Appendix 11

Mine Water
Management Strategy

BYERWEN COAL PROJECT

Mine Water Management Strategy

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Revision History

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Glossary

AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval, which describes the average, or expected, value of the periods between exceedances of a given rainfall total accumulated over a given duration.
AWBM	Australian Water Balance Model, which is a widely applied hydrological model based on partial area saturation overland flow.
BOM	Bureau of Meteorology
CHPP	Coal Handling Preparation Plant, where coal is washed to increase the quality of the product
Clean water	Water from undisturbed catchments, suitable for discharge without treatment
CP	Compliance Point
Datadrill	Continuous patched-point meteorological datasets for any given location in Australia
DERM	Department of Environment and Resource Management (now EHP)
DSA	Design Storage Allowance
EA	Environmental Authority
EC	Electrical Conductivity
EHP	Department of Environment and Heritage Protection (formerly DERM)
ESP	Exchangeable sodium percentage
GAP	Goonyella to Abbot Point
Mine-affected water	Water from disturbed catchments, potentially unsuitable for direct discharge due to salt concentration. It may also contain sediment that requires removal prior to release to the environment.
ML	Mining Lease
MRL	Mandatory Reporting Level
Pan evaporation	Evaporation measured in a Class A pan
Pan factor	Relationship between pan evaporation and evaporation observed from a large open waterbody.
ROM	Run Of Mine, coal delivered from the pit face prior to washing
RP	Release Point
Sediment-affected water	Water from disturbed catchments, suitable for discharge after sediment removal
Sedimentation dam	A structure that is designed to settle suspended sediment
TDS	Total dissolved salts
VRC	Volumetric Runoff Coefficient, which defines the proportion of rainfall appearing as runoff over the long term
WRD	Waste rock dump

1 Introduction

1.1 BACKGROUND

Kellogg Brown & Root Pty Ltd (KBR) has been commissioned by Byerwen Coal Pty Ltd (the Proponent) to develop a site water management strategy and water balance for the Byerwen Coal Project (herein referred to as the ‘Project’). The Project is located in central Queensland around 130 km west of Mackay within the headwaters of the Burdekin Basin. This report presents the following:

- Water management philosophy for the Project, which involves segregation of water types based on quality.
- Expected water quality from the mine affected catchments.
- Release strategy, modelled on the Fitzroy Basin model water conditions (in the absence of similar model conditions for the Burdekin Basin).
- Water management infrastructure, including conceptual arrangement of dams, mixing locations, release points and downstream compliance points.
- Water demands and supply arrangements.
- Contingency measures that would be implemented during water surplus and water deficit situations.
- Water balance model description, design basis and indicative water infrastructure requirements.
- Impact assessment in terms of hydrology, hydraulics and water quality.

This package of work forms part of a wider study of the proposed Project providing technical information which will be input into the Environmental Impact Statement (EIS) for the Project.

1.2 WATER MANAGEMENT OBJECTIVES

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.

1.3 PROJECT COMPONENTS

Waste Rock Dump (WRD)

Waste rock is scheduled to be placed back into each pit from approximately year three of the commencement of operations of that pit. There are six pit operational areas (South Pit 1, South Pit 2, East Pit 1, East Pit 2, West Pit Complex and North Pit 1) where this will occur, Waste rock will be dumped in-pit once the initial mining strips are established, however out of pit dumping will continue sporadically over the life of mine. During the initial years of pit operations, waste rock will either be trucked or crushed (in-pit) and conveyed to out of pit dumps. Runoff from WRDs will be captured by on site dams.

Coal Handling and Preparation Plant (CHPP)

There will be two CHPPs used for the Byerwen Project, the southern CHPP and the northern CHPP. Waste streams from the CHPPs include coarse and fine rejects and process water. Process water will be recovered and recycled to the maximum possible extent.

Mine Infrastructure Area (MIA)

There will be two MIAs, one in the southern tenement area adjacent to the southern CHPP and one in the northern tenement area adjacent to the northern CHPP. Both MIAs will contain similar facilities although the northern MIA will be smaller than the southern MIA. The northern MIA will support production of 5 Mtpa ROM compared to 15 Mtpa ROM from the southern tenement area. The southern MIA is located at the top of the catchment and does not intersect any watercourses. The northern MIA is located on a small tributary of Kangaroo Creek and standard drainage design (culverts and overland flow paths) will allow avoidance of nuisance flooding. Oil/water separators would be provided in locations where floatable contaminants could be discharged, such as vehicle maintenance facilities.

Co-disposal facility

Coarse rejects material will report to the rejects hopper from where it will be directed to the co-disposal sump or a reclaim bunker. If necessary, reclaim bunker material can be reclaimed by front end loader. The thickener underflow material will be pumped to the co-disposal sump where it will be slurried and combined with other reject material for pumping to the co-disposal facility.

Two co-disposal dams will be required, one for the northern CHPP and one for the southern CHPP. The southern co-disposal dam will hold approximately 10,000 ML and be 2,000 m by 500 m by 10 m deep. The northern co-disposal dam will hold approximately 900 ML and be 300 m by 300 m by 10 m deep.

Recoverable water from the co-disposal dam will flow into a return water dam from where it will be recirculated through the CHPP as required.

Infrastructure corridors

There are two infrastructure corridors within the project tenements, the central infrastructure corridor and the southern infrastructure corridor.

The central infrastructure corridor will connect the southern CHPP and MIA to the northern CHPP and MIA and contain:

- road for light and heavy mine site vehicles
- power lines
- raw water supply pipeline
- communications.

The central infrastructure corridor will be used for the transfer of mining equipment between the various pits in the Project so as to limit impacts on public roads.

The southern infrastructure corridor will connect the Goonyella to Abbot Point (GAP) railway to the southern CHPP and contain:

- southern rail line
- drainage diversions to divert water flowing between West pit 1 and South pit 1
- raw water supply
- power lines.

Where roads or the rail loop crosses watercourses culverts or bridges would need to be constructed.

1.4 OTHER RELATED REPORTS

This study draws on inputs from a range of other studies that have been completed for the Project. These include:

- Surface Water Quality Report – KBR (2012a).
- Flooding Assessment – KBR (2012b).
- Final Void Assessment – KBR (2012c).
- Hydrogeological Assessment – Rob Lait & Associates (2012).
- Geochemistry Assessment – Terrenus Earth Sciences (2012).
- Mine plan designs developed by Minserve.

Refer to the EIS for a more detailed description of the Project during construction, operation and decommissioning phases.

2 Water management approach

2.1 WATER SEGREGATION

Water within the Project area would be segregated based on quality. This would 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, which might be desirable to dilute waters of higher electrical conductivity for example.

Three water classifications have been nominated for the Project:

- Mine-affected water, which would be water from disturbed catchments and groundwater inflow into the pits. Mine-affected water is potentially unsuitable for direct discharge primarily due to salt concentration or alkalinity. It may also contain sediment that requires removal prior to release.
- Sediment-affected water, which would be water from disturbed catchments, suitable for discharge after sediment removal in accordance with a water management plan that would be prepared for the Project such as areas undergoing rehabilitation and the MIAs.
- Clean water, which would be 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 where possible. Water pumping would also be required, which would most likely be implemented using polypipe or layflat hose.

2.1.1 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.

Process water associated with the CHPP and co-disposal facility would be managed in a closed circuit such that there are no releases. The process water therefore does not form part of the mine-affected water circuit and is not included in this study.

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

Mine-affected water would be contained on site in dams for periods of time until there is sufficient dilution to allow release to the environment and still achieve water quality objectives. 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.

2.1.2 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 would be prepared for the Project.

On the basis of the soil and waste rock characteristics, the waste rock may be 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.

2.1.3 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. In some cases 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.

There are three locations where mining pits intersect a drainage line and a clean water pump-out arrangement is required. This occurs as follows:

- West Pit 1 – A clean water dam (Dam C4) would be required on the eastern side of the active mining pit. The location of the dam would shift (east) along the catchment as the mining face progresses. The extent of the clean water catchment would diminish as mining progresses, until at the end of mining none would remain and the dam would no longer be required. C4 would pump to a permanent clean dam upstream (C7) which will be used for blending with mine affected water (M4). A permanent drainage realignment would be implemented for the catchment upslope of the mined extent. This realignment would be constructed at the beginning of mining in this area.
- South Pit 1 – Two clean water dams (Dam C6 and C8) would be required to drain a clean catchment cut off by South Pit 1 mining disturbance. The location of the dams would shift (east) along the catchment as the mining face progresses. initially

only one dam would be required, however once mining progresses to a point where the catchment flow path junction exists, when the original dam (C6) would continue moving to the north, while the new dam (C8) would shift east. The extent of the clean water catchments would diminish as mining progresses, until at the end of mining the remaining catchment area would drain to either the new drainage line, or the final void of South Pit 1. KBR (2012c) provides a final void assessment, which 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. Dams C6 and C8 would pump to a permanent clean dam upstream (C5) which will be used for blending with mine affected water. A permanent drainage realignment would be implemented for the catchment upstream of the mined extent. This realignment would be constructed at the beginning of mining in this area.

- North Pit 1 – One clean water dams (Dam C1) would be constructed upstream of the mining area. The location of the dam would remain fixed for the duration of the mining period in that area. Once mining in the area was completed, drainage would be allowed to return to (close to) pre-mining conditions with the exception of a small diversion around the rehabilitated spoil.

One further clean water dam would be constructed adjacent to West Pit 3 (Dam C3). The drainage line does not intersect the mining pit, however the undisturbed catchment would be dammed in order to provide clean water for dilution and mixing with mine affected water.

Water quality of the clean water circuit would be typical of the existing waterways. The clean water circuit would flow to the receiving waterway when runoff occurs, except in situations where a dam is proposed. Releases from clean water dams would be made in accordance with a water management plan that would be prepared for the Project.

2.2 CONTINGENCY MEASURES

2.2.1 Water surplus

The mine-affected water circuit would be operated in a manner that prevents uncontrolled release to the environment.

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.

2.2.2 Water deficit

The largest demand at the Project is coal washing (CHPP) and this would be satisfied through an external supply (Sunwater pipeline). This is considered to be a reliable source. The next major demand is for dust suppression, which can be satisfied from a number of sources including mine or sediment affected water (where the quality is suitable).

In situations where water captured within the Project dams cannot satisfy dust suppression demands, water would be sourced from the water allocation available from Sunwater.

3 Water demand and supply

3.1 CHPP

The largest water demands for the Project are associated with the CHPP. This water would be supplied by Sunwater. A schematic of the proposed water demands and distribution of the Sunwater allocation is provided in Figure 3.1. It should be noted that this is an estimate and assumes the CHPP/co-disposal system is already charged with water. The process water circuit, of which the CHPP is part, is a closed system fed by the external source. This provides a consistent and reliable water source and it is therefore not included in the 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.

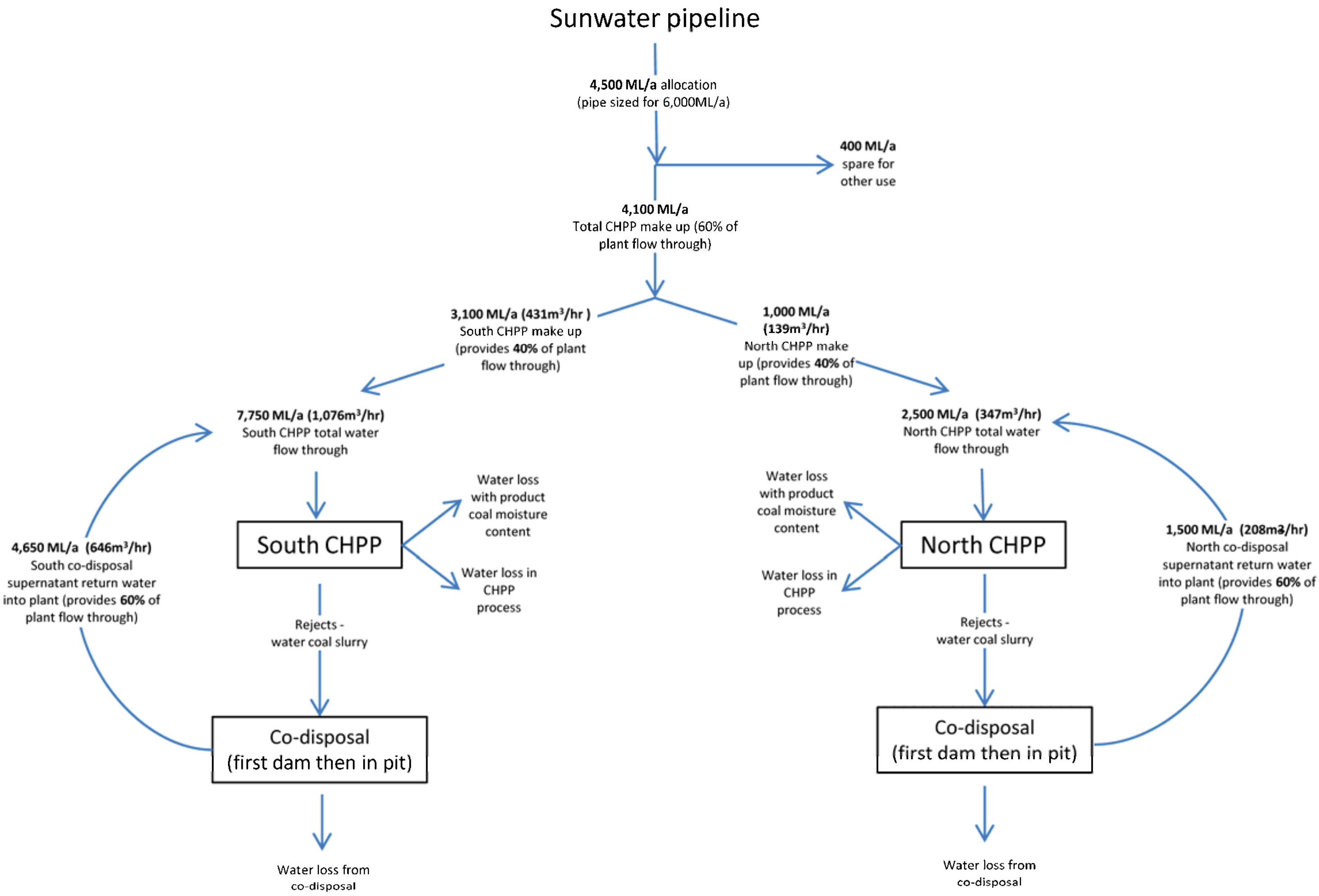


Figure 3.1
DISTRIBUTION OF SUNWATER ALLOCATION

3.2 DUST SUPPRESSION

Water would be required for dust suppression on haul roads. Typical application rates at other coal mines in the Bowen Basin are 3–4 mm/d, varying based on the exposed haul road area, climatic conditions and road usage patterns.

The haul road length would vary throughout the life of the Project, and hence the dust suppression water demand would also vary. The indicative haul road length and associated water demand at critical stages throughout the mine life is shown in Table 3.1.

Table 3.1 Haul road dust suppression water demand

Year	Haul road length (km)			Surface Area (ha)*	Water demand^	
	Out of pit	In pit	Total		m^3/d	ML/d
1	4.8	0.3	5.1	20.2	808	0.8
3	11.8	0.3	12.1	48.2	1928	1.9
5	11.8	0.5	12.3	49.2	1968	2.0
10	21.9	5.0	26.9	107.6	4304	4.3
25	16.3	9.5	22.6	90.4	3616	3.6
46	16.3	9.5	22.6	90.4	3616	3.6

** assumes a typical irrigated width of 40 m*

^ assumes water application rate of 4 mm/d

The haul road water demand increases over time as the area of active road increases. The water demand peaks in Year 10 at around 4.3 ML/d.

3.3 TRUCK WASH AND WORKSHOP

The workshop and truckwash would require water. The combined water demand is estimated to be 0.2 ML/d, which has been nominated based on experience from other mines in the Bowen Basin. A recycling rate of 75% is assumed (i.e. 25% loss). It is assumed that mine water can be used in the workshop and truck wash.

4 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 permitted in the guidelines and recommended in the ANZECC guidelines and Queensland Water Quality Guidelines (QWQG).

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 1. Interpretation of the flow gauging data will need to consider the influence of any mine releases on the gauge.

Two receiving environment compliance locations are proposed as identified in Table 4.1 and shown on Figure 4.1. The receiving environment flow gauging stations are also shown.

Table 4.1 Locations of proposed environmental monitoring locations

Description	Type	Mining Area	Easting	Northing
Suttor River upstream of mine releases at edge of ML (MP1)	Flow gauging station	West Pit 1 & 2, East Pit 1 & 2, South Pit 1 & 2	584817	7645806
Suttor River downstream of mine releases at edge of ML (CP1)	Compliance point	West Pit 1 & 2, East Pit 1 & 2, South Pit 1 & 2	584806	7642521
Kangaroo Creek upstream of North Pit contribution (MP2)	Flow gauging station	North Pit 1, West Pit 3	588199	7659529
Kangaroo Creek downstream of North Pit contribution at edge of ML (CP2)	Compliance point	North Pit 1, West Pit 3	590101	7660695

Notes: Coordinates are GDA 1994 MGA Zone 55'

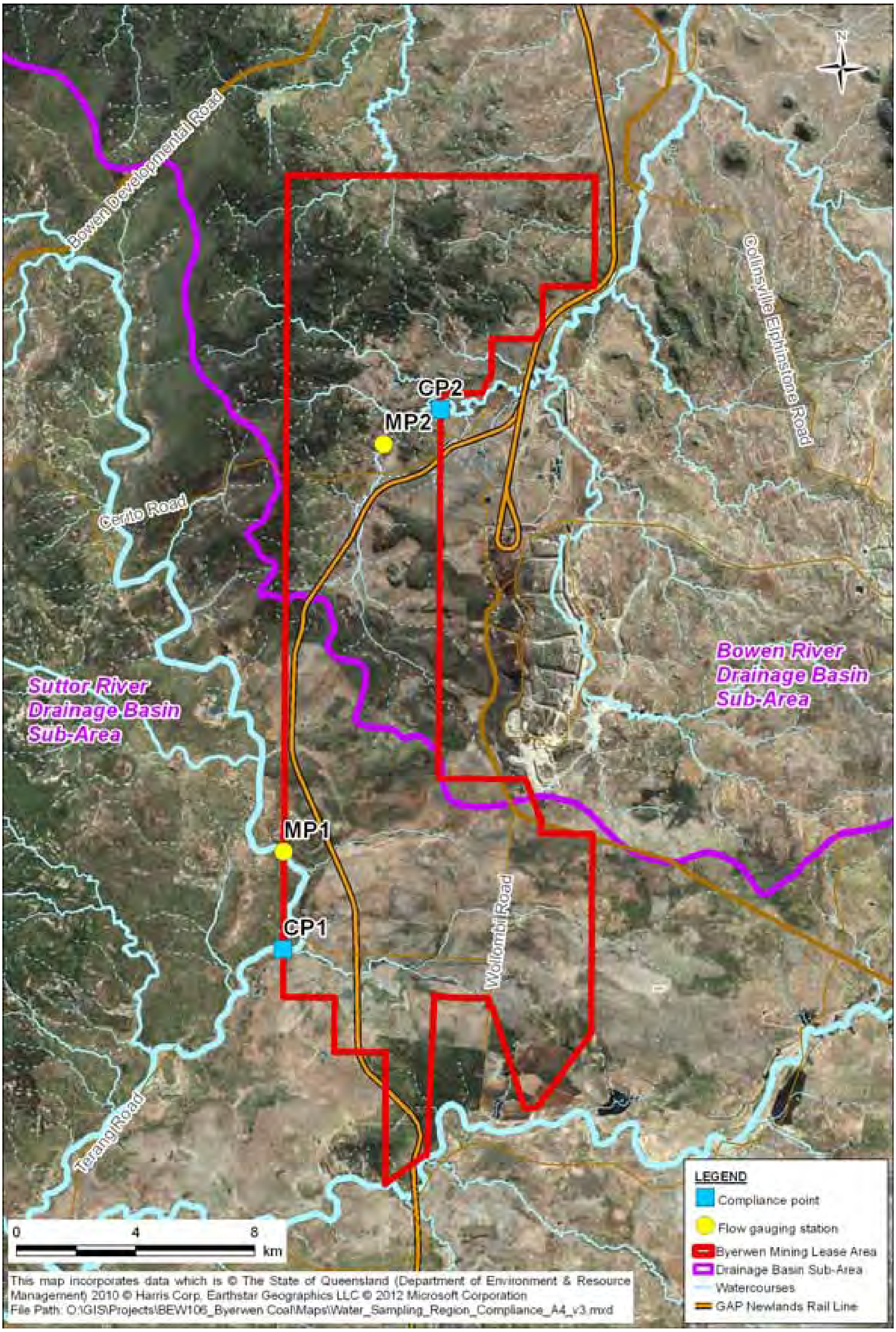


Figure 4.1
PROPOSED COMPLIANCE POINTS

4.1 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 are considered in order to ensure this objective is met:

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

These factors are discussed further below.

4.1.1 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. The streamflow at both gauging stations was filtered using automated techniques described in J.G Arnold *et al* (1995) to identify the baseflow component and the typical flow conditions at which baseflow prevails. The waterways in the region are highly ephemeral and only 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 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.

4.1.2 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 Surface Water Quality, KBR 2012a for further details).

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.

4.1.3 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.

4.1.4 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.

4.2 PROPOSED RELEASE RULES

The release rules modelled for Suttor River releases and Kangaroo Creek releases are presented in Tables 4.2 and 4.3 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 4.2 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 4.3 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*

4.2.1 Monitoring and assessing compliance

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.

5 Mine water balance model

5.1 MODEL DESCRIPTION

A water balance model of the Project was developed using Goldsim software, a package commonly adopted for mine site water balance studies.

The model was run many times (100), each time sampling different climatic sequences from the 123 year historical climate dataset. 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 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 was based on containment of a design storm event.

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.

Details of the water balance model design basis is summarised in Table 5.1.

Table 5.1 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
Lake evaporation	Moreton lake evaporation
Road dust suppression source	Mine water
Dam type	Combination of turkey's nest (flat site) and valley dam (in natural drainage depressions)
Dam stage-storage relationships	Embankments 1V:3H Maximum 6 m height (including freeboards)
Dam seepage	Seepage negligible (excluded)
Co-disposal	Treated as black box – excluded from water balance
Water quality	EC modelled only – as probability distributions
Groundwater flow	Based on hydrogeological assessment undertaken by Rob Lait & Associates (2012)
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 Tables 4.2 and 4.3 Maximum end-of-pipe EC (varies with flow in receiving environment) – refer Tables 4.2 and 4.3 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 DERM (2012)and a 5% chance of utilising the contingency measure over the life of mine
Land disturbance	As per mine staging plans developed by Minserve with the following exceptions: • Pre-strip: 200 m in advance of pit edge. • Rehabilitation establishment period: 3 years.

5.2 CLIMATE DATA

Climate data used in the water balance model is based on 123 years (1889–2012) of patched-point daily data. The patched-point data is sourced from the DataDrill database. DataDrill accesses grids of data interpolated (using splining and kriging techniques) from point observations by the Bureau of Meteorology. The patched-point data is considered superior to site observations for modelling purposes because it provides greater temporal and spatial detail than using individual site records.

A summary of the rainfall and evaporation data, extracted from DataDrill at a point located over the Byerwen mining lease, is shown in Figure 5.1.

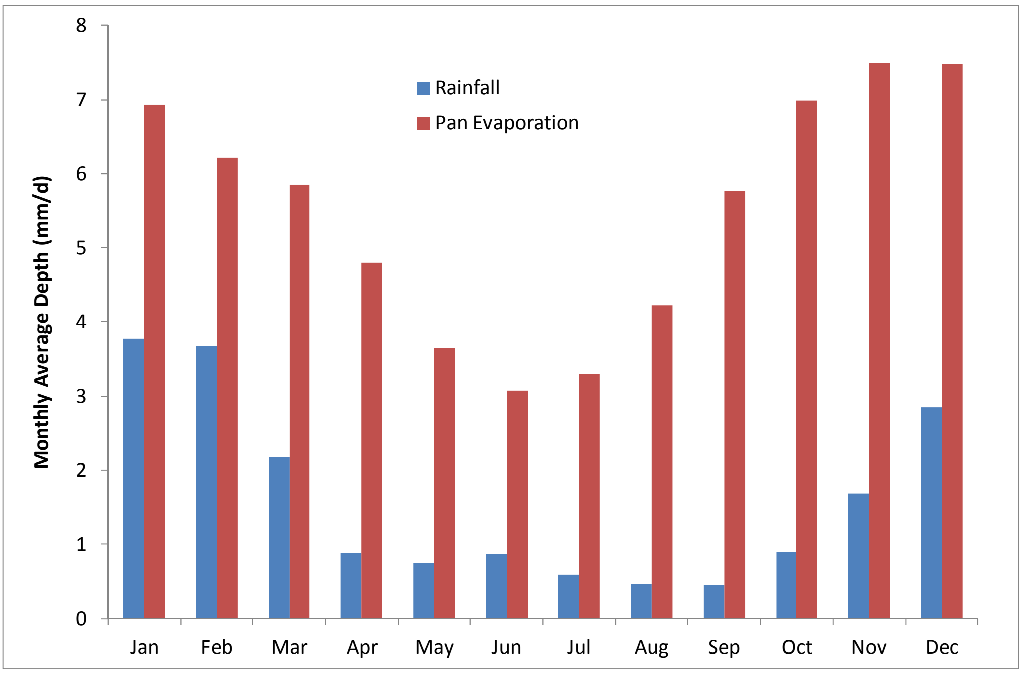


Figure 5.1
MONTHLY AVERAGE RAINFALL AND EVAPORATION

The long-term annual rainfall record is shown in Figure 5.2.

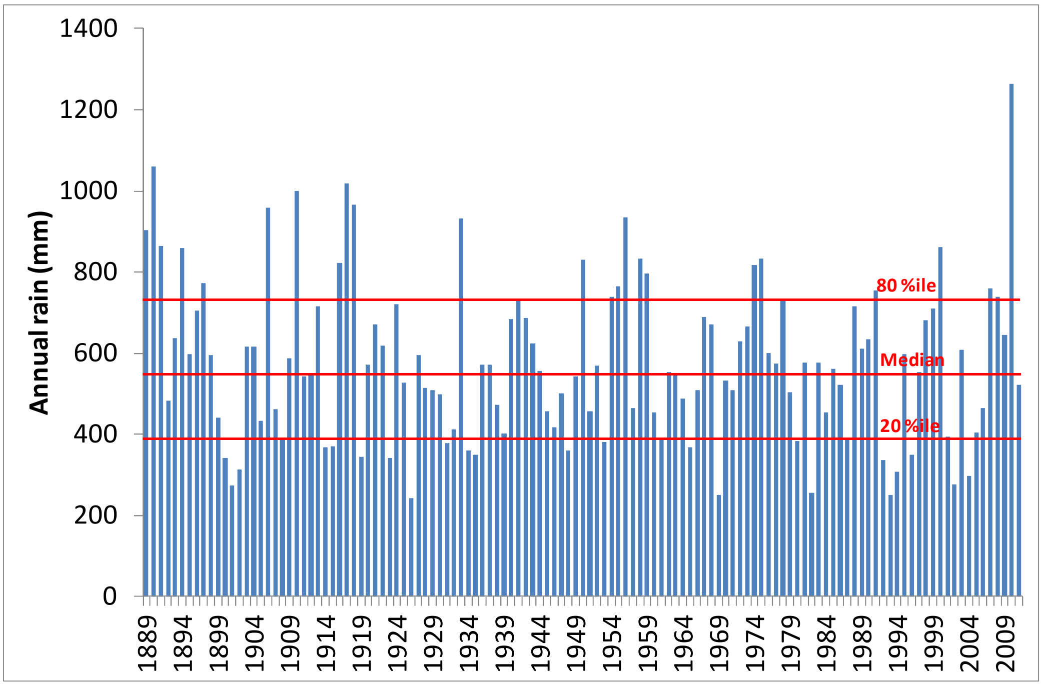


Figure 5.2
ANNUAL RAINFALL DERIVED FROM DATADRILL

5.3 WATER QUALITY

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 are fundamental in the design of the water management system.

The data that is available is sourced from:

- surface water monitoring
- geochemical investigations of the rock types likely to be present in the waste rock dumps and exposed in the pit wall
- groundwater monitoring.

There is a large scatter in the results, both temporary and spatially, which needs to be reflected in the analyses and design of the water management system. The distribution of EC values for each water type was reflected in the water balance model using a Monte Carlo simulation approach.

Four separate salinity profiles were generated for the model based on available monitoring data sets. 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. The profiles are assigned to the catchment types from which they were derived.

5.3.1 Natural catchments within the Suttor River catchment

Monitoring location FSS07 was identified as a suitable reference site for the Suttor River catchment (refer KBR 2012a for further details) which has been adopted in this assessment to represent any external catchment inputs from areas not distributed by mining. The distribution of TDS values in this data is shown in Figure 5.3.

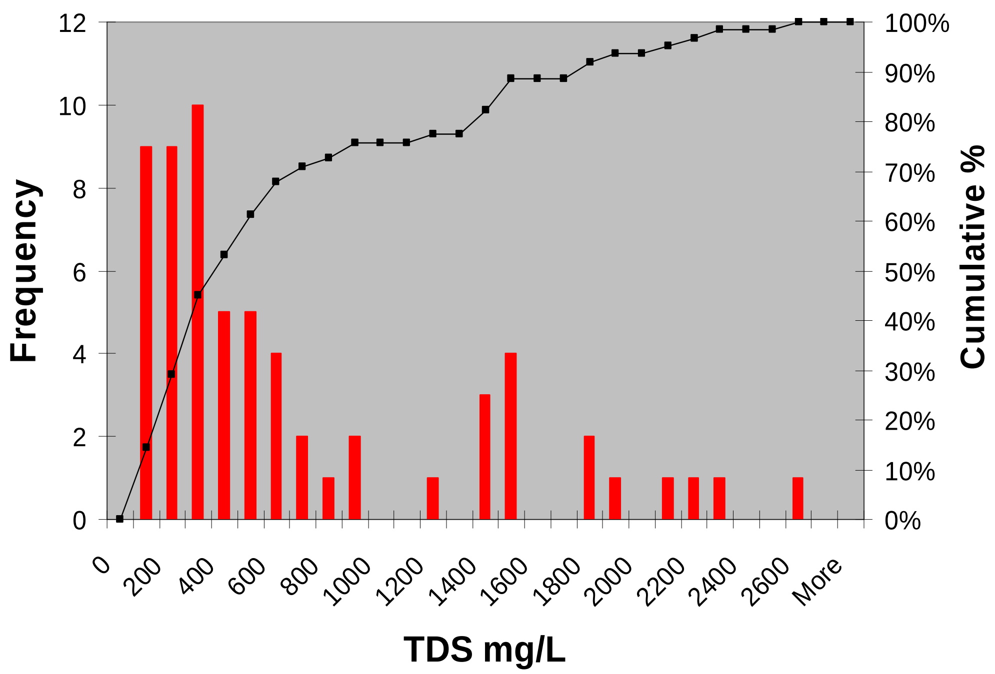


Figure 5.3
SUTTOR RIVER CATCHMENT TDS VARIATION (BASED ON FSS07)

5.3.2 Natural catchments within the Rosella Creek catchment

Monitoring location FSS05 was identified as a suitable reference site for the Rosella Creek catchment (refer KBR 2012a for further details) which has been adopted in this assessment to represent any external catchment inputs from areas not distributed by mining. Kangaroo Creek lies within the Rosella Creek catchment. The distribution of TDS values in this data is shown in Figure 5.4.

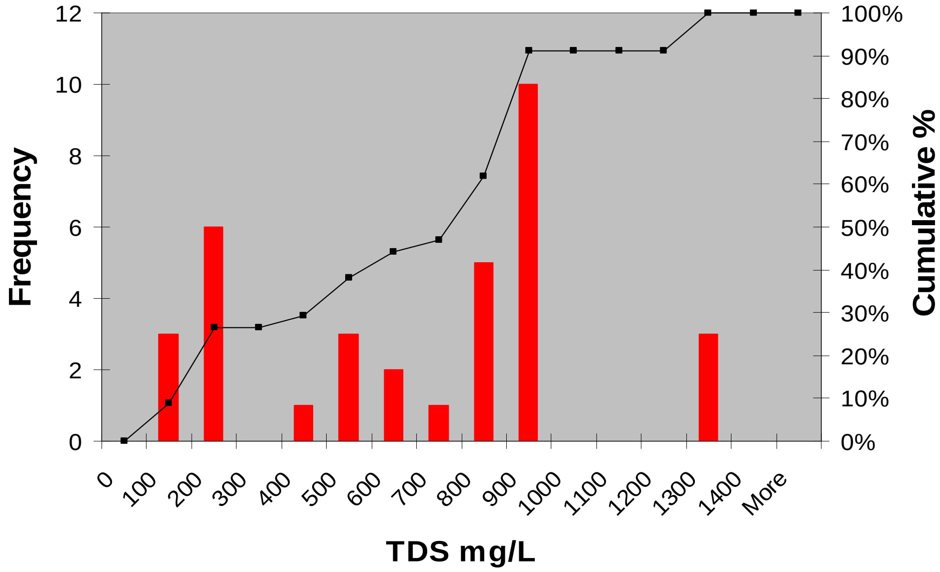


Figure 5.4
KANGAROO CREEK CATCHMENT TDS VARIATION (BASED ON FSS05)

5.3.3 Waste rock geochemistry

Waste rock reporting to the spoil dumps would be a mixture of various overburden lithologies. The available EC data (1:5 extracts were used as a highly conservative approach) for all lithologies were lumped together to provide an indication of the likely spread of results from a mixed waste rock dump. This approach is considered conservative and the results are presented in Figure 5.4.

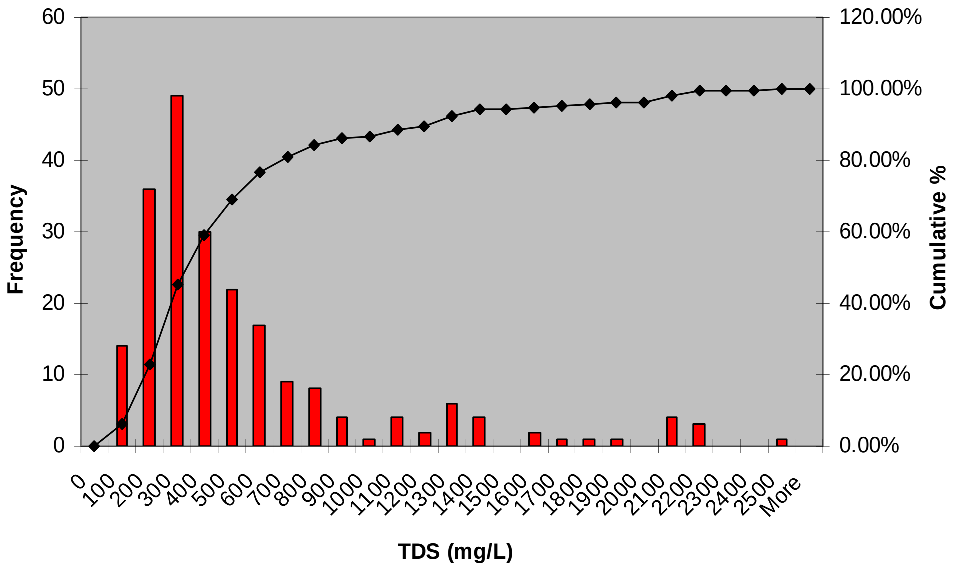


Figure 5.5
PREDICTED WASTE ROCK EC (1:5 EXTRACTS)

5.3.4 Groundwater quality

Groundwater quality data is available from monitoring undertaken during wet and dry seasons over 2011 and 2012 over four separate monitoring events; however, any numerical data analysis can be improved with a larger data set. The electrical conductivity information adopted was gathered between September 2011 and July 2012 and compiled for following units:

- Rangal Coal Measures (RCM) – 15 independent observations
- Fort Cooper Coal Measures (FCCM) – 15 independent observations
- Moranbah Coal Measures (MCM) – 4 independent observation.

On the basis that the majority of the groundwater will be attributed to the coal measures, the electrical conductivity values observed from the coal measures were extracted, transformed and analysed, as shown in Figure 5.5.

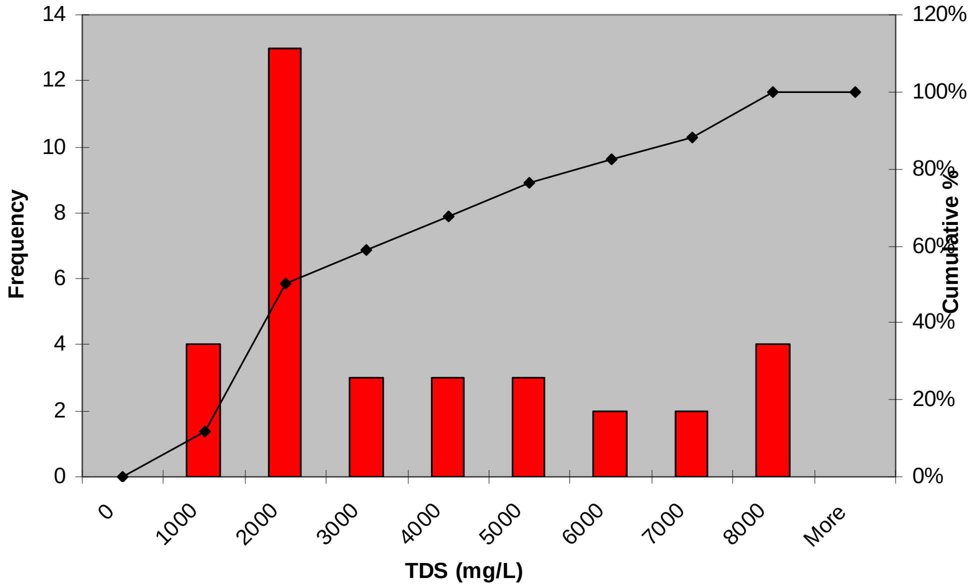


Figure 5.6
GROUNDWATER EC VARIATION IN THE COAL MEASURES

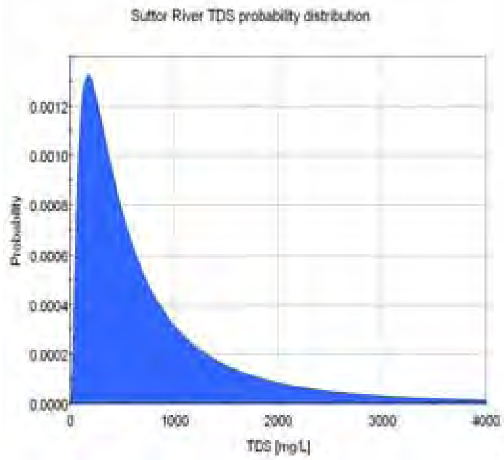
5.3.5 Adopted total dissolved salt ranges

Probability functions were fitted to the TDS distributions presented above. Three of the datasets followed a log normal distribution and one was best represented with a gamma distribution. The probability distribution functions are shown in Table 5.2.

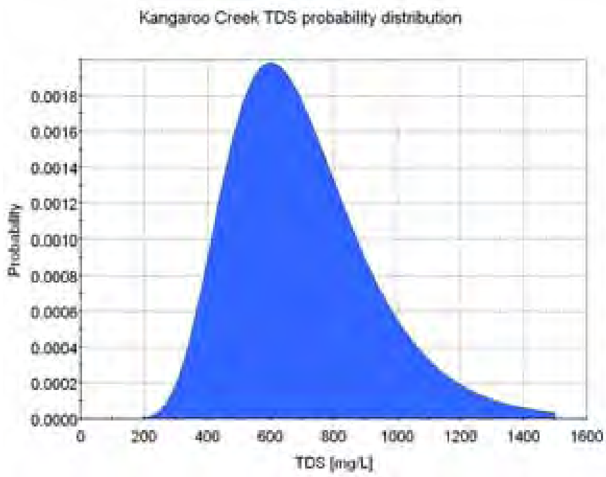
Table 5.2 Adopted probability distribution functions

<table>
<tr><th>Water quality characteristics</th><th>Probability distribution</th></tr>
<tr><td>Undisturbed – Suttor

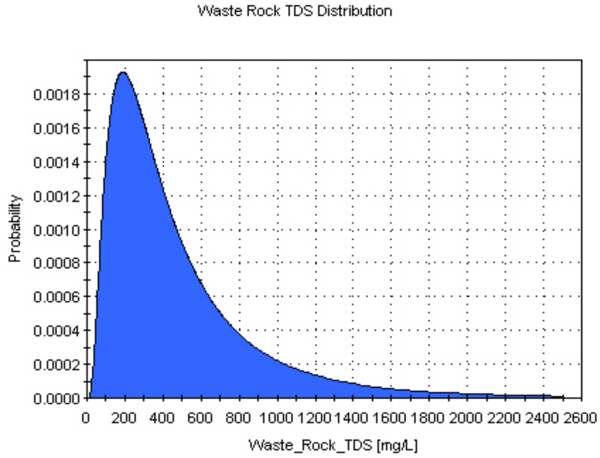
Type: Log Normal Distribution

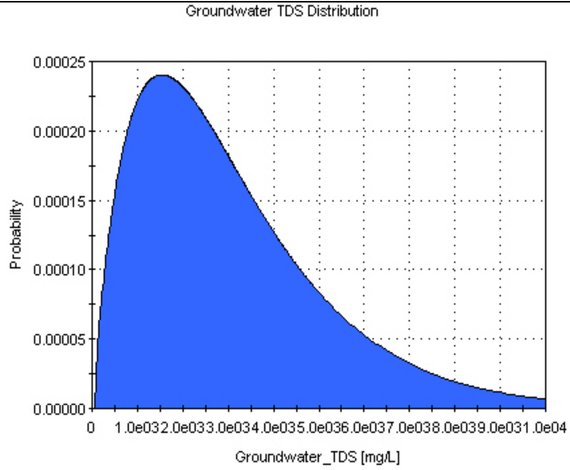
Mean: 900mg/L
SD:1,300mg/L</td><td>
</td></tr>
<tr><td>Undisturbed – Kangaroo

Type: Log Normal Distribution

Mean: 700mg/L
SD: 230mg/L</td><td>
</td></tr>
<tr><td>Cleared/disturbed</td><td>1.5 times the undisturbed catchment characteristics</td></tr>
<tr><td>Waste Rock

Type: Log Normal Distribution

Mean: 495mg/L
SD: 742mg/L</td><td>
</td></tr>
</table>

Water quality characteristics	Probability distribution
Groundwater Type: Gamma Distribution Mean: 3100mg/L SD: 2200mg/L	

The table above provides a visual representation of the probability distribution for each catchment. Table 5.3 describes the statistical variation between the raw data sets and the probability distributions by comparing the values at given percentiles. From the data below, 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 (80th percentile).

Table 5.3 Comparison of data distribution

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

5.3.6 Summary of water type and water quality relationships

Catchments within the Project area will change over time, as will the water quality draining from these catchments as the land use changes. Dams and drainage will need to be reconfigured to facilitate the change in catchment types and maintain correct segregation of water qualities and mining progresses. A summary of the areas, water type and water quality characteristics are provided in Table 5.4.

Table 5.4 Proposed water type and water quality relationships

Area	Water type	Water quality characteristics
Undisturbed land	Clean	Undisturbed
Pre-strip	Mine affected	Cleared/disturbed
Open cut pit	Mine affected	Waste rock
ROM	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
MIA	Sediment affected	Cleared/disturbed

5.4 CATCHMENT HYDROLOGY

5.4.1 Runoff model

Stream gauging data is collected in the vicinity of the Project by EHP and the Bureau of Meteorology. 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 Australian Water Balance Model (AWBM) has been used to derive catchment runoff time series for use in the water balance. AWBM is a partial area saturation overland flow model. The use of partial areas divides the catchment into regions that produce runoff (contributing areas) during a rainfall-runoff event and those that do not. These contributing areas vary within a catchment according to antecedent catchment conditions, allowing for the spatial variability of surface storage in a catchment. The use of the partial area saturation overland flow approach is simple, and provides a good representation of the physical processes occurring in most Australian catchments (Boughton, 1993). This is because daily infiltration capacity is rarely exceeded, and the major source of runoff is from saturated areas.

The AWBM model was calibrated to both of these catchments. The calibrated hydrology model was able to match the flow duration curve and catchment yield very closely to the recorded data. The relative difference between observed and modelled runoff volume was –13.7% for Kangaroo Creek at Byerwen, and –1.3% for Suttor River at Eaglefield. The flow duration curves, shown comparing observed versus modelled runoff, is shown in Figures 5.6 and 5.7.

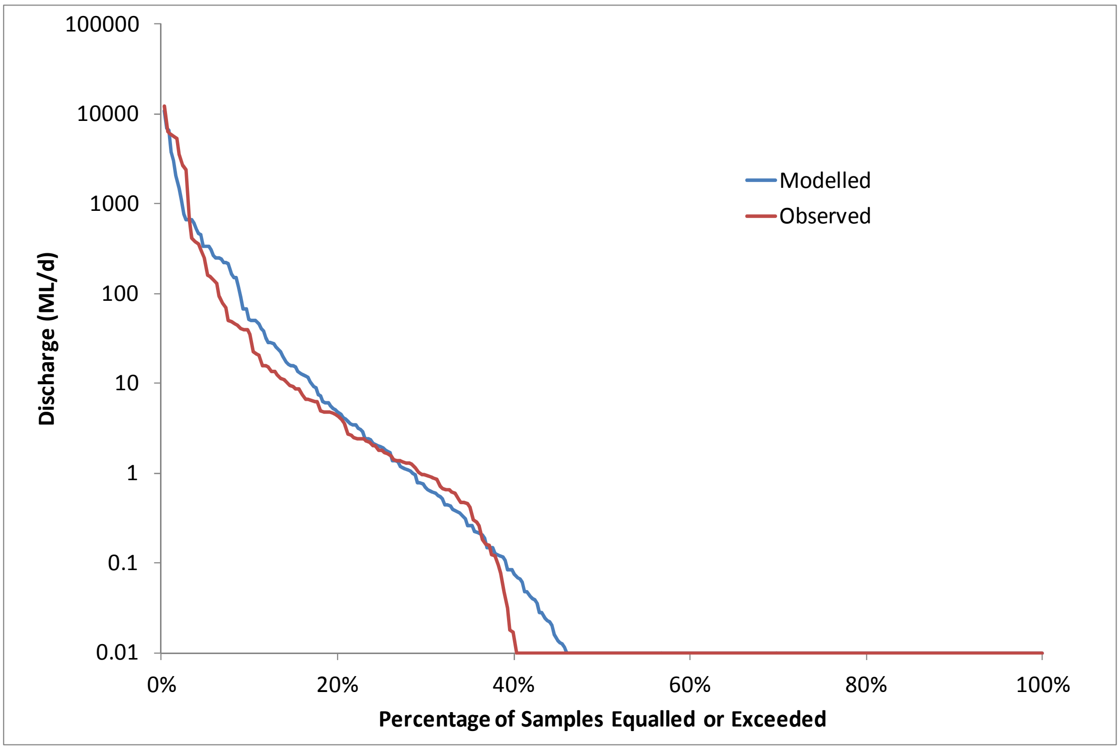


Figure 5.7
FLOW DURATION CURVE – KANGAROO CREEK AT BYERWEN

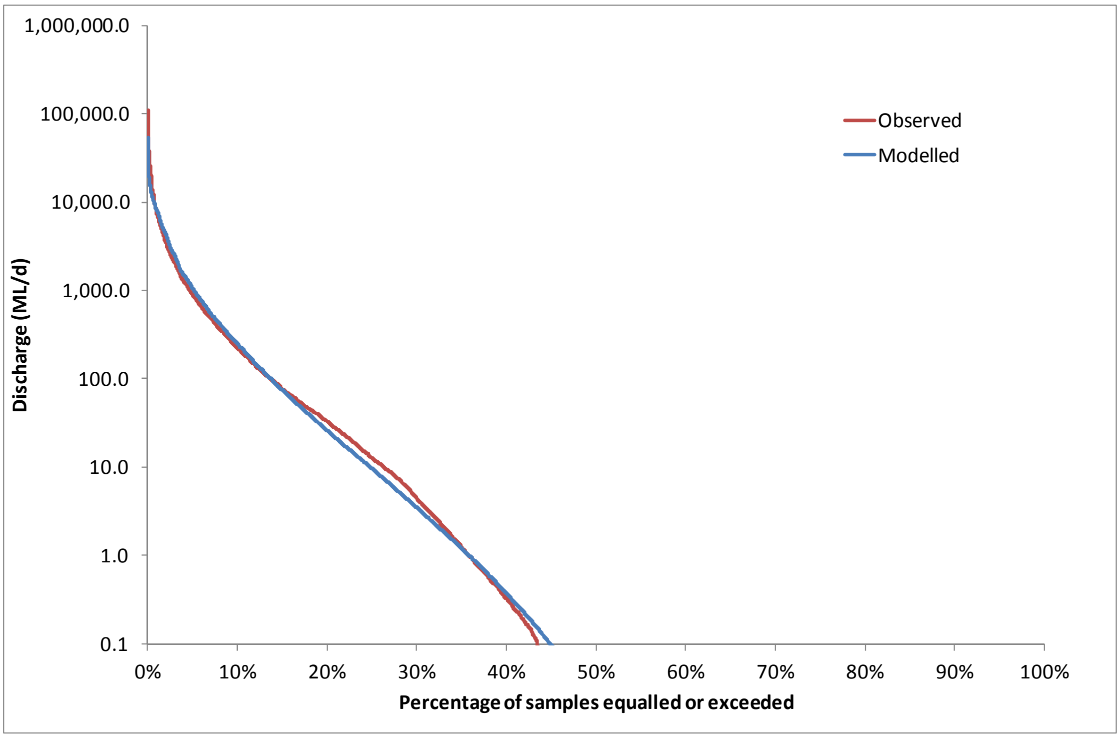


Figure 5.8
FLOW DURATION CURVE – SUTTOR RIVER AT EAGLEFIELD STATION

The calibrated AWBM parameters are shown in Table 5.5.

Table 5.5 AWBM parameters for receiving waterways

Parameter	Explanation of parameter	Suttor River calibrated	Kangaroo Creek calibrated
A1 A2	Partial areas represented by surface Storages	0.134 0.433	0.134 0.433
BFI	Baseflow index – indicates the ratio of base flow to total stream flow.	0.100	0.100
C1 C2 C3	Surface storage capacities	10.8 110.5 221.0	2.2 76.1 170.6
Kbase Ksurf	Recession constants – simulates the delay of baseflow and stormflow reaching the outlet.	0.77 0.45	0.573 0.050

The AWBM parameters from mine affected catchments have to be derived from other sites as there is no mine development yet in the Project area. The nearest mine is Xstrata's Newlands operation, for which reliable and long term flow monitoring has been recorded. AWBM parameters have been calibrated using this observed data (KBR, 2012a), which is provided in Table 5.6.

Table 5.6 AWBM parameters for mine affected catchments

	Explanation of parameter	Pre-strip	Pit	Active waste rock dump	Rehabilitated waste rock dump
A1 A2	Partial areas represented by surface storages	0.1 0.9	0.1 0.9	0.1 0.9	0.109 0.891
BFI	Baseflow index – indicates the ratio of base flow to total stream flow.	0	0	0.9	1
C1 C2	Surface storage capacities	12 54	12 38	12 38	12 221
Kbase Ksurf	Recession constants – simulates the delay of baseflow and stormflow reaching the outlet.	1 0	1 0	0.7 0	0.7 0

5.5 HYDROGEOLOGY

Groundwater yields into the open pits have been predicted by an analytical hydrogeological model (Rob Lait & Associates, 2012).

The predicted flow rates to open cut pits over the life of the mine is summarised in Table 5.7.

Table 5.7 Groundwater Inflow (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**

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.

6 Water management infrastructure

6.1 DESIGN CRITERIA

6.1.1 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 (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 (Section 6.3.1).

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.

6.1.2 Sediment-affected water dams

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

6.1.3 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).

6.2 INFRASTRUCTURE REQUIREMENTS

6.2.1 Infrastructure layout

The mine water infrastructure requirements include six clean water dams, 14 mine water dams, 17 in-pit sumps and 27 sediment dams. The conceptual layout of the dams over the various mine stages is shown over nine figures in Appendix A. Also shown on the figures is the catchment areas draining to the dams and the water transfer between dams and to the environment. These figures provide a visual representation to illustrate the mine water management strategy proposed for the Project but do not represent final designs/locations details for construction purposes.

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 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.

6.2.2 Infrastructure 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 DSA (DERM, 2012) and met the acceptable level of risk of utilising an emergency contingency measure. For the purpose of modelling all mine 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 dam capacities are provided in Table 6.1.

Table 6.1 Maximum dam storage requirement

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
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
Sediment affected			
S1	54	–	–
S2	29	–	–
S3	21	–	–
S4	35	–	–
S5	16	–	–
S6	45	–	–
S7	23	–	–
S8a	44	–	–
S8b	44	–	–
S9	24	–	–
S10	24	–	–
S11	22	–	–
S12	27	–	–
S13	15	–	–
S14a	47	–	–
S14b	47	–	–
S15a	47	–	–
S15b	47	–	–
S16a	38	–	–

Dam	Volume (ML)	Height (m)	Footprint (ha)*
S16b	38	–	–
S17	32	–	–
S18	24	–	–
S19	42	–	–
S20	24	–	–
S21a	38	–	–
S21b	38	–	–
S22	32	–	–
In pit Sumps			
SP1a	361	–	–
SP1b	362	–	–
SP1c	362	–	–
SP1d	362	–	–
SP2a	174	–	–
SP2b	174	–	–
EP1	29	–	–
EP2	37	–	–
WP1a	228	–	–
WP1b	228	–	–
WP2a	206	–	–
WP2b	207	–	–
WP3a	317	–	–
WP3b	317	–	–
WP3c	316	–	–
NP1a	173	–	–
NP1b	173	–	–

* *footprint calculation provided for "turkey's nest" type dams only (assumed 7 m deep). Areas for levee dams and valley dams will be based on stage-storage relationship using existing topography*

6.2.3 Infrastructure details and staging

The water management infrastructure would involve a number of dams, with the ability to transfer water between storages and release to the environment. A discussion of the system and how it evolves over the life of the Project is provided below.

Mine Infrastructure Areas

There will be two MIAs, one in the southern tenement area adjacent to the southern CHPP and one in the northern tenement area adjacent to the northern CHPP. 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.

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 is to be in place before mining operations commence at the North Pit. Also to be in place before mining operations commence is one clean water dams (C1), to collect surface runoff from the surrounding valleys west of the North Pit 1 mining operations. This dam collects water from drainage lines that are not be affected by the drainage diversion.

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

Spoil 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 the mine affected water dam M1. As the spoil dump is progressively rehabilitated, salinity in runoff would reduce and sediment would become the primary concern for runoff generated from the spoil dump. As salinity decreases to natural catchment concentrations sediment capture dams (S6 and S7) are to be constructed south of the spoil 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 spoil dump has been rehabilitated the sediment, mine and clean water dams would be decommissioned.

West Pit

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. As mentioned above a drainage realignment would 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 dam constructed for the purpose of holding mine affected water (M4). This dam would be located immediately west of West Pit 1, between the West Pit Complex and the GAP railway in the former drainage line gully (now devoid of flow due to the drainage diversion).

Spoil from West Pit 1 is to be placed immediately north of the pit. This spoil would be rehabilitated over time, initially however the spoil 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 spoil dump expands and the early spoil 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. The dam M11 would 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, which would act as a co-disposal area for spoil (from West and South pits) as this area is well located to prevent sediment laden flow from entering the environment. The dam 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.

Spoil from West Pit 2 would be disposed sequentially with spoil from West Pit 1 and two mine water dams (M13 and M14) will need to be constructed to 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 should be placed between the western extents of the spoil mound (and the spoil mound shaped) to allow flow into the sediment dam between the spoil 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 spoil generated from West Pit 2 and West Pit 3 (which would also be placed sequentially). As the spoil area moves north, further sediment affected water dams (S14a and S14b) would be required past the north eastern extent of the spoil mound in addition to sediment dams (S15a and S15b) located to the south east of the rehabilitated spoil.

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 the proposed mine affected water dam. 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.

South pit 1

South Pit 1r 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 to prevent surface runoff from entering the mining areas of South Pit 1, in effect this would create a clean water dam (C6). 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 need to be in place. In effect, 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 C7 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. As such, 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 between the mining area boundary and drainage diversion 1.

Spoil is to be placed between the GAP railway and Suttor River. A mine dam (M6) will be used to capture saline waters from the spoil. 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 spoil dump (S2, S3 and S5). Further spoil is to be located between the GAP railway and South Pit 1. Similar sediment dam arrangements would be used for this spoil (S9 and S10). Once the spoil dumps are sufficiently rehabilitated, the sediment capture dams are to be decommissioned.

As the mining extent of South Pit 1 moves east, the generated spoil would be dumped in the void remaining from the previous mining extents. As this spoil mound develops, a sediment capture dam (S16a, S16b, S21a and S21b) would be required on the northern and south eastern extents of the spoil mound to capture sediment laden runoff and allow it to settle before discharging to the environment. Some spoil (balance) would also be transported to the void from mining activities at West Pit 1, where co-disposal would occur.

After mining operations at South Pit 1 cease, the rehabilitated spoil area would diminish the catchment of the clean water dam C6, reducing the volume of water that can be captured in that dam. The rehabilitation strategy involves removal of dam C6. KBR (2012c) provides a final void assessment including consideration of the catchment clean water catchment that drained to dam C6. This showed 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 would have a reduced catchment area and would be decommissioned after the mining operations at the site 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. Water from South Pit 1 would be released at M7.

South pit 2

The smaller of the south pits, South Pit 2 is not to begin being mined until year 10 of production. As stated above, the pit would be bound to the north by drainage diversion 2. Spoil from South Pit 2 would be stored west of the pit in two separate waste rock dumps. As per the other spoil mounds, two mine affected water dams (M8 and M10) would operate during the early stages, and as sediment becomes the main concern a sediment capture dam (S11) would take the place of the mine affected water dam where the captured water is allowed to remain ponded before being released to the environment.. Mining in South Pit 2 would progress from west to east. As the mining progresses the spoil would be used to backfill the void, as such the mine affected water dam at the north-west corner of the pit would reach a stage where it no longer acts as a mine affected water dam but rather as a sediment affected runoff 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 second drainage diversion stream at M10.

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

East pit 1

East Pit 1 is located near the southern CHPP towards the eastern boundary of the site. The eastern pits (East Pit 1 and 2) are some of the last to be started in the mining sequence. At this stage, spoil is proposed to be placed immediately west of East Pit 1 with a final goal of a rehabilitated spoil mound and no final void after operations on East Pit 1 have ceased.

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 the catchment (C5) near South Pit 1 and released at M5. A sediment capture dams (S17 and S22) would also operate to the north and south of the spoil dump. Water would be released to the environment through Drainage Diversion 1 after settling.

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 proposed mining area of East Pit 2 and will be diverted north as to stop ingress of flow into the pit. Spoil is proposed to be placed immediately west of East Pit 2 with a final goal of a rehabilitated spoil mound 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 the catchment near South Pit 1 (C5) and released at M12. Sediment capture dams (S8 and S20) would also operate to the east of the spoil dump. Water would be discharged to Drainage Diversion 2 after settling.

6.3 REGULATED STRUCTURES

The Manual for Assessing Hazard Categories and Hydraulic Performance of Dams (DERM 2012) sets out the requirements of the administering authority, for hazard category assessment and certification of the design of ‘regulated structures’, constructed as part of environmentally relevant activities (ERAs) under the Environmental Protection Act 1994 (EP Act).

The term regulated structures includes land-based containment structures, levees, bunds and voids. 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.

DERM (2012) 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 Table 6.2 at any time when the contained volume equals the dam volume (the level at which it will overflow across the spillway), and the dam volume is greater than that indicated in the table.

Table 6.2 Contaminant concentrations and minimum dam volumes

Contaminant	Liquor	Total solids	Dam volume (ML)
Arsenic	1.0 mg/L	500 mg/kg	2.5
Boron	5.0 mg/L	15,000 mg/kg	2.5
Cadmium	0.01 mg/L	100 mg/kg	2.5
Cobalt	1.0 mg/L	500 mg/kg	2.5
Copper	1.0 mg/L	5,000 mg/kg	2.5
Lead	0.5 mg/L	1,500 mg/kg	2.5
Mercury	0.002 mg/L	75 mg/kg	2.5
Nickel	1.0 mg/L	3,000 mg/kg	2.5
Selenium	0.02 mg/L	150 mg/kg	2.5
Zinc	20 mg/L	35,000 mg/kg	2.5
Cyanide (un-ionised HCN)	10 mg/L	2,500 mg/kg	2.5
pH	Outside 5 to 9 (range)	Net acid generation pH < 4.5	2.5
TPH C6 – C36	90 mg/L	–	2.5

Contaminant	Liquor	Total solids	Dam volume (ML)
TPH C6 – C14	60 mg/L	–	2.5
Benzene	0.1 mg/L	–	2.5
Phenol	3 mg/L	–	2.5
Benzo(a)Pyrene	0.001 mg/L	–	2.5
Chloride	2500 mg/L	–	25
Fluoride	2.0 mg/L	–	25
Sulphate	1000 mg/L	–	25
Salinity (electrical conductivity)	4000 µS/cm	–	25

6.3.1 Hazard category assessment

Three hazard categories exist for dam under the DERM (2012) guidelines, as follows:

- Low Hazard Category.
- Significant Hazard Category.
- High Hazard Category.

Table 6.3 presents the classified hazard category of the 47 proposed dams (excluding in pit sumps) plus two co-disposal dams. The following sections describe the reasoning behind the classifications.

Clean water dams

The proposed clean dams are deemed to fall within the Low Hazard category for ‘failure to contain’ and ‘dam break’ scenarios, using the following rationale:

- Loss of life or harm to humans – The downstream waterways are predominantly rural and people are rarely present in the riparian zone.
- General environmental harm – The dam volumes of C1, C5 and C7 are relatively small resulting in relatively low failure flow rates, equivalent to relatively frequent flood events in the receiving environment. Using the empirical dam break peak discharge relationship presented in DERM (2010) for these size dams (100 ML), the peak failure discharge is 131 m^3/s. This is equivalent to much less than a 20 year ARI flood flow in Suttor River which means such an event should not cause excessive scour or damage to riparian vegetation. The clean dams C4, C6 and C8 are larger in volume resulting in large flows of between 400 – 600 m^3/s upon dam break. However the flow is most likely to be caught by West Pit 1 and South Pit 1 respectively resulting in no environmental harm to watercourses.. Contaminants are not expected to be present in the stored water. Salinity of stored water is expected to be within the range naturally observed in the receiving environment.
- Loss of stock – The closest stock present to the Project (that are not agisted on the holder’s land) is at Wollombi, part of which is on the Project site. Water quality is expected to be within an allowable range for stock, of particular note is Australia & New Zealand Environment and Conservation Council guidelines for livestock which recommend a TDS below 2,500 mg/L.

- General economic loss or property damage – Downstream of C5 and C7 is the GAP railway corridor. The flows from the dam break are equivalent to a 50 year ARI in the local tributary at the rail crossing which is within the design of bridge and no property damage or economic loss should be sustained. As stated above in the event of failure of dams C4 and C6 the water would most likely accumulate in West Pit 1 and South Pit 1 respectively resulting in scour damage and economic loss due to pit flooding. However the clean dams are proposed to be dug into the ground, negating the possibility of a dam break occurring and unintentional spills will be caught by levees protecting the pit.

Sediment dams

The proposed sediment dams are deemed to fall within the Low Hazard category for failure to contain' and 'dam break' scenarios, using the following rationale:

- Loss of life or harm to humans – The downstream waterways are predominantly rural and people are rarely present in the riparian zone.
- General environmental harm – The average sediment dam volume is 30 ML and the average dam break flow is 50 m^3/s. This is equivalent to much less than a 20 year ARI flood flow in the Suttor River which should not cause excessive scour or damage to riparian vegetation. The largest sediment dam is 54 ML, which results would result in a peak discharge of 82 m^3/s under a dam break scenario. Contaminants are not expected to be present in the stored water. Salinity of stored water is expected to be within the range naturally observed in the receiving environment.
- Loss of stock – The closest stock present to the Project (that are not agisted on the holder's land) is at Wollombi, part of which is on the Project site. Water quality is expected to be within an allowable range for stock, of particular note is Australia & New Zealand Environment and Conservation Council guidelines for livestock which recommend a TDS below 2,500 mg/L.
- General economic loss or property damage – All sediment dam break flows are within channel capacity and are within the downstream GAP railway crossing design.

Mine water dams

All but one proposed mine dam (M7) are deemed to fall within the Significant Hazard category for 'failure to contain' and 'dam break' scenarios, using the following rationale:

- Loss of life or harm to humans – The downstream waterways are predominantly rural and people are rarely present in the riparian zone. Within the mine site, workers are not likely to be present within the failure flow paths as activities would be centred around the open cut pit and MIA.
- General environmental harm – The average dam volume of the mine dams excluding M7, is 350 ML and the average dam break flow is 210 m^3/s. This is equivalent to much less than a 20 year ARI flood flow in Suttor River which should not cause excessive scour or damage to riparian vegetation. Mine water dams in the Kangaroo Creek catchment are located near the catchment headwaters.

While there has not been a flood study completed in these catchments, the dam break peak discharges are likely to cause scour and erosion in these reaches. These dams have tentatively been nominated a Significant Hazard rating, but this should be reviewed when more design information becomes available. Contaminants are not expected to be present in the stored water on the basis of geochemical testing (refer RGS (2012) for further details). Salinity of stored water is expected to be over the range naturally observed in the receiving environment, resulting in a significant hazard rating.

- Loss of stock – The closest stock present to the Project (that are not agisted on the holder's land) is at Wollombi, part of which is on the Project site. Water quality is expected to be within an allowable range for stock, of particular note is Australia & New Zealand Environment and Conservation Council guidelines for livestock which recommend a TDS below 2,500 mg/L. While this TDS is not normally expected to be held in mine water dams, in the event of release of higher salinity water than the ANZECC guidelines, it is not expected stock would choose to consume the water or if they did, would be unlikely to result in stock loss.
- General economic loss or property damage – dams M4, M5. M10 and M12 discharge into the diversion channels. All dam break flows are within the diversion channel design capacity resulting in no damage to diversion channels and no breaching of pits. With the exception of dam M12, these dams have the potential for scour damage to the downstream GAP railway bridges resulting in a significant hazard rating as the dam break peak flows exceed the railway design flood immunity.

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 railway bridge downstream.

Co-disposal dams

There are also two co-disposal dams situated on site at each of the CHPPs. The southern co-disposal dam will hold approximately 10 000 ML and be 2000 m by 500 m by 10 m deep. The northern co-disposal dam will hold approximately 900 ML and be 300 m by 300 m by 10 m deep. The co-disposal dams are considered to be within the high hazard category due to the types of material held and general environmental harm caused by a dam break scenario. No further analysis is required as this is the highest hazard category, and will therefore be subject to specific design criteria as per DERM (2012).

Current geochemical data suggests the waste rock is non acid generating. Therefore none of the runoff entering the dams is expected to exceed the contaminant thresholds presented in Table 6.2.

Summary of hazard category assessment

A summary of the hazard category assessment outcomes is presented in Table 6.3.

Table 6.3 Hazard category assessment

Dam	Volume (ML)	Failure to contain scenario	Dam break scenario	Containment scenario	Hazard category	Regulated structure?
Mine affected						
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
Clean water						
C1	100	Low	Low	Low	Low	Not regulated
C3	250	Low	Low	Low	Low	Not regulated
C4	469	Low	Low	Low	Low	Not regulated
C5	100	Low	Low	Low	Low	Not regulated
C6	651	Low	Low	Low	Low	Not regulated
C7	100	Low	Low	Low	Low	Not regulated
C8	150	Low	Low	Low	Low	Not regulated
Sediment affected						
S1	54	Low	Low	Low	Low	Not regulated
S2	29	Low	Low	Low	Low	Not regulated
S3	21	Low	Low	Low	Low	Not regulated
S4	35	Low	Low	Low	Low	Not regulated
S5	16	Low	Low	Low	Low	Not regulated
S6	45	Low	Low	Low	Low	Not regulated
S7	23	Low	Low	Low	Low	Not regulated
S8a	44	Low	Low	Low	Low	Not regulated
S8b	44	Low	Low	Low	Low	Not regulated
S9	24	Low	Low	Low	Low	Not regulated
S10	24	Low	Low	Low	Low	Not regulated
S11	22	Low	Low	Low	Low	Not regulated
S12	27	Low	Low	Low	Low	Not regulated
S13	15	Low	Low	Low	Low	Not regulated
S14a	47	Low	Low	Low	Low	Not regulated
S14b	47	Low	Low	Low	Low	Not regulated
S15a	47	Low	Low	Low	Low	Not regulated
S15b	47	Low	Low	Low	Low	Not regulated
S16a	38	Low	Low	Low	Low	Not regulated

Dam	Volume (ML)	Failure to contain scenario	Dam break scenario	Containment scenario	Hazard category	Regulated structure?
S16b	38	Low	Low	Low	Low	Not regulated
S17	32	Low	Low	Low	Low	Not regulated
S18	24	Low	Low	Low	Low	Not regulated
S19	42	Low	Low	Low	Low	Not regulated
S20	24	Low	Low	Low	Low	Not regulated
S21a	38	Low	Low	Low	Low	Not regulated
S21b	38	Low	Low	Low	Low	Not regulated
S22	32	Low	Low	Low	Low	Not regulated
Co-disposal dams						
South	10 000	High	High	Significant	High	Regulated
North	900	High	High	Significant	High	Regulated

This assessment is based on conceptual design of the water management systems and is therefore of a preliminary nature. The hazard category assessment will need to be re-assessed during detailed design and then regularly during operation.

6.3.2 Hydraulic performance of Regulated Structures

The design criteria for Regulated Structures associated with the Project is presented in Table 6.4.

Table 6.4 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 hr duration	1:100 AEP 72 hr 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

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 DERM (2012).

Structures requiring a DSA should be brought down to this level by the 1 November each year in preparedness for the upcoming wet season.

6.3.3 Regular assessment

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 Design Storage Allowance and Mandatory Reporting Limits (MRL)
- assessment of the potential impacts of any failure of the dam embankments.

6.3.4 Referable dams

Under the Water Supply (Safety and Reliability) Act 2008 (Qld), dam assessment must include a Failure Impact Assessment in accordance with 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 1500 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 mine water management strategy that is considered a referable dam, all other dams are not referable. A Failure Impact Assessment will be completed by QCoal when designs of the dam are available.

6.4 INTERACTION BETWEEN DAMS AND FLOODWATERS

The concept design of mine water dams is based on turkey's nest design. The crest of these dams will be designed at or above the flood immunity requirements for its hazard rating, as stipulated in Table 6.4. Sediment dams would typically be constructed as an excavated dam in order to collect waste rock dump toe runoff. These would be located outside the 100 year ARI flood level in the nearby waterway.

Clean water dams may be sited within the flood extent of local tributaries, since there is no water quality implication of floodwaters interacting with the impounded water. In these situations the dam would be designed such that there is no scour or damage to the dam as a result of flooding.

Water infrastructure such as pumps and pipes will be designed such that they remain operational during flood events.

7 Potential impacts and mitigation measures

7.1 MINE WATER DISCHARGES

Controlled releases from the mine site would occur in accordance with the release conditions described in Section 4.2. The release conditions specify the maximum discharge rate and end-of-pipe EC that can occur, however the actual release rate and EC will depend on the flow and dilution available in the receiving environment. The water balance model indicates that these maximum conditions are often not met because of downstream constraints. Table 7.1 summarises the modelled mine water discharges into the Suttor River.

Table 7.1 Suttor River mine water discharge analysis

	Recession/Low flow	Medium flow	High flow
% of time when releases occurring	7%	18%	75%
% of release water volume	1%	5%	94%
Mean rate of water discharged (ML/d)	7	11	54
Mean EC released (µS/cm)	950	950	930
Maximum EC released (µS/cm)	1,720	2,440	3,680

The table indicates that releases most often occur during high flow conditions (75% of the time when releases occur it will be at times of high flow) and that most of the mine water gets released during high flow conditions (94% of the total volume of water released is at high flow conditions). This is because higher discharge rates and dilution ratios are possible during high flow events.

The table also indicates that recession flow is not a major component of the mine water release strategy. Modelling suggests that only around 1% of the volume of water released occurs during recession flow.

Table 7.2 summarises the modelled mine water discharges into Kangaroo Creek.

Table 7.2 Kangaroo Creek mine water discharge analysis

	Recession/low flow	Medium flow	High flow
% of time releases occurring	14%	52%	34%
% of release water volume	2%	30%	68%
Mean rate of water discharged (ML/d)	7	23	79
Mean EC released (µS/cm)	960	950	820
Maximum EC released (µS/cm)	1,300	2,100	2,200

The table suggests that releases to Kangaroo Creek may occur more frequently in medium flow conditions than in Suttor River. However, the majority (approximately

70%) of water discharged from the mine (in terms of volume) would be associated with high flows in Kangaroo Creek.

7.2 HYDROLOGY

7.2.1 Suttor River

The Project has the potential to alter the hydrology of surface water systems by capturing water in dams, loosing water in the form of dust suppression or pond evaporation, and releasing water during flow events.

The potential changes to hydrology were assessed using the water balance model described in Section 5. Daily runoff over a 46 year period (equivalent to the mine life) was calculated for two scenarios: without the Project; with the Project. The flow duration curve for both scenarios is presented in Figure 7.1.

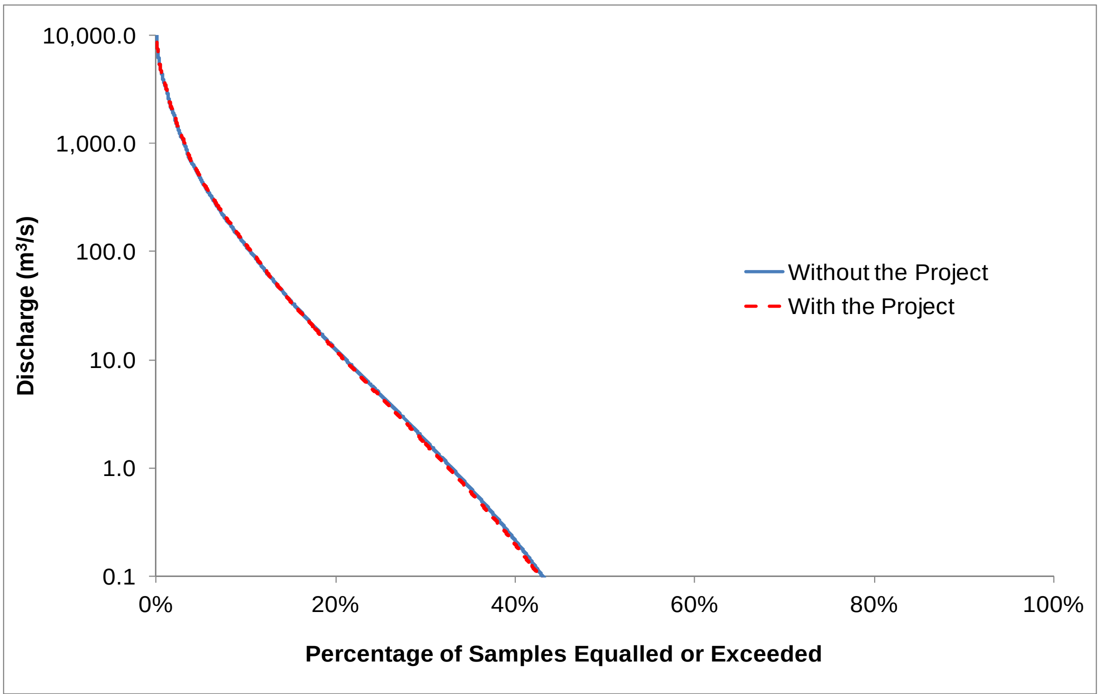


Figure 7.1
FLOW DURATION CURVE – SUTTOR RIVER AT COMPLIANCE POINT

As can be seen in the figure, the mine has a negligible impact on Suttor River hydrology. This is because the Suttor River catchment is much larger than the catchment affected by mining, so any influence is significantly dampened. In addition, the release rules developed for the Project are structured to release most water during high flow periods. The relative flow contribution from mine discharges when there is high flow in the Suttor River is therefore small. Table 7.3 demonstrates this in further detail, showing that the flow above 250 ML/d is the only range that has increased in Suttor River.

Table 7.3 Change in Suttor River flow frequency caused by the Project

Flow range	Percent increase with addition of the Project
<5ML/d	–1.9%
5–25ML/d	–0.4%
25–86.4ML/d	–0.6%
86.4–250ML/d	–0.1%
250–864ML/d	0.3%
>864ML/d	0.3%

The total volume of water discharged in the Suttor River at the downstream compliance point (CP1) increases marginally (≈1%) as a result of the Project. Table 7.4 shows the water balance for the Suttor River.

Table 7.4 Suttor River water balance (cumulative volumes over 46 year mine life)

	Source	Without the Project (GL)	With the Project (GL)
Inflows	Suttor River upstream (MP1)	1,424	1,424
	Surface runoff captured within the Project	127	160
	Groundwater	0	3
	3rd party (Sunwater) for use in dust suppression	0	19
Storage	Dams	0	1
Outflows	Suttor River at compliance point	1,551	1,567
	Dam Evaporation	0	7
	Dust Suppression	0	31
Net Gain/Loss		0	0

Based on this analysis, changes to Suttor River hydrology as a consequence of the Project are expected to be minimal. Table 7.4 shows an increase in the total volume of water in Suttor River however as shown in Table 7.3, the majority of water is released during periods of very high flow and will therefore have minimal impact to the river hydrology.

7.2.2 Kangaroo Creek hydrology

Using the same methodology as Suttor River, the flow duration curve (Figure 7.2) with and without the Project was derived for Kangaroo Creek. Table 7.5 presents a detailed breakdown of the impact within each flow band.

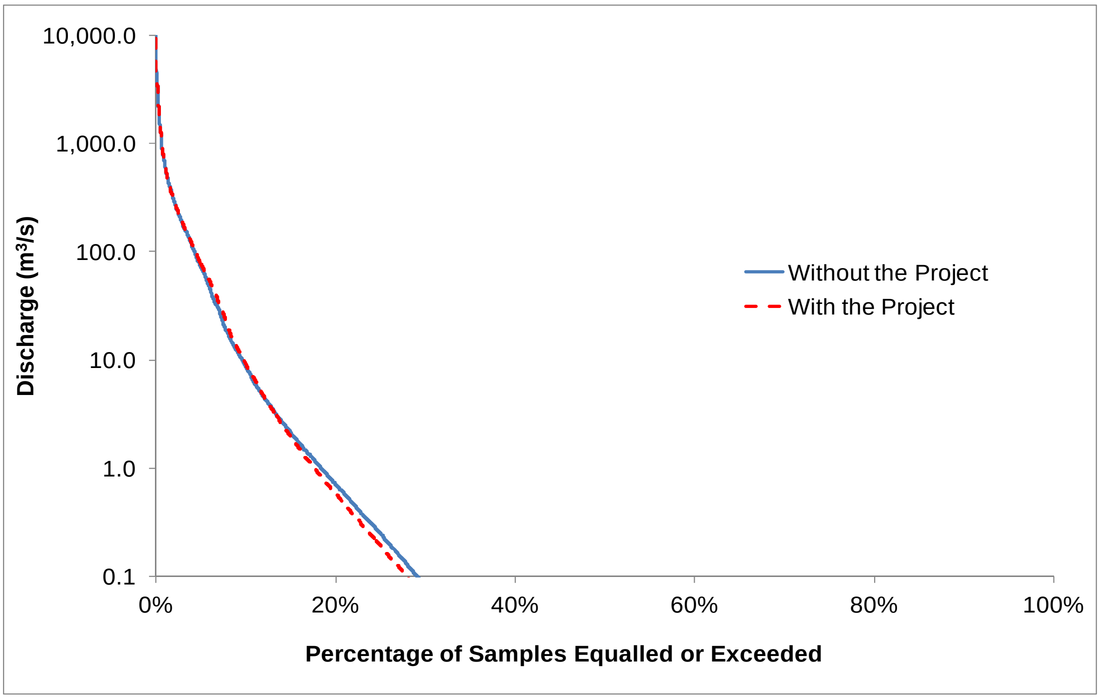


Figure 7.2
FLOW DURATION CURVE – KANGAROO CREEK AT COMPLIANCE POINT

Table 7.5 Change in Kangaroo Creek flow frequency caused by the Project

Flow Range	Per cent increase with addition of the Project
<1ML/d	–7.8%
1–7ML/d	0.2%
7–75ML/d	5.5%
75–200ML/d	–0.9%
>200ML/d	–0.3%

The total volume of water discharged in Kangaroo Creek at the downstream compliance point (CP2) increases marginally (=1%) as a result of the Project. Table 7.6 shows the water balance for Kangaroo Creek.

Table 7.6 Kangaroo Creek water balance (cumulative volumes over 46 year mine life)

	Source	Without the Project (GL)	With the Project (GL)
Inflows	Kangaroo upstream	264	265
	Surface runoff captured by the project	81	107
	Groundwater	0	3
	3rd party (Sunwater) for use in dust suppression	0	21
Storage	Dams	0	1
Outflows	Dust suppression	0	30
	Dam Evaporation	0	18
	Kangaroo creek at compliance point	346	347
Net Gain/Loss		0	0

7.2.3 Local tributaries

The impact of mine discharge on hydrology in local tributaries will be more pronounced than in the larger river systems because the flow changes will constitute a larger proportion of the usual flow. However, the maximum discharges from the mine water system have been capped at 864 ML/d (or 10 m^3/s), which is a relatively frequent flow event in these systems. For example a 10 m^3/s flow in Diversion 1 relates to a design storm event with an average recurrence interval (ARI) of 3–4 months.

7.3 HYDRAULICS

Releases from the mine water system have the potential to influence flooding in local tributaries. However, as described above, the maximum release rate permissible under the proposed operational rules for the Project is 10 m^3/s from all combined releases into the Suttor River catchment. This compares with the design flow rate (1,000 year ARI) of 228 m^3/s for Diversion 1 and 272 m^3/s for Diversion 2 (KBR, 2012b).

The design flow rates for the diversions have been conservatively calculated based on the existing catchment upstream of the railway crossing (i.e. the downstream end of the diversion). During mining substantial parts of the catchment will be captured within the mine water system, reducing flows reporting to the diversion. This reduction is expected to more than compensate for the additional mine discharges that could be released into a diversion if they happened to coincide with a flood peak.

7.4 WATER QUALITY

7.4.1 Suttor River salinity

By virtue of the release conditions, there is no change to the 80^{th} percentile EC in the Suttor River since no releases are permitted from the mine when the EC in the Suttor River upstream of the mine is 2,040 µS/cm or above. There is a very slight increase in the modelled EC at percentiles below the 80^{th} percentile, reflecting the effect of the releases. However these are of a very low order (10s of microsiemens per centimetre) and would not have measurable impact on the river water quality.

The effect in terms of salt load (flux) is more apparent and is shown in Table 7.7.

Table 7.7 Suttor River salt balance (cumulative volumes over 46 year mine life)

	Source	Without the Project (thousand tonnes)	With the Project (thousand tonnes)
Inflows	Suttor salt flux upstream	1,138	1,138
	Runoff salt captured by the Project	101	113
	Ground water salt	0	9
Storage	Dams	0	1
Outflows	Suttor salt flux at compliance point	1,239	1,246
	Dust Suppression	0	13
Net Gain/Loss		0	0

7.4.2 Kangaroo Creek salinity

The water balance model suggests similar findings for Kangaroo Creek as described above for Suttor River. The effect in terms of salt load (flux) is shown in Table 7.8.

Table 7.8 Kangaroo Creek salt balance (cumulative volumes over 46 year mine life)

		Without the Project (thousand tones)	With the Project (thousand tones)
Inflow	Kangaroo salt flux upstream	186	186
	Runoff salt captured by the project	56	62
	Groundwater salt	0	10
Storage	Dams	0	1
Outflow	Dust suppression	0	13
	Kangaroo salt flux at compliance point	242	244
Net Gain/Loss		0	0

7.4.3 Erosion and sediment mobilisation

Sediment mobilised during construction activities has the potential to discharge to waterways leading to deleterious effects on water quality and aquatic habitats. Sediment exposed or generated during construction may also be blown by wind into surface water bodies. Areas of disturbed soil will be managed to reduce sediment mobilisation or erosion by best practice management techniques.

An Erosion and Sediment Control Plan will be developed for the Project. The key features in the Erosion and Sediment Control Plan will involve:

- concentrating work to as small an area as practicable to limit the amount of disturbed area exposed at any one time
- minimising the number of passes by heavy earth moving equipment when undertaking soil stripping activities
- implementing sediment limitation devices (e.g. settlement/evaporation dams, drainage ditches) to restrict sediment movement off site
- constructing bunds to restrict flow velocities across the Project area and therefore reducing scour of waterway bed and banks
- limiting vegetation clearing work during heavy rainfall
- adopting stormwater controls and upstream treatment, such as infiltration devices and vegetation filters
- revegetating and/or use of other stabilisation techniques, considering seasonal influences, upon completion of works
- minimising vegetation disturbance, especially riparian vegetation
- implementing dust suppression measures including irrigation, energy dissipation and scour protection measures such as matting, riprap and gabions.

Construction activities at or near drainage features can mobilise sediment and alter flow and quality characteristics. These potential impacts can be managed by:

- installing suitable stormwater management infrastructure prior to commencing construction activities
- minimising disturbance by earthmoving equipment, especially in riparian areas.

7.4.4 Contaminant mobilisation

Potential sources of onsite water contaminants during mining are predominately diesel and other petroleum based fuel and lubricants used by excavation and construction machinery. Litter may also detrimentally impact water quality. There may be some minor releases through spills/accidents, but these will most likely occur in pits and be contained within the mine water management system.

The potential impacts will be mitigated by:

- the transfer of fuels and chemicals controlled and managed to prevent spills outside of bunded areas
- a management system that requires any significant spillage or leakage to be immediately reported and an appropriate emergency clean-up operation implemented to prevent possible mobilisation of contaminants.

These measures will reduce the likelihood and the consequences of the above impacts.

7.5 MONITORING PROGRAM

A water quality monitoring program will be implemented within the Project area for the life of the Project. Monitoring is proposed for water storages, release points and the receiving environment. A Receiving Environment Monitoring Program (REMP) would be developed to assess the local receiving waters for the specified discharge locations. The purpose of the REMP is to assess the overall condition of the local receiving waters. Table 7.9 provides an indication of the likely water quality characteristics which will be assessed as part of the program, and would be confirmed during development of the REMP in consultation with the regulator.

Table 7.9 Monitoring program

Location	Number of locations	Quality characteristic	Monitoring frequency
Water storages	Varies throughout mine life	pH Electrical conductivity Sulfate Aluminium (total) Copper (total) Lead (total) Nickel (total) Uranium (total) Zinc (total)	Quarterly
Release points	Varies throughout mine life	Aluminium (total and filtered) Cadmium (total and filtered) Chromium (total and filtered) Copper (total and filtered) Iron (total and filtered) Lead (total and filtered) Nickel (total and filtered) Zinc (total and filtered) Boron (total and filtered) Manganese (total and filtered) Molybdenum (total and filtered) Selenium (total and filtered) Silver (total and filtered) Uranium (total and filtered) Vanadium (total and filtered) Ammonia Nitrate Petroleum hydrocarbons (C6–C9) Petroleum hydrocarbons (C10–C36) Sodium	Commencement of release and thereafter weekly during release
		Electrical conductivity pH Turbidity Suspended solids Sulfate	Daily during release
Receiving environment	4 (2 compliance points, 2 upstream points) Palustrine wetland	pH Electrical conductivity Turbidity Suspended solids Sulfate Sodium	Daily (during the release of mine water); Monthly (of natural flow)

Biological indicators such as macroinvertebrate surveys will also be periodically undertaken. Refer to the Aquatic Ecology technical appendix for further details.

7.6 UNPLANNED DISCHARGES

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 water inventory without compromising the downstream water quality
- maintaining the required DSA at the beginning of the wet season
- having contingency measures available in the event that a dam exceeds it operational storage capacity, such as in-pit storage
- 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.

With these measures in place there are no modelled scenarios in which unplanned discharges occur.

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.

7.7 PALUSTRINE WETLAND

According to wetland mapping (Queensland Wetlands 2009), a small Palustrine Wetland is located near the western mining lease boundary of the site. This wetland has a catchment area of 4.2 km^2.

During mining the catchment supplying water to the wetland will be disrupted by construction of a waste rock dump associated with West Pit, reducing flow to the wetland. In the first year of mining the catchment will reduce from 4.2 km^2 to 2.9 km^2, and then there will be a further reduction from 2.9 km^2 to 2.4 km^2 around year 5.

The remediation strategy for this part of the Project involves returning the land to a similar hydrological profile, creating a similar catchment for the wetland. The area should be rehabilitated by around year 16, allowing the natural hydrological processes currently feeding the wetland to be reinstated.

The catchment of the Palustrine wetland will be reduced for a period of around 16 years. In a median rainfall year the surface water flowing to the wetland would reduce from approximately 170 ML to 95 ML as a result of the catchment reduction, resulting in a shortfall of some 75 ML per annum over the 16 year disturbance period. The impacts of this change in hydrology on the wetland ecology are discussed in the Aquatic Ecology Impact Assessment (AMEC, 2012).

7.8 CUMULATIVE IMPACTS

Local and regional mining projects considered as part of a review of potential cumulative impacts are presented, according to their respective catchments, within Table 7.10.

Table 7.10 Local and regional projects

Bowen River catchment	Suttor River catchment
Drake Coal Project	Goonyella Riverside Mine
Sarum Project	Wards Well Underground
Jax Project	Newlands Coal Project
Newlands Coal Project	
Newlands Coal Extension Project	
Sonoma Coal Project	

As discussed within Sections 7.1 to 7.6 above, impacts within the Suttor River and Kangaroo Creek resulting from sediment and contaminant mobilisation, changes in hydrology and hydraulics and changes in salt loads are expected to be minor. This is due to the proposed management and mitigation strategies which include a detailed mine water management system, sediment basins, restrictions to site water discharges, progressive rehabilitation and water quality monitoring.

At a local level, these watercourses would also be impacted to a degree by potential increases in salt loads and sediment resulting from the Sonoma Coal Project, Newlands Coal Project and Newlands Coal Extension Project. A potential exists for a degree of cumulative impact on the abovementioned watercourses. However, given that the abovementioned projects have been and will be required to implement similar management and mitigation strategies to the Project, impacts from these projects are also anticipated to be minor. Cumulative impacts are therefore not expected to be significant however there is insufficient data available to quantify this.

At a regional level, activities associated with other coal mining projects within the Bowen and Suttor Catchments (refer to Table 7.10) will have a certain cumulative impact on these catchments and wider Burdekin Basin. Quantification of the scale of those impacts is not possible without appropriate levels of data. It is noted that EHP are currently undertaking investigations within the Fitzroy Catchment to quantify the cumulative impacts of mining on water resources. In the longer term, it may be necessary for similar studies to be undertaken within the Burdekin Basin.

8 Conclusions

The water management strategy for the Project will involve segregation of water into three types: mine-affected, sediment-affected and clean. Water from sediment-affected catchments will be suitable for release after passing through sedimentation basins. Water collected from mine-affected catchments will be released from site when there is sufficient flow in the receiving waterway, and when water quality objectives can be satisfied.

Discharge limit and receiving environment trigger values have been proposed based on environmental values in the downstream systems and baseline environmental monitoring.

A water balance model has been developed to assess the ability of the proposed water management infrastructure to meet the design and environmental compliance objectives. In extreme rainfall scenarios it may be necessary to utilise contingency measures to temporarily store or remove excess accumulated water. These may include:

- transfer of water between dams to balance storages
- use of mine-affected water in the processing circuit (which could be tolerated for short periods without detriment to the plant)
- 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).

The water balance model demonstrates that the design objectives can be satisfied by the proposed water management infrastructure.

The mine water system is not expected to have any significant impacts on the hydrological regime in Suttor River or Kangaroo Creek. The catchment of a palusrine wetland adjacent to the Suttor River would be affected during a 16 year period as a result of mining. The remediation strategy for the area will include returning the land to a similar hydrological profile, creating a similar catchment for the wetland.

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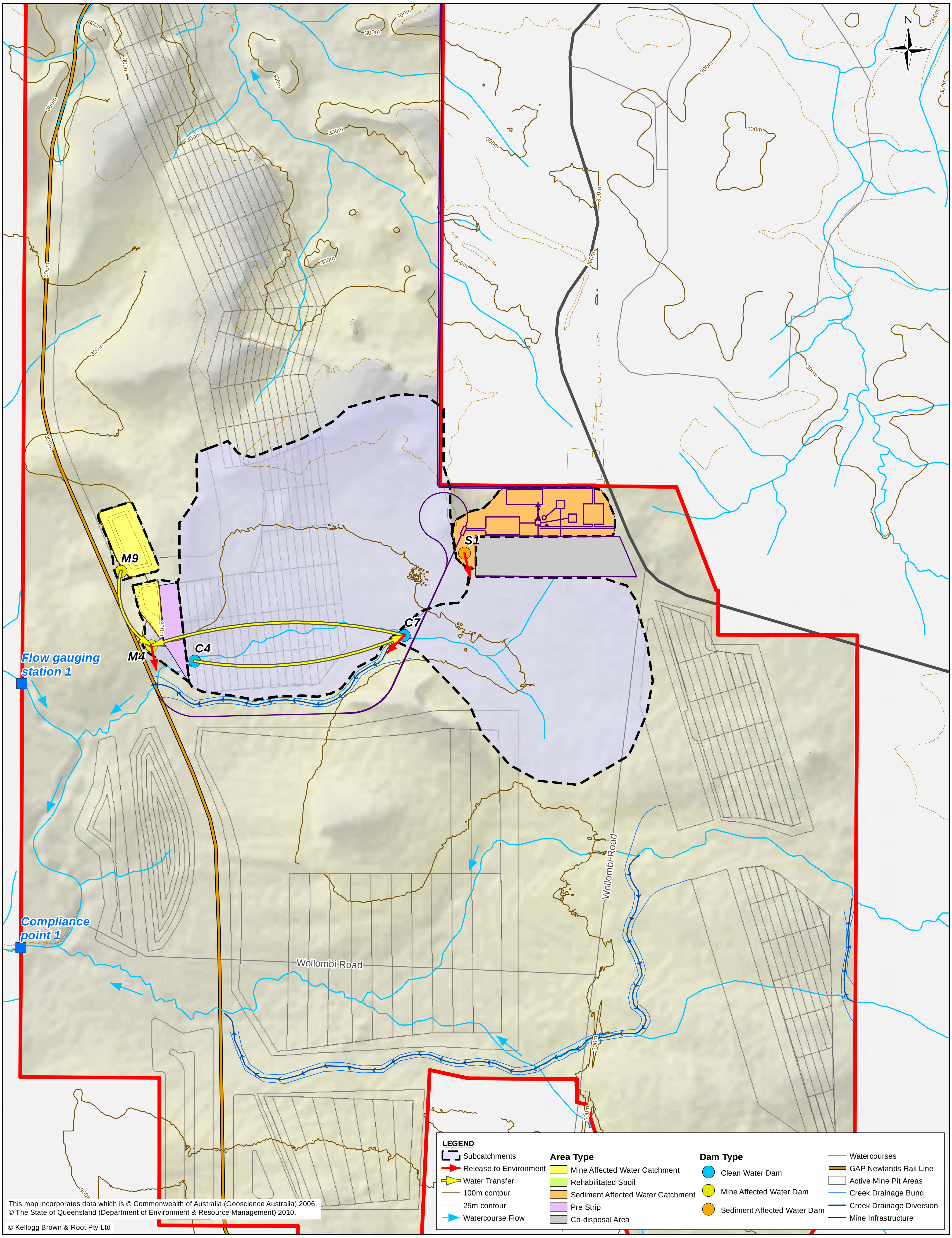
Appendix A

FIGURES



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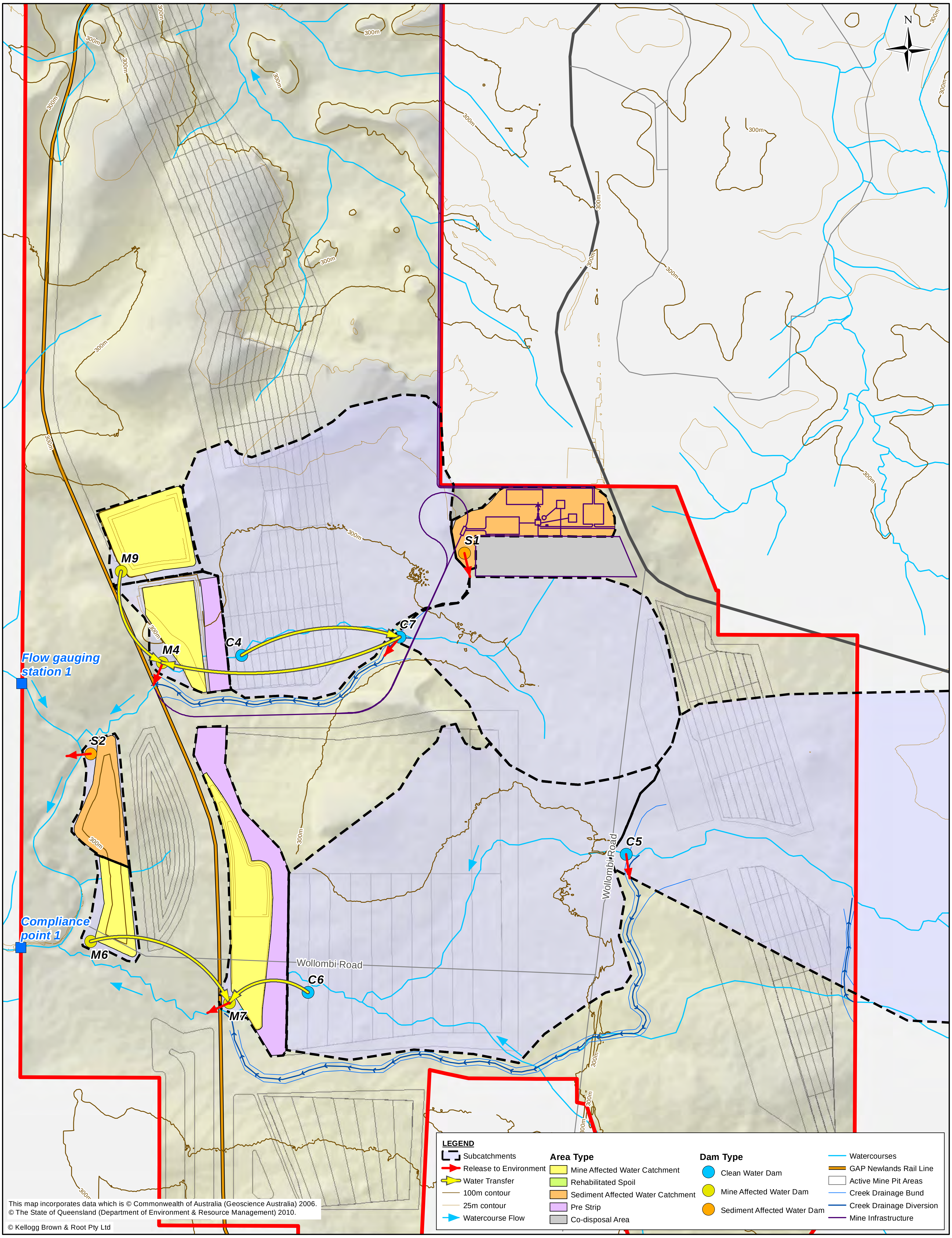

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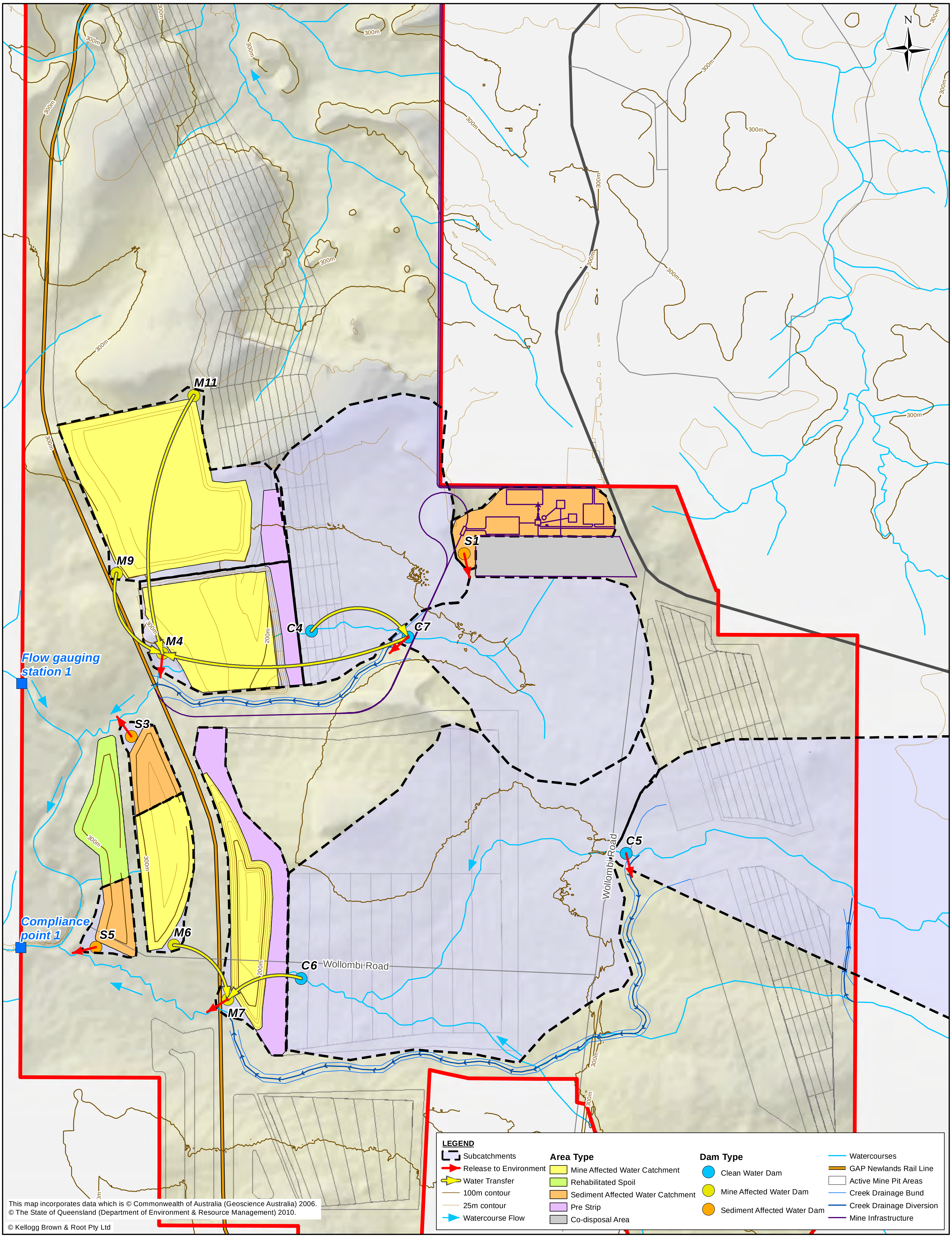

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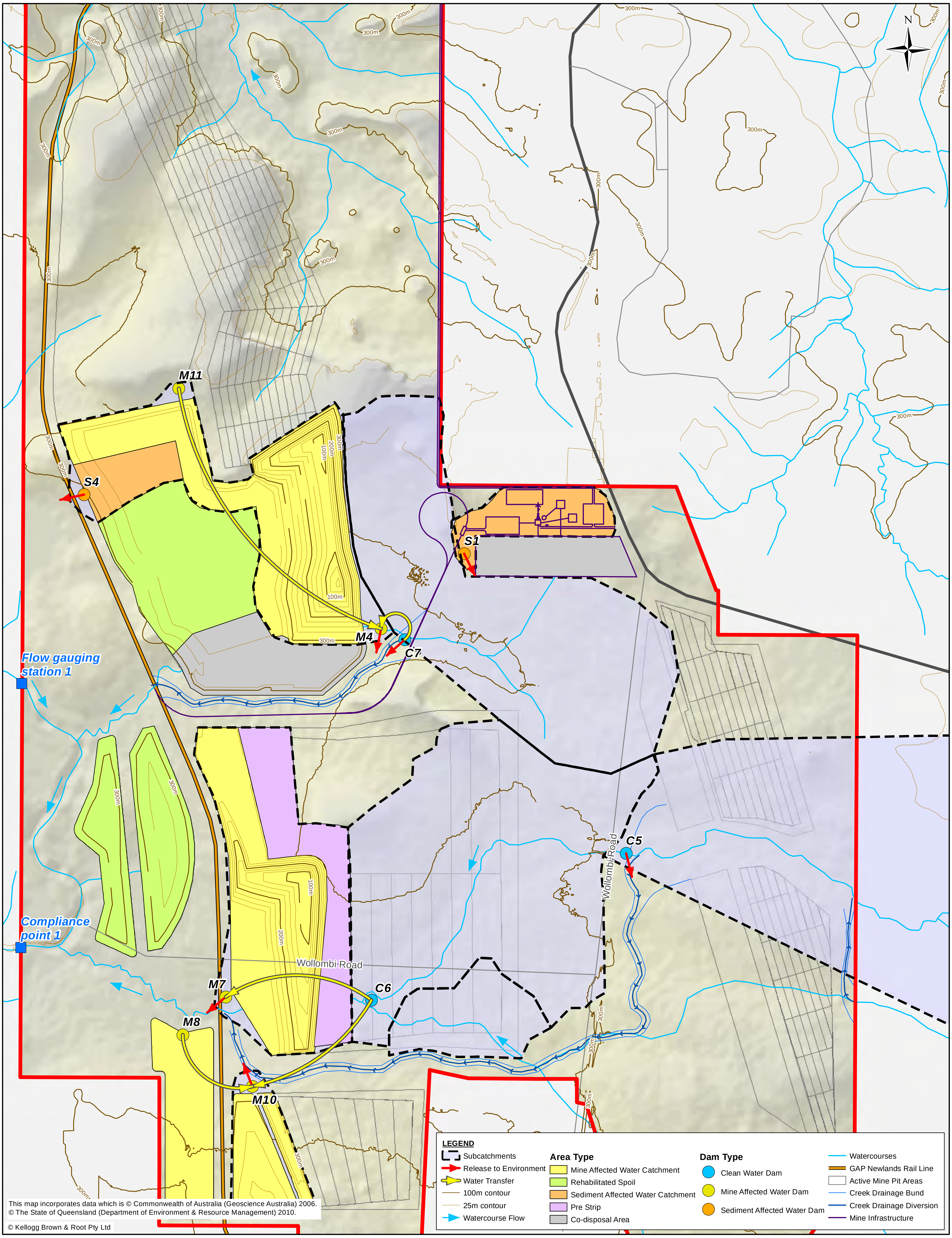

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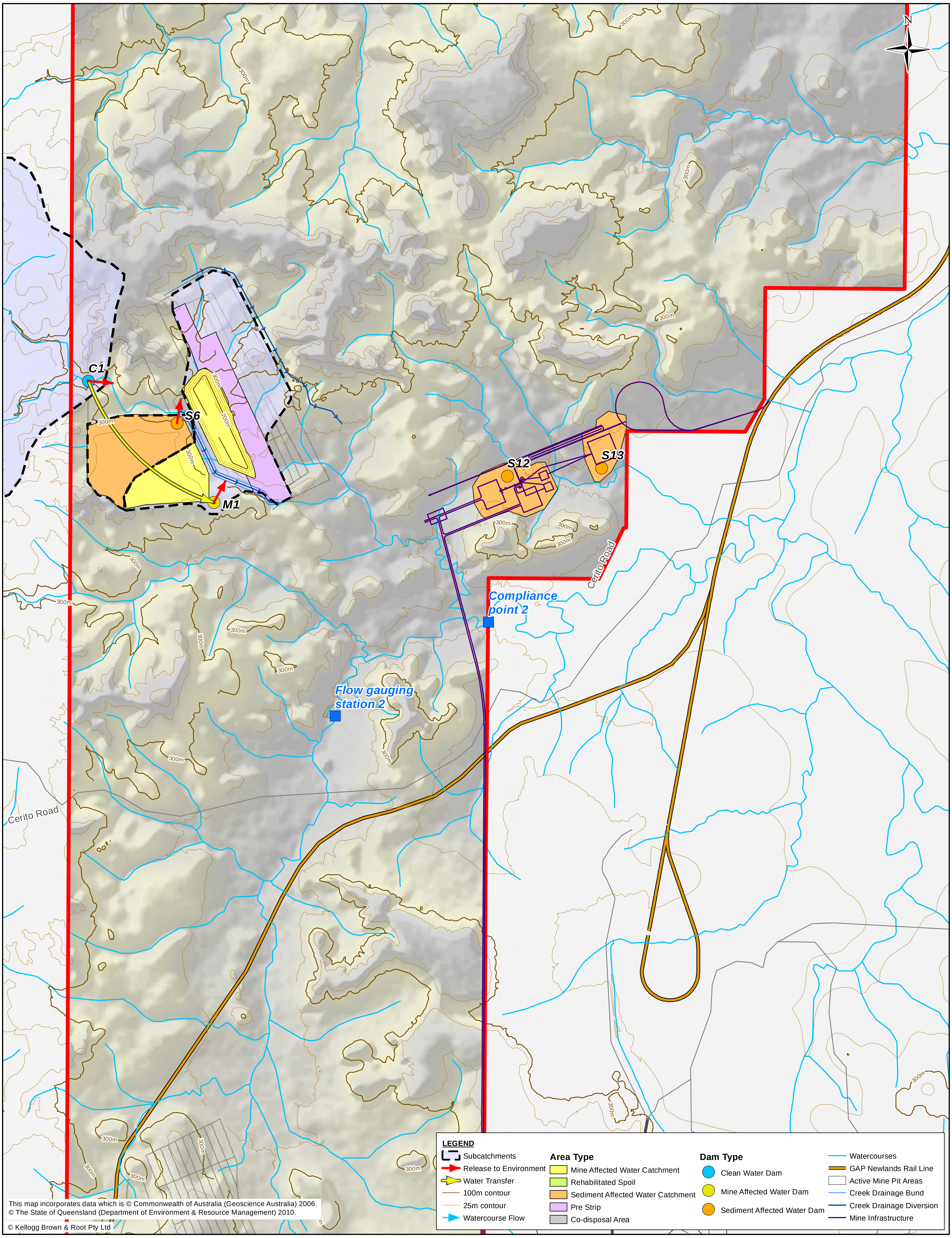

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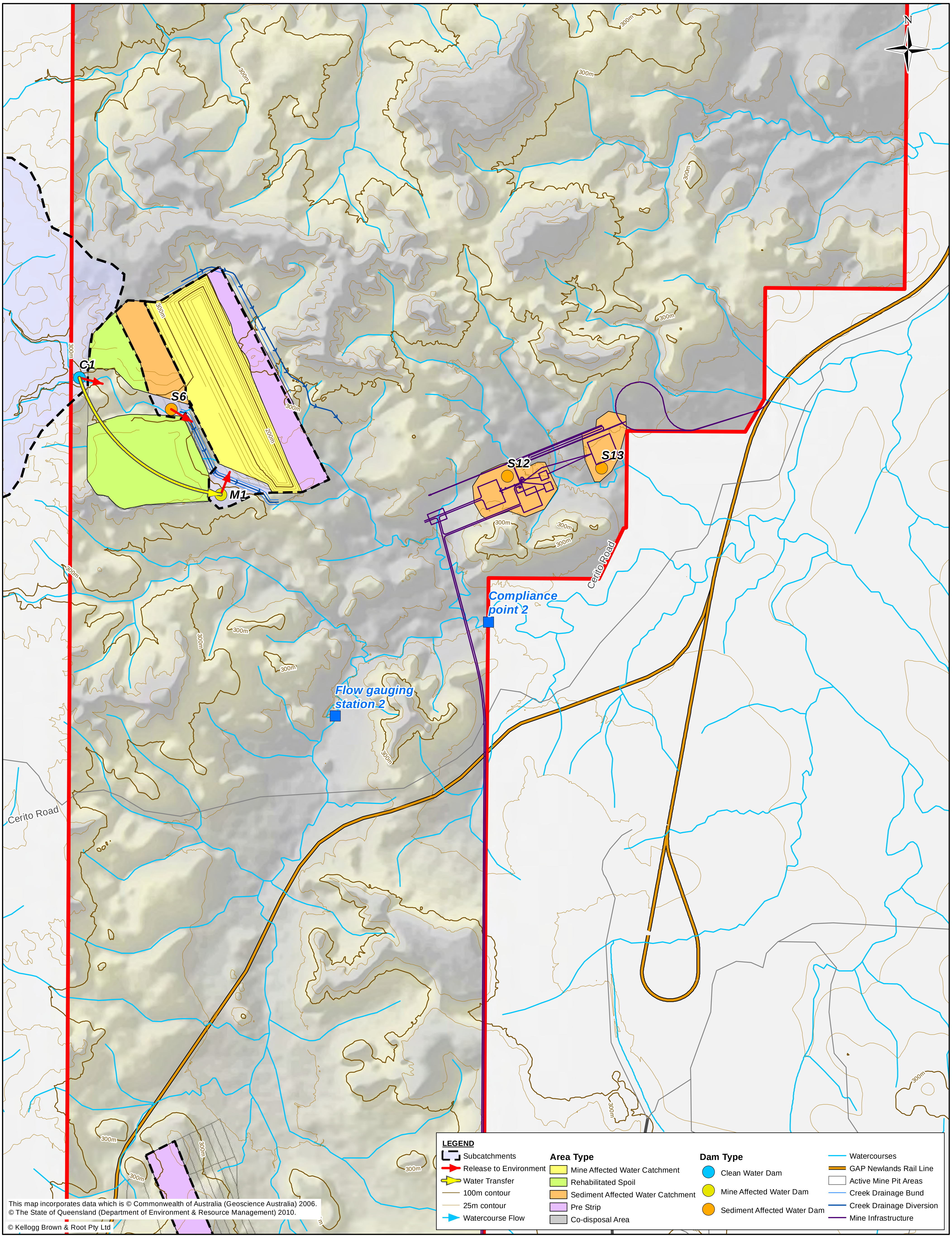

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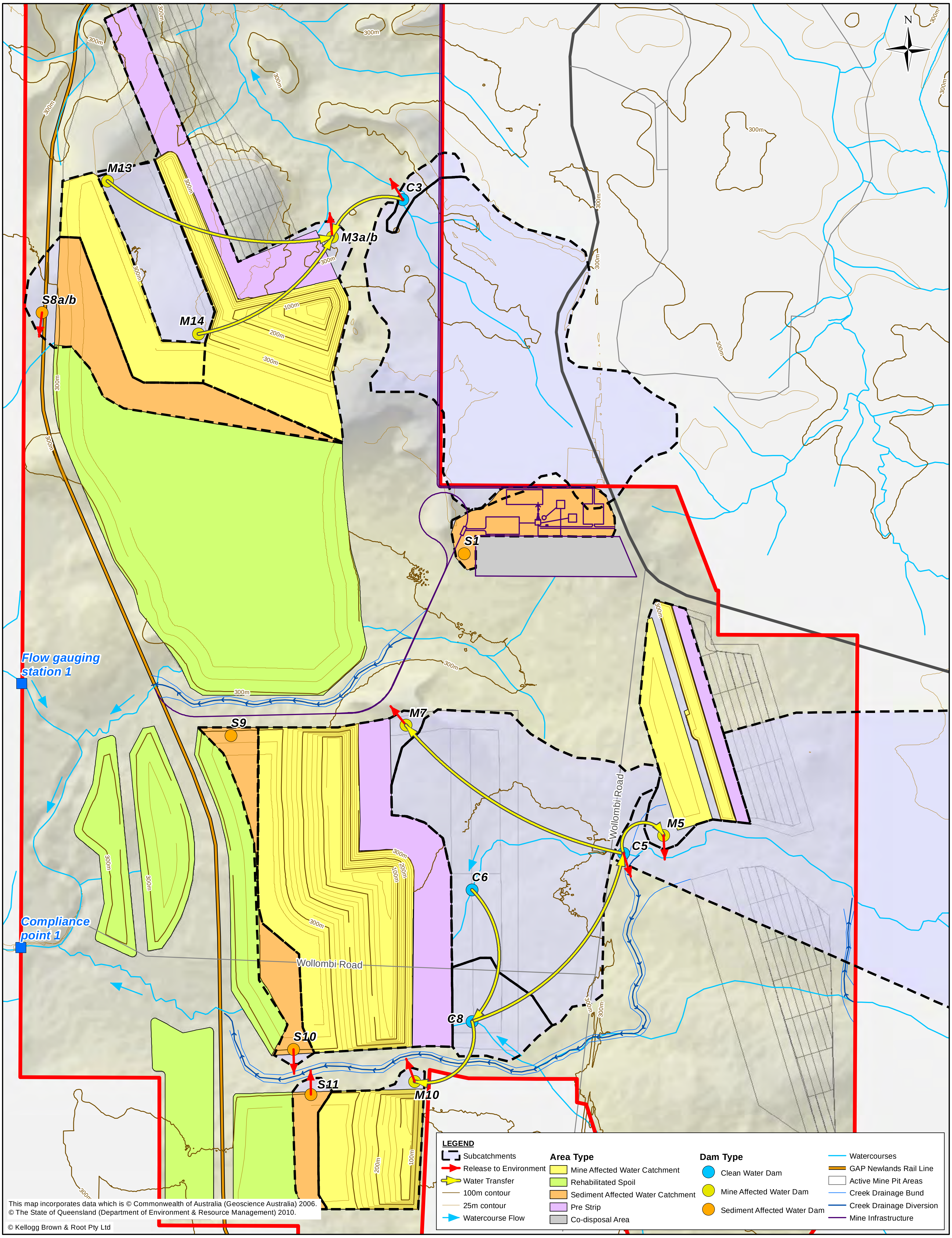

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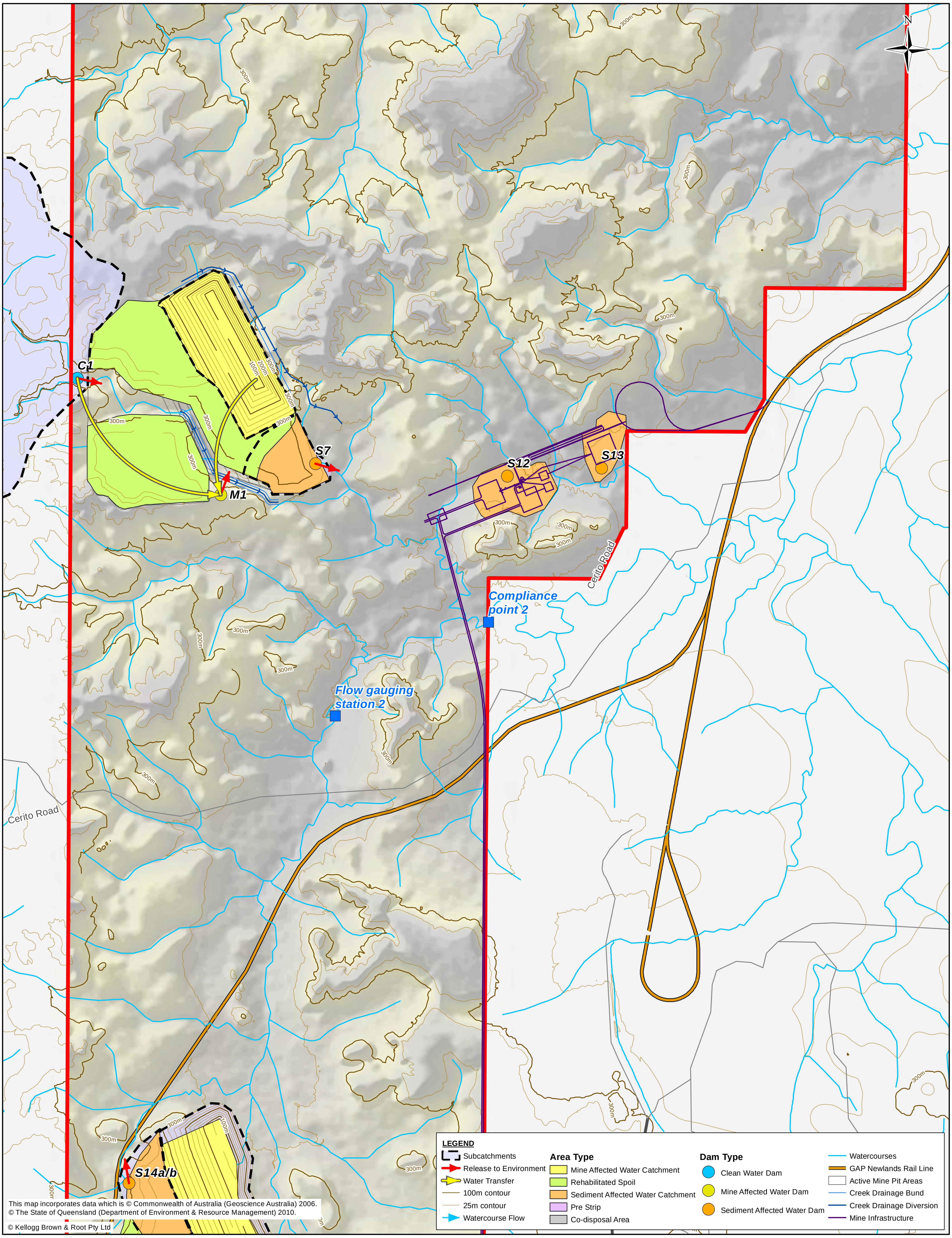

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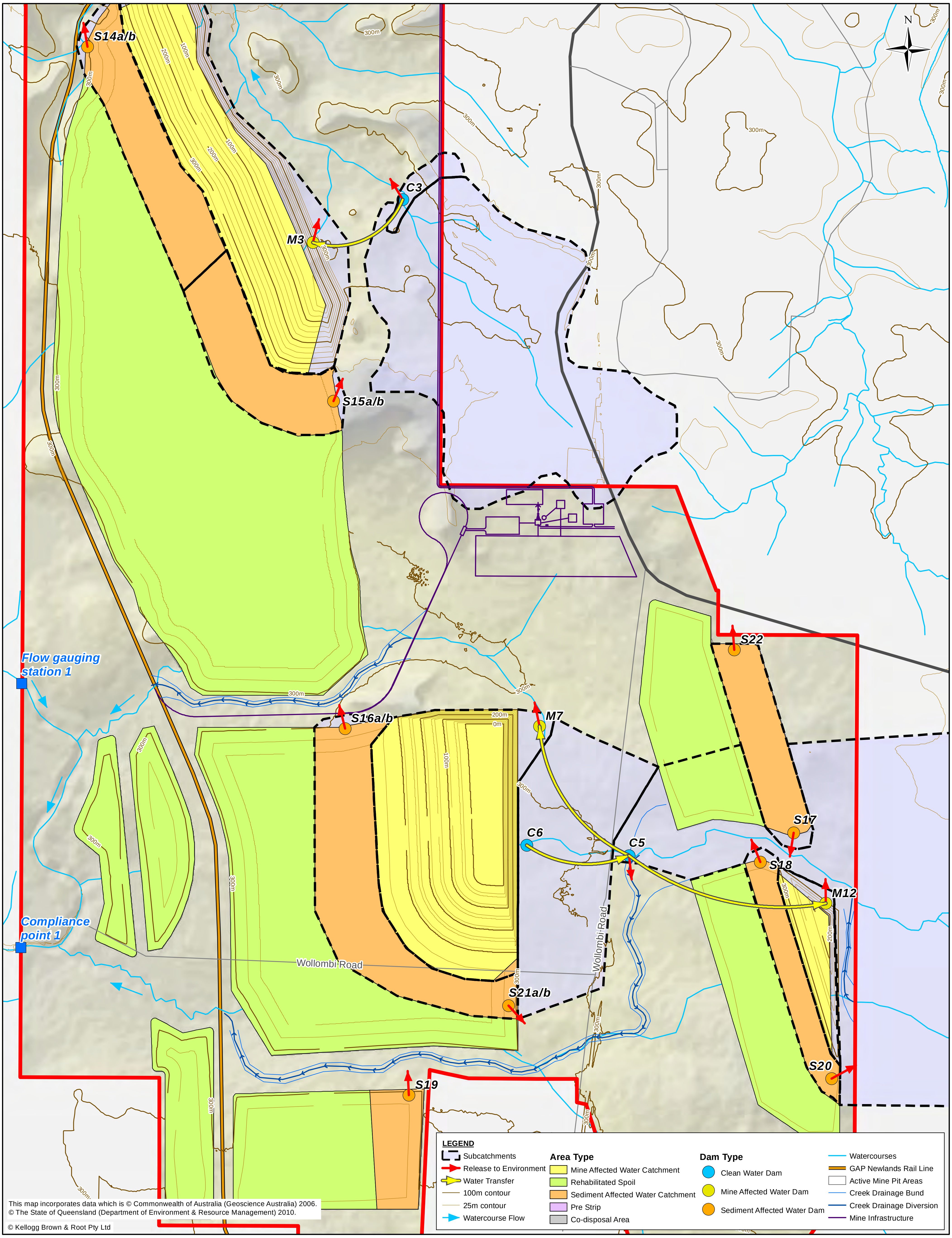

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