APPENDIX D

Surface Water Impact Assessment

SURFACE WATER IMPACT ASSESSMENT FOR DRAYTON MINE CONSENT MODIFICATION

HANSEN BAILEY
December 2011

www.wrmwater.com.au

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water + environment

WRM Water & Environment Pty Ltd
ABN: 96 107 404 544 ACN: 107 404 544

Level 5, Paddington Central,
107 Latrobe Terrace, PO Box 809,
Paddington Qld 4064 Australia
tel +61 7 3367 1279 fax +61 7 3367 1679
www.wrmwater.com.au

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For and on behalf of
WRM Water & Environment Pty Ltd

Greg Roads
Principal Engineer

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1 INTRODUCTION

Anglo Coal (Drayton Management) Pty Ltd (Anglo) operates the Drayton open cut coal mine (Drayton) located in the Hunter Valley, approximately 12 km south of Muswellbrook. The location of Drayton is shown in Figure 1.1.

Anglo is applying for project approval as a Section 75W Modification under the EP&A Act to recover additional coal reserves within its mining lease and optimise the configuration of the final landform of the existing pits. The Modification consists of three minor extension areas – the Northern Modification Area, Southern Modification Area and Eastern Modification area.

- The northern modification area is 8.84 ha in area and is mainly required to facilitate greater working room and 'laying down' of the highwall within the approved North Pit.
- The eastern modification area is 20.3 ha and will extend the existing East Pit. This will remove the mine Industrial Dam and existing rehabilitation.
- The southern modification area is 7.38 ha and is to facilitate 'laying down' of the highwall and final void in the South Pit to a safe and workable area.

A total additional disturbance of 36.5 ha is proposed. No increases in production levels, employee numbers or extension of mine life are proposed. The three modification areas have been previously disturbed and rehabilitated. The locations of the three modification areas are shown in Figure 1.2.

This report, prepared by WRM Water & Environment Pty Ltd, presents the methodology and results of surface water investigations undertaken to assess the potential impacts of the Modification on local surface hydrology and the Drayton water management system.

This report includes a further six sections:

- Section 2 describes the existing environment with respect to surface water resources and the existing minesite water management system;
- Section 3 describes the potential impacts of the Modification on surface water resources;
- Section 4 assesses the impacts of the Modification on the minesite water balance.
- Section 5 presents a summary of the conclusions of the surface water assessment studies; and
- Section 6 provides a list of references.

The report also includes an appendix describing the calibration of the water balance model.

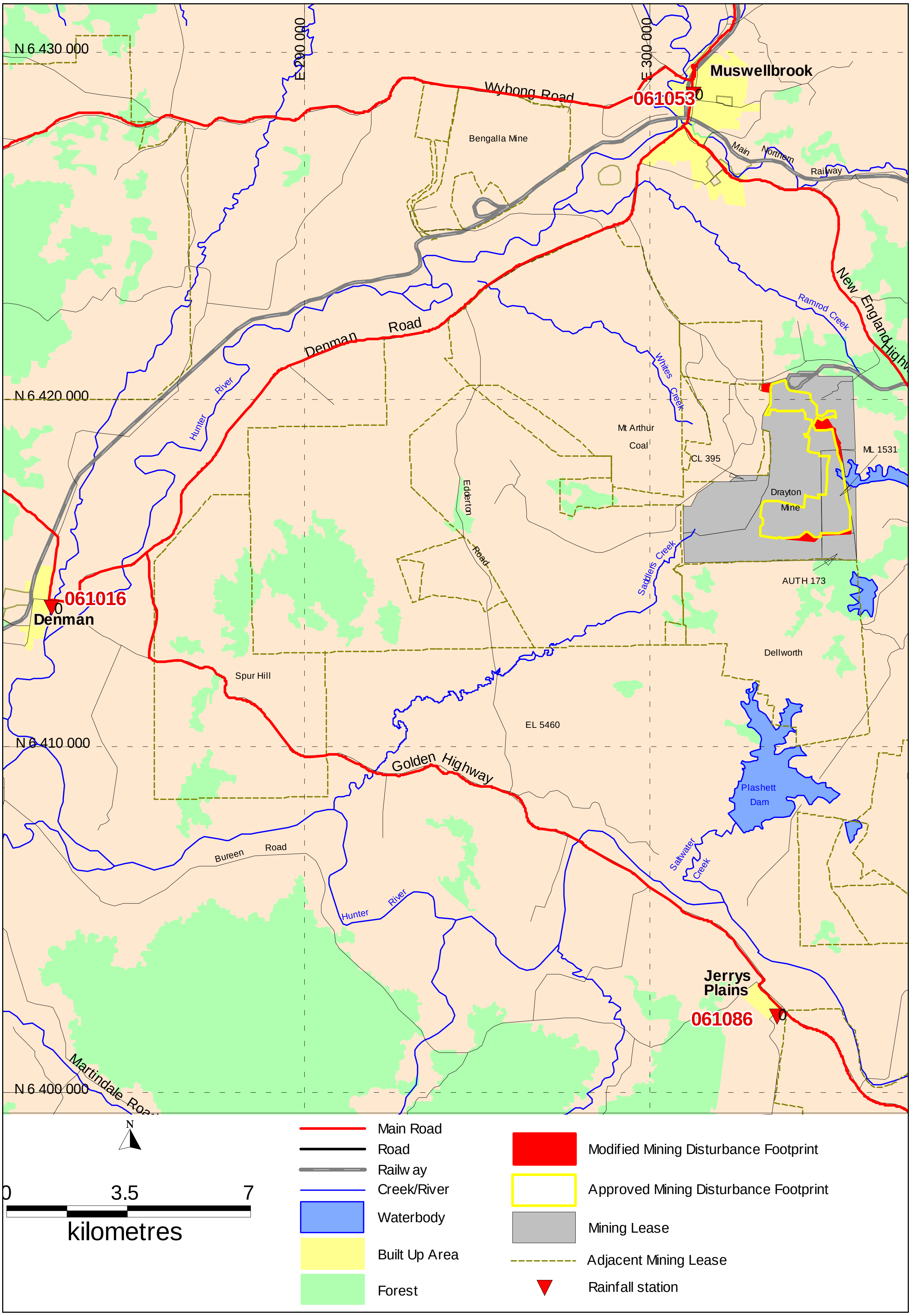

Figure 1.1 Locality Plan, Drayton Coal Mine

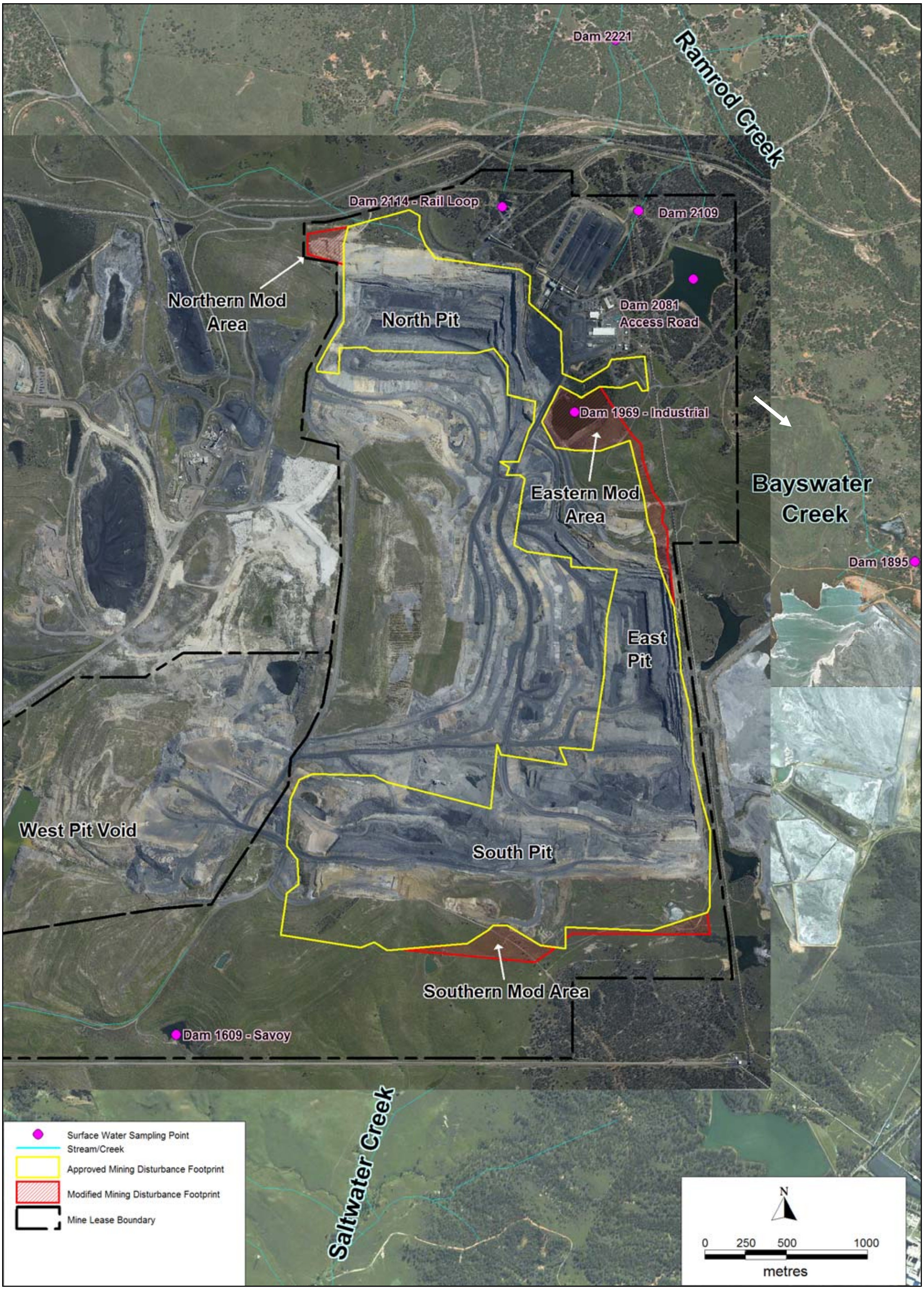

Figure 1.2 Proposed Drayton Modifications

2 EXISTING SURFACE WATER ENVIRONMENT

2.1 REGIONAL DRAINAGE NETWORK

The regional drainage network in the vicinity of Drayton Mine is shown in Figure 1.1. Drayton is located to the north and east of the Hunter River between Jerrys Plains, Denman and Muswellbrook. The Hunter River has a catchment area of approximately 13,400km^2 to Jerrys Plains immediately downstream of Drayton Mine. The catchment extends some 110km to the north and 140km to the west and includes the major tributaries of the Pages River, Dart Brook and the Goulburn River.

The Hunter River is a regulated river supplying water from Glenbawn Dam to a range of industrial and agricultural users as well as town water supplies. Glenbawn Dam is located on the upper headwaters of the Hunter River.

Two major tributaries, Glennies Creek and Wollombi Brook, drain into the Hunter River some 10km downstream of the mine. The total catchment area of the Hunter River to Singleton, located 30km downstream, which includes these two tributaries is 16,400km^2.

2.2 LOCAL DRAINAGE NETWORK

Figure 1.2 shows the topography and the location of tributaries draining the Drayton Mine. Drayton Mine is located in the upper headwaters of four minor watercourses;

- Ramrod Creek;
- Bayswater Creek;
- Saltwater Creek; and
- Saddlers Creek.

The northern areas of Drayton Mine drain via four minor gullies to the Ramrod Creek catchment. Three of the gullies converge some 1.5km downstream of Drayton Mine and the fourth converges some 6km downstream. Ramrod Creek drains into the Hunter River some 10km to the north west of the mine immediately downstream of Muswellbrook.

The eastern areas of Drayton Mine drain to or used to drain to Bayswater Creek. Almost all of the Bayswater Creek catchment within the Drayton Mine is active pit area and does not drain off site. Bayswater Creek drains into Lake Liddell and the headwater dams upstream of the Ash Dam on land owned and operated by Macquarie Generation.

The southern areas of Drayton Mine are located within the Saltwater Creek and Saddlers Creek catchments. The Saddlers Creek and Saltwater Creek catchments on the Drayton Mine site are either active pit area and do not drain off site or are undisturbed. Saltwater Creek drains into

Plashett Reservoir on land owned by Macquarie Generation. Saddlers Creek drains to the Hunter River.

2.3 RAINFALL AND EVAPORATION

Table 2.1 shows summary details of Bureau of Meteorology rainfall recording stations in the vicinity of Drayton. The locations of the various stations are shown in Figure 1.1.

Table 2.1 Rainfall Stations

Station No.	Station Name	Elevation (m)	Lat. (°S)	Long. (°E)	Distance from Site (km)	Opened	Closed
061086	Jerrys Plains Post Office	90	32.497	150.909	12	1884	-
061053	Muswellbrook (Lower Hill St)	143	32.261	150.885	15	1870	-
061016	Denman (Palace Street)	105	32.388	150.689	19	1883	-

Table 2.2 shows mean monthly rainfalls for the three rainfall stations shown in Table 2.1. Note that the mean monthly values are for different periods. The mean annual rainfall in the area of interest ranges from 594 to 644mm, with maximum monthly rainfalls occurring during the summer months.

Table 2.2 also shows mean monthly evaporation (based on a Class A evaporation pan) recorded at Jerry's Plains Post Office (Station No. 61086), located some 16km to the south of Drayton mine. Mean annual evaporation is 1613mm, which is more than double mean annual rainfall.

Figure 2.1 shows the annual distribution of average monthly rainfall and evaporation in the local area. Mean evaporation is similar to mean rainfall in the winter months, but substantially exceeds rainfall for the remainder of the year.

Table 2.2 Mean Monthly Rainfall and Evaporation

Month	Mean Monthly Rainfall (mm)			Mean Monthly Evap'n (mm)
	Muswellbrook (Lower Hill St) (061053) [1870 -]	Jerrys Plains Post Office (061086) [1884 -]	Denman (Palace Street) (061016) [1887 -]	Jerrys Plains Post Office (061086) [8 years data]
January	69.8	77.0	72.4	212
February	66.9	72.5	66.5	165
March	52.8	58.3	53.0	143
April	43.7	44.6	40.4	113
May	41.8	40.7	36.9	86
June	51.6	48.3	42.4	59
July	48.7	42.5	39.0	68
August	39.4	36.4	34.8	81
September	40.5	41.4	39.0	112
October	48.9	52.3	49.1	169
November	55.2	61.1	54.5	196
December	67.5	68.9	66.0	210
Total	627	644	594	1613

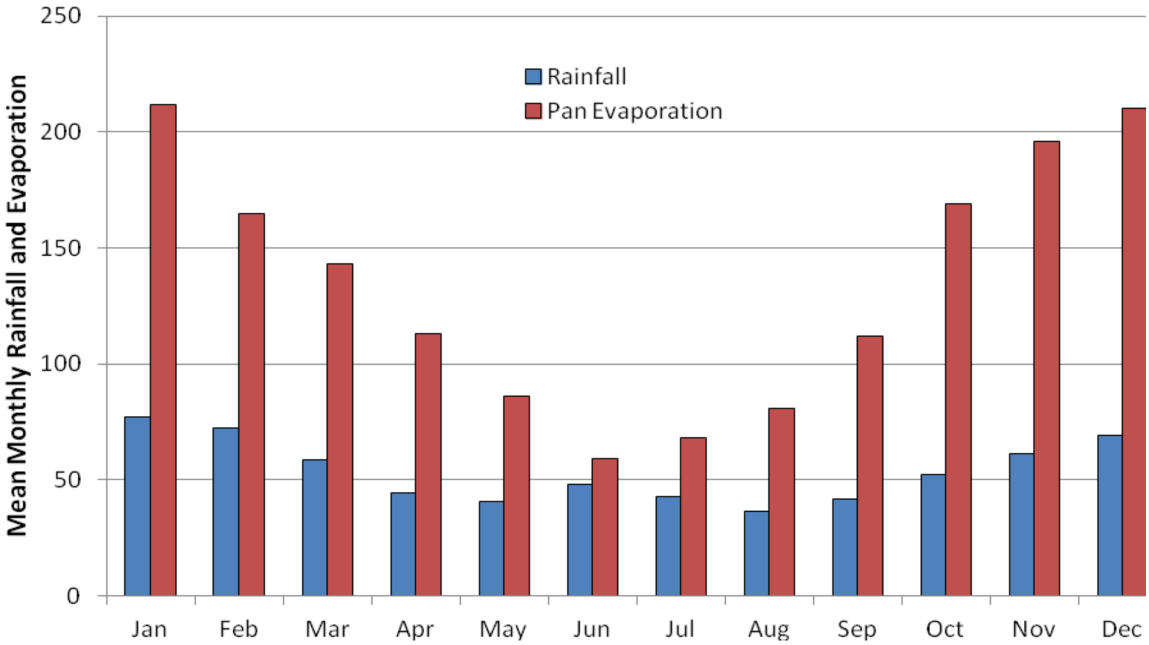

Figure 2.1 Distribution of Monthly Rainfall and Evaporation (Jerrys Plains Post Office)

2.4 SURFACE WATER QUALITY

Anglo monitors water quality in all minesite water storages on Drayton Mine and in the downstream catchments. A summary of the water quality tested in the downstream catchments is given in Table 2.3. Drayton does not discharge water to any of these catchments. Rather the catchments are mostly undisturbed with small areas of previously rehabilitated mining areas. The following is of note:

- Runoff is generally saline with electrical conductivity (EC) ranging from 2,000 to 8,000 µS/cm. The highest EC's are found in Saddlers Creek reflecting highly saline natural catchment runoff. The EC of Bayswater Creek and Ramrod Creek is measured in dams, which would elevate recorded levels above background.
- pH is slightly alkaline ranging from 7.6 to 9.2.
- Total suspended solids (TSS) is generally low.

Table 2.3 Downstream Drayton Mine Water Quality

Parameter		Bayswater Dam	Ramrod Ck	Saddlers Ck
pH	10%ile	9.20	8.48	8.6
	Median	8.80	7.9	8.32
	90%ile	8.21	7.52	7.6
EC (µS/cm)	10%ile	4774	3296	8382
	Median	3310	2220	5495
	90%ile	2045	1742	1201.8
TSS (mg/l)	10%ile	20	60.4	78.6
	Median	6	19	8
	90%ile	1	4	3

A summary of the water quality tested in the various water storages on the minesite is given in Table 2.4. The summary is based on monthly samples collected between January 2008 and July 2011. The results indicate that runoff draining the minesite catchments has similar water quality characteristics to the natural catchments with runoff that is saline and slightly alkaline.

Table 2.4 Drayton Mine Water Quality Data

Parameter		Savoy Dam	Industrial Dam	Access Rd Dam	Rail Loop Dam	West Pit Void
pH	10%ile	8.28	8.60	8.6	8.3	8
	Median	8.00	8.20	8.2	8.1	7.85
	90%ile	7.70	7.90	7.64	7.7	7.6
EC (µS/cm)	10%ile	6440	5710	5404	5864	8335
	Median	5240	4720	4780	4990	7805
	90%ile	4580	4010	4354	2990	6865
TSS (mg/l)	10%ile	14.8	47.6	85.4	57.8	15
	Median	6	16	12	12	7
	90%ile	2.2	6	4	4.4	3.5

2.5 EXISTING MINE WATER MANAGEMENT SYSTEM

The existing Drayton mine water management system is operated in accordance with the Drayton Water Management Plan (WMP) (Anglo, 2009) and the Anglo Environment Way Management System.

Figure 2.2 shows the locations and catchments of the major water storages and the three active pits; East Pit, North Pit and South Pit on the Drayton Mine. The catchment areas are based on the aerial photo taken in October 2010. Figure 2.3 shows a schematic of Drayton's mine water management system and the various connection and flow paths between the water storages. Drayton's water management system is based on a closed system, as Drayton does not possess a discharge licence. All mine water is stored on-site in established dams and voids and is utilised by the mining operation primarily for coal processing and dust suppression purposes.

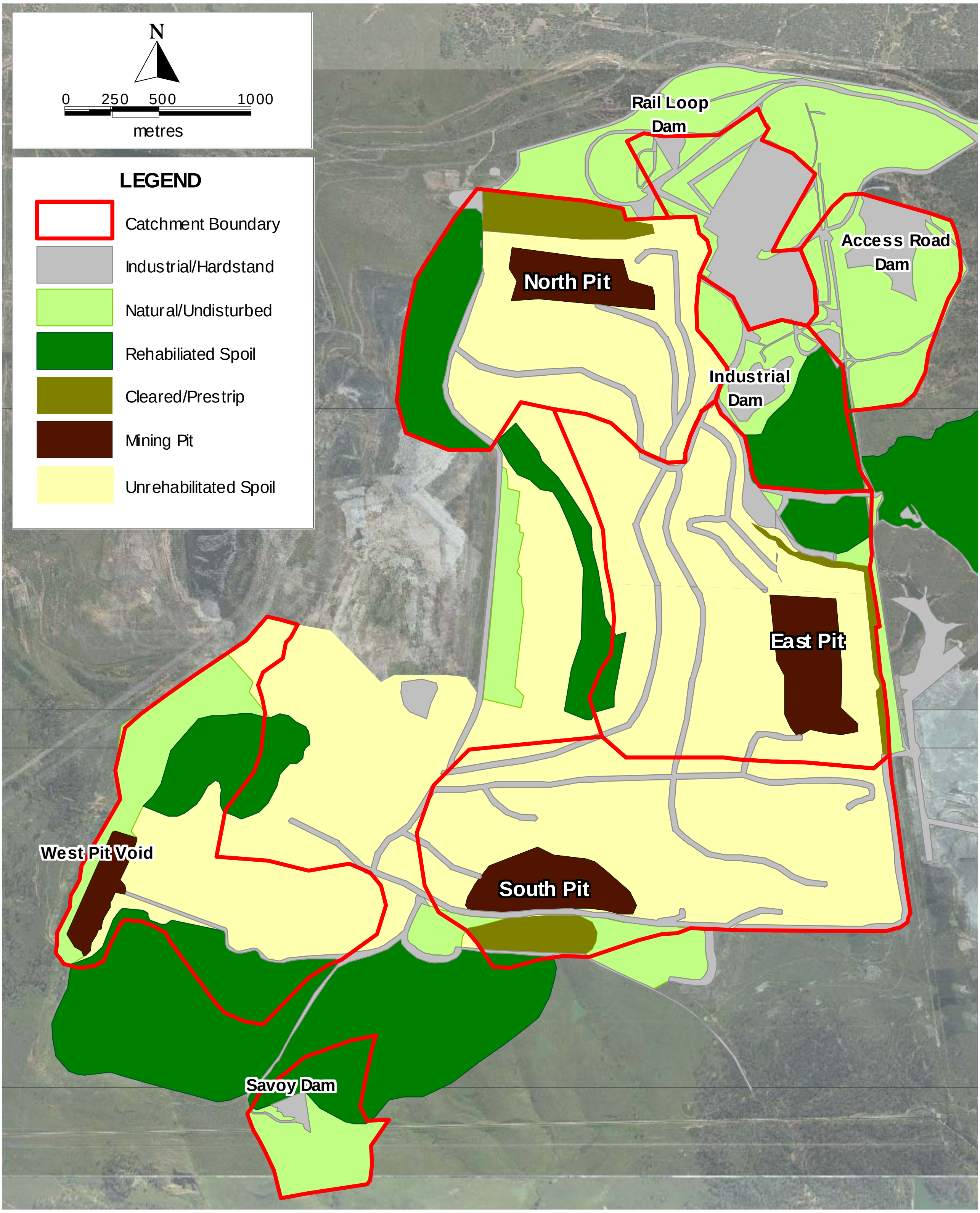

Figure 2.2 Drayton Mine Water Management System

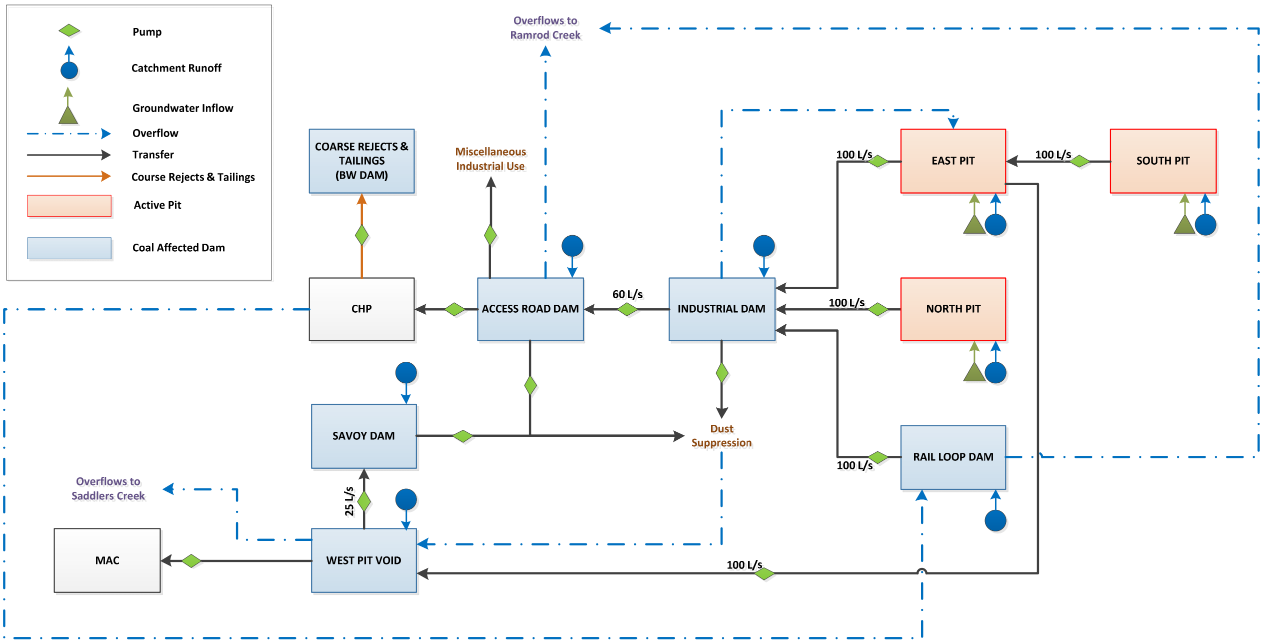

Figure 2.3 Drayton Mine Water Management System Schematic

2.6 MINE WATER STORAGES

Table 2.5 shows details of the main water management storages on the Drayton minesite. The catchment areas and landuse draining to the various dams are given in Appendix A. The dams are connected by a pipe network, which enables a transfer of water according to mine operational requirements. The West Pit Void, currently subleased to Mount Arthur Coal (MAC), is used as a repository for excess water on the mine for later reuse. The agreement allows Drayton to store water within the West Pit Void until January 2017, upon which time any stored water has to be removed back to the Drayton Mine. The agreement also allows 600 ML per annum to be transferred to MAC when required.

Table 2.5 Capacities of Site Mine Water Storages

MINE WATER STORAGE	Storage Capacity (ML)	Supply Source	Water Use
Access Road Dam (2081)	750	o Pumped transfers from Industrial Dam o Natural and rehabilitated catchment runoff	o CHP Use o Industrial Use o Stockpile and haul road dust suppression
Industrial Dam (1969)	750	o Pumped transfers from active pits and Rail Loop Dam o Natural and rehabilitated catchment runoff	o Pumped transfers to Access Road Dam o Haul Road dust suppression o Industrial washdown
Rail Loop Dam (2114)	18	o Industrial and natural areas catchment runoff	o Pumped transfers to Industrial Dam o Stockpile and haul road dust suppression
Savoy Dam (1609)	140	o Natural and rehabilitated catchment runoff	o Pumped transfers to Industrial Dam o Haul road dust suppression
West Pit Void (SW13)	4043	o Natural, rehabilitated and spoil catchment runoff o Pumped transfers of excess water from active pits	o Pumped transfers to Industrial Dam o Pumped to MAC

2.7 TAILINGS DISPOSAL SYSTEM

Anglo Australia has submitted an application under 75W of the Environment Planning and Assessment Act 1979 to place raw tailings within the East Pit Void, rather than a co-disposal dry tailings product. The East Pit will be separated into the East Pit South, which will store tailings and mining will continue in East Pit North.

Approximately 3 million m^3 of dewatered tailings is proposed to be placed in the East Pit South to 2017. Tailings emplacement will be up to RL 104. Subsequently, 1,500 ML of water will be stored to increase the in-pit level to RL114 behind an in situ pillar to enable mining to the north. Following the tailings placement, Macquarie Generation may then complete filling the void to the currently approved design level with fly ash material or alternatively the void will be capped to DTIRIS-MR standards. It has been assumed that the application to place tailings within the East Pit South Void will be approved in this assessment.

3 POTENTIAL IMPACTS AND MITIGATION MEASURES

3.1 POTENTIAL IMPACTS

The potential impacts of the project are as follows:

- Reduction in off-site catchment flows;
- Potential impact of the removal of the Industrial Dam on minesite water management;
- Potential to increase overflows of poor quality mine water;
- Potential to increase sedimentation of the waterways;
- Potential to impact on mining operations due to the build up of water in the active pits; and
- Potential to require off site water supplies.

3.2 REDUCTION IN CATCHMENT FLOWS

The Modification will result in an additional 36.5ha of disturbed area at Drayton that will require runoff to be captured within the water management system.

3.2.1 Northern Modification Area

The northern modification area is 8.84 ha in area and is mainly required to facilitate greater working room and 'laying down' of the highwall within the approved North Pit.

The northern modification area is located in the upper headwaters of Ramrod Creek. The catchment area of Ramrod Creek to the lease boundary under the currently approved final landform is 184 ha. The northern modification area will reduce the Ramrod Creek catchment draining to the lease boundary by only 1.7ha to 182.3 ha. Under current conditions, the majority of the northern modification area drains directly to the North Pit. The loss of an additional 1.6 ha as a result of Drayton Mine is not significant when compared to the total catchment area of Ramrod Creek to the Hunter River of 3,978ha.

3.2.2 Eastern Modification Area

The eastern modification area is 20.3 ha and will extend the existing East Pit northward to remove the mine Industrial Dam and existing rehabilitation. Under existing conditions and the currently approved final landform, the Industrial Dam and the rehabilitation area drains to the East Pit. Therefore, the proposed eastern modification does not change the catchment area draining off site.

3.2.3 Southern Modification Area

The southern modification area is 7.38 ha and is to facilitate 'laying down' of the highwall and final void in the South Pit to a safe and workable area. The southern modification area drains to Saltwater Creek or the headwater dams upstream of the Liddell Ash Dam on land owned by Macquarie Generation.

The proposed final landform would increase the catchment draining to Saltwater Creek by 0.6 ha and would reduce some 40.1 ha of catchment draining to the headwater dams upstream of the Liddell Ash Dam on the Macquarie Generation site when compared to the existing approved final landform. It appears that a significant area of rehabilitated dump drained to these headwater dams under the previously approved final landform. It is expected that the removal of catchment draining to the headwater dams would reduce the potential for clean water to overflow into the Ash Dam and thereby reduce the Ash Dam's potential for overflowing.

3.3 REMOVAL OF THE INDUSTRIAL DAM

The Industrial Dam is a 750 ML storage currently used as a pit water repository to supply water for haul road dust suppression, industrial wash down and as a back up to the Access Road Dam to supply water to the CHP. It is proposed to shift the current functions from the Industrial Dam to the Access Road Dam. That is:

- pit water will be pumped directly to the Access Road Dam;
- pit water will be transferred to the West Pit void if the Access Road Dam is full;
- haul road dust suppression will be taken from the Access Road Dam, with back up from the Savoy Dam and the ES Pit tailings water recovery system;
- industrial wash down water will be taken from the Access Road Dam; and
- the Rail Loop dam will be pumped to the Access Road Dam.

An assessment of the impact of these changes on the minesite water balance is given in Section 4.

3.4 INCREASED SEDIMENTATION OF WATERWAYS

The proposed Modification would not increase the sediment loads draining to the downstream waterways because the disturbance areas drain into the open-cut-pits. Additional sediment control measures around the workings are not required.

3.5 OVERFLOWS OF POOR QUALITY MINE WATER

An assessment of the impact of these changes on overflows from the minesite storages is given in Section 4.

4 MINE WATER BALANCE

4.1 OVERVIEW

A computer-based simulation model (OPSIM) was used to assess the dynamics of the site water balance under conditions of varying rainfall and catchment conditions. The OPSIM model works to dynamically simulate the operation of the site's water management system and in doing so keeps complete account of all site water and representative water quality on a daily time step.

The model has been configured to simulate the operations of all major components of the water management system including:

- climatic variability – rainfall and evaporation;
- catchment runoff and collection;
- pit dewatering;
- pump and gravity transfers;
- water storage filling, spilling and leaking;
- industrial water extraction, usage and return; and
- controlled and uncontrolled releases.

4.2 METHODOLOGY

The OPSIM water balance model of the Drayton Mine water management system, previously developed to assess the impact of the proposed changes to the tailings disposal system (Water Solutions, 2011), was used as the basis for the assessment. For this study, the runoff parameters in the previous OPSIM model were recalibrated to match the recorded and predicted storage volumes over the period 2007 to 2011. Details of the OPSIM model configuration and calibration is given in Appendix A.

The calibrated model was used to assess the impact of the proposed modification on the mine site water balance over the final five years of mine life (2012 to 2016) assuming the minesite catchments change over that time. Two different stages of mine life were included in the model.

- It was assumed that the existing catchments represent the minesite conditions from 2012 to 2014 inclusive; and
- The final void catchments represent the minesite conditions from 2015 to 2016 inclusive.

Although the catchment areas are expected to continuously change as the minesite is continually rehabilitated, the simplification is expected to reasonably represent minesite conditions over the 2012 to 2016 period.

The model simulates the operation of the mine water management system over the different mine stages sequentially from 2012 to 2016, a period of 5 years. To assess the effects of varying climatic conditions, the model was run for multiple cycles with a different rainfall input sequence for each cycle. The first cycle of the model used rainfall data commencing in 1889 and ending in 1893. The second cycle of the model uses a 5 year period of rainfall data offset by one year, commencing in 1890. For each subsequent cycle of the model, the rainfall data used is offset by one year until the mine water system has been tested for 118 cycles against 122 years of rainfall data. The initial storage conditions in all dams at the start of each model cycle have been assigned the values recorded by the site water management team at or near July 2011. Under this scenario, the model provides a probabilistic approach to predicting the behaviour of the minesite water management system over the remaining five years of mine life.

The adopted rainfall sequence for the simulations was based on a synthetic rainfall data set interpolated from point observations by the Bureau of Meteorology (SILO Data Drill, Jeffrey et al., 2001). A comparison of Silo data against recorded data is given in Appendix A.

4.3 MINESITE WATER MANAGEMENT SYSTEM

Figure 4.1 and Figure 4.2 show the locations and catchments of the various dams and pits on the Drayton Mine under proposed mining conditions (2012 to 2014) and proposed final void (2015 to 2016). A schematic of the minesite water management system over both periods is given in Figure 4.3.

For the proposed mining conditions, the only difference from existing approved conditions, given in Figure 2.2, is that the Industrial Dam catchment will drain to East Pit North. The changes to the water management system as a result of the removal of the Industrial Dam are given in Section 3.3. The operating rules for the remaining dams are given in Table A 3 in Appendix A.

For the final void conditions (2015 to 2016) the same operational rules are applied until the completion of mining but the catchment areas draining to the open cut pits change. At the end of mining, any water remaining in the West Pit Void, in excess of MAC requirements will be pumped back to the South Pit and all pumping will cease.

4.4 SITE WATER REQUIREMENTS

Table 4.1 shows the expected water demands over the five year life of the project. CHP makeup demand has been taken from a previous report (Water Solutions, 2011) and is based on a 4.8 million tonnes per annum (Mtpa) washed raw feed rate, a 60% plant efficiency rate, 14% fine tailings split and a 40% decant return rate.

Table 4.1 Site Water Demands

Demand	Demand	
	ML/yr	kl/d
CHP Makeup	640	1,750
Haul Road Watering	600	1,643
Stockpile Dust Suppression	50	137
Industrial Use	400	1,095
Total	1,690	4,625

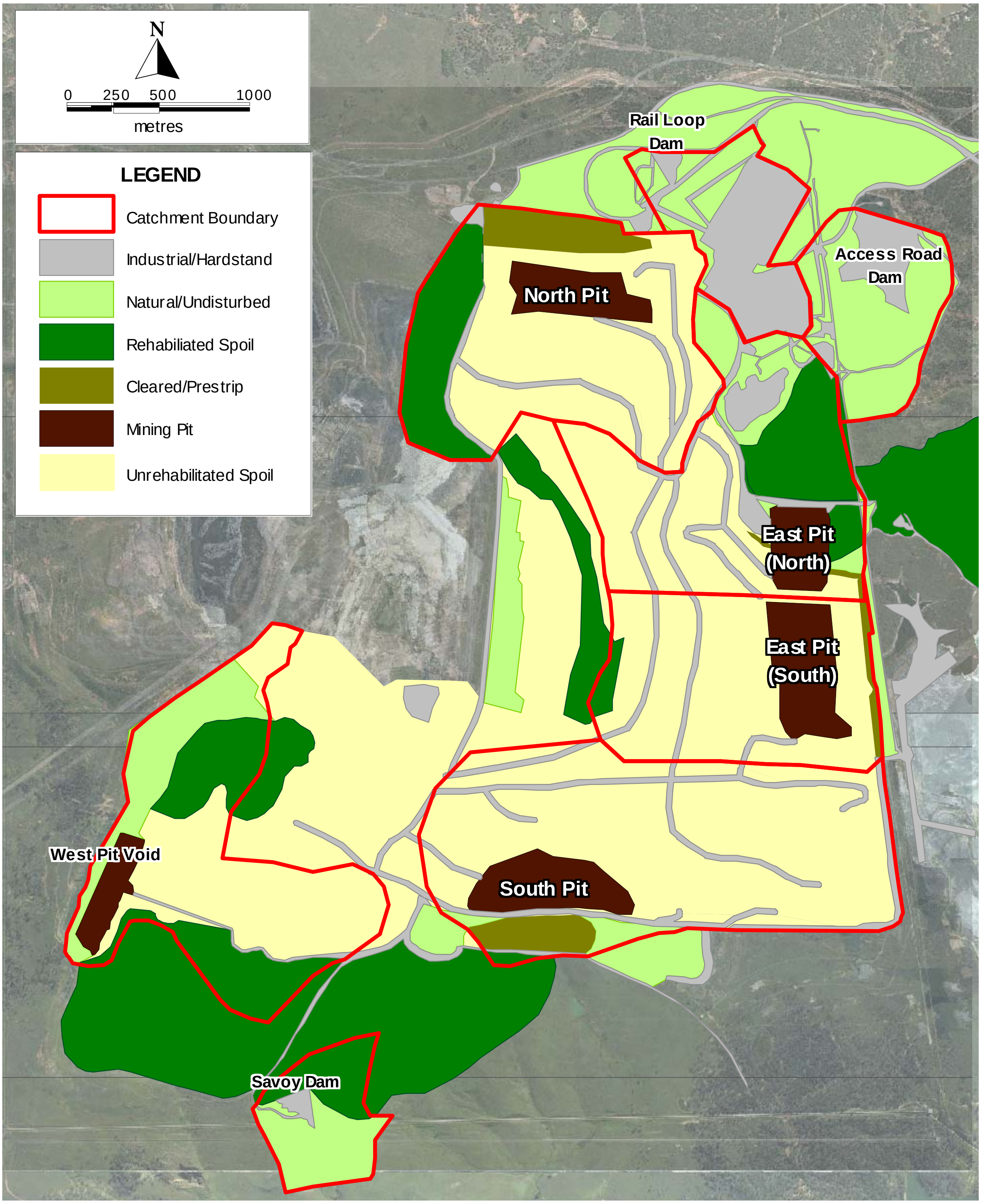

Figure 4.1 Existing Conditions Minesite Catchments (With Industrial Dam Removed)

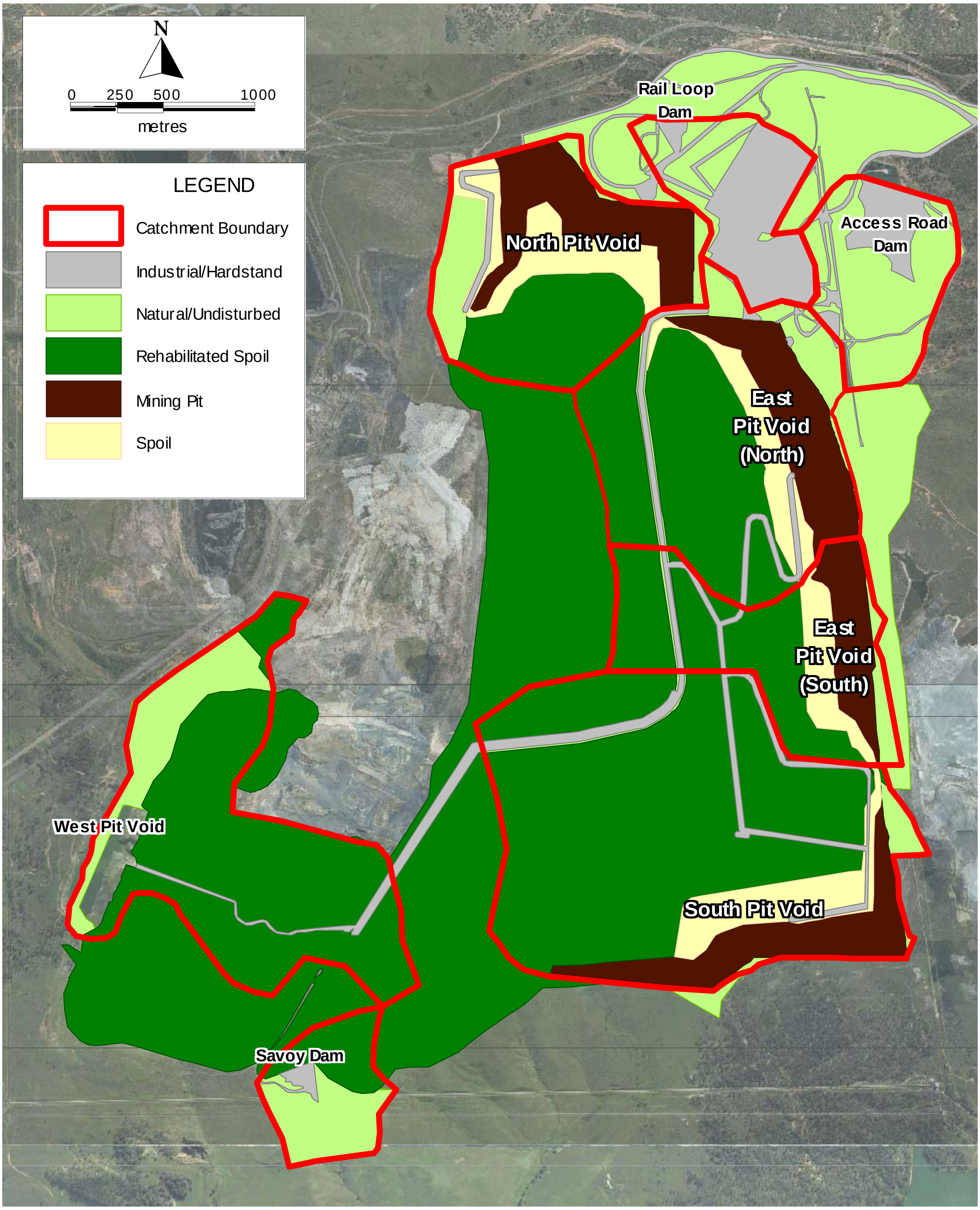

Figure 4.2 Final Void Minesite Catchments

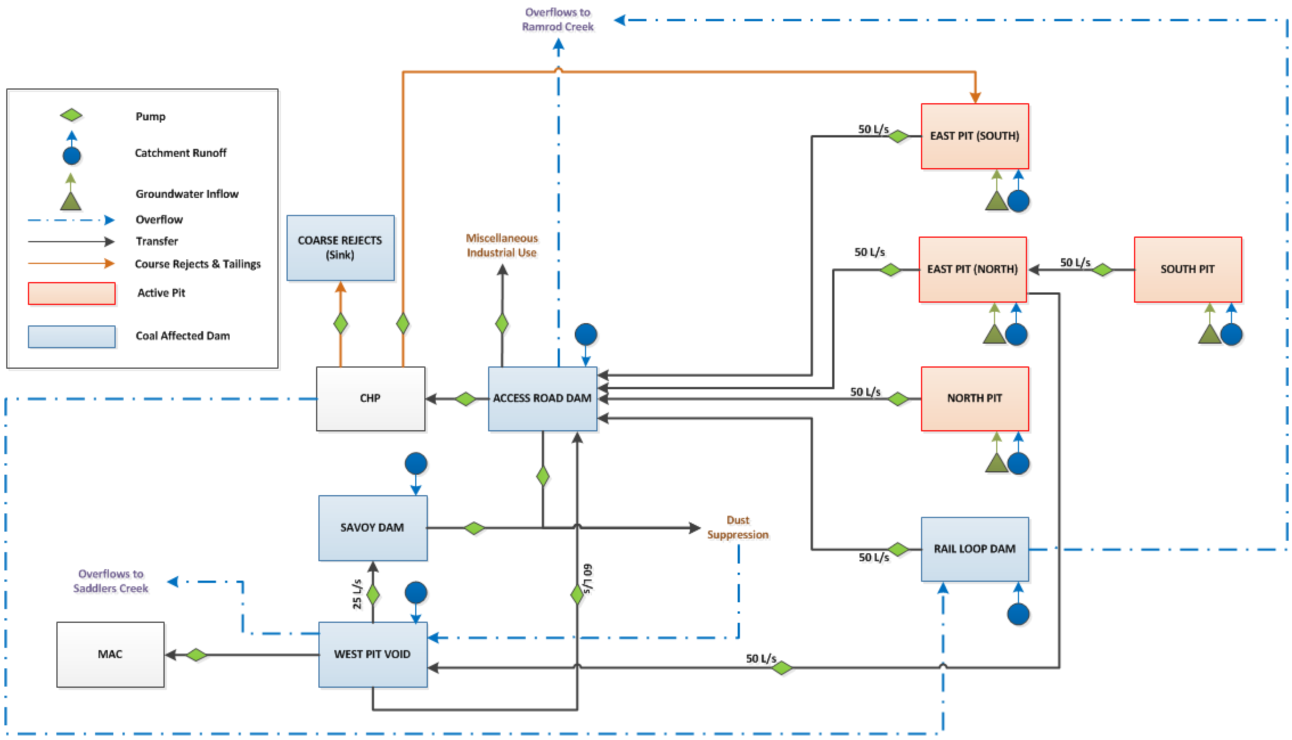

Figure 4.3 Minesite Water Management Schematic

4.5 GROUNDWATER INFLOWS

Table 4.2 shows the estimated groundwater inflow to the three active pits on the Drayton Mine over the remaining five year life estimated by AGE (2006). The proposed Modification is not expected to change the rates of groundwater inflows from the AGE estimates.

Table 4.2 Drayton Mine Groundwater Inflows

Year	ML/yr	kL/d
North Pit	390	1,070
South Pit	165	350
East Pit	400	1,143

4.6 MINESITE CATCHMENT CHANGES

Table 4.3 shows the catchment areas draining to the various open-cut-pits and mine water dams under the approved conditions (with the East Pit Void tailings dam in place) for both existing (mining) conditions and for the final void. The catchment areas proposed under this modification for both existing (mining) conditions and for the final void are also shown. The following is of note:

- The catchment area of the Industrial Dam drains to the East Pit North under proposed conditions.
- Substantial changes to catchment areas are proposed between the existing approved final void and the proposed final void.

- o North Pit catchment area reduces by 18%.
- o East Pit North catchment increases due to the inclusion of the Industrial Dam catchment.
- o The South Pit catchment area increases substantially. The final void has moved to the eastern lease boundary taking in catchment that was to drain to the headwater dams upstream of the Ash Dam on the Macquarie Generation site. As discussed in Section 3.2.3, the removal of this catchment is expected to improve the performance of the Macquarie Generation Ash Dam.
- o East Pit South tailings dam catchment reduces substantially, which will improve the operation of the tailings dam under mining conditions and improve the ability to rehabilitate the site post mining.

Table 4.3 Existing and Proposed Pit and Dam Catchment Areas, Mining and Final Void Conditions

Pit/Dam	Catchment Areas (ha)			
	Mining Conditions		Final Void	
	Existing	Proposed	Existing	Proposed
North Pit	187.5	187.5	173.1	141.6
East Pit North	103.7	162.1	155.4	188.5
South pit	244.5	244.5	162.2	317.9
West Pit Void	165.3	165.3	165.3	165.3
Industrial Dam	58.4	0.0	38.4	0.0
Access Road Dam	68.2	68.2	68.2	68.2
Rail Loop Dam	62.9	62.9	62.9	62.9
Savoy Dam	40.6	40.6	40.6	40.6
East Pit South	134.0	134.0	204.3	109.6

4.7 WATER BALANCE MODEL RESULTS

4.7.1 Minesite Storage Volume

Figure 4.4 and Figure 4.5 show the predicted in-pit and out-of-pit storage volume on the Drayton Mine (50^{th} percentile) as well as the 90^{th} and 10^{th} percentile confidence limits of the estimate. The active pits include East Pit North, North Pit and South Pits. The out-of-pit storages include the West Pit Void, Access Road Dam, Rail Loop Dam and Savoy Dam. The following is of note:

- Under median rainfall conditions, there would be no build up of water in the active pits and a general draw down of water from the out of pit storages with total minesite inventory falling from 3,550ML to 2,420ML over the five year period.
- Under 10^{th} percentile (wet) conditions, there would be no draw down of water in the out-of-pit storages and a moderate build up of water in the active pits. A maximum of 500 ML of water would build up in the active pits for the 10^{th} percentile wet conditions. Given that the excess water can be spread over the three pits or temporarily pumped to the Savoy Dam, the build-up of water is not expected to significantly impact on mining.
- Under the 90^{th} percentile (dry) conditions, on-site inventories fall to 2,000 ML after two years of mining. It has been assumed that 2,000 ML in the West Pit Void is owned by Mount Arthur Coal and is not available for mine site use. Off site supplies would be required should 90^{th} percentile (dry) conditions prevail over the next 5 years.

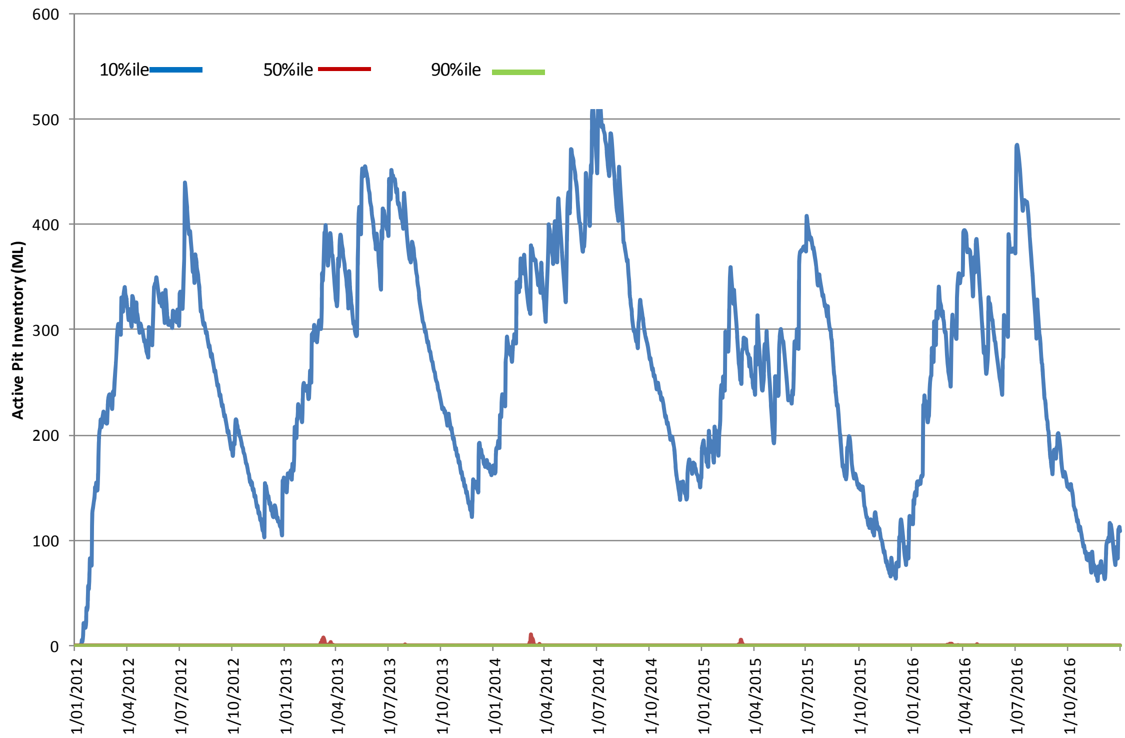

Figure 4.4 Simulated In-Pit Storage Inventory, 90th Percentile (dry), 50th Percentile (median) and 10th percentile (wet) conditions, 2012 to 2016.

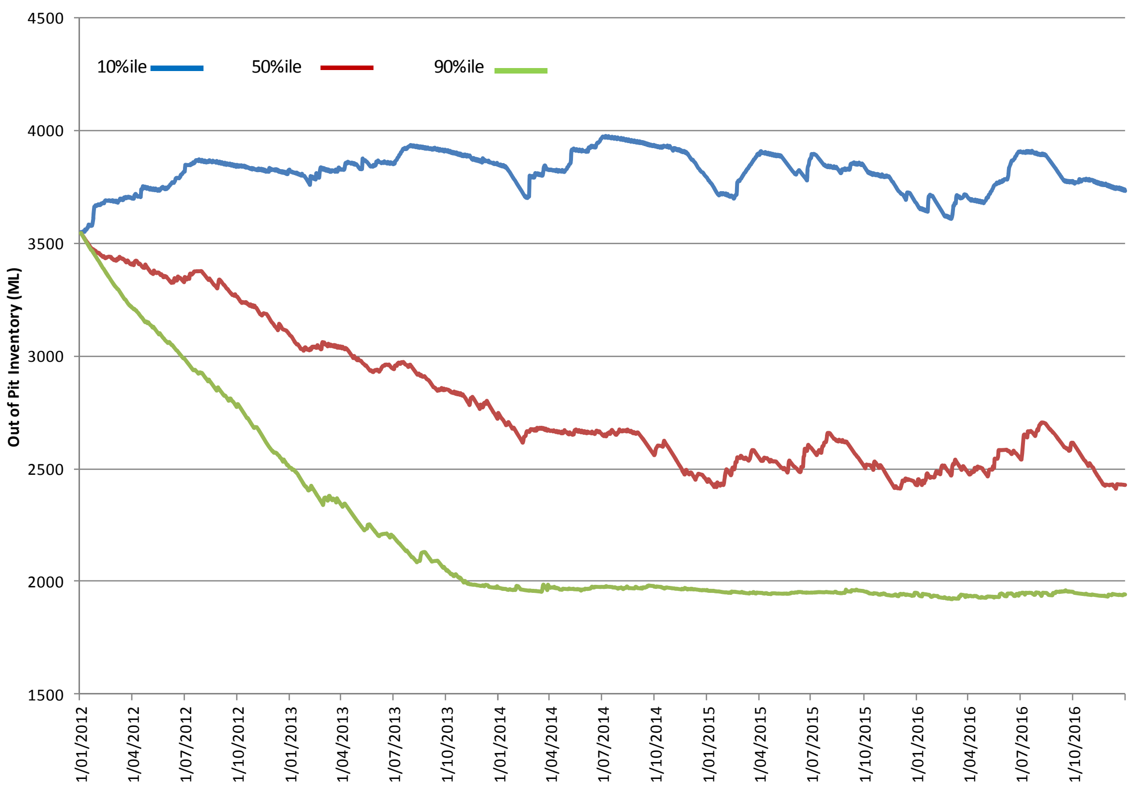

Figure 4.5 Simulated Out-of Pit Storage Inventory, 90th Percentile (dry), 50th Percentile (average) and 10th percentile (wet) conditions, 2012 to 2016.

4.7.2 Makeup Water Requirements

Figure 4.6 shows the cumulative off-site water requirements for the Drayton Mine for 50th Percentile (median) conditions over the next five years as well as the 90th and 10th percentile confidence limits of the estimate. The results show the following:

- No off-site water would be required for the 10th percentile wet year.
- Under median rainfall conditions, some off-site water may be required in year 4 and year 5. A total of 400 ML would need to be sourced externally over the last two years of the life of the mine.
- Under 90th percentile (dry) conditions, off site water supplies would be required from year 2 with a total of 1,750ML required over the 5 year period.

Historically, Drayton has been able to source sufficient water from on-site to supply all minesite water requirements. The additional coal washing and associated losses in the tailings circuit has lead to an increase in off-site requirements. It is expected that a reduction in coal washing and reduced coal production would occur if very dry conditions occur over the next five years.

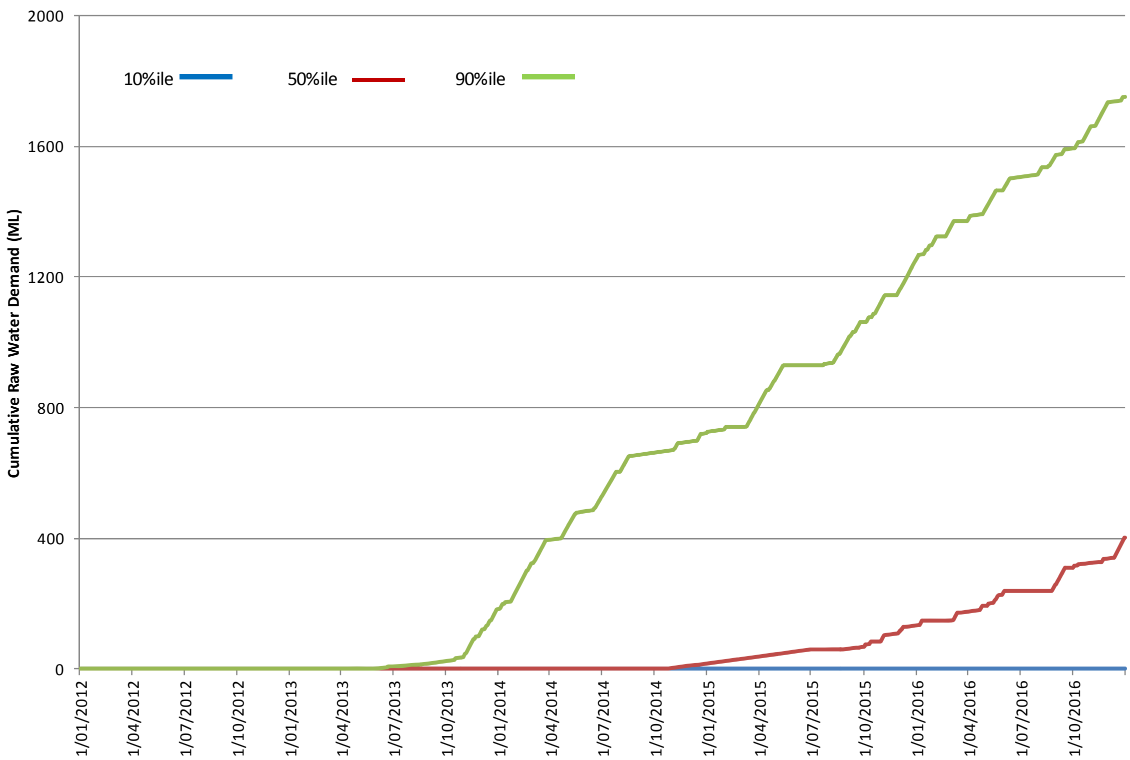

Figure 4.6 Offsite Make-up Water Requirements,90th Percentile (dry), 50th Percentile (median) and 10th percentile (wet) conditions, 2012 to 2016

4.7.3 Uncontrolled Spills

Table 4.4 shows the predicted spills from the minesite storages over the 5 year period for the median conditions as well as the 90th and 10th percentile confidence limits of the estimate. The results show that the main minesite storages, Access Road Dam, Savoy Dam and the West Pit void do not spill over the final five year mine life. Under median conditions, two spills are predicted from the Rail Loop Dam. The Rail Loop dam is only 18 ML, which is considered too small for its catchment. To prevent spills during the 10th percentile year, it is recommended to increase the capacity of the Rail Loop Dam by 50 ML.

Table 4.4 Predicted Spills from Minesite Storages

Dam	Simulation	No. Days of Spill	Max Vol Spill
Rail Loop Dam	10%ile	5	78.5
	50%ile	2	14.0
	90%ile	0	0
Access Road Dam	10%ile	0	0
	50%ile	0	0
	90%ile	0	0
Savoy Dam	10%ile	0	0
	50%ile	0	0
	90%ile	0	0
West Pit Void	10%ile	0	0
	50%ile	0	0
	90%ile	0	0

5 CONCLUSIONS

The proposed Modification at Drayton represents a relatively minor change to the drainage network and the existing water management system. Although an additional 36.5 ha of disturbance is proposed as part of the modification, the majority of this disturbance drained in-pit. As such, the proposed modification is not expected to increase the sediment loads draining to the downstream waterways or reduce downstream catchment flows.

The proposed final landform would increase the catchment draining to Saltwater Creek by 0.6 ha and would reduce some 40.1 ha of catchment draining to the headwater dams upstream of the Liddell Ash Dam on the Macquarie Generation site when compared to the existing approved final landform. It appears that a significant area of rehabilitated dump drained to these headwater dams under the previously approved final landform. It is expected that the removal of catchment draining to the headwater dams would reduce the potential for clean water to overflow into the Ash Dam and thereby reduce the Ash Dam's potential for overflowing.

Water balance modelling of the proposed Modification was undertaken to assess the impact on the minesite water management system. The results of the water balance modelling are as follows:

- Under median rainfall conditions, there would be no build up of water in the active pits and a general draw down of water from the out of pit storages with total minesite inventory falling from 3,550ML to 2,420ML over the five year period.
- Under 10th percentile (wet) conditions, there would be no draw down of water in the out-of-pit storages and a moderate build up of water in the active pits. A maximum of 500 ML of water would build up in the active pits for the 10th percentile wet conditions. Given that the excess water can be spread over the three pits or temporarily pumped to the Savoy Dam, the build-up of water is not expected to significantly impact on mining.
- Under the 90th percentile (dry) conditions, on-site inventories fall to 2,000 ML after two years of mining. It has been assumed that 2,000 ML in the West Pit Void is owned by Mount Arthur Coal and is not available for mine site use. Off site supplies would be required should 90th percentile (dry) conditions prevail over the next 5 years or production will reduce.
- No off-site water would be required for the 10th percentile wet year.
- Under median rainfall conditions, some off-site water may be required in year 4 and year 5. A total of 400 ML would need to be sourced externally over the last two years of the life of the mine under median rainfall conditions.
- Under 90th percentile (dry) conditions, off site water supplies would be required from year 2 with a total of 1,750ML required over the 5 year period.
- The main minesite storages, Access Road Dam, Savoy Dam and the West Pit void do not spill over the final five year mine life. Under median conditions, two spills are predicted from the Rail Loop Dam. The Rail Loop dam is only 18 ML, which is considered too small for its catchment. To prevent spills during the 10th percentile year, it is recommended to increase the capacity of the Rail Loop Dam by 50 ML.

6 REFERENCES

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APPENDIX A

WATER BALANCE MODELLING

A.1 METHODOLOGY

An OPSIM water balance model of the Drayton Mine water management system, previously developed to assess the impact of the proposed changes to tailings disposal system (Water Solutions, 2011), was used for the assessment. The model was updated by recalibrating the runoff parameters to match the storage volumes over the period 2007 to 2011 using available meteorological data for the site. The model was also updated to include a salt balance. The model was then modified to include the final landform on the Drayton Mine.

The updated model of the Drayton Mine Water Management System was used to determine:

- The frequency and volume of potential spills from various dams;
- The reliability of the storages to supply the mine site water requirements; and
- The ability to dewater the pit.

A.2 THE OPSIM MODEL

The OPSIM model estimates runoff and evaporation at each of the site water storages on a daily basis using historical climate data. It also simulates the transfer of water between storages, the harvesting of water and the controlled discharge of water if required.

Table A 1 provides a summary of the inflows and outflows included in the OPSIM model. Details of the model configuration, input data and results are provided in the following sections.

Table A 1 Simulated Inflows and Outflows to Mine Water Management System

Inflows	Outflows
Direct rainfall on water surface of storages	Evaporation from water surface of storages
Catchment runoff	CHPP demand
Groundwater inflows to Open Cut Pit	Dust suppression demand
Raw water supply	Vehicle washdown
	Off site spills from storages
	Controlled Releases

A.3 METEOROLOGY

A.3.1. Site Rainfall

A representative long-term rainfall sequence for Drayton Mine was obtained from the Bureau of Meteorology's SILO Data Drill. These synthetic data are derived by interpolation of recorded rainfall data between stations as described by Jeffreys *et al* (2001). Rainfall data from the SILO Data Drill is available from the late 1800s and is corrected for missing data and accumulated totals. Hence, this data is more reliable and easier to use for computer modelling than raw recorded rainfall data.

Figure A 1 shows a comparison of mean monthly rainfall recorded at the Jerrys Plains Post Office rainfall station (#061086), Denman Palace St Gauge (#061016) and the Muswellbrook Lower Hill St gauge (#061053) with the SILO Data Drill rainfalls over the project area from 1889 to

2010. The comparison indicates that the SILO data provides a good representation of recorded rainfall data at Drayton.

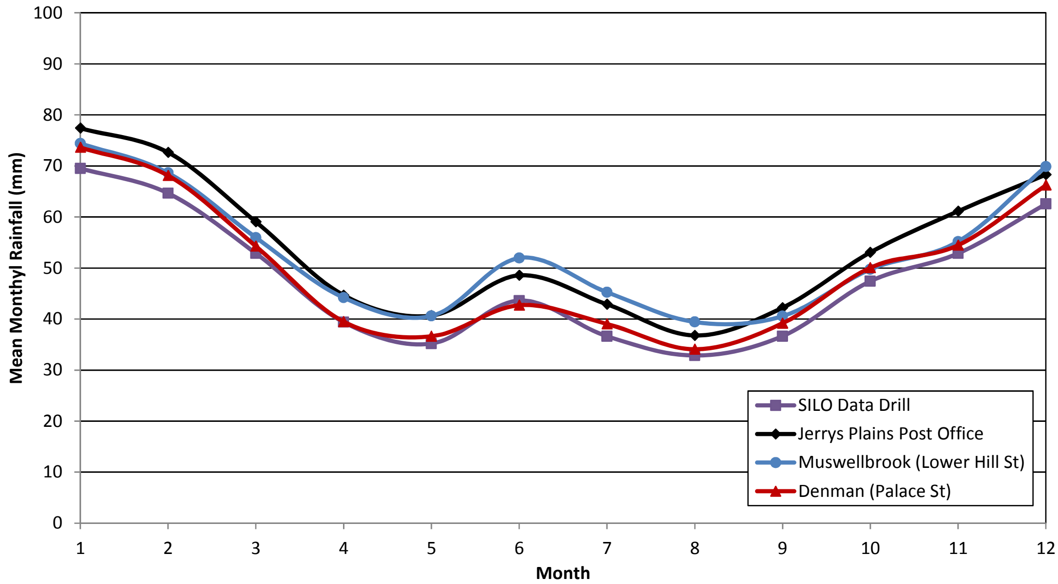

Figure A 1 Comparison of Mean Monthly Rainfalls of Surrounding Rainfall Stations with SILO Data Drill, 1889 to 2010

A.3.2. Evaporation

The pan evaporation data for the area was obtained from the SILO Data Drill database (Jeffrey et al., 2001). Pan factors were applied to the pan evaporation data to match Morton's lake evaporation (Morton, 1983). Morton's method is regarded as suitable for the estimation of lake evaporation in non-arid areas (Mulder, 1997). Table A 2 shows the adopted pan evaporation and pan factors used to estimate evaporation from the onsite storages.

Table A 2 Adopted Monthly Lake Evaporation Factors

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly Average	211	167	148	106	71	53	62	87	117	156	182	215
Monthly Lake Pan Factors	0.9	0.92	0.93	0.87	0.83	0.77	0.78	0.84	0.88	0.92	0.92	0.89

For the mining pits, the values shown in Table A 2 were factored by 0.7 to reflect the likely reduction in evaporation due to the depth of the open cut below surface level. For AWBM soil moisture evapotranspiration, the values shown in Table A 2 were factored by 0.99 to convert to areal evapotranspiration.

A.4 DRAYTON MINE WATER BALANCE MODEL CALIBRATION

A.4.1. Methodology

The calibration model was run over the period Jan 2007 to mid-2011, for which stored water volumes in the minesite storages were available. It was assumed that catchment areas draining to the active pits do not change over the calibration period. The change in catchment area over this period is only minor when compared to the total mine site catchment so the impact on the water balance of this assumption is not expected to be significant.

A.4.2. Water Management System

Figure A 2 shows a schematic of the Drayton water management system over the calibration period. The locations of the various storages and active working areas are shown in Figure A 3. A summary of the main features of the water management system is as follows:

- Active pits are dewatered to the Industrial Dam at a nominal pump rate of 100 L/s;
- CHP make-up demand is sourced from the Access Road Dam;
- The Rail Loop Dam receives runoff from the CHP and industrial areas;
- Coal stockpile dust suppression is sourced from the Access Road Dam, which is topped up by water in the Industrial Dam;
- The Industrial Dam supplies the East Pit fill point for haul road dust suppression;
- The Savoy Dam supplies the West Pit fill point for haul road dust suppression (via the Turkeys Nest Dam which is not explicitly modelled);
- West Pit Void receives inflows from the active pits should additional dewatering be required.

Full details of the operational rules adopted over the calibration period are given in Table A 3.

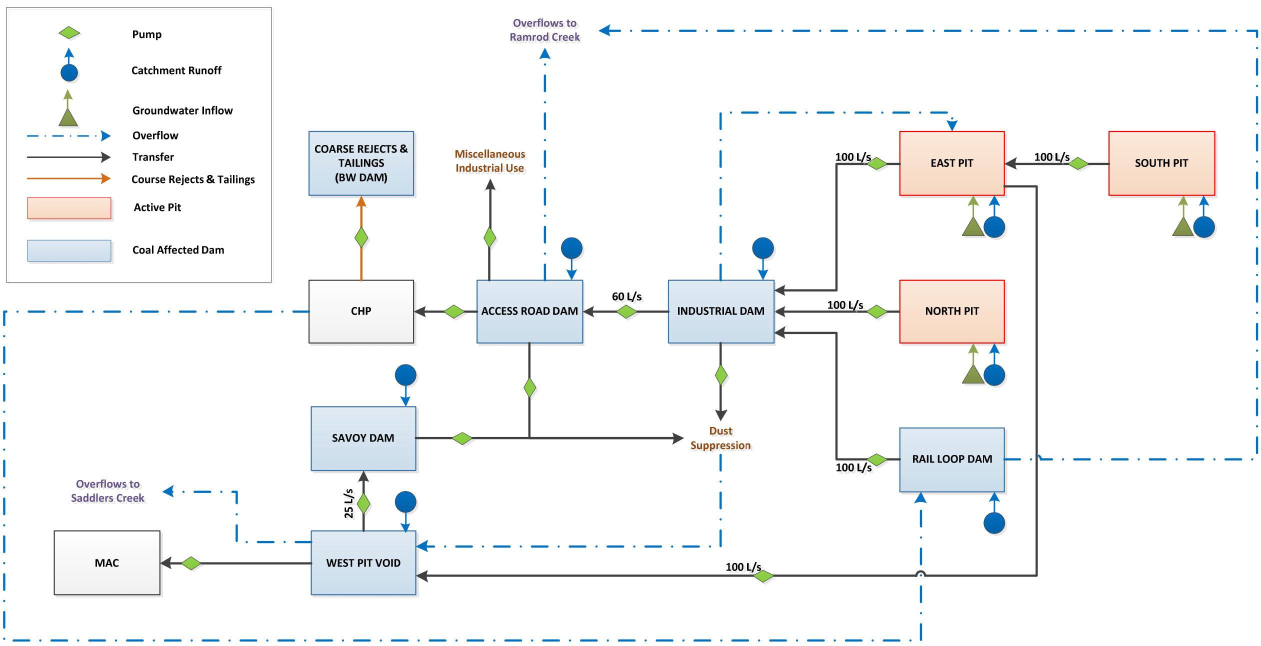

Figure A 2 OPSIM Model Schematic of Drayton Surface Water Management System for the Calibration Period (Jan 2007-May 2011)

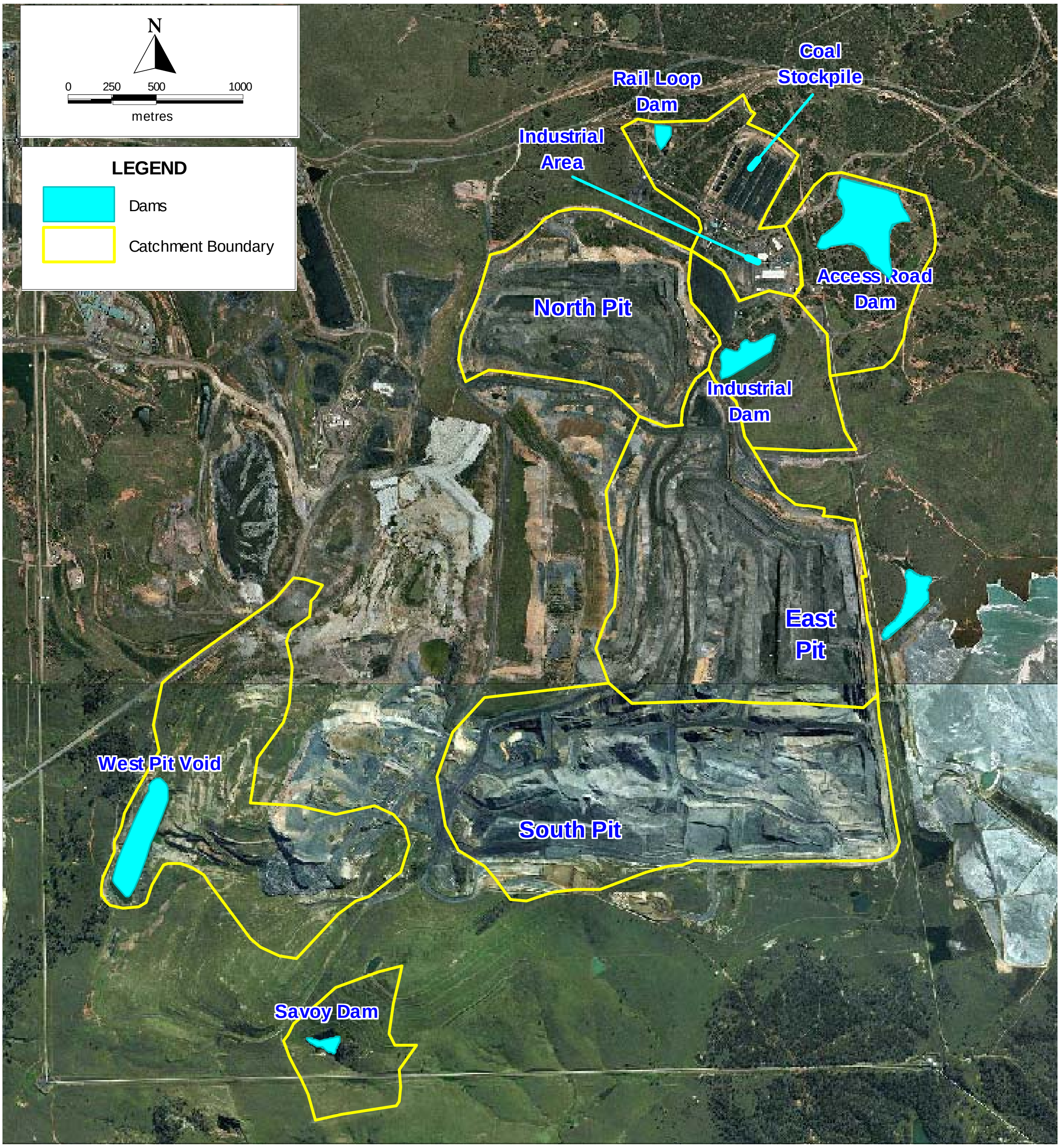

Figure A 3 Existing Drayton Mine Site Storages and Active Working Areas

Table A 3 Adopted Drayton Operational Guidelines for Calibration Period 2007-2010

	Operational Description	Operating Rules
1	Supply to Demands	
1.1	CHP Make Up	Supplied from the Access Rd dam at a rate of 237kL/d 100% loss assumed.
1.2	Miscellaneous Industrial use	Sourced from the Access Road Dam at a rate of 650kL/d. 100% loss assumed.
1.3	Haul Road Dust Suppression	2 Haul Road Fill locations: • West Pit Fill Point: 15% of haul road dust suppression demand is sourced from Savoy Dam at a rate of 292kL/d. • East Pit Fill Point: 85% of haul road dust suppression is sourced from the Industrial Dam at a rate of 1,660kL/d. • 100% loss assumed.
1.4	Stockpile Dust Suppression	• Supplied from the Access Rd dam at a rate of 42kL/d. • 100% loss assumed.
2	Transfer of Mine Waters	
2.1	North Pit	• Continuous pumping from pit dewatering pumps (when required) at a nominal maximum rate of 100L/s. • Pit dewatering directed to Industrial Dam. • Received groundwater inflows at a rate of 550kL/d (200ML/yr).
2.2	South pit	• Continuous pumping from pit dewatering pumps (when required) at a nominal maximum rate of 100L/s. • Pit dewatering directed to East Pit. • Received groundwater inflows at a rate of 450kL/d (164ML/yr).
2.3	East Pit	• Continuous pumping from pit dewatering pumps (when required) at a nominal maximum rate of 100L/s. • Pit dewatering directed to Industrial Dam. • Received groundwater inflows at a rate of 1,100kL/d (400ML/yr). • If pit water increases above 310 ML then additional direct transfer to West Pit Void at 100L/s
3	Operation of Key Storages	
3.1	Access Road Dam	• Primary mine water storage for CHP and industrial use. • Receives inflows from the following locations: o Pumped transfers from Industrial Dam at 60L/s when required. • Supplies to the following locations: o Drayton CHP o Industrial Area o Stockpile Dust Suppression • Storage overflows to Ramrod Creek
3.2	Industrial Dam	• Receives inflows from the following locations: o Pumped transfers from East Pit o Pumped transfers from North Pit o Pumped transfers from Rail Loop Dam • Supplies to the following locations: o East Pit Fill Point for haul road dust suppression. o Pumped transfers to the Access Road Dam at 60L/s when required. • Storage overflows to East Pit.
3.3	Rail Loop Dam	• Mine water collection and transfer storage. • Receives catchment runoff inflows from the CHP and industrial areas. • Supplies to the Industrial Dam at 100L/s. • Maintained at empty to prevent uncontrolled spills. • Storage overflows to Ramrod Creek.
3.4	Savoy Dam	• Mine water collection and transfer storage. • Supplies to West Pit Fill Point for haul road dust suppression. • Receives pumped transfers from West Pit Void at 25 L/s (when required to ensure supply of water for dust suppression).
3.5	West Pit Void	• Receives pumped inflows from East Pit when stored water exceeds 90m AHD. • Supples to Savoy Dam when required. • Storage overflows to Saddlers Creek. • No other transfers to or from West Pit Void over calibration period.
4	General	All storages and pits receive local catchment runoff and lose water through evaporation.

A.4.3. Storages and Mining Pits

The adopted capacities of minesite storages included in the OPSIM calibration model are shown in Table A 4. The full supply volume is the nominal volume available below the spillway crest. The operating volume is the target maximum storage volume to minimise uncontrolled spills. The initial free volume is the observed volume recorded in each storage, applied at the start of the modelling period, ie January 2007.

Table A 4 Capacities of Site Mine Water Storages

MINE WATER STORAGE	Full Supply Volume (ML)	Operating Volume (ML)	Initial Free Volume (ML)
Access Road Dam (2081)	750	600	310
Industrial Dam (1969)	750	596	555
Rail Loop Dam (2114)	18	0	11
Savoy Dam (1609)	140	50	140
West Pit Void (SW13)	4043	4043	412

Note that Delpah Dam and A Transfer Dam were included in the previous water balance modelling of the Drayton Mine (Water Solutions, 2011). Advice from personnel on site suggests that these dams do not play a role in the water balance and as such were excluded from the model.

The operating volume of the Rail Loop Dam was set to zero in an attempt to match the number of modelled spills with the actual spills over the calibration period.

The adopted capacities of the active pits are shown in Table A 5. The full supply volume is the nominal volume available, above which uncontrolled spills would occur.

Table A 5 Capacities of Site Mine Water Pits

PIT STORAGE	Full Supply Volume (ML)	Initial Free Volume (ML)
North Pit	17905	0
East Pit	17138	0
South Pit	993	0

The locations of these storages and pits are shown in Figure A 3.

A.4.4. Catchment Areas and Land Use Classifications

The adopted catchment areas reporting to each of the existing Drayton storages are presented in Figure A 4 and detailed in Table A 6.

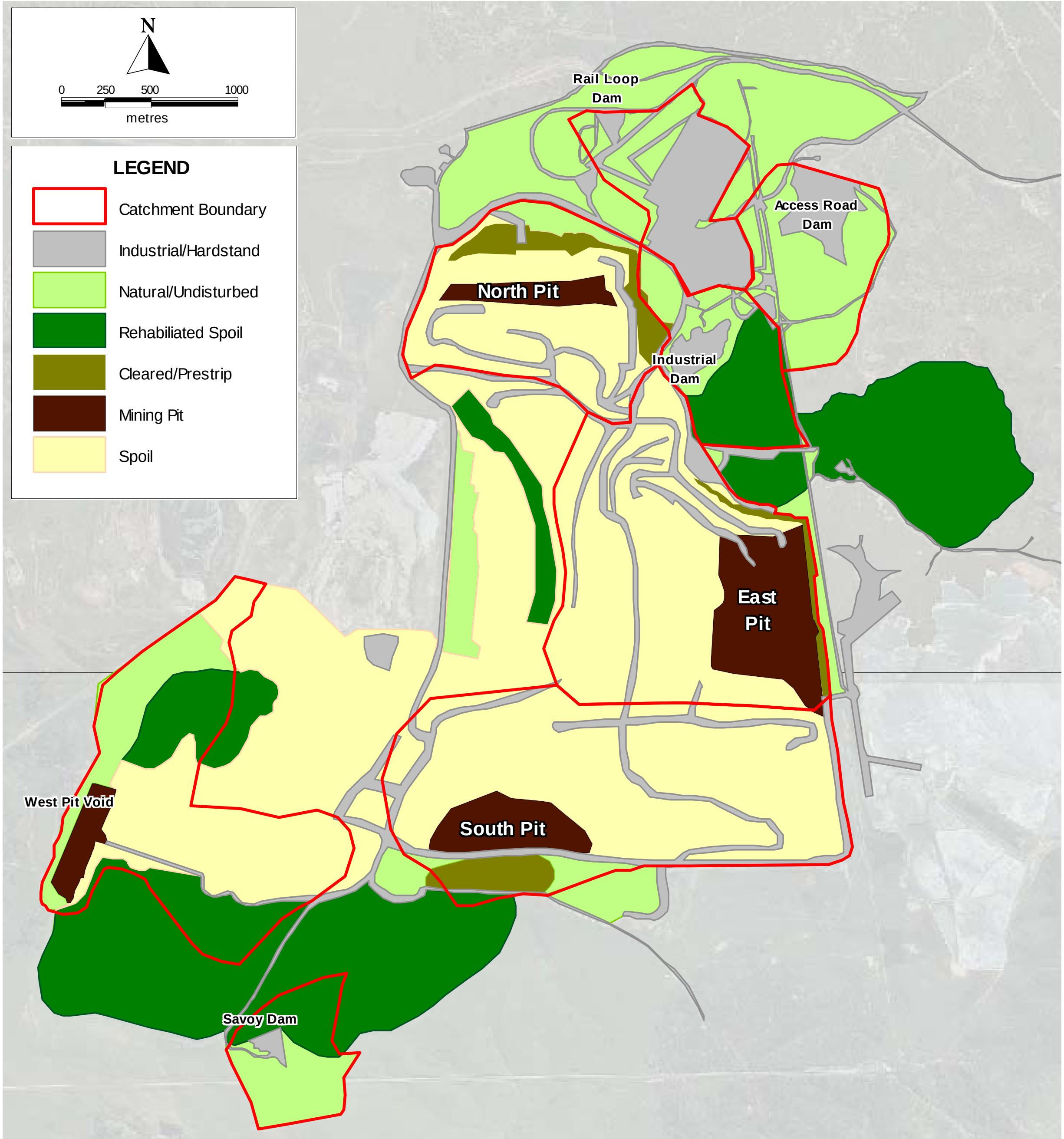

Figure A 4 Existing Drayton Mine Catchments and Land Use Classifications

Table A 6 Existing Drayton Catchment Areas

Storage Name	Catchment Area (ha)						
	Natural	Cleared	Mining Pit	Hardstand	Rehab	Spoil	Total
North Pit	7.6	14.7	10.9	15.0	0.0	84.5	**132.7**
South Pit	6.3	11.4	22.2	31.6	0.0	71.4	**143.0**
East Pit	0.0	5.9	44.4	24.9	0.0	139.1	**214.3**
Access Rd Dam	48.1	0.0	0.0	19.3	0.6	0.0	**68.0**
Rail Loop Dam	18.5	0.0	0.0	44.7	0.0	0.0	**63.2**
Savoy Dam	23.2	0.0	0.0	2.3	15.1	0.0	**40.6**
Industrial Dam	17.3	0.0	0.0	10.4	29.9	0.0	**57.6**
West Pit Void	31.4	0.0	9.7	2.2	45.2	76.6	**165.2**

A.4.5. Demands

The adopted total demand over the calibration period is 2,720 kL/d, consisting of the CHP makeup demand, industrial usage and dust suppression of haul roads and coal stockpiles. Each of these demands are detailed below.

Annual values of the CHP makeup requirements for 2007-2009 were obtained from previous calibration modelling of the Drayton minesite (Water Solutions, 2011), listed in Table A 7.

The volume of water required for CHP makeup is generally related to the annual coal production tonnages. Insufficient production data was available to conduct a net water balance over the CHPP to assess the net water requirements, so it was assumed that the CHP Makeup requirement would provide an accurate representation.

Table A 7 Drayton CHP Makeup Requirements

Year	ML/yr	kL/d	Source
2007	63	170	Drayton Mine Extension (Water Solutions, 2011)
2008	166	450	Drayton Mine Extension (Water Solutions, 2011)
2009	25*	91	Drayton Mine Extension (Water Solutions, 2011)
Average		237	

*January 2009 - to September 2009

Annual values of industrial usage for 2007-2010 are provided in Table A 8. The average industrial demand of 650 kL/d was adopted over the calibration period. The industrial usage demand is sourced from the Access Road Dam and is assumed to be 100% lost.

Table A 8 Drayton Industrial Usage

Year	ML/yr	kL/d	Source
2007	130	356	Drayton Mine Extension (Water Solutions, 2011)
2008	272	745	Annual Environment Management Report 2008 (Anglo Coal)
2009	360	986	Annual Environment Management Report 2009 (Anglo Coal)
2010	188	515	Annual Environment Management Report 2010 (Anglo Coal)
Average	238	650	

Annual rates of coal stockpile dust suppression for 2007-2010 are provided in Table A 9. The average coal stockpile dust suppression demand of 50 kL/d was adopted over the calibration period, sourced from the Access Road Dam and assumed to be 100% lost.

Table A 9 Drayton Coal Stockpile Dust Suppression Usage

Year	ML/yr	kL/d	Source
2007	27	74	Drayton Mine Extension (Water Solutions, 2011)
2008	2	5	Annual Environment Management Report 2008 (Anglo Coal)
2009	6	16	Annual Environment Management Report 2009 (Anglo Coal)
2010	38	104	Annual Environment Management Report 2010 (Anglo Coal)
Average	18	50	

Annual rates haul road dust suppression for 2007-2010 are provided in Table A 10. The average haul road dust suppression demand of 1786 kL/d was adopted over the calibration period. Based on advice from on-site personnel, 85% is sourced from East Pit Fill Point (Industrial Dam) and 15% from the West Pit Fill Point (Savoy Dam).

Table A 10 Drayton Haul Road Dust Suppression Usage

Year	ML/yr	kL/d	Source
2007	470	1288	Drayton Mine Extension (Water Solutions, 2011)
2008	603	1652	Annual Environment Management Report 2008 (Anglo Coal)
2009	814	2230	Annual Environment Management Report 2009 (Anglo Coal)
2010	720	1973	Annual Environment Management Report 2010 (Anglo Coal)
Average	652	1786	

A.4.6. Groundwater Inflows

The rates of groundwater inflow into the active pits were adopted from the previous calibration modelling (Water Solutions, 2011), detailed in Table A 11.

Table A 11 Drayton Groundwater Inflows

Year	ML/yr	kL/d
North Pit	200	550
South Pit	165	450
East Pit	400	1100

A.4.7. AWBM Calibration

The OPSIM model uses the AWBM model to estimate runoff volumes from on-site catchments, based on available rainfall and evaporation data. The AWBM (Boughton, 2003) is a saturated overland flow model which allows for variable source areas of surface runoff. The model uses daily rainfalls and estimates of catchment evapotranspiration to calculate daily values of runoff using a daily water balance of soil moisture. The model has a baseflow component which simulates the recharge and discharge of a shallow groundwater store. Runoff depth calculated by the AWBM model is converted into runoff volume by multiplying by the contributing catchment area. The various parameters of the AWBM model are shown in Table A 12.

Table A 12 Summary of AWBM Model Parameters

Parameter Specification	Description
Partial Area Fractions	Parameters A1, A2 & A3. Fraction of catchment area represented by surface storages No. 1, 2 & 3.
Soil Store Capacities	Parameter C1, C2 & C3. Soil moisture storage capacities for smallest store (No. 1), middle store (No. 2) and largest store (No. 3).
Base Flow Index	Parameter BFI. Proportion of runoff directed to baseflow store.
Daily Baseflow Recession Constant	Parameter K. Rate at which water discharges from baseflow store.
Lake to Evapotranspiration Factor	Factor to convert open water evaporation to evapotranspiration.

To estimate catchment runoff inflows to the OPSIM model, separate AWBM model parameters were developed for the following catchment types:

- Natural/undisturbed;
- Industrial/hardstand/roads;
- Spoil, unrehabilitated;
- Spoil, rehabilitated;
- Mining Pit;
- Cleared/Prestrip.

In the absence of recorded runoff data for the different catchment types, reasonable parameter values were selected based on experience in similar previous studies and expected values of volumetric runoff coefficients. Adopted AWBM model parameter values are shown Table A 13. The overall representation of catchment runoff was validated by matching the stored volume in all storages on the minesite over the calibration period.

Table A 13 Adopted AWBM Model Parameters for Various Catchment Types

AWBM Model Parameter		Natural	Industrial/ Hardstand	Unrehab Spol	Rehab Spoil	Mining Pit	Cleared/ Prestrip
Surface Store Depth (mm)	C1	40	4.08	13	7.7	3	2.4
	C2	85	12.96	48	77	11.75	10.8
	C3	145	0	0	0	0	9.96
	Avg.	100	12.07	41	70.7	10	0.1
Partial Areas	A1	0.2	0.1	0.2	0.1	0.2	0.1
	A2	0.4	0.9	0.8	0.9	0.8	0.9
	A3	0.4	0	0	0	0	0
Base flow index	BFI	0	0	0.85	0.15	0	0
Base flow recession constant	K	1	1	0.7	0.98	1	1
Lake to Evapotranspiration Factor		0.99	0.99	0.99	0.99	0.99	0.99
Long Term Runoff Coefficient	RC	0.048	0.312	0.138	0.085	0.348	0.344

A.4.8. Water Quality Parameters

Water quality was modelled in OPSIM as Total Dissolved Solids (TDS) in mg/L. The adopted salinity concentrations of the various catchment types included in the calibration model are provided in Table A 14. These values are based on the assessment of water quality information currently collected for a number of storages (with non-homogenous catchments) across the Drayton minesite and experience at similar minesites. The results of the calibration of the catchment runoff salinities are provided in Section A.4.10. The equivalent electrical conductivity (EC) values assuming a typical conversion of 0.75 are also given.

Table A 14 Catchment Inflow Salinity Concentrations (TDS and EC)

Catchment Type	TDS (mg/L)	EC (µS/cm)
Cleared/Prestrip	2000	2667
Mining Pit	4000	5333
Natural/Undisturbed Catchment	200	267
Indsutrial/Harstand	2000	2667
Spoil	2000	2667
Rehabilitated Spoil	1000	1333
Groundwater	4720	6300

A.4.9. Storage Volume Calibration Results

The modelled AWBM parameters were calibrated using known site performance and operations from January 2007 to May 2011 at the existing Drayton mine. The modelled total site inventory for the Industrial Dam, Savoy Dam, Access Road Dam, Rail Loop Dam and the North, South, East and West Pits were compared to the recorded total inventory. The results of the calibration are shown in Figure A 5.

SILO Data Drill rainfall was selected for this calibration as it was found that the provided Drayton site data showed consistently higher daily values than surrounding Bureau of Meteorology stations, potentially indicating an incorrectly calibrated on-site gauge.

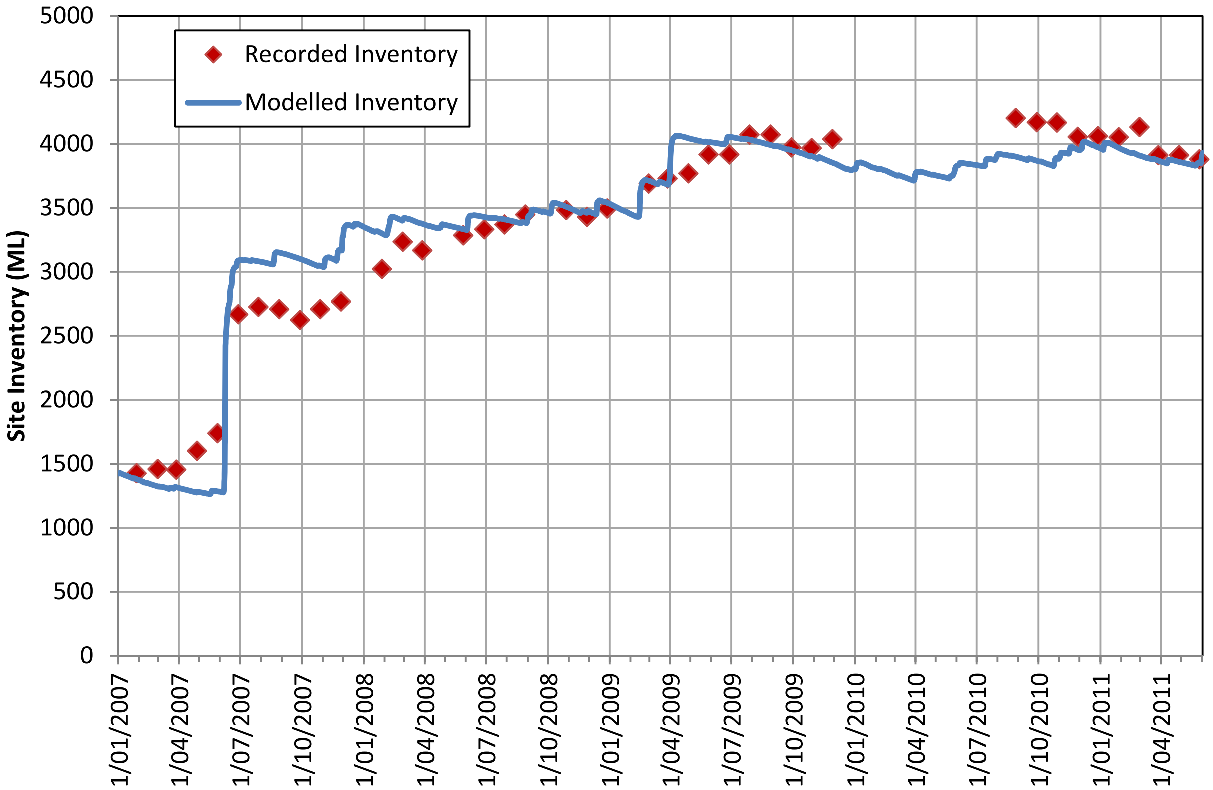

Figure A 5 Modelled and Recorded Total Inventory (Stored Volume)

The following is of note with the calibration of the AWBM parameters for the OPSIM model:

- The behaviour of the modelled site inventory over January 2007 to May 2011 is in good agreement with the recorded inventory;
- In September 2009, 2000ML stored in the West Pit Void was transferred to the ownership of MAC. This 2000ML has not been removed from the recorded total site inventory to allow direct comparison with the modelled results;
- All demands are met 100% of the time over the calibration period;
- No controlled discharges occurred over the calibration period;
- The modelled results showed one spill from the Rail Loop Dam in conjunction with the June 2007 rainfall event.

The calibration results are marginally different to the calibration given in Water Solutions (2011) due to the use of more up to date storage volume information. The current calibration parameters generate more runoff than what was proposed by Water Solutions (2011).

A.4.10. Water Quality Calibration Results

The concentration of salts assigned to the various catchment types was calibrated using recorded salinities in on-site storages with non-homogenous catchments from January 2007 to May 2011. Initial salinities were estimated from a linear interpolation of the recorded site data. The modelled water quality for the Industrial Dam, Savoy Dam and Access Road Dam were each compared to the recorded storage salinities. Recorded storage salinities were converted from EC (µS/cm) to TDS (mg/L) assuming a typical conversion of 0.75. The results of the calibration are shown in Figure A 6, Figure A 7 and Figure A 8.

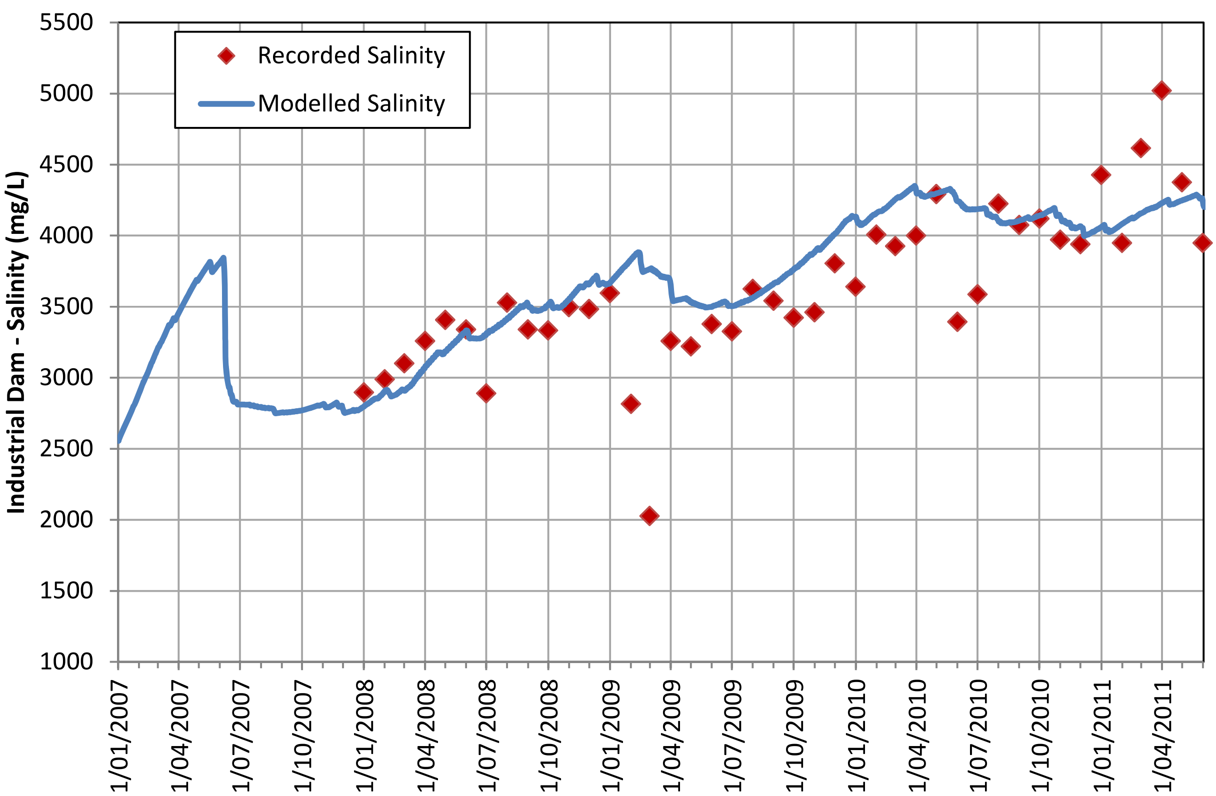

Figure A 6 Modelled and Recorded Industrial Dam TDS, Jan 2007 to May 2011

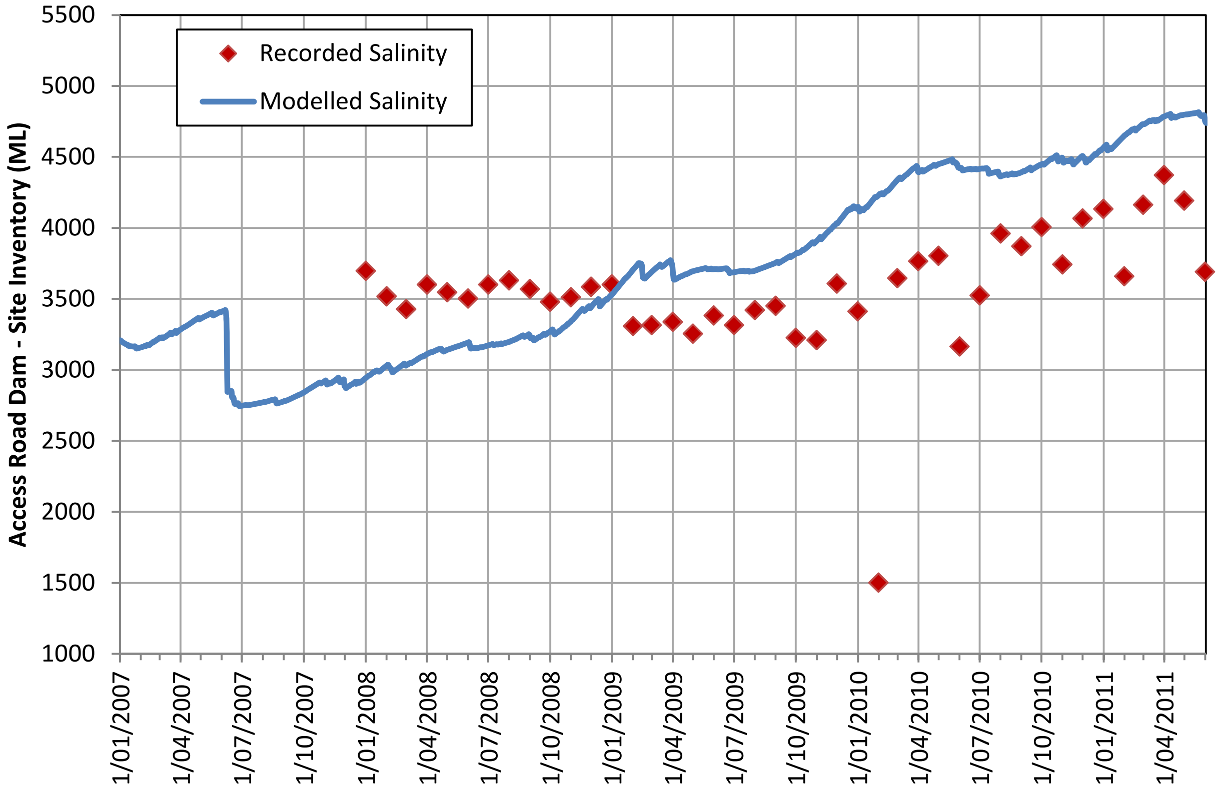

Figure A 7 Modelled and Recorded Access Road Dam TDS, Jan 2007 to May 2011

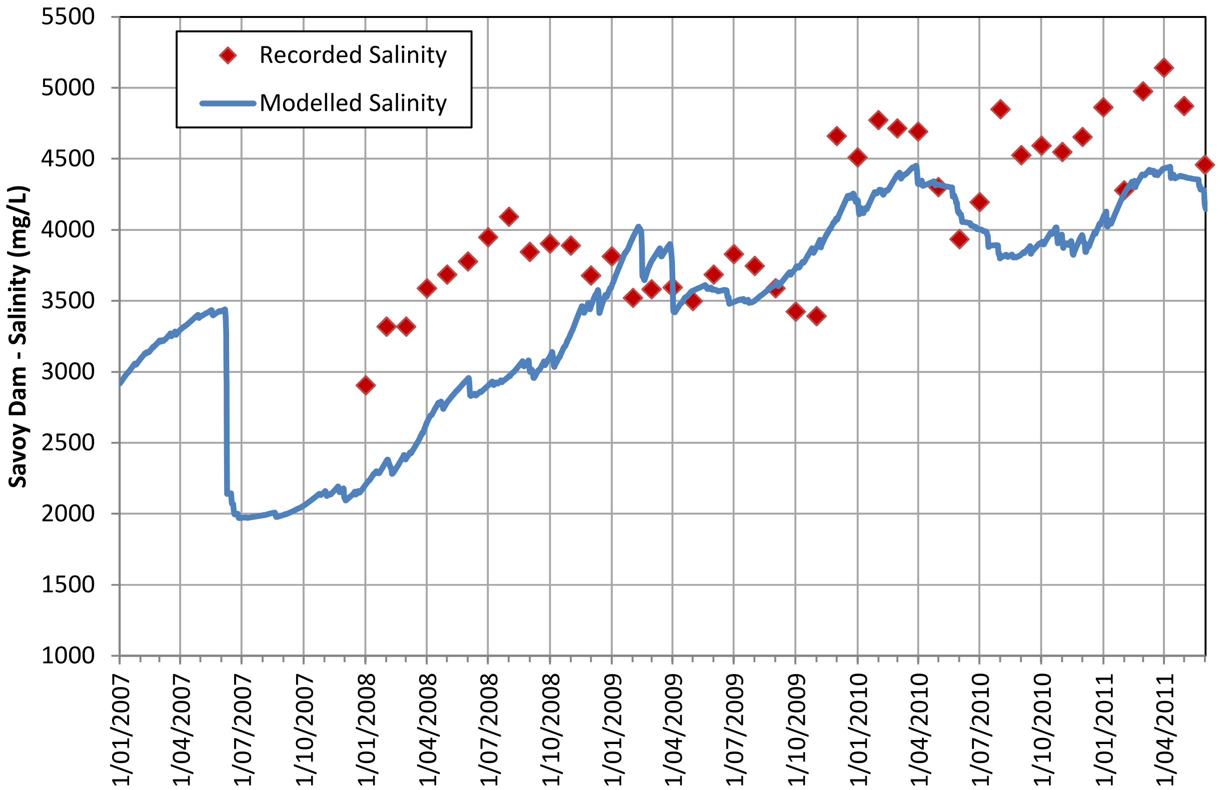

Figure A 8 Modelled and Recorded Savoy Dam TDS, Jan 2007 to May 2011

The following is of note with the calibration of the catchment runoff salinities for the OPSIM model:

- The overall TDS calibration in the three storages appears reasonable.
- It is expected that TDS concentrations in the Industrial Dam and Access Road Dam would reflect the pit and spoil runoff TDS as well as groundwater TDS as they mostly contain pumped inflows from the open cut pits
- Runoff from natural catchments vary greatly with high TDS concentrations measured to the south and lower concentrations in the north.

A.4.11. Limitations of the Water Balance Model Calibration

The results of the OPSIM modelling need to be interpreted with caution. Key limitations of the OPSIM model and known discrepancies between the model and water management practice are outlined below:

- The AWBM parameters adopted for the model appear reasonable based on past experience and the available calibration data for Drayton Mine.
- TDS concentrations applied to minesite catchments are based on past experience and the limited water quality data available to date. More water quality information is required to accurately calibrate the water balance model to observed site data.
- TDS is not necessarily the critical contaminant that will control the operation of the water management system and the site water management system will need to evolve and be operated to recognise the results of future water quality and quantity monitoring programs.