Chapter 8

Water Management

TABLE OF CONTENTS

8.1 Introduction 8-1
8.2 Water Management System 8-1
8.2.1 Mine Affected Water 8-2
8.2.2 Sediment Affected Water 8-2
8.2.3 Clean Water 8-2
8.2.4 Drainage Diversions 8-2
8.3 Process Water, Water Demand and Water Supply 8-5
8.3.1 Potable Water 8-6
8.3.2 Water Conservation Measures 8-7
8.4 Mine Water Balance Model 8-7
8.4.1 Water Volume 8-7
8.4.1.1 Catchment Hydrology 8-9
8.4.1.2 Groundwater Inflows 8-9
8.4.2 Water Quality 8-10
8.5 Release Strategy 8-11
8.5.1 Derivation of Release Rules 8-14
8.5.1.1 Receiving Environment Flow Triggers 8-14
8.5.1.2 Receiving Environment Water Quality 8-15
8.5.1.3 Mine Release Flow Thresholds 8-15
8.5.1.4 Mine Release Water Quality 8-15
8.5.2 Proposed Release Rules 8-15
8.6 Water Management Infrastructure 8-16
8.6.1 Overview 8-16
8.6.2 Description of Infrastructure Staging 8-17
8.6.2.1 Mine Infrastructure Areas 8-17
8.6.2.2 North Pit 8-17
8.6.2.3 West Pit Complex 8-27
8.6.2.4 South Pit 1 8-28
8.6.2.5 South Pit 2 8-29
8.6.2.6 East Pit 1 8-29
8.6.2.7 East Pit 2 8-29
8.6.3 Dam Design and Sizing 8-29
8.6.3.1 Mine Affected Water Dams 8-29
8.6.3.2 Sediment Affected Water Dams 8-30
8.6.3.3 Clean Water Dams 8-30
8.6.3.4 Dam Sizing 8-30
8.6.4 Dam Hazard Assessment 8-31
8.6.4.1 Dam Design and Management 8-33
8.6.4.2 Referable Dams 8-33
8.7 Unplanned Releases and Contingency Measures 8-34

Tables

Table 8-1 Estimated Water Demand 8-5
Table 8-2 Proposed Water Type and Water Quality Relationships 8-7
Table 8-3 Water Balance Model – Design Basis 8-8
Table 8-4 Groundwater Inflow Estimates (L/s) 8-9

Table 8-5 Salinity Profiles 8-11
Table 8-6 Release Conditions – Suttor River Catchment 8-16
Table 8-7 Release Conditions – Kangaroo Creek Catchment 8-16
Table 8-8 Maximum Mine Affected Water and Clean Water Dam Sizing 8-30
Table 8-9 Dam Hazard Assessment 8-32
Table 8-10 Design Criteria of Proposed Regulated Structures 8-33

Figures

Figure 8-1 Drainage Diversions 8-4
Figure 8-2 Water Balance for CHPPs 8-6
Figure 8-3 Proposed Compliance and Flow Monitoring Points 8-13
Figure 8-4 Mine Water Management – Year 1 South 8-18
Figure 8-5 Mine Water Management – Year 3 South 8-19
Figure 8-6 Mine Water Management – Year 5 South 8-20
Figure 8-7 Mine Water Management – Year 10 South 8-21
Figure 8-8 Mine Water Management – Year 25 South 8-22
Figure 8-9 Mine Water Management – Year 46 South 8-23
Figure 8-10 Mine Water Management – Year 16 North 8-24
Figure 8-11 Mine Water Management – Year 25 North 8-25
Figure 8-12 Mine Water Management – Year 46 North 8-26

8. WATER MANAGEMENT

8.1 Introduction

This chapter describes the water management strategy, mine site water balance and proposed mine water management system for the project, and is based on the technical report Mine Water Management Strategy provided in **Appendix 11.** Impacts associated with the operation of the water management system, and measures to mitigate impacts, are described in **Chapter 15 – Surface Water**, **Chapter 16 – Hydrology and Hydraulics**, **Chapter 19 – Aquatic Ecology** and other chapters where relevant.

8.2 Water Management System

The objective of the project water management strategy is to be able to manage water generated within the project area and reuse or control releases to the environment in a manner that does not cause adverse impacts to surface water quality or stream hydrology. Therefore the strategy aims to:

- release to the environment only when the receiving waterway is flowing or has recently flowed
- contain sediment within the mining area
- maintain water quality in the receiving environment within the ranges observed in the catchment prior to mining disturbance.

Water within the project area will be segregated based on quality. This will maximise opportunities for water reuse, minimise the mine water inventory and minimise changes to the hydrological regime (e.g. by allowing clean water to pass around disturbed areas). It also provides an opportunity to undertake controlled blending of different water types to improve the quality of water proposed for release.

Three water classifications have been nominated for the project:

- mine affected water, which is water from disturbed catchments or groundwater inflow into open pits, which is potentially unsuitable for direct discharge primarily due to salt concentration or alkalinity and / or which may contain sediment that requires removal prior to release
- sediment affected water, which is water from disturbed catchments, suitable for discharge after sediment removal in accordance with a water management plan
- clean water, which is water from undisturbed catchments bypassing mine affected areas, suitable for natural discharge.

There would be a need to move water around the site, which would be achieved using gravity open channel or pipes, or pumping.

Process water associated with the CHPPs and co-disposal facilities will be managed in a closed circuit such that there are no planned releases. The process water system is therefore not connected to the mine water management system.

Runoff from the MIA, CHPPs, coal stockpiles and other infrastructure areas, that is potentially contaminated (e.g. with oils), will be directed to other structures designed to improve the quality of the water such as an oily water separator or environmental control dam. It will then be released into the mine water system as mine affected water or sediment affected water, depending on water quality.

8.2.1 Mine Affected Water

Mine affected water may not be suitable for direct release, likely due to elevated salinity and alkalinity. This water may be generated from:

- groundwater ingress to open cut pits
- pit wall runoff
- runoff from fresh waste rock spoil dumping faces, prior to rehabilitation.

Water that accumulates in pits as a result of groundwater inflow and surface water runoff will be collected in sumps and pumped to mine affected water dams at the surface. Construction of levees and drainage diversions will also be required to ensure pit workings and mine infrastructure are protected from surface runoff.

Mine affected water will be contained in dams for periods of time until there is sufficient dilution to allow release to the environment and still achieve water quality objectives (refer **Chapter 15**). This may be achieved either through dilution in the receiving environment, blending water within the mining area or a combination of these strategies.

Mine affected water will be available for general site uses such as in dust suppression or coal washing (CHPP) if quality is deemed adequate at the time.

8.2.2 Sediment Affected Water

Areas that drain disturbed areas such as the MIA, coal stockpiles, recently rehabilitated waste rock dumps, access roads and laydown areas have the potential to generate sediment laden runoff. Sediment affected water would pass through sedimentation dams prior to release to the environment, once the applicable sediment concentrations have been satisfied. If these sources also contain elevated salinity, then they would be reclassified as mine affected water and included in that water circuit. Releases would be made in accordance with a water management plan that specifies the sediment load suitable for release.

On the basis of the waste rock characteristics (refer **Chapter 9**), it is likely the waste rock will be sodic and potentially dispersive. Sedimentation basins would therefore likely be required until the disturbed areas are sufficiently rehabilitated and stabilised.

Sediment affected water will be available for general site uses such as in dust suppression or coal washing (CHPP) if quality is deemed adequate at the time.

8.2.3 Clean Water

In most cases runoff from undisturbed catchments upstream of the mining area would be diverted around the disturbed area and released directly to the environment. Where this is not the case a clean water dam is proposed either to facilitate the diversion, or to provide a source of clean water that can be used to blend with mine affected water (if required) to facilitate release.

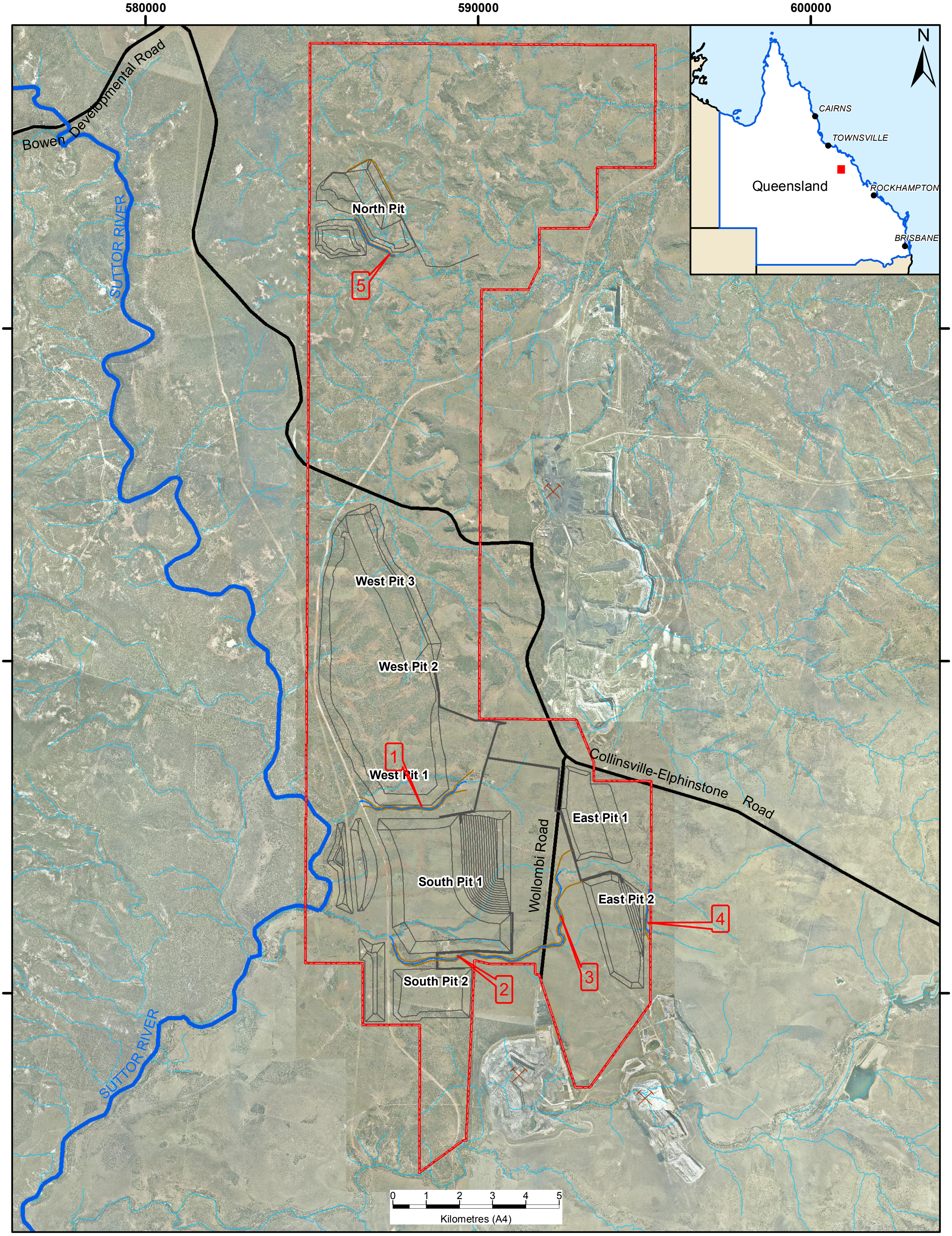
8.2.4 Drainage Diversions

The project will involve five diversions where existing watercourses or drainage lines are located within the footprint of open pits and / or waste rock dumps. The diversions are:

- Diversion 1 – a drainage line that intersects West Pit 1 will be diverted between West Pit1 and South Pit 1

- Diversion 2 – a drainage line / watercourse that intersects South Pit 1 will be diverted between South Pit 1 and South Pit 2
- Diversion 3 – connected to, and upstream of, diversion 2, which will divert a drainage line upstream of South Pit 1 into Diversion 2
- Diversion 4 – a drainage line that flows through East Pit 2 will be diverted north until it reaches another existing drainage line
- Diversion 5 – a drainage line that intersects North Pit will be diverted between North Pit and the out of pit waste rock dump

The design and hydrology of drainage diversions is described in **Chapter 16**. These diversions are shown in **Figure 8-1**.



Legend

- Project Area
- Waste Rock Dumps and Pits
- Existing Mine Site
- Suttor River
- Drainage Bund
- Drainage Diversion
- Drainage Line
- Formed Roads

Drainage Diversions

QCOAL GROUP

Figure 8-1

Byerwen Coal Project

environmental and licensing professionals pty ltd

Date: *30/01/2013*

Author: samuel.ferguson

Map Scale: 1:150,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

G:\CLIENTS\A-TO-D\BYEGEN - Byerwen EIS\GIS\Maps\EIS Chapters\EIS_Chpt_8_WaterManagement\BYEGEN_watercourses diversions.mxd

8.3 Process Water, Water Demand and Water Supply

Process water will be imported to site from an external supply source (SunWater's Burdekin to Moranbah pipeline system) and reused. The process water circuit, of which the CHPP is part, is a closed system fed by the external source. Supernatant or decant water from the co-disposal facilities will be recycled to the process plants for coal washing. Some water will be lost through evaporation, in coal processing or as part of the coal moisture content. This provides a consistent and reliable water source and it is therefore not included in the mine site water balance. This is considered a conservative approach to the mine water management strategy as the use of mine affected water is assumed as being reduced resulting in higher raw water usage and potentially larger than required dam sizes. A schematic of the water balance for CHPPs is provided in **Figure 8-2**. It should be noted that this is an estimate and assumes the CHPP/co-disposal system is already charged with water.

The estimated average and maximum water demands for the project is summarised in **Table 8-1**.

Table 8-1 Estimated Water Demand

Activity	Demand (MLpa)	
	Average	Maximum
Dust suppression	1,300	1,600
Vehicle washdown	70	70
Potable water	9	10
Northern CHPP raw water	1,000	3,400
Southern CHPP raw water	3,100	1,100
Total	**5,479**	**6,180**

The estimated average demand for process water at the southern and northern CHPPs is 3,100 MLpa and 1,000 MLpa respectively.

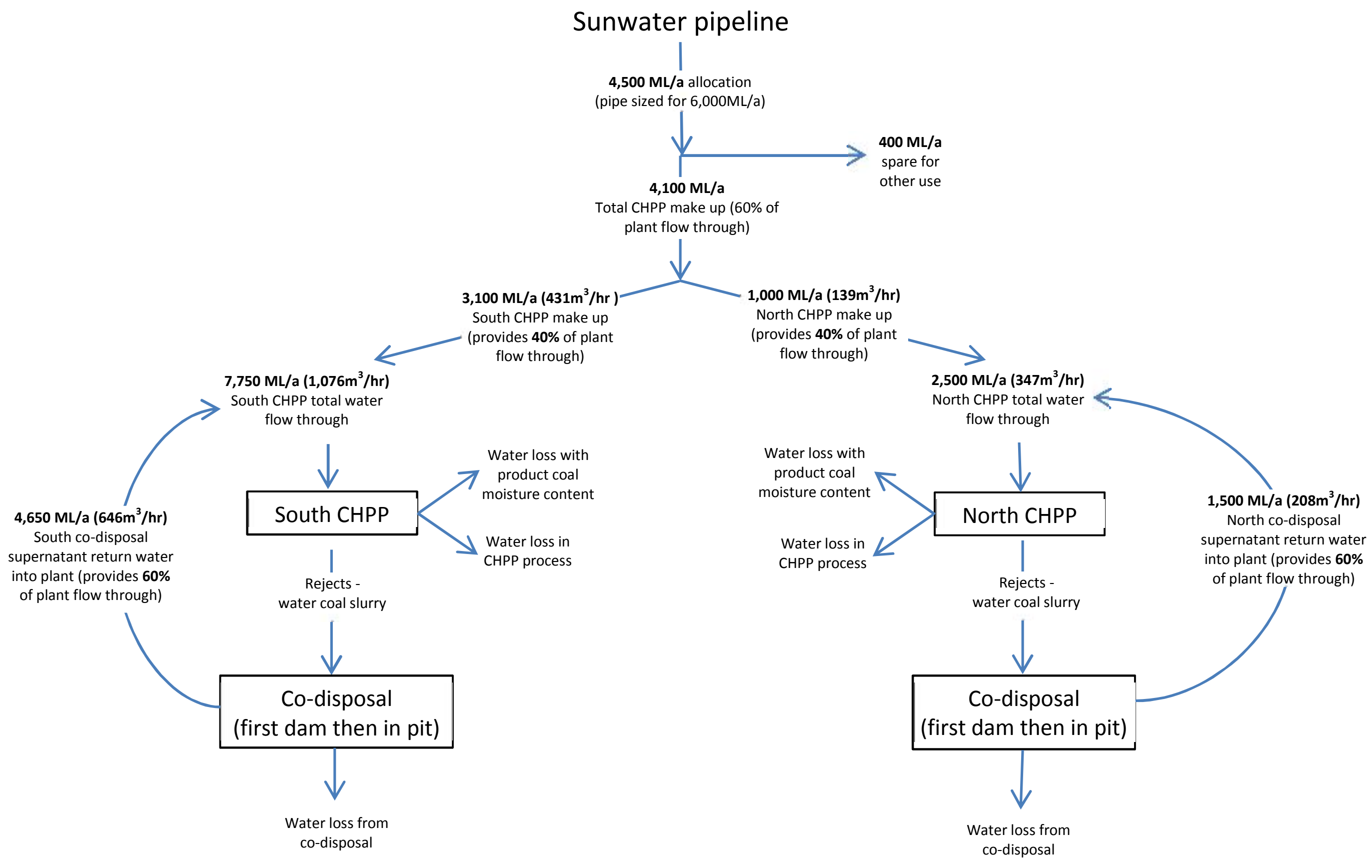


Figure 8-2 Water Balance for CHPPs

In addition to the process water demand, the following water volumes will also be demanded for dust suppression, vehicle washdowns and potable water:

- Up to 4.4 ML/d for dust suppression
- Approximately 0.2ML/d for vehicle washdowns
- Approximately 0.03ML/d for potable water, based on 50 L per person per day

The largest water demand at the project is coal washing (CHPP) and this would be satisfied through an external supply (SunWater's pipeline system) or from recovered process water. This is considered to be a reliable source. Water for dust suppression and vehicle washdowns can be satisfied from a number of sources including raw water from SunWater or mine or sediment affected water (where the quality is suitable). In the situations where water captured within the project dams cannot satisfy dust suppression demands, water would be sourced from the water allocation available from SunWater.

A combined fire, washdown and dust suppression reticulation system will be provided around the CHPPs, and will also service the site office and workshop facilities. Dust suppression sprays will be provided around the CHPP area, and will also service the CHPP site offices and workshops.

8.3.1 Potable Water

As there is no accommodation planned on the mining leases, approximately 50 L of potable raw water will be required per person per day. Water for potable water will be supplied by SunWater and treated to potable standard on site. The WTP will require various chemicals to treat the raw water including chlorine, ammonium sulphate, sodium hypochlorite and sodium hydroxide. All WTP chemicals will be transported in accordance with the Australian Dangerous Goods Code (Australian Transport Council, 2007) and stored in bunded tanks in accordance with requirements of relevant Australian Standards.

8.3.2 Water Conservation Measures

The co-disposal dam will contain a return water dam for reuse of decant water within the process plants. Water collected in water management infrastructure will, if of suitable quality, be used within process plants or for dust suppression and vehicle wash downs.

8.4 Mine Water Balance Model

The mine water balance model comprises modelling, in the mine water management system, of the volume of water and the salinity of water. The salinity of water is the primary constraint to the release of water from the mine water management system.

Catchments within the project area will change over time, as will the water quality draining from these catchments as the land use changes. A summary of the catchment areas, water type and water quality characteristics are provided in **Table 8-2**.

Table 8-2 Proposed Water Type and Water Quality Relationships

Catchment area	Water type	Water quality characteristics
Undisturbed land	Clean	Undisturbed
Pre-strip	Mine affected	Cleared/disturbed
Open cut pit	Mine affected	Waste rock
Active waste rock dump	Mine affected	Waste rock
Rehabilitation in progress	Sediment affected	Cleared/disturbed
Completed Rehabilitation	Clean	Undisturbed
Groundwater	Mine affected	Groundwater

8.4.1 Water Volume

A water balance model of the project was developed using Goldsim software, a package commonly adopted for mine site water balance studies. The scope of the water balance model covers the mine affected and clean water circuits of the project only. The sediment affected water circuit is not represented as the design basis for these dams is based on containment of a design storm event.

The model duration runs over the 46 year mine life, based on selected snapshots of project development phases. These snapshots have been weighted towards the earlier stages of mining where there is more certainty around the mine plan. The snapshots adopted were for years 1, 3, 5, 10, 16, 25 and 46.

The model includes all major components of the water balance including:

- Water inputs:
  - incident rainfall to dams
  - groundwater inflow to open pits
  - surface runoff from open pits
  - surface runoff from waste rock dumps.

- Water losses:
  - evaporative losses from dams
  - seepage losses from dams (excluded as assumed to be negligible)
  - dust suppression
  - releases to the environment.

The design basis adopted in the model is provided in **Table 8-3**.

Table 8-3 Water Balance Model – Design Basis

Aspect	Criteria
Simulation	Monte Carlo – 123 realisations of historical climate
Model timestep	Daily
Mine stages	Years 1, 3, 5, 10, 15, 16, 25, 40
Climate data	Datadrill record 1889–2012. Climate data (rainfall and evaporation) is provided in **Chapter 12** and **Appendix 11**. On average pan evaporation exceeds rainfall in every month of the year in the project area.
Lake evaporation	Moreton lake evaporation
Road dust suppression source	Mine water
Dam type	Combination of turkey's nest (flat site) and one clean water valley dam (dam C3 in natural drainage depression)
Dam stage-storage relationships	Embankments 1V:3H Maximum 6 m height (including freeboards)
Dam seepage	Seepage negligible (excluded)
Co-disposal	Treated as part of process water circuit and therefore excluded from mine water balance
Water quality	EC modelled only – as probability distributions
Groundwater flow	Based on hydrogeological assessment provided in **Appendix 18**
EC-TDS conversion	Assumed TDS (mg/l) = 0.67 x EC (µS/cm)
Release constraints	Maximum end-of-pipe discharge rate (varies with flow in receiving environment) – refer **Table 8-6** and **Table 8-7** Maximum end-of-pipe EC (varies with flow in receiving environment) – refer **Table 8-6** and **Table 8-7** Maximum receiving environment EC
Priority for release	Dams with highest volume in storage given highest priority to release.
Dam sizing	Satisfies the DSA requirement as per the DERM Manual for Assessing Hazard Categories and Hydraulic Performance of Dams (DERM, 2012) and a 5% chance of utilising the contingency measure over the life of mine

Aspect	Criteria
Land disturbance	As per mine staging plans provided in **Chapter 7** with the following assumptions: • pre-strip: 200 m in advance of pit edge • rehabilitation establishment period of 3 years

8.4.1.1 Catchment Hydrology

The project area is bisected by the sub-catchment divide for the Suttor River (Suttor River sub-catchment) and Kangaroo Creek (Rosella Creek sub-catchment). Both these subcatchments form part of the Burdekin River catchment. The catchment hydrology is further described in **Chapter 15**.

The Australian Water Balance Model (AWBM) has been used to derive catchment runoff time series for use in the water balance model. Two gauges are available relative close to the project that have been used to calibrate a daily runoff (AWBM) model. These are:

- Suttor River at Eaglefield (120304A) – The catchment area upstream of this gauge is 1,915 km^2. The record extends from 22/08/1967 to the present day (data extracted 4/09/2012). There were 2,659 missing entries (out of 16,451 entries), so provides a relatively complete record.
- Kangaroo Creek at Byerwen (120218A) – The catchment area upstream of this gauge is 390 km^2. The gauge was operational over the period 1980 to 1989, although there is a very high proportion of missing data (64% missing).

The calibrated hydrology model was able to match the flow duration curve and catchment yield very closely to the recorded data. This is further described in **Appendix 11**.

8.4.1.2 Groundwater Inflows

Groundwater inflow estimates used in the water balance model are described in **Chapter 17** and a summary is provided in **Table 8-4**. Flow rates generally increases over time as the pits progress deeper down dip. South Pit 1 and North Pit 1 are predicted to have the highest inflows. East Pit 1 is shallow relative to the groundwater table and does not intersect groundwater.

Table 8-4 Groundwater Inflow Estimates (L/s)

Year	East Pit 1	East Pit 2	South Pit 1	South Pit 2	West Pit 1	West Pit 2	West Pit 3	North Pit 1
1	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00
3	0.00	0.00	0.10	0.00	0.07	0.00	0.00	0.00
5	0.00	0.00	0.51	0.00	0.28	0.00	0.00	0.00
10	0.00	0.00	0.97	0.05	1.04	0.00	0.00	0.00
16	nd*	nd	nd	nd	nd	nd	nd	0.81
25	0.00	0.00	1.57	1.06	0.00	0.16	0.10	2.97
46	0.00	0.15	3.01	0.00	0.00	0.00	1.12	3.70

*nd = no data

8.4.2 Water Quality

The contaminant transport module was adopted as part of the Goldsim model to predict the movement and accumulation of salt within the system. The model couples salts associated with water inflows to determine the change in salt mass and associated concentration over time.

There is a range of water quality data available that can be used to estimate the likely quality of water both within the mine site and in the receiving environment, both of which will be fundamental in the design of the water management system. The data that is available is sourced from:

- surface water monitoring (refer **Chapter 15**)
- geochemical investigations of the rock types likely to be present in the waste rock dumps and exposed in the pit wall (refer **Chapter 9**)
- groundwater monitoring (refer **Chapter 17**).

Four separate salinity profiles were generated for the model:

- natural catchments within the Suttor River catchment
- natural catchments within the Rosella Creek catchment (which contains the Kangaroo Creek catchment)
- waste rock geochemistry
- groundwater quality

The profiles are assigned to the catchment types in the mine water management system. Each profile was derived based on available data sets (for each catchment) by arranging the data into histograms. Monitoring data was selected based on suitable reference sites (in the case of overland flow from external catchments), or observed conditions within the defined catchment system.

Table 8-5 provides the observed salinity data (measured as total dissolved solids) and the salinity profiles (probability distribution) adopted for modelling purposes for the various water types. Total dissolved solids (TDS) values for water draining from the waste rock catchment may be slightly underestimated at the upper and lower extremes of the dataset, but there is a good fit of the median values. Groundwater concentrations of TDS have a slightly longer “tail” of data at both ends of the probability distribution as well as a higher median value. The TDS distribution for the Kangaroo Creek catchment provides a good fit above the median, but overestimates the concentrations below the median. This is due to the unusual double peak in the distribution of raw data, however the adopted distribution is considered conservative and is well represented around the discharge threshold concentration (80^{th} percentile).

Table 8-5 Salinity Profiles

Percentile	TDS Waste Rock (mg/L)		TDS Groundwater (mg/L)		TDS Suttor River Catchment (mg/L)		TDS Kangaroo Creek Catchment (mg/L)	
	Raw Data	Probability Distribution	Raw Data	Probability Distribution	Raw Data	Probability Distribution	Raw Data	Probability Distribution
0.1	140	130	1,000	820	77	129	105	440
0.25	200	210	1,210	1,480	192	244	234	535
0.5	340	360	2,130	2,570	358	494	770	663
0.8	705	690	5,520	4,550	1,326	1,158	825	866
0.9	1,210	930	6,970	5,840	1,706	1,748	836	993
0.95	1,560	1,270	7,310	6,980	2,025	2,359	1,241	1,108
0.99	2,120	1,940	7,600	8,910	2,371	3,451	1,271	1,326
Mean		495		3,100		900		700
Standard deviation		742		2,200		1,300		230

8.5 Release Strategy

It will be necessary for the project to release water to the environment to balance the mine water inventory. This will be achieved through a controlled release strategy that allows discharge into the environment when water quality and flow conditions are within acceptable limits.

The proposed controlled release conditions for the Project have been developed based on the Model Water Conditions for Coal Mines in the Fitzroy Basin – Version 2, July 2012 (DEHP, 2012). Although the project is not located in the Fitzroy Basin, these guidelines reflect the current regulatory expectations regarding mine water management in the region and are therefore a useful guide.

The release conditions have been customised to suit the local catchment of the project area, as recommended in the ANZECC guidelines (ANZECC, 2000) and Queensland Water Quality Guidelines (QWQG) (DERM, 2009). The derivation of water quality objectives for the project is described in **Chapter 15**.

Salinity of mine affected water is the key constraint to water quality intended for release and is therefore the modelled water quality parameter. However, other water quality parameters will be measured during operations against the water quality objectives described in **Chapter 15**.

Release limits applicable to the project would be specified for electrical conductivity, pH, turbidity and sulfate.

Trigger investigation levels would also apply, which are values that if exceeded, trigger further investigation and reporting processes. This normally includes comparing upstream and downstream water quality data and assessing the risk of causing environmental harm. Trigger investigation levels apply to aluminium, cadmium, chromium, copper, iron, lead, nickel, zinc, boron, manganese, selenium, silver, uranium, vanadium, ammonia, nitrate, hydrocarbons and sodium.

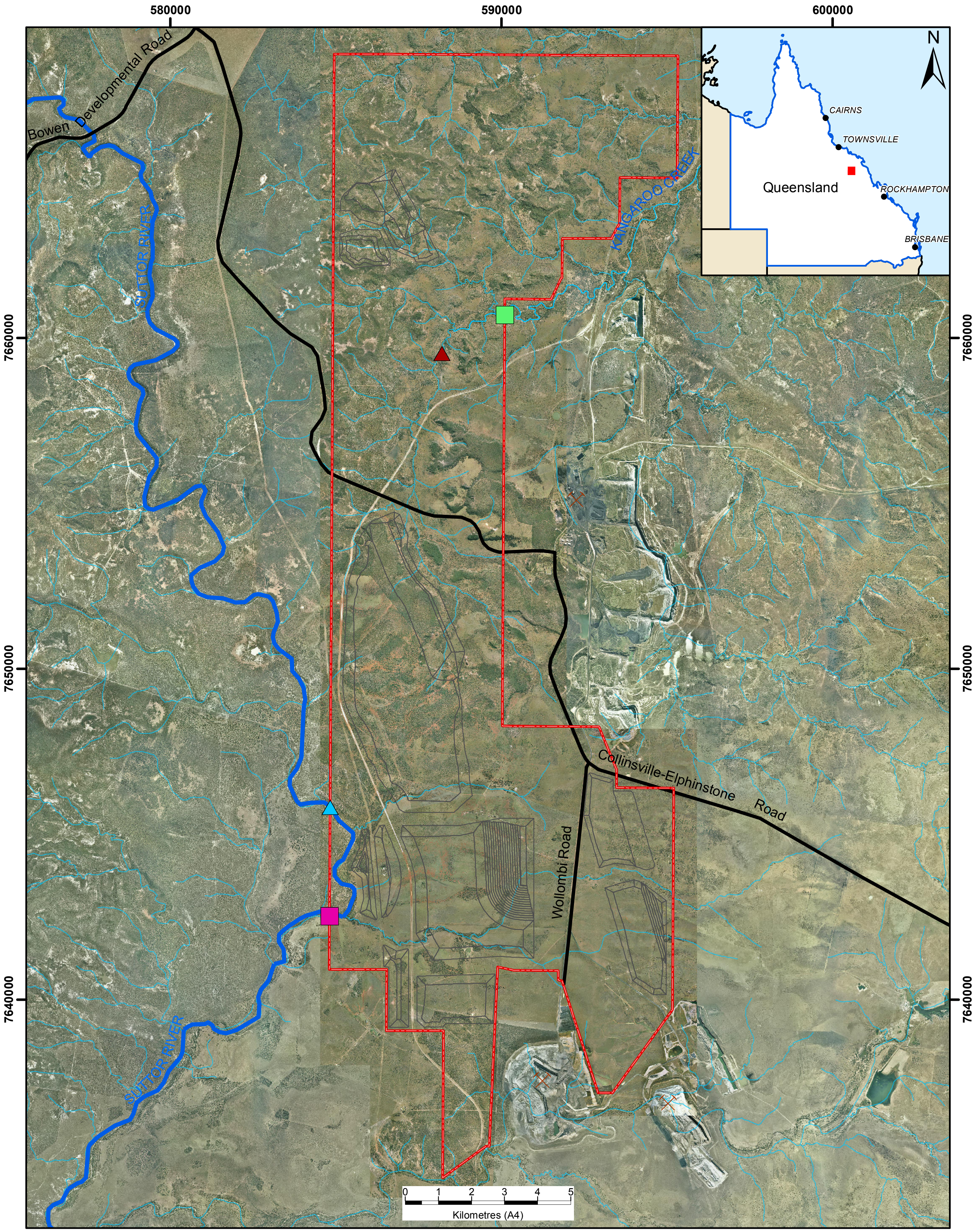
Exceedances of water quality objectives will trigger the management measures described in **Chapter 15**.

It is proposed that discharge of mine affected water to the environment will be permitted on the basis of:

- End-of-pipe water quality: This controls the water quality that enters the environment. A range of water quality indicators will be used to ensure the water quality is suitable for release. The salinity limits (measured as electrical conductivity) vary based on the flow in the receiving waterway.
- Flow in the receiving environment: Discharges will only be permitted during or immediately following flow in the receiving environment.
- Receiving waterway (downstream) water quality: This controls the water quality in the receiving environment at a downstream location, below a mixing zone. This provides an opportunity to utilise dilution in the receiving waterway, while ensuring that the water quality in the receiving waterway is maintained within a range experienced in the natural environment.

Flow in the receiving environment is ideally measured upstream of mine site discharges. This is possible in the Suttor River, but not in Kangaroo Creek since the discharge location from West Pit 3 is at the head of the catchment. In the absence of a non-mine affected analogue catchment with similar size, a flow gauging station is proposed downstream of the releases from West Pit 3, but upstream of releases from North Pit. Interpretation of the flow gauging data will need to consider the influence of any mine releases on the gauge.

Two receiving environment compliance points are proposed as shown on **Figure 8-3**. The receiving environment flow gauging monitoring points are also shown.



Legend

- Project Area
- Waste Rock Dumps and Pits
- Existing Mine Site
- Drainage Line
- Formed Roads

Compliance Points

- CP1
- CP2

Flow Monitoring Points

- MP1
- MP2

Proposed Compliance and Monitoring Points	QCOAL GROUP
Figure 8-3	**Byerwen Coal Project**
Date: *30/01/2013*	**Author:** samuel.ferguson
	Map Scale: 1:150,000
Revision: R1	**Coordinate System:** GDA 1994 MGA Zone 55

G:\CLIENTS\A-TO-D\BYEGEN - Byerwen EIS\GIS\Maps\EIS Chapters\EIS_Chpt_8_WaterManagement\BYEGEN_compliancepoints.mxd

environmental and licensing professionals pty ltd

8.5.1 Derivation of Release Rules

Release rules have been developed with the objective of ensuring releases do not result in unacceptable water quality in the receiving environment. Several factors were considered in order to ensure this objective is met:

- receiving environment flow
- receiving environment water quality
- mine release rate
- mine release water quality.

8.5.1.1 Receiving Environment Flow Triggers

Mine discharges are permitted when flow conditions in the receiving environment are above a minimum level, and are derived from a runoff event. Runoff can be separated into two components:

- surface runoff, defined as the immediate runoff response of a catchment due to saturated soils or rainfall intensity becoming greater than soil infiltration rate
- baseflow, typically the delayed runoff response of a catchment and is caused by shallow infiltration that later feeds the surface water systems.

An analysis of the waterways in the project was conducted using historical streamflow data in both river systems to identify the baseflow component and the typical flow conditions at which baseflow prevails. The waterways in the region are highly ephemeral and have flow approximately 40% of the time. Of this, approximately 20% is baseflow. Release of water during periods of baseflow is proposed with water of higher quality (low EC) and at lower release rates than release of water during storm-related surface runoff events. Storm-related surface runoff events occur only around 30% of the time and it is during these windows that dilution of lower quality (high EC) mine water with the receiving environment can occur.

The higher the flow rate the more releases that can occur without compromising the river hydrology or water quality. Three flow regimes have been nominated for the receiving environment:

- low/recession flow
- medium flow
- high flow.

Flow triggers were determined from historical streamflow records on both Suttor River and Kangaroo Creek. The records were filtered to eliminate non flow days and the resulting data used to determine river/creek characteristics during flow periods.

The medium flow trigger is representative of a surface runoff event and was calculated to be 5 ML/d (0.06 m^3/s) in the Suttor River and 1 ML/d (0.01 m^3/s) in Kangaroo Creek. This was calculated based on the 20th percentile during periods of flow and is reached approximately 30% of the time.

The high flow threshold trigger is 210 ML/d (2.4 m^3/s) in Suttor River and 100 ML/d (1.2 m^3/s) in Kangaroo Creek. This represents the 80th percentile during flow periods and is indicative of a substantial flow event which occurs approximately 8% of the time relative to the entire year.

The low/recession flow trigger is representative of periods of baseflow after a runoff event occurs. This flow regime is triggered after a medium flow event ceases and continues for 42 days thereafter.

In summary, Suttor River and Kangaroo Creek have no flow around 60% of the time. When there is flow in these waterways that is not storm-event related (i.e. baseflow) discharge would not occur, except for the period immediately following a substantial flow event. 80% of the time when flow is present in the receiving waterway, controlled releases from the mine will be permitted to occur, if required.

8.5.1.2 Receiving Environment Water Quality

The mine water system will be operated with consideration of the water quality objectives in the receiving environment, and be operated in a manner that meets these objectives. Water quality objectives have been derived to protect the environmental values in these waterways and have been developed based on a baseline monitoring program (refer to **Chapter 15**).

While a range of parameters will be monitored, the critical water quality indicator that is likely to constrain releases to the environment is salinity (measured as electrical conductivity). The electrical conductivity trigger values are based on the 80th percentile electrical conductivity values observed in the baseline monitoring program within each catchment using a reference site.

8.5.1.3 Mine Release Flow Thresholds

Mine release flow thresholds have been derived to meet several objectives:

- maximise opportunities for release of mine water during flow event windows
- control the maximum release rate from all dams into the river system, to ensure no adverse hydraulic issues (e.g. flooding, scour)
- ensure the river hydrology is not significantly altered by mine site releases.

Mine water releases will occur at a rate that ensures sufficient dilution is available in the receiving environment to meet water quality objectives. Therefore the mine water releases may not always occur at the maximum release rate.

The release locations would be configured to enable the mine to respond to release opportunities as soon as possible. This is likely to involve gravity release systems (e.g. sluice gates or weirs) that are controlled by telemetry systems. This would allow releases to be made when access is difficult and not be constrained by pumping capacity during release windows.

8.5.1.4 Mine Release Water Quality

Maximum limits have been derived for end-of-pipe releases to the environment. These vary depending on the flow in the receiving environment.

8.5.2 Proposed Release Rules

The release rules modelled for Suttor River releases and Kangaroo Creek releases are presented in **Table 8-6** and **Table 8-7** respectively. It should be noted that within the model all releases were stopped when the downstream compliance EC reached the compliance value (2,040 µS/cm in Suttor River and 1,270 µS/cm in Kangaroo Creek), including when the background levels were naturally outside this range.

Table 8-6 Release Conditions – Suttor River Catchment

Flow regime	Suttor River Upstream	Mine discharges		Suttor River Downstream
	Upstream flow trigger	Maximum combined discharge	End of pipe EC limit	Maximum EC during release
Low/No flow	Recession flow*	0.3 m^3/s	2,040 µS/cm	2,040 µS/cm
Medium	5–210 ML/d	2.9 m^3/s	2,500 µS/cm	2,040 µS/cm
High	>210 ML/d	10 m^3/s	6,500 µS/cm	2,040 µS/cm

** After a flow event exceeding 5 ML/d, release of high quality water (EC <2,040 µS/cm) is permitted for a period of up to 42 days after 'medium' flow ceases*

Table 8-7 Release Conditions – Kangaroo Creek Catchment

Flow regime	Kangaroo Creek Upstream	Mine discharges		Kangaroo Creek Downstream
	Upstream flow trigger	Maximum combined discharge	End of pipe EC limit	Maximum EC during release
Low/No flow	Recession flow*	0.1 m^3/s	1,270 µS/cm	1,270 µS/cm
Medium	1–100 ML/d	1.0 m^3/s	2,500 µS/cm	1,270 µS/cm
High	>100 ML/d	2.3 m^3/s	6,500 µS/cm	1,270 µS/cm

** After a flow event exceeding 1 ML/d, release of high quality water (EC <1,270 µS/cm) is permitted for a period of up to 42 days after 'medium' flow ceases*

8.6 Water Management Infrastructure

8.6.1 Overview

The mine water infrastructure requirements include six clean water dams, 14 mine affected water dams, 17 in-pit sumps and 27 sediment affected water dams. The conceptual layout of the dams (other than in-pit sumps) over the various mine stages of mine life in the southern and northern areas is shown in **Figure 8-4** to **Figure 8-12**. Mine affected water dams are denoted with an 'M', clean water dams with a 'C' and sediment affected water dams with an 'S'. Also shown on the figures are the catchment areas draining to the dams, the water transfer between dams and to the environment and the release points for water from dams. The indicative size of mine affected water dams and clean water dams is shown, but, due to their very small size (less than 1ha), a conceptual location of sediment affected water dams is shown.

These figures show the natural drainage lines without project infrastructure and the catchment divide between the Suttor River and Rosella Creek catchments.

The majority of water transfer would be done through open channel or with the use of polypipe or layflat hose. Release to the environment would be accomplished using a combination of weirs, sluice gates and pumping to allow for all high and low capacity discharge occurrences.

Smaller mixing dams will also be required at release points. These will allow controlled mixing of clean and dirty water before release. Mixing is predominately done during periods of recessional flow and therefore large amounts of mixing is not required and dam sizes would be small (i.e. <5 ML).

Release points of mine affected water dams will be on drainage lines to minimise the risk of scour with the exception of M3a, M3b and M5. Scour protection may be required at the latter's release point.

8.6.2 Description of Infrastructure Staging

8.6.2.1 Mine Infrastructure Areas

The MIAs are located at top of catchments and do not intersect watercourse but will require drainage design. Water from MIAs will be collected by sediment dams (S1, S12, S13) before being released to the environment.

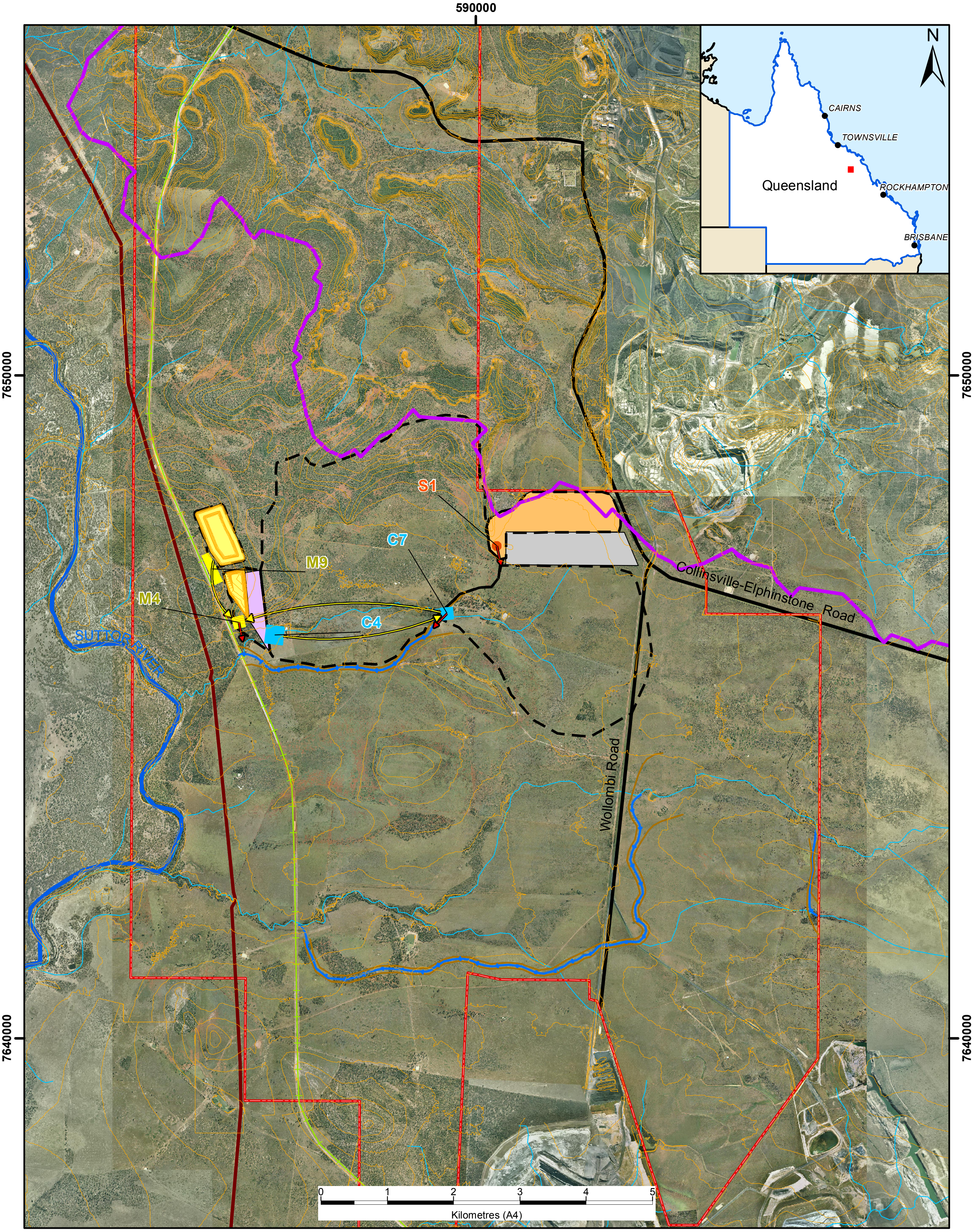
8.6.2.2 North Pit

A small drainage diversion is planned to allow water to bypass the North Pit and flow to a tributary of Kangaroo Creek. This drainage diversion and one clean water dams (C1) will be in place before mining operations commence at the North Pit. C1 will collect surface runoff from the surrounding valleys west of the North Pit 1 mining operations. This dam collects water from drainage lines that will not be affected by the drainage diversion.

A mine affected water dam (M1) will be required to accept groundwater or surface runoff that collects in the North Pit. This will be constructed south east of the pit. Water within the North Pit would collect in a sump and be pumped to M1.

Waste rock from the North Pit would be placed west of the pit. During initial stages of the dump construction, runoff from the dump has the potential to produce saline water. This water would be collected in M1. As the waste rock dump is progressively rehabilitated, salinity in runoff would reduce and sediment would become the primary concern for runoff generated from the dump. As salinity decreases to natural catchment concentrations sediment capture dams (S6 and S7) will be constructed south of the waste rock dump to collect sediment laden runoff. Sediment would settle out of the water column before being released to Kangaroo Creek.

Mine affected water would be mixed with water from the clean water dams before being released to the environment. Once mining operations cease in the North Pit, the North pit would remain open as a final void. The drainage diversion put in place would remain as a permanent structure to divert water around the North Pit and its final void. Once the waste rock dump has been rehabilitated the sediment, mine and clean water dams would be decommissioned.



Legend

- Project Area
- Main Catchment Divide
- Burdekin to Moranbah Pipeline
- GAP Rail line
- Drainage Bund
- Drainage Diversion
- Drainage Lines
- Subcatchments
- Clean Water Dam
- Mine Affected Water Dam
- Sediment Affected Water Dam
- Release to Environment
- Water Transfer
- Formed Roads
- Contour

Area Type

- Mine Affected Water Catchment
- Rehabilitated Waste Rock Dump
- Sediment Affected Water Catchment
- Pre Strip
- Co-disposal Area

Mine Water Management Year 1 South (10m)

QCOAL GROUP

Figure 8-4

Byerwen Coal Project

environmental and licensing professionals pty ltd

Date: *7/05/2013*

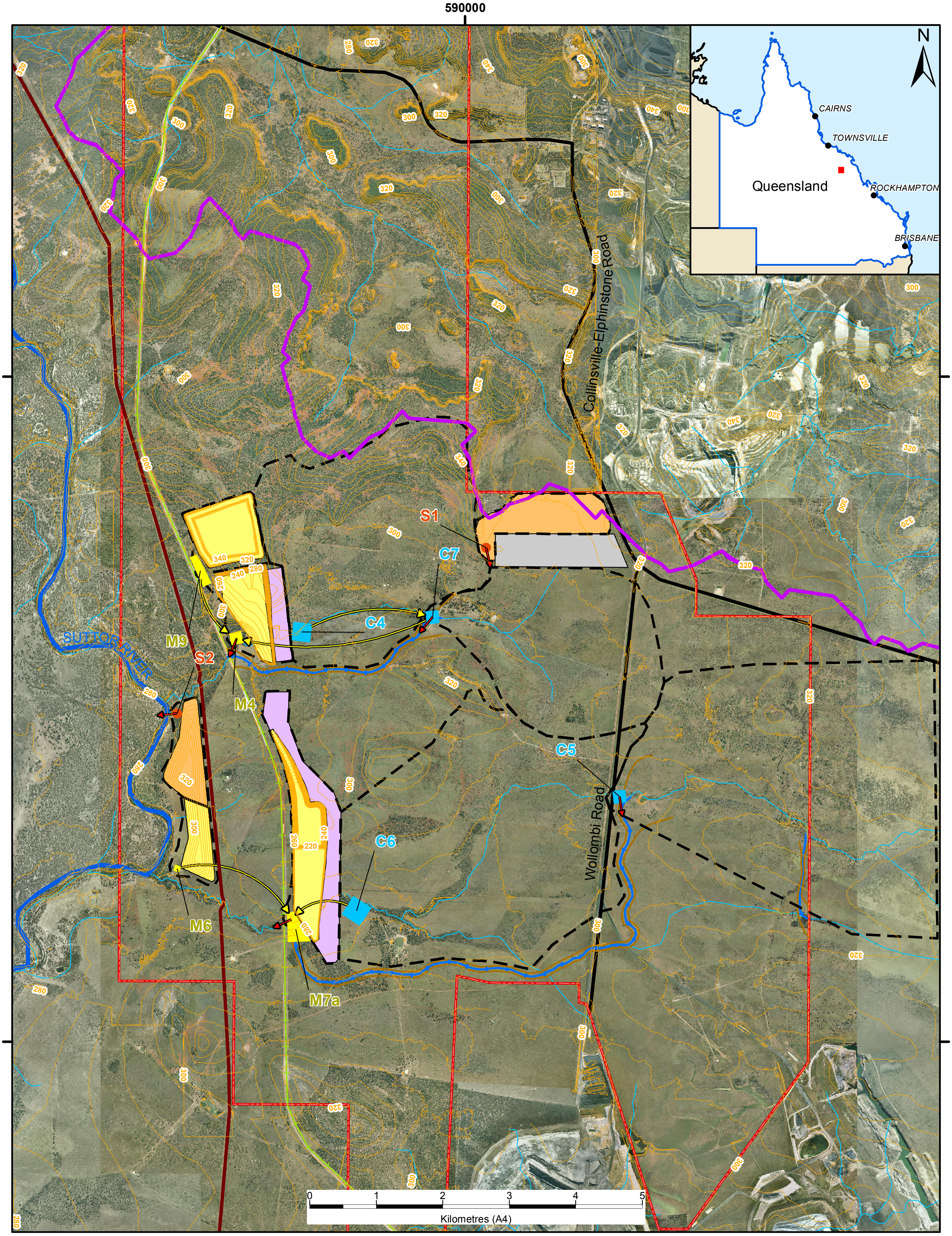
Author: samuel.ferguson

Map Scale: 1:75,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

G:\CLIENTS\A-TO-D\BYEGEN - Byerwen EIS\GIS\Maps\EIS Chapters\EIS_Chpt_8_WaterManagement\BYEGEN_MWM_Yr1_S.mxd



Legend

- Project Area
- Main Catchment Divide
- Burdekin to Moranbah Pipeline
- GAP Rail line
- Drainage Bund
- Drainage Diversion
- Drainage Lines
- Subcatchments
- Clean Water Dam
- Mine Affected Water Dam
- Sediment Affected Water Dam
- Formed Roads
- Release to Environment
- Water Transfer
- Contours

Area Type

- Mine Affected Water Catchment
- Rehabilitated Waste Rock Dump
- Sediment Affected Water Catchment
- Pre Strip
- Co-disposal Area

Mine Water Management Year 3 South

QCOAL GROUP

Figure 8-5

Byerwen Coal Project

environmental and licensing professionals pty ltd

Date: 7/05/2013

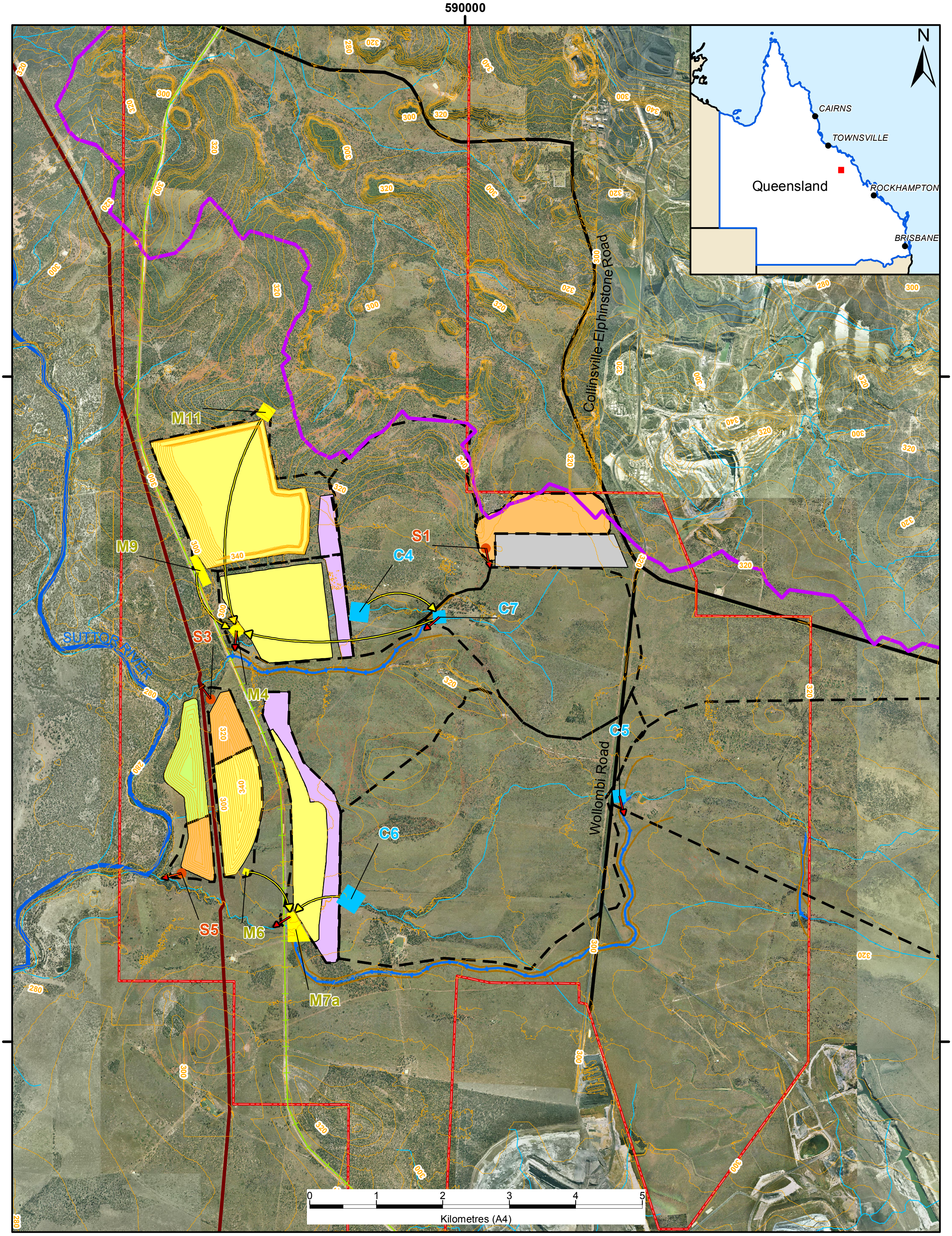
Author: samuel.ferguson

Map Scale: 1:75,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

G:\CLIENTS\A-TO-D\BYEGEN - Byerwen EIS\GIS\Maps\EIS Chapters\EIS_Chpt_8_WaterManagement\BYEGEN_MWM_Yr3_S.mxd



Legend

Project Area	Subcatchments	Contours
Main Catchment Divide	Release to Environment	**Area Type**
Burdekin to Moranbah Pipeline	Water Transfer	Mine Affected Water Catchment
GAP Rail line	Clean Water Dam	Rehabilitated Waste Rock Dump
Drainage Bund	Mine Affected Water Dam	Sediment Affected Water Catchment
Drainage Diversion	Sediment Affected Water Dam	Pre Strip
Drainage Lines	Formed Roads	Co-disposal Area

Mine Water Management Year 5 South

QCOAL GROUP

Figure 8-6

Byerwen Coal Project

environmental and licensing professionals pty ltd

Date: 7/05/2013

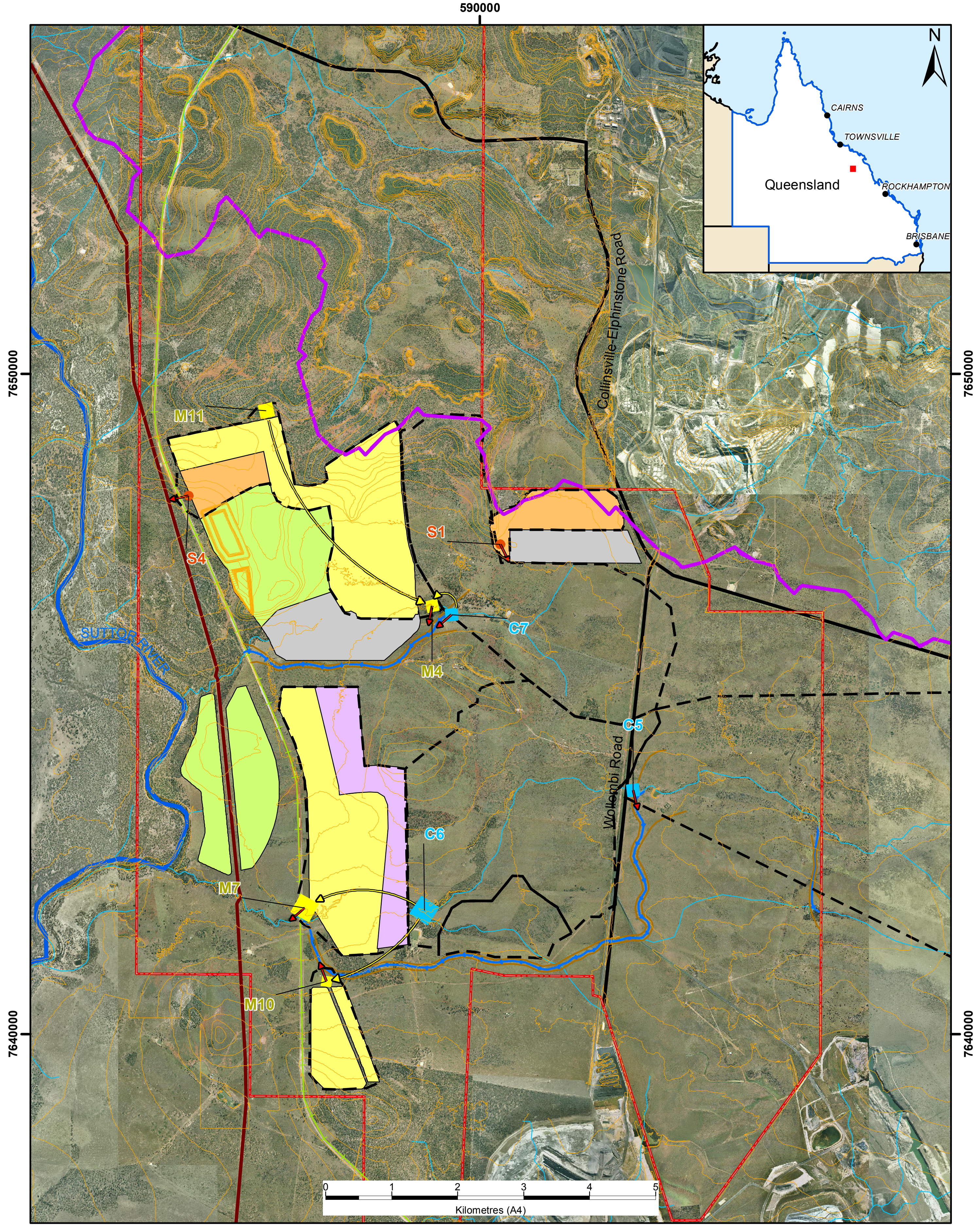
Author: samuel.ferguson

Map Scale: 1:75,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

G:\CLIENTS\A-TO-D\BYEGEN - Byerwen EIS\GIS\Maps\EIS Chapters\EIS_Chpt_8_WaterManagement\BYEGEN_MWM_Yr5_S.mxd



Legend

Project Area	Subcatchments	Contour
Main Catchment Divide	Release to Environment	**Area Type**
Burdekin to Moranbah Pipeline	Water Transfer	Mine Affected Water Catchment
GAP Rail line	Formed Roads	Rehabilitated Waste Rock Dump
Drainage Bund	Clean Water Dam	Sediment Affected Water Catchment
Drainage Diversion	Mine Affected Water Dam	Pre Strip
Drainage Lines	Sediment Affected Water Dam	Co-disposal Area

Mine Water Management Year 10 South

QCOAL GROUP

Figure 8-7

Byerwen Coal Project

environmental and licensing professionals pty ltd

elp

Date: 7/05/2013

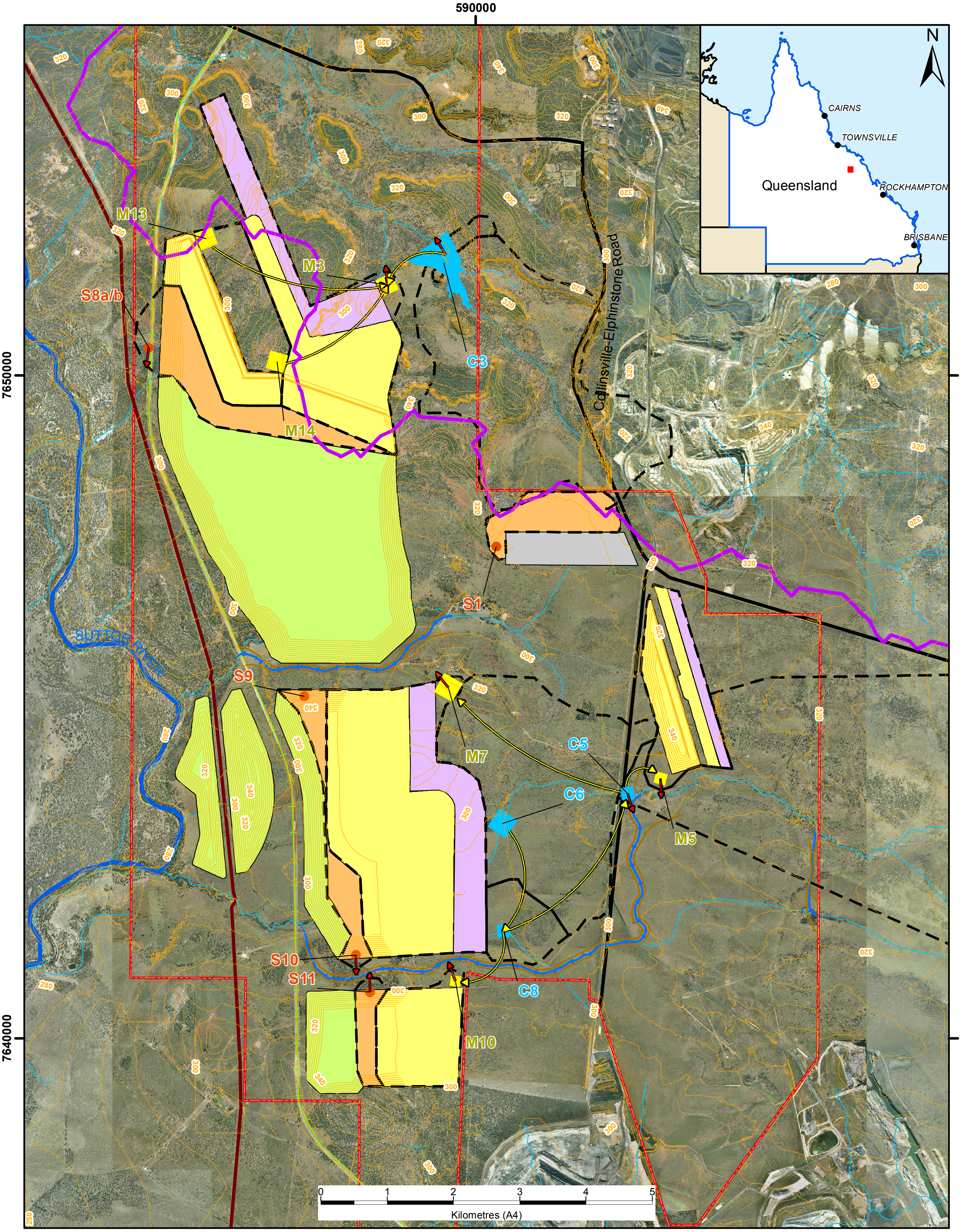
Author: samuel.ferguson

Map Scale: 1:75,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

G:\CLIENTS\A-TO-D\BYEGEN - Byerwen EIS\GIS\Maps\EIS Chapters\EIS_Chpt_8_WaterManagement\BYEGEN_MWM_Yr10_S.mxd



Legend

- Project Area
- Main Catchment Divide
- Burdekin to Moranbah Pipeline
- GAP Rail line
- Drainage Bund
- Drainage Diversion
- Drainage Lines
- Subcatchments
- Formed Roads
- Release to Environment
- Water Transfer
- Clean Water Dam
- Mine Affected Water Dam
- Sediment Affected Water Dam
- Contours

Area Type

- Mine Affected Water Catchment
- Rehabilitated Waste Rock Dump
- Sediment Affected Water Catchment
- Pre Strip
- Co-disposal Area

Mine Water Management Year 25 South

QCOAL GROUP

Figure 8-8

Byerwen Coal Project

environmental and licensing professionals pty ltd

Date: 7/05/2013

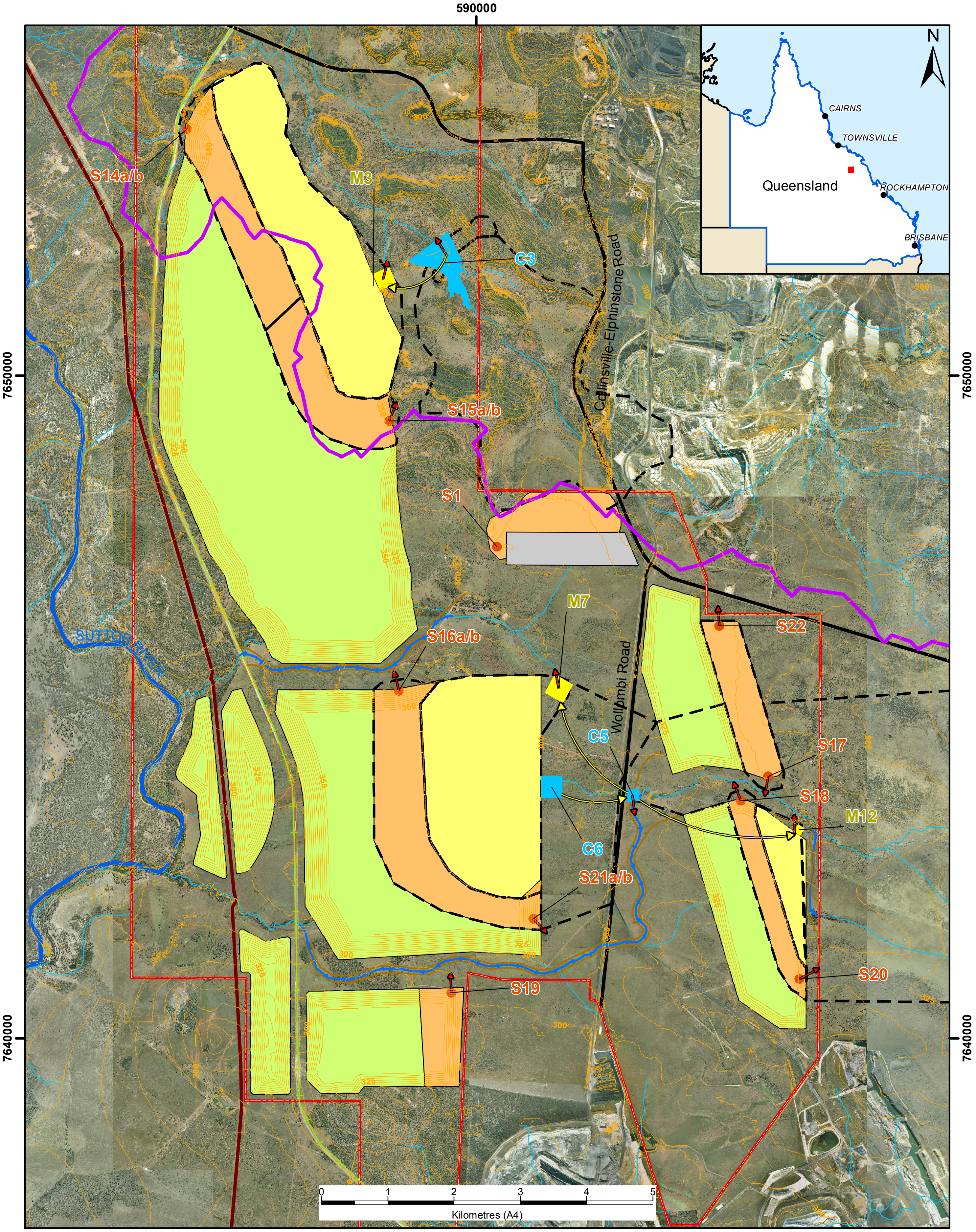
Author: samuel.ferguson

Map Scale: 1:75,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

G:\CLIENTS\A-TO-D\BYEGEN - Byerwen EIS\GIS\Maps\EIS Chapters\EIS_Chpt_8_WaterManagement\BYEGEN_MWM_Yr25_S.mxd



Legend

- Project Area
- Main Catchment Divide
- Burdekin to Moranbah Pipeline
- GAP Rail line
- Drainage Bund
- Drainage Diversion
- Drainage Lines
- Subcatchments
- Formed Roads
- Release to Environment
- Water Transfer
- Clean Water Dam
- Mine Affected Water Dam
- Sediment Affected Water Dam
- Contours

Area Type

- Mine Affected Water Catchment
- Rehabilitated Waste Rock Dump
- Sediment Affected Water Catchment
- Pre Strip
- Co-disposal Area

Mine Water Management Year 46 South

QCOAL GROUP

Figure 8-9

Byerwen Coal Project

environmental and licensing professionals pty ltd

Date: 7/05/2013

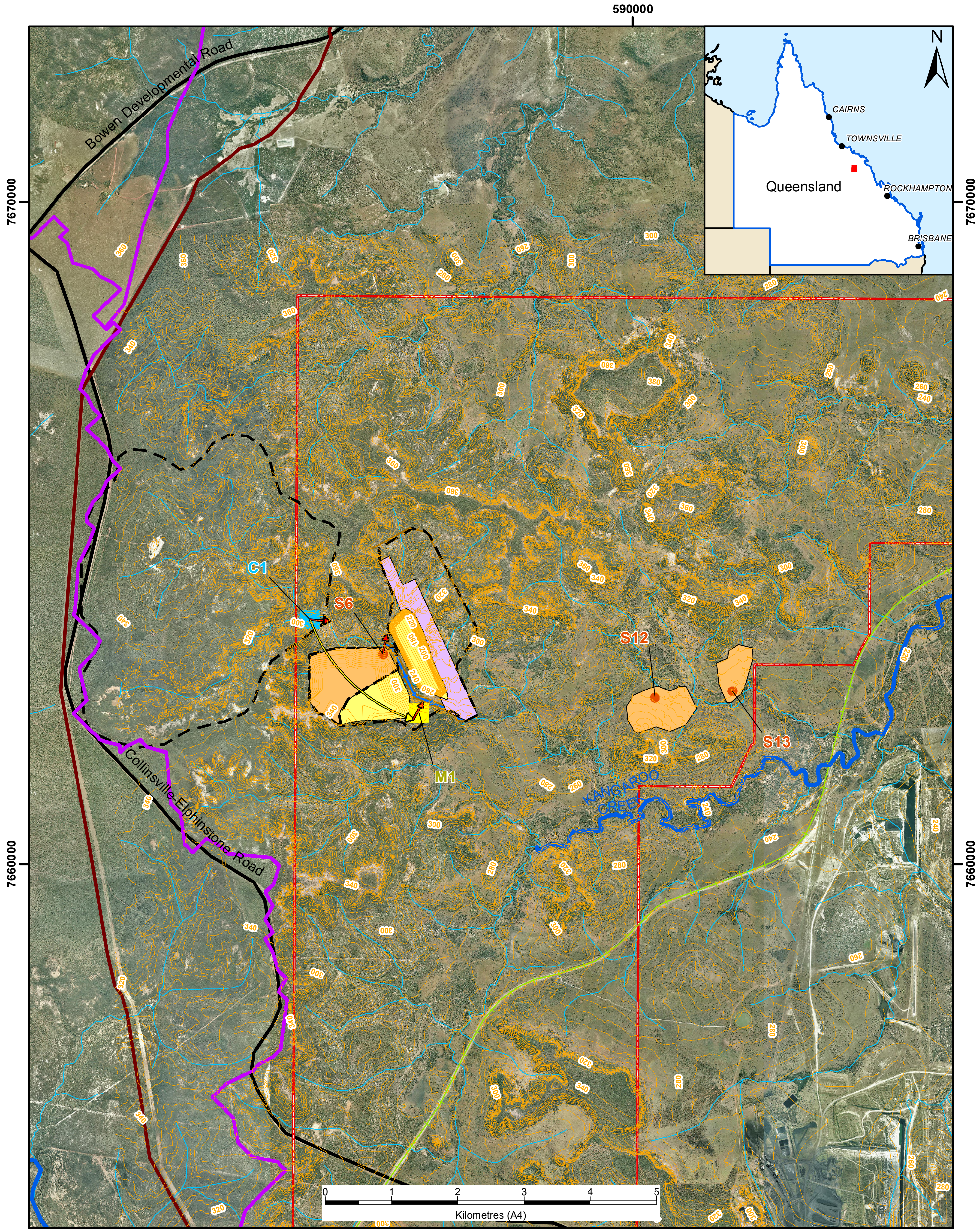
Author: samuel.ferguson

Map Scale: 1:75,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

G:\CLIENTS\A-TO-D\BYEGEN - Byerwen EIS\GIS\Maps\EIS Chapters\EIS_Chpt_8_WaterManagement\BYEGEN_MWM_Yr46_S.mxd



Legend

- Project Area
- Main Catchment Divide
- Burdekin to Moranbah Pipeline
- GAP Rail line
- Drainage Bund
- Drainage Diversion
- Drainage Lines
- Subcatchments
- Formed Roads
- Release to Environment
- Water Transfer
- Clean Water Dam
- Mine Affected Water Dam
- Sediment Affected Water Dam
- Contours

Area Type

- Mine Affected Water Catchment
- Rehabilitated Waste Rock Dump
- Sediment Affected Water Catchment
- Pre Strip
- Co-disposal Area

Mine Water Management Year 16 North

QCOAL GROUP

Figure 8-10

Byerwen Coal Project

environmental and licensing professionals pty ltd

***Date:** 7/05/2013*

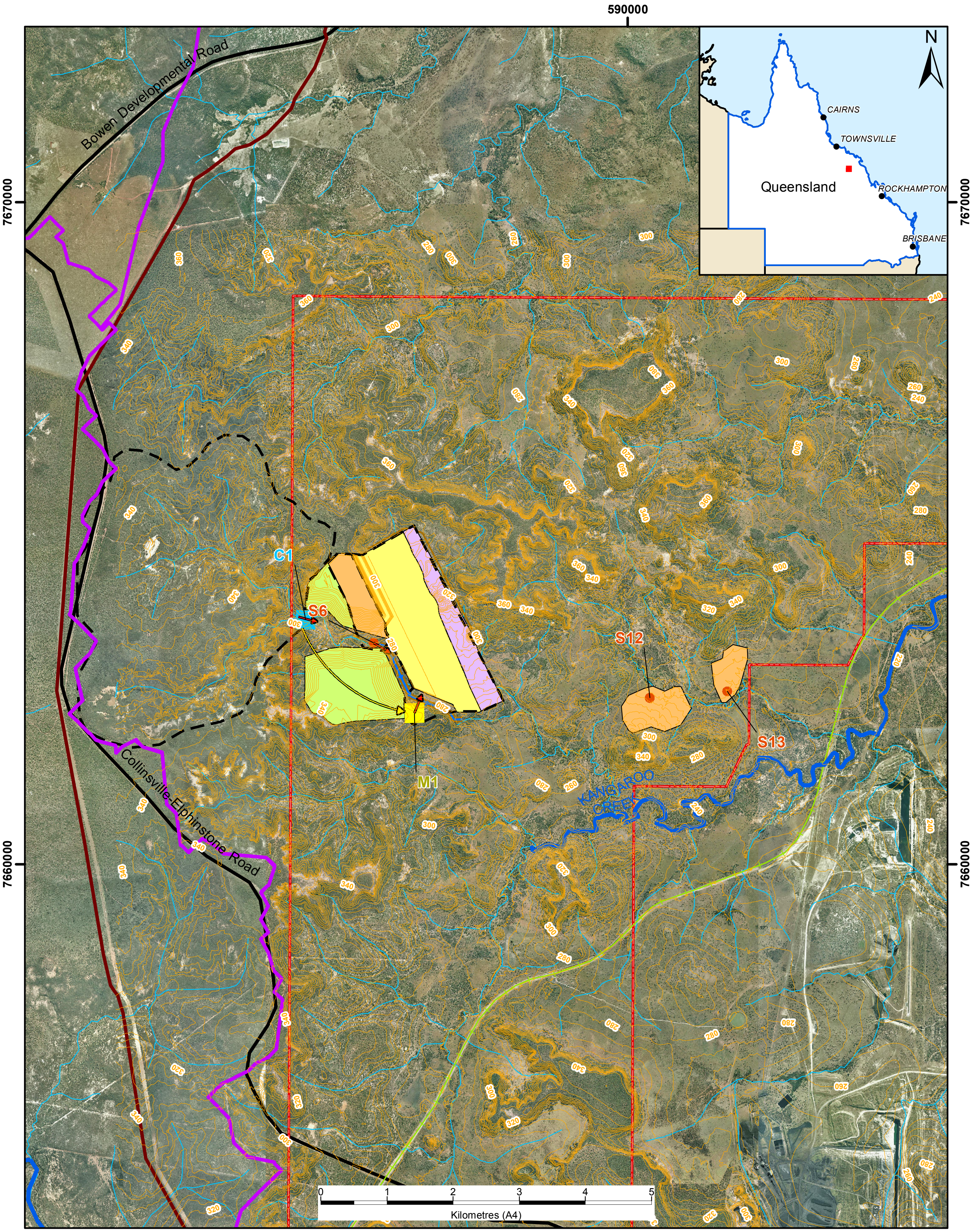
Author: samuel.ferguson

Map Scale: 1:75,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

G:\CLIENTS\A-TO-D\BYEGEN - Byerwen EIS\GIS\Maps\EIS Chapters\EIS_Chpt_8_WaterManagement\BYEGEN_MWM_Yr16_N.mxd



Legend

- Project Area
- Main Catchment Divide
- Burdekin to Moranbah Pipeline
- GAP Rail line
- Drainage Bund
- Drainage Diversion
- Drainage Lines
- Subcatchments
- Formed Roads
- Release to Environment
- Water Transfer
- Clean Water Dam
- Mine Affected Water Dam
- Sediment Affected Water Dam

Area Type

- Mine Affected Water Catchment
- Rehabilitated Waste Rock Dump
- Sediment Affected Water Catchment
- Pre Strip
- Co-disposal Area

Mine Water Management Year 25 North

QCOAL GROUP

Figure 8-11

Byerwen Coal Project

environmental and licensing professionals pty ltd

Date: *7/05/2013*

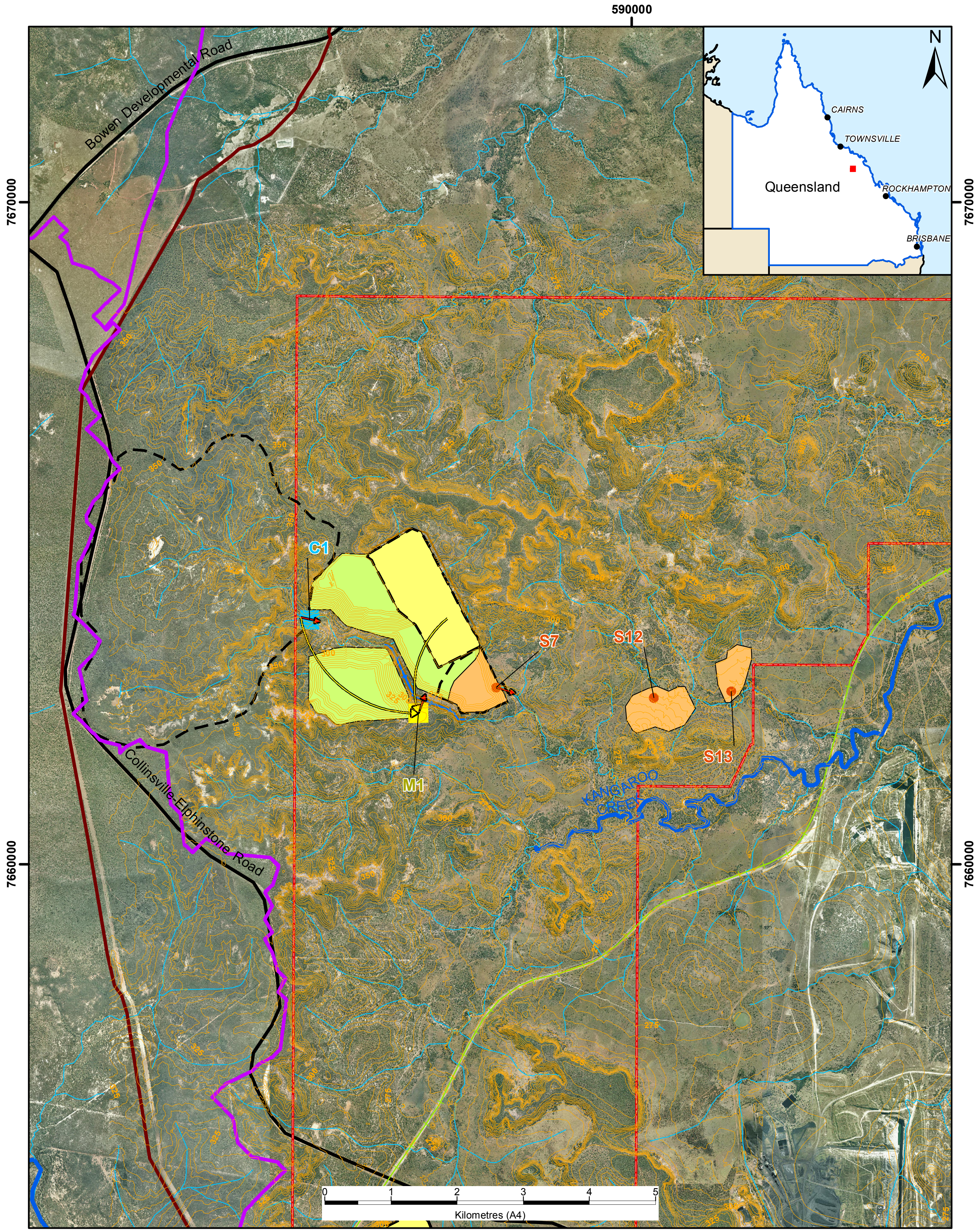
Author: samuel.ferguson

Map Scale: 1:75,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

G:\CLIENTS\A-TO-D\BYEGEN - Byerwen EIS\GIS\Maps\EIS Chapters\EIS_Chpt_8_WaterManagement\BYEGEN_MWM_Yr25_N.mxd



Legend

- Project Area
- Main Catchment Divide
- Burdekin to Moranbah Pipeline
- GAP Rail line
- Drainage Bund
- Drainage Diversion
- Drainage Lines
- Subcatchments
- Formed Roads
- Release to Environment
- Water Transfer
- Clean Water Dam
- Mine Affected Water Dam
- Sediment Affected Water Dam
- Contours

Area Type

- Mine Affected Water Catchment
- Rehabilitated Waste Rock Dump
- Sediment Affected Water Catchment
- Pre Strip
- Co-disposal Area

Mine Water Management Year 46 North (10m)

QCOAL GROUP

Figure 8-12

Byerwen Coal Project

Date: *7/05/2013*

Author: samuel.ferguson

Map Scale: 1:75,000

Revision: R1

Coordinate System: GDA 1994 MGA Zone 55

environmental and licensing professionals pty ltd

G:\CLIENTS\A-TO-D\BYEGEN - Byerwen EIS\GIS\Maps\EIS Chapters\EIS_Chpt_8_WaterManagement\BYEGEN_MWM_Yr46_N.mxd

8.6.2.3 West Pit Complex

The West Pit Complex comprises of three separate pits (West Pit 1, 2 and 3). The earliest mining at the site would take place in West pit 1 with some of the final stages of mining to be completed in West Pit 3. The progressive nature of the mining has been developed so that each of the three pits would operate in succession with minimal overlap. A drainage diversion will be required before mining in the West Pit Complex commences. While this realignment would divert water from upstream, there is still some catchment which would flow towards West Pit 1, particularly during the early stages of mining. As such, it is proposed that a clean water dam (C4) be constructed to store the clean water and prevent surface runoff from entering the mining area. The dam should be constructed along the current drainage path and would progressively move upstream (east) along that drainage line as West Pit 1 progresses. The clean water catchment would diminish accordingly. Water captured by C4 will be pumped to a stationary clean dam (C7) upstream. Water collected from this dam would be mixed with mine affected water and discharged at M4.

Initially any mine affected water collected in West Pit 1 would be diverted to a sump and be pumped to a M4. This dam would be located immediately west of West Pit 1, between the West Pit Complex and the GAP rail line in the former drainage line gully (which will be devoid of flow due to the drainage diversion).

Waste rock from West Pit 1 will be placed immediately north of the pit. This waste rock would be rehabilitated over time, initially however the waste rock would be a potential source of sediment laden runoff, and runoff with salinity. Water will be captured by dams M9 and M11 while salinity levels are above background levels. As salinity in the runoff decreases and the sediment laden runoff becomes the primary concern, water will be taken to a sediment dam (S4) before being released to the environment. This dam would allow sediment to settle from the water before release to the environment. This runoff capture dam would migrate north as required as the waste rock dump expands and the early waste rock is rehabilitated.

As the mining of West Pit 1 moves north (towards West Pit 2), mine affected water dams M11 and M9 will be decommissioned. M11 will be located north of the pit complex in an area that can be utilised by both West Pit 1 and West Pit 2 (overlap of use between the two pits would be minimal). The formerly mined West Pit 1 area would act as a disposal area for waste rock from West Pit 1 and South Pit 1 as this area is well located to prevent sediment laden flow from entering the environment. M11 can be decommissioned once the area is deemed to be sufficiently rehabilitated (around year 25 of operation).

Water falling within West Pit 2 will be initially diverted to an in pit sump and pumped to mine water affected dams (M3a and M3b) located to the east of the pit.

Waste rock from West Pit 2 would be disposed sequentially with waste rock from West Pit 1 and two mine water dams (M13 and M14) will capture saline runoff. Sediment dams (S8a and S8b) would be required as sediment laden runoff becomes the primary concern from the rehabilitating spoil. These dams will be placed between the western extents of the waste rock dumps, and the dumps shaped to allow flow into the sediment dam between the waste rock dump and West Pit 2 and 3. These dams can be placed in some of the formed gullies in the area and move north as required by the progressing spoil and mining extent. As the sediment dam moves north it can cater for the waste rock generated from West Pit 2 and West Pit 3 (which would also be placed sequentially). As the waste rock area moves north, further sediment affected water dams (S14a and S14b) would be required past the north eastern extent of the waste rock dump in addition to sediment dams (S15a and S15b) located to the south east of the rehabilitated waste rock.

A new clean-water dam (C3) would also be required to facilitate dilution for the release of the mine affected water captured from West Pit 2. The best option for a clean water capture in this area would be to dam one of the tributaries of Kangaroo Creek east of M3a/b. Water from M3a and M3b would be mixed with clean water from C3 before being released to the environment.

West Pit 3 will be the last pit to be mined and water will initially be diverted to a sump and pumped out to dams M3a and M3b.

Once operations in the West Pit Complex have been completed, the sediment affected runoff, mine affected water and clean water dams would all be decommissioned in that area. Approximately half of the extent of West Pit 3 would remain open as a final void.

8.6.2.4 South Pit 1

South Pit 1 would be bound to the north and south by drainage line diversions. To the north, drainage line diversion 1 would separate South Pit 1 from West Pit 1. The natural drainage line which intersects South Pit 1 would be diverted and would separate South Pit 1 and South Pit 2. The catchment which remains after the drainage realignment would be dammed by clean water dam C6 to prevent surface runoff from entering the mining areas of South Pit 1. As the mined area progresses east, the clean water dam would need to be repositioned. To complicate the repositioning of the dam is the junction in the natural drainage line. Once the mining has reached the point at which the two flow paths merge (or separate), two clean water capture dams would needed. As the clean water dam (C6) is a moving body, only one additional clean water capture dam would be constructed (C8). This is expected to happen around year 15 of operation. Both C6 and C8 would be pumped to a stationary clean dam (C5) upstream. This clean water dam would facilitate mixing for disposal of mine affected water from South Pit 1 and 2 as well as East Pit 1 and 2 at various stages of operation.

Initial mining would take place on the west of South Pit 1, progressively moving east. Initially a mine affected water dam (M7) would be constructed to the west of South Pit 1. As mining progresses M7 would be moved east of the mining operation and then finally to the north-east of South Pit 1 between the mining area and drainage diversion 1. Water from South Pit 1 would be released at M7.

Waste rock will be placed between the GAP rail line and Suttor River. A mine dam (M6) will be used to capture saline waters from the waste rock. Water from M6 will be transferred to M7 for release. As salinity becomes less of an issue with rehabilitation, sediment capture dams would be implemented at both ends of the waste rock dump (S2, S3 and S5). Further waste rock is to be located between the GAP rail line and South Pit 1. Similar sediment dam arrangements would be used for this spoil (S9 and S10). Once the waste rock dumps are sufficiently rehabilitated, the sediment capture dams will be decommissioned.

As the mining extent of South Pit 1 moves east, the generated waste rock would be dumped in the void remaining from the previous mining extents. As this dump develops, sediment capture dams (S16a, S16b, S21a and S21b) will be required on the northern and south eastern extents of the dump to capture sediment laden runoff and allow it to settle before discharging to the environment. Some waste rock will also be transported to the void from mining activities at West Pit 1.

After mining operations at South Pit 1 cease, the catchment of the clean water dam C6 would be reduced thereby reducing the volume of water that can be captured in that dam. The rehabilitation strategy involves removal of dam C6. **Chapter 11** provides a final void assessment including consideration of the clean water catchment that drained to dam C6. This shows that despite the catchment inputs, the final void would remain as a permanent sink and not result in any releases of water to the environment.

The clean water dam C8 will be decommissioned after the mining operations at South Pit 1 have ceased. The sediment capture dams and mine affected water dams would be decommissioned progressively. The north east extents of South Pit 1 would remain open as a final void. Following mine closure water from the catchment of C6 will report to the South Pit 1 final void. **Chapter 11** describes the impact of this on the levels of final void water, which will not result in final void water overtopping the void.

8.6.2.5 South Pit 2

The smaller of the south pits, South Pit 2 will not commence mining until year 10 of operation. South Pit 2 will be bound to the north by drainage diversion 2. Waste rock from South Pit 2 would be stored immediately west of the pit in two separate waste rock dumps. Two mine affected water dams (M8 and M10) would operate during the early stages. As sediment becomes the main concern, a sediment capture dam (S11) would take the place of mine affected water dams. Mining in South Pit 2 would progress from west to east. As the mining progresses the waste rock would be used to backfill the void and therefore M10 would reach a stage where it no longer acts as a mine affected water dam but rather as a sediment affected water dam.

Mine affected water collected from South Pit 2 would be blended with clean water collected before entering South Pit 1 and would be released into the drainage diversion 2 at M10.

Once mining operations in South Pit 2 have ceased, and the waste rock is sufficiently rehabilitated, the dams in the area would be decommissioned.

8.6.2.6 East Pit 1

Waste rock from East Pit 1 will be placed immediately west of East Pit 1 and the pit backfilled so that there is no final void. During operation, one mine affected water dam (M5) would be constructed south of East Pit 1. Water collected in this dam would be blended with clean water collected from C5 and released at M5. Sediment capture dams (S17 and S22) would also operate to the north and south of the waste rock dump. Water would be released to the environment through drainage diversion 2 after settling.

8.6.2.7 East Pit 2

East Pit 2 is located south of East Pit 1, separated by a natural drainage line. A drainage line runs through the mining area of East Pit 2 and will be diverted north to stop ingress of flow into the pit. Waste rock is proposed to be placed immediately west of East Pit 2 with a final goal of a rehabilitated waste rock dump over most of the mined area and a small void in the last area to be mined in that pit. During operation of East Pit 2, one mine affected water dam (M12) would be constructed north of East Pit 2. Water collected in this dam would be blended with clean water collected from C5 and released at M12. Sediment capture dams (S8 and S20) would also operate to the east of the dump. Water would be discharged to drainage diversion 2 after settling.

8.6.3 Dam Design and Sizing

8.6.3.1 Mine Affected Water Dams

The proposed water management system for mine affected catchments has been designed such that there are no unplanned releases to the environment. This has been achieved by:

- a probabilistic approach to design, such that all dams meet the required Design Storage Allowance (DSA) as per the Manual for Assessing Hazard Categories and Hydraulic Performance of Dams (the Manual) (DERM, 2012) and there is a 5% or lower chance that the pits will need to be used to store water
- viable contingency measures that may be used for extreme climate scenarios.

The DSA is the minimum storage allowance provided by a dam for the wet season. The adopted design criteria meets the standards required for the corresponding hazard rating of the containment structures (refer **Section 8.6.4**).

This means that there is a low risk that a contingency measure will be required. The design basis has been selected as this represents an appropriate balance between dam size and inconvenience to the mining operation associated with utilising a contingency measure.

Consideration was also given to the fact that the project will operate several open cut mining pits for the majority of the mine life, providing an opportunity for emergency storage in one pit while still being able to maintain mining operations in the remaining pits.

8.6.3.2 Sediment Affected Water Dams

Sediment dam volumes were designed based on containment of a 10 year ARI 24 hour design storm event.

8.6.3.3 Clean Water Dams

Clean water demands serve two purposes:

- protect the mining areas from catchment runoff
- provide a clean water supply for use in dilution to achieve end-of-pipe and downstream water quality objectives.

Clean water dams serving the first function are designed to have a very low risk of exceeding capacity, as the consequence of overtopping is likely to result in flooding of the pit. Preliminary sizing have been based on a 1% AEP. The dam volume is a function of pipe and pump out capacity, and a reasonable combination of storage volume and pump capacity has been selected, although this will be investigated in greater details during detailed design.

Clean water dams serving the second function have been sized based on the reliability of supply to meet site requirements. Care was taken to ensure natural catchment flows will continue (i.e. dam volumes are not excessively large).

8.6.3.4 Dam Sizing

The mine water infrastructure requirements were determined by running the water balance model in design mode and selecting dam capacities that satisfy the design criteria of the design storage allowance (DSA) (DERM, 2012) and met the acceptable level of risk of utilising an emergency contingency measure. For the purpose of modelling all mine affected water and clean water dams have been modelled as 'turkey's nest' type dams with the exception of C3 which is proposed as a valley dam and stage storage relationship has been extracted from survey data. The proposed mine affected water and clean water dam capacities are provided in **Table 8-8**. Sediment affected water dams will range in size between 15 and 54 ML (less than 1 ha per dam). In-pit sumps range in size between 173 and 362 ML, other than the East Pits which are 29 to 37 ML.

Table 8-8 Maximum Mine Affected Water and Clean Water Dam Sizing

Dam	Volume (ML)	Height (m)	Footprint (ha)*
Mine Affected			
M1	571	7.0	8.2
M3a	475	7.0	6.8
M3b	476	7.0	6.8
M4	183	7.0	2.6

Dam	Volume (ML)	Height (m)	Footprint (ha)*
M5	137	7.0	2.0
M6	29	4.0	0.7
M7	588	7.0	8.4
M8	127	7.0	1.8
M9	392	7.0	5.6
M10	130	7.0	1.9
M11	392	7.0	4.3
M12	60	5.0	1.2
M13	484	7.0	6.9
M14	484	7.0	6.9
Clean Water			
C1	100	7.0	7.1
C3	250	3.2	20.2
C4	469	7.0	6.7
C5	100	7.0	2.9
C6	651	7.0	9.3
C7	100	7.0	2.9
C8	150	7.0	2.1

8.6.4 Dam Hazard Assessment

The Manual for Assessing Hazard Categories and Hydraulic Performance of Dams (DERM, 2012) (the Manual) sets out the requirements for hazard category assessment and certification of the design of 'regulated structures'. Structures may be assessed as being in one of three hazard categories: low, significant or high. Where categorised as a significant or high hazard, the structure is referred to as a regulated structure.

The Manual describes the assessment process to determine the hazard category of the dams. Two failure event scenarios need to be considered in the assessment as follows:

- failure to contain
- dam break.

The following considerations need to be made when evaluating the failure scenarios:

- loss of life or harm to humans
- general environmental harm
- loss of stock
- general economic loss or property damage.

The minimum hazard category of a dam is at least 'significant' if a dam will contain, or could potentially contain, contaminants at concentrations which exceed the values or range shown in the Manual (also refer **Appendix 11**).

A dam hazard assessment was conducted for all mine affected water dams, co-disposal dams, sediment affected water dams and clean water dams, with details provided in **Appendix 11**.

All clean water dams and sediment affected water dams were classified as low hazard and are therefore not regulated dams. **Table 8-9** provides a summary of the dam hazard assessment for mine affected water dams and the north and south co-disposal dams. These dams are all assessed as regulated dams with majority having a significant hazard category and M7 and the two co-disposal dams having a high hazard category.

M7 is considered the only dam to be categorized with a high hazard rating for 'failure to contain' and 'dam break' scenarios. The dam break flow of M7 is 410 m^3/s which is greater than the diversion channel capacity into which it discharges, which will result in damage to the diversion channel as well as possible ingress of water into the mining pits. There is also potential for damage to the GAP rail line bridge downstream.

The co-disposal dams are considered to be within the high hazard category due to the types of material held and general environmental harm that would be caused by a dam break scenario and will be designed in accordance with the Manual.

Table 8-9 Dam Hazard Assessment

Dam	Volume (ML)	Failure to contain scenario	Dam break scenario	Containment scenario	Hazard category	Regulated structure?
M1	571	Significant	Significant	Significant	Significant	Regulated
M3a	475	Significant	Significant	Significant	Significant	Regulated
M3b	476	Significant	Significant	Significant	Significant	Regulated
M4	183	Significant	Significant	Significant	Significant	Regulated
M5	137	Significant	Significant	Significant	Significant	Regulated
M6	29	Significant	Low	Significant	Significant	Regulated
M7	588	Significant	High	Significant	High	Regulated
M8	127	Significant	Low	Significant	Significant	Regulated
M9	392	Significant	Low	Significant	Significant	Regulated
M10	130	Significant	Significant	Significant	Significant	Regulated
M11	392	Significant	Significant	Significant	Significant	Regulated
M12	60	Significant	Low	Significant	Significant	Regulated
M13	484	Significant	Significant	Significant	Significant	Regulated
M14	484	Significant	Significant	Significant	Significant	Regulated
South Co-disposal	10,000	High	High	Significant	High	Regulated

Dam	Volume (ML)	Failure to contain scenario	Dam break scenario	Containment scenario	Hazard category	Regulated structure?
North Co-disposal	900	High	High	Significant	High	Regulated

8.6.4.1 Dam Design and Management

The design criteria for regulated structures are presented in **Table 8-10**. The DSA for the site requires containment of the 1% and 5% AEP for high and significant hazard rating respectively. The method of operational simulation for performance based containment was used to determine the DSA with a safety factor or design simulation margin (DSM) of 50% added to the calculated DSA in accordance with the Manual. Structures requiring a DSA will be brought down to this level by the 1 November each year in preparedness for the upcoming wet season.

Table 8-10 Design Criteria of Proposed Regulated Structures

Aspect	Design (significant hazard)	Design (high hazard)
Wet season containment (DSA)	1:20 AEP	1:100 AEP
Storm event containment (MRL)	1:10 AEP 72 hour duration	1:100 AEP 72 hour duration
Spillway capacity	1:100 AEP To 1:1000 AEP	1:10 000 To 1:100 000 AEP
Flood level for embankment crest levels	1: 100 AEP + 0.5 m freeboard	1:1000 AEP + 0.5 m freeboard

Regulated structures will be subject to the normal obligations that must be satisfied for regulated structures, as shown below:

- submission of detailed designs and documentation by a suitably qualified engineer
- annual inspections by a suitably qualified engineer
- design of a spillway to cater for a specific ARI based on the hazard category assigned to the dams
- inclusion of a suitable DSA and Mandatory Reporting Limits (MRL)
- assessment of the potential impacts of any failure of the dam embankments.

Contaminant increases (particularly salinity) in mine affected water dams will be mitigated by regular releases of mine affected water in accordance with the release criteria described above.

There are no planned releases from co-disposal facilities and therefore no impacts to downstream environments. Dam design, construction and operation in accordance with the guidelines and management methods described above will result in very low risk of uncontrolled release or catastrophic failure of regulated dams. Contingency measures for unplanned releases are described below.

8.6.4.2 Referable Dams

Under the *Water Supply (Safety and Reliability) Act 2008* (Qld), dam assessment must include a Failure Impact Assessment in accordance with Guidelines for Failure Impact Assessment of Water Dams (DERM, 2010) if the dam being considered meets the following criteria:

- more than 10 m in height and have a storage capacity of more than 1,500 ML, or

- more than 10 m in height and have a storage capacity of more than 750 ML and a catchment area that is more than three times its maximum surface area.

The southern co-disposal dam is the only dam within the project's water management systems that may be considered a referable dam, all other dams are not referable. A Failure Impact Assessment will be completed by the proponent, if required, when detailed designs of the southern co-disposal dam are available.

8.7 Unplanned Releases and Contingency Measures

The design of the water management strategy reduces the risk of unplanned discharges to the environment through the following:

- minimising clean water catchments entering mine affected catchments
- developing rules that provide opportunities to reduce the mine affected water inventory without compromising the downstream water quality.
- maintaining the required DSA at the beginning of the wet season
- having contingency measures (see below) available in the event that a dam exceeds it operational storage capacity
- a system that allows the mine infrastructure to perform as planned (i.e. pumps activate at pre-determined triggers, and discharges occur when release rules are met)
- backup equipment (pumps, monitoring devices) that can be utilised in the event of a failure of the duty equipment.

Despite these measures, there remains a risk of unforeseen circumstances occurring. These may include geotechnical failure of dam walls, extreme climatic sequences never experienced in the historical record (or beyond design capacity), equipment failure or operator error.

The time at which such events may occur cannot be predicted, however it is reasonable to assume they would be associated with high rainfall periods when there is also likely to be high flows in the receiving environment. In terms of water quality impacts, this means that the unplanned release is likely to be a small component of the existing flow. The main water quality concern associated with the project is salinity, and any salinity associated with unplanned releases would quickly be diluted.

Any unplanned release from the southern co-disposal dam would flow towards and along the diversion channel between West Pit 1 and South Pit 1 and then into the Suttor River. Any unplanned release from the northern co-disposal dam would flow towards and along a tributary of Kangaroo Creek and then into Kangaroo Creek.

In the event of higher than anticipated groundwater ingress, or exceptionally wet conditions, it is possible that surplus water would be generated. Contingency measures that would be considered to prevent uncontrolled releases to the environment include:

- transfer of water between dams to balance storages
- use of mine affected water in the processing circuit
- emergency storage of surplus water in an open pit (this may temporarily suspend or slow mining)
- enhanced evaporation (e.g. mist irrigation over waste rock dumps)
- preferential use of surplus water for general site requirements (e.g. dust mitigation) where the quality is acceptable.

Trigger levels would be identified during detailed design that would trigger various actions, and if the water inventory approaches the storage capacity, contingency measures would be instigated.