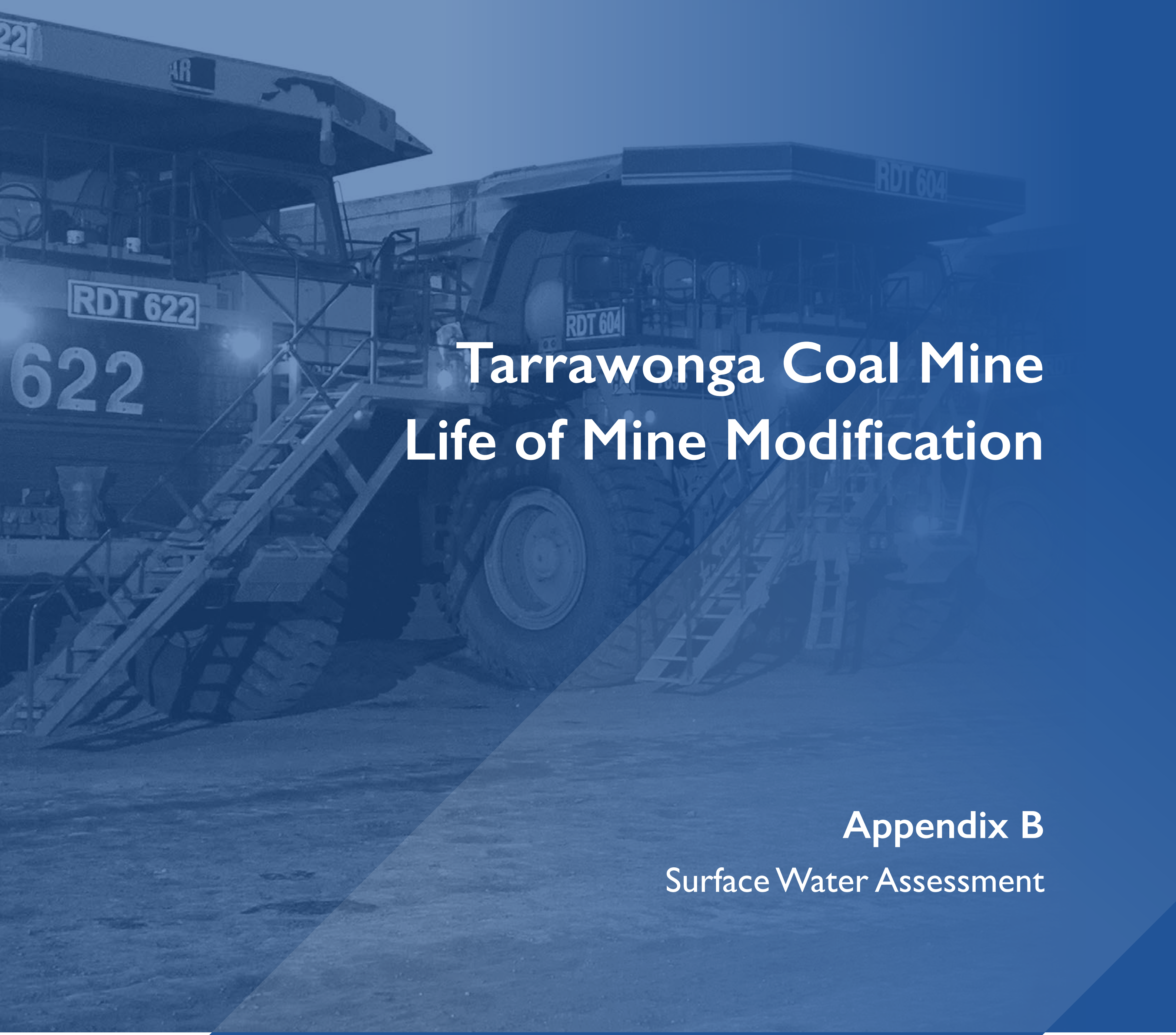

Tarrawonga Coal Mine
Life of Mine Modification

Appendix B

Surface Water Assessment

WHITEHAVEN COAL

REPORT

Tarrawonga Coal Mine Life of Mine Modification

Surface Water Assessment and Site Water Balance

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Revision	Description	Author	Reviewer	Approved	Date
a	Draft Report Sections 1 to 6	CAW	DNB / TSM	TSM	29/7/2019
b	Draft Report	CAW	DNB / TSM	TSM	2/8/2019
c	Draft Report	CAW	DNB / TSM	TSM	13/8/2019
d	Draft Report	CAW	DNB / TSM	TSM	15/8/2019
e	Draft Report	CAW	DNB / TSM	TSM	14/10/2019
f	Final Report	CAW	DNB / TSM	TSM	18/10/2019

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1.0 INTRODUCTION

1.1 BACKGROUND AND OVERVIEW

The Tarrawonga Coal Mine is located approximately 42 kilometres (km) north-northwest of Gunnedah in New South Wales (NSW), as illustrated in Figure 1. The mine is owned and operated by Tarrawonga Coal Pty Limited (TCPL), a wholly owned subsidiary of Whitehaven Coal Limited (Whitehaven).

The Tarrawonga Coal Mine is an open cut coal mine which has been in operation since 2006. Run-of-mine (ROM) coal is crushed and screened on-site and the sized ROM coal is loaded onto on-highway trucks for transport via the Approved ROM Coal Transport Route to the Whitehaven coal handling and preparation plant (CHPP).

Mining operations at the Tarrawonga Coal Mine are conducted in accordance with Project Approval (PA) 11_0047. PA 11_0047 was granted by the NSW Planning Assessment Commission under delegation from the NSW Minister for Planning and Infrastructure pursuant to section 75J of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act) on 22 January 2013.

TCPL proposes a modification of PA 11_0047. The Tarrawonga Coal Mine Life of Mine Modification (the Modification) will be sought under section 4.55(2) of the EP&A Act.

1.2 PROPOSED MODIFICATION

The proposed modification comprises the following key activities:

- ROM coal production rate increase from 3.0 to 3.5 million tonnes per annum (Mtpa);
- increase in ROM coal transported along the Northern Section of the haul road from 3.0 to 3.5 Mtpa;
- reduction of the open cut extent to avoid mining:
  - the Upper Namoi alluvium; and
  - Goonbri Creek.
- a revision of the post-mining landform and land use;
- relocation of the ROM coal stockpile and associated infrastructure;
- construction of a new site access road and intersection to allow haulage of ROM coal along a section of Goonbri Road; and
- construction and use of a water transfer pipeline between the Tarrawonga Coal Mine and the proposed Vickery Extension Project (which is the subject of a separate Development Application for State Significant Development [SSD] 7480).

Figure 2 to Figure 4 illustrate the progression of the mine development for Year 3, Year 7 and final landform.

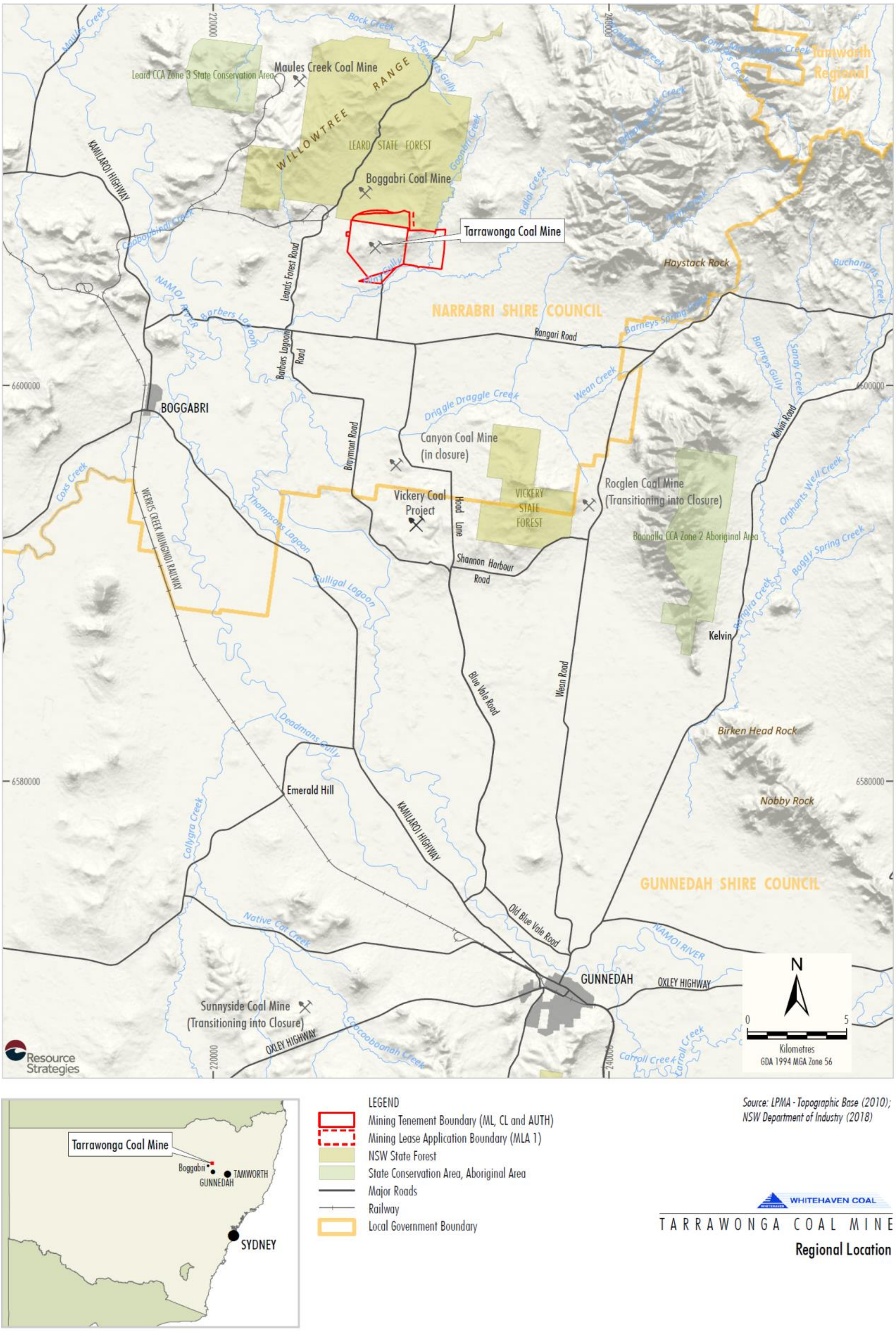

Figure 1 Site Locality

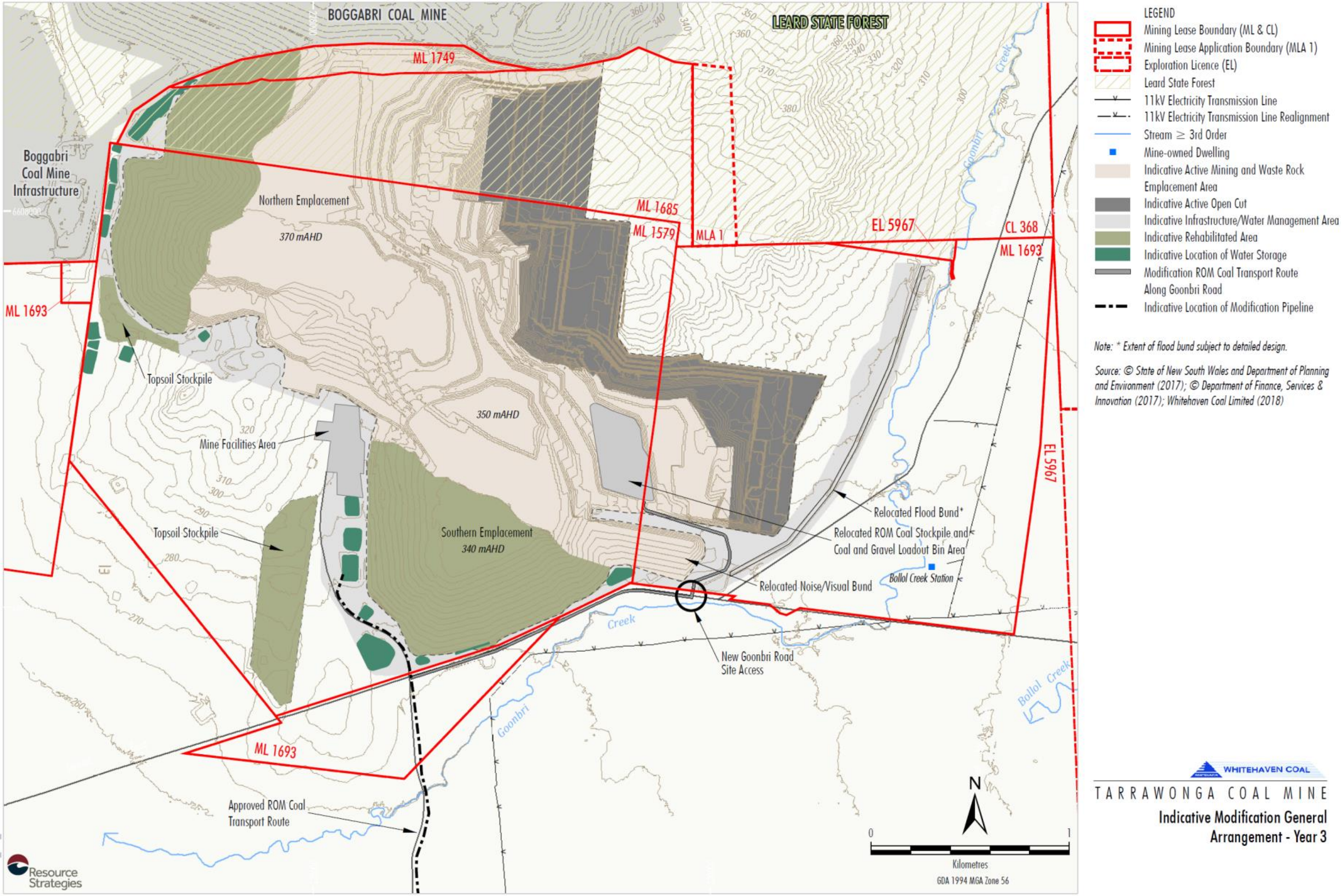

Figure 2 Year 3 Indicative Modification General Arrangement

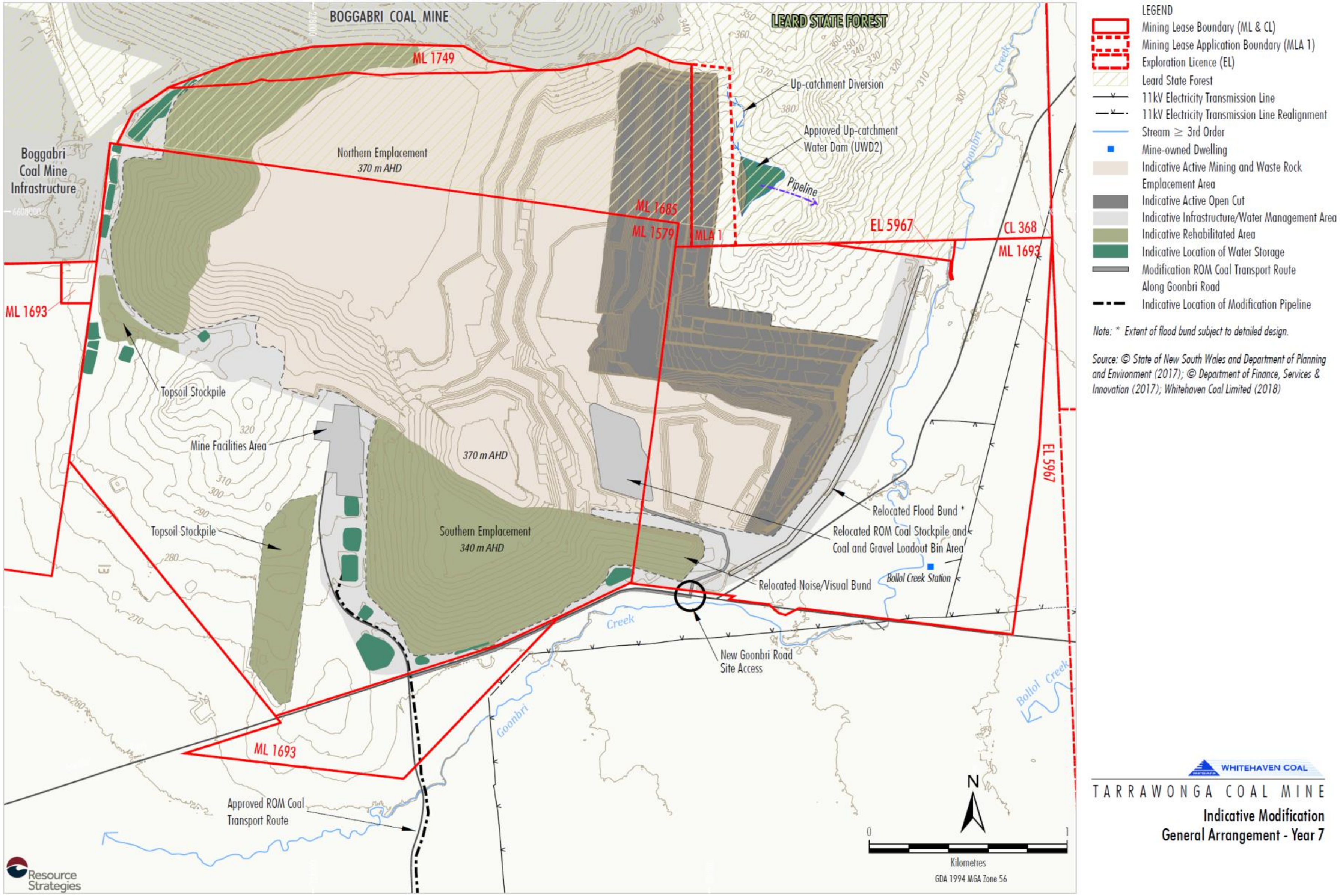

Figure 3 Year 7 Indicative Modification General Arrangement

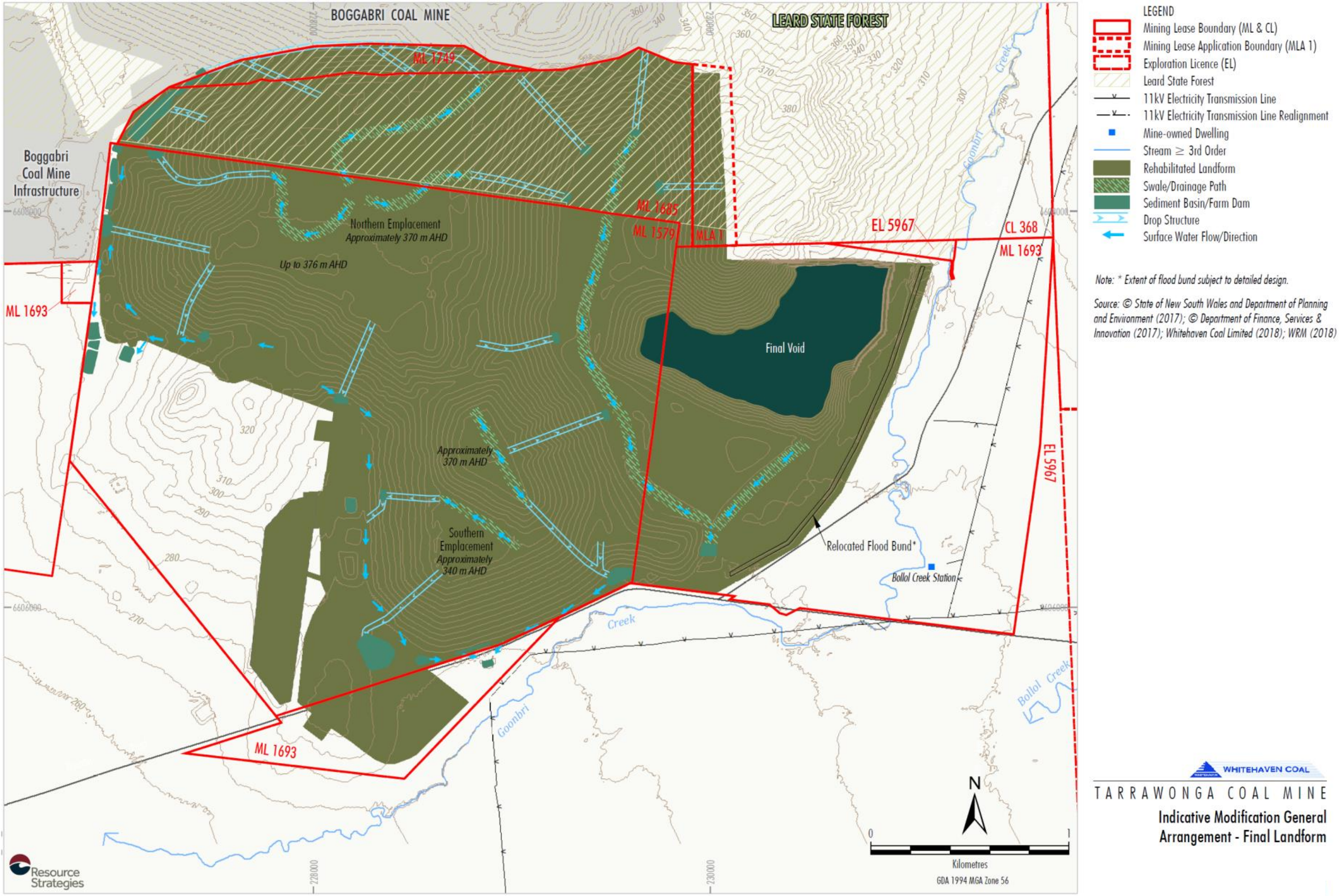

Figure 4 Final Modification Indicative General Arrangement

1.3 PURPOSE AND SCOPE

Hydro Engineering & Consulting Pty Ltd (HEC) has been commissioned by TCPL to prepare a Surface Water Assessment and Site Water Balance in support of the Modification. The purpose of the Surface Water Assessment and Site Water Balance is to:

- review the environmental management performance (surface water) of the current Tarrawonga Coal Mine operations with respect to the quality of mine water, licensed releases and the surrounding environment;
- develop a conceptual water management system for the Life of Mine considering the proposed modifications and revised post-mining landform;
- revise the site water and salt balance model to reflect the proposed modifications;
- assess the potential flood extent of Goonbri Creek and assess whether the revised open cut extension is above the level of a probable maximum flood (PMF);
- assess the potential effects of the Modification on surrounding and downstream catchments, including comparison with the existing approved operation;
- review the existing surface water management and monitoring and provide recommendations for additional monitoring or improvements to the surface water management system;
- provide a description of the proposed water transfer pipeline between the Tarrawonga Coal Mine and the proposed Vickery Extension Project; and
- revise the final void and salt water balance model for Tarrawonga Coal Mine to reflect the revised post-mining landform.

2.0 BASELINE SURFACE WATER RESOURCES

The Tarrawonga Coal Mine is situated predominantly on the hills and foot slopes of the Leard State Forest, as shown in Figure 5. The elevation of the site currently varies from approximately 370 metres (m) AHD[1] in the centre of the site to 270 m AHD in the centre of the southern boundary. The slopes and upland areas of the Tarrawonga Coal Mine and its surrounds are drained by a series of ephemeral streams. The southern and eastern extents of the mine traverse the floodplains of Goonbri and Bollol Creeks while Nagero Creek is located to the west of the mine site (refer Figure 5).

The mine is located entirely within the Namoi River catchment. The Namoi River has a catchment area of approximately 42,000 square kilometres (km^2), extending from Woolbrook in the east to Walgett in the west. The Namoi River catchment is bounded by the Gwydir River catchment to the north, the Macleay and Manning River catchments to the east, the Hunter River catchment to the south-east and the Macquarie and Castlereagh River catchments to the south. The Namoi River is a tributary of the Barwon River, which ultimately flows into the Murray-Darling System.

2.1 RAINFALL AND EVAPORATION

Patched Point Data[2] was obtained for four Bureau of Meteorology (BoM) rainfall stations within the vicinity of the Tarrawonga Coal Mine, as shown in Figure 5. Table 1 provides a summary of average rainfall recorded at each station.

Table 1 Average Monthly Rainfall – 1889 to 2019

Average Monthly Rainfall (millimetres [mm])				
Site Number	**55007**	**55054**	**55076**	**55058**
Site Name	**Boggabri Post Office**	**Boggabri Retreat**	**Boggabri (Kanownda)**	**Turrawan (Wallah)**
Latitude (degrees)	**-30.71**	**-30.70**	**-30.51**	**-30.44**
Longitude (degrees)	**150.05**	**150.28**	**150.21**	**149.94**
January	72	73	78	80
February	62	61	62	60
March	47	46	50	51
April	34	35	35	35
May	42	39	39	42
June	44	45	44	46
July	41	42	39	41
August	37	37	35	37
September	38	40	37	38
October	50	50	51	51
November	60	59	59	59
December	64	61	63	64
Annual	**591**	**589**	**592**	**602**

[1] Australian Height Datum.

[2] The Patched Point Dataset combines observations and interpolations from surrounding stations to provide daily data for a selected set of stations – refer https://legacy.longpaddock.qld.gov.au/silo/ppd/

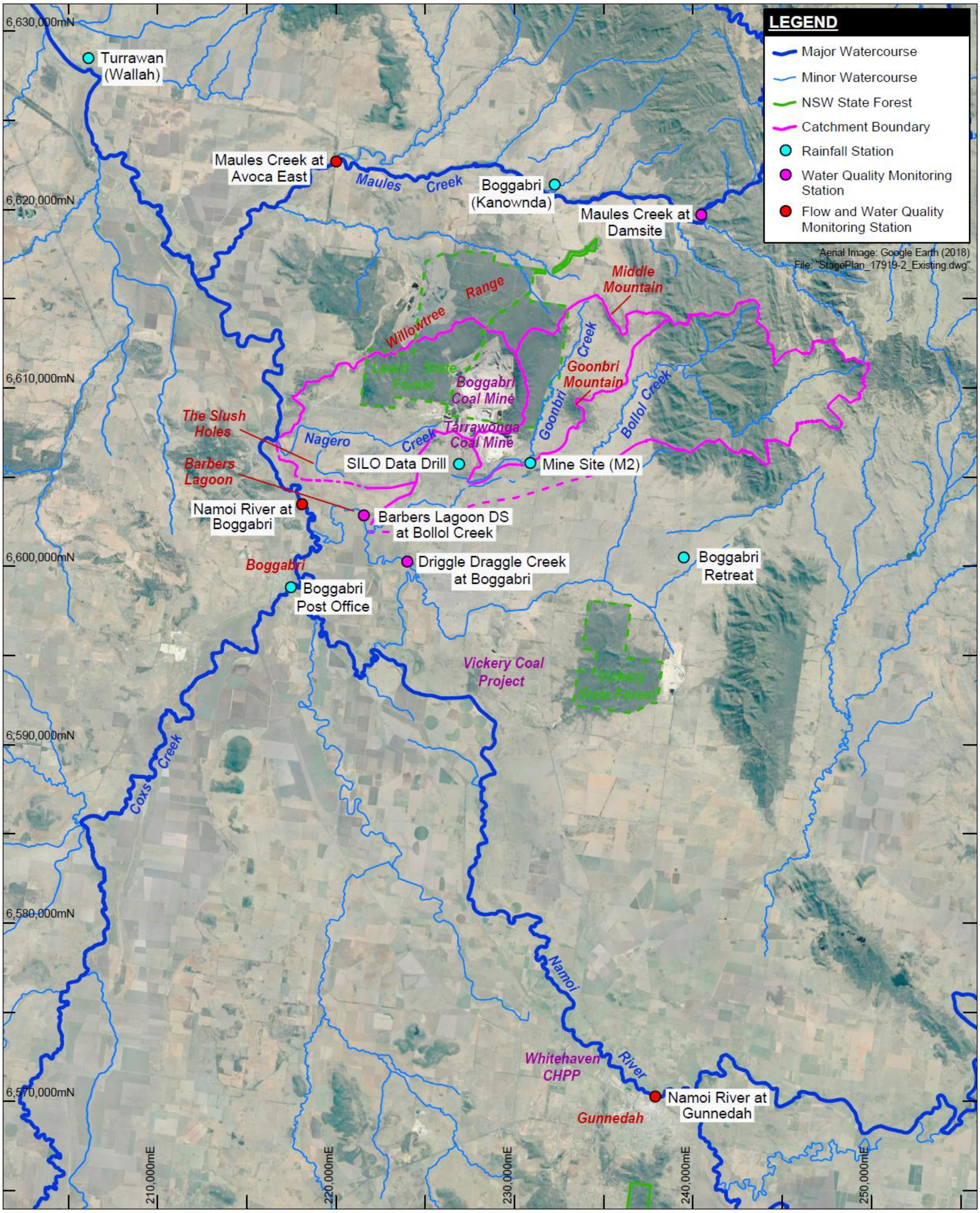

Figure 5 Surface Water Systems and Regional Monitoring Sites

Table 1 illustrates that rainfall tends to be higher in the summer months, peaking at an average of 80 mm in January at Turrawan (Wallah). The recorded average long-term annual rainfall was similar at each location, ranging from 589 mm at Boggabri Retreat to 602 mm at Turrawan (Wallah).

Rainfall has also been recorded at the Tarrawonga Coal Mine by TCPL between January 2013 and November 2018. Table 2 presents a comparison of the Patched Point Data for the BoM sites, SILO Data Drill[3], and rainfall data recorded by TCPL at the mine site, for the period January 2013 to November 2018.

Table 2 Average Monthly Rainfall – 2013 to 2018

Annual Monthly Rainfall (mm)						
Site Number	**55007**	**55054**	**55076**	**55058**	**Tarrawonga Coal Mine (M2)**	**SILO Data Drill**
Site Name	**Boggabri Post Office**	**Boggabri Retreat**	**Boggabri (Kanownda)**	**Turrawan (Wallah)**		
Latitude (degrees)	**-30.71**	**-30.70**	**-30.51**	**-30.44**	**-30.65**	**-30.65**
Longitude (degrees)	**150.05**	**150.28**	**150.21**	**149.94**	**150.19**	**150.15**
January	78	67	76	67	78	68
February	23	33	33	23	29	27
March	59	60	69	90	56	64
April	33	25	23	27	41	27
May	31	32	29	30	34	30
June	56	60	60	65	64	57
July	19	20	20	19	20	18
August	46	46	44	53	56	47
September	34	32	28	32	28	33
October	36	44	50	36	55	41
November	64	63	46	72	64	53
December	36	53	47	37	52	45
Annual	**515**	**534**	**524**	**552**	**576**	**509**

Table 2 illustrates that the average annual rainfall recorded between 2013 and 2018 at the Tarrawonga Coal Mine was higher than that reported for the BoM stations and the SILO Data Drill. The average annual rainfall recorded at Turrawan of 552 mm was closest to that recorded at the mine site (576 mm). Therefore, the long-term daily Patched Point Data for Turrawan has been used in the water balance assessments for the mine site.

Average monthly pan evaporation, calculated from long-term synthetic data obtained from the SILO Data Drill for the mine site is provided in Table 3. This data is considered the most appropriate for the assessment because it is generated for the site location from long-term regional data.

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

Table 3 Average Monthly Pan Evaporation

Month	Pan Evaporation (mm)
January	267
February	215
March	198
April	134
May	89
June	61
July	67
August	94
September	132
October	184
November	226
December	269
Annual Average	**1,937**

Source: SILO Data Drill for Tarrawonga Coal Mine.

Note: Number of years on record = 130.

Comparison of Table 1 and Table 3 illustrates that average annual pan evaporation is approximately three times greater than average annual rainfall in the vicinity of the Tarrawonga Coal Mine, with average pan evaporation exceeding average rainfall in all months.

2.2 CATCHMENTS AND SURFACE WATER RESOURCES

The slopes and upland areas of the Tarrawonga Coal Mine and its surrounds are drained by a series of ephemeral streams that rise in the Willowtree Range. The local drainage catchments associated with the mine are Nagero Creek, Goonbri Creek and Bollol Creek (refer Figure 5). The headwaters and mid-reaches of these streams comprise small confined channels with occasional pockets of adjoining floodplain.

As the streams descend onto the expansive alluvial flats below the mine site, they transition into poorly defined drainage paths, which become expansive ponded overland flow areas during and following heavy rainfall. The overland flow moves slowly down-gradient (west and south-west) toward the Namoi River.

2.2.1 Goonbri Creek

Goonbri Creek rises on the eastern slopes of the Willowtree Range (Figure 5). The creek flows generally southward along the eastern boundary of the Leard State Forest and is flanked on its eastern side by Middle Mountain and Goonbri Mountain, which form a discontinuous line of hills. Downstream of the Tarrawonga Coal Mine, Goonbri Creek flows generally westward and south-westward, crossing the approved ROM Coal Transport Route and ultimately disperses as overland flow on the adjacent alluvial flats and the Namoi River floodplain.

Goonbri Creek comprises a relatively shallow low capacity channel that is confined on its western bank by the lower slopes of the Willowtree Range and overflows onto the adjacent plains on its eastern bank during moderate and high flows. Downstream of the Dripping Rock Road crossing, Goonbri Creek has a relatively incised channel with sufficient capacity to contain moderate flood flows. Flows from the creek ultimately disperse onto the alluvial flats south and west of the mine site.

The alluvial flats have very low natural slopes which are difficult to discern. The slopes generally fall in a westerly and south-westerly direction at between 0.15 per cent (%) and 0.40% gradient. The flatness of the terrain on the alluvial flats and the effect of ongoing cropping and cultivation have prevented the formation of well-defined drainage features.

Goonbri Creek has a catchment area of approximately 37 km^2 to the southern extent of the Tarrawonga Coal Mine (Figure 5). The valley is more than 500 m wide and has gently sloping sides. The channel slope is 0.003 metres per metre (m/m) (Lampert & Short, 2004).

The dominant land uses in the Goonbri Creek catchment are forestry/mining in the higher elevations comprising the Leard State Forest, and agricultural land uses including grazing and cropping on the alluvial floodplains. Several rural residences (including those owned by TCPL) are located within the catchment.

2.2.2 Bollol Creek

Bollol Creek rises in the hills north and east of Goonbri Mountain (Figure 5). The creek initially flows south and westward through a confined valley before dispersing out onto the alluvial flats south of the lower reaches of Goonbri Creek. Bollol Creek then flows south and westward as sheet flow in several pathways associated with shallow, discontinuous swales and divots before eventually reaching Barbers Lagoon to the south and into a series of lagoons to the west known as the Slush Holes, which are relic river channels of the Namoi River. Local anecdotal evidence indicates that the bulk of the flow passes south-west to Barbers Lagoon and ultimately to the Namoi River.

Bollol Creek has an inferred catchment area of approximately 119 km^2, although the actual catchment area contributing flow at different points on the floodplain varies with changing patterns of local cropping and vegetation. The dominant land use in the Bollol Creek floodplain is mixed agricultural, including cropping and livestock grazing.

The Bollol Creek valley is flat and up to 2 km wide. The channel slope is 0.006 m/m (Lampert & Short, 2004). Bollol Creek is characterised as a meandering gravel river. Typical characteristics for this category are long pools separated by short riffles. The river may run dry or have isolated pools during periods of no flow. Riparian vegetation includes River Oaks and Tea Tree. The floodplain is continuous with flood channels and supports pasture and crops (Lampert & Short, 2004).

2.2.3 Nagero Creek

Nagero Creek drains the western and south-western slopes of the Willowtree Range on the western side of the Tarrawonga Coal Mine (Figure 5). The creek flows in a westerly and south-westerly direction, ultimately flowing into the Slush Holes. Nagero Creek has a catchment area of approximately 80 km^2 to the confluence with the Namoi River. During large flood events the Slush Holes become backwater areas of the Namoi River, while at other times they become isolated billabongs.

Nagero Creek has a well-defined incised channel with well-vegetated banks, while the creek bed comprises sand and/or rock. The bed slope varies between approximately 0.02 m/m at the top of the catchment to 0.008 m/m downstream of the Boggabri Coal Mine (Parsons Brinckerhoff Australia, 2010).

The dominant land uses in the Nagero Creek catchment include mining (i.e. Boggabri Coal Mine and a small portion of the existing Tarrawonga Coal Mine), agriculture (sheep and cattle grazing, mixed cropping) and rural settlement.

2.2.4 Licensed Discharge Points

The Tarrawonga Coal Mine is subject to an Environment Protection Licence (EPL) No. 12365, which includes licensed wet weather release into the Goonbri Creek catchment at Licensed Discharge Points (LDP) 2, 3, 24, 26 and 27 (refer Figure 6).

The Boggabri Coal Mine is subject to an existing EPL (No. 12407), which includes licensed wet weather release into the Nagero Creek catchment. The Tarrawonga Coal Mine EPL No. 12365 includes licensed wet weather release into the Nagero Creek catchment (LDP1 in Figure 6).

2.3 SURFACE WATER FLOW REGIME

2.3.1 Local Watercourses

Casual observation and anecdotal evidence from mine site staff and local landholders indicate that the local streams in their upper reaches are highly ephemeral, respond quickly to rainfall, flow for relatively short periods after rainfall and exhibit little flow persistence following rainfall due to limited interaction between shallow alluvial aquifers and the bed of the streams.

Water ponding is more prevalent and persistent in the lower alluvial floodplain areas due to the slow-moving nature of flows and the relatively low seepage loss (groundwater recharge) rates in these areas. Flow in these areas is associated with larger, less frequent events. There are no recorded flow data available for any of the local watercourses.

2.3.2 Regional Watercourses

Recorded flow data is available at two locations within the vicinity of the Tarrawonga Coal Mine monitored by WaterNSW. A streamflow gauging station is located on the Namoi River at Boggabri (GS 419012) and on Maules Creek at Avoca East (GS 419051), as illustrated in Figure 5. The Namoi River at Boggabri gauging station has a catchment area of 22,600 km^2 and an estimated mean annual flow of 810,537 megalitres (ML) (WaterNSW, 2019), equivalent to approximately 35.9 mm of runoff per annum or 6 % of the average annual rainfall at Turrawan (Wallah). Figure 7 presents the flow duration curve for the Namoi River at Boggabri based on daily recorded streamflow from February 1955 to May 2019 (more than 64 years).

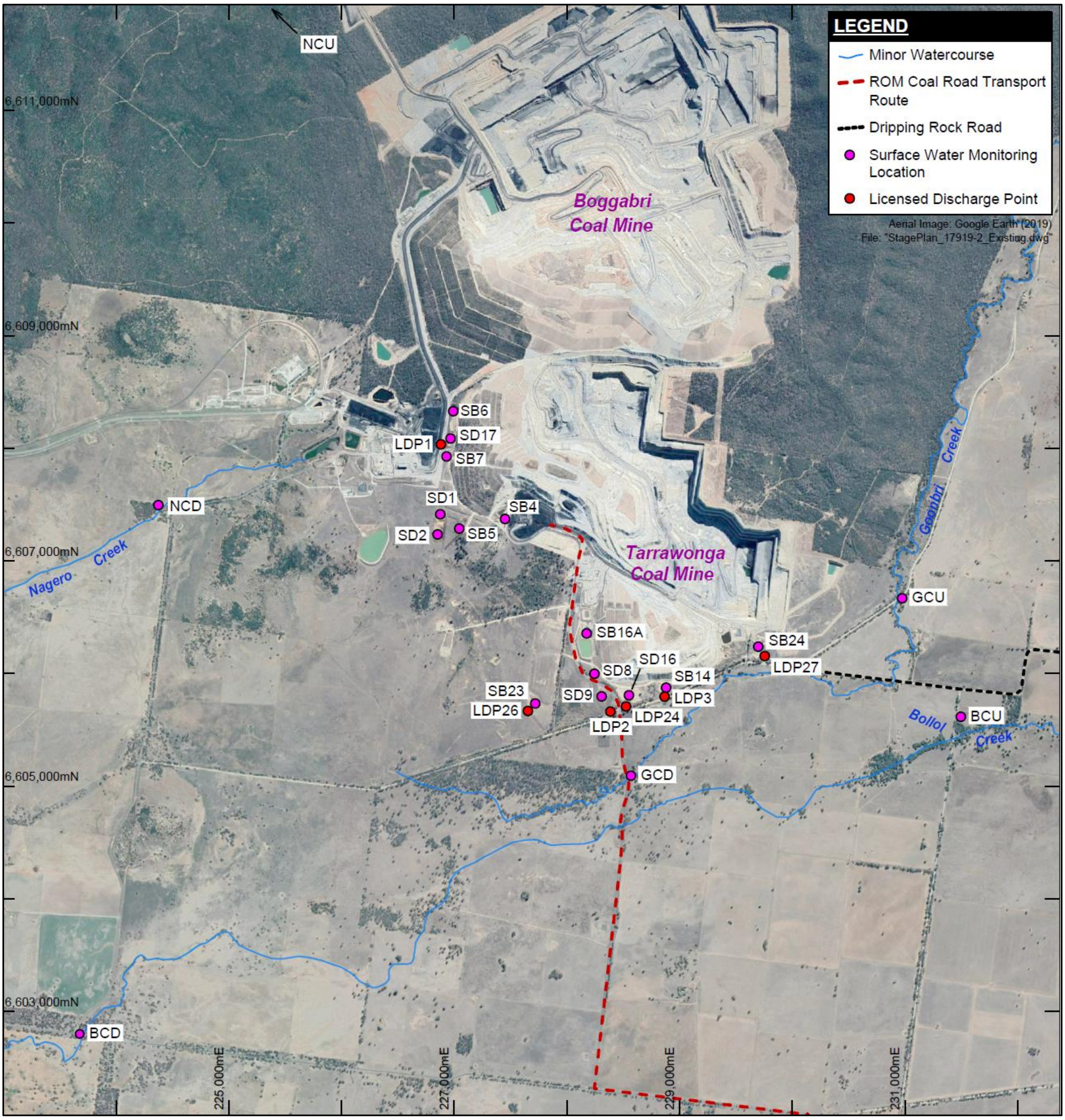

Figure 6 Site Specific Surface Water Monitoring Sites

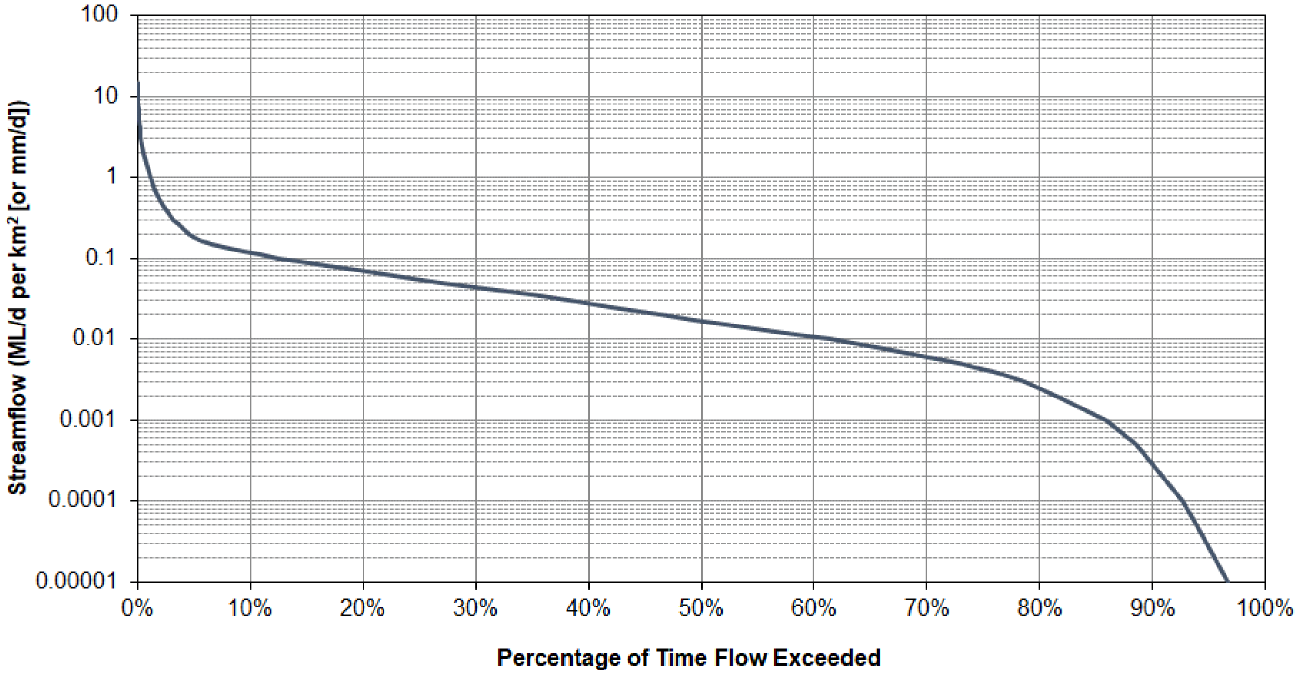

Figure 7 Namoi River at Boggabri (GS 419012) Flow Duration Curve

Figure 7 illustrates that flow in the Namoi River at Boggabri is perennial, with a non-negligible streamflow rate recorded approximately 94% of the time (1 megalitre per day [ML/d] or 0.00004 millimetres per day [mm/d]).

Maules Creek at Avoca East gauging station has a catchment area of 739 km^2 and an estimated mean annual flow of 18,684 ML (WaterNSW, 2019), equivalent to about 28.1 mm of runoff per annum or 5 % of the average annual rainfall at Turrawan (Wallah). Figure 8 presents the flow duration curve for Maules Creek at Avoca East based on daily recorded streamflow from July 1975 to May 2019 (more than 43 years).

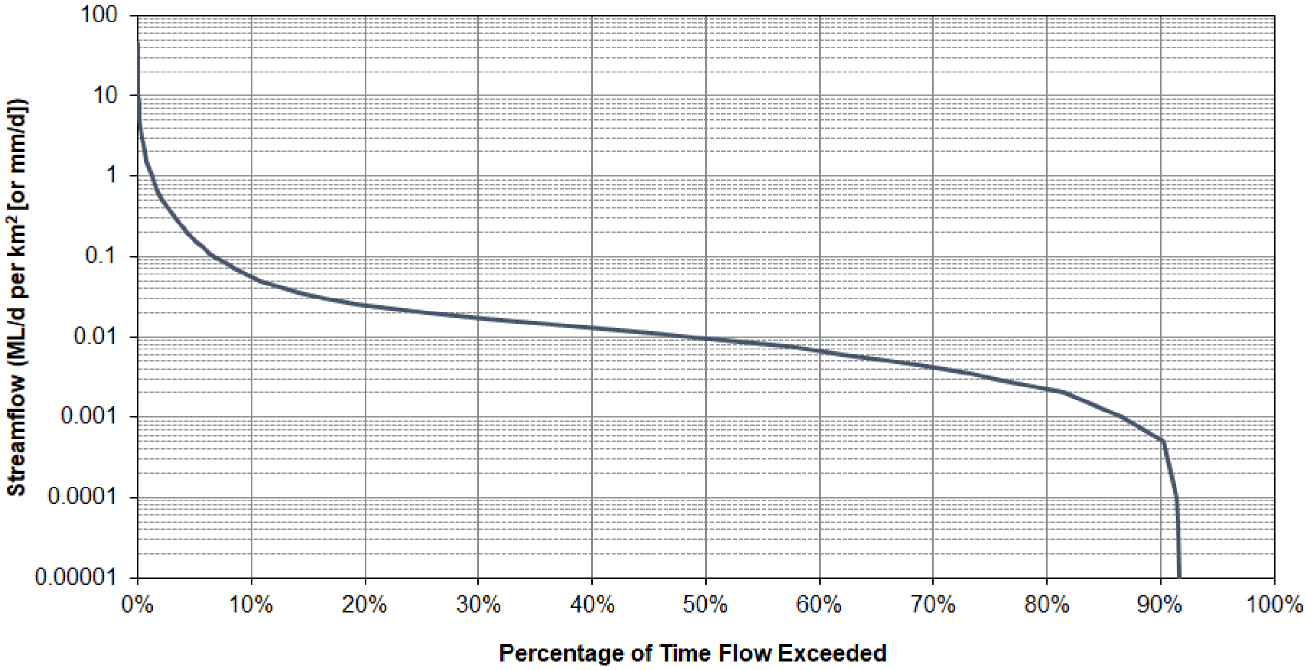

Figure 8 Maules Creek at Avoca East (GS 419051) Flow Duration Curve

Figure 8 illustrates that Maules Creek at Avoca East is effectively perennial, with a non-negligible streamflow rate recorded approximately 91% of the time (0.1 ML/d or 0.0001 mm/d).

The outcomes of the above analysis are consistent with that stated in the *Namoi Subregion Bioregional Assessment* (Herr *et al.,* 2018). The Bioregional Assessment identified that the Namoi River is a perennial stream whereas Maules Creek at Avoca East is near perennial. The remainder of the Namoi river basin waterways within the Bioregional Assessment area are considered to be temporary intermittent streams (Herr *et al*., 2018).

2.3.3 Flooding

The Namoi River valley has experienced a number of significant floods. The largest confirmed flood occurred in February 1955, with significant floods also being recorded in January 1971, February 1984 and November 2000 (NSW Department of Land and Water Conservation, 2003). Flooding along the reaches of the Namoi River nearest to Boggabri is characterised by outbreaks from the main channel and associated inundation of the extensive floodplain areas on both sides of the river channel. Floodplain flow is dominated by flow in flood runners (i.e. preferential flow paths during flood events). Flow patterns are also affected by a series of relic channels which form semi-permanent lagoons between floods (NSW Department of Land and Water Conservation, 2003).

The Tarrawonga Coal Mine is predominantly on elevated land with the lowest level of the site at approximately 270.5 m AHD. The maximum water level was 241.4 m AHD recorded in the Namoi River at Boggabri and 257.7 m AHD recorded in Maules Creek at Avoca East. As such, the Tarrawonga Coal Mine is located above any conceivable flooding of the Namoi River or Maules Creek.

Lower sections of the site along Goonbri Creek could however be affected by extreme flooding from Goonbri Creek (refer Section 6.0) and possibly Bollol Creek and would be protected by a flood bund as described in Section 6.2.

2.4 SURFACE WATER QUALITY

The surface water quality characteristics of local and regional water resources reflect the catchment geology, soils, vegetation and land use. Data available to characterise surface water quality, its spatial and temporal variability is scarce for local (i.e. mine area) catchments, being limited to monitoring data collected by TCPL during periods when the local ephemeral systems have flowed and when access to collect samples was possible. Publicly available regional water quality monitoring data have been collated to provide comparison with the mine area catchment water quality data. The water quality characteristics of water held on site in the existing mining operations has also been characterised as a baseline of the existing water management system.

Management of water quality for natural and semi-natural water resources is guided by the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (the Guidelines) which were revised in 2018 to supersede the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) Guidelines (2000).

The revised Water Quality Management Framework detailed in the ANZECC & ARMCANZ (2018) Guidelines states that where locally relevant water quality guideline values are not available, the default guideline values should be adopted. However, updated default guideline values are yet to be published under the 2018 Guidelines and, as such, adoption of the ANZECC & ARMCANZ (2000) Guideline default values is recommended.

In NSW, the level of protection applied to most waterways is that for 'slightly to moderately disturbed' ecosystems, for which the ANZECC & ARMCANZ (2000) Guideline recommends adoption of the 95% protection level trigger values for aquatic ecosystems. The baseline water quality data has been assessed against the ANZECC & ARMCANZ (2000) Guideline default trigger levels for the protection of Aquatic Ecosystems in south-east Australian Upland Rivers, in accordance with the perceived principal beneficial uses of the surface water resources in the area. The mine is located in a rural area where the major land use is agriculture, including livestock grazing. Therefore, the water quality data has also been assessed against the ANZECC & ARMCANZ (2000) Guideline values for livestock. The guideline trigger values used in the assessment are summarised in Table 4 below.

Table 4 Water Quality Guideline Trigger Values Used in Baseline Water Quality Assessment

Parameter	ANZECC & ARMCANZ (2000) Guideline		
	Aquatic Ecosystems (95%ile level of species protection)	Aquatic Ecosystems (Upland Rivers in NSW)	Livestock
pH (pH units)	6.5 - 8	-	-
EC (µS/cm)	-	30 - 350	-
Turbidity (NTU)	-	2 – 25	-
TDS (mg/L)	-	-	4,000 (beef cattle)
Nitrate (mg/L)	0.7	-	400
Total Nitrogen (mg/L)	-	0.25	
Total Phosphorous (mg/L)	-	0.02	
Calcium (mg/L)	-	-	1,000
Sulphate as SO_4 (mg/L)	-	-	1,000
Arsenic (mg/L) (As III)	0.024	-	0.5
Boron (mg/L)	0.37	-	5
Molybdenum (mg/L)	-	-	0.15
Selenium (mg/L)	0.011	-	0.02
Zinc (mg/L)	0.008	-	20

EC = Electrical Conductivity; µS/cm = micro Siemens per centimetre; NTU = Nephelometric Turbidity Unit; TDS = Total Dissolved Solids; mg/L = milligrams per litre.

The water quality guideline trigger values listed in Table 4 have been used as a basis for interpretation of the baseline water quality data in the following sections. Where multiple trigger values are specified for a parameter, the most conservative trigger value has been adopted for comparison.

Tarrawonga Coal Mine EPL 12365 specifies concentration limits of constituents discharged at monitoring/discharge points at the site - LDPs are shown in Figure 6. The constituent concentration limits are specified in Table 5.

Table 5 Constituent Concentration Limits at LDP 1, 2, 3, 24, 26 and 27

Parameter	Concentration Limit
pH (pH units)	6.5 – 8.5
Oil and Grease (mg/L)	10
Total Suspended Solids (mg/L)	50

TSS = Total Suspended Solids.

The TSS concentration limits may be exceeded for discharged waters provided that (Condition L2.5 of EPL 12365):

a. The discharge occurs solely as a result of rainfall measured at the premises that exceeds 38.4 mm over any consecutive 5-day period immediately prior to the discharge occurring; and
b. All practical measures have been implemented to dewater all sediment dams within five days of rainfall such that they have sufficient capacity to store runoff from a 38.4 mm, 5-day rainfall event.

2.4.1 Water Quality Characteristics of Regional Water Resources

Water quality data monitored by WaterNSW is available for six sites in the vicinity of the Tarrawonga Coal Mine. Water quality data is available for the Namoi River at Gunnedah (GS 419001) and Boggabri (GS 419012) and for Maules Creek at Dam Site (GS 419044) and Avoca East (GS 419051). A relatively small amount of data is available for Barbers Lagoon at Bollol Creek and Driggle Draggle Creek, which are Namoi River Lagoons downstream of the Tarrawonga Coal Mine. The locations of the monitoring sites are shown in Figure 5. Outlier values that were isolated or inconsistent with all other observations (i.e. orders of magnitude higher) were removed from the datasets prior to analysis. A summary of the available data for Barbers Lagoon, Driggle Draggle Creek and Maules Creek at Dam Site is provided in Table 6 below. Exceedances of the water quality guideline trigger values are shown in bold.

Table 6 Water Quality Summary for Barbers Lagoon, Driggle Draggle Creek and Maules Creek at Dam Site

Parameter	Trigger Value	Monitoring Period	No. of Samples	Min.	Mean	Max.	Percentage of Exceedances
Barbers Lagoon Downstream at Bollol Creek (Downstream of Tarrawonga Coal Mine)							
pH (pH units)	6.5 - 8†	Jun 2000 to Mar 2004	7	7.4	7.7	**8.2**	14%
EC (µS/cm)	30 - 350‡		7	188	348	**557**	43%
Turbidity (NTU)	2 - 25‡		6	**45**	**304**	**1,115**	100%
Driggle Draggle Creek at Boggabri (Downstream of Tarrawonga Coal Mine)							
pH (pH units)	6.5 - 8†	Oct 2003	1	-	7.0	-	-
EC (µS/cm)	30 - 350‡		1	-	117	-	-
Maules Creek at Dam Site (Upstream of Tarrawonga Coal Mine)							
pH (pH units)	6.5 - 8†	Oct 1976 to Aug 1991	43	7.2	7.8	**8.7**	19%
EC (µS/cm)	30 - 350‡		45	220	**535**	**1,100**	96%
Turbidity (NTU)	2 - 25‡	Feb 1978 to Aug 1991	36	**0.8**	21	**210**	44%

† ANZECC & ARMCANZ (2000) default guideline trigger value for aquatic ecosystems (95%ile level of species protection for slightly to moderately disturbed ecosystems).

‡ ANZECC & ARMCANZ (2000) default guideline trigger value for Upland Rivers in NSW.

The data in Table 6 shows that the water quality of Barbers Lagoon, Driggle Draggle Creek and Maules Creek at Dam Site was neutral to alkaline during the monitoring period. Turbidity records exceeded the trigger value for 100% of samples at Barbers Lagoon and for 44% of samples at Maules Creek at Dam Site. The trigger value for EC was exceeded in 96% of samples at Maules Creek at Dam Site with a mean value of 535 µS/cm recorded.

Table 7 presents a summary of available water quality monitoring data for Maules Creek at Avoca East. Exceedances of the water quality guideline trigger values are shown in bold.

Table 7 Water Quality Summary for Maules Creek at Avoca East (GS 419051)

Parameter	Trigger Value	No. of Samples	Min.	Mean	Max.	Percentage of Exceedances
pH (pH units)	6.5 - 8†	167	7	7.6	**8.8**	13%
EC (µS/cm)	30 - 350‡	175	155	**352**	**1,010**	46%
Turbidity (NTU)	2 - 25†	126	**0.5**	13	**380**	27%
TSS (mg/L)	-	48	2	16	63	-
TDS (mg/L)	4,000^	2	220	225	230	-
Chloride (mg/L)	-	7	17	24	28	-
Nitrate (mg/L)	0.7‡	7	0.20	0.29	0.49	0%
Total Nitrogen (mg/L)	0.25‡	48	0.13	**0.43**	**1.70**	62%
Total Phosphorus (mg/L)	0.02‡	53	**0.04**	**0.15**	**0.73**	93%
Calcium (mg/L)	1,000^	7	25.5	29.0	33.4	0%
Sulphate as SO_4 (mg/L)	1,000^	7	8.9	15.4	24.0	0%
Dissolved Boron (mg/L)	-	2	0.1	0.1	0.1	-
Dissolved Magnesium (mg/L)	-	2	11.0	11.0	11.0	-
Dissolved Potassium (mg/L)	-	7	1.0	1.7	3.1	-
Dissolved Silica (mg/L)	-	2	15.0	16.0	17.0	-
Dissolved Sodium (mg/L)	-	7	23.8	26.6	28.1	-
Total Boron (mg/L)	0.37†	1	-	0.008	-	-
Total Iron (mg/L)	-	1	-	0.050	-	-
Total Magnesium (mg/L)	2,000^	5	9.3	11.0	13.2	0%
Total Zinc (mg/L)	0.008†	1	-	0.02	-	-

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

‡ ANZECC & ARMCANZ (2000) default guideline trigger value for Upland Rivers in NSW.

^ ANZECC & ARMCANZ (2000) guideline trigger values for livestock.

The data in Table 7 shows that the water quality of Maules Creek at Avoca East was neutral to alkaline during the monitoring period. Recorded EC exceeded the ANZECC & ARMCANZ (2000) default guideline trigger value in 46% of samples, with a mean of 352 µS/cm recorded. Total nitrogen and total phosphorus concentrations exceeded the ANZECC & ARMCANZ (2000) default guideline trigger value in 62% and 93% of samples, respectively.

Table 8 presents a summary of available water quality monitoring data for the Namoi River at Gunnedah (GS 419001). Exceedances of the water quality guideline trigger values are shown in bold.

Table 8 Water Quality Summary for Namoi River at Gunnedah (GS 419001)

Parameter	Trigger Value	No. of Samples	Min.	Mean	Max.	Percentage of Exceedances
pH (pH units)	6.5 - 8†	629	**6.2**	8.1	**9.1**	61%
EC (µS/cm)	30 - 350‡	823	**28**	**495**	**1,200**	77%
Turbidity (NTU)	2 - 25†	729	**0.8**	**70**	**2,000**	51%
TDS (mg/L)	4,000^	65	130	321	560	0%
Total Alkalinity (mg $CaCO_3$/L)	-	21	140	184	250	-
Chloride (mg/L)	-	157	9	39	112	-
Nitrate (mg/L)	0.7‡	99	0.01	0.4	**5.0**	13%
Total Nitrogen (mg/L)	0.25‡	419	0.10	**0.74**	**4.80**	33%
Total Phosphorus (mg/L)	0.02‡	564	**0.03**	**0.14**	**1.79**	100%
Calcium (mg/L)	1,000^	157	15.0	38.1	66.0	0%
Sulphate as SO_4 (mg/L)	1,000^	158	0.5	43.1	89.0	0%
Dissolved Barium (mg/L)	-	4	0.1	0.1	0.3	-
Dissolved Boron (mg/L)	-	64	0.1	0.1	0.2	-
Dissolved Iron (mg/L)	-	10	0.004	0.06	0.52	-
Dissolved Magnesium (mg/L)	-	69	6.1	23.6	55.4	-
Dissolved Potassium (mg/L)	-	156	0.8	2.7	5.1	-
Dissolved Sodium (mg/L)	-	158	9.1	36.9	110.2	-
Total Boron (mg/L)	0.37†	17	0.007	0.085	0.340	0%
Total Iron (mg/L)	-	24	0.004	0.44	8.10	-
Total Magnesium (mg/L)	2,000^	89	10.9	23.2	43.9	0%
Total Zinc (mg/L)	0.008†	3	0.006	**0.015**	**0.03**	67%

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

‡ ANZECC & ARMCANZ (2000) default guideline trigger value for Upland Rivers in NSW.

^ ANZECC & ARMCANZ (2000) guideline trigger values for livestock.

mg $CaCO_3$/L = milligrams of calcium carbonate per litre.

The data in Table 8 shows that the water quality of the Namoi River at Gunnedah (GS 419001) ranged from slightly acidic to alkaline during the monitoring period. Recorded EC exceeded the ANZECC & ARMCANZ (2000) default guideline trigger value in 77% of samples, with a mean of 495 µS/cm. Total nitrogen and total phosphorus concentrations exceeded the ANZECC & ARMCANZ (2000) default guideline trigger value in 33% and 100% of samples, respectively. Total boron concentrations were all less than the ANZECC & ARMCANZ (2000) default guideline trigger value while total zinc concentrations exceeded the default trigger value in 67% of samples.

Table 9 presents a summary of available water quality monitoring data for the Namoi River at Boggabri (GS 419012). Exceedances of the water quality guideline trigger values are shown in bold.

Table 9 Water Quality Summary for Namoi River at Boggabri (GS 419012)

Parameter	Trigger Value	No. of Samples	Min.	Mean	Max.	Percentage of Exceedances
pH (pH units)	6.5 - 8†	147	7.1	8.0	**8.8**	56%
EC (µS/cm)	30 - 350‡	147	182	**516**	**937**	87%
Turbidity (NTU)	2 - 25‡	84	**0.6**	19	**170**	37%
Chloride (mg/L)	-	63	16	37	81	-
Nitrate (mg/L)	0.7‡	6	0.08	0.34	0.70	0%
Total Phosphorus (mg/L)	0.02‡	3	**0.10**	**0.15**	**0.18**	100%
Calcium (mg/L)	1,000^	63	7.6	37.0	59.9	0%
Dissolved Potassium (mg/L)	-	63	1.2	2.2	9.4	-
Dissolved Sodium (mg/L)	-	63	17.0	34.9	58.9	-
Total Magnesium (mg/L)	-	63	7.9	21.8	34.5	-

† ANZECC & ARMCANZ (2000) default guideline trigger value for aquatic ecosystems (95%ile level of species protection for slightly to moderately disturbed ecosystems).

‡ ANZECC & ARMCANZ (2000) default guideline trigger value for Upland Rivers in NSW.

^ ANZECC & ARMCANZ (2000) guideline trigger values for livestock.

The data in Table 9 shows that the water quality of the Namoi River at Boggabri (GS 419012) was neutral to alkaline during the monitoring period. Recorded EC exceeded the ANZECC & ARMCANZ (2000) default guideline trigger value in 87% of samples, with a mean of 516 µS/cm. Total phosphorus concentrations exceeded the ANZECC & ARMCANZ (2000) default guideline trigger value in all three samples.

2.4.2 Surface Water Quality Characteristics of Local Water Resources

Water quality sampling has been conducted by TCPL on Nagero Creek, Goonbri Creek and Bollol Creek at the locations shown in Figure 6. Monitoring data is available for Goonbri Creek upstream (GCU) between 2012 and 2018, Goonbri Creek downstream (GCD) between 2012 and 2017, Bollol Creek upstream (BCU) between 2007 and 2016, Bollol Creek downstream (BCD) between 2008 and 2016 and Nagero Creek upstream (NCU) and Nagero Creek downstream (NCD) between 2009 and 2016[4]. Quarterly samples, when sufficient streamflow permits, and event based sampling is undertaken at GCU and GCD. Event based sampling is undertaken at NCU, NCD, BCU and BCD. TCPL submitted a variation to EPL 12365 in April 2019 to remove sites NCU and NCD from the EPL discharge based sampling. Consequently, monitoring of Nagero Creek has since ceased.

Results of the water quality monitoring for these creeks are summarised in Table 10 and Table 11 below. Exceedances of the water quality guideline trigger values are shown in bold.

4 NCU and NCD are now monitored by Boggabri Coal Operations Pty Ltd. Data sharing occurs between mines consistent with the *Boggabri-Tarrawonga-Maules Creek Complex Water Management Strategy* (Idemitsu Australia Resources Limited and Whitehaven Coal Limited, 2019).

Table 10 Water Quality Summary for Goonbri Creek, Bollol Creek and Nagero Creek – Physico–chemical Parameters and Hydrocarbons

Parameter		Goonbri Creek		Bollol Creek		Nagero Creek	
		GCU	GCD	BCU	BCD	NCU	NCD
pH (pH units) Trigger Value: 6.5 - 8†	No. of Samples	25	21	6	9	6	17
	Min.	6.5	6.7	6.8	6.7	6.8	6.7
	Mean	7.4	7.5	7.2	6.9	7.0	7.2
	Max.	**8.3**	**8.2**	7.5	7.3	7.3	7.8
	Trigger Value % Exceedance	8%	10%	0%	0%	0%	0%
EC (µS/cm) Trigger Value: 350‡	No. of Samples	25	21	6	9	6	17
	Min.	15	91	95	48	34	94
	Mean	177	298	161	115	115	174
	Max.	**549**	**751**	195	167	170	345
	Trigger Value % Exceedance	8%	29%	0%	0%	0%	0%
TSS (mg/L)	No. of Samples	25	21	6	9	6	17
	Min.	5	5	24	16	7	30
	Mean	155	150	117	55	142	358
	Max.	1,230	748	221	150	554	1,370
TOC (mg/L)	No. of Samples	25	21	5	6	4	16
	Min.	6	5	9	14	10	8
	Mean	16	18	17	32	21	14
	Max.	57	50	26	78	40	38
Oil and Grease (mg/L)	No. of Samples	25	20	5	7	4	14
	Min.	5	5	2	2	5	5
	Mean	5	5	4	4	5	5
	Max.	8	5	5	5	5	6

TOC = Total Organic Carbon

† ANZECC & ARMCANZ (2000) default guideline trigger value for aquatic ecosystems (95%ile level of species protection for slightly to moderately disturbed ecosystems).

‡ ANZECC & ARMCANZ (2000) default guideline trigger value for Upland Rivers in NSW.

Table 11 Water Quality Summary for Goonbri Creek – Total Metals & Metalloids

Parameter		Goonbri Creek	
		GCU	GCD
Antimony (mg/L)	No. of Samples	17	17
	Min.	0.001	0.001
	Mean	0.002	0.002
	Max.	0.010	0.010
Arsenic (mg/L) Trigger Value: 0.024†	No. of Samples	17	17
	Min.	0.002	0.001
	Mean	0.006	0.007
	Max.	0.022	**0.026**
	Trigger Value % Exceedance	0%	6%
Molybdenum (mg/L) Trigger Value: 0.15^	No. of Samples	17	17
	Min.	0.001	0.001
	Mean	0.003	0.002
	Max.	0.020	0.010
Selenium (mg/L) Trigger Value: 0.011†	No. of Samples	17	17
	Min.	<0.01	<0.01
	Mean	<0.01	<0.01
	Max.	<0.01	<0.01
	Trigger Value % Exceedance	0%	0%

† ANZECC & ARMCANZ (2000) default guideline trigger value for aquatic ecosystems (95%ile level of species protection for slightly to moderately disturbed ecosystems).

^ ANZECC & ARMCANZ (2000) guideline trigger values for livestock.

The data in Table 10 shows that the water quality of Goonbri Creek, Bollol Creek and Nagero Creek ranged from mildly acidic to alkaline during the monitoring period. The recorded EC exceeded the ANZECC & ARMCANZ (2000) guideline default trigger value in 8% and 29% of samples collected at the upstream and downstream monitoring sites on Goonbri Creek, respectively. Recorded TSS concentrations were highest at NCD, ranging from 30 to 1,370 mg/L, while BCD recorded the lowest range of TSS concentrations from 16 to 150 mg/L. Oil and grease concentrations were typically less than 5 mg/L, excepting at GCU, where a maximum concentration of 8 mg/L was recorded.

The concentration of arsenic recorded at GCD exceeded the ANZECC & ARMCANZ (2000) default trigger value in 6% of samples, with a maximum concentration of 0.026 mg/L recorded as shown in Table 11. Selenium concentrations were less than the ANZECC & ARMCANZ (2000) default guideline trigger value and limit of detection in all samples recorded.

2.4.3 Tarrawonga Coal Mine Surface Water Quality

Water quality is monitored in site water management storages on a quarterly basis in accordance with a site sampling program. The locations of the monitoring sites are shown in Figure 6. The available data from this program, which is summarised in Table 12 and Table 13 below, illustrates the characteristics of mine site water quality. Outlier values that were isolated or inconsistent with all other observations (i.e. orders of magnitude higher) were removed from the datasets prior to analysis. The ANZECC & ARMCANZ (2000) guideline trigger values are for aquatic ecosystems and livestock and therefore are not directly relevant to the site water management storages. As such, exceedances have not been shown in bold; however, the trigger value has been provided for comparison.

Table 12 Water Quality Summary for Site Storages – Physico–chemical and Hydrocarbons

Trigger Value:	6.5 - 8†				30 - 350‡				-				-				-			
	pH (pH units)				EC (µS/cm)				TSS (mg/L)				TOC (mg/L)				Oil and Grease (mg/L)			
Location	No. of Samples	Min	Mean	Max	No. of Samples	Min	Mean	Max	No. of Samples	Min	Mean	Max	No. of Samples	Min	Mean	Max	No. of Samples	Min	Mean	Max
SD1	2	7.5	8.1	8.6	2	605	798	990	2	23	55	86	-	-	-	-	2	<2.0	<2.0	<2.0
SD2	2	8.4	8.4	8.5	2	276	336	395	2	15	59	102	1	5.0	5.0	5.0	2	<2.0	3.5	5.0
SB5	14	6.5	8.3	8.9	14	531	1,488	3,750	14	7	41	144	4	4.0	6.3	8.0	14	<2.0	3.8	13.0
SB6	1	-	7.5	-	1	-	310	-	1	-	104	-	-	-	-	-	1	-	<2.0	-
SB7	8	7.5	8.2	8.7	8	197	363	560	8	10	103	387	6	3.0	4.2	6.0	8	<2.0	5.9	13.0
SD8	11	8.1	8.6	8.9	11	190	719	1,450	11	11	29	84	-	-	-	-	10	<2.0	2.4	6.0
SD9	21	6.9	8.0	9.0	22	123	247	440	22	5	117	1,940	13	7.0	8.5	11.0	22	<2.0	4.1	10.0
SB14	42	7.4	8.3	9.7	43	232	642	1,980	43	5	123	1,300	41	3.0	7.1	19.0	41	<2.0	5.0	10.0
SB16A	18	8.0	8.4	9.4	18	474	955	5,300	18	14	87	330	18	1.0	8.7	51.0	18	1.0	4.9	7.0
SD16	70	7.2	8.4	9.8	71	252	717	5,300	71	5	59	330	69	1.0	6.3	51.0	77	1.0	5.3	21.0
SD17	34	7.4	8.4	9.1	35	229	605	2,040	35	5	79	456	31	2.0	7.8	29.0	38	<2.0	4.9	12.0
SB23	4	7.8	7.8	7.9	5	148	193	254	5	16	45	70	5	3.0	9.4	16.0	5	<5.0	5.0	5.0
SB24	2	8.2	8.5	8.7	3	351	901	1,980	3	31	38	42	2	11.0	11.0	11.0	3	<2.0	4.0	5.0
Pit°	41	7.1	8.3	8.9	41	727	2,662	4,260	40	2	101	1,620	33	1.0	4.2	29.0	40	<2.0	4.7	10.0

† ANZECC & ARMCANZ (2000) default guideline trigger value for aquatic ecosystems (95%ile level of species protection for slightly to moderately disturbed ecosystems).
‡ ANZECC & ARMCANZ (2000) default guideline trigger value for Upland Rivers in NSW.
° Sample location varies depending on extent of open cut pit.

Table 13 Water Quality Summary for Site Storages – Total Metals and Metalloids

Trigger Value:	-				0.024†				0.15^				0.011†			
	Antimony (mg/L)				Arsenic (mg/L)				Molybdenum (mg/L)				Selenium (mg/L)			
Location	No. of Samples	Min.	Mean	Max.	No. of Samples	Min.	Mean	Max.	No. of Samples	Min.	Mean	Max.	No. of Samples	Min.	Mean	Max.
SB14	26	<0.001	0.001	0.010	26	<0.001	0.004	0.010	26	<0.001	0.005	0.020	26	<0.01	<0.01	<0.01
SB16A	18	<0.001	0.003	0.010	18	0.002	0.006	0.022	18	0.008	0.036	0.192	18	<0.01	<0.01	<0.01
SD16	55	<0.001	0.002	0.010	55	<0.001	0.008	0.200	55	<0.001	0.019	0.192	55	<0.01	<0.01	<0.01
SD17	27	<0.001	0.001	0.010	27	<0.001	0.003	0.010	27	<0.001	0.009	0.043	27	<0.01	<0.01	<0.01
Pit°	2	0.002	0.005	0.007	8	0.006	0.011	0.026	2	0.048	0.075	0.101	3	<0.01	<0.01	<0.01

† ANZECC & ARMCANZ (2000) default guideline trigger value for aquatic ecosystems (95%ile level of species protection for slightly to moderately disturbed ecosystems).
^ ANZECC & ARMCANZ (2000) guideline trigger values for livestock.
° Sample location varies depending on extent of open cut pit.

The data in Table 12 shows that the mine site and sediment dam water quality during the monitoring period was generally neutral to alkaline, with a maximum pH of 9.8 recorded in SD16. A maximum EC of 5,300 µS/cm was recorded at SB16A and SD16 and the maximum EC for the open cut pit was 4,260 µS/cm. TSS concentrations were generally higher in the open cut pit than the sediment dams excepting for SD9 which recorded a mean TSS concentration of 117 mg/L and maximum concentration of 1,940 mg/L as compared with a mean concentration of 101 mg/L and a maximum concentration of 1,620 mg/L for the open cut pit.

The TOC concentrations in the sediment dams ranged from 1 mg/L to 51 mg/L, while TOC concentrations in the open cut pit ranged from 1 mg/L to 29 mg/L. Oil and grease concentrations in the sediment dams ranged from 1 mg/L to 21 mg/L, while oil and grease concentrations in the open cut pit ranged from <2 mg/L to 10 mg/L.

A maximum concentration of 0.007 mg/L antimony was recorded in the open cut pit, 0.2 mg/L arsenic at SD16 and 0.192 mg/L molybdenum at SB16A and SD16 (Table 13). Concentrations of selenium were below the limit of detection in all samples and at all locations monitored.

2.4.4 Wet Weather and Controlled Release Water Quality

Water quality samples are also collected following wet weather or controlled release events from the Tarrawonga Coal Mine in accordance with EPL 12365. Table 14 provides a summary of wet weather release events from Tarrawonga Coal Mine storages as detailed in Tarrawonga Coal Mine *Annual Environmental Management* and *Annual Review* reports.

As shown in Table 14, the majority of wet weather and controlled release events occurred prior to 2015, with only one wet weather release event occurring in 2018.

Table 14 Wet Weather and Controlled Release Events

Year	Release Events	Location
2007	2 wet weather release events	LDP1 (SD1, SD2) LDP2 (SD8)
2008	2 wet weather release events	LDP1 (SD17) LDP2 (SD8, SD9) LDP3 (SB14)
2009	1 wet weather release event	LDP2 (SD9)
2010	12 wet weather release events	LDP1 (SD17) LDP2 (SD9) LDP3 (SB14) LDP24 (SD16)
2011	5 wet weather release events	LDP1 (SD17) LDP2 (SD9) LDP3 (SB14)
2012	3 wet weather release events 2 controlled release events	LDP2 (SD9) LDP3 (SB14) LDP24 (SD16) LDP26 (SB23) LDP27 (SB24)
2013	1 wet weather release event 1 controlled release event	LDP2 (SD9) LDP26 (SB23)
2014	1 wet weather release event	LDP1 (SD17) LDP2 (SD9)
2015	No wet weather or controlled release events	
2016	No wet weather or controlled release events	
2017	No wet weather or controlled release events	
2018	1 wet weather release event	LDP1 (SD17)

Table 15 summarises the quality of wet weather release from mine storages in comparison with the ANZECC & ARMCANZ (2000) guideline trigger value and EPL 12365 release limits. The percentage of exceedances against the EPL 12365 release limits has been presented.

Table 16 presents a summary of the water quality data for Goonbri Creek, Bollol Creek and Nagero Creek following wet weather release in comparison with the ANZECC & ARMCANZ (2000) guideline trigger value and EPL 12365 release limits. The percentage of exceedances against the ANZECC & ARMCANZ (2000) guideline trigger value has been presented. Outlier values that were isolated or inconsistent with all other observations (i.e. orders of magnitude higher) were removed from the datasets prior to analysis. Exceedances of the water quality guideline trigger values are shown in bold.

Table 15 Wet Weather Release Water Quality Summary for Site Storages – Physico–chemical and Hydrocarbons

EPL Limit:	6.5 - 8.5					-				50					-				10				
Trigger Value:	6.5 - 8†					30 - 350‡				-					-				-				
	pH					**EC (µS/cm)**				**TSS[1] (mg/L)**					**TOC (mg/L)**				**Oil and Grease (mg/L)**				
Location	No. of Samples	Min.	Mean	Max.	EPL Limit % Exceedance	No. of Samples	Min.	Mean	Max.	No. of Samples	Min.	Mean	Max.	EPL Limit % Exceedance	No. of Samples	Min.	Mean	Max.	No. of Samples	Min.	Mean	Max.	EPL Limit % Exceedance
SD1	1	-	7.5	-	-	1	-	540	-	1	-	**524**	-	-	-	-	-	-	1	-	3.0	-	-
SD2	1	-	7.8	-	-	1	-	610	-	1	-	**290**	-	-	-	-	-	-	1	-	2.0	-	-
SD8	3	6.8	7.5	8.2	0%	3	475	790	1,170	3	5	**68**	**173**	33%	-	-	-	-	3	<2.0	2.0	2.0	0%
SD9	12	7.1	7.3	8.0	0%	12	43	126	271	12	12	**75**	**228**	50%	10	5.0	11.2	19.0	12	<2.0	4.5	5.0	0%
SB14	15	6.8	7.6	8.4	0%	15	74	299	661	15	30	**495**	**2,630**	73%	13	3.0	8.2	18.0	15	<2.0	6.7	**33**	7%
SD16	12	7.3	7.9	**8.8**	17%	12	301	674	857	12	6	**82**	**263**	50%	12	3.0	6.2	20.0	13	<5.0	5.5	9.0	0%
SD17	7	7.3	7.8	8.4	0%	7	232	319	425	7	**137**	**1,030**	**3,970**	71%	5	4.0	14.8	36.0	7	<2.0	4.1	5.0	0%
SB23	4	7.6	7.8	7.9	0%	4	137	183	234	4	**396**	**850**	**1,340**	25%	4	4.0	8.0	15.0	4	5.0	5.0	5.0	0%
SB24	1	-	7.3	-	-	1	-	76	-	1	-	37	-	-	1	-	11.0	-	1	-	5.0	-	-
Mean	-	*7.1*	*7.6*	*8.3*	*4%*	-	*210*	*402*	*603*	-	***98***	***383***	***1,434***	*50%*	-	*3.8*	*9.9*	*21.6*	-	*3.0*	*4.2*	*9.8*	*2%*

† ANZECC & ARMCANZ (2000) default guideline trigger value for aquatic ecosystems (95%ile level of species protection for slightly to moderately disturbed ecosystems).

‡ ANZECC & ARMCANZ (2000) default guideline trigger value for Upland Rivers in NSW.

[1] The TSS limit does not apply when discharge occurs solely as a result of rainfall measured at the premises that exceeds 38.4 mm over any consecutive 5-day period immediately prior to the discharge occurring (Condition L2.5 of EPL 12365).

Table 16 Wet Weather Release Water Quality Summary for Goonbri Creek, Bollol Creek and Nagero Creek

Parameter		Goonbri Creek		Bollol Creek		Nagero Creek[1]	
		GCU	GCD	BCU	BCD	NCU	NCD
pH (pH units) Trigger Value: 6.5 - 8†	No. of Samples	3	4	10	19	11	15
	Min.	7.0	7.2	6.7	6.2	6.6	6.5
	Mean	7.3	7.6	7.1	7.0	7.1	7.1
	Max.	7.6	8.0	7.9	**8.3**	**8.1**	**8.2**
	Trigger Value % Exceedance	0%	0%	0%	21%	9%	7%
EC (µS/cm) Trigger Value: 350‡	No. of Samples	3	4	10	19	11	14
	Min.	97	97	63	77	26	48
	Mean	200	**417**	212	137	107	183
	Max.	**401**	**710**	**633**	**471**	**379**	**903**
	Trigger Value % Exceedance	33%	50%	10%	5%	9%	13%
TSS (mg/L)	No. of Samples	3	4	10	19	10	14
	Min.	12	35	6	5	24	29
	Mean	163	763	122	42	341	143
	Max.	388	2,720	584	122	1,940	616
TOC (mg/L)	No. of Samples	3	4	6	15	10	13
	Min.	10	9	7	13	7	8
	Mean	24	13	15	28	16	17
	Max.	38	23	28	87	30	26
Oil and Grease (mg/L)	No. of Samples	3	4	10	19	11	14
	Min.	5	5	2	2	4	2
	Mean	5	5	4	4	5	5
	Max.	5	5	5	8	5	5

† ANZECC & ARMCANZ (2000) default guideline trigger value for aquatic ecosystems (95%ile level of species protection for slightly to moderately disturbed ecosystems).

‡ ANZECC & ARMCANZ (2000) default guideline trigger value for Upland Rivers in NSW.

[1] Nagero Creek sites now monitored by Boggabri Coal Operations Pty Ltd.

The data in Table 15 shows that the EPL 12365 release limit for pH was exceeded in 17% of samples from SD16, though the pH level of release waters from all other storages did not exceed the release limit. The mean TSS concentrations exceeded the EPL release limit for all storages excepting SB24. However, the majority of TSS concentration exceedances occurred during periods in which rainfall exceeded 38.4 mm over five consecutive days immediately prior to the release occurring (i.e. the exceedances are allowed for in EPL 12365 under these conditions). In instances where the TSS concentration exceeded the EPL release limit though rainfall did not exceed 38.4 mm prior to release, the non-licensed release was reported to the NSW Environment Protection Authority (EPA). Oil and grease concentrations were typically less than the release limit of 10 mg/L excepting at SB14 in which a maximum concentration of 33 mg/L was recorded in one release sample. Note that SB14 will be converted to a sump that will be formed behind a new access track due to the expansion of the Southern Emplacement, subject to required approvals (TCPL, 2018).

The data in Table 16 illustrates that the pH levels recorded in Goonbri Creek, Bollol Creek and Nagero Creek following wet weather release were similar to baseline levels, with near neutral to alkaline conditions. Recorded EC in Goonbri Creek were similar to baseline following wet weather release, though recorded EC in Bollol Creek and Nagero Creek were elevated and exceeded the ANZECC & ARMCANZ (2000) default guideline trigger value. TSS concentrations were elevated at GCD and NCU following wet weather release while TOC and oil and grease concentrations were fairly consistent with baseline conditions following wet weather release.

2.4.5 Water Quality Summary

The following summarises the baseline water quality characteristics of the regional surface water systems in comparison with the baseline water quality characteristics of the mine area surface water systems:

- The regional surface water systems were characterised by near neutral to alkaline conditions during the monitoring period, except for the Namoi River at Gunnedah, which recorded slightly acidic to alkaline conditions. Slightly acidic to alkaline conditions were also recorded in Goonbri Creek, Bollol Creek and Nagero Creek during the monitoring period.
- The regional surface water systems generally experienced elevated levels of EC and turbidity in comparison with the ANZECC & ARMCANZ (2000) guideline trigger value, while only the maximum levels of EC recorded in Goonbri Creek exceeded the guideline trigger value.
- TSS concentrations recorded in Maules Creek at Avoca East were low in comparison with TSS concentrations recorded in Goonbri Creek and Nagero Creek, ranging from 2 to 63 mg/L in Maules Creek at Avoca East as opposed to 5 to 1,370 mg/L recorded in Goonbri Creek and Nagero Creek.

Following wet weather release from the mine site to Goonbri Creek, Bollol Creek and Nagero Creek:

- The pH levels in Goonbri Creek, Bollol Creek and Nagero Creek were similar to baseline levels, with near neutral to alkaline conditions recorded.
- Recorded EC in Goonbri Creek was similar to baseline conditions following wet weather release, though EC in Bollol Creek and Nagero Creek was elevated and exceeded the ANZECC & ARMCANZ (2000) default guideline trigger value. The EC levels recorded in Bollol Creek and Nagero Creek following wet weather release were typically less than that recorded in regional surface water systems.
- TSS concentrations were elevated at GCD and NCU following wet weather release, consistent with the increased concentrations of TSS released from the sediment dams.
- TOC and oil and grease concentrations were fairly consistent with baseline conditions, with the oil and grease concentrations released from the mine site storages typically less than the EPL release limit of 10 mg/L excepting at SB14 in which a maximum concentration of 33 mg/L was recorded in one release sample.

3.0 SURFACE WATER MANAGEMENT SYSTEM

3.1 OVERVIEW

Accepted best practice principles for mine site water management have been applied to the development of the water management system for the Tarrawonga Coal Mine. These principles include avoiding, to the maximum extent practical, the contamination of water as a result of mining activities, minimising the use of imported water where feasible and minimising changes to the flow regimes of downstream waters. Integration of these principles to the water management system has resulted in:

- minimising the disturbance of land to the extent practical, and progressive and ongoing isolation and diversion of clean water runoff around mine-disturbed areas to downstream receiving waters;
- containment and preferential use of mine water and disturbed area runoff from the Tarrawonga Coal Mine to meet dust control and crusher operational requirements; and
- management protocols that see progressive rehabilitation activities on mine waste rock emplacement areas and other areas disturbed by mining, and the passive management of runoff (i.e. allowing runoff to drain off-site from sediment dams that are not actively dewatered between rainfall events), after they have become stabilised by vegetation. Runoff from rehabilitated areas that have been reshaped, topsoiled and seeded, but where vegetation has not yet become sufficiently well established to enable uncontrolled release, would be actively managed via sediment control storages.

3.2 EXISTING OPERATIONAL WATER MANAGEMENT SYSTEM

The existing water management system is comprised of process water dams and a series of sediment basins/dams, collection drains, toe drains and contour banks for managing sediment-laden runoff from the Tarrawonga Coal Mine, as illustrated in Figure 9.

The sediment basins/dams have been designed such that water is transferred between a series of ponds thereby allowing sediment to settle. Water is then transferred to a process water dam for site usage or released off-site via an LDP if the stored water volume exceeds the operational volume of the basin/dam. Pumps between water storages are transferable, with water transfers managed to minimise overflow, the accumulation of water in the open cut pit and off-site water supply. Figure 10 shows a schematic representation of the existing water management system storages and their inter-linkages.

Groundwater inflow to the open cut pit, in addition to direct rainfall and runoff, is collected in a sump and pumped to process water dams PW4 and PW5. Water is sourced from SB4, PW2 and PW5 and used for haul road dust suppression, ROM stockpile dust suppression, vehicle washdown and coal crusher dust suppression. Off-site water supply is used to supplement water demands when there is a shortfall of stored water on-site.

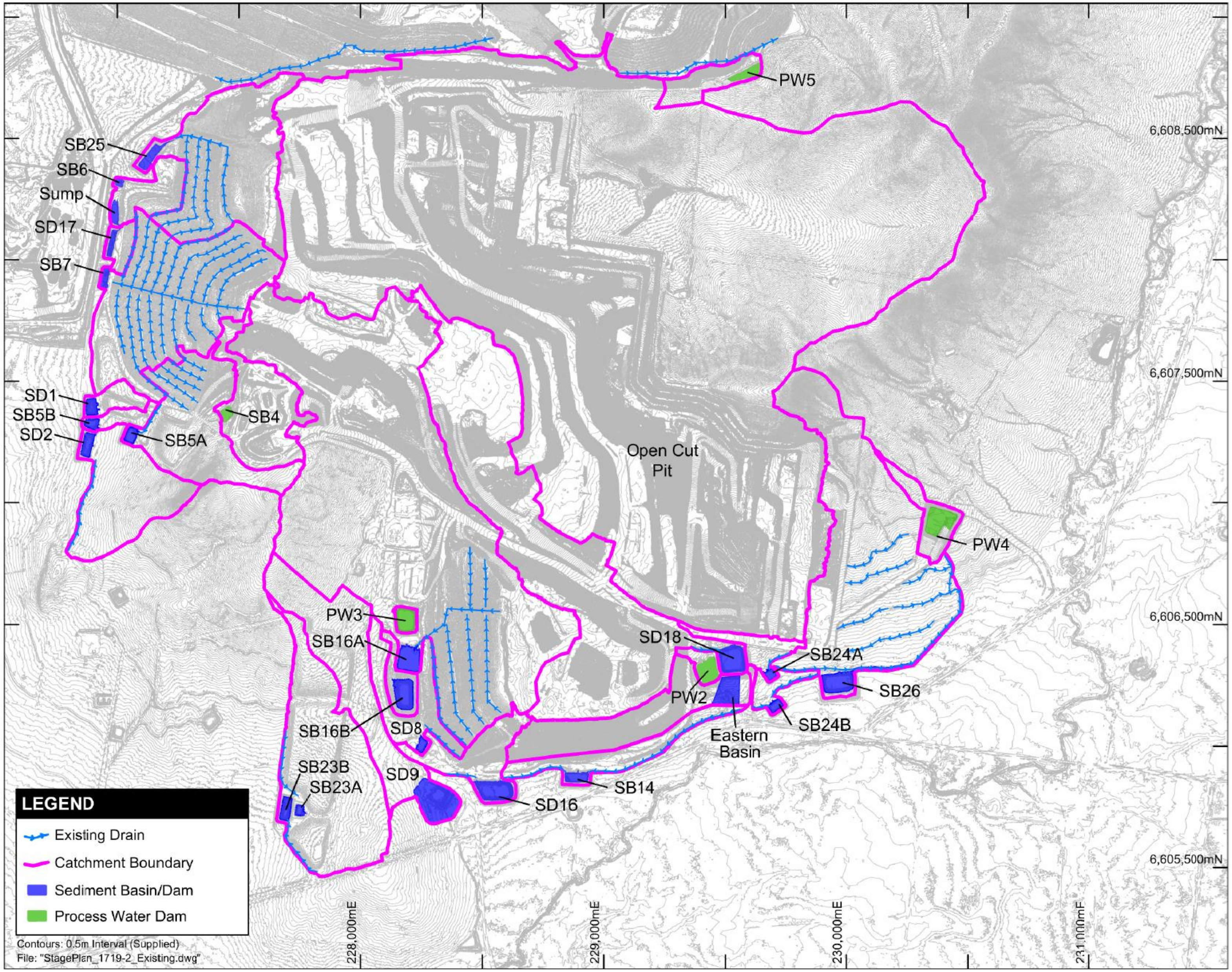

Figure 9 Existing Surface Water Management Layout

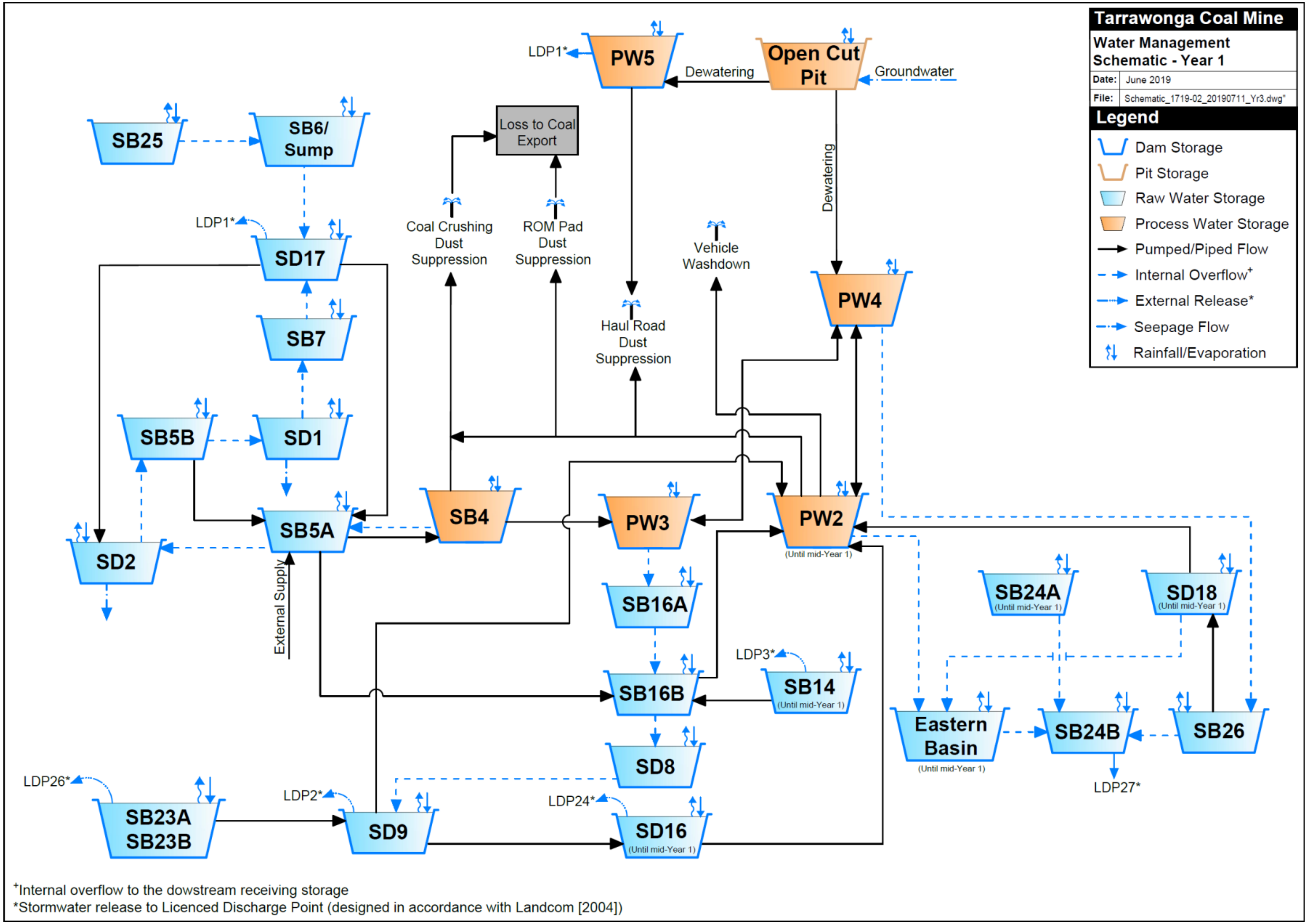

Figure 10 Year 1 Indicative Site Water Management Schematic

The process water dams are designed and managed to reduce the risk of overflow. When the stored volume within the process water dams and open cut pit sump exceeds the operational volume, open cut pit dewatering is ceased, resulting in the accumulation of water in the open pit. As described in the *Tarrawonga Coal Project Surface Water Assessment* (Gilbert & Associates, 2011a), Mine Water Surge Storages (MWSS) may be required to enable the pit to be dewatered effectively and to reduce the risk of pit inundation. Consistent with that approved under the *Tarrawonga Coal Project Surface Water Assessment* (Gilbert & Associates, 2011a), the MWSS would be established by excavating a void in the overburden in advance of the mine area to enable the pit to be rapidly dewatered if prolonged or intense rainfall occurs that cannot otherwise be quickly removed from the pit without exceeding the capacity of the existing Tarrawonga Coal Mine water storages.

3.3 PROPOSED OPERATIONAL WATER MANAGEMENT SYSTEM

The proposed Modification water management system would retain most of the elements of the existing Tarrawonga Coal Mine system. Additional components would be constructed and some elements of the existing system would be decommissioned as they became redundant during the life of the mine.

The water management system has been assessed at three stages (Year 3, Year 7 and Year 11), representative of key Modification dates.

Year 3 Mine Layout

The proposed development at Year 3 is illustrated in Figure 2 and Figure 11. At this stage the open cut pit would be advancing eastwards with runoff from rehabilitated and partially rehabilitated waste rock emplacement areas directed to sediment basins/dams in the west and south via contour banks, collection drains and drop structures. Runoff from active waste rock emplacement areas would be directed back towards the open cut pit, where practicable. Some sediment basins/dams in the south would be removed and replaced to facilitate contouring and rehabilitation of the southern waste rock emplacement between Year 1 and Year 3. A clean water diversion dam (RW1) would be located upslope of the open cut pit to collect runoff from the natural, undisturbed catchment and release the clean water off-site to Goonbri Creek.

The ROM Coal Stockpile and Coal and Gravel Loadout Bin Area would be relocated to the south of the active open cut area. The Modification Pipeline is expected to be in place by Year 3 with off-site water transferred to a raw water dam (RWD). Process water dam PW2 would be removed to facilitate contouring and rehabilitation of the southern waste rock emplacement and PW4 would be replaced by PW6. PW3 would replace PW2 as the primary source of on-site water supply.

Year 7 Mine Layout

The proposed development at Year 7 is illustrated in Figure 3 and Figure 12. Between Year 3 and Year 7, the open cut pit would continue to advance eastwards. Progressive contouring and rehabilitation of the waste rock emplacement areas would continue with additional contour banks, collection drains, drop structures and plateau drains[5] constructed to divert runoff from the rehabilitated and partially rehabilitated areas to the sediment basins/dams in the west and south.

SB4 would be decommissioned and the catchment area directed to SB5A. PW6 would be decommissioned and replaced with PW7.

5 Plateau drains are to be located on the top (plateau) of the northern emplacement.

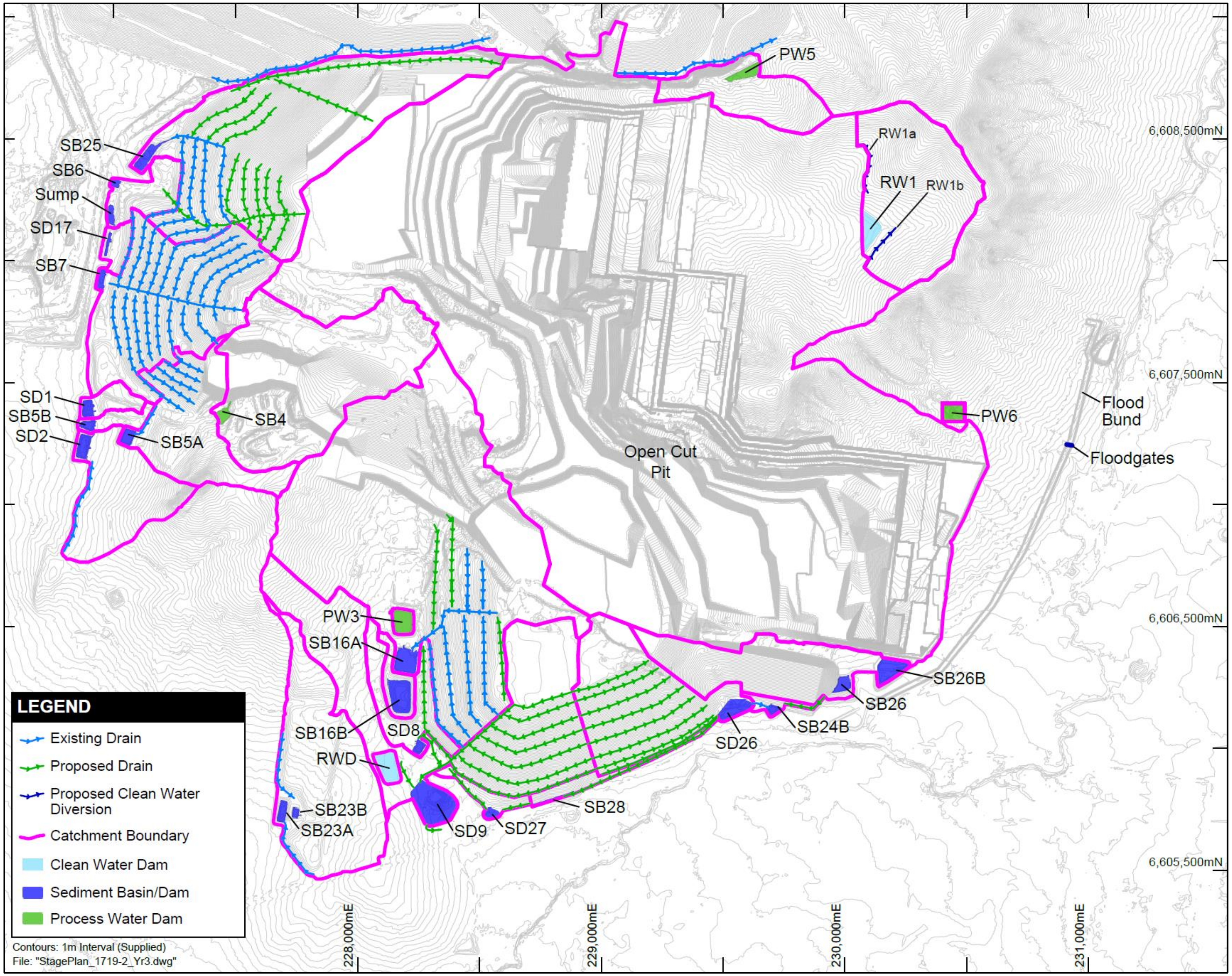

Figure 11 Year 3 Indicative Surface Water Management Layout

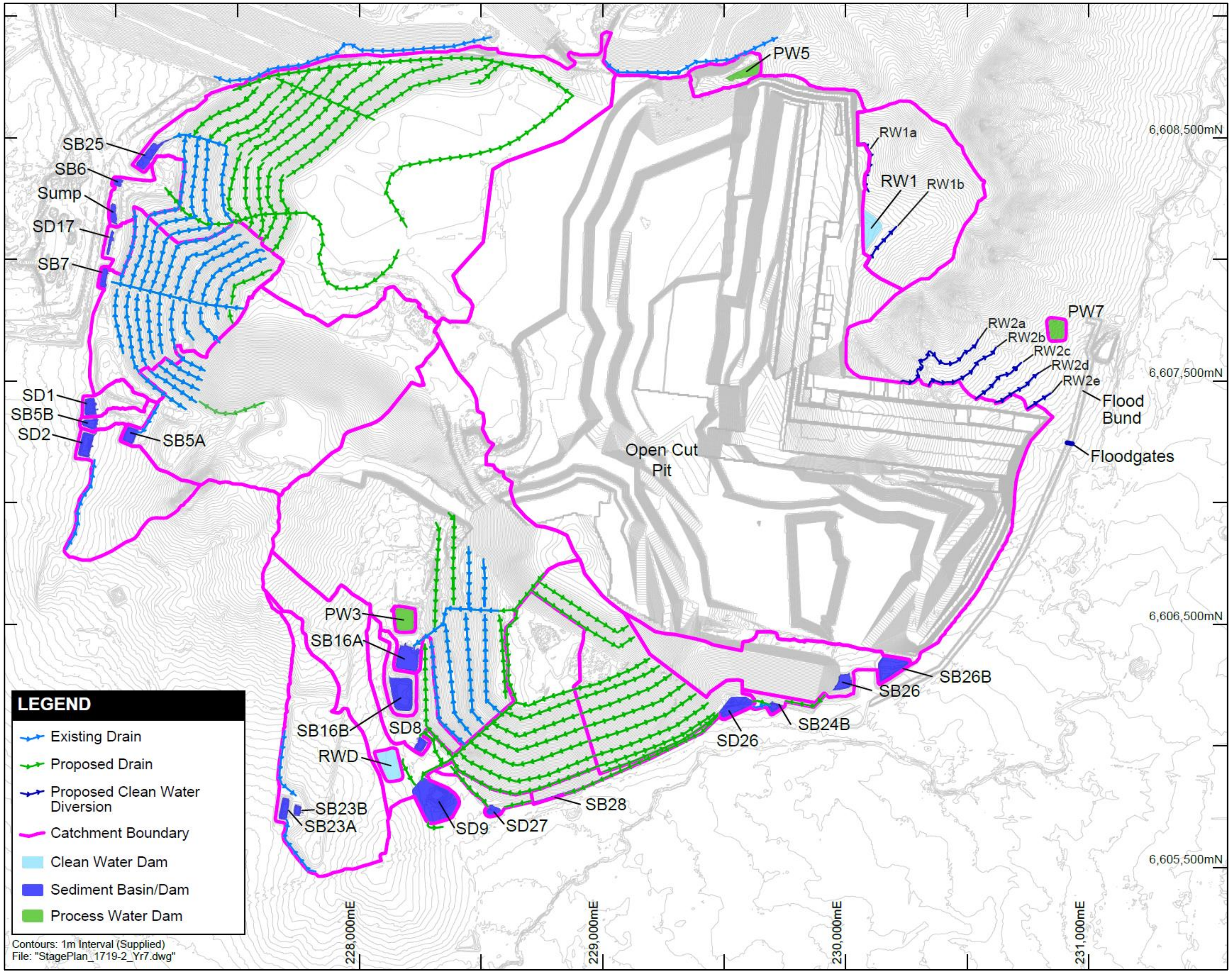

Figure 12 Year 7 Indicative Surface Water Management Layout

Year 11 Mine Layout

The proposed development at Year 11 is illustrated in Figure 13. By Year 11 the open cut pit would comprise the most eastern portion of the Tarrawonga Coal Mine. The majority of the western portion of the site would be rehabilitated with contouring and rehabilitation commencing in the central portion of the site. Additional contour banks, collection drains, drop structures and plateau drains would be constructed to divert runoff from the rehabilitated and partially rehabilitated areas to the sediment basins/dams in the west and south.

PW7 would be decommissioned with the catchment directed to the open cut pit.

3.3.1 Water Storages

The existing and proposed water storages are listed in Table 17 with a summary of the proposed operational details and release location. Figure 14 shows a schematic representation of the proposed Year 2 to Year 11 water management system storages and their inter-linkages.

Table 17 Summary of Existing and Proposed Water Storages

Dam Name	Release Location	Operational Details
Sediment Basin/Dam		
SB25	LDP1	• Pump to PW3 when supply shortfall occurs (assumed to occur post-decommissioning of PW2) • Overflow to SB6/Sump
SD6/Sump	LDP1	• Overflow to SD17
SD17	LDP1	• Pump to SD2 and SB5A • Release to LDP1
SB7	LDP1	• Overflow to SD17
SD1	LDP1	• Overflow to SB7
SD2	LDP1	• Overflow to SB5B
SB5B	LDP1	• Pump to SB5A • Overflow to SD1
SB5A†	LDP1	• Pump to SB4 until (assumed) mid-Year 5 and then to PW3 • Overflow to SD2
SB4	LDP1	• Supply coal crushing dust suppression until (assumed) mid-Year 5 at which point is decommissioned and catchment is directed to SB5A • Pump excess water to PW3 until decommissioned • Overflow to SD2 until decommissioned
SD9	LDP2	• Pump to SD16 until (assumed) mid-Year 1 and then to SD27 • Pump to PW2 until (assumed) mid-Year 1 and then to PW3 • Release to LDP2
SB16A	LDP2	• Pump to PW3 when supply shortfall occurs (assumed to occur post-decommissioning of PW2) • Overflow to SB16B
SB16B	LDP2	• Pumps to PW2 until (assumed) mid-Year 1 and then to PW3 • Overflow to SD8
SD8	LDP2	• Overflow to SD9
SB14/SB28	LDP3/LDP24	• SB14 assumed to be decommissioned in mid-Year 1 and replaced with SD28 • SB14 pump to SD16B and release to LDP3 • SB28 pump and overflow to SD27 (LDP24)

Table 17 (Continued) Summary of Existing and Proposed Water Storages

<table>
<tr><th>Dam Name</th><th>Release Location</th><th>Operational Details</th></tr>
<tr><td colspan="3">Sediment Basin/Dam</td></tr>
<tr><td>SD16/SD27</td><td>LDP24</td><td>• SD16 assumed to be decommissioned in mid-Year 1 and replaced with SD27
• SD27 pump to PW3 when supply shortfall occurs (assumed to occur post-decommissioning of PW2)
• Release to LDP24</td></tr>
<tr><td>SB23A/SB23B</td><td>LDP26</td><td>• Pump to SD9
• Release to LDP26</td></tr>
<tr><td>SD18</td><td rowspan="7">LDP27</td><td>• Pump to PW2 and overflow to Eastern Basin until decommissioned in mid-Year 1 (assumed)
• Catchment redirected to SB26</td></tr>
<tr><td>SB24A</td><td>• Overflow to SB24B until decommissioned in mid-Year 1 (assumed)
• Catchment redirected to SB26</td></tr>
<tr><td>SB24B</td><td>• Release to LDP27</td></tr>
<tr><td>Eastern Basin</td><td>• Overflow to SB24B until decommissioned in mid-Year 1 (assumed)
• Catchment redirected to SD26</td></tr>
<tr><td>SB26</td><td>• Pump to SD18 until (assumed) mid-Year 1 and then to PW3
• Overflow to SB24B</td></tr>
<tr><td>SD26</td><td>• Assumed to be commissioned in mid-Year 1
• Pump to PW3
• Overflow to SB24B</td></tr>
<tr><td>SB26B</td><td>• Assumed to be commissioned in mid-Year 3
• Pump to SB26
• Overflow to SB26</td></tr>
<tr><td colspan="3">Raw Water Dam</td></tr>
<tr><td>RWD</td><td>SD9 (LDP2)</td><td>• Assumed to be commissioned in Year 2 to collect and transfer off-site water supply
• Pump to PW3
• Overflow to SD9</td></tr>
<tr><td>RW1</td><td>Open cut pit</td><td>• Pump/pipe clean water off-site to Goonbri Creek
• Overflow to open cut pit (in extreme rainfall events only)</td></tr>
<tr><td colspan="3">Process Water Dam</td></tr>
<tr><td>PW2</td><td>PW2 (LDP27)</td><td>• Supply site water demands until (assumed) mid-Year 1 at which point is decommissioned and catchment is directed to SB26
• Overflow to Eastern Basin until decommissioned</td></tr>
<tr><td>PW3</td><td>SB16A (LDP2)</td><td>• Supply site water demands following decommissioning of PW2 (assumed mid-Year 1)
• Pump to PW4
• Overflow to SB16A</td></tr>
<tr><td>PW4/6/7</td><td>SB26 (LDP27)</td><td>• Store and transfer open cut pit dewatering for re-use on site
• Pump to PW2 until (assumed) mid-Year 1 and then PW3
• Overflow to SB26</td></tr>
<tr><td>PW5</td><td>LDP1</td><td>• Store and transfer open cut pit dewatering for re-use on site
• Supply haul road dust suppression
• Release to LDP1</td></tr>
</table>

† SB5A is at times used to temporarily store water transferred from the Boggabri Coal Mine.

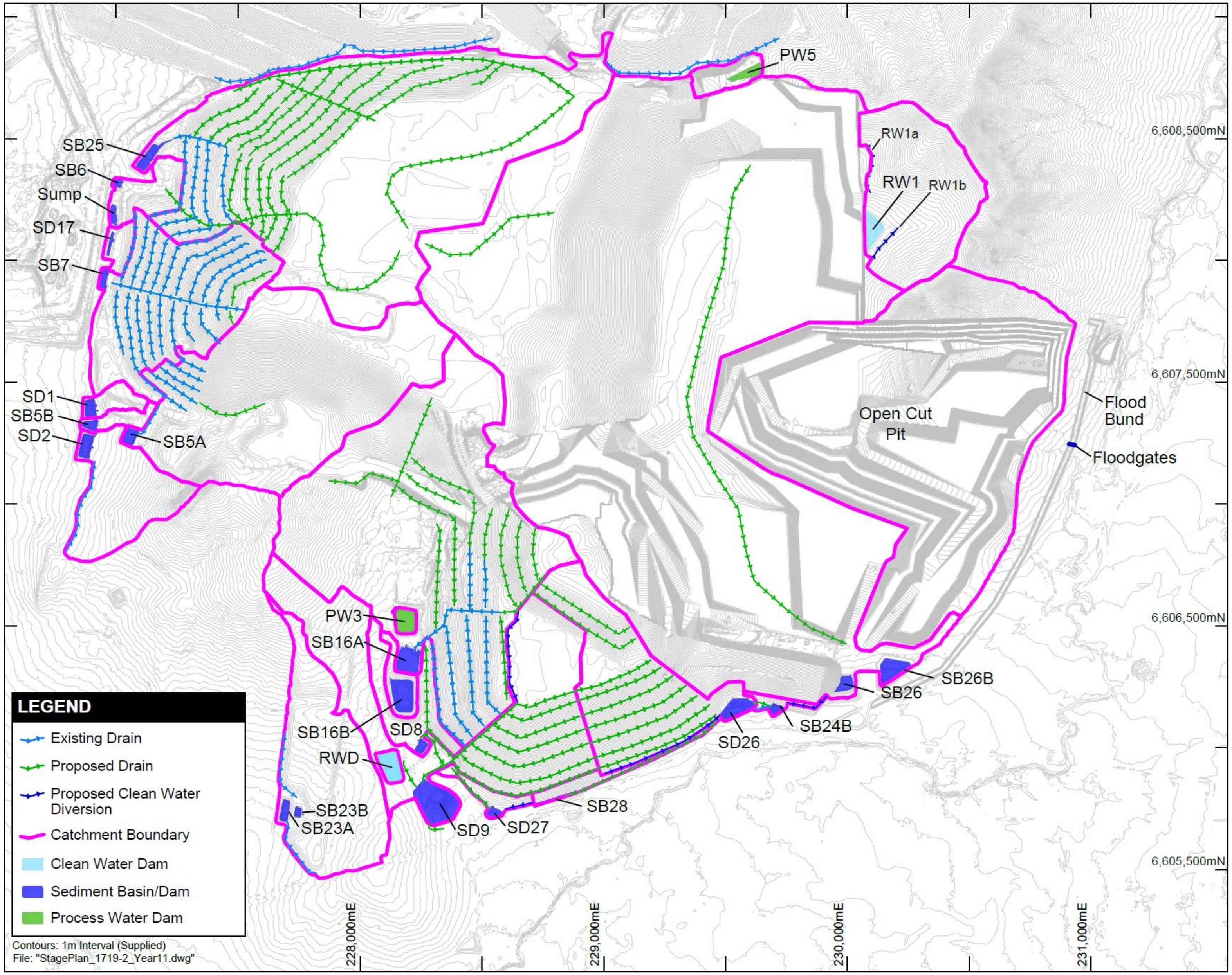

Figure 13 Year 11 Indicative Surface Water Management Layout

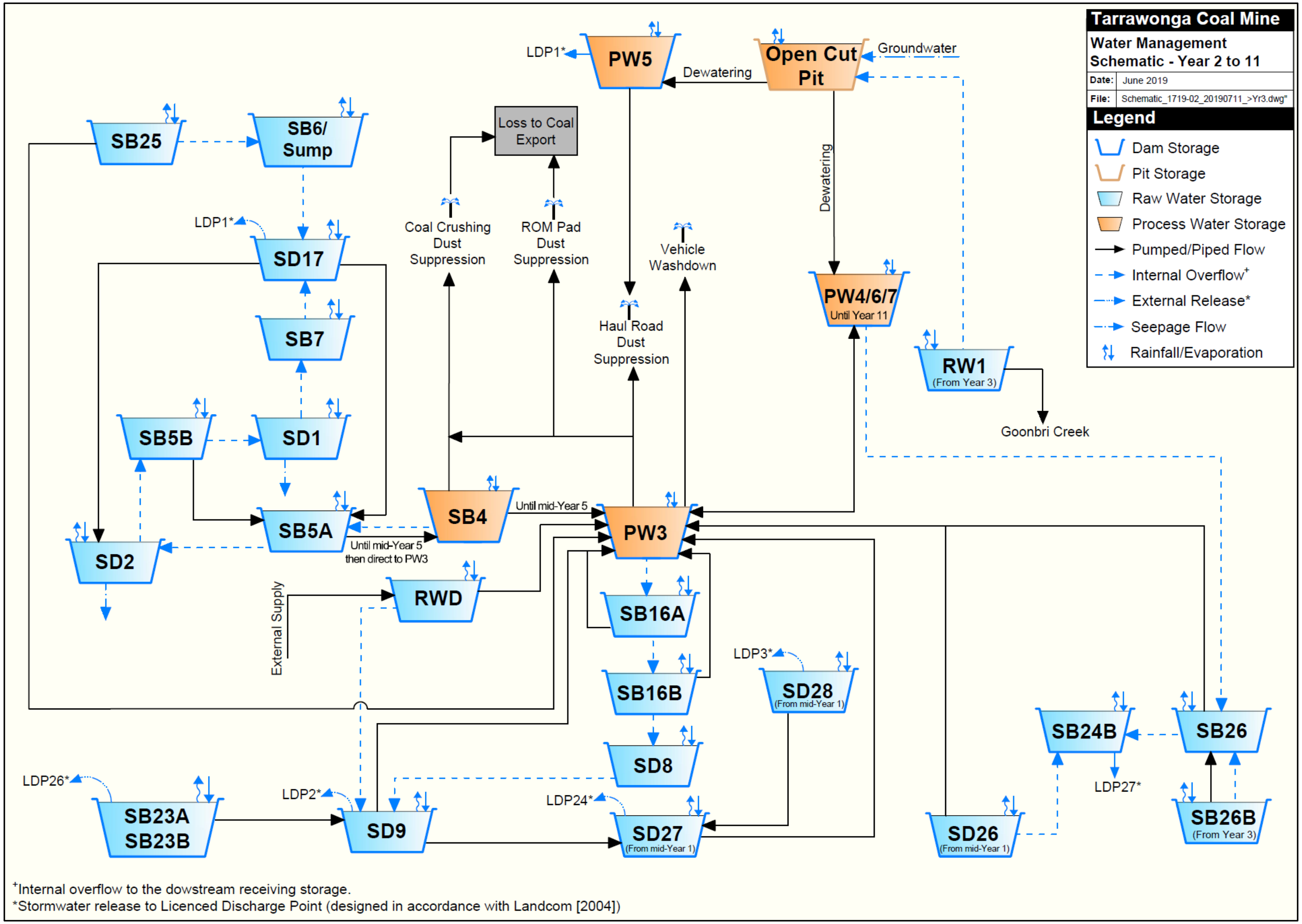

Figure 14 Year 2 to Year 11 Indicative Site Water Management Schematic

3.3.1.1 Clean Water / Raw Water Dams

The clean water diversion dam (RW1) located upslope of the open cut pit has been conceptually designed to store runoff from the 1% Annual Exceedance Probability (AEP), 72-hour rainfall event. The 1% AEP, 72-hour rainfall depth for the mine site is 219 mm (BoM, 2019). The resulting total capacity of RW1 was calculated based on the maximum catchment area, rainfall depth and the conservative adoption of a 100% runoff coefficient. A summary of estimated catchment areas, resulting total capacity and storage surface area of RW1 is provided in Table 18.

Table 18 Conceptual Design of Clean Water Diversion Dam (RW1)

Description	Years Required	Estimated Maximum Catchment Area (ha)	Maximum Operating Volume (ML)	Estimated Pump Rate (L/s)
RW1	Years 3 to 11	31	42	100

L/s = litres per second.

Note that RW1 was previously proposed in the Tarrawonga Coal Project Environmental Assessment (as UWD2) and approval received.

The RWD will be used as buffer storage for water supplied to the site from the external sources. The dam will be a 'turkeys nest' dam and will not be used to harvest runoff from land. The RWD will be designed to provide sufficient storage for off-site water supply (refer Section 4.2.3 for further details).

3.3.1.2 Sediment Basins / Dams

The existing sediment basins/dams are designed and managed in accordance with EPL 12365 as follows:

- Type F sediment retention basin;
- sediment dams to be in place for more than three years unless otherwise stated;
- adequate capacity to capture runoff from a 90th percentile 5-day duration rainfall event (Department of Environment and Climate Change [DECC], 2008) of 38.4 mm (Gunnedah 5-day rainfall depth in Table 6.3a of Landcom, 2004);
- a volumetric runoff coefficient of 0.63 assuming soil hydrologic group D – Table F2 of Landcom (2004); and
- allowance for sediment storage zone capacity equal to 50% of the above calculated settling zone capacity.

Proposed additional sediment basins/dams and upgrades to existing sediment basins/dams have been conceptually designed for the site by WRM Water and Environment (WRM) (2019a and 2019b). The storage capacity of the existing and proposed sediment basins/dams were reviewed against the above design criteria based on the maximum catchment area estimated to be reporting to the sediment basin/dam over the mine life. The existing or proposed capacity of all sediment basins/dams were consistent with the above specified design criteria except for SB5A. An additional sediment basin (SB26B) is also proposed to manage runoff from the increased catchment area of SB26 from Year 7 to Year 11.

The conceptual design for the upgrade of SB5A and construction of SB26B comprised adoption of a nominal 3 m depth and 1V:2.5H excavated side slopes. A summary of estimated maximum catchment areas, resulting minimum required capacity and minimum required pump rate of both sediment basins are provided in Table 19. The pump rate has been specified based on the requirement that the sediment basins can be emptied within five days of filling, as per Landcom (2004).

Table 19 Conceptual Design of SB5A Upgrade and SB26B

Sediment Basin	Years Proposed	Estimated Maximum Catchment Area (ha)	Settling Zone Volume (ML)	Sediment Zone Volume (ML)	Minimum Required Capacity (ML)	Minimum Required Pump Rate (L/s)
SB5A	Year 3* to 11	67	16	8	25	40
SB26B	Year 3** to 11	220	53	27	80	130

* The maximum catchment area contributing to SB5A is expected to occur from Year 7; however, it is recommended that the capacity of SB5A is increased from Year 3 to account for the increase in catchment area to SB4 (refer Section 4.3.4).

** SB26B is proposed to be operational from Year 3; however, the conceptual design is based on the maximum contributing catchment area (Years 7 to 11).

3.3.1.3 Process Water Dams

The process water dams are designed and managed to reduce the risk of overflow. PW2, PW3 and PW4 are constructed as 'turkeys nest' dams with no external catchment area. PW6 and PW7 will be designed and managed as per PW4, with a minimum capacity equivalent to the existing capacity of PW4. PW5 has an external catchment area and hence the existing capacity has been reviewed based on the requirement to store and convey runoff for a 1% AEP, 72-hour rainfall event adopting a conservative runoff coefficient of 100%. Based on the operational characteristics of PW5 listed in Table 20, the existing capacity of PW5 is sufficient to meet the requirements of the specified design criteria over the mine life.

Table 20 Operational Characteristics of PW5

Description	Years Required	Estimated Maximum Catchment Area (ha)	Maximum Operating Volume (ML)	Estimated Pump Rate (L/s)
PW5	Existing to Year 11	12	6.8	80

3.3.2 Water Management Drains

Contour banks, collection drains, drop structures, plateau drains and diversion drains will be progressively constructed over the mine life to manage surface water runoff. The methodology and design criteria applied to each type of drain was based on the length of time the drains would be in use as follows (WRM, 2019a):

- Operational – used during operations and rehabilitated prior to closure; and
- Permanent – permanent, long-term structures that would form part of the final landform.

3.3.2.1 Contour Banks, Collection Drains, Drop Structures and Plateau Drains

Contour banks, collection drains, drop structures and plateau drains have been conceptually designed for the mine life by WRM (2019a and 2019b). Contour banks were assumed to be short-term structures and were sized as follows:

- centroid spacing approximately 60 m apart;
- sized to convey the peak flow resulting from a 5% AEP rainfall event with 0.3 m freeboard and a peak velocity of 0.8 m/s; and
- batter slopes of 1V:2H.

Drop structures, collection drains and plateau drains would be either operational or permanent structures depending on the mine plan. Long-term structures have been conceptually designed with more conservative design criteria to reduce the risk of failure (WRM, 2019a).

Drop structures and collection drains were designed in accordance with International Erosion Control Association (IECA) (2008), as follows (WRM, 2019a and WRM, 2019b):

- sized to convey the 2% AEP peak discharge (long-term structure) or 10% AEP peak discharge (operational structure) with 0.3 m freeboard; and
- rock lined based on the 2% AEP peak velocity (long-term structure) or 10% AEP peak discharge (operational structure).

Plateau drains were considered long-term structures and designed on the basis of the following criteria (WRM, 2019a and WRM, 2019b):

- sized to convey a 2% AEP peak discharge with 0.3 m freeboard and maximum flow velocity of 1.5 m/s;
- vegetated channel and 1% longitudinal slope; and
- batter slopes of 1V:4H.

3.3.2.2 Clean Water Diversions Drains

Clean water diversion drains will be required upslope of the open cut pit to direct clean water runoff to RW1 as shown on Figure 11. Clean water diversion drains will also be required upslope of the open cut pit to direct clean water runoff to Goonbri Creek through the floodgates as shown on Figure 12. The clean water collection drains have been conceptually designed to capture and convey the peak flow from the 2% AEP rainfall event in accordance with the design criteria for the plateau drains at Tarrawonga Coal Mine. The maximum catchment area reporting to each section of the drain was calculated based on the stage plans and 0.5 m contour data for the Tarrawonga Coal Mine area provided by TCPL. The maximum catchment area was then used to calculate the peak flow rate from the 2% AEP rainfall event using the Bransby-Williams equation (IEAust, 1998). Flow depth and velocity at the design peak flow rate was calculated using the Manning equation (Henderson, 1996) for uniform flow conditions. The collection drains have been conceptually designed assuming 1V:4H excavated side slopes.

The drains are recommended to be grass-lined and as such the flow conditions for long grass have been assessed in order to estimate peak flow depths. Grass-lined drains should be inspected at regular intervals to identify sections of erosion or scouring.

The clean water diversion drains have been sized conservatively for a typical section assuming a maximum contributing catchment area of 8 hectares (ha). The conceptual design characteristics for the clean water diversion drains are summarised in Table 21.

Table 21 Summary of Conceptual Drain Design

Peak Flow Rate (m^3/s)	Minimum Estimated Longitudinal Gradient (%)	Base Width (m)	Capacity sizing for design flow		Erosion protection requirements for design flow	
			Required Drain Depth (m)*	Flow Area (m^2)#	Peak Velocity (m/s)	Recommended Lining
0.7	0.5	1.0	1.0	2.7	0.8	Grass

* Includes a 0.3 m freeboard allowance.

Calculated from base width, peak flow depth and 1V:4H excavated side slopes.

m^3/s = cubic metres per second.

3.3.3 Water Demand

The site water demands, comprising haul road dust suppression, ROM stockpile and coal crusher dust suppression and vehicle washdown, will be required for the remainder of the mine life. ROM stockpile and coal crusher dust suppression rates will increase in proportion with the increase in ROM coal production while haul road dust suppression and vehicle washdown will increase in proportion with the increase in haul road area.

3.3.4 Water Supply

Water will be supplied for site purposes from a number of sources during the life of the Tarrawonga Coal Mine, including (as available):

- open cut pit dewatering;
- internal runoff collection at the mine site;
- any remaining TCPL allocations in the Gunnedah-Oxley Basis Murray Darling Basis Porous Rock Groundwater Source after inflows are accounted for. TCPL hold 300 ML (i.e. WAL29548 = 50 ML and WAL31084 = 250 ML), so if the annual inflows are lower, the remaining volume could be extracted via advanced dewatering;
- the proposed Vickery Extension Project (subject to approval of the Vickery Extension Project SSD 7480 and licence availability); and
- water sharing and transfers between mines consistent with the Boggabri-Tarrawonga-Maules Creek Coal Mine Complex (BTM Complex) Water Management Strategy (Idemitsu Australia Resources Limited and Whitehaven, 2019).

3.3.5 Proposed Vickery Extension Project Pipeline

The Modification would include construction of a water transfer pipeline that connects to the proposed Vickery Extension Project (SSD 7480) (Figure 1). The pipeline will transfer water from the Vickery Extension Project to the RWD to supplement on-site water shortfalls. The volume of groundwater pumped from the bores will be within Whitehaven's licensed water entitlements.

The pipeline is to be installed substantially above ground and as such there is likely to be little surface disturbance required. Road crossings are proposed at Goonbri Road and Rangari Road. This would involve excavation to install the pipeline below the road surface prior to reinstating the road to its existing condition, including the bitumen road surface. Any surface disturbance away from the road surface itself would be reinstated to existing levels, covered with topsoil recovered ahead of surface disturbance activities and revegetated. Any surface disturbance associated with pipeline installation (including the road crossing) would include localised erosion and sediment controls as specified in Landcom (2004), which may include the use of localised sediment sumps, grassed filter strips, straw bale filters and/or sediment fence. Pipeline installation would occur, if possible, during forecast dry weather to reduce the risks of impacts of any surface disturbance.

The groundwater extracted from the Vickery Extension Project is expected to be of similar quality to the groundwater within the Tarrawonga Coal Mine region. The groundwater EC monitored within the Tarrawonga Coal Mine region ranges from 571 µS/cm (MW2) to 3,251 µS/cm (MW1), on average, compared with an average EC of 115 µS/cm to 298 µS/cm recorded in Goonbri Creek and Bollol Creek in the vicinity of the Tarrawonga Coal Mine (refer Section 2.4.2). As Goonbri Creek and Bollol Creek are ephemeral and only flow during high rainfall periods, it is unlikely that minor leakage, should it occur, from the pipeline will have a noticeable impact on surface water quality. Regardless, it is recommended that water quality monitoring on Bollol Creek downstream of the pipeline route (i.e. at BCD) is continued throughout the mine life to assess potential changes in surface water quality due to the Modification.

Construction erosion and sediment controls and flow monitoring would be included in the detailed pipeline design, as summarised in Section 8.1.

3.4 PROPOSED FINAL LANDFORM WATER MANAGEMENT SYSTEM

The surface water management system proposed for the final landform is illustrated in Figure 15. Post-mining, all mining areas, excepting the final void catchment, will be regraded to a stable landform and revegetated. The final landform will comprise a series of permanent drop structures, plateau drains and collection drains to enable the final landform to be free-draining. These structures have been conceptually designed by WRM (2019a and 2019b) with further detail to be outlined in a future Mining Operations Plan and/or closure plan.

Plateau drains will be located on the top (plateau) of the rehabilitated northern emplacement, southern emplacement and adjacent rehabilitated, former active mining area to collect and divert runoff to adjacent drop structures. The plateau drains have been conceptually sized to convey a 2% AEP peak discharge with a maximum flow velocity of 1.5 m/s (WRM, 2019a). The plateau drains will be vegetated and will have a 1% longitudinal slope.

Consistent with the approved project, the Modification proposes the use of drop structures. The drop structures will be rock lined due to the steep longitudinal gradient and high flow velocities. The drop structures have been conceptually sized to convey the 2% AEP peak discharge, with the size of rock lining to be based on the 2% AEP peak velocity (WRM, 2019a). The drop structures will discharge to the existing sediment dams to provide for energy dissipation/erosion protection prior to discharge to the downstream drainage network. Alternatively, energy dissipaters/erosion protection will be provided at the outlet of the drop structures. Collection drains will be constructed in the rehabilitated, former active mining area to convey runoff to a sediment dam downstream prior to discharge off-site.

The majority of operational sediment dams will be retained in final landform to provide for energy dissipation/erosion protection. Runoff from the rehabilitated final landform will be conveyed to the sediment dams prior to release off-site. The sediment dam spillways have been designed for a 1% AEP peak discharge (WRM, 2019b).

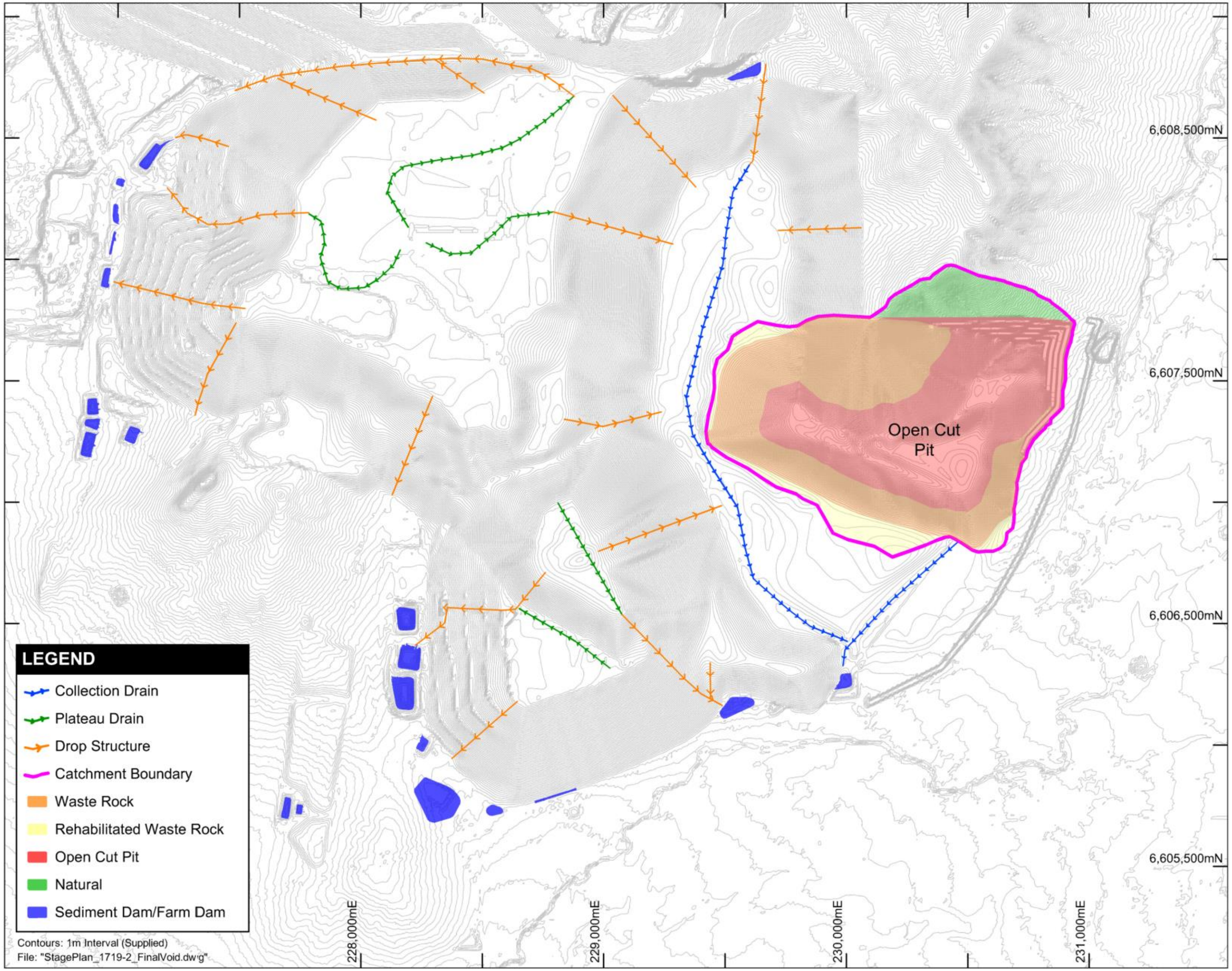

Figure 15 Final Landform Indicative Surface Water Management Layout

4.0 OPERATIONAL WATER AND SALT BALANCE MODELLING

4.1 MODEL DESCRIPTION

The water balance model has been developed to simulate the storages and linkages shown in schematic form in Figure 10 and Figure 14. The model has been developed using the GoldSim® simulation package. The model simulates the behaviour of water held in and pumped between all simulated water storages. For each storage, the model simulates:

Change in Storage = Inflow – Outflow

Where:

Inflow includes rainfall runoff, groundwater inflow (for the open cut pit), water sourced from off-site and all pumped inflows from other storages.

Outflow includes evaporation, overflow, controlled release off-site and all pumped outflows to other storages or to a demand sink (e.g. the haul road dust suppression).

The model operates on an 8-hourly time step and is simulated for an 11-year period equivalent to the remainder of the mine life. The model simulates 130, 11 year "realisations", derived using a climatic data set from 1889 to 2018[6]. The first realisation uses climatic data from 1889-1909, the second 1890-1910, the third 1891-1911, and so on. This method effectively includes all historical climatic events in the water balance model, including high, low and median rainfall periods. The results from all realisations were used to generate water storage volume estimates and other relevant water balance statistics. Results can be extracted for any water balance component for any time period in the simulation for statistical analysis.

4.2 MODEL ASSUMPTIONS AND DATA

A summary of key model assumptions and underpinning data are provided in the sub-sections that follow.

4.2.1 Rainfall and Evaporation

As detailed in Section 2.1, long-term daily rainfall data for Turrawan (Patched Point Data) and long-term daily pan evaporation (SILO Data Drill) have been used in the water balance assessment for the mine site.

4.2.2 Rainfall Runoff Simulation and Catchment Areas

For water surface areas, rainfall was assumed to add directly to the storage volume with no losses. Rainfall runoff in the water balance model is simulated using the Australian Water Balance Model (AWBM) (Boughton, 2004). The AWBM is a nationally-recognised catchment-scale water balance model that estimates catchment yield (flow) from rainfall and evaporation.

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6 Additional climate data after 2018 was generated by "wrapping" data from the beginning of the climate data set to after 2018. In this way, data from the beginning and end of the data set was used in the same number of realisations as all other data.

The AWBM simulation of flow from six different sub-catchment types was undertaken, namely: undisturbed (natural) areas, hardstand (for example, roads and infrastructure areas), open cut pit/pre-strip, active waste rock emplacement, partially rehabilitated waste rock emplacement and rehabilitated areas. The AWBM parameters were adopted from the calibrated OPSIM water balance model for Tarrawonga Coal Mine detailed in the WRM *Site Water Balance* (WRM, 2018). Catchment evaporation pan factors were set to 1 for hardstand areas and 0.85 for all other sub-catchment types.

Catchment areas for the open cut pits, dams and ponds were calculated for Years 1, 3, 7 and 11 on the basis of the stage plans (refer Figure 17 to Figure 20). Each modelled storage catchment area was then divided into sub-catchment areas corresponding with the sub-catchment types specified above. In the model, the catchment areas are linearly interpolated between the values derived from the stage plans. Figure 16 illustrates the estimated total catchment area for the mine site progression.

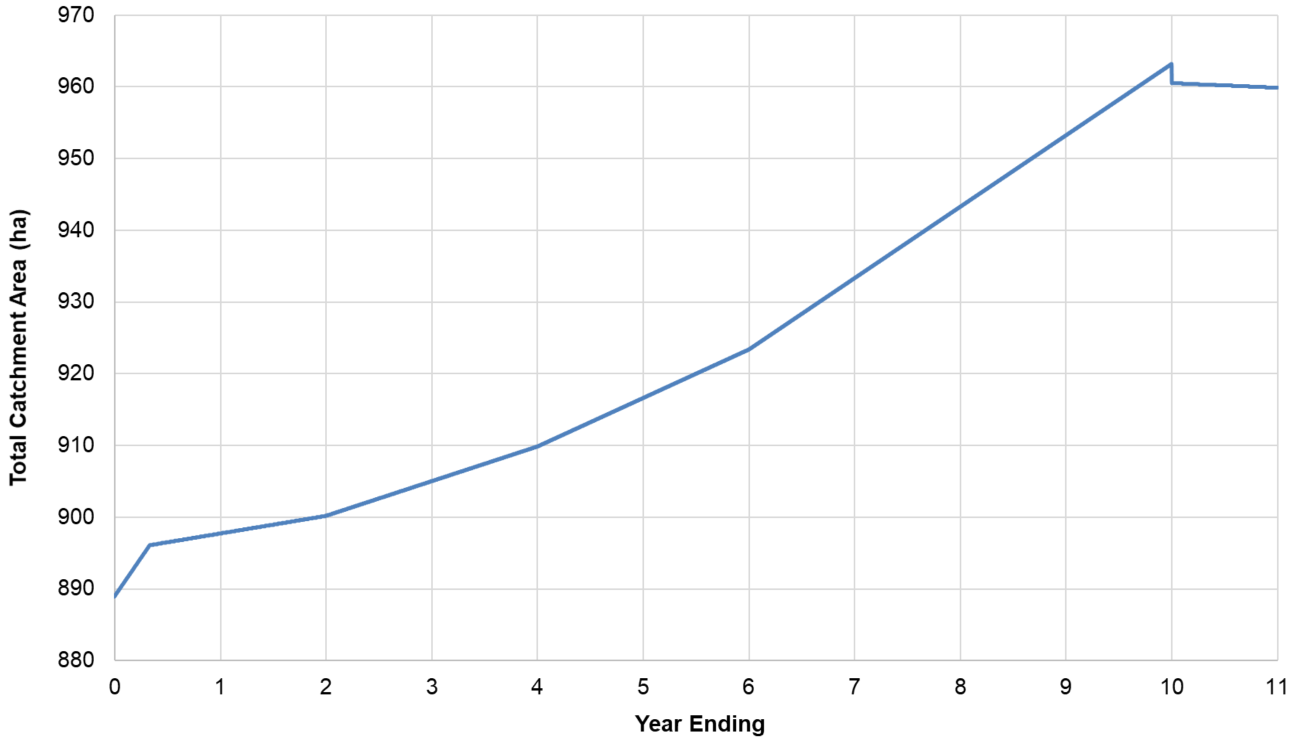


Figure 16 Final Landform Surface Water Management Layout

The total catchment area is expected to increase from 888 ha at present to 963 ha by Year 11. When PW7 is consumed by the open cut pit in Year 11, the catchment area will reduce to 960 ha.

4.2.3 Storage Characteristics

The storage characteristics of all modelled storages, detailed in Table 22, were obtained from the following sources:

- existing sediment basins/dams and process water dams – as per the previous water balance assessment for Tarrawonga Coal Mine (WRM, 2018);
- proposed additional and upgraded sediment basins/dam – as per the *Concept Drainage Design* reports (WRM, 2019a and WRM, 2019b) and Section 3.3.1.2;
- clean water/raw water dams – per Section 3.3.1.1; and
- process water dams – PW6 and PW7 storage characteristics assumed to be equivalent to PW4 as per Section 3.3.1.3.

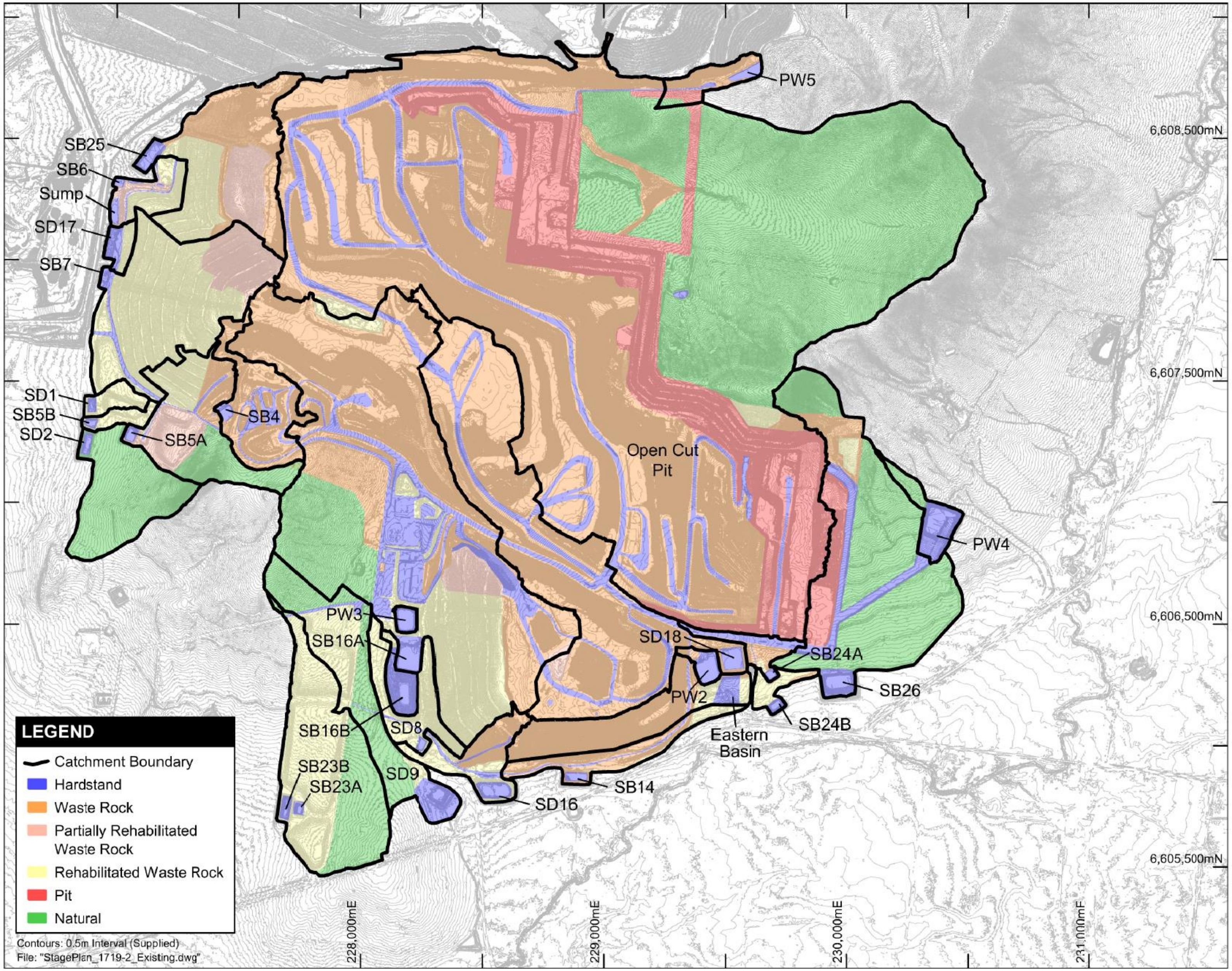


Figure 17 Year 1 Indicative Sub-catchment Boundaries

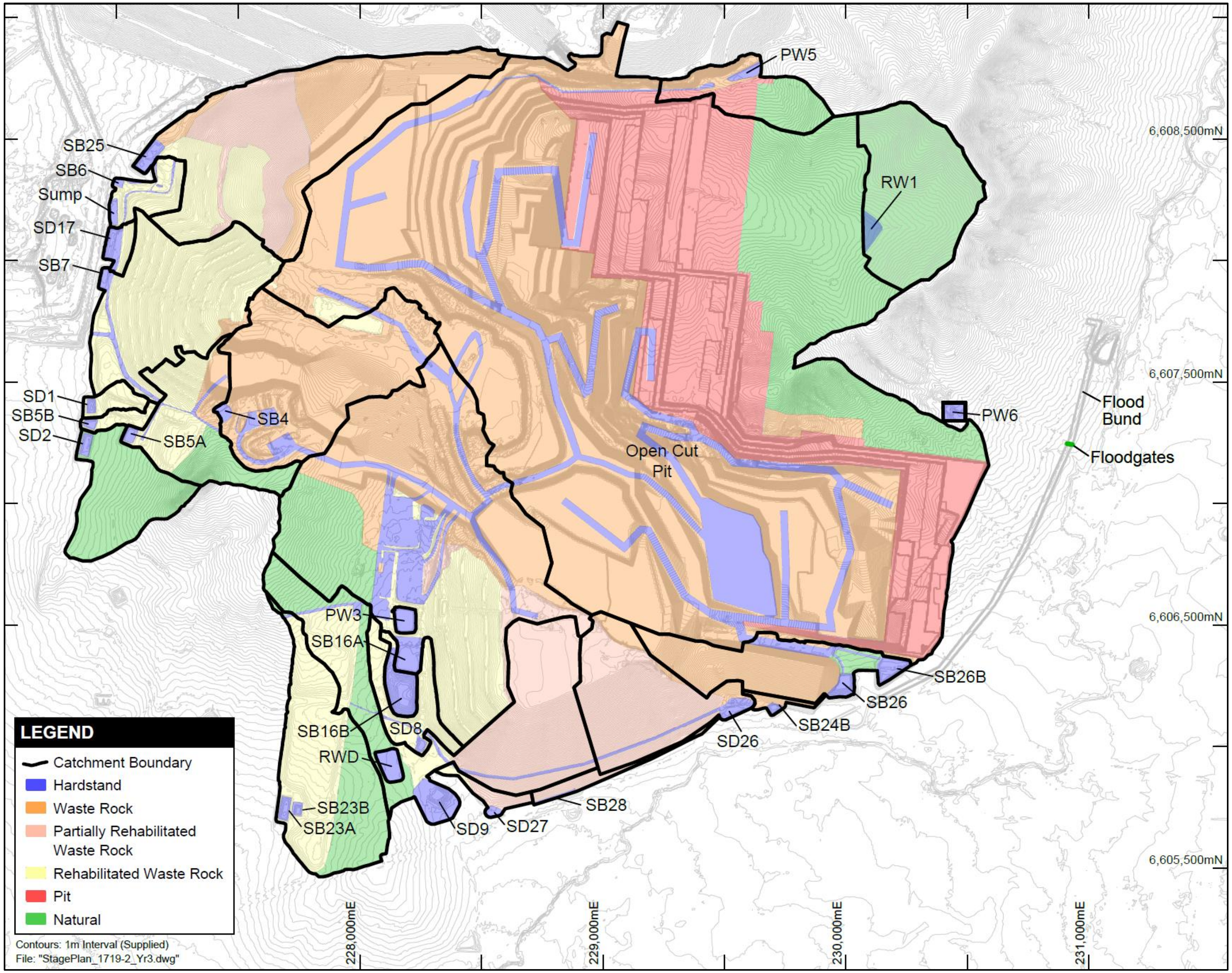


Figure 18 Year 3 Indicative Sub-catchment Boundaries

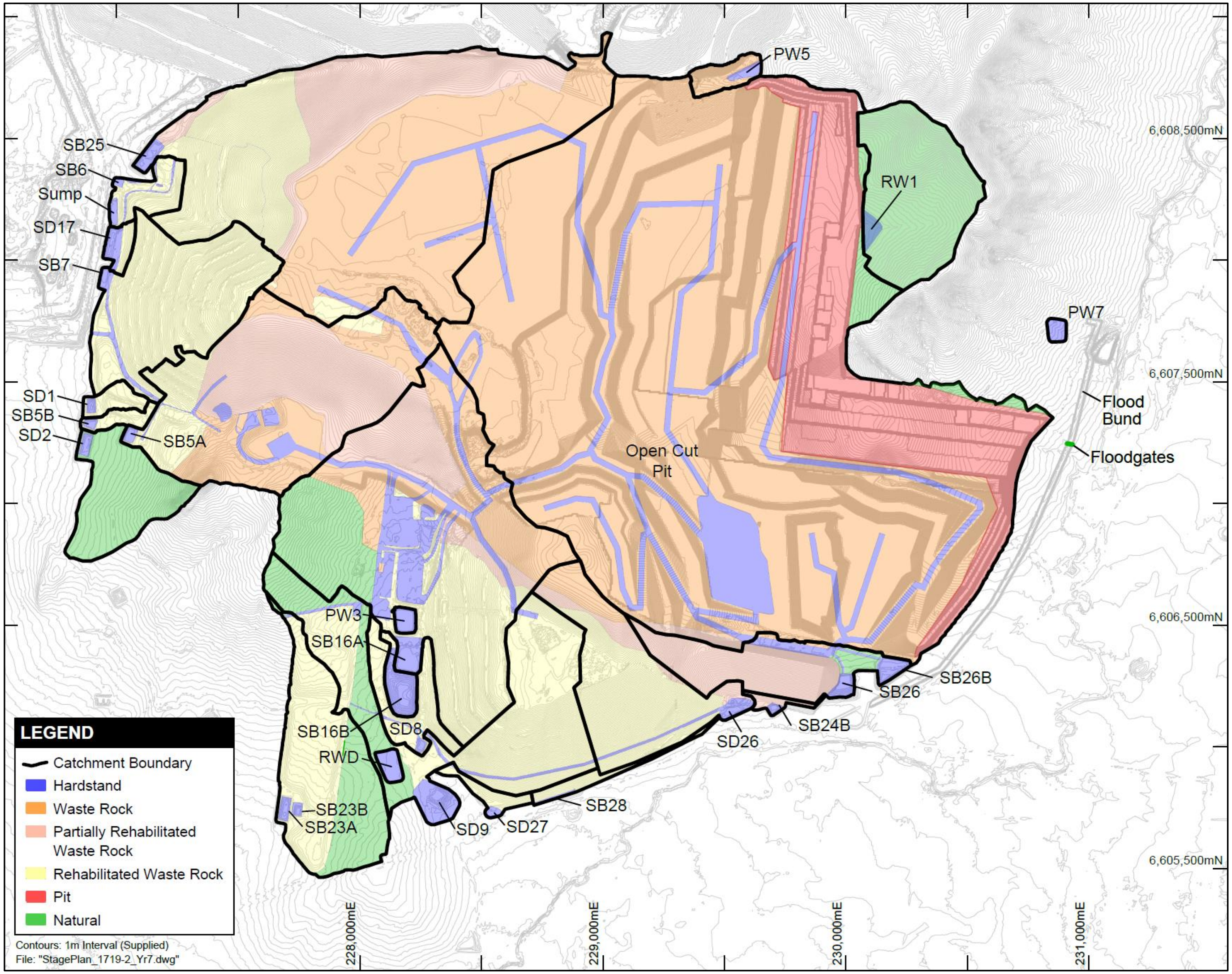


Figure 19 Year 7 Indicative Sub-catchment Boundaries

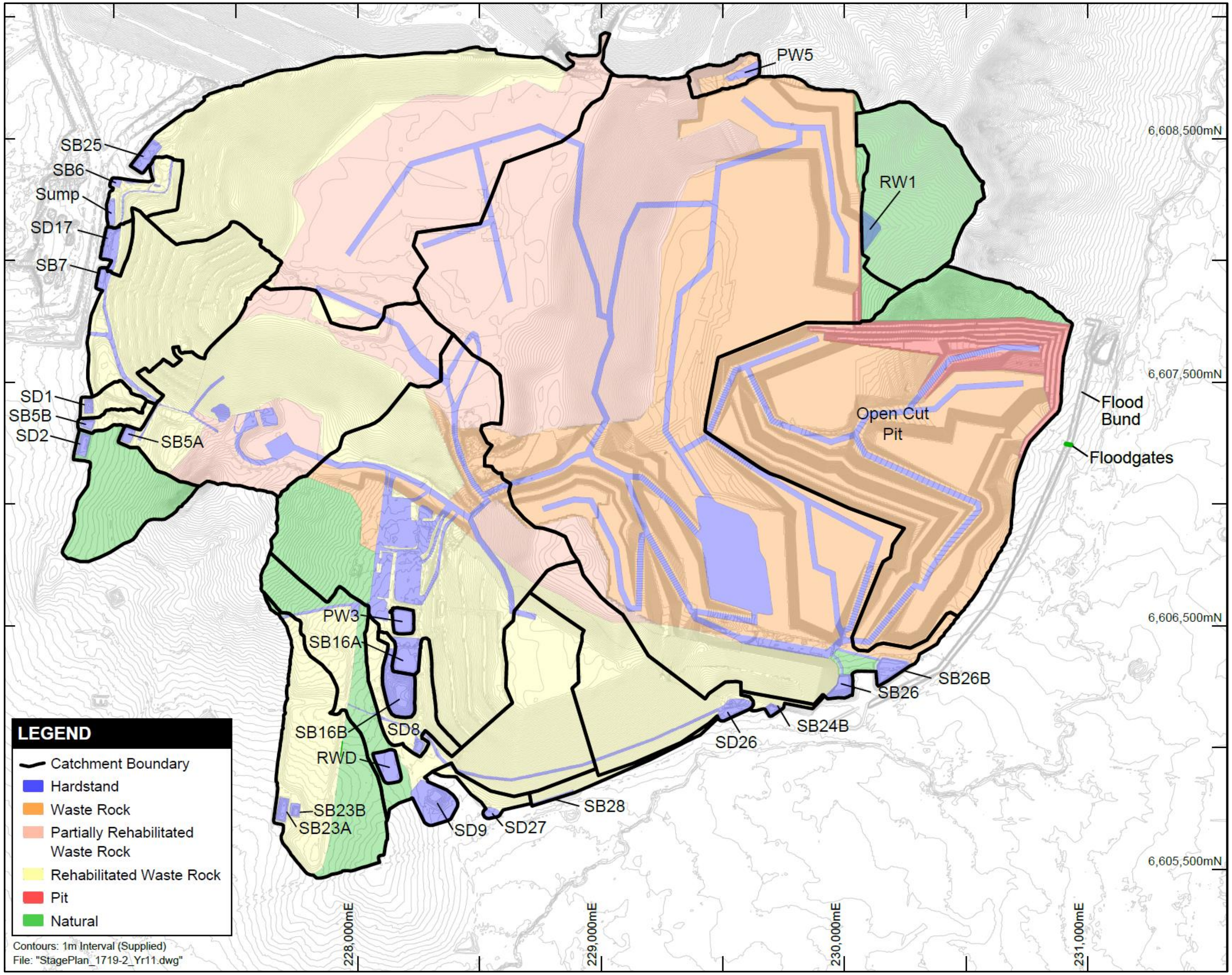


Figure 20 Year 11 Indicative Sub-catchment Boundaries

Table 22 Simulated Water Storage Characteristics

Dam Name	Status	Total Storage Volume (ML)	Operating Volume (ML)	Dead Storage Volume (ML)
Sediment Basins/Dams				
SB25	Current	9.0	HOV = 9.0	0.9
	Proposed	50.2	HOV = 50.2	5.0
SD6/Sump	Current	4.9	HOV = 4.9	0.5
SD17	Current	9.7	HOV = 9.7	1.0
SB7	Current	2.7	HOV = 2.7	0.3
	Proposed	15.0	HOV = 15.0	1.5
SD1	Current	7.6	HOV = 7.6	0.8
SD2	Current	29.4	HOV = 10.1	2.9
SB5B	Current	3.1	HOV = 3.1	0.3
SB5A	Current	7.8	HOV = 6.1	0.8
	Proposed	26.1	HOV = 13.9	2.6
SB4	Current	6.0	HOV = 1.2	0.6
SD9	Current	53.0	HOV = 46.0	5.0
SB16A	Current	36.4	HOV = 36.4	3.6
SB16B	Current	96.9	HOV = 67.0	5.0
SD8	Current	3.5	HOV = 3.5	0.4
SB14/SB28	Current	1.1	HOV = 1.1	0.1
SD16/SD27	Current	3.6	HOV = 3.6	0.4
SB23A/SB23B	Current	13.4	HOV = 13.4	1.3
SD18	Current	34.0	HOV = 34.0	3.4
SB24A	Current	3.6	HOV = 3.6	0.4
SB24B	Current	4.8	HOV = 4.8	0.5
Eastern Basin	Current	26.0	HOV = 26.0	2.6
SB26	Current	35.5	HOV = 16.0	3.6
SD26	Proposed	12.9	HOV = 11.4	1.3
SB26B	Proposed	78.7	HOV = 78.7	5.0
Raw Water Dams				
RWD	Proposed	23.2	HOV = 13.7	1.2
RW1	Proposed	42.5	HOV = 33.8	1.0
Process water dams				
PW2	Current	22.8	HOV = 14.8	1.1
PW3	Current	26.5	LOV2 = 8.4 LOV1 = 12.4 HOV1 = 19.0	1.3
PW4/6/7	Current/Proposed	268.5	HOV = 242.3	5.0
PW5	Current	10.8	HOV = 2.9	1.0
Open cut pit Sump	Current	130.0	HOV = 130.0	5.0

Level-volume-area relationships for each modelled storage were obtained from WRM (2018) for existing storages and estimated for proposed storages based on the proposed capacity and surface area of the storage and from contour plans provided by TCPL.

A High Operating Volume (HOV) was specified for each storage to restrict transfer to a storage when the transfer may result in excess overflow (refer Section 4.2.4). A Low Operating Volume (LOV) was specified for PW3 in order to maintain the volume of PW3 at a sufficient capacity to ensure no shortfall in water supply.

4.2.4 Pumped Transfers and Operating Rules

Simulated pumped transfer rates between storages and the triggers that dictate whether pumping occurs are summarised in Table 23. As specified in Section 4.2.3, the operational rules in the water balance model were optimised to reduce simulation of excess overflow from storages and to simulate the required rate of off-site water supply.

A dead storage volume (DSV) was specified for each storage to represent the volume at which pumping is ceased. For sediment basins/dams, a DSV of 10% of the storage capacity was assumed, while 5% of the storage capacity was adopted for the process water dams.

Table 23 Modelled Pump Rates and Triggers

Source	Destination	Pump Rate (L/s)	Trigger
Sediment Basins/Dams			
SB25	PW3	80	If >DSV + 1 ML and PW3<LOV1, pump out; if <DSV, turn off
SD17	SB5A	46	If >DSV + 1 ML and SB5A<HOV, pump out; if <DSV, turn off
	SD2	46	If >DSV + 1 ML and SD2<HOV, pump out; if <DSV, turn off
SB5B	SB5A	46	If >DSV + 1 ML and SDB5A<HOV, pump out; if <DSV, turn off
SB5A	SB4	Water supply demand rate	If prior to SB4 decommissioning, if >DSV + 1 ML and SB4<HOV, pump out; if <DSV, turn off
	SB16B		If prior to RWD commissioning, if >DSV + 1 ML and SB16B<HOV, pump out; if <DSV, turn off
	PW3		If SB4 decommissioned, if >DSV + 1 ML and PW3<LOV1, pump out; if <DSV, turn off
SB4	Water supply demand	Water supply demand rate	If >DSV + 1 ML, pump out; if <DSV, turn off
	PW3	46	If >DSV + 1 ML and PW3<LOV1, pump out; if <DSV, turn off
SD9	SD16	46	If >DSV + 1 ML and SD16<HOV, pump out; if <DSV, turn off
	PW2	46	If prior to PW2 decommissioning, if >DSV + 1 ML and PW2<HOV, pump out; if <DSV, turn off
	PW3	46	If PW2 decommissioned, if >DSV + 1 ML and PW3<LOV2, pump out; if <DSV, turn off
SB16A	PW3	46	If PW2 decommissioned, if >DSV + 1 ML and PW3<LOV2, pump out; if <DSV, turn off
SB16B	PW2	46	If prior to PW2 decommissioning, if >DSV + 1 ML and PW2<HOV, pump out; if <DSV, turn off
	PW3	46	If PW2 decommissioned, if >DSV + 1 ML and PW3<LOV1, pump out; if <DSV, turn off

Table 23 (Continued) Modelled Pump Rates and Triggers

Source	Destination	Pump Rate (L/s)	Trigger
SB14/SB28	SB16B	6	If prior to SB14 decommissioning, if >DSV + 1 ML and SB16B<HOV, pump out; if <DSV, turn off
	SD16	6	If SB14 decommissioned, if >DSV + 1 ML and SD16<HOV, pump out; if <DSV, turn off
SD16/SD27	PW2	46	If prior to PW2 decommissioning, if >DSV + 1 ML and PW2<HOV, pump out; if <DSV, turn off
	PW3	46	If PW2 decommissioned, if >DSV + 1 ML and PW3<LOV1, pump out; if <DSV, turn off
SB23	SD9	46	If >DSV + 1 ML and SD9<HOV, pump out; if <DSV, turn off
Sediment Basins/Dams			
SD18	PW2	46	If prior to PW2 decommissioning, if >DSV + 1 ML and PW2<HOV, pump out; if <DSV, turn off
	PW3	46	If PW2 decommissioned, if >DSV + 1 ML and PW3<LOV1, pump out; if <DSV, turn off
SB26	SD18	46	If prior to SD18 decommissioning, if >DSV + 1 ML and SD18<HOV, pump out; if <DSV, turn off
	PW3	46	If SD18 decommissioned, if >DSV + 1 ML and PW3<LOV1, pump out; if <DSV, turn off
SD26	PW3	46	If >DSV + 1 ML and PW3<LOV1, pump out; if <DSV, turn off
SB26B	SB26	46	If >DSV + 1 ML and SB26<HOV, pump out; if <DSV, turn off
Clean Water/Raw Water Dams			
RW1	Goonbri Ck	50	if >DSV + 1 ML, pump out; if <DSV, turn off
RWD	PW3	Water supply demand rate	If >DSV + 1 ML and PW3<LOV1, pump out; if <DSV, turn off
Process Water Dams			
PW2	Water supply demand	Water supply demand rate	If >DSV + 1 ML, pump out; if <DSV, turn off
PW3	Water supply demand	Water supply demand rate	If >DSV + 1 ML, pump out; if <DSV, turn off
	PW4/6/7	46	If prior to PW7 decommissioning, if >HOV1 and PW4/6/7<HOV, pump out; if <HOV1, turn off
PW4/6/7	PW2	46	If prior to PW2 decommissioning, if >DSV + 1 ML and PW2<HOV, pump out; if <DSV, turn off
	PW3	46	If PW2 decommissioned, if >DSV + 1 ML and PW3<HOV1, pump out; if <DSV, turn off
PW5	Water supply demand	Water supply demand rate	If >DSV + 1 ML, pump out; if <DSV, turn off
Open cut pit	PW5	Water supply demand rate	if >DSV + 5 ML and PW5<HOV, pump out; if <DSV, turn off
	PW4	46	If prior to PW7 decommissioning, if >DSV + 1 ML and PW4/6/7<HOV, pump out; if <DSV, turn off

4.2.5 Initial Storage Volume

The total storage volume on site in April 2019 was 170 ML (pers. comm. TCPL). As the distribution of the total volume between the site storages is unknown, the ratio of storage volume recorded in each pond in July 2018 to the total recorded storage volume was calculated and applied to the total storage volume recorded in April 2019. Table 24 presents the adopted initial volumes for the primary storage ponds. The remaining ponds were assumed to be empty at the start of the model simulation.

Table 24 Adopted Initial Storage Volume

Storage	Initial Volume (ML)
SB16A	21.1
SB16B	49.2
PW2	11.7
PW3	14.7
PW4	14.7
Open cut pit	58.6
Total	**170.0**

4.2.6 Evaporation from Storage Surfaces

The water surface area of each storage was multiplied by daily pan evaporation obtained from SILO Data Drill and by a pan factor[7] to calculate an evaporation volume. Monthly pan factors for Gunnedah (approximately 40 km south of the site), obtained from McMahon *et al.* (2013), were used for the site for all months except August, September and October (no data available for these months). For August, September and October, pro-rated pan factors for Tamworth, obtained from McMahon *et al.* (2013), were adopted. The Tamworth pan factors were pro-rated based on the average ratio of Tamworth to Gunnedah pan factors for the months in which data was available at both locations. The adopted monthly pan evaporation factors are listed in Table 25.

Table 25 Adopted Monthly Pan Evaporation Factors

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pan Factor	0.842	0.856	0.827	0.812	0.766	0.709	0.734	0.74	0.732	0.773	0.788	0.848

4.2.7 Seepage

Seepage from SD1 and SD2 was simulated in the water balance at a rate of 50 kilolitres per day (kL/d) as specified in the WRM *Site Water Balance* (WRM, 2018).

4.2.8 Groundwater Inflow

Forecast open pit groundwater inflow rates, provided by HydroSimulations Pty Ltd (HydroSimulations) (now trading as SLR Consulting Pty Ltd), are presented in Table 26 (Hydrosimulations, 2019). For the purposes of the modelling it was assumed that evaporation of groundwater inflow from the pit face was accounted for in the groundwater model, hence the groundwater inflow rates provided represent net inflow to the open cut pit.

[7] A pan factor is a multiplier (usually less than one) used to convert monitored pan evaporation data to estimates of open water evaporation.

Table 26 Groundwater Inflow Rates

Year	Predicted Groundwater Inflow Rate (ML/yr)
1	0.16
2	0.16
3	0.17
4	0.17
5	0.17
6	0.20
7	0.22
8	0.25
9	0.25
10	0.25
11	0.27

ML/yr = megalitres per year.

4.2.9 Salinity Estimates

Catchment runoff salinity or EC values were estimated from surface water monitoring data for Goonbri Creek, Bollol Creek, site basins/dams and the open cut pit (as summarised in Section 2.4). Groundwater monitoring data for bores within the vicinity of the Tarrawonga Coal Mine, in conjunction with the open cut pit monitoring data, were used to estimate groundwater inflow EC to the open cut pit. An EC to TDS conversion factor of 0.64 mg/L was adopted (Abrol et al., 1988). Note that only data from the previous two years of monitoring were used to estimate sub-catchment runoff EC (to maintain consistency with the current catchment characteristics), whereas Section 2.4 presents long-term summaries of water quality data. A summary of the modelled inflow salinities is provided in Table 27.

Table 27 Modelled Inflow Salinity

<table>
<tr><th colspan="2">Component</th><th>EC (µS/cm)</th><th>Basis</th></tr>
<tr><td colspan="2">External Supply</td><td>1,000</td><td>Nominally adopted based on the average EC for local surface water and groundwater sources</td></tr>
<tr><td colspan="2">Groundwater</td><td>3,287</td><td>Estimated based on the average EC of the open cut pit for the previous two years and the maximum EC of monitored groundwater in the vicinity of the Mine</td></tr>
<tr><td rowspan="6">Sub-catchment Runoff</td><td>Undisturbed</td><td>186</td><td>Average EC for Goonbri Creek and Bollol Creek (refer Section 2.4.2)</td></tr>
<tr><td>Hardstand</td><td>909</td><td>Estimated from the water quality records for SD17 (refer Section 2.4.3) accounting for the area of hardstand sub-catchment</td></tr>
<tr><td>Open Cut Pit</td><td>909</td><td>Assumed to be equivalent to hardstand EC</td></tr>
<tr><td>Active Waste Rock</td><td>888</td><td>Estimated from the water quality records for SD16 (refer Section 2.4.3) accounting for the area of active waste rock sub-catchment</td></tr>
<tr><td>Partially Rehabilitated Waste Rock</td><td>537</td><td>Estimated from the water quality records for SB16A (refer Section 2.4.3) accounting for the area of partially rehabilitated waste rock sub-catchment</td></tr>
<tr><td>Rehabilitated Waste Rock</td><td>186</td><td>Assumed to be equivalent to undisturbed area EC</td></tr>
</table>

Following model simulation, the predicted salinity concentration in the site water storages were reviewed against monitored water quality records and found to be consistent.

4.2.10 Site Water Demands

The site water demands comprise haul road dust suppression, ROM stockpile and coal crusher dust suppression and vehicle washdown.

4.2.10.1 Haul Road Dust Suppression

Dust suppression demand for haul roads was calculated as the difference between daily pan evaporation and rainfall multiplied by the haul road area. The haul road area was calculated using a haul road length estimated from stage plans for Years 1, 3, 7 and 11 of the mine and assuming a haul road width of 30 m. Resulting haul road areas are presented in Table 28, with areas linearly interpolated between the given years in the model simulation. A maximum daily dust suppression rate was applied on the basis of the maximum rate recorded in 2017 (3.1 ML/d) at the Tarrawonga Coal Mine and pro-rated to the estimated increase in haul road length that would occur between Year 1 and the end of the Modification (Year 11).

Dust suppressant binders are currently being used as a measure to reduce water demand for dust suppression at the Tarrawonga Coal Mine. Usage of dust suppressant binders from 2018 onwards has resulted in a reduction in water consumed of approximately 40-45% for dust suppression. Conservatively, the operational site water balance assumed that a commercial dust suppressant binder was not used.

Table 28 Haul Road Areas

Year:	Year 1	Year 3	Year 7	Year 11
Area (ha):	48.5	45.1	53.7	61.1

Simulated daily haul road dust suppression demand is illustrated in Figure 21. The median simulated demand varies between approximately 0.9 ML/d (Year 1) and 1.2 ML/d (Year 11) in winter months to a maximum of 2.9 ML/d (Year 2) to 3.9 ML/d (Year 11) in the summer months. The average dust suppression demand is 2.2 ML/d over the full 11 year simulation period (accounting for the estimated increase in dust suppression area), which is consistent with the average haul road dust suppression usage rate of 1.8 ML/d measured at the site in 2017.

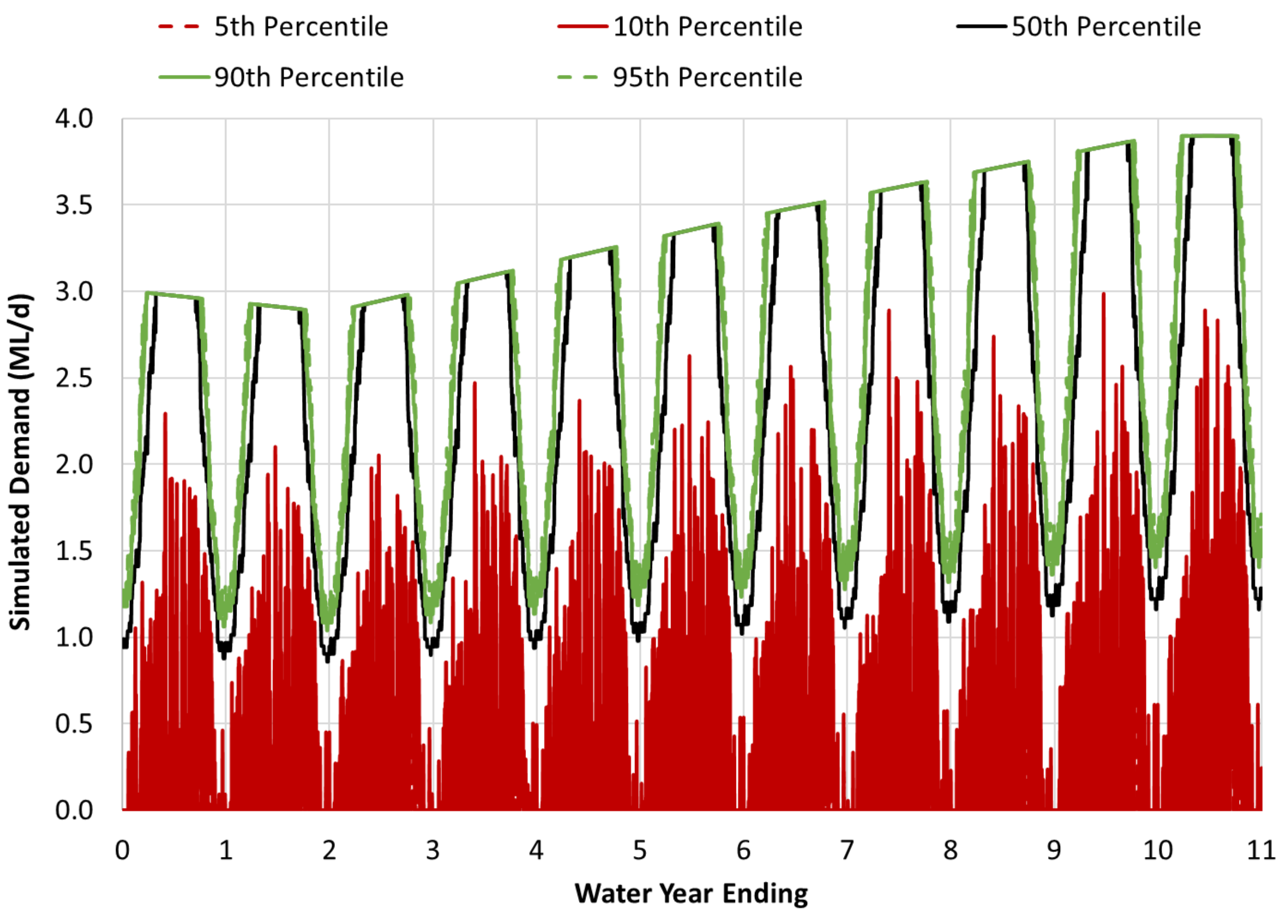


Figure 21 Simulated Haul Road Dust Suppression Demand

4.2.10.2 Coal Crusher Dust Suppression

The ROM coal is processed on-site in a crusher prior to transportation to the Whitehaven CHPP near Gunnedah. The WRM *Site Water Balance* (2018), states that the coal crusher dust suppression demand in 2017 was estimated at 35 ML (WRM, 2018). ROM coal production was 1.87 Mt in 2017 and hence the coal crusher dust suppression demand rate was calculated as 18.7 megalitres per million tonnes (ML/Mt). This demand rate along with the ROM coal production rate has been used to forecast the coal crusher dust suppression demand for the mine life.

4.2.10.3 ROM Stockpile Dust Suppression

As per WRM (2018), the product coal moisture content is 7% w/w, consisting of 5% from pit floor sources (ROM coal) and 2% from ROM stockpile and coal crusher sources. For the purposes of the model simulation, it was assumed that the 5% coal moisture content was an inflow to the system (in situ coal moisture content) with the additional 2% from ROM pad and coal crusher sources being the net outflow from the system. The ROM coal production rate and estimated combined loss from the ROM pad and coal crusher is presented in Table 29. ROM stockpile dust suppression was calculated as the difference in net water loss from coal export and the estimated coal crusher dust suppression demand.

Table 29 Estimated Coal Export Loss

Year	Coal Production Rate (Mt/yr)	Net Water Loss from Coal Export (ML/yr)
1	2.3	46
2	2.9	58
3	3.5	70
4	3.5	70
5	3.5	70
6	3.5	70
7	3.5	70
8	2.7	54
9	2.4	49
10	2.1	42
11	1.0	21

Mt/year = million tonnes per year.

4.2.10.4 Vehicle Washdown

Per WRM (2018), the 2017 vehicle washdown water usage rate was estimated at 4 kL/d for a haul road length of 16.2 km; hence the water usage rate was calculated as 0.25 kilolitres per kilometre (kL/km) per day. The vehicle washdown demand was applied to the estimated haul road length for the remainder of the mine life

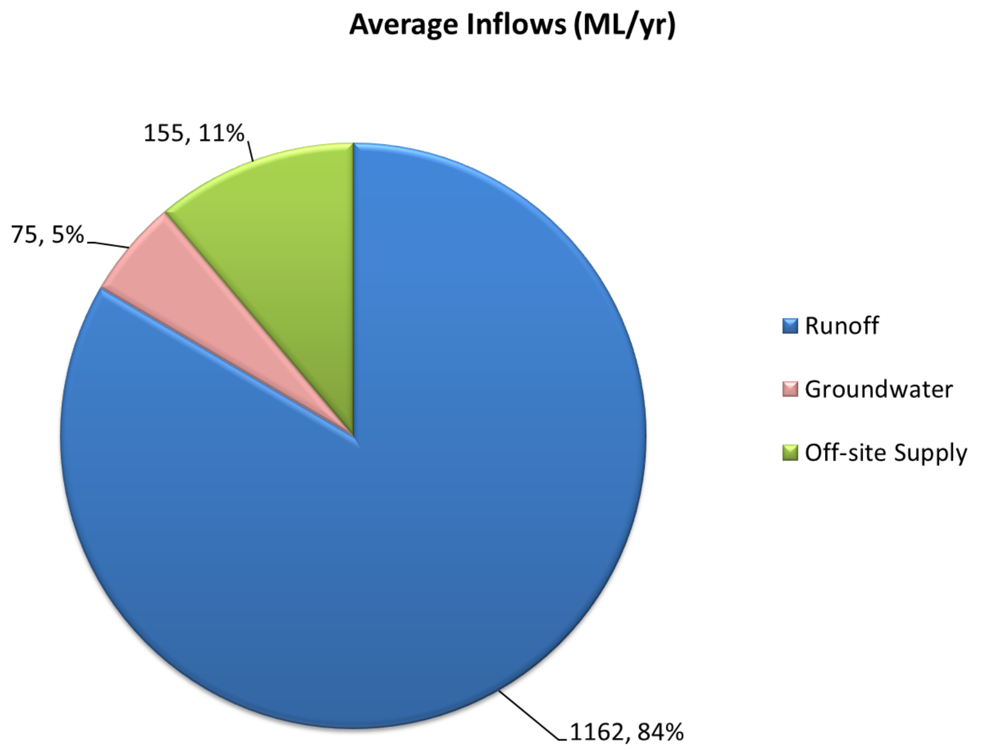
4.3 OPERATIONAL WATER BALANCE MODEL RESULTS

4.3.1 Overall Site Water Balance

Model-predicted average inflows and outflows (averaged over the 11 year simulation period and all realisations) are shown in Figure 22.

Figure 22 shows that rainfall runoff contributes the majority of system inflows while water usage for haul road dust suppression dominates system outflows.

An average volumetric runoff coefficient of 0.17 was calculated for the site based on the AWBM rainfall runoff predictions for the 11-year simulation period and 130 realisations. This value is consistent with the average volumetric runoff coefficient of 0.13 calculated from the calibrated site water balance detailed in the WRM *Site Water Balance* report (2018).



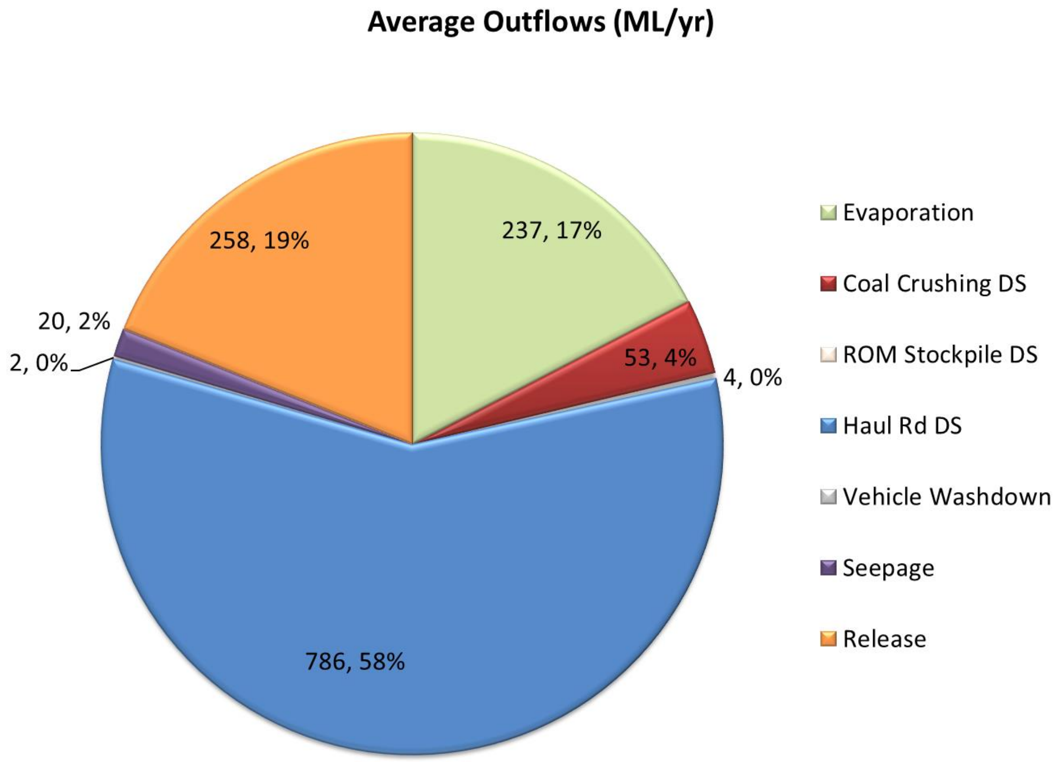


Figure 22 Average Predicted System Water Balance

4.3.2 Stored Water Volumes

Predicted total stored water volumes (in all storages except the open cut pit) are shown in Figure 23 as probability plots over the simulation period in comparison to the total available water storage capacity of the basins/dams. Note that the total available water storage varies in time as basins/dams are decommissioned, commissioned or upgraded. These probability plots show the range of likely total stored water volumes, with the solid plot representing the median or "50th percentile" volumes and the broken lines (5th/95th and 10th/90th percentile volumes) representing long-term lower and higher rainfall conditions, respectively. There is a 90% chance that the total water volume will fall between the 5th/95th percentile volume plots while there is an 80% chance that the total water volume will fall between the 10th/90th percentile volume plots. It is important to note that the plots do not represent a single climatic realisation – the probability plots are compiled from all 130 realisations (refer Section 4.1) – e.g. the median volume plot does not represent model forecast volume for median climatic conditions.

Note that the model simulation commences in July; hence each year is from 1 July to 30 June.

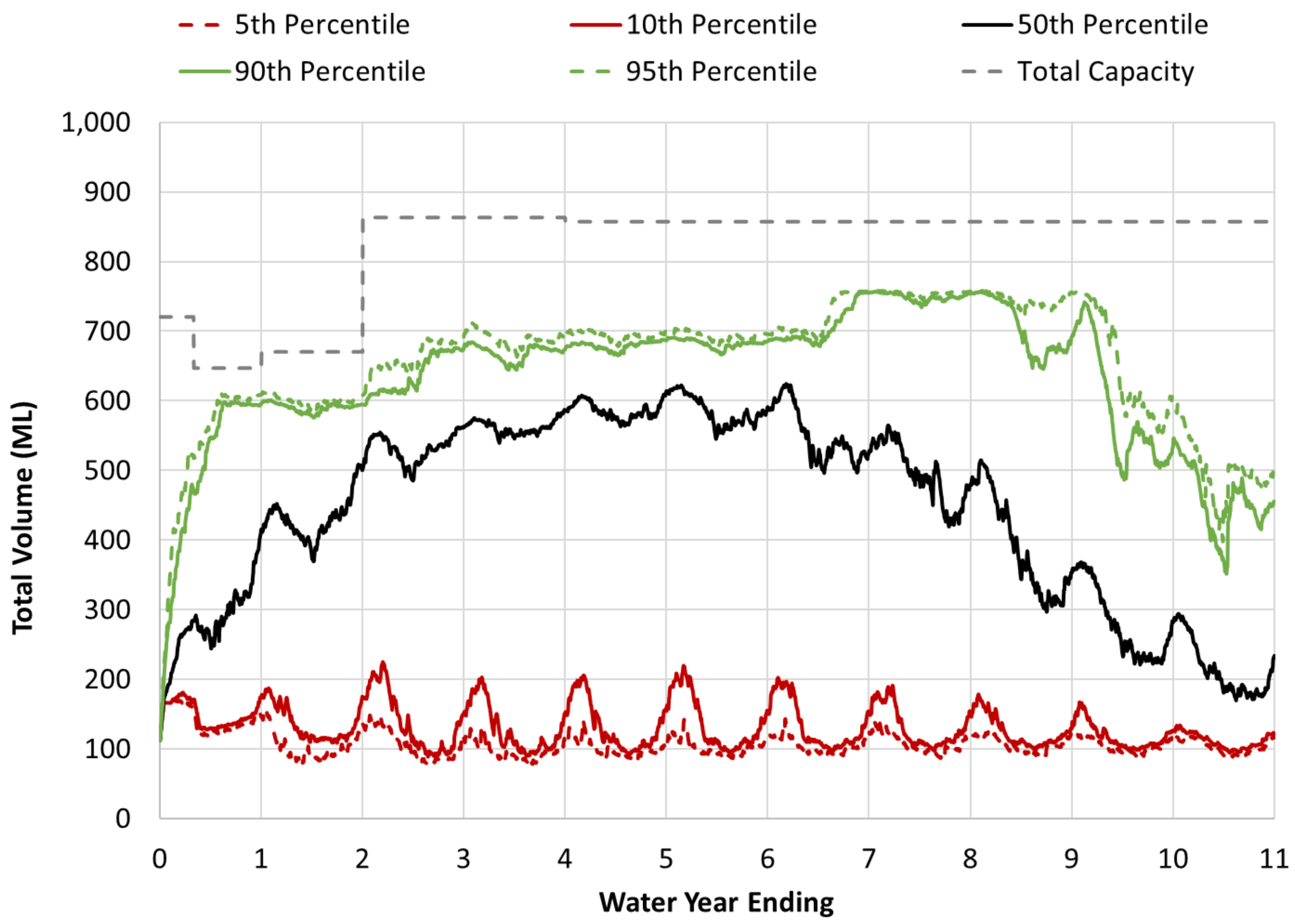


Figure 23 Simulated Total Water Inventory

Figure 23 illustrates that the forecast 95th percentile inventory peaks at approximately 757 ML in Year 10 of the mine life in comparison with the maximum available storage capacity of 857 ML in Year 10. The median forecast stored volume varies between approximately 170 ML and 622 ML over the mine life. While the simulated 95th percentile stored water inventory is shown to be below the total capacity, this is a statistical result and stored water volume is simulated to exceed total capacity at times, resulting in release to LDPs and internal overflow between storages.

4.3.3 Release from Licensed Discharge Points

Predicted total release volumes to the LDPs over the mine life for the 95th percentile, 50th percentile (median) and 5th percentile are presented in Figure 24. The total release volumes have been calculated from the predicted release volumes for all 130 of the 11-year realisations simulated.

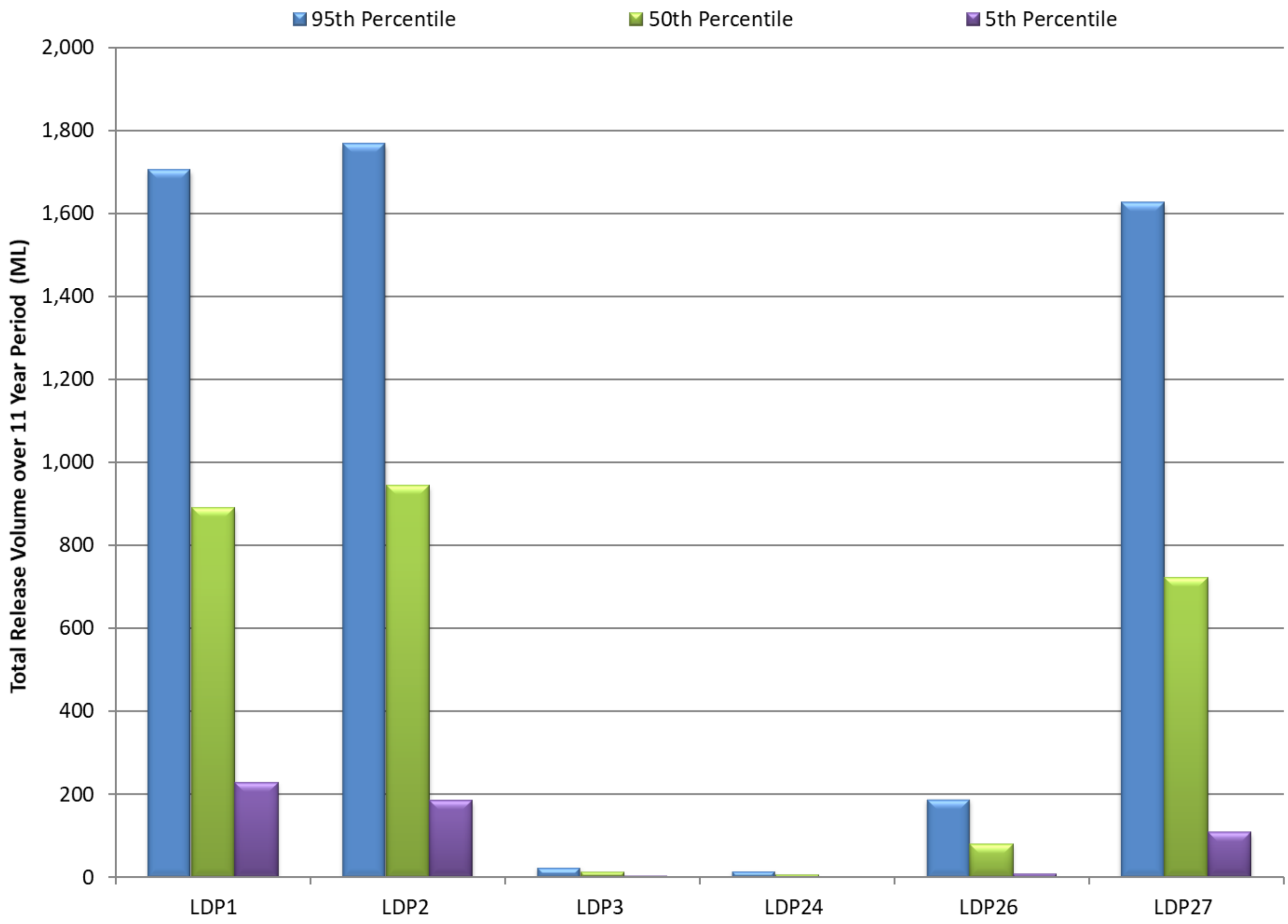


Figure 24 Predicted Total Release Volume to LDPs

For the statistics plotted, Figure 24 illustrates that the total release to LDP1 is predicted to range between 891 ML (50th percentile) and 1,706 ML (95th percentile) over the duration of the mine life. For the 50th percentile, release to LDP1 is predicted to occur a total of 969 days over the 11-year (4,017 days) operational period of the mine (i.e. approximately 24% of days).

For the statistics plotted, total release to LDP27 is predicted to range between 723 ML (50th percentile) and 1,626 ML (95th percentile) over the duration of the mine life, while total release to LDP3 and LDP24 is predicted to range from 13 ML and 7 ML, respectively (50th percentile) and 24 ML and 16 ML respectively (95th percentile).

The results presented in Figure 24 represent potential total release volumes considering the full range of climatic conditions which may occur over the remainder of the mine life (11 years). However, it should be noted that, as per Section 2.4.4, only one release event has occurred since 2014 as a result of the dry conditions that have been experienced at the mine site in recent years.

Based on the predicted total release volume, the average EC of release waters is predicted to range between 221 µS/cm at LDP26 and 817 µS/cm at LDP27. The predicted average EC of release waters to all LDPs except LDP26 exceeds the ANZECC & ARMCANZ (2000) guideline default trigger value (350 µS/cm) although they are within the range of baseline EC values recorded for regional surface water systems (refer Section 2.4.1) and local surface water systems (refer Section 2.4.2).

4.3.4 Overflow from Process Water Dams

The process water dams have been designed to reduce the risk of overflow to the downstream receiving environment (refer Section 3.3.1.3). Based on the 99th percentile statistic, no overflow is predicted from the process water dams for the life of the mine (less than 1% spill risk).

4.3.5 Water Management Implications

When the stored volume within the process water dams and open cut pit sump exceeds the operational volume, open cut pit dewatering is ceased resulting in the accumulation of water in the open pit. The risk of mining disruption has been assessed by comparing the number of days per year in which more than 200 ML (in excess of the sump capacity) is predicted to be held in the open cut pit. This arbitrary volume has been chosen to represent conditions which may require construction of a MWSS to avoid prolonged mining disruption. Table 30 presents the model predictions for the average, 75th percentile and 95th percentile distributions of the number of days per year in which more than 200 ML (in excess of the sump capacity) is predicted to be held in the open cut pit. The 95th percentile values represent the number of days per year which would be expected to be exceeded in 5% of years and the 75th percentile values are those which would be expected to be exceeded in 25% of years.

Table 30 Predicted Annual Number of Days in Excess of 200 ML Stored in Pit

Open Cut Pit	Number of Days Annually		
	Average	75th Percentile	95th Percentile
	65	92	181

Predicted total stored water volumes in the open cut pit are shown in Figure 25 as probability plots over the simulation period in comparison to the sump storage capacity.

Figure 25 illustrates that, based on the median distribution, the open cut pit water volume will generally be less than the sump total storage capacity. However, up to 1,230 ML is predicted to be stored in the open cut pit based on the 95th percentile statistic. During these periods, excess water would be required to be stored in an inactive part of the open cut pit or the MWSS until capacity in the process water dams becomes available. If water is to be stored in the open cut pit for prolonged periods of time, this may cause interruptions to ROM coal production.

4.3.6 Predicted Off-site Supply Requirements

Figure 26 presents the total annual average off-site supply over the life of the mine based on the simulated 130 realisations.

Figure 26 shows that the average annual off-site supply requirement will range between 63 ML in Year 3 and 384 ML in Year 11. The annual off-site supply requirement is predicted to be greater in Year 1 as the current volume of the site storages is low (170 ML as per Section 4.2.5), hence additional off-site water supply is predicted to ensure no shortfall of water for site water demands.

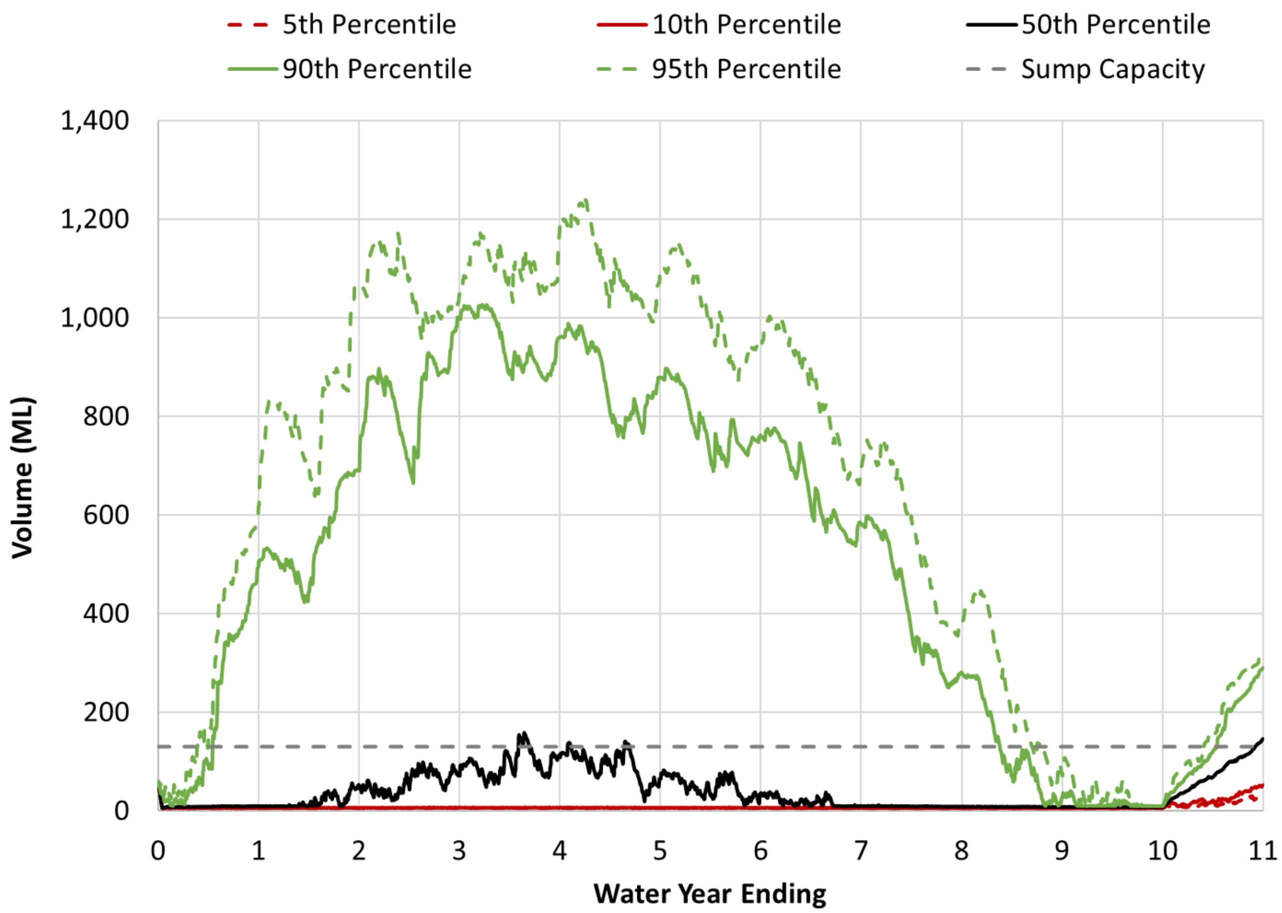


Figure 25 Simulated Open Cut Pit Stored Water Volume

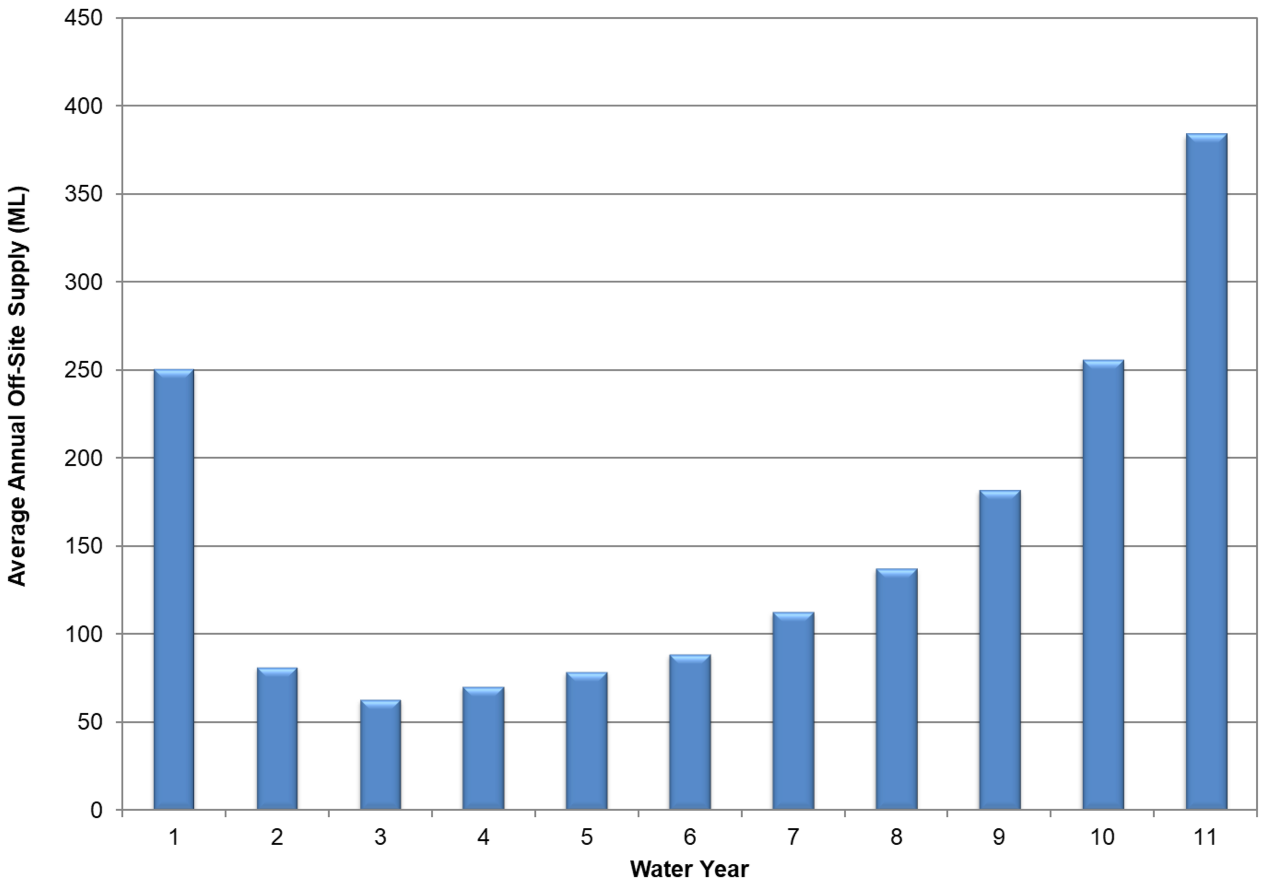


Figure 26 Predicted Average Annual Off-site Supply Volume

5.0 FINAL VOID WATER BALANCE MODELLING

5.1 MODEL DESCRIPTION

A daily timestep, final void water and salt balance model has been set up using the GoldSim® simulation package. The model simulates the volume and salinity of the final void water body by simulating the inflows, outflows and resultant volume of water and salt mass:

Change in Storage = Inflow – Outflow

Where:

Inflow includes direct rainfall, runoff and groundwater inflow.

Outflow includes evaporation.

5.2 KEY DATA AND ASSUMPTIONS

The model simulates inflow from remnant final void catchment rainfall runoff (including direct rainfall), groundwater inflow from bedrock as well as outflow due to evaporation on a daily basis. Key model input data include the following:

- A catchment area of 123.2 ha comprising 9.96 ha of rehabilitated waste rock sub-catchment, 10.4 ha of natural undisturbed sub-catchment, 55.7 ha of remnant open cut pit sub-catchment and 47.2 ha of remnant waste rock sub-catchment (refer Section 3.4).
- A 130-year rainfall data set (1889 to 2018 inclusive) obtained from SILO Patched Point for the mine development location and a 130-year evaporation data set for the same period obtained from the SILO Data Drill (refer Section 2.1). The data set was repeated several times over to generate an extended period of data for final void simulation – to ensure equilibrium water levels were reached during the simulation period.
- A constant pan factor of 0.7 was assumed for calculation of evaporation from the final void until the water level reached 10 m below the spillway at which point the monthly pan factors were taken from McMahon *et al*. (2013) as listed in Table 25. The lower pan factor used for lower final void levels reflects lower evaporation likely at depth as a result of shading effects.
- Rainfall runoff was estimated using the AWBM applied to the final void sub-catchments, in a manner similar to the operational water balance model (refer Section 4.2.2). Direct rainfall was simulated on the contained water surface.
- Groundwater inflow to the final void is expected to occur predominately from the surrounding spoil and lesser so from the coal seams and other areas including regolith, overburden, interburden and volcanics (HydroSimulations, 2019). Predicted rates of groundwater flux versus water level in the open cut were provided by the groundwater specialist for the Modification (HydroSimulations, 2019) as shown in Table 31. When the final void water level was less than 170 m AHD, a constant groundwater inflow rate of 0.9 ML/d was adopted. If the final void water level exceeded 270 m AHD, a constant groundwater inflow rate of 0.45 ML/d was adopted.

Table 31 Predicted Final Void Groundwater Inflow Rate

Final Void Water Level (m AHD)	Predicted Groundwater Inflow Rate (ML/d)
170	0.90
180	0.90
190	0.90
200	0.90
210	0.88
220	0.87
230	0.84
240	0.80
250	0.73
260	0.62
270	0.45

- Catchment runoff salinity (EC) values were estimated from surface water monitoring data for Goonbri Creek, Bollol Creek and the monitored site sediment dams. The EC value for the rehabilitated and undisturbed sub-catchment areas was estimated as 186 µS/cm, the remnant open cut pit sub-catchment EC value was estimated as 909 µS/cm and the remnant waste rock sub-catchment EC value was estimated as 888 µS/cm.
- A groundwater inflow EC of 3,287 µS/cm was adopted based on the average EC of the open cut pit for the previous two years.
- The rate of evaporation was adjusted based on the simulated final void water salinity (per Morton *et al.*, 1985).

In simulating pit lake salinity, the model assumes conservation of mass and fully mixed conditions.

5.3 SIMULATED FUTURE PERFORMANCE

Model-predicted final void water levels and EC values are shown in Figure 27.

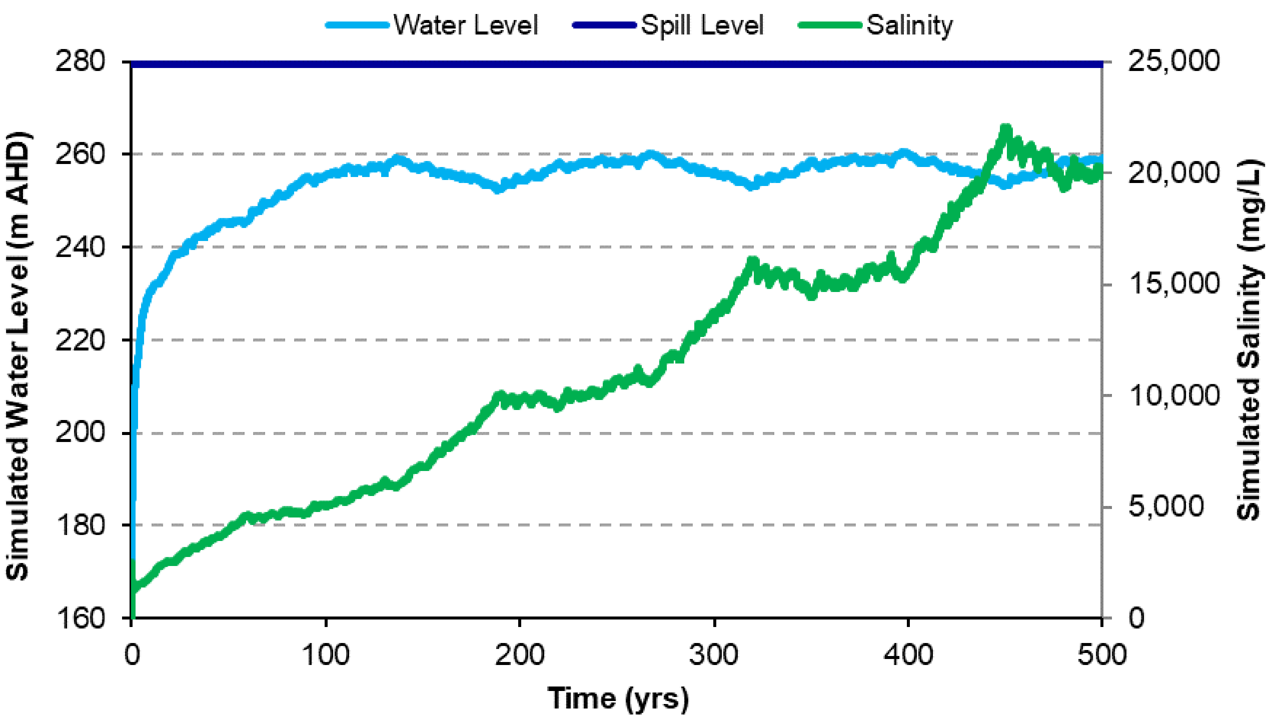


Figure 27 Predicted Final Void Water Levels and EC: Base Case

Results indicate that the final void would reach a peak equilibrium level more than 19 m below the spill level, with an average equilibrium level approximately 22 m below the spill level (i.e. the final void is contained). Equilibrium levels would be reached slowly over a period of more than 100 years. Note that, given the water level and groundwater flux relationship provided, groundwater outflow was not simulated to occur – i.e. the final void would remain a groundwater sink. Final void salinity levels would increase slowly as a result of evapo-concentration.

6.0 GOONBRI CREEK FLOOD ASSESSMENT

6.1 INTRODUCTION

Flood modelling of the proposed realigned Goonbri Creek was undertaken as part of the Tarrawonga Coal Project Surface Water Assessment (SWA). With the removal of the need for the realignment of Goonbri Creek, revision of the flood modelling has been undertaken in order to:

- ensure that the extent of the revised open cut extension/bunding is above the level of a PMF event;
- provide preliminary findings on the requirement for a permanent flood bund as the modified open cut is located high in the landscape;
- provide hydraulic data for comparison with previous modelling for the Tarrawonga Coal Project SWA (as detailed in Gilbert & Associates, 2011a and 2011b); and
- undertake flood modelling in accordance with contemporary guidelines – i.e. the revised Australian Rainfall and Runoff (ARR) flood estimation guidelines (Ball *et al.*, 2019).

The section of Goonbri Creek adjacent to Tarrawonga Coal Mine, and a small portion of the south-western extent of the mine, are located in the Upper Namoi Valley Flood Management Plan (FMP) Management Zone C. Flood work approvals in the Upper Namoi Management Zone C are subject to the assessment criteria specified in the *Floodplain Management Plan for the Upper Namoi Valley Floodplain 2019* under the *Water Management Act 2000.*

It should be noted that overland flows from Bollol Creek currently flow into the lower reaches of Goonbri Creek during periods of high flow, with the flood extent spreading across the alluvial plain. However, for the purposes of assessing the extent of the revised open cut extension/bunding in relation to the level of a PMF event, only the Goonbri Creek section has been modelled at this stage.

6.2 GOONBRI CREEK FLOOD BUND

A flood bund may need to be constructed to the east of the open cut pit as illustrated in Figure 28. The flood modelling for the Modification assumed an average bund height of approximately 6 m above ground level based on the 1 m contours for the Tarrawonga Coal Mine, obtained from TCPL. The extent and design of the flood bund will be subject to detailed design and appropriate modelling prior to construction.

6.3 HYDROLOGIC MODELLING – ESTIMATION OF PEAK FLOW RATES

The flood extent of Goonbri Creek has been assessed for the 1% AEP rainfall event and the probable maximum precipitation (PMP) event. Design peak flow rates at two locations on Goonbri Creek were estimated from a rainfall-runoff routing model developed using the RORB model package (Laurenson and Mein, 2010). RORB is a widely accepted rainfall routing model for simulating flood hydrographs generated from rainfall events falling on the modelled catchment.

The model extent, sub-catchment layout and creek chainages are shown in Figure 28. The catchment boundaries were derived from a combination of 5 m topographic contours for the area external to the Tarrawonga Coal Mine, sourced from the NSW Government[8], and 1 m contours for the Tarrawonga Coal Mine, obtained from TCPL. The catchment boundary was derived based on the final extent of the proposed open cut area.

[8] Sourced from NSW Government Spatial Services: http://spatialservices.finance.nsw.gov.au/

RORB modelled rainfall losses and routing parameters were derived using guidelines provided for ungauged catchments in ARR (Ball *et al.,* 2019). A conservative approach was taken to the selection of design rainfall losses, to reflect ARR recommendations – i.e. the adoption of relatively low values for design rainfall events with a low AEP (rarer events). Design rainfall temporal patterns and areal reduction factors were also derived from ARR for the 1% AEP rainfall event and from Hydrometeorological Advisory Service (2003a, 2003b) for the PMP event. In line with the ARR guidelines, there are 10 'ensemble' temporal patterns applicable to each design rainfall event, each with different durations. For each AEP, the RORB model was run using the ten temporal patterns[9] for a range of applicable event durations. For each duration, the average of the modelled peak flow rates for each temporal pattern was calculated at a number of model output locations. The design flow rate was then assessed at two key model output locations (refer Figure 28): Goonbri Creek adjacent to the northern extent of the Tarrawonga Coal Mine (Chainage 25,460 m) and adjacent to the southern extent of the final void (Chainage 13,978 m).

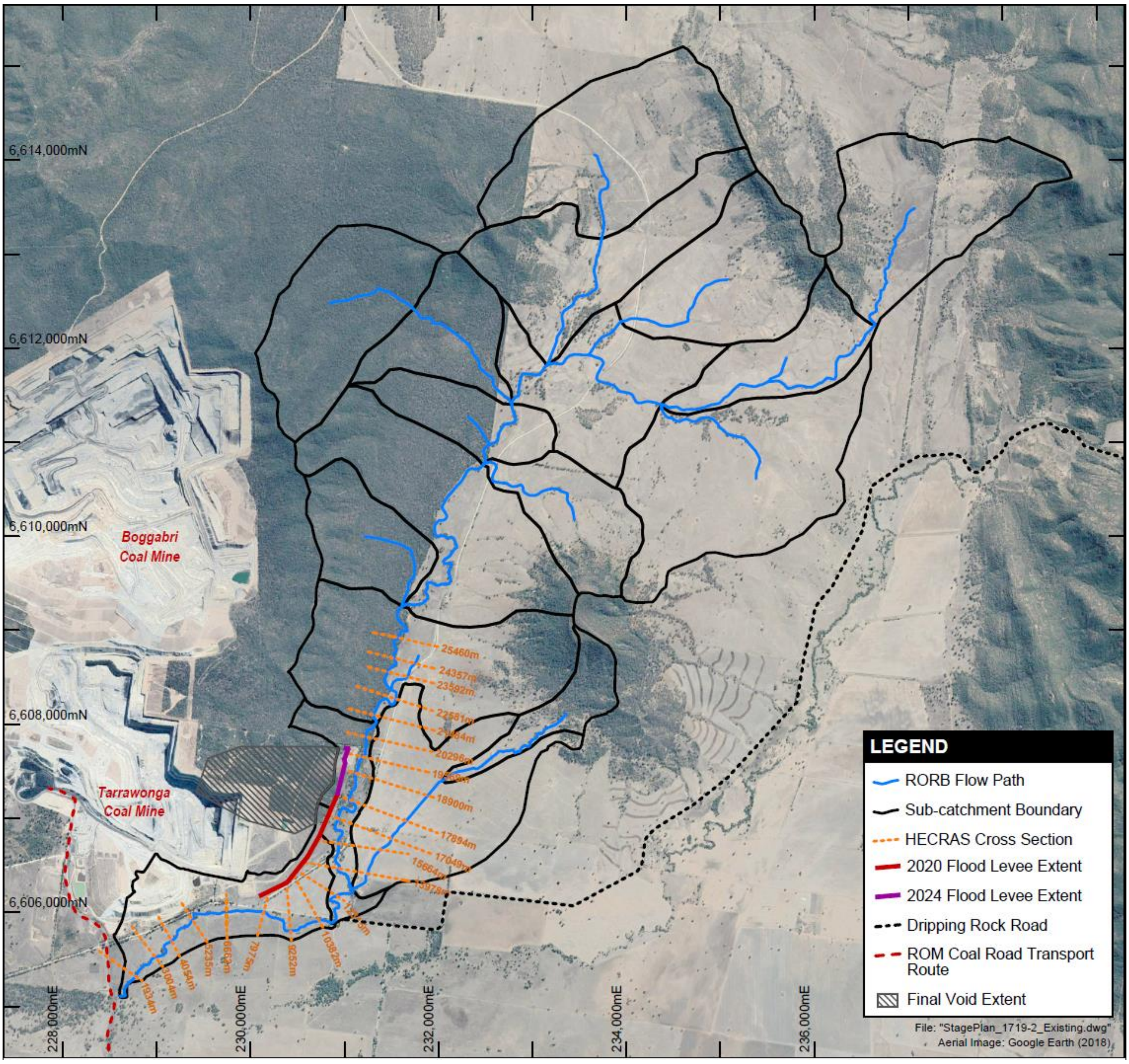


Figure 28 Goonbri Creek Hydrologic and Hydraulic Modelling Extent

9 Sourced from the ARR Data Hub: http://data.arr-software.org/

Table 32 gives the critical duration[10] and the resulting design peak flow rates used as input to the hydraulic model.

Table 32 Design Peak Flow Rates for Goonbri Creek

Chainage (m)	1% AEP		PMP	
	Critical Duration	Peak Flow (m^3/s)	Critical Duration	Peak Flow (m^3/s)
25,460	2 hours	175.6	2 hours	1,910
13,978	3 hours	175.7	2.5 hours	2,309

6.4 HYDRAULIC MODELLING – ESTIMATION OF PEAK FLOOD LEVELS

Peak flow water levels in Goonbri Creek were modelled using the HEC-RAS modelling package (1-dimensional version) (USACE, 2010). HEC-RAS is a standard and commonly used model for predicting water surface profiles for steady, gradually varied flow in natural or constructed channel systems. Inputs to the HEC-RAS model were as follows:

- creek/floodplain cross-sections: derived from a Digital Elevation Model (DEM) created from 1 m contour data and LiDAR data provided by TCPL;
- estimates of channel or natural creek roughness/friction factors: derived from literature guidelines and aerial photographs;
- flow rates: estimated as detailed in Section 6.3; and
- boundary conditions at each end of the stream reach: upstream and downstream water surface gradient estimated from LiDAR data provided by TCPL.

The adopted HEC-RAS cross-section alignments are illustrated in Figure 28. The cross-sections extended to the mine boundary in the west and the assumed catchment boundary between Goonbri Creek and Bollol Creek in the east. During periods of high flow, it is likely that the flood extent between Goonbri Creek and Bollol Creek will merge, with the flood extent spreading across the alluvial plain. However, for the purposes of assessing the extent of the revised open cut extension/bunding in relation to the level of a PMF, only the Goonbri Creek section has been modelled. In summary, by setting the bound of the HEC-RAS cross-sections at the assumed catchment boundary, a conservative assessment of the Goonbri Creek flood levels has been undertaken.

Table 33 presents the predicted 1% AEP and PMF water level based on the natural alignment of Goonbri Creek, in comparison with the previously estimated (Tarrawonga Coal Project SWA) 1% AEP and PMF water level and the planned maximum level of the flood bund at the associated locations. The predicted flood inundation extent is shown in Figure 29 for the 1% AEP and Figure 30 for the PMF.

[10] The critical duration rainfall event is that which produces the peak design flow rate at a given location.

Table 33 Estimated Peak Flood Levels for Goonbri Creek

Chainage (m)	Water Level Elevation (m AHD)				Ground Level Adjacent to Final Void (m AHD)	Planned Maximum Flood Bund Elevation (m AHD)
	PMP		1% AEP			
	Current Modelling	Previous Modelling*	Current Modelling	Previous Modelling*		
25,460	295.3		293.0			
24,357	294.2		291.9			
23,592	293.4		290.9			
22,581	291.9		289.7			
21,484	290.6		288.7			
20,296	288.6	290.4	287.1	288.5		
19,569	287.0	289.1	285.2	287.3	298.25	302.0
18,900	286.1	287.9	284.9	286.3	294.75	298.0
17,894	284.6	286.6	283.4	285.2	291.75	293.0
17,049	283.7	285.6	282.3	284.1	291.25	293.0
15,664	282.6	284.2	280.9	282.3	289.25	288.0
13,978	281.4	282.3	279.5	280.3		284.0
12,315	280.4	280.2	278.4	278.5		283.0
10,382	278.7	278.7	276.7	277.3		283.0
9,252	277.8	277.2	275.4	275.4		282.0
7,975	276.7	276.5	274.3	274.7		281.0
6,662	275.6	275.2	273.1	273.1		
5,235	274.2	273.1	271.7	271.3		
4,054	272.8	272.0	270.3	270.3		
3,004	271.7	271.0	269.4	269.4		
1,934	270.3	269.2	268.0	267.7		

* Source: Gilbert & Associates (2011b)

The previous hydraulic modelling adopted different sub-catchment boundaries, cross-sectional characteristics and an alignment of Goonbri Creek incorporating the proposed diversion of Goonbri Creek (no longer required). As such, the previously estimated water levels vary to that of the current modelling in some sections of Goonbri Creek.

As shown in Table 33, the planned flood bund will be of sufficient elevation to restrict predicted PMP and 1% AEP flows in Goonbri Creek from extending to the final void. In the sections to the south of the flood bund (Chainage 9,252 to 6,662 m), there may be some localised flooding along the south-eastern boundary of the mine site during a PMF, as illustrated in Figure 30. Note that the flooding extent to the west of the flood bund at Chainage 9,252 m and Chainage 7,975 m is due to backwater effects, rather than overtopping of the flood bund and will flow back to Goonbri Creek as flood levels reside.

Figure 30 shows that the PMF is predicted to extend to the flood bund from Chainage 7,975 to 17,049 m. Upstream of Chainage 17,049 m, the PMF is not predicted to extend to the flood bund and as such there may be potential to reduce the extent or height of the flood bund in this reach. However, it is recommended that 2-dimensional flood modelling is undertaken to confirm the potential extent of flooding from the combined Goonbri and Bollol Creek catchment during a PMP event.

A 2-dimensional flood modelling approach is recommended based on the nature of Goonbri and Bollol Creek catchment flooding in high rainfall periods (overland flow from Bollol Creek flows into the lower reaches of Goonbri Creek and the extent of flooding in both catchments spreads across the alluvial plain). A 2-dimensional approach to flood modelling would provide an improved understanding of flow characteristics which occur in multiple directions (i.e. upstream to downstream and across the stream, as opposed to only upstream to downstream which is inherent in 1-dimensional flood modelling).

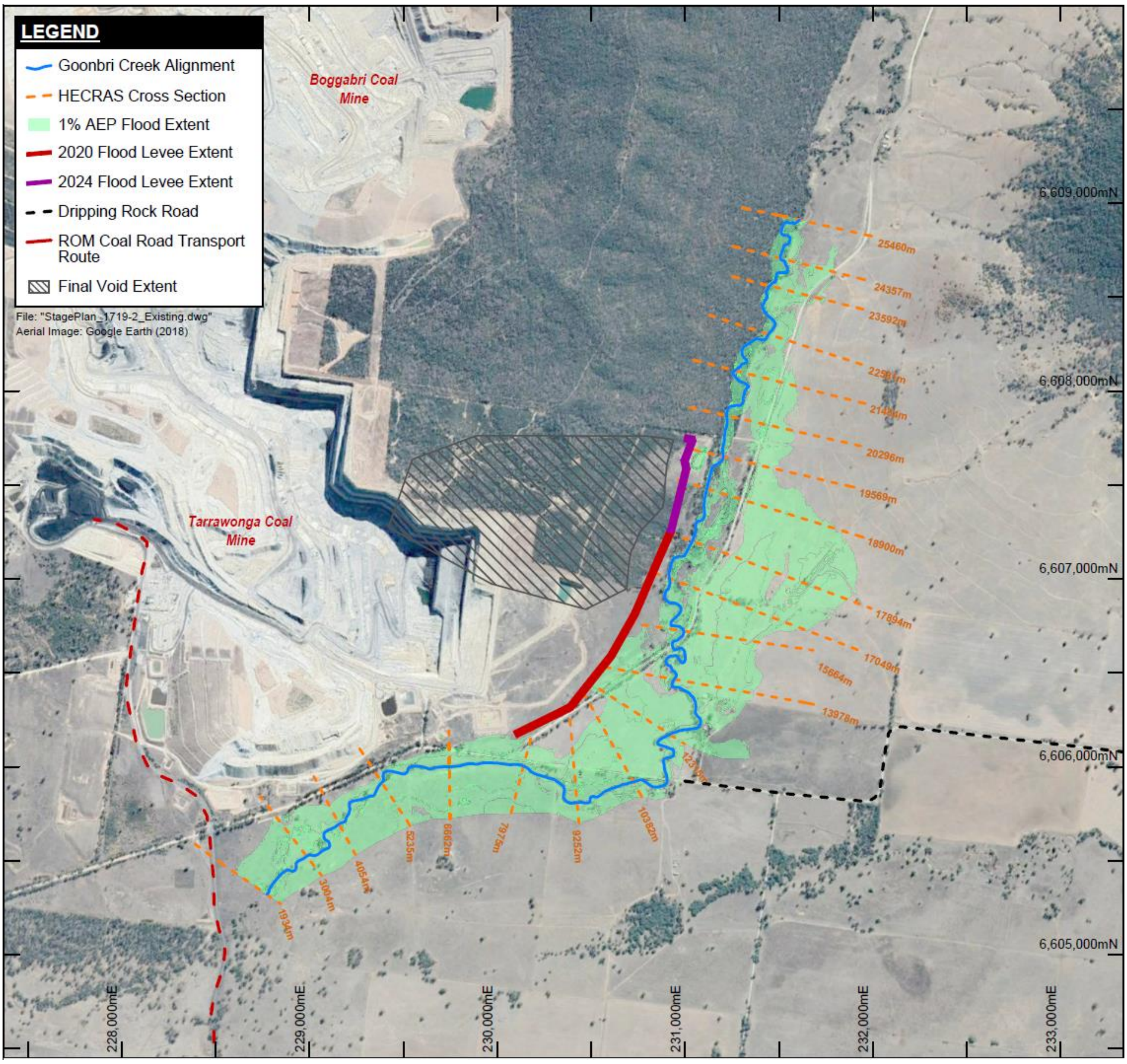


Figure 29 Goonbri Creek Predicted 1% AEP Flood Extent

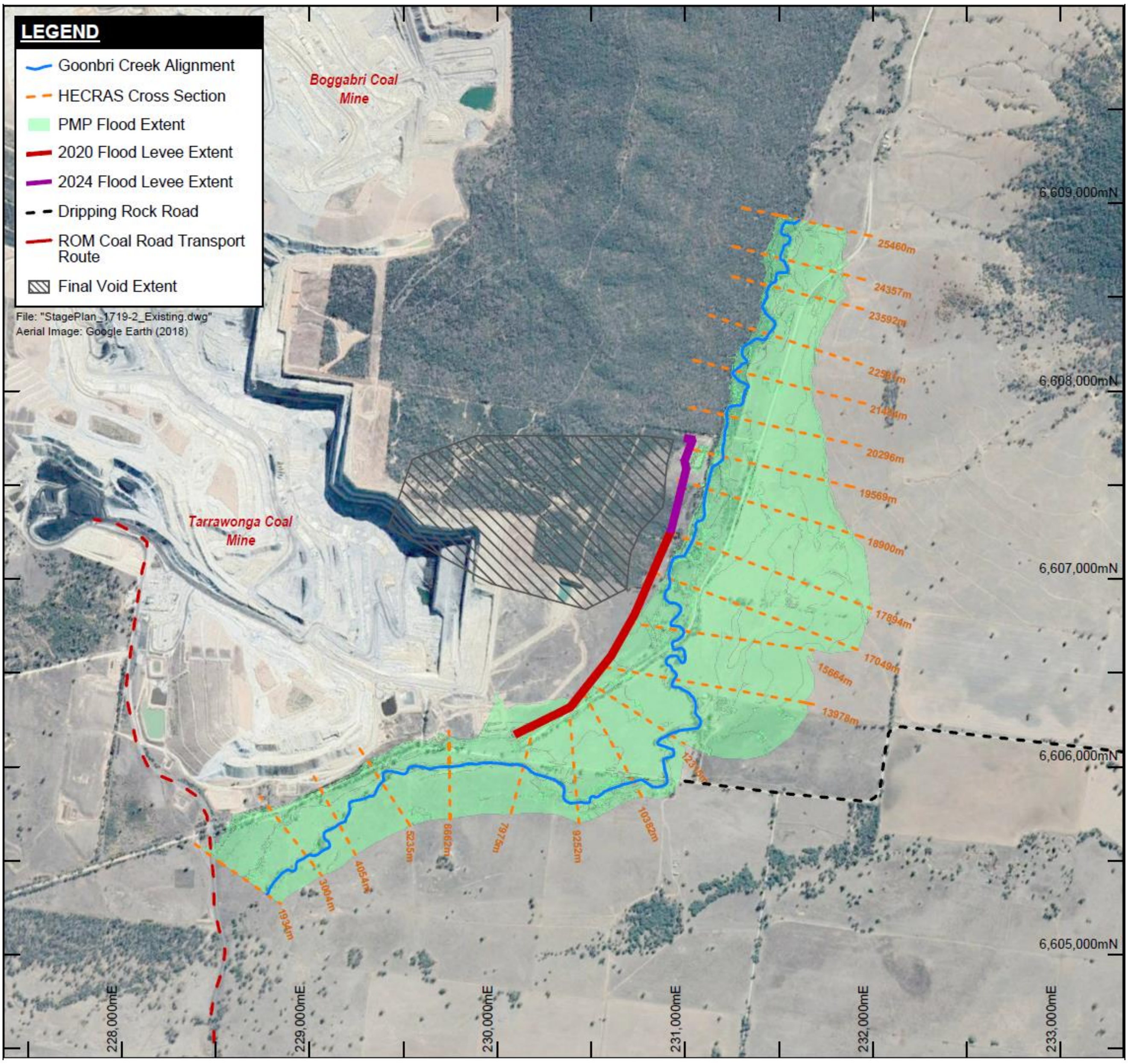


Figure 30 Goonbri Creek Predicted PMF Extent

7.0 POTENTIAL SURFACE WATER IMPACTS

The potential operational impacts of the Modification on local and regional surface water resources are:

- Changes to flows in local creeks due to the progressive extension and subsequent capture and re-use of drainage from active mine catchment areas.
- Changes to the Goonbri / Bollol Creek floodplain due to the proposed flood bund which would protect against extreme flood events entering the mine.
- Potential for export of contaminants (principally sediments and soluble salts) in mine catchment area runoff, controlled releases and unplanned spills from containment storages (principally sediments, soluble salts, oils and greases).

7.1 CATCHMENT AREA REDUCTION AND CATCHMENT YIELD EFFECTS

The Modification would result in approximately 90 ha less disturbance at the site compared to the approved project. Notwithstanding, the potential effects on total flow in the surface water catchments have been assessed on the basis of the reduction in catchment area due to the Modification. Table 34 lists the total area captured over the life of the Tarrawonga Coal Mine from Nagero Creek, Goonbri / Bollol Creek and the Namoi River (at Turrawan) catchment.

Table 34 Total Area Captured by Modification from Surface Water Catchments

Year	Nagero Creek		Goonbri / Bollol Creek		Namoi River at Turrawan*
	Captured Area (km^2)	Percentage of Total Catchment Area	Captured Area (km^2)	Percentage of Total Catchment Area	Percentage of Total Catchment Area
Year 1	4.3	5.4%	4.3	2.6%	0.04%
Year 3	4.5	5.6%	4.5	2.7%	0.04%
Year 5	4.8	6.0%	4.4	2.7%	0.04%
Year 11	5.2	6.4%	4.4	2.7%	0.04%
Final Landform	0.8	1.0%	1.2	0.7%	0.01%

* Total catchment area of 24,110 km^2

Table 34 shows that the maximum area captured by the Modification from Nagero Creek catchment is estimated at 5.2 km^2 in Year 11, equating to 6.4% of the total catchment area of Nagero Creek. The maximum area captured by the Modification from Goonbri / Bollol Creek catchment is estimated at
4.5 km^2 in Year 3, equating to 2.7% of the total catchment area of Goonbri / Bollol Creek. This compares with an estimated maximum reduction of 6.9% from Nagero Creek catchment and 3.0% from Goonbri / Bollol Creek catchment for the approved Tarrawonga Coal Mine (Gilbert & Associates, 2011a). Post-closure, a 1.0% reduction of the Nagero Creek catchment and 0.7% reduction of the Goonbri / Bollol Creek catchment are estimated due to the Modification.

The maximum area captured by the Modification from the Namoi River (at Turrawan) is estimated at 9.6 km^2 in Year 11, equating to 0.04% of the total catchment area. With a mean annual flow volume of 596,092 ML, the maximum reduction in flow due to the Modification is estimated at 237 ML (0.04%). This represents a small and likely indiscernible impact to flow in the Namoi River at Turrawan. Post-closure, this is estimated to reduce to 0.01% of the total flow (60 ML).

The cumulative effects of the Boggabri Coal Mine, Maules Creek Coal Mine and Tarrawonga Coal Mine on total flow in the associated surface water catchments have been assessed based on the estimated maximum reduction in total catchment area from the three operations. Table 35 shows the maximum percentage decrease in catchment area of Nagero Creek, Goonbri / Bollol Creek and the Namoi River (at Turrawan) due to the cumulative development of the Boggabri Coal Mine, Maules Creek Coal Mine and Tarrawonga Coal Mine.

Table 35 Cumulative Percentage Decrease in Catchment Area

Catchment	Maximum Percentage Decrease in Catchment Area			
	Modification	Boggabri Coal Mine*	Maules Creek Coal Mine**	Cumulative
Nagero Creek	6.4%	25.4%	0.8%	32.6%
Bollol / Goonbri Creeks	2.7%	0.6%	-	3.3%
Namoi River at Turrawan	0.04%	0.09%	0.07%	0.19%

* Estimated based on the maximum mining disturbance and infrastructure area shown in the *Boggabri Mine Project Approval Environmental Assessment* (Umwelt, 2018).

** Estimated based on the maximum mining disturbance and infrastructure area shown in the *Maules Creek Coal Project Environmental Assessment* (Hansen Bailey, 2011).

Table 35 shows that, cumulatively, the Boggabri Coal Mine, Maules Creek Coal Mine and Tarrawonga Coal Mine will result in an estimated 32.6% reduction in the total catchment area of Nagero Creek, an estimated 3.3% reduction in the total catchment area of Goonbri / Bollol Creek and an estimated 0.19% reduction in the total catchment area of the Namoi River at Turrawan during the operational life of the projects (assuming that the three operations reach the maximum extent concurrently). With a mean annual flow volume of 596,092 ML in the Namoi River at Turrawan, the maximum reduction in flow is estimated at 1,133 ML (0.19%). This represents a small and likely indiscernible impact to flow in the Namoi River at Turrawan.

7.2 IMPACTS ON LOCAL FLOOD REGIME

As described in Section 6.0, a flood bund is proposed to be constructed to the east of the open cut pit in 2020, with an extension in 2024, to protect the open cut extension from Goonbri Creek flooding in a PMF. The results of the hydraulic modelling detailed in Section 6.0 indicate that flood levels on the western overbank of Goonbri Creek will extend to the proposed flood bund in a PMF event (Figure 30) and to some sections of the proposed flood bund in a 1% AEP event (Figure 29). On the eastern overbank of Goonbri Creek, flood levels are likely to extend into the Bollol Creek catchment. Due to the reduction in floodplain area on the western overbank of Goonbri Creek at the location of the flood bund, the extent of flooding on the eastern overbank of Goonbri Creek and into Bollol Creek catchment may increase. However, the floodplain area within this region is extensive and the increased extent of flooding to the east of Goonbri Creek, and any associated increase in flow velocity or erosion, is likely to be indiscernible in comparison with variation in natural flooding conditions.

7.3 IMPACTS OF CONTROLLED RELEASE AND OVERFLOW FROM WATER STORAGES

The Modification water management system has been designed such that mine water is contained on site and controlled release and overflow to the LDPs only occurs from active sediment control structures following settlement. Sediment dams/basins would include broad spillways and level spreaders or similar (refer Landcom [2004]) with appropriate armouring (e.g. rockfill) to mitigate the risk of erosion caused by overflow. Details would be included in an updated Erosion and Sediment Control Plan for the Modification. The sediment basins/dams will continue to operate in accordance with the Tarrawonga Coal Mine EPL 12365. As such, it is expected that there will be a low risk of adverse water quality impacts on the adjacent surface water systems due to the Modification.

8.0 MONITORING, MITIGATION AND MANAGEMENT

Surface water monitoring is currently undertaken at Tarrawonga Coal Mine in accordance with EPL 12365 and will continue for the remainder of the mine life. Additional monitoring is recommended for the proposed pipeline to the Vickery Extension Project and for the proposed site water storages. A summary of the existing and recommended surface water monitoring is provided in Table 36.

Table 36 Existing and Recommended Surface Water Monitoring

Type of Monitoring	Monitoring Sites/Locations	Parameters	Frequency	Recommendation
Wet weather and controlled release water quality	SD17, SD9, SB14, SD16, SB24B, SB27, SB28	Oil and grease, pH and TSS	Event-based	Continue existing storages and include new storages releasing to LDPs**
Ambient water quality	BCU, BCD, NCU^, NCD^, GCU and GCD	Oil and grease, pH, TSS, antimony, arsenic, molybdenum and selenium	Quarterly (GCU and GCD) Discharge event (BCU, BCD, NCU, NCD)	Continue
Surface water quality	Mining void†	Oil and grease, pH, TSS, antimony, arsenic, molybdenum and selenium	Six Monthly	Continue
Weather station	M2	Rainfall	Continuous	Continue
Water level	All water management system storages	Stored water level	At least 1 per month	Continue existing dams and include new dams**
Pipeline leakage, integrity and erosion and sediment control	Pipeline to Vickery Extension Project – inlet and outlet	Pipeline leakage monitoring (e.g. differential flow monitoring)	Regular	Commence once pipeline installed
	Pipeline to Vickery Extension Project disturbance area	Visual integrity of pipeline and sediment and erosion control	Dependent on determined site risk	Commence once pipeline installed
Erosion and sediment control	Erosion and sediment control structures	Integrity/function, silt build up	Monthly and within five days of high rainfall event	Continue existing and add proposed additional sediment controls**
Site water demands	Haul road dust suppression, coal crusher dust suppression and vehicle washdown	Water usage rates	Continuous	Continue

** Refer Section 3.0

^ TCPL submitted a variation of EPL 12365 in April 2019 to remove NCU and NCD from the EPL.

† TCPL have submitted a variation in April 2019 for the mining void to be removed from routine monitoring under EPL12365

8.1 OPERATIONAL MONITORING AND MANAGEMENT

On-going water quality monitoring in accordance with EPL 12365 and comparison with trigger values (refer Section 2.4) will enable continued analysis and management of water quality impacts. Where the site water storages currently discharging to an LDP are proposed to be decommissioned and replaced (i.e. SB14 and SD16), water quality monitoring of the replacement sediment basin/dam will occur in accordance with EPL 12365.

To enable calibration and update of the site water balance model, it is recommended that monitoring of the water level of site water storages and water usage rates be continued.

As stated in Section 3.3.5, localised erosion and sediment controls will be implemented during the pipeline installation period. Monitoring of the integrity/function and silt accumulation of the sediment controls is recommended to be undertaken monthly and within five days of high rainfall events.

Pipeline leakage monitoring (e.g. differential flow monitoring installed at either end of the pipeline) would occur following construction of the pipeline to the Vickery Extension Project. It is recommended that the route of the pipeline is inspected by TCPL personnel to check for minor leaks, with the frequency of visual inspection to be determined based on the adopted site risk.

8.2 POST-MINING MONITORING AND MANAGEMENT

Water quality monitoring should continue for two years following cessation of operations with monitoring data reviewed at annual intervals (as part of the annual review process) over this period. Reviews should involve assessment against long-term performance objectives that are derived from baseline conditions or a justifiable departure from these, with due allowance for climatic variations. If objectives are not substantially met within the two-year period, management measures should be revised and the monitoring period extended.

8.3 POTENTIAL CONTINGENCY MEASURES

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

- conducting additional monitoring (e.g. increase in monitoring frequency or additional sampling locations) to confirm impacts and inform the proposed contingency measures; and
- refinements to the water management system design such as additional sedimentation dams, increases to pumping capacity, installation of new structures as required to address the identified issue.

Annual forecast water balance modelling will inform near term water supply reliability for the Modification as it progresses. Such forecasts will allow TCPL to plan for contingency measures such as implementation of water reduction measures (including reduced production), should water shortfalls be predicted.

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