Appendix L

Surface water study

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MOUNT THORLEY OPERATIONS 2014 AND WARKWORTH CONTINUATION 2014 SURFACE WATER ASSESSMENT

Prepared for Coal & Allied Operations Pty Limited

June 2014

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REPORT TITLE: Mount Thorley Operations 2014 and Warkworth Continuation 2014 – Surface Water Assessment

CLIENT: Coal & Allied Operations Pty Limited

REPORT NUMBER: 0605-09-D7

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For and on behalf of
WRM Water & Environment Pty Ltd

David Newton
Director

EXECUTIVE SUMMARY

WRM Water & Environment Pty Ltd was commissioned by EMGA Mitchell McLennan (EMGA), on behalf of Coal & Allied Operations Pty Limited (Coal & Allied), to undertake a surface water impact assessment to determine potential impacts on surface water resources due to the Mount Thorley Operations (MTO) and Warkworth Continuation 2014 Projects (the proposal).

The proposal involves an extension to the approved mining footprint at Warkworth Mine and completion of mining at MTO (among other things), for a period of 21 years.

MTO is an open cut coal mine approximately 15 kilometres (km) south-west of Singleton in the Hunter Valley, NSW. The mine is operated by Coal & Allied on behalf of Mount Thorley Joint Venture (MTJV). Immediately to the north is Warkworth Mine, operated by Warkworth Mining Limited on behalf of MTJV. Since 2004, the two mines have integrated at an operational level and are known as Mount Thorley Warkworth (MTW), with a single management team responsible for the operations.

MTW currently holds a high security Water Access Licence with an allocation of up to 1,012 mega Litres (ML) enabling extraction from the Hunter River, as well as two licenced discharge locations, operated in accordance with the Hunter River Salinity Trading Scheme (HRSTS) and existing Environmental Protection Licences (EPL) 1376 and 1976.

Under current catchment conditions (since the upgrade to the Glenbawn Dam in 1988), the Hunter River is perennial. The Hunter River water quality is characterised by low salinity and moderate alkalinity. However, numerous water quality parameters exceed water quality guidelines, particularly for nutrients and pH. Wollombi Brook is ephemeral, and has a high level of connectivity between surface water and the groundwater aquifer. Water quality in Wollombi Brook is characterised by low salinity and slight alkalinity. Parameters which exceed water quality guidelines include chloride and sodium.

The potential changes to surface water and water management during the life of the proposal that have been investigated include:

- Additional water demand from external third party sources (ie neighbouring mines or the Hunter River) to meet increased operational water requirements for the proposal;
- Loss of catchment area draining to Wollombi Brook and the Hunter River due to capture of runoff within onsite storages during mining. This could potentially reduce runoff volumes to Wollombi Brook and the Hunter River;
- Adverse impacts on the quality of surface runoff draining from the local site catchment to Wollombi Brook and the Hunter River;
- Change in downstream water quality associated with possible overflows from the mine water management system;
- Increase in saline water controlled discharges (HRSTS); and
- Interference with flood flows along Wollombi Brook and the Hunter River associated with changes in the respective flood plains.

A key component of the methodology for the surface water impact assessment has been the development of a detailed computer model of the mine water balance. The model was configured to represent the inflows to and outflows from the mine water management system as well as transfers of water between mine site storages. The mine water balance model was

calibrated against observed system performance during 2012 to 2013. The mine water system model was simulated on a daily basis over the 21 year life of the proposal using 93 difference rainfall sequences based on recorded historical data.

The results of the water balance model indicate that there is a step change in external water requirements which occurs in around Year 2, consistent with the increase in production at Warkworth Mine and the decrease in groundwater inflows to at MTO. External water requirement from Year 3 to year 21 are generally consistent with:

- A 50 per cent chance that between 1,500ML/a to 2,000ML/a of external water will be required; and
- A 10 per cent chance that between 3,000ML/a to 3,700ML/a of external water will be required.

Note that the current MTJV allocation is 1,012ML/a (at 100% Available Water Determination (AWD)).

The results of the water balance modelling indicate a low probability of pit inundation, and no offsite uncontrolled release (overflows) from saline storages.

HRSTS discharges will be required for site water management, with the following discharge characteristics:

- Overall, much greater volumes are discharged from MTO than Warkworth Mine, which is consistent with the capacity of the discharges structures (300ML/d at MTO and 100ML/d at Warkworth Mine) and dam volumes;
- There is a 50 per cent chance of controlled releases from MTO will not be required in any year of project life, and small volumes of controlled discharges (100ML) will be required from Warkworth Mine in any year of project life; and
- There is a 10 per cent chance of controlled releases from MTO of between 1,000ML to 2,000ML will be required in any year of project life, and around 400ML from Warkworth Mine in any year of project life.

There is a maximum reduction of 0.56 per cent of the Wollombi Brook catchment to the Hunter River, and a maximum reduction of 0.19 per cent of the Hunter River (not including Wollombi Brook) during mining. Post-mining, the reduction in catchment area is 0.44 per cent and 0.04 per cent for Wollombi Brook and the Hunter River respectively. There is a median net runoff reduction to the Hunter River of up to 75ML/a during mining, and up to 104ML/a post-mining.

MTW currently undertakes an extensive surface water monitoring program, which will continue to be implemented for the proposal. Monitoring includes on site dams (both saline and sediment), receiving waters (upstream and downstream Hunter River, Wollombi Brook and their tributaries), and additional monitoring which is undertaken during periods of controlled release under the HRSTS. Additional saline storages and sediment dams constructed as part of the proposal will be monitored in accordance with the current monitoring program.

Overall, the impacts of the Project on surface water resources are unlikely to be significantly greater than those of the existing mining operation.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

1.1 OVERVIEW

WRM Water & Environment Pty Ltd (WRM) was commissioned by EMGA Mitchell McLennan Pty Limited (EMM), on behalf of Coal & Allied Operations Pty Limited (Coal & Allied), to undertake an assessment of surface water impacts due to the Mount Thorley Operations (MTO) 2014; as well as the Warkworth Continuation 2014.

As the water management systems at MTO and Warkworth Mine are significantly integrated, the surface water impact assessment has been based on the combined projects (the proposal). This assessment forms part of the environmental impact statement (EIS) for each project. Details of the proposal and the methodology and results of the surface water impact assessment are provided in this report.

1.2 MOUNT THORLEY OPERATIONS EIS

1.2.1 Background

Mount Thorley Operations (MTO) is an open cut coal mine approximately 15 kilometres (km) south-west of Singleton in the Hunter Valley, NSW. The mine is operated by Coal & Allied on behalf of Mount Thorley Joint Venture (MTJV). The site currently operates under Development Consent No. DA 34/95 (the MTO development consent) issued by the then Minister for Planning on 22 June 1996 under Part 4 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

Immediately to the north is Warkworth Mine. Since 2004, the two mines have integrated at an operational level and are known as Mount Thorley Warkworth (MTW), with a single management team responsible for all the operations. Equipment, personnel, water, rejects and coal preparation are all shared between the mines. The MTW operations involve employ approximately 1,300 persons, which includes full-time personnel and a small number of short-term contractors. Ownership of the two mines remains separate.

Mining activities approved under DA 34/95 have mostly been completed with the exception of Loders Pit and Abbey Green North Pit (AGN); rehabilitation is well-progressed on the east of the site. Run-of-mine (ROM) coal from MTO is transported to either the MTO or Warkworth Mine coal preparation plant (CPP) for processing. Extraction of coal from other pits has been completed; overburden emplacement is ongoing. Product coal from the CPPs is transported via conveyor to the Mount Thorley Coal Loader (MTCL). Coal loaded onto trains at the MTCL is transported to the Port of Newcastle for export.

The proposal at MTO seeks an approval under Part 4, Division 4.1 of the EP&A Act to complete mining and rehabilitation activities within the current limits of approval.

1.2.2 Proposal Description

MTO has approval to mine until 22 June 2017 under its development consent. The proposal seeks a 21 year development consent period from the date of any approval. If approval is granted in 2015, operations at MTO are forecast to continue to the end of 2035, an 18 year extension over the current approval. The proposal seeks a continuation of all aspects of MTO as it presently operates and extends or alters them, including:

- Mining in Loders Pit and AGN Pit. Mining in Loders Pit is expected to be completed in approximately 2020. Mining in AGN Pit is yet to commence; however, it is anticipated to take approximately two years and be completed before 2022;
- Transfer of overburden between MTO and Warkworth Mine to assist in rehabilitation and development of the final landform;
- Maintain existing extraction rate of 10 million tonnes per year (Mtpa) of ROM coal;
- Maintain and upgrade to the integrated MTW water management system (WMS), including:
  - upgrade to the approved discharge point and rate of discharge into Loders Creek from 100ML/d to 300ML/d via the Hunter River Salinity Trading Scheme (HRSTS);
  - ability to transfer and accept mine water from neighbouring operations (ie Bulga Coal Complex, Wambo Mine, Warkworth Mine and Hunter Valley Operations);
  - increase in the storage capacity of the southern out-of-pit (SOOP) dam from 1.6 giga litres (GL) to 2.2GL
- Maintain and upgrade the integrated MTW tailings management:
  - including use of the northern part of Loders Pit as a TSF after completion of mining; and
  - wall lift to Centre Ramp Tailings Facility to approximately RL150
- Upgrade to the MTO CPP to facilitate an increase in maximum throughput to 18Mtpa with the ability to receive this coal from Warkworth Mine;
- Acknowledge all approved interactions with Bulga Coal Complex; and
- Continuation of coal transfer between Warkworth Mine and MTO and transportation of coal via the MTCL to Port of Newcastle.

All activities, including coal extraction will be within disturbance areas approved under the existing development consent.

The proposal is shown in Figure 1.1.

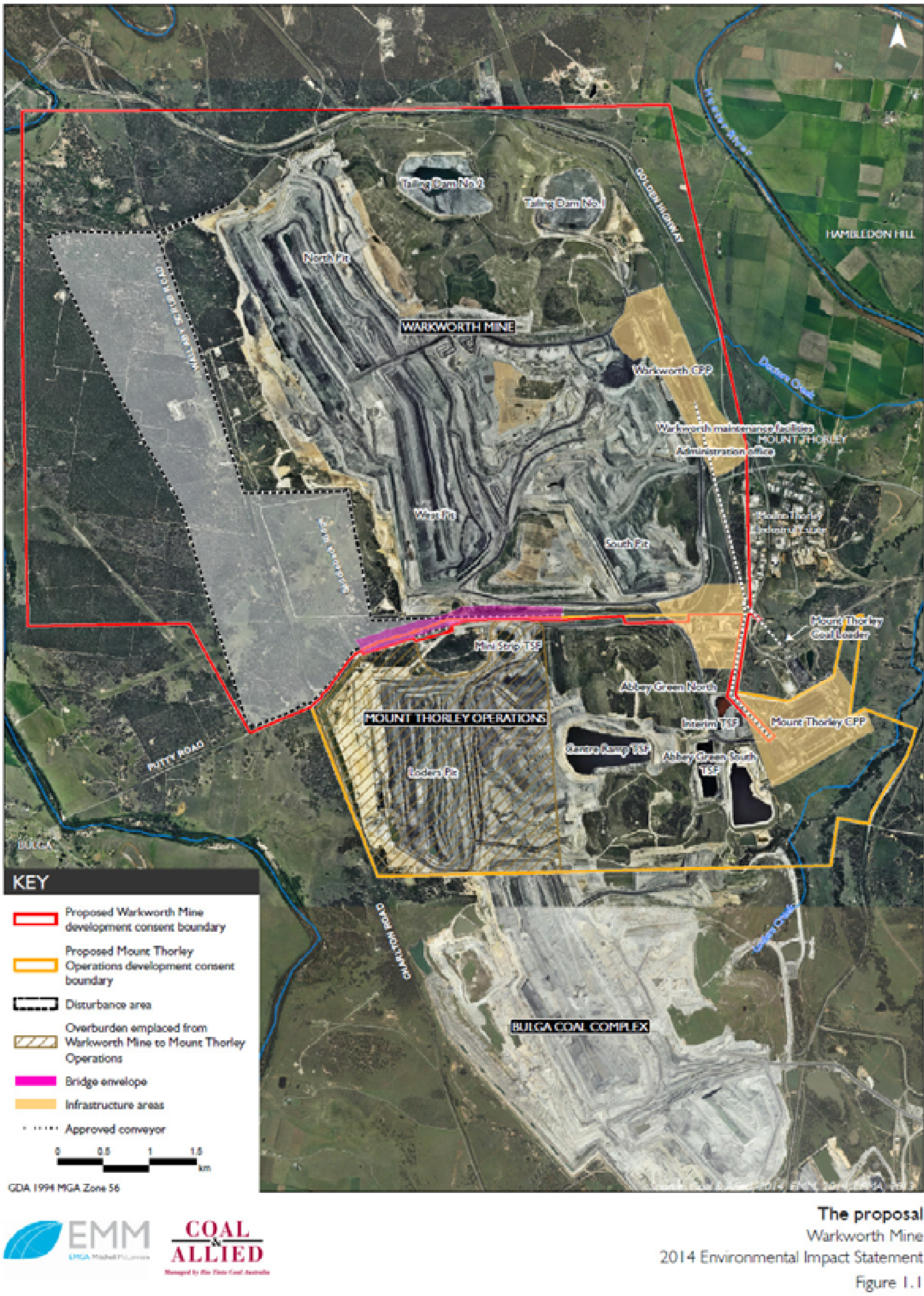

Figure 1.1 Proposal Site Layout

1.3 WARKWORTH MINE EIS

1.3.1 Background

Warkworth Mine is an open cut coal mine approximately eight kilometres (km) south-west of Singleton in the Hunter Valley, NSW. The mine is operated by Coal & Allied on behalf of Warkworth Mining Limited. The site currently operates under Development Consent No. DA 300-9-2002-i (the Warkworth Mine development consent) issued by the then Minister for Planning in May 2003 under Part 4 of the EP&A Act. The site also operates under two separate Commonwealth approvals (*Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)); EPBC 2002/629 and EPBC 2009/5081.

Warkworth Mine has been in operation since 1981 and the originally approved operation has been modified several times. Immediately to the south of Warkworth Mine is MTO. As noted in Section 1.2.1, the two mines have integrated at an operational level, however, ownership remains separate.

Warkworth Mine currently operates three integrated open cut mining areas, namely North, West and South pits with West and North pits being the focus of production. ROM coal from Warkworth Mine is transported to either the Warkworth or Mount Thorley CPP for processing. Product coal from the CPPs is transported via conveyor to either the MTCL or to the Redbank Power Station. Coal loaded onto trains at the MTCL is transported to the Port of Newcastle for export.

The proposal at Warkworth Mine seeks an approval under Part 4, Division 4.1 of the EP&A Act to extend mining beyond the current limits.

1.3.2 Proposal Description

Warkworth Mine has approval to operate until 19 May 2021 under its development consent. The proposal seeks a 21 year development consent period from the date of any approval. If approval is granted in late 2014, operations at Warkworth Mine are forecast to continue to 2035, a 14 year extension over the current approval. The proposal seeks a continuation of all aspects of Warkworth Mine as it presently operates together with:

- An extension of the approved mining footprint by approximately 698ha to the west of current operations (referred to herein as the proposed 2014 extension area);
- The ability to transfer overburden to MTO to complete MTO's final landform;
- The closure of Wallaby Scrub Road;
- An option to develop an underpass beneath Putty Road for the third bridge crossing yet to be constructed (while retaining the current approval for an overpass);
- Minor changes to the design of the Northern out-of-pit (NOOP) dam; and
- The continued use of secondary access gates to the mine site and offsets for activities such as drilling, offset management, equipment shutdown pad access amongst other things.

The proposal is shown in Figure 1.1.

1.4 DIRECTOR-GENERAL'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS

Section 78A(8A) of the EP&A Act states that a development application for a State Significant Development must be accompanied by an EIS prepared in accordance with the Environmental Planning & Assessment Regulation 2000 (EP&A Regulation). Clause 3 of Schedule 2 of the EP&A Regulation states that prior to the preparation of an EIA, the applicant must make a written application to the Director-General for Environmental Assessment Requirements (DGRs). A request for DGRs was made by Coal & Allied on 1 April 2014. This assessment, which forms part of the EIS, addresses the DGRs concerning surface water.

1.5 REPORT STRUCTURE

This report is structured as follows:

- Section 2 describes the existing surface water environment in the vicinity of the proposal;
- Section 3 provides an overview of the relevant legislation and guidelines relating to surface water resources;
- Section 4 details the assessment of the potential surface water impacts from the proposal;
- Section 5 details the flooding impacts from the proposal;
- Section 6 provides more detail on the site water balance used for the assessment of impacts;
- Section 7 describes the management and monitoring which will be undertaken as part of the proposal; and
- Section 8 summarises the outcomes of the study.

2 EXISTING SURFACE WATER ENVIRONMENT

2.1 RAINFALL AND EVAPORATION

Summary details of existing Bureau of Meteorology (BOM) rainfall stations in the vicinity of MTW are shown in Table 2.1. Bulga (Down Town) is the closest open BOM rainfall station to MTW, whereas Jerrys Plains has the longest period of record (130 years). Table 2.2 shows mean monthly rainfalls for the Jerrys Plains and Bulga (Down Town) rainfall stations, over the entire period of record as well as coincident periods of record (1960 to 2013). The mean annual rainfall over the long term (1884 to 2013) at Jerrys Plains station is 645mm. The mean annual rainfall over the coincident period is 668mm and 695mm at Jerrys Plains and Bulga Down Town, respectively. This indicates that rainfalls are around four per cent higher at Bulga than Jerrys Plains.

Table 2.1 BOM Rainfall Stations – Open (Australian Government Bureau of Meteorology, 2014)

Station Name	Station No.	Lat.	Long.	Opened	Elevation	Distance from MTW
Jerrys Plains Post Office	061086	32.50°	150.91°	1884	87 m	17 km NW
Bulga (South Wambo)	061191	32.61°	150.98°	1959	80 m	7.2 km W
Bulga (Down Town)	061143	32.65°	151.02°	1960	69 m	4 km W
Singleton STP	061397	32.59°	151.17°	2002	45 m	8.5 km E
Mibrodale (Hillsdale)	061309	32.69°	150.97°	1963	120 m	9.7 km SW
Mibrodale School	061422	32.70°	151.00°	2010	88 m	7.4 km SW

Long term daily rainfall for the MTW site from January 1889 to December 2012 (124 years) has been obtained from the DSITIA Data Drill service. Table 2.2 shows the Data Drill rainfall long term (124 years) monthly averages. The Data Drill rainfall is filtered to reduce anomalies such as missing data or accumulated rainfall totals and has been adopted for the water balance modelled for this study.

Table 2.2 also shows mean monthly pan evaporation (based on Class A evaporation pan) recorded by the BOM at Jerrys Plains over the period 1957 to 1972. Mean annual evaporation is 1,641mm, with significant seasonal variation, as shown in Figure 2.1. Table 2.2 shows a comparison of the long term monthly averages of Morton's lake evaporation. Average annual lake evaporation is more than double the average annual rainfall.

Table 2.2 Mean Monthly Rainfall and Evaporation (mm/month)

Month	Rainfall					Pan Evaporation	Lake Evaporation
	Jerrys Plains		Bulga Down Town	Data Drill Rainfall		Jerrys Plains	Data Drill
	1884-2013	1960-2013	1960-2013	1960-2012	1889-2012	1957-1972	1889-2012
Jan	77.7	84.5	85.2	76.2	73.0	220.1	186.1
Feb	73.1	82.8	91.3	83.6	77.8	169.5	150.9
Mar	59.1	60.1	73.3	62.5	66.8	155.0	135.2
Apr	44.0	40.6	45.6	46.7	49.1	120.0	92.0
May	40.7	46.1	49.4	44.9	43.9	89.9	59.3
Jun	48.3	44.9	46.3	45.2	50.0	60.0	40.8
Jul	42.7	35.8	27.2	29.6	38.8	71.3	48.3
Aug	36.1	36.7	34.9	34.1	35.1	80.6	74.3
Sep	41.7	43.1	39.0	38.8	40.1	111.0	105.1
Oct	52.1	57.6	56.9	53.4	52.4	164.3	143.4
Nov	62.3	68.4	69.7	62.8	59.7	195.0	165.5
Dec	68.1	70.3	75.1	72.3	70.9	204.6	89.2
Total	**645**	**668**	**695**	**650**	**658**	**1,641**	**1,390**

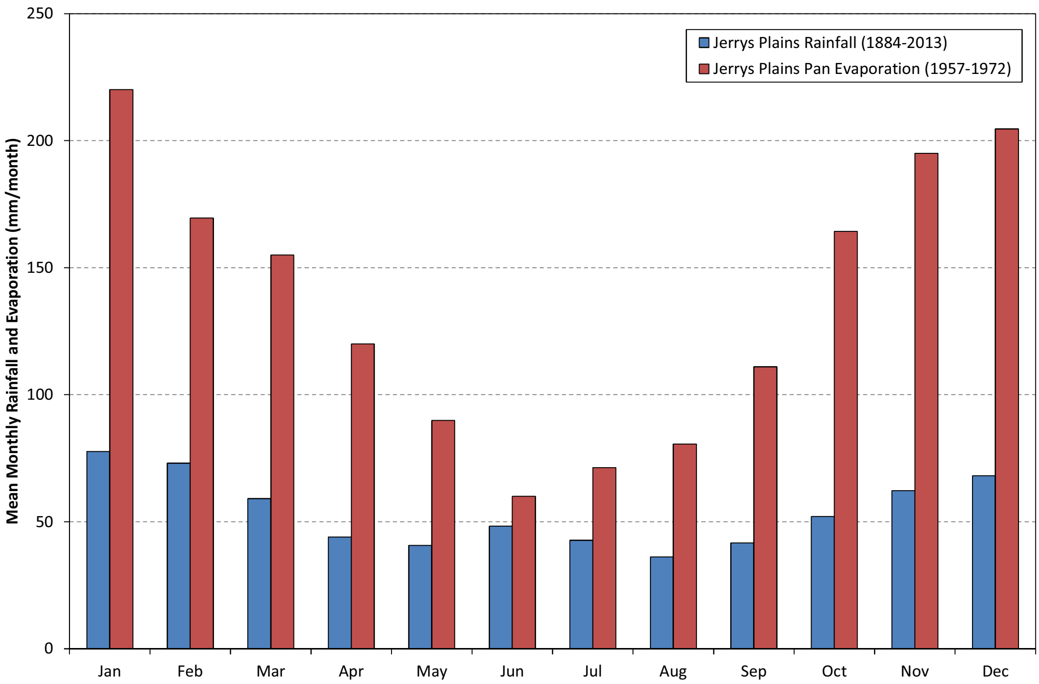

Figure 2.1 Distribution of Monthly Rainfall and Pan Evaporation at Jerrys Plains Post Office (Australian Government Bureau of Meteorology, 2014)

2.2 REGIONAL DRAINAGE NETWORK

The regional drainage network in the area of interest is shown in Figure 2.2. MTW is located on the southern side of the Hunter River, and the eastern side of Wollombi Brook. The Hunter River has a catchment area of approximately 16,400km^2 to Singleton.

The Hunter River catchment upstream of MTW includes Glennies Creek Dam (located 25km north of Singleton) and Glenbawn Dam (located 22km north of Muswellbrook), which command catchment areas of approximately 233km^2 and 1,300km^2 respectively, or a combined nine per cent of the total river catchment to Singleton. Glennies Creek Dam was completed in 1983 with a total storage capacity of 283,000ML. Glenbawn Dam was commissioned in 1957 with a storage capacity of 300,000ML. The Glenbawn Dam was raised in 1988 to a total storage capacity of about 750,000ML.

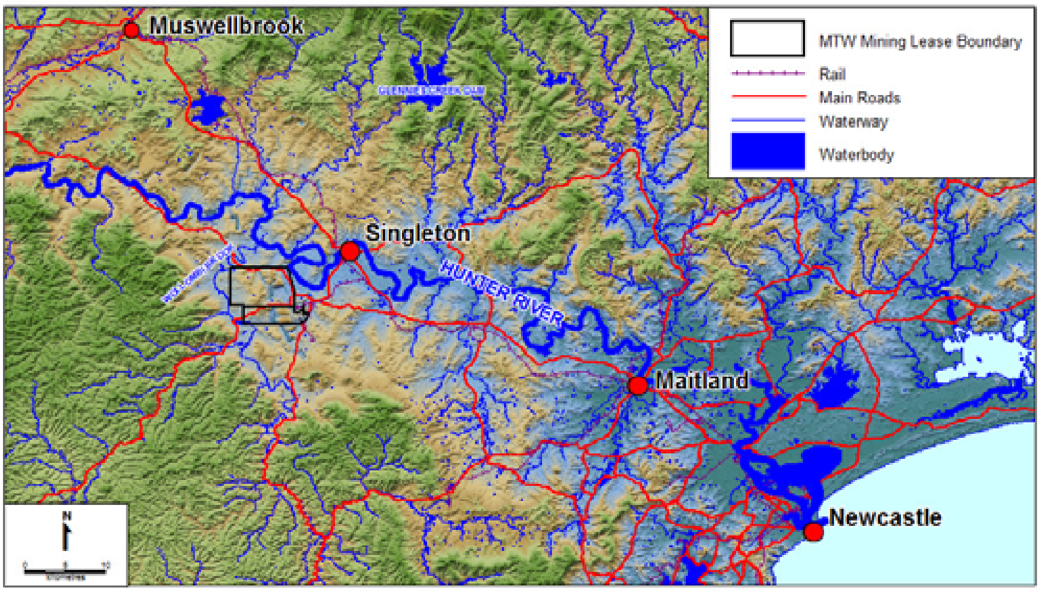

Figure 2.2 MTW Regional Drainage

2.3 LOCAL DRAINAGE NETWORK

Figure 2.3 shows the local drainage network in the vicinity of MTW. Wollombi Brook drains in a north-easterly direction around the site and joins the Hunter River approximately 3.5km north of MTW.

North and West Pit at Warkworth Mine are surrounded by natural landforms that slope inwards towards the active mining areas, however in the proposed extension area of Warkworth mine the natural landform generally slopes westwards towards Wollombi Brook. Clean water diversions (Dam 6N) have been constructed to divert clean water away from the active pits. Doctors Creek diversion protects West Pit, and Sandy Hollow Creek diversion protects North Pit. The catchment areas and the diversion structures are progressively changing with the westward advancing highwall.

At MTO, the clean catchment west of Loders Pit (Salt Pan Creek) drains westward towards Wollombi Brook. Doctors Creek and Loders Creek capture runoff from undisturbed areas east of the mining operations, and are the receiving waterways for controlled site discharges under the HRSTS (refer Section 3.5).

Other drainage lines within the mining lease mostly drain westward or north-westward to Wollombi Brook. All are ephemeral and first or second order watercourses as identified from 1:25,000 topographic maps.

There are no surface water bodies in the disturbance area of the proposal.

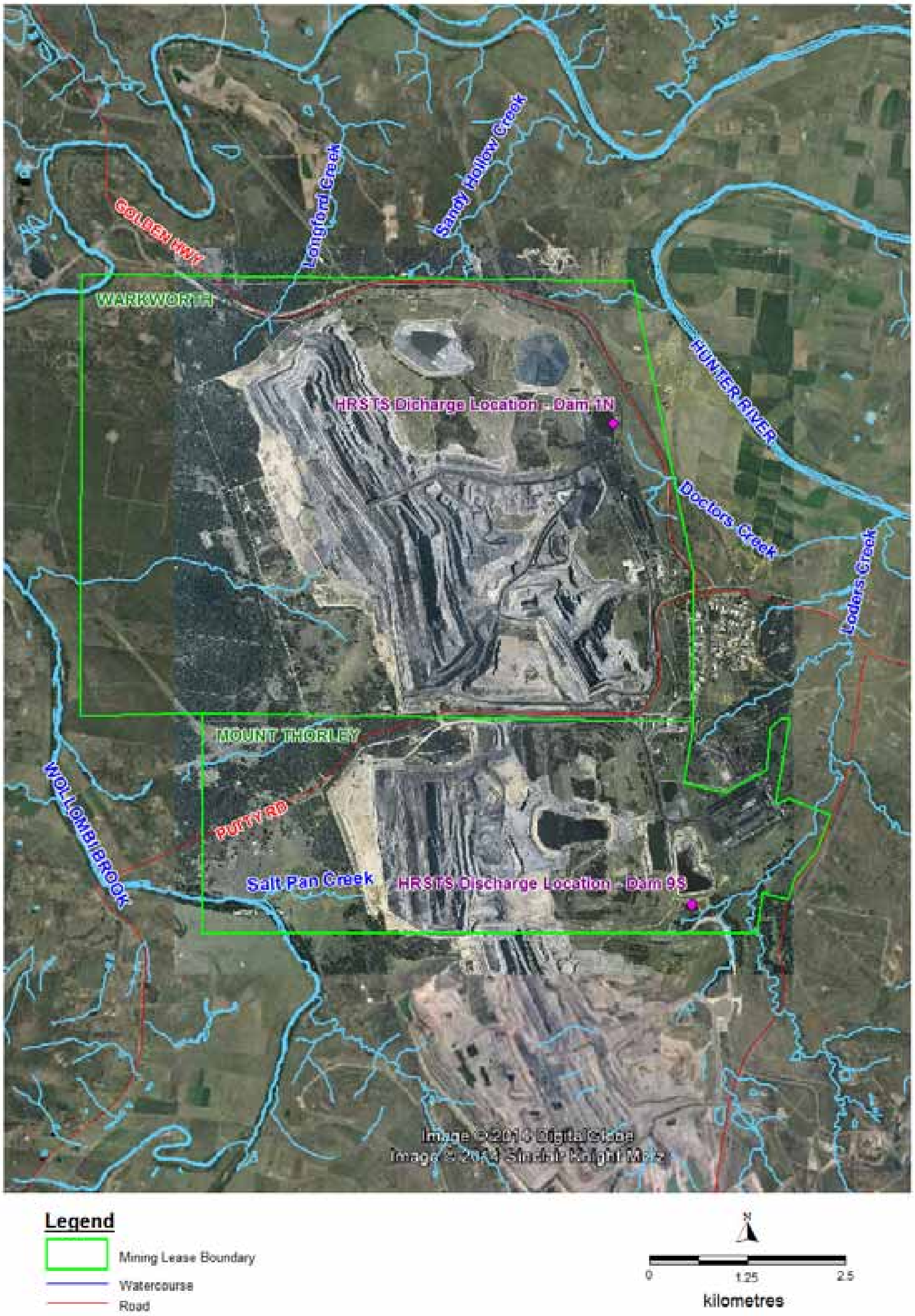

Figure 2.3 MTW Local Drainage (Background Aerial Photography: Coal & Allied, Google Earth)

2.4 STREAMFLOW

Figure 2.4 shows the New South Wales Office of Water (NOW) stream gauging locations in the vicinity of MTW. Flow data is presented for the following three locations:

- Station No. 210001 - Hunter River at Singleton 210001 (approximately 28km downstream of Wollombi Brook confluence). The catchment area of the river to the gauge is approximately 16,400km^2.
- Station No. 210004 - Wollombi Brook at Warkworth (approximately 7km upstream of the Hunter River confluence). The catchment area of the brook to the gauge is approximately 1,848km^2.
- Station No. 210028 – Wollombi Brook at Bulga (20km upstream of the Hunter River confluence). The catchment area of the brook to the gauge is approximately 1,672km^2.

The following sections present the recorded flow information for Wollombi Brook and the Hunter River.

2.4.1 Hunter River

The recorded flow-duration relationship for the Hunter River at Singleton (Station No. 210001) is shown in Figure 2.5 for the periods 1913 to 1957, 1958 to 1987, and 1988 to 2013. Glenbawn Dam was completed in 1958 and upgraded in 1987. Under current catchment conditions (since the upgrade to Glenbawn Dam in 1987), the river is perennial, with a minimum flow rate of about 10 Megalitres / day (ML/d). The median (50th percentile) flow rate is about 300 ML/d and the 95th percentile flow rate is greater than 100ML/d. Comparison of the three flow-duration curves indicates that the upgraded Glenbawn Dam has increased the frequency of low flows (due to regulation) and moderately reduced the frequency of high flows.

2.4.2 Wollombi Brook

Figure 2.6 shows the recorded flow-duration relationship for Wollombi Brook at Warkworth (Station No. 210004), for the periods 1908 to 2013 and 1949 to 2013. Figure 2.6 also shows the recorded flow-duration relationship for Wollombi Brook at Bulga (Station No. #210028) for the period 1949 to 2013. The flow-duration relationship indicates the brook is ephemeral, with an 80th percentile flow rate of about 2ML/d at Warkworth, and about 0.2ML/d at Bulga. The median (50th percentile) flow rate is about 40ML/d at Warkworth, and about 30ML/d at Bulga. During significant flood events, water levels at the Warkworth stream gauge may be affected by backwater from the Hunter River.

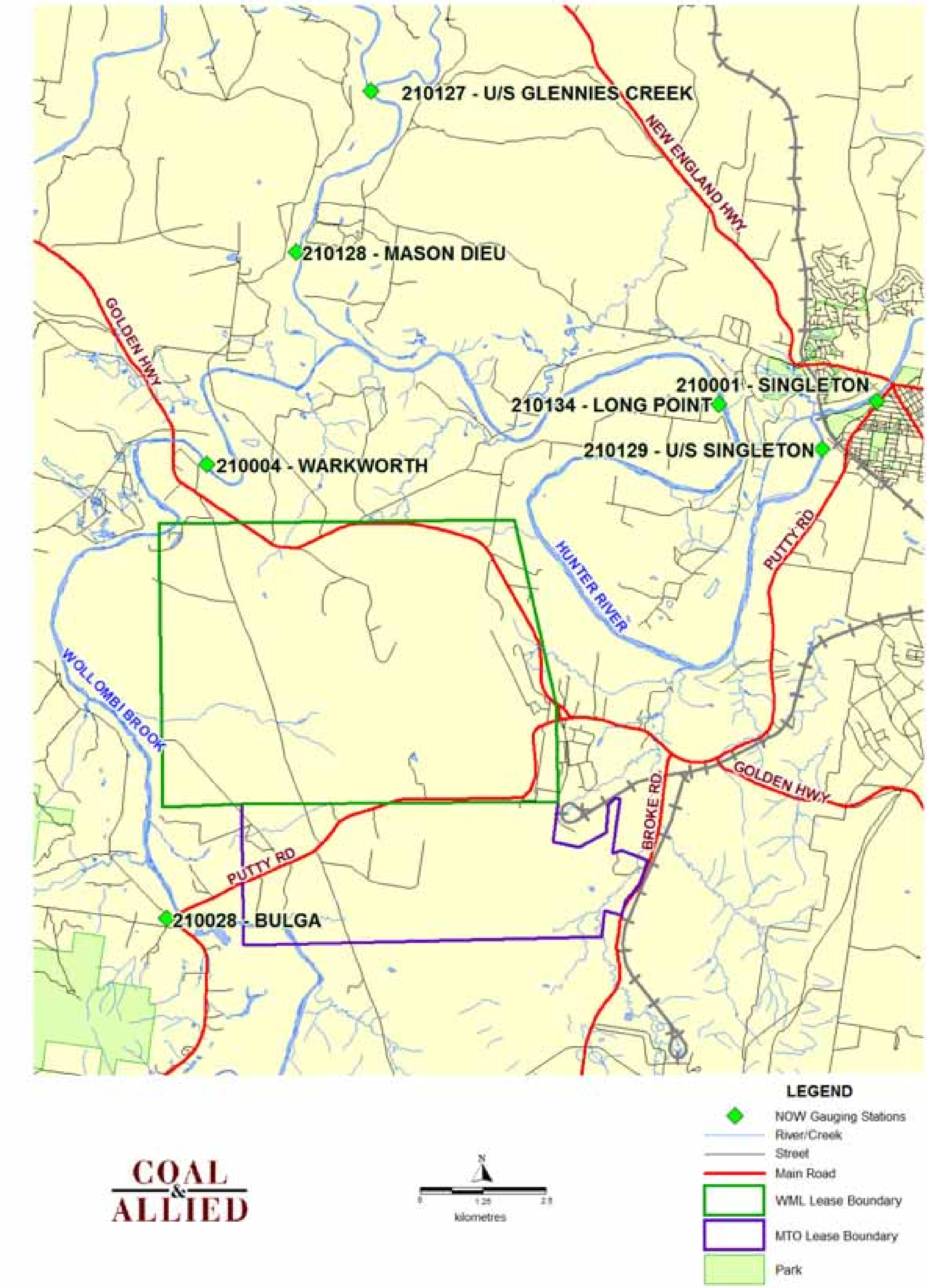

Figure 2.4 NOW Stream Gauging Locations

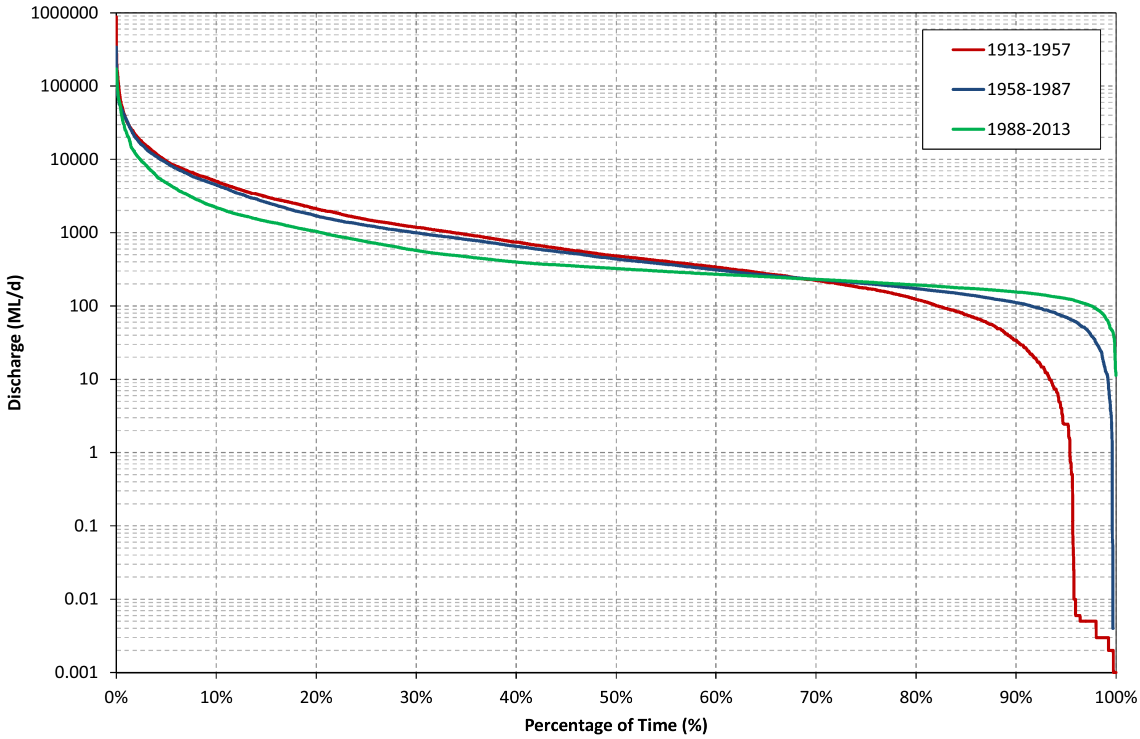

Figure 2.5 Stream Discharge Duration Curve #210001 Hunter River at Singleton

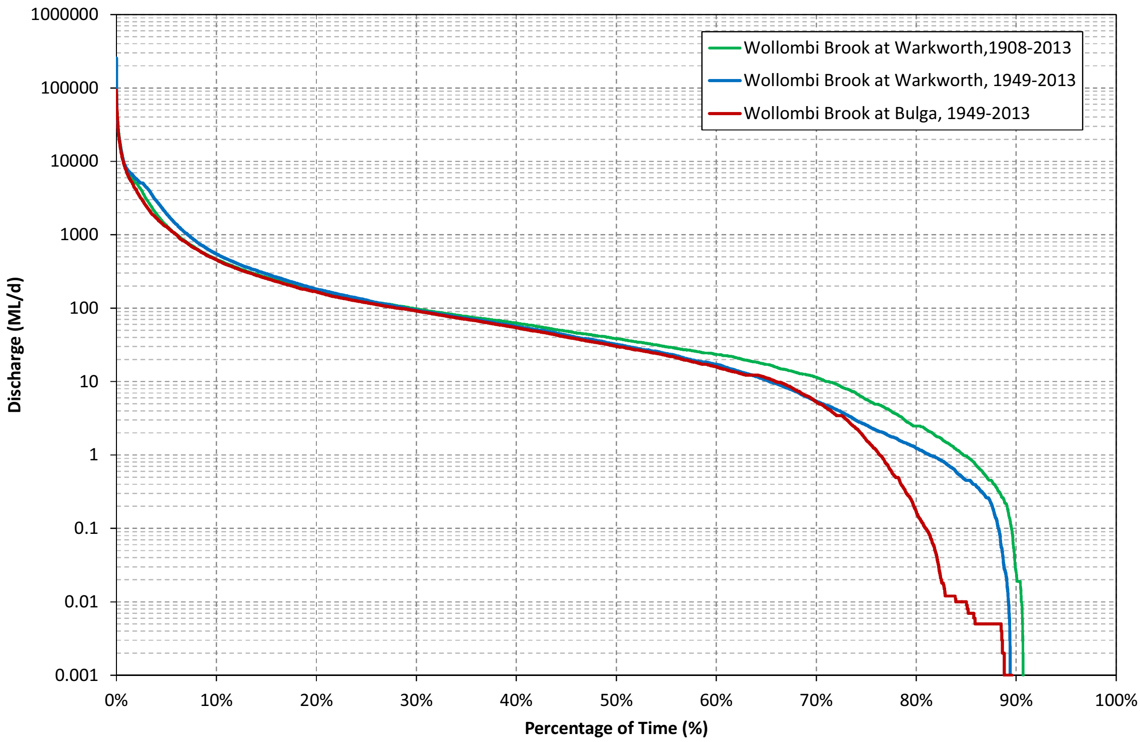

Figure 2.6 Stream Discharge Duration Curve #210004 Wollombi Brook at Warkworth, #210028 Wollombi Brook at Bulga

Table 2.3 shows the estimated annual runoff volume for the Wollombi Brook catchment to the Bulga gauge. The volumetric runoff coefficient is relatively high, with a mean value of about 11 per cent. There are no significant water storages on Wollombi Brook, however there is a high level of connectivity between surface water and the groundwater aquifer (ref. *Water sharing in the Lower Wollombi Brook water source*, http://www.hcr.cma.nsw.gov.au/water_sharing/macro_hunter_lowerwollombibrook.pdf).

Figure 2.7 shows a plot of annual runoff versus rainfall for the Wollombi Brook catchment at Bulga. Very little runoff is generated by the catchment when annual rainfall is less than about 400mm. Once annual rainfall exceeds this value, the volume of surface runoff increases substantially.

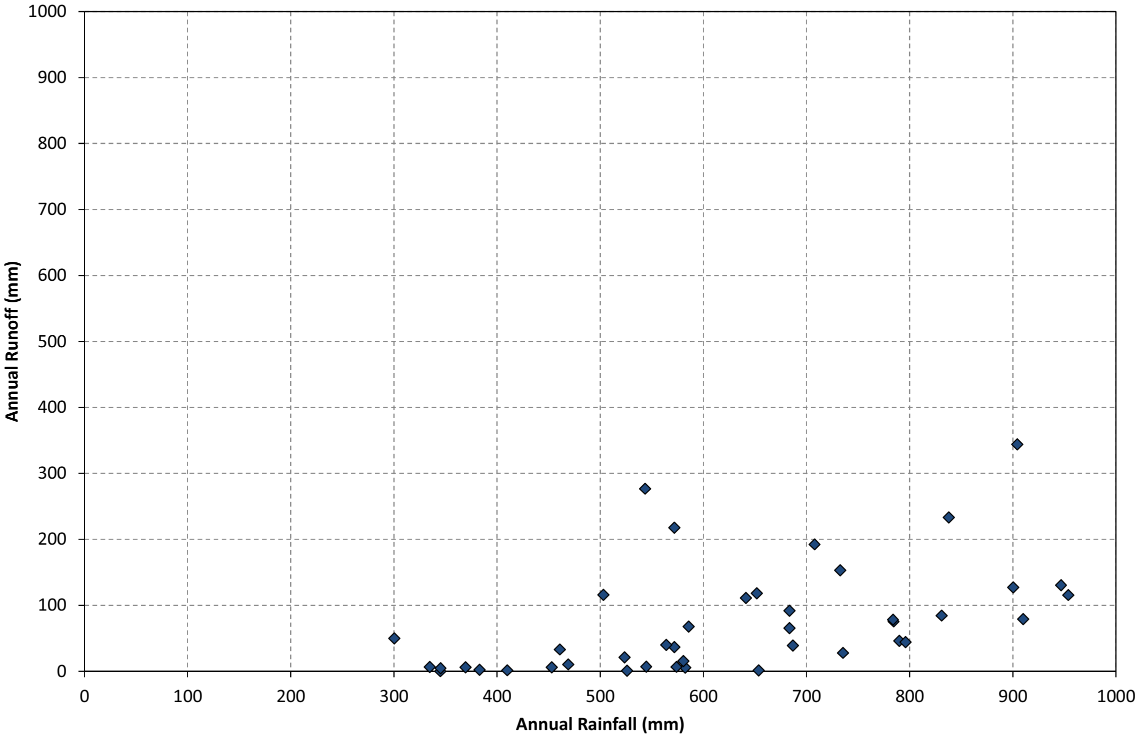

Figure 2.7 Annual Runoff versus Rainfall for Wollombi Brook at Bulga Gauging Station

Table 2.3 Annual Rainfall and Runoff Volumes for Wollombi Brook to Bulga Gauging Station

Year	Annual Rainfall [a] (mm)	Annual Runoff Volume (GL)	Annual Runoff Volume (mm)	Volumetric Runoff Coefficient
1953	544	463	277	0.509
1954	831	141	84	0.101
1955	572	364	217	0.380
1956	708	322	192	0.272
1957	335	11	6	0.019
1958	582	9	6	0.010
1963	904	575	344	0.380
1964	503	194	116	0.230
1965	383	4	2	0.006
1966	410	3	1	0.004
1967	586	113	68	0.116
1968	735	47	28	0.038
1969	790	77	46	0.058
1970	574	11	7	0.012
1971	641	186	111	0.173
1972	785	126	75	0.096
1973	796	74	44	0.055
1974	733	256	153	0.209
1975	572	61	37	0.064
1976	838	390	233	0.278
1977	652	197	118	0.181
1978	947	218	130	0.138
1979	581	26	15	0.026
1980	345	0	0	0.000
1981	784	131	78	0.100
1982	564	66	40	0.070
1983	545	12	7	0.013
1984	900	212	127	0.141
1985	687	65	39	0.057
1986	524	35	21	0.040
2001	684	153	92	0.134
2002	461	55	33	0.072
2003	526	2	1	0.002
2004	654	2	1	0.002
2005	369	10	6	0.016
2006	345	7	4	0.012
2007	954	193	116	0.121
2008	684	109	65	0.096
2009	469	17	10	0.022
2010	453	10	6	0.014
2011	910	132	79	0.087
2012	300	84	50	0.167
Mean	**623**	**123**	**73**	**0.108**

[a] Based on rainfall for the Broke (Harrowby) Station which has been adopted as representative of rainfall over the Wollombi Brook catchment.

An analysis of flow data for Wollombi Brook at the Bulga and Warkworth stream gauges indicates that a loss of flow is sometimes observed along the reach of Wollombi Brook adjacent to MTW, despite an additional catchment area of 176km^2 between the two stations. The magnitude of flow losses is difficult to quantify due to the potentially large impact of inaccuracies in the rating curves at both stream gauges. Since the accuracy of flow rating curves typically decreases as flow rate increases, periods that include moderate to high flows can sometimes indicate a large loss of flow which may be an artefact of the site rating curves rather than an actual loss of flow. For this reason, estimates of flow losses were made for periods that excluded high flows.

Table 2.4 shows the minimum, mean and maximum loss of monthly flow between the two stations. Results are shown for three cases, which each exclude flows above a threshold mean monthly flow. Note that months that showed an increase in flow were assigned a flow loss of zero. The analysis is based on 489 months from 1954 to 2013 over which corresponding flow data was available for both the Bulga and Warkworth stations.

The results of the low flow analysis, summarised in Table 2.4, show that the estimated loss of flow is sensitive to the adopted threshold of high flows that are excluded from the analysis. However, it is apparent that a measureable loss of flow from Wollombi Brook, perhaps of the order of 10 to 50ML per month, occurs adjacent to MTW under existing conditions.

Given the significant surface and groundwater entitlements in the area, some loss of flow along this reach is not unexpected. However, due to the large number of potential locations for extraction of flow, it is not possible to accurately determine where the flow loss is occurring.

Table 2.4 Assessment of Low Flow Losses, Wollombi Brook

	Flow Loss, Bulga to Warkworth (ML/month)		
Adopted Threshold Mean Monthly Flow [a]	**Minimum**	**Mean**	**Maximum**
30th percentile = 90 ML/d (2,740 ML/m)	0	70	1725
50th percentile = 29 ML/d (882 ML/m)	0	16	733
70th percentile = 6 ML/d (183 ML/m) b	0	3	156

[a] Months with mean monthly flow above the threshold value were not included in the analysis

2.5 EXISTING MINE WATER MANAGEMENT SYSTEM

The MTW water management system is a network of infrastructure (ie dams, pipelines, contour drains) to control the movement of water around the site and prevent unscheduled release of water off site. Water is managed according to its type. Water type is determined by catchment area, quality and use. The main types of water managed at MTW include mine water , sediment water and clean water.

Figure 2.8 shows the main elements of the water management system. Figure 2.9 shows a schematic diagram of the conceptual configuration of the existing mine water management system. The existing MTW mine water management system is described in detail in MTW's Water Management Plan (Coal & Allied, 2012).

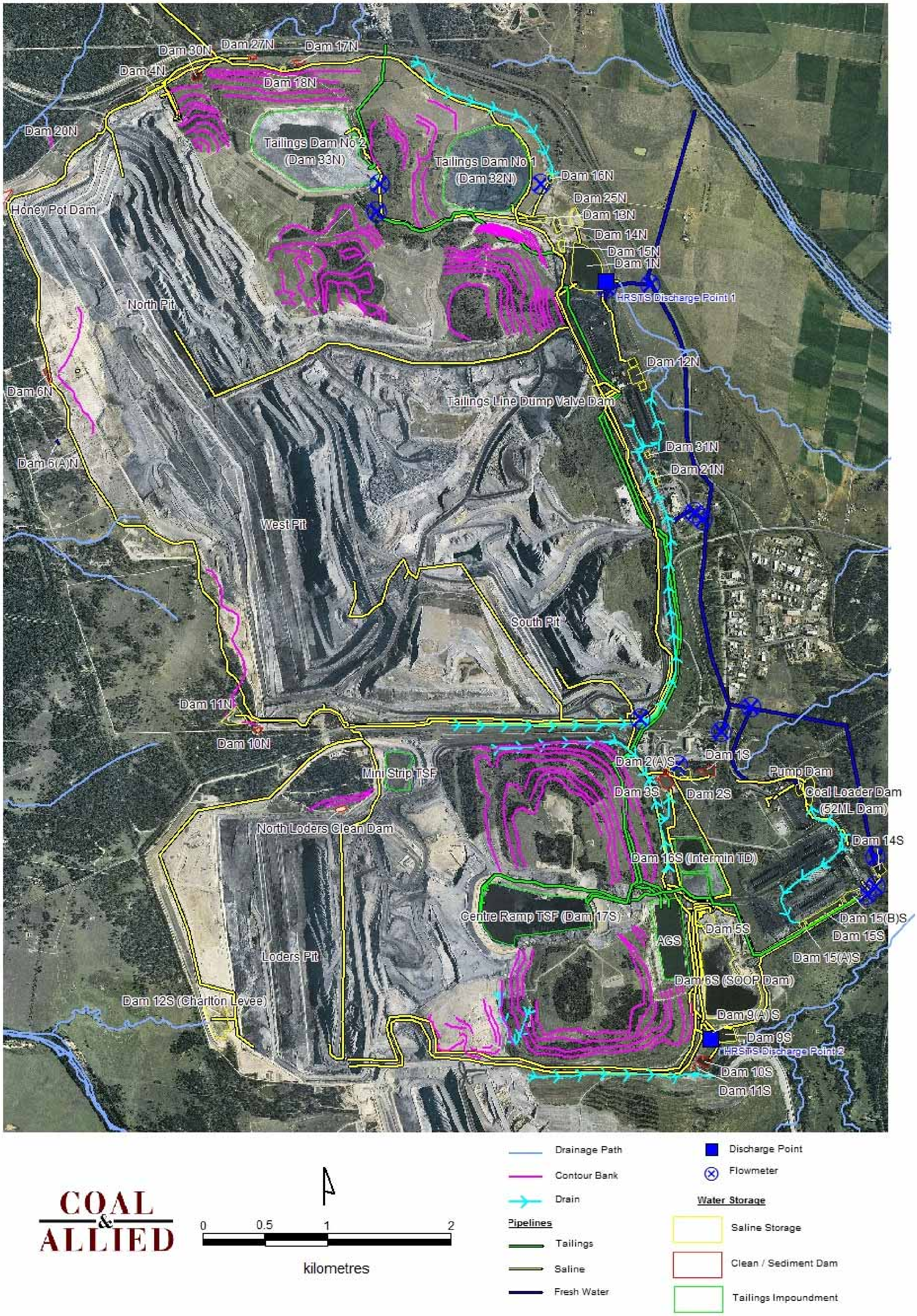

Figure 2.8 MTW Water Management System Infrastructure - Existing

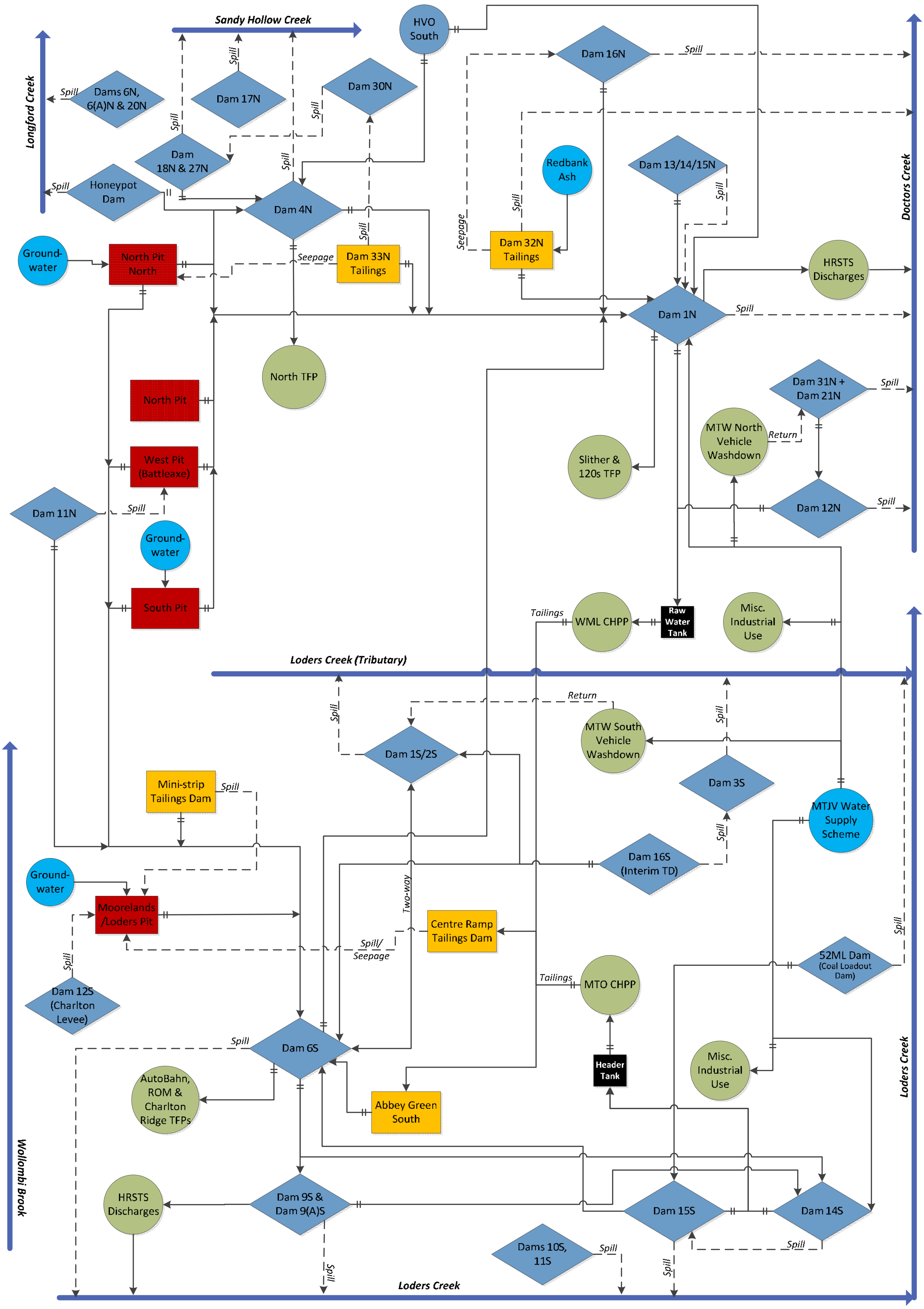

Figure 2.9 MTW Water Management System Schematic - Existing

2.6 SURFACE WATER QUALITY

2.6.1 New South Wales Office of Water (NOW) Monitoring

Hunter River water quality data has been collected by NOW since the 1970s. Discrete data collected in the Hunter River at Singleton (#210001) and Wollombi Brook at Warkworth (#210004) is summarised in Table 2.5 and compared to the trigger values in the Australia and New Zealand Environment Conservation Council (ANZECC) water quality guidelines (2000). Additionally, electrical conductivity (EC) has been monitored continuously at Wollombi Brook at Warkworth (#210004) since 1992, and Hunter River Upstream of Singleton (#210129) since 1993. Locations of the water quality gauging stations are shown in Figure 2.4. Note that the trigger value for mercury (ecosystem protection) is less than the Limit of Reporting; therefore it cannot be determined if the mercury values measured are higher or lower than the ANZECC trigger value for ecosystem protection.

Review of the NOW water quality data indicates the Hunter River:

- Is moderately alkaline, with a median pH of 8.24;
- Is fresh, with a median EC of 621µS/cm;
- Has a median value greater than the ANZECC guideline trigger value for pH (ecosystem protection), total nitrogen (ecosystem protection) and total phosphorus (ecosystem protection); and
- Has a median value lower than the ANZECC guideline trigger value for all other monitored parameters.

Review of the NOW water quality data indicates Wollombi Brook:

- Is slightly alkaline, with a median pH of 7.56;
- Is fresh, with a median EC of 595µS/cm;
- Has a median value greater than the ANZECC guideline trigger values for chloride (irrigation) and sodium (irrigation); and
- Has a median value lower than the ANZECC guideline trigger value for all other monitored parameters.

2.6.2 Coal & Allied Monitoring

Receiving Waters

Controlled discharges from Dam 1N and Dam 9S are directed to Doctors Creek and Loders Creek respectively, which are tributaries of the Hunter River. Runoff from undisturbed areas and small areas of disturbed catchment is treated via sediment dams on the site. Overflows from these sediment dams discharge to Wollombi Brook and Longford Creek (a tributary of Wollombi Brook), as well as Sandy Hollow Creek, Loders Creek and Doctors Creek (which are tributaries of the Hunter River). A tabular summary of the MTW surface water quality monitoring data for watercourses is detailed in Appendix A. Sampling locations are shown in Figure 2.10. Review of the site water quality monitoring results for receiving waters indicates:

- The Hunter River upstream of the Loders Creek confluence has a median EC of 645µS/cm and a median pH of 8.0. The Hunter River downstream of the Loders Creek confluence has a median EC of 630µS/cm and a median pH of 8.1.

- Loders Creek (water quality impacted by controlled discharges under the HRSTS) has a median EC of approximately 4,200µS/cm and a median pH of 8.1. Pre-mining water quality data (BHP Ltd, 1980) at Loders Creek indicated ECs varying between 2,000µS/cm and 14,200µS/cm, with an average of 7,100µS/cm. The salinity was attributed to seepage from the Saltwater Creek coal measures which sub-crop in areas of Loders Creek (MER, 2012).
- It is difficult to determine the Doctors Creek catchment runoff water quality characteristics, as the water quality is impacted by controlled discharges under the HRSTS. The water quality monitoring results indicate a median EC of 4,695µS/cm and a median pH of 8.2;
- Longford Creek has a median EC of 288µS/cm and a median pH of 7.4;
- Sandy Hollow Creek has a median EC of 270µS/cm and a median pH of 7.7;
- Wollombi Brook has a median EC of 680µS/cm and a median pH of 7.5; and
- Salt Pan Creek has a median EC of 16,810µS/cm and a median pH of 8.1.

Site Dams

The primary saline water storages at MTW (Dam 6S, Dam 1N and Dam 9S) are routinely monitored for EC, pH and turbidity. Additionally, a comprehensive analysis of water quality in a number of saline and sediment dams is undertaken on a quarterly basis. A tabular summary of the results of the MTW site water quality monitoring program for site dams is detailed in Appendix A. Locations of site dams are shown in Figure 2.8. Review of the site water quality monitoring results for the site dams indicates:

- The primary mine water storages at MTW (Dam 1N, Dam 6S and Dam 9S) are characterised as brackish and strongly alkaline, with median ECs of approximately 7,000µS/cm and median pH values of 8.7 to 9.0;
- Water quality of sediment dams varies considerably in salinity from fresh to brackish, with median ECs of between 300µS/cm and 8,400µS/cm. The sediment dams' water quality ranges from moderately alkaline to very strongly alkaline, with median pH values between 7.9 and 9.8.

2.6.3 Water Quality Monitoring Results Analysis

Box and whisker plots have been used to graphically depict water quality in the Hunter River to illustrate the spread of data at four locations:

- Upstream of Glennies Creek;
- Upstream of Loders Creek;
- Downstream of Loders Creek; and
- Upstream of Singleton.

Figure 2.11 and Figure 2.12 show box and whisker plots for EC and Total Suspended Solids (TSS) as measured in the Hunter River from both NOW and site monitoring locations over the period 2003 to 2013. Note that the monitoring frequency of samples by MTW and NOW are different (quarterly versus daily), and therefore results are not directly comparable and are to provide an indication only. Review of the results indicates that there is a slight decrease in EC downstream of the Loders Creek confluence. Additionally, the median EC downstream of Loders Creek is lower than upstream of Glennies Creek, indicating the releases from MTW do not appear to be adversely affecting salinity in the Hunter River. TSS levels increase slightly across the Loders Creek confluence.

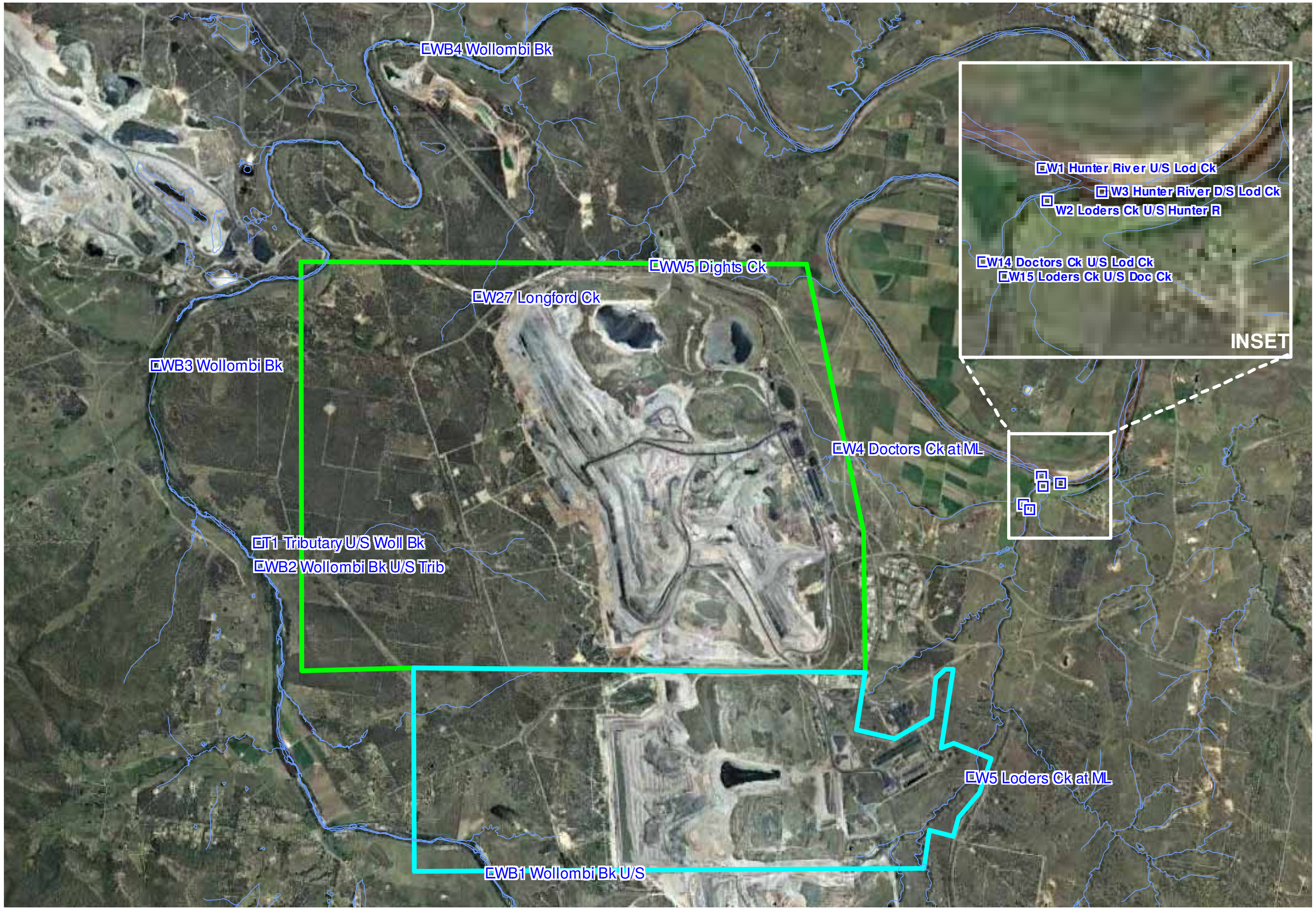

Figure 2.10 MTW Receiving Water Monitoring Locations

Table 2.5 Summary of Discrete NOW Water Quality Data - Hunter River at Singleton and Wollombi Brook at Warkworth (New South Wales Office of Water, 2011) and ANZECC Trigger Values

		ANZECC Trigger Value				Hunter River at Singleton			Wollombi Brook at Warkworth		
Parameter	**Unit**	**Irrigation**	**Livestock drinking**	**Eco-system^^**	**Recreational**	**90%ile**	**Median**	**Count**	**90%ile**	**Median**	**Count**
Aluminium as Al	mg/L	5 (LTV) 20 (STV)	5	0.055^^^^	0.2						
Arsenic as As	mg/L	0.1 (LTV) 2.0 (STV)	0.5	0.024 (As III) 0.013 (As V)	0.05						
Barium as Ba	mg/L				1						
Bicarbonate (HCO_3)	mg/L					275	221	70	232	513	9
Boron (Total)	mg/L	0.5	5	0.37	1	0.13	<LOR	38	0.13	<LOR	38
Calcium (Ca)	mg/L		1,000			50.0	37.0	70	26.0	19.9	9
Chloride as Cl	mg/L	175***			400	153	100	71	459	260	9
EC (uncompensated)	µS/cm	950***		125-2,200		820	621	687	1,172	595	64
EC (25C)	µS/cm					1,014	730	65	2,307	804	500
Iron as Fe (Soluble)	mg/L	0.2			0.3	0.121	0.004	8			
Iron as Fe (Total)	mg/L					0.711	0.035	52	0.83	0.25	6
Fluoride (Soluble)	mg/L	1 (LTV) 2 (STV)	2			0.52	0.22	39	0.39	0.39	1
Lead as Pb (Total)	mg/L	2 (LTV) 5 (STV)		0.0034		0.011	0.003	8	0.011	0.003	8
Lithium as Li	mg/L	2.5									
Magnesium as Mg	mg/L		2,000**			43.0	30.7	70	45.2	24.2	9
Manganese as Mn (Total)	mg/L	0.2 (LTV) 10 (STV)		1.9	0.1	0.155	0.057	10	0.155	0.057	10
Mercury as Hg (Total)	mg/L	0.002		0.0006		0.005	0.001	6			
Nitrite and nitrate as N	mg/L		30	0.7^^^	1	0.26	0.03	107	0.12	0.01	144
pH	pH	6.0 - 9.0		6.5 - 8^	6.5 - 8.5	8.51	8.24	483	8.08	7.56	276
Potassium as K (soluble)	mg/L					4.4	3.1	69	8.2	5.2	9
Selenium as Se (total)	mg/L	0.02 (LTV) 0.05 (STV)	0.02	0.011	0.01						
Silicon as Si	mg/L										
Sodium as Na (soluble)	mg/L	115***			300	100.3	71.6	70	265.4	171.6	9
Sulphate as SO_4	mg/L		1,000		400	80.0	38.2	70	53.8	29.0	9

		ANZECC Trigger Value				Hunter River at Singleton			Wollombi Brook at Warkworth		
Parameter	**Unit**	**Irrigation**	**Livestock drinking**	**Eco-system^^**	**Recreational**	**90%ile**	**Median**	**Count**	**90%ile**	**Median**	**Count**
Total Dissolved Solids (TDS)	mg/L		2,000*		1,000						
Total Nitrogen (Total N)	mg/L	5		0.5^		1.10	0.56	105	0.89	0.47	143
Total Phosphorus (Total P)	mg/L	0.05		0.05^		0.152	0.060	240	0.035	0.013	297
Total Suspended Solids (TSS)	mg/L					47	21	72	16	6	71
Turbidity	NTU										
Zinc as Zn (Total)	mg/L	2 (LTV) 5 (STV)	20	0.008	5	0.09	<LOR	23	0.09	<LOR	23

* Lowest recommended value.
** Cattle (insufficient information on other livestock).
*** Sensitive crops.
^ Lowland river (<150m altitude).
^^ 95 per cent of species protected.
^^^ Nitrate only.
^^^^ pH greater than 6.5.

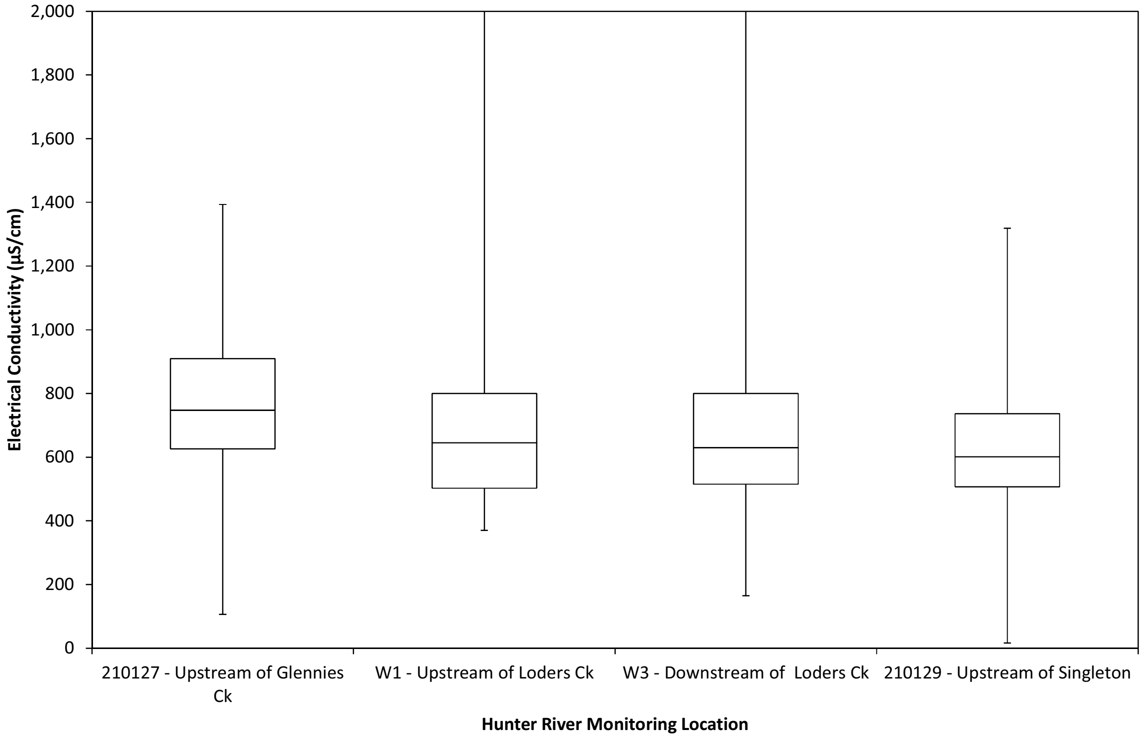

Figure 2.11 Hunter River EC Monitoring Data – Box and Whisker Plot

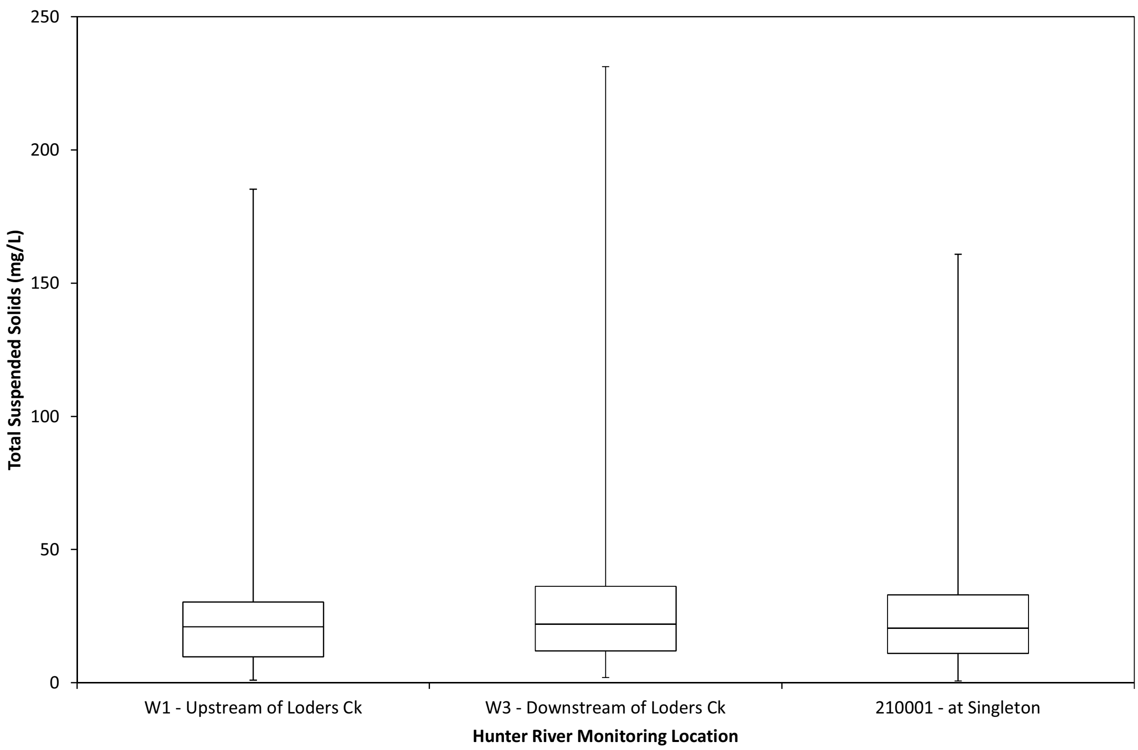

Figure 2.12 Hunter River TSS Monitoring Data – Box and Whisker Plot

3 RELEVANT LEGISLATION AND GUIDELINES

3.1 OVERVIEW

The following legislation, plans, policies and regulations are relevant to this assessment:

- *Protection of the Environment Operations Act 1997*;
- *Water Management Act 2000* and applicable Water Sharing Plans;
- State Water Management Outcomes Plan (SWMOP) and Hunter and Central Rivers Catchment Action Plan (CAP);
- Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002; and
- National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000) (refer Section 2.6).

The relevance of key legislation is briefly outlined in the following sections.

3.2 PROTECTION OF THE ENVIRONMENT OPERATIONS ACT 1997

Warkworth Mine and MTO are licensed under the *Protection of the Environment Operations Act 1997.* The existing licences (EPL 1976 for MTO and EPL 1376 for Warkworth Mine) make provision for release of water from the sites at Dam 1N and Dam 9S. Licence discharge limit conditions are the same for each EPL, as shown in Table 3.1.

Table 3.1 MTO & Warkworth Mine Discharge Conditions (EPL 1376 & 1976)

Pollutant	Unit	Limit
pH	pH units	Lower: 6.5 Upper: 9.0
Total suspended solids	mg/L	120
Volume	ML/d	100 (at each discharge location)

(NSW Government Office of Environment & Heritage, 2011)

3.3 WATER MANAGEMENT ACT 2000

3.3.1 Water Sharing Plans

The *Water Management Act 2000* applies to surface waters within the MTW area and the Hunter River itself through the following Water Sharing Plans:

1. **Hunter Unregulated and Alluvial Water Sources Water Sharing Plan 2009.** Surface water in Wollombi Brook and its tributaries is regulated under this plan. Water volumes extracted from these catchments require a water entitlement (an unregulated river access licence). The plan limits annual extraction to provide for no new growth in water entitlements.
2. **Hunter Regulated River Water Sharing Plan 2003.** All water extractions from the Hunter River will be managed under appropriate Water Access Licences (WALs). MTW holds approximately 1,012 ML/a of high security units of Hunter River water shares under the MTJV Supply Scheme. Water will continue to be extracted from existing licences and therefore, there will be no cumulative impact on water supplies in the Hunter River catchments caused by the proposal.

3.4 STATE WATER MANAGEMENT OUTCOMES PLAN (SWMOP) AND HUNTER AND CENTRAL RIVERS CATCHMENT ACTION PLAN (CAP)

The SWMOP (established under the *Water Management Act 2000*) and CAP (established under the *Catchment Management Authorities Act 2003*) set out the broad targets and strategic directions for the state and for the catchment. Natural resources features to be protected and enhanced are identified, along with actions to achieve key outcomes. The proposal is consistent with the SWMOP and CAP objectives because:

- Surface disturbance is restricted to the area covered by the application (the Site). Impacts will be mitigated within MTW's water management system described in Section 3. Erosion and sediment controls for the proposal will be designed and operated in accordance with 'Managing urban stormwater: soils and construction' requirements (Landcom, 2004);
- Any extraction of water will be in accordance with licensing provisions; and
- Discharges under the proposal will only occur in accordance with the site EPL and where applicable, the Hunter River Salinity Trading Scheme (HRSTS).

3.5 PROTECTION OF THE ENVIRONMENT OPERATIONS (HUNTER RIVER SALINITY TRADING SCHEME) REGULATION 2002

The HRSTS was introduced by the NSW Government to reduce salinity levels in the Hunter River, and operates under the Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002.

Releases of mine water to the Hunter River can be made in compliance with the conditions of an EPL and in accordance with credits purchased under the HRSTS. The HRSTS limits the quantity of salt that may be discharged through a cap and trade system that also restricts discharge to periods of high flow.

Under the HRSTS, credit holders are permitted to discharge saline water to the Hunter River on a managed basis. The aim is to maintain river salinity levels below 600µS/cm at Denman and 900µS/cm at Singleton. This is achieved through:

- Discharge scheduling that allows discharge only at times when the river flow and salinity level are such that salt can be discharged without breaching the salinity targets; and
- Sharing the allowable discharge according to licensed holdings of tradeable salinity credits.

The discharge schedule prohibits discharges during low flow periods. Discharges are regulated in proportion to credit holdings during high flow periods and unlimited discharges are permitted during flood flow periods, subject to tributary protection limits and the overarching requirement to achieve the upper limit salinity levels at Denman and Singleton.

A total of 1,000 credits are available for allocation through the scheme. Consequently, a holding of one credit entitles the owner to discharge 0.1 per cent of the total allowable discharge for the period.

If discharge of further excess water to the Hunter River system is required, under the scheme, credits may be obtained on a day to day basis through trade between licensed users, or, for long term use, through public auction.

Under the HRSTS, the Hunter River is separated into three sectors upstream of Singleton: Upper, Middle and Lower. MTW lies in the Lower Sector (downstream of Glennies Creek confluence). The HRSTS flow and river salinity thresholds for the Lower Sector are presented in Table 3.2.

Table 3.2 HRSTS Flow & River Salinity Thresholds, Lower Sector

Hunter River Flow Rate (ML/d)	Block Classification	River Target Salinity (EC)	Discharge Procedure
<2,000	Low	n/a	No discharges allowed
2,000 – 10,000	High	900µS/cm	Limited discharges allowed, controlled by salt credits and Total Allowable Discharge (TAD)
>10,000	Flood	900µS/cm	Unlimited discharges

(Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002*)*

The water in the river is divided into numbered blocks. The scheme operators monitor the flow and salinity in each block, and calculate the Total Allowable Discharge (TAD) of salt to meet the salinity target. Credit holders are notified via a dedicated website of the TAD and the start and end times for each release.

MTW is currently a Licence Holder and Scheme Participant of the HRSTS. Warkworth Mine currently hold 68 credits and MTO holds 78 credits, totalling 146 credits, which entitles MTW to discharge 14.6 percent of the TAD for a given period.

4 IMPACT ASSESSMENT

4.1 OVERVIEW

The potential changes to surface water and water management during the life of the proposal that have been investigated in the following sections comprise:

- Additional water demand from external third party sources (ie neighbouring mines or the Hunter River) to meet increased operational water requirements for the proposal;
- Loss of catchment area draining to Wollombi Brook and the Hunter River due to capture of runoff within onsite storages during mining. This could potentially reduce runoff volumes to Wollombi Brook and the Hunter River;
- Change in the quality of surface runoff draining from the local site catchment to Wollombi Brook and the Hunter River;
- Adverse impacts on downstream water quality associated with possible overflows from the mine water management system;
- Increase in saline water controlled discharges (HRSTS); and
- Interference with flood flows along Wollombi Brook and the Hunter River associated with changes in the respective flood plains.

4.2 MINE SITE WATER REQUIREMENTS

A significant proportion of mine site water requirements will be sourced from water collected on the site, including rainfall runoff and groundwater inflows to the open cut pits (Year 0 and Year 3) which will be transferred to the mine water management system for recycling.

The results of the water balance modelling (see Section 6.6) show that external water may be required to meet all site demands. Total external water requirements are characterised as:

- A minimum of 140ML/a of external raw water (from the Hunter River) will be required for the life of the proposal. This is consistent with site demands of industrial use and vehicle wash of around 140ML/a which are supplied from raw water sources only;
- There is a 90 per cent chance that at least 450ML of external water will be required in any year of project life.
- A step change in external water requirement occurs in around Year 2 which is consistent with the decrease in pit inflows at MTO, and an increase in production at Warkworth Mine. External water requirement from Year 3 to Year 21 is generally consistent with:
  - A 50 per cent chance that between 1,500ML/a to 2,000ML/a of external water will be required; and
  - A 10 per cent chance that between 3,000ML/a to 3,700ML/a of external water will be required.

MTW has identified the following possible sources of additional water for the proposal, which will be negotiated on an as-needed basis when mutually beneficial:

- Water sharing with Hunter Valley Operations (directly to the north of Warkworth Mine). This strategy has been successfully adopted in the past;
- Water sharing with Bulga Coal Complex (directly to the south of MTO); and
- Water sharing with Wambo Mine.

If required, additional water licences would be sought and purchased by Coal & Allied over the life of the project to meet external water demands. As all off-site water supplies for the project would be obtained from licensed sources, there will be no adverse impact on other licensed users who will still have access to their entitlement (subject to climatic conditions and the operation of the water supply scheme).

4.3 LOSS OF CATCHMENT AREA

During active mining operations, the mine water management system will capture runoff from areas that would have previously flowed to Wollombi Brook or the Hunter River. The indicative mine plans are shown in Figure 6.4 to Figure 6.11 for Years 3 to 21. A breakdown of the catchment areas reporting to the mine storages is provided in Appendix B.

Table 4.1 shows the total catchment area captured within the MTW mine water management system over the life of the proposal, including sediment dam areas. The maximum captured Wollombi Brook area of 10.5km^2 occurs during Year 14 to Year 22 of the proposal, representing 0.56 per cent of the Wollombi Brook catchment to the confluence of the Hunter River. Note that although the catchment area of sediment dams is included in the catchment loss calculations, these sediment dams may overflow to Wollombi Brook during periods of rainfall, reducing the volume of water lost from the downstream catchment. Refer to Section 4.6.2 for further information on the Hunter River flow volume.

Table 4.1 also shows the catchment area captured in the final landform (including the South Pit void). The final landform restored the Hunter River catchment area (excluding the Wollombi Brook catchment) to 99.96 per cent of its pre-mining catchment area. The final landform captures 8.6km^2 or 0.44 per cent of the Wollombi Brook catchment to the confluence of the Hunter River.

Table 4.1 Receiving Waters Catchment Area during and after MTW Mining Operations

Mine Stage	Wollombi Brook to Hunter River confluence		Hunter River (excluding Wollombi Brook) to Singleton	
	Area (km²)	Proportion of Pre-mining Area (%)	Area (km²)	Proportion of Pre-mining Area (%)
Pre-Mining	1,888	100%	16,400	100%
Existing (2013)	1,885	99.84%	16,371	99.82%
Proposal				
Year 0	1,885	99.84%	16,371	99.82%
Year 3	1,881	99.79%	16,368	99.81%
Year 9	1,878	99.60%	16,368	99.81%
Year 14	1,878	99.44%	16,368	99.81%
Year 21	1,878	99.44%	16,368	99.81%
Final Landform	1,879	99.54%	16,394*	99.96%

Notes: * Includes South Pit final void.

4.4 SURFACE WATER QUALITY

The MTW water management plan has the following key objectives in relation to surface water quality of receiving waters:

- Preferential re-use of poor quality mine water in preference to clean water;
- Minimise the use of fresh water; and
- Protect clean water systems.

Potential impacts on surface water quality in the receiving waters will be managed by implementation of the following measures:

- MTW site water management system (detailed in Section 6.5);
- Compliance with HRSTS discharge limits (detailed in Section 6.5.8);
- Sediment and Erosion Control Plan (detailed in Section 7.3); and
- Surface water monitoring program (detailed in Section 7.5).

The results of the water balance modelling show that no uncontrolled release of saline water occurs over the life of the proposal. Excess saline water is released in accordance with the existing rules of the HRSTS. Downstream impacts on surface water quality as salinity will be in accordance with the acceptable limits under the HRSTS. Refer to Section 4.6.4 for impacts on other water quality parameters.

4.5 UNCONTROLLED OFFSITE RELEASES

The results of the water balance modelling indicate that under the current model assumptions and configuration, there is a low risk of the MTW water management system accumulating water over the 21 year project life. The results show that the system recovers well after each wet season. The model results show no uncontrolled spills of saline water from the saline water storages.

Overflows of water from sediment dams will occur during wet periods that exceed the design standard of the sediment control system (as per the design intent). Monitoring of sediment dams' water quality will continue, as described in Section 7.5.

4.6 IMPACTS OF CONTROLLED RELEASES UNDER HRSTS

4.6.1 Overview

MTW is a current participant of the HRSTS, which provides the opportunity to discharge saline water without exceeding salt concentration limits in the Hunter River. Further details of the HRSTS are provided in Section 3.5. Under the proposal, MTW will continue to be a Scheme participant. Controlled discharges are currently made from Dam 9S at MTO, and Dam 1N at Warkworth Mine. The proposal seeks an increase in the maximum release rate at MTO to 300ML/d (currently 100ML/d); however, the release rate of Warkworth Mine will remain unchanged. The water balance has modelled a discharge rate of 200ML/d at MTO, to be conservative with regards to mine water containment performance.

Figure 4.1 and Figure 4.2 show the simulated annual controlled discharges to the Hunter River under the HRSTS from MTO and Warkworth Mine, respectively. Review of the results shows that:

- Overall, much greater volumes are discharged from MTO than Warkworth Mine, which is consistent with the capacity of the discharge structures (200ML/d at MTO and 100ML/d at Warkworth Mine) and dam volumes;
- There is a 50 per cent chance of controlled releases from MTO will not be required in any year of the life of the proposal, and small volumes of controlled discharges (100ML) will be required from Warkworth Mine in any year of the life of the proposal; and
- There is a 10 per cent chance of controlled releases from MTO of between 1,000ML to 2,000ML will be required in any year of the life of the proposal, and around 400ML from Warkworth Mine in any year of the life of the proposal.

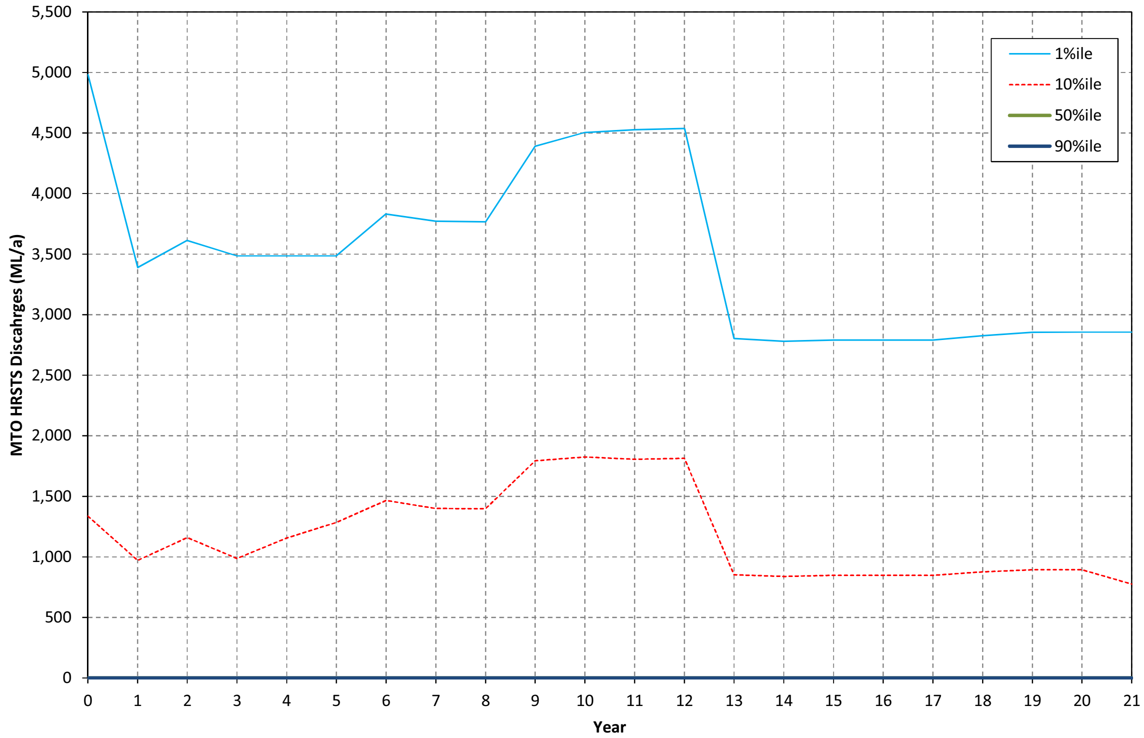

Figure 4.1 MTO Discharges to Hunter River

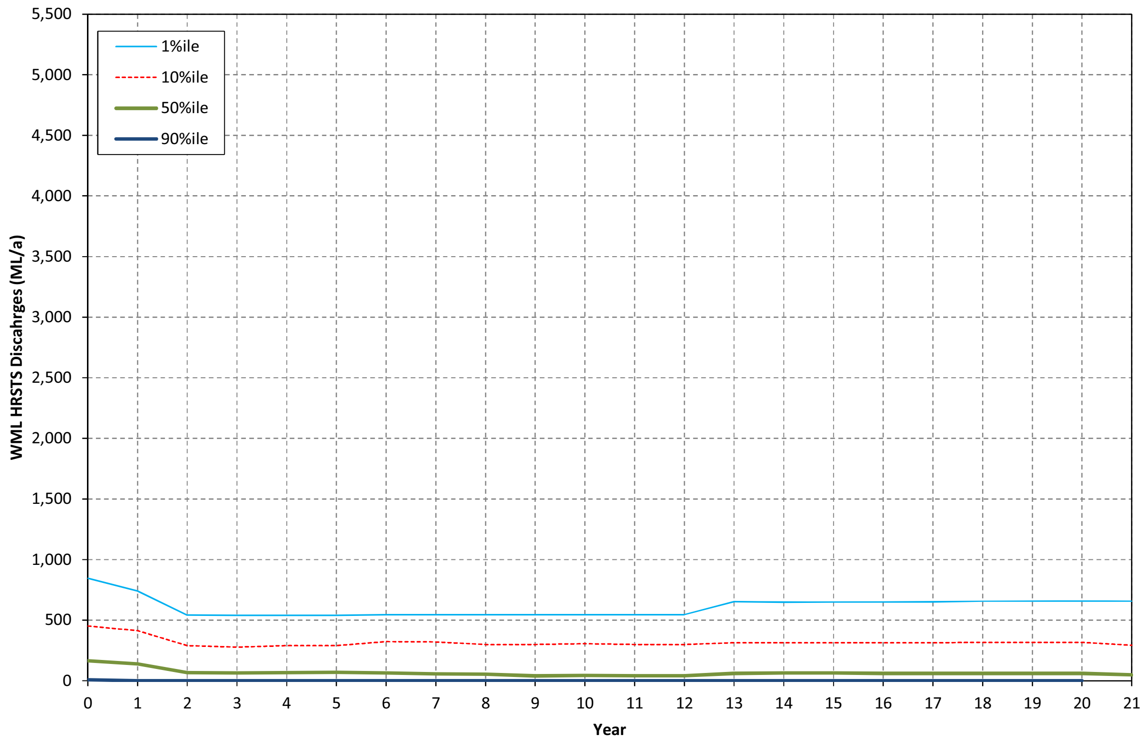

Figure 4.2 Warkworth Mine Discharges to Hunter River

Controlled releases of saline water under the HRSTS have the following potential impacts:

- Impacts on the total flow volume in the Hunter River;
- Impacts on stream condition, including bank erosion; and
- Water quality impacts.

These potential impacts are discussed in the following sections.

4.6.2 Hunter River Flow Volume

Table 4.2 shows the net impact of the MTW water management system on Hunter River flow volumes over the life of the proposal. The median runoff captured in the system is based on the captured catchment areas (see Appendix B), and the harvestable rights runoff coefficient (0.07ML/ha). The simulated median controlled discharges (HRSTS) and simulated median sediment dam overflows to the Hunter River are used to estimate the median net reduction in runoff in the Hunter River. The HRSTS discharges and sediment dam overflows offset the reduction in Hunter River flows caused by the loss of catchment area. The results show that the median annual reduction in flows to the Hunter River varies between 16 and 75ML/a during the life of the proposal, and the median annual reduction is 104ML/a post-mining. This is approximately 0.02 per cent of the median annual Hunter River discharge to Singleton (estimated from NOW's IQQM model - full development case with 2004 water sharing plan rules).

Table 4.2 Net Impact of Mine Water Management System on Hunter River Flow Volumes over Project Life

Mine Stage	Median Runoff Captured (ML/a)	Median Discharge to Hunter River (ML/a)	Median Sedimentation Dam Overflows (off-site)	Median Net Runoff Reduction (ML/a)
Year 0 (existing)	225	181	25	19
Year 3	215	81	118	16
Year 9	231	40	116	75
Year 14	246	66	151	29
Year 21	243	48	154	41
Post-Mining	104	0	0	104

Figure 4.3 shows the impact of MTW HRSTS discharges on the Hunter River flow characteristics (IQQM simulated). Flow characteristics are shown for the wettest and driest realisations (defined by the total flow in the Hunter River over the simulated 22 year period of the life of the proposal), for scenarios both with and without MTW HRSTS discharges. Note that under the rules of the HRSTS, discharges only occur when flows in the Hunter River are greater than 2,000ML/d, and a maximum total discharge rate from MTW of 300ML/d has been simulated. Results show that the impacts of HRSTS discharges on the Hunter River flow characteristics are negligible during both wet periods and dry periods.

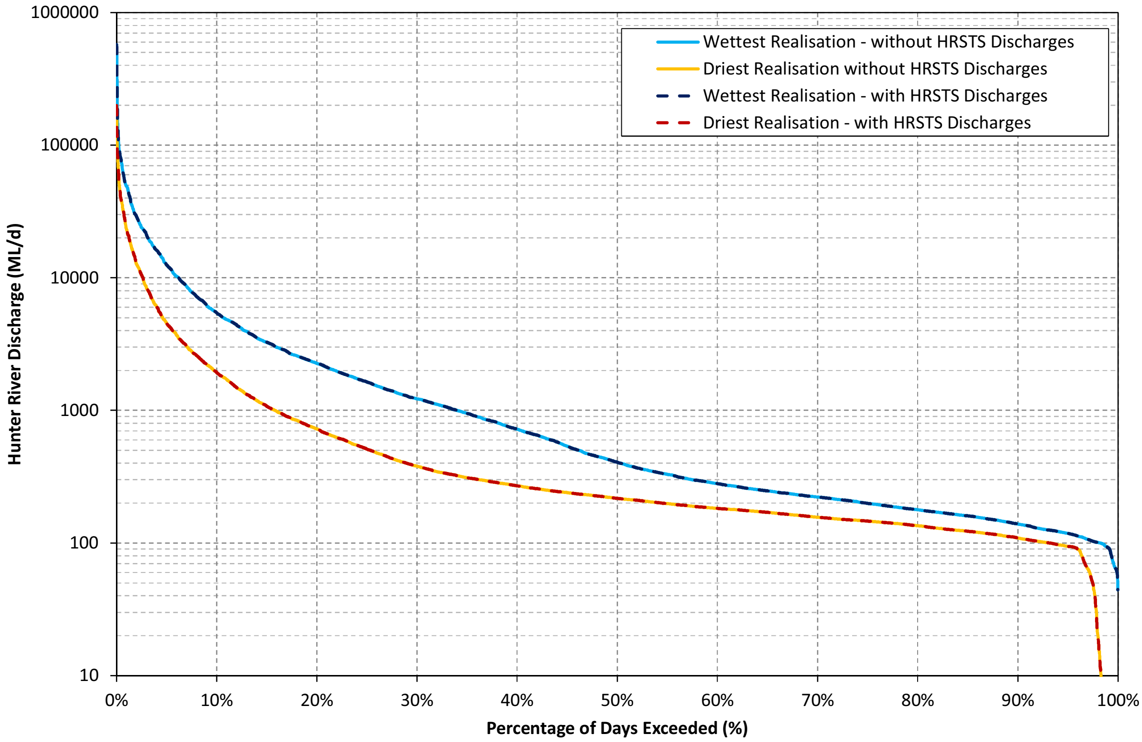

Figure 4.3 Hunter River Discharges (IQQM Simulated) Flow Characteristics – Impact of MTW HRSTS Discharges

4.6.3 Stream Condition

The proposed flow rate of the controlled discharge will be less than 300ML/d (3,500L/s) from Dam 9S to Loders Creek (increased rate of discharge from current approval), and less than 100ML/d (1,160L/s) from Dam 1N to Doctors Creek (no change to approved rate of discharge). It is possible that controlled discharges may occur at times when there is no natural flow in Loders Creek or Doctors Creek. Note that current MTW operations have discharged flows of this magnitude to Doctors Creek in the past when required and it is not expected that discharges under the proposal will have an additional impact on the stream condition of Doctors Creek to that already experienced under the current operations.

The mine directly adjacent to MTO to the south (Bulga Coal Mine (BCM)) is also currently seeking approval for an increased controlled discharge rate to Loders Creek. The Bulga Optimisation Project (Umwelt, 2014) has estimated a maximum sustainable discharge to the Loders Creek system with considerations of potential cumulative impacts of discharges from both MTO and BCM. The results of the analysis are summarised as:

- There is one area of erosion risk identified in Loders Creek downstream of MTO discharges;
- Hydraulic analysis indicates that limited the peak discharge rate to 60 per cent of the bank full capacity will most likely ensure a low risk of erosion during discharges;
- Bank full capacity in Loders Creek upstream and downstream of the Northern Dam tributary (a dam proposed in the BOP) is 23.6m^3/s and 43.4m^3/s, respectively. Therefore the maximum discharge at 60% of the bank full capacity is 14.2m^3/s (1,200ML/d) and 26.0m^3/s (2,250ML/d), respectively.

- Due to the locations of the discharge points at BCM, the BCM discharge rates are limited by the upstream creek capacities. The BCM proposed discharge rates are therefore much less than the 60% bank full flows for the downstream reaches of Loders Creek.
- The BCM proposed maximum discharge rate upstream of the Northern Dam tributary is 300ML/d; and 800ML/d downstream of the Northern Dam tributary.

The MTO and BCM combined maximum discharges rates of 600ML/d upstream of the Northern Dam tributary and 1,100ML/d downstream of the Northern Dam tributary are significantly less than the 60% bank full capacity of Loders Creek. Therefore it is considered that there is a low potential risk of erosion during discharges in Loders Creek downstream of the MTO discharge location.

As specified under the rules of the HRSTS, controlled discharges may only occur when the 'high' or 'flood' flow block is passing MTW. Therefore, controlled releases from the proposal will only occur when the Hunter River is in an increased state of flow (at least 2,000ML/d). Based on the comparatively low controlled discharge rate, it is not expected that controlled discharges would result in adverse hydraulic impacts on the Hunter River, such as increased bed and bank erosion.

4.6.4 Water Quality Impacts

Discharges under the HRSTS are controlled so that the salt concentration in the Hunter River Lower Sector (downstream of Glennies Creek confluence) does not exceed 900µS/cm. An important component of meeting the salinity goal is to discharge the salt load evenly throughout the discharge period to avoid short periods of elevated salinity in the Hunter River (DECCW, 2010).

Controlled discharges from the proposal will continue to be released in accordance with HRSTS and EPL 1376 and 1976 requirements.

Table 4.3 shows a comparison of site and NOW water quality monitoring data in the Hunter River in the vicinity of MTW, with ANZECC (2000) guideline trigger values and site water quality monitoring at the discharge dams. The comparison shows:

- Discharge dam water quality (median) is better than Hunter River water quality and the lowest recommended ANZECC guidelines trigger value for the following parameters:
  - Manganese, selenium, phosphorus (total) and zinc.
- Discharge dam water quality (median) is better than the lowest recommended ANZECC trigger value, but worse than the Hunter River water quality for the following parameters:
  - Arsenic, boron, barium, calcium, calcium carbonate, iron (filtered), potassium, lithium, magnesium, rubidium, and strontium.
- Discharge dam water quality (median) is poorer than the lowest recommended ANZECC trigger value but better than the Hunter River water quality for the following parameter:
  - Aluminium.
- Discharge dam water quality (median) is poorer than the lowest recommended ANZECC trigger value and the Hunter River water quality for the following parameters:
  - Chloride, sodium and sulphate.

It is likely that the elevated sodium and chloride concentrations are the main salt component of the salts generated on site, discharges of which are controlled by the HRSTS. The ANZECC guideline trigger value of 115mg/L for sodium and 175mg/L for chloride applies to irrigation of sensitive crops. A trigger value of 300mg/L for sodium and 400mg/L for chloride applies for recreational use. There are no sodium or chloride trigger values for livestock drinking or ecosystem protection.

The median sulphate levels in the discharge dams exceed the ANZECC guideline trigger value for recreational use (400mg/L), and are equal to the ANZECC guideline trigger value for livestock drinking use (1,000mg/L).

As controlled discharges occur during high flow events in the Hunter River, significant dilution of discharges is expected. The 'worst case' dilution ratio for MTW discharges to Hunter River flows is 1:5 (400ML/day discharge rate to 2,000ML/day minimum flow required in the Hunter River flow for discharge under HRSTS). In the immediate vicinity of the Loders Creek confluence with the Hunter River, inside a mixing zone, contaminant concentration will be elevated compared to adjacent areas. However, secondary velocity currents induced by the nearby channel bends and turbulence induced by the riparian vegetation will promote mixing of the discharge water with the Hunter River flow. It is therefore likely that complete mixing of the discharge water with the river flow will occur within a few hundred metres of the outlet.

Table 4.3 Water Quality - Hunter River and MTW Discharge Dams

Water Quality Parameter		ANZECC (2000)	Hunter River		Discharge Dam	
		Trigger Value (Lowest)	W1 – U/S Loders Ck (Site monitoring)	At Singleton (NOW monitoring)	Dam 1N	Dam 9S
Al - Total (mg/l)	10%ile	0.055	0.33	-	0.09	0.26
	Median	(Ecosystem)	0.52	-	0.16	0.38
	90%ile		5.73	-	10.06	0.71
	N		5	-	5	9
As - Total (mg/l)	10%ile	0.013	0.001	-	0.001	0.002
	Median	(Ecosystem)	0.001	-	0.013	0.007
	90%ile		0.001	-	0.017	0.025
	N		10	-	10	13
B (mg/l)	10%ile	0.37	0.00		0.06	0.08
	Median	(Ecosystem)	0.04	<LOR	0.08	0.10
	90%ile		0.05	0.13	0.11	0.12
	N		9	38	10	13
Ba (mg/l)	10%ile	1	0.022	-	0.015	0.027
	Median	(Recreational)	0.031	-	0.033	0.051
	90%ile		0.085	-	0.114	0.085
	N		9	-	9	12
Ca - Total (mg/l)	10%ile	1,000	27		15	7
	Median	(Livestock	39	37.0	40	13
	90%ile	drinking)	44	50.0	50	17
	N		7	70	18	8
$CaCO_3$ - Total Hard (mg/l)	10%ile		77	-	502	200
	Median		163	-	590	200
	90%ile		249	-	848	200
	N		2	-	13	1
Cl- (mg/l)	10%ile	175	132		-	856
	Median	(Irrigation)	136	100	-	946
	90%ile		140	153	-	964
	N		2	71	0	3

Water Quality Parameter		ANZECC (2000)	Hunter River		Discharge Dam	
		Trigger Value (Lowest)	W1 – U/S Loders Ck (Site monitoring)	At Singleton (NOW monitoring)	Dam 1N	Dam 9S
Fe - Filtered (mg/L)	10%ile	0.2 (Irrigation)	0.03		0.02	0.01
	Median		0.12	0.004	0.05	0.01
	90%ile		0.21	0.121	0.09	0.01
	N		3	8	4	1
K - Total (mg/l)	10%ile	-	3		23	27
	Median		4	3.1	36	30
	90%ile		4	4.4	44	34
	N		7	69	5	8
Li (mg/l)	10%ile	2.5 (Irrigation)	0.002	-	0.131	0.197
	Median		0.005	-	0.275	0.212
	90%ile		0.030	-	0.358	0.294
	N		5	-	5	9
Mg - Total (mg/l)	10%ile	2,000 (Livestock drinking)	23		25	13
	Median		28	30.7	36	19
	90%ile		35	43.0	67	25
	N		7	70	6	9
Mn - Total (mg/l)	10%ile	0.1 (Recreational)	0.056		0.004	0.005
	Median		0.110	0.057	0.008	0.011
	90%ile		0.352	0.155	0.046	0.030
	N		9	10	9	12
Na - Total (mg/l)	10%ile	115 (Irrigation)	42	-	1,306	1,720
	Median		73	-	1,800	1,860
	90%ile		80	-	1,900	2,197
	N		7	-	5	8
P - Total (mg/l)	10%ile	0.05 (Irrigation & Ecosystem)	0.06		0.01	0.01
	Median		0.09	0.060	0.02	0.02
	90%ile		2.35	0.152	0.48	0.03
	N		6	240	6	9
Rb - Total (mg/l)	10%ile	-	0.001	-	0.043	0.048
	Median		0.002	-	0.061	0.055
	90%ile		0.004	-	0.063	0.060
	N		5	-	5	9
Se (mg/l)	10%ile	0.01 (Recreational)	0.00	-	0.00	0.00
	Median		0.00	-	0.01	0.01
	90%ile		0.05	-	0.01	0.01
	N		9	-	10	13
Si (mg/l)	10%ile	-	3.01	-	5.62	5.30
	Median		12.20	-	6.25	6.40
	90%ile		14.82	-	7.65	9.24
	N		4	-	4	5
SO_4 - Total (mg/l)	10%ile	400 (Recreational)	26		444	730
	Median		34	38.2	1,011	939
	90%ile		145	80.0	1,304	1,290
	N		8	70	10	11

Water Quality Parameter		ANZECC (2000)	Hunter River		Discharge Dam	
		Trigger Value (Lowest)	W1 – U/S Loders Ck (Site monitoring)	At Singleton (NOW monitoring)	Dam 1N	Dam 9S
Sr - Total (mg/l)	10%ile	-	0.125	-	0.316	0.382
	Median		0.380	-	0.640	0.648
	90%ile		0.490	-	0.833	0.882
	N		5	-	5	9
Zn - Total (mg/l)	10%ile	0.008 (Ecosystem)	0.005		0.005	0.005
	Median		0.005	<LOR	0.005	0.005
	90%ile		0.019	0.09	0.036	0.021
	N		10	23	10	13

4.7 FLOODING AND STREAM GEOMORPHOLOGY

The potential interactions between the proposed operations and the 1 in 100 year Average Recurrence Interval (ARI) design flood event for the Hunter River to the east and Wollombi Brook to the west has been investigated. The proposal will not result in any additional flood risk to infrastructure adjacent to the Hunter River along the eastern side of the mining lease (see Section 5).

The results of a flood study for Wollombi Brook (see Section 5) indicate that the proposal is located outside the 100 year ARI flood extent for Wollombi Brook. Hence, the proposal will not impact on flooding behaviour in Wollombi Brook and will not have any measurable effect on the geomorphology of Wollombi Brook.

4.8 WATER ALLOCATIONS

The water management system for the proposal has been designed to minimise the capture of clean runoff wherever possible.

Dams solely for the capture, containment and recirculation of mine affected water consistent with best management practice to prevent the contamination of a water source are "excluded works" and are exempt from the requirement for water supply works approvals and WALs under the Water Management Act 2000. On this basis, water captured in the site water management structures, with the exception of rainfall runoff from undisturbed natural catchments, is not subject to licensing.

The capture of runoff from undisturbed natural catchment draining to any of the proposal's water management dams and mining areas may require a Water Access Licence (WAL). Figure 4.4 shows the clean water catchment areas requiring a WAL for runoff capture. Table 4.4 shows the estimated average volume of water captured within the water management system over the life of the proposal.

The intercepted average and maximum annual runoff has been estimated using average and maximum annual rainfalls at Jerrys Plains (Station No. 061086) of 644.5mm and 1,191.2mm respectively. A volumetric runoff coefficient of 0.108 has been used based on the runoff coefficient utilised for harvestable rights calculations at MTW (10 per cent of runoff =

0.07ML/ha = 7mm runoff. 100 per cent of runoff = 70mm. 70mm/644.5mm average annual rainfall = 10.8 per cent).

The total unregulated river access entitlement for the Hunter Unregulated and Alluvial Water Sources is 80,619 units (ML/a). The proposal is located on the boundary of the Singleton Water Source and the Lower Wollombi Brook Water Source, which have unregulated river access component shares of 960 units (ML/a) and 6,663 units (ML/a), respectively.

The predicted average annual impacts on the share components for the Singleton Water Source (67.3 ML/a) and for the Lower Wollombi Brook Water Source (10.0ML/a) under the Hunter Unregulated and Alluvial Water Sources Water Sharing Plan is approximately 8 per cent and 0.1 per cent, respectively, on an annual average basis for the life of the proposal.

MTW holds approximately 1,012ML/a of high security units of Hunter River water shares under the Mount Thorley Joint Venture (MTJV) Supply Scheme.

The total surface water entitlement (general and high security access licences) for the Hunter Regulated River water source is 151,792 units (ML/a). The proposal is located in Management Zone 2, which has an entitlement of 57,094 units (ML/a).

The MTW contiguous land holdings for the harvestable rights calculation are 4,007 ha in the Hunter River catchment and 2,667 ha in the Wollombi Brook catchment. At a harvestable right of 0.07ML/a, this equates to a volume of 280ML and 187ML in the Singleton and Lower Wollombi Brook Water Sources respectively.

Table 4.4 Surface Water Allocations

Water Sharing Plan		Hunter Unregulated and Alluvial Water Sources		Hunter Regulated River
Water Source		**Lower Wollombi Brook**	**Singleton**	**Hunter Regulated River**
Predicted annual take (ML/a)	Average	10	73	1,876
	Maximum	18	135	4,410
Predicted annual impact on water source (%)	Average	0.1	8	3.3
	Maximum	0.3	14	7.7
MTW current licences/ Harvestable Right		187 ML/a	280 ML/a	1,012 units
Additional water potentially required for the integrated operation (ML/a)	Average	0	0	864*
	Maximum	0	0	3,398*

Notes: * These volumes may be obtained from surplus mine water from nearby mining operations under water sharing agreements - refer Section 4.2.

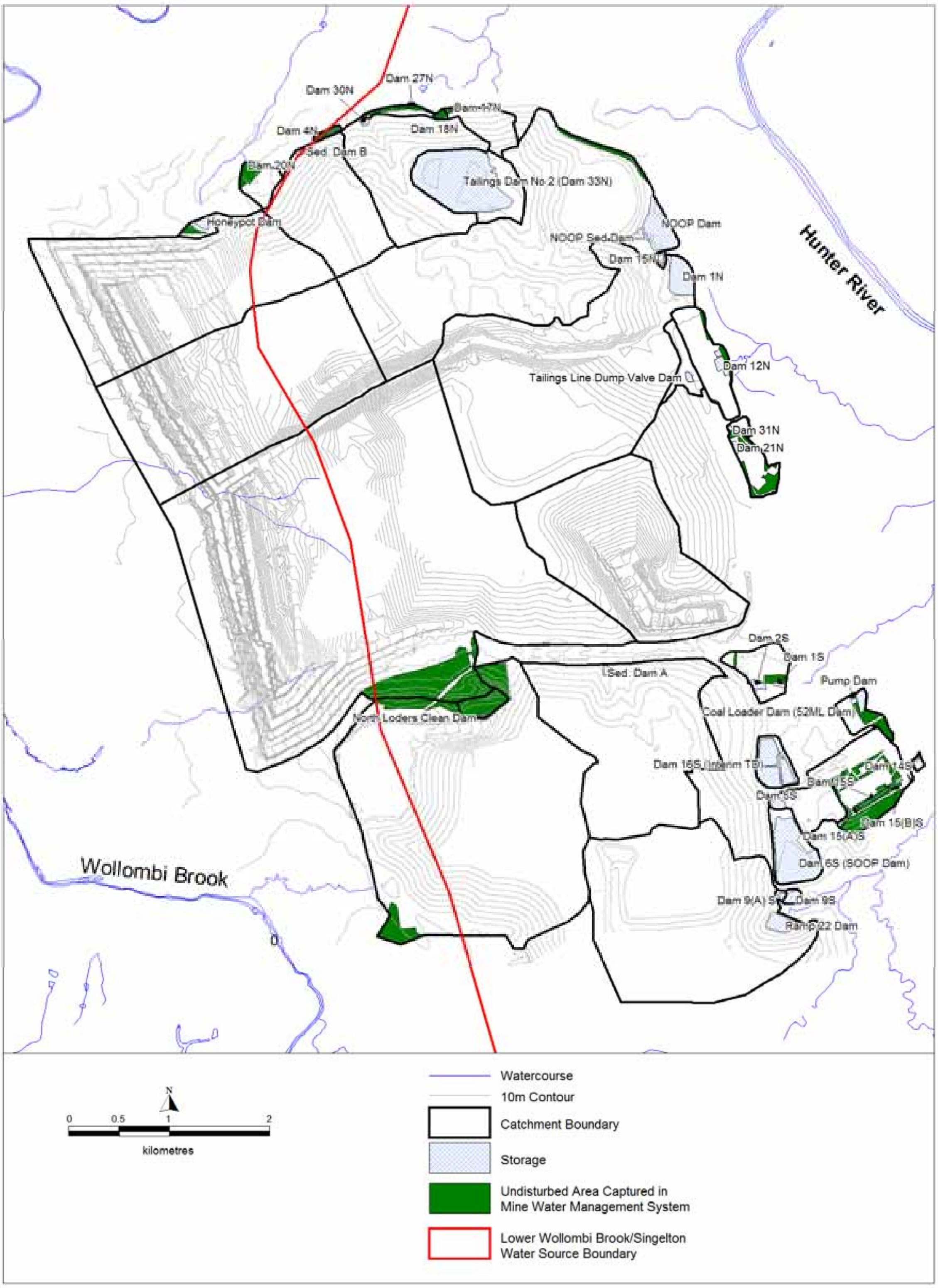

Figure 4.4 Undisturbed Catchment Areas Requiring Water Allocation Licence for Runoff Capture

5 FLOODING

5.1 OVERVIEW

The proposal may potentially impact on flooding in the Hunter River to the east and Wollombi Brook to the west. Since the proposal involves the advancement of mining to the west, there will be no increase in flood risk to infrastructure along the eastern side of the mining lease from the Hunter River. A desktop assessment was undertaken to assess flood levels along the Hunter River adjacent to the mine. For Wollombi Brook, a flood study was undertaken to estimate design flood levels adjacent to the mine. The methodology and results of the flood investigations are described below.

5.2 HUNTER RIVER FLOODING

Water level data for the Hunter River is available adjacent to the mine site at Mason Dieu (Station No. 210128), Long Point (Station No. 210134), Upstream Singleton (Station No. 210129) and Singleton (Station No. 210001). The locations of these stations are shown in Figure 2.4. Of these stations, only gauge levels from Long Point and Singleton can be translated into Australian Height Datum (AHD) levels. The peak levels recorded at these stations and at the two stations on Wollombi Brook (Bulga and Warkworth) for the June 2007 event are shown in Table 5.1. The June 2007 event was the largest flood event in the Hunter River at Singleton since the February 1955 event, and the third largest on record.

The minimum ground level along the eastern boundary of the MTW mining leases is approximately 50mAHD, which is about 1m higher than the maximum June 2007 flood level recorded at Long Point, located about 5km to the north-east. The proposal will not increase the Hunter River flood risk to infrastructure along the eastern side of the mining lease.

Table 5.1 Peak Recorded Levels for June 2007 Event

Station Number	River	Station Name	Peak Water Level (mAHD)
210134	Hunter River	Long Point	48.98
210001	Hunter River	Singleton	41.67
210028	Wollombi Brook	Bulga	63.48
210004	Wollombi Brook	Warkworth	56.30

5.3 WOLLOMBI BROOK FLOODING

5.3.1 Previous Flood Investigations

Two previous flood studies for Wollombi Brook have been undertaken: the first by the University of New South Wales Water Research Laboratory in April 1996 for an EIS prepared by Sinclair Knight Merz for the South Lemington open cut mine (SKM 1997), and the second by BMT WBM for Cessnock City Council in December 2010

The SKM (1997) study performed a frequency analysis on peak flood level data from the Warkworth gauge to determine design flood levels which were correlated to design discharges at Bulga. The study estimated a 100 year ARI design discharge of 2,700 m^3/s for Wollombi Brook at Bulga.

The BMT WBM (2010) study performed a flood frequency analysis (FFA) on a “synthetic” data series, which was a manipulated annual series which included gap filling and adjustment of recorded peak flow values to provide consistency in the annual flow records between the gauges. A flood frequency analysis was performed on the adjusted annual peak flows at Paynes Crossing, Bulga and Warkworth to determine the return period of a certain magnitude event. The FFA estimated a 100 year ARI design discharge of around 2,500m^3/s for Wollombi Brook at Bulga. The design flood discharges adopted for the study were based on an interactively calibrated hydrologic and hydraulic model using IFD design rainfall estimates. As the study was focussed on flood management at Wollombi Village, design discharges at Bulga using the calibrated hydrologic model have not been provided in the report.

5.3.2 Design Flood Discharges

For this study, a flood frequency analysis (FFA) of available data for the Bulga gauge was used to estimate design discharges. The available data at the Warkworth stream gauge includes a greater number of years, however the station is frequently affected by backwater flooding from the Hunter River and hence, the estimated discharges at the Warkworth gauge are unreliable. Annual recorded peak flood discharges for the Bulga gauge were available for the years 1949-1959, 1963-1987 and 2000-2013 totalling 50 years of data.

The methodology recommended in Book 4, Section 2 of Australian Rainfall and Runoff (ARR, 1998) was used to fit a Log-Pearson Type III distribution to the annual series of recorded peak flood discharges for the Bulga gauge. Figure 5.1 is a flood frequency plot for Wollombi Brook at Bulga. Design discharges estimated from the FFA are shown in Table 5.2 and are compared with the design discharges used in the SKM (1997) study, and the BMT WBM (2010) study. Discharges from this study are slightly higher than those in the BMT WBM (2010) study for the larger ARI events, and are therefore considered to be more conservative. Note that the recorded peak flood discharge for the June 2007 event at Bulga was 875m^3/s. Comparing this recorded discharge with the results shown in Table 5.2 indicates that the June 2007 event was between a five to ten year ARI event in Wollombi Brook at Bulga.

Table 5.2 Design Discharges for Wollombi Brook

ARI (years)	Design Discharge from FFA (m³/s)	SKM (1997) Design Discharge	BMT WBM (2010) Design Discharge
5	470	600	750
10	880	1,400	1,000
20	1,400	1,900	1,500
50	2,100	2,500	2,000
100	2,700	2,700	2,500

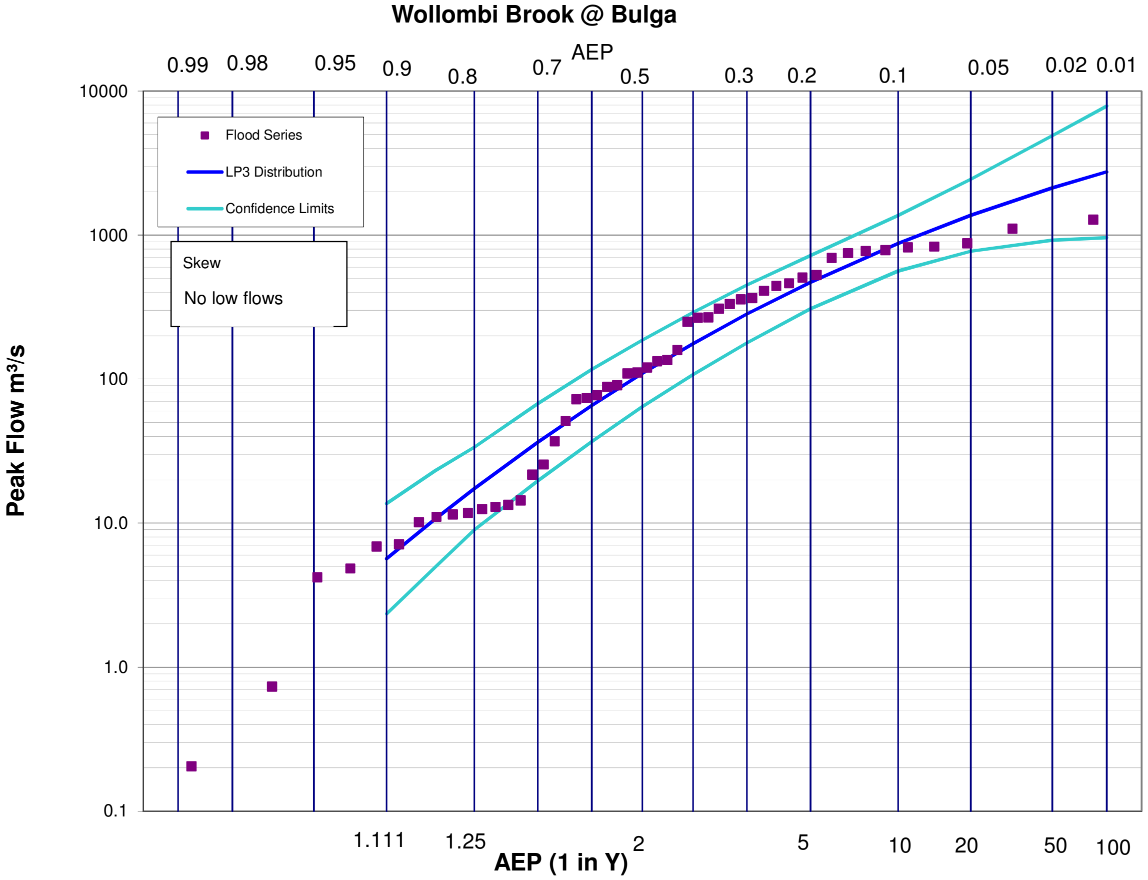

Figure 5.1 Flood Frequency Analysis Plot, Wollombi Brook at Bulga

5.3.3 Design Flood Levels

Methodology

The HEC-RAS steady state hydraulic model was used to estimate the 100 year ARI design flood levels in Wollombi Brook adjacent to the mine site. The model was calibrated to recorded flood levels and discharges for the June 2007 event.

Model Configuration

Figure 5.2 shows the location of the cross-sections used in the HEC-RAS model. A total of 23 cross-sections were used in the study. Cross-section data was based on 2m contours obtained from aerial survey undertaken by AAMHatch in September 2008. The vertical accuracy of the data is +/- 2m, which was considered adequate for this study given the significant available freeboard between estimated flood levels and the proposed pit extent.

Downstream Boundary Condition

The adopted downstream boundary condition was a fixed water level which was selected to match a selected level at the Warkworth stream gauge. A frequency analysis was performed on available peak water level data for the Warkworth stream gauge to estimate design water levels. Annual recorded peak flood levels for the Warkworth gauge were available for the years 1908-2013 (except 1953) totalling 105 years of data. The predicted water level for the 100 year ARI event from the analysis was 59.0mAHD which is slightly lower than the 59.4mAHD estimated by the SKM (1997) study. The slightly higher value of 59.4mAHD was adopted as the target starting water level at the Warkworth gauge.

Model Calibration

The HEC-RAS model was calibrated to match recorded peak discharges and water levels for the June 2007 flood event. A uniform friction loss coefficient (Manning's 'n') value of 0.045 was adopted for all cross-sections in the model based on calibration to recorded flood levels. A comparison of the recorded and calculated flood levels for the calibration event is included in Table 5.2.

Table 5.3 Recorded and Estimated Flood Levels for June 2007 Event

Water Level (mAHD)	Bulga Station	Warkworth Station
Recorded value	63.48	56.30
Estimated value	63.50	56.31

Estimated Flood Levels

Estimated flood levels for the 100 year ARI design event vary from 59.4mAHD at Warkworth to 65.7mAHD at Bulga. Note that the 100 year ARI design flood level at Bulga is about 2.2m higher than the June 2007 peak flood level (63.5mAHD). Although the estimated 100 year ARI design discharge for this study is similar to the previous SKM study (SKM, 2007), the estimated design flood level at Bulga from this study is 1.2m higher than the SKM study.

Figure 5.2 shows the 100 year ARI design flood extent and flood level at each cross-section. Note that the proposal is outside the 100 year ARI extent of flooding from Wollombi Brook. An existing levee across Salt Pan Creek prevents flood waters from Wollombi Brook entering Loders Pit at MTO.

5.3.4 Flood Impacts

As shown in Figure 5.2 the proposal is located outside the 100 year ARI design flood extent. Figure 5.3 shows a cross-section of Wollombi Brook adjacent to the proposal, indicating that the 100 year ARI design flood level is about 11m below the top of the extended pit high wall. Hence, the proposal will have no impact on flood flows, velocities or flood levels along Wollombi Brook for events up to and including the 100 year ARI flood event. For this reason, the proposal does not require measures to mitigate flood impacts on Wollombi Brook.

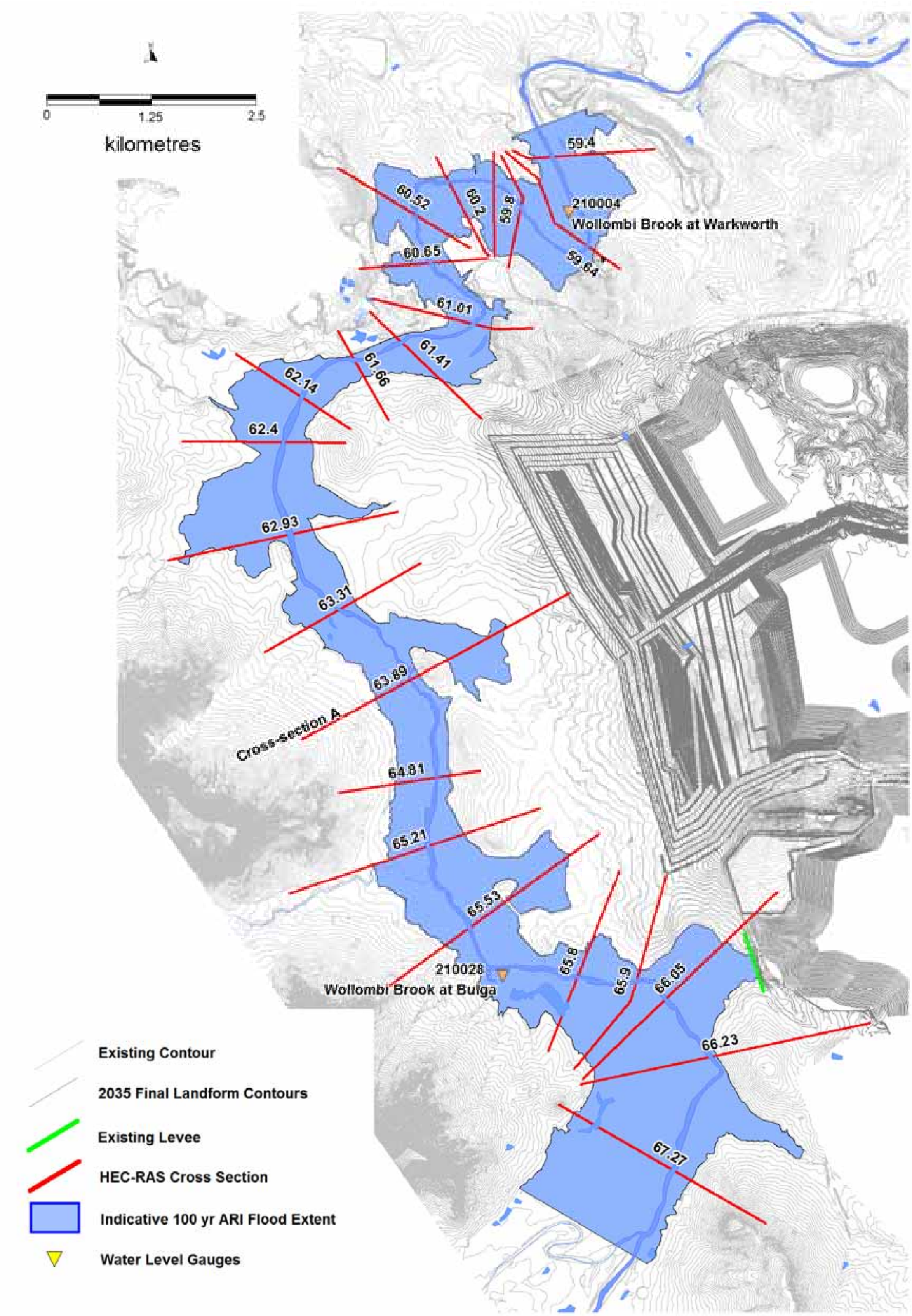

Figure 5.2 HEC-RAS Model Configuration and 100 Year ARI Design Flood Extent

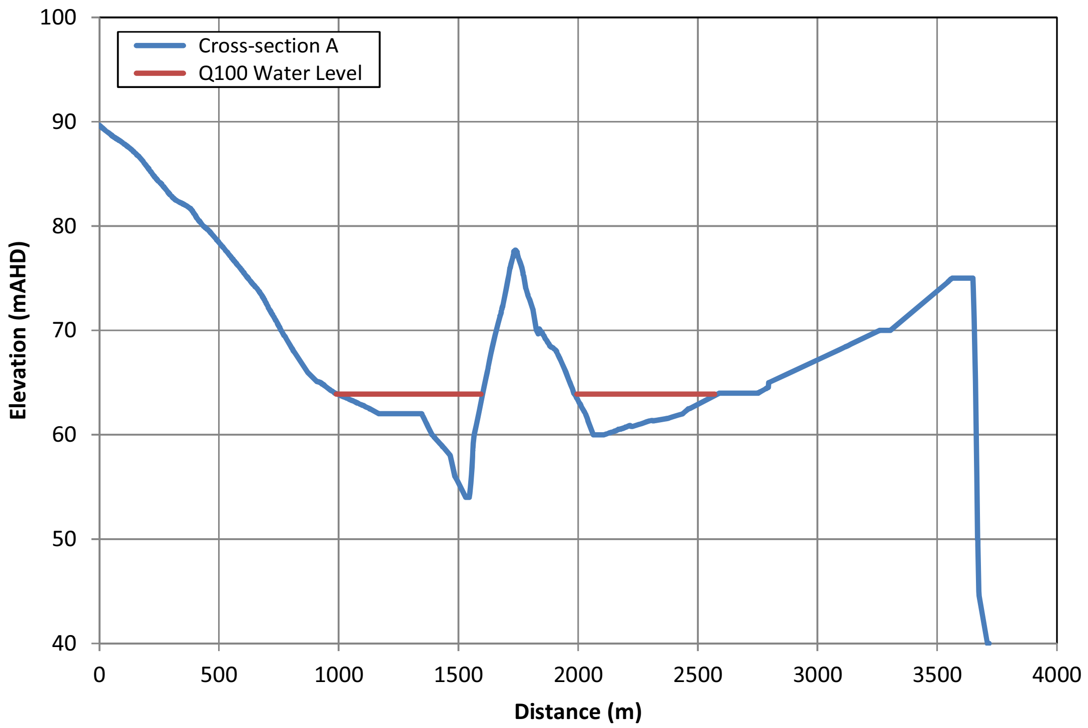

Figure 5.3 Flood Level at Cross-Section A, Adjacent to Extended Pit Highwall

6 MINE WATER BALANCE

6.1 OVERVIEW

The computer based OPSIM model was used to simulate the site water balance for the proposal. The model simulates the operations of all major components of the proposed water management system, including:

- Climatic variability – rainfall and evaporation;
- Catchment runoff;
- Controlled discharges (under the HRSTS) and uncontrolled overflows;
- Groundwater inflows; and
- Site water usage (CHPP, haul road dust suppression and stockpile dust suppression, vehicle wash).

6.2 SIMULATION METHODOLOGY

The water balance model has been run for the ‘forecast’ simulation methodology.

The forecast water balance results are generated by running multiple climate sequences through the model and taking a statistical representation of the results for the different climate cases modelled. These results more accurately reflect the actual performance of the system because they take into account the dynamic nature of the mine staging, groundwater inflows, and CHPP throughputs. In these runs the model configuration changes over time, to reflect the changes due to mine development.

The forecast water balance model has been run on a daily time-step for a 22 year period, corresponding to the period of operation of the proposal (21 years) plus one year of the existing system (total 22 years). The model was run for multiple climate sequences, each referred to as a “realisation”. Each realisation is based on a 22 year sequence extracted from the historical rainfall data. The first of 93 realisations is based on rainfall data from 1893 to 1914. The second is based on data from 1894 to 1915, and so on. This approach provides the widest possible range of climate scenarios covering the full range of climatic conditions represented in the historical rainfall record.

The model configuration changes over the 21 year project life, reflecting changes in the water management system over time. The different stages of the mine life are linked in the model to reflect variations over time such as catchments, ROM coal production and groundwater inflows. Five different representative stages of mine life were modelled (Years 0, 3, 9, 14 and 21). Although the catchment areas will continuously change as mining under the proposal progresses, the adopted approach of modelling discrete stages will provide a reasonable representation of conditions over the 21 year period.

The operational rules and physical layout for each representative stage of mine progression are applied to a range of years given in Table 6.1.

Table 6.1 Application of Representative Mine Stage to Full Mine Life

Representative Mine Stage	Applied Range of Mine Life	Period (years)
Year 0	Year 0 – 1	2
Year 3	Year 2 – 5	4
Year 9	Year 6 – 12	7
Year 14	Year 13 – 17	5
Year 21	Year 18 - 21	4

6.3 SIMULATION OF RAINFALL RUNOFF

The OPSIM model uses the Australian Water Balance Model (AWBM) (Boughton, 2003) to estimate daily runoff from daily rainfall. The AWBM is a saturated overland flow model which allows for variable source areas of surface runoff.

AWBM uses a group of connected conceptual storages (three surface water storages and one ground water storage) to represent a catchment. Water in the conceptual storages is replenished by rainfall and is reduced by evapotranspiration. Simulated surface runoff occurs when the storages fill and overflow. Figure 6.1 shows a conceptual configuration of the AWBM model.

The model uses daily rainfalls and estimates of catchment evapotranspiration to calculate daily values of runoff using a daily balance of soil moisture. The model has a baseflow component which simulates the recharge and discharge of a shallow subsurface store. Runoff depth calculated by the AWBM model is converted into runoff volume by multiplying by the contributing catchment area.

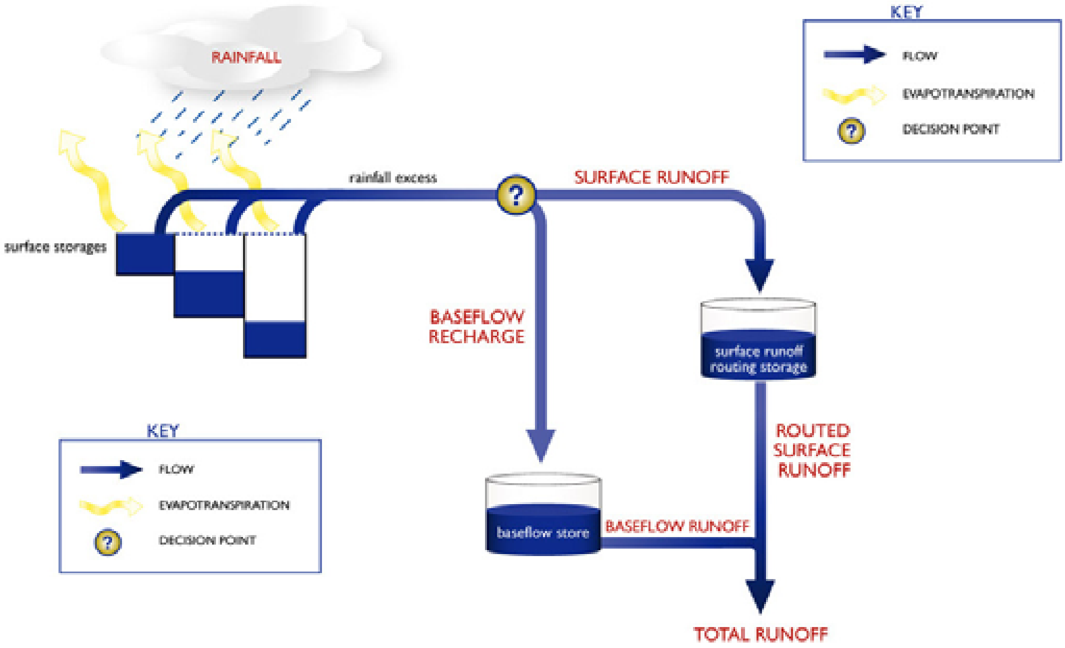

Figure 6.1 AWBM Model Configuration

The model parameters define the storage depths, the proportion of the catchment draining to each of the storages, and the rate of flux between them (Boughton, 2003).

The AWBM model parameters selected have been derived from the previous water balance modelling undertaken at MTW (WRM, 2014). Table 6.2 presents the calibrated AWBM model parameters and long term runoff coefficients over the period 1893 to 2006.

Table 6.2 MTW Catchment Yield (AWBM) Parameters

Parameter	Natural/ Undisturbed	Cleared/ Prestrip	Mining Pit	Tailings	Rehabilitated Spoil	Unrehabilitated Spoil	Roads/Industrial/ Hardstand
A1	0.2	0.1	0.1	0.1	0.1	0.1	0.1
A2	0.4	0.9	0.9	0.9	0.9	0.9	0.9
A3	0.4	0	0	0	0	0	0
S1	30	1	2.3	1	9.4	12.5	2.3
S2	50	11	6.9	11	94	125	6.9
S3	90	0	0	0	0	0	0
BFI	0.15	0	0	0	0.15	0.7	0
K_b	0.98	0	0	0	0.98	0.99	0
K_s	0.96	0	0	0	0.96	0.96	0
Long term Runoff Coefficient, C_v	12.5 %	40.4 %	46.1 %	40.4 %	9.9 %	7.2 %	46.1 %

6.4 WATER BALANCE MODEL CALIBRATION

The MTW OPSIM model was last updated and calibrated as part of the 2013 water balance model update (WRM Water & Environment Pty Ltd, 2014). The model was calibrated over the period May 2012 to June 2013 to the recorded total site inventory (see Figure 6.2). It was determined that the difference between recorded and simulated storage inventories in January and February 2013 is due to one or a combination of factors:

- Inaccurate recorded inventories in the pits; and/or
- Water stored in storages which are not recorded being pumped back into the recorded storage inventory system over time after rainfall events.

Nevertheless, the 2013 MTW OPSIM water balance model is considered to provide a reasonable representation of the response of the site's water management system to a range of climatic scenarios. The MTW 2013 OPSIM water balance model has been used as a basis for the proposed surface water investigations.

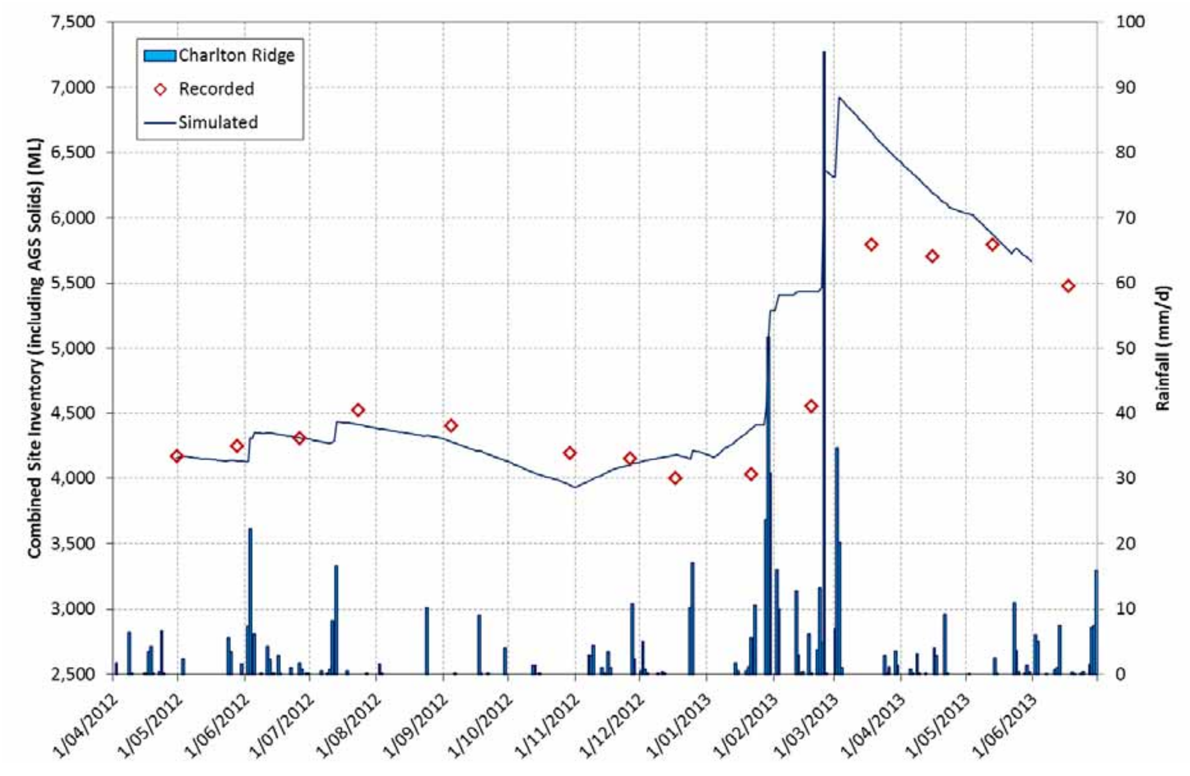

Figure 6.2 Combined Site Inventory, Recorded vs. Simulated

6.5 PROPOSED WATER MANAGEMENT SYSTEM

6.5.1 Proposed Mine Water Storages

A number of new storages or upgrades to existing storages are proposed at MTW in this proposal and are described below:

- North-Out-of-Pit Dam (NOOP Dam): Saline water storage located directly to the north of Dam 1N at Warkworth Mine. NOOP Dam has a proposed capacity of 740ML.

- SOOP Dam: Primary water storage for MTO (existing), also referred to as Dam 6S. Increase in storage capacity to 2.2GL within the same footprint.
- Ramp 22 Dam: Sediment dam situated at the current Dam 10S and Dam 11S location at MTO. Joint sediment dam with Bulga Coal Mine to the south. Runoff from both MTW and Bulga will be directed to this dam.
- Sediment Dam A: Sediment dam located at MTO to capture runoff from future spoil and rehabilitated areas. Exact location yet to be confirmed.
- Sediment Dam B: Sediment dam location at Warkworth Mine to capture runoff from future spoil and rehabilitation areas. Exact location yet to be confirmed.

Note also that a new pit/tailings storage facility (Abbey Green North) will be mined in approximately 2018 and 2019, however does not form part of this proposal. AGN is the designated tailings storage facility during Years 9 to 12.

6.5.2 Water Management System Layout and Operating Rules

The changes to the approved mine under the proposal will result in a number of potential changes to the water management system layout. The proposed water management system is shown in the schematic in Figure 6.3, with proposed changes highlighted. The mine stage layouts are presented in Figure 6.4 to Figure 6.10. Table 6.3 details the proposed OPSIM model operating rules.

The water management system will evolve as the mine develops, simulated as follows:

- Year 3: Tailings are directed to both the Centre Ramp Tailings Storage Facility (CRTSF) and AGS. Construction of the North-Out-of-Pit (NOOP) Dam is complete. Construction of Ramp 22 Dam is complete, replacing Dam 10S and 11S. Dam 32N (TD1) has been capped and rehabilitated. Dam 6N and Dam 12S have been mined out.
- Year 9: Tailings are directed to the CRTSF and Abbey Green North (AGN) TSF. Mining has been completed in Loders Pit, which has been partially backfilled. Mini-strip TSF has been rehabilitated. Sediment Dam A has been constructed. AGS is covered and rehabilitated.
- Year 14: Tailings are directed to the partially backfilled Loders Pit. CRTSF has been capped and rehabilitated. Sediment Dam B has been constructed. AGN is covered and rehabilitated.
- Year 21: Tailings Dam 2 (Dam 33N) has been capped and rehabilitated. Considerable areas of the site have now been rehabilitated.

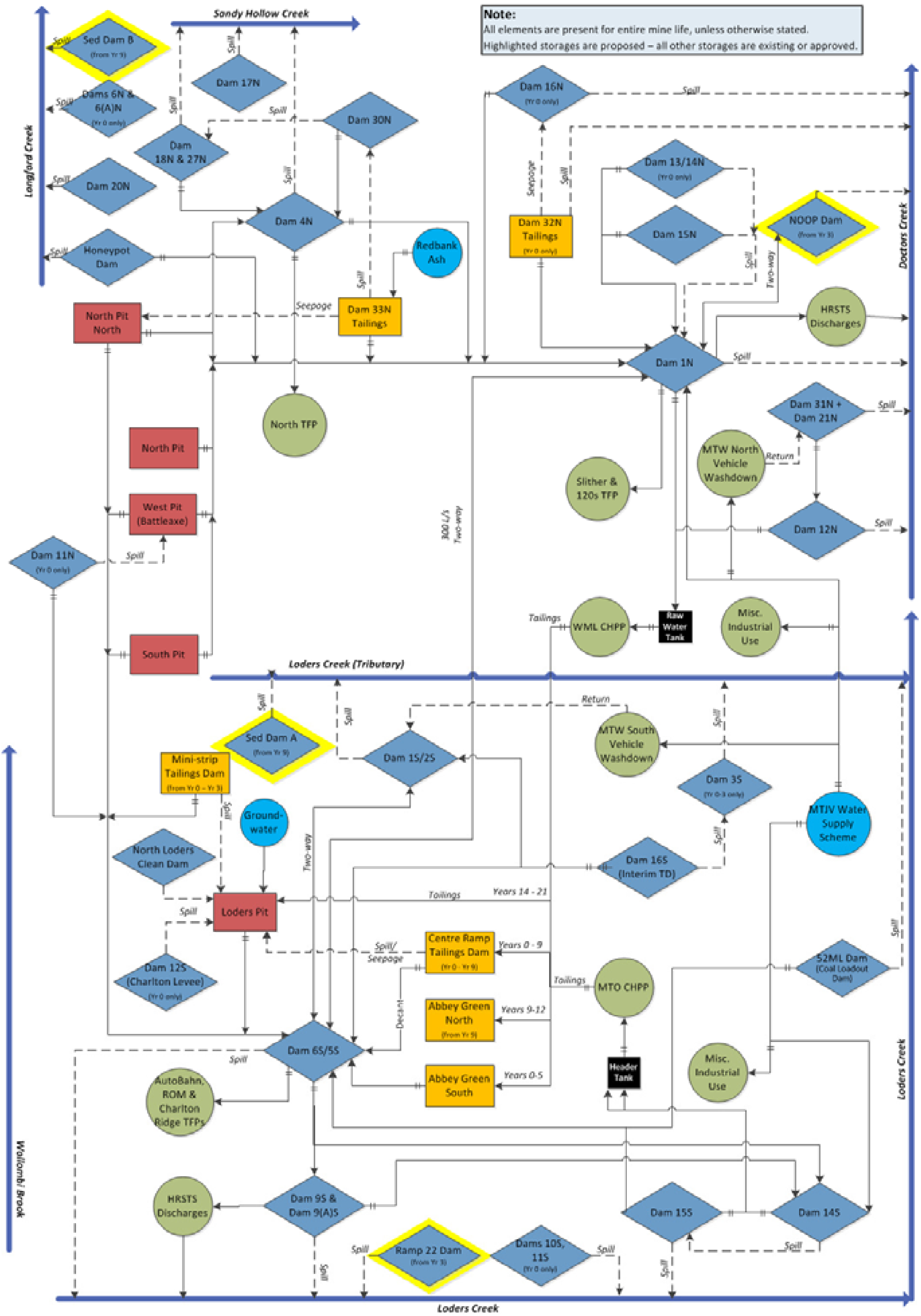

Figure 6.3 Proposed Water Management System Schematic

Table 6.3 Proposal OPSIM Model Operating Rules

Node No.	Node Name	Operating Rules
Water Supply		
161	MTJV Water Supply Scheme	▪ Supplies to the following locations as required: ▫ Dam 14S ▫ Dam 1N ▫ MTW South Vehicle Washdown ▫ MTW North Vehicle Washdown ▫ MTW South Misc. Industrial Use ▫ MTW North Misc. Industrial Use
Controlled Discharges		
311	Dam 1N HRSTS Discharge	▪ Warkworth controlled release point from Dam 1N under the following conditions: ▫ >70% of MOL capacity ▫ Maximum 100ML/d ▫ Under 'High' flows – releases so that downstream EC does not exceed 900μS/cm. ▫ Under 'Flood' flows – not limited by salts. ▪ Discharged to Hunter River via Doctor's Creek. ▪ Storage overflows to Doctor's Creek.
313	Dam 9S HRSTS Discharge	▪ Mount Thorley controlled release point from Dam 9S under the following conditions: ▫ >70% of MOL capacity ▫ Maximum 100ML/d ▫ Under 'High' flows – releases so that downstream EC does not exceed 900μS/cm. ▫ Under 'Flood' flows – not limited by salts. ▪ Discharged to Hunter River via Loders Creek. ▪ Storage overflows to Loders Creek.
Water Demands		
150	MTW North CHPP (Warkworth Mine)	▪ Supplied from Dam 1N via the Raw Water Tank ▪ Tailings directed to Abbey Green South/ CRTSF/Abbey Green North/Loders Pit – depending on stage.
250	MTW South CHPP (MTO)	▪ Supplied from the following locations (via the Header Tank): ▫ Dam 14S ▫ Dam 15S ▪ Tailings directed to Abbey Green South / CRTSF/Abbey Green North/Loders Pit – depending on stage.
181	MTW South Vehicle Washdown	▪ Supplied from MTJV Supply Scheme as per Table 6.11. ▪ 85% loss assumed. ▪ Return directed to Dam 1S/2S.
183	MTW South CHPP Miscellaneous Industrial Use	▪ Suppled from MTJV Supply Scheme as per Table 6.11. ▪ 100% loss assumed.
281	MTW North Vehicle Washdown	▪ Supplied from MTJV Supply Scheme as per Table 6.11. ▪ 85% loss assumed. ▪ Return directed to Dam 31N/21N.
283	MTW North CHPP Miscellaneous Industrial Use	▪ Suppled from MTJV Supply Scheme as per Table 6.11. ▪ 100% loss assumed.

Node No.	Node Name	Operating Rules
307	AutoBahn, ROM and Charlton Ridge Truck Fill Points (TFPs)	▪ Supplied from Dam 6S at a maximum rate of 3,481kL/d on a 'non-rain day'. ▪ Reduction in demand for days of rain. ▪ 100% loss assumed.
308	Slither and 120s Truck Fill Points (TFPs)	▪ Supplied from Dam 1N at a maximum rate of 2,320kL/d on a 'non-rain day'. ▪ Reduction in demand for days of rain. ▪ 100% loss assumed.
	North Truck Fill Point	▪ Supplied from Dam 4N at a maximum rate of 1,610kL/d on a 'non-rain day'. ▪ Reduction in demand for days of rain. ▪ 100% loss assumed.
Operational Pits		
190	Loders Pit	▪ Continuous dewatering from pit dewatering pumps (when required) at a nominal maximum rate of 100L/s. ▪ Pit dewatering directed to Dam 6S (SOOP Dam). ▪ Receives seepage from Dam 17S (Centre Ramp TD) at a rate of 12,000kL/d. ▪ Receives pumped transfers from the following locations for Years 14-21: ▫ MTW North CHPP (tailings) ▪ MTW South CHPP (tailings)Receives spillway overflows from the following locations: ▫ Mini-strip TSF ▫ Dam 12S (Charlton Levee) ▫ Dam 17S (CRTSF) ▪ Receives groundwater inflows as per Table 6.4.
290	North Pit North	▪ Continuous dewatering from pit dewatering pumps (when required) at a nominal maximum rate of 100L/s. ▪ Pit dewatering directed to Dam 4N, Dam 1N, Dam 6S. ▪ Receives seepage from Dam 33N at a rate of 50kL/d. ▪ Receives groundwater inflows as per Table 6.4.
291	West Pit	▪ Continuous dewatering from pit dewatering pumps (when required) at a nominal maximum rate of 280L/s. ▪ Pit dewatering directed to Dam 6S (SOOP Dam) or Dam 1N. ▪ Receives spillway overflows from Dam 11N.
293	South Pit	▪ Continuous dewatering from pit dewatering pumps (when required) at a nominal maximum rate of 280L/s. ▪ Pit dewatering directed to Dam 6S (SOOP Dam) or Dam 1N. ▪ Receives groundwater inflows as per Table 6.4.
295	North Pit	▪ Continuous dewatering from pit dewatering pumps (when required) at a nominal maximum rate of 100L/s. ▪ Pit dewatering directed to Dam 1N.
Water Storages		

Node No.	Node Name	Operating Rules
102	Dam 1S/2S	▪ Receives pumped transfers from the following locations: ▫ Dam 6S (SOOP Dam). ▫ Dam 16S (Interim TD). ▪ Receives return from MTW South Vehicle Washdown. ▪ Pump transfers to Dam 6S when >12ML. ▪ Storage overflows to Loders Creek Tributary.
103	Dam 3S	▪ Rehabilitated area sediment dam (clean catchment). ▪ Receives storage overflows from Dam 16S. ▪ Storage overflows to Loders Creek Tributary. ▪ Mined out from Yr 9 onwards.
104	Sediment Dam A	▪ Present for Yr 9 onwards. ▪ Storage overflows to Loders Creek tributary.
105	Dam 5S	▪ Storage overflows to Dam 6S (SOOP Dam).
106	Dam 6S (SOOP Dam)	▪ Primary mine water storage for Mount Thorley. ▪ Receives pumped transfers from the following locations: ▫ Loders Pit ▫ Mini-strip TSF ▫ Dam 1S/2S ▫ Dam 15S (South CPP) ▫ Dam 16S ▫ Dam17S (Centre Ramp TSF) ▫ Dam 1N ▫ Dam 11N ▫ North Pit North ▫ West Pit ▫ South Pit ▫ Abbey Green South ▫ Coal Loader Dam (52ML Dam) ▪ Receives storage overflows from Dam 5S. ▪ Supplies to the following locations: ▫ Dam 2S ▫ Dam 14S ▫ Dam 1N ▫ Dam 9S ▫ AutoBahn TFP ▫ ROM TFP ▫ Charlton Ridge TFP ▪ Storage overflows to Loders Creek.
107	Ramp 22 Dam	▪ Present from Yr 3 onwards. ▪ Storage overflows to Loders Creek.
109	Dam 9S	▪ Mount Thorley HRSTS controlled release point (max. 200ML/d). ▪ Receives pumped transfers from the following locations: ▫ Dam 6S (SOOP Dam) ▫ Dam 9(A)S ▪ Supplies to Dam 14S as required. ▪ Storage overflows to Loders Creek.
110	Dam 10S	▪ Present for Yr 0 only. ▪ Rehabilitated area sediment dam (clean catchment). ▪ Storage overflows to Dam 11S.

Node No.	Node Name	Operating Rules
111	Dam 11S	▪ Present for Yr 0 only. ▪ Rehabilitated area sediment dam (clean catchment). ▪ Receives storage overflows from Dam 10S. ▪ Storage overflows to Loders Creek.
112	Dam 12S (Charlton Levee)	▪ Present for Yr 0 only. ▪ Storage overflows to Loders Pit.
113	Dam 9(A)S	▪ Rehabilitated area sediment dam. ▪ Pump transfers to Dam 9S. ▪ Storage overflows to Loders Creek.
114	Dam 14S	▪ Receives pumped transfers from the following locations: ▫ Dam 6S (SOOP Dam) ▫ Dam 9S ▫ MTJV Water Supply Scheme (as required) ▪ Supplies to Header Tank as required. ▪ Storage overflows to Dam 15S.
115	Dam 15S (South CHPP)	▪ Receives overflows from Dam 14S. ▪ Supplies to Header Tank as required. ▪ Pump transfers to Dam 6S when >10ML. ▪ Storage overflows to Loders Creek.
116	Dam 16S (Interim TD)	▪ Pump transfers to Dam 2S or Dam 6S to maintain empty. ▪ Storage overflows to Dam 3S.
117	Dam 17S (Centre Ramp TSF)	▪ Receives pumped transfers from the following locations for Years 0-9: ▫ MTW North CHPP (tailings) ▫ MTW South CHPP (tailings) ▪ Seeps to Loders Pit at a rate of 12,000kL/d. ▪ Storage overflows to Loders Pit (no spillway). ▪ Rehabilitated from Yr 14 onwards.
118	Coal Loader Dam (52ML Dam)	▪ Pump transfers to Dam 6S to maintain empty. ▪ Storage overflows to Loders Creek Tributary.
119	Loders Pit North Clean Water Dam	▪ Clean water catchment. ▪ Storage overflows to Loders Pit.
191	Mini-strip TSF	▪ Supplies to Dam 6S as required. ▪ Storage overflows to Loders Pit.

Node No.	Node Name	Operating Rules
201	Dam 1N	▪ Primary mine water storage for Warkworth. ▪ Warkworth HRSTS controlled release point (max 100ML/d). ▪ Receives pumped transfers from the following locations: ▫ Dam 6S ▫ Dam 4N ▫ North Pit North ▫ North Pit ▫ West Pit ▫ South Pit ▫ Dams 13/14/15N ▫ NOOP Dam ▫ Dam 16N ▫ Dam 32N ▫ Dam 33N ▫ MTJV Water Supply Scheme ▪ Receives storage overflows from Dams 13/14/15N. ▪ Supplies to the following locations: ▫ MTW North CHPP & miscellaneous industrial use via Raw Water Tank ▫ NOOP Dam ▫ Slither and 120s TFPs ▪ Transfers to Dam 6S @ 300L/s when > 240ML. ▪ Storage overflows to Doctor's Creek.
204	Dam 4N	▪ Receives pumped transfers from the following locations: ▫ North Pit North ▫ Dam 27N ▫ Honeypot Dam ▫ Dam 30N ▪ Pump transfers to Dam 1N to maintain empty. ▪ Supplies to North Pit TFP. ▪ Storage overflows to Sandy Hollow Creek.
205	Sediment Dam B	▪ Present for Yr 9 onwards. ▪ Storage overflows to Longford Creek.
206	Dam 6N	▪ Present for Yr 0 only. ▪ Clean water catchment. ▪ Receives storage overflows from Dam 6(A)N. ▪ Storage overflows to Longford Creek.
207	Abbey Green South	▪ Tailings storage facility. ▪ Receives pumped transfers from the following locations for Years 0-5: ▫ MTW North CHPP (tailings) ▫ MTW South CHPP (tailings) ▪ Pump transfers to the following locations at a nominal rate of 100L/s: ▫ Dam 6S ▫ Capped and rehabilitated from Yr 9 onwards.
208	Abbey Green North	▪ Present for Yr 9 onwards. ▪ Receives pumped transfers from the following locations for Years 9-12: ▫ MTW North CHPP (tailings) ▫ MTW South CHPP (tailings) ▪ Capped and rehabilitated from Yr 14 onwards.

Node No.	Node Name	Operating Rules
211	Dam 11N	▪ Present for Yr 0 only. ▪ Clean water catchment. ▪ Pump transfers to Dam 6S (SOOP Dam) to maintain empty. ▪ Storage overflows to West Pit.
212	Dam 12N	▪ Receives pumped transfers from Dam 31N (CC8). ▪ Supplies to Raw Water Tank as required. ▪ Storage overflows to Doctor's Creek.
215	Dams 13/14/15N	▪ Supplies to Dam 1N as required. ▪ Storage overflows to Dam 1N. ▪ (Dams 13N & 14N not present from Yr 3 onwards)
216	Dam 16N	▪ Present for Yr 0 only. ▪ Receives seepage from Dam 32N (Tailings Dam 1). ▪ Pump transfers to the Dam 1N to maintain empty. ▪ Storage overflows to Doctor's Creek.
217	Dam 17N	▪ Rehabilitated area sediment dam (clean catchment). ▪ Storage overflows to Sandy Hollow Creek.
218	Dam 18N	▪ Storage overflows to Dam 27N.
220	Dam 20N	▪ Clean water catchment. ▪ Storage overflows to Longford Creek.
227	Dam 27N	▪ Receives storage overflows from the following locations: ▫ Dam 18N ▫ Dam 30N ▪ Pump transfers to Dam 4N at a rate of 25L/s to maintain empty. ▪ Storage overflows to Sandy Hollow Creek.
228	NOOP Dam	▪ Present from Yr 3 onwards. ▪ 2-way transfer with Dam 1N. ▪ Storage overflows to Doctors Creek.
230	Dam 30N	▪ Receives storage overflows from Dam 33N (Tailings Dam 2). ▪ Transfers to Dam 4N to maintain empty (50L/s). ▪ Storage overflows to Dam 27N.
231	Dam 31N (CC8) + Dam 21N	▪ Pump transfers to Dam 12N at a rate of 70L/s. ▪ Receives return from MTW North Vehicle Washdown. ▪ Storage overflows to Doctor's Creek,
232	Dam 32N (Tailings Dam 1)	▪ Present for Yr 0 only (rehabilitated from Yr 3 onwards). ▪ Seeps to Dam 16N at a rate of 50kL/d. ▪ Pump transfers to Dams 1N to maintain empty. ▪ Storage overflows to Doctor's Creek.
233	Dam 33N (Tailings Dam 2)	▪ Seeps to North Pit North at a rate of 50kL/d. ▪ Receives moisture in ash from Redbank Power Station at a rate of 68kL/d. ▪ Pump transfers to Dams 1N to maintain empty. ▪ Storage overflows to Dam 30N.
306	Dam 6(A)N	▪ Clean water catchment. ▪ Storage overflows to Dam 6N.
381	Honeypot Dam	▪ Pump transfers to Dam 1N to maintain empty. ▪ Storage overflows to Longford Creek.
Receiving Waters		

Node No.	Node Name	Operating Rules
174	Loders Creek (including Tributary)	▪ Receives controlled HRSTS discharges from Dam 9S. ▪ Receives storage overflows from the following locations: ▫ Sediment Dam A ▫ Dam 1S/2S ▫ Dam 3S ▫ Dam 6S (SOOP Dam) ▫ Dam 9S ▫ Dam 9(A)S ▫ Ramp 22 Dam ▫ Dam 11S ▫ Dam 15S (South CPP) ▫ Coal Loader Dam (52ML Dam)
175	Wollombi Brook	▪ Not linked to MTW water management system.
176	Hunter River	▪ Receives controlled releases from the following locations: ▫ Dam 1N (via Doctors Creek) ▫ Dam 9S (via Loders Creek)
275	Doctor's Creek	▪ Receives controlled HRSTS discharges from Dam 1N. ▪ Receives storage overflows from the following locations: ▫ Dam 1N ▫ Dam 12N ▫ Dam 16N ▫ Dam 31N (CC8) + 21N ▫ Dam 32N ▫ NOOP Dam
276	Longford Creek	▪ Receives storage overflows from the following locations: ▫ Dam 6N/6(A)N ▫ Honeypot Dam ▫ Sediment Dam B ▫ Dam 20N
277	Sandy Hollow Creek	▪ Receives storage overflows from the following locations: ▫ Dam 4N ▫ Dam 17N ▫ Dam 27N

6.5.3 Groundwater Inflows

Groundwater inflows into the proposed operation are not expected to be significant. The groundwater impact assessment (AGE 2014a, AGE 2014b) has predicted total groundwater inflow rates to Warkworth Mine and MTO from two sources: Permian inflows and spoil inflows. The predicted inflows from spoil to the open cut pits include rainfall runoff baseflow and seepage from tailings dams, both of which are already simulated in the surface water balance model. Comparison of the surface water balance estimates and the groundwater model estimates indicate flows are of the same order of magnitude. However, the surface water balance model simulates rainfall runoff baseflow on a daily basis whereas the groundwater model uses annual average rainfall. Therefore the spoil inflow estimates from the surface water balance model are considered more suitable for the purposes of the surface water balance modelling than the spoil inflows from the groundwater model.

The Permian inflows to the open cut pits were reduced to account for evaporation from the pit faces and the entrained moisture losses due to mining. These water losses were estimated as follows:

- Evaporation from the open cut pits was based on pit face lengths estimated from the indicative mine plans and actual coal seam heights (36m at Warkworth, and 21m at Mount Thorley). An evaporation rate of 2.63mm/d was adopted based on a Morton's Lake Average rate of 3.8mm/d, an evapotranspiration factor of 0.99 and a shading factor for deep pits of 0.7.
- The entrained losses due to mining were calculated from production schedule and an assumption that the raw feed to the CHPP has a moisture content of 5 per cent.

At Warkworth Mine, the losses from coal moisture entrainment and evaporation resulted in a predicted nil 'pumpable' Permian groundwater inflows for the life of the project. This is consistent with the existing operation, which has very little groundwater inflow. At MTO, groundwater inflows occur for Years 1 to 5. After Year 6, inflows are nil as mining has finished and Loders Pit has been filled in.

The groundwater inflow rates were averaged over the years covered by each mine state, as detailed in Table 6.4.

Table 6.4 Adopted Groundwater Inflows (ML/a)

Year	Warkworth	Mount Thorley
Year 0 (2 years)	0	186
Year 3 (4 years)	0	10
Year 9 (7 years)	0	0
Year 14 (5 years)	0	0
Year 21 (4 years)	0	0
Total	**0**	**413 ML**

An uncertainty analysis of the groundwater model inputs was undertaken (AGE, 2014) to put potential error bars around predictive results. The predictive groundwater model simulation for the uncertainty analysis showed 95th percentile worst case inflows resulted in an increase of 'pumpable' Permian groundwater inflows by 157ML/a in Year 15. This equates to approximately 2.6% of the total inflows to MTW (refer Table 6.13), and is therefore not expected to greatly impact on the performance of the MTW water management system. It is likely that the only significant impact of increased groundwater inflows of this magnitude on the site water balance would be to reduce the external water requirement by an equal amount.

6.5.4 Catchments and Land Use Classifications

The changes in the physical layout are represented in the indicative mine plans given in Figure 6.4 to Figure 6.11 for Years 3, 9, 14 and 21 respectively. Catchment areas (separated by the different land use types) reporting to the mine site storages are provided in Appendix B.

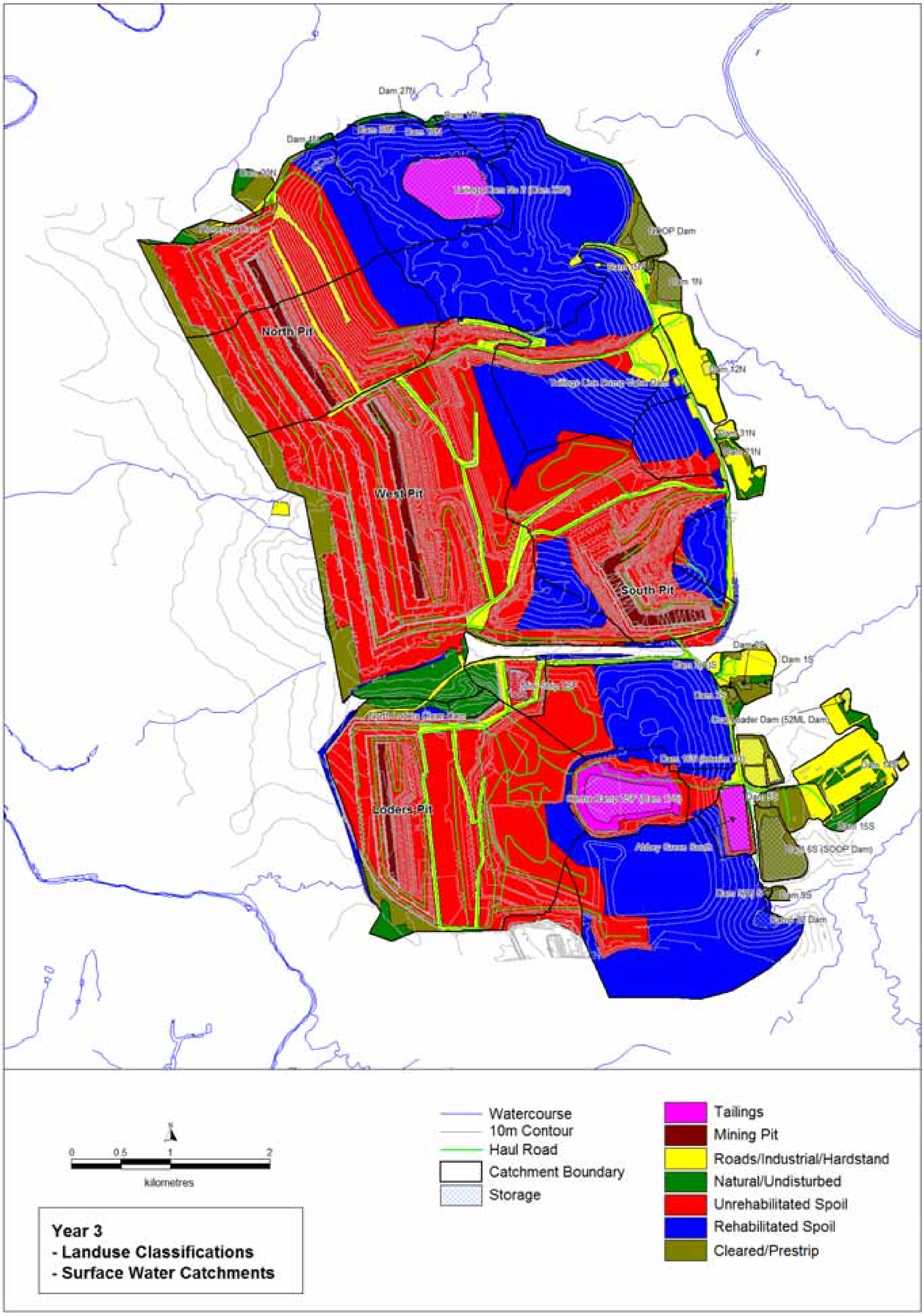

Figure 6.4 MTW Surface Catchments & Land Use Classifications – Year 3

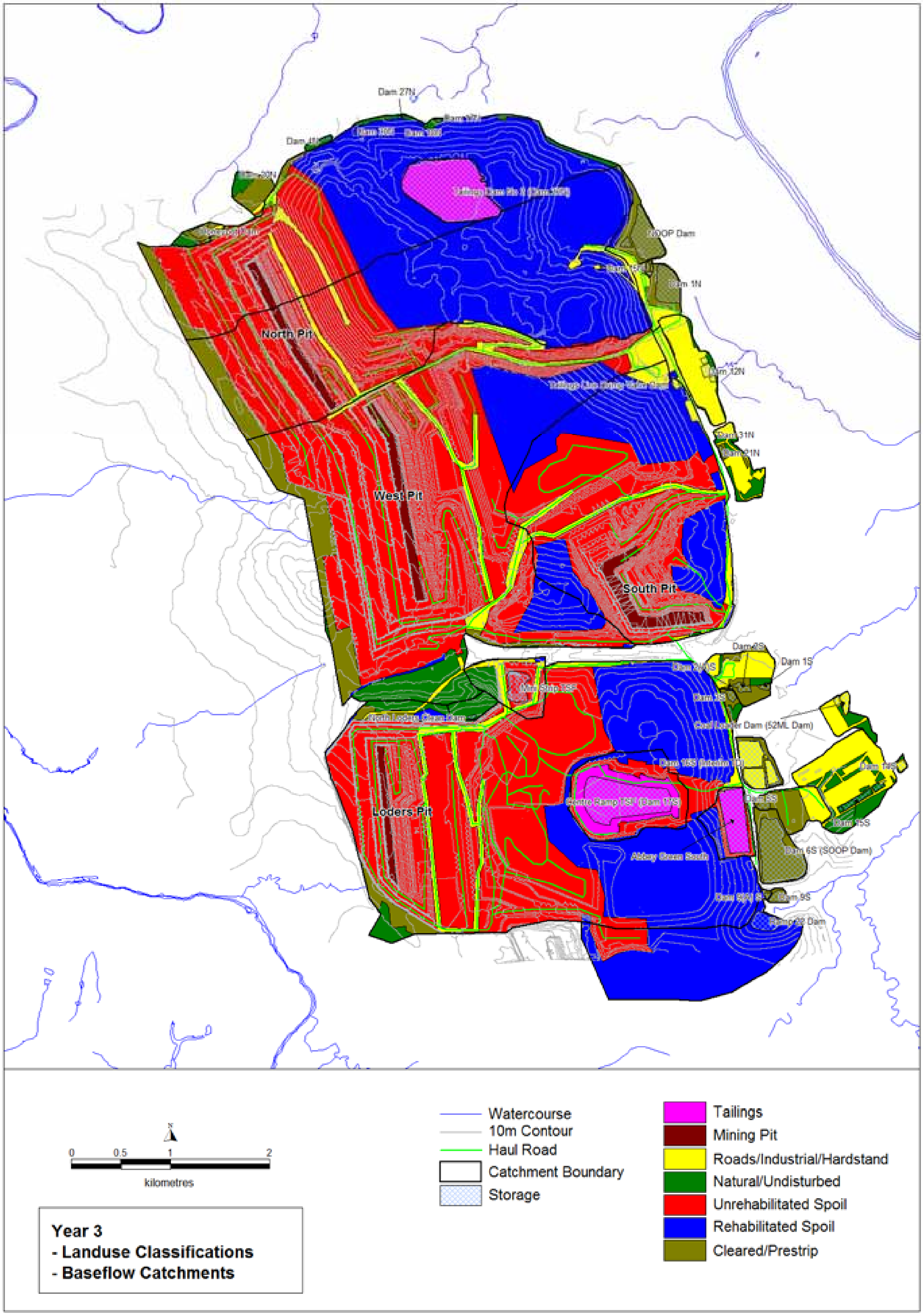

Figure 6.5 MTW Baseflow Catchments & Land Use Classifications – Year 3

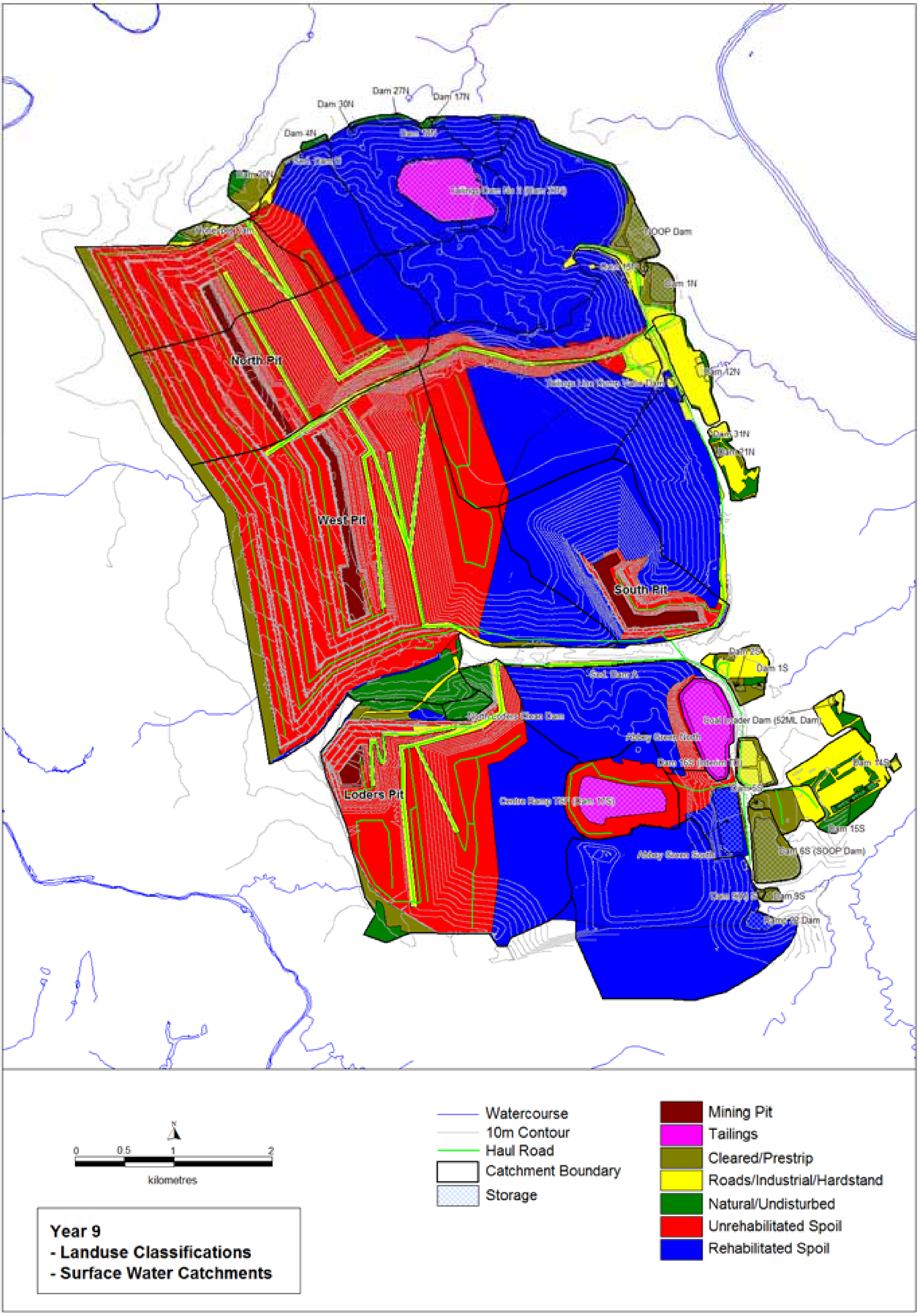

Figure 6.6 MTW Surface Catchments & Land Use Classifications – Year 9

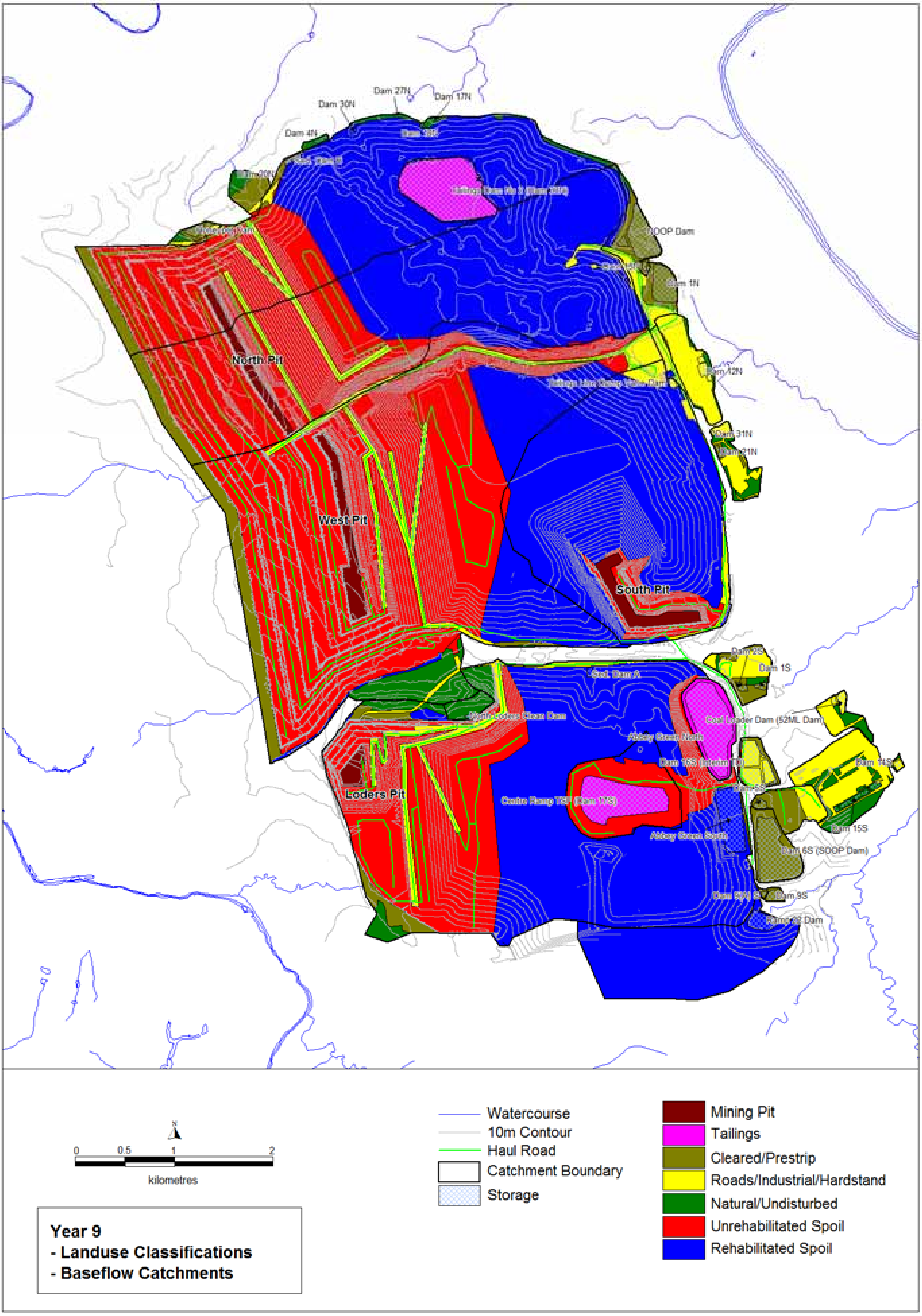

Figure 6.7 MTW Baseflow Catchments & Land Use Classifications – Year 9

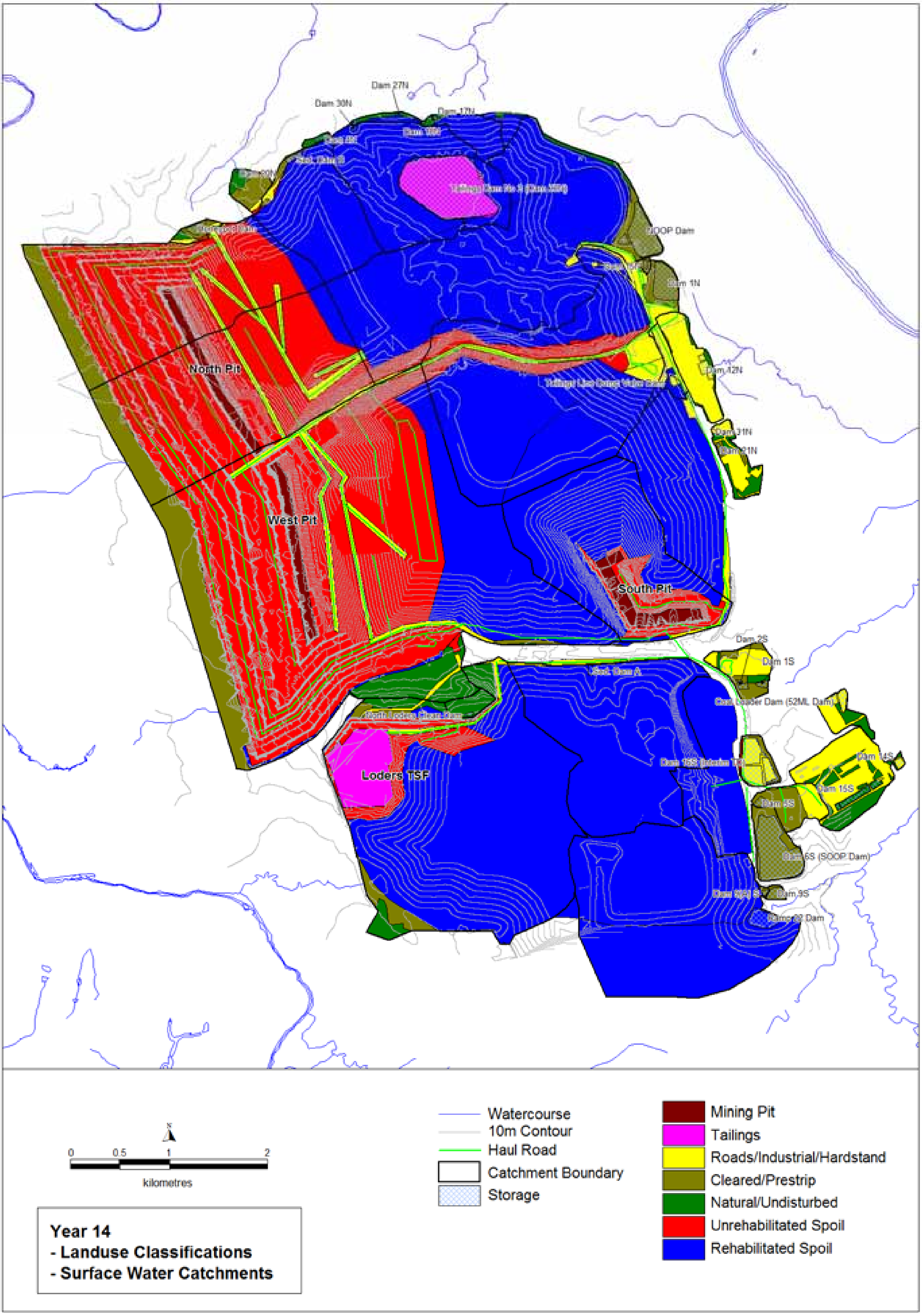

Figure 6.8 MTW Surface Catchments & Land Use Classifications – Year 14

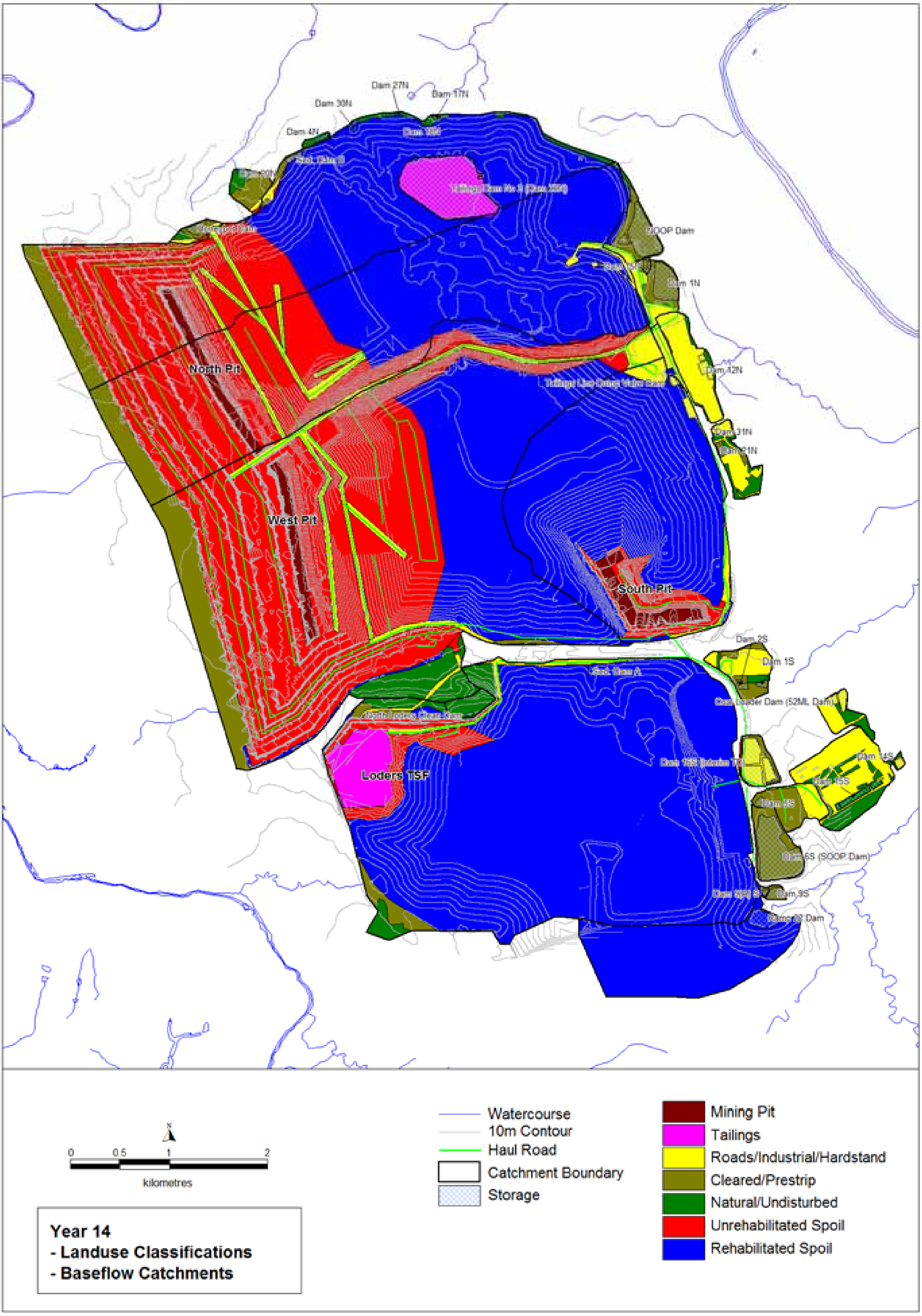

Figure 6.9 MTW Baseflow Catchments & Land Use Classifications – Year 14

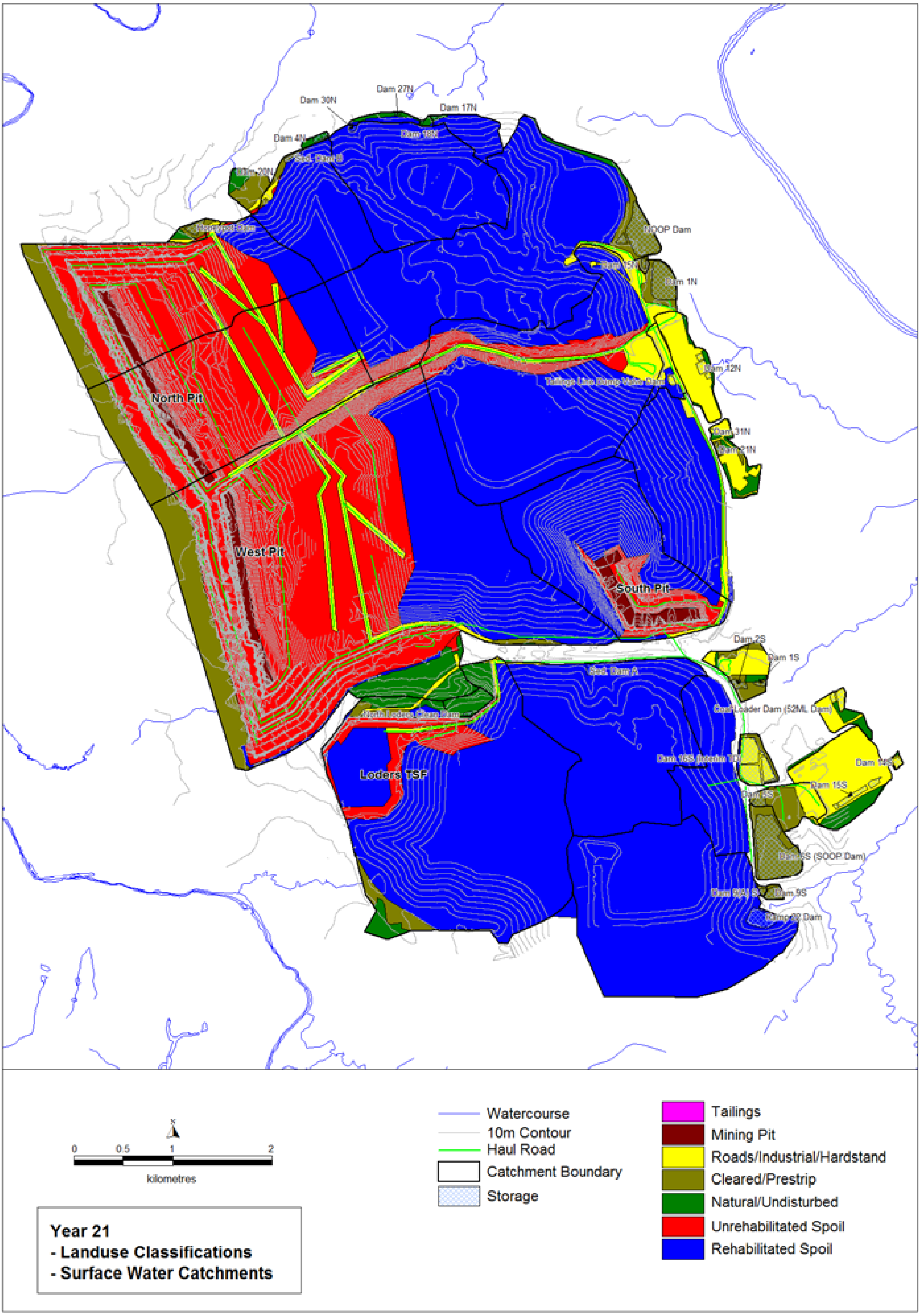

Figure 6.10 MTW Surface Catchments & Land Use Classifications – Year 21

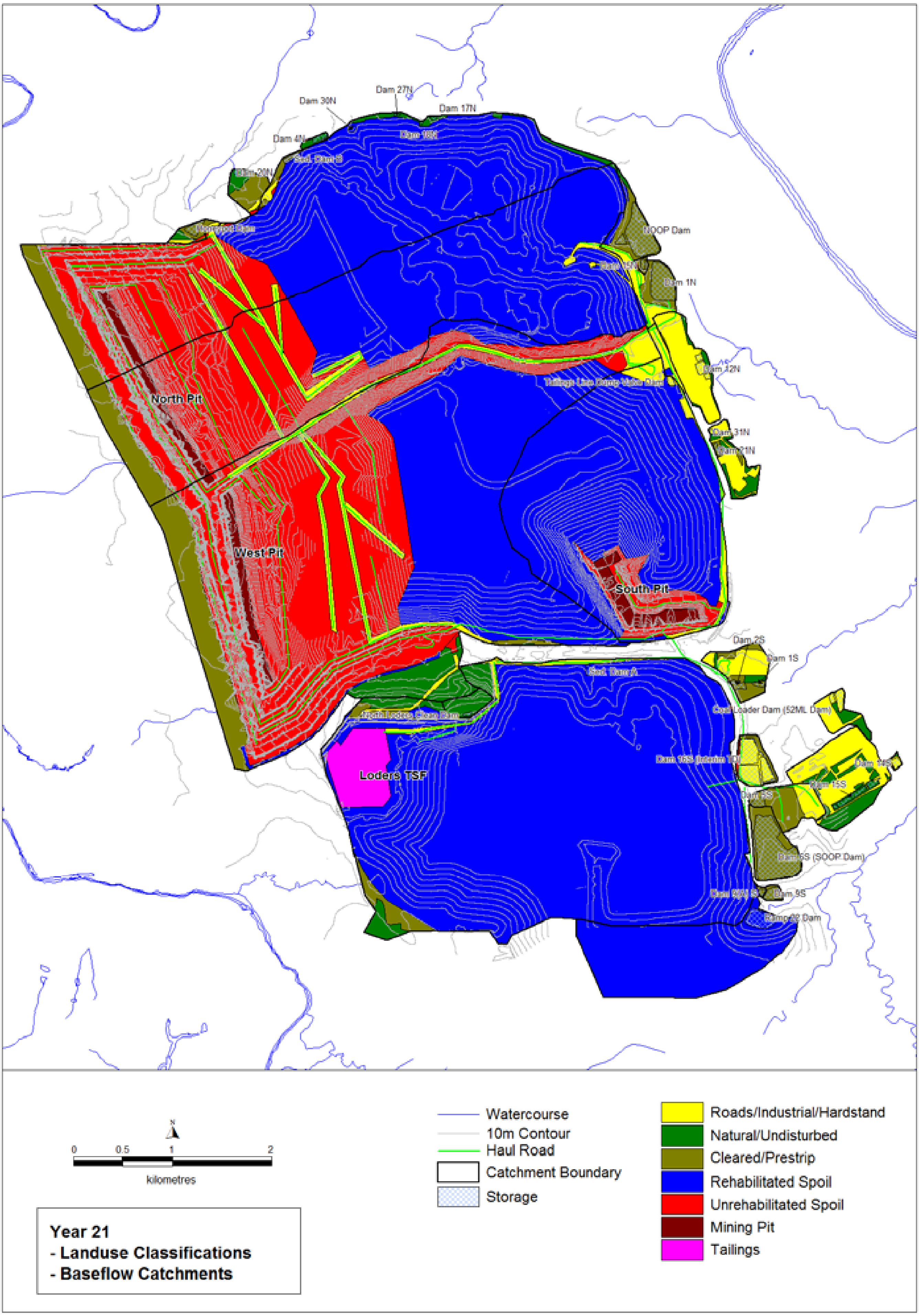

Figure 6.11 MTW Baseflow Catchments & Land Use Classifications – Year 21

6.5.5 Water Quality

An estimate of salinity generation rates for each land use type and water source (raw water, groundwater) has been made based on the MTW water quality monitoring program (refer Section 2.6.2). It is proposed to adopt the salinity generation rates shown in Table 6.5.

Table 6.5 MTW Salinity Generation Rates

Land Use Classification / Salt Source	Salinity Generation Rate (µS/cm)	Basis
Natural/Undisturbed	300	Wollombi Brook, Dam 11N
Cleared/Prestrip	1,500	Dam 12S, Dam 6N
Mining Pit	15,000	Assumed same as groundwater salinity
Unrehabilitated Spoil	4,000	Dam 1N, Dam 6S
Rehabilitated Spoil	600	Dam 30N
Roads/Industrial/Hardstand	3,000	Dam 15S
Tailings	10,000	Dam 1N, Dam 6S
MTJV Raw Water Supply	650	Hunter River
Groundwater	15,000*[a]	(AGE, 2014a)

Notes: *[a] Average water quality of alluvial aquifers in Mount Thorley area, samples taken from 1993 to 2013 indicates an EC of between 931 to 27,800µS/cm.

6.5.6 Water Demands

CHPP

The MTW coal preparation facilities consist of two plants:

- Warkworth Mine CPP (North Plant); and
- MTO CPP (South Plant).

MTW has provided forecast total washed and unwashed coal throughputs and production rates. Based on the provided production schedule and the 2013 plant characteristics (WRM, 2014), plant moisture balances for each of the North CHPP and South CHPP have been determined and are shown in Table 6.6 to Table 6.9.

Note that 0.5 Mtpa of coal bypass will be produced for the life of the proposal. It is assumed that the bypass coal has negligible water requirements and therefore does not impact the site water balance.

Table 6.6 Warkworth Mine CPP (North Plant) – Year 0

Item	Mtpa (wet)	t/day (wet)	Total Moisture (%)	Dry Solids (t/day)	Moisture (kL/d)
Raw Feed	9.22	25,254	5.5	23,865	1,389
Product Coal	6.59	18,056	8.8	16,467	1,589
Tailings	4.79	13,133	83.1	2,219	10,913
Coarse Rejects	2.22	6,029	14.1	5,179	850
				Process Plant Makeup Requirement	**11,963**
				Plant yield (wet)	71.5 %
				Plant yield (dry)	69.0 %
				Fine/coarse split (dry)	30 %
				Water use (L/ROM tonne (wet))	474

Table 6.7 Warkworth Mine CPP (North Plant) – Year 3 to Year 21

Item	Mtpa (wet)	t/day (wet)	Total Moisture (%)	Dry Solids (t/day)	Moisture (kL/d)
Raw Feed	9.52	26,093	5.5	24,568	1,435
Product Coal	6.81	18,655	8.8	17,014	1,642
Tailings	4.95	13,569	83.1	2,293	11,276
Coarse Rejects	2.27	6,229	14.1	5,351	878
				Process Plant Makeup Requirement	**12,361**
				Plant yield (wet)	71.5 %
				Plant yield (dry)	69.0 %
				Fine/coarse split (dry)	30.0 %
				Water use (L/ROM tonne (wet))	474

Table 6.8 MTO CPP (South Plant) – Year 0

Item	Mtpa (wet)	t/day (wet)	Total Moisture (%)	Dry Solids (t/day)	Moisture (kL/d)
Raw Feed	7.92	21,688	4.8	20,647	1,041
Product Coal	5.63	15,418	7.6	14,246	1,172
Tailings	2.62	7,165	73.2	1,920	5,245
Coarse Rejects	1.90	5,198	13.8	4,480	717
				Process Plant Makeup Requirement	**6,093**
				Plant yield (wet)	71.1 %
				Plant yield (dry)	69.0 %
				Fine/coarse split (dry)	30.0 %
				Water use (L/ROM tonne (wet))	281

Table 6.9 MTO CPP (South Plant) – Year 3 to Year 21

Item	Mtpa (wet)	t/day (wet)	Total Moisture (%)	Dry Solids (t/day)	Moisture (kL/d)
Raw Feed	9.45	25,901	4.8	24,658	1,243
Product Coal	6.72	18,413	7.6	17,014	1,399
Tailings	3.12	8,557	73.2	2,293	6,263
Coarse Rejects	2.27	6,207	13.8	5,351	857
				Process Plant Makeup Requirement	**7,276**
				Plant yield (wet)	71.1 %
				Plant yield (dry)	69.0 %
				Fine/coarse split (dry)	30.0 %
				Water use (L/ROM tonne (wet))	281

Haul Road Dust Suppression

A dry day haul road watering rate of 3.5mm/d was determined based on the average recorded rate over the 2013 period (WRM, 2014). This rate has been adopted and applied to the varying watered haul road length as the mine develops, with an assumed watered width of 20m. The resultant average dust suppression water requirements are presented in Table 6.10. Estimates of haul road lengths were based on indicative mine plan information as presented in Figure 6.4 to Figure 6.11.

Table 6.10 Estimated Haul Road Dust Suppression Requirements

Mining Stage	Dust Suppression Area (ha)	Maximum Daily Dust Suppression (kL/d)*	Yearly Average Dust Suppression (ML/a)**
Year 0	199	6,962	1,623
Year 3	185	6,478	1,510
Year 9	174	6,106	1,423
Year 14	140	4,910	1,144
Year 21	136	4,770	1,107

* For a non-rainfall (<0.1 mm) day.
** Based on long term average including rainfall days.

Miscellaneous Industrial Demand and Vehicle Washdown

The miscellaneous industrial use and the vehicle washdown are sourced directly from the MTJV raw water pipeline. Usage is metered; however the breakdown of industrial use and vehicle washdown is not available at Warkworth Mine. The MTW 2013 water balance update (WRM, 2014) estimated the usages and return rates at the north and south workshops and vehicle washdown locations.

The average rates over 2012/13 were estimated as follows:

- South vehicle washdown 53kL/d (8kL/d return, 45kL/d loss)
- South workshop misc. industrial use 151kL/d (100 per cent loss)

- North vehicle washdown 53kL/d (8kL/d return, 45kL/d loss)
- North workshop misc. industrial use 59kL/d (100 per cent loss)

These usages have been assumed to vary based on plant throughput. A return rate of 15 per cent has been adopted for vehicle washdown.

Demand Summary

Table 6.11 shows a summary of demands over the life of the proposal.

Table 6.11 Summary of Demands (ML/a)

Demand	2014	2017	2023	2028	2035
CHPP gross (net)*[a]	6,591 (2,466)	7,168 (2,731)	7,168 (2,731)	7,168 (2,731)	7,168 (2,731)
Haul Road Dust Suppression*[b]	1,623	1,510	1,423	1,144	1,107
Misc. Industrial Use & Vehicle Washdown – gross (net)*[a]	135 (126)	146 (136)	146 (136)	146 (136)	146 (136)
Total – gross (net)*[a]	**8,349 (4,215)**	**8,824 (4,377)**	**8,737 (4,290)**	**8,458 (4,011)**	**8,421 (3,974)**

*[a] Net rates include return.
*[b] Long term average (dependant on rainfall). Based on haul road lengths of 92.6km, 87.2km, 70.1km and 68.1km for 2017, 2023, 2028 and 2035 year indicative mine plans respectively.

6.5.7 Proposed Sediment Dams

Conceptual sediment dam locations have been proposed based on the indicative mine plans and are shown in Figure 6.4 to Figure 6.11. The locations and sizes of the sediment dams are conceptual for inclusion in the water balance modelling and will be refined and confirmed through detailed design and incorporated into the MTW Water Management Plan (WMP).

Sizing of the proposed sediment basins has been undertaken in accordance with the Blue Book (DECC, 2008) requirements for Type D basins. Adopted sediment dam sizes are shown in Table 6.12. Note that the pump rates shown in Table 6.12 are based on a 5 day management period. To reduce these required pumping rates, the guidelines specify adjustment factors to the 5-day volumes for alternate management periods as 85 per cent for 2 days, 125 per cent for 10 days, and 170 per cent for 20 days.

A summary of the assumptions and parameters adopted for the concept sizing of the sediment basins is as follows:

- The catchment areas used to size each sediment dam are the maximum area draining to a dam at any time during the mine life;
- Type D basin (for dispersive soils);
- Design rainfall: duration of disturbance >3 years, 90^{th} percentile, 5 day rainfall depth (for standard receiving waters) = 42.8mm;
- Volumetric runoff coefficient C_v = 0.69;
- Sediment storage zone = 50 per cent of settling zone; and
- Maximum 5m storage depth.

Table 6.12 Proposed Sediment Dam Sizing

Sediment Dam	Catchment Area (ha)*	5-Day Volume (ML)	5-Day Pump Out Rate (L/s)
Sediment Dam A	238	105	244
Sediment Dam B	102	45	105

Notes: * Maximum catchment area reporting to sediment dam over project life.

6.5.8 Hunter River Salinity Trading Scheme

To model future HRSTS discharges from MTW, a Hunter River streamflow and water quality time series was obtained from NOW's IQQM model (full development case with 2004 water sharing plan rules) for the period 16/09/1892 to 30/6/2007. The modelling rules for HRSTS discharges are based on Hunter River stream flow and salinity, and discharge dam volumes and salinity (refer Appendix C).

It is assumed that the number of salt credits held by MTW is not a limitation to releases. Historically there have been sufficient credits available for trade.

The proposal includes an upgrade to the approved discharge point at MTO (Dam 9S) to increase the maximum discharge rate to 300ML/d. The maximum discharge rate at Warkworth Mine (Dam 1N) will remain at 100ML/d.

Controlled releases to the Hunter River under HRSTS are allowed at MTO when the combined inventory of Dam 6S + Dam 9S is greater than 1,500ML, and at Warkworth Mine when the inventory of Dam 1N is greater than 220ML. This ensures that water is not being released at times when the on-site inventory is low and water retention is a key objective.

6.6 WATER MANAGEMENT SYSTEM PERFORMANCE ASSESSMENT

6.6.1 Overview

Key surface water issues for the proposal include:

- Potential for uncontrolled spills from the saline water dams;
- Potential to impact on production due to in-pit water accumulation; and
- Potential for inadequate supplementary water supply from external sources to meet mine-site demands for production and dust suppression.

An assessment of the impacts of the proposal's mine water management system has been undertaken using the water balance model, against the following key performance indicators:

- Mine water inventory: the risk of accumulation (or reduction) of the overall mine water inventory at the proposal, and the associated volumes;
- External water requirements: the risk of requiring imported external water to supplement on-site mine water supplied and the reliability of water supply;
- Uncontrolled spillway discharges: the risk of uncontrolled discharges from the site storages to receiving waters; and
- Overall site water balance.

6.6.2 Interpretation of Results

Water balance results have been analysed in two ways:

- By mine stage – the results for each climatic realisation are averages over the duration of each mine stage (results presented in Section 6.6.3); and
- Annual statistical results – a statistical analysis is performed on an annual basis as a percentile (results presented in Sections 6.6.4 to 6.6.8).

The modelling methodology of a forecast simulation is described in Section 6.2. In interpreting the results of the water balance assessment, it should be noted that the results provide a statistical analysis of the water management system's performance over the 21 years of mine life, based on 93 realisations with different climatic sequences. The 50th percentile probability represents the median results, the 10th percentile represent 10 per cent exceedance and the 90th percentile results represent 90 per cent exceedance. There is an 80 per cent chance that the result will fall within the 10th and 90th percentiles and a 98 per cent chance the result will fall between the 1st and 99th percentiles. Importantly, note that a percentile trace shows the percentile chance of a particular value on each day, and ***does not*** represent continuous results from a single model realisation e.g. the 50th percentile trace does not represent the model time series for median climatic conditions.

6.6.3 Overall Site Water Balance

A water balance for one of the 93 modelled realisations is presented in Table 6.13, averaged over each stage of modelled mine life. The results are presented in Table 6.13 to allow a direct comparison of inflows, outflows and overall water balance between each of the mine stages for the average of all climate realisations for each mine stage. It should be recognised that the following items are subject to climatic variability:

- Rainfall runoff;
- Haul road dust suppression;
- Evaporation;
- External water requirement;
- Controlled releases; and
- Site releases/spills.

The results for the mine stage averages over all climatic realisations show that over the life of the proposal:

- External raw water supply is required in every stage of mine life, with the greatest amount required in Year 21;
- The largest demand from the water management system is due to the CHPP (includes fine tailings moisture retention, product coal and rejects moisture);
- Total mine water demand (including CHPP makeup, dust suppression and miscellaneous industrial use and vehicle washdown) ranges between approximately 4,000ML/a to 4,400ML/a, with the highest demand in Year 3;
- No overflows from the saline water storages occurred in the simulation period; and
- The combined spill volumes from the sediment dams is highest in Year 14 (316ML/a), which corresponds to the stage with the highest rainfall yield, and ranges between 91ML/a and 316ML/a for the remaining stages.

Table 6.13 MTW Average Water Balance for Each Mine Stage over all Climatic Realisations

Process	Volume (ML/a)				
	Year 0 (2 years)	Year 3 (4 years)	Year 9 (7 years)	Year 14 (5 years)	Year 21 (4 years)
INFLOWS					
Rainfall Runoff	3,524	3,846	4,111	4,210	4,278
Groundwater	186	10	0	0	0
External Raw Water Requirements	1,251	1,807	1,720	1,519	1,803
ROM moisture	877	978	978	978	978
Redbank Power Station	25	25	25	25	25
Total Inflows	**5,873**	**6,665**	**6,833**	**7,016**	**7,084**
OUTFLOWS					
Evaporation	495	656	751	607	817
Fine tailings moisture retention	1,774	1,965	1,965	1,965	1,965
Haul road dust suppression	1,644	1,533	1,471	1,195	1,171
Misc. ind. demand & vehicle wash	126	136	136	136	136
Product coal moisture	1,008	1,110	1,110	1,110	1,110
Coarse rejects moisture	572	633	633	633	633
HRSTS Discharges	561	453	548	369	366
Offsite Sediment Dam Releases	91	214	240	316	315
Offsite Saline Dam Releases	0	0	0	0	0
Total Outflows	**6,253**	**6,679**	**6,803**	**6,274**	**6,450**
Change in Site Water Inventory	***-380***	***-14***	***+30***	***+742***	***+634***

6.6.4 Pit Storage Characteristics

An assessment of pit inventory characteristics has been undertaken to determine the likelihood of water inundating the pit, which could impact production. A forecast assessment has been used.

Figure 6.12 shows the predicted probability of the modelled total in-pit storage volume. A build-up of water in the active pits generally occurs when the out-of-pit storages are too full to accept additional pit water, or the catchment runoff draining to the pit is greater than the dewatering pump capacity.

Figure 6.13, Figure 6.14, Figure 6.15 and Figure 6.16 show the predicted probability of the modelled in-pit storage volume as a percentage of days for North Pit, West Pit, South Pit and Loders Pit, respectively. The assessment of in-pit inventory shows that:

- There is a one per cent chance of total in-pit volume up to 1,900ML at any year of project life;
- There is a 10 per cent chance of total in-pit volume up to 400ML at any year of project life;
- All individual pits are considered to have a low probability of pit inundation, and are likely to accumulate volumes of up to 900ML only in extreme climate conditions.

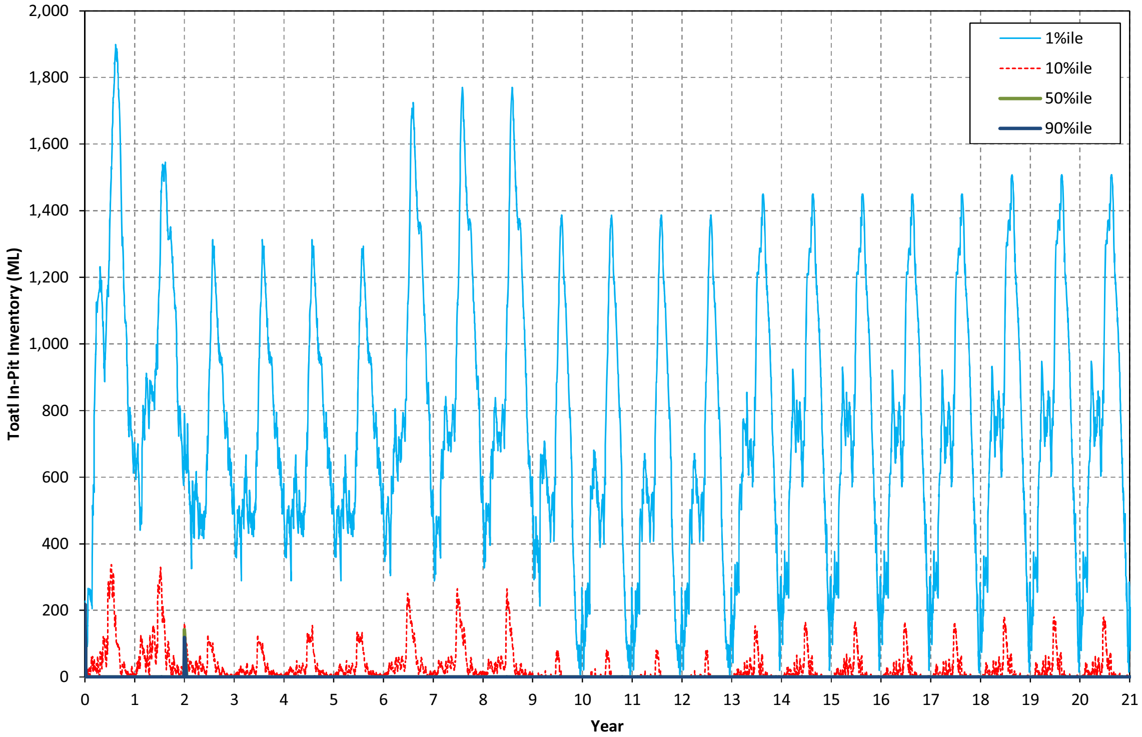

Figure 6.12 Total In-Pit Storage Inventory (ML)

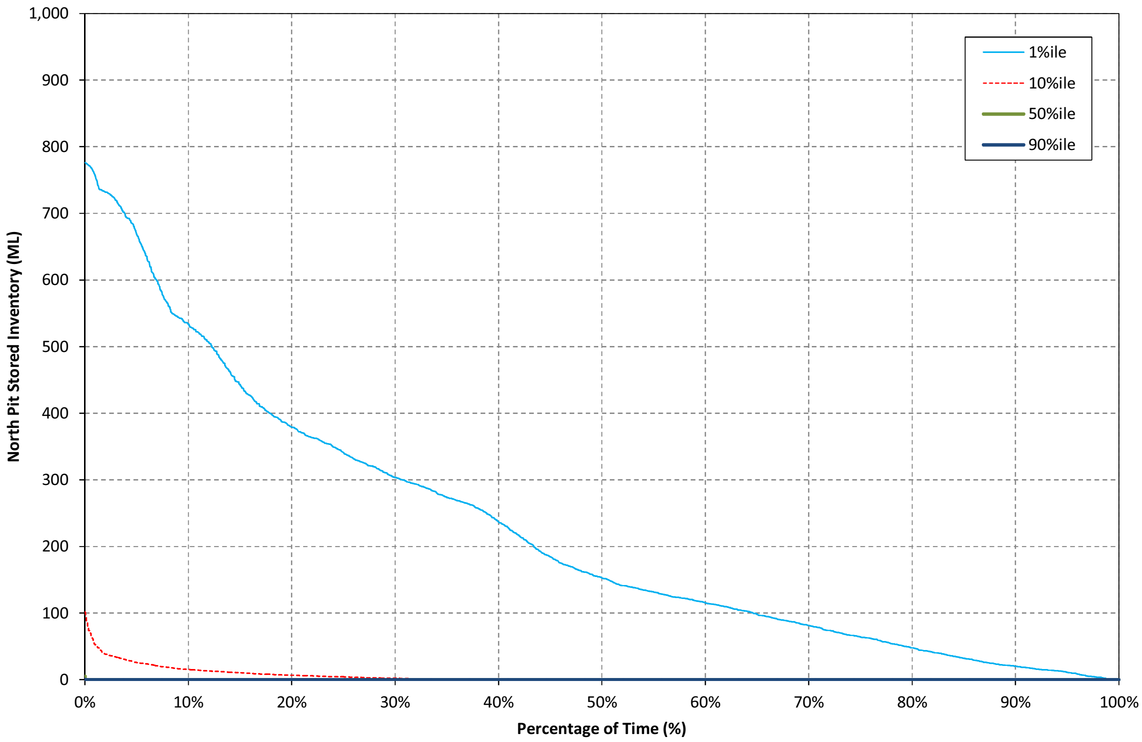

Figure 6.13 North Pit Inundation Characteristics

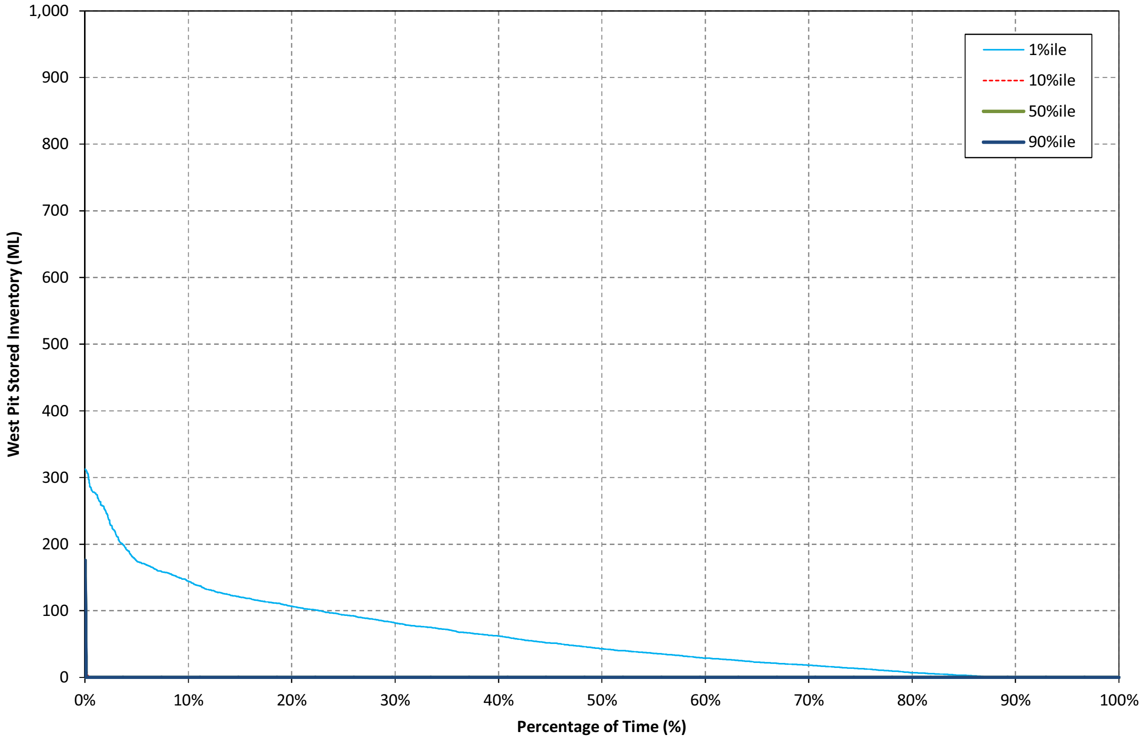

Figure 6.14 West Pit Inundation Characteristics

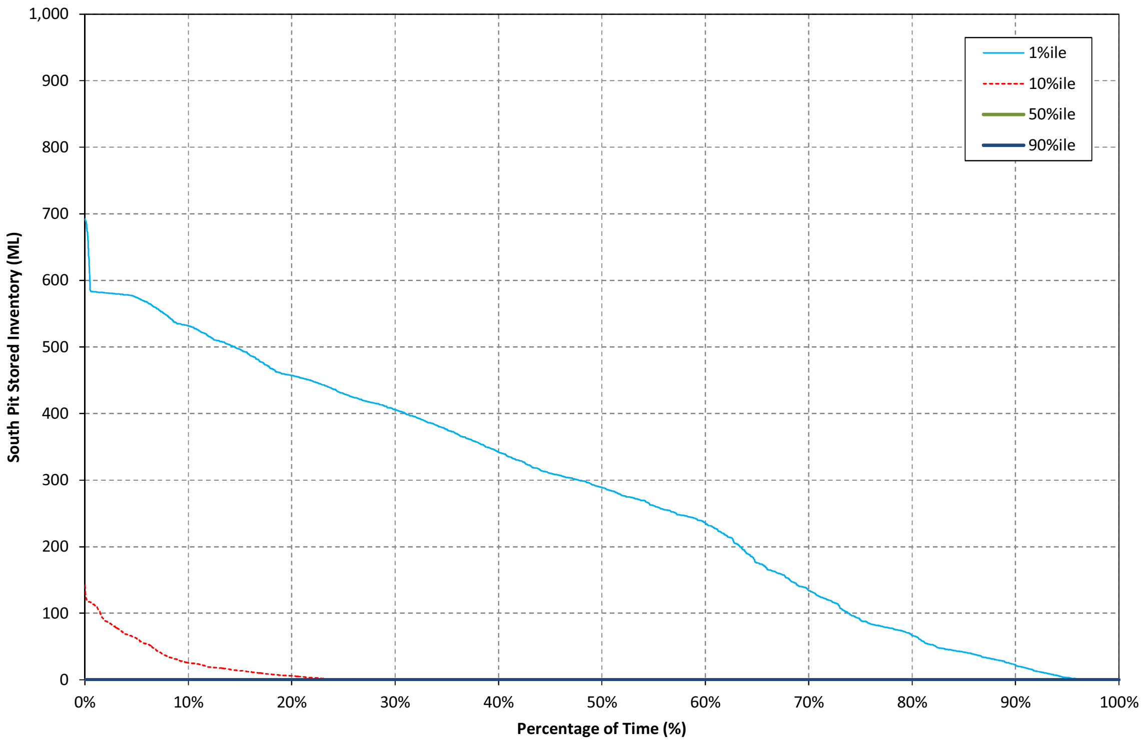

Figure 6.15 South Pit Inundation Characteristics

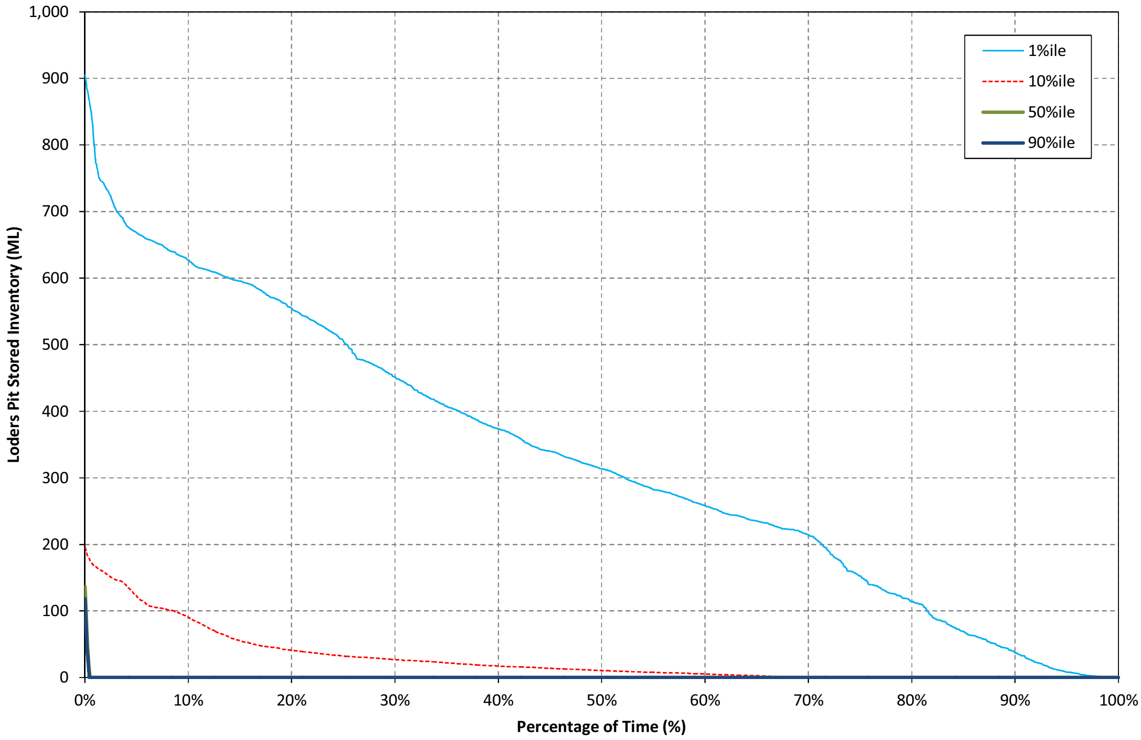

Figure 6.16 Loders Pit Inundation Characteristics

6.6.5 Out-of-Pit Storage Characteristics

A forecast assessment has been undertaken to estimate the future out-of-pit water inventory. The out-of-pit water storages included in the analysis are the four main saline water storage dams on site (existing and proposed):

- Dam 6S (SOOP Dam);
- Dam 9S;
- Dam 1N; and
- NOOP Dam (proposed).

Figure 6.17 shows the predicted probability of the modelled total out-of-pit storage inventory. The combined capacity (to spillway) of the four primary saline water storages is 2,621ML (prior to construction of NOOP Dam), and 3,363ML including the NOOP Dam capacity. The results show that:

- Consistent with the in-pit inventory results, the water management system is not at risk of accumulating water over the life of the project and is able to recover prior to each subsequent wet season;
- The total out-of-pit inventory:
  - Has a one per cent chance of reaching at least 2,000ML in Years 0 to 2, and at least 2,500ML in any year after that;
  - Has a 10 per cent chance of reaching between 1,500ML to 2,500ML in any year;

– Has a 50 per cent chance of reaching an inventory of at least 300ML in any year;

– Has a 90 per cent chance of reaching an inventory of at least 0ML to 100ML in any year (equivalent to a 10 per cent chance of not exceeding approximately 0ML to 100ML in any year).

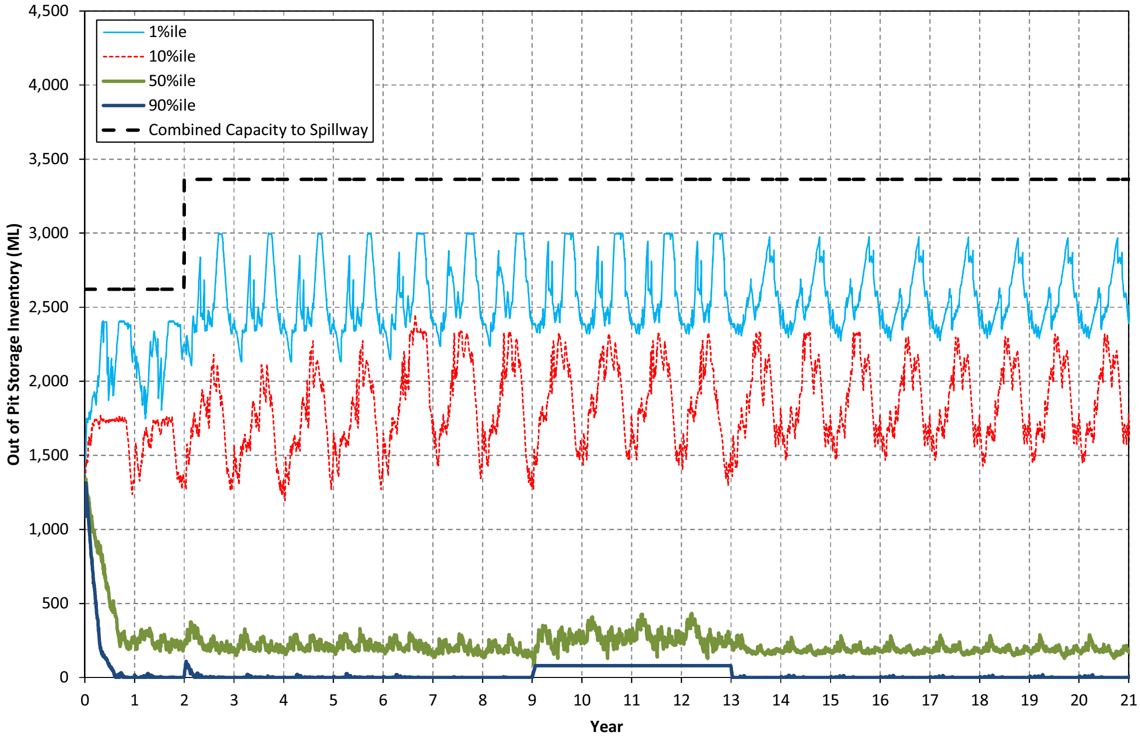

Figure 6.17 Out-of-Pit Water Inventory

6.6.6 Controlled HRSTS Discharges to Hunter River

The potential for controlled releases under the proposal has been assessed using a forecast assessment simulation. The predicted probability of the annual controlled discharges from MTO and Warkworth Mine are provided in Figure 6.18 and Figure 6.19 respectively. The results show that:

- Overall, much greater volumes are discharged from MTO than Warkworth Mine, which is consistent with the capacity of the discharge structures (200ML/d at MTO and 100ML/d at Warkworth Mine) and dam volumes;
- There is a 50 per cent chance of controlled releases from MTO will not be required in any year of the life of the proposal, and small volumes of controlled discharges (100ML) will be required from Warkworth Mine in any year of the life of the proposal; and
- There is a 10 per cent chance of controlled releases from MTO of between 1,000ML to 2,000ML will be required in any year of the life of the proposal, and around 400ML from Warkworth Mine in any year of the life of the proposal.

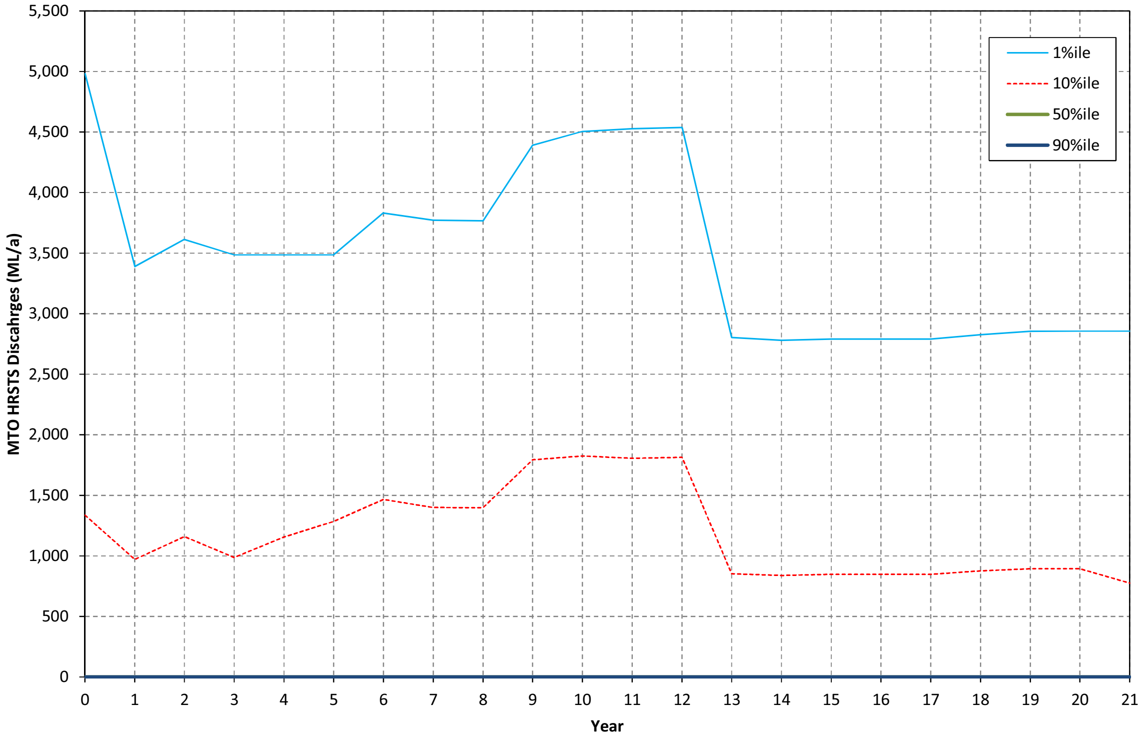

Figure 6.18 MTO Discharges to Hunter River

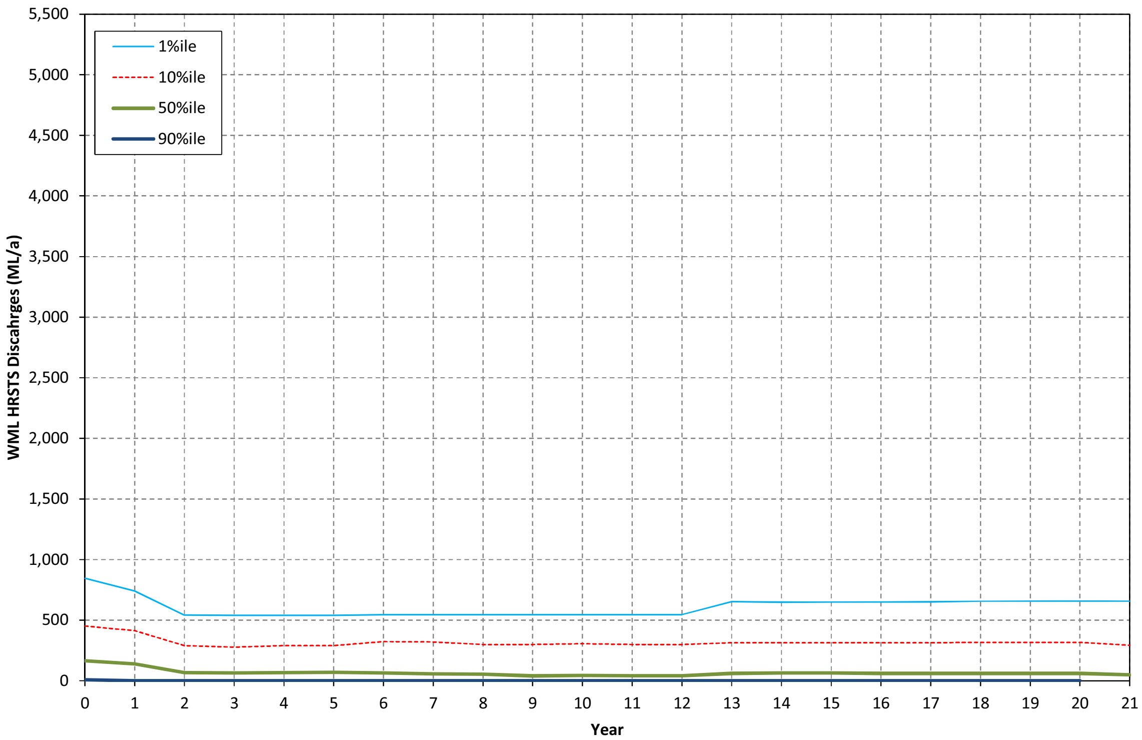

Figure 6.19 Warkworth Mine Discharges to Hunter River

6.6.7 External Water Requirements

For the purposes of current investigations, the term 'external water requirements' represents the amount of imported water from external third party sources, such as the Hunter River (or other sources such as water sharing agreements with nearby mine sites) that is required to sustain the nominated design production rate and associated operational demands for the proposal. The simulation of the water management system assumes that any shortfall in water captured onsite is made up from imported water – that is, during dry periods imported water is used to ensure that all operational demands are met. Note that the current MTJV allocation is 1,012ML/a (at 100 per cent Available Water Determination (AWD)).

This potential requirement for external water supply has been assessed using a forecast assessment simulation. The predicted probability of annual external water requirement is provided in Figure 6.20. The results show that:

- A minimum of 140ML/a of external raw water (from the Hunter River) will be required for the life of the proposal. This is consistent with site demands of industrial use and vehicle wash of around 140ML/a which are supplied from raw water sources only;
- There is a 90 per cent chance that at least 450ML of external water will be required in any year of project life.
- A step change in external water requirement occurs in around Year 2 which is consistent with the modelled decrease in groundwater inflows at MTO, and an increase in production. From Year 3 onwards the external water requirements are generally consistent with:
  - A 50 per cent chance that between 1,500ML/a to 2,000ML/a of external water will be required; and
  - A 10 per cent chance that between 3,000ML/a to 3,700ML/a of external water will be required.

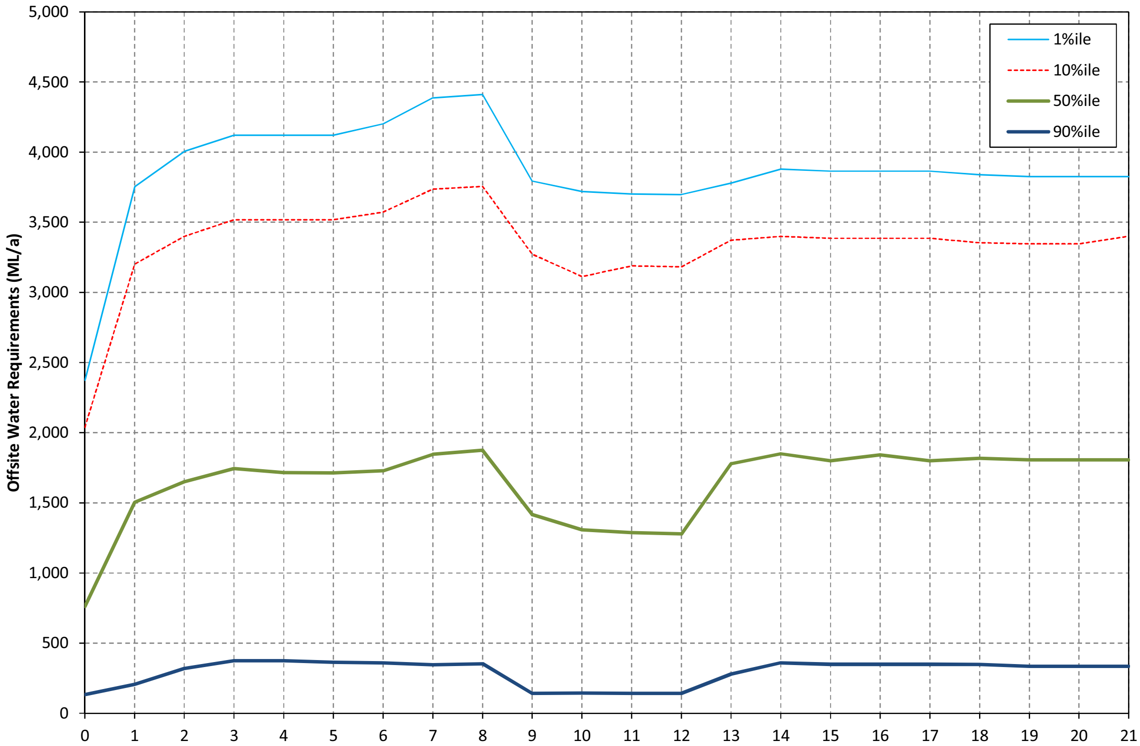

Figure 6.20 MTW External Water Requirements

6.6.8 Uncontrolled Offsite Discharges

Expected discharges from the proposal have been assessed on the basis of simulated spillway overflows from site storages to receiving waters. The assessment includes storages which have the ability to discharge via a spillway into the receiving waters, including saline dams and sediment dams. No saline water discharges were simulated for the life of the project. Figure 6.21 shows the sediment dam offsite overflows, assessed using a forecast simulation. Results show that sediment dam overflows increase over the life of the proposal, consistent with the increase in rehabilitation of spoil areas and diversion of these areas offsite.

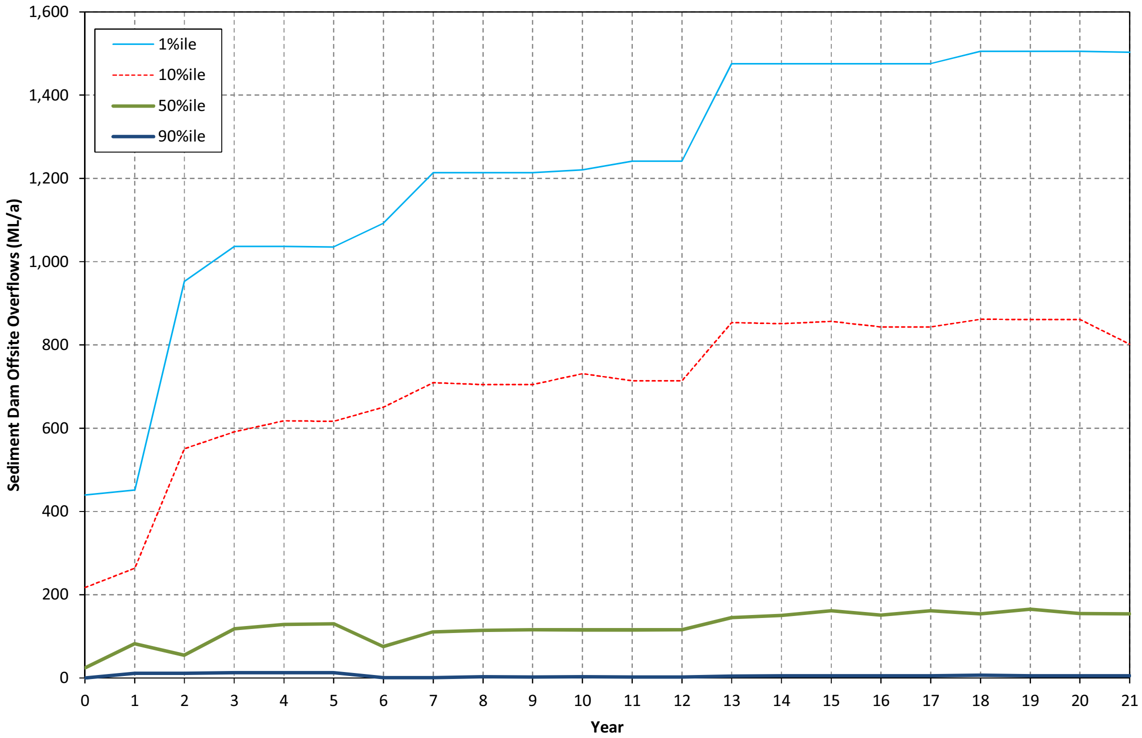

Figure 6.21 Sediment Dam Offsite Overflows (ML/a)

6.7 FINAL LANDFORM STORAGE AND WATER QUALITY BEHAVIOUR

6.7.1 Overview

The behaviour of the MTW final voids has been simulated to assess the long term accumulation of water and salts. Two final voids will remain: North Pit and West Pit final voids at Warkworth mine, as well as a depression at MTO at the location of the partially backfilled Loders Pit, which is proposed to be used for tailings storage.

6.7.2 Groundwater Behaviour

Figure 6.22 shows the estimated groundwater inflows to the Warkworth final void and Loders depression (AGE, 2014), and outflows. An iterative methodology was used to achieve agreement between the surface water model and groundwater model. The groundwater inflows from the spoil to the void are initially quite high, and decrease sharply. This is a result of the capping of tailings dams which used to seep to the void. The groundwater inflows from spoil then reach an equilibrium which is essentially rainfall runoff baseflow through the spoil piles. Note that water seeps out of the Loders depression, some of which flows to the Warkworth Void and some flows to the Wollombi alluvium. The potential impact on the Wollombi alluvium is discussed further in the AGE (2014) Groundwater Impact Assessment.

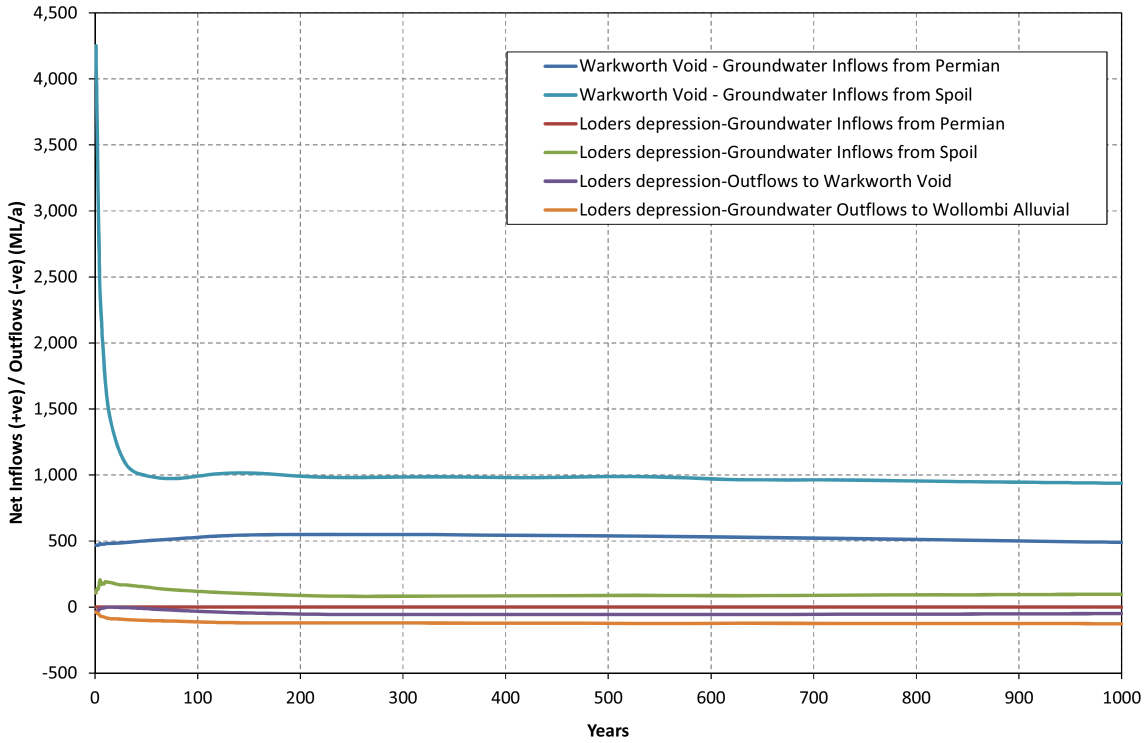

Figure 6.22 Final Void Groundwater Inflow/Outflow (AGE, 2014)

6.7.3 OPSIM Model Configuration

The final landform configuration and contributing catchment area are shown in Figure 6.23. Following mine closure, there are no further operational demands and all infrastructure and mine water storages are rehabilitated. The water balance and final equilibrium water level of the final void is dependent on the rainfall and runoff entering the void, evaporation loss from the void, and the inflow or outflow of groundwater. Permanent drainage of spoil dumps will be constructed on the eastern (low-wall) side to minimise capture of surface runoff in the final void. The model was run for a period of 1,000 years, using looped Data Drill rainfall and evaporation. The following assumptions were made with regards to salinity:

- Permian groundwater inflow salinity at both Warkworth mine and MTO: 10,000µS/cm, based on the average of bore water quality monitoring for Permian groundwater at the mines.
- Spoil groundwater inflow salinity (including water seeping from tailings dams and rainfall runoff baseflows through the spoil pile): 9,000µS/cm, based on measurement at the pit face of the spoil seepage water quality.
- Rainfall runoff surface flow salinity for rehabilitated spoil: 600µS/cm, based on median water quality measured in Dam 30N which has a rehabilitated spoil surface runoff catchment.

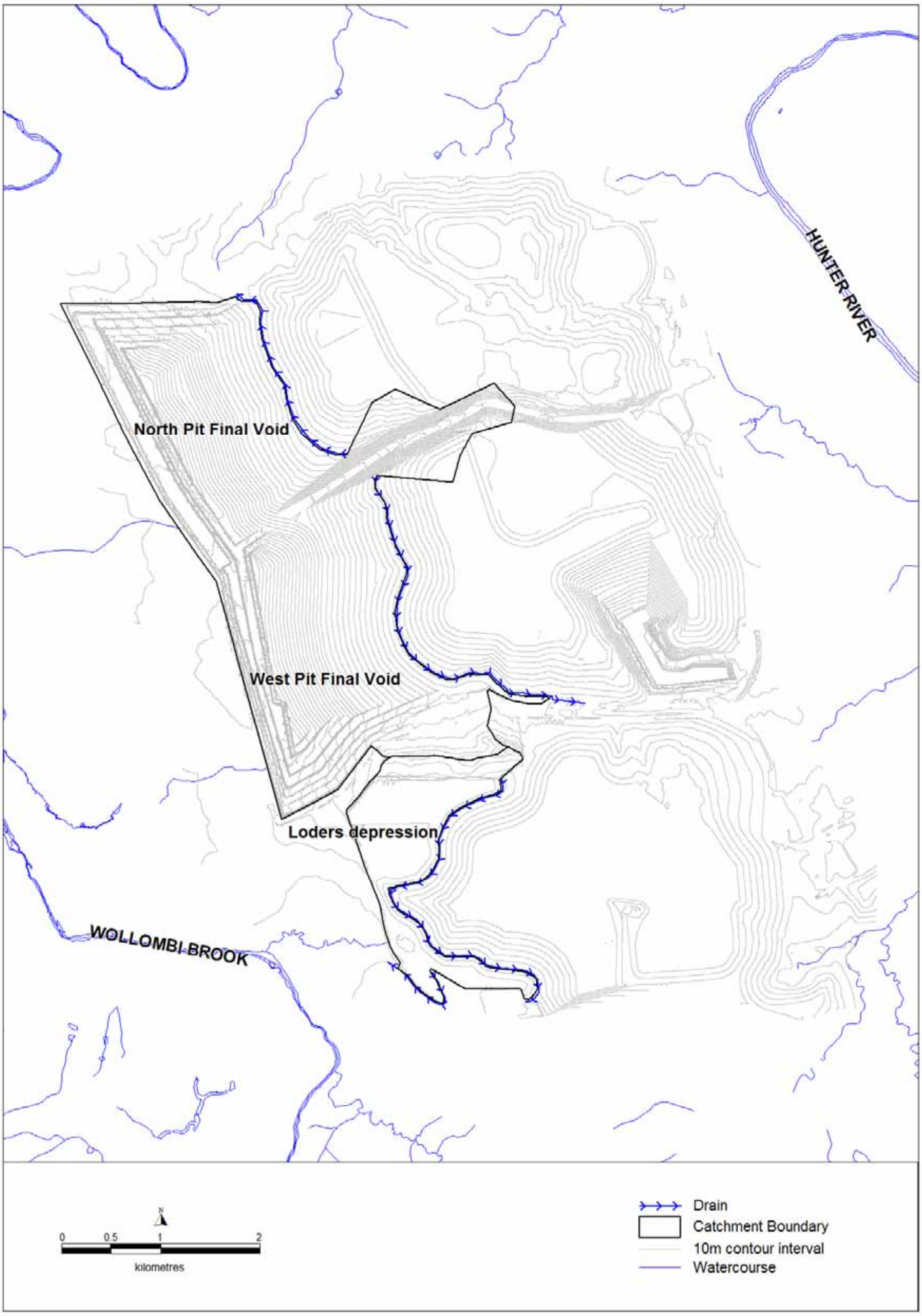

Figure 6.23 MTW Final Landform Catchment Plan

6.7.4 OPSIM Model Results

Figure 6.24 shows the simulated Warkworth final void water level and salinity as EC. The final void water level increases until it reaches equilibrium of inflows and outflows at approximately 20m AHD. This is approximately 54m below the crest level of the void. The salinity increases at a rate of approximately 30µS/cm per year, reaching 30,000µS/cm over the modelled 1,000 year period. This is due to the concentration of salts from evaporation.

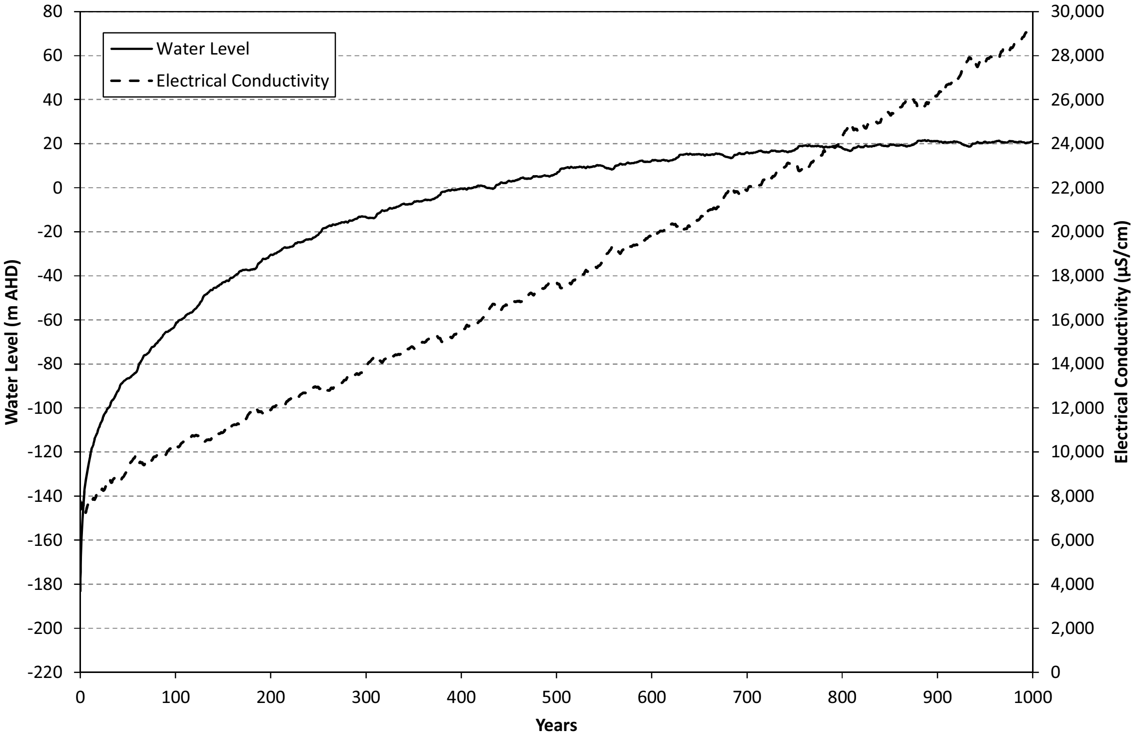

Figure 6.24 Warkworth Final Void Water Level and Salinity

Figure 6.25 and Figure 6.26 shows the Loders depression water level and stored volume, respectively. The depression stores water for approximately the first 100 years, and thereafter is mostly empty, with a lake forming at times for periods of up to 10 years in response to large rainfall events. The maximum water level reached is approximately 67m AHD (1,300ML) in the first 100 years, and thereafter approximately 64m AHD (500ML). This is approximately 3m and 6m lower than the crest level respectively. Note that a level of 67m AHD and 64m AHD equates to approximately 45% and 20% of the capacity of the depression, respectively.

Figure 6.27 shows the Loders depression salinity as a monthly average. A monthly average has been presented as the model shows artificial large spikes in EC when there are very small water volumes stored in the void. Figure 6.27 also shows the 90th percentile, median and 10th percentile ECs over the period when the depression is regularly emptying (100 to 1000 years). The results show a median EC of 3,000µS/cm, and 90th percentile EC of 8,000µS/cm.

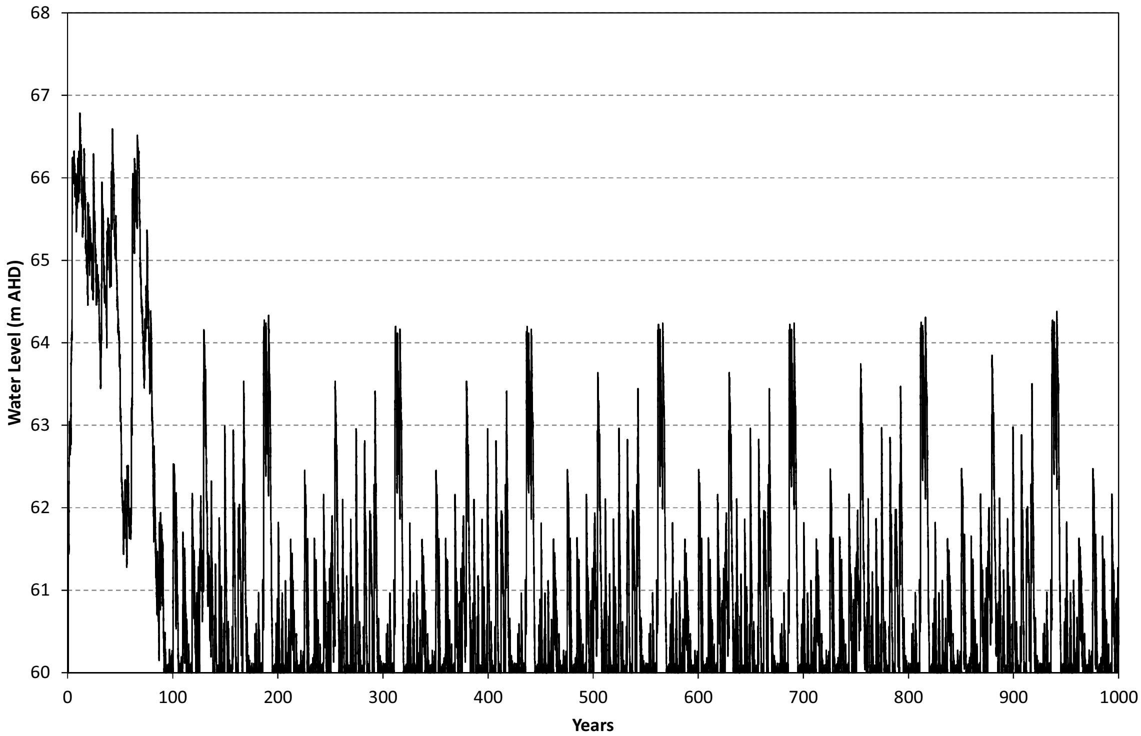

Figure 6.25 Loders Depression Water Level

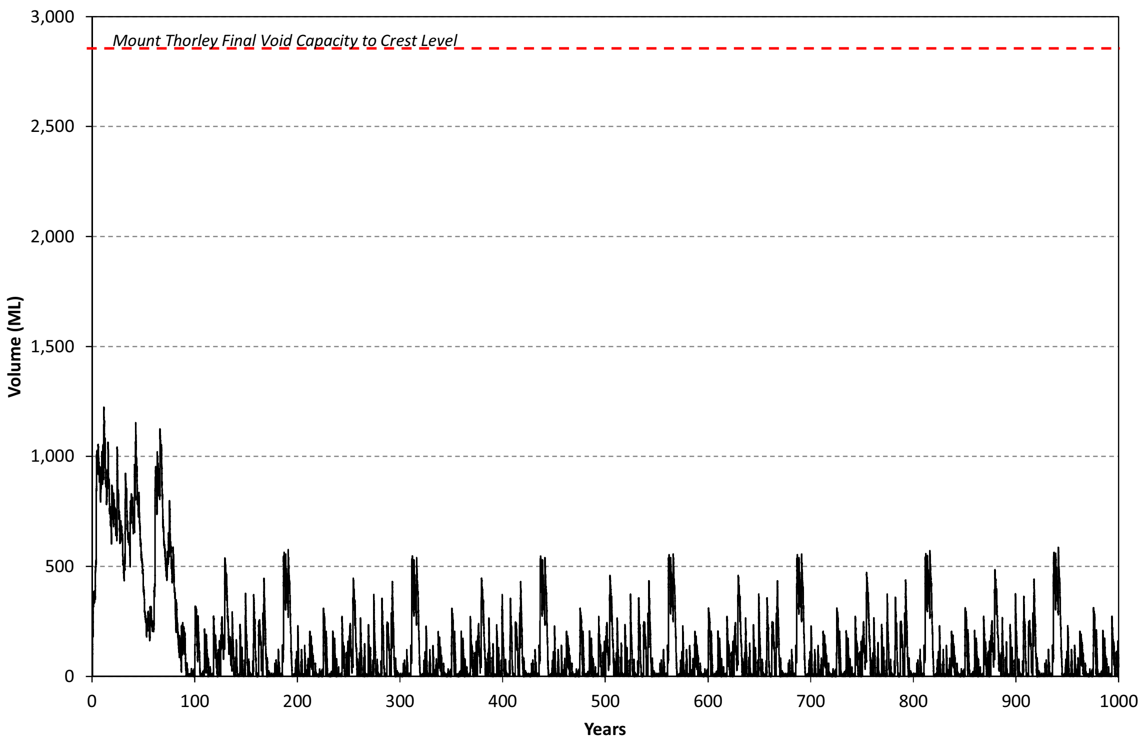

Figure 6.26 Loders Depression Stored Volume

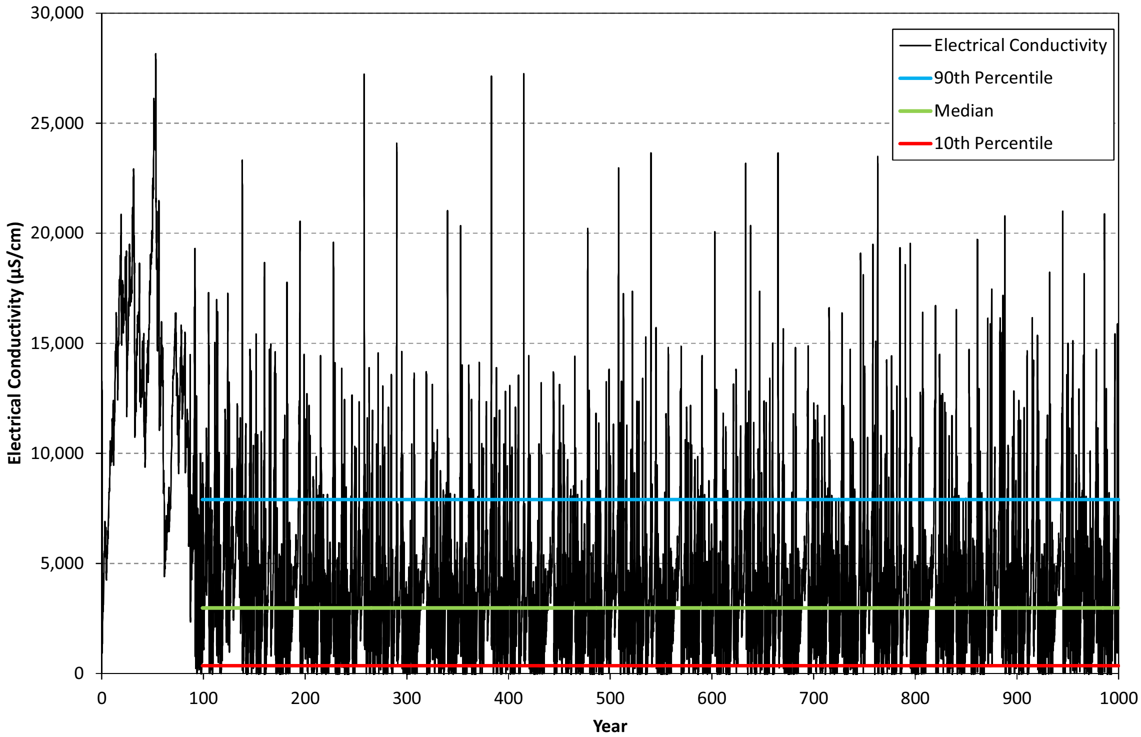

Figure 6.27 Loders Depression Salinity (Monthly Average)

6.8 MINE WATER BALANCE SUMMARY

The forecast results of the mine water balance model show that there is a step change in external water requirements which occurs in around Year 2, consistent with the increase in CHPP throughput and decrease in groundwater inflows to Mount Thorley. From Year 3 onwards the external water requirements are generally consistent:

- There is a 50 per cent chance that between 1,500ML/a to 2,000ML/a of external water will be required; and
- There is a 10 per cent chance that between 3,000ML/a to 3,700ML/a of external water will be required.

Note that the current MTJV allocation is 1,012ML/a (at 100 per cent Available Water Determination (AWD)).

Note that Tailings Dam 2 (Dam 33N) will remain uncapped until the contract with Redbank Power Station to accept ash expires in 2031. The Year 21 mine layout (Figure 6.10) shows the TD2 as rehabilitated, however the water balance model assumes it is uncapped for the life of the mine. Rainfall runoff on the TD2 contributes less than 100ML/a to the water balance in an average rainfall year (45ha catchment area x 658mm/a long term average annual rainfall x 40% long term volumetric runoff coefficient), which is 1.4% of the Year 21 total inflows of around 7,100ML/a (refer Table 6.13). The effect of capping the TD2 on the water balance model results will reduce the external water requirements by approximately 100ML/a for the Year 21 mine stage only, which are estimated at 1,800ML/a on average (note that the year 21 mine stage is modelled as the final 4 years of the project life). Therefore this assumption is not considered to have a significant impact on the water balance model results.

The results of the water balance modelling indicate a low probability of pit inundation, and no offsite uncontrolled release (overflows) from saline storages.

HRSTS discharges will be required for site water management, with the following discharge characteristics:

- Overall, much greater volumes are discharged from MTO than Warkworth Mine, which is consistent with the capacity of the discharges structures (200ML/d at MTO and 100ML/d at Warkworth Mine) and dam volumes;
- There is a 50 per cent chance that controlled releases from MTO will not be required in any year of the life of the proposal, and small volumes (100ML) will be discharged from Warkworth Mine in any year of the life of the proposal; and
- There is a 10 per cent chance that controlled releases from MTO of between 1,000ML to 2,000ML will be required in any year of the life of the proposal, and around 400ML from Warkworth Mine in any year of the life of the proposal.

6.9 ADAPTIVE MANAGEMENT OF MINE WATER BALANCE

The model results presented above represent the application of the adopted mine water management system rules over the mine life, regardless of climatic conditions. In reality, there are numerous options for adaptive management of the mine water management system to accommodate climatic conditions. For example, temporary adjustments to pumping arrangements could be made to accommodate very wet or dry periods. These alternative management approaches would be used to reduce the risks to the project associated with climatic variability.

7 MITIGATION MEASURES

7.1 OVERVIEW

Surface water at the Site is managed in accordance with MTW's WMP which was prepared in consultation with NOW and the NSW Environment Protection Authority. The impacts of the proposal on surface water resources will be mitigated through the implementation of the following measures to be documented in the revised site Water Management Plan:

- A mine site water management system to control the flow and storage of water of different qualities across the site;
- A sediment control plan to reduce sediment loads from disturbed area runoff; and
- A surface water monitoring program to continually assess environmental impacts and ensure that the site water management system is meeting its objectives of managing impacts on receiving waters.

An overview of each of these management measures are provided in the following sections.

7.2 MINE WATER MANAGEMENT SYSTEM

A key objective of the MTW mine water management system is to minimise the risk of uncontrolled releases from mine site storages. To achieve this objective, operation of the mine water management system will be based on the following principles:

- Diversion of clean surface water runoff away from areas disturbed by mining activities;
- Operation of the mine water management system to ensure no uncontrolled releases of mine water from the site;
- Collection of potentially sediment-affected runoff in sediment dams for treatment prior to release from site;
- Transfer of groundwater and seepage inflows to the open cut pits to the mine water system for reuse;
- Collection of contaminated water from industrial areas for treatment in an oil and grease separator prior to recycling in the mine water management system; and
- Minimisation of fresh water usage by recycling water from the mine water system before taking additional water from external sources.

Details of the operation of the mine water management system are provided in Section 6.5.

An important component of the mine water management system will be to ensure that contingency measures are in place to accommodate either a surplus or deficit of water on site. Appropriate water licences or external sources will be obtained to meet the potential shortfall in water during dry conditions. Mine operations will also be planned to ensure that mining can continue during extended wet periods when water may accumulate in the open cut mining areas.

The site water management plan will detail reporting and action procedures to identify any lack of compliance with objectives and a process for implementing corrective actions.

7.3 EROSION AND SEDIMENT CONTROL PLAN

The design of sediment control measures for the proposal will be based on the principle of ensuring that runoff from disturbed areas is separated from clean area runoff and collected in sediment dams for treatment. Design of proposed erosion and sediment control measures will be based on the recommended design standards in the following guidelines:

- Managing Urban Stormwater, Soils and Construction (Landcom, 2004); and
- Managing Urban Stormwater, Soils and Construction, Volume 2E Mines and Quarries (DECC, 2008).

Proposed sediment dam sizes and locations are detailed in Section 6.5.7.

7.4 DRAINAGE OF FINAL LANDFORM

The rehabilitated overburden east of mining operations will be drained using the approach currently adopted at MTW which is based on:

- Topsoiling and revegetation of the finished landform;
- Construction of contour drains across the batter slope to minimise the potential for rilling and gullying of the finished landform;
- Collection of inflows from contour drains in rock chutes which flow downslope; and
- Flows from rock chutes are directed to sediment basins prior to release from site.

7.5 SURFACE WATER MONITORING PROGRAM

The existing MTW surface water monitoring program is described in Section 2.6.2.

The surface water monitoring locations and frequencies of the receiving waterways are considered appropriate to identify any changes in water quality associated with the proposal.

The site dam watering monitoring program will be updated to include additional locations as new dams are constructed:

- Saline storages: EC, pH and TSS will be monitored on a monthly basis. A comprehensive analysis will be undertaken annually.
  - NOOP Dam.
- Sediment dams: EC, pH and TSS will be monitored on a monthly basis. A comprehensive analysis will be undertaken annually.
  - Ramp 22 Dam;
  - Sediment Dam A; and
  - Sediment Dam B.

8 CONCLUSION

The proposed surface water management system has been developed in conjunction with the mine planning and operational teams to develop a surface water management system that has minimal impacts on surface water resources. The proposed surface water management system is a continuation of the current surface water management system, and the results of the surface water impact assessment indicate that the impacts of the proposal on surface water resources are unlikely to be significantly different to the existing approved operations.

The forecast results of the mine water balance model show that there is a step change in external water requirements which occurs in around Year 2, consistent with the increase in CHPP throughput and decrease in groundwater inflows to Mount Thorley. From Year 3 onwards the external water requirements are generally consistent:

- There is a 50 per cent chance that between 1,500ML/a to 2,000ML/a of external water will be required;
- There is a 10 per cent chance that between 3,000ML/a to 3,700ML/a of external water will be required; and
- There is a one per cent chance that between 3,700ML/a to 4,500ML/a of external water will be required.

Note that the current MTJV allocation is 1,012ML/a (at 100 per cent Available Water Determination (AWD)).

The results of the water balance modelling indicate a low probability of pit inundation, and no offsite uncontrolled release (overflows) from saline storages.

HRSTS discharges will be required for site water management, with the following discharge characteristics:

- Overall, much greater volumes are discharged from MTO than Warkworth Mine, which is consistent with the capacity of the discharges structures (200ML/d at MTO and 100ML/d at Warkworth Mine) and dam volumes;
- There is a 50 per cent chance that controlled releases from MTO will not be required in any year of project life, and small volumes (100ML) will be discharged from Warkworth Mine in any year of project life;
- There is a 10 per cent chance that controlled releases from MTO of between 1,000ML to 2,000ML will be required in any year of project life, and around 400ML from Warkworth Mine in any year of project life; and
- There is a one per cent chance that between 3,000ML to 4,500ML from MTO will be discharged in any year of mine life; and 500ML to 800ML of discharges from Warkworth Mine in any year of project life.

There is a maximum reduction of 0.56 per cent of the Wollombi Brook catchment to the Hunter River, and a maximum reduction of 0.19 per cent of the Hunter River (not including Wollombi Brook) during mining. Post-mining, the reduction in catchment area is 0.44 per cent and 0.04 per cent for Wollombi Brook and the Hunter River respectively. There is a median net runoff reduction to the Hunter River of up to 75ML/a during mining, and up to 104ML/a post-mining.

MTW currently undertakes an extensive surface water monitoring program, which will continue to be implemented for the proposal. Monitoring includes on site dams (both saline and sediment), receiving waters (upstream and downstream Hunter River, Wollombi Brook and their tributaries), and additional monitoring which is undertaken during periods of controlled release under the HRSTS. Additional saline storages and sediment dams constructed as part of the proposal will be monitored in accordance with the current monitoring program.

If required, additional water licences would be obtained from licensed sources, and therefore there will be no adverse impact on other licensed users who will still have access to their entitlement (subject to climatic availability and the operation of the water supply scheme).

Overall, the impacts of the Project on surface water resources are unlikely to be significantly greater than those of the existing mining operation.

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APPENDIX A

SUMMARY OF MTW WATER QUALITY MONITORING PROGRAM RESULTS

Water Quality Parameter		Hunter River		Loders Creek			Doctors Creek		Longford Creek	Sandy Hollow Creek	Wollombi Brook		Saltpan Creek
		W1	W3	W2	W5	W15	W4	W14	W27	WW5	Wollombi_ Brook	Wollombi_ Brook Upstream	SP1
Al - Total (mg/l)	10%ile	0.33	0.11	0.56	0.06	0.08	0.13	0.56	3.33	6.60	0.04	-	-
	Median	0.52	1.11	1.20	0.33	0.25	0.28	3.66	14.70	6.60	0.05	-	-
	90%ile	5.73	15.65	1.52	8.76	2.86	0.47	8.59	30.54	6.60	0.05	-	-
	N	5	6	3	5	5	3	4	3	1	2	0	0
As - Total (mg/l)	10%ile	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.002	0.001	-	-
	Median	0.001	0.001	0.001	0.002	0.002	0.004	0.002	0.004	0.002	0.001	-	-
	90%ile	0.001	0.003	0.002	0.006	0.003	0.006	0.008	0.006	0.004	0.001	-	-
	N	10	9	4	12	6	3	6	4	3	9	0	0
B (mg/l)	10%ile	0.00	0.03	0.03	0.05	0.02	0.06	0.02	0.04	0.03	0.02	-	-
	Median	0.04	0.04	0.04	0.08	0.07	0.08	0.05	0.05	0.04	0.05	-	-
	90%ile	0.05	0.06	0.04	0.09	0.14	0.14	0.08	0.05	0.04	0.06	-	-
	N	9	9	4	10	5	3	6	3	3	8	0	0
Ba (mg/l)	10%ile	0.022	0.021	0.027	0.064	0.012	0.153	0.018	0.061	0.069	0.055	-	-
	Median	0.031	0.032	0.034	0.086	0.071	0.220	0.048	0.089	0.082	0.098	-	-
	90%ile	0.085	0.126	0.039	0.130	0.110	0.244	0.108	0.107	0.112	0.251	-	-
	N	9	9	4	11	5	3	6	3	3	8	0	0
Ca - Total (mg/l)	10%ile	27	24	37	18	25	11	13	5	13	12	-	-
	Median	39	39	50	78	49	20	35	6	15	14	-	-
	90%ile	44	49	105	119	113	22	65	10	17	15	-	-
	N	7	8	6	7	7	3	5	5	2	3	0	0
$CaCO_3$ - Total Hard (mg/l)	10%ile	77	86	336	392	140	584	38	41	-	109	-	-
	Median	163	230	560	1,111	210	584	88	41	-	109	-	-
	90%ile	249	266	944	1,830	1,506	584	138	41	-	109	-	-
	N	2	3	3	2	3	1	2	1	0	1	0	0
Cl- (mg/l)	10%ile	132	140	-	3,231	2,407	1,830	515	25	-	180	-	-
	Median	136	144	-	3,275	2,675	1,830	515	34	-	191	-	-
	90%ile	140	147	-	3,319	2,943	1,830	515	42	-	201	-	-
	N	2	2	0	2	2	1	1	2	0	2	0	0
EC Field (uS/cm (25TRef))	10%ile	440	450	600	1,726	2,180	1,200	620	200	162	368	437	6,786
	Median	645	630	800	7,270	4,840	5,760	3,305	288	270	764	600	16,810
	90%ile	890	890	1,082	12,570	8,108	16,024	11,620	390	442	1,060	923	24,880
	N	90	81	85	135	88	37	26	31	32	138	18	15
EC Lab (uS/cm (25TRef))	10%ile	810	533	470	4,200	646	25,320	535	-	-	746	-	-
	Median	810	845	1,135	4,200	6,770	25,320	4,695	-	-	830	-	-
	90%ile	810	7,240	5,925	4,200	10,978	25,320	9,475	-	-	886	-	-
	N	1	84	84	1	85	1	56	0	0	3	0	0
Fe - Filtered (mg/L)	10%ile	0.03	0.05	0.01	0.04	0.01	0.02	0.05	0.32	0.59	0.05	-	-
	Median	0.12	0.22	0.02	0.13	0.03	0.02	0.23	0.35	1.71	0.06	-	-
	90%ile	0.21	0.22	0.02	1.85	0.12	0.02	2.21	2.73	2.82	1.12	-	-
	N	3	3	2	6	3	2	3	3	2	5	0	0
K - Total (mg/l)	10%ile	3	3	4	15	8	26	7	6	7	4	-	-
	Median	4	4	4	27	14	45	19	7	7	5	-	-
	90%ile	4	4	5	34	25	71	32	10	8	6	-	-
	N	7	7	2	7	6	3	5	5	2	3	0	0
Li (mg/l)	10%ile	0.002	0.004	0.005	0.019	0.017	0.048	0.012	0.005	0.005	0.002	-	-
	Median	0.005	0.006	0.005	0.088	0.037	0.093	0.037	0.007	0.005	0.004	-	-
	90%ile	0.030	0.039	0.007	0.140	0.053	0.107	0.207	0.013	0.005	0.005	-	-
	N	5	6	3	5	5	3	4	3	1	2	0	0
Mg - Total (mg/l)	10%ile	23	14	23	26	41	143	15	3	11	16	-	-
	Median	28	28	29	317	136	205	29	7	13	18	-	-
	90%ile	35	36	34	418	388	243	94	7	15	19	-	-
	N	7	7	3	7	6	3	5	5	2	3	0	0
Mn - Total (mg/l)	10%ile	0.056	0.003	0.050	0.038	0.016	0.011	0.011	0.030	0.025	0.227	-	-
	Median	0.110	0.108	0.114	0.073	0.081	0.012	0.092	0.047	0.052	0.428	-	-
	90%ile	0.352	0.766	0.130	0.313	0.416	0.037	0.298	0.050	0.098	2.030	-	-
	N	9	9	4	10	5	3	6	3	3	8	0	0
Na - Total (mg/l)	10%ile	42	40	67	480	362	2,226	107	19	21	102	-	-
	Median	73	66	88	2,380	896	3,970	563	26	28	104	-	-
	90%ile	80	80	106	2,794	2,590	5,274	1,111	38	35	110	-	-
	N	7	7	3	7	6	3	5	5	2	3	0	0
P - Total (mg/l)	10%ile	0.06	0.07	0.06	0.05	0.04	0.14	0.13	0.04	0.15	0.02	-	-
	Median	0.09	0.19	0.11	0.06	0.07	0.20	0.88	0.13	0.16	0.02	-	-
	90%ile	2.35	2.62	0.15	0.17	0.10	0.36	3.89	0.27	0.16	0.02	-	-
	N	6	6	3	4	4	3	5	4	2	2	0	0
pH Field	10%ile	7.5	7.6	7.4	7.9	7.4	7.8	7.3	6.9	7.1	7.0	7.2	7.5
	Median	8.0	8.1	8.0	8.2	8.0	8.7	8.1	7.4	7.7	7.4	7.6	8.1
	90%ile	8.4	8.4	8.3	8.6	8.4	9.0	8.6	7.8	8.1	8.0	8.0	8.6
	N	89	80	85	133	88	37	26	31	32	137	18	15
pH Lab	10%ile	7.6	7.7	7.5	7.9	7.3	8.3	7.3	6.8	-	8.0	-	-
	Median	7.6	8.2	8.1	8.0	8.1	8.8	8.2	6.8	-	8.0	-	-
	90%ile	7.6	9.0	8.9	8.1	8.9	9.3	8.7	6.8	-	8.0	-	-
	N	1	86	87	2	85	2	56	1	0	1	0	0
Rb - Total (mg/l)	10%ile	0.001	0.001	0.002	0.010	0.002	0.007	0.003	0.007	0.018	0.003	-	-
	Median	0.002	0.002	0.003	0.014	0.006	0.008	0.007	0.024	0.018	0.003	-	-
	90%ile	0.004	0.009	0.004	0.025	0.011	0.008	0.019	0.038	0.018	0.004	-	-
	N	5	6	3	5	5	3	4	3	1	2	0	0
Se (mg/l)	10%ile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
	Median	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	-	-
	90%ile	0.05	0.07	0.00	0.01	0.55	0.01	0.11	0.01	0.00	0.01	-	-
	N	9	8	4	10	5	3	6	3	3	8	0	0
Si (mg/l)	10%ile	3.01	4.01	10.60	0.16	0.20	0.43	0.07	2.89	5.50	5.95	-	-
	Median	12.20	14.50	13.00	2.65	1.11	1.26	0.16	10.63	5.50	7.04	-	-
	90%ile	14.82	15.60	16.20	4.97	4.75	2.09	10.43	18.37	5.50	8.13	-	-
	N	4	5	3	4	4	2	3	2	1	2	0	0
SO_4 - Total (mg/l)	10%ile	26	21	32	274	232	713	28	4	20	2	-	-
	Median	34	32	35	550	1,300	1,001	33	9	29	5	-	-
	90%ile	145	186	37	2,099	2,516	1,288	850	24	34	13	-	-
	N	8	6	2	10	4	2	5	4	3	9	0	0
Sr - Total (mg/l)	10%ile	0.125	0.163	0.384	0.379	0.177	1.564	0.139	0.102	0.190	0.207	-	-
	Median	0.380	0.351	0.400	1.600	0.550	1.820	0.510	0.129	0.190	0.231	-	-
	90%ile	0.490	0.487	0.520	3.244	2.862	2.604	0.959	0.171	0.190	0.254	-	-
	N	5	6	3	5	5	3	4	3	1	2	0	0
TSS (mg/L)	10%ile	5	8	10	4	3	8	15	3	19	2	5	5
	Median	21	22	21	14	14	35	54	43	45	6	5	10
	90%ile	65	61	59	97	80	78	110	129	94	18	9	20
	N	88	80	84	129	83	36	25	30	32	135	14	13
Turbidity (NTU)	10%ile	17.0	22.0	42.2	3.9	240.0	-	100.0	-	-	-	-	-
	Median	17.0	22.0	55.0	3.9	240.0	-	100.0	-	-	-	-	-
	90%ile	17.0	22.0	67.8	3.9	240.0	-	100.0	-	-	-	-	-
	N	1	1	2	1	1	0	1	0	0	0	0	0
Zn - Total (mg/l)	10%ile	0.005	0.005	0.003	0.005	0.005	0.007	0.006	0.005	0.017	0.004	-	-
	Median	0.005	0.022	0.005	0.007	0.008	0.012	0.026	0.018	0.025	0.005	-	-
	90%ile	0.019	0.064	0.006	0.030	0.042	0.013	0.134	0.043	0.173	0.005	-	-
	N	10	9	4	12	6	3	6	4	3	9	0	0

N = Number of samples
Note: The value of analytes analysed in a concentration below the detection limit were replaced for the value of the detection limit.

Water Quality Parameter		Saline Storage								Sediment Dam / Clean Water Storage				
		Dam 1N	Dam 11N	Dam 25N	Dam 6S	Dam 9S	Dam 12S	Dam 15S	Dam 2S	Dam 6N	Dam 27N	Dam 30N	Dam 1S	Dam 3S
Al - Total (mg/l)	10%ile	0.09	0.91	19.60	0.09	0.26	0.51	0.21	-	0.28	-	0.09	0.18	2.71
	Median	0.16	14.90	26.00	0.47	0.38	18.00	0.37	-	0.28	-	0.09	0.48	3.89
	90%ile	10.06	25.86	36.72	1.33	0.71	62.04	1.15	-	0.28	-	0.09	5.85	4.83
	N	5	8	3	9	9	5	7	0	1	0	1	7	4
As - Total (mg/l)	10%ile	0.001	0.001	0.002	0.021	0.002	0.003	0.002	-	0.002	-	0.001	0.005	0.002
	Median	0.013	0.004	0.004	0.026	0.007	0.005	0.011	-	0.002	-	0.002	0.008	0.005
	90%ile	0.017	0.007	0.009	0.030	0.025	0.015	0.026	-	0.002	-	0.002	0.010	0.009
	N	10	8	3	10	13	8	15	0	1	0	2	12	4
B (mg/l)	10%ile	0.06	0.04	0.05	0.07	0.08	0.02	0.01	-	0.10	-	0.05	0.03	0.05
	Median	0.08	0.05	0.06	0.08	0.10	0.05	0.07	-	0.10	-	0.05	0.05	0.05
	90%ile	0.11	0.07	0.08	0.09	0.12	0.05	0.09	-	0.10	-	0.05	0.05	0.06
	N	10	8	3	9	13	7	13	0	1	0	1	11	4
Ba (mg/l)	10%ile	0.015	0.077	0.127	0.098	0.027	0.118	0.025	-	0.247	-	0.070	0.013	0.043
	Median	0.033	0.129	0.197	0.104	0.051	0.225	0.057	-	0.247	-	0.070	0.049	0.068
	90%ile	0.114	0.270	0.200	0.117	0.085	0.358	0.099	-	0.247	-	0.070	0.133	0.091
	N	9	7	3	7	12	8	14	0	1	0	1	11	4
Ca - Total (mg/l)	10%ile	15	3	4	11	7	2	10	-	4	-	9	8	4
	Median	40	5	5	13	13	3	12	-	4	-	11	20	4
	90%ile	50	11	8	16	17	16	16	-	4	-	13	39	5
	N	18	6	3	9	8	5	9	0	1	0	2	8	4
$CaCO_3$ - Total Hard (mg/l)	10%ile	502	17	88	199	200	5	53	-	-	-	142	169	47
	Median	590	56	88	199	200	5	115	-	-	-	142	506	47
	90%ile	848	95	88	199	200	5	177	-	-	-	142	842	47
	N	13	2	1	1	1	1	2	0	0	0	1	2	1
Cl- (mg/l)	10%ile	-	107	81	856	856	585	863	-	1,280	-	65	316	262
	Median	-	377	159	928	946	585	913	-	1,280	-	91	942	401
	90%ile	-	587	342	1,060	964	585	963	-	1,280	-	117	1,708	651
	N	0	3	3	9	3	1	2	0	1	0	2	3	4
EC Field (uS/cm (25TRef))	10%ile	3,790	156	297	5,122	4,956	190	2,465	1,372	8,269	278	484	595	2,066
	Median	7,260	220	478	6,140	7,460	460	4,895	2,190	8,385	351	581	1,230	3,560
	90%ile	8,725	2,591	1,417	7,392	8,729	2,212	7,860	5,670	8,501	594	899	7,010	5,285
	N	110	18	6	24	112	99	106	17	2	10	8	106	18
EC Lab (uS/cm (25TRef))	10%ile	737	193	-	-	7,857	177	7,950	-	-	-	-	2,445	-
	Median	6,440	255	-	-	7,950	383	7,950	-	-	-	-	2,785	-
	90%ile	8,875	1,787	-	-	8,008	589	7,950	-	-	-	-	3,125	-
	N	120	4	0	0	4	2	1	0	0	0	0	2	0
Fe - Filtered (mg/L)	10%ile	0.02	0.61	-	-	0.01	0.73	0.02	-	-	-	-	0.03	0.09
	Median	0.05	0.79	-	-	0.01	0.79	0.05	-	-	-	-	0.09	0.10
	90%ile	0.09	3.25	-	-	0.01	2.96	0.25	-	-	-	-	0.13	0.11
	N	4	3	0	0	1	3	3	0	0	0	0	4	2
K - Total (mg/l)	10%ile	23	3	2	23	27	9	18	-	36	-	9	10	8
	Median	36	8	4	25	30	20	29	-	36	-	10	14	11
	90%ile	44	30	7	28	34	34	35	-	36	-	11	40	17
	N	5	7	3	9	8	5	9	0	1	0	2	8	4
Li (mg/l)	10%ile	0.131	0.008	0.009	0.169	0.197	0.008	0.074	-	0.418	-	0.012	0.004	0.016
	Median	0.275	0.016	0.015	0.177	0.212	0.017	0.169	-	0.418	-	0.012	0.007	0.022
	90%ile	0.358	0.076	0.023	0.204	0.294	0.134	0.273	-	0.418	-	0.012	0.021	0.038
	N	5	8	3	9	9	5	6	0	1	0	1	6	4
Mg - Total (mg/l)	10%ile	25	3	6	26	13	2	9	-	15	-	14	0	5
	Median	36	5	7	32	19	10	21	-	15	-	20	17	8
	90%ile	67	56	14	39	25	58	44	-	15	-	25	131	9
	N	6	7	3	9	9	5	9	0	1	0	2	8	4
Mn - Total (mg/l)	10%ile	0.004	0.005	0.050	0.003	0.005	0.038	0.005	-	0.002	-	0.018	0.015	0.014
	Median	0.008	0.059	0.088	0.006	0.011	0.120	0.009	-	0.002	-	0.018	0.047	0.027
	90%ile	0.046	0.106	0.158	0.214	0.030	0.199	0.018	-	0.002	-	0.018	10.137	0.036
	N	9	6	3	9	12	7	13	0	1	0	1	10	4
Na - Total (mg/l)	10%ile	1,306	26	115	1,340	1,720	29	992	-	2,220	-	82	70	361
	Median	1,800	37	203	1,450	1,860	51	1,580	-	2,220	-	114	346	530
	90%ile	1,900	770	386	1,594	2,197	526	2,032	-	2,220	-	145	1,413	923
	N	5	7	3	9	8	5	9	0	1	0	2	8	4
P - Total (mg/l)	10%ile	0.01	0.03	0.26	0.01	0.01	0.05	0.03	-	0.05	-	0.06	0.30	0.05
	Median	0.02	0.17	0.26	0.02	0.02	0.20	0.07	-	0.05	-	0.06	0.66	0.09
	90%ile	0.48	0.72	0.59	0.05	0.03	0.51	0.09	-	0.05	-	0.06	0.94	0.12
	N	6	8	3	7	9	4	5	0	1	0	1	5	4
pH Field	10%ile	8.4	7.8	7.8	8.7	8.4	7.4	8.6	8.4	9.8	7.6	7.9	8.0	8.9
	Median	8.7	8.1	8.4	9.0	8.8	8.1	8.9	8.9	9.8	7.9	8.3	8.8	9.2
	90%ile	8.9	9.0	8.7	9.1	9.0	8.7	9.1	9.2	9.8	9.1	8.9	10.0	9.5
	N	109	17	6	24	111	98	105	17	2	10	8	88	18
pH Lab	10%ile	7.7	7.0	-	-	8.7	7.1	9.0	-	-	-	-	8.0	-
	Median	8.7	7.1	-	-	8.7	7.7	9.0	-	-	-	-	9.1	-
	90%ile	9.0	8.1	-	-	8.7	7.9	9.0	-	-	-	-	9.3	-
	N	123	3	0	0	1	3	1	0	0	0	0	20	0
Rb - Total (mg/l)	10%ile	0.043	0.020	0.027	0.035	0.048	0.008	0.015	-	0.002	-	0.005	0.005	0.014
	Median	0.061	0.036	0.042	0.041	0.055	0.053	0.036	-	0.002	-	0.005	0.007	0.018
	90%ile	0.063	0.063	0.065	0.042	0.060	0.127	0.050	-	0.002	-	0.005	0.027	0.019
	N	5	7	3	9	9	5	6	0	1	0	1	6	4
Se (mg/l)	10%ile	0.00	0.01	0.01	0.01	0.00	0.00	0.00	-	0.01	-	0.01	0.00	0.01
	Median	0.01	0.01	0.01	0.01	0.01	0.00	0.01	-	0.01	-	0.01	0.00	0.01
	90%ile	0.01	0.01	0.01	0.02	0.01	0.01	0.03	-	0.01	-	0.01	0.01	0.02
	N	10	7	3	9	13	7	13	0	1	0	1	11	4
Si (mg/l)	10%ile	5.62	0.28	-	3.38	5.30	4.62	1.97	-	-	-	-	1.46	17.80
	Median	6.25	20.90	-	6.85	6.40	4.70	5.10	-	-	-	-	2.05	17.80
	90%ile	7.65	37.30	-	13.81	9.24	46.22	6.70	-	-	-	-	3.97	17.80
	N	4	5	0	4	5	3	6	0	0	0	0	4	1
SO_4 - Total (mg/l)	10%ile	444	12	53	784	730	43	279	-	1	-	33	32	242
	Median	1,011	34	131	869	939	67	789	-	1	-	53	164	346
	90%ile	1,304	224	202	924	1,290	435	923	-	1	-	73	864	586
	N	10	6	3	10	11	5	12	0	1	0	2	8	4
Sr - Total (mg/l)	10%ile	0.316	0.096	0.212	0.934	0.382	0.110	0.170	-	0.644	-	0.528	0.223	0.177
	Median	0.640	0.145	0.258	1.180	0.648	0.160	0.370	-	0.644	-	0.528	0.280	0.248
	90%ile	0.833	0.529	0.336	1.460	0.882	0.721	1.348	-	0.644	-	0.528	1.928	0.349
	N	5	8	3	9	9	4	7	0	1	0	1	7	4
TSS (mg/L)	10%ile	5	22	124	9	8	21	15	14	5	22	5	7	12
	Median	17	54	513	41	18	91	36	56	7	46	9	36	36
	90%ile	114	150	1350	136	88	1042	163	605	8	50	25	251	80
	N	118	19	6	24	110	99	105	17	2	5	7	104	18
Turbidity (NTU)	10%ile	4.9	13.1	-	-	7.9	780.8	140.0	-	-	-	-	-	-
	Median	17.4	62.0	-	-	22.0	2080.0	140.0	-	-	-	-	-	-
	90%ile	135.0	1292.4	-	-	47.4	3064.0	140.0	-	-	-	-	-	-
	N	46	3	0	0	47	3	1	0	0	0	0	0	0
Zn - Total (mg/l)	10%ile	0.005	0.005	0.026	0.005	0.005	0.008	0.005	-	0.005	-	0.005	0.005	0.009
	Median	0.005	0.044	0.054	0.005	0.005	0.028	0.013	-	0.005	-	0.005	0.005	0.020
	90%ile	0.036	0.089	0.096	0.006	0.021	7.458	0.027	-	0.005	-	0.005	0.029	0.021
	N	10	8	3	10	13	8	15	0	1	0	2	12	4

N = Number of samples
Note: The value of analytes analysed in a

APPENDIX B

MTW CATCHMENT AND LAND USE CLASSIFICATION TABLES

Table B. 1 Year 0 Catchment Areas and Land Use Classifications (ha) - Surface component

Storage	**Land Use**							**Grand Total**
	Cleared/ Prestrip	**Mining Pit**	**Natural/ Undisturbed**	**Rehab. Spoil**	**Roads/ Industrial/ Hardstand**	**Tailings**	**Unrehab. Spoil**	
AGS	1.3			4.8	0.4	14.3	5.8	**26.7**
52ML Dam			4.1		8.7			**12.8**
Dam 10S	2.8			48.9			0.9	**52.6**
Dam 11N			53.7					**53.7**
Dam 11S	0.7			0.1				**0.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 12S	64.3		7.9		5.9			**78.1**
Dam 14S			0.4		1.0			**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16N	2.1		7.6	63.9			1.0	**74.7**
Dam 16S	4.9					12.5		**17.4**
Dam 17S (CRTSF)				11.9	14.2	29.2	24.9	**80.2**
Dam 18N				1.0				**1.0**
Dam 1N	14.1			58.0	21.3		103.6	**197.0**
Dam 1S/2S	10.1		2.2		15.6			**27.9**
Dam 20N	8.5		3.8		0.8			**13.0**
Dam 27N			0.5	5.1				**5.6**
Dam 30N	11.3			91.7				**103.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 32N (TD1)	1.2			40.7				**41.9**
Dam 33N (TD2)	2.4			13.1		45.9		**61.4**
Dam 3S	7.4		1.5	141.9	6.2		25.8	**182.8**
Dam 4N			1.9					**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6N	1.9		7.0		0.1			**9.1**
Dam 6S	26.9							**26.9**
Dam 9(A)S	0.9			0.0				**0.9**
Dam 9S	2.4							**2.4**
Dams 13,14,15N	12.3			146.3	4.0		2.1	**164.8**
Honeypot Dam	6.8		35.8		4.0			**46.7**
Loders Pit	8.2	12.7	8.1	3.3	25.1		347.7	**405.2**
Mini Strip TSF			7.4	0.3	11.2		15.7	**34.6**
North Loders Clean Dam			8.9					**8.9**
North Pit	49.3	6.2	5.0	10.9	9.0		148.1	**228.6**
North Pit North	20.9	5.4		8.5	9.7		124.9	**169.4**
South Pit	0.2	7.4	1.2	37.7	15.6		272.5	**334.6**
West Pit	25.5	19.2	74.7	18.0	35.0		462.8	**635.1**
Grand Total	**302.3**	**50.9**	**262.2**	**706.1**	**273.8**	**101.9**	**1,535.8**	**3,233.6**

Table B. 2 Year 0 Catchment Areas and Land Use Classifications (ha) - Baseflow component

Storage	Land Use							Grand Total
	Cleared/ Prestrip	Mining Pit	Natural/ Undisturbed	Rehab. Spoil	Roads/ Industrial/ Hardstand	Tailings	Unrehab. Spoil	
AGS	1.3			4.8	0.4	14.3	5.8	**26.7**
52ML Dam			4.1		8.7			**12.8**
Dam 10S	1.2			0.9				**2.1**
Dam 11N			53.7					**53.7**
Dam 11S	0.7			0.1				**0.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 12S	64.3		7.9		5.9			**78.1**
Dam 14S			0.4		1.0			**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16N	2.1		0.8				1.0	**4.0**
Dam 16S	4.9					12.5		**17.4**
Dam 17S (CRTSF)				3.4	9.0	29.2	14.7	**56.4**
North Loders Clean Dam			8.9					**8.9**
Dam 1N	14.1			0.7	5.7		0.6	**21.0**
Dam 1S/2S	10.1		2.2		15.6			**27.9**
Dam 20N	8.5		3.8		0.8			**13.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 32N (TD1)	1.2			40.7				**41.9**
Dam 33N (TD2)						45.9		**45.9**
Dam 3S	3.1		1.5		0.3			**4.9**
Dam 4N			1.9					**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6N	1.9		7.0		0.1			**9.1**
Dam 6S	26.9							**26.9**
Dam 9(A)S	0.9			0.0				**0.9**
Dam 9S	2.4							**2.4**
Dams 13,14,15N	7.8			0.5	1.4		0.9	**10.7**
Honeypot Dam	6.8		35.8		4.0			**46.7**
Loders Pit	14.2	12.7	8.1	297.2	47.6		423.4	**803.1**
Mini Strip TSF			7.4	0.3	11.2		15.7	**34.6**
North Pit	55.5	6.2	5.8	233.8	14.5		152.9	**468.7**
North Pit North	32.6	5.4	7.3	179.2	9.7		124.9	**359.1**
South Pit		7.4	0.1	114.8	27.1		307.9	**457.3**
West Pit	25.0	19.2	76.4	24.5	45.8		535.2	**726.1**
Grand Total	**301.4**	**50.9**	**263.6**	**900.9**	**294.8**	**101.9**	**1,583.0**	**3496.9**

Table B. 3 Year 3 MTW Catchment Areas and Land Use Classifications (ha) – Surface component

Storage	Land Use							Grand Total
	Cleared/ Prestrip	Mining Pit	Natural/ Undisturbed	Rehab. Spoil	Roads/ Industrial/ Hardstand	Tailings	Unrehab. Spoil	
AGS	1.3			6.4	0.2	14.7	5.0	**27.6**
52ML Dam			4.1		8.7			**12.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 14S			0.4		1.0			**1.4**
Dam 15N	1.4							**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16S	5.5				11.9			**17.4**
Dam 17S (CRTSF)				9.1		51.8	26.0	**87.0**
Dam 18N			0.8	0.2				**1.0**
Dam 1N	13.3			149.8	34.0		35.3	**232.4**
Dam 1S/2S	10.1		2.2		15.6			**27.9**
Dam 20N	8.2		3.8		0.7		0.3	**13.0**
Dam 27N			2.5	3.0				**5.6**
Dam 30N			0.0	103.0				**103.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 33N (TD2)				16.4		45.0		**61.4**
Dam 3S	3.3		1.5	118.2	3.2		49.3	**175.5**
Dam 4N			1.9	0.1				**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6S	26.9							**26.9**
Dam 9(A) S	0.6			0.3				**0.9**
Dam 9S	2.4							**2.4**
Honeypot Dam	3.8		2.1		0.4		0.5	**6.8**
Loders Pit	17.4	11.2	15.6	19.0	32.8		381.2	**477.1**
Mini Strip TSF			7.4	0.5	10.2		16.3	**34.3**
NOOP Dam	17.7		4.2	264.0	4.5		0.1	**290.5**
North Loders Clean Dam			8.9					**8.9**
North Pit Mid	22.8	12.2		30.7	10.6		183.2	**259.4**
North Pit North	15.7	6.0	0.4	38.7	10.7		159.1	**230.5**
Ramp 22 Dam	0.3			267.9			33.8	**302.0**
South Pit		18.5		37.4	17.7		227.3	**300.9**
West Pit	53.4	20.4	35.8	55.4	42.9		522.6	**730.5**
Grand Total	**220.2**	**68.2**	**122.1**	**1120.1**	**291.1**	**111.5**	**1640.1**	**3572.9**

Table B. 4 Year 3 MTW Catchment Areas and Land Use Classifications (ha) – Baseflow component

Storage	Runoff Set							Grand Total
	Cleared/ Prestrip	Mining Pit	Natural/ Undisturbed	Rehab. Spoil	Roads/ Industrial/ Hardstand	Tailings	Unrehab. Spoil	
AGS	1.3			6.4	0.2	14.7	5.0	**27.6**
52ML Dam			4.1		8.7			**12.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 14S			0.4		1.0			**1.4**
Dam 15N	1.4							**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16S	5.5				11.9			**17.4**
Dam 17S (CRTSF)				9.1		51.8	26.0	**87.0**
Dam 1N	13.3			0.7	7.7		0.0	**21.8**
Dam 1S/2S	10.1		2.2		15.6			**27.9**
Dam 20N	8.2		3.8		0.7		0.3	**13.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 33N (TD2)				1.7		44.3		**46.0**
Dam 3S	3.1		1.5		0.3			**4.9**
Dam 4N			1.9	0.1				**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6S	26.9							**26.9**
Dam 9(A)S	0.6			0.3				**0.9**
Dam 9S	2.4							**2.4**
Honeypot Dam	3.8		2.1		0.4		0.5	**6.8**
Loders Pit	17.9	11.2	15.5	287.5	41.9		476.5	**850.5**
Mini Strip TSF			7.4	0.5	10.1		16.3	**34.3**
NOOP Dam	18.5			2.5	2.5			**23.5**
North Loders Clean Dam			8.9					**8.9**
North Pit Mid	22.8	12.2	0.4	306.8	16.3		183.7	**542.2**
North Pit North	15.7	6.0	8.3	220.5	10.7		159.1	**420.3**
Ramp 22 Dam				123.2			14.3	**137.5**
South Pit		18.5	0.3	156.8	32.3		246.8	**454.8**
West Pit	53.5	20.4	35.8	108.6	60.2		554.5	**832.9**
Grand Total	**221.0**	**68.3**	**123.1**	**1224.7**	**306.5**	**110.8**	**1683.1**	**3737.5**

Table B. 5 Year 9 MTW Catchment Areas and Land Use Classifications (ha) – Surface component

Storage	Land Use							Grand Total
	Cleared/ Prestrip	Mining Pit	Natural/ Undisturbed	Rehab. Spoil	Roads/ Industrial/ Hardstand	Tailings	Unrehab. Spoil	
AGN						36.7	0.9	**37.6**
52ML Dam			4.1		8.7			**12.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 14S			0.4		1.0			**1.4**
Dam 15N	1.4							**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16S	3.0				12.1		0.7	**15.8**
Dam 17S (CRTSF)				9.1		29.2	46.8	**85.1**
Dam 18N			0.8	0.2				**1.0**
Dam 1N	13.3			229.4	34.2		116.7	**393.6**
Dam 1S/2S	8.6		1.9		12.9			**23.4**
Dam 20N	8.2		3.8		0.7		0.3	**13.0**
Dam 27N			2.5	3.0				**5.6**
Dam 30N			0.0	103.0				**103.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 33N (TD2)				16.4		45.0		**61.4**
Dam 4N			1.9					**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6S	26.9							**26.9**
Dam 9(A) S	0.6			0.3				**0.9**
Dam 9S	2.4							**2.4**
Honeypot Dam	3.8		1.1		1.4		0.5	**6.8**
Loders Pit	17.2	7.0	22.6	143.9	37.4		287.2	**515.3**
NOOP Dam	17.7		4.2	264.9	4.4			**291.2**
North Loders Clean Dam			8.9					**8.9**
North Pit Mid	15.3	13.2		50.9	17.6		244.6	**341.6**
North Pit North	14.9	6.1			12.0		158.4	**191.4**
Ramp 22 Dam	0.3			300.7			0.3	**301.3**
Sed. Dam A				133.8	1.0		16.4	**151.2**
Sed. Dam B	2.8			72.9	1.5		25.1	**102.3**
South Pit		18.0		171.9	2.7		44.4	**237.0**
West Pit	40.0	22.3	35.1	81.1	42.2		587.7	**808.4**
Grand Total	**174.7**	**66.6**	**117.8**	**1581.5**	**275.8**	**110.9**	**1530.1**	**3875.1**

Table B. 6 Year 9 MTW Catchment Areas and Land Use Classifications (ha) – Baseflow component

Storage	Runoff Set							Grand Total
	Cleared/ Prestrip	Mining Pit	Natural/ Undisturbed	Rehab. Spoil	Roads/ Industrial/ Hardstand	Tailings	Unrehab. Spoil	
AGN						36.7	0.9	**37.6**
52ML Dam			4.1		8.7			**12.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 14S			0.4		1.0			**1.4**
Dam 15N	1.4							**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16S	3.0				12.1		0.7	**15.8**
Dam 17S (CRTSF)				9.1		29.2	46.8	**85.1**
Dam 1N	13.3			0.8	7.7		0.0	**21.8**
Dam 1S/2S	8.6		1.9		12.9			**23.4**
Dam 20N	8.2		3.8		0.7		0.3	**13.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 33N (TD2)				1.7		44.3		**46.0**
Dam 4N			1.9	0.1				**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6S	26.9							**26.9**
Dam 9(A)S	0.6			0.3				**0.9**
Dam 9S	2.4							**2.4**
Honeypot Dam	3.8		1.1		1.4		0.5	**6.8**
Loders Pit	18.9	7.0	22.6	471.8	42.5		321.0	**883.8**
NOOP Dam	17.7		0.8	2.5	2.5			**23.5**
North Loders Clean Dam			8.9					**8.9**
North Pit Mid	15.4	13.2	0.4	327.9	22.5		245.1	**624.4**
North Pit North	17.7	6.1	7.9	254.7	13.5		183.6	**483.4**
Ramp 22 Dam				137.5				**137.5**
South Pit		18.0		381.4	18.1		45.6	**463.0**
West Pit	40.1	22.3	35.2	175.5	60.4		702.8	**1036.3**
Grand Total	**194.0**	**66.6**	**119.5**	**1763.2**	**290.0**	**110.1**	**1547.2**	**4090.5**

Table B. 7 Year 14 MTW Catchment Areas and Land Use Classifications (ha) – Surface component

Storage	Land Use							Grand Total
	Cleared/ Prestrip	Mining Pit	Natural/ Undisturbed	Rehab. Spoil	Roads/ Industrial/ Hardstand	Tailings	Unrehab. Spoil	
52ML Dam			4.1		8.7			**12.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 14S			0.4		1.0			**1.4**
Dam 15N	1.4							**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16S	3.0				12.1		0.7	**15.8**
Dam 17N			0.8	18.4				**19.2**
Dam 18N			0.8	0.2				**1.0**
Dam 1N	13.3			296.8	34.2		49.3	**393.6**
Dam 1S,2S	8.6		1.9		12.9			**23.4**
Dam 20N	8.2		3.8	0.1	0.7		0.2	**13.0**
Dam 27N			2.5	3.0				**5.6**
Dam 30N			0.0	103.0				**103.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 33N (TD2)				16.4		45.0		**61.4**
Dam 4N			1.9	0.1				**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6S	26.9							**26.9**
Dam 9(A) S	0.6			0.3				**0.9**
Dam 9S	2.4							**2.4**
Honeypot Dam	3.8		1.1		1.4		0.5	**6.8**
Loders Pit	17.1		22.6	376.4	9.3	42.2	47.8	**515.3**
NOOP Dam	17.7		4.2	340.9	5.7		10.0	**378.6**
North Loders Clean Dam			8.9					**8.9**
North Pit Mid	28.9	12.8		11.5	23.8		249.9	**326.9**
North Pit North	29.0	6.8		10.9	13.4		217.1	**277.2**
Ramp 22 Dam	0.3			301.0			0.0	**301.3**
Sed. Dam A				235.3	0.8			**236.1**
Sed. Dam B	2.8			97.6	1.4		0.4	**102.3**
South Pit		18.5		172.2	2.7		43.6	**237.0**
West Pit	68.8	20.5	35.1	181.2	44.7		601.8	**952.2**
Grand Total	**248.8**	**58.6**	**118.6**	**2165.3**	**258.8**	**87.2**	**1221.3**	**4158.8**

Table B. 8 Year 14 MTW Catchment Areas and Land Use Classifications (ha) – Baseflow component

Storage	Land Use							
	Cleared/ Prestrip	Mining Pit	Natural/ Undisturbed	Rehab. Spoil	Roads/ Industrial/ Hardstand	Tailings	Unrehab. Spoil	Grand Total
52ML Dam			4.1		8.7			**12.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 14S			0.4		1.0			**1.4**
Dam 15N	1.4							**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16S	3.0				12.1		0.7	**15.8**
Dam 1N	13.3			0.8	7.7		0.0	**21.8**
Dam 1S/2S	8.6		1.9		12.9			**23.4**
Dam 20N	8.2		3.8	0.1	0.7		0.2	**13.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 33N (TD2)				1.7		44.3		**46.0**
Dam 4N			1.9	0.1				**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6S	26.9							**26.9**
Dam 9(A)S	0.6			0.3				**0.9**
Honeypot Dam	3.8		1.1		1.4		0.5	**6.8**
Loders Pit	17.8		22.6	861.9	14.3	42.2	47.8	**1006.5**
NOOP Dam	17.7		0.8	2.5	2.5			**23.5**
North Loders Clean Dam			8.9					**8.9**
North Pit Mid	29.0	12.8	0.4	364.1	30.1	0.3	260.4	**697.1**
North Pit North	31.8	6.8	7.9	290.0	14.8	0.4	217.5	**569.2**
Ramp 22 Dam				137.5				**137.5**
South Pit		18.5		382.8	18.1		43.6	**463.0**
West Pit	68.9	20.5	35.2	342.0	62.9		650.6	**1180.1**
Grand Total	**247.0**	**58.6**	**119.5**	**2383.8**	**273.2**	**87.2**	**1221.3**	**4390.4**

Table B. 9 Year 21 MTW Catchment Areas and Land Use Classifications (ha) – Surface component

Storage	Runoff Set							Grand Total
	Cleared/ Prestrip	Mining Pit	Natural/ Undisturbed	Rehab. Spoil	Roads/ Industrial/ Hardstand	Tailings	Unrehab. Spoil	
52ML Dam			4.1		8.7			**12.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 14S			0.4		1.0			**1.4**
Dam 15N	1.4							**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16S	3.0				12.1		0.7	**15.8**
Dam 17N			0.8	18.4				**19.2**
Dam 18N			0.8	0.2				**1.0**
Dam 1N	13.3			296.8	34.3		49.3	**393.7**
Dam 1S/2S	8.6		1.9		12.9			**23.4**
Dam 20N	8.2		3.8	0.1	0.7		0.2	**13.0**
Dam 27N			2.5	3.0				**5.6**
Dam 30N				164.4				**103.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 4N			1.9	0.1				**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6S	26.9							**26.9**
Dam 9(A)S	0.6			0.3				**0.9**
Dam 9S	2.4							**2.4**
Honeypot Dam	3.8		1.1		1.4		0.5	**6.8**
Loders Pit	17.1		22.6	375.1	9.2	42.2	47.9	**514.1**
NOOP Dam	17.7		4.2	340.8	5.7		9.9	**378.6**
North Loders Clean Dam			8.9					**8.9**
North Pit Mid	29.1	14.3		30.1	23.8		229.8	**327.1**
North Pit North	28.9	10.4		33.1	13.5		191.3	**277.1**
Ramp 22 Dam	0.3			300.8			0.0	**301.2**
Sed. Dam A				237.0	0.8			**237.8**
Sed. Dam B	2.8			97.6	1.4		0.4	**102.3**
South Pit		18.5		172.2	2.7		43.5	**237.0**
West Pit	68.8	19.5	35.1	249.5	44.7		534.5	**952.1**
Grand Total	**248.9**	**62.7**	**118.6**	**2336.1**	**258.9**	**42.2**	**1108.0**	**4159.3**

Table B. 10 Year 21 MTW Catchment Areas and Land Use Classifications (ha) – Baseflow component

Storage	Land Use							Grand Total
	Cleared/ Prestrip	**Mining Pit**	**Natural/ Undisturbed**	**Rehab. Spoil**	**Roads/ Industrial/ Hardstand**	**Tailings**	**Unrehab. Spoil**	
52ML Dam			4.1		8.7			**12.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 14S			0.4		1.0			**1.4**
Dam 15N	1.4							**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16S	3.0				12.1		0.7	**15.8**
Dam 1N	13.3			0.7	7.7		0.0	**21.8**
Dam 1S/2S	8.6		1.9		12.9			**23.4**
Dam 20N	8.2		3.8	0.1	0.7		0.2	**13.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 4N			1.9	0.1				**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6S	26.9							**26.9**
Dam 9(A)S	0.6			0.3				**0.9**
Dam 9S	2.4							**2.4**
Honey Pot Dam	3.8		1.1		1.4		0.5	**6.8**
Loders Pit	17.8		22.6	909.8	14.1	42.2		**1006.5**
NOOP Dam	17.7		0.8	2.5	2.5			**23.5**
North Loders Clean Dam			8.9					**8.9**
North Pit Mid	29.1	14.3	0.4	382.8	30.1	0.3	240.3	**697.2**
North Pit North	31.7	10.4	7.9	358.2	14.9	0.5	191.7	**569.3**
Ramp 22 Dam				137.5				**137.5**
South Pit		18.5		382.8	18.1		43.6	**463.0**
West Pit	68.9	19.5	35.2	410.3	63.0		583.2	**1180.0**
Grand Total	**231.7**	**62.7**	**119.5**	**2586.8**	**273.2**	**42.5**	**1060.2**	**4392.9**

APPENDIX C

MODELLING OF RELEASES UNDER THE HRSTS

The following approach to the HRSTS modelling was adopted:

1. Hunter River Streamflow time series – simulated streamflow data was obtained from NOW's IQQM model (full development case with 2004 water sharing plan rules) for the period 16/09/1892 to 30/6/2007.
2. Salinity –Recorded salinity data was obtained for the Hunter River at Singleton (#210129) from the PINEENA database, covering the period February 1993 to October 2009. Based on the recorded historical data, a relationship between streamflow and water quality was developed. EC's for 'High' flows only (2,000 – 10,000ML/d) were plotted against flow rates and a logarithmic trend line fitted to the data, giving salinity as a function of flow rate.
3. The salinity function was then applied to get a Hunter River flow and EC time series at Singleton which was used in OPSIM as the reference node.
4. In OPSIM, controlled discharges were simulated using an Environmental Transfer (ETN) node with two 'rules' for discharge. Rule 1 limits the volume of discharges based on the flow rates in the Hunter River, as shown in Table C. 1. Rule 2 limits the salt load discharged based on the salinity in the Hunter River and the discharge dams (Dam 9S and Dam 1N), as shown in Table C. 2.

Table C. 1 HRSTS Rule 1 (Volume Limit Rating)

Hunter River Qref (ML/d)	Site Discharge Qmax (ML/d)	Apply Rule 2	Comment
0	0	x	No site discharges allowed when Hunter River flows are <2,000 ML/d.
2,000	0	x	
2,000	100	✓	When Hunter River flows are 2,000 – 10,000 ML/d, up to 100 ML/d can be discharged from each discharge location, with salinity restrictions as per 'Rule 2'.
10,000	100	✓	
High	100	✓	When Hunter River flows are >10,000 ML/d, up to 100 ML/d can be discharged from each discharge location, with salinity restrictions as per 'Rule 2'.

Where:

- Qref is the reference volume [ML/d] (in this case, the Hunter River).
- Qmax is the discharge limit [ML/d] for Qref. At Warkworth Mine, this rate is 100ML/d. At MTO, this rate is 200ML/d.

Table C. 2 HRSTS Rule 2 (EC Rating)

Method	Cr (μS/cm)	K Value	Comment
K + Cr	0	900	If the EC in the Hunter River is zero, the concentration in the Hunter River can inrease by up to 900μS/cm due to discharges under the HRSTS.
K + Cr	900	0	If the EC in the Hunter River is 900μS/cm, the concentration in the Hunter River cannot increase due to discharges under the HRSTS.

Where:

- Cr is the concentration at the Reference Node (in this case, the Hunter River).
- K is the concentration increase (linearly interpolated between the specified values and the limiting transfer concentration is calculated as K+Cr).

In addition, discharges do not occur when the inventory in the source dams is below a nominal threshold, as follows:

- Dam 1N - if the volume in Dam 1N is less than 220ML (70 per cent of maximum operating volume)
- Dam 9S – if the combined volumes in Dam 9S and Dam 6S is less than 1,500ML (70 per cent of maximum operating volume).

Note that it is assumed that the number of salt credits held by MTW is not a limitation to releases. Historically there have been sufficient credits available for trade.

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