LIDDELL COAL OPERATIONS

APPENDIX K

Surface Water Assessment
(Gilbert and Associates, 2013)

APPENDICES

HYDROLOGY AND WATER MANAGEMENT CONSULTANTS

Gilbert & Associates Pty Ltd

REPORT

LIDDELL COAL MINE

MODIFICATION 5

Surface Water Assessment

Prepared for: Liddell Coal Operations

Sep-13
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1.0 INTRODUCTION

Liddell Coal Operations (LCO) is an established open-cut mine located at Ravensworth, approximately 25 kilometres (km) north-west of Singleton in the Upper Hunter Valley of New South Wales (refer Figure 1-1). LCO is operated and managed by Liddell Coal Operations Pty Limited, a wholly owned subsidiary of Glencore Coal Pty Limited (Glencore), on behalf of a joint venture between Glencore (67.5 per cent) and Mitsui Matsushima Australia (32.5 per cent). LCO commenced operations in 1923 as an underground mine, with open cut mining commencing in 1946.

Current operations include open cut mining, coal handling and washing and rail loading within ML1597 and the existing development consent boundary DA 305-11-01. Open cut operations extract coal which was not removed during previous underground mining, which finished in 1995. Open cut mining occurs using conventional truck and excavator methods, followed by coal washing, with product coal loaded onto trains for transport to the port of Newcastle.

Development consent DA 305-11-01 was granted in 2002 for continued operations at LCO for 21 years and allows mining of up to 8 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal until December 2023. DA 305-11-01 has since been modified on four occasions.

LCO is now seeking a further modification to allow for an extension of open cut mining operations beyond the currently approved mining area, which will be reached in 2014, so as to maximise coal recovery and maintain continuity of coal production (referred to herein as 'the Modification'). The Modification primarily relates to an extension of the existing Entrance and South Pits to the south east.

The key components of the Modification include the following:

- Expansion of the open cut mining area – Proposed extension of the South and Entrance Pits to the south east, and, upon completion of mining in these open cut pits, the mining of coal resources under the current Mine Infrastructure Area (MIA) which would be relocated to a temporary location. The extension would enable the recovery of an additional 38 million tonnes (Mt) of ROM coal (approximately).

- Extension to the Life of Mine – The proposed extension of open cut mining activities would lead to an associated extension of the life of mine at the Liddell Colliery from 2023 to 2028.

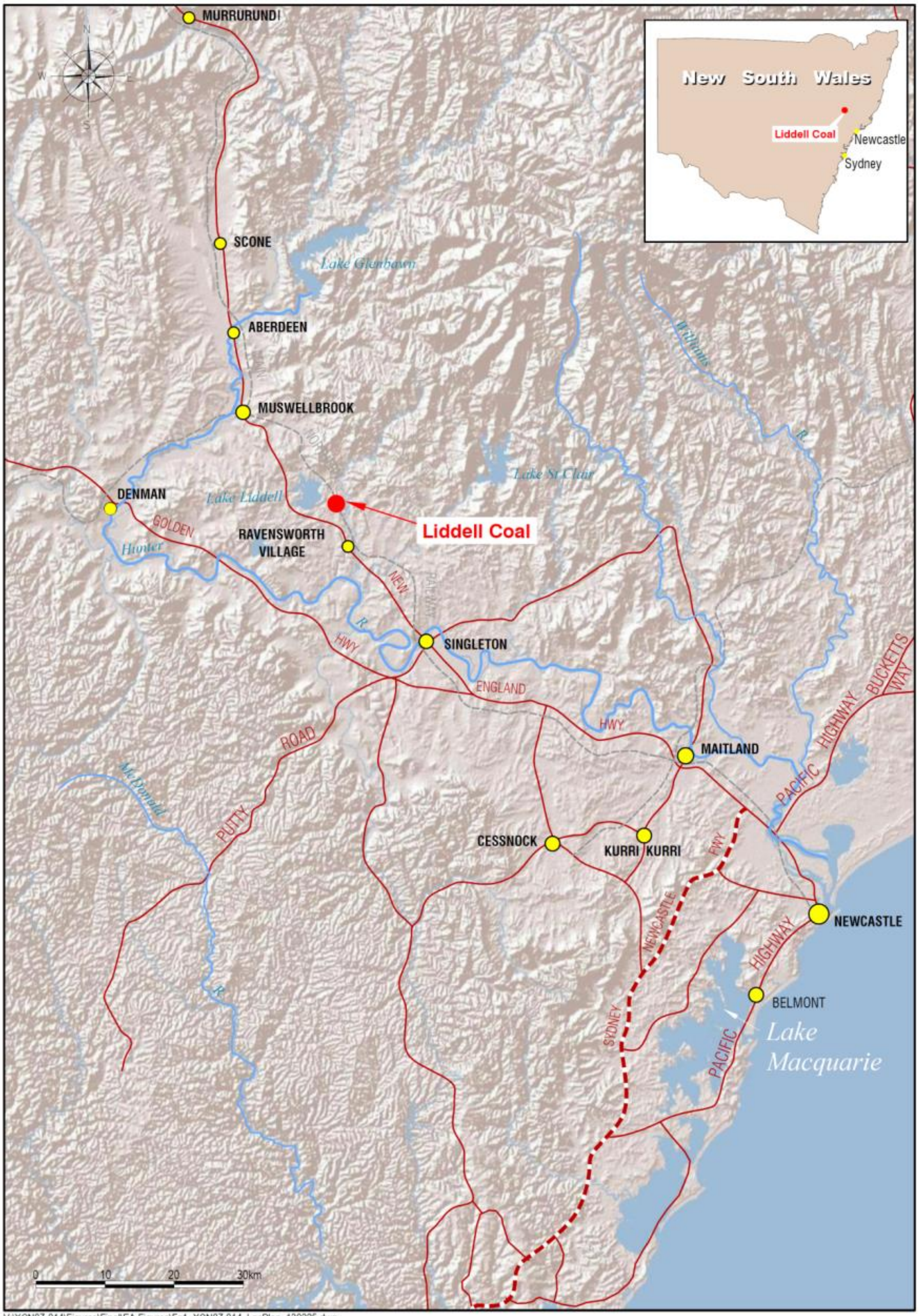

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Figure 1-1 Locality Plan

- Additional Tailings Emplacement Areas – A tailings emplacement area would be constructed within the final void of the South Pit to store the additional tailings associated with the extension of open cut mining activities.

- Coal Processing – Coal would continue to be processed at the LCO Coal Handling and Preparation Plant (CHPP) at the approved rate of up to 8 Mtpa. Coal would however no longer be received from, or sent to, the Cumnock CHPP for processing as currently approved under DA 305-11-01, as this CHPP has been removed following the cessation of mining operations at Cumnock No. 1 Colliery. LCO seeks to maintain an additional contingency for coal processing by delivery of up to 1.5 Mtpa of ROM coal to the nearby approved Ravensworth Central Coal Processing facility (RCCP) for washing via a new connection to an existing overland conveyor or by road transport to the RCCP facility. In addition, up to 2 Mtpa may be received for processing from the nearby Glencore Mt Owen Complex via the same existing overland conveyor.

- Minor additional infrastructure:

    - Construction and commissioning of a transfer point and conveyor connected to the existing Mt Owen/Glendell/Macquarie Generation conveyor is proposed (refer Figure 1-2), enabling LCO to send coal to RCHPP, and receive coal and crushed gravel from the Mt Owen Complex, via the existing conveyor system. The new conveyor would deliver/take material to/from a new 50,000 tonne stockpile; and

    - Infrastructure and auxiliary surface disturbance to support the new mining areas would be required, including power lines, water management infrastructure and haul roads.

The proposed works lie wholly within both the existing development consent boundary and the mining lease ML 1597 boundary. No changes are proposed to the approved operating hours, mining method or mining equipment.

Gilbert & Associates Pty Ltd (G&A) were engaged to undertake a surface water assessment as part of the Environmental Assessment of the Modification.

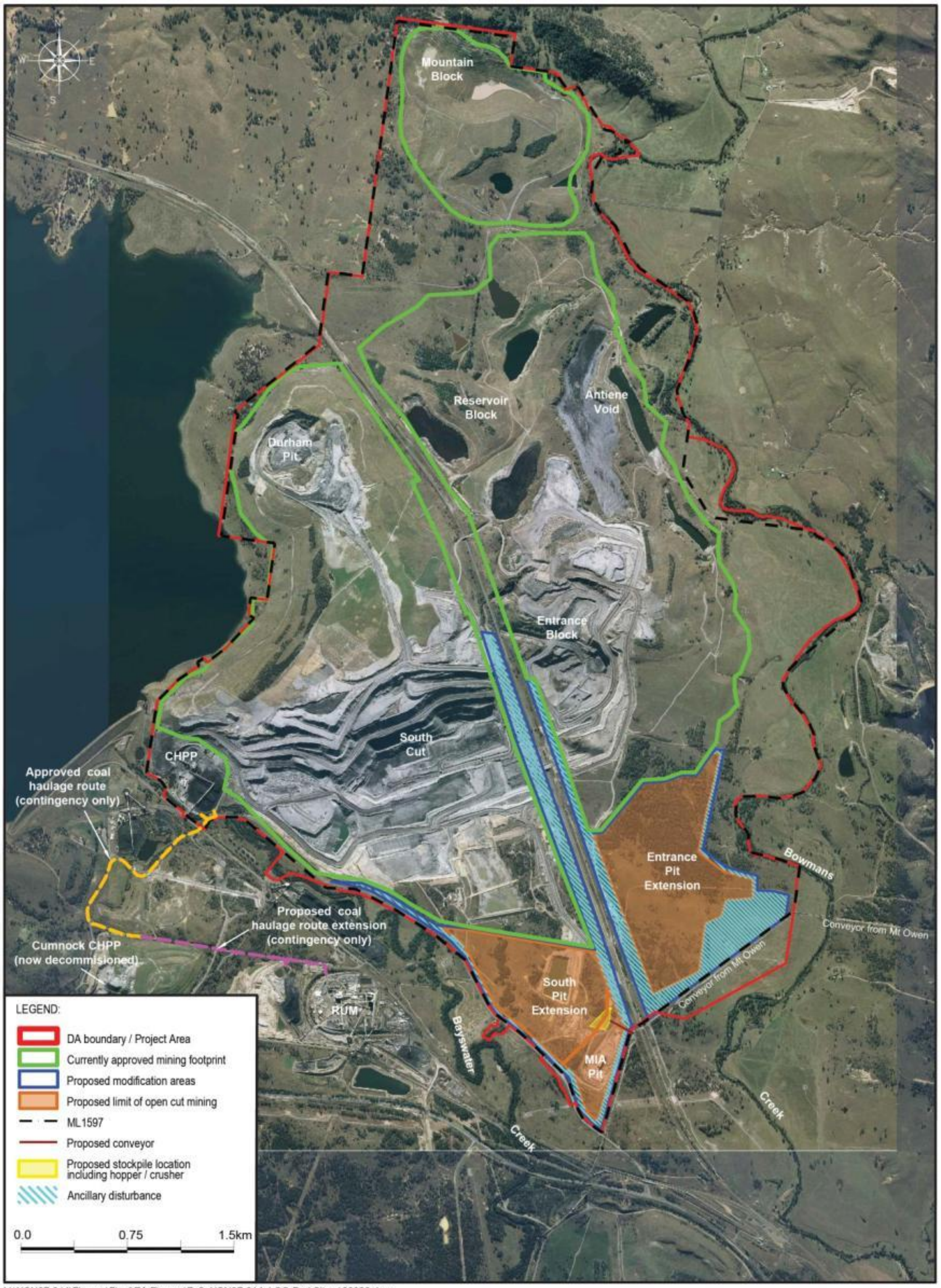

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Figure 1-2 Proposed Open Cut Pit Extension

1.1 Purpose and Scope of Work

This report describes the findings of the surface water assessment completed in support of the proposed Modification and as required by the Director-General's requirements (DGRs). The scope of work for the surface water assessment included:

- Undertaking a surface water drainage assessment;
- Assessing a water balance for the operations throughout the proposed mine life;
- Undertaking a flood study of Bayswater and Bowmans Creeks; and
- Assessment of the drainage of the final landform and water balance of the final voids.

The assessment was based on information provided by LCO on the existing and proposed operations. It also relies on information and predictions of groundwater interactions with the proposed mining operations provided by SKM (2013).

The specific DGRs related to surface water and where they have been addressed in this report are summarised below.

• A detailed assessment of the potential impacts of the Modification using appropriate quantitative modelling on:	
o The quantity and quality of both surface and groundwater resources, with particular reference to the Hunter River, alluvial groundwater, and the evaporative sink extension;	*The quantity of surface water resources is addressed in Section 6.0. Refer to Section 2.5 and 5.3.6 for the references to the Hunter River*
o Ground and surface water users, both in the vicinity of and downstream of the Modification;	*Refer to Section 2.4 for surface water users*
o The riparian and ecological values of the watercourses both on site and downstream of the proposal;	*Refer Umwelt (2013) & Eco Logical Australia (2013)*
o Environmental flows; and	*Refer Section 6.1*
o Flooding;	*Refer to Section 3.0*
• Comparison of these impact predictions against those associated with the existing mine plan, including detailed explanations for any differences;	*Refer to Section 6.0*
• Plans for the proposed tailings dam, including detailed design and completion criteria;	*Planned tailings disposal described in Section 4.5*

• A detailed assessment of the environmental, hydro-geological, hydrological, and geomorphic considerations of the final drainage alignments; and	*Refer to Section 4.4 for the hydrological considerations*
• A revised site water balance for the mine	*Refer to Section 5.0*

2.0 EXISTING SURFACE WATER HYDROLOGY

2.1 Site Location, Layout and Topography

The layout of the LCO surface facilities is shown in Figure 2-1. The mine is located adjacent to and east of Lake Liddell and 7km north-west of Ravensworth. Coal is currently mined from two open cut pits, known as the South Pit and the Entrance Pit. Mining is occurring in the Foybrook Formation, within the Vane Subgroup of the Wittingham Coal Measures, including through the former Liddell Colliery underground longwall and bord and pillar workings (Liddell seam), as well as the deeper Barrett seam.

Coal is transported by truck to a CHPP for washing. Product coal is stockpiled on the eastern side of the CHPP prior to loading onto trains for transport to Newcastle. Currently, fine rejects from the CHPP are pumped as slurry to a two-cell tailings storage facility constructed in the former Reservoir open cut pit – known as Reservoir West and Reservoir South.

The mine area is traversed by the Main Northern Railway line, with the Entrance Pit located to the east and the South Pit to the west of the railway line (refer Figure 1-2). The mine is bounded by Bowmans Creek to the east and Bayswater Creek to the south-west, both of which flow into the Hunter River further south. Topography in the area consists of rolling hills with changes in elevation of up to 50 m.

Figure 2-1 Site Layout

2.2 Climate

LCO experiences a dry, temperate climate with an annual average rainfall of approximately 645 mm. Long-term historical rainfall data is available from numerous Bureau of Meteorology stations in the surrounding region. The closest station with a long-term record is located at Jerrys Plains (Station No.61086 with 128 years of record). Average monthly rainfall calculated from rainfall recorded at Jerrys Plains is summarised in Figure 2-2 below. Rainfall is greater in the summer months between October and March and lower in the winter months between April and September.

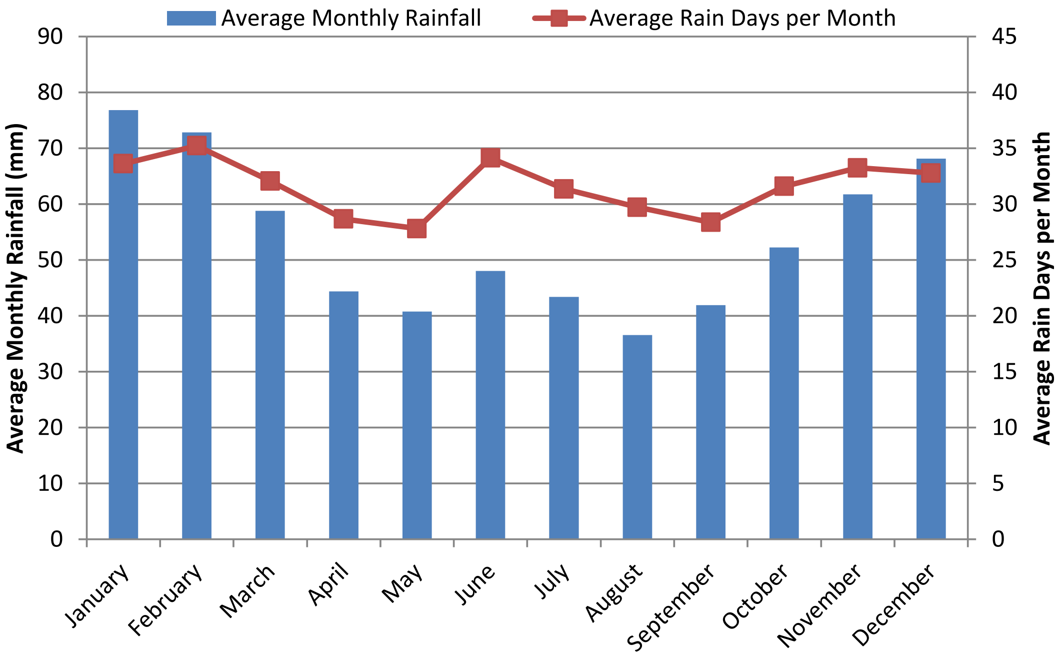


Figure 2-2 Average Monthly Rainfall (Jerrys Plains, BoM Station 61086)

Summary monthly evaporation data for the nearest Bureau of Meteorology (BoM) stations is presented in Table 2-1.

Table 2-1 Summary of Mean Monthly Pan Evaporation (mm)

Month	Mean Evaporation at Scone*	Mean Evaporation at Cessnock**
January	220	175
February	175	140
March	155	120
April	105	84
May	68	57
June	48	45
July	56	53
August	84	77
September	117	105
October	155	133
November	180	151
December	220	177
Totals	*1582*	*1310*

* *BoM data for station 61089 (1950 – present) located approximately 40km north-west, 8.6% of data set was missing*

** *BoM data for station 61242 (1973 - 2012) located approximately 50km south-east, 1.1% of the data set was missing*

2.3 Regional Hydrology, Runoff, and Streamflow

ML 1597 area lies within the catchments of Lake Liddell to the northwest, Bowmans Creek to the east and Bayswater Creek to the southwest (refer Figure 2-1). Both Bowmans Creek and Bayswater Creek flow south to the Hunter River. Bayswater Creek has a total catchment area of approximately 96 km^2 and is a fourth order stream. Bowmans Creek has a total catchment area of approximately 265 km^2 (Fluvial Systems, 2009) and is a fifth order stream. Flows in Bayswater Creek are dominated by releases from Lake Liddell by Macquarie Generation. Lake Liddell is used as a cooling water source for the adjacent Liddell Power Station which is operated by Macquarie Generation. The main drainage feature running through ML 1597 is Chain of Ponds Creek which is a tributary of Bayswater Creek. Chain of Ponds Creek is a second order stream.

Streamflow in both Bayswater Creek and Bowmans Creek has been monitored by the NSW Office of Water (NOW). Data from streamflow gauging stations with the longest period of record are summarised in Table 2-2. Locations of the gauging stations are indicated in Figure 2-1. The recorded flow has been compared a regional long-term rainfall record (sourced from the Silo Data Drill - see Section 5.2.1).

Table 2-2 Summary of Gauging Stations

	Bayswater Creek		Bowmans Creek	
Station Number	**210110**	**210059**	**210042**	**210130**
Period of Record	1/12/1959 – current	3/11/1973 – 28/6/2001	24/3/1956 – 23/11/1999	29/10/1993 – current
Catchment Area	74 km^2	88 km^2	170 km^2	240 km^2
Average Recorded Flow	4,888 ML/year	6,692 ML/year	16,860 ML/year	12,192 ML/year
Average Rainfall for Recorded Flow Period	657 mm/year	703 mm/year	635 mm/year	670 mm/year
Days with Missing Data	57 %	0.6 %	7 %	4 %
Zero Flow Days	2 %	5 %	35 %	0.6 %
Catchment Yield*	10 %	11 %	16 %	8 %

**Estimated average proportion of rainfall which reports as runoff*

2.4 Regional Surface Water Use

Adjacent land use comprises primarily coal mining with Mount Owen and Glendell mines to the east, Ravensworth Underground Mine to the south and west, and Ravensworth Operations and Coal and Allied Operations to the south. In addition, land to the northwest is used for power generation. Land to the north and north east is privately owned and used primarily for cattle grazing.

The main surface water resource in the region is the Hunter River, one of the largest coastal catchments in NSW. The Hunter River catchment drains a total of 22,000 km^2. Extraction and use of water from the Hunter River is subject to regulation under the *Water Sharing Plan for the Hunter Regulated River Water Source 2003*, which was enacted under the *Water Management Act, 2000* in 2004. Key objectives of the Water Sharing Plan are to:

"(a) protect, preserve, maintain or enhance the important river flow dependent and high priority groundwater dependent ecosystems of these water sources,
(b) protect, preserve, maintain or enhance the Aboriginal, cultural and heritage values of these water sources,
(c) protect basic landholder rights,
(d) manage these water sources to ensure equitable sharing between users,

(e) provide opportunities for market based trading of access licences and water allocations within sustainability and system constraints,

(f) provide recognition of the connectivity between surface water and groundwater,

(g) provide sufficient flexibility in water account management to encourage responsible use of available water, and

(h) adaptively manage these water sources."

Glenbawn Dam, which is about 30 km north of LCO near Scone, is used to regulate flows downstream including reaches near LCO. Water is extracted from the Hunter River for basic landholder stock and domestic rights, while extraction licences for mining, industry, water utility provision, high security and general security entitlements have also been issued. Significant volumes of water are also taken and stored for power station use in Lake Liddell. The Hunter River is the major regional source of farm water supply for irrigation, stock watering and domestic use.

Surface water usage also occurs on Bowmans Creek. Bowmans Creek has a total of 13 private water users for stock, domestic and irrigation purposes. Bayswater Creek has no private water users[1].

2.5 Hunter River Salinity Trading Scheme

The Hunter River Salinity Trading Scheme (HRSTS) was originally established by the then Department of Land and Water Conservation (DLWC) and Hunter River Trust in 1995 as a pilot trial to manage salinity discharges to the Hunter, such that salt concentrations would be held below irrigation and environmental standards. The scheme is now managed by NOW under a statutory regulation attached to the *Protection of Environment Operations Act 1997*[2]. The regulation came into effect on 1 December 2002. The stated objectives of the HRSTS are:

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

(i) at the lowest overall cost to the community, and

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

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

The scheme attempts to achieve these objectives by prohibiting releases of saline waters during periods of low flow and controlling releases of saline water during periods of high flow such that specific salinity targets at various points in the river are not exceeded. The scheme is administered by NOW, which is the agency responsible for setting and announcing conditions for allowable discharge in accordance with the salinity targets. The operational parameters used to regulate the scheme are advised on a daily basis for each of the various sections of the Hunter River. NOW can apply

[1] Information was provided through the NSW Office of Water through the Freedom of Information Act

[2] Protection of Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002.

discount factors and other controls to ensure that the salinity targets are met during announced discharge periods.

Participants in the scheme are issued with tradeable discharge credits. Each credit entitles the holder to a 0.1% share of the available salt discharge capacity announced during high flow periods. The total allowable discharge is determined by NOW on a day-to-day basis, by reference to salinity targets for the Hunter River catchment – i.e. an electrical conductivity (EC) of 600 µS/cm at Denman and 900 µS/cm at Glennies Creek and Singleton.

The amount of saline water that may be discharged by a given discharge licence holder is determined by reference to the salinity of the discharge waters, the river flow, the number of credits held and any overriding limit that may be applied as a condition of the licence. LCO presently holds 66 credits, with controlled release occurring to Chain of Ponds Creek. Releases must comply with LCO's Environment Protection Licence (EPL) 2094.

3.0 FLOOD ASSESSMENT

A flooding assessment was undertaken for Bayswater Creek and Bowmans Creek, which bound existing operations to the east and west respectively. The extent of the flood assessment is shown on Figure 3-1. The aim of the assessment was to determine the potential flooding risk to the proposed Modification posed by the two creeks. Peak flow rates considered were those corresponding to a 100-year average recurrence interval (ARI) and 250-year ARI. Hydrologic modelling was first undertaken to estimate the peak flow rate in each creek. Hydrologic modelling was undertaken using the RORB runoff-routing model (Laurenson and Mein, 1997). Predicted peak flow rates were used as input to a hydraulic model of the two creeks in the vicinity of LCO to provide predictions of water levels at these peak flows and assess the potential for creek inflows to proposed mine workings. The hydraulic model used was the HEC-RAS backwater model (USACE, 2010). The following sub-sections describe the hydrologic and hydraulic modelling in further detail. The third sub-section outlines the overall implications to the proposed Modification.

3.1 Hydrologic Modelling

Rainfall intensity–frequency-duration data for the Lake Liddell area were sourced from the BoM[3] and used to provide rainfall intensities and totals for different durations and ARIs up to the 100-year ARI. 250-year ARI rainfall intensities were derived by interpolating between the 100-year ARI values and probable maximum precipitation values estimated using BoM methods (BoM, 2004). Derived rainfall totals are given in Attachment A. The rainfall totals were distributed in time using temporal patterns given in IEAust (1998) and the distributed rainfall used as input to models of both creeks.

3.1.1 Bayswater Creek

The total modelled catchment area of Bayswater Creek was approximately 74 km^2. This included approximately 64 km^2 for the catchment area of Lake Liddell and 10 km^2 downstream of the Lake Liddell spillway to the rail loop bridge crossing (refer Figure 3-1). A catchment and sub-catchment map is provided in Attachment A. The flow routing effects of Lake Liddell were included in the model, with the following conservative assumptions (in terms of peak flow rate prediction) made:

- the lake was full at the time of the modelled rainfall event;
- the relationship between flood storage volume and water elevation in the lake above the spillway level was estimated by assuming a constant lake surface area, which underestimates storage volume above the spillway.

The model was uncalibrated (because of the lack of information on the operation of Lake Liddell during high rainfall events) and model parameters were set using recommendations in IEAust (1998) – model parameters used are given in Attachment A. A number of rainfall event durations were run through the model to assess the

[3] BoM Rainfall IFD accessed from http://www.bom.gov.au/hydro/has/cdirswebx/cdirswebx.shtml

"critical" duration, or the one which produces the peak predicted flow rate for a given ARI. Predicted peak flow rates for Bayswater Creek are summarised in Table 3-1. The flow rate tabulated is at the Pikes Gully Road crossing where the hydraulic modelling commenced (refer Figure 3-1).

Table 3-1 Peak Flow Rates – Bayswater Creek

ARI	Peak Flow Rate	Critical Duration
100-year	56.9 m^3/s	9 hours
250-year	70.4 m^3/s	9 hours

3.1.2 Bowmans Creek

The modelled catchment area of Bowmans Creek adjacent to the southern extent of the Entrance Pit was approximately 177 km^2. A catchment and sub-catchment map is provided in Attachment A. Insufficient concurrent recorded catchment rainfall intensity and streamflow data was available for RORB model calibration and therefore model parameters were set using recommendations in IEAust (1998) – model parameters used are given in Attachment A. Predicted peak flow rates for Bayswater Creek are summarised below in Table 3-2.

Table 3-2 Modelled Peak Flow Rates – Bowmans Creek

ARI	Peak Flow Rate	Critical Duration
100-year	691 m^3/s	9 hours
250-year	854 m^3/s	9 hours

3.2 Hydraulic Modelling

Peak flow rates estimated from the hydrologic modelling were used as inputs to HEC-RAS hydraulic models of the creeks as constant (i.e. steady) flow rates. HEC-RAS is a standard and commonly used model for predicting water surface profiles for steady, gradually varied flow in natural or constructed channel systems. In addition to flow rates, HEC-RAS uses the following as input:

- channel or natural creek cross-sectional data to a sufficient degree of accuracy that frictional losses caused by bed shear and form losses caused by flow expansions and contractions are accurately modelled;

- estimates of channel or natural creek roughness/friction factors based on site photographs;

- starting (boundary) conditions at either end of the channel or stream reach being modelled (estimated as depth at both ends).

Creek cross-sectional data was derived from a Lidar survey completed in August 2012. Cross-sections were provided by GSS Environmental. The Lidar survey was unable to distinguish between the flowing creek water surface and ground surface; therefore, it was conservatively assumed that the channel base coincided with the water surface level. The implications of this are discussed in Section 3.4. The model plan extents are shown in Figure 3-1.

Estimates of channel roughness (Manning's n) were made on the basis of literature guidelines (Chow, 1986) and site photographs taken by G&A and provided by LCO personnel. Estimated values are included in Attachment A.

Bounding water levels at the upstream and downstream end of modelled reaches were set to 'normal' channel flow depth – i.e. the depth that flow would occur under steady flow conditions at a uniform longitudinal slope. The longitudinal slope was set based on the observed longitudinal slope.

It is important to note that HEC-RAS is a one-dimensional flow model. It predicts flow depth and velocity assuming uniform flow conditions at each given cross-section. Flow conditions in some reaches of the creeks could be strongly two or three dimensional. However, given the conservative assumptions made in the modelling, the predicted water levels are considered likely to give a reasonable indication of peak flow water levels at the nominated ARIs.

Figure 3-1 Flood Assessment Study Area

3.2.1 Bayswater Creek

Predicted peak water levels in Bayswater Creek were below the open cut pit shell edge elevations (i.e. the lowest point on the edge of the open cut as it is progressively mined rather than at any one point in time) adjacent to the creek for both peak flow rates modelled. Predicted water levels for the 100-year and 250-year peak flow rates are shown in Figure 3-2 and tabulated in Attachment A. The sensitivity of the 100-year peak flow water levels to Manning's n was also assessed by halving and doubling the estimated Manning's n (refer Figure 3-3). Relative to the estimated Manning's n, reducing the Manning's n values by half resulted in lowering the predicted water surface depth by a maximum of 0.6m and an average of 0.37m. Doubling the Manning's n values increased the predicted water depth by a maximum of 0.88m and an average of 0.75m.

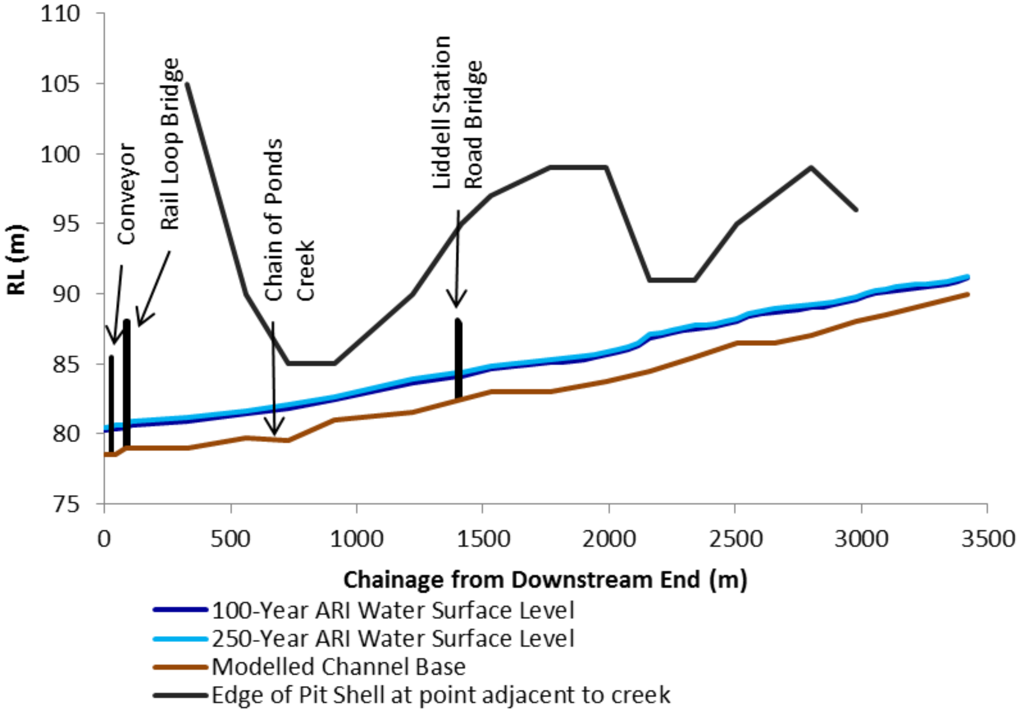


Figure 3-2 Bayswater Creek Predicted Peak Water Surface Levels

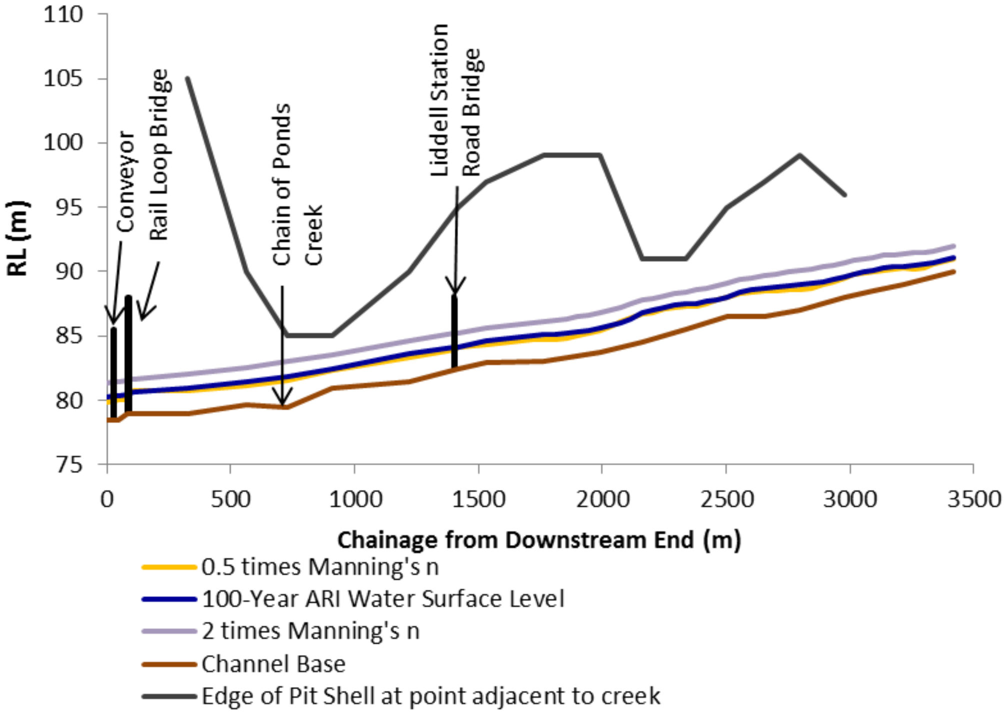


Figure 3-3 Bayswater Creek Water Surface Levels for Varying Manning's n

3.2.2 Bowmans Creek

Predicted peak water levels in Bowmans Creek were well below the open cut pit shell edge elevations (i.e. the lowest point on the edge of the open cut as it is progressively mined rather than at any one point in time) adjacent to the creek for both peak flow rates modelled. Predicted water levels for the 100-year and 250-year peak flow rates are shown in Figure 3-4 and tabulated in Attachment A. The sensitivity of the water levels to Manning's n was also assessed by halving and doubling the estimated Manning's n values (refer Figure 3-5). Relative to the estimated Manning's n, reducing the Manning's n values by half resulted in lowering the predicted water surface depth by a maximum of 0.23m and an average of[4] 0.15m. Doubling the Manning's n values increased the predicted water surface depth by a maximum of 0.59m and an average of 0.48m.

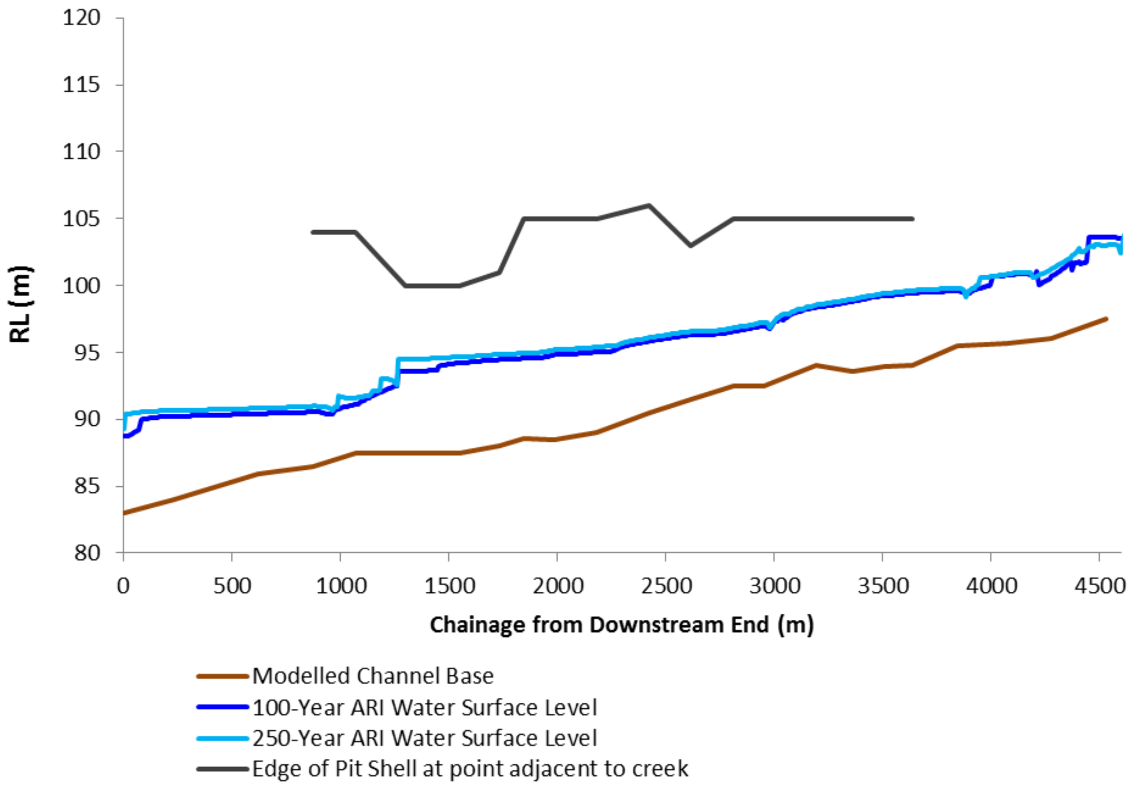


Figure 3-4 Bowmans Creek Water Surface Levels

[4] These results apply to predicted water depths upstream of 70m from the downstream end of the modelled reach. Higher effects were observed in the downstream 70m likely due to some model instability near the downstream model boundary.

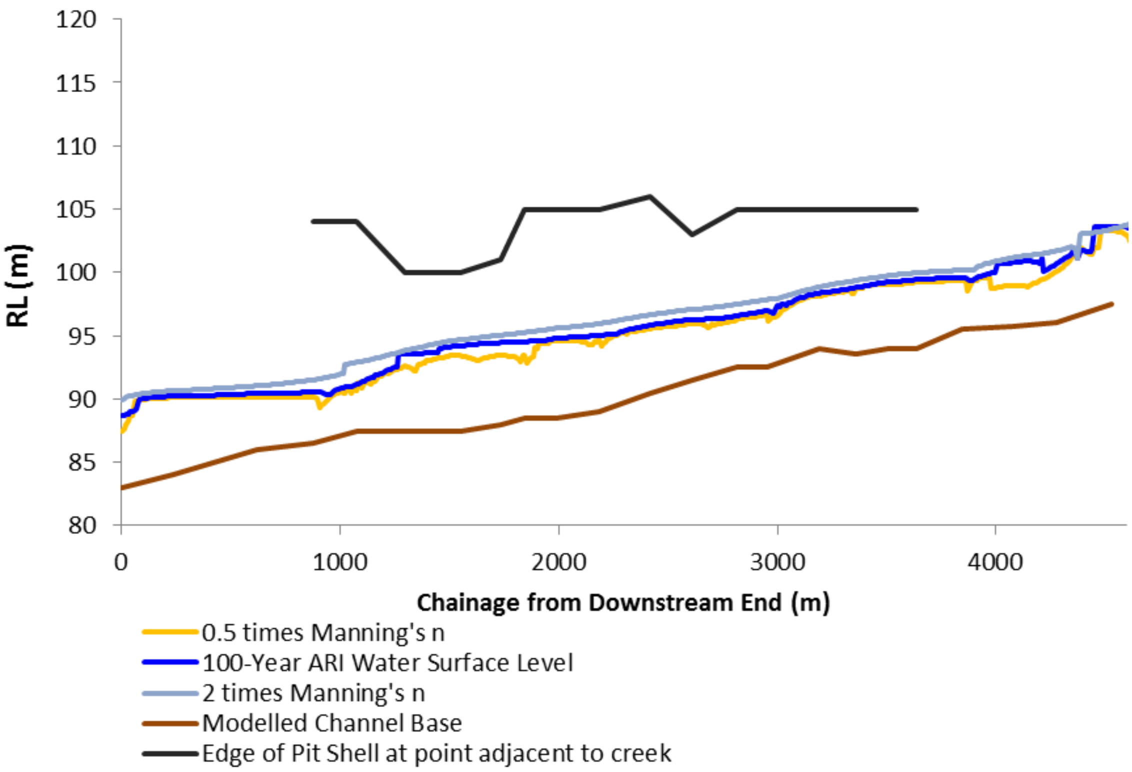


Figure 3-5 Bowmans Creek Water Surface Levels for Varying Manning's n

3.3 Implications of Flood Assessment

Results from the flood assessment indicate that the edges of both open cut pits are above the estimated 100-year and 250-year peak flow water levels. However, the predicted peak water surface elevations are also relevant to the planning of overburden emplacement area drainage (see Section 4.4).

3.4 Limitations of Flood Assessment

The predicted flood level estimates were limited by the quality of data used in the assessment. The Lidar survey used for deriving the cross-sections was unable to distinguish between the water surface and ground surface and therefore recorded the water surface elevation in the creek and not the creek bed. As a result, the water surface elevation at the time the Lidar survey was undertaken, was used as the base elevation for the channel. The ramifications of this are that the flood levels predicted are likely to be conservatively high. The degree of conservatism is unknown.

A second limitation comes from the lack of survey data for two bridges along Bayswater Creek. The Liddell Station Road Bridge was surveyed; however, the conveyor and rail loop bridge at the downstream end of the modelled reach were unable to be surveyed. The dimensions were estimated using photographs of the bridges supplied by LCO personnel. While the dimensions were estimated, the flood levels did not approach the decks of either downstream bridge but did reach the pylons. The effect of the estimation of the bridge cross-sections is likely to be small at the flow rates modelled.

Finally, the volume of water which would spill from Lake Liddell was estimated assuming the same water surface area for elevations greater than the spill elevation of 132 m AHD. This was considered to be a conservative approach to estimating the spill rate from the lake.

4.0 SURFACE WATER MANAGEMENT

4.1 Existing Water Management System

The water management system at LCO includes management of water from the existing open cut operations as well as several former underground workings. The surface water management components include the stormwater drainage system, interlinked storage dams, the open cuts, the tailings storages, the former underground mines (with dewatering bores), the CHPP and associated water reticulation systems. The current mine operations (as of August 2012) are shown in Figure 2-1 and a schematic of the existing water management system is presented in Figure 4-1. Only storages which capture runoff from disturbed mine areas or groundwater have been included. Figure 4-1 does not include dams which intercept runoff from undisturbed or rehabilitated areas and direct this water around disturbed areas and to local creeks.

The main components of the water management system are:

- The Raw Water Transfer Void (RWTV). Currently the main water storage on site, with a capacity of approximately 500 ML. It is located south-east of the South Pit. The RWTV receives water pumped from both open cut pits, other dams and the former Liddell underground workings via bores. The RWTV provides make-up supply to the CHPP, supply to neighbouring Coal & Allied operations (via agreement) and water-truck fill points (for dust suppression). The RWTV has been built adjacent to Chain of Ponds Creek and controlled discharge from the RWTV occurs to Chain of Ponds Creek under the provisions of the HRSTS and EPL 2094.

- Liddell Underground. This comprises the former Liddell Colliery underground workings, split into three groups (at different depths): Liddell Seam (8 South Underground), Middle Liddell Seam (Middle Underground) and the M49 Underground (includes both Upper Liddell seam and Middle Liddell seam underground workings) (refer to Figure 4-2). The undergrounds join/spill into each other at different levels as indicated on Figure 4-1, while the 8 South and Middle undergrounds also spill to the South Pit as they are progressively mined through. Bores are used to dewater the M49 and Middle Undergrounds. Water recovered from these operations is transferred to the RWTV or direct to the Mt Owen Complex.

- Hazeldene Underground. The former Hazeldene Colliery underground workings are generally located beneath the north-eastern end of the LCO area and beneath Bowmans Creek. The workings are split into (at different depths): Pikes Gully Seam, Upper Liddell Seam and Liddell Seam. For the purposes of water balance modelling (refer Section 5.0) these have been combined together. Bores into the Hazeldene Underground are used to transfer water to Dam 4/Dam 17. For geotechnical stability, the water level in the former Hazeldene Underground workings is kept at 60m AHD by pumping.

- South Pit. Water accumulating in the South Pit is pumped to the RWTV. Water volumes are normally kept to a practical minimum so as not to restrict mining.

Runoff from upslope overburden emplacements (to the north) is directed to the South Pit.

- Entrance Pit. Water accumulating in the Entrance Pit is also pumped to the RWTV. Water volumes are normally kept to a practical minimum so as not to restrict mining. Runoff from upslope overburden emplacements (to the north) is directed to the Entrance Pit.

- Dam 4. Dam 4 is a disused open cut void adjacent to Bowmans Creek at the north-eastern end of the LCO area. Dam 4 was previously used to store water decanted from the Antiene Tailings Dam. Water in Dam 4 is used for control of spontaneous combustion in the Entrance Pit. Water in Dam 4 can also be pumped to the Mt Owen Transfer Dam or direct to Mt Owen Complex. As of late 2012, water liberated from settling tailings in the Reservoir West Tailings Dam was also being pumped to Dam 4.

- Dam 17. Dam 17 is another disused open cut void adjacent to Bowmans Creek and just south of Dam 4. It is understood that Dam 4 and Dam 17 are hydraulically connected. Water from Dam 17 is used for control of spontaneous combustion in the South Pit and as a supply to water truck fill points. Water can be pumped to/from the RWTV, to/from Dam 4, from the Hazeldene bores, to the Mt Owen Transfer Dam or direct to Mt Owen.

- Transfer Dam. A small dam located just east of the LCO lease area, its main purpose is to provide transient storage for water transferred from LCO to Mt Owen.

- Reservoir West and South Tailings Dams. Current tailings storages (in an old open cut void) at the northern end of the colliery area.

- Decant Dam. A small dam located between the Reservoir Tailings Dams, for storing decanted tailings water. Water is decanted from the surfaces of the Reservoir West and Reservoir South Tailings dams to be reused on site.

Additional surface water storages include two water storages located within the CHPP area: the South Dam and the Settling Pond which are used to capture runoff from the CHPP area.

As indicated above, water is pumped from the former underground workings to surface water storages, primarily the RWTV. This is done to prevent inflow to the open cut pits (from the former underground workings) from disrupting the open cut operations.

Mine water supply is drawn from the former underground workings, which act as sinks and storage areas for regional groundwater (SKM, 2013). The RWTV is also used to store water transferred to site from Coal & Allied operations (via agreement).

Current water uses on-site comprise make-up to the CHPP, control of spontaneous combustion, and haul road dust suppression. In addition, water may be sent off-site to

Coal & Allied operations at a rate of 1820 ML per year (by agreement) and to the Mt Owen Complex at a rate of approximately 5 ML/d.

LCO hold 66 credits under the HRSTS. It is understood that pumping infrastructure currently limits the discharge rate from the RWTV to Chain of Ponds Creek to approximately 45 ML/d. LCO may increase this rate in the future subject to the limitations of EPL2094.

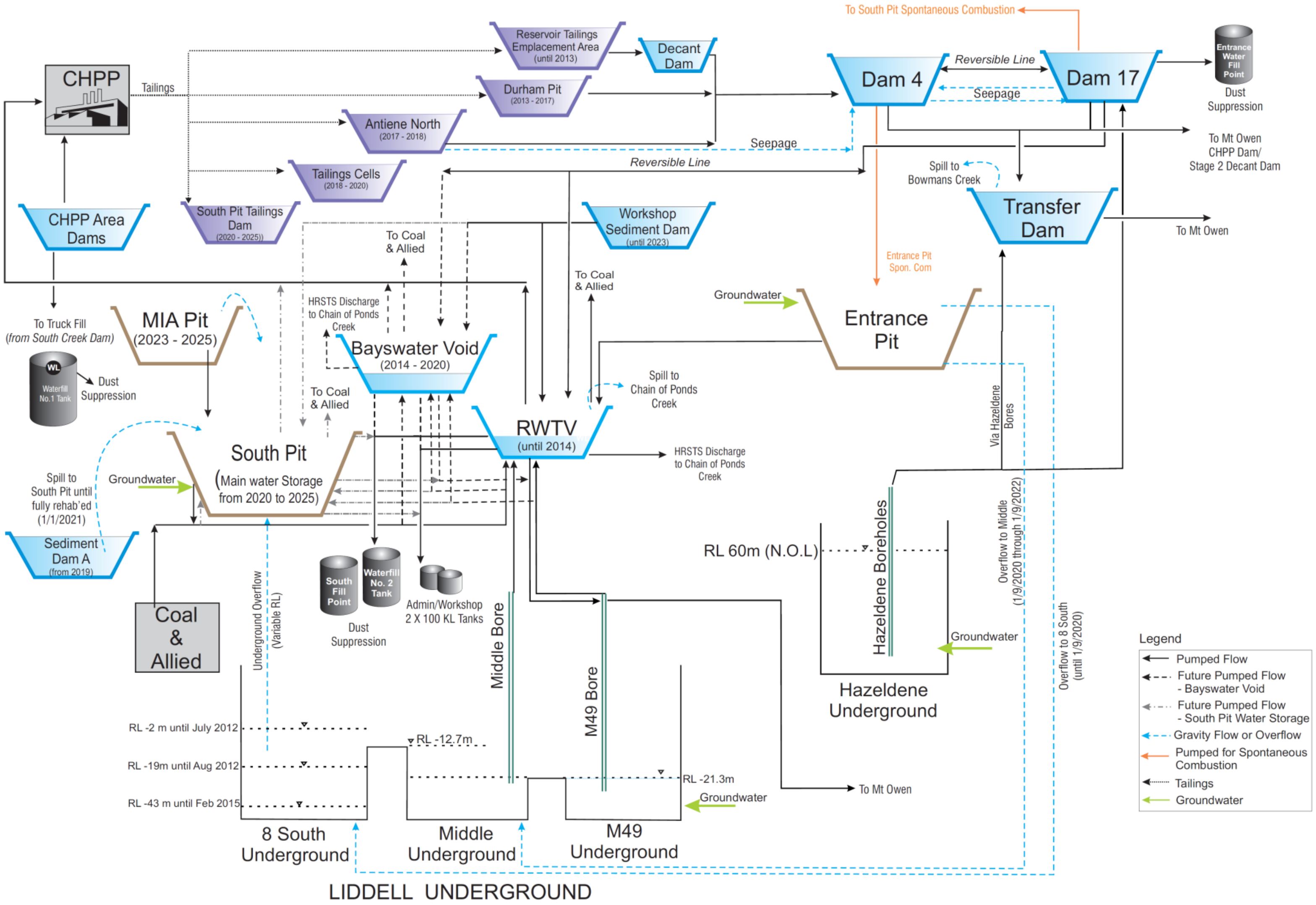


Figure 4-1 Schematic of Existing and Future Water Management System

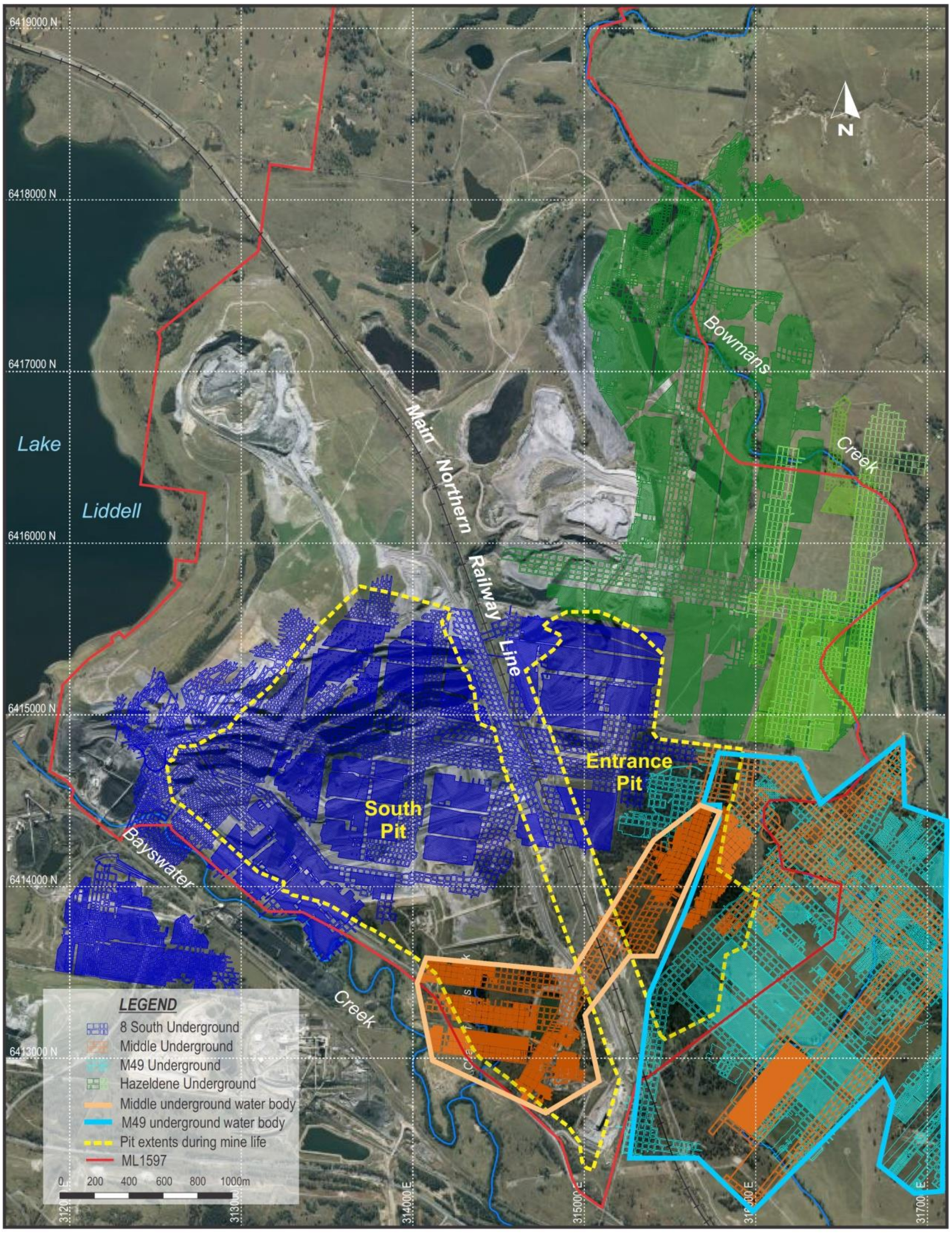


Figure 4-2 Former Underground Workings

4.2 Water Management System – Issues, Principles and Approach

The key issues for water management at Liddell are:

- management of site runoff,
- containment of mine affected water with no unplanned discharges of water off-site,
- pro-active dewatering of the underground workings to minimise interruption to mining operations,
- maintaining a viable, reliable water supply for the CHPP and dust suppression, and
- management of excess water through controlled release of water under the HRSTS to Chain of Ponds Creek.

As mining progresses in both the South Pit and the Entrance Pit, additional water would be encountered from the former underground workings, together with rainfall runoff and groundwater inflow. To enable mining operations to continue, water from the open cut pits would need to be removed. In order to control inflows to open cut operations from the former underground workings, the workings would continue to be dewatered (in advance of mining) via bores. Water encountered during mining would be dewatered and transferred to the main water storage.

Water management for the Modification would continue to be based on adherence to well-established, best water management practices in the Australian Mining Industry (Minerals Council of Australia, 1997). These principles are:

- Efficient use of water based on the concepts of ‘reduce, re-use and recycle’.
- Avoiding or minimising contamination of clean water streams and catchments.
- Protecting downstream water quality for beneficial uses.

As is the case for the current operations, the Modification would result in different water types being produced from different areas or parts of the operation.

The principal types of water would be:

- Water dewatered from open cut pits.
- Water dewatered from the former underground workings.
- Runoff and seepage from overburden emplacement areas.
- Runoff and seepage from ROM and product coal stockpiles.
- Supernatant and rainfall yield from the tailings disposal areas.
- Haul road and hardstand area runoff.
- Runoff from the industrial area, workshop and vehicle re-fuelling areas.

- Effluent from the domestic sewage treatment facility.
- Runoff from rehabilitated and revegetated areas.

The management of these waters would be dependent on quality, generation rate and the inherent capacity for it to be re-used and/or recycled.

As mining progresses, the overburden emplacement areas would also advance, with emplacement occurring behind the advancing open cut pits. Runoff from rehabilitated areas would initially be directed to mine water storages and retained within the mine water management system. Once rehabilitated areas revegetate and become stable, runoff would be directed to sediment retention storages prior to being allowed to drain to local drainages.

4.3 Modification Water Management System Description

The Modification water management system comprises the mine and process water circuits (including tailings water) and the interlinked mine dewatering, water transfer and drainage containment works which are used as water sources for the mining operations. The water management system is shown in schematic form in Figure 4-1.

The water management system would operate as a managed self-contained system but with export of water to the nearby Mt Owen Complex and to Coal & Allied operations (via an existing agreement). The water balance of the system would fluctuate with climatic conditions and as the extent and status of the mining operation evolves over time. Depending on the climatic conditions that are experienced during the mine life and the ability to temporarily store water in active open cut pits, there may be periods where surplus water would need to be discharged offsite. Under these circumstances, water would be discharged under licence and in accordance with the HRSTS (refer Section 5.1.1).

The water management system would evolve over time to meet the changing requirements of the mine.

4.3.1 Operational Objectives

The operational objectives of the system are:

- To maintain a low risk of uncontrolled discharge occurring from the process water (CHPP) or mine water systems over the mine life.
- To minimise the need to export water and salt to the Hunter River by maximising re-use on-site and by transferring excess water to other nearby mining operations.
- To minimise risks of disruption to mining operations by efficient mine and underground workings dewatering.
- To ensure that effective control over generation of airborne particulates is not interrupted due to lack of water by maintaining a reliable water supply.

- To ensure uninterrupted operation of the CHPP by maintaining a reliable water supply.

LCO would be guided in its decisions using a life-of-mine water balance model (refer Section 5.0) which would enable prediction of future water supply security and risks of excess open cut pit water.

4.3.2 Progressive Development of Site Drainage Management

The approach to managing runoff from catchment areas which are undisturbed by surface mining activities is to divert them around surface mining and other disturbance areas and to isolate mine area runoff from undisturbed areas. The objective of this strategy is to reduce the volumes of water that would need to be managed on-site. Over the life of the mine, this would involve the construction of diversion bunds and drains around the open cut mine and overburden emplacement areas. Toe drains and isolation bunds would also be constructed around the perimeter of additional out-of-pit overburden emplacements and other areas disturbed by mining to collect and convey drainage from these areas to containment storages, thereby isolating mine drainage from undisturbed area runoff. Diversions and drains would continue to be constructed with capacities consistent with the Site Water Management Plan.

The layout and extent of the planned main surface drainage management works are shown on Mining Stage Plans, Figure 4-3 to Figure 4-6. The concepts presented are subject to final design as part of the Mining Operations Plan and Site Water Management Plan in consultation with the relevant authorities.

Due to the progression of the South Pit and Entrance Pit, the main water storage on-site would change throughout the mine life. Until 2014, the main water storage would be the RWTV, however this lies in the planned future extent of the South Pit. From approximately 2014 to 2020, the main water storage would become the Bayswater Void which would be located south of (and within the planned future extent of) the Entrance Pit. From 2020 onwards, the completed South Pit would become the main water storage. The main water storage would store water removed from the open cut and former underground workings to enable safe and efficient ongoing mining operations.

2014 Layout

Figure 4-3 shows the planned mine layout in 2014. Mining in the South Pit and Entrance Pit would have advanced southwards with ongoing development of the overburden emplacements behind (north of) the active mining areas. The Bayswater Void would have been excavated (with an estimated storage capacity of some 2,500 ML) and water would be transferred from the RWTV to the Bayswater Void in preparation for mining through the RWTV in subsequent years.

Drainage from the western side of the South Pit overburden emplacement would be directed to the South Pit and pumped to the Bayswater Void. Drainage from the western side of the Entrance Pit overburden emplacement would be directed under the Main Northern Railway line (via an existing underpass) to the South Pit. Drainage from the South Pit overburden emplacement would be directed to the South Pit.

Drainage from the southern and eastern sides of the Entrance Pit overburden emplacement would be directed to Dam 17. Toe drains along the western edge of the South Pit overburden emplacement area and eastern edge of the Entrance Pit emplacement area would be located above the 100-year flood levels for Bayswater Creek and Bowmans Creek respectively.

2017 Layout

Figure 4-4 shows the planned mine layout in approximately 2017. Mining in the South Pit would have advanced southwards, mining through the RWTV. The southern progression of both the South Pit and Entrance Pit would result in the ongoing development of the overburden emplacements behind (north of) the active mining areas. The Bayswater Void would be the main water storage on site.

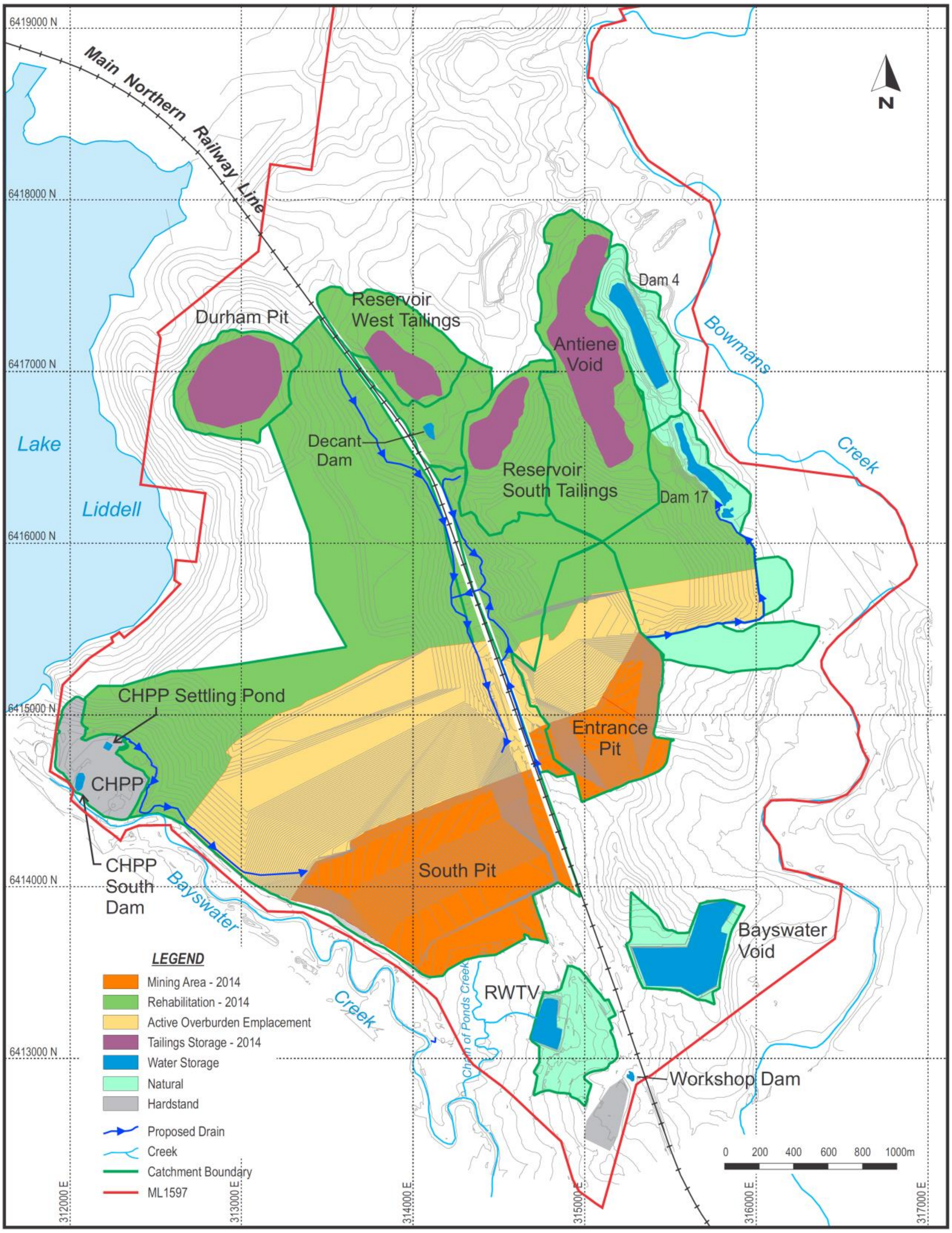
Similar to 2014, drainage from the South Pit overburden emplacement would be directed to the South Pit. Drainage from the western side of the Entrance Pit overburden emplacement would be directed under the Main Northern Railway line (via an existing underpass) to the South Pit void. Water in South Pit would be pumped to the Bayswater Void. Drainage from the southern and eastern sides of the Entrance Pit overburden emplacement would be directed to Dam 17. By 2017 it is intended that the Reservoir Tailings Dams would be fully rehabilitated and runoff would be directed to existing clean water dams (which are not part of the mine water management system) prior to draining off site.

2021 Layout

Figure 4-5 shows the planned mine layout in approximately 2021. By 2021, mining would have ceased in the South Pit and the South Pit would be the main water storage. Drainage from the rehabilitated South Pit overburden emplacement area would be directed via contour drains to the newly constructed Sediment Dam A. While receiving runoff from the active overburden emplacement areas, Sediment Dam A would spill to South Pit. Once the overburden emplacement areas have been completely rehabilitated, Sediment Dam A would spill off site to Bayswater Creek. Along the eastern boundary, drains would be constructed to direct runoff from south to north into Dam 17. Runoff from the western side of the Entrance Pit overburden emplacement area would also be directed to Sediment Dam A.

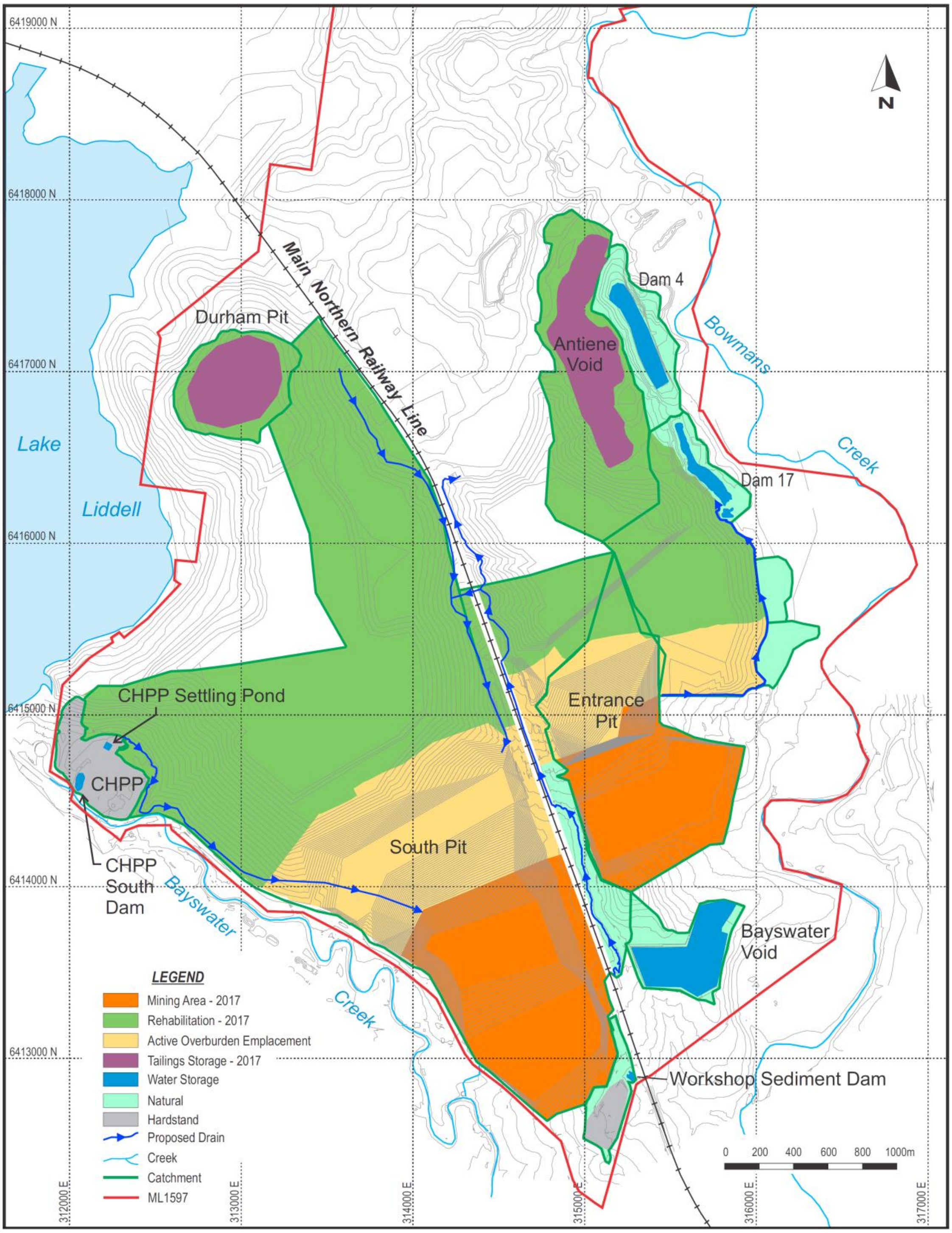
Final Landform

Figure 4-6 shows the planned mine layout for the final landform. The South Pit and Entrance Pit final landforms would be connected underground via the remnant Middle Underground workings (refer to Section 5.2.7). Drainage from the rehabilitated overburden emplacement areas would be directed off site via a system of swales, berm drains and drop structures. The northern portion of the South Pit overburden emplacement area would eventually drain into Lake Liddell while the remaining area would ultimately drain to Bayswater Creek. The west side of the Entrance Pit overburden emplacement area would be directed to a drain adjacent to the Main Northern Railway line and would drain to the south to Bowmans Creek, while the remainder would ultimately drain directly or via small tributaries to Bowmans Creek. Post mining surface water management is discussed further in Section 7.0 and drainage of the overburden emplacement areas is discussed further in Section 4.4.



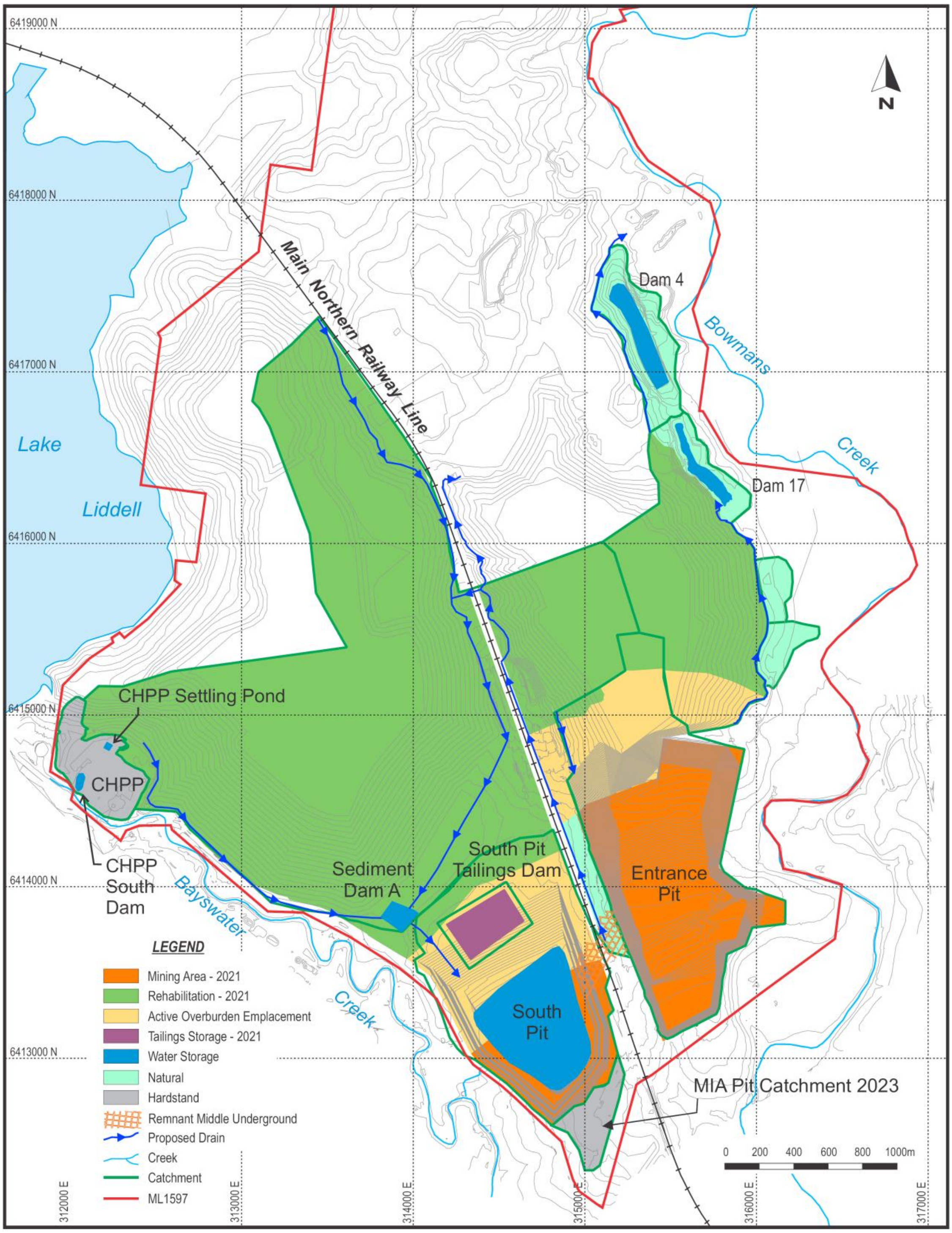
Note: Runoff from coloured areas reports to the water management system. Non-coloured areas represent either fully rehabilitated or undisturbed areas from which runoff does not report to the water management system.

Figure 4-3 2014 Site Layout



Note: Runoff from coloured areas reports to the water management system. Non-coloured areas represent either fully rehabilitated or undisturbed areas from which runoff does not report to the water management system.

Figure 4-4 2017 Site Layout



Note: Runoff from coloured areas reports to the water management system. Non-coloured areas represent either fully rehabilitated or undisturbed areas from which runoff does not report to the water management system.

Figure 4-5 2021 Site Layout

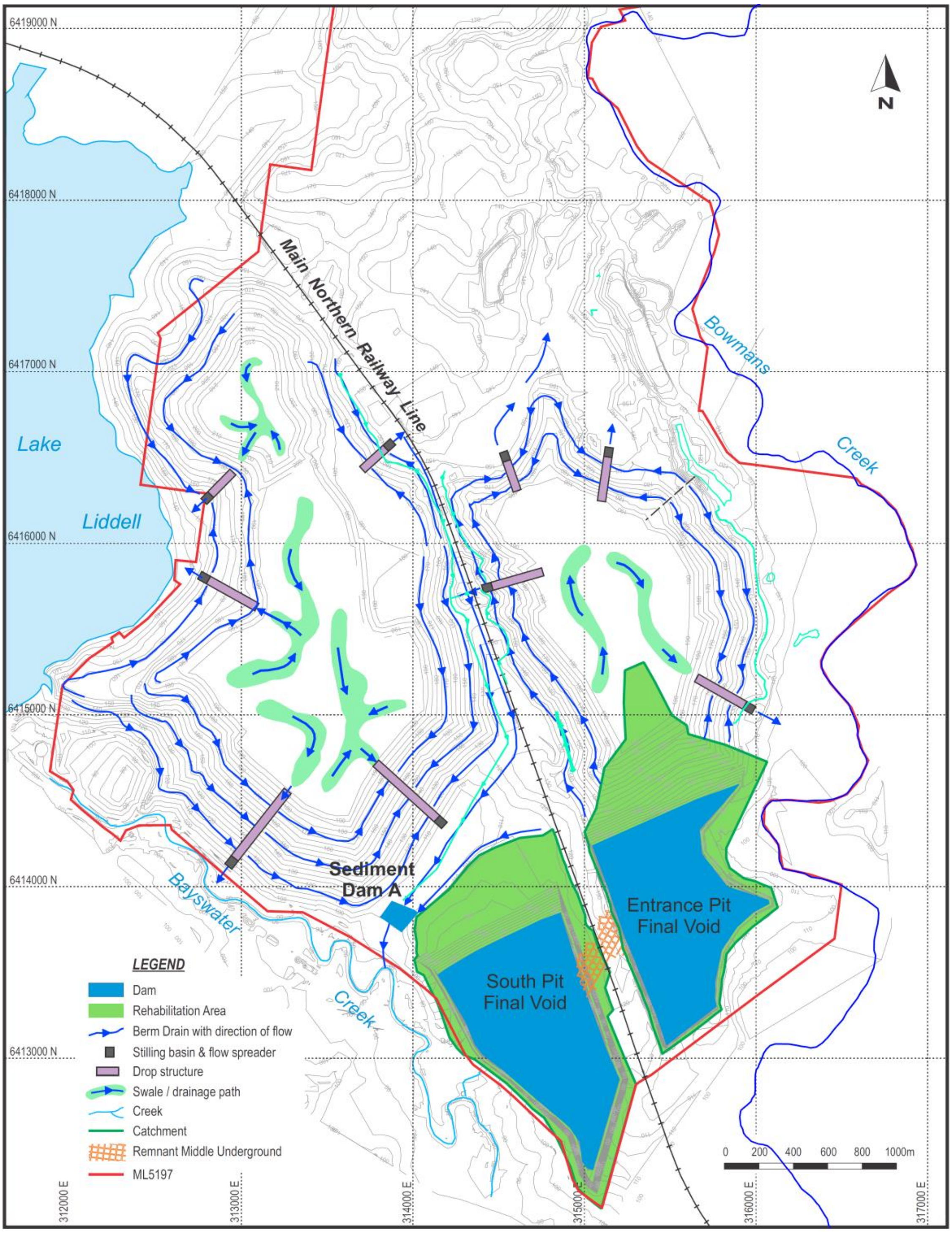


Figure 4-6 Conceptual Final Landform Drainage

4.3.3 Open Cut Pits and Interaction with Former Underground Workings

The South Pit would progress in a southerly direction. It is anticipated to be mined until approximately 2019. The MIA pit, located south of the South Pit, would be mined from the middle of approximately 2023 through to the end of the mine life in 2025 (refer to Figure 4-5). The MIA Pit is anticipated to be shallow (the estimated base elevation is -10 m AHD) and would be immediately adjacent to the South Pit. It would form part of the South Pit final void once mining is complete. The Entrance Pit would also progress in a southerly direction, with mining planned until the end of 2023. At the end of mining, the South Pit (including the MIA Pit) and the Entrance Pit would remain as the final voids on site.

As both the South Pit and Entrance Pit advance, they would progressively intersect former underground workings. To mitigate the effect of inflow from the underground workings to the open cut operations, water would be pumped from the underground workings in advance of mining.

As indicated in Section 4.1, there are two remnant sets of underground workings at the Liddell Colliery: the Hazeldene Underground and the Liddell Underground. The plan extents of the underground workings are shown in Figure 4-2 The Hazeldene Underground is located to the East and North of the Entrance Pit, and the open cut operations do not interact with it. Water is to be pumped out of the Hazeldene Underground into the Dam 17 or the Mt Owen Transfer Dam such that a water surface elevation of 60 m AHD is maintained for geotechnical stability of the underground and the Entrance Pit high wall design.

The Liddell Underground consists of three seams (refer Section 4.1 and Figure 4-2). The seams generally dip from the northeast to the southwest, however the seams also undulate with localised higher and lower elevation areas.

Although the underground workings targeted different seams, there are locations where the underground workings intersect. Therefore, above certain elevations the undergrounds may spill into each other. The M49 Underground spills into the Middle Underground at an elevation of -21.3m AHD and the Middle Underground spills to the 8 South Underground at an elevation of -12.7 m AHD. The 8 South Underground spills directly into the South Pit.

As the South Pit and Entrance Pit advance, they would mine through the former Liddell Underground. In the process, because of the dip of the seams, water would discharge from the Entrance Pit into the undergrounds, and from the undergrounds into the South Pit. As open cut mining progresses, the elevation of the intersection between the open cut pits and the former underground workings would decrease and the total capacity available to store water in the former underground workings would decrease. A more detailed description of the planned mining progression is described in Section 5.2.7.

The operational plan for the former underground workings is to maintain water in the workings until shortly before they are intersected by the open cut operations to mitigate the risk of spontaneous combustion. Dewatering would then occur via bores to the main water storage.

4.3.4 System Inflows

Rainfall induced runoff from active mining areas would vary with climatic conditions and the extent of disturbance throughout the mine life (refer Section 4.3.2). Runoff from active mining areas, containing elevated salinity and potentially high in suspended sediments, would be captured in contained water storages or open cut pits.

The open cut pit workings would become sinks for incident rainfall, infiltration through mine waste rock emplacements, rainfall runoff and inflow from the former underground workings. Sumps would be excavated in the floor of the active open cut pits as part of routine mining operations to facilitate efficient dewatering operations and to minimise interruption to mining.

Time-varying groundwater inflows to the open cut pits and former underground workings have been predicted by SKM (2013). Predicted groundwater inflow rates provided by SKM (2013) are presented in Section 5.2.8.

4.3.5 Water Consumption

The main water requirement for LCO would continue to be for CHPP makeup supply, to replace water pumped out with CHPP tailings (refer Section 4.5) and moisture lost with product coal and CHPP coarse reject. Water would also be required for control of spontaneous combustion, washdown of mobile equipment, dust suppression on haul roads, ROM coal stockpiles and conveyor systems. Some water would also be used for fire fighting and other minor non-potable water uses. Water may also be supplied to nearby Coal & Allied operations, Mt Owen Complex and other neighbouring operations such as the needs require (under agreement).

The water consumption requirements and the water balance of the system would fluctuate with climatic conditions and as the extent of the mining operation changes over time. Fluctuations in water consumption have been accounted for in the site water balance model – refer Section 5.2.10 for details.

4.4 Overburden Emplacement Area Drainage Management

The aims of overburden emplacement area drainage management are to prevent runoff from draining off-site prior to full rehabilitation and stabilisation of emplacements, to prevent erosion of the emplacements and to minimize sediment generation in the long-term. To accomplish these aims, overburden would be placed in mined out portions of the mine open cut pits and in designated areas adjacent to the workings. Conceptually, the final surfaces of the overburden emplacements would be constructed to form a regular pattern of berms and batters. The batters (constructed no steeper than 4 horizontal:1 vertical slope) would be separated by berms which would form “contour” drains at maximum spacings of 150 m downslope. Where possible these drains would flow directly to the natural surface. Otherwise flow would be directed to gully lines (drop structures) constructed down the batter. The final top surfaces of overburden emplacements would also be designed with a network of small swale drains, directing runoff to the head of batter gully lines.

Sediment traps and settling dams would be constructed at the end of contour drains and gully lines to reduce suspended sediment prior to passive drainage off site. These settling dams and ponds would also be constructed at intervals along the gully lines to retard flows and to settle sediment carried in runoff - particularly during the vegetation establishment phase. The settling ponds would be provided with low flow outlets so that the ponds would slowly drain following rainfall-runoff events. Wide shallow by-wash spillways would also be provided to facilitate low energy overflows during the more intense or prolonged rainfall events. Settling dams would be designed in accordance with Landcom (2004) and DECCW (2008). Within the gully lines, where high energy flows or high flow volumes are likely to concentrate, specific hydraulic works such as rip rap scour protection blankets, drop structures or other energy dissipation devices would be provided. A combination of suitable vegetation and rock mulching would be used to stabilise flow pathways in other flow areas in pool and riffle areas respectively.

Freshly placed overburden typically has a high infiltration capacity. Water infiltrating the material is retained in the pore space of the overburden material with the remainder mostly becoming seepage through the overburden. A proportion of the rainfall that infiltrates through the surface of the overburden is also returned to the atmosphere as evapotranspiration. As vegetation becomes established on the rehabilitated overburden emplacements, the hydrological balance would tend to change with a greater proportion of rainfall contributing to evapotranspiration and a reduced proportion contributing to seepage.

As the surface vegetation matures moisture levels in the near surface root zone would increase compared to the non-vegetated condition with the result that surface runoff may tend to increase. The erosion potential associated with increased runoff would however tend to reduce by the stabilising and insulating effect of the vegetation, with the result that sediment movement off the rehabilitated and revegetated overburden emplacement areas would tend to reduce with time.

4.5 Tailings and Rejects Disposal and Water Recovery

Two rejects streams (coarse and fine) are produced by the CHPP. LCO have estimated that currently and in the future, on average approximately 35% by weight of ROM coal feed to the CHPP becomes rejects, with 26% by weight of ROM coal feed becoming coarse and the remaining 9% fine.

Coarse reject, which has a particle size equivalent to gravel with some silt and clay, is placed as a dry fill in overburden emplacement areas. It is proposed that this disposal process would continue to be used over the remaining life of mine.

Fine reject or tailings, which has a particle size equivalent to clayey silt, is pumped as a slurry at nominally 25% solids by weight after thickening in the CHPP (i.e. thickener underflow) to the Reservoir West and Reservoir South Tailings Dams. Tailings water from these two storages is decanted into the Decant Dam. Water from the Decant Dam is pumped to Dam 4. These tailings storages are expected to be filled in 2013 at which time the tailings deposits would be left to dry and consolidate before the area is rehabilitated.

The following future tailings disposal plan has been advised by LCO. From 2013 to approximately 2018 tailings would be primarily directed to the Durham Tailings Emplacement Area (DTEA), located northwest of the Reservoir Tailings Dams (refer Figure 4-3). The DTEA is estimated to have a capacity for 3.85 million m^3 of tailings with a potential additional 2 million m^3 available within the existing void from 2019 to 2020 subject to further detailed design. Water from the Durham Pit would be pumped to the CHPP for use in processing via the RWTV or Bayswater Void. Concurrently, to assist in the timely decommissioning and capping of the Antiene Tailings Dam, LCO propose to place a highly consolidated layer of tailings over the surface of the existing tailings surface, in effect creating a more stable platform to commence rehabilitation works. This additional layer would also provide for an additional 1 million m^3 of capacity. Based on past experience, LCO would directly reclaim water from the surface of the Antiene Tailings Dam to Dam 4.

The South Pit Tailings Dam would be located within the upper levels of the South Pit, which would be isolated from the final void water storage by a confining embankment (refer Figure 4-5). It is planned to store tailings produced from approximately 2021 through the end of the mine life in the South Pit Tailings Dam. The South Pit Tailings Dam would have a capacity of some 1.34 million m^3. Water would be reclaimed from the tailings storage for re-use in the CHPP. Once mining has ceased and the CHPP is no longer operational, water remaining in the South Pit Tailings Dam would be directed to the South Pit water storage.

LCO also propose to emplace tailings on the advancing overburden dumps of the South Pit between 2018 and 2019 in a series of emplacement cells. These cells would enable sufficient tailings disposal capacity but may require rehandling following reasonable desiccation and final co-disposal with solid (coarse) rejects within the overburden emplacements.

For all of the tailings storages, reclaimable water would be pumped to the RWTV, Bayswater Void or South Pit water storage (depending on the year) for reuse in the CHPP. LCO anticipate that the tailings storages would be fully rehabilitated within five years of the cessation of tailings placement dependent on climatic conditions and operational needs.

5.0 SIMULATED PERFORMANCE OF WATER MANAGEMENT SYSTEM

5.1 Model Description

The water balance model of the Liddell water management system simulates changes in stored volumes of water in all storages in response to inflows, outflows and internal pumped transfers. For each storage, the model simulates:

Change in Storage = Inflow – Outflow

Where:

Inflow includes rainfall runoff (for surface storages), groundwater inflow or leakage (to the underground reservoirs and open cuts), pumped inflow and tailings water[5] (for tailings storage voids).

Outflow includes evaporation, supply to the CHPP, supply for truck fill (dust suppression), use for spontaneous combustion control, supply for Coal & Allied operations, supply to Mt Owen, leakage (between underground storages), controlled discharge and spills from storages (if any).

The structure of the model is generally as shown in Figure 4-1. Note that water pumped to the CHPP (as supply makeup) is "lost" from the system. CHPP water can re-enter the system as tailings water when tailings is discharged to any of the tailings storages.

The model was set up using the GoldSim® simulation package. The model operates on a sub-daily time-step and can be setup to simulate any period up to the projected end of mine operations – currently set to 1 June 2025. Storage surface sub-catchment areas (refer Section 5.2.2) were measured from plans provided by LCO. This included plans for March 2012, as well as annual future mine contour stage plans from 2014 through 2021 (assumed to be mid-year) - refer Figure 4-3 to Figure 4-6. Also provided was the final landform plan assumed to be as at approximately mid 2025. The model assumes linear interpolation of catchment areas between all snapshots. The model simulation reported herein is from 1 January 2014, the Modification start date. The model simulation however commenced in December 2012 so that the simulation could commence with actual monitored stored water volumes.

The model simulates 120, 11½-year "realisations" or sequences, derived using the climatic record from 1892 to 2011[6]. The first realisation uses climatic data from 1892-1904, the second 1893-1905, the third 1894-1906, and so on. These were used to generate water storage volume estimates and other relevant water balance statistics. This method effectively includes all recorded historical climatic events in the water balance model, including high, low and median rainfall periods. Results can be extracted for any water balance component for any time period in the simulation and statistical analyses undertaken.

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[5] Tailings water can be defined as the water that is liberated from tailings upon settling.

[6] Additional climate data after 2011 was generated by "wrapping" data from the beginning of the climate record to after 2011. In this way, the drought period of 2005-06 could be simulated as occurring at varying time through the mine life.

5.1.1 Hunter River Release Simulation

Simulation of periods available for controlled discharge (licensed release) under the HRSTS was included in the model. Simulated/historically recorded flows in the Hunter River were used along with relationships between flow and EC developed from historical recorded data, to simulate EC in the river and to model allowable release according to the number of credits held by LCO (currently 66).

The first stage of this involved simulation of flow in the Hunter River at Singleton for the period 1892 to 1962. Flow simulation was undertaken using the Hunter River IQQM (the model used by the NSW Office of Water (NOW) to set licence allocation levels in the Hunter Valley). For the period from 1962 onwards, recorded river flow data was used. In this way a daily river flow record from 1892 to 2011 was developed, in parallel to the climatic data set.

The second stage of this process involved simulating river EC levels versus flow rate. This was developed from recorded concurrent flow and EC data at the Hunter River at Singleton.

The third stage of the process involved developing a relationship between river flow rate and river registers for declared "high" flow events. This was developed using historical river registers sourced from the NOW Water Information website, correlated against recorded Hunter River daily flows. This correlation was extended to "flood" flow events in the Hunter River (during which no daily discharge restriction applies). According to the HRSTS rules these should occur when river flows at Singleton exceed 10,000 ML/day, however in practice these have often not been declared until river flows were higher.

The water balance model simulated discharges from the RWTV and Bayswater Void whenever the simulated flow in the Hunter River was predicted to be high or in flood flow. A salinity of 3,520 mg/L was assumed (based on the average of recorded TDS values at the main water storage). A peak discharge rate of 350 litres per second was assumed based on data supplied by LCO. Water was simulated to be released from the RWTV if the volume stored was greater than the estimated low storage volume of 100 ML and from the Bayswater Void if the estimated storage was greater than half of the capacity of 2.4 GL.

5.2 Model Input/Assumptions

5.2.1 Rainfall and Evaporation

A record of 120 years of rainfall data (1892-2011 inclusive) was obtained for the site from the Silo Data Drill[7]. A 120-year pan evaporation data set for the site was also obtained from this source.

[7] The Data Drill is a system which provides synthetic data sets for a specified point in Australia by interpolation between surrounding point records held by the BoM (refer http://www.longpaddock.qld.gov.au/silo/)

5.2.2 Catchment Areas

Modelled dam and storage catchment areas were derived from snapshot plans supplied by LCO. Table 5-1 below summarises the areas used in the model for selected years.

Table 5-1 Modelled Catchment Areas

Storage	Total Catchment Area (ha)			
	Jun -2014	Jun-2017	Jun-2021	Jun-2025
Antiene Void	87	87	0	0
Entrance Pit	82	110	154	136
Bayswater Void	26	26	0	0
CHPP Settling Pond	20	20	20	20
CHPP South Dam	1	1	1	1
Dam 17	73	95	102	107
Dam 4	26	26	46	46
Durham Tailings Emplacement Area	35	35	35	0
South Pit (incl. MIA Pit)	533	634	118	142
Sediment Dam A	0	0	523	530
Reservoir West	33	0	0	0
Reservoir South	40	0	0	0
Decant Dam	20	0	0	0
Tailings Cells	26	26	26	0
South Pit Tailings	0	0	9	0
Workshop Sediment Dam	13	13	13	0

The catchment areas were split into different sub-catchment types, as defined for rainfall-runoff modelling (refer Section 5.2.3). Sub-catchments were defined on the basis of vegetation coverage and surface type. The sub-catchment split was undertaken with the aid of a 2012 mine aerial photograph). Sub-catchment types included in the model were: hardstand, natural surface, open cut tailings, overburden and rehabilitated overburden. The change in the total catchment area and sub-catchments over the Modification period are shown in Figure 5-1.

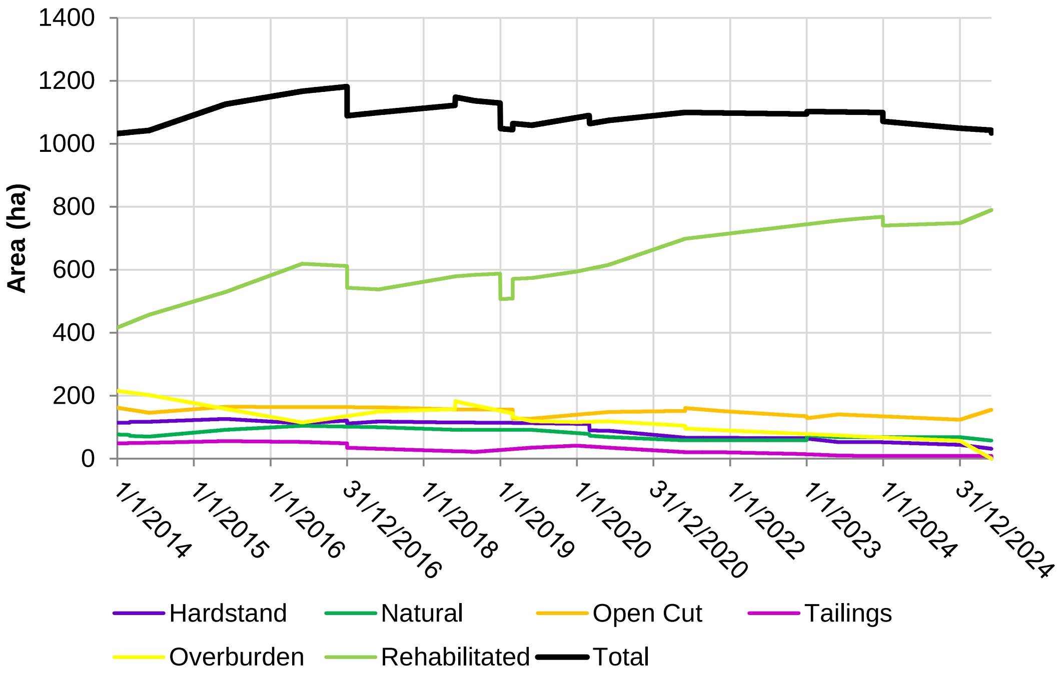

Figure 5-1 Catchment and Sub-catchment Areas Variation with Time

5.2.3 Rainfall Runoff

The water balance model includes a simulation of daily rainfall-runoff from rainfall and evaporation data. For dam storage surface areas (i.e. water), rainfall was assumed to add directly to storage volume with no losses. For other sub-catchments, rainfall runoff was simulated using the Australian Water Balance Model (AWBM) – Boughton (2004). The AWBM is a catchment-scale water balance model that estimates streamflow from rainfall and evaporation. Different AWBM parameters were used for each sub-catchment type. AWBM parameters for natural surface sub-catchments were taken from regional AWBM calibrations undertaken using streamflow gauging stations. Parameters for other sub-catchments were set based on experience with similar projects.

5.2.4 Evaporation from Storage Surfaces

Storage volumes calculated by the model are used to calculate storage surface area (i.e. water area) based on storage volume-area-level relationships for each water storage either provided by LCO or estimated from supplied plans. For the tailings storages a number of different methods were used to calculate storage surface area as follows:

- Reservoir Tailings Emplacements and Antiene Tailings Dam: calculated assuming existing contours and supplied tailings beach level estimates
- Durham Tailings Emplacement Area: calculated assuming pit shell contours and supplied volume of tailings with an assumed tailings beach slope of 1%
- South Pit Tailings Dam: calculated assuming a constant surface area.

Evaporation from storages is calculated in the model by multiplying storage surface area by daily pan evaporation rate and by a pan factor. A pan factor of 0.9 was used in the model for all storages (except the tailings storages and pits), to allow for the typically lower evaporation from open water bodies compared to evaporation pans. A pan factor of 0.8 was used for the open cut pits to allow for shading over the stored water surface due to depth below natural surface. A pan factor of 1.1 is considered appropriate for the tailings storages because the tailings are dark with low reflectance, which would likely increase the effective evaporation rate.

5.2.5 Above Ground Storages

The capacity, timing, and initial volumes stored in the above ground storages is summarised in Table 5-2. Dam capacities were derived from contour plans or data supplied by LCO. Dams were assumed to be empty upon commissioning.

The model operated using a series of operating trigger volumes for certain water storage dams. In general, when the volume in the storage rose above a “high” trigger volume, the model attempted to pump water to other storages. When the volume in the RWTV, Bayswater Void or South Pit water storage fell below a “low” trigger volume, the model attempted to pump water to these key storages from other storages. The high operating volumes were advised by LCO.

Table 5-2 Modelled Initial Above Ground Storage Volumes and Capacity

Storage	Capacity (ML)	High Operating Volume (ML)	Initial Volume (ML)
Antiene Void	1227*	-	0
Bayswater Void	2400	2056	0
CHPP South Dam	11	-	6
CHPP Settling Pond	2	-	0
Dam 4	1220	668	353
Dam 17	520	306	200
Decant Dam	188	-	0
Durham Pit	2,327*	-	0
Entrance Pit	13,450^	-	0
MIA Pit	1265	-	0
RWTV	507	402	383
Reservoir West Tailings Emplacement Area	1085*	-	150
Reservoir South Tailings Emplacement Area	322*	-	0
Sediment Dam A	165	-	0
South Pit	97,500^	-	0
South Pit Water Storage	93,300†	-	0
South Pit Tailings Dam	1790*	-	0
Tailings Cells	2112*	-	0
Transfer Dam	36	-	18
Workshop Sediment Dam	13	-	0

* *Capacity would reduce as tailings is added*

^ *Estimated capacity in 2018*

† *Estimated capacity of South Pit when it becomes a water storage. Estimates were based on the 2020 mining stage plan.*

5.2.6 Storage Start and End Dates

Through the Modification period the main water storage would change, additional storages would be constructed and existing storages decommissioned. The modelled storage start and end dates are summarised in Table 5-3.

Table 5-3 Modelled Start and End Dates

Storage	Start Date	End Date
Bayswater Void	2/3/2014	1/3/2020
Decant Dam	Existing	31/12/2016
Durham Pit	Existing	29/5/2023
RWTV	Existing	1/2/2014
Reservoir West Tailings Emplacement Area	Existing	31/12/2016
Reservoir South Tailings Emplacement Area	Existing	31/12/2016
Sediment Dam A	2/3/2019	1/6/2025
South Pit Water Storage	2/3/2020	1/6/2025
South Pit Tailings Dam	1/6/2021	31/5/2025
Tailings Cells	2/12/2018	1/1/2019
Workshop Sediment Dam	Existing	2/1/2023

5.2.7 Underground Storages

As discussed in Section 4.3.3, the South Pit and Entrance Pit would mine through the former Liddell Underground workings. As the former underground workings are mined out, water retained in the undergrounds would discharge to open cut pits. In time, the discharge elevations would decrease and the total capacity available to store water in the underground workings would also decrease. The estimated capacity of the underground workings in time is summarised in Table 5-4. The total capacity of the underground workings, prior to being mined through, was provided by Glencore and the following description of the progression of mining through the former underground workings has been developed from discussions with LCO personnel. The reduction in the capacity was based on assuming that the volume lost was proportional to the area which was mined though.

Table 5-4 Total Capacity of Liddell Underground Available over Time

Underground	Estimated Capacity at		
	Beginning of Open Cut Mining	Completion of South Pit (31/12/2019)	Completion of Entrance Pit (End of Mining: 31/12/2023)
8 South	2829 ML	681 ML	0 ML
Middle	446 ML	367 ML	289 ML
M49	2494 ML	2494 ML	2315 ML
Total	*5768 ML*	*3542 ML*	*2783 ML*

The South Pit is currently intersecting the 8 South Underground with water from the 8 South Underground discharging directly into the South Pit until the end of 2017. The discharge elevation from 8 South into South Pit decreases as open cut mining proceeds. By the end of 2017 it is anticipated that the South Pit would have finished mining through the western side of the 8 South Underground and the 8 South Underground would no longer discharge into the South Pit. Between 2018 and 2022, the South Pit would be mining through the Middle Underground, with the Middle Underground discharging directly into the South Pit.

The Entrance Pit initially intersects the 8 South Underground with water in the Entrance Pit overflowing to the 8 South Underground until 2020. The discharge elevation from the Entrance Pit to the 8 South Underground would decrease as the open cut progresses southwards. By the middle of 2020, once the Entrance Pit has mined through the 8 South Underground, there would be no storage capacity remaining in the 8 South Underground. After 2020, the Entrance Pit would be mining through the Middle Underground and would overflow directly into the Middle Underground until 2022. Because the Middle Underground spans between the South Pit and the Entrance Pit (refer Figure 4-6), by 2022, it is anticipated that the Entrance Pit would begin to overflow via the remnant Middle Underground beneath the Main Northern Railway line into the South Pit. The remnant Middle Underground would thereafter remain an underground conduit between the open cut pits.

The M49 Underground spills into the Middle Underground throughout the Modification period.

5.2.8 Groundwater Inflow Rates

Groundwater inflow rate estimates to the open cut operations and underground workings were provided by SKM (2013). The groundwater model predicted groundwater inflows to the South Pit between 2014 and 2023 with inflow rates ranging between 2.7 ML/d and 8.6 ML/d. Groundwater inflows into the Entrance Pit were predicted between 2014 and 2023 with rates ranging from 0.01 ML/d to 1.9 ML/d. Inflows to the open cut pits were distinct from water which would be pumped from the underground workings to the surface.

The groundwater model predicted inflow rates to the Hazeldene, Middle and M49 former underground workings were based on maintaining a target water level in these former underground workings by extracting water using dewatering bores (i.e. the groundwater inflow rates were equated to the bore extraction rates calculated by the groundwater model). For the Hazeldene underground, groundwater inflows were predicted to range between 0.4 and 0.8 ML/d. Inflow rates ranged between 0 and 1.3 ML/d for the M49 Underground and 0.03 to 0.2 ML/d for the Middle Underground. The predicted groundwater inflow rates are summarised in Table 5-5. The predicted total groundwater inflow rate versus time is plotted in Figure 5-2.

Table 5-5 Predicted Groundwater Inflow Rates

Year	Predicted Groundwater Inflow Rate (ML/d)					
	South Pit	Entrance Pit	8 South	Middle	M49	Hazeldene
2014	8.57	0.04	0.00	0.05	1.33	0.44
2015	6.05	0.01	0.00	0.04	1.27	0.43
2016	3.64	0.01	0.00	0.03	1.21	0.41
2017	2.82	0.01	0.00	0.20	1.15	0.41
2018	3.48	0.01	0.00	0.11	1.09	0.40
2019	2.72	0.02	0.00	0.09	1.04	0.39
2020	2.56	0.42	0.00	0.07	0.96	0.38
2021	2.31	0.00	0.00	0.06	0.88	0.38
2022	2.31	1.88	0.00	0.03	0.00	0.36

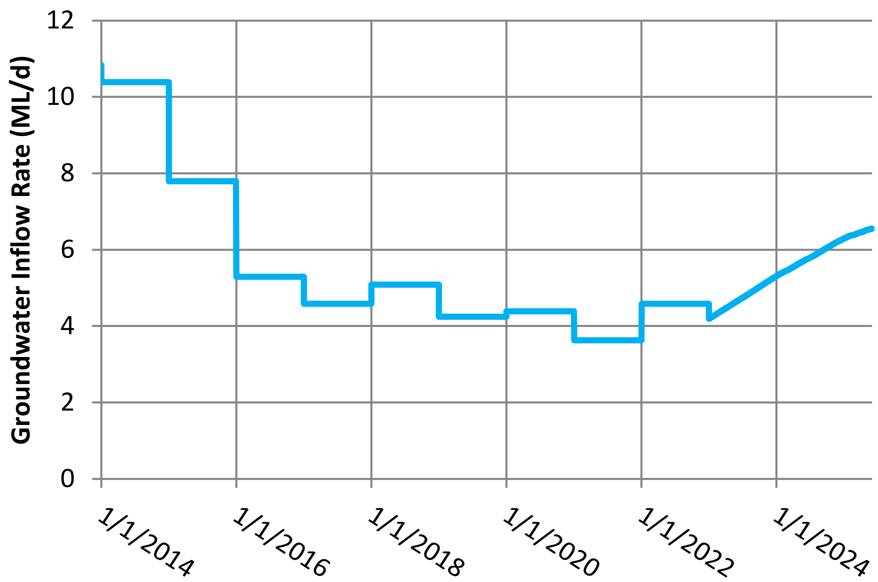

Figure 5-2 Predicted Total Groundwater Inflow Rates

The groundwater model only provided inflow rates up to the end of 2022 as this is when mining in the Entrance Pit is scheduled to be completed. The water balance model was required to simulate the remaining mine life (including the Modification) up to mid-2025 to allow for mining in the MIA Pit (into which zero groundwater inflow was predicted). Therefore after 2022, the groundwater inflow rates were based on modelled final void (post-mining, long-term) groundwater inflow rates, which were estimated separately from the life-of-mine inflows by SKM (2013). For the former underground workings and the MIA Pit, the predicted groundwater inflow rates were negligible post-mining. For the open cut pits, based on advice from SKM, it was assumed that it would take approximately 50 years for the surrounding aquifers to recover to a 'steady-state'. Therefore the predicted inflow rates at any time between the end of 2022 and mid-2025 were calculated by linearly interpolating between the values predicted at the end of 2022 (Table 5-5) and the fully recovered post-mining values which were assumed to apply at the end of year 2072.

5.2.9 Pumping Rates

Pumping rates were based on existing pump capacities supplied by LCO and were altered where necessary to meet the operational objectives (e.g. to not simulate a shortfall in supply while there was still a volume of water simulated within the system). Pump rate capacities are summarised in Table 5-6.

Table 5-6 Modelled Pumping Rate Capacities

From	To	Pump Capacity (L/s)
CHPP Area Dams	CHPP	165
Dam 4	Dam 17*	100†
Dam 4	Transfer Dam	100
Dam 17	Main Water Storage*^	150†
Dam 17	Transfer	100
Dam 17	Mt Owen	100
Entrance Pit	Main Water Storage^	45
Hazeldene Underground	Dam 17	100†
Hazeldene Underground	Transfer Dam	100†
M49	Main Water Storage^	85
M49	Mt Owen	85
Middle Liddell	Main Water Storage^	45
Main Water Storage^	CHPP	150
Main Water Storage^	Coal & Allied	200
MIA Pit	Main Water Storage^	90†
South Pit	Main Water Storage^	500†
Tailings Dams	Dam 4	80
Tailings Dams	CHPP	80
Transfer Dam	Mt Owen	100
Workshop Sediment Dam	Main Water Storage^	150

** Reversible pump line*

^ Main water storage changes between RWTV, Bayswater Void and the South Pit (refer Section 4.3.2)

† *Pump rate assumed in the absence of any other information*

5.2.10 Demands

Five water demands on the water management system are:

1. Make-up to the CHPP.
2. Haul road supply for dust suppression.
3. Water used to control spontaneous combustion.
4. Water used for administration and the workshop
5. Water supplied to neighbouring mining operations under agreement.

CHPP make-up demand depends upon the future ROM coal washing (CHPP feed) rate as summarised in Table 5-7. Water is supplied to the CHPP to make-up water lost to tailings, coarse reject and in increased moisture in product coal (above that in ROM coal). The following key assumptions were made in this regard (based on data supplied by LCO):

- ROM coal moisture 3% (by weight).
- Product coal comprises 65% of ROM coal.
- Product coal moisture 8% (by weight).
- Tailings comprise 9% of ROM coal.
- Tailings pumped at 25% solids concentration (by weight).
- Coarse rejects moisture 12% (by weight).

Table 5-7 CHPP Feed Demand Rate

Year	CHPP Feed Rate (Mtpa)	CHPP Water Demand (ML/d)
2014	7.1	6.0
2015	6.9	6.0
2016	7.2	6.3
2017	7.0	6.2
2018	7.0	6.2
2019	7.0	6.2
2020	7.2	6.3
2021	5.3	4.7
2022	5.3	4.7
2023	4.3	3.8
2024	4.6	4.1
2025	2.0	1.8

Haul road demand was derived for each month of the year (i.e. seasonally varying) from recorded usage data supplied by LCO. Future demands were calculated based on the estimated future haul road length (from future mine stage plans) compared with haul road length during the period of recorded data. The estimated haul road demand is summarised in Table 5-8. The haul road demand is first satisfied from Dam 17, then the CHPP area dams and then the main water storage.

Table 5-8 Haul Road Demand

Years:	2014-2015	2015 - 2017	2017 - 2020	2020 - 2025
Estimated Total Length (km)	13.0	13.3	16.3	9.0
Month		**Haul Road Water Demand Rate (ML/d)**		
January	29	29	36	20
February	22	23	28	15
March	29	30	37	20
April	23	24	29	16
May	30	30	38	21
June	18	19	23	12
July	24	24	30	16
August	24	25	31	17
September	24	25	31	17
October	29	30	37	20
November	32	33	41	22
December	31	32	39	21

From information provided by LCO, the water demand to control spontaneous combustion was set at 7.5 L/s (0.65 ML/d) total, evenly split between the South Pit and Entrance Pit overburden emplacements, with 10% lost and the remainder reporting to the respective open cut pit. From information provided by LCO, the average demand for the administration and workshop area was set to 0.11 ML/d.

Water demand by Coal & Allied (i.e. water supplied to operations off site) was set at 0.3 ML/d. Whilst an agreement is in place to supply up to 35 ML/week (5 ML/d), this maximum volume of water has not been requested by Coal & Allied since the agreement has been in place. Therefore, to best represent this demand in the water balance, the average of the actual volumes of water historically supplied was used, based on records provided by LCO. The demand for water by the Mt Owen Complex[8] was set at 4.32 ML/d (1577 ML/a) based on records provided by LCO. Water was modelled as provided to the Mt Owen Complex only if the water stored in the main water storage was greater than 500 ML.

5.2.11 Tailings Water

The majority of the water used in the CHPP is pumped out from thickener underflow as tailings slurry. A proportion of the water in the tailings slurry is liberated as the tailings settle within the tailings storages. The water that is liberated and available for reclaim is termed “bleed” water. The proportion of tailings water that becomes bleed water has been set at 56% based on a tailings test undertaken by LCO personnel in early 2007. Further details of future tailings discharge and water recovery are provided in Section 4.5)

[8] This could equally simulate supply to other Glencore operations in the region.

5.3 Simulated System Performance (Model Results)

5.3.1 Overall Water Balance

Figure 5-3 and Figure 5-4 below summarise model predicted system inflows and outflows for the Modification period averaged over all climatic realisations.

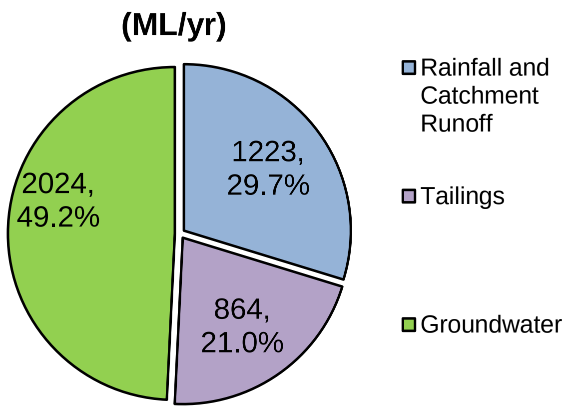

Figure 5-3 Average Model Inflows

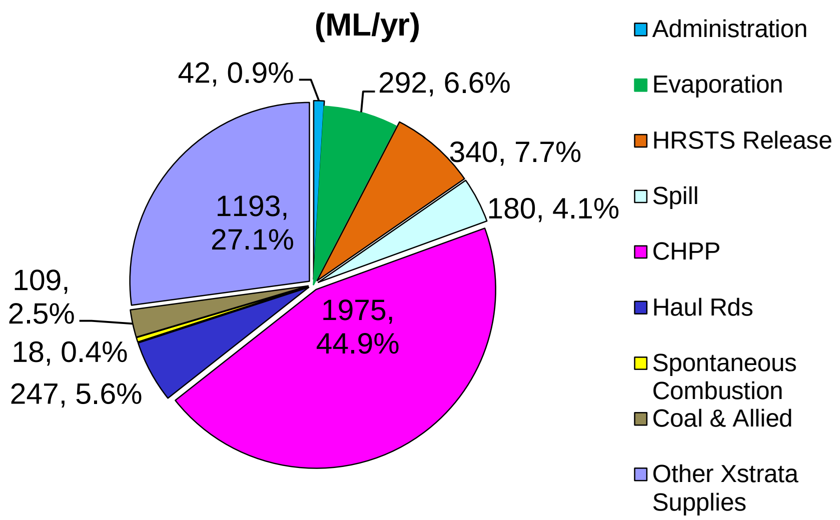

Figure 5-4 Average Model Outflows

Predicted average inflows total 4,111 ML/a while average outflows total 4,396 ML/a (the difference between these two represents modelled average change in stored water volume). Model results for high rainfall (90th percentile), median and low rainfall (10th percentile) 11½-year periods were extracted from model results and are summarised in Table 5-9 below.

Table 5-9 Water Balance Model Results Averaged over Mine Life (ML/annum)

	10th Percentile Rainfall Sequence (Dry)	Average Rainfall Sequence	90th Percentile Rainfall Sequence (Wet)
Inflows			
Catchment Runoff	946	1,223	1,523
Groundwater	2,017	2,024	2,026
Tailings Water	862	864	865
Total Inflows	*3,826*	*4,111*	*4,414*
Outflows			
CHPP Use	1,975	1,975	1,975
Truckfill (Haul Road Dust Suppression) Use	233	247	260
Evaporation	273	292	315
Release to Hunter River	128	340	554
Spills*	63	180	279
Spontaneous Combustion Use	18	18	18
Coal & Allied Supply	109	109	110
Other Glencore Operations	1001	1,193	1,348
Administration	42	42	42
Total Outflows	*3,841*	*4,396*	*4,900*

** Spills were from Sediment Dam A once it was receiving fully rehabilitated runoff.*

5.3.2 Total Water Stored

Figure 5-5 shows the model predicted total volume of water held in all storages (including open cut pits and underground storages) versus time over the remaining mine life (with the Modification). Figure 5-5 shows plots of median stored water volume over all 120 climatic realisations, as well as 10 and 90-percentile volumes.

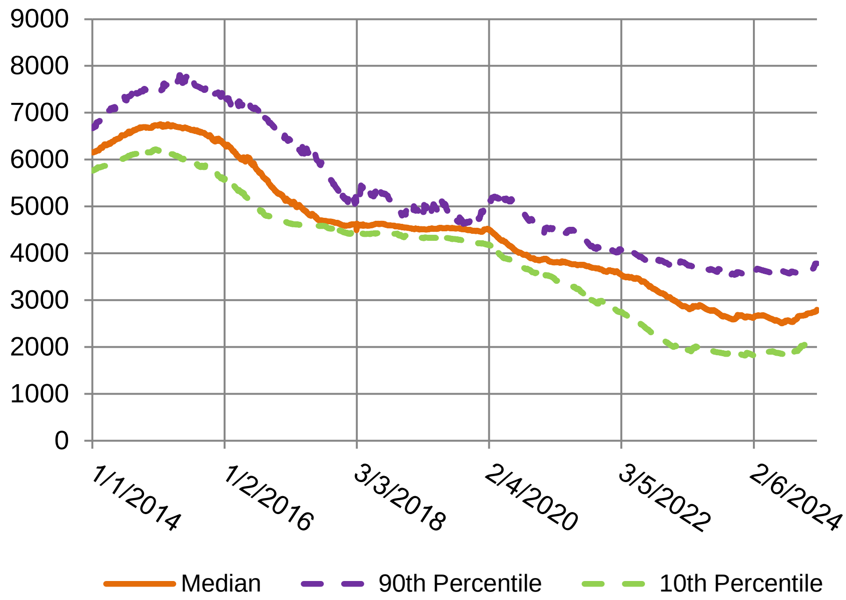

Figure 5-5 Predicted Total Stored Water Volume

In Figure 5-5 the peak in the predicted water volume stored on site in 2015 is related to the predicted groundwater inflow rates at this time. As shown in Figure 5-2, the groundwater inflow rates are greatest from 2014 to 2015 with inflow rates of approximately 11 ML/d. Figure 5-5 indicates a gradual fall in total water stored as the former underground workings are gradually dewatered.

5.3.3 Water Supply Reliability

Predicted water supply reliability is expressed as total water supplied divided by total demand (i.e. a volumetric reliability) averaged over the Modification period. The simulated water supply reliabilities for the various mine water demands are summarised in Table 5-10. Reliability is averaged over all realisations and over the 11½-year Modification period, maximum reliability refers to the highest reliability in any one 11½-year period (averaged over those 11½-years) and minimum reliability is the lowest reliability in any 11½-year period (also averaged over those 11½-years).

Table 5-10 Simulated Water Supply Performance

	Simulated Reliability		
	Minimum	**Average**	**Maximum**
Supply Reliability for			
CHPP Use	>99.9%*	>99.9%*	>99.9%*
Haul Road Dust Suppression Use	82.7%	94.0%	>99.9%*
Spontaneous Combustion Use	86.2%	99.2%	>99.9%*
Coal & Allied Supply	96.4%	99.9%	>99.9%*
Other Glencore Supplies	56.0%	77.8%	>99.9%*

** The inherent uncertainty in the representativeness of low rainfall periods in the historical climate data set used in the model precludes the use of the term "100%".*

5.3.4 Mining Disruption

The risk of disruption to mining has been assessed by tracking the number of days in each realisation where there was more than 200 ML stored in each active open cut pit. The South Pit would be actively mined until 2019 while the Entrance Pit would be mined until 2023.

Results indicate that the South Pit would contain more than 200 ML of water for an average (over all realisations) of 266 days from 2014 to 2020 (its operational period). The maximum number of days with volumes greater than 200ML was predicted to be 1746. The predicted water volume in South Pit for the median and at the 75th and 90th percentile risk level is shown on Figure 5-6. It is important to note that this data is compiled from all climatic realisations and represent probability "envelopes" rather than results from a single possible climatic scenario. Figure 5-6 shows that South Pit is predicted to have a volume greater than 200 ML in the beginning of 2014 in more than 50% of modelled scenarios and in 2015 for 25% of scenarios. The higher volumes in 2014 can be attributed to the predicted groundwater inflow rates (refer to Table 5-5). The higher volumes in 2015 are due to the inflow of water from the 8 South Underground as the South Pit mines through it and the capacity of the 8 South Underground decreases and the increased runoff from the overburden emplacement areas. Overall the future water volume in the South Pit is likely to be low most of the time.

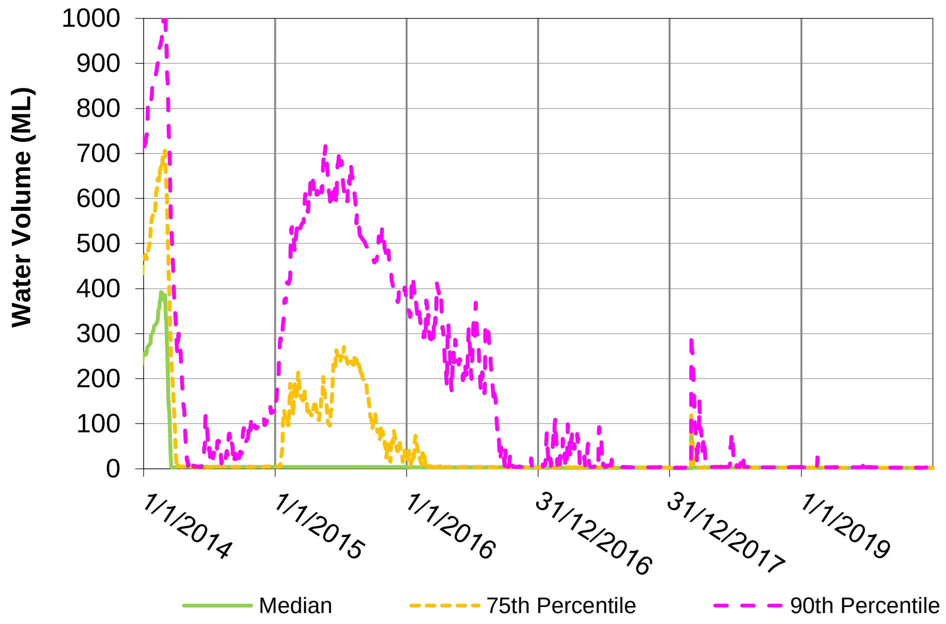

Figure 5-6 Predicted South Pit Water Volume

The Entrance Pit and would contain more than 200 ML of water for an average of 6 days from 2014 to 2023. The maximum number of days with volumes greater than 200ML was predicted to be 181. The predicted water volume in the Entrance Pit for the median and at the 75th and 90th percentile risk level is shown on Figure 5-7. Figure 5-7 shows that the greatest volumes are predicted to occur in 2022. The higher volumes in 2022 can be attributed to the predicted groundwater inflow rates (refer to Table 5-5). Overall the future water volume in the Entrance Pit is likely to be low most of the time.

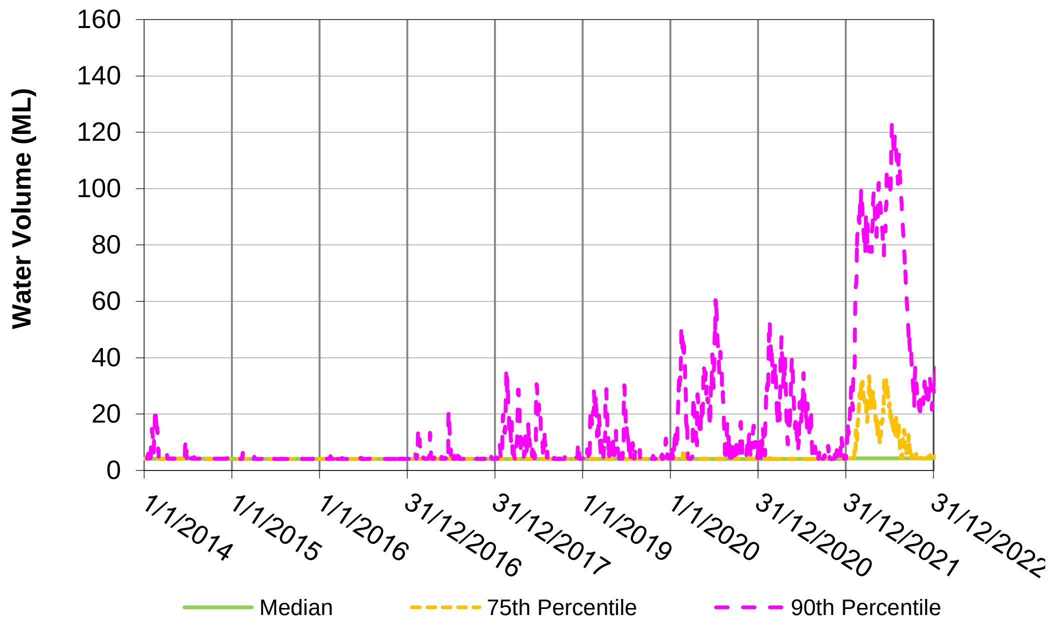

Figure 5-7 Predicted Entrance Pit Water Volume

5.3.5 Spills

Spills were only predicted from Sediment Dam A once it was receiving runoff from fully rehabilitated areas. No other spills off site from any storages were simulated.

5.3.6 Controlled Release

Figure 5-8 shows model predicted annual (calendar year) release volumetric statistics from the RWTV and Bayswater Void via the HRSTS (statistical results derived from all 120 realisations). Model results indicate that there was less than 800 ML released annually on average over all realisations, while the simulated annual release exceeded 1600 ML in less than 10% of modelled climate scenarios. Similar statistics of the number of days of releases predicted is shown in Figure 5-9. All controlled releases from LCO would be made in accordance with the requirements of the HRSTS.

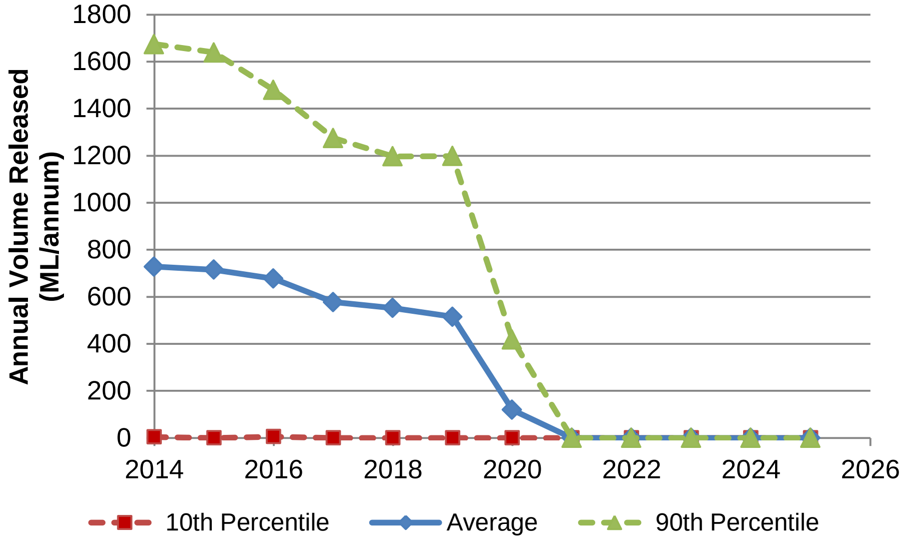

Figure 5-8 Predicted Annual Hunter River Controlled Discharge

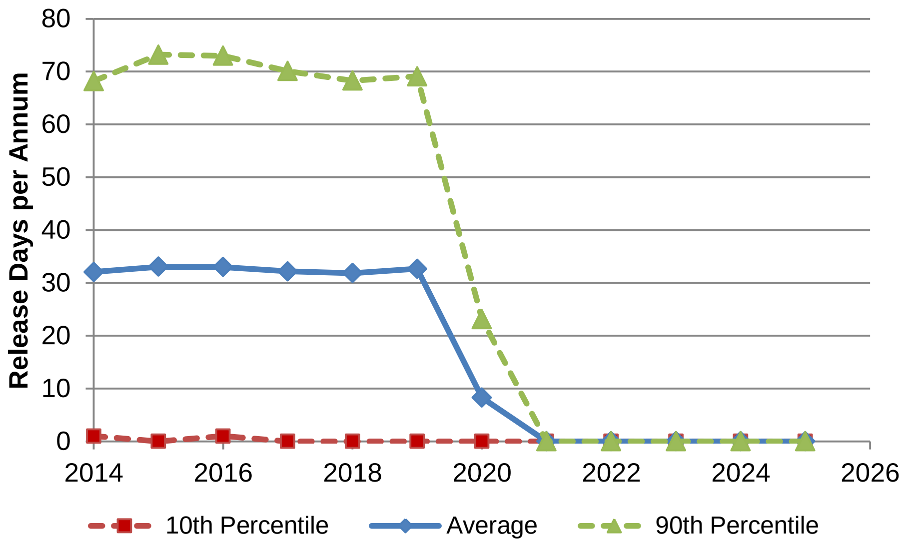

Figure 5-9 Predicted Number of Release Days

5.4 Water Management Implications

Groundwater is predicted to account for the majority of water inflows to the mine (refer Figure 5-3). Managing groundwater inflows to the open cut pits and former underground workings would be key to minimising possible disruptions to mining.

A significant component of inflow to the water management system is also predicted to comprise runoff from the rehabilitated overburden emplacement areas which would, in 2019, cover an estimated 800 ha (refer Figure 5-1). Control of runoff from these areas would be an important aspect for both operational water management and the ultimate rehabilitation of the mine. It is recommended that detailed catchment plans be developed in advance of mining. These plans should address sediment and erosion control measures for the initial development (clearing and initial overburden stripping operations), overburden emplacement area design, landform drainage design and re-vegetation scheduling. Drainage design should accommodate the changing hydrological response of overburden emplacement areas following rehabilitation as well as optimising the diversion of runoff from fully rehabilitated areas away from active mine disturbance areas.

The water balance for LCO would be affected by climatic conditions. The system has the flexibility to accommodate this variability through transient storage in the on-site water storages, through the ability to discharge excess water off-site in a controlled fashion and by transfer of water to the Mt Owen Complex or other neighbouring operations. The discharge of water to the Hunter River is regulated by the HRSTS to ensure that salinity levels in the river do not exceed target levels required to meet defined beneficial uses. The ability to discharge water to the Hunter River is also dependent on the number of salt credits held (currently 66). By monitoring and reviewing the operational performance of the water management system, and using the developed water balance model as a tool, it would be possible to assess the adequacy of the credits held by LCO and to purchase additional credits as required.

6.0 ASSESSMENT OF MODIFICATION SURFACE WATER IMPACTS

The potential impacts on local and regional surface water resources are:

- Changes to flows in local creeks due to expansion and subsequent capture and use of drainage from mine area catchments.
- Potential for export of contaminants (principally sediments and soluble salts) in mine area runoff and accidental spills from containment storages (principally sediments, soluble salts, oils and greases), causing degradation of local and regional water courses.
- Short term increases in salinity during periods of licensed discharge under the HRSTS.

6.1 Flow Regime in Local Creeks

There is potential for the Modification to affect the flow regime in Bayswater and Bowmans Creeks, both groundwater-derived baseflow and surface runoff.

The effect on baseflow was assessed by estimating the contribution of baseflow from historic streamflow records and comparing this to predictions of baseflow loss made by SKM (2013). As indicated in Section 2.3, two streamflow gauges are/were located on Bowmans Creek adjacent to LCO. The streamflow data from GS210042 (the streamflow gauge with the longest period of record) was partitioned using analytical technics (Boughton, 1988) to estimate the contribution of baseflow to streamflow at the gauging station. Results from the model suggested that historically baseflow has accounted for 25% of streamflow over the 41 years of available data. Although gauging stations were located on Bayswater Creek, Bayswater Creek has been highly modified by Lake Liddell. Distinguishing natural variance in creek flows and isolating the contribution of baseflow *not* due to Lake Liddell was not considered feasible. The contribution of baseflow to the total streamflow in Bayswater Creek is expected to be similar to that of Bowmans Creek.

Groundwater modelling undertaken by SKM (2013) predicted that prior to 2019, groundwater losses from the Bowmans Creek alluvium would be similar for both the approved operations and the proposed Modification. Predicted losses from the alluvium between 2014 and 2019 ranged between 120 ML/annum to 150 ML/annum. With the Modification, the groundwater losses would increase relative to the approved operations after 2019. The estimated losses increase by 110 ML/annum between 2021 and 2022. Peak losses would occur at the end of mining in the Entrance Pit (approximately in 2022) with a rate of 270 ML/annum. The increased baseflow loss of 220 ML/annum would account for approximately 5% of the baseflow on average, representing an annual loss of approximately 1.3% of mean annual streamflow in those years.

The effect of the Modification on the surface runoff of streamflow was assessed estimating changes to mine site catchments which contribute to runoff to each creek. The effect of runoff captured from the expanding mine area on local creek runoff is likely to be proportional to the change in contributing catchment areas. Changes in the catchment are summarised in Table 6-1. For Bowmans Creek, relative to approved operation, the Modification would result in less than 1 km^2 decrease in the creek catchments at the estimated maximum extents of mining (0.95 km^2) and for the final landform (0.98 km^2). This represents a reduction of approximately 0.5% from the Bowmans Creek catchment. For Bayswater Creek, at the maximum extents of mining, an additional 0.78 km^2 would be excised, and at the end of mining the catchment excision would increase by 1.0 km^2 relative to the approved operations. This represents an increase of 1.06% and 1.36% respectively. Average flow rates would be expected to reduce in proportion.

Table 6-1 Changes to Contributing Catchment of Local Creeks

	Bowmans Creek		Bayswater Creek	
Catchment Excision (km^2)	Maximum Extents	Final Landform	Maximum Extents	Final Landform
Increased Catchment Excision (km^2)*	0.95	0.98	0.78	1.0
Proportion Creek Catchment (%)^	0.53	0.55	1.06	1.36

** Increased catchment excision relative to the approved mining operation*

^ Creek catchment adjacent to Liddell Colliery

The combined effect of the increased catchment area reduction and predicted maximum reduction in baseflow in Bowmans Creek (SKM, 2013) is estimated to amount to a reduction in streamflow of approximately 2%.

The above estimated changes to average flow rates are unlikely to be discernible from natural variations in the downstream creek flows over extended periods of time. Predicted average impacts on downstream water users are therefore considered insignificant and would diminish with distance downstream.

6.2 Release of Contaminants in Drainage Off Site

Sediment dams capturing runoff from areas of pre-strip and rehabilitation would be designed in accordance with the provisions for sediment retention basins in Landcom (2004) and DECCW (2008).

Upslope diversion drains have been designed to mitigate the risk of erosion due to high flow velocities by appropriate design of grades, cross-sections and use of vegetation and/or rip-rap.

The risk of spill from the mine water storages, which are planned to capture runoff from all mine disturbance areas, has been evaluated as part of the site water balance (Section 5.0). There were no spills simulated during the 120 climatic realisations simulated and subject to adherence with the operational protocols and other assumptions inherent in the modelling (refer Section 5.2), there is a very low risk of spill occurring from the mine water storages over the Modification period to either Bowmans or Bayswater Creeks.

6.3 Salinity in Hunter River Due to Controlled Releases

The water management system would continue to be developed in accordance with best management principles including minimising contamination of site water, maximising reuse of mine water on site, continued export of water to the Mt Owen Complex and Coal & Allied operations and managing water so that any releases from site are controlled in accordance with the HRSTS. By segregation and preferential re-use of the more saline water on site (such as occurs in the tailings storages, with re-use of this water in the CHPP), off site discharges of salt to the Hunter River would be controlled. If the proposed water management system is maintained and appropriate planning and management implemented, there is no foreseeable risk of significant additional contaminants being discharged from site.

7.0 POST-MINING SURFACE WATER MANAGEMENT

7.1 Final Landform Drainage Management

The proposed final landform drainage plan is shown on Figure 4-6. The final landform consists of two final voids, one in the South Pit and one in the Entrance Pit. Rehabilitated in-pit overburden emplacements are located to the north of each final void. The catchment area of the final voids would be reduced to the maximum extent practicable, by directing drainage from upslope areas around the final voids and either directly or to tributaries of Bowmans and Bayswater Creeks. The remaining catchment areas of the final voids would comprise the incident area of the voids themselves, the sides of the voids and a small portion of the overburden emplacement areas. The approximate depths, surface areas and contributing catchment areas of final voids are given in Table 7-1.

Table 7-1 Final Voids

Final Void	Depth (m)	Area (ha)	Catchment Area (ha)
South Pit	165	94	152
Entrance Pit	190	71	137

7.2 Final Void Model Findings

A water and salt balance model of the final voids was developed to simulate future conditions. Inflows to the voids comprised direct rainfall over the void water surface, runoff from the void catchment area and groundwater inflow. Outflows comprised evaporation and groundwater outflow. In addition, contained water could be transferred between the voids via the remnant Middle Underground workings at an elevation of approximately -60 m AHD. The estimated capacity of the Entrance Pit void was 67,250 ML at the spill elevation of 95 m AHD and the estimated capacity of the South Pit void was 74,140 ML at the spill elevation of 80 m AHD.

Rainfall runoff from the void catchments was estimated using the AWBM applied to the final void sub-catchments (in a manner similar to the mine water balance model – refer Section 5.2.3). Daily rainfall and evaporation data for the past 120 years was taken from the Silo Data Drill (refer Section 5.2.1) and data from the beginning of the record added to data after 2011 to generate an additional 120 years for the model simulation.

Final void groundwater inflow and outflow rates were provided by SKM (2013) for long-term end of mine conditions[9]. Groundwater inflow and outflow rates were estimated for each void for a number of final void water surface elevations, with groundwater inflows predicted at low void water levels and groundwater outflows at higher void water levels (once the Entrance Pit reached 85 m AHD and the South Pit

[9] Groundwater inflows and outflows were provided for predicted 50th percentile and +/- 1 standard deviation groundwater inflow and outflow rates

reached 65 m AHD). Maximum inflow rates (i.e. with empty voids) were estimated to be 42.8 ML/d for the Entrance Pit and 13.9 ML/d for the South Pit.

For simulation of void salinity, the salinity of runoff was set to 800 mg/L based on the mean monitored salinity at existing dams at LCO which solely capture runoff from rehabilitated areas. The groundwater salinity was estimated to be 3,000 mg/L based on the average groundwater salinity presented in SKM (2013).

Final void water balance model results indicate that the water level in both final voids would stabilise within approximately 50 years from the end of mining with a water surface elevation near approximately 67 m AHD in both voids (refer Figure 7-1). Neither void was predicted to spill. At an equilibrium water surface elevation of 67 m AHD, the Entrance Pit would continue to receive groundwater inflows (as it would below the net zero groundwater inflow elevation of 85 m AHD). The South Pit water level however would be stabilised by groundwater outflow to the regional hard rock aquifer (SKM, 2013).

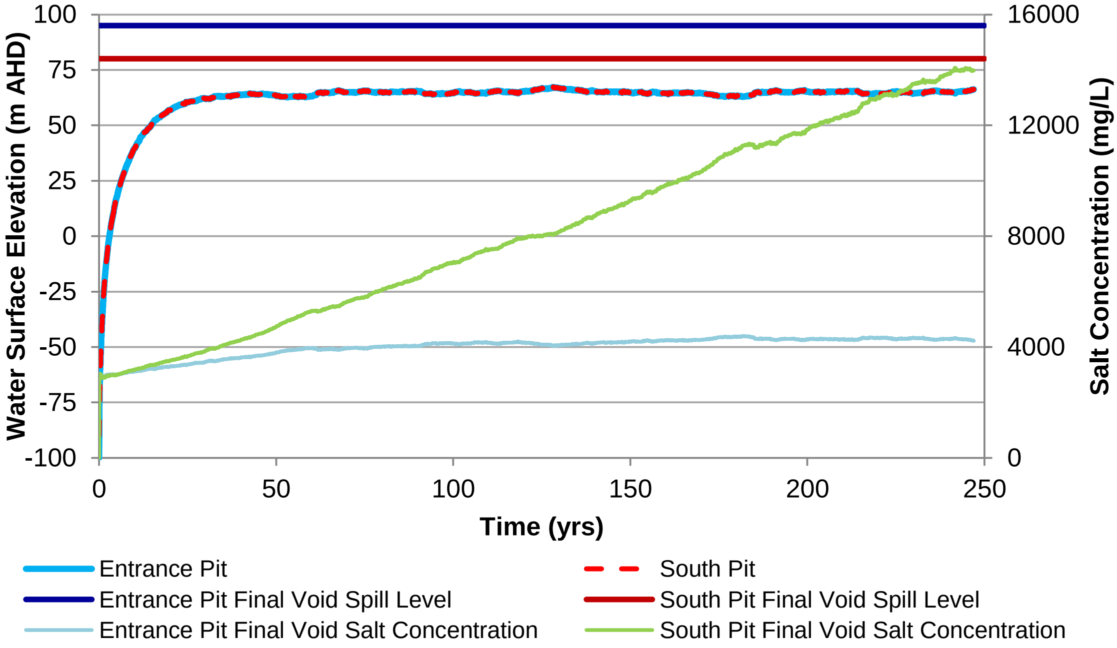

Figure 7-1 Predicted Final Void Water Levels – Entrance Pit and South Pit

Predicted salinity in the Entrance Pit stabilised at approximately 4,200 mg/L (refer Figure 7-1). The salinity in the South Pit void is predicted to rise following mining due to the dominance of evaporation in the final void water balance (accounting for 80% of outflows during the simulation period).

8.0 RECOMMENDATIONS

The following recommendations are made for the proposed Modification:

- The site water balance should be reviewed at least annually to update predictions of water supply security and the need to release water. Cumulative flow meters have been installed on all major pumped water streams with flows recorded monthly. Monitoring should continue to include the quantity of water pumped to the CHPP, haul road dust suppression usage and volumes and solids concentrations of tailings pumped to the tailings dams. This data should be used to calibrate various components of the model, including the rainfall runoff component (following periods of rainfall) and open cut groundwater inflows (during periods of low or no rainfall).
- Undertake suitable physical testing of tailings to calculate tailings properties for use in the water balance model. Continue periodic surveys to enable estimates of in-situ tailings density to be made and to monitor storage capacity.
- Undertake survey of all main water storages not already surveyed to confirm level – volume – area relationships for use in the water balance model.
- The integrity of overburden emplacement area toe drains should continue to be visually checked on a monthly basis or after significant rainfall (50 mm or more rainfall in a 24-hour period) to check for any signs of visible erosion or instability, with repairs implemented as required.
- Commissioning of two gauging stations on Bowmans Creek, one upstream of LCO and one immediately downstream of the proposed Entrance Pit Final Void location in order to monitor the effect of mining on streamflow.

9.0 REFERENCES

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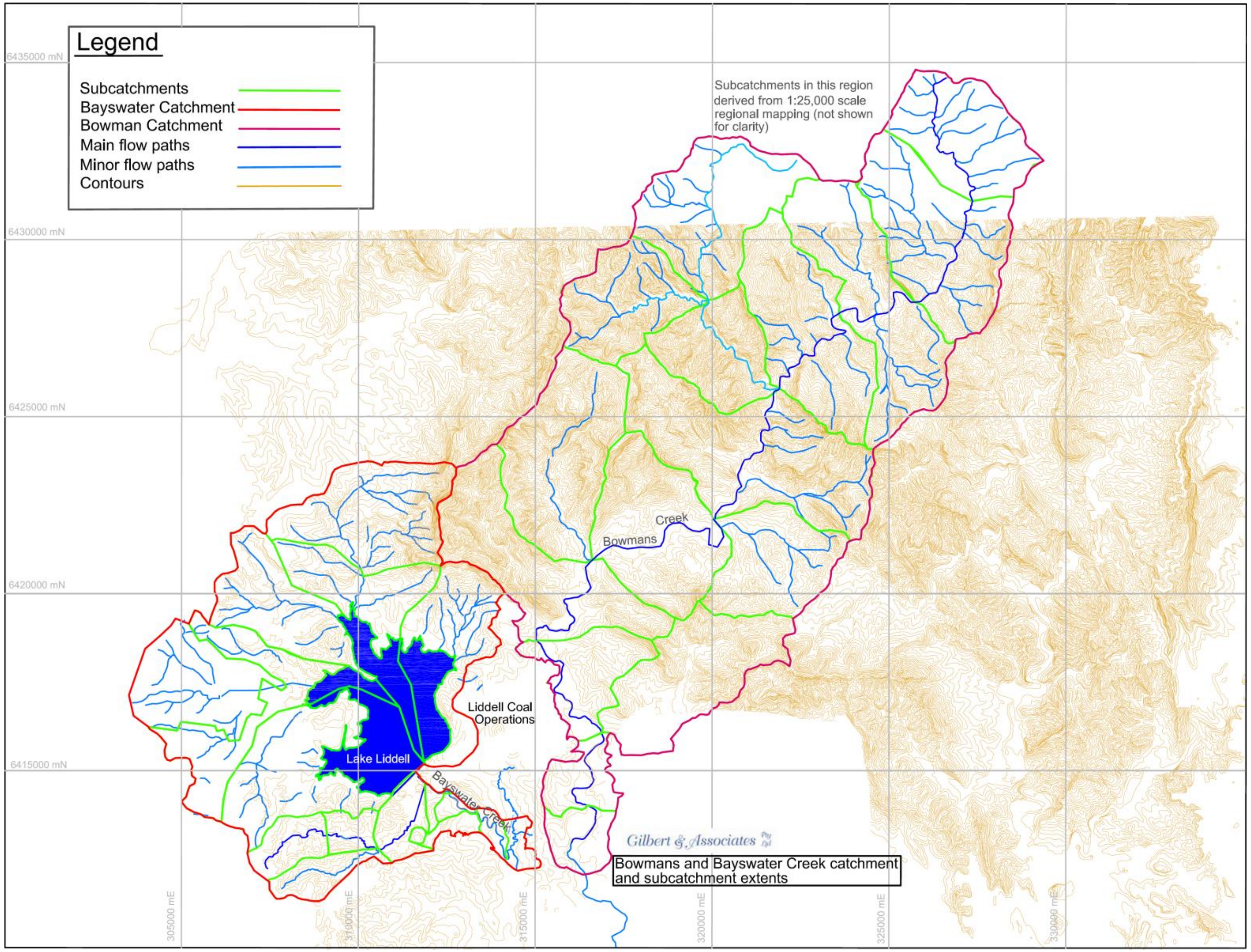
ATTACHMENT A

FLOOD ASSESSMENT MODEL PARAMETERS AND DETAILED RESULTS


Legend
Subcatchments
Bayswater Catchment
Bowman Catchment
Main flow paths
Minor flow paths
Contours
Subcatchments in this region derived from 1:25,000 scale regional mapping (not shown for clarity)
6435000 mN
6430000 mN
6425000 mN
6420000 mN
6415000 mN
305000 mE
310000 mE
315000 mE
320000 mE
325000 mE
330000 mE
Bowmans Creek
Liddell Coal Operations
Lake Liddell
Bayswater Creek
Gilbert & Associates
Bowmans and Bayswater Creek catchment and subcatchment extents

Modelling Parameters and Results for Bayswater and Bowmans Creek Flood Assessment

Table A1 Rainfall Intensity, Frequency and Duration Data

Average Rainfall (mm/hr)		
Duration (hrs)	1 in 250	1 in 100
1	58.6	51
2	39.3	33.7
3	30.6	26.2
4	25.7	21.9
5	22.2	19
6	20.1	17
9	15.6	13.2
12	13.1	11
18	10.2	8.63
24	8.5	7.24
36	6.6	5.61
48	5.5	4.64
72	4.2	3.49

Table A2 Hydrological Parameters for Bayswater Creek

ARI	Initial Loss (mm/hr)	Continuing Loss (mm/hr)	Kc*
100 Year	10	2.5	8.82
250 Year	10	2.5	8.82

*As derived from Yu (1989) as documented in Pearse, M. Jordan, P. and Collins, Y. "A simple method for estimating RORB model parameters for ungauged rural catchments." Engineers Australia Hydrology and Water Resources Symposium, 2002.

Table A3 Hydrological Parameters for Bowmans Creek

ARI	Initial Loss (mm/hr)	Continuing Loss (mm/hr)	Kc*
100 Year	10	2.5	13.21
250 Year	10	2.5	13.21

*See note above in Table A2

Table A4 Hydraulic Modelling Parameters

Creek	Mannings n Channel	Mannings n Right Bank	Mannings n Left Bank	U/S Normal Depth Slope	D/S Normal Depth Slope
Bayswater	0.07	0.14	0.14	0.005	0.002
Bowmans	0.07	0.06 - 0.14	0.06 - 0.14	0.005	0.004

Table A5 Predicted Water Surface Levels for Bayswater Creek

Chainage (m from downstream end)	Water Surface Elevation (RL – m)	
	100-year ARI	250-year ARI
0	80.27	80.48
25.36	80.32	80.53
27.86	80.33	80.54
44.06	80.39	80.61
80.26	80.44	80.65
82.53	80.35	80.56
91.23	80.56	80.79
109.25	80.64	80.87
326.51	80.91	81.13
560.52	81.45	81.66
725.47	81.86	82.08
909.49	82.42	82.61
1219.16	83.68	83.88
1400.97	84.14	84.37
1406.72	84.04	84.28
1415.87	84.14	84.36
1528.57	84.61	84.82
1575.89	84.73	84.94
1623.20	84.84	85.04
1670.52	84.93	85.13
1717.83	85.02	85.22
1765.15	85.09	85.30
1809.78	85.15	85.36
1854.41	85.23	85.43
1899.05	85.33	85.54
1943.68	85.47	85.67
1988.31	85.64	85.84
2031.17	85.80	85.99
2074.02	86.02	86.22
2116.88	86.30	86.50
2159.74	86.81	87.11
2204.19	87.02	87.25
2248.63	87.22	87.44
2293.08	87.38	87.60
2337.53	87.51	87.74
2379.18	87.56	87.79

Chainage (m from downstream end)	Water Surface Elevation (RL – m)	
	100-year ARI	250-year ARI
2420.84	87.66	87.87
2462.49	87.84	88.04
2504.15	88.06	88.25
2553.29	88.40	88.60
2602.44	88.56	88.79
2651.59	88.69	88.92
2701.08	88.78	89.02
2750.57	88.89	89.13
2800.06	89.01	89.25
2844.53	89.09	89.32
2889.00	89.21	89.43
2933.47	89.38	89.59
2977.95	89.59	89.80
3016.84	89.84	90.06
3055.73	90.01	90.23
3094.62	90.14	90.36
3134.89	90.25	90.48
3175.16	90.35	90.58
3215.43	90.43	90.66
3256.43	90.47	90.69
3297.42	90.56	90.75
3338.41	90.70	90.87
3379.40	90.90	91.05
3420.39	91.11	91.25

Table A6 Predicted Water Surface Levels for Bowmans Creek

Chainage (m from downstream end)	Water Surface Elevation (RL – m)	
	100-year ARI	250-year ARI
0	87.41	88.50
9.77	87.64	89.38
19.54	87.97	90.28
29.31	88.31	90.31
39.08	88.71	90.33
48.85	88.66	90.35
58.62	89.84	90.37
68.39	89.88	90.38
78.16	89.91	90.39
87.93	89.94	90.41
97.7	89.96	90.42
107.47	89.98	90.43
117.24	89.99	90.43
127.01	90.01	90.44
136.78	90.02	90.45
146.55	90.03	90.46
156.32	90.04	90.46
166.09	90.06	90.47
175.86	90.06	90.48
185.63	90.07	90.48
195.4	90.08	90.49
205.17	90.09	90.49
214.94	90.10	90.50
224.71	90.11	90.50
234.48	90.11	90.51
244.318	90.11	90.50
254.156	90.11	90.50
263.994	90.11	90.50
273.832	90.11	90.50
283.67	90.11	90.50
293.508	90.11	90.50
303.346	90.11	90.50
313.184	90.11	90.50
323.022	90.11	90.50
332.86	90.11	90.50
342.698	90.11	90.50

Chainage (m from downstream end)	Water Surface Elevation (RL – m)	
	100-year ARI	250-year ARI
352.536	90.11	90.50
362.374	90.11	90.50
372.212	90.11	90.50
382.05	90.10	90.50
391.888	90.10	90.50
401.726	90.10	90.50
411.564	90.10	90.50
421.402	90.10	90.50
431.24	90.10	90.50
441.078	90.10	90.50
450.916	90.12	90.50
460.754	90.14	90.50
470.592	90.15	90.50
480.43	90.16	90.50
490.268	90.16	90.50
500.106	90.17	90.51
509.944	90.17	90.51
519.782	90.17	90.51
529.62	90.17	90.52
539.458	90.18	90.55
549.296	90.18	90.56
559.134	90.18	90.56
568.972	90.18	90.56
578.81	90.18	90.56
588.648	90.18	90.56
598.486	90.19	90.57
608.324	90.19	90.57
618.162	90.19	90.57
628	90.19	90.57
637.838	90.19	90.57
647.676	90.19	90.57
657.514	90.19	90.57
667.352	90.19	90.57
677.19	90.19	90.57
687.028	90.19	90.57
696.866	90.19	90.56
706.704	90.19	90.56

Chainage (m from downstream end)	Water Surface Elevation (RL – m)	
	100-year ARI	250-year ARI
716.542	90.18	90.56
726.38	90.18	90.56
736.218	90.18	90.56
746.056	90.18	90.56
755.894	90.18	90.56
765.732	90.18	90.56
775.57	90.18	90.56
785.408	90.18	90.56
795.246	90.17	90.56
805.084	90.17	90.55
814.922	90.17	90.55
824.76	90.17	90.55
834.598	90.16	90.55
844.436	90.16	90.55
854.274	90.16	90.54
864.112	90.15	90.54
873.95	90.15	90.54
883.834	90.10	90.50
893.718	90.01	90.45
903.602	89.36	90.35
913.486	89.51	89.66
923.37	89.66	89.81
933.254	89.81	89.99
943.138	89.98	90.15
953.022	90.12	90.53
962.906	90.24	90.57
972.79	90.37	91.14
982.674	90.60	90.89
992.558	90.45	91.12
1002.442	90.71	90.14
1012.326	90.47	90.20
1022.21	90.46	90.28
1032.094	90.91	90.37
1041.978	90.72	90.46
1051.862	90.44	90.59
1061.746	90.84	90.76
1071.63	90.67	90.97

Chainage (m from downstream end)	Water Surface Elevation (RL – m)	
	100-year ARI	250-year ARI
1081.408	91.26	91.15
1091.186	91.03	91.29
1100.964	90.84	91.46
1110.742	91.25	91.68
1120.52	91.53	92.96
1130.298	91.28	92.30
1140.076	91.16	92.13
1149.854	91.53	92.08
1159.632	91.44	91.86
1169.41	91.75	92.15
1179.188	91.99	92.01
1188.966	91.83	92.20
1198.744	91.97	92.68
1208.522	92.12	92.71
1218.3	92.04	92.73
1228.078	92.14	92.73
1237.856	92.26	92.76
1247.634	92.27	92.71
1257.412	92.30	92.68
1267.19	92.40	92.64
1276.968	92.45	92.52
1286.746	92.49	94.39
1296.524	92.62	94.39
1306.353	92.56	94.39
1316.182	92.50	94.38
1326.011	92.37	94.38
1335.84	92.22	94.38
1345.669	92.20	94.37
1355.498	92.78	94.37
1365.327	92.78	94.36
1375.156	92.80	94.36
1384.985	92.82	94.35
1394.814	93.04	94.35
1404.643	93.07	94.34
1414.472	93.09	94.33
1424.301	93.13	94.33
1434.13	93.16	94.33

Chainage (m from downstream end)	Water Surface Elevation (RL – m)	
	100-year ARI	250-year ARI
1443.959	93.20	94.33
1453.444	93.21	94.33
1462.929	93.23	94.33
1472.414	93.26	94.35
1481.899	93.31	94.36
1491.384	93.37	94.37
1500.869	93.42	94.38
1510.354	93.47	94.38
1519.839	93.50	94.39
1529.324	93.41	94.40
1538.809	93.46	94.41
1548.294	93.50	94.41
1557.905	93.39	94.39
1567.516	93.32	94.38
1577.127	93.34	94.39
1586.738	93.28	94.40
1596.349	93.22	94.41
1605.96	93.17	94.43
1615.571	93.12	94.44
1625.182	93.07	94.45
1634.793	93.03	94.45
1644.404	93.14	94.46
1654.015	93.22	94.47
1663.626	93.26	94.47
1673.237	93.30	94.48
1682.848	93.33	94.48
1692.459	93.36	94.49
1702.07	93.39	94.49
1711.681	93.42	94.50
1721.292	93.44	94.50
1730.903	93.46	94.51
1740.335	93.45	94.50
1749.767	93.44	94.50
1759.199	93.42	94.49
1768.631	93.40	94.49
1778.063	93.38	94.48
1787.495	93.35	94.47

Chainage (m from downstream end)	Water Surface Elevation (RL – m)	
	100-year ARI	250-year ARI
1796.927	93.31	94.47
1806.359	93.26	94.48
1815.791	93.19	94.49
1825.223	92.99	94.50
1834.655	93.41	94.50
1844.087	93.43	94.48
1853.562	92.82	94.47
1863.037	93.15	94.44
1872.512	93.28	94.41
1881.987	93.39	94.37
1891.462	94.08	94.33
1900.937	93.96	93.91
1910.412	94.37	93.89
1919.887	94.37	94.38
1929.362	94.37	94.47
1938.837	94.38	94.49
1948.312	94.43	94.57
1957.787	94.50	94.66
1967.262	94.56	94.72
1976.737	94.60	94.77
1986.212	94.65	94.84
1996.048	94.64	94.84
2005.885	94.64	94.83
2015.722	94.63	94.82
2025.559	94.62	94.82
2035.396	94.62	94.81
2045.233	94.61	94.80
2055.07	94.61	94.79
2064.907	94.60	94.79
2074.744	94.59	94.78
2084.581	94.57	94.77
2094.418	94.56	94.75
2104.255	94.54	94.74
2114.092	94.52	94.71
2123.929	94.48	94.70
2133.766	94.24	94.66
2143.603	94.25	94.23

Chainage (m from downstream end)	Water Surface Elevation (RL – m)	
	100-year ARI	250-year ARI
2153.44	94.26	94.26
2163.277	94.56	94.28
2173.114	94.52	94.30
2182.951	94.74	94.33
2192.832	94.21	94.56
2202.713	94.34	94.66
2212.594	94.51	94.73
2222.475	94.68	94.84
2232.356	94.78	94.94
2242.237	94.90	95.04
2252.118	95.05	95.23
2261.999	94.98	95.16
2271.88	95.13	95.33
2281.761	95.22	95.43
2291.642	95.20	95.40
2301.523	95.19	95.40
2311.404	95.16	95.42
2321.285	95.28	95.46
2331.166	95.38	95.57
2341.047	95.37	95.55
2350.928	95.34	95.55
2360.809	95.41	95.58
2370.69	95.43	95.60
2380.571	95.44	95.62
2390.452	95.46	95.65
2400.333	95.55	95.73
2410.214	95.56	95.74
2420.095	95.58	95.76
2429.686	95.61	95.78
2439.278	95.63	95.80
2448.87	95.64	95.82
2458.462	95.66	95.84
2468.054	95.68	95.85
2477.646	95.69	95.87
2487.238	95.70	95.88
2496.83	95.71	95.90
2506.422	95.73	95.93

Chainage (m from downstream end)	Water Surface Elevation (RL – m)	
	100-year ARI	250-year ARI
2516.014	95.75	95.96
2525.606	95.78	95.96
2535.198	95.78	96.00
2544.79	95.82	96.03
2554.382	95.85	96.05
2563.974	95.86	96.06
2573.566	95.88	96.10
2583.158	95.91	96.12
2592.75	95.94	96.15
2602.342	95.96	96.17
2611.934	95.98	96.19
2621.882	95.97	96.18
2631.83	95.95	96.17
2641.778	95.93	96.15
2651.726	95.91	96.13
2661.674	95.87	96.10
2671.622	95.83	96.06
2681.57	95.60	96.00
2691.518	95.73	95.83
2701.466	95.91	95.95
2711.414	95.83	96.12
2721.362	95.98	96.04
2731.31	95.95	96.13
2741.258	95.95	96.12
2751.206	96.06	96.13
2761.154	96.05	96.24
2771.102	96.03	96.23
2781.05	96.14	96.24
2790.998	96.12	96.35
2800.946	96.19	96.36
2810.894	96.25	96.41
2820.791	96.35	96.52
2830.688	96.37	96.54
2840.585	96.39	96.55
2850.482	96.41	96.57
2860.379	96.42	96.60
2870.276	96.44	96.63

Chainage (m from downstream end)	Water Surface Elevation (RL – m)	
	100-year ARI	250-year ARI
2880.173	96.47	96.65
2890.07	96.49	96.69
2899.967	96.51	96.71
2909.864	96.55	96.73
2919.761	96.58	96.78
2929.658	96.61	96.79
2939.555	96.64	96.85
2949.452	96.68	96.91
2959.422	96.10	96.27
2969.392	96.33	96.52
2979.362	96.55	96.80
2989.332	96.47	97.03
2999.302	96.60	97.27
3009.272	96.75	97.64
3019.242	96.95	97.55
3029.212	97.07	97.25
3039.182	97.19	97.37
3049.152	97.31	97.49
3059.122	97.40	97.60
3069.092	97.48	97.70
3079.062	97.58	97.77
3089.032	97.69	97.84
3099.002	97.78	97.93
3108.972	97.86	98.01
3118.942	97.94	98.14
3128.912	98.06	98.09
3138.882	97.99	98.19
3148.852	98.13	98.18
3158.822	98.12	98.30
3168.792	98.13	98.30
3178.762	98.10	98.27
3188.732	98.21	98.23
3198.702	98.14	98.35
3208.672	98.26	98.31
3218.642	98.22	98.42
3228.612	98.33	98.39
3238.582	98.29	98.47

Chainage (m from downstream end)	Water Surface Elevation (RL – m)	
	100-year ARI	250-year ARI
3248.552	98.39	98.43
3258.522	98.35	98.55
3268.492	98.47	98.49
3278.462	98.43	98.61
3288.432	98.53	98.58
3298.402	98.41	98.68
3308.372	98.48	98.64
3318.342	98.56	98.74
3328.312	98.66	98.71
3338.282	98.35	98.80
3348.252	98.37	98.74
3358.222	98.76	98.87
3368.069	98.76	98.93
3377.916	98.75	98.93
3387.763	98.74	98.94
3397.61	98.94	98.99
3407.457	98.93	98.98
3417.304	98.92	99.03
3427.151	98.98	99.03
3436.998	99.03	99.03
3446.845	99.03	99.10
3456.692	99.04	99.16
3466.539	99.04	99.16
3476.386	99.04	99.17
3486.233	99.05	99.18
3496.08	99.05	99.18
3505.927	99.06	99.19
3515.301	99.06	99.19
3524.675	99.06	99.19
3534.049	99.06	99.19
3543.423	99.06	99.20
3552.797	99.08	99.22
3562.171	99.09	99.23
3571.545	99.10	99.24
3580.919	99.12	99.27
3590.293	99.14	99.29
3599.667	99.16	99.31

Chainage (m from downstream end)	Water Surface Elevation (RL – m)	
	100-year ARI	250-year ARI
3609.041	99.18	99.33
3618.415	99.20	99.34
3627.789	99.22	99.36
3637.163	99.24	99.39
3646.98	99.24	99.39
3656.797	99.25	99.40
3666.614	99.25	99.41
3676.431	99.26	99.42
3686.248	99.27	99.43
3696.065	99.28	99.44
3705.882	99.28	99.44
3715.699	99.29	99.45
3725.516	99.29	99.45
3735.333	99.30	99.46
3745.15	99.30	99.47
3754.967	99.31	99.47
3764.784	99.31	99.47
3774.601	99.32	99.48
3784.418	99.32	99.48
3794.235	99.32	99.49
3804.052	99.33	99.50
3813.869	99.33	99.50
3823.686	99.34	99.51
3833.503	99.34	99.51
3843.32	99.35	99.51
3852.891	99.32	99.49
3862.462	99.26	99.41
3872.033	98.52	98.67
3881.604	98.93	99.08
3891.175	99.37	99.38
3900.746	99.32	99.55
3910.317	99.35	99.75
3919.888	99.44	99.74
3929.459	99.53	99.73
3939.03	99.60	99.74
3948.716	99.60	99.73
3958.402	99.60	99.72

Chainage (m from downstream end)	Water Surface Elevation (RL – m)	
	100-year ARI	250-year ARI
3968.088	99.61	99.71
3977.774	98.73	99.71
3987.46	98.76	99.72
3997.146	98.79	99.73
4006.832	98.82	99.74
4016.518	98.85	99.76
4026.204	98.88	99.77
4035.89	98.91	99.74
4045.576	98.94	99.76
4055.262	98.97	100.61
4064.948	98.99	99.18
4074.634	99.00	99.21
4084.32	98.98	99.23
4094.006	98.97	99.24
4103.692	98.96	99.24
4113.378	98.95	99.23
4123.064	98.92	99.22
4132.75	98.90	99.21
4142.436	98.87	99.19
4152.062	98.95	99.27
4161.688	99.03	99.35
4171.314	99.10	99.44
4180.94	99.18	99.54
4190.566	99.27	99.64
4200.192	99.35	99.74
4209.818	99.43	99.84
4219.444	99.47	99.95
4229.07	99.56	100.06
4238.696	99.66	100.18
4248.322	99.76	100.29
4257.948	99.87	100.41
4267.574	99.98	100.53
4277.2	100.09	100.65
4286.826	100.21	100.78
4296.452	100.32	100.91
4306.078	100.45	101.03
4315.704	100.60	101.15

Chainage (m from downstream end)	Water Surface Elevation (RL – m)	
	100-year ARI	250-year ARI
4325.33	100.74	101.27
4334.956	100.90	101.40
4344.582	101.07	101.65
4354.208	101.29	101.70
4363.834	101.46	101.86
4373.46	101.12	101.96
4383.086	101.90	102.07
4392.712	101.95	102.18
4402.338	101.74	102.24
4411.964	101.65	102.32
4421.59	101.54	102.38
4431.216	101.46	102.46
4440.842	101.38	102.61
4450.468	101.99	102.69
4460.094	101.95	102.75
4469.72	101.92	102.86
4479.346	103.40	103.06
4488.972	103.39	102.95
4498.598	103.38	102.88
4508.224	103.36	102.72
4517.85	103.33	102.70
4527.476	103.32	102.55
4537.102	103.30	102.46
4546.728	103.27	102.57
4556.354	103.24	102.27
4565.98	103.21	102.27
4575.606	103.18	102.27
4585.232	103.11	101.99
4594.736	103.01	102.42
4604.239	102.83	103.47
4613.742	102.50	103.40
4623.245	102.42	103.64
4632.748	102.22	103.53
4642.251	102.03	103.69
4651.754	103.05	103.63
4661.257	103.13	103.79