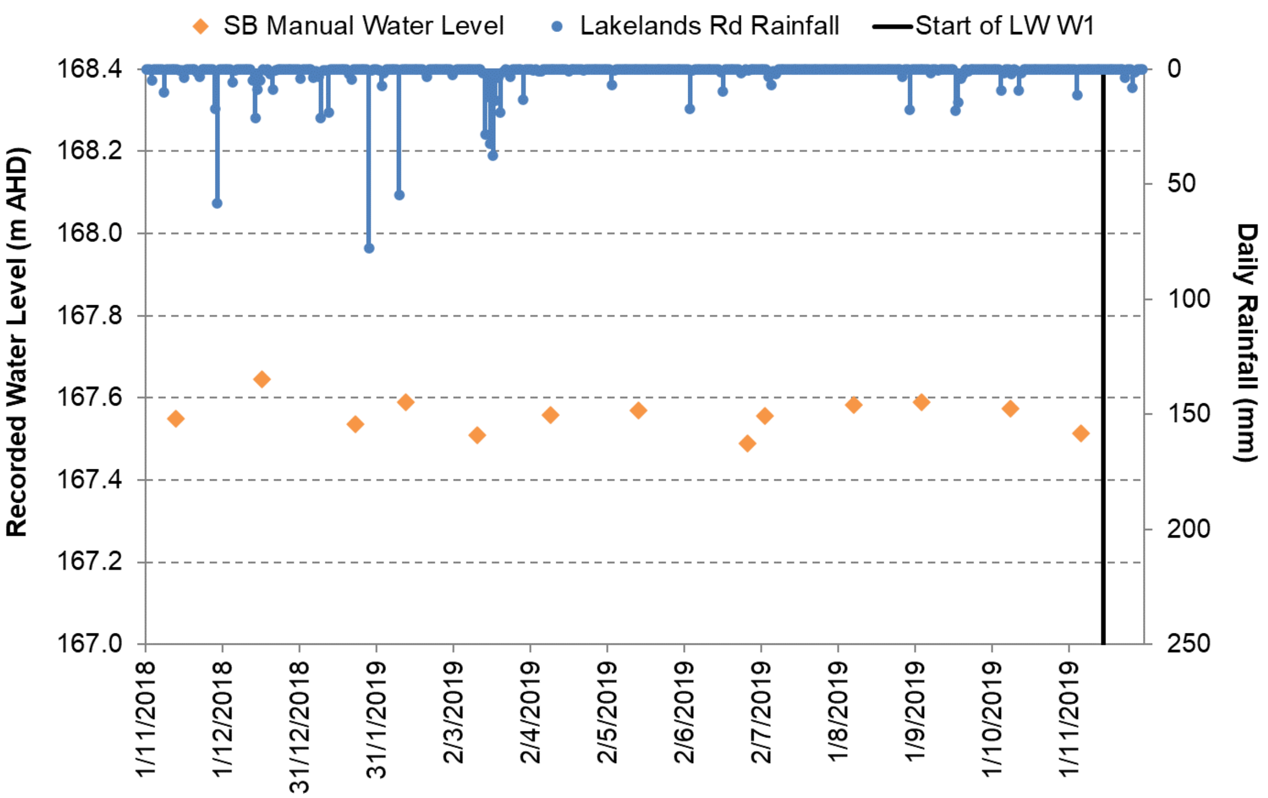


Chart B18 Stonequarry Creek SB Water Level

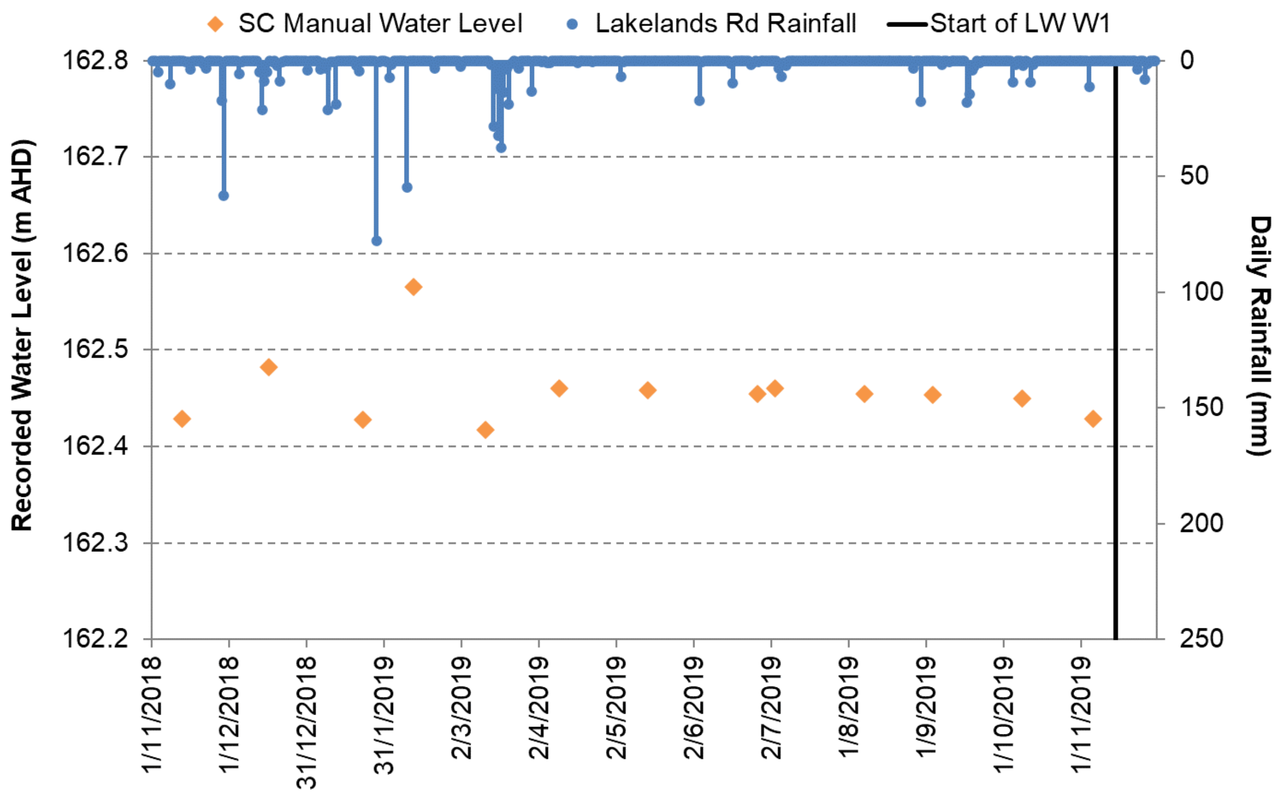


Chart B19 Stonequarry Creek SC Water Level

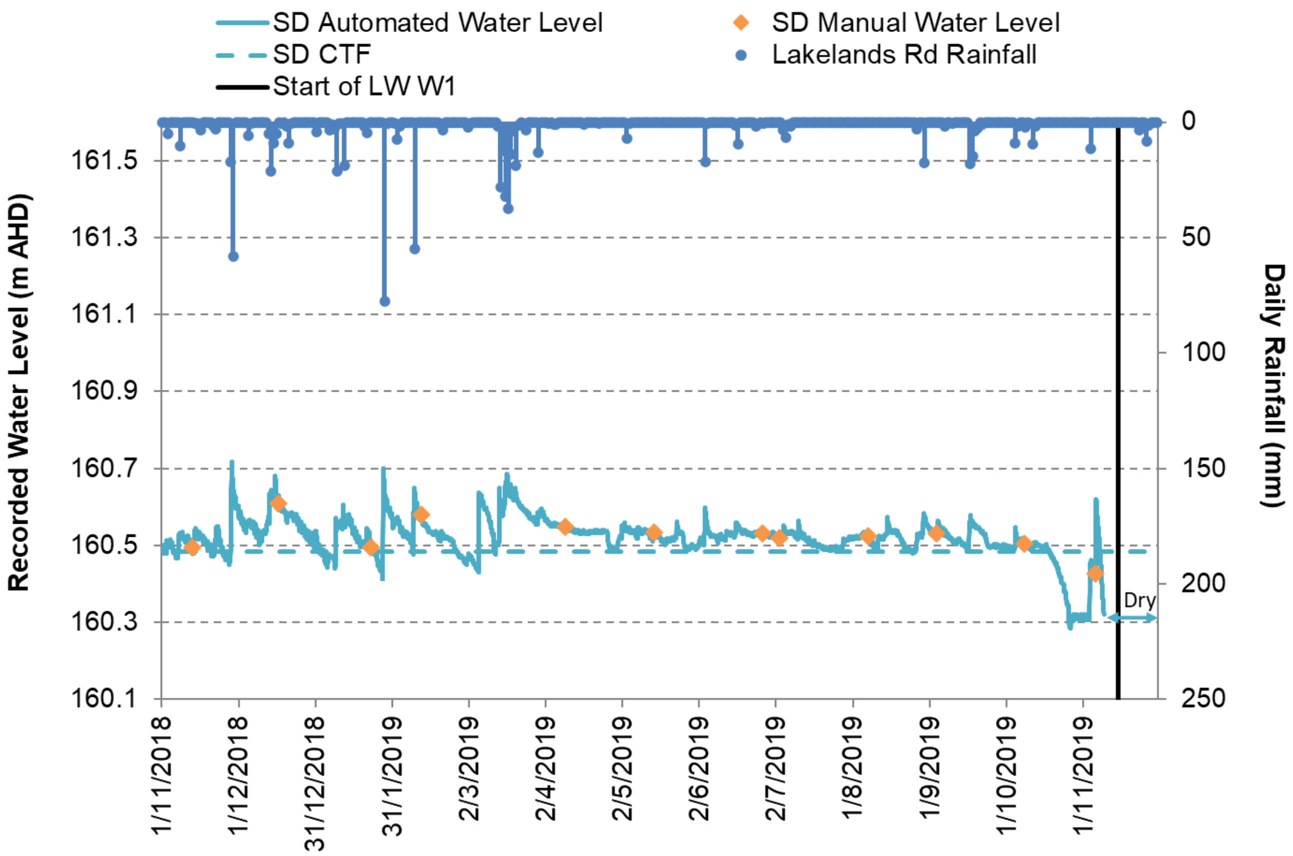


Chart B20 Stonequarry Creek SD Water Level

APPENDIX C – SURFACE WATER QUALITY MONITORING

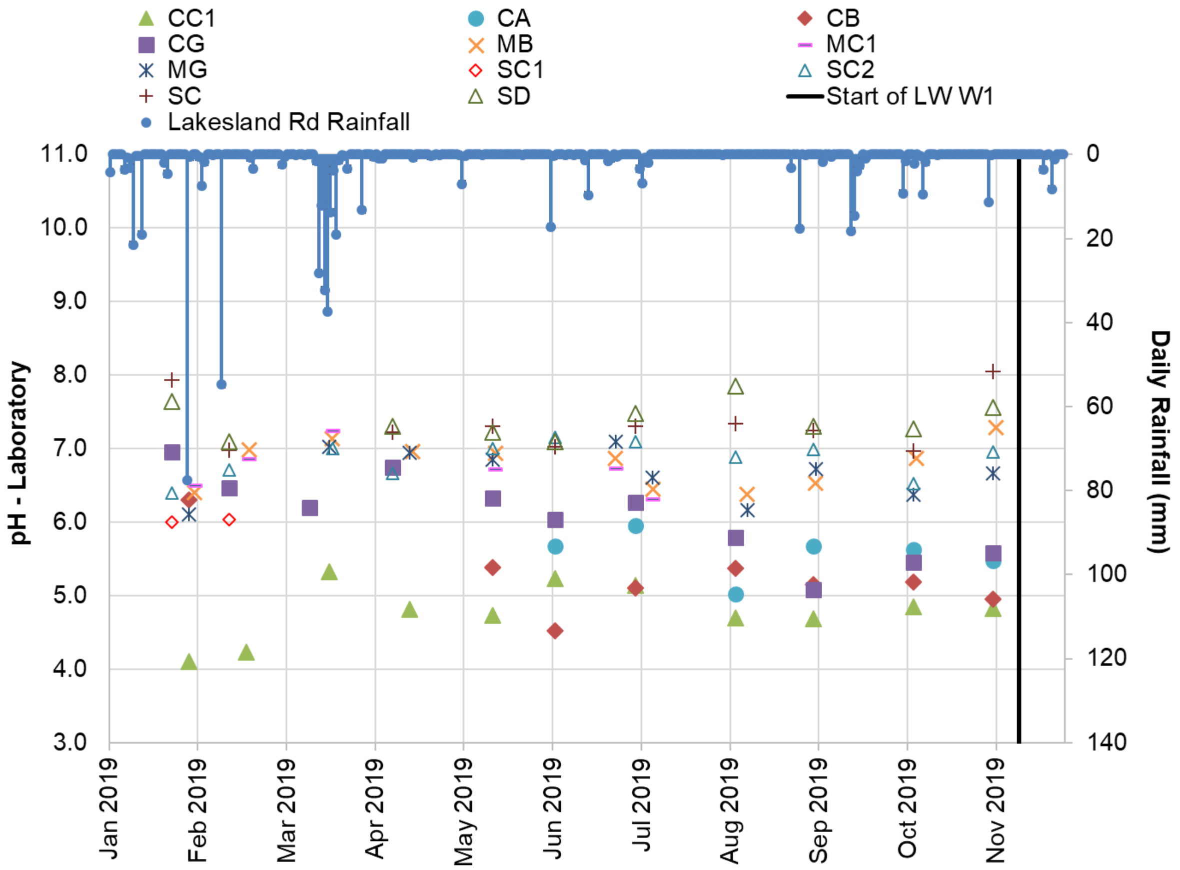


Chart C1 pH Values (Laboratory)

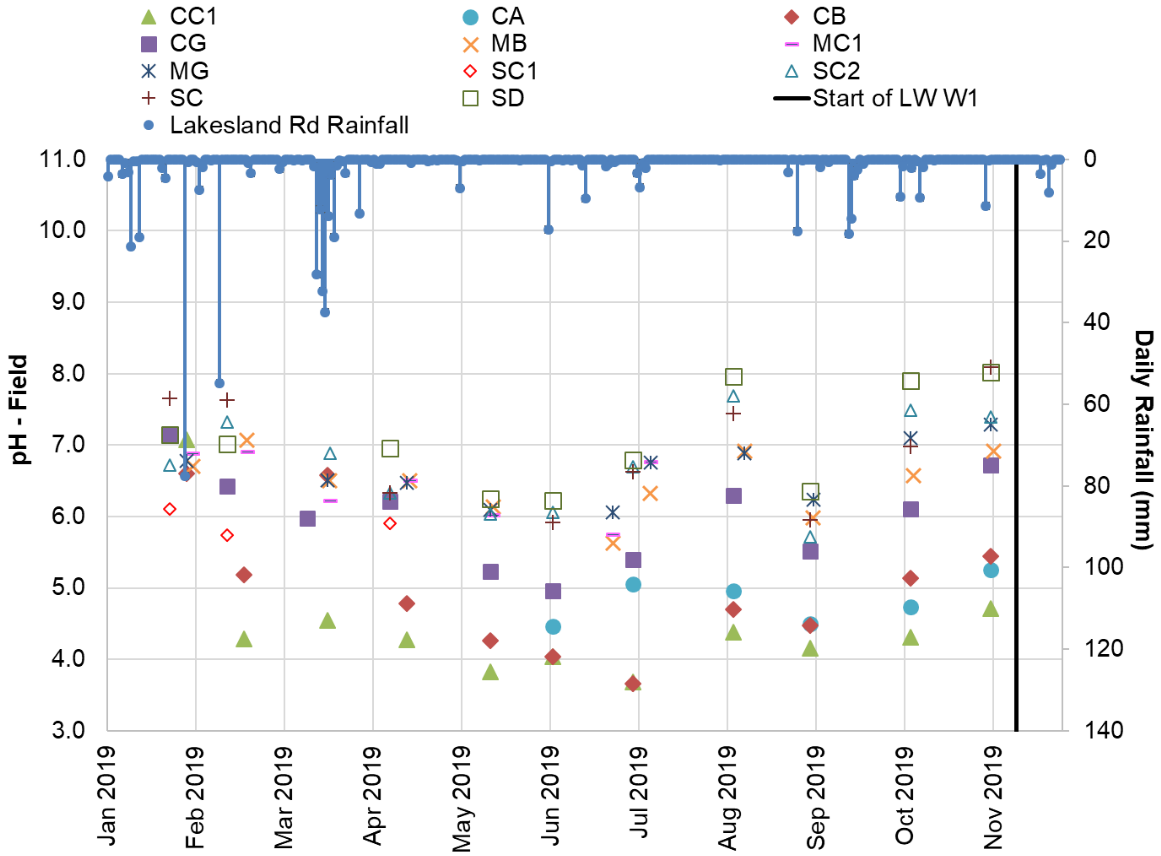


Chart C2 pH Values (Field)

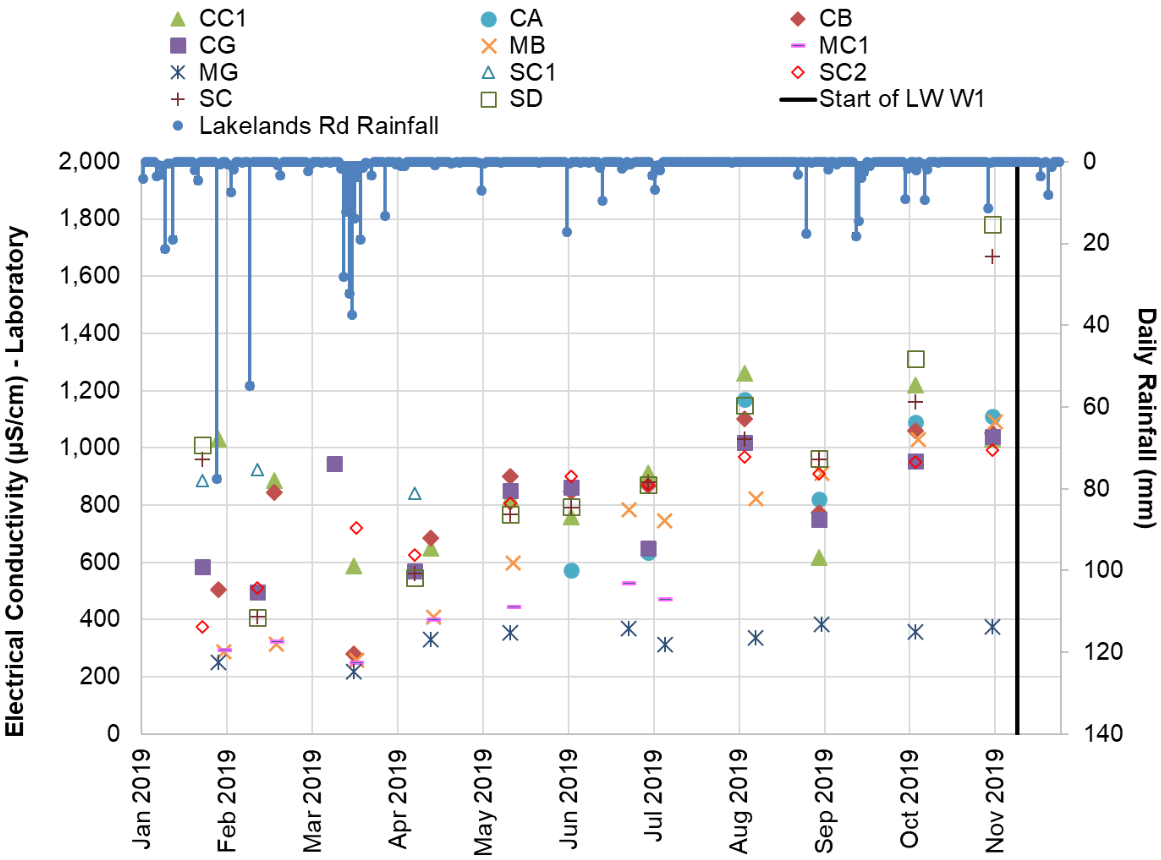


Chart C3 Electrical Conductivity (Laboratory)

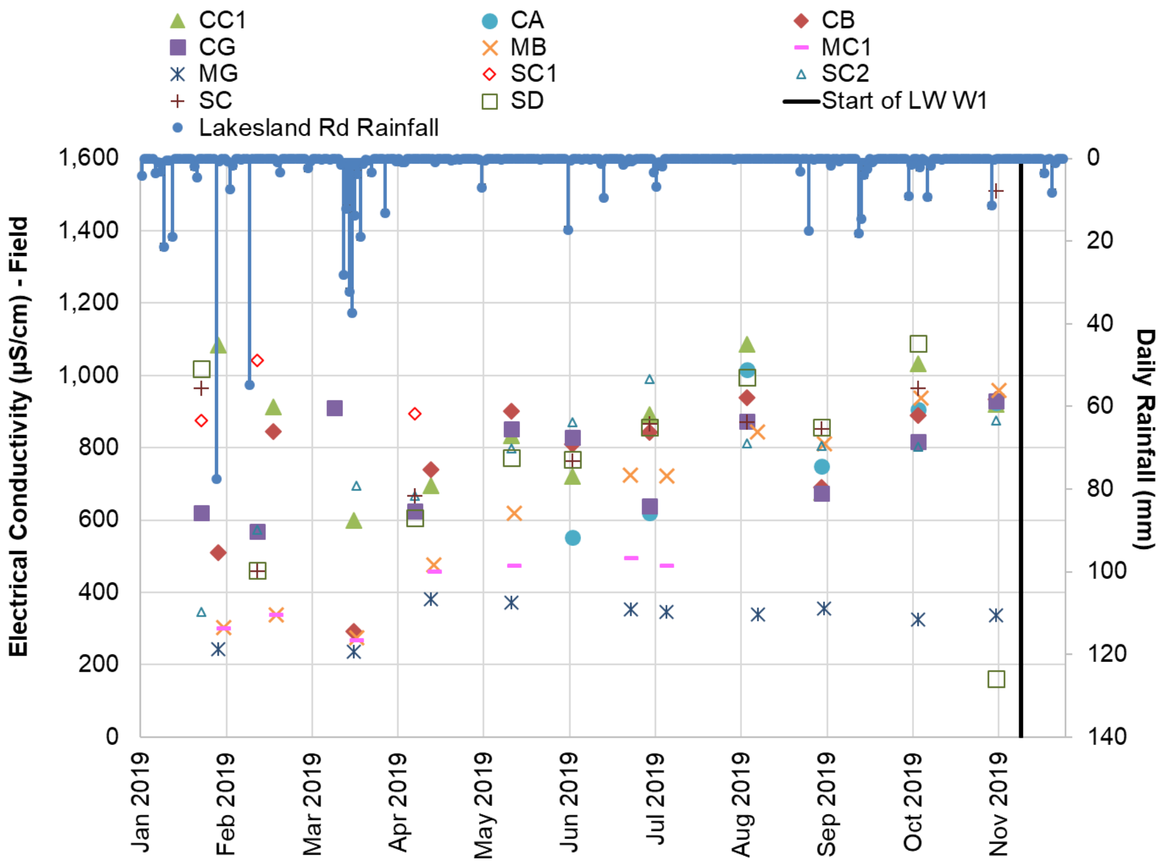


Chart C4 Electrical Conductivity (Field)

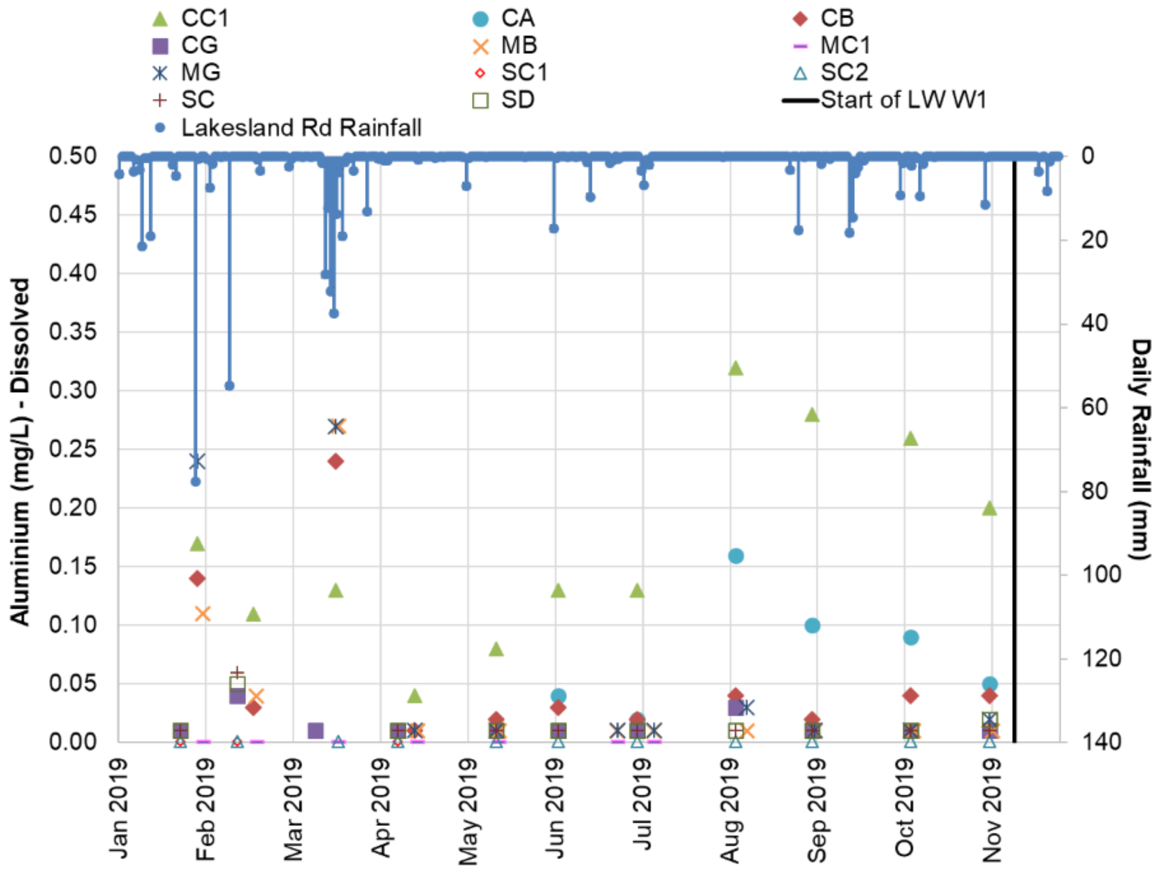


Chart C5 Dissolved Aluminium

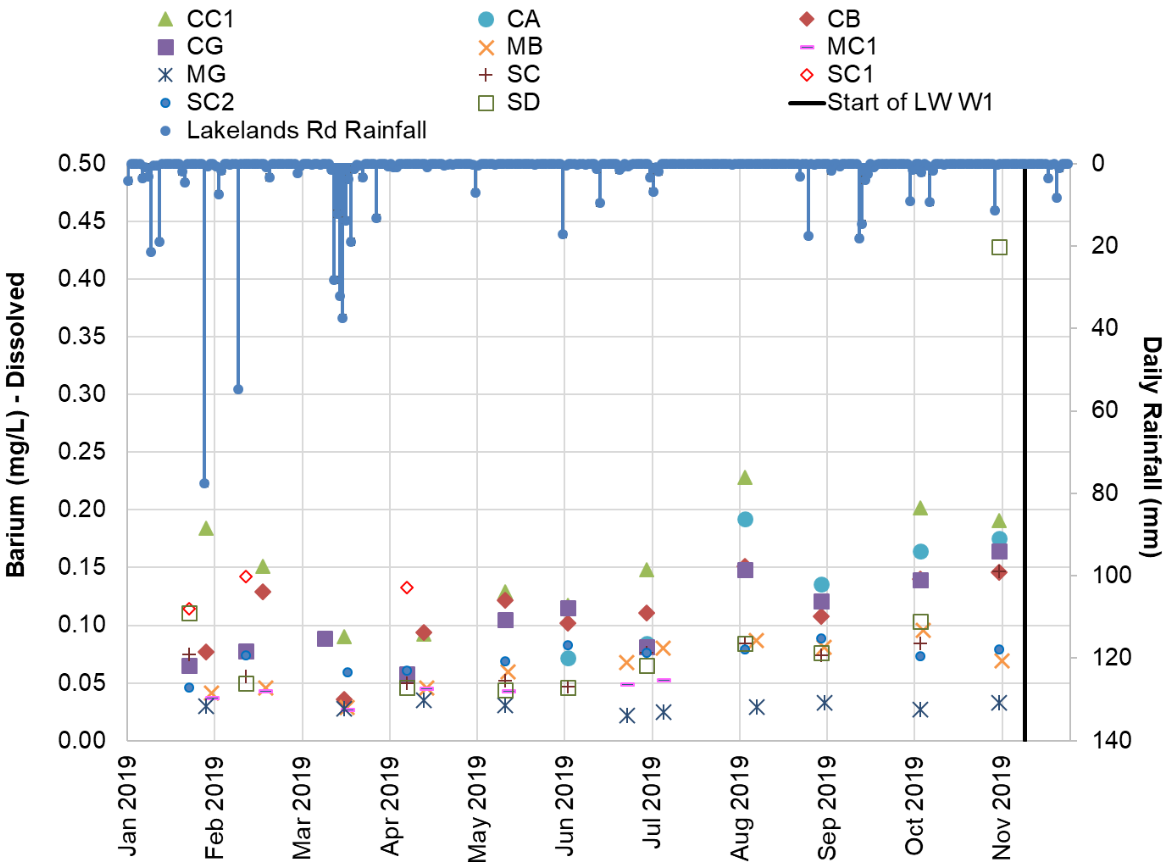


Chart C6 Dissolved Barium

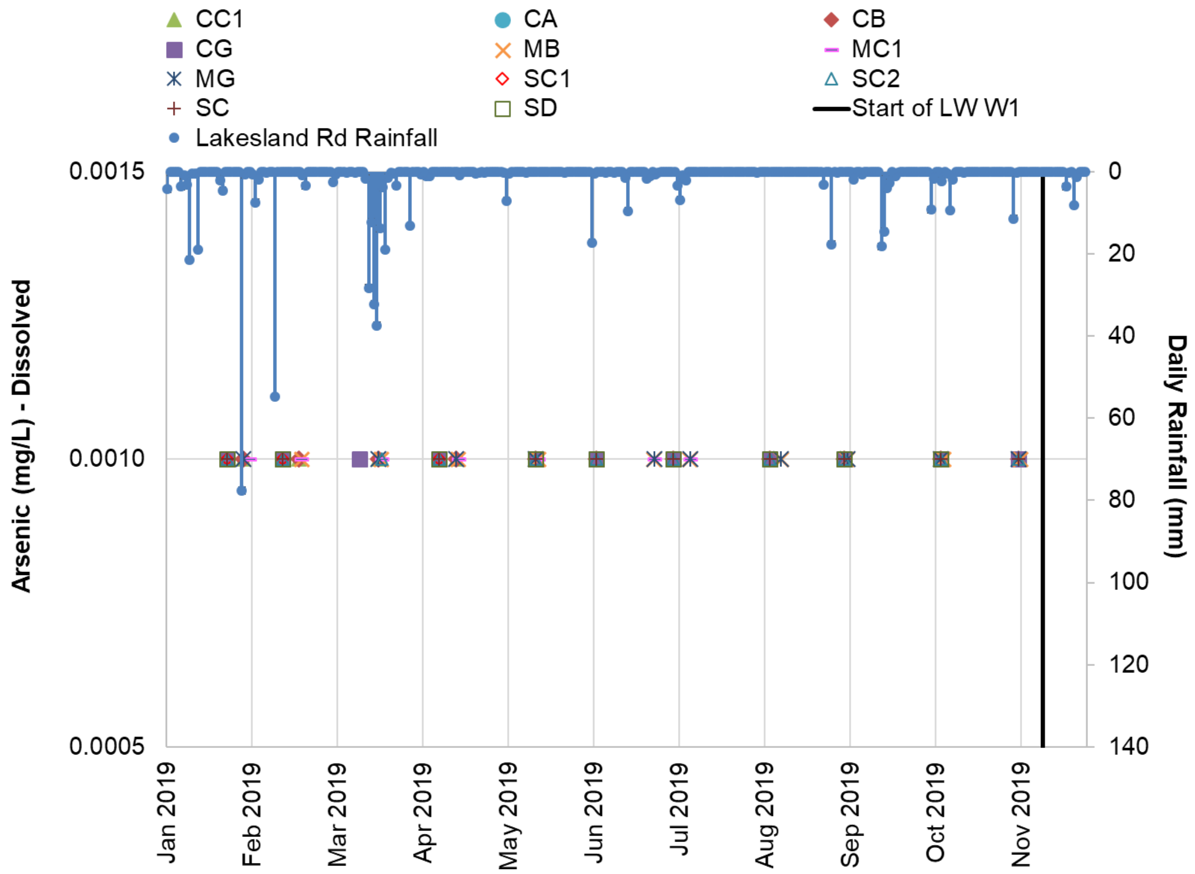


Chart C7 Dissolved Arsenic[7]

[7] All samples were recorded at the Limit of Detection (LOD) during the baseline monitoring period.

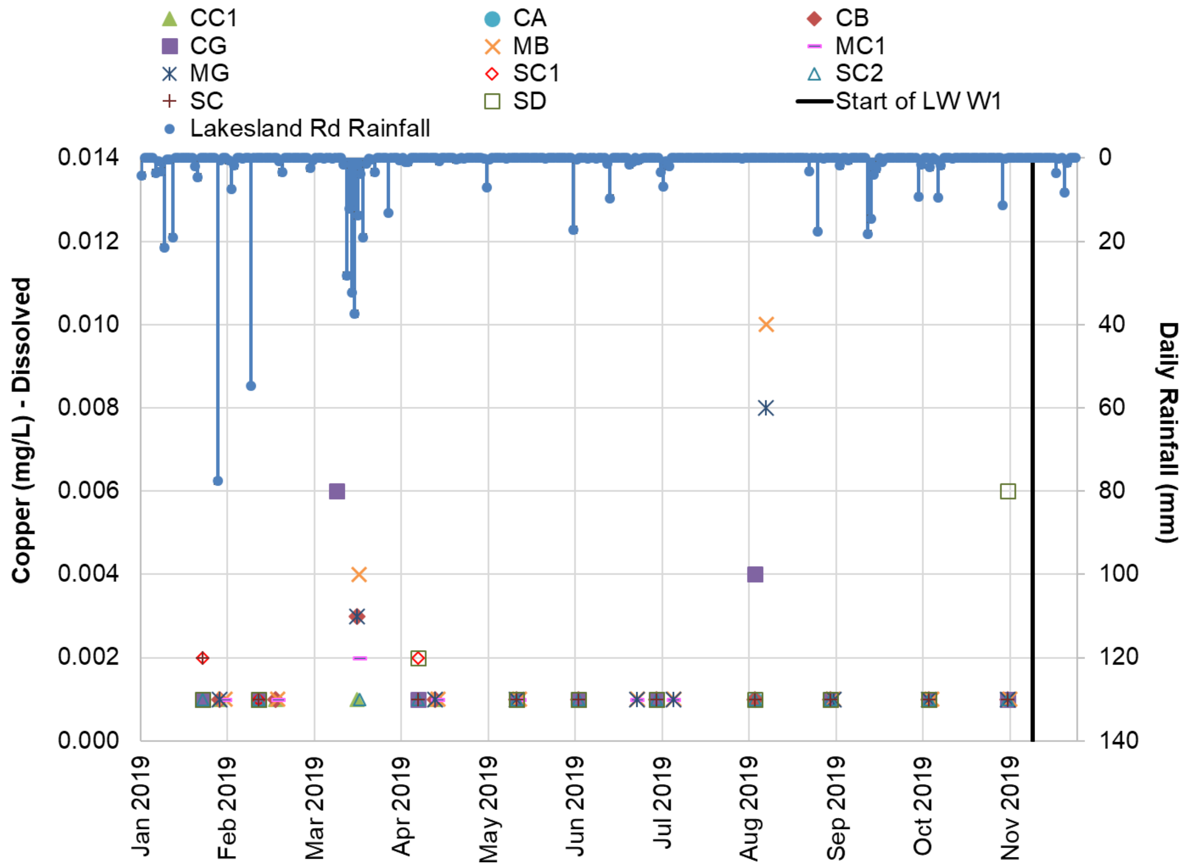


Chart C8 Dissolved Copper

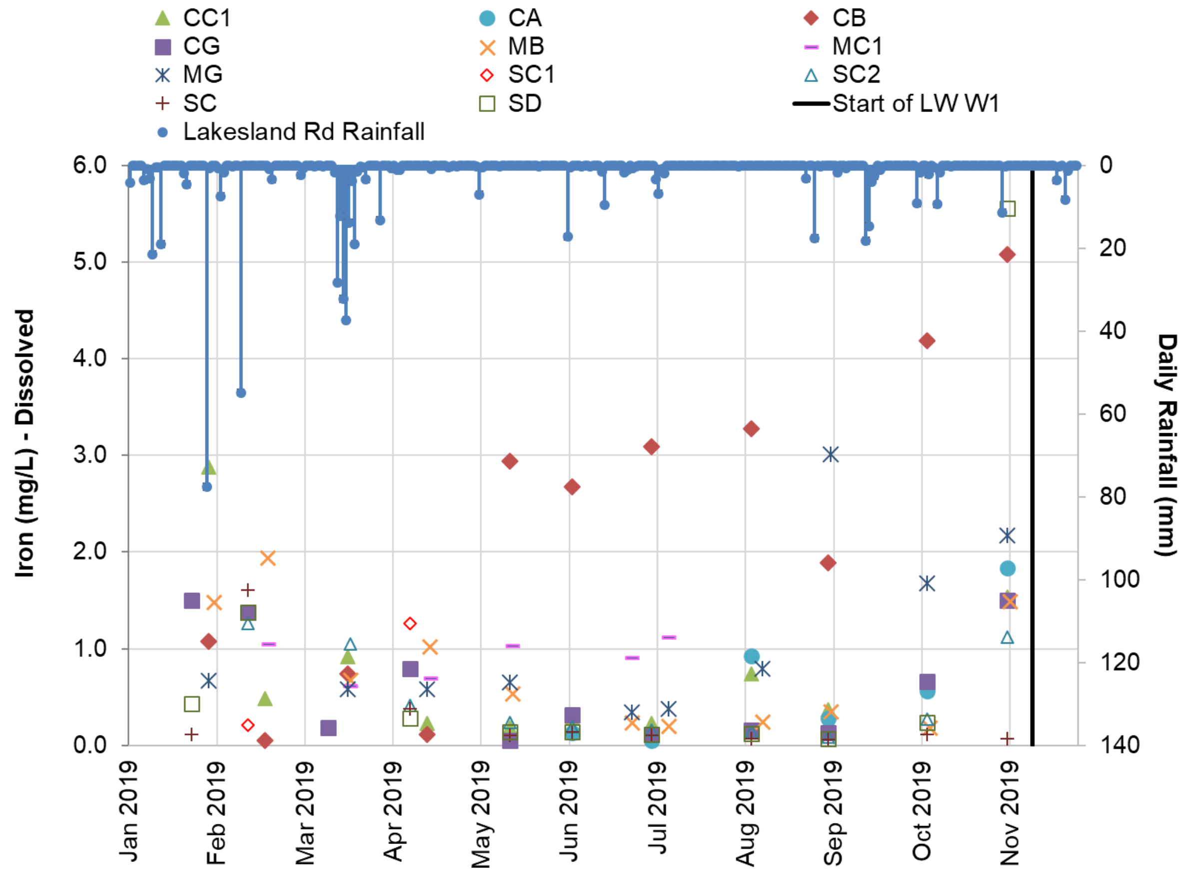


Chart C9 Dissolved Iron

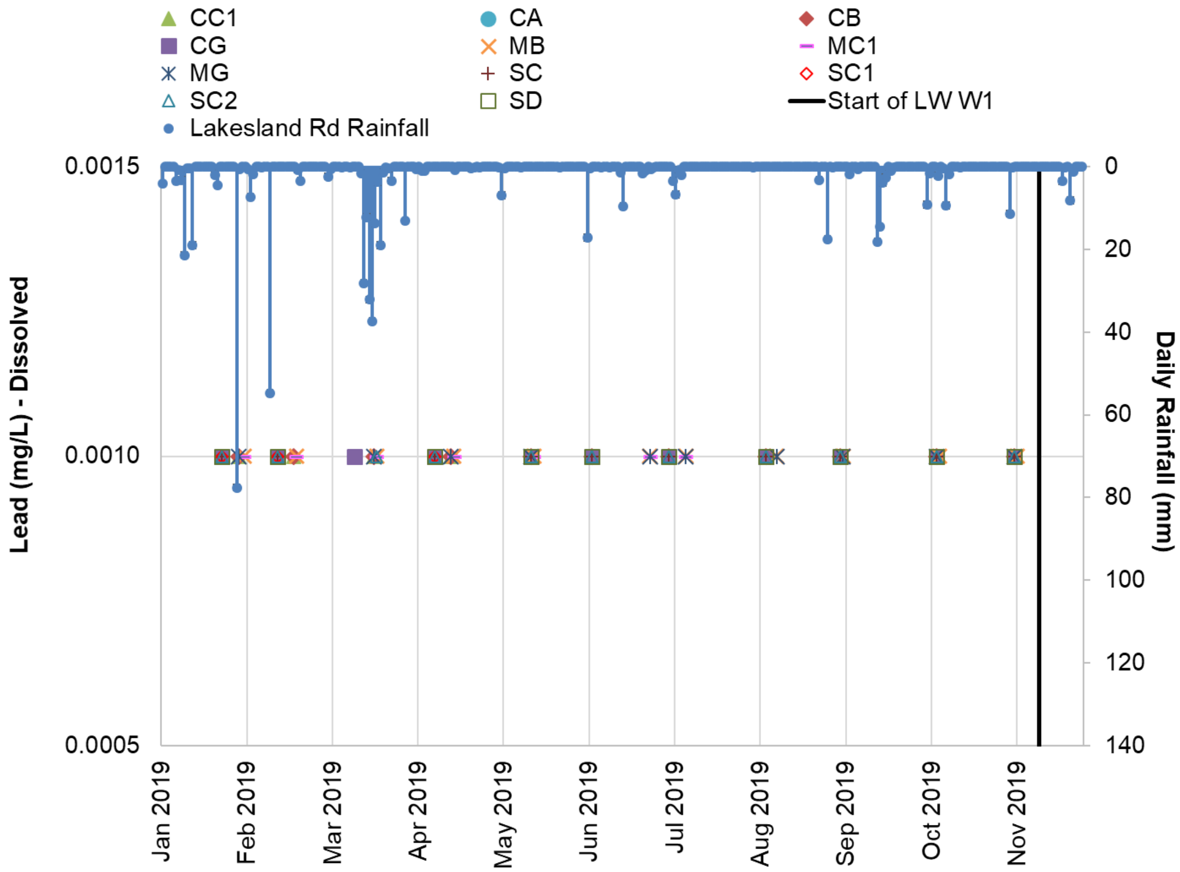


Chart C10 Dissolved Lead[8]

[8] All samples were recorded at the Limit of Detection (LOD) during the baseline monitoring period.

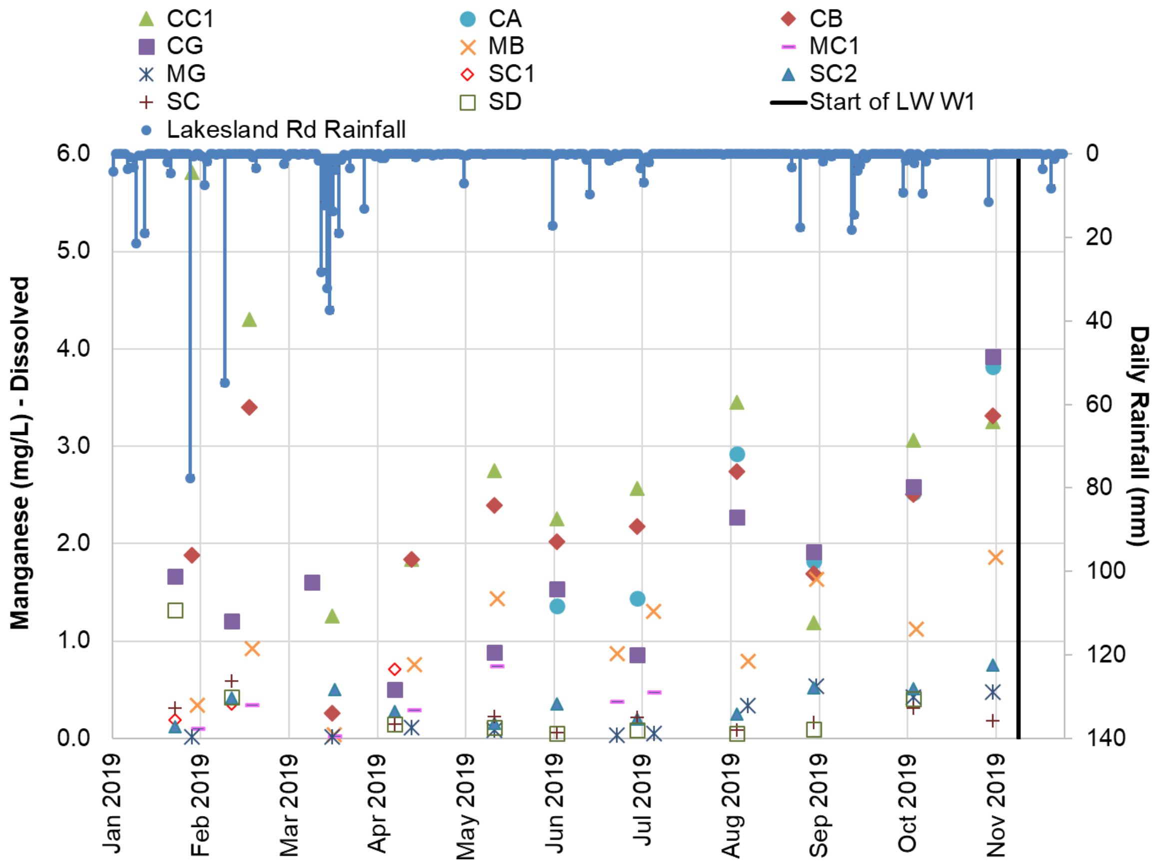


Chart C11 Dissolved Manganese

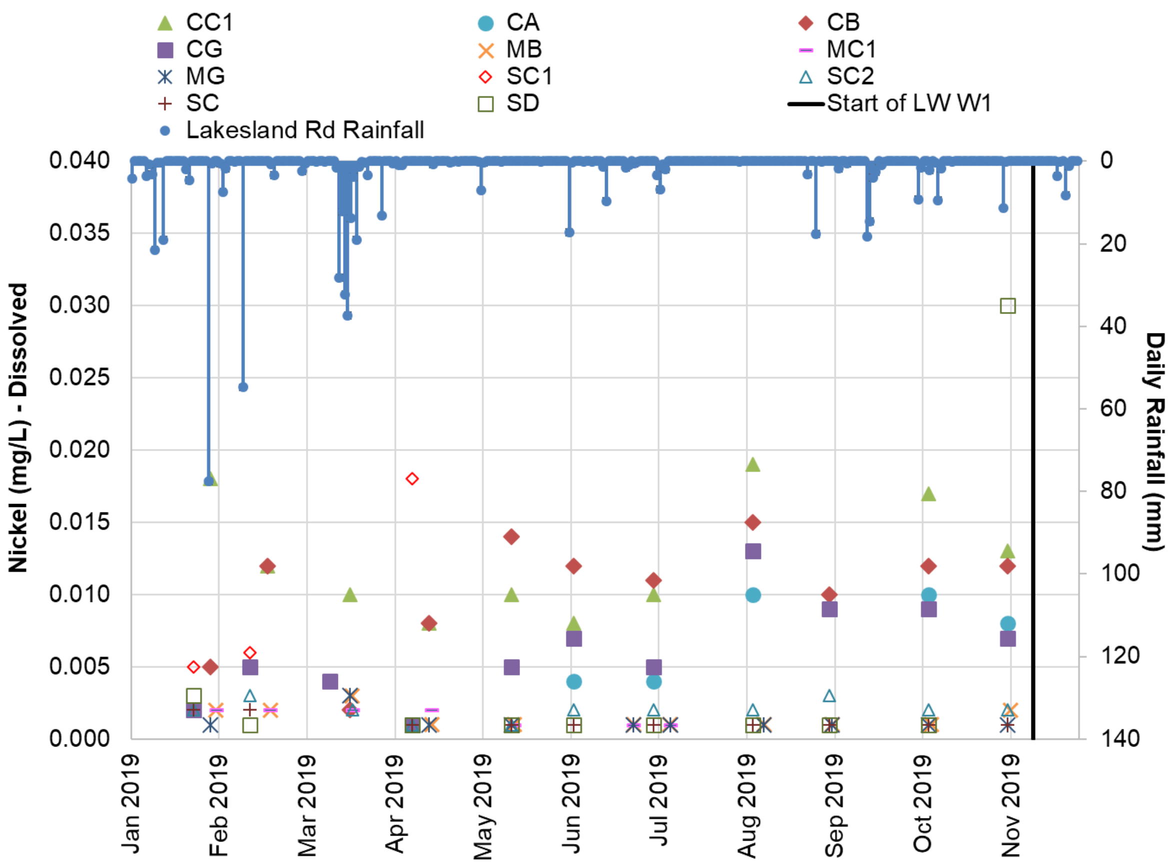


Chart C12 Dissolved Nickel

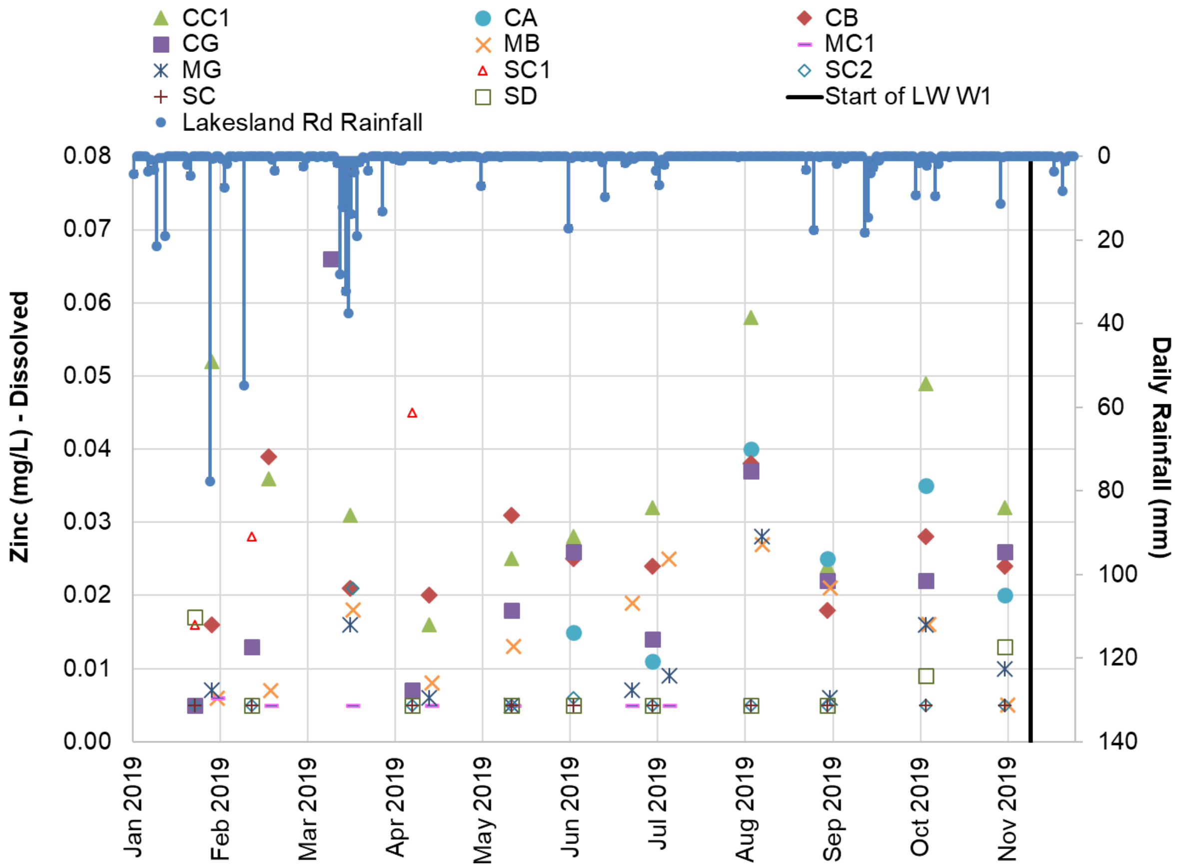
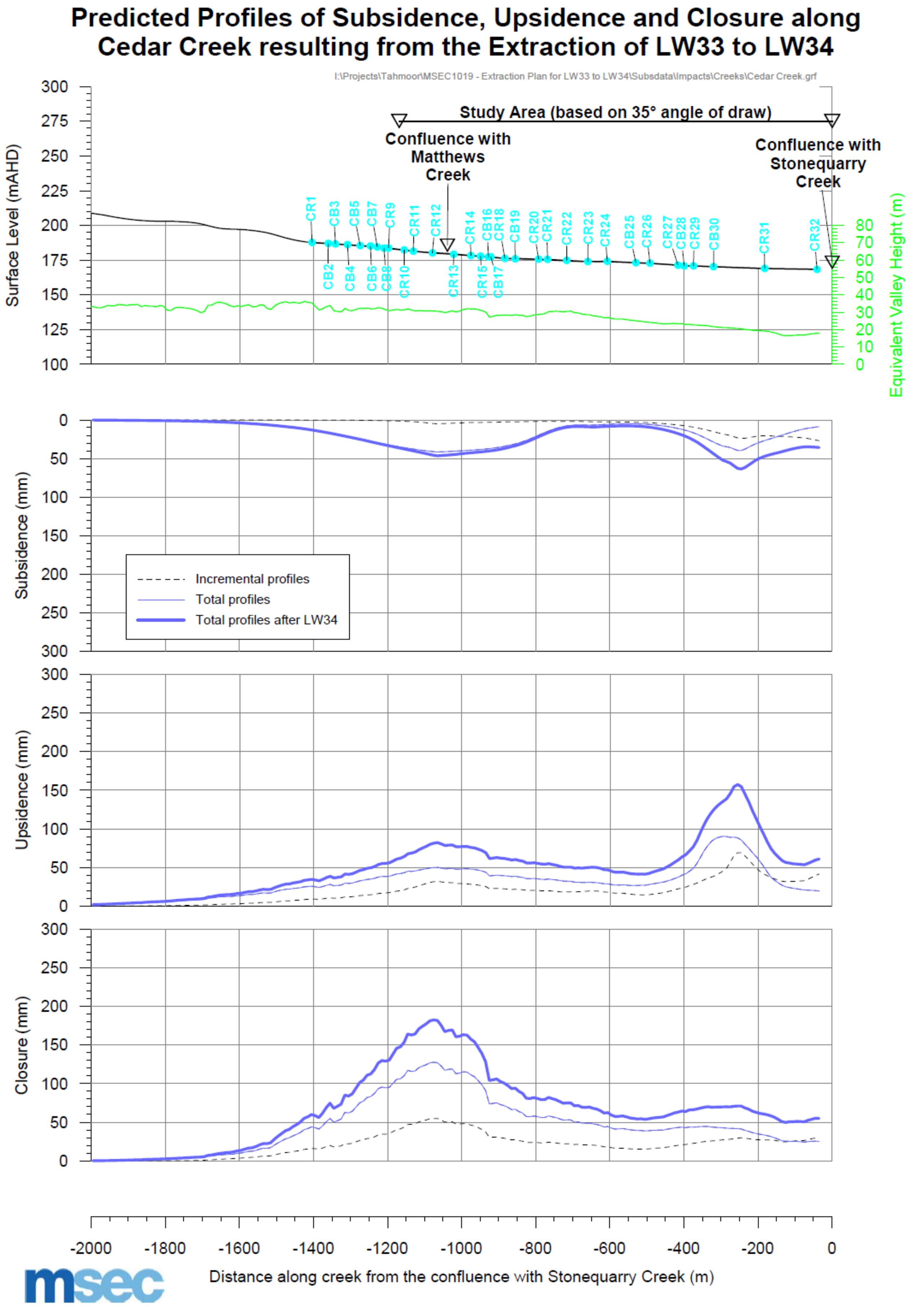


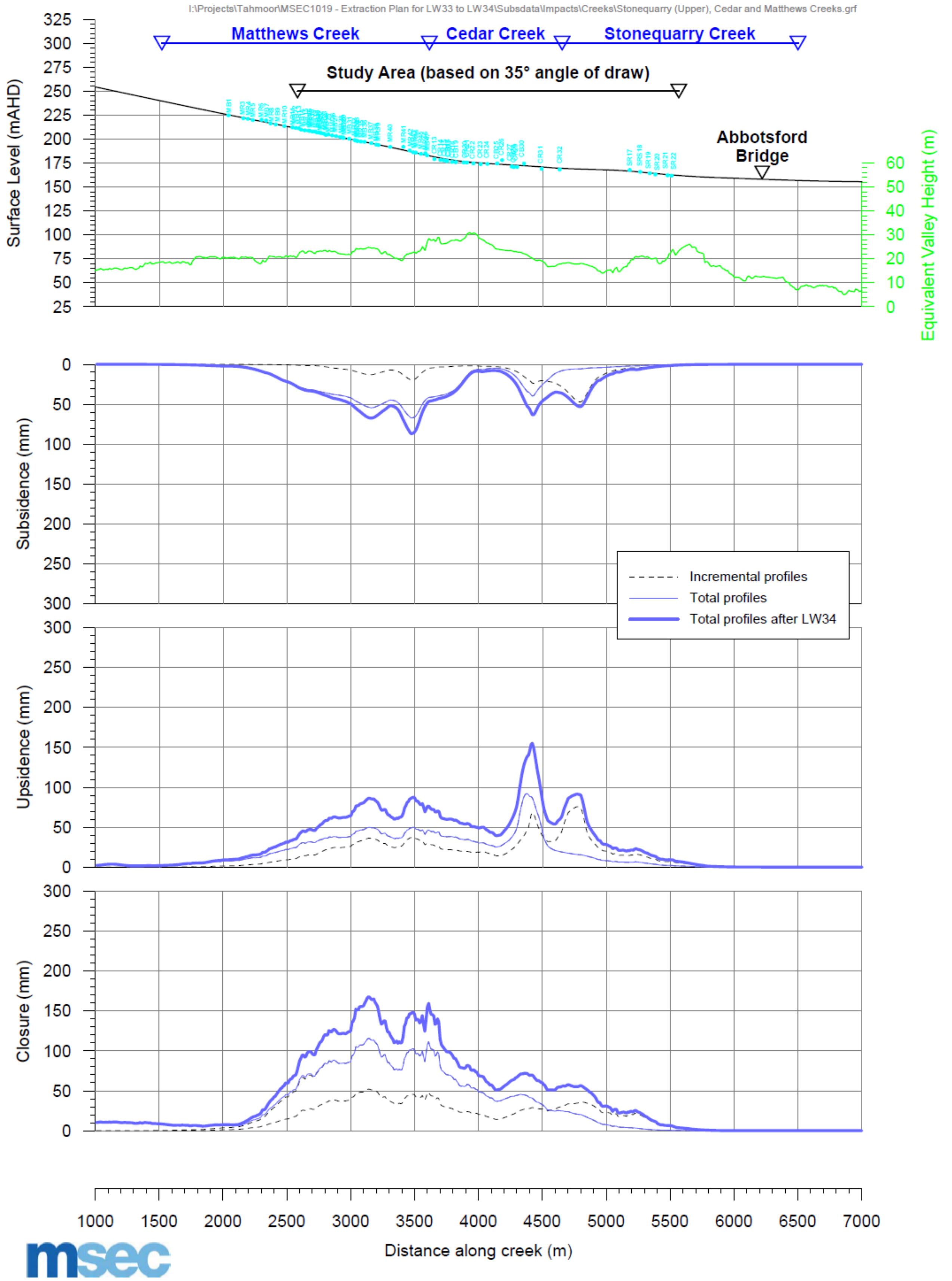
Chart C13 Dissolved Zinc

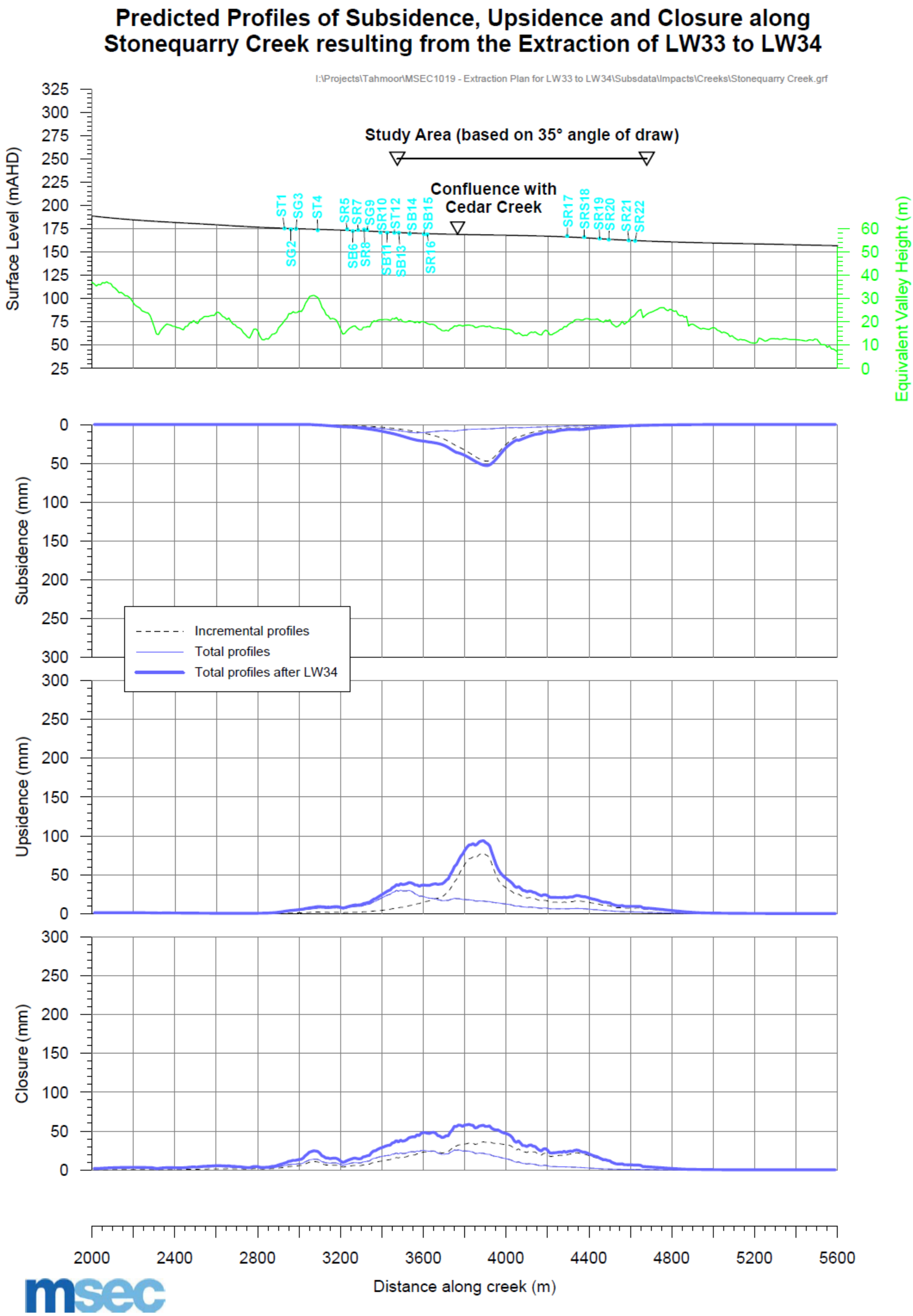
APPENDIX D – SURFACE WATER SUBSIDENCE PREDICTIONS



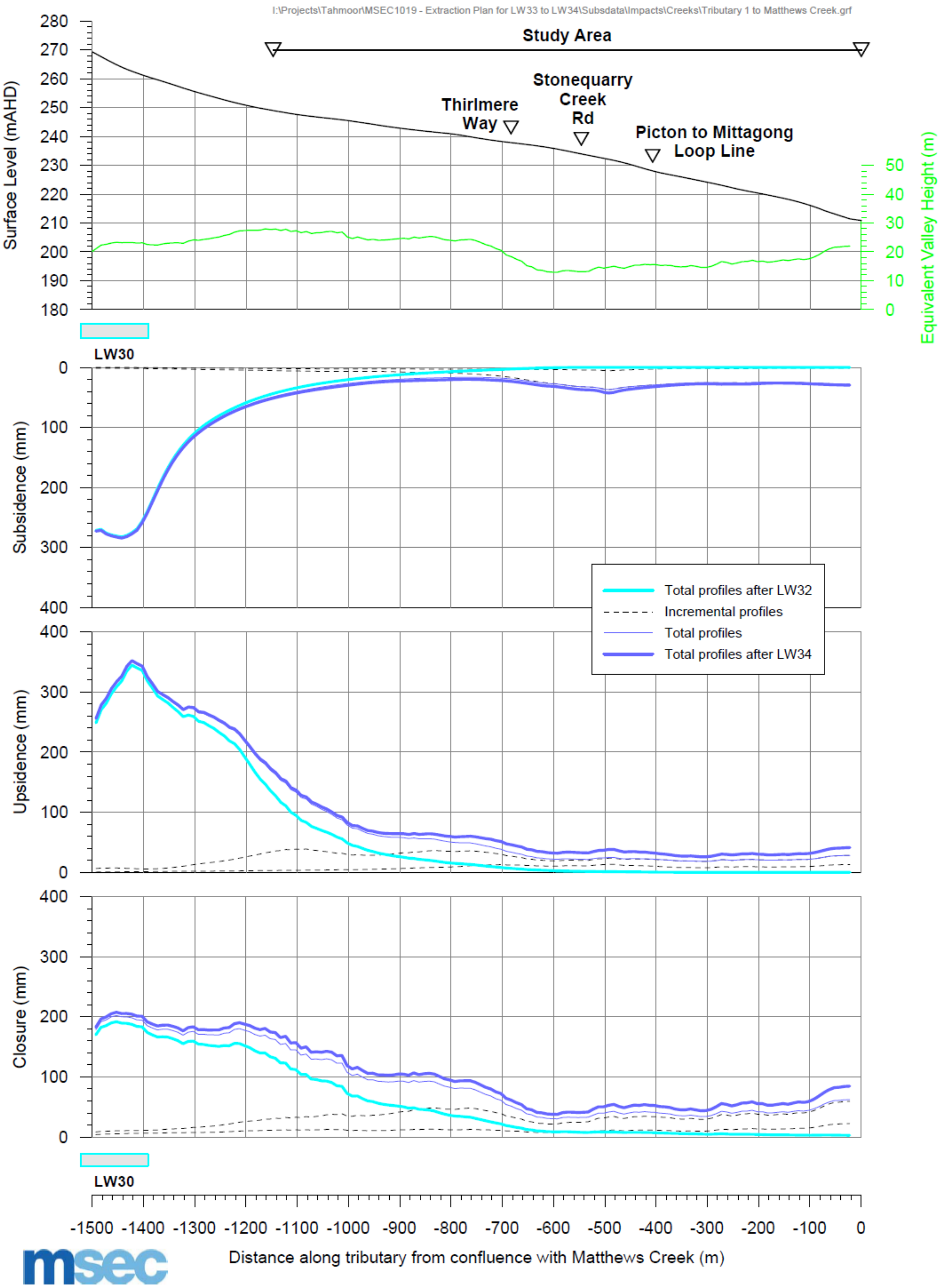
Predicted Profiles of Subsidence, Upsidence and Closure along Cedar Creek resulting from the Extraction of LW33 to LW34
I:\Projects\Tahmoor\MSEC1019 - Extraction Plan for LW33 to LW34\Subsdata\Impacts\Creeks\Cedar Creek.grf
Study Area (based on 35° angle of draw)
Confluence with Matthews Creek
Confluence with Stonequarry Creek
Surface Level (mAHD)
Equivalent Valley Height (m)
Subsidence (mm)
Upsidence (mm)
Closure (mm)
Incremental profiles
Total profiles
Total profiles after LW34
Distance along creek from the confluence with Stonequarry Creek (m)
msec

Predicted Profiles of Subsidence, Upsidence and Closure along Stonequarry (Upper), Cedar and Matthews Creeks resulting from the Extraction of LW33 to LW34




Predicted Profiles of Subsidence, Upsidence and Closure along
Stonequarry Creek resulting from the Extraction of LW33 to LW34
I:\Projects\Tahmoor\MSEC1019 - Extraction Plan for LW33 to LW34\Subsdata\Impacts\Creeks\Stonequarry Creek.grf
Study Area (based on 35° angle of draw)
Confluence with
Cedar Creek
Surface Level (mAHD)
Equivalent Valley Height (m)
Subsidence (mm)
Upsidence (mm)
Closure (mm)
Incremental profiles
Total profiles
Total profiles after LW34
Distance along creek (m)

Predicted Profiles of Subsidence, Upsidence and Closure along Tributary 1 to Matthews Creek resulting from the Extraction of Longwalls 33 to 34



APPENDIX E – FLOOD IMPACT STUDY

Matthew Creek Catchment Flood Impact Study for LW W1-W2

Tahmoor NSW

Tahmoor Coking Coal Operations

1072-05-B1, 3 May 2019

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

Contents

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1 Introduction

Tahmoor Coking Coal Operations (TCCO) 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 LW31-37 as documented in our previous report *Tahmoor Coal Flood Impact Study: LW31-37* (WRM, 2014).

TCCO has revised the configuration of longwall panels LW33-LW37 which are potentially impacted by Matthews Creek catchment. The Matthews Creek Catchment includes Mathews Creek which flows northeast before joining Cedar Creek and then Stonequarry Creek. The revised longwall panels are referred to as Longwall West 1 (LW W1) and Longwall West 2 (LW W2). The locations of LW W1 and LW W2 are shown in Figure 2.1.

WRM was commissioned by TCCO to undertake a flood impact assessment for LW W1 and LW W2 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 developed in the previous study (WRM, 2014) 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 ground levels based on LiDAR flown in November 2018 and the updated design surface elevations for the proposed subsidence of LW W1 and LW W2 provided by Mine Subsidence Engineering Consultants (MSEC).

The 1% AEP design discharges from the previous study were adopted to reassess the existing conditions and post-subsidence conditions for LW W1 and LW W2.

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 and LW W2.

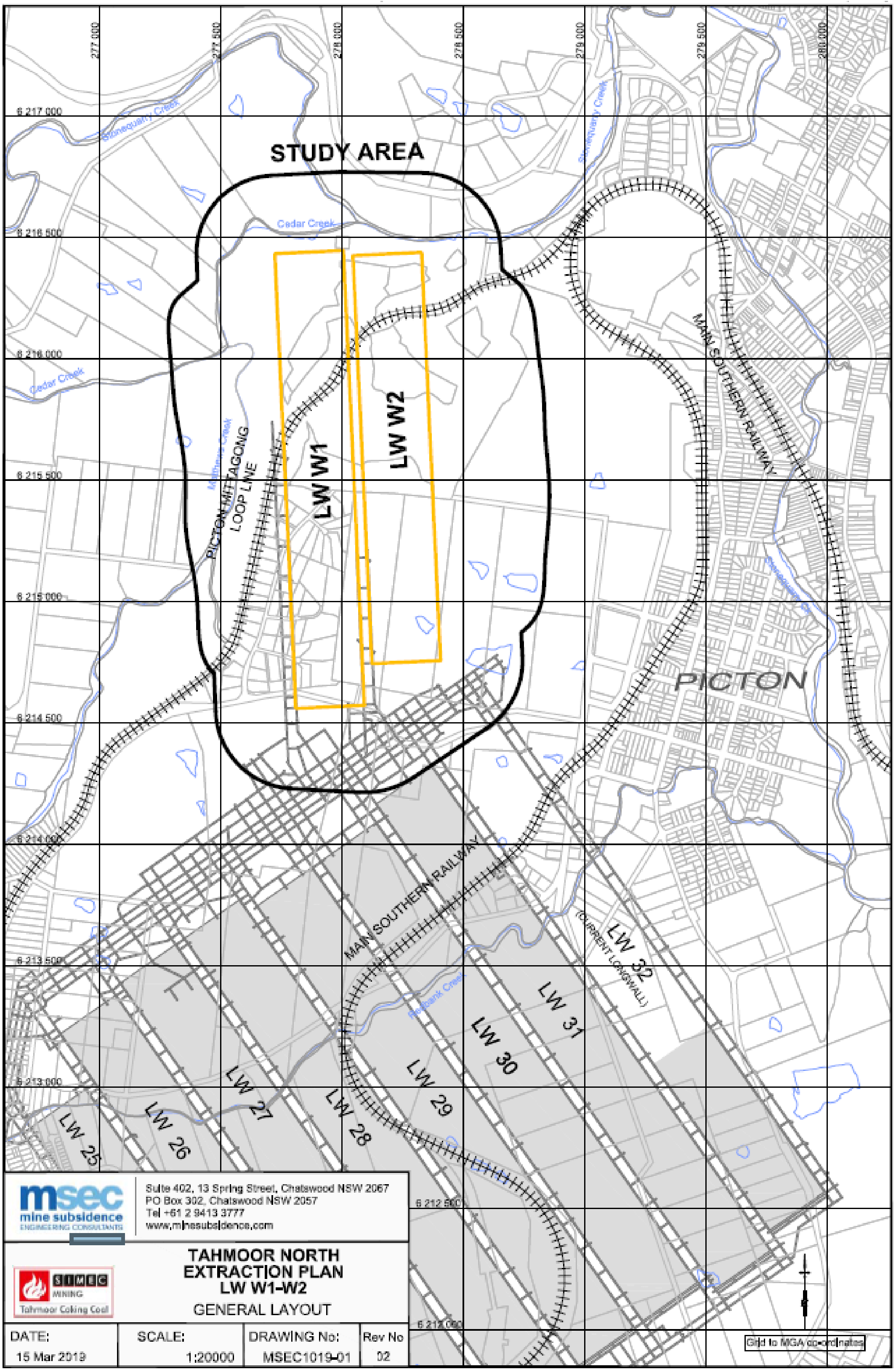

Figure 2.1 – Locations of LW W1 and LW W2

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

Duration (hr)	Spatial Zone A	Spatial Zone B	Spatial Zone C	Spatial Zone D
	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

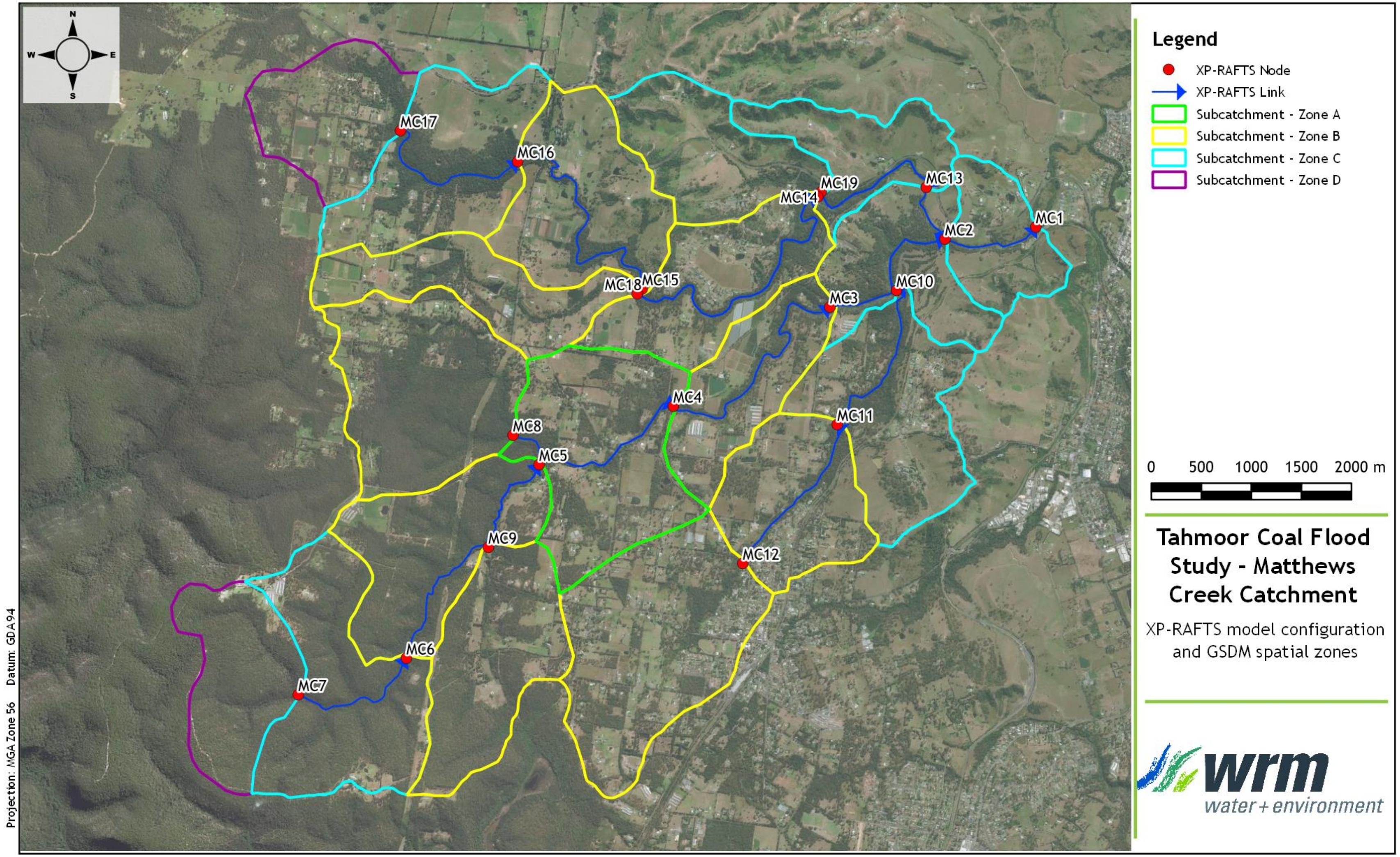

Figure 3.1 – XP-RAFTS subcatchments and spatial zones

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.

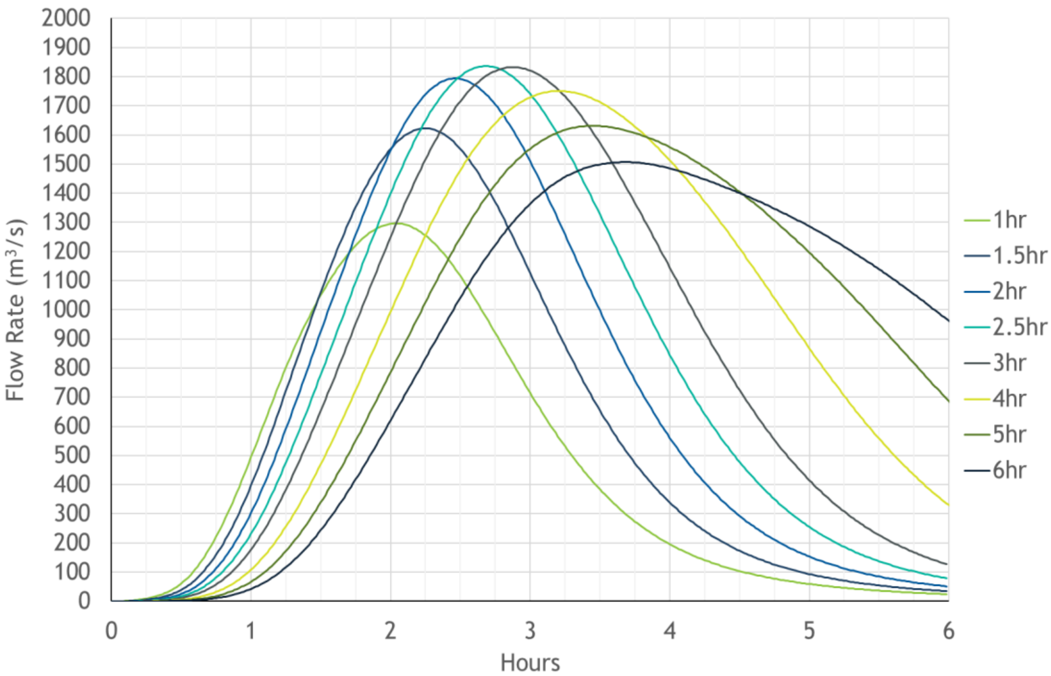

Figure 4.1 - PMP discharges at the XP-RAFTS downstream boundary of Matthews Creek catchment

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 and LW W2 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 and LW W2 shown in Figure 5.1 to Figure 5.4 indicate a change in ground surface elevations of up to 0.7 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 0.07 m;
- The peak flood velocity is predicted to increase by up to 0.02 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	196.41	-0.07
RP3	174.30	174.27	-0.03
RP4	174.10	174.03	-0.07
RP5	173.89	173.86	-0.03
RP6	174.15	174.12	-0.03
RP7	173.83	173.80	-0.03
RP8	172.89	172.87	-0.02
RP9	172.60	172.58	-0.02
RP10	171.68	171.67	-0.01

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	3.27	0.02
RP4	2.07	2.08	0.01
RP5	1.77	1.76	-0.01
RP6	2.01	2.02	0.01
RP7	1.84	1.84	-
RP8	2.98	2.95	-0.03
RP9	2.59	2.57	-0.02
RP10	3.75	3.74	-0.01

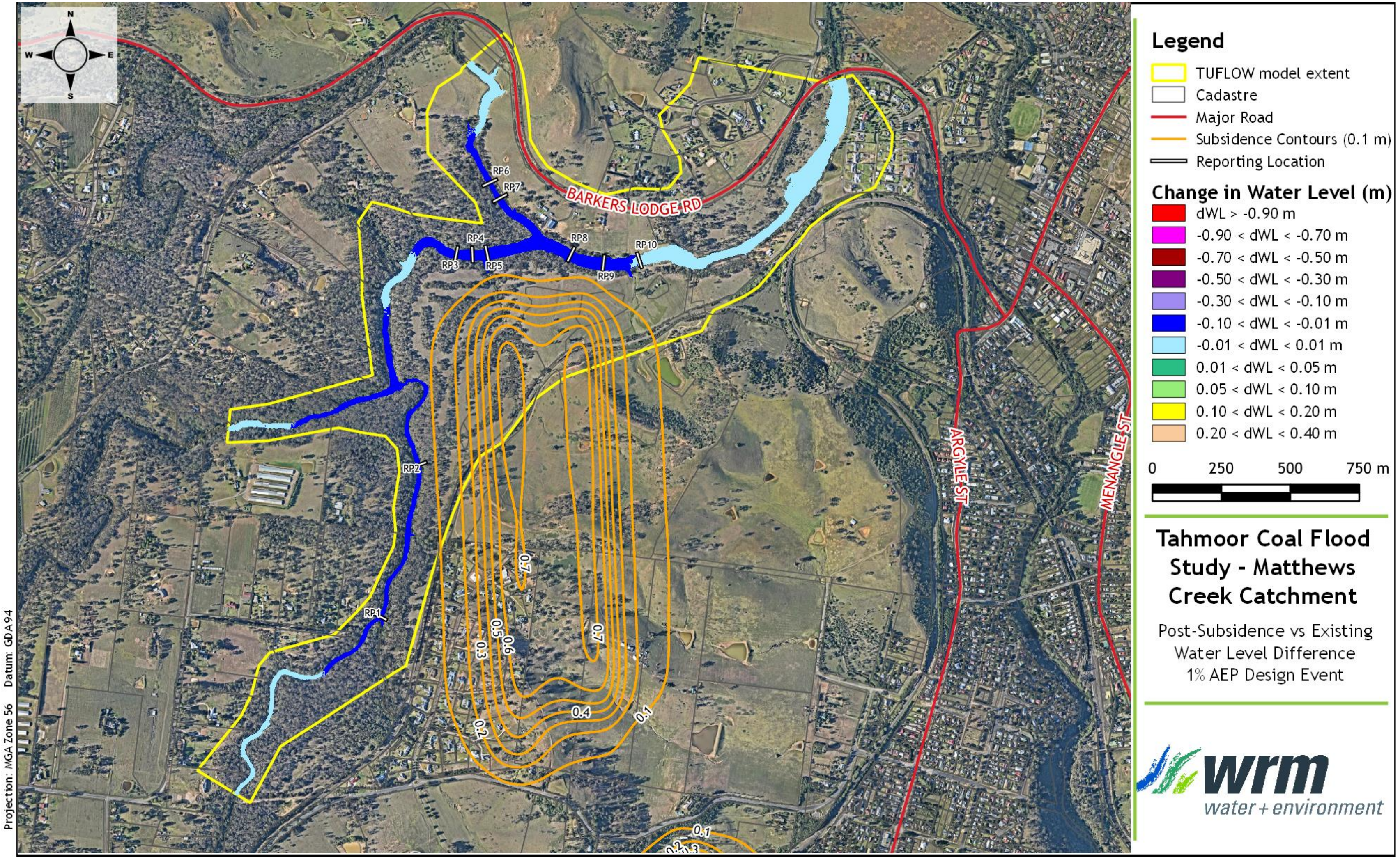

Figure 5.1 – Matthews Creek catchment 1% AEP event impact – change in water level

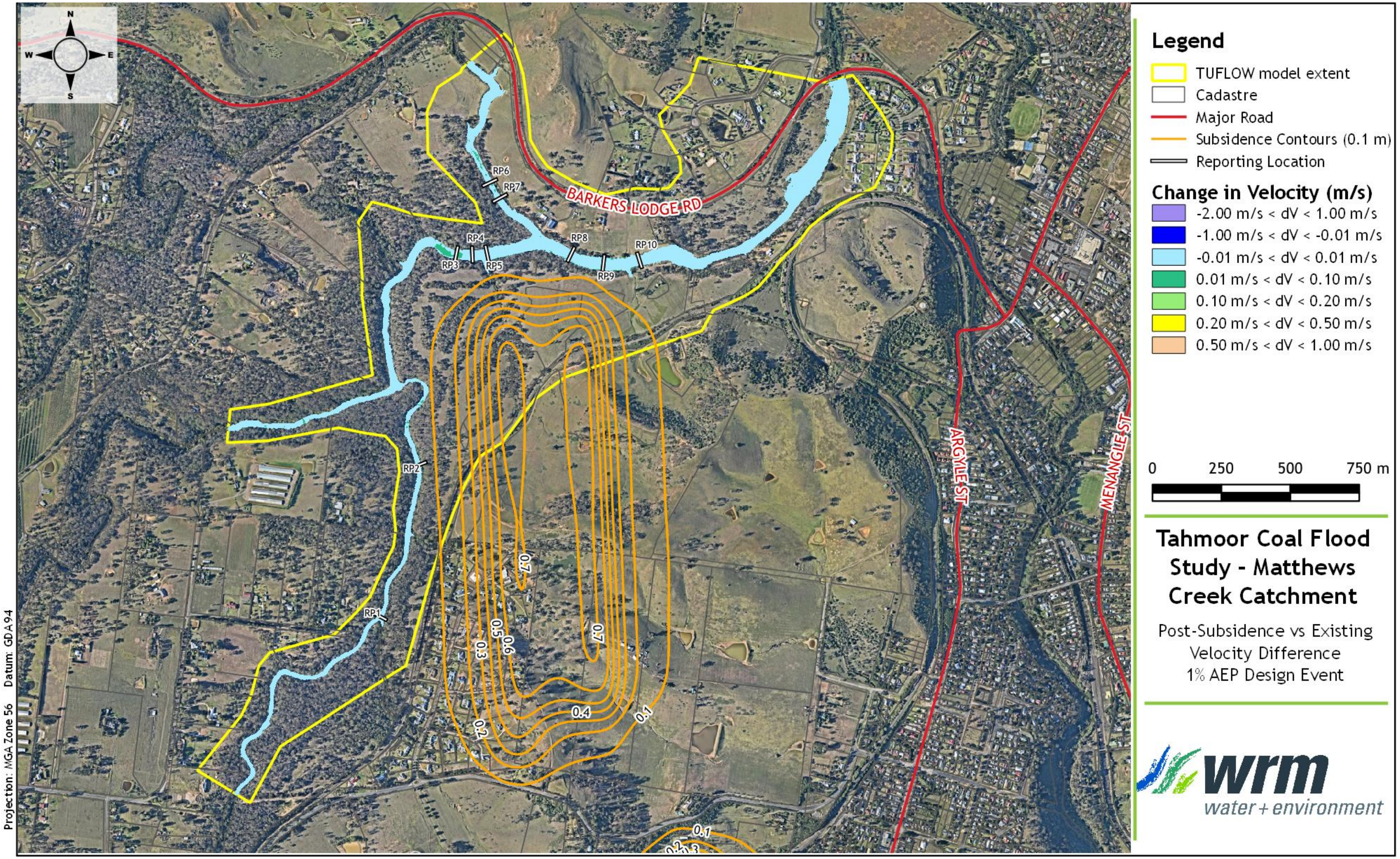

Figure 5.2 – Matthews Creek catchment 1% AEP event impact – change in velocity

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 1.4 m;
- The peak flood level is predicted to decrease by up to 0.06 m;
- The peak flood velocity is predicted to increase by up to 0.02 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	214.49	-0.03
RP2	200.12	200.06	-0.06
RP3	180.16	180.11	-0.05
RP4	179.83	179.79	-0.04
RP5	179.82	179.77	-0.05
RP6	179.69	179.65	-0.04
RP7	179.60	179.55	-0.05
RP8	178.00	177.96	-0.04
RP9	176.81	176.79	-0.02
RP10	176.31	176.29	-0.02

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	5.20	0.02
RP4	4.13	4.14	0.01
RP5	3.45	3.45	-
RP6	2.57	2.58	0.01
RP7	2.47	2.48	0.01
RP8	5.51	5.50	-0.01
RP9	5.72	5.69	-0.03
RP10	6.10	6.08	-0.02

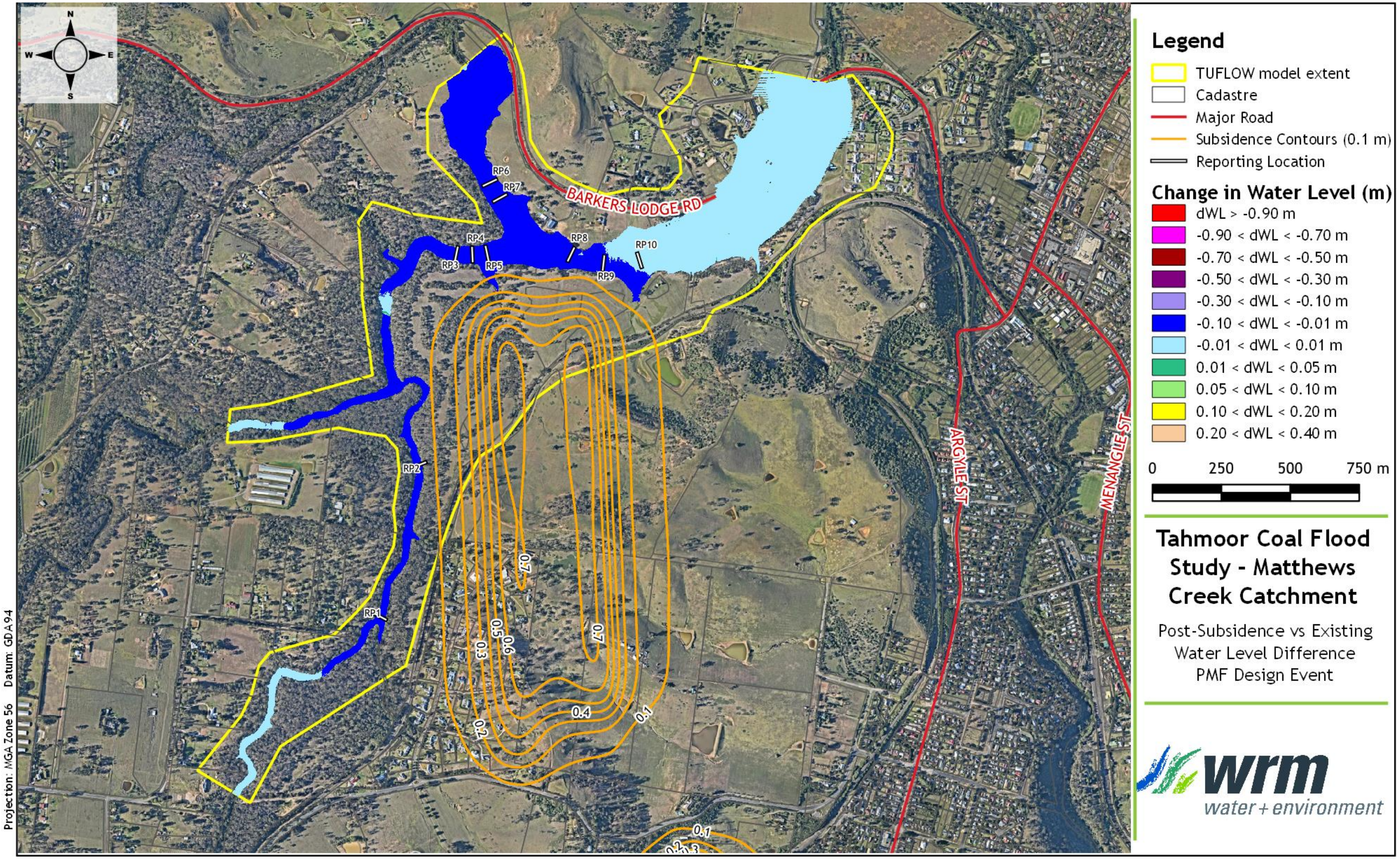

Figure 5.3 – Matthews Creek catchment PMF event impact – change in water level

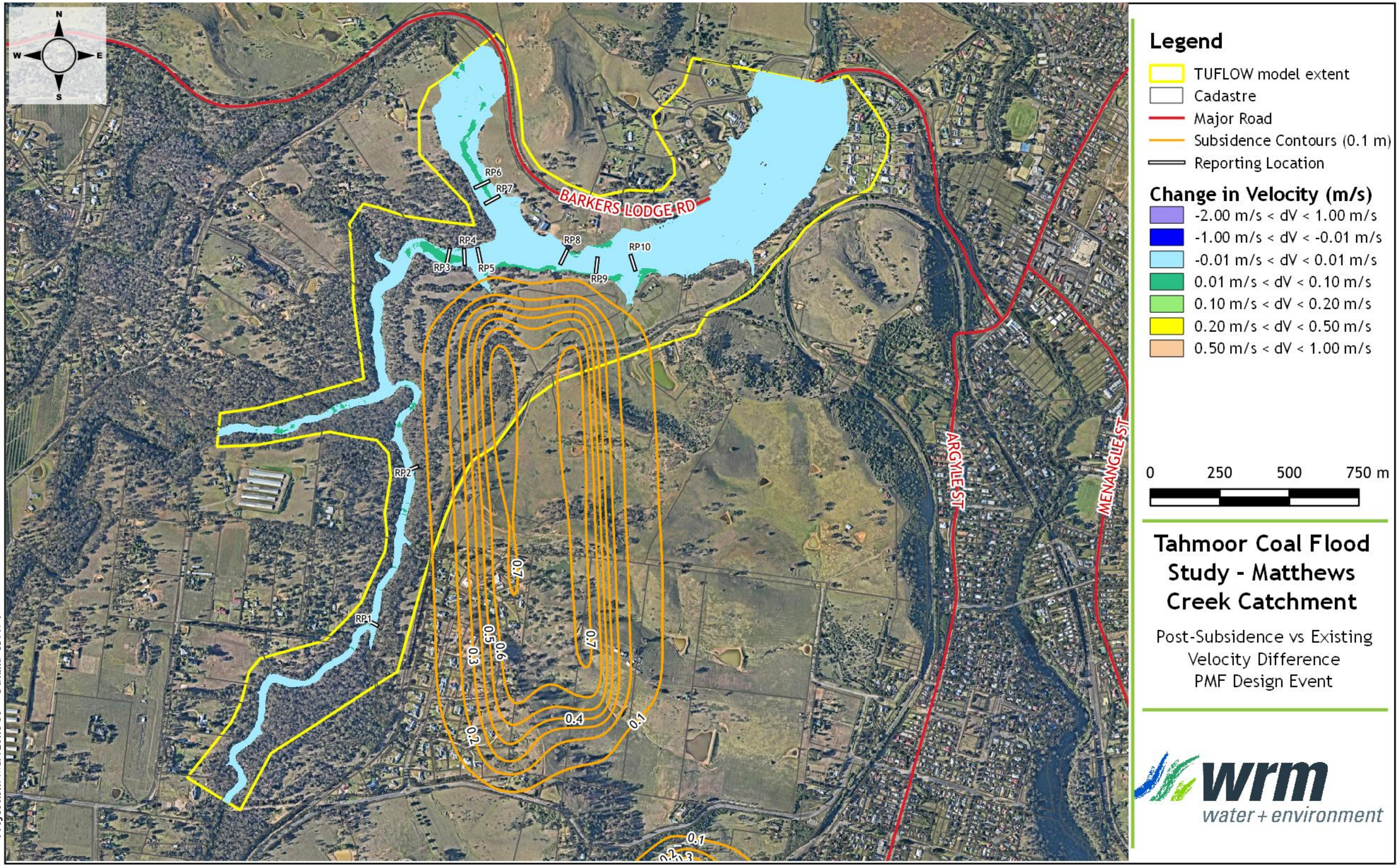

Figure 5.4 – Matthews Creek catchment PMF event impact – change in velocity

6 Summary

Hydrologic (XP-RAFTS) and hydraulic (TUFLOW) models were used to assess the impacts of the revised longwall panels LW W1 and LW W2 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 and LW W2 will have negligible impacts on peak water levels and velocities.

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 0.07 m;
- The peak flood velocity is predicted to increase by up to 0.02 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:

- The crest of Barkers Lodge Road is overtopped during the PMF event under existing and post-subsidence conditions by up to 1.4 m;
- The peak flood level is predicted to decrease by up to 0.06 m;
- The peak flood velocity is predicted to increase by up to 0.02 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
BMT WBM (2017)	*'TUFLOW User Manual Build 2017-09'*, BMT WBM Pty Ltd, 2017.
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
XP Software (2013)	*'XP-RAFTS User Manual'*, XP Software, Australia, 2013.

Appendix A - 1% AEP event model results

Figure A.1 – Matthews Creek catchment existing conditions – 1% AEP event flood depth

Figure A.2 – Matthews Creek catchment existing conditions – 1% AEP event velocity

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

Figure A.4 – Matthews Creek catchment post-subsidence conditions – 1% AEP event velocity

Appendix B - PMF event model results

Figure B.1 – Matthews Creek catchment existing conditions – PMF event flood depth

Figure B.2 – Matthews Creek catchment existing conditions – PMF event velocity

Figure B.3 – Matthews Creek catchment post-subsidence conditions – PMF event flood depth

Figure B.4 – Matthews Creek catchment post-subsidence conditions – PMF event velocity