

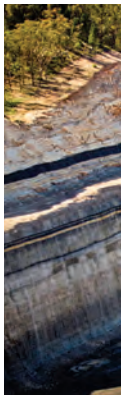


MOOLARBENCOAL

Moolarben Coal Complex
Open Cut Optimisation Modification

Environmental Assessment

APPENDIX F

Controlled Water Release Impact Assessment

YANCOAL
兖煤澳大利亚有限公司

Controlled Water Release Impact Assessment for the Goulburn River

Moolarben Coal Operations Pty Ltd

October 2017

Assignment No 26513

www.**advisian**.com

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WorleyParsons Group

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Project No: 26513

Moolarben Coal Pty Ltd – Controlled Water Release Impact Assessment

Rev	Author	Review	Date	Comments
Rev 1	LS	AT	31 May 2017	Preliminary Draft
Rev 2	LS	RS, MCO	25 July 2017	Draft
Rev 3	LS	AT	13 October 2017	Final

Abbreviations

AEMR	Annual Environmental Management Report
ARI	Average Recurrence Interval
BOM	Bureau of Meteorology
CHPP	Coal Handling and Processing Plant
DPI Water	NSW Department of Primary Industries - Water
EC	Electrical Conductivity
EPA	Environment Protection Authority
EP&A	Environmental Planning & Assessment Act
EPL	Environment Protection Licence
HRSTS	Hunter River Salinity Trading Scheme
HUWSP	Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources
km	kilometre
m	metre
MCO	Moolarben Coal Operations Pty Ltd
MCC	Moolarben Coal Complex
ML	Megalitre
NSW	New South Wales, Australia
OC	Open Cut
OEH	Office of Environment and Heritage
SWMP	Surface Water Management Plan
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UG	Underground
UMC	Ulan Mine Complex
UCML	Ulan Coal Mines Limited
WMP	Water Management Plan

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Appendices

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1 Introduction

1.1 Background

Advisian has been engaged by Moolarben Coal Operations Pty Limited (MCO), a subsidiary of Yancoal Australia Limited, to prepare a Controlled Water Release Impact Assessment for the Goulburn River. The Impact Assessment has been prepared to support an Environmental Assessment of an increase in total discharge from the Moolarben Coal Complex (MCC) of 20 megalitres per day (ML/day), as well as relocation of an existing discharge point to improve environmental outcomes. The Impact Assessment will also support an application by MCO for a variation to Environment Protection Licence (EPL) 12932.

Stage 1 of the MCC was approved in September 2007 under Part 3A of the *Environmental Planning and Assessment (EP&A) Act 1979*. Stage 2 of the MCC was approved in January 2015 under Part 3A of the EP&A Act.

The MCC is located approximately 40 kilometres (km) north-east of Mudgee in the Western Coalfields of New South Wales (NSW). The Ulan Mine Complex (UMC), operated by Ulan Coal Mines Ltd (UCML), is located to the north-west of the MCC and the Wilpinjong Coal Mine is located to the south-east. Figure 1.1 shows the location of the MCC.

Figure 1.2 shows the location of the local drainage system. The Goulburn River drains in a north-easterly direction to the west and north of the MCC. The section of the Goulburn River located immediately downstream of the MCC to the north, known as the Goulburn River Diversion, was diverted as part of the development of the UMC in 1982.

1.2 Proposed Modification

EPL 12932 (version 26 May 2016) permits discharge of mine water from three existing licenced discharge points (EPL ID1, EPL ID2 and EPL ID28 on Figure 1.1), subject to stringent water quality concentration limits. The EPL specifies that the maximum combined discharge from the discharge points must not exceed 10 ML/day.

EPL 12932 also permits discharge of water from sediment dams following gravity settlement of sediment or periods of significant rainfall. No change to the operation of sediment dams at the MCC is proposed as part of this Modification.

Recent site water balance modelling undertaken by WRM (2017) indicates that the MCC is predicted to be a water surplus site in certain years and climatic sequences, and the ability to release additional water will be required to prevent uncontrolled discharges from on-site storages and to minimise future impacts on operations (i.e. to minimise storage of mine water in active open cuts).

MCO therefore intends to seek approval from the NSW Environment Protection Authority (EPA) for an increase in the combined volume of the controlled release of mine water from the site into the Goulburn River from 10 ML/day to 20 ML/day, with no change to the current release concentration limits.

In addition, MCO proposes to relocate EPL ID1 to reduce the potential for scour and increase the discharge limit from this point to a maximum of 20 ML/day. The proposed discharge point would be located at the confluence of Bora Creek and the Goulburn River Diversion (refer Figure 1.1). The proposed discharge water quality concentration limits would remain consistent with the current concentration limits as set out in the EPL. No change to the existing approved discharge quantities from EPL ID2 and EPL ID28 is proposed under the modification.

This Assessment considers the impacts on the downstream flow regime, water quality and channel stability resulting from the discharge of 20 ML/day from the relocated discharge point.

1.3 Scope of Report

This report has been prepared to assess the potential impacts of the proposed increased volume of controlled water release on the Goulburn River, downstream of the relocated EPL ID1. No change is proposed to the approved discharge water quality concentration limits or discharge quantities from EPL ID2 and EPL ID28. Therefore there would be no incremental impact to the Goulburn River upstream of EPL ID1.

This report includes:

1. An **assessment of existing conditions** (Section 2), including descriptions of the existing drainage system, flow regime, water quality and channel stability in the Goulburn River.
2. A description of the **proposed modification** (Section 3).
3. An **assessment of the potential impacts** (Section 4) of the modification on the downstream water flow regime, water quality and stream characteristics.
4. **Proposed management and mitigation measures** (Section 5) to minimise any potential impacts of the modification on the flow regime, water quality and stream characteristics.

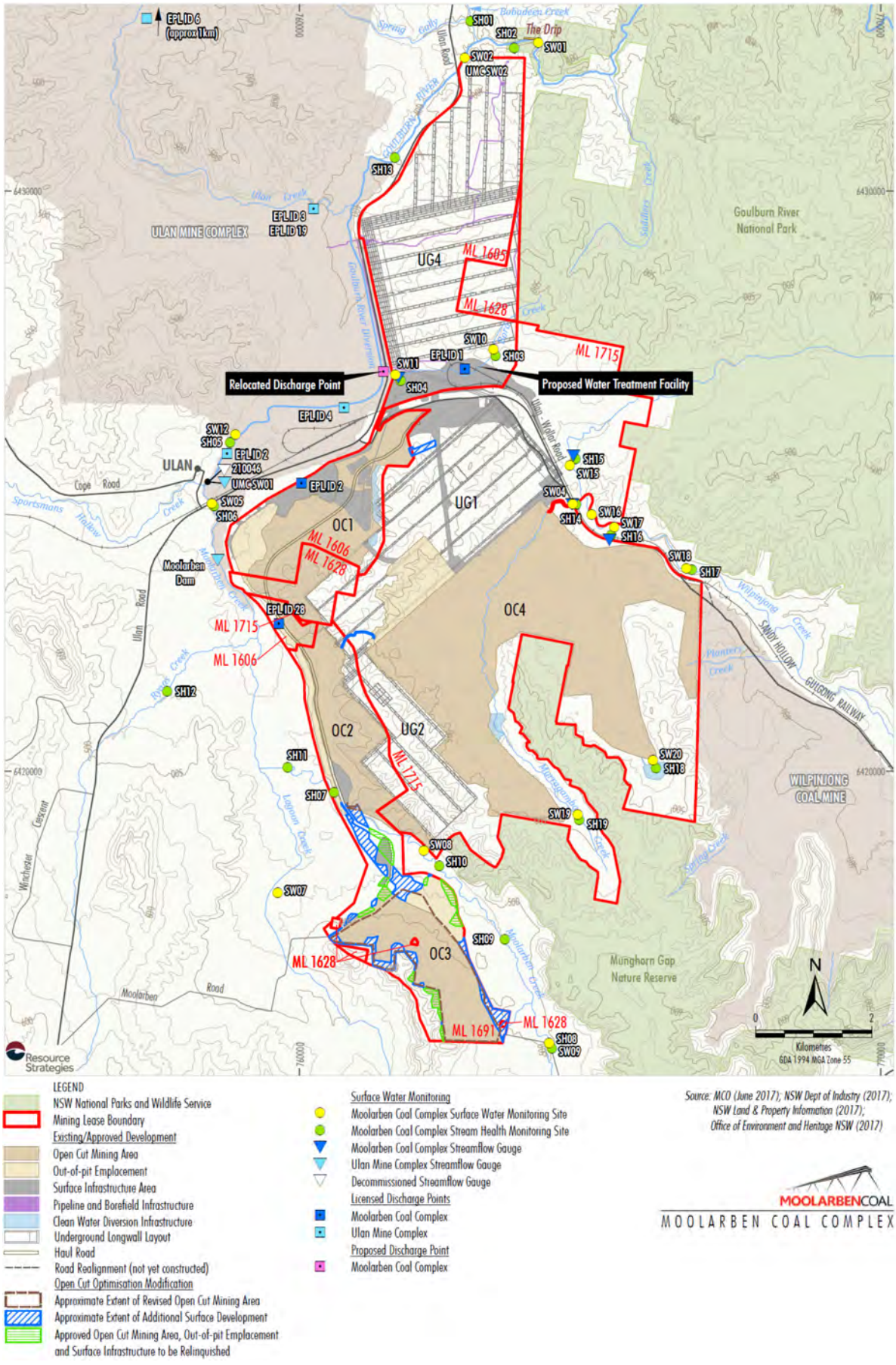


Figure 1.1: Features of the Assessment Area

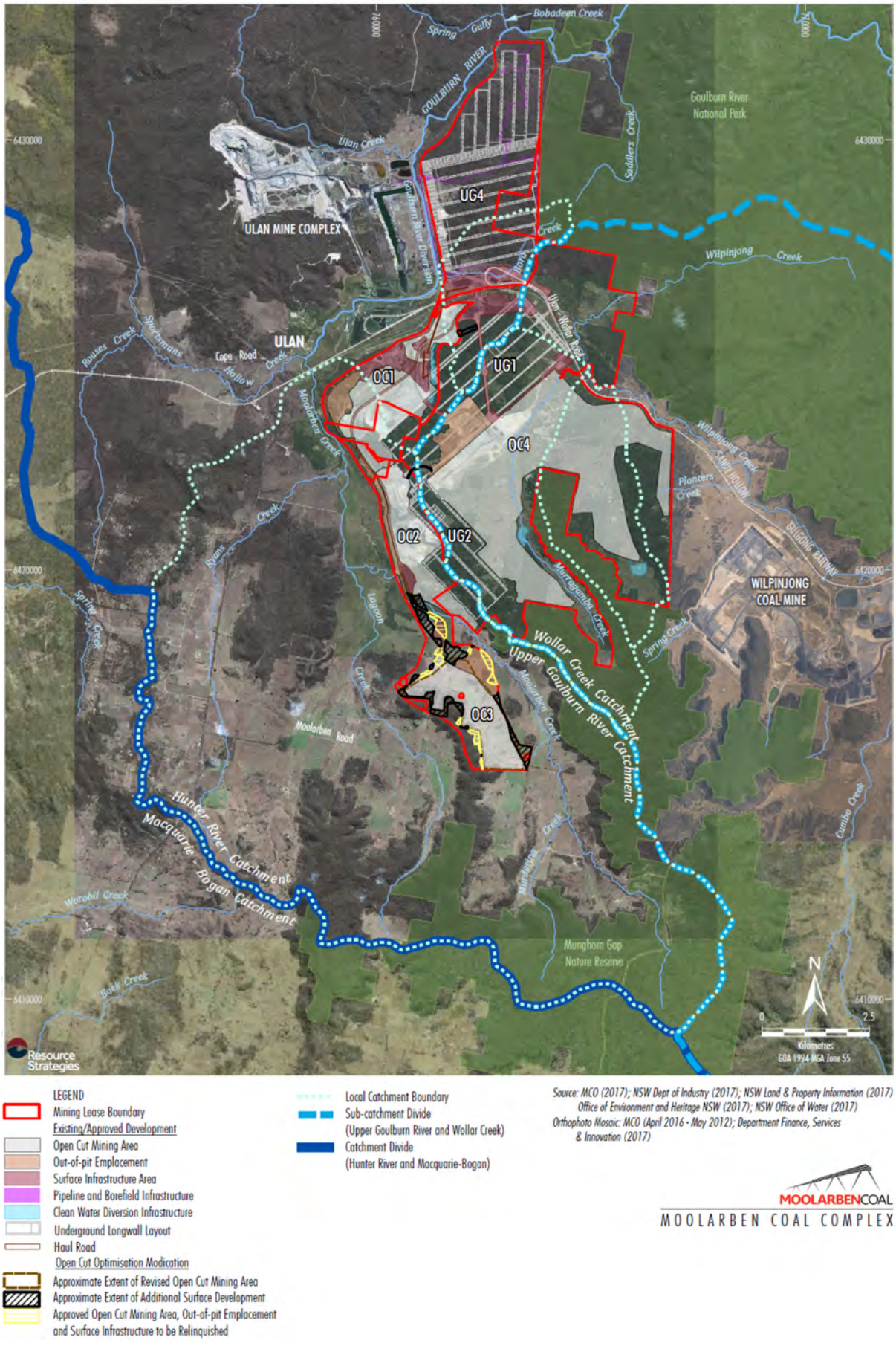


Figure 1.2: Local Drainage Network

2 Existing Conditions

2.1 Moolarben Site Water Management

The Moolarben Water Management System is detailed in *Appendix 1 Site Water Balance* of the *Water Management Plan* (WMP) (MCO, 2016a) and comprises small dams, pumps and pipelines which transfer water around the site for dust suppression and coal processing. Water that is not immediately utilised within the site is stored in a number of mine water storages.

Discharge of surplus site water to the Goulburn River is regulated by the requirements of EPL 12932. The EPL contains various conditions regarding discharge of site waters including discharge locations, monitoring requirements, discharge volumes and discharge concentration limits.

MCO has three existing licenced discharge points under EPL 12932, namely:

- EPL ID1 – to Bora Creek from Cockies Dam;
- EPL ID2 – to Goulburn River from Open Cut 1 (OC1) Sediment Dam 6;
- EPL ID28 – to Moolarben Creek from OC2 Dam.

The locations of these discharge points are shown on Figure 1.1. The flow and water quality discharge limits and requirements for the discharge points are presented in Table 2.1.

Table 2.1: EPL 12932 Discharge Limits

EPL ID	Discharge Volume[1]	EC[1] (100%ile) (µS/cm)	EC[1] (50%ile) (µS/cm)	Oil & Grease[2] (mg/L)	pH[1]	Total Suspended Solids[2] (mg/L)	Turbidity[1] (NTU)
1	10 ML/day	900	800	10	6.5 – 8.5	50	25
2	10 ML/day	900	800	10	6.5 – 8.5	50	25
28	1 KL/day	900	800	10	6.5 - 8.5	50	25

Notes:

[1] Measured continuously during any discharge.

[2] Measured daily during any discharge.

Iron and Zinc must also be measured daily during discharge.

The combined total discharge from EPL ID1, EPL ID2 and EPL ID28 must not exceed 10 ML/day.

An approved emergency discharge event occurred from December 2010 to January 2011 following sustained heavy rainfall in November/December 2010, resulting in unexpected inflow volume into site water storages (MCO, 2011). Approval was granted by the Office of Environment and Heritage (OEH) under the EPL for an emergency discharge. The conditions of discharge were governed by the volumetric flow within Moolarben Creek. Discharge from EPL ID18, EPL ID19 and EPL ID20 were not to exceed the volume of natural daily flow in Moolarben Creek as measured at monitoring point 21 (Moolarben flow gauging point).

During the emergency discharge event discharge volumes varied from 0-33 ML/day, EC ranged from 445 to 1,040 µS/cm, pH varied between the discharge points from 4.3 to 7.1 and TSS varied between the three discharge points from 25 mg/L to 680 mg/L.

2.2 Ulan Mine Complex

The UMC is located to the north-west of the MCC and consists of two approved underground (UG) mining operations and an open cut (OC) (not operating since 2016). Water is discharged from the UMC under the conditions of their EPL 394. The UMC has a number of EPA licenced discharge points as shown on Figure 1.1, including EPL ID6 and EPL ID3/EPL ID9 located on Ulan Creek.

The EPL 394 limit conditions are summarised in Table 2.2.

Table 2.2: UMC EPL 394 Surface Water Limit Conditions

EPL ID	Location	Surface Water Limits			
		Volume (kL/day)	EC (µS/cm)	pH	Oil & Grease (mg/L)
1	Millers Dam	85	810	6.5-8.5	10
2	Effluent Storage Dam[1,2]	600	900	6.5-8.5	10
3	Outlet from Rowans Dam to Ulan Creek[1,2]	10,000	900	6.5-8.5	10
4	Drainage Outlet from Truckfill Dam to unnamed watercourse[1,2]	2,000	900	6.5-8.5	10
6	Discharge to Ulan Creek from the Bobadeen Reverse Osmosis Plant[2]	15,000	900*	6.5-8.5	Not specified
18 (SW02)	Downstream Goulburn River gauging station	Not specified	No Limit Applicable*	Not specified	Not specified
19	Discharge to Ulan Creek from the NWSD Water Treatment Plant[2]	30,000#	900*	6.5-8.5	Not specified

Source: http://ulancoal.com.au/EN/Environment/Pages/EnvironmentMonitoringResults.aspx (Table 9)

Notes:

[1] Additional water quality limits: Iron <5 mg/L, Zinc <5 mg/L

[2] Additional water quality limit for Total Suspended Solids <50 mg/L

** In accordance with EPL 394, the EC for EPL ID6 & EPL ID19 reduced to 900 µs/cm, and EC for point 18 (SW02) criteria was removed from 31 March 2014.*

The EPL specifies a total daily discharge limit of 30 ML/day between EPL ID 3, EPL ID6 and EPL ID19. Table 2.3 shows that approved discharge quantities have generally increased over time, with a discharge limit of 30 ML/day into Ulan Creek being approved in May 2012 and currently in place.

As shown in Table 2.3, UMC discharges into Ulan Creek from EPL ID3 have occurred since April 2004, from EPL ID6 since June 2007, and EPL ID19 since December 2011.

The aggregated data for quantity and quality discharged from these locations between 1 November 2008 and 31 December 2014 is shown in Table 2.4.

Since May 2012, when a discharge limit of 30 ML/day was approved, an average volume of 10.7 ML/day has been discharged into Ulan Creek. Ulan Creek discharges into the Goulburn River downstream of the Goulburn River Diversion.

Table 2.3: Approved UMC EPL 394 Discharge Quantities

Date	Approved Discharge Quantities for Ulan Mine (EPL 394) Licenced Discharge Points							
	EPL ID1 (kL/day)	EPL ID2 (kL/day)	EPL ID3 (ML/day)	EPL ID4 (ML/day)	EPL ID6 (ML/day)	EPL ID19 (ML/day)	EPL ID 3+6+19* (ML/day)	EPL ID 3+19* (ML/day)
Prior to 28/04/2004	85	600	18	2				
28/04/2004	85	600		2				
20/06/2007	85	600		2	15			
8/03/2008	85	600		2	15			
14/10/2009	85	600		2	15			
16/02/2010	85	600	10	2	15			
17/12/2010	85	600	10	2	15			
8/12/2011	600	85	10	2	15	10		10
22/12/2011	600	85	10	2	15	10		10
10/05/2012	600	85	10	2	15	30	30	30

** Refers to approved combined discharge quantities*

Table 2.4: UMC Aggregated Surface Water Quantity and Quality Discharges into Ulan Creek from EPL ID3, EPL ID6 and EPL ID19 (Nov 2008 – Dec 2014)

Statistic	Flow (ML/day)	pH	EC (µS/cm)	TSS (mg/L)
Mean	9.1	7.4	693	2

2.3 Rainfall and Evaporation

The closest Bureau of Meteorology (BOM) Weather Station to the MCC is Ulan Water Station (Station 062036). Daily rainfall data has been collected from this weather station since 1906. Table 2.5 provides average monthly rainfall depths at Ulan Water Station for the period from 1906 to 2017.

MCO has collected daily rainfall for the local area since February 2007. The dataset comprises consolidated data collected from the Ulan, and MCC (Admin, Rayner and Woodhead) Weather Stations. The average monthly rainfall depths for this dataset are also included in Table 2.5.

Table 2.5: Average Monthly Rainfall (mm)

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Stn 062036 (1906 to 2017)	73.3	59.9	52.8	41.2	45.2	46.3	47.5	47.1	42.5	55.2	57.5	65.8	644.1
Local data (2007 to 2017)	83.7	71.5	46.9	38.6	57.2	59.0	43.4	48.9	54.1	72.8	111.1	115.6	769.2

Table 2.5 shows that the highest rainfalls in the area are received in the months of January, February, November and December. The lowest monthly average rainfall is received in April. The average annual rainfall at Ulan Water Station is 644 mm and 769 mm at the local weather stations. The difference in average annual rainfall between the Ulan Water Station and the local weather stations is primarily associated with the different periods of record.

The closest BOM weather station with evaporation data is Scone SCS Station (061089), located approximately 114 km north-east of Ulan, with evaporation data available for the period from 1950 to present. Average daily evaporation for this station is shown in Table 2.6, which shows that average daily evaporation is low (1.6 to 7.1 mm/day). The highest evaporation months are January and December.

Table 2.6: Average Daily Evaporation (mm) at Scone SCS (1950-2017)

Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
7.0	6.2	4.9	3.5	2.3	1.6	1.8	2.7	3.9	5.1	6.2	7.1

2.4 Goulburn River System

The MCC is located within the Upper Goulburn River catchment. The drainage network in the vicinity of the MCC is shown on Figure 1.2.

2.4.1 The Goulburn River

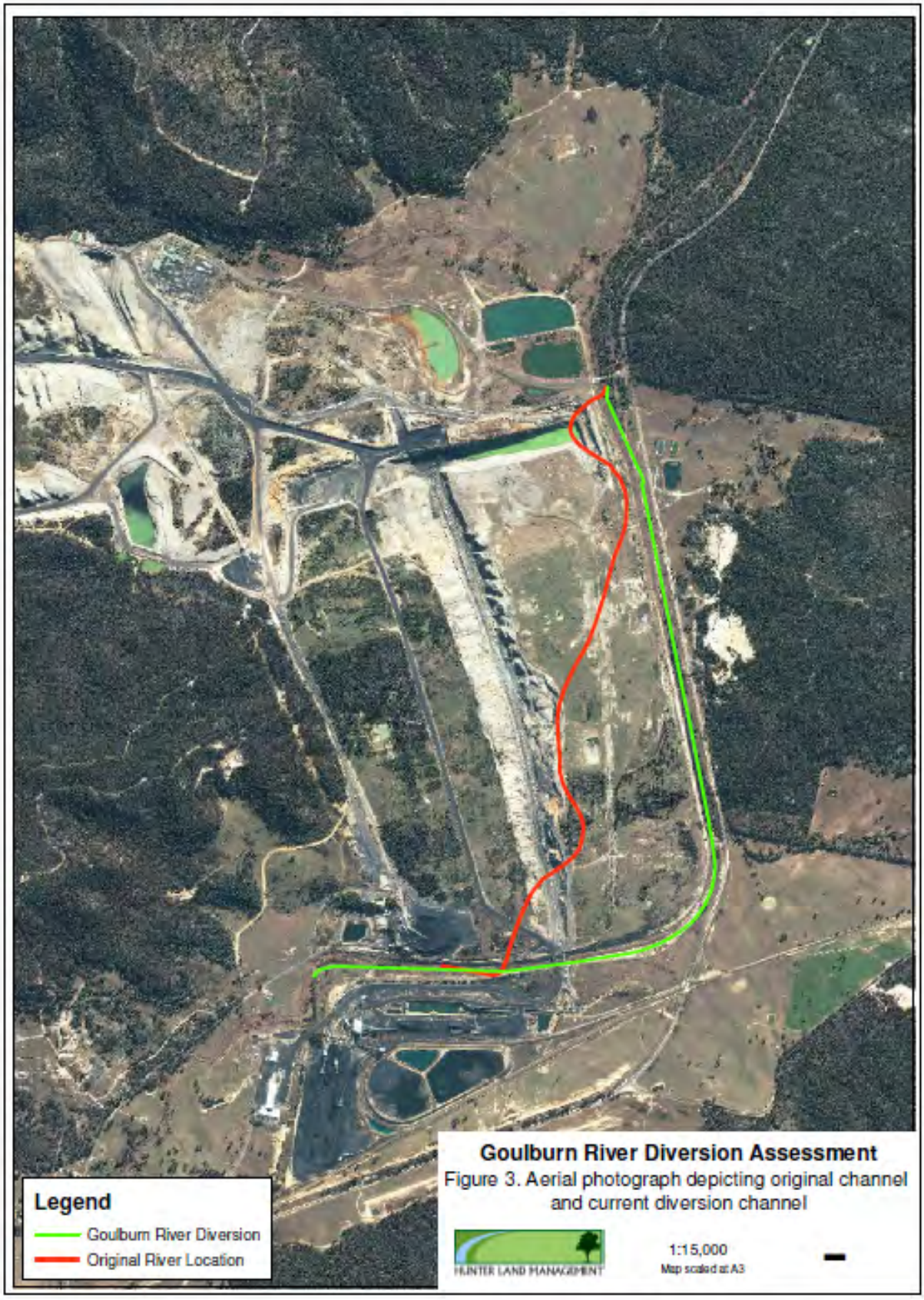
The Goulburn River is approximately 221 km in length. It commences on the eastern slopes of the Great Dividing Range at the confluence of Moolarben Creek and Sportsmans Hollow Creek, near the village of Ulan, and discharges into the Hunter River south of Denman, approximately 150 km downstream of the MCC. The majority of the river flows through the Goulburn River National Park. The Goulburn River descends 337 m over its course and has a catchment area of approximately 114 km^2 to the Ulan Road Bridge, north west of the MCC.

The Goulburn River runs along the north-western boundary of the MCC, flowing in a north easterly direction in the vicinity of the MCC.

2.4.2 The Goulburn River Diversion

The expansion of the UMC into open cut operations in 1982 resulted in the requirement to divert the Goulburn River to provide access to the coal resource. Construction of the Diversion commenced in 1981 and was completed in 1982, diverting 3.6 km of the Goulburn River approximately 700 m east of its original flow-path. The modified channel now covers 4.2 km. An aerial photo showing the location of the Goulburn River Diversion and the original river location is provided in Figure 2.1.

The bed of the Diversion generally comprises a bedrock base with an average gradient of 0.3 to 1% (Hunter Land Management, 2006). The Diversion has a trapezoidal channel cross section along most of its length and has sufficient capacity to convey the 100 year Average Recurrence Interval (ARI) flood event within its banks (UCML, 2013).



(Source: Hunter Land Management, 2006)

Figure 2.1: Goulburn River - Original Location and Diversion

2.4.3 Local Drainage Network

A number of local creeks drain through the MCC or are located in the vicinity of the MCC, as shown on Figure 1.1.

Moolarben Creek

Moolarben Creek is the primary tributary of the upper Goulburn River catchment and flows in a northerly direction along the western boundary of the MCC. The Moolarben Creek Dam is located on Moolarben Creek, approximately 1.5 km upstream of the confluence with Sportsmans Hollow Creek. It was constructed between 1955 and 1957 to supply cooling water for the Ulan Power Station (Tickle, 2005). The Moolarben Creek Dam is located on land owned by the UMCL and has a storage volume of approximately 170 ML. UCML has a licence (WAL19047) to extract up to 600 ML per year of water from Moolarben Creek Dam (Ulan Coal, 2016a). Environmental flows are released from the dam in accordance with the licence conditions for this structure. Water licence works approval 20WA209953 requires that:

> *'Flow of not less than 7 L/sec pass out of the Moolarben Dam into Moolarben Creek downstream of the dam at all times, provided that when the flow into the stored water is less than 7 L/sec, the flow to be passed out of the dam wall shall be that flowing into the stored water for the time being'*.

According to the *Ulan Coal Annual Review 2016* (Ulan Coal, 2016b), 145 ML was released from Moolarben Dam into Moolarben Creek during the 2016 reporting period in accordance with this condition.

Bora Creek

Bora Creek is an ephemeral stream that discharges into the Goulburn River Diversion about 4 km downstream from the town of Ulan. It drains a small catchment that extends to the north-east of the Goulburn River and the MCC. The MCC Coal Handling and Processing Plant (CHPP) and part of the MCC underground 4 (UG4) mine are located within the Bora Creek Catchment.

Ulan Creek

Ulan Creek joins the Goulburn River to the west of the UG4 area, downstream of the MCC. Ulan Creek is an ephemeral creek that runs through the UMC in a southerly then easterly direction. Water has been discharged into Ulan Creek from the UMC via the Bobadeen Water Treatment Facility and Rowans Dam licenced discharge points, in accordance with EPL 394 since 2004. A discharge limit of 30 ML/day for the UMC was approved in May 2012. Further details of the UMC discharges are provided in Section 2.2.

Bobadeen Creek

Bobadeen Creek flows through the north-eastern section of the UMC in a south-easterly direction to the Goulburn River. Bobadeen Creek is ephemeral and experiences very low flows. It is understood that the UMC participates in a salinity offset scheme (the Bobadeen Irrigation Scheme), irrigating around 240 hectares (ha) of pastures and discharging up to 11 ML/day within the catchment of Bobadeen Creek.

Wilpinjong Creek

Wilpinjong Creek drains in a south-easterly direction along the eastern boundary of the MCC and joins Wollar Creek, before draining into the Goulburn River approximately 26 km downstream of the MCC.

Murragamba and Eastern Creeks

Murragamba Creek drains in a north-easterly direction through the MCC open cut 4 (OC4) mine area before draining into Wilpinjong Creek. The Murragamba Creek and (locally termed) Eastern Creek catchments cover an area of about 3,400 ha, and comprise approximately 6% of the total area of the Wollar Creek catchment. Murragamba and Eastern Creeks are low order ephemeral drainage systems that only flow in response to rainfall. Both systems have insufficient baseflow to sustain flow in these creek lines, hence there are no surface water discharges from these creeks into Wilpinjong Creek during periods of low or no rainfall.

2.4.4 Goulburn River Flow Regime

Flows in the upper reaches of the Goulburn River in the vicinity of the MCC (i.e. upstream of its confluence with Bobadeen Creek) have been altered over time by:

- the presence of Moolarben Dam, which has significantly reduced flows from Moolarben Creek into the Goulburn River;
- the construction of the Goulburn River Diversion upstream of Ulan Creek, which has altered the original flow-path, size and shape of the Goulburn River channel; and
- discharges from the UMC downstream of Ulan Creek, which commenced in 2004.

The following flow gauges are located on the Goulburn River in the vicinity of the MCC:

- **Flow gauge 210046:** This gauge was operated from March 1956 to July 1982 (prior to the commencement of mining at the MCC) by the Department of Primary Industries (DPI) Water. The gauge was located at the headwaters of the Goulburn River approximately 100 m downstream of the confluence of Sportsmans Hollow Creek, Moolarben Creek and the Goulburn River (refer Figure 1.1). Historical flow records from this flow gauge have been obtained from the Pinneena archive for use in this assessment.
- **Flow gauges UMC SW01 and UMC SW02:** These gauges are owned and operated by UCML and are located upstream and downstream of the junction with Ulan Creek respectively, as shown on Figure 1.1. UMC SW01 is located immediately upstream of gauge 210046. Flow gauge UMC SW02 is located on the Goulburn River downstream of the proposed discharge point and the confluence with Ulan Creek. Measurement of flows, pH and EC at these locations are undertaken continuously via a data logger.

There are no existing operational DPI Water flow gauges in the vicinity of the MCC.

The flow duration graph for gauge 210046 for the period of March 1956 to September 1982 is presented in Figure 2.2.

The construction of Moolarben Dam in 1957 is likely to have altered the flow regime downstream of the dam in Moolarben Creek and in the Goulburn River. As monitoring at gauge 210046 covers the period 1956 to 1982, data from this site is considered to be indicative of the existing flow regime with the dam in place.

Data for flow gauge UMC SW01 (located upstream of the proposed discharge point) is available for the period from November 2007 to November 2010. Data after this time appears to be faulty. The Ulan Coal *Surface Water Monitoring Program* (Ulan Coal, 2016a) states that "*gauging data at SW01 is incomplete due to difficulties in ascertaining a robust rating curve due to the presence of reeds and periods of no flow*". Due to the limited flow data record at flow gauge UMC SW01, the flow data for flow gauge 210046 is considered to be a more reliable indicator of flows on the Goulburn River upstream of Ulan Creek and has therefore been used for this assessment.

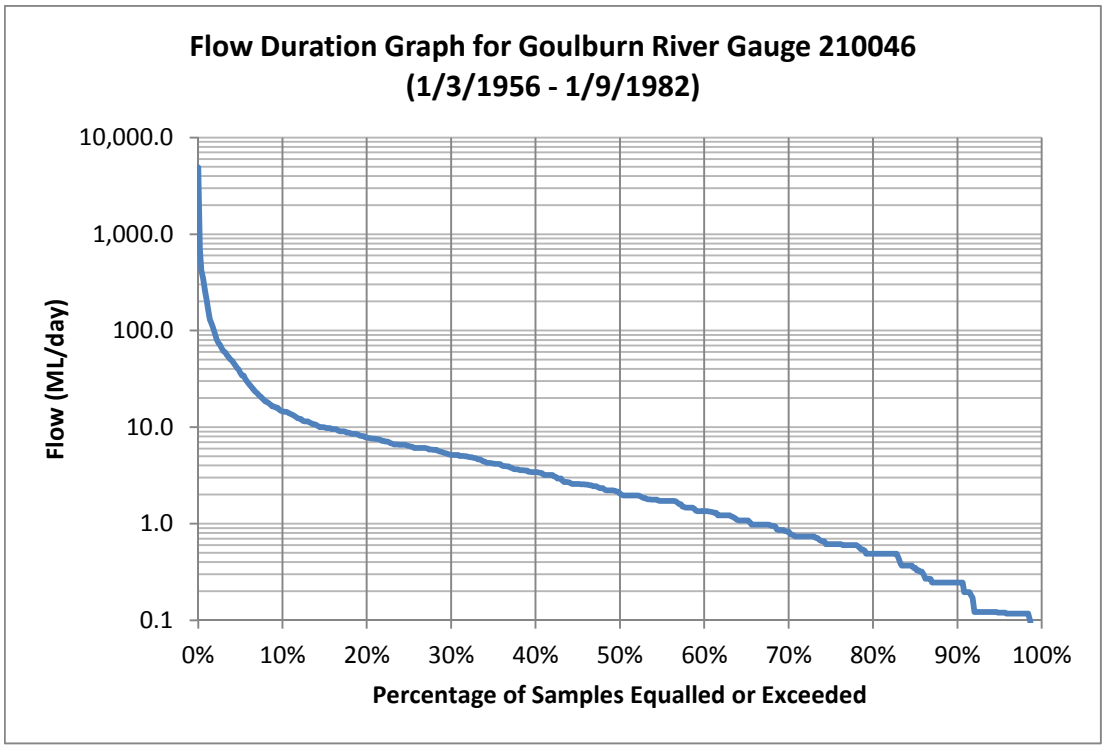


Figure 2.2: Flow Duration Graph for Goulburn River Gauge 210046 (1956-1982)

Discharges from the UMC (commencing 2004) have influenced the flow regime in the Goulburn River downstream of the confluence with Ulan Creek. The flow duration graph for UMC SW02 for the period November 2007 to September 2016 is presented in Figure 2.3. Flows at this location have been adopted to represent downstream discharges for this assessment.

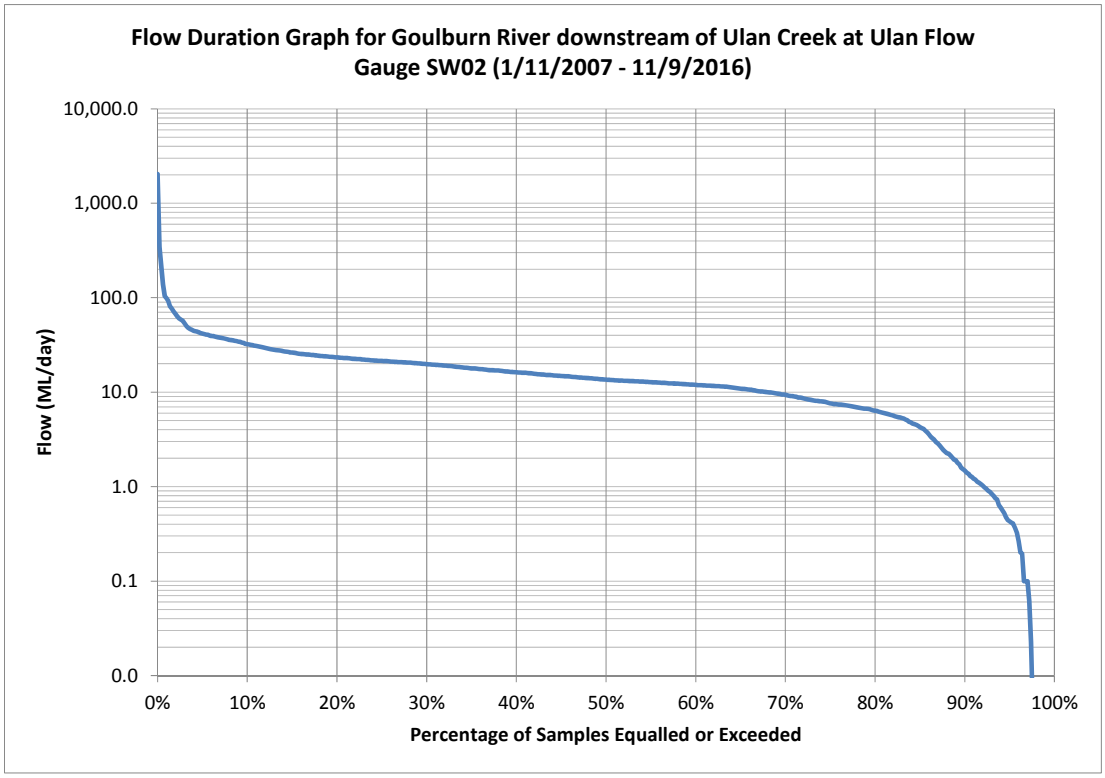


Figure 2.3: Flow Duration Graph for Goulburn River at Flow Gauge UMC SW02

2.4.5 Channel Characteristics

A site inspection of Bora Creek, the Goulburn River Diversion and the Goulburn River was carried out by Dr Steve Perrens of Advisian on 28 and 29 March 2017 to identify the existing channel characteristics.

Bora Creek

Bora Creek is a narrow channel that is moderately vegetated. Channel bed widths vary from around 1.5 m to 3 m. The channel bed is formed in the natural surface soils and has a coarse sandy base with rounded gravel (refer Figure 2.4). The banks of Bora Creek are sandy with some stabilising trees and vegetation. In various sections of the creek there are significant debris including tree branches. No flow was observed in Bora Creek during the site inspection, although some small residual pools from the rainfall event on 26 March 2017 were observed.

Pre-mining inspections of Bora Creek indicates areas of deeply eroded steep but stable banks (Moolarben Biota, 2008). The recent site inspection indicates that Bora Creek continues to shows signs of varying degrees of erosion. Active erosion, including significant scour holes, was observed at some locations.

MCC discharge point EPL ID1 is located adjacent to Bora Creek within the rail loop (refer Figure 1.1). Bora Creek ends at the confluence with the Goulburn River Diversion.

Figure 2.4: Bora Creek Showing Sandy Channel Bed

Goulburn River Diversion

During the site inspection it was observed that the Goulburn River Diversion downstream of the MCC is a generally uniform, well vegetated channel with trapezoidal channel dimensions. River bank heights vary from around 4 m to 20 m, and channel bed widths vary from around 30 m to 40 m. The banks of the Diversion comprise sandstone bedrock with some clay horizons exposed throughout the middle and upper banks, as shown in Figure 2.5 and Figure 2.6. Typical channel cross-sections for the Diversion are presented in Appendix A (Chainages 2000 to 4200).

The channel bed is formed in the natural sandstone bedrock and has a rocky base covered with a layer of sediment. The channel is well vegetated with reeds and grass as shown in Figure 2.5 and Figure 2.6.

Figure 2.5: Goulburn River Diversion at the confluence with Bora Creek, looking downstream

Figure 2.6: Goulburn River Diversion near the confluence with Bora Creek, looking upstream

The Diversion has an average longitudinal gradient of 0.3% to 1%. The confluence with Bora Creek is located approximately halfway along the Diversion. The Diversion ends just south of the confluence with Ulan Creek, where the Goulburn River then continues its original natural course.

Goulburn River (Downstream of Diversion)

Downstream of the confluence with Ulan Creek, the Goulburn River is a broad, well vegetated channel. At the time of the site inspection flow was observed in the Goulburn River. River bank heights vary from around 5 m to 10 m, and channel widths vary from around 50 m to 80 m. The channel bed is formed in the natural surface soils and has a coarse sandy base. The channel contains various sand bars, elongated permanent pools and rocky outcrops as shown in Figure 2.7.

Figure 2.7: Elongated pools in the Goulburn River downstream of Ulan Creek, upstream of the confluence with Bobadeen Creek

Downstream of the confluence with Bobadeen Creek, the Goulburn River continues as a sandy, well defined channel with occasional flood debris scattered across the channel (Figure 2.8). The banks are generally well vegetated and stabilised with trees, and the channel contains various elongated permanent pools where reed growth (eg. phragmites) is a typical feature (Figure 2.9).

Figure 2.8: Goulburn River Downstream of Bobadeen Creek

Figure 2.9: Goulburn River Downstream of Bobadeen Creek

The 'Drip' is a well-known natural feature of the Goulburn River and is located approximately 800 m downstream of the confluence with Bobadeen Creek. The 'Drip' is located in the Goulburn River National Park, between stream health monitoring site MCC SH02 and surface water monitoring site MCC SW01 (refer Figure 1.1). At the 'Drip', water from surrounding hillsides to the north seeps through the sandstone rock strata and drips into the pools below. The channel base is broad (up to 60 m wide) and rocky with large boulders and elongated pools located within the channel (refer Figure 2.10). In some sections, the gorges are over 20 m high.

Figure 2.10: Pool at the Base of the 'Drip'

2.4.6 Channel Stability

2.4.6.1 Site Observations

The channel stability of Bora Creek, the Goulburn River Diversion and the Goulburn River, as observed during the site inspection, is described as follows:

- Bora Creek shows signs of varying degrees of erosion. Active erosion, including significant scour holes, were observed at some locations.
- In the upstream section of the Goulburn River between the confluence with Moolarben Creek and Sportsmans Hollow Creek and the Diversion, the channel is broad and shallow, lined with reeds and sediment and appears stable.
- The channel bed and banks of the Diversion in the vicinity of the proposed discharge point are generally comprised of bedrock, with some clay horizons exposed throughout the mid and upper banks. Sediment overlies the rock-lined base, with plentiful reeds/phragmites lining the channel. The channel also appears stable in the location of the relocated discharge point.
- Downstream of the Diversion, where the Goulburn River returns to its natural course, the channel was observed to be stable, with some minor areas of local erosion.
- At the 'Drip', the channel is constrained by rock and appears to be very stable.

2.4.6.2 Baseline Channel Stability Monitoring

Baseline channel stability monitoring was undertaken by MCO in 2009 prior to the commencement of mining. Monitoring points in the vicinity of the proposed discharge location are shown in Figure 2.11, including Goulburn River GR-pt 1 and points BC-pt 1 to BC-pt 10 on Bora Creek. The channel stability monitoring included:

- documenting locations and dimensions of significant erosive or depositional features so that any subsequent changes could be evaluated;
- establishing photographic points at representative locations, so that photos could be taken in a repeatable manner;
- written descriptions of the stream at each of the photographic points, focussing on evidence of erosion and exposed soils; and
- measurement of cross-sections at strategic locations.

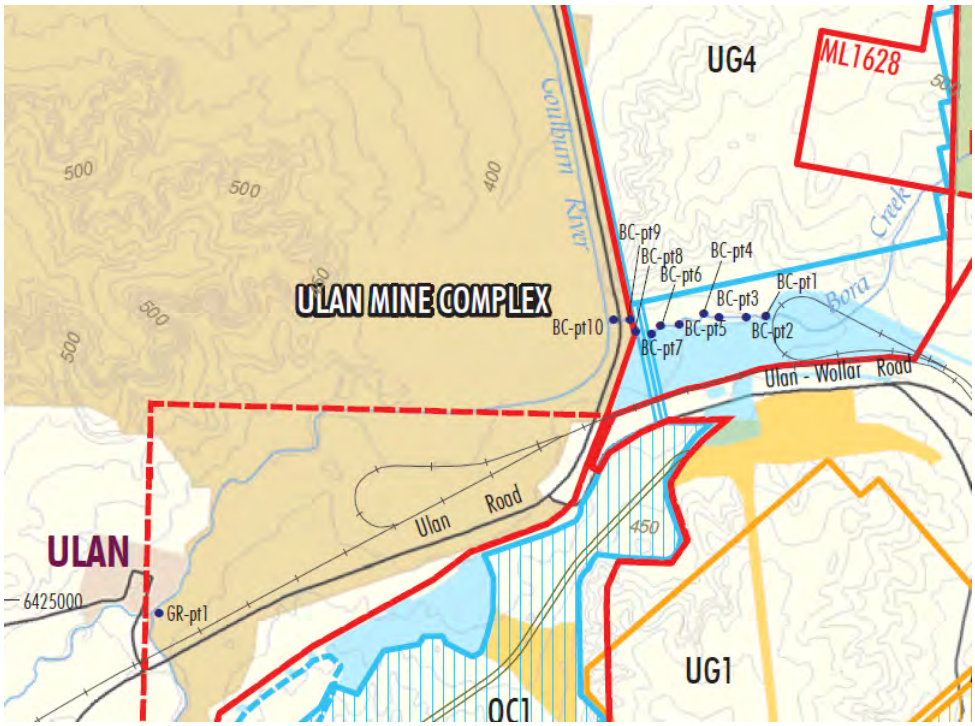


Figure 2.11: MCO Baseline Channel Stability Monitoring Locations

The baseline channel stability monitoring program utilised the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Ephemeral Stream Assessment to classify each monitoring location (MCO, 2016c) (Table 2.7). Table 2.8 provides the baseline channel stability classification results for the sites on the Goulburn River and Bora Creek in the vicinity of the proposed discharge point.

Table 2.8 shows that the Goulburn River was classified as 'Very Stable' during the baseline monitoring period while the section of Bora Creek upstream of the confluence with the Diversion ranged from 'Very Active' to 'Stable'. The Bora Creek sites located immediately upstream of the Goulburn River Diversion and proposed discharge point were classified as 'Very Active' and 'Active'.

Table 2.7: CSIRO Channel Stability Classification System

Activity Rating (%)	Classification	Discussion of Classification
80 +	Very Stable	Drainage line is very stable and likely to be in original form. It is able to withstand all flow velocities that have previously occurred in this area and only minimal monitoring is required, predominantly after high flow events, to ensure condition does not deteriorate.
70 - 80	Stable	Drainage line is stable. It is important to assess this zone in relation to other classifications and define whether this zone is moving from potentially stabilising to a more stable form or if it is deteriorating from a very stable form. The nature of this relationship will identify the type of monitoring required.
60 - 69	Potentially Stabilising	Drainage line is potentially stabilising. Ongoing monitoring is required while rehabilitation works are not needed in the immediate future.
50 - 59	Active	Drainage line is actively eroding and remedial actions are required. It is important to classify if erosion is caused primarily by upstream flows, lateral flows or unstable wall materials so that appropriate rehabilitation can be carried out.
< 50	Very Active	Drainage line is very actively eroding and immediate remedial actions are required. It is important to classify if erosion is caused primarily by upstream flows, lateral flows or unstable wall materials so that appropriate rehabilitation works can be carried out.

Source: MCO (2016) SWMP

Table 2.8: Baseline Classification of Channel Stability Monitoring Sites

Site Location	Site Number	Classification
Goulburn River	GR-pt 1	Very Stable
Bora Creek	BC-pt1	Very Stable
	BC-pt2 (upstream)	Potentially Stabilising
	BC-pt 2 (downstream)	Stable
	BC-pt3	Active/Potentially Stabilising
	BC-pt 4 (upstream)	Stable
	BC-pt 4 (downstream)	Active
	BC-pt5	Active
	BC-pt6	Active
	BC-pt7	Active/Potentially Stabilising
	BC-pt8	Active to Very Active
	BC-pt9	Very Active
	BC-pt10	Active

2.4.6.3 Ongoing Channel Stability Monitoring

Ongoing channel stability monitoring at the locations shown on Figure 2.11 is undertaken by MCO to assess any impacts that may be attributed to mining. Monitoring is undertaken annually or following significant flow (50 year ARI and greater).

The results of the annual channel stability monitoring and implementation of any required actions are described in the Moolarben *Annual Reviews*. The 2016 Annual Review (MCO, 2016b) states that "*Bora Creek continues to show signs of increasing stability downstream in 2016 with areas of active erosion in the upper reaches. This condition is unchanged since the last monitoring period*".

2.5 Goulburn River Water Quality

2.5.1 Surface Water Quality Trigger Levels

The surface water quality trigger levels adopted in the MCO *Surface Water Management Plan* (SWMP) (MCO, 2016c) for the Goulburn River are provided in Table 2.9. The levels are a combination of site-specific trigger values derived from water quality monitoring and the default ANZECC Guideline (2000) trigger values for upland rivers in slightly to moderately disturbed ecosystems in south-east Australia.

The SWMP was updated in 2016 and submitted for approval. Based on analysis of additional water quality data in the Goulburn River, revised triggers for pH and EC were proposed in the updated SWMP.

Table 2.9: Adopted Surface Water Quality Trigger Levels for the Goulburn River

Goulburn River Monitoring Sites	pH **ANZECC Guideline**	EC **(µS/cm)** **80th %ile Trigger Value**	Turbidity **(mg/L)** **ANZECC Guideline**
SW01, SW02 and SW12	6.5 – 8.5*	900*	25

* As per the updated SWMP submitted for approval in 2016.

The SWMP (MCO, 2016c) includes a 'Surface Water Response and Contingency Plan'. The Plan includes a series of actions to be implemented in the event that surface water monitoring at the Goulburn River identifies water quality results consistently outside the limits set out in Table 2.9.

2.5.2 Routine Monthly Monitoring Results

Routine monthly surface water quality monitoring has been undertaken by MCO in the Goulburn River since February 2005, in accordance with the SWMP (MCO, 2016c). Water quality data is also collected by UCML at UMC flow gauges UMC SW01 and UMC SW02 on the Goulburn River. A summary of the monitoring program for the relevant monitoring sites is provided in Table 2.10. The stations are listed from upstream to downstream. Figure 1.1 shows the locations of the surface water quality monitoring sites.

It should be noted that the MCO and UCML monitoring locations are named using a very similar terminology. This assessment uses MCC and UMC as prefixes to distinguish the sites.

Surface water monitoring site MCC SW08 on Moolarben Creek is located upstream of all MCC and UMC mining operations and discharge points and so can be used to characterise the upstream water quality. Sites UMC SW01 and MCC SW12 are located on the Goulburn River upstream of the proposed discharge point and so can be used to characterise water quality upstream of the proposed discharge point. Sites UMC SW02, MCC SW02 and MCC SW01 are located downstream of the MCC and UMC mining operations and all discharge points and so can be used to characterise downstream water quality.

Table 2.10: Surface Water Quality Monitoring Sites

Monitoring Site	Parameters Measured	Frequency	Length of Record
Moolarben Creek **MCC SW08** ▪ Upstream of MCC and UMC mining operations and discharge points ▪ Upstream of Moolarben Dam	pH Electrical conductivity (EC) Total dissolved solids (TDS) Total suspended solids (TSS)	Monthly	February 2005 – March 2017
	Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, Cr, Li, Ba, Sr, Turbidity, DO, Total P and Total N	Six Monthly	
Goulburn River **UMC SW01** ▪ Upstream of proposed discharge point and UMC discharge points ▪ Downstream of Moolarben Dam	pH Electrical conductivity (EC)	Continuous	Nov 2007 – Sept 2016
Goulburn River **MCC SW12** ▪ Upstream of proposed discharge point and UMC discharge points ▪ Downstream of Moolarben Dam	pH Electrical conductivity (EC) Total dissolved solids (TDS) Total suspended solids (TSS)	Monthly	October 2008 – March 2017
	Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, Cr, Li, Ba, Sr, Turbidity, DO, Total P and Total N	Six Monthly	
(PROPOSED DISCHARGE POINT - located at the confluence of Goulburn River and Bora Creek)			
Goulburn River **UMC SW02** ▪ Downstream of proposed discharge point ▪ Downstream of Ulan Creek and UMC discharge points	pH Electrical conductivity (EC)	Continuous	Nov 2007 – Sept 2016
Goulburn River **MCC SW02** ▪ Downstream of proposed discharge point ▪ Downstream of Ulan Creek and UMC discharge points ▪ Upstream of the 'Drip'	pH Electrical conductivity (EC) Total dissolved solids (TDS) Total suspended solids (TSS)	Monthly	February 2005 – March 2017
	Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, Cr, Li, Ba, Sr, Turbidity, DO, Total P and Total N	Six Monthly	
Goulburn River **MCC SW01** ▪ Located at the 'Drip', downstream of all MCC and UMC operations and discharge points	pH Electrical conductivity (EC) Total dissolved solids (TDS) Total suspended solids (TSS)	Monthly	February 2005 - March 2017
	Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, Cr, Li, Ba, Sr, Turbidity, DO, Total P and Total N	Six Monthly	

Table 2.11 summarises the monthly surface water quality monitoring results for the MCC and UMC monitoring sites for the period February 2005 to March 2017. The adopted surface water trigger levels for Goulburn River (refer Section 2.5.1) are also included in Table 2.11 for comparison.

Table 2.11: Monthly Surface Water Quality Monitoring Summary

Monitoring Site	Parameter	Trigger Level	Count	Min	20%	Mean	80%	Max
Moolarben Creek MCC SW08 ▪ Upstream of MCC and UMC mining operations and discharge points ▪ Upstream of Moolarben Dam SW08	pH		50	5.9	6.8	7.2	7.6	7.9
	pH (field)		120	4.5	5.8	6.6	7.3	8.0
	EC(µS/cm)		89	340	2,240	3,188	3,964	6,990
	EC (field) (µS/cm)		72	1,960	3,216	4,046	4,856	5,910
	TSS (mg/L)		145	<2	3	24	28	96
	TDS (mg/L)		145	246	1,528	2,071	2,700	6,400
	Turbidity (NTU)		77	0.4	7	48	54	420
Goulburn River UMC SW01 ▪ Upstream of proposed discharge point and UMC discharge points ▪ Downstream of Moolarben Dam	pH		2,855	6.3	6.9	7.1	7.3	9.0
	EC (µS/cm)		3,141	38	405	548	714	1,095
Goulburn River MCC SW12 ▪ Upstream of proposed discharge point and UMC discharge points ▪ Downstream of Moolarben Dam	pH	**6.5 - 8.5**	51	6.3	6.7	7.2	7.5	7.8
	pH (field)		79	5.4	6.6	7.1	7.6	8.7
	EC (µS/cm)	**900**	89	110	398	540	704	935
	EC (field) (µS/cm)		32	50	404	553	713	1,080
	TSS (mg/L)		103	1	3	18	19	564
	TDS (mg/L)		104	142	262	346	420	628
	Turbidity (NTU)	**25**	37	4	10	35	34	298
(PROPOSED DISCHARGE POINT – Located at the confluence of Goulburn River and Bora Creek)								
Goulburn River UMC SW02 ▪ Downstream of proposed discharge point ▪ Downstream of Ulan Creek and UMC discharge points	pH		2,823	2.8	7.6	7.7	8.0	8.9
	EC (µS/cm)		3,133	8	630	734	831	1,248
Goulburn River MCC SW02 ▪ Downstream of proposed discharge point ▪ Downstream of Ulan Creek and UMC discharge points ▪ Upstream of the 'Drip'	pH	**6.5 - 8.5**	51	7.0	7.5	7.8	8.0	8.3
	pH (field)		121	4.4	6.4	7.2	8.1	8.7
	EC(µS/cm)	**900**	89	310	641	734	834	1,020
	EC (field) (µS/cm)		74	200	730	898	1,134	1,560
	TSS (mg/L)		147	1	1	12	6	844
	TDS (mg/L)		147	199	386	453	510	790
	Turbidity (NTU)	**25**	80	0.4	2	14	11	370
Goulburn River MCC SW01 ▪ Located at the 'Drip', downstream of all MCC and UMC operations and discharge points	pH	**6.5 - 8.5**	50	6.6	7.5	7.7	8.0	8.3
	pH (field)		123	5.4	6.4	7.3	8.2	9.3
	EC(µS/cm)	**900**	89	401	609	711	813	941
	EC (field) (µS/cm)		74	300	660	796	910	1,500
	TSS (mg/L)		147	1	1	8	5	310
	TDS (mg/L)		147	194	341	412	481	700
	Turbidity (NTU)	**25**	80	<0.1	1	7	5	150

Source: MCO Water Quality Database and Compilation of Data from UMC AEMRs

Note: Highlighted cells indicate where existing water quality values are above adopted trigger levels.

For the monitoring site MCC SW08 on Moolarben Creek, Table 2.11 shows that:

- pH ranges from slightly acidic to slightly alkaline, which is consistent with pH levels in the Goulburn River.
- EC (lab) is very high with an average of 3,188 µS/cm . This is much higher than the average EC in the Goulburn River, which ranges between 540 µS/cm and 734 µS/cm and has an adopted trigger level of 900 µS/cm. As MCC SW08 is located upstream of all discharge points and mining operations, the high EC can be attributed to other sources in the catchment (e.g. sub-cropping coal seams).
- TSS concentrations are low, which is consistent with TSS in Goulburn River.
- Average TDS concentrations mirror the variation in EC, as expected.
- Average Turbidity in Moolarben Creek is 48 NTU which is above the trigger value for the Goulburn River of 25 NTU.

For the monitoring sites on Goulburn River upstream of the proposed discharge point (UMC SW01 and MCC SW12), the main features of the water quality data summarised Table 2.11 are:

- pH is slightly alkaline with means in the range of 7.1 and 7.2, which is within the adopted trigger levels for the Goulburn River.
- Average EC (lab) varies between 540 µS/cm and 548 µS/cm, which is below the adopted trigger level for Goulburn River of 900 µS/cm.
- TSS concentrations are low reflecting the fact that TSS concentrations are closely related to flow rates.
- The average TDS concentration of 346 mg/L mirrors the variation EC, as expected.
- Turbidity at MCC SW12 has a mean of 35 NTU which is above the adopted trigger level for the Goulburn River of 25 NTU.

For the monitoring sites on the Goulburn River downstream of the proposed discharge point (UMC SW02, MCC SW02 and MCC SW01), the main features of the water quality data summarised in Table 2.11 are:

- pH is slightly alkaline with means in the range of 7.2 to 7.8, which is within the adopted trigger levels for the Goulburn River.
- Average EC (lab) varies between 711 µS/cm and 734 µS/cm, which is below the adopted trigger level for Goulburn River of 900 µS/cm.
- TSS concentrations are generally low reflecting the fact that TSS concentrations are closely related to flow rates.
- Average TDS concentrations range from 412 mg/L to 453 mg/L which, as expected, mirrors the variation in EC.
- Average Turbidity ranges from 7 NTU to 14 NTU, which is below the adopted trigger level for the Goulburn River of 25 NTU.

2.5.3 Dissolved Metals Analysis

As described in Table 2.10, monitoring of metals is conducted by MCO on a six monthly basis for the surface water monitoring sites on Goulburn River and Moolarben Creek (MCC SW08). Monitoring of metals is also undertaken following rainfall greater than 30 mm in 24 hours. Table 2.12 summarises the monitoring results at the relevant monitoring sites for a selected suite of metals for the period February 2005 to March 2017. In order to increase the dataset for metals, rainfall event monitoring has been included in the data analysis presented in Table 2.12 below. The ANZECC default trigger values for freshwater, 95% species protection (Table 3.4.1 ANZECC 2000 Guidelines) have been included for comparison.

Table 2.12: Six Monthly Summary of Surface Water Quality Monitoring for Metals

Monitoring Site	Parameter (mg/L)	ANZECC Default Trigger	Count	Min	20%	Mean	80%	Max
Moolarben Creek MCC SW08 ▪ Upstream of MCC and UMC mining operations and discharge points ▪ Upstream of Moolarben Dam	Dissolved Aluminium	**0.055**	4	<0.02	0.02	0.15	0.23	0.54
	Dissolved Iron	**-**	28	<0.05	0.55	1.69	1.76	10.50
	Dissolved Manganese	**1.9**	24	0.04	0.08	0.65	0.84	3.52
	Dissolved Nickel	**0.011**	23	<0.001	0.002	0.005	0.007	0.008
	Dissolved Zinc	**0.008**	27	<0.005	0.006	0.007	0.009	0.027
	Dissolved Cadmium	**0.0002**	23	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Dissolved Copper	**0.0014**	24	<0.001	0.005	0.0009	0.0016	0.0020
	Dissolved Arsenic	**0.013**	23	<0.001	0.001	0.001	0.001	0.001
	Dissolved Lead	**0.0034**	22	<0.001	<0.001	<0.001	<0.001	<0.001
Goulburn River MCC SW12 ▪ Upstream of proposed discharge point and UMC discharge points ▪ Downstream of Moolarben Dam	Dissolved Aluminium	**0.055**	6	1.10	1.12	3.86	6.25	8.92
	Dissolved Iron	**-**	31	0.11	1.07	3.70	5.62	13.80
	Dissolved Manganese	**1.9**	28	0.05	0.07	0.12	0.16	0.26
	Dissolved Nickel	**0.011**	28	<0.001	<0.001	0.003	0.004	0.029
	Dissolved Zinc	**0.008**	30	<0.005	<0.005	0.01	0.010	0.024
	Dissolved Cadmium	**0.0002**	28	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Dissolved Copper	**0.0014**	28	<0.001	<0.001	0.0021	0.0040	0.0070
	Dissolved Arsenic	**0.013**	28	<0.001	<0.001	0.001	0.002	0.003
	Dissolved Lead	**0.0034**	27	<0.001	<0.001	0.0045	0.0070	0.0190
(PROPOSED DISCHARGE POINT – Located at the confluence of Goulburn River and Bora Creek)								
Goulburn River MCC SW02 ▪ Downstream of proposed discharge point ▪ Downstream of Ulan Creek and UMC discharge points ▪ Upstream of the confluence with Bobadeen Creek	Dissolved Aluminium	**0.055**	6	0.10	0.10	0.36	0.41	1.40
	Dissolved Iron	**-**	34	0.03	0.13	1.81	2.52	10.30
	Dissolved Manganese	**1.9**	29	<0.001	0.03	0.24	0.23	2.42
	Dissolved Nickel	**0.011**	28	0.003	0.004	0.011	0.013	0.044
	Dissolved Zinc	**0.008**	33	<0.005	<0.005	0.016	0.023	0.098
	Dissolved Cadmium	**0.0002**	28	<0.0001	0.0001	0.0001	0.0001	0.0002
	Dissolved Copper	**0.0014**	29	<0.001	<0.001	0.0018	0.0034	0.0070
	Dissolved Arsenic	**0.013**	28	<0.001	<0.001	0.001	0.002	0.003
	Dissolved Lead	**0.0034**	27	<0.001	<0.001	0.0018	0.0018	0.010
Goulburn River MCC SW01 ▪ Located approximately 1 km downstream of the confluence with Bobadeen Creek, downstream of all MCC and UMC operations and discharge points	Dissolved Aluminium	**0.055**	7	<0.02	0.07	2.54	1.13	15.80
	Dissolved Iron	**-**	34	<0.05	0.24	1.79	2.58	10.30
	Dissolved Manganese	**1.9**	29	<0.001	0.03	0.18	0.23	1.79
	Dissolved Nickel	**0.011**	28	0.003	0.004	0.010	0.013	0.040
	Dissolved Zinc	**0.008**	33	<0.005	0.003	0.013	0.019	0.072
	Dissolved Cadmium	**0.0002**	28	<0.0001	0.0001	0.0001	0.0001	0.0001
	Dissolved Copper	**0.0014**	29	<0.001	<0.001	0.0016	0.0024	0.0080
	Dissolved Arsenic	**0.013**	28	<0.001	0.001	0.001	0.002	0.004
	Dissolved Lead	**0.0034**	27	<0.001	<0.001	0.0015	0.0017	0.0090

Note: Highlighted cells indicate where existing water quality values are above ANZECC default trigger levels for 95% species protection.

The main features of the water quality data summarised in Table 2.12 are:

- The datasets for Dissolved Aluminium concentrations are very limited (between 4 and 7 sampling events at each site) and results therefore may not be adequate to characterise water quality. For this limited dataset, Dissolved Aluminium levels are above the ANZECC trigger value for all monitoring sites.
- Average Dissolved Iron concentrations at Moolarben Creek MCC SW08 is 1.69 mg/L. In the Goulburn River, Dissolved Iron values show a decreasing trend from upstream to downstream, with the mean ranging from 3.70 mg/L at MCC SW12 to 1.79 mg/L at MCC SW01. There is no ANZECC default trigger level for 95% species protection for Iron.
- The mean and 80th percentile Dissolved Manganese concentrations are below ANZECC trigger levels at all monitoring locations. The concentrations of Dissolved Manganese is highest at Moolarben Creek MCC SW08 with a mean of 0.65 mg/L. In the Goulburn River, the mean Dissolved Manganese level is 0.12 mg/L at MCC SW12 and then increases to 0.24 mg/L at MCC SW02. Dissolved Manganese levels then drop to a mean of 0.18 mg/L at MCC SW01.
- The mean and 80th percentile Dissolved Nickel concentrations are below ANZECC trigger levels at all monitoring locations with the exception of MCC SW02 and MCC SW01. Dissolved Nickel values are low at Moolarben Creek MCC SW08 with a mean of 0.005 mg/L. In the Goulburn River, Dissolved Nickel levels show an increasing trend from a mean of 0.003 mg/L at MCC SW12 to 0.011 mg/L at MCC SW02. The Dissolved Nickel level then slightly decreases to a mean of 0.010 mg/L at SW01.
- Dissolved Zinc concentrations are above ANZECC Trigger levels at all monitoring sites. At MCC SW08 on Moolarben Creek, mean Dissolved Zinc is 0.007mg/L. In the Goulburn River, Dissolved Zinc levels show an increasing trend from a mean of 0.01 mg/L at MCC SW12 to a mean of 0.016 mg/L at MCC SW02. Dissolved Zinc then slightly decreases to a mean of 0.013 mg/L at MCC SW01.
- Dissolved Cadmium levels are below ANZECC Trigger levels at all monitoring sites, and below laboratory testing limits at both MCC SW08 on Moolarben Creek and MCC SW12 on the Goulburn River. Dissolved Cadmium levels are very low at MCC SW02 and MCC SW01.
- Dissolved Copper concentrations are lowest on Moolarben Creek at MCC SW08 where the mean is below the ANZECC trigger level. Dissolved Copper concentrations are slightly above the ANZECC trigger level in the Goulburn River and shows a decreasing trend from upstream to downstream with a mean of 0.0021 mg/L at MCC SW12 ranging to a mean of 0.0016 mg/L at MCC SW01.
- Dissolved Arsenic concentrations are below the ANZECC trigger level at all monitoring sites, being a consistent average of 0.001 mg/L at all sites.
- Dissolved Lead concentrations are lowest at Moolarben Creek MCC SW08 where levels are below laboratory detection limits. The mean, 80th percentile and maximum Dissolved Lead concentrations are above ANZECC trigger levels at MCC SW12. Maximum Dissolved Lead concentrations are above the ANZECC Trigger level at both MCC SW02 and MCC SW01. Dissolved Lead concentrations show a decreasing trend in the Goulburn River with a mean of 0.0045 mg/L at MCC SW12 ranging to 0.0015 mg/L at MCC SW01.

In general, dissolved metal concentrations in the Goulburn River are variable and, in some cases, are above ANZECC default trigger levels for 95% species protection both upstream and downstream of the relocated discharge point. In particular, the mean and 80th percentile Dissolved Aluminium and Dissolved Zinc concentrations exceed trigger levels at all monitoring sites (including those upstream of the MCC and UMC), and the mean and 80th percentile Dissolved Copper concentrations exceed trigger levels at all monitoring sites on the Goulburn River. Dissolved metal concentrations are generally lower at Moolarben Creek MCC SW08 than at monitoring sites on the Goulburn River, with the exception of Dissolved Manganese.

2.5.4 Goulburn River Stream Health

A review of Goulburn River stream health has been undertaken by Marine Pollution Research Pty Ltd (MPR) (2017). A summary of this review is provided below.

The upper section of the Goulburn River, upstream of the Goulburn River National Park, has been modified by historic development, including the construction of the Moolarben Dam (constructed in the 1950s) and the Goulburn River Diversion (constructed in the 1980s). Review of baseline aquatic ecology data shows that prior to the commencement of the MCC, aquatic ecology diversity and abundance was reflective of a disturbed environment, as evidenced by SIGNAL and Diversity scores. Threatened species database searches also show the upper Goulburn River catchment does not provide habitat for threatened aquatic ecology species.

Following review of the available stream health monitoring data, MPR (2017) concluded aquatic ecology monitoring data indicates discharges from UMC during 2011 to 2017 have not resulted in an adverse impact to key aquatic indicators when compared to pre-2011 levels.

3 Proposed Discharge Arrangement

Recent site water balance modelling undertaken by WRM (2017) indicates that the MCC is predicted to be a water surplus site in certain years and climatic sequences. The ability to release water is required to minimise impacts on operations. MCO therefore intends to seek EPA approval for an increase in the total volume of the controlled release of water from the site into the Goulburn River from 10 ML/day to 20 ML/day.

EPL ID1 is proposed to be relocated from its existing location on Bora Creek to a more suitable location at the confluence of Bora Creek and the Goulburn River Diversion. The revised location was chosen by MCO in consultation with Advisian and MPR during the site visit in March 2017.

Treatment Plant Storage Dams and a Water Treatment Plant (WTP) are proposed to be constructed in the vicinity of the rail loop to treat site water prior to discharge. The general location of the proposed WTP is shown on Figure 1.1. The water would be treated such that the quality of the treated discharge water would comply with the existing EPL water quality concentration limits.

During baseline channel stability monitoring (refer Section 2.4.6), sections of Bora Creek were classified as 'Active' to 'Very Active'. In order to eliminate any potential erosion impacts on Bora Creek, it is proposed that discharge waters would be transported from the WTP via a pipeline along the side of Bora Creek and not directly as flow within Bora Creek itself. The pipeline would discharge water at the proposed new discharge point.

Figure 3.1 shows the rock shelf where the discharge point is proposed to be situated (foreground), with the well vegetated Goulburn River Diversion channel located in the background. The rock-shelf would provide natural scour protection and is considered to be an ideal location for discharge as the potential for scour would be minimal. It is however recommended that a flow spreader/diffuser be installed at the proposed discharge point. Discharge water would then drain from the rock platform onto exposed rock at the base of the Goulburn River Diversion (refer Figure 3.2). Due to the stability of the well vegetated, rock-based channel at the relocated discharge point, no additional scour protection is anticipated to be required in this location.

Figure 3.1: Location of Proposed Discharge Point at the confluence of Bora Creek and Goulburn River Diversion

Figure 3.2: Location of Proposed Discharge Point looking from rock platform towards base of the Goulburn River Diversion Channel

4 Potential Impacts

Analysis has been undertaken to consider the effect of the increased discharge on flow regime, channel stability and water quality in the Goulburn Diversion and River downstream of the discharge point. This has been undertaken using the HEC-RAS hydraulic model, described further below.

4.1 Hydraulic Modelling

The HEC-RAS Version 5.0.3 (February 2016) hydraulic model is the latest windows-based release from US Army Corps of Engineers, Hydrologic Engineering Centre. HEC-RAS is an integrated package of hydraulic analysis programs capable of performing one-dimensional steady flow water surface profile calculations. The model is appropriate for this study because the section of the Goulburn River running adjacent to the MCC has a well-defined channel and floodplain.

The steady flow component of the model can handle a full network of channels, a dendritic system or a single river reach and is capable of modelling subcritical, supercritical and mixed flow water surface profiles. The basic computational procedure is based on the solution of the one-dimensional energy equation. Energy losses are evaluated by friction using the Manning's Equation.

4.1.1 HEC-RAS Model Setup

The hydraulic model was used to determine the impacts of the increased discharge volume on water level and velocity downstream of the relocated discharge point. The model extends from the proposed discharge point downstream to the 'Drip', a distance of approximately 7.4 km.

The model comprises eight surveyed river cross-sections obtained from the *Goulburn River Diversion Baseline Assessment Final Report* (Hunter Land Management, 2006) as well as two additional cross-sections (at chainage 8400 and 9400) which were estimated from 1:25,000 topographic mapping.

The cross-sections include:

- Chainage 2000, which is located in the Diversion close to the proposed discharge point;
- Chainage 2400 - Chainage 4200, which are located in the Diversion downstream of the proposed discharge point;
- Chainage 4600, which is located in the Goulburn River approximately 2.6 km downstream of the proposed discharge point;
- Chainage 5050, which is located in the Goulburn River around 3 km downstream of the proposed discharge point, just upstream of the confluence with Ulan Creek;
- Chainage 8400, which is located upstream of the 'Drip' and Bobadeen Creek; and
- Chainage 9400, which is located at the 'Drip', downstream of Bobadeen Creek.

The locations of the surveyed and estimated sections are shown on Figure 4.1.

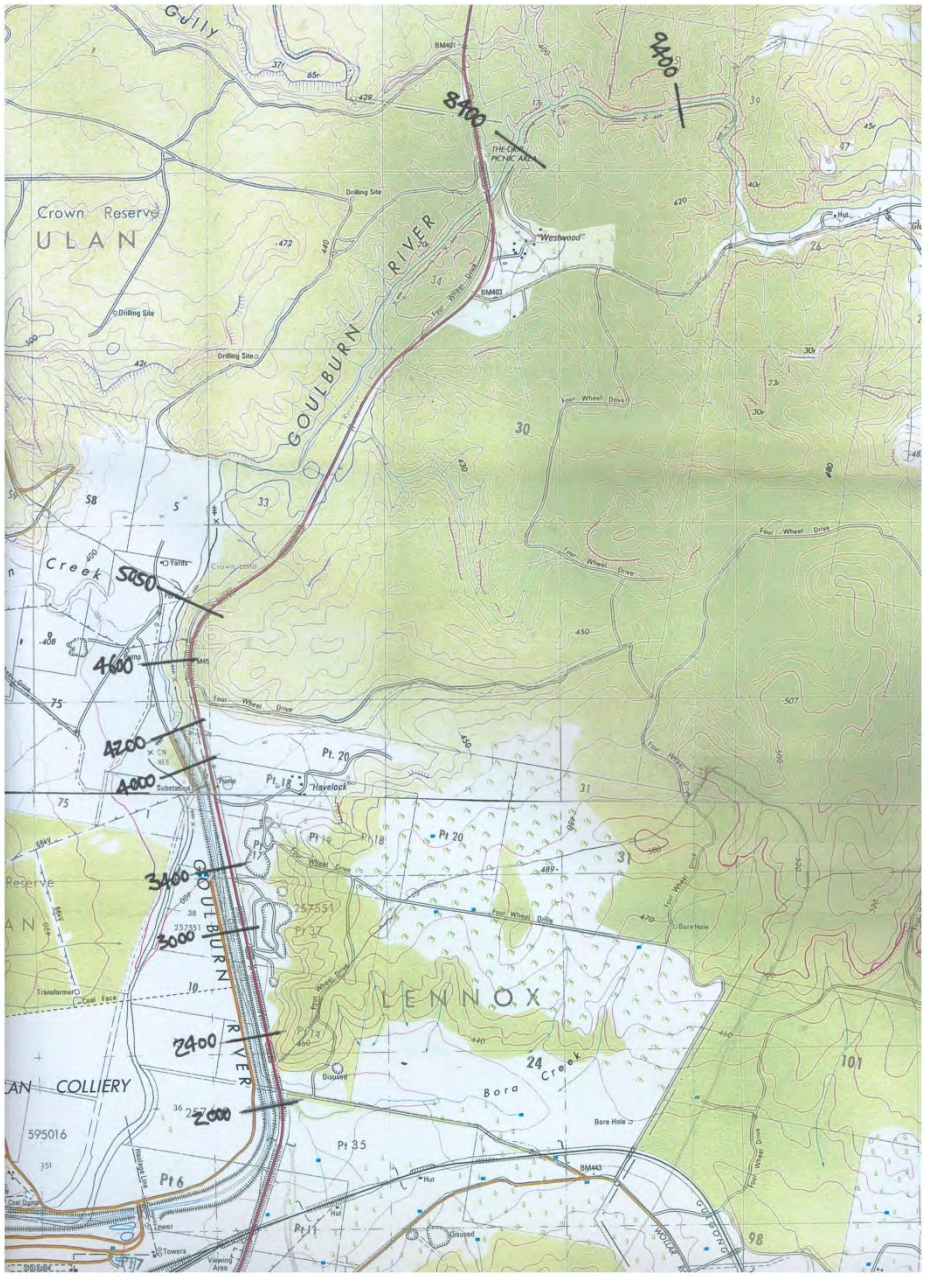


Figure 4.1: Plan View of HEC-RAS Cross-Section Locations

Table 4.1 shows the Manning's 'n' roughness values that were assigned to the cross-sections to represent surface roughness across the channel and adjoining overbank areas. The roughness values were identified based on the site inspection observations, site photos and the HEC-RAS User Manual (HEC-RAS, 2016).

Table 4.1: Manning's 'n' Values used in HEC-RAS Analysis

Location	Manning's 'n' Value	Type of Channel and Description
Diversion Channel	0.027	Excavated, straight and uniform channel with short grass and few weeds
Diversion Channel Overbank	0.050	Light brush and trees in winter
Goulburn River Channel downstream of the Diversion	0.045	A natural stream that is clean, winding with some pools and shoals and some weeds and stones
Goulburn River Overbank downstream of the Diversion	0.12	Trees with some heavy stands of timber, few down trees, little undergrowth and flow into branches

4.1.2 HEC-RAS Model Flows

Flows for input to the model were obtained from the flow duration curves for gauge 210046 (upstream of the proposed discharge point, refer Figure 2.2) and flow gauge UMC SW02 (downstream of the discharge point, refer Figure 2.3). Three flow regimes were modelled in HEC-RAS to represent a range of flows in the Goulburn River:

- 'High Flow' (flow which is exceeded by 10% of the historic record).
- 'Medium' Flow (flow which is exceeded by 50% of the historic record).
- 'Low Flow' (flow which is exceeded by 90% of the historic record).

In order to consider the effect of the proposed discharge, three scenarios were modelled under each of the flow regimes:

- Existing flows (no discharge from MCC) obtained from the flow duration curves for 210046 and UMC SW02.
- EPL approved flows – existing flow plus additional 10 ML/day discharge from MCC.
- Proposed flows – EPL approved flows plus additional 10 ML/day (ie. existing flows plus 20 ML/day discharge from MCC).

Table 4.2 contains the flows modelled in HEC-RAS for the three scenarios and flow regimes. The percentage of the additional discharge of the total flow in the river is also provided in Table 4.2.

Table 4.2: Modelled Flow Scenarios

Location	Flow Regime	'Existing Flows' (No Discharge from MCC) (ML/day)	EPL Approved Flows (existing + 10 ML/day) (ML/day)	Proposed Flows (existing + 20 ML/day) (ML/day)
Goulburn River upstream of CH 5050 (Gauge 210046)	High	16	26 (38%)	36 (56%)
	Medium	2	12 (82%)	22 (91%)
	Low	0.25	10.25 (98%)	20.25 (99%)
Goulburn River downstream of CH 5050 (Gauge UMC SW02)	High	30	40 (25%)	50 (40%)
	Medium	15	25 (40%)	35 (57%)
	Low	1.5	11.5 (87%)	21.5 (93%)

As detailed in Table 4.2, a flow change location has been added downstream of chainage 5050 (the approximate location that Ulan Creek enters the Goulburn River) in the HEC-RAS Model, to increase flows at this location based on the flows recorded at flow gauge SW02. SW02 is located downstream of the Goulburn River / Ulan Creek confluence.

4.2 HEC-RAS Results

Results of the HEC-RAS analysis are summarised in Table 4.3 below. Cross-sections illustrating these results are contained in Appendix A. A longitudinal profile of the low flow regime is shown in Figure 4.2, showing the pre-existing, EPL Approved and Proposed scenarios.

The results presented in Table 4.3 show that increases in water level and velocity at all cross-sections are very minor.

The low flow scenario is the scenario where the proposed discharge would constitute the largest proportion of the total flow. Therefore, the proposed discharge's contribution to water quality in the downstream system would also be highest during this scenario (compared to higher natural flows).

For the low flow scenario in which the MCC discharge constituted the majority of the flow, the estimated velocity is within the range expected to result in minimal scour, even on a bare sandy surface. Reference to Table 5.2 (Maximum Design Flow Velocities in Waterways) of the '*Blue Book*' (Landcom, 2004) shows that critical velocities for mobilisation of sediment on bare soil are between 0.2 m/s and 0.6 m/s. Given that the Goulburn River and Diversion consist of well vegetated channels, the estimated average velocity for all flows modelled is not expected to result in any scour.

In addition, the average velocity for the low flow scenario for a 20 ML/day release at Chainage 9400 is within the existing range of velocities at this location (i.e. lower than the existing velocity at this location for a high flow scenario).

For the scenario in which 20 ML/day is discharged under a high flow scenario (16 ML/day at the confluence with Bora Creek and 30 ML/day downstream of Ulan Creek), the maximum depth in the Diversion would increase by 0.06 m and the average velocity would increase by 0.1 m/s (at Chainage 2000). The maximum depth at the 'Drip' (located immediately downstream of Chainage 9400) would increase by 0.02 m and the average velocity by a maximum of 0.07 m/s. These increases would not be expected to result in any increase in erosion of the Diversion or at the 'Drip'.

The very minor changes in depth and velocity described above are based on the proposed 20 ML/day discharge from the MCC. The changes in depth and velocity are even less significant when compared to a 10 ML/day release (i.e. the currently approved EPL release limit).

The cross-sections in Appendix A show that both the Diversion and the Goulburn River downstream of the discharge point have capacity to contain large flows and are capable of accepting an additional flow of 20 ML/day discharge without any significant impact on water levels and velocities.

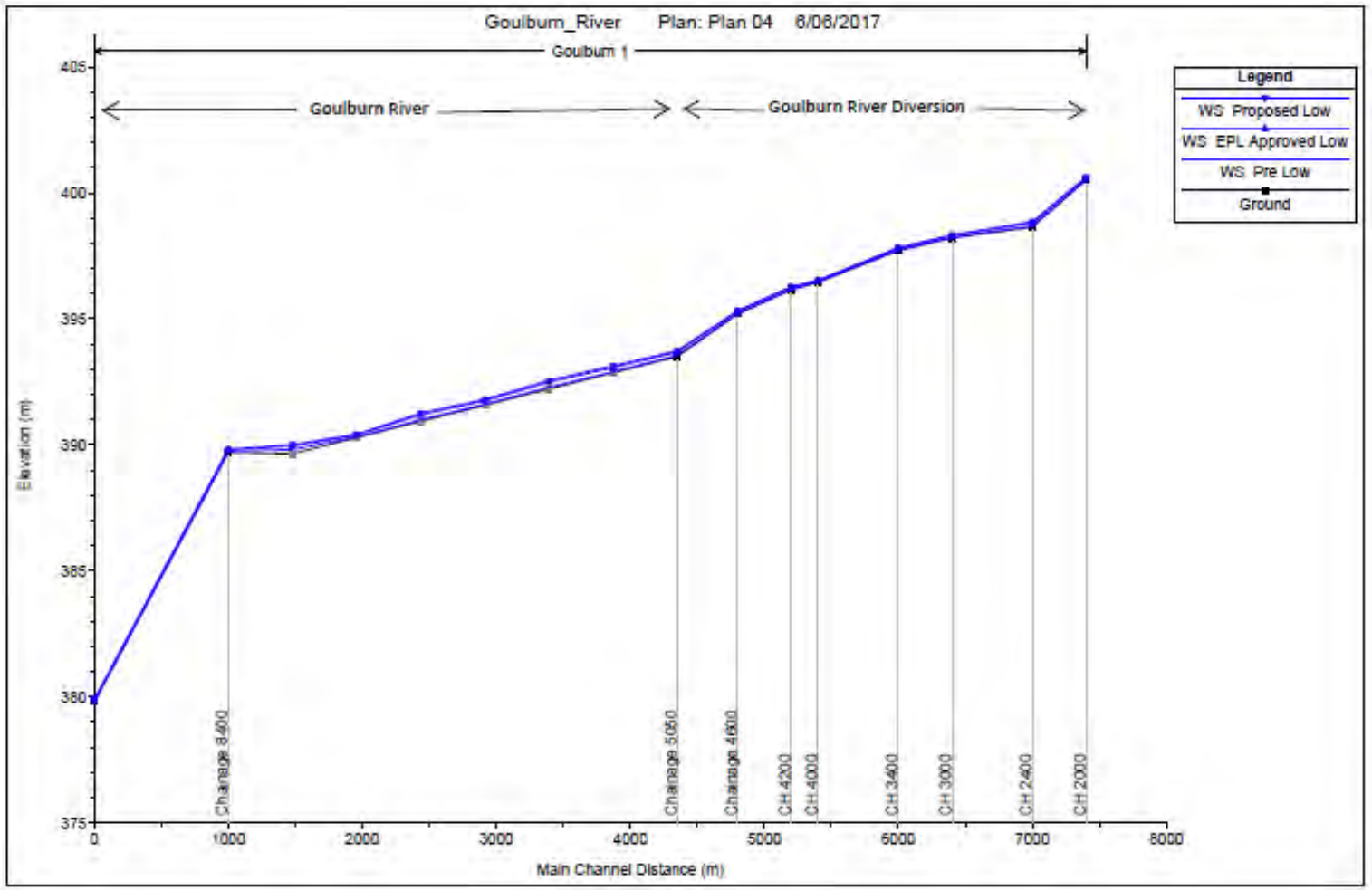


Figure 4.2: Profile of Low Flow Scenario

Table 4.3: HEC-RAS Modelling Results

Chainage		Flow Scenario	Existing (No Discharge from MCC) Flows					EPL Approved Flows (+ 10 ML/day)					Proposed Flows at Proposed New Discharge Point (+ 20 ML/day)				
			Flow	Min Channel Elevation	Water Surface Elevation	Water Depth	Channel Velocity	Flow	Min Channel Elevation	Water Surface Elevation	Water Depth	Channel Velocity	Flow	Min Channel Elevation	Water Surface Elevation	Water Depth	Channel Velocity
			(m^3/s)	(m AHD)	(m AHD)	(m)	(m/s)	(m^3/s)	(m)	(m AHD)	(m)	(m/s)	(m^3/s)	(m)	(m AHD)	(m)	(m/s)
Goulburn River Diversion	2000	Low	0.000	400.52	400.54	0.02	0.25	0.120	400.52	400.59	0.07	0.51	0.230	400.52	400.61	0.09	0.53
	2400	Low	0.000	398.64	398.68	0.04	0.07	0.120	398.64	398.80	0.16	0.20	0.230	398.64	398.85	0.21	0.24
	3000	Low	0.000	398.21	398.23	0.02	0.06	0.120	398.21	398.29	0.08	0.16	0.230	398.21	398.32	0.11	0.21
	3400	Low	0.000	397.71	397.73	0.02	0.08	0.120	397.71	397.80	0.09	0.20	0.230	397.71	397.82	0.11	0.25
	4000	Low	0.000	396.46	396.47	0.01	0.07	0.120	396.46	396.52	0.06	0.18	0.230	396.46	396.53	0.07	0.22
	4200	Low	0.000	396.15	396.17	0.02	0.06	0.120	396.15	396.24	0.09	0.15	0.230	396.15	396.27	0.12	0.19
	4600	Low	0.000	395.19	395.22	0.03	0.23	0.120	395.19	395.29	0.10	0.68	0.230	395.19	395.31	0.12	0.78
Goulburn R	5050	Low	0.000	393.50	393.55	0.05	0.07	0.120	393.50	393.68	0.18	0.20	0.230	393.50	393.73	0.23	0.25
	8400	Low	0.020	389.70	389.73	0.03	0.28	0.130	389.70	389.80	0.10	0.16	0.250	389.70	389.82	0.12	0.21
	9400	Low	0.020	379.80	379.83	0.03	0.28	0.130	379.80	379.86	0.06	0.54	0.250	379.80	379.88	0.08	0.61
Goulburn River Diversion	2000	Medium	0.020	400.52	400.55	0.03	0.41	0.140	400.52	400.59	0.07	0.53	0.260	400.52	400.60	0.08	0.59
	2400	Medium	0.020	398.64	398.73	0.09	0.14	0.140	398.64	398.81	0.17	0.21	0.260	398.64	398.85	0.21	0.25
	3000	Medium	0.020	398.21	398.26	0.05	0.08	0.140	398.21	398.30	0.09	0.17	0.260	398.21	398.33	0.12	0.22
	3400	Medium	0.020	397.71	397.75	0.04	0.17	0.140	397.71	397.81	0.10	0.21	0.260	397.71	397.83	0.12	0.25
	4000	Medium	0.020	396.46	396.50	0.04	0.09	0.140	396.46	396.52	0.06	0.19	0.260	396.46	396.53	0.07	0.23
	4200	Medium	0.020	396.15	396.19	0.04	0.12	0.140	396.15	396.25	0.10	0.16	0.260	396.15	396.27	0.12	0.19
	4600	Medium	0.020	395.19	395.26	0.07	0.24	0.140	395.19	395.29	0.10	0.70	0.260	395.19	395.32	0.13	0.79
Goulburn R	5050	Medium	0.020	393.50	393.57	0.07	0.25	0.140	393.50	393.69	0.19	0.21	0.260	393.50	393.74	0.24	0.25
	8400	Medium	0.170	389.70	389.80	0.10	0.22	0.290	389.70	389.82	0.12	0.24	0.410	389.70	389.84	0.14	0.26
	9400	Medium	0.170	379.80	379.87	0.07	0.57	0.290	379.80	379.88	0.08	0.63	0.410	379.80	379.89	0.09	0.67

Chainage		Flow Scenario	Existing (No Discharge from MCC) Flows					EPL Approved Flows (+ 10 ML/day)					Proposed Flows at Proposed New Discharge Point (+ 20 ML/day)				
			Flow	Min Channel Elevation	Water Surface Elevation	Water Depth	Channel Velocity	Flow	Min Channel Elevation	Water Surface Elevation	Water Depth	Channel Velocity	Flow	Min Channel Elevation	Water Surface Elevation	Water Depth	Channel Velocity
			(m^3/s)	(m AHD)	(m AHD)	(m)	(m/s)	(m^3/s)	(m)	(m AHD)	(m)	(m/s)	(m^3/s)	(m)	(m AHD)	(m)	(m/s)
Goulburn River Diversion	2000	High	0.190	400.52	400.60	0.08	0.55	0.300	400.52	400.61	0.09	0.61	0.420	400.52	400.62	0.10	0.65
	2400	High	0.190	398.64	398.83	0.19	0.23	0.300	398.64	398.87	0.23	0.26	0.420	398.64	398.89	0.25	0.30
	3000	High	0.190	398.21	398.31	0.10	0.19	0.300	398.21	398.34	0.13	0.23	0.420	398.21	398.36	0.15	0.26
	3400	High	0.190	397.71	397.82	0.11	0.23	0.300	397.71	397.83	0.12	0.27	0.420	397.71	397.85	0.14	0.30
	4000	High	0.190	396.46	396.53	0.07	0.21	0.300	396.46	396.54	0.08	0.24	0.420	396.46	396.55	0.09	0.27
	4200	High	0.190	396.15	396.26	0.11	0.17	0.300	396.15	396.28	0.13	0.20	0.420	396.15	396.30	0.15	0.23
	4600	High	0.190	395.19	395.30	0.11	0.74	0.300	395.19	395.33	0.14	0.83	0.420	395.19	395.35	0.16	0.89
Goulburn R	5050	High	0.190	393.50	393.71	0.21	0.23	0.300	393.50	393.75	0.25	0.27	0.420	393.50	393.79	0.29	0.29
	8400	High	0.350	389.70	389.83	0.13	0.23	0.460	389.70	389.84	0.14	0.26	0.580	389.70	389.86	0.16	0.25
	9400	High	0.350	379.80	379.89	0.09	0.65	0.460	379.80	379.90	0.10	0.69	0.580	379.80	379.91	0.11	0.72

4.3 Channel Stability

As described in Section 2.4.6, the Goulburn River Diversion is a well vegetated channel. A discharge of 20 ML/day is not expected to have a significant effect on water levels and velocities during high flow events and therefore should not adversely impact on channel stability. As described in Section 3, during the site inspection no scour or channel instability was observed in the Diversion in the vicinity of the proposed discharge point.

The relocation of the existing discharge point (EPL ID1) on Bora Creek to the proposed discharge point at the Goulburn River Diversion is considered to be beneficial in terms of minimising scour risks to Bora Creek. As observed during the site inspection (refer Section 2.4.5) and identified in channel stability monitoring (Section 2.4.6), there is risk of erosion potential on Bora Creek. The relocation of EPL ID1 is therefore considered to be a positive environmental outcome.

4.4 Water Quality

4.4.1 Proposed Discharge

As described in Section 3, all discharge water would be treated at the WTP and blended to comply with the EPL release criteria prior to release.

4.4.2 EPL Discharge Criteria

To assess potential impacts of the proposed discharge on the downstream receiving water quality, an analysis has been undertaken to estimate the concentrations of EC and pH levels in the Goulburn River for the low, medium and high flow regimes.

The analysis is based on the following data and assumptions:

- Existing concentrations for EC and pH in the downstream receiving water were based on the average monitoring results from MCC SW01 located at the 'Drip'. This monitoring location is representative of the receiving environment downstream of all operations and includes discharges from the UMC.
- The water quality at the proposed discharge point was assumed to be characterised by the current EPL limit values for EC and pH.
- The existing flows in the Goulburn River downstream of Ulan Creek were identified from the flow duration graph for flow gauge UMC SW02 (refer Section 2.4.4).

The results of the analysis are presented in Table 4.4. The adopted surface water quality triggers for the Goulburn River (refer Section 2.5.1) have also been included in Table 4.4 for reference.

Table 4.4: Estimated EC and pH Concentrations in the Goulburn River

Flow Scenario at Flow Gauge UMC SW02	Water Quality at MCC SW01		Water Quality of Proposed Mine Discharge (based on EPL Discharge Limits)			Estimated Concentrations for Goulburn River downstream of MCC SW01		
	Avg EC (µS/cm)	Avg pH	Flow (ML/day)	Avg EC (µS/cm)	Avg pH	Flow (ML/day)	Avg EC (µS/cm)	Avg pH
Low 1.5 ML/day	715	7.7	20	900	7.5	21.5	887	7.5
Medium 15 ML/day	715	7.7	20	900	7.5	35	821	7.6
High 30 ML/day	715	7.7	20	900	7.5	50	789	7.6
Adopted Surface Water Quality Triggers for the Goulburn River							**900**	**6.5 - 8.5**

Table 4.4 shows that for the 'Low flow' scenario, where the contribution of a 20 ML/day discharge to total flow is 93%, the results comply with the adopted trigger levels for the Goulburn River. For the 'Low flow' scenario there is no dilution factor due to the very low flowrate, with the MCC discharge constituting the majority of the flow. The medium and high flow scenarios also do not exceed the adopted trigger levels.

It should be noted that the quality of water to be discharged following treatment is expected to be at or below the values adopted for the analysis, so the results presented in Table 4.4 are conservative.

In terms of TSS, it is expected that the WTP would control and minimise the level of TSS in discharge waters. As a comparison, the UCM WTP controlled releases have typically produced discharges with a mean TSS of 2 mg/L (refer Table 2.4). Immediately downstream of the proposed discharge point, released water would travel through approximately 2.5 km of the Goulburn River Diversion. The Diversion has a thick reed lined bed (refer Section 2.4.5) which would effectively filter and further limit the amount of TSS received downstream of the Diversion.

In addition, relocating the discharge point to avoid releasing water along Bora Creek would reduce erosion potential (compared to releasing water along the length of Bora Creek from the existing discharge location), resulting in a reduction in TSS reaching the Goulburn River Diversion. Any increase in concentration of TSS downstream of MCC SW01 due the proposed discharges of 20 ML/day is therefore expected to be negligible. In comparison to the approved EPL discharge point, it is likely the proposed relocated discharge point, in combination to the proposed water treatment facilities, would reduce downstream TSS.

4.4.3 Dissolved Metals

RGS (2017) has completed a review of the geochemical nature of mine materials and water quality in on-site water storages. As a result of this review, RGS concludes that the concentrations of the following dissolved metals can be slightly elevated in some on-site water storages compared to 95th percentile freshwater aquatic ecosystem guideline values:

- Aluminium;
- Cadmium;
- Copper;
- Manganese;
- Nickel; and
- Zinc.

Review of baseline surface water quality monitoring indicates that Aluminium, Copper and Zinc levels are naturally elevated upstream of the MCC when compared to the 95th percentile freshwater aquatic ecosystem guideline values (based on the 80th percentile of the available monitoring data summarised in Table 2.12). Upstream monitoring of Cadmium, Manganese and Nickel indicates that levels of each of these analytes are not naturally elevated upstream of the MCC.

Accordingly, MCC would aim to limit the concentrations of dissolved metals in discharge water via the water treatment process as follows:

- Aluminium, Copper and Zinc to the 80th percentile upstream concentration; and
- Cadmium, Manganese and Nickel to the ANZECC 95% freshwater aquatic ecosystem guideline values.

4.4.4 Hunter River Salinity Trading Scheme

The Hunter River Salinity Trading Scheme (HRSTS) was originally established by the then Department of Land and Water Conservation and the Hunter River Trust in 1995 as a pilot trial to manage salinity discharges to the Hunter River, such that salt concentrations would be maintained within acceptable irrigation and environmental standards.

The scheme is now managed by the NSW EPA under a statutory regulation attached to the *Protection of Environmental Operations Act, 1997*. The regulation came into effect on 1 December 2002. The stated objectives of the HRSTS are:

a) to minimise the impact of discharges of saline water on irrigation, other water uses and on aquatic ecosystems in the Hunter River catchment:

i. at the lowest overall cost to the community, and

ii. in a way that provides ongoing financial incentives to reduce pollution, and

b) to facilitate sustainable water management by industry in the Hunter River catchment.

The HRSTS achieves these objectives by prohibiting the release of saline water during periods of low flow in the Hunter River and controlling releases of saline water during periods of high flow such that specific salinity targets at various points in the river are not exceeded.

Participants in the HRSTS are issued with tradeable discharge credits. Each credit entitles the holder to a share of the available salt discharge capacity announced by DPI Water during high flow periods.

The HRSTS does not apply to discharges from the MCC. Notwithstanding, the proposed increase in discharge would result in negligible impacts to entities discharging under the HRSTS given the salt load from the MCC would represent a negligible proportion of the total salt load in the Hunter River during high flow and flood flow conditions.

5 Management and Mitigation Measures

5.1 Water Treatment Plant

A WTP is proposed to be constructed in the vicinity of the rail loop. The WTP would be designed to treat and blend site waters to comply with existing EPL water quality concentration limits prior to discharge, which would mitigate potential downstream water quality impacts.

In addition, the WTP would treat water such that dissolved metal concentrations are at or below ANZECC trigger levels (either 95% species protection trigger levels or 80th percentile levels for the Goulburn River where baseline concentrations upstream of the relocated discharge location exceed the 95% species protection level).

5.2 Piping of Water to the Relocated Discharge Point

To avoid erosion potential along the length of Bora Creek, water from the WTP would be piped to the relocated discharge point at the confluence of Bora Creek and the Goulburn River Diversion.

5.3 Scour Protection at Outlet of Relocated Discharge Point

As described in Section 3, the need for scour protection at the discharge outlet is expected to be minimal. However the inclusion of a flow spreader/diffuser at the proposed discharge point would minimise the likelihood of any scour from occurring at the base of the Diversion. Discharged water would then be diffused over the rock shelf before draining into the Goulburn River Diversion.

Routine inspection of the discharge outlet would be undertaken to identify the need for any further scour protection, should any bed or bank erosion start to occur. However this is considered to be very unlikely based on observations that the channel is very well vegetated, stabilised and is founded on bedrock.

5.4 Water Quality Monitoring

Regular monthly water quality monitoring of Goulburn River sites MCC SW12, MCC SW02, and MCC SW01 would continue in accordance with the MCO SWMP (MCO, 2016c).

Monitoring of all discharge events would be undertaken at the existing and proposed discharge points in accordance with EPL requirements (refer Table 2.1).

Any exceedances of the surface water quality trigger levels for the Goulburn River would be managed in accordance with the 'Surface Water Response and Contingency Plan' which is provided in the SWMP (MCO, 2016c).

6 Conclusion

This Controlled Water Release Impact Assessment supports a proposal by MCO to relocate EPL 12932 site discharge point 1 from Bora Creek to the confluence with the Goulburn River Diversion and increase the discharge limit from 10 ML/day to 20 ML/day. It is proposed that water discharged at this location would be treated prior to release and that discharge concentrations would comply with the existing EPL water quality concentration limits.

The relocated discharge point would be situated at the confluence of Bora Creek and the Goulburn River Diversion. Water would be piped to a rock platform at the confluence, be discharged via a flow spreader/diffuser and then drain into the Goulburn River Diversion. The relocation of the existing discharge point is considered to be beneficial in terms of minimising potential scour risks to Bora Creek.

At the location of the proposed discharge point, the Goulburn River Diversion is a stable, trapezoidal, reed lined channel with a bedrock base and banks. Downstream of the Diversion the Goulburn River is a broad natural channel that is stable and well vegetated with sandbars, pools and rock outcrops.

The impacts on the existing flow regime (water level and velocity) due to the proposed discharge were modelled using the HEC-RAS hydraulic model. Three flow scenarios were considered (High, Medium and Low Flow).

Based on the results of the HEC-RAS analysis, the estimated increases in water level in the Diversion and the Goulburn River due to the proposed discharges were found to be minimal and easily contained within the channel's capacity. Estimated increases in velocity are not expected to lead to scour at or downstream of the proposed discharge point. Regular monitoring of the proposed discharge point would be undertaken and, if required, suitable scour protection would be provided to minimise any bed or bank erosion that may result from the increased discharge.

An assessment of the impacts of the proposed discharge point on concentrations of EC and pH levels in the Goulburn River downstream of the 'Drip' was undertaken. The results were found to be within surface water quality trigger levels developed based on baseline water quality in the Goulburn River and/or ANZECC trigger values.

TSS levels are anticipated to be low as the WTP will control and minimise the level of TSS in discharge waters. It is expected that relocating the discharge point to avoid potential erosion along Bora Creek would also have a beneficial impact on TSS. The thick reed lined bed of the Diversion would further filter and limit the amount of TSS received downstream.

Water quality monitoring of Goulburn River and monitoring of discharge events would continue to be undertaken by the MCC in accordance with the SWMP (MCO, 2016c). Any exceedance of the adopted trigger levels would be managed in accordance with the 'Surface Water Response and Contingency Plan' in the SWMP (MCO, 2016c).

In consideration of the above, the Modification would not result in any adverse impacts to downstream water quality.

7 References

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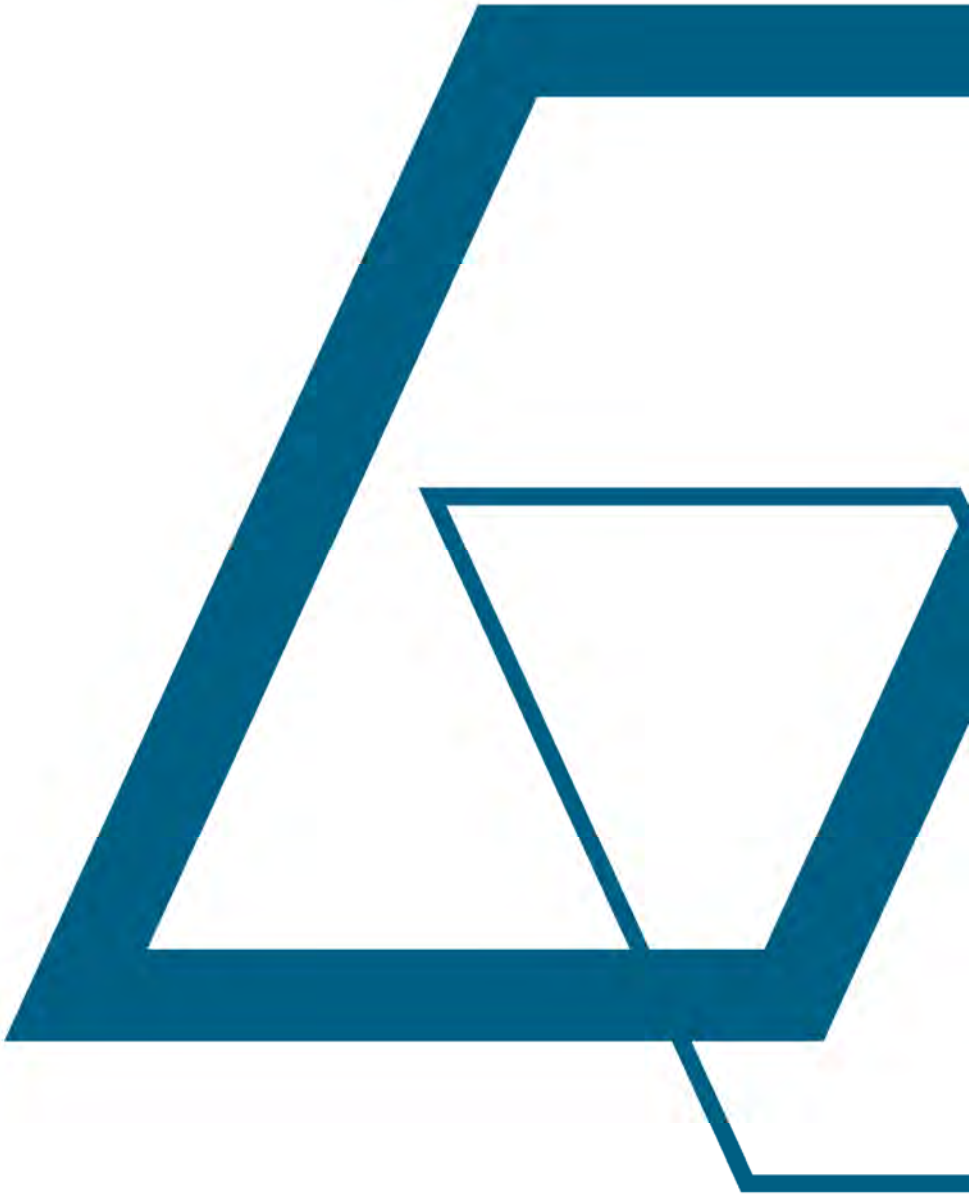
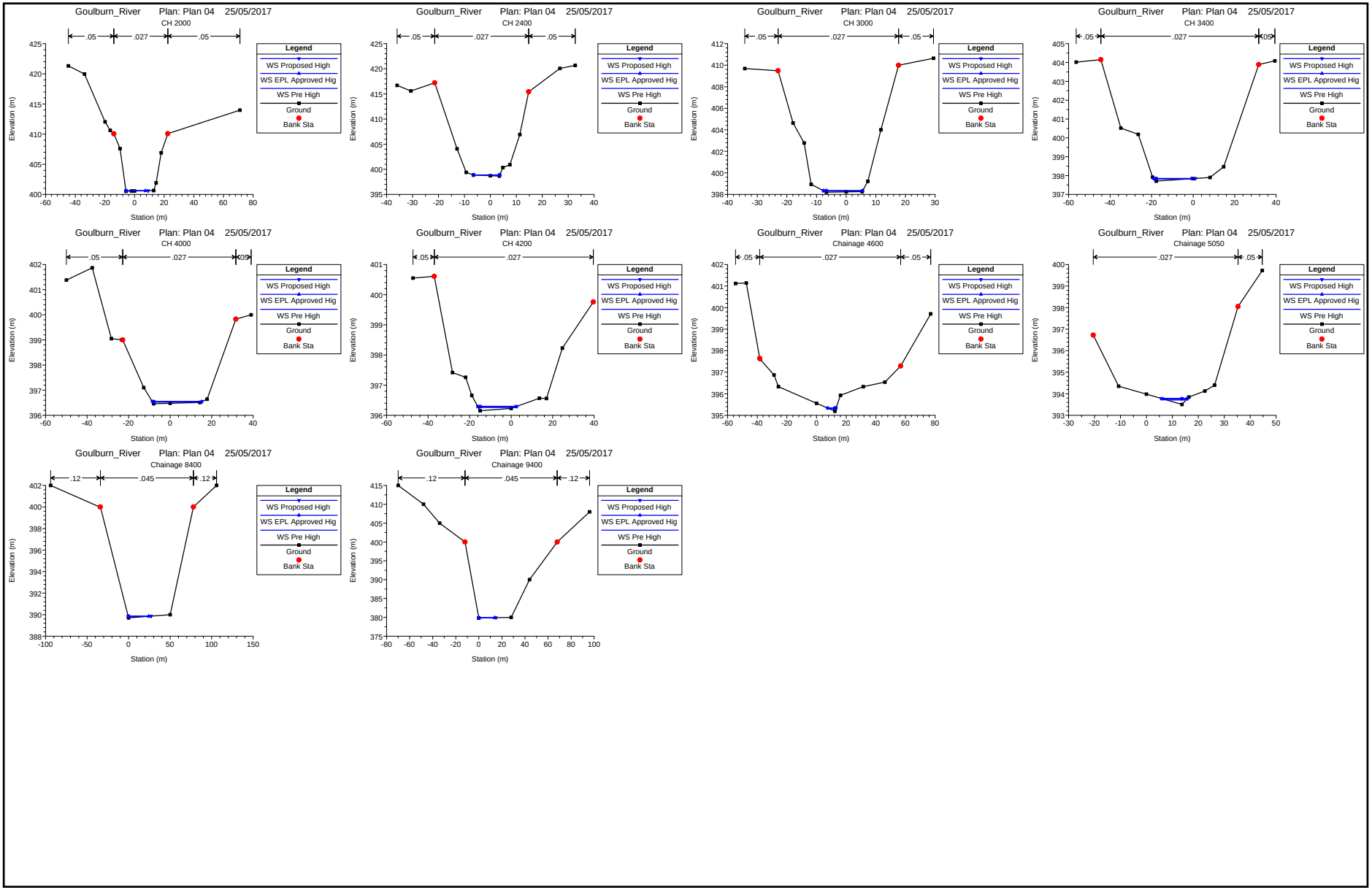
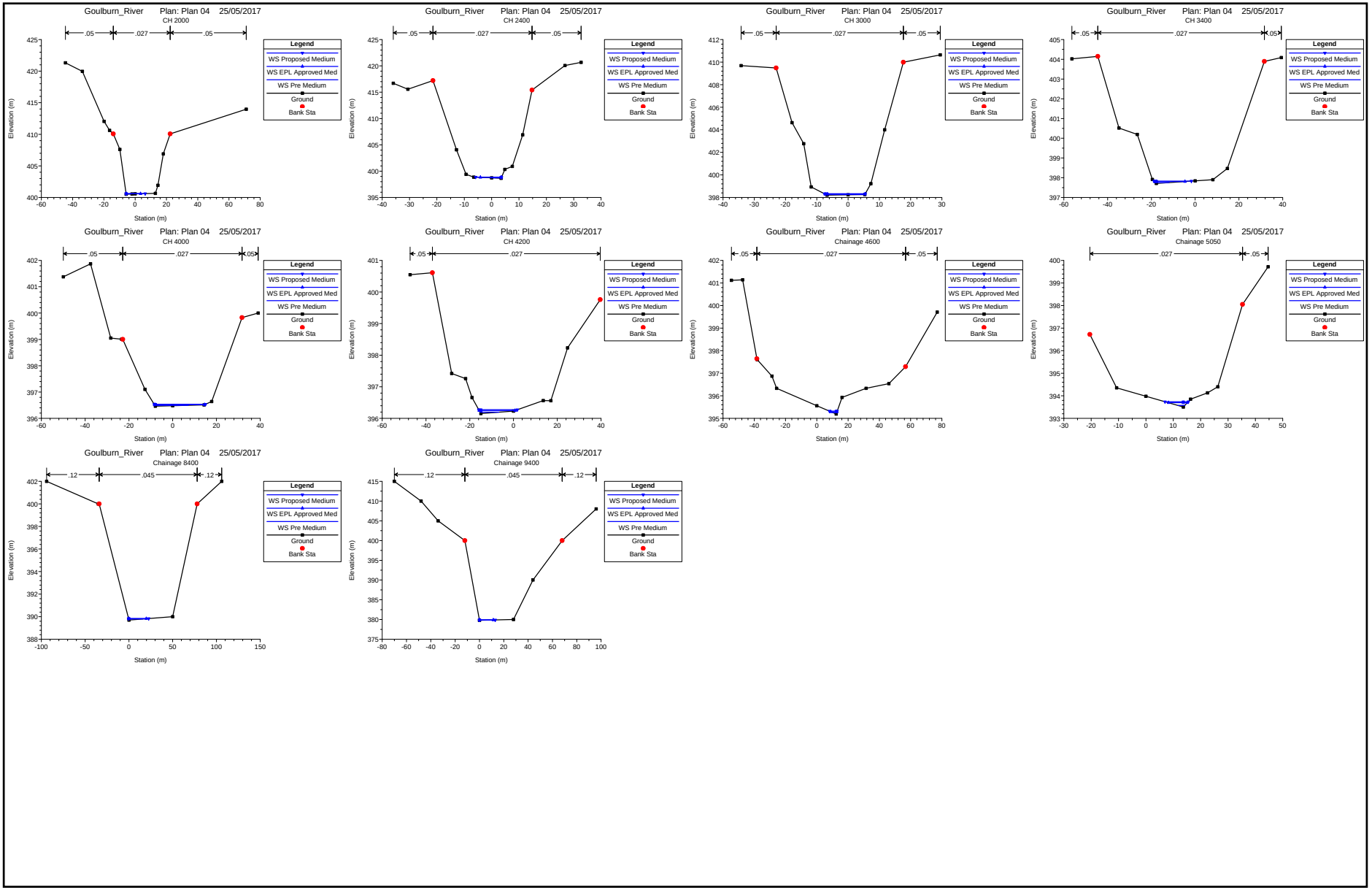
Appendix A Hydraulic Modelling Results



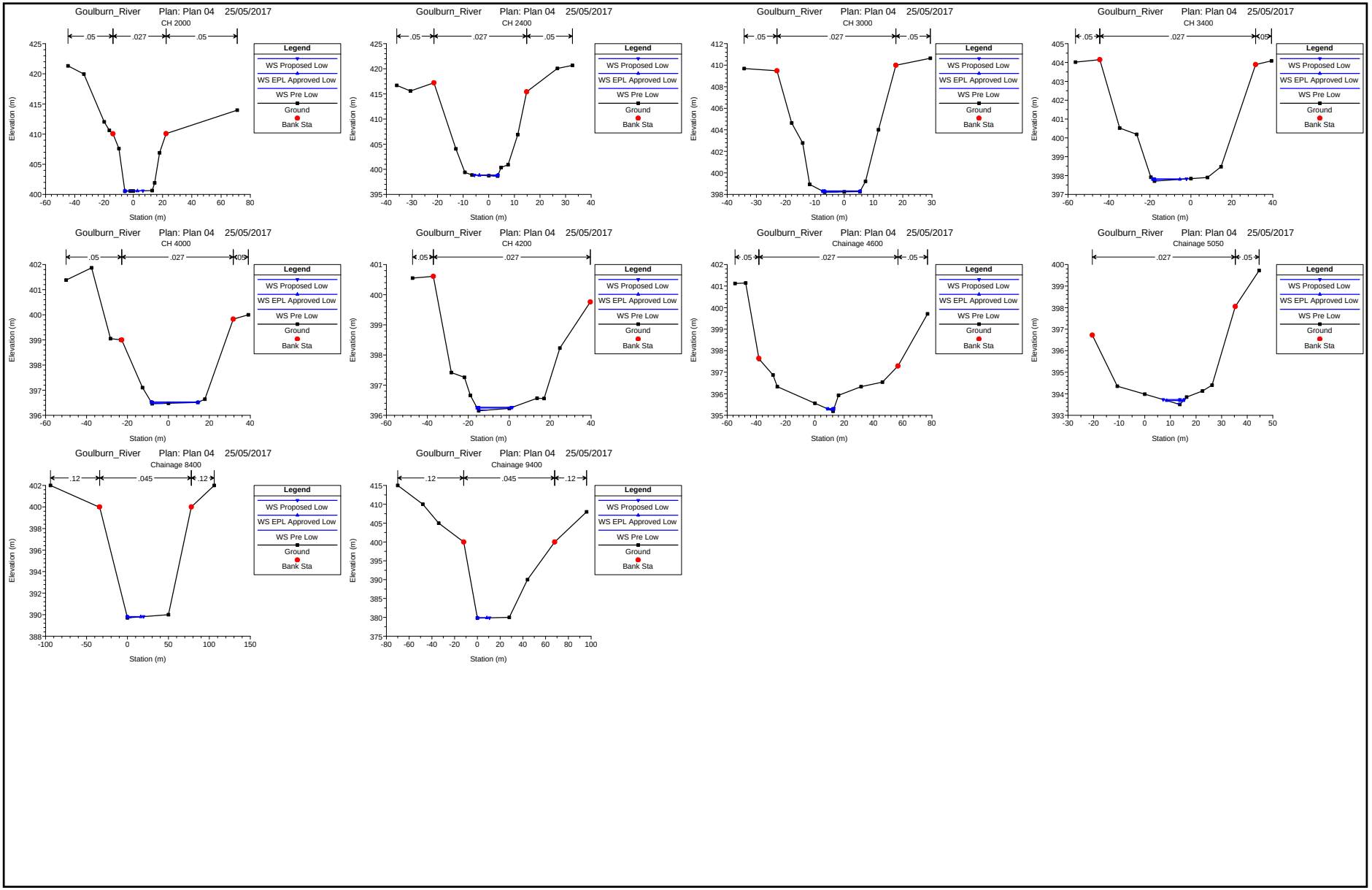
HEC-RAS Results for all Cross-sections - High Flows



HEC-RAS Results for all Cross-sections - Medium Flows



HEC-RAS Results for all Cross-sections - Low Flows



HEC-RAS Results Table

HEC-RAS Plan: Plan 03 River: Goulburn Reach: 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
1	10	Pre High	0.19	400.52	400.60	400.60	400.61	0.022428	0.55	0.33	10.56	0.99
1	10	Pre Medium	0.02	400.52	400.55	400.55	400.56	0.027400	0.41	0.06	3.23	0.99
1	10	Pre Low	0.00	400.52	400.54	400.54	400.54	0.030149	0.25	0.01	1.46	0.91
1	10	EPL Approved Hig	0.30	400.52	400.61	400.61	400.63	0.021141	0.61	0.50	13.07	0.99
1	10	EPL Approved Med	0.14	400.52	400.59	400.59	400.60	0.024232	0.53	0.26	9.18	1.01
1	10	EPL Approved Low	0.12	400.52	400.59	400.59	400.60	0.023656	0.51	0.23	8.61	0.99
1	10	Proposed High	0.42	400.52	400.62	400.62	400.64	0.020465	0.65	0.64	15.03	1.00
1	10	Proposed Medium	0.26	400.52	400.60	400.60	400.62	0.021500	0.59	0.43	12.19	0.99
1	10	Proposed Low	0.23	400.52	400.61	400.61	400.62	0.017476	0.53	0.44	12.28	0.90
1	9	Pre High	0.19	398.64	398.83		398.83	0.000872	0.23	0.81	8.48	0.23
1	9	Pre Medium	0.02	398.64	398.73	398.69	398.73	0.000974	0.14	0.16	3.80	0.22
1	9	Pre Low	0.00	398.64	398.68	398.66	398.68	0.000613	0.07	0.04	1.90	0.15
1	9	EPL Approved Hig	0.30	398.64	398.87		398.87	0.000925	0.26	1.14	10.06	0.25
1	9	EPL Approved Med	0.14	398.64	398.81		398.82	0.000827	0.21	0.67	7.70	0.22
1	9	EPL Approved Low	0.12	398.64	398.80		398.81	0.000826	0.20	0.60	7.26	0.22
1	9	Proposed High	0.42	398.64	398.89		398.90	0.000942	0.30	1.40	10.31	0.26
1	9	Proposed Medium	0.26	398.64	398.85		398.86	0.000914	0.25	1.02	9.48	0.24
1	9	Proposed Low	0.23	398.64	398.85		398.85	0.000894	0.24	0.96	9.22	0.24
1	8	Pre High	0.19	398.21	398.31		398.31	0.000872	0.19	0.96	12.90	0.23
1	8	Pre Medium	0.02	398.21	398.26	398.23	398.26	0.000636	0.08	0.30	12.42	0.16
1	8	Pre Low	0.00	398.21	398.23	398.22	398.23	0.000953	0.06	0.05	4.90	0.17
1	8	EPL Approved Hig	0.30	398.21	398.34		398.34	0.000837	0.23	1.31	13.14	0.23
1	8	EPL Approved Med	0.14	398.21	398.30		398.30	0.000894	0.17	0.80	12.78	0.22
1	8	EPL Approved Low	0.12	398.21	398.29	398.26	398.30	0.000881	0.16	0.73	12.74	0.22
1	8	Proposed High	0.42	398.21	398.36		398.37	0.000829	0.26	1.61	13.35	0.24
1	8	Proposed Medium	0.26	398.21	398.33		398.33	0.000839	0.22	1.18	13.05	0.23
1	8	Proposed Low	0.23	398.21	398.32		398.33	0.000846	0.21	1.12	13.01	0.23
1	7	Pre High	0.19	397.71	397.82	397.78	397.82	0.001918	0.23	0.81	15.37	0.32
1	7	Pre Medium	0.02	397.71	397.75		397.75	0.003603	0.17	0.13	6.25	0.37
1	7	Pre Low	0.00	397.71	397.73		397.73	0.001679	0.08	0.04	3.32	0.23
1	7	EPL Approved Hig	0.30	397.71	397.83	397.79	397.84	0.002122	0.27	1.12	18.08	0.34
1	7	EPL Approved Med	0.14	397.71	397.81	397.77	397.81	0.001820	0.21	0.67	13.95	0.30
1	7	EPL Approved Low	0.12	397.71	397.80	397.76	397.80	0.001833	0.20	0.59	13.14	0.30
1	7	Proposed High	0.42	397.71	397.85	397.80	397.85	0.002252	0.30	1.40	20.21	0.36
1	7	Proposed Medium	0.26	397.71	397.83	397.79	397.83	0.002071	0.25	1.00	17.09	0.34
1	7	Proposed Low	0.23	397.71	397.82	397.78	397.83	0.002011	0.25	0.95	16.64	0.33
1	6	Pre High	0.19	396.46	396.53		396.53	0.002427	0.21	0.89	23.11	0.34
1	6	Pre Medium	0.02	396.46	396.50	396.48	396.50	0.001375	0.09	0.26	15.32	0.22
1	6	Pre Low	0.00	396.46	396.47	396.47	396.47	0.002699	0.07	0.04	5.76	0.27
1	6	EPL Approved Hig	0.30	396.46	396.54		396.54	0.002198	0.24	1.24	23.61	0.34
1	6	EPL Approved Med	0.14	396.46	396.52		396.52	0.002567	0.19	0.73	22.87	0.34
1	6	EPL Approved Low	0.12	396.46	396.52		396.52	0.002532	0.18	0.67	22.78	0.33
1	6	Proposed High	0.42	396.46	396.55		396.56	0.002067	0.27	1.54	24.06	0.34
1	6	Proposed Medium	0.26	396.46	396.53		396.54	0.002244	0.23	1.11	23.43	0.34
1	6	Proposed Low	0.23	396.46	396.53		396.53	0.002312	0.22	1.04	23.33	0.34
1	5	Pre High	0.19	396.15	396.26		396.26	0.000854	0.17	1.07	16.92	0.22
1	5	Pre Medium	0.02	396.15	396.19	396.18	396.20	0.001672	0.12	0.19	8.65	0.26
1	5	Pre Low	0.00	396.15	396.17		396.17	0.000955	0.06	0.05	4.42	0.17
1	5	EPL Approved Hig	0.30	396.15	396.28		396.28	0.000849	0.20	1.48	18.03	0.23
1	5	EPL Approved Med	0.14	396.15	396.25		396.25	0.000853	0.16	0.89	16.39	0.21
1	5	EPL Approved Low	0.12	396.15	396.24		396.24	0.000851	0.15	0.81	16.14	0.21
1	5	Proposed High	0.42	396.15	396.30		396.30	0.000849	0.23	1.83	18.97	0.23
1	5	Proposed Medium	0.26	396.15	396.27		396.27	0.000857	0.19	1.32	17.61	0.22
1	5	Proposed Low	0.23	396.15	396.27		396.27	0.000856	0.19	1.25	17.41	0.22
1	4	Pre High	0.19	395.19	395.30	395.30	395.33	0.018462	0.74	0.25	4.38	0.99
1	4	Pre Medium	0.02	395.19	395.26		395.26	0.003463	0.24	0.10	2.74	0.40
1	4	Pre Low	0.00	395.19	395.22	395.22	395.22	0.013665	0.23	0.01	0.97	0.67
1	4	EPL Approved Hig	0.30	395.19	395.33	395.33	395.36	0.018085	0.83	0.36	5.27	1.02
1	4	EPL Approved Med	0.14	395.19	395.29	395.29	395.32	0.019163	0.70	0.20	3.90	0.99
1	4	EPL Approved Low	0.12	395.19	395.29	395.29	395.31	0.019590	0.68	0.17	3.67	0.99
1	4	Proposed High	0.42	395.19	395.35	395.35	395.39	0.017267	0.89	0.47	6.01	1.01
1	4	Proposed Medium	0.26	395.19	395.32	395.32	395.35	0.017766	0.79	0.32	4.97	1.00
1	4	Proposed Low	0.23	395.19	395.31	395.31	395.35	0.018045	0.78	0.30	4.80	1.00
1	3	Pre High	0.19	393.50	393.71		393.72	0.000796	0.23	0.80	7.62	0.23
1	3	Pre Medium	0.02	393.50	393.57		393.58	0.004087	0.25	0.09	2.56	0.43
1	3	Pre Low	0.00	393.50	393.55		393.55	0.000519	0.07	0.04	1.74	0.14
1	3	EPL Approved Hig	0.30	393.50	393.75		393.76	0.000828	0.27	1.13	9.06	0.24
1	3	EPL Approved Med	0.14	393.50	393.69		393.69	0.000778	0.21	0.65	6.87	0.22
1	3	EPL Approved Low	0.12	393.50	393.68		393.68	0.000761	0.20	0.58	6.51	0.22
1	3	Proposed High	0.42	393.50	393.79		393.79	0.000821	0.29	1.45	10.27	0.24
1	3	Proposed Medium	0.26	393.50	393.74		393.74	0.000823	0.25	1.00	8.54	0.24
1	3	Proposed Low	0.23	393.50	393.73		393.73	0.000811	0.25	0.94	8.29	0.23
1	2.8571*	Pre High	0.19	392.86	393.11		393.11	0.002282	0.24	0.76	6.10	0.22
1	2.8571*	Pre Medium	0.02	392.86	393.01		393.01	0.000555	0.08	0.27	3.64	0.10
1	2.8571*	Pre Low	0.00	392.86	392.90		392.90	0.009106	0.14	0.02	0.99	0.32
1	2.8571*	EPL Approved Hig	0.30	392.86	393.17		393.17	0.001980	0.26	1.15	7.50	0.21
1	2.8571*	EPL Approved Med	0.14	392.86	393.08		393.08	0.002491	0.23	0.59	5.39	0.22
1	2.8571*	EPL Approved Low	0.12	392.86	393.07		393.07	0.002627	0.23	0.52	5.03	0.23
1	2.8571*	Proposed High	0.42	392.86	393.21		393.22	0.001907	0.27	1.54	9.17	0.21
1	2.8571*	Proposed Medium	0.26	392.86	393.15		393.15	0.002050	0.25	1.01	7.01	0.21

HEC-RAS Plan: Plan 03 River: Goulburn Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
1	2.8571*	Proposed Low	0.23	392.86	393.14		393.14	0.002114	0.25	0.93	6.75	0.22
1	2.7143*	Pre High	0.19	392.22	392.53		392.53	0.000751	0.16	1.16	7.64	0.13
1	2.7143*	Pre Medium	0.02	392.22	392.30		392.31	0.010707	0.26	0.09	2.06	0.40
1	2.7143*	Pre Low	0.00	392.22	392.29		392.29	0.000489	0.05	0.06	1.69	0.08
1	2.7143*	EPL Approved Hig	0.30	392.22	392.59		392.59	0.000818	0.18	1.70	10.12	0.14
1	2.7143*	EPL Approved Med	0.14	392.22	392.50		392.50	0.000720	0.15	0.94	6.70	0.13
1	2.7143*	EPL Approved Low	0.12	392.22	392.48		392.48	0.000701	0.14	0.85	6.35	0.12
1	2.7143*	Proposed High	0.42	392.22	392.63		392.63	0.000854	0.19	2.18	11.93	0.14
1	2.7143*	Proposed Medium	0.26	392.22	392.57		392.57	0.000800	0.17	1.49	9.26	0.14
1	2.7143*	Proposed Low	0.23	392.22	392.56		392.56	0.000784	0.17	1.40	8.84	0.13
1	2.5714*	Pre High	0.19	391.57	391.78		391.79	0.004843	0.32	0.58	5.51	0.32
1	2.5714*	Pre Medium	0.02	391.57	391.72		391.72	0.000439	0.08	0.30	3.95	0.09
1	2.5714*	Pre Low	0.00	391.57	391.61		391.61	0.016267	0.18	0.02	0.92	0.43
1	2.5714*	EPL Approved Hig	0.30	391.57	391.83		391.84	0.004133	0.34	0.88	6.80	0.30
1	2.5714*	EPL Approved Med	0.14	391.57	391.76		391.76	0.005213	0.31	0.45	4.88	0.32
1	2.5714*	EPL Approved Low	0.12	391.57	391.75		391.75	0.005545	0.30	0.39	4.55	0.33
1	2.5714*	Proposed High	0.42	391.57	391.87		391.88	0.003805	0.35	1.18	8.24	0.30
1	2.5714*	Proposed Medium	0.26	391.57	391.81		391.82	0.004268	0.33	0.77	6.36	0.30
1	2.5714*	Proposed Low	0.23	391.57	391.80	391.72	391.81	0.004492	0.33	0.71	6.10	0.31
1	2.4286*	Pre High	0.19	390.93	391.23	391.05	391.23	0.000504	0.13	1.42	10.01	0.11
1	2.4286*	Pre Medium	0.02	390.93	390.98	390.98	391.00	0.072065	0.51	0.04	1.66	1.00
1	2.4286*	Pre Low	0.00	390.93	390.99		391.00	0.000435	0.05	0.06	1.99	0.08
1	2.4286*	EPL Approved Hig	0.30	390.93	391.29	391.08	391.29	0.000523	0.15	2.06	12.62	0.11
1	2.4286*	EPL Approved Med	0.14	390.93	391.20	391.04	391.20	0.000501	0.12	1.13	8.54	0.11
1	2.4286*	EPL Approved Low	0.12	390.93	391.18	391.03	391.19	0.000496	0.12	1.00	7.81	0.11
1	2.4286*	Proposed High	0.42	390.93	391.33	391.10	391.33	0.000537	0.16	2.65	14.58	0.12
1	2.4286*	Proposed Medium	0.26	390.93	391.27	391.07	391.27	0.000518	0.14	1.82	11.70	0.11
1	2.4286*	Proposed Low	0.23	390.93	391.26	391.07	391.26	0.000513	0.14	1.71	11.25	0.11
1	2.2857*	Pre High	0.19	390.29	390.40	390.40	390.43	0.053521	0.75	0.25	4.23	1.00
1	2.2857*	Pre Medium	0.02	390.29	390.34	390.34	390.35	0.056193	0.46	0.05	1.92	0.90
1	2.2857*	Pre Low	0.00	390.29	390.31	390.31	390.32	0.036018	0.23	0.01	0.96	0.64
1	2.2857*	EPL Approved Hig	0.30	390.29	390.43	390.43	390.46	0.051707	0.84	0.36	5.10	1.01
1	2.2857*	EPL Approved Med	0.14	390.29	390.39	390.39	390.42	0.045604	0.66	0.21	3.92	0.91
1	2.2857*	EPL Approved Low	0.12	390.29	390.38	390.38	390.41	0.056847	0.69	0.17	3.55	1.00
1	2.2857*	Proposed High	0.42	390.29	390.45	390.45	390.49	0.047831	0.88	0.47	5.86	1.00
1	2.2857*	Proposed Medium	0.26	390.29	390.42	390.42	390.45	0.051182	0.80	0.32	4.81	1.00
1	2.2857*	Proposed Low	0.23	390.29	390.41	390.41	390.45	0.052746	0.79	0.29	4.63	1.00
1	2.1429*	Pre High	0.35	389.64	390.05		390.05	0.000163	0.09	3.73	19.10	0.07
1	2.1429*	Pre Medium	0.17	389.64	389.98		389.98	0.000122	0.07	2.46	15.36	0.06
1	2.1429*	Pre Low	0.02	389.64	389.81		389.81	0.000045	0.03	0.62	7.36	0.03
1	2.1429*	EPL Approved Hig	0.46	389.64	390.09		390.09	0.000179	0.10	4.46	20.97	0.07
1	2.1429*	EPL Approved Med	0.29	389.64	390.03		390.03	0.000149	0.09	3.35	18.07	0.06
1	2.1429*	EPL Approved Low	0.13	389.64	389.95		389.95	0.000110	0.06	2.09	14.06	0.05
1	2.1429*	Proposed High	0.58	389.64	390.11		390.12	0.000197	0.11	5.10	22.46	0.08
1	2.1429*	Proposed Medium	0.41	389.64	390.07		390.07	0.000169	0.10	4.13	20.14	0.07
1	2.1429*	Proposed Low	0.25	389.64	390.01		390.01	0.000143	0.08	3.04	17.19	0.06
1	2	Pre High	0.35	389.70	389.83		389.84	0.004098	0.23	1.49	22.50	0.29
1	2	Pre Medium	0.17	389.70	389.80		389.80	0.005403	0.22	0.80	16.49	0.31
1	2	Pre Low	0.02	389.70	389.73		389.73	0.047568	0.28	0.06	4.63	0.76
1	2	EPL Approved Hig	0.46	389.70	389.84		389.85	0.004667	0.26	1.76	24.45	0.31
1	2	EPL Approved Med	0.29	389.70	389.82		389.82	0.005010	0.24	1.21	20.23	0.31
1	2	EPL Approved Low	0.13	389.70	389.80		389.80	0.003068	0.16	0.81	16.58	0.24
1	2	Proposed High	0.58	389.70	389.86		389.87	0.003643	0.25	2.28	27.86	0.28
1	2	Proposed Medium	0.41	389.70	389.84		389.84	0.004973	0.26	1.56	23.00	0.32
1	2	Proposed Low	0.25	389.70	389.82		389.82	0.003910	0.21	1.18	20.05	0.28
1	1	Pre High	0.35	379.80	379.89	379.89	379.91	0.057128	0.65	0.53	12.21	1.00
1	1	Pre Medium	0.17	379.80	379.87	379.87	379.88	0.063372	0.57	0.30	9.25	1.01
1	1	Pre Low	0.02	379.80	379.83	379.83	379.83	0.042528	0.28	0.06	4.20	0.72
1	1	EPL Approved Hig	0.46	379.80	379.90	379.90	379.92	0.054005	0.69	0.67	13.74	0.99
1	1	EPL Approved Med	0.29	379.80	379.88	379.88	379.90	0.057167	0.63	0.46	11.40	0.99
1	1	EPL Approved Low	0.13	379.80	379.86	379.86	379.87	0.065668	0.54	0.25	8.30	1.01
1	1	Proposed High	0.58	379.80	379.91	379.91	379.93	0.052627	0.72	0.80	15.02	1.00
1	1	Proposed Medium	0.41	379.80	379.89	379.89	379.92	0.054993	0.67	0.60	13.03	0.99
1	1	Proposed Low	0.25	379.80	379.88	379.88	379.90	0.059845	0.61	0.41	10.69	1.00