Central Queensland Coal Project

Chapter 9 – Surface Water

Environmental Impact Statement

CDM Smith

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Central Queensland Coal Project

Chapter 9 – Surface Water

24 October 2017

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Table of Contents

List of Figures

List of Tables

List of Plates

9 Surface Water

This chapter describes the Environmental Values (EVs) of surface water resources that may be affected by the Central Queensland Coal Project (herein referred to as 'the Project'). Existing water quality conditions for surface waters upstream, downstream and within the Project area and potential changes to the hydrological regime, flooding and surface drainage because of the proposed activities are discussed. Potential impacts of the Project on the existing water quality EVs are outlined and appropriate mitigation measures are proposed to manage any impacts. Appendix A5a – Surface Water and Groundwater Quality Results and Appendix A5b – Historical Surface Water Quality Results present the laboratory data used in this assessment. Note that Appendix A5b – Historical Surface Water Quality Results references the original proponent; Styx Coal Pty Ltd, and the original Project name, Styx Coal Mine Project; however, the Central Queensland Coal Pty Ltd is the new proponent for the Project and the Project has been renamed as Central Queensland Coal Project to better reflect the change of Proponent. This proponent and title change does not affect the technical studies.

9.1 Project Overview

The Project is located 130 km northwest of Rockhampton in the Styx Coal Basin in Central Queensland. The Project will be located within Mining Lease (ML) 80187 and ML 700022, which are adjacent to Mineral Development Licence (MDL) 468 and Exploration Permit for Coal (EPC) 1029, both of which are held by the Proponent.

The Project will involve mining a maximum combined tonnage of up to 10 million tonnes per annum (Mtpa) of semi-soft coking coal (SSCC) and high grade thermal coal (HGTC). Development of the Project is expected to commence in 2018 and extend for approximately 20 years until the current reserve is depleted.

The Project consists of three open cut operations that will be mined using a truck and shovel methodology. The run-of-mine (ROM) coal will ramp up to approximately 2 Mtpa during Stage 1 (Year 1-4), where coal will be crushed, screened and washed to SSCC grade with an estimate 80% yield. Stage 2 of the Project (Year 4-20) will include further processing of up to an additional 4 Mtpa ROM coal within another coal handling and preparation plant (CHPP) to SSCC and up to 4 Mtpa of HGTC with an estimated 95% yield. At full production two CHPPs, one servicing Open Cut 1 and the other servicing Open Cut 2 and 4, will be in operation.

A new train loadout facility (TLF) will be developed to connect into the existing Queensland Rail North Coast Rail Line. This connection will allow the product coal to be transported to the established coal loading infrastructure at the Dalrymple Bay Coal Terminal (DBCT).

The Project is located within the Livingstone Shire Council (LSC) Local Government Area (LGA). The Project is generally located on the "Mamelon" property, described as real property Lot 11 on MC23, Lot 10 on MC493 and Lot 9 on MC496. The TLF is located on the "Strathmuir" property, described as real property Lot 9 on MC230. A small section of the haul road to the TLF is located on the "Brussels" property described as real property Lot 85 on SP164785.

9.2 Relevant Legislation, Plans and Guidelines

Chapter 1 - Introduction presents the regulatory framework relevant to the Project. Those that relate to water are:

- *Environmental Protection Act 1994* (EP Act);
- *Environmental Protection (Water) Policy 2009* (EPP Water);
- *EP Act Guideline: Application Requirements for Activities with Impacts to Water version 2* (EHP 2014);
- *Water Act 2000* (Water Act);
- *Sustainable Planning Act 2009* (SP Act);
- *Fisheries Act 1994;*
- Department of Environment and Heritage Protection (EHP) Queensland Water Quality Guidelines 2009 (QWQG); and
- Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000) (herein referred to as the ANZECC guidelines).

The following Codes and Manuals apply to the Project in the context of flooding, drainage structure design and regulated structure assessment:

- Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EHP 2016); and
- State Development Assessment Provisions (DILGP 2013), 5.2 Constructing or raising waterway barrier works in fish habitats state code.

This assessment has been prepared to address the requirements of the ToR by establishing the existing surface water Environmental Values (EVs) under the relevant legislation, plans and guidelines and assessing the potential impacts on the EVs by the Project.

9.2.1 Environmental Protection Act 1994

The EP Act provides the key legislative framework for environmental management and protection in Queensland. The object of the EP Act is to 'Protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains ecological processes on which life depends' (s3).

The EP Act has a range of subordinate legislation which assists in achieving the object, including the EP Regulation and EPP Water. Among certain aspects, the EP Regulation controls activities with potential to release contaminants into the environment (Environmentally Relevant Activities [ERAs]); contains referrable wetland requirements, prescribes water contaminants (Schedule 9) and sets EVs for wetlands (s 81A). The EP Act and EP Regulation regulate mining and associated ERAs through EA conditions. These conditions provide a means to regulate surface water management for the Project.

9.2.2 Environmental Protection (Water) Policy 2009

The EPP (Water) seeks to achieve the objectives set within the EP Act in relation to Queensland waterways. That is, it seeks to: 'Protect Queensland's waters while allowing for development that is ecologically sustainable' (s3 EP Act).

This purpose of this policy is achieved by:

- Identifying EVs and management goals for Queensland waters;
- Stating water quality guidelines and water quality objectives to enhance or protect the EVs;
- Providing a framework for making consistent, equitable and informed decisions about Queensland waters; and
- Monitoring and reporting on the condition of Queensland waters.

Schedule 1 of the EPP (Water) defines EVs for waters within Queensland. EVs and water quality objectives (WQOs) are prepared for drainage basins (at the sub-basin level); however, the setting of values and objectives is at different stages of development throughout Queensland. These EVs and WQOs are set under the EP Act, and its subordinate legislation, while basin resource plans are set under the Water Act.

9.2.3 Sub-basin EVs and WQOs

The Project is wholly contained within the Styx River Basin. Specific EVs and WQOs for the Styx River Basin were released in 2014 as part of the Styx River, Shoalwater Creek and Water Park Creek Basins Environmental Values and Water Quality Objectives (EHP 2014a).

9.2.4 Water Act 2000

The Water Act provides a structured system for the planning, protection, allocation and use of Queensland's surface waters and groundwater. Under section 808 of the Water Act, a person must not take, supply or interfere with water unless authorised. Authorisation under the Water Act for the taking of water from overland flow, groundwater, a watercourse, lake or spring comes via a water entitlement and a development application.

The Water Act provides for the protection of natural ecosystems and security of supply to water users through the development of water resource plans (WRPs), and other activities. Each managed catchment in Queensland has a separate WRP and associated Resource Operations Plan (ROP) to provide a framework to apply (under the Water Act, Chapter 2 Part 6) and regulate water extractions to ensure that they are maintained as a sustainable resource. The Project is located within the Styx River Basin (see Figure 9-3), which is not covered by any WRP or ROP.

Tooloombah Creek and Deep Creek are both defined as watercourses under the Water Act and border the MLA area to the east and west, respectively (see Figure 9-3). Deep Creek is traversed by the haul road to the TLF and several first and second order drainage features are traversed by the haul road connecting Open Cut 1 to the MIA or diverted around mine pits. Water storage dams are also proposed to be located on first and second order drainage features (see Figure 9-3).

The following approval could potentially be required under the Water Act:

- Placing fill or excavating in a watercourse, as required for works associated with construction of haul roads, bridges and culverts under a Riverine Protection Permit (RPP) described in section 266 of the Water Act (if the works do not comply with the guidelines in 'Riverine protection permit exemption requirements' WSS/2013/726, Version 1.02' (DNRM 2016)).

As the proposed water related operational works will be located within a Mining Lease area, they are an authorised activity under the *Mineral Resources Act 1989* and EP Act. The Project has no requirement for an authorisation to divert the flow of water under the Water Act authorised under an EA; however, this does not exempt the Project from requiring an RPP where the activity does not meet the exemption requirements under the Water Act.

9.2.5 Planning Act 2017

Placing fill in a waterway or constructing waterway barrier works (as defined under the Fisheries Act) associated with the construction of haul road, bridges, culverts and any other waterway crossings outside the boundaries of the mining leases will be required to obtain development approval under the *Planning Act 2017* where they do not comply with the requirements of a self-assessable code (DAFF 2013).

9.2.6 Fisheries Act 1994

The main purpose of the *Fisheries Act 1994* (Fisheries Act) is to provide for the use, conservation and enhancement of the fish resources and habitats to apply and promote the principles of Ecologically Sustainable Development (ESD). It regulates the taking and possession of specific fish, removal of marine vegetation, the control of development in areas of fish habitat and listed noxious fish species. An approval is not required for waterway barrier works within waterways as mining activities are exempt from the Fisheries Act.

All waters of the state are protected against degradation by direct or indirect impact under s125 of the EP Act. If litter, soil, a noxious substance, refuse or other polluting matter is on land, in waters or in a fish habitat and the polluting adversely affects fisheries resources or habitat then penalties apply. There is no mapped fish habitat area within the Project area.

9.2.7 Queensland Water Quality Guidelines 2009

The Queensland Water Quality Guidelines (EHP 2009) (QWQG) provide tailored guideline values for Queensland water types and regions. The QWQG also provide a framework for deriving and applying specific guidelines that are local to the waterways in Queensland. Where more locally relevant guidelines are appropriately developed, and meet relevant technical requirements (such as those identified in QWQG), then they would in turn take precedence. Locally accepted WQOs are listed under Schedule 1 of the EPP (Water). The Project is wholly contained within the Styx River Basin, which has specific WQOs under Schedule 1 of EPP (Water) that take precedence over the QWQGs.

9.2.8 Australian and New Zealand Guidelines for Water Quality 2000

The ANZECC fresh and marine water quality guidelines provide a baseline for monitoring and measuring surface water quality for different ecosystems within Australia and New Zealand. The ANZECC guidelines provide threshold values that identify water quality levels based on multiple chemical and physical parameters. For example, the level of water quality at a certain site can be determined by comparing a range of parameters (e.g. pH, turbidity and conductivity) against threshold values outlined by the ANZECC guidelines. For this section, WQOs for toxicants (metals, inorganics etc.) have been based on the ANZECC guidelines, as per the Styx River, Shoalwater Creek and Water Park Creek Basins Environmental Values and Water Quality Objectives (EHP 2014a) (see Section 9.3).

Sediments can act as a source or sink for contaminants, thereby directly affecting the quality of surface waters. For this section, this Guideline will also be used to compare sediment quality data obtained from on-site sampling (for the Project baseline study) against the Interim Sediment Quality Guidelines for toxicants in sediment (Section 3.5 ANZECC guidelines) (see Section 9.3.1).

9.3 Environmental Objectives and Performance Outcomes

9.3.1 Environmental Objective

The environmental objective relevant to surface water provided in Schedule 5 of the EP Regulation is to:

- Operate in a way that protects the EVs of water and wetlands;
- Locate operational activities in such a way that minimises serious environmental harm on areas of high conservation value and special significance and sensitive land uses; and
- Design the water management infrastructure and facilities in such a way that permits operation of the site in accordance with best practice environmental management.

9.3.2 Performance Outcomes

The main aim for the Project is for no actual or potential discharge to waters of contaminants that may cause an adverse effect on an EV from the operation of the activity. The following are the Project's performance outcomes for surface water:

- The activity will be managed so that adverse effects on EVs are prevented or minimised;
- The activity will be managed in a way that prevents or minimises adverse effects on wetlands;
- Regulated structures will comply with the 'Manual for Assessing Consequence Categories and Hydraulic Performance of Structures' (EHP, 2016);
- Infrastructure will be designed with sufficient flood immunity as to prevent the contamination of otherwise clean water runoff from external contributing catchments;
- Infrastructure will be located outside of flood storage and flood conveyance areas to the extent possible and with the aim of minimising the impact of any activity on existing flood behaviour;
- The storage and handling of contaminants will include effective means of secondary containment to prevent or minimise releases to the environment from spillage or leaks;
- Contingency measures will prevent or minimise adverse effects on the environment due to unplanned releases or discharges of contaminants to water;
- The activity will be managed so that stormwater contaminated by the Project that may cause an adverse effect on an EV will not leave the site without prior treatment; and
- Stormwater drains and hydraulic structures such as spillways, culverts and floodways, will be designed with appropriate scour protection measures to reduce the migration of sediments to receiving waters.

9.4 Description of Environmental Values

The QWQG defines EVs for water as the qualities of water that make it suitable for supporting aquatic ecosystems and human water uses. These EVs need to be protected, by maintaining or enhancing the water quality from the effects of habitat alteration, waste releases, contaminated runoff and changed flows to ensure healthy aquatic ecosystems and waterways that are safe for community use. For management purposes, waters are grouped into catchments and sub-catchments and EVs are provided at a catchment level for protection of defined water uses.

The following terms for water are used herein:

- Watercourse – A significant / high order defined drainage feature of watercourse as classified by DNRM (see Section 9.4.3);
- Drainage feature – A minor tributary that flows only intermittently and for the duration of rainfall events;
- Waterway – A creek or drainage feature with a defined bank, usually used in the context of defining impacts due to changes in water quality; and
- Waters – General term for a receiving body of water (creek, dam, pool etc.), usually used in the context of defining impacts due to changes in water quality.

9.4.1 Climate

Long-term rainfall and evaporation data were collected from the Scientific Information for Land Owners (SILO) Climate Data website (Department of Science, Information Technology, Innovation and the Arts 2015) at the following coordinate location:

- Latitude: 22.70 degrees south; and
- Longitude: 149.65 degrees east.

These coordinates represent the approximate location of the MLA.

SILO represents a gridded dataset based on records provided by the Bureau of Meteorology (BoM). The data is then processed to fill gaps in data and produce a spatially complete dataset. Table 9-1 and Figure 9-1 summarise monthly averages of the SILO long-term data.

Table 9-1 Data drill average monthly rainfall and evaporation

Month	Rainfall (mm)	Evaporation (mm)
January	159.7	199.6
February	140.0	165.9
March	91.3	177.7
April	36.8	141.0
May	33.5	115.1
June	38.1	96.6
July	25.2	103.3
August	20.0	125.9
September	18.3	156.1
October	46.2	205.2
November	62.7	217.5
December	108.0	223.3
Annual Average Total	779.8	1927.2

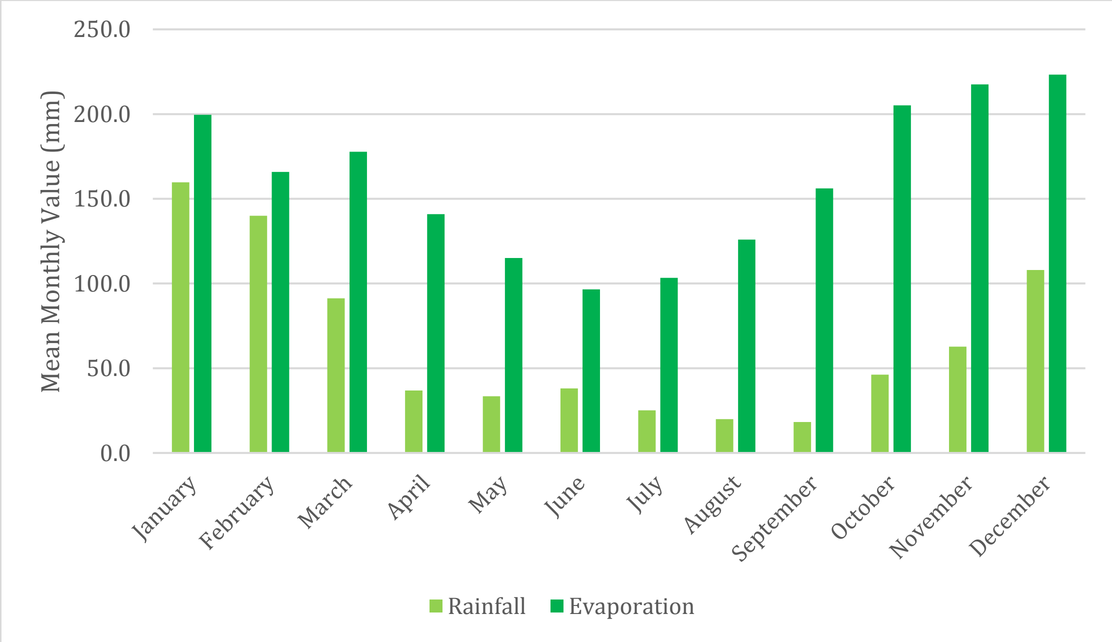

Figure 9-1 Graph of average monthly rainfall and evaporation from SILO

Some general trends can be observed from the SILO data, such as:

- A distinct wet season during the months of December, January and February, with monthly rainfall averages greater than 100 mm;
- A distinct dry season between the months April through October with less than 50 mm mean monthly rainfall between these months; and
- Evaporation rates that are highest during the summer months, and lowest mid-year. In any given month, the average evaporation is greater than the average rainfall.

9.4.1.1 Comparison between Data Sources

Due to the gridded and somewhat synthetic nature of the long-term SILO data, a comparison with rainfall station data gathered from the nearby Strathmuir rainfall gauge was prepared to assess the validity of long-term SILO climatic data. The Strathmuir rain gauge (33189) was selected due to its 76-year data record and proximity (within 8 km) to the Project site. A comparison of mean monthly rainfall values between the Strathmuir rain gauge and SILO data is presented in Figure 9-2. The graph indicates good agreement between gauge records and data acquired through SILO.

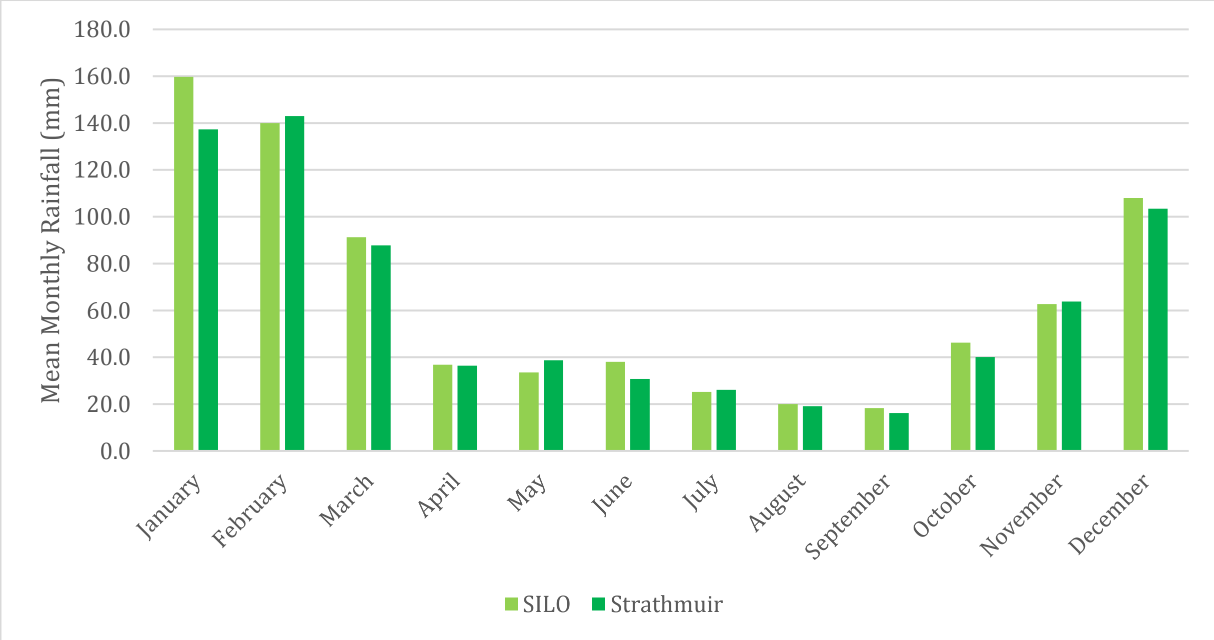

Figure 9-2 Comparison of SILO data to gauge data

9.4.2 Catchment Overview

The Project is wholly contained within the Styx River Basin, which is comprised of Styx River, Waverley and St Lawrence Creeks. The Project is bordered by two watercourses as defined under the Water Act, namely Tooloombah Creek and Deep Creek (see Figure 9-3). These creeks meet at a confluence downstream of the Project area to form the Styx River. The total catchment area of the Styx River is 3,013 km^2.

The catchment's upper reaches are steep with the water transported in defined channels but as the water reaches the middle region of the catchment (Project Area), the topography flattens out with Deep Creek overflowing into the floodplain. Most of the catchment is undisturbed in the upper reaches, and features extensive vegetation, whilst the mid-catchment region is used for dryland cropping and subsequently has been significantly cleared. Established vegetation in the upper reaches leads to high losses that reduce the quantity of runoff, whilst the clearing of land in the middle catchment increases the peak flow as a higher proportion of the rainfall is converted to runoff. Downstream of Ogmore Road the Styx River becomes tidally influenced.

Deep Creek has a total catchment area of 298.01 km^2. Erosion can be seen in this creek at the interface between the top of channel and the overbank. This erosion is most likely caused when local runoff makes its way over the un-vegetated banks and into the channel. There are several locations along the Deep Creek alignment where breakout flows have caused the erosion of a secondary flow path. These breakouts are only engaged during events where the main channel is flowing under full bank discharge. Floodplain erosion is also evident within the southern section of the Project Area where the local landowner has attempted to ameliorate the land by installing contour bunds to slow the flow of runoff across the floodplain.

Tooloombah Creek has a catchment area of 369.68 km^2. The creek channel is generally well defined, with little evidence of floodplain discharges during flood events. The creek's main channel is significantly deeper than Deep Creek, with steep side slopes that are fully vegetated with minimal erosion evident. The Tooloombah Creek channel is approximately 20 m wide with defined smooth curves in the channel path as it flows into Styx River.

The Styx River discharges to the Great Barrier Reef Marine Park (see Figure 9-3), which is approximately 40 km downstream of the ML area. The Great Barrier Reef Marine Park is listed as a World Heritage Area. The Fitzroy Basin Association Natural Resource Management (NRM) body reports the most significant risk to the entire Great Barrier Reef Marine Park is sediment. It is estimated that approximately 1.95 million tonnes of sediment is deposited each year into the reef from the catchments within the NRM body (Waterhouse, et al. 2015). This amounts to 23% of the total sediment load that reaches the Great Barrie Reef (Waterhouse, et al. 2015). This estimation is based on the six Australian Water Resources Council basins within the Fitzroy Region which discharge into the Great Barrier Reef Marine Park: Fitzroy, Styx, Shoalwater, Water Park Creek, Calliope and Boyne (Waterhouse, et al. 2015). The leading land use source of sediment is grazing land which accounts for 85% of the extra sediment entering the Great Barrier Reef Marine Park. It is estimated that the Styx Basin contributes approximately 68.100 t per year of sediment into the reef; however, this load contribution is based on limited monitoring results (Waterhouse, et al. 2015).

The Fitzroy Basin Association NRM body manages waters within the Styx Basin. The NRM area covers approximately 156,000 km^2, and is approximately 37% of the total GBR catchment area (423,122 km^2) (Dougall, et al. 2014). The region has been split into 192 Neighbourhood Catchments. The project is located within the F5 Neighbourhood Catchment which is described as having a high sediment delivery ratio to the Great Barrier Reef, and a low number of landholders within the basin (Waterhouse, et al. 2015).

Cattle grazing is the dominant land use of the area (80%) with most of the catchment undeveloped. Wetlands consist of 14% of the total basin area. There are approximately 187 lacustrine/palustrine wetlands in the Styx drainage basin with the main wetland systems comprised of estuarine (265.8 km^2), palustrine (89.7 km^2) and riverine (52.4 km^2) (EHP 2017). These wetland areas provide a diverse range of habitats for different wildlife, and have been decreasing in size since 2001.

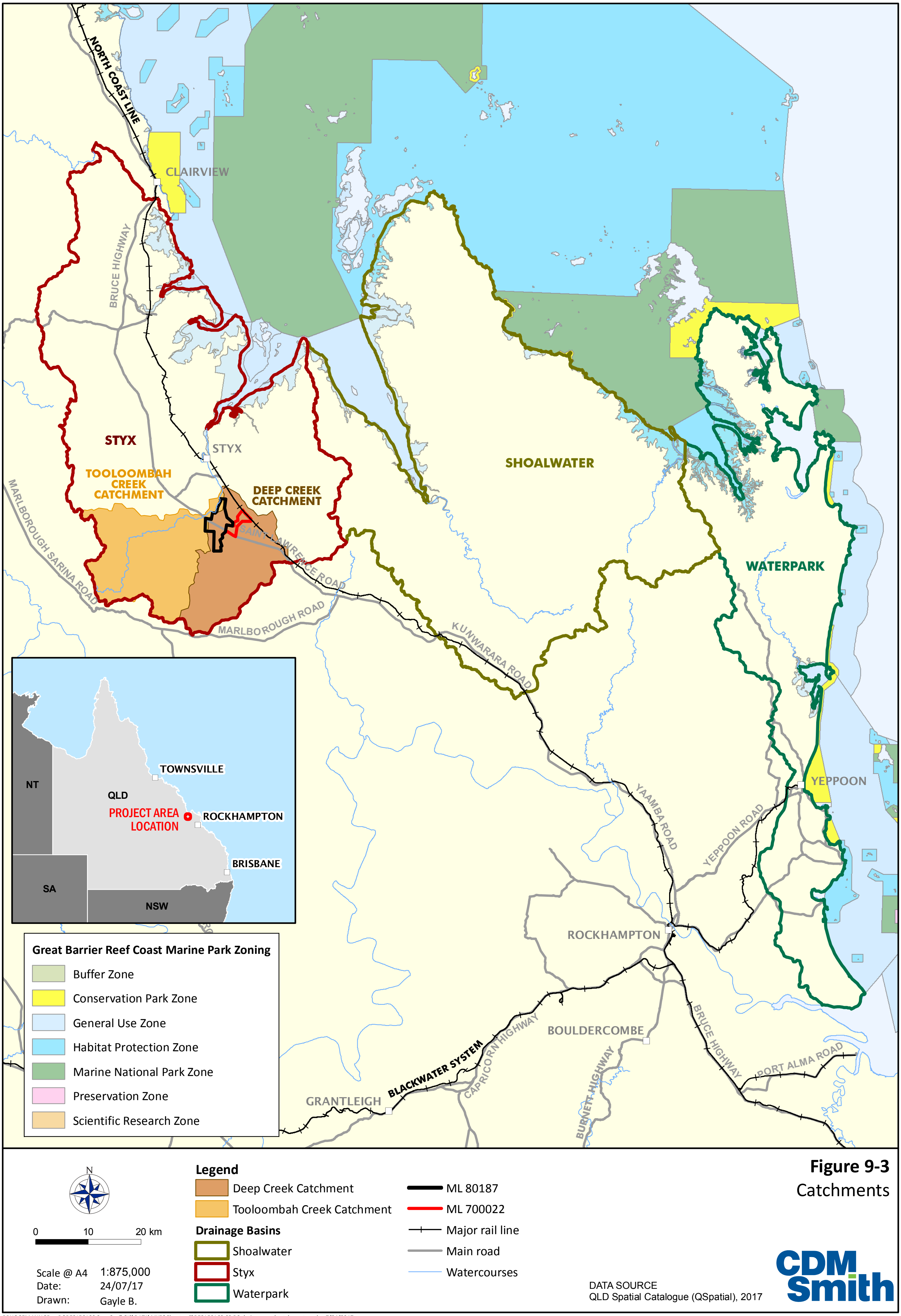

Figure 9-3
Catchments

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9.4.3 Existing Waterways and Local Catchments

Two water features surround the Project area which are defined as watercourses by DNRM (see Figure 9-4), in accordance with the definition of a watercourse provided in the Water Act. These are:

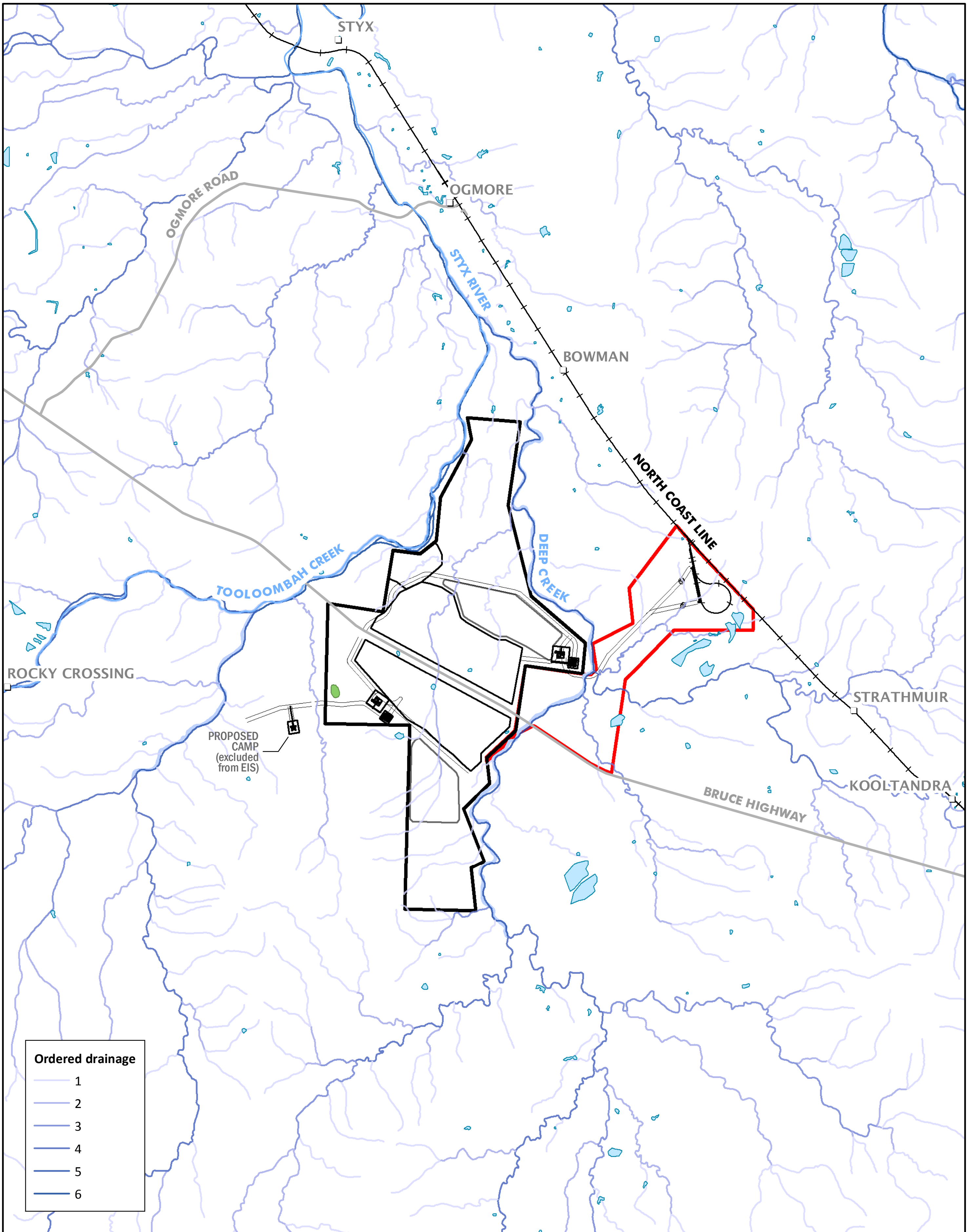
- Tooloombah Creek; and
- Deep Creek.

Both watercourses are located outside the Project area; however, several of their tributary drainage features reside within the Project area. These drainage features are minor in nature, are ranked as either first or second order drainage features and are classified as non-perennial. This implies that the drainage features do not continually contain water and the stream flow is seasonal in nature and directly following rainfall events.

The Project surface infrastructure is predominantly located within the Deep Creek catchment as shown in Figure 9-3, except for the pit dewater dam which is located within the Tooloombah Creek catchment. Clean water diversions of existing drainage lines are proposed to prevent contamination through contact with stockpiling, processing and mine pit areas. The diversions direct water to the same watercourse in which they would otherwise discharge to, albeit further downstream than the diversion discharge location. The proposed diversions are discussed in detail in Section 9.6.3.

Surface water features within the Project area include (see Figure 9-4):

- Minor un-named drainage lines feeding into Tooloombah Creek:
  - Two 1st order drainage lines; and
  - One 2nd order drainage line.
- Minor un-named drainage lines feeding into Deep Creek:
  - Nine 1st order drainage lines; and
  - One 2nd order drainage line.



N

0 1 2 km

Scale @ A4 1:100,000
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Legend

- ML 80187
- ML 700022
- Proposed mine infrastructure
- Reservoir
- Wetland Protection Area
- Watercourse (defined by Water Act, 2000)
- North Coast Rail Line
- Main road

Figure 9-4
Local watercourse, drainage features, wetlands and dams

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017

CDM Smith

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9.4.3.1 Deep Creek

Deep Creek borders the Project area to the east, outside of the MLA, and will be traversed by the proposed haul road that connects the MIA with the TLF. The creek runs in a northerly direction, meeting Tooloombah Creek 2 km downstream of the Project area, and forming the Styx River thereafter. Deep Creek was observed in February 2017 with shallow pools less than 1 m in depth along the southern boundary of the Project area (see Plate 9-1).

Most locations inspected during February 2017 were dry with some pools identified at localised depressions. The channel was identified as having short grass growing along the channel floor, and with trees and short grasses established along the banks (see Plate 9-2). The channel bed comprised of silty sand substrate, with the channel generally described as smooth with little vegetation which would provide resistance to flow. Several trees were observed to have fallen across the channel, creating an obstruction to flow and causing visible erosion on the banks. The water was highly turbid, indicative of the presence of fines (clays and silts) that are not readily settled by the force of gravity.

Plate 9-1: Deep Creek downstream, Bruce Highway Bridge along the southern boundary of the Project area, showing turbid pooled water (Feb 2017)

Plate 9-2: Deep Creek beneath Bruce Highway along the southern boundary of the Project area, showing a dry, silty sand substrate (Feb 2017)

9.4.3.2 Tooloombah Creek

Tooloombah Creek borders the Project area to the west, outside of the MLA. Tooloombah Creek was observed in February 2017 with depths of water accumulated within the creek banks greater than 0.5 m. The creek was identified as having boulders, protruding rock bars and a rocky substrate that was clearly visible under the water. Significant and dense vegetation had established on the banks, including full-grown trees (see Plate 9-3), creating a stable bank that appeared resistant to scour. The water within the creek was brackish, most likely a combination of the saline tidal wedge and freshwater runoff, as demonstrated by the varying electric conductivity measurements taken in Tooloombah Creek of 872 µs/cm and 2,737 µs/cm. The rocky substrate produces less silt and therefore lower turbidity than observed in Deep Creek (see Section 9.5 for details).

No water was observed in Tooloombah Creek past the transition from a rocky substrate to a sandy substrate, which occurs upstream of the Bruce Highway bridge that crosses Tooloombah Creek. This suggests that:

- Tooloombah Creek is tidal up to the point of the Bruce Highway;
- The rock substrate creates less pervious substrate that holds pooled water for longer periods;
- Water flows through the sandy substrate further upstream of the Bruce Highway and surfaces at the rocky substrate sections further downstream;
- There is groundwater connectivity in the lower reaches of Tooloombah Creek; or
- Some combination of the above factors.

Plate 9-3: Tooloombah Creek downstream of Bruce Highway Bridge, western Project boundary (Feb 2017)

Plate 9-4: Tooloombah Creek upstream of Bruce Highway Bridge, western Project boundary (Feb 2017)

9.4.3.3 Styx River

Styx River, downstream of the confluence of Deep Creek and Tooloombah Creek, was observed during February 2017 with significant depth of water accumulated within the river banks. The river was observed to be tidally influenced, with the water surface level rising significantly on two occasions over the day. The tidal nature of the Styx River supports well established vegetation on the river banks, making the banks stable and resistant to scour (see Plate 9-5). The water is visibly saline as evidenced by the clearer green tint colour when compared to the turbid brown colour of waters observed in Deep Creek. This is further supported by electrical conductivity values of 13,103 µs/cm observed in the Styx River (see Section 9.5 for details).

Plate 9-5: Styx River, downstream confluence between Deep Creek and Tooloombah Creek (Feb 2017)

9.4.3.4 Minor Drainage Features

Three un-named surface water features drain the Project area into Deep Creek, along the eastern boundary of the MLA. The most distinct drainage feature is the 2nd order stream that runs through Open Cut 1 in a northeast direction passing under the Bruce Highway and finally discharging to Deep Creek to the northwest of MIA 2. This drainage feature is impounded by two existing farm dams, one of which is located within the proposed Open Cut 1 pit shell. The upper catchment of this 2nd order stream will be diverted towards Deep Creek as a clean water diversion around the proposed mine pits. The middle portions the drainage feature will be mined out as the pits progress.

There are three unnamed surface water features that drain the western section of the Project area into Tooloombah Creek. These features are not clearly defined and are classified as 1st order drainage features.

9.4.4 Wetlands and Farm Dams

According to EHP, wetlands are defined as: '*Areas of permanent or periodic/intermittent inundation, whether natural or artificial, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6 m*' (DERM, 2011 and Wetland definition, WetlandInfo, Department of Environment and Heritage Protection, Queensland, viewed 18 August 2017, <https://wetlandinfo.ehp.qld.gov.au/wetlands/what-are-wetlands/definitions-classification/wetland-definition.html>).

There are three types of wetlands that have been identified within the project area and surrounding areas:

- Riverine: Riverine wetlands are those systems that are contained within a channel (e.g. river, creek or waterway) and their associated streamside vegetation;
- Lacustrine: wetlands within a topographic depression or dammed river channel that cover an area greater than 8 ha without persistent emergent vegetation and include dams; and
- Palustrine: wetlands dominated by persistent emergent vegetation and include swamps, bogs, and billabongs.

There are two wetlands of high ecological significance, one of which (Ref 688644) is located in the west of the site and subject to clearing for the mine pit dewatering dam. The other wetland (Ref 688938) is located to the south west of Open Pit 1 (see Plate 9-6). Several lakes and rural water storage dams on either side of the Bruce Highway alignment are mapped as artificial wetlands by EHP.

Table 9-2 Wetlands and dams within and surrounding the Project area

Wetland type	Ref. number	Lot / plan	Description	Area (ha)
Palustrine	696686	10/MC493	Within Project area (Open Cut 1) - Rural Water Storage	0.41
Palustrine	-	10/MC493	Within Project area (Open Cut 1) - Rural Water Storage	0.78
Palustrine	-	9/MC496	Within Project area (Open Cut 2) - Rural Water Storage	0.40
Palustrine	696684	9/MC496	Within Project area – Lake	0.34
Palustrine	-	11/MC23	Within Project area – Rural Water Supply	1.53
Perennial	-	10/MC493	Within Project area – Lake	0.42
Palustrine	688938	10/MC493	Within Project area – Wetland (high ecological significance)	2.98
Palustrine	688644	10/MC493	To the west of the Project area	0.98
Palustrine	696683	11/MC23	Contour bunds to the south of the Project area	4.95
Palustrine	693160	11/MC23	Contour bunds to the south of the Project area	7.69

Plate 9-6 Wetland of high ecological significance (ref. 688938)

There are four existing farm dams of varying size within the Project area (see Figure 9-4), all dams are located adjacent to the Bruce Highway. These dams are predominantly used for stock water, are highly disturbed and do not support vegetation communities. The two rural water storages located on the southern side of the Bruce Highway (plan MC493) are shown in Plate 9-7 and Plate 9-8. There is also catchment contouring within the Mamelon property to the south of the Bruce Highway for capturing and storing overland runoff and preventing erosion. Existing contour bunds will be upgraded to environment dams that capture runoff from overburden stockpiles and remove sediment prior to discharge to Deep Creek.

Plate 9-7 Rural Water Storage (ref.696686)

Plate 9-8 Rural Water Storage (Open Cut 1)

9.4.5 Water Supply within the Broader Catchment Area

The Ogmore Water Supply System provides non-potable water to the Ogmore township, sourced from Montrose Creek and located northwest of the Project. Water is stored in four reservoirs with a total capacity of 88,000 litres. The creek water is typical of an unprotected surface water catchment and is not suitable for potable uses unless treated.

Surrounding properties source water from Tooloombah and Deep Creek through licenced extractions, as well as from bores and farm dams that capture and store surface runoff (see Section 9.4.6 for additional information).

9.4.6 Existing Water Users

The Project is predominately situated within the Mamelon cattle grazing property, which both runs cattle and produces dryland crops. The Mamelon property is owned by the Proponent and is currently being leased for these uses. Supporting this land use is a series of farm dams and surface contour bunds that capture and store runoff generated by the local contributing catchments. Groundwater bores also lift water to dams and / or storage tanks in the surrounding region for domestic and stock water use (see Chapter 10 - Groundwater for a reference to registered and unregistered bores).

There are several surface water entitlements in Tooloombah and Deep Creek for irrigation, stock and domestic supply. These entitlements are summarised in Table 9-3. The entitlements that may be impacted by the Project by being located adjacent to or downstream of operations include the following:

- 119/CP900367 - Irrigation entitlement located on parcel of land adjacent to the Mamelon property, separated by Deep Creek, and approximately 3 km downstream of mine infrastructure and environment dam release point locations on Deep Creek;
- 1/RP616700 - Domestic / stock supply entitlement located on parcel of land adjacent to the Mamelon property and straddling Tooloombah Creek. The extraction point appears to supply a small off-stream storage on the western overbank of Tooloombah Creek, approximately 1 km downstream of the pit dewater dam discharge location; and
- 45/MPH26062 - Irrigation entitlement on parcel of land directly bordering the Project to the north and extracting approximately 6 km downstream of the mine dewater dam proposed discharge location on Tooloombah Creek.

Table 9-3 Environmental values for waters associated with the Project

Water Source	Location	Authorised Use	Entitlement Per Water Year	Maximum Extraction Rate	Water Name / Type
Tooloombah Creek	1/RP616700	Domestic Supply; Stock	18 ML	-	Tooloombah Creek / Watercourse (Surface Water)
Deep Creek	119/CP900367	Irrigation	20 ha	-	Deep Creek / Watercourse (Surface Water)
Tooloombah Creek	45/MPH26062	Irrigation	8 ha	-	Tooloombah Creek / Watercourse (Surface Water)

9.5 Water Quality Assessment

9.5.1 Environmental Values and Water Quality Objectives

WQOs are long-term goals for water quality management. They are numerical concentration levels or narrative statements of indicators established for receiving waters to support and protect the designated EVs for those waters. They are generally based on scientific criteria or water quality guidelines but may be modified by other inputs (e.g. social, cultural or, economic inputs).

EVs for water are the qualities of water that support a level of aquatic ecosystem function and / or human water uses. These EVs can be impacted by the effects of habitat alteration, waste releases, contaminated runoff and changed flows to ensure healthy aquatic ecosystems and waterways that are safe for community use.

To protect the waterways and associated EVs, WQOs are established for different indicators such as pH, nutrients and toxicants. The EPP (Water) provides provisions to protect and enhance the suitability of Queensland's waters for various beneficial uses and has established EVs and WQOs for a number of Basins including the Styx Basin. The EVs considered applicable to the Project are outlined in Table 9-4. Water quality objectives associated with the Project for the protection of aquatic ecosystem EVs are summarised in Table 9-5 and Table 9-6.

Table 9-4 Environmental Values for Styx River Basin and adjacent coastal waters

Water	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human Consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
Surface Fresh Waters												
Southern Styx fresh waters (including Granite, Tooloombah and Wellington creeks)	✓	✓	✓	✓	X	✓	✓	✓	✓	✓	X	✓

Notes: ✓ - river basin is suitable for the environmental value; X - river basin is not suitable for the environmental value.

Table 9-5 Water quality objectives for waters associated with the Project (EPP Water)

Criteria source (EV)	Parameter	WQO
Physico-chemical		
Aquatic ecosystem – Deep Creek and Tooloombah Creek	Ammonia nitrogen	<20 µg/L
	Oxidised nitrogen	<60 µg/L
	Total nitrogen	<500 µg/L
	Filterable reactive phosphorus	<20 µg/L
	Total phosphorus	<50 µg/L
	Chlorophyll a	<5 µg/L
	Dissolved oxygen	85% - 110% saturation
	Turbidity	<50 NTU
	Suspended solids	<10 mg/L
	pH	6.5 - 8.0

Criteria source (EV)	Parameter	WQO
	Toxicants (metals, inorganics etc.)	See Table 9-6
Aquatic ecosystem – Styx River	Ammonia nitrogen	<10 µg/L
	Oxidised nitrogen	<10 µg/L
	Total nitrogen	<300 µg/L
	Filterable reactive phosphorus	<8 µg/L
	Total phosphorus	<25 µg/L
	Chlorophyll a	<4 µg/L
	Dissolved oxygen	85% - 100% saturation
	Turbidity	Not Determined
	Suspended solids	Not Determined
	pH	7.0 - 8.4
	Toxicants (metals, inorganics etc.)	See Table 9-6
Stock watering – Total Dissolved Solids	Total Dissolved Solids	
	Beef	4,000 mg/L
	Dairy cattle	2,500 mg/L
	Sheep	5,000 mg/L
	Horses	4,000 mg/L
	Pigs	4,000 mg/L
	Poultry	2,000 mg/L
	Aluminium	5 mg/L
	Metal or metalloids	
	Arsenic	0.5 mg/L
	Beryllium	Not Determined
	Boron	5 mg/L
	Cadmium	0.01 mg/L
	Chromium	1 mg/L
	Cobalt	1 mg/L
	Copper	0.4 mg/L (sheep), 1 mg/L (cattle), 5 mg/L (pigs and poultry)
	Fluoride	2 mg/L
	Iron	Not sufficiently toxic
	Lead	0.1 mg/L
	Manganese	Not sufficiently toxic
	Mercury	0.002 mg/L
	Molybdenum	0.15 mg/L
	Nickel	1 mg/L
	Selenium	0.02 mg/L
	Uranium	0.2 mg/L
	Vanadium	Not Determined
	Zinc	20 mg/L

Criteria source (EV)	Parameter	WQO		
Human consumer	Sodium	20 mg/L		
	Total dissolved solids (prior to treatment)	<600 mg/l		
Primary recreation	Temperature	16 - 34°C		
	Dissolved oxygen	>80%		
Heavy metals and metalloid long-term trigger level				
		Soil cumulative contaminant loading limit (CCL) (kg/ha)	**Long-term trigger value (LTV) in irrigation water (up to 100 years) (mg/L)**	**Short-term trigger value (LTV) in irrigation water (up to 20 years) (mg/L)**
Irrigation	Aluminium	Not Determined	5.000	20.000
	Arsenic	20	0.100	2.000
	Beryllium	Not Determined	0.100	0.500
	Boron	Not Determined	0.500	Table 9.2.18 of ANZECC
	Cadmium	2	0.010	0.050
	Chromium (CRVI)	Not Determined	0.100	1.000
	Cobalt	Not Determined	0.050	0.100
	Copper	140	0.200	5.000
	Fluoride	Not Determined	1.000	2.000
	Iron	Not Determined	0.200	10.000
	Lead	260	2.000	5.000
	Lithium	Not Determined	2.500	2.500
	Manganese	Not Determined	0.200	10.000
	Mercury	2	0.002	0.002
	Molybdenum	Not Determined	0.010	0.050
	Nickel	85	0.200	2.000
	Selenium	10	0.020	0.050
	Uranium	Not Determined	0.010	0.100
	Vanadium	Not Determined	0.100	0.500
	Zinc	300	2.00	5.000
Biological				
Human consumer	Giardia	0 cysts		
	Cryptosporidium	0 cysts		
	Blue–green algae (cyanobacteria)	<100 cells/mL		
	pH	6.5 -8.5		
	Total Dissolved Solids (TDS)	600 mL		
	Sodium	180 mg/L		
	Sulfate	250 mg/L		
	Dissolved oxygen	>85% saturate		

Table 9-6 Water quality objectives for toxicants (ANZECC)

Criteria source (EV)	Parameter	WQO
Aquatic Ecosystems	Aluminium	0.055
	Arsenic	0.024
	Beryllium	ND
	Boron	0.37
	Cadmium	0.0002
	Chromium (CRVI)	0.001
	Cobalt	ND
	Copper	0.0014
	Fluoride	ND
	Iron	ND
	Lead	0.0034
	Lithium	ND
	Manganese	1.9
	Mercury	0.0006
	Molybdenum	ND
	Nickel	0.011
	Selenium	0.005
	Uranium	ND
	Vanadium	ND
	Zinc	0.008

9.5.2 Field Assessment – Historical

Water quality sampling was undertaken for the Project in 2011 and 2012. During this time, eight sampling events were undertaken. The sampling locations within the current and historical sampling scopes are presented in Figure 9-5. The relevant scope of each of the sampling location is shown in Table 9-7. The results from these sampling events are presented in Table 9-13 to Table 9-21 and are discussed in the following sections.

Table 9-7 Current and historical sampling sites

Site ID	Current Sampling Scope	Historical Sampling Scope
To1	✓	✓
To2	✓	✓
To3	✓	✗
St1	✓	✓
St2	✗	✓
Ba1	✗	✓
Ba1x	✓	✗
De1	✓	✓
De2	✓	✓
De3	✓	✓
De4	✓	✗

9.5.2.1 Monitoring Results

Stream Conditions

The stream/waterway conditions during each sampling event is presented in Table 9-8. Based on the timing of rainfall prior to sampling, and observations during sampling, the sample events represent a range of events from no-flow or baseflow periods to storm flow events. The February and March events present flows likely to largely represent storm flows more than baseflow events. However, it is considered unlikely that any of the sampling rounds coincided with the peak storm discharge.

Table 9-8 Waterway conditions and sites sampled per round

Sample Round	Dates	Rainfall in previous		Deep Creek	Tooloombah Creek	Styx River[1]
		week	month			
1	1-5/6/11	0	18	Baseflow	Baseflow	45 mins after high
2	27-29/9/11	0	7.4	No flow	Baseflow	30 mins after low, outgoing
3	25-26/10/11	0	43	No flow	Baseflow	1 hr before low, outgoing
4	21-22/11/11	0	0.2	No flow	Baseflow	Low, nil
5	13-14/12/11	46	79	No flow	Baseflow	2 hr after high, nil
6	31/1/12	55	137	Storm/base flow	Storm/base flow	1 hr before high, outgoing
7	21-22/2/12	78	211	Storm flow	Storm flow	Mid tide, coming in, outgoing
8	20/3/12	139	298	Storm flow	Storm flow	1.5 hr after low, outgoing

1. Tides taken from Hay Point tidal predictions, using McEwan Inlet, 24 mins after Hay Point (approximately 25 km north of Styx bridge). Flow (outgoing, incoming, nil) based on observations at the St1 site at the time of sampling.

Tooloombah Creek

The two Tooloombah Creek sites were quite similar, more so than was found between the Deep Creek sites. The lack of similarity in water quality characteristics at the Deep Creek sites is likely due to the no flow periods and isolated pools that formed whereas the Tooloombah Creek was flowing for the entire period, albeit slowly during low flow periods. The Tooloombah Creek sites did however report differences in dissolved oxygen, with a large increase at the To2 site during the lower flow October round which was not matched at To1. Broadly, the pattern of flow responses to rainfall and prolonged lack of rainfall were similar between the creeks, though Tooloombah Creek displayed a less ‘flashy’ response than the smaller Deep Creek sites.

Tooloombah Creek recorded the highest salinity (a measure of conductivity and total dissolved solids) of the three freshwater lowland streams prior to December (excluding the peak in TDS seen in Deep Creek in December 2011), which decreased to a lower salinity from January to March 2012. Tooloombah Creek represents the largest of the three freshwater catchments included in the monitoring program, with cleared and eroded lands comparable to the Deep Creek catchment. The elevated salinity is associated with the drier periods and is likely due to the increased proportional influence of groundwater on creek surface flows during baseflow periods. High salinity is found in groundwater in the region. During rain events and due to the larger catchment size, salinity levels were reduced in Tooloombah Creek compared to Deep Creek due likely to greater levels of runoff.

Generally, Tooloombah Creek displayed the following characteristics:

- Dissolved oxygen showed two patterns for the two sites, with a peak at To2 in the October – November low flow period (not seen at To1), and a peak at To1 in January (site To2 was inaccessible and may have been similar). Otherwise dissolved oxygen remained generally within the 70 – 100% saturation range;
- Conductivity, pH and chloride rose gradually to December 2011, followed by a large fall in January, continuing to gradually decrease until March. pH varied from a high of 8.4 to a low of 5.9, conductivity 1,407 to 193.7 µS/cm, and chloride from 366 to 21 mg/L;
- Total dissolved solids, alkalinity, magnesium, sodium, anions and cations showed a gradual decrease to December 2011, and afterwards a similar pattern as seen for conductivity, pH and chloride because of the rains. Potassium did not show any pattern, varying only over a relatively narrow range (2 – 4 mg/L); and
- Nutrients were relatively low or falling prior to the December rainfall event, with rises noted in Ammonia, TKN, TP, and FRP, and Nitrite at To2, during the December to January wet period.

Again, the disturbed areas and grazing activities are reflected in the elevated nutrient levels found in this creek.

Styx River

The two Styx River monitoring sites (St1 and St2) were divided by water quality into the Ogmore Bridge site (St2) and the St1 site located at the confluence of Tooloombah and Deep Creeks. The St1 site was more heavily influenced by runoff from the two creeks, whereas the St2 site showed a larger influence from saline waters (i.e. the estuarine influence).

Water quality at the St1 site showed the interplay between the freshwater runoff from Deep and Tooloombah Creeks, and the influence from the Styx Estuary (i.e. St2). Conductivity was generally seen to increase over the dry period, to a much greater extent than was seen in either Deep or Tooloombah Creeks, while for the other parameters the results were generally a mix of the three sources (i.e. Deep, Tooloombah and Styx Estuary).

When examining the key physical-chemical parameters for the Deep and Tooloombah Creeks with St1 (pH, conductivity, anions and cations), the St1 site was found to be more like Tooloombah Creek than to Deep Creek generally (visually from the data), and more similar to the freshwater creeks overall, which is consistent with the relative sizes of the two catchments (and therefore flows). A multivariate similarity assessment showed similarity of about 71%, compared to the St2 site (with a similarity to all other sites of only 44%).

Generally, the St1 site displayed similar levels and overall patterns to the upstream creeks, with some slight delays in temporal trends evident and reduced flood peak concentrations (from examination of the Fitzroy Basin Association storm flow monitoring). This may be due in part to mixing and influence with the salt wedge from the estuary, evident in the higher salinity levels at this site (especially at depth during low flow periods). A high peak in bioavailable phosphorous (FRP) was seen in December, though this was not observed in the Deep or Tooloombah Creek sites (located further upstream).

For phys-chem properties:

- Dissolved oxygen varied from around 70 to 95% prior to October, rising to very high levels during October to December, dropping again during the post December rain period;
- Conductivity, TDS and alkalinity reflected the overall influence of the estuary during the low-flow period, with a gradual rise (especially at depth for conductivity) to December, followed by a rapid fall with levels matching the upstream creeks during the January to March 2012 period;
- pH remained relatively stable, possibly indicative of the stronger buffering capacity of the more saline waters; and
- turbidity and suspended solids show the flashy behaviour of the river at this point, strongly influenced by rainfall runoff from the Deep and Tooloombah Creeks.

The St2 site was very similar to the St1 site, except that the saline influence was much more pronounced during the low flow period. In flood / stormflow periods, water quality was very similar between the two sites.

Observations were made of flow direction and tide levels during the monitoring period. On all occasions other than one (September 2011), flow direction was seawards (i.e. outgoing), and the tidal bore was not observed, even though the site was visited on several occasions when the regional tide was predicted to be incoming. Based on the flow observed from the Deep and Tooloombah Creeks on many of the occasions during the low flow period, it is quite possible that outgoing flows prior to December 2011 were the result of tide return, and that in fact incoming tides were missed by the sampling team.

9.5.2.2 Comparison of Results with Guidelines

Protection of Aquatic Ecosystems

Compliance with the guideline levels are summarised in Table 9-9.

Other than conductivity, which exceeded the guideline values in all freshwater streams, median statistics for phys-chem parameters largely met the QWQGs. The exceptions were dissolved oxygen in Deep Creek and suspended solids in Deep and Tooloombah Creeks, and the Styx River.

All waterways showed exceedances for ammonia at virtually all times (dry or flood), with organic nitrogen and total nitrogen almost always above the guidelines at Deep and Tooloombah Creeks, total phosphorous at Deep Creek and the St2 Styx River site, and oxidized nitrogen at the St2 Styx River site.

During rainfall periods, exceedances were also encountered for organic nitrogen, total nitrogen, total phosphorous and bioavailable phosphorous (FRP) at all sites. The St2 Styx River site also recorded exceedances for NOx during rainfall.

The toxicants data show many exceedances across the sites, with the most common being for iron (though based on a low reliability trigger value), aluminium, copper, selenium (except at St1) and zinc (except at Tooloombah). Antimony and vanadium exceeded the guideline value at Deep and Tooloombah Creeks.

Other exceedances were recorded for lead (Deep), chromium (Deep, Tooloombah, Styx at St1), silver (Deep, Tooloombah) tin (Tooloombah) and uranium (Tooloombah – 1 occurrence only).

The water quality confirms the disturbed nature of the catchment due to catchment disturbance and nutrient inputs, which are consistent with impacts from land clearing, erosion and cattle grazing and the nature of the soils.

Livestock and Irrigation

Comparison with the ANZECC water quality guidelines for irrigation indicate that all freshwaters (i.e. all sites other than St2) were suitable for livestock and irrigation with the following exceptions:

- Chloride levels – water in Tooloombah Creek recorded chloride levels unsuitable for sensitive crops, and the Styx River St1 site was unsuitable for sensitive or moderately sensitive crops, all generally at times other than the recorded flood periods. This also means that there may be a risk of cadmium toxicity from using this irrigation water (particularly at St1);
- Sodium levels –the Styx River sites recorded sodium at levels unsuitable for sensitive or moderately sensitive crops with the St2 site suitable at best for tolerant crops;
- Aluminum and iron recorded levels above the recommended Long Term Value (LTV) in irrigation water (from Table 4.2.10 of the ANZECC Guidelines) during wet periods;
- Manganese was variously above the LTV; and
- Phosphorous was above the LTV, though this was noted as intended to minimise bioclogging of irrigation equipment only.

The ANZECC Guidelines for livestock watering indicated TDS levels encountered in the streams were generally in the range regarded as having 'no adverse effects on animals expected'. Of the toxicants aluminum was above the recommended low risk range during wet periods.

Drinking Water

When compared to Table 7.3.1 - *Guidelines for drinking water supply in the vicinity of storage off-takes or in groundwater supplies*, before treatment in the QWQG, the recommended water quality objectives were exceeded for manganese and iron, and during rainfall events turbidity and, to a lesser degree, suspended solids. Dissolved oxygen was below the target in Deep Creek but generally above in the other creeks (including the Styx River St1 site).

Based on the Australian Drinking Water Guidelines 2011 (NHMRC and NRMMC, 2011), salinity (as total dissolved solids) can be regarded as of good quality in Deep Creek (except during December flows), fair quality in Tooloombah Creek, and poor to unacceptable at the St1 site (and unacceptable at the St2 site).

Several of the toxic metals did breach the ADWG's and would require removal prior to use in potable water supplies. The key elements included iron and manganese (as mentioned above) and aluminum for aesthetic reasons; and antimony and / or arsenic at the other Creek sites, plus lead at Deep Creek. Exceedances were found during the December to March (wet) period only, except for antimony at Tooloombah Creek in November 2011 (10 µg/L).

Table 9-9 Summary of compliance with WQOs – Deep Creek

Creek System	Phys-chem			Turbidity/SS			Nutrients			Metals		
	Param	Median	WQO	Param	Median	WQO	Param	Median	WQO	Param	Median	WQO
Deep Creek	DO	69.75	85-110	Turbidity	11.35	50	Ammonia	40	20[1]/900[2]	Al	8,713.5	55[5]
	EC	571.8	375[1]/1000[2]	SS	13	10	Nitrate	20	1,100[2]	Fe	4,173.5	300[4]
	pH	7.6	6.5-8	Turbidity above QWQG during wet periods.			NO_x	20	60	Pb	10	3.4
	DO moderately below QWQG except during flow periods. Conductivity above QWQG (below EHP except Nov-11 at De1). pH generally good, but elevated during late dry, and low after wet (Jan-11).						Org N	640	420	Se	20	11
							TN	700	500/3,400[3]	Vn	20	10[2]/6[4]
							TP	60	50/2,000[3]	Zn	16	8
							FRP	<10	20	Cu	3.35	1.4/2[2]
							Nutrients generally showed exceedances for NH_4, Org N, TN, TP at all times but exceedances were more pronounced during the wet post December period. FRP exceeded the guidelines post December only.			Metals detected above the trigger levels were Al, Sb, Fe, Pb, Se, V, Zn, Cr, Cu and Ag. As, Ba, Bo, Mn, Sr, and Ti were also detected, but without any exceedances.		

1. Water Quality Objectives from QWQG unless otherwise noted. Guideline values are for lowland streams in Central Queensland for all sites other than St2, which used upper estuary values for central Queensland.
2. EHP (2009) – Final Model Water Conditions for Coal Mines in the Fitzroy Basin.
3. EHP (2011) – Fitzroy River Sub-basin Environmental Values and Water Quality Objectives.
4. ANZECC Guidelines low reliability value (for marine waters for St2).
5. for pH >6.5.
6. Al - Aluminium, Sb - Antimony, Fe - Iron, Pb - Lead, Se - Selenium, V - Vanadium, Zn - Zinc, Cr - Chromium, Cu - Cooper, Ag - Silver, As - Arsenic, Ba - Barium, Mn - Manganese, Sr - Strontium, Ti - Titanium.

Table 9-10 Summary of compliance with WQOs – Tooloombah Creek

Creek System	Phys-chem			Turbidity/SS			Nutrients			Metals		
	Param	Median	WQO	Param	Median	WQO	Param	Median	WQO	Param	Median	WQO
Tooloombah Creek	DO	93.4	85-110	Turbidity	10.55	50	Ammonia	40	20[1]/900[2]	Al	5,180	55[5]
	EC	1,041.5	375[1]/1000[2]	SS	10	10	Nitrate	20	1,100[2]	Fe	2,400	300[4]
	pH	7.8	6.5-8	Turbidity was above QWQG during the Jan 12 and Mar 12 rainfall peaks. SS remained above from December onwards (wet period).			NO_x	20	60	Se	15	11
	Dissolved oxygen showed exceedances above and below the QWQG, with EC generally above. pH was slightly above during Oct/Nov 11 and very low (5.9) in Jan 12.						Org N	460	420	Sn	8	3[4]
							TN	600	500/3,400[3]	Vn	7.5	10[2]/6[4]
							TP	40	50/2,000[3]	Cr	1.5	1
							FRP	<10	20	Cu	2	1.4/2[2]
							Ammonia, Org N, and TN were always above the QWQG, with TP and FRP above during rainfall periods.			Au	0.75	0.05/1[2]
										Ur	1	1[2]
										Metals detected above the trigger levels were Al, Sb, Fe, Se, Sn, V, Cr, Cu, Ag and U. As, Ba, Mn, Sr and Ti were also detected, but without any exceedances.		

1. Water Quality Objectives from QWQG unless otherwise noted. Guideline values are for lowland streams in Central Queensland for all sites other than St2, which used upper estuary values for central Queensland.
2. EHP (2009) – Final Model Water Conditions for Coal Mines in the Fitzroy Basin.
3. EHP (2011) – Fitzroy River Sub-basin Environmental Values and Water Quality Objectives.
4. ANZECC Guidelines low reliability value (for marine waters for St2).
5. for pH >6.5.
6. Al - Aluminium, Sb - Antimony, Fe - Iron, Pb - Lead, Se - Selenium, V - Vanadium, Zn - Zinc, Cr - Chromium, Cu - Cooper, Ag - Silver, As - Arsenic, Ba - Barium, Mn - Manganese, Sr - Strontium, Ti - Titanium.

Table 9-11 Summary of compliance with WQOs – Styx River (St1)

Creek System	Phys-chem			Turbidity/SS			Nutrients			Metals		
	Param	Median	WQO	Param	Median	WQO	Param	Median	WQO	Param	Median	WQO
Styx River (St1)	DO	90.6	85-110	Turbidity	7.6	50	Ammonia	30	20[1]/900[2]	Al	7,070	55[5]
	EC	1,942	375[1]/1000[2]	SS	13	10	Nitrate	25	1,100[2]	Fe	3261.3	300[4]
	pH	7.6	6.5-8	Turbidity was elevated from December onwards, and suspended solids from November onwards.			NO_x	25	60	Zn	9.5	8
	Dissolved oxygen was above the QWQG from October onwards. Conductivity remained above at all times. pH was very high in June but within the QWQG on other occasions.						Org N	450	420	Cu	5	1.4/2[2]
							TN	500	500/3,400[3]	Vn	16.25	10[2]/6[4]
							TP	120	50/2,000[3]	Cr	1.625	1
							FRP	<10	20	Metals detected above the trigger levels were Al, Sb, Fe, Se, Sn, V, Cr, Cu, Ag and U. As, Ba, Mn, Sr and Ti were also detected, but without any exceedances.		
							Ammonia was above the QWQG on all occasions, with Org N, TN, TP and FRP above during rainfall periods.					

1. Water Quality Objectives from QWQG unless otherwise noted. Guideline values are for lowland streams in Central Queensland for all sites other than St2, which used upper estuary values for central Queensland.
2. EHP (2013) – Final Model Water Conditions for Coal Mines in the Fitzroy Basin.
3. EHP (2011) – Fitzroy River Sub-basin Environmental Values and Water Quality Objectives.
4. ANZECC Guidelines low reliability value (for marine waters for St2).
5. for pH >6.5.
6. Al - Aluminum, Sb - Antimony, Fe - Iron, Pb - Lead, Se - Selenium, V - Vanadium, Zn - Zinc, Cr - Chromium, Cu - Cooper, Ag - Silver, As - Arsenic, Ba - Barium, Mn - Manganese, Sr - Strontium, Ti - Titanium.

Table 9-12 Summary of compliance with WQOs – Styx River (St2)

<table>
<tr><th rowspan="2">Creek System</th><th colspan="3">Phys-chem</th><th colspan="3">Turbidity/SS</th><th colspan="3">Nutrients</th><th colspan="3">Metals</th></tr>
<tr><th>Param</th><th>Median</th><th>WQO</th><th>Param</th><th>Median</th><th>WQO</th><th>Param</th><th>Median</th><th>WQO</th><th>Param</th><th>Median</th><th>WQO</th></tr>
<tr><td rowspan="8">Styx River (St2)</td><td>DO</td><td>75.2</td><td>85-110</td><td>Turbidity</td><td>14.3</td><td>50</td><td>Ammonia</td><td>50</td><td>20[1]/900[2]</td><td>Al</td><td>7,448</td><td>55[5]</td></tr>
<tr><td>EC</td><td>1,417.5</td><td>375[1]/1000[2]</td><td>SS</td><td>27</td><td>10</td><td>Nitrate</td><td>20</td><td>1,100[2]</td><td>Mn</td><td>392</td><td>80[4]</td></tr>
<tr><td>pH</td><td>7.7</td><td>6.5-8</td><td colspan="3" rowspan="6">Turbidity and suspended solids exceeded the QWQG during rainfall events.</td><td>NO_x</td><td>20</td><td>60</td><td>Se</td><td>22</td><td>3[4]</td></tr>
<tr><td colspan="3" rowspan="5">Dissolved oxygen was variable, being mostly above the QWQG though Sep 11 and Nov 11 were below (dry periods). Two low pH readings were found obtained during Sep 11 and Mar 12.</td><td>Org N</td><td>480</td><td>420</td><td>Zn</td><td>18</td><td>15</td></tr>
<tr><td>TN</td><td>400</td><td>500/3,400[3]</td><td>Cu</td><td>3</td><td>1.3</td></tr>
<tr><td>TP</td><td>190</td><td>50/2,000[3]</td><td></td><td></td><td></td></tr>
<tr><td>FRP</td><td><10</td><td>20</td><td colspan="3" rowspan="2">Metals detected above the trigger levels were Al, Mn, Se, Zn and Cu. Sb, As, Ba, Bo, Fe, Sr, Ti, V, Cr and U were also detected, but without any exceedances.</td></tr>
<tr><td colspan="3">Ammonia, NOx and TP were generally above the guidelines (though less so for TP during the dry), with Org N, TH and FRP above during rainfall periods (Dec 11 onwards).</td></tr>
</table>

1. Water Quality Objectives from QWQG unless otherwise noted. Guideline values are for lowland streams in Central Queensland for all sites other than St2, which used upper estuary values for central Queensland.
2. EHP (2013) – Final Model Water Conditions for Coal Mines in the Fitzroy Basin.
3. EHP (2011) – Fitzroy River Sub-basin Environmental Values and Water Quality Objectives.
4. ANZECC Guidelines low reliability value (for marine waters for St2).
5. for pH >6.5.
6. Al - Aluminium, Sb - Antimony, Fe - Iron, Pb - Lead, Se - Selenium, V - Vanadium, Zn - Zinc, Cr - Chromium, Cu - Cooper, Ag - Silver, As - Arsenic, Ba - Barium, Mn - Manganese, Sr - Strontium, Ti – Titanium.

Table 9-13 Historical water quality data - physical-chemical characteristics - Deep Creek

Site	Date	Flow Type	DO	EC	pH	Turbidity	Temp	Redox	TDS	TSS	Bicarb Alk	SO_4	Cl	Fl	Ca	Mg	Na	K	Anions	Cations
			%sat	uS/cm		NTU	^oC	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L
De1	1/6/11	Baseflow	80.4	461	6.92	13.1	15.71	-	536	6	89	29	116	<0.1	20	16	72	3	5.65	5.52
De2	2/6/11	Baseflow	83.4	476	7.06	12.9	16.68	-	562	6	88	28	119	0.1	20	16	73	3	5.7	5.57
De3	3/6/11	Baseflow	85.8	447	7.21	17.2	14.79	-	508	6	100	24	118	0.1	17	16	82	3	5.83	5.81
De3	5/6/11	Baseflow	85.8	447	7.21	17.2	14.79	-	508	6	100	24	118	0.1	17	16	82	3	5.83	5.81
De1	29/9/11	No flow	58.4	849	8.0	7.6	20.7	185	-	-	-	-	-	-	-	-	-	-	-	-
De2	29/9/11	No flow	34.7	795	8.1	7.5	20.6	194	593	13	102	42	171	0.1	28	25	92	4	7.74	7.56
De3	29/9/11	No flow	30	754	7.9	9.8	21.5	242	445	11	173	14	144	0.1	26	22	100	3	7.81	7.53
De3	25/10/11	No flow	78.3	619	8.4	44.0	25.2	171	341	20	121	6	112	0.3	17	16	80	3	5.7	5.72
De1	26/10/11	No flow	73.5	918	7.1	6.5	22.0	135	-	-	-	-	-	-	-	-	-	-	-	-
De2	26/10/11	No flow	26.6	767	7.7	9.2	23.1	190	493	13	100	27	184	0.1	29	25	90	6	7.75	7.57
De1	21/11/11	No flow	63.6	1,254	8.0	7.6	29.2	99	-	-	-	-	-	-	-	-	-	-	-	-
De2	21/11/11	No flow	66	925	8.1	6.0	26.4	141	545	9	132	16	218	-	30	30	108	6	9.12	8.82
De3	21/11/11	No flow	100.6	727	8.3	27.8	26.6	131	465	25	181	4	160	-	25	22	111	4	8.21	7.99
De1	13/12/11	No flow	34.4	355	8.2	Too turbid	29.5	215	-	-	-	-	-	-	-	-	-	-	-	-
De2	13/12/11	No flow	57.1	397	8.0	959	28.3	125	10,600	668	55	26	78	-	<1	<1	89	<1	3.84	3.87
De3	13/12/11	No flow	58.8	523.6	7.5	Too turbid	27.7	134	3,020	472	75	4	84	0.1	5	8	70	2	3.95	4
De1	31/1/12	Storm/ baseflow	120.3	262	4.96	180.5	26.4	214	302	98	44	13	40	<0.1	9	7	29	4	2.28	2.39
De2	31/1/12	Storm/ baseflow	156.6	465	5.53	166.5	29.4	222	307	99	44	14	39	<0.1	9	7	29	4	2.27	2.39
De1	21/2/12	Storm flow	90.1	0.07	7.2	5.0	29.1	160	388	<5	114	34	152	0.1	27	21	90	6	7.27	7.14
De2	21/2/12	Storm flow	81.3	683	7.3	6.8	28.3	144	351	5	92	31	139	0.1	24	19	77	6	6.4	6.26
De2	20/3/12	Storm flow	95.3	268	7.5	179.5	28.5	134	267	170	40	<1	44	<0.1	8	6	28	3	2.04	2.19

Table 9-14 Historical water quality data – nutrients and biological characteristics - Deep Creek

Site	Date	Flow Type	Ammonia	Nitrite	Nitrate	NOx	TKN	TN	TP	FRP	E.coli
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Cfu/100ml
De1	1/6/11	Baseflow	0.03	<0.01	0.03	0.03	0.7	0.7	0.04	<0.01	~90
De2	2/6/11	Baseflow	0.03	<0.01	0.03	0.03	0.4	0.4	<0.01	<0.01	~30
De3	3/6/11	Baseflow	0.02	<0.01	0.12	0.12	0.5	0.6	0.1	-	-
De3	5/6/11	Baseflow	0.02	<0.01	0.12	0.12	0.5	0.6	0.1	-	-
De2	29/9/11	No flow	0.03	<0.01	0.02	0.02	0.4	0.4	0.04	0.02	-
De3	29/9/11	No flow	0.02	<0.01	0.02	0.02	0.4	0.4	0.04	<0.01	-
De3	25/10/11	No flow	0.01	<0.01	0.02	0.02	0.4	0.4	0.01	<0.01	-
De2	26/10/11	No flow	0.03	<0.01	0.02	0.02	0.6	0.6	0.04	<0.01	-
De2	21/11/11	No flow	0.04	<0.01	0.01	0.01	1	1	0.08	<0.01	-
De3	21/11/11	No flow	0.01	<0.01	<0.01	<0.01	0.7	0.7	0.02	<0.01	-
De2	13/12/11	No flow	0.12	0.03	0.16	0.19	6.2	6.4	2.2	<0.01	-
De3	13/12/11	No flow	0.14	<0.01	<0.01	<0.01	2.8	2.8	0.58	<0.01	-
De1	31/1/12	Storm / baseflow	0.06	<0.01	0.01	0.01	1.2	1.2	0.26	0.11	-
De2	31/1/12	Storm / baseflow	0.31	<0.01	0.01	0.01	1.6	1.6	0.26	0.11	-
De1	21/2/12	Storm flow	0.07	<0.01	<0.01	<0.01	0.5	0.5	0.03	0.02	-
De2	21/2/12	Storm flow	0.08	<0.01	<0.01	<0.01	0.4	0.4	0.04	0.02	-
De2	20/3/12	Storm flow	0.14	<0.01	0.02	0.02	1	1	0.16	0.07	-

Table 9-15 Historical water quality data – dissolved metals - Deep Creek

Site	Date	Flow Type	Al	An	As	Ba	Bo	Cr	Cu	Fe	Pb	Mn	Se	Sr	Ti	Vn	Zn
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
De1	1/6/11	Baseflow	<0.1	-	<0.01	<0.1	-	<0.001	0.002	<0.05	<0.01	0.08	<0.01	-	-	<0.01	0.029
De2	2/6/11	Baseflow	<0.1	-	<0.01	<0.1	-	<0.001	<0.001	<0.05	<0.01	0.04	<0.01	-	-	<0.01	0.006
De3	3/6/11	Baseflow	<0.1	-	<0.01	<0.1	-	<0.001	<0.001	<0.05	<0.01	0.04	<0.01	-	-	<0.01	<0.005
De3	5/6/11	Baseflow	<0.1	-	<0.01	<0.1	-	<0.001	<0.001	<0.05	<0.01	0.04	<0.01	-	-	<0.01	<0.005
De2	29/9/11	No flow	<0.1	<0.01	<0.01	<0.1	<0.1	<0.001	0.001	0.06	<0.01	0.89	<0.01	0.4	<0.01	<0.01	0.03
De3	29/9/11	No flow	<0.1	<0.01	0.01	0.1	<0.1	<0.001	<0.001	0.09	<0.01	0.82	<0.01	0.4	<0.01	<0.01	<0.005
De3	25/10/11	No flow	<0.1	<0.01	<0.01	<0.1	<0.1	<0.001	<0.001	<0.05	<0.01	0.08	<0.01	<0.1	<0.01	<0.01	<0.005
De2	26/10/11	No flow	<0.1	<0.01	<0.01	<0.1	<0.1	<0.001	<0.001	<0.05	<0.01	1.28	<0.01	0.4	<0.01	<0.01	<0.005
De2	21/11/11	No flow	<0.1	<0.01	<0.01	0.1	<0.1	<0.001	<0.001	0.14	<0.01	0.43	<0.01	0.5	<0.01	<0.01	<0.005
De3	21/11/11	No flow	<0.1	<0.01	<0.01	<0.1	0.1	<0.001	<0.001	<0.05	<0.01	0.34	<0.01	0.4	<0.01	<0.01	<0.005
De3	13/12/11	No flow	<0.1	<0.1	<0.1	<0.1	<0.1	<0.001	0.004	<0.1	<0.1	0.2	<0.1	<1	<0.1	<0.1	0.009
De1	31/1/12	Storm / baseflow	8.72	<0.01	<0.01	<0.1	<0.1	<0.001	0.003	4.17	<0.01	0.04	<0.01	0.1	0.2	0.02	<0.005
De2	31/1/12	Storm / baseflow	8.71	<0.01	<0.01	<0.1	<0.1	<0.001	0.003	4.18	<0.01	0.04	<0.01	0.1	0.2	0.02	<0.005
De1	21/2/12	Storm flow	<0.1	<0.01	<0.01	<0.1	0.1	<0.001	0.001	<0.05	0.01	0.06	0.02	0.4	<0.01	<0.01	<0.005
De2	21/2/12	Storm flow	<0.1	<0.01	<0.01	<0.1	<0.1	<0.001	0.001	<0.05	0.01	<0.01	0.02	0.4	<0.01	<0.01	<0.005
De2	20/3/12	Storm flow	1.96	0.01	<0.01	<0.1	<0.1	0.002	0.003	1.62	<0.01	0.03	<0.01	0.1	0.07	<0.01	<0.005

Table 9-16 Historical water quality data - physical-chemical characteristics - Tooloombah Creek

Site	Date	Flow Type	DO	EC	pH	Turbidity	Temp	Redox	TDS	TSS	Bicarb Alk	SO_4	Cl	Fl	Ca	Mg	Na	K	Anions	Cations
			%sat	uS/cm		NTU	ºC	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L
To1	3/6/11	Baseflow	94.7	866	7.59	5.93	16.05	-	740	<5	212	42	232	0.2	65	47	104	2	11.6	11.7
To2	4/6/11	Baseflow	92.11	848	7.4	1.67	15.64	-	778	<5	209	41	228	0.2	63	46	104	2	11.5	11.5
To1	29/9/11	Baseflow	70.1	951	8	5.6	22.3	192	-	-	-	-	-	-	-	-	-	-	-	-
To2	29/9/11	Baseflow	88.9	965	7.9	3	23.7	227	676	9	178	39	223	0.2	52	38	91	2	10.7	9.73
To1	25/10/11	Baseflow	76.1	1132	8.1	5.4	24.2	166	669	5	162	40	254	0.2	54	45	105	3	11.2	11
To2	25/10/11	Baseflow	136.6	1146	8.4	7.2	27.1	166	674	8	153	38	250	0.2	53	44	104	3	10.9	10.9
To2	21/11/11	Baseflow	127.5	1407	8.3	4.7	28.8	144	820	9	168	33	366	-	50	52	155	3	14.4	13.6
To1	22/11/11	Baseflow	74.5	1276	8.2	1.2	28.4	180	718	<5	183	39	313	-	53	48	129	2	13.3	12.3
To1	14/12/11	Baseflow	87.7	1225	7.7	15	27.7	148	608	<5	140	24	243	0.2	43	37	98	3	10.2	9.53
To2	14/12/11	Baseflow	108	1320	7.8	18.8	30.1	159	657	12	151	23	270	0.2	45	42	108	3	11.1	10.5
To1	31/01/12	Storm/baseflow	143.4	392	5.86	119.8	29.6	225	247	51	40	10	28	<0.1	9	6	20	3	1.8	1.89
To1	21/02/12	Storm flow	90.1	463	7.8	13.9	28.6	163	240	10	91	10	80	0.1	21	15	43	2	4.28	4.2
To1	20/03/12	Storm flow	98.8	193.7	7.5	125	28.6	139	235	23	41	<1	21	0.2	6	4	18	2	1.41	1.46

Table 9-17 Historical water quality data – nutrients and biological characteristics – Tooloombah Creek

Site	Date	Flow Type	Ammonia	Nitrite	Nitrate	NOx	TKN	TN	TP	FRP	*E.coli*
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Cfu/100ml
To1	3/6/11	Baseflow	0.02	<0.01	0.03	0.03	0.4	0.4	0.03	-	-
To2	4/6/11	Baseflow	0.02	<0.01	0.02	0.02	0.6	0.6	0.02	-	-
To2	29/9/11	Baseflow	0.03	<0.01	0.01	0.01	0.4	0.4	0.07	<0.01	-
To1	25/10/11	Baseflow	0.02	<0.01	0.02	0.02	0.4	0.4	0.01	<0.01	-
To2	25/10/11	Baseflow	0.02	<0.01	0.02	0.02	0.4	0.4	<0.01	<0.01	-
To2	21/11/11	Baseflow	0.04	<0.01	0.01	0.01	0.7	0.7	0.03	<0.01	-
To1	22/11/11	Baseflow	0.02	<0.01	0.02	0.02	0.5	0.5	0.05	<0.01	-
To1	14/12/11	Baseflow	0.1	<0.01	<0.01	<0.01	0.6	0.6	0.04	<0.01	-
To2	14/12/11	Baseflow	0.06	<0.01	<0.01	<0.01	0.6	0.6	0.08	0.02	-
To1	31/01/12	Storm / baseflow	0.25	<0.01	0.01	0.01	1.2	1.2	0.17	0.06	-
To1	21/02/12	Storm flow	0.06	<0.01	0.02	0.02	0.4	0.4	0.04	0.01	-
To1	20/03/12	Storm flow	0.69	<0.01	0.02	0.02	1.2	1.2	0.15	0.02	-

Table 9-18 Historical water quality data – dissolved metals - Tooloombah Creek

Site	Date	Flow Type	Al	An	As	Ba	Bo	Cr	Cu	Fe	pH	Mn	Se	Sr	Ti	Vn	Zn
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
To1	3/6/11	Baseflow	<0.10	-	<0.01	<0.1	<0.001	<0.001	<0.05	0.01	<0.01	-	-	-	0.001	<0.01	<0.005
To2	4/6/11	Baseflow	<0.10	-	<0.01	<0.1	<0.001	<0.001	<0.05	0.03	<0.01	-	-	-	0.001	<0.01	<0.005
To2	29/9/11	Baseflow	<0.10	<0.01	<0.01	<0.1	<0.001	<0.001	<0.05	0.04	<0.01	0.5	<0.01	<0.01	<0.001	<0.01	0.01
To1	25/10/11	Baseflow	<0.10	<0.01	<0.01	<0.1	<0.001	<0.001	<0.05	0.02	<0.01	0.5	<0.01	<0.01	<0.001	<0.01	<0.005
To2	25/10/11	Baseflow	<0.10	<0.01	<0.01	<0.1	<0.001	<0.001	<0.05	0.02	<0.01	0.5	<0.01	<0.01	<0.001	<0.01	<0.005
To2	21/11/11	Baseflow	<0.10	<0.01	0.01	0.1	<0.001	<0.001	<0.05	0.04	0.02	0.6	<0.01	<0.01	<0.001	<0.01	<0.005
To1	22/11/11	Baseflow	<0.10	0.01	<0.01	<0.1	<0.001	<0.001	<0.05	0.29	<0.01	0.6	<0.01	<0.01	<0.001	<0.01	<0.005
To1	14/12/11	Baseflow	<0.10	<0.01	<0.01	<0.1	0.002	0.001	<0.05	0.05	<0.01	0.5	<0.01	<0.01	<0.001	<0.01	<0.005
To2	14/12/11	Baseflow	<0.10	<0.01	<0.01	<0.1	<0.001	0.001	<0.05	0.12	<0.01	0.5	<0.01	<0.01	<0.001	<0.01	<0.005
To1	31/01/12	Storm / baseflow	7.47	<0.01	<0.01	<0.1	<0.001	0.002	3.18	0.03	<0.01	0.1	<0.01	0.18	<0.001	0.01	<0.005
To1	21/02/12	Storm flow	<0.1	<0.01	<0.01	<0.1	<0.001	<0.001	0.05	0.01	0.01	0.2	<0.01	<0.01	<0.001	<0.01	<0.005
To1	20/03/12	Storm flow	2.89	<0.01	<0.01	<0.1	<0.001	0.002	1.62	0.01	<0.01	<0.1	0.01	0.08	<0.001	<0.01	<0.005

Table 9-19 Historical water quality data - physical-chemical characteristics – Styx River

Site	Date	Flow Type	DO	EC	pH	Turbidity	Temp	Redox	TDS	TSS	Bicarb Alk	SO_4	Cl	Fl	Ca	Mg	Na	K	Anions	Cations
			%sat	uS/cm		NTU	°C	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L
St2	4/6/11	Baseflow	114.6	1,390	7.63	5.41	18.49	-	1,080	<5	306	68	422	0.4	64	55	227	6	19.4	17.8
St1	5/6/11	Baseflow	90.9	987	9.19	5.63	16.74	-	850	<5	190	42	291	0.2	58	45	139	2	12.9	12.7
St1	27/9/11	Baseflow	-	1,942	6.9	-	23.3	-	-	-	-	-	-	-	-	-	-	-	-	-
St2	27/9/11	Baseflow	-	5,450	6.8	11.8	23.9	125	-	-	-	-	-	-	-	-	-	-	-	-
St1	29/9/11	Baseflow	87.3	1,873	7.8	5.9	22.8	244	1,260	9	192	60	531	0.2	64	58	252	3	20.1	19
St2	29/9/11	Baseflow	49.8	8,200	6.9	9.7	22.4	203	6,400	21	266	379	2,800	0.4	124	192	1,490	47	92.2	88
St1	25/10/11	Baseflow	113.6	2,562	6.8	8.4	28.7	104	1,510	9	177	69	646	0.2	76	74	333	4	23.2	24.5
St2	25/10/11	Baseflow	158.4	5,100	8.0	12.7	27.1	145	3,120	13	208	187	1,340	0.3	85	123	780	25	45.8	48.9
St1	21/11/11	Baseflow	116.4	3,830	7.6	6.8	29.9	98	2,270	13	226	106	998	-	111	107	487	4	34.9	35.6
St2	21/11/11	Baseflow	177.4	5,600	8.2	7.9	28.7	118	4,440	18	214	240	1,650	-	85	147	969	26	56.2	59.2
St1	13/12/11	Baseflow	161	2,264	7.7	67.7	32.3	186	1,050	27	103	37	487	0.1	38	44	224	4	16.6	15.4
St2	13/12/11	Baseflow	163.2	1,445	8.1	109.9	32.2	198	736	33	103	24	324	0.2	27	29	154	7	11.7	10.6
St1	31/1/12	Storm/baseflow	90.6	321.5	7.12	201.4	27.2	196	268	84	44	9	30	<0.1	8	6	21	3	1.91	1.88
St2	31/1/12	Storm/baseflow	125.5	206	7.32	162.1	27.2	213	303	103	41	10	35	<0.1	7	6	26	4	2.01	2.08
St2	22/2/12	Storm flow	81.4	189.9	8.1	177.2	24.3	176	1,110	548	44	4	28	<0.1	6	5	22	2	1.75	1.72
St2	20/3/12	Storm flow	91.9	1,953	6.4	157.2	28.4	140	242	52	40	<1	22	<0.1	6	4	20	2	1.42	1.55

Table 9-20 Historical water quality data – nutrients and biological characteristics – Styx River

Site	Date	Flow Type	Ammonia	Nitrite	Nitrate	NOx	TKN	TN	TP	FRP	*E.coli*
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Cfu/100ml
St2	4/6/11	Baseflow	0.03	<0.01	0.04	0.04	0.4	0.4	<0.01	<0.01	17
St1	5/6/11	Baseflow	0.02	<0.01	0.04	0.04	0.5	0.5	0.12	<0.01	10
St1	29/9/11	Baseflow	0.02	<0.01	0.03	0.03	0.5	0.5	0.12	<0.01	-
St2	29/9/11	Baseflow	0.03	<0.01	0.02	0.02	0.2	0.2	0.06	<0.01	-
St1	25/10/11	Baseflow	<0.01	<0.01	0.02	0.02	0.3	0.3	<0.01	<0.01	-
St2	25/10/11	Baseflow	0.04	<0.01	0.01	0.01	0.3	0.3	<0.01	<0.01	-
St1	21/11/11	Baseflow	0.04	<0.01	0.03	0.03	0.3	0.3	<0.01	<0.01	-
St2	21/11/11	Baseflow	0.02	<0.01	0.02	0.02	0.3	0.3	0.4	<0.01	-
St1	13/12/11	Baseflow	0.08	<0.01	<0.01	<0.01	1.1	1.1	0.33	0.21	-
St2	13/12/11	Baseflow	0.12	<0.01	<0.01	<0.01	0.9	0.9	0.28	0.2	-
St1	31/1/12	Storm / baseflow	0.06	<0.01	0.01	0.01	1.0	1.0	0.2	0.07	-
St2	31/1/12	Storm / baseflow	0.07	<0.01	<0.01	<0.01	1.4	1.4	0.3	0.09	-
St2	22/2/12	Storm flow	0.05	<0.01	0.02	0.02	1.9	1.9	0.41	<0.01	-
St2	20/3/12	Storm flow	0.08	<0.01	0.02	0.02	0.8	0.8	0.19	0.05	-

Table 9-21 Historical water quality data – dissolved metals – Styx River

Site	Date	Flow Type	Al	As	Ba	Bo	Cd	Cr	Cu	Fe	Mn	Se	Sr	Ti	Ur	Vn	Zn
			mg/L	mg/L	mg/L	mg/L	mg/l	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
St2	4/6/11	Baseflow	<0.10	<0.01	<0.1	-	0.0001	<0.001	0.001	<0.05	0.08	<0.01	-	-	<0.001	<0.01	0.026
St1	5/6/11	Baseflow	<0.10	<0.01	<0.1	-	<0.0001	<0.001	<0.001	<0.05	0.19	<0.01	-	-	<0.001	<0.01	0.005
St1	29/9/11	Baseflow	<0.10	<0.01	0.1	<0.1	<0.0001	<0.001	<0.001	<0.05	0.28	<0.01	0.8	<0.01	<0.001	<0.01	0.03
St2	29/9/11	Baseflow	<0.10	0.1	0.2	0.7	<0.0001	<0.001	<0.001	<0.05	0.38	<0.01	1.9	<0.01	0.001	<0.01	0.02
St1	25/10/11	Baseflow	<0.10	<0.01	0.2	0.1	<0.0001	<0.001	<0.001	<0.05	0.55	<0.01	1.0	<0.01	<0.001	<0.01	<0.005
St2	25/10/11	Baseflow	<0.10	<0.01	0.1	0.4	<0.0001	<0.001	<0.001	<0.05	0.03	0.01	1.2	<0.01	<0.001	<0.01	<0.005
St1	21/11/11	Baseflow	<0.10	<0.01	0.3	0.2	<0.0001	<0.001	<0.001	<0.05	0.2	<0.01	1.6	<0.01	<0.001	<0.01	<0.005
St2	21/11/11	Baseflow	<0.10	<0.01	0.1	0.6	<0.0001	<0.001	0.002	<0.05	<0.01	<0.01	1.5	<0.01	<0.001	<0.01	<0.005
St1	13/12/11	Baseflow	<0.10	<0.01	0.1	<0.1	<0.0001	0.002	0.006	<0.05	0.13	<0.01	0.6	<0.01	<0.001	<0.01	0.011
St2	13/12/11	Baseflow	<0.10	<0.01	<0.1	0.1	<0.0001	<0.001	0.002	<0.05	0.18	<0.01	0.4	<0.01	<0.001	<0.01	<0.005
St1	31/1/12	Storm / baseflow	9.41	<0.01	<0.1	<0.1	<0.0001	<0.001	0.002	4.34	0.06	<0.01	0.1	0.26	<0.001	0.02	<0.005
St2	31/1/12	Storm / baseflow	10.8	<0.01	<0.1	<0.1	<0.0001	<0.001	0.003	5.3	0.06	<0.01	0.1	0.3	<0.001	0.02	<0.005
St2	22/2/12	Storm flow	0.51	<0.01	<0.1	<0.1	<0.0001	<0.001	0.002	0.44	0.02	<0.01	<0.1	0.02	<0.001	<0.01	0.006
St2	20/3/12	Storm flow	2.42	<0.01	<0.1	<0.1	<0.0001	0.002	0.003	1.58	0.02	0.03	<0.1	0.07	<0.001	<0.01	<0.005

9.5.3 Field Assessment - Current

Surface water assessments were conducted at nine sites across three separate campaigns in February, May and June 2017. A summary of each assessment is as follows:

- A site visit was carried out from 20 to 25 February to ascertain the extent and accessibility of potential water quality monitoring locations. This site visit sampled locations that were accessible and had standing water;
- A site visit was carried out from 1 to 4 May to re-sample sites that were visited during the February event. Due to wet weather preceding the campaign, all the sites were wet, however one site (To3) remained inaccessible; and
- A site visit was carried out from 12 to 16 June to re-sample sites that were visited during previous events.

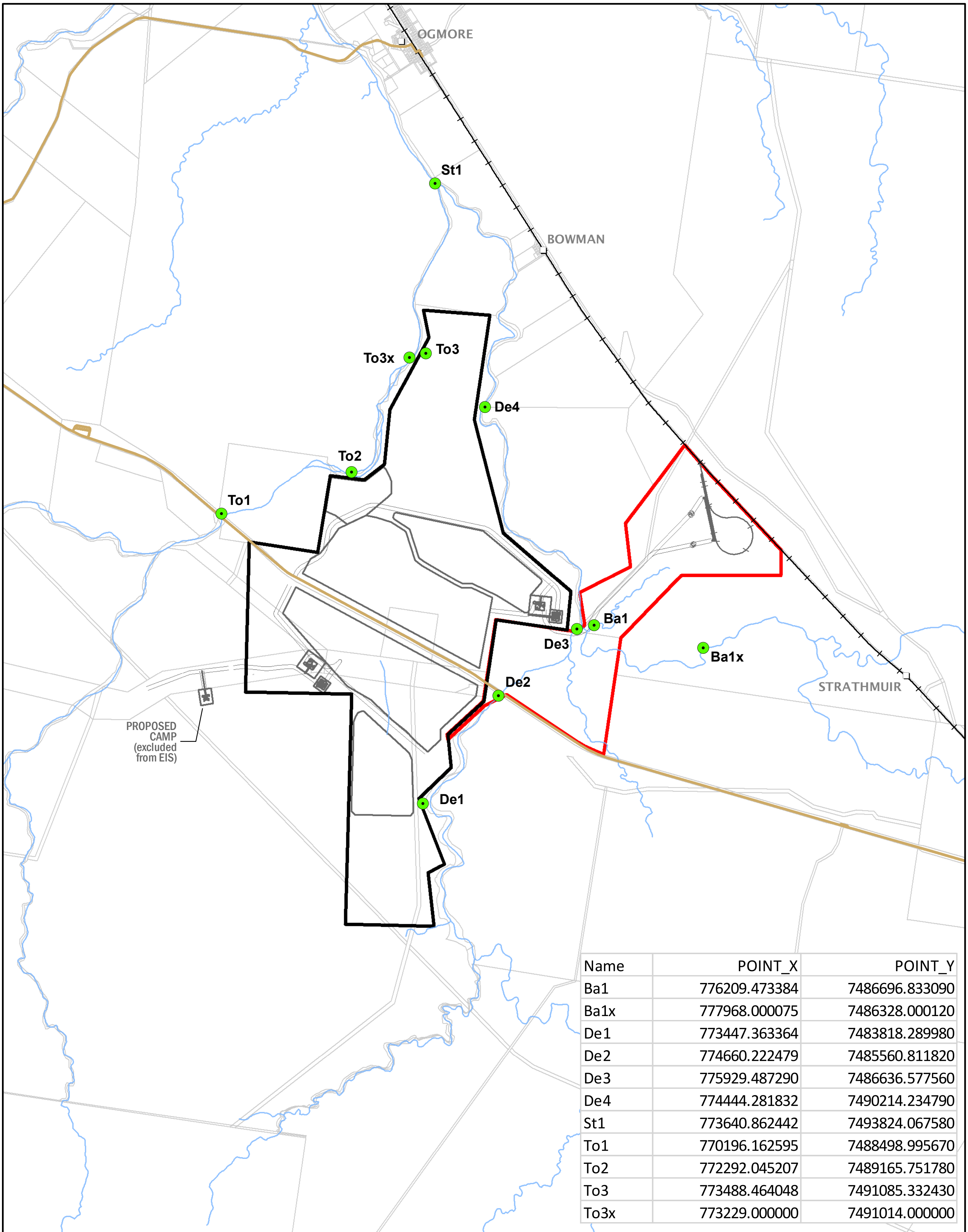
Site characteristics such as flow conditions, bank stability and water depth were recorded at each site. Survey site selection was based on proximity to the Project and the presence of water. Site selection was also guided by the *Monitoring and Sampling Manual 2009 Environmental Protection (Water) Policy 2009* (EHPa 2009).

9.5.3.1 Site Condition

The nearest operating rainfall gauge is at Strathmuir (BoM station 033189). The mean rainfall for the months of January and February are 137.3 mm and 143.3 mm, respectively. This station recorded a dry February except for 3 mm that was recorded on the 13th of that month. January recorded a total of 62 mm. Two sampling locations were dry at the time of the February sampling, which is representative of the dry conditions observed during February 2017 in the weeks and days leading up to the sampling event.

The mean rainfall for the months of March, April and May is 87.8 mm, 36.4 mm and 38.7 mm, respectively. A total of 510 mm of rainfall was recorded at the Strathmuir station in March 2017. This included 245 mm that was recorded on a single day on 30 March. This rainfall event was associated with Cyclone Debbie, which formed as a low pressure system over the Coral Sea on 22 March 2017. Rainfall from this cyclone and from March generally, is associated with the sampling locations having standing water at the time of the May sampling event.

The vegetation recorded at the sampling locations was described as RE 11.3.25 – Forest Red Gum (*Eucalyptus tereticornis*) and Weeping Tea-tree (*Melaleuca leucadendra*) open forest over a variable understorey but generally including Weeping Bottlebrush (*M. viminalis*). A summary of site description including flow conditions and vegetation for each of the survey sites is presented in Table 9-22. Photos have been provided as a visual reference to the various creeks within the Project area. Note that the photos are not intended to represent peak flow conditions during a flood event.



Name	POINT_X	POINT_Y
Ba1	776209.473384	7486696.833090
Ba1x	777968.000075	7486328.000120
De1	773447.363364	7483818.289980
De2	774660.222479	7485560.811820
De3	775929.487290	7486636.577560
De4	774444.281832	7490214.234790
St1	773640.862442	7493824.067580
To1	770196.162595	7488498.995670
To2	772292.045207	7489165.751780
To3	773488.464048	7491085.332430
To3x	773229.000000	7491014.000000

Figure 9-5
Surface water sampling locations

N

0 1 2 km

Scale @ A4 1:80,000
Date: 15/09/17
Drawn: Gayle B.

Legend

- Surface water sampling location
- ML 80187
- ML 700022
- Proposed mine infrastructure
- North Coast Rail Line
- Main road
- Cadastral boundary
- Watercourse

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017

CDM Smith

BRUGGEMANNGD B:\BES150160 Styx Coal\GIS\DATA\MXD\FINAL\03 EIS Preparation\BES150160.03-042 R2 surface water sampling.mxd 9/15/2017

Table 9-22 Surface water survey site descriptions

Deep Creek, Site DE1 (photos taken May 2017)	
Site location	773447 m easting, 7483818 m northing South of the mine area
Flow condition	Slow / minimal flow
Bank and stream bed width	8 m
Maximum water depth (m)	0.2 – 0.3 m
Presence of bank erosion	Minimal
Bank slopes steepness	50°
Dominant habitat vegetation	RE 11.3.25 – Forest Red Gum (*Eucalyptus tereticornis*) and Weeping Tea-tree (*Melaleuca leucadendra*) open forest over a variable understorey but generally including Weeping Bottlebrush (*M. viminalis*).
	

Deep Creek, Site DE2 (photos taken May 2017)	
Site location	774660 m easting, 7485560 m northings To the east of the mine area, under the Bruce Highway.
Flow condition	Slow flow
Bank and stream bed width	5 – 10 m
Maximum water depth (m)	0.8 m
Presence of bank erosion	Minimal
Bank slopes steepness	45°
Dominant habitat vegetation	RE 11.3.25 – Forest Red Gum (*Eucalyptus tereticornis*) and Weeping Tea-tree (*Melaleuca leucadendra*) open forest over a variable understorey but generally including Weeping Bottlebrush (*M. viminalis*).
	

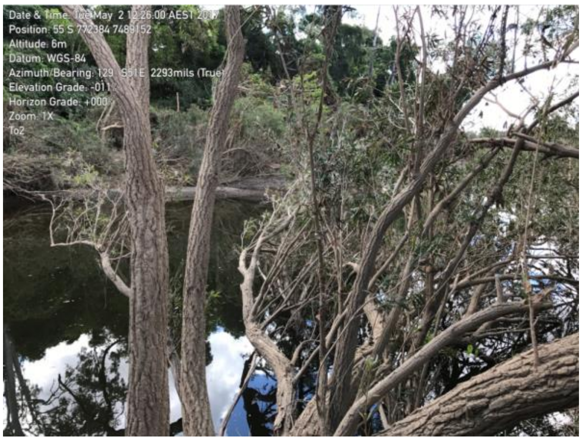
Deep Creek, Site DE3 (photos taken May 2017)	
Site location	775929 m easting, 7486636 m northings To the east of the mine area, close to the proposed haul road.
Flow condition	Flow
Bank and stream bed width	3 – 4 m
Maximum water depth (m)	0.5 m
Presence of bank erosion	Partial
Bank slopes steepness	60°
Dominant habitat vegetation	RE 11.3.25 – Forest Red Gum (*Eucalyptus tereticornis*) and Weeping Tea-tree (*Melaleuca leucadendra*) open forest over a variable understorey but generally including Weeping Bottlebrush (*M. viminalis*).
	

Deep Creek, Site DE4 (photos taken May 2017)	
Site location	774444 m easting, 7490214 m northings To the north of the mine area.
Flow condition	Slow flow
Bank and stream bed width	2 – 3 m
Maximum water depth (m)	0.3 – 0.4 m
Presence of bank erosion	Minimal
Bank slopes steepness	30 – 45°
Dominant habitat vegetation	RE 11.3.25 – Forest Red Gum (*Eucalyptus tereticornis*) and Weeping Tea-tree (*Melaleuca leucadendra*) open forest over a variable understorey but generally including Weeping Bottlebrush (*M. viminalis*).
	

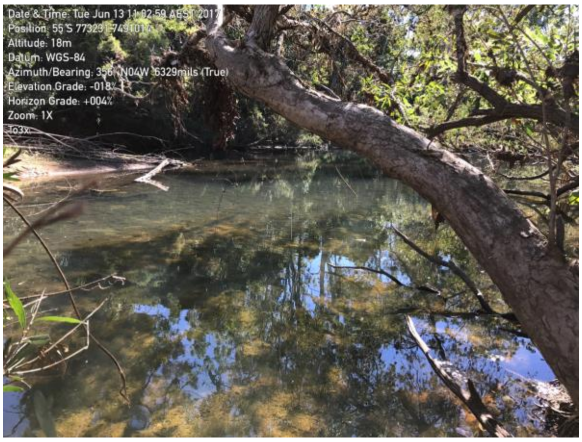
Styx River, Site ST1 (photos taken May 2017)	
Site location	773640 m easting, 7493824 m northings To the north of the Project area, to the west of the North Coast rail line.
Flow condition	Flow
Bank and stream bed width	20 m
Maximum water depth (m)	Deep
Presence of bank erosion	Minimal
Bank slopes steepness	45°
Dominant habitat vegetation	RE 11.3.25 – Forest Red Gum (*Eucalyptus tereticornis*) and Weeping Tea-tree (*Melaleuca leucadendra*) open forest over a variable understorey but generally including Weeping Bottlebrush (*M. viminalis*).
	

Tooloombah Creek, Site TO1 (photos taken May 2017)	
Site location	770196 m easting, 7488498 m northings Located to the west of the Project area.
Flow condition	Slow flow
Bank and stream bed width	5 – 10 m
Maximum water depth (m)	> 1 m
Presence of bank erosion	Minimal
Bank slopes steepness	25 – 45°
Dominant habitat vegetation	RE 11.3.25 – Forest Red Gum (*Eucalyptus tereticornis*) and Weeping Tea-tree (*Melaleuca leucadendra*) open forest over a variable understorey but generally including Weeping Bottlebrush (*M. viminalis*).
	

Tooloombah Creek, Site TO2 (photos taken May 2017)	
Site location	772292 m easting, 7489165 m northings Located to the north of the mine area.
Flow condition	Slow flow
Bank and stream bed width	15 – 20 m
Maximum water depth (m)	Deep
Presence of bank erosion	Minimal
Bank slopes steepness	60°
Dominant habitat vegetation	RE 11.3.25 – Forest Red Gum (*Eucalyptus tereticornis*) and Weeping Tea-tree (*Melaleuca leucadendra*) open forest over a variable understorey but generally including Weeping Bottlebrush (*M. viminalis*).



Tooloombah Creek, Site TO3x (photos taken June 2017)	
Site location	773231 m easting, 7491014 m northings Located to the north of the mine area.
Flow condition	Very slow/no flow
Bank and stream bed width	5 – 10 m
Maximum water depth (m)	1 m
Presence of bank erosion	Minimal
Bank slopes steepness	45°
Dominant habitat vegetation	RE 11.3.25 – Forest Red Gum (*Eucalyptus tereticornis*) and Weeping Tea-tree (*Melaleuca leucadendra*) open forest over a variable understorey but generally including Weeping Bottlebrush (*M. viminalis*).



Barrack Creek, Site BA1x (photos taken May 2017)	
Site location	776563 m easting, 7486323 m northings
Flow condition	Slow flow
Bank and stream bed width	10 m
Maximum water depth (m)	0.3 m
Presence of bank erosion	Minor
Bank slopes steepness	45°
Dominant habitat vegetation	RE 11.3.25 – Forest Red Gum (*Eucalyptus tereticornis*) and Weeping Tea-tree (*Melaleuca leucadendra*) open forest over a variable understorey but generally including Weeping Bottlebrush (*M. viminalis*).
	

9.5.3.2 Water Quality and Sediment Sampling Method

A total of nine survey sites were sampled for surface water quality (Figure 9-5). Sample sites included four on Deep Creek (De1, De2, De3 and De4), three on Tooloombah Creek (To1, To2, To3), one on Styx River and one on Barrack Creek.

The following physical parameters were tested in-situ using a hand-held water quality meter:

- Water temperature (°C);
- pH (standard unit);
- Dissolved Oxygen (DO) (% (percent saturation));
- Conductivity (µS/cm (Microsiemens per centimetre)); and
- Turbidity (NTU (Nephelometric Turbidity Units)).

Measurements were taken from streams and pools at a depth at least 0.10 m below the surface and 0.10 m above the watercourse bed. Time of day was also recorded to assist in interpreting results.

Water samples were also collected at a depth of 0.30 m. Samples were stored at 4°C, as per National Association of Testing Authorities (NATA) guidelines and all samples were analysed at a NATA accredited lab. Water samples were tested for the following parameters:

- Total Dissolved Solids;
- Suspended Solids;
- Total Alkalinity;
- Sulphate;
- Chloride;
- Ammonia;
- Nitrite;
- Nitrate;
- Total Nitrogen;
- Total Phosphorus;
- Reactive Phosphorus;
- Fluoride;
- Dissolved Major Cations;
- Dissolved Metals;
- Ionic Balance;
- Total Petroleum Hydrocarbons; and
- BTEXN (benzene, toluene, ethylbenzene, xylene, naphthalene).

9.5.4 Surface Water Quality Assessment

Baseline water quality values for samples captured during February, May and June sampling events are presented in Table 9-23, Table 9-24 and Table 9-25. The February survey followed a very dry period and no flow was recorded in the creeks. Heavy rains associated with Cyclone Debbie were experienced in the area in late March and flowing water was recorded during the May survey. The results were collated and the mean, median, 80th and 20th percentiles presented in Table 9-26. The samples are compared against the Styx River, Shoalwater Creek and Water Park Creek Basins Environmental Values, Water Quality Objectives 2014, and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

Some of the physical and chemical water quality values at the sampled sites exceeded the WQO for those EVs. The following section provides a brief assessment of the results for the key parameters.

9.5.4.1 Turbidity and Suspended Solids

Turbidity exceeded the 50 NTU for three of the 23 samples. Suspended solids exceeded 40 mg/L for two of the 14 water samples. During the February sampling event, turbidity and suspended solids exceedances were observed at both De2 and De3. This is likely attributed to the low standing water height at the time of sampling due to the dry conditions and limited rainfall during the months of January and February. There were no exceedances for turbidity and suspended solids recorded during the May or June sampling events.

9.5.4.2 Electrical Conductivity

Testing showed that all surface water samples exceeded the ANZECC guideline value for conductivity. High conductivity values can result from excess sodium, magnesium, calcium, chloride, sulphate and bicarbonate in streams. These salts may originate from irrigation water, soils or fertilisers. High salinity values in streams may also result from rising water tables. The higher values at the Styx River site is likely the result of estuarine influence in this section of the river. It is noted that conductivity values along Tooloombah Creek were considerably higher than Deep Creek during all surveys and regardless of flow conditions. Tooloombah Creek is a rocky creek and markedly different in form from Deep Creek. The conductivity results likely indicate a differing geological background or parent source between the two creeks.

9.5.4.3 pH

Three of the water samples recorded values outside the WQO guideline range of pH 6.5 - 8, including St1(pH 8.15), To1 (pH 8.04) and To2 (pH 8.1). These exceedances all occurred during the February sampling event when very dry conditions had preceded the survey.

9.5.4.4 Nutrients and Productivity

Total nitrogen exceeded the guideline value for seven of the 23 samples. The February sampling event identified total nitrogen exceedances occurring for six of the seven water samples. Only one sample in May (St1) exceeded the guideline value (none in June) potentially indicating that dry conditions in February (including stock access, particularly to Deep Creek) contributed to the high values recorded.

Total phosphorous exceedances were recorded for 10 of the 23 samples. The February and May sampling events both recorded five exceedances each of seven and eight samples respectively. No exceedances were recorded in June.

Nitrogen and phosphorus in surface water come from a number of sources. Naturally, organic plant matter and silt containing macronutrients can enter waterways from surrounding environments and riparian vegetation. Elevated nutrient levels can often be the result of anthropogenic sources and given the downstream catchment location of the Project, grazing (through direct defecation and pasture runoff) and the erosion of nutrient laden sediments are likely key sources in and upstream of the Project area.

9.5.4.5 Dissolved Heavy Metals

The dissolved aluminium guideline value of 0.055 mg/L was exceeded at De3 (0.06 mg/L) during the February sampling event. The dissolved copper guideline value of 0.0014 mg/L was exceeded at St1 (0.002 mg/L) during the February sampling event as was the dissolved zinc guideline value of 0.008 mg/L at St1 (0.025 mg/L).

During the May sampling event, the dissolved copper guideline value was exceeded at four of the locations, including St1 (0.002 mg/L), To1 (0.002 mg/L), De1 (0.003 mg/L), De2 (0.002 mg/L) and De3 (0.018 mg/L). No other dissolved heavy metal exceedances were recorded during the May sampling event.

During the June sampling event, the dissolved aluminium guideline value of 0.055 mg/L was exceeded at De3 (0.55 mg/L). Dissolved copper exceeded the guideline value (0.001 mg/L) at St1. (0.003 mg/L). St1 also exceeded the dissolved zinc guideline value of 0.005 mg/L. The dissolved zinc recording at St1 was 0.006 mg/L.

While Project specific sampling recorded limited exceedances, the results showed copper concentrations at the Styx River site (which sits at the confluence of Tooloombah Creek and Deep Creek) were consistently above guideline values across the three surveys.

Surface water systems can often exhibit naturally high heavy metal concentrations due to local geology and soil composition; however, concentration levels can often be increased through environmental disturbance (for example soil erosion) and other anthropogenic activities (for example mining and agriculture). Heavy metals present in a system due to soil erosion are typically associated with sediment particulates and although they will be measures under total metals, they are typically not bioavailable. As such, dissolved metals provide a more accurate concentration of bioavailable metals that can accumulate in the food chain through direct ingestion or passive diffusion (for example direct contact) with organisms (ANZECC guidelines).

Table 9-23 Surface water quality results during February 2017 sample events

Parameter	WQOs	Styx River	Barrack Creek	Tooloombah Creek			Deep Creek			
		St1	Ba1	To1	To2	To3	De1	De2	De3	De4
In-situ results										
Water Temperature (°C)	16 – 34[5]	29.9	Dry	26.6	29.5	Inaccessible	Dry	27.1	26.2	28.7
Dissolved Oxygen (mg/l)[7]	6.77 – 8.76[2]	5.07	Dry	14.5	3.3	Inaccessible	Dry	3.01	1.3	2.8
pH	6.5 – 8.0[2]	8.15	Dry	8.04	8.1	Inaccessible	Dry	7.65	7.48	7.51
Conductivity- base flow (µS/cm)	20-250[1]	13,103	Dry	872	2,737	Inaccessible	Dry	271.9	373.7	258.8
Turbidity (NTU)	50[2]	12.6	Dry	14.5	3.3	Inaccessible	Dry	XXX	XXX	116
Laboratory results										
Total Dissolved Solids (mg/L)	600[4]	7,810	Dry	348	1,660	Inaccessible	Dry	1,540	3,570	236
Suspended Solids (mg/L)	10[2]	13	Dry	-5	-5	Inaccessible	Dry	1,100	161	32
Total Alkalinity as $CaCO_3$ (mg/L)	≥20[1]	194	Dry	122	115	Inaccessible	Dry	74	80	54
Sulphate (mg/L)	250[4]	501	Dry	12	22	Inaccessible	Dry	8	4	12
Chloride (mg/L)	-	4,510	Dry	119	849	Inaccessible	Dry	34	68	31
Ammonia N (mg/L)	0.02	0.05	Dry	0.05	0.05	Inaccessible	Dry	0.12	0.25	0.03
Nitrite	-	-0.01	Dry	-0.01	-0.01	Inaccessible	Dry	-0.01	-0.01	-0.01
Nitrate	0.7[1]	-0.01	Dry	0.02	0.05	Inaccessible	Dry	0.05	0.03	0.02
Total Nitrogen (mg/L)	0.5[2]	1.2	Dry	0.6	0.8	Inaccessible	Dry	4	5.5	1.5
Total Phosphorus as P (mg/L)	0.05[2]	0.16	Dry	0.06	0.05	Inaccessible	Dry	1.38	1.26	0.21
Reactive Phosphorus (mg/L)	0.02[2]	0.01	Dry	-0.01	-0.01	Inaccessible	Dry	0.01	0.01	-0.01
Fluoride	1.0[2]	0.4	Dry	0.3	0.3	Inaccessible	Dry	0.2	0.2	0.2
Dissolved Major Cations										
Calcium (mg/L)	-	128	Dry	20	65	Inaccessible	Dry	4	3	4
Magnesium (mg/L)	-	286	Dry	18	76	Inaccessible	Dry	4	5	5
Sodium (mg/L)	-	2,150	Dry	72	286	Inaccessible	Dry	42	66	32
Potassium (mg/L)	-	68	Dry	2	3	Inaccessible	Dry	3	2	4
Dissolved Metals										
Aluminium (mg/L)	0.055[1]	-0.01	Dry	-0.01	-0.01	Inaccessible	Dry	-0.01	0.06	-0.01
Arsenic (mg/L)	0.024[1]	0.004	Dry	0.002	0.002	Inaccessible	Dry	0.003	0.002	0.002
Barium (mg/L)	1.0[1]	0.271	Dry	0.028	0.15	Inaccessible	Dry	0.022	0.034	0.03
Cadmium (mg/L)	0.0002[1]	-0.0001	Dry	-0.0001	-0.0001	Inaccessible	Dry	-0.0001	-0.0001	-0.0001
Chromium (mg/L)	0.001[1]	-0.001	Dry	-0.001	-0.001	Inaccessible	Dry	-0.001	-0.001	-0.001
Cobalt (mg/L)	1.0[3]	-0.001	Dry	-0.001	-0.001	Inaccessible	Dry	-0.001	0.001	-0.001
Copper (mg/L)	0.0014[1]	0.002	Dry	-0.001	-0.001	Inaccessible	Dry	0.001	-0.001	-0.001

Lead (mg/L)	**0.0034[1]**	-0.001	Dry	-0.001	-0.001	Inaccessible	Dry	-0.001	-0.001	-0.001
Manganese (mg/L)	**1.9[1]**	0.006	Dry	0.102	0.153	Inaccessible	Dry	0.382	0.366	0.202
Molybdenum (mg/L)	**0.010[6]**	0.002	Dry	-0.001	-0.001	Inaccessible	Dry	-0.001	-0.001	-0.001
Nickel (mg/L)	**0.011[1]**	0.001	Dry	-0.001	-0.001	Inaccessible	Dry	0.003	0.002	0.002
Selenium (mg/L)	**0.005[1]**	-0.01	Dry	-0.01	-0.01	Inaccessible	Dry	-0.01	-0.01	-0.01
Silver (mg/L)	**0.00005[1]**	-0.001	Dry	-0.001	-0.001	Inaccessible	Dry	-0.001	-0.001	-0.001
Uranium (mg/L)	**0.01[6]**	-0.001	Dry	-0.001	-0.001	Inaccessible	Dry	-0.001	-0.001	-0.001
Vanadium (mg/L)	**0.1[6]**	-0.01	Dry	-0.01	-0.01	Inaccessible	Dry	-0.01	-0.01	-0.01
Zinc (mg/L)	**0.008[1]**	0.025	Dry	-0.005	-0.005	Inaccessible	Dry	-0.005	-0.005	0.012
Iron (mg/L)	**0.2[6]**	-0.05	Dry	-0.05	0.07	Inaccessible	Dry	0.08	0.08	-0.05
Mercury (mg/L)	**0.0006[1]**	-0.0001	Dry	-0.0001	-0.0001	Inaccessible	Dry	-0.0001	-0.0001	-0.0001
Ionic Balance										
Total Anions (mg/L)	-	142	Dry	6.04	26.7	Inaccessible	Dry	2.6	3.6	2.2
Total Cations (mg/L)	-	125	Dry	5.66	22	Inaccessible	Dry	2.43	3.48	2.1
Ionic Balance (%)	-	6.13	Dry	3.26	9.62	Inaccessible	Dry	----	1.65	----
Total Petroleum Hydrocarbons										
C6 - C9 Fraction (µg/L))	-	-20	Dry	-20	-20	Inaccessible	Dry	-20	-20	-20
C10 - C14 Fraction (µg/L)	-	-50	Dry	-50	-50	Inaccessible	Dry	-50	-50	50
C15 - C28 Fraction (µg/L)	-	-100	Dry	-100	-100	Inaccessible	Dry	200	180	150
C29 - C36 Fraction (µg/L)	-	-50	Dry	-50	-50	Inaccessible	Dry	150	200	70
C10 - C36 Fraction (sum) (µg/L)	-	-50	Dry	-50	-50	Inaccessible	Dry	350	380	270
BTEXN										
Benzene (µg/L)	**950[1]**	-1	Dry	-1	-1	Inaccessible	Dry	-1	-1	-1
Toluene (µg/L)	-	-2	Dry	-2	-2	Inaccessible	Dry	3	-2	-2
Ethylbenzene (µg/L)	-	-2	Dry	-2	-2	Inaccessible	Dry	-2	-2	-2
meta- & para-Xylene (µg/L)	-	-2	Dry	-2	-2	Inaccessible	Dry	-2	-2	-2
ortho-Xylene (µg/L)	**350[1]**	-2	Dry	-2	-2	Inaccessible	Dry	-2	-2	-2
Total Xylenes (µg/L)	-	-2	Dry	-2	-2	Inaccessible	Dry	-2	-2	-2
Sum of BTEX (µg/L)	-	-1	Dry	-1	-1	Inaccessible	Dry	3	-1	-1
Naphthalene (µg/L)	**16[1]**	-5	Dry	-5	-5	Inaccessible	Dry	-5	-5	-5

Source: 1 – ANZECC; 2 – EPP (Water) 'Aquatic Ecosystem'; 3 – EPP (Water) 'Stock Water'; 4 – EPP (Water) 'Human Consumer'; 5 – EPP (Water) 'Primary Recreation'; 6 – EPP (Water) 'Irrigation'.
7 – the WQO for dissolved oxygen is based on a conversion from the % saturation to mg/L assuming temperature at 25°C and altitude of 300 mAHD. The dissolved oxygen WQO was a percentage of saturation is 85% to 110%. Red font = Data above or below trigger values. Note: Values that say '<0.0001' are described as 'undetectable' by the laboratory. Note: Turbidity reading XXX = >880 NTU

Table 9-24 Surface water quality results during May 2017 sample events

Parameter	WQOs	Styx River	Barrack Creek	Tooloombah Creek			Deep Creek			
		St1	Ba1	To1	To2	T03	De1	De2	De3	De4
In-situ results										
Water Temperature (°C)	16 – 34[5]	23.7	22.2	22.3	24.1	Inaccessible	19.7	20.0	20.0	20.2
Dissolved Oxygen (mg/l)	6.77 – 8.76[2]	5.57	5.62	4.85	5.70	Inaccessible	5.55	6.03	6.22	6.88
pH	6.5 – 8.0[2]	7.09	7.57	7.49	7.88	Inaccessible	7.48	7.20	6.98	7.60
Conductivity- base flow (µS/cm)	20-250[1]	1,127	1,293	713	839	Inaccessible	380.4	348.9	355.9	404.5
Turbidity (NTU)	50[2]	12.3	6.0	4.0	2.5	Inaccessible	23.5	28.7	32.9	14.0
Laboratory results										
Total Dissolved Solids (mg/L)	600[4]	687	906	432	615	Inaccessible	298	274	290	318
Suspended Solids (mg/L)	10[2]	10	6	6	8	Inaccessible	6	<5	15	6
Total Alkalinity as $CaCO_3$ (mg/L)	≥20[1]	148	60	141	140	Inaccessible	86	81	83	87
Sulphate (mg/L)	250[4]	40	41	32	33	Inaccessible	17	15	16	16
Chloride (mg/L)	-	318	434	167	210	Inaccessible	88	76	76	91
Ammonia N (mg/L)	0.02	0.06	0.03	0.02	0.02	Inaccessible	0.02	<0.01	<0.01	0.01
Nitrite (mg/L)	-	<0.01	<0.01	<0.01	<0.01	Inaccessible	<0.01	<0.01	<0.01	<0.01
Nitrate (mg/L)	0.7[1]	0.06	<0.01	<0.01	<0.01	Inaccessible	<0.01	<0.01	0.02	<0.01
Total Nitrogen (mg/L)	0.5[2]	0.7	0.1	0.2	0.2	Inaccessible	0.2	0.2	0.3	0.2
Total Phosphorus as P (mg/L)	0.05[2]	0.03	0.02	0.22	0.08	Inaccessible	0.16	0.15	0.15	0.02
Reactive Phosphorus (mg/L)	0.02[2]	<0.01	<0.01	<0.01	<0.01	Inaccessible	<0.01	<0.01	<0.01	<0.01
Fluoride (mg/L)	1.0[2]	0.2	0.1	0.2	0.2	Inaccessible	<0.1	<0.1	<0.1	<0.1
Dissolved Major Cations										
Calcium (mg/L)	-	34	25	35	39	Inaccessible	14	12	13	13
Magnesium (mg/L)	-	33	48	26	30	Inaccessible	12	11	11	13
Sodium (mg/L)	-	169	197	85	96	Inaccessible	55	51	52	60
Potassium (mg/L)	-	4	4	3	3	Inaccessible	3	3	3	3
Dissolved Metals										
Aluminium (mg/L)	0.055[1]	<0.01	<0.01	<0.01	<0.01	Inaccessible	<0.01	<0.01	<0.01	<0.01
Arsenic (mg/L)	0.024[1]	0.001	<0.001	<0.001	<0.001	Inaccessible	<0.001	<0.001	<0.001	<0.001
Barium (mg/L)	1.0[1]	0.112	0.201	0.074	0.082	Inaccessible	0.057	0.052	0.058	0.072
Cadmium (mg/L)	0.0002[1]	<0.0001	<0.0001	<0.0001	<0.0001	Inaccessible	<0.0001	<0.0001	<0.0001	<0.0001
Chromium (mg/L)	0.001[1]	<0.001	<0.001	<0.001	<0.001	Inaccessible	<0.001	<0.001	<0.001	<0.001
Cobalt (mg/L)	1.0[3]	<0.001	<0.001	<0.001	<0.001	Inaccessible	<0.001	<0.001	<0.001	<0.001
Copper (mg/L)	0.0014[1]	0.002	<0.001	0.018	<0.001	Inaccessible	0.002	0.002	0.003	<0.001

Lead (mg/L)	**0.0034[1]**	<0.001	<0.001	<0.001	<0.001	Inaccessible	<0.001	<0.001	<0.001	<0.001
Manganese (mg/L)	**1.9[1]**	0.43	0.055	0.009	0.035	Inaccessible	0.078	0.04	0.201	0.169
Molybdenum (mg/L)	**0.010[6]**	<0.001	<0.001	<0.001	<0.001	Inaccessible	<0.001	<0.001	<0.001	<0.001
Nickel (mg/L)	**0.011[1]**	0.001	0.001	0.002	<0.001	Inaccessible	0.001	0.001	0.002	0.001
Selenium (mg/L)	**0.005[1]**	<0.01	<0.01	<0.01	<0.01	Inaccessible	<0.01	<0.01	<0.01	<0.01
Silver (mg/L)	**0.00005[1]**	<0.001	<0.001	<0.001	<0.001	Inaccessible	<0.001	<0.001	<0.001	<0.001
Uranium (mg/L)	**0.01[6]**	<0.001	<0.001	<0.001	<0.001	Inaccessible	<0.001	<0.001	<0.001	<0.001
Vanadium (mg/L)	**0.1[6]**	<0.01	<0.01	<0.01	<0.01	Inaccessible	<0.01	<0.01	<0.01	<0.01
Zinc (mg/L)	**0.008[1]**	<0.005	<0.005	<0.005	<0.005	Inaccessible	<0.005	<0.005	<0.005	<0.005
Iron (mg/L)	**0.2[6]**	<0.05	<0.05	<0.05	<0.05	Inaccessible	<0.05	<0.05	<0.05	<0.05
Mercury (mg/L)	**0.0006[1]**	<0.0001	<0.0001	<0.0001	<0.0001	Inaccessible	<0.0001	<0.0001	<0.0001	<0.0001
Ionic Balance										
Total Anions (mg/L)	-	12.8	14.3	8.19	9.41	Inaccessible	4.55	4.07	4.14	4.64
Total Cations (mg/L)	-	11.9	13.9	7.66	8.67	Inaccessible	4.16	3.8	3.89	4.4
Ionic Balance (%)	-	3.63	1.51	3.37	4.1	Inaccessible	4.58	3.5	3.02	2.58
Total Petroleum Hydrocarbons										
C6 - C9 Fraction (µg/L))	-	<20	<20	<20	<20	Inaccessible	<20	<20	<20	<20
C10 - C14 Fraction (µg/L)	-	<50	<50	<50	<50	Inaccessible	<50	<50	<50	<50
C15 - C28 Fraction (µg/L)	-	<100	<100	<100	<100	Inaccessible	<100	<100	<100	<100
C29 - C36 Fraction (µg/L)	-	<50	<50	<50	<50	Inaccessible	<50	<50	<50	<50
C10 - C36 Fraction (sum) (µg/L)	-	<50	<50	<50	<50	Inaccessible	<50	<50	<50	<50
BTEXN										
Benzene (µg/L)	**950[1]**	<1	<1	<1	<1	Inaccessible	<1	<1	<1	<1
Toluene (µg/L)	-	<2	<2	<2	<2	Inaccessible	<2	<2	<2	<2
Ethylbenzene (µg/L)	-	<2	<2	<2	<2	Inaccessible	<2	<2	<2	<2
meta- & para-Xylene (µg/L)	-	<2	<2	<2	<2	Inaccessible	<2	<2	<2	<2
ortho-Xylene (µg/L)	**350[1]**	<2	<2	<2	<2	Inaccessible	<2	<2	<2	<2
Total Xylenes (µg/L)	-	<2	<2	<2	<2	Inaccessible	<2	<2	<2	<2
Sum of BTEX (µg/L)	-	<1	<1	<1	<1	Inaccessible	<1	<1	<1	<1
Naphthalene (µg/L)	**16[1]**	<5	<5	<5	<5	Inaccessible	<5	<5	<5	<5

Source: 1 – ANZECC Guidelines; 2 – EPP (Water) 'Aquatic Ecosystem'; 3 – EPP (Water) 'Stock Water'; 4 – EPP (Water) 'Human Consumer'; 5 – EPP (Water) 'Primary Recreation'; 6 – EPP (Water) 'Irrigation'.
7 – the WQO for dissolved oxygen is based on a conversion from the % saturation to mg/L assuming temperature at 25°C and altitude of 300 mAHD. The dissolved oxygen WQO was a percentage of saturation is 85% to 110%. Red font = Data above or below trigger values. Note: Values that say '<0.0001' are described as 'undetectable' by the laboratory. Note: Turbidity reading XXX = >880 NTU

Table 9-25 Surface water quality results during June 2017 sample events

Parameter	WQOs	Styx River	Barrack Creek	Tooloombah Creek			Deep Creek			
		St1	Ba1x	To1	To2	To3x	De1	De2	De3	De4
In-situ results										
Water Temperature (°C)	16 – 34[5]	19.9	20.1	20	19.3	18.3	16	15.6	15.8	16.1
Dissolved Oxygen (mg/l)	6.77 – 8.76[2]	5.96	4.85	5.57	6.01	5.19	4.6	5.41	5.46	5.5
pH	6.5 – 8.0[2]	7.54	7.38	7.62	7.68	7.58	7.41	7.5	7.38	7.5
Conductivity- base flow (µS/cm)	-	1,227	1,288	742	788	1,133	353.9	357.9	318.3	382.3
Turbidity (NTU)	50[2]	5.9*	6.4	18.2	2.2*	3.9*	10.2*	17.7*	18.6*	14.1*
Laboratory results										
Total Dissolved Solids (mg/L)	600[4]	869	1,010	620	576	889	261	233	267	295
Suspended Solids (mg/L)	10[2]	6	<5	<5	<5	16	<5	9	<5	7
Total Alkalinity as $CaC0_3$ (mg/L)	≥20[1]	179	56	161	142	167	98	92	104	105
Sulphate (mg/L)	250[4]	48	41	36	35	47	14	12	12	13
Chloride (mg/L)	-	420	455	227	251	404	88	75	85	112
Ammonia N (mg/L)	0.02	0.03	0.02	0.04	0.02	0.02	0.06	0.02	0.02	0.02
Nitrite (mg/L)	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate (mg/L)	0.7[1]	<0.01	<0.05	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	0.03
Total Nitrogen (mg/L)	0.5[2]	0.3	0.2	0.2	0.2	0.3	0.3	0.5	0.2	0.2
Total Phosphorus as P (mg/L)	0.05[2]	<0.01	0.02	0.01	0.01	0.02	0.02	0.04	0.02	0.02
Reactive Phosphorus (mg/L)	0.02[2]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoride (mg/L)	1.0[2]	0.2	<0.1	0.2	0.2	0.2	<0.1	<0.1	0.1	0.1
Dissolved Major Cations										
Calcium (mg/L)	-	35	26	41	43	62	16	9	8	13
Magnesium (mg/L)	-	36	48	22	35	49	13	9	10	14
Sodium (mg/L)	-	209	187	106	110	163	62	60	73	74
Potassium (mg/L)	-	3	4	3	3	2	2	3	2	3
Dissolved Metals										
Aluminium (mg/L)	0.055[1]	0.03	<0.01	<0.01	0.010	<0.01	<0.01	<0.01	0.550	<0.01
Arsenic (mg/L)	0.024[1]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
Barium (mg/L)	1.0[1]	0.094	0.198	0.072	0.087	0.125	0.055	0.048	0.057	0.056
Cadmium (mg/L)	0.0002[1]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium (mg/L)	0.001[1]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt (mg/L)	1.0[3]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (mg/L)	0.0014[1]	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Lead (mg/L)	0.0034[1]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Manganese (mg/L)	**1.9[1]**	0.122	0.044	0.064	0.040	0.085	0.034	0.008	0.081	0.144
Molybdenum (mg/L)	**0.010[6]**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel (mg/L)	**0.011[1]**	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002	0.001
Selenium (mg/L)	**0.005[1]**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver (mg/L)	**0.00005[1]**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium (mg/L)	**0.01[6]**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium (mg/L)	**0.1[6]**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc (mg/L)	**0.008[1]**	0.006	<0.005	<0.005	<0.005	0.027	<0.005	<0.005	<0.005	<0.005
Iron (mg/L)	**0.2[6]**	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.370	<0.05
Mercury (mg/L)	**0.0006[1]**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Ionic Balance										
Total Anions (mg/L)	-	16.4	14.8	10.4	10.6	15.7	4.73	4.2	4.72	5.53
Total Cations (mg/L)	-	13.9	13.5	8.54	9.89	14.3	4.62	3.88	4.45	5.1
Ionic Balance (%)	-	8.4	4.68	9.65	3.69	4.82	1.24	4.05	3.02	4.06
Total Petroleum Hydrocarbons										
C6 - C9 Fraction (µg/L))	-	<20	<20	<20	<20	<20	<20	<20	<20	<20
C10 - C14 Fraction (µg/L)	-	<50	<50	<50	<50	<50	<50	<50	<50	<50
C15 - C28 Fraction (µg/L)	-	<100	<100	<100	<100	<100	<100	<100	<100	<100
C29 - C36 Fraction (µg/L)	-	<50	<50	<50	<50	<50	<50	<50	<50	<50
C10 - C36 Fraction (sum) (µg/L)	-	<50	<50	<50	<50	<50	<50	<50	<50	<50
BTEXN										
Benzene (µg/L)	**950[1]**	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene (µg/L)	-	<2	<2	<2	<2	<2	<2	<2	<2	<2
Ethylbenzene (µg/L)	-	<2	<2	<2	<2	<2	<2	<2	<2	<2
meta- & para-Xylene (µg/L)	-	<2	<2	<2	<2	<2	<2	<2	<2	<2
ortho-Xylene (µg/L)	**350[1]**	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total Xylenes (µg/L)	-	<2	<2	<2	<2	<2	<2	<2	<2	<2
Sum of BTEX (µg/L)	-	<1	<1	<1	<1	<1	<1	<1	<1	<1
Naphthalene (µg/L)	**16[1]**	<5	<5	<5	<5	<5	<5	<5	<5	<5

*- Turbidity measured in the laboratory

Source: 1 – ANZECC; 2 – EPP (Water) 'Aquatic Ecosystem'; 3 – EPP (Water) 'Stock Water'; 4 – EPP (Water) 'Human Consumer'; 5 – EPP (Water) 'Primary Recreation'; 6 – EPP (Water) 'Irrigation'. 7 – the WQO for dissolved oxygen is based on a conversion from the % saturation to mg/L assuming temperature at 25oC and altitude of 300 mAHD. The dissolved oxygen WQO was a percentage of saturation is 85% to 110%. Red font = Data above or below trigger values. Note: Values that say '<0.0001' are described as 'undetectable' by the laboratory. Note: Turbidity reading XXX = >880 NTU

Table 9-26 Stream water quality including mean, median and 80th and 20th percentiles

Parameter	WQOs	Combined water quality Results				
		Sample number	Mean	Median	80th%	20th%
In-situ results						
Water Temperature (°C)	**16 – 34[5]**	14	24.30	23.90	28.70	20.00
Dissolved Oxygen (%S) Lower	**6.77 – 8.76[2]**	14	7.59	7.54	8.04	7.20
pH	**6.5 – 8.0[2]**	14	1,648.44	558.75	1,293.00	348.90
Conductivity- base flow (µS/cm)	**-**	14	5.46	5.56	6.22	3.01
Turbidity (NTU)	**50[2]**	14	146.16	14.25	116.00	4.00
Laboratory results						
Total Dissolved Solids (mg/L)	**600[4]**	14	1,356.00	523.50	1,660.00	290.00
Suspended Solids (mg/L)	**40[2]**	14	98.43	7.00	32.00	5.00
Total Alkalinity as $CaC0_3$ (mg/L)	**≥20[1]**	14	104.64	86.50	141.00	74.00
Sulphate (mg/L)	**250[4]**	14	54.93	16.50	40.00	12.00
Chloride (mg/L)	**-**	14	505.07	105.00	434.00	68.00
Ammonia N (mg/L)	**0.02**	14	0.05	0.03	0.06	0.01
Nitrite (mg/L)	**-**	14	0.01	0.01	0.01	0.01
Nitrate (mg/L)	**0.7[1]**	14	0.02	0.02	0.05	0.01
Total Nitrogen (mg/L)	**0.5[2]**	14	1.12	0.45	1.50	0.20
Total Phosphorus as P (mg/L)	**0.05[2]**	14	0.28	0.15	0.22	0.03
Reactive Phosphorus (mg/L)	**0.02[2]**	14	0.01	0.01	0.01	0.01
Fluoride (mg/L)	**1.0[2]**	14	0.193	0.200	0.300	0.100
Aluminium (mg/L)	**0.055[1]**	14	0.014	0.010	0.010	0.010
Arsenic (mg/L)	**0.024[1]**	14	0.002	0.001	0.002	0.001
Barium (mg/L)	**1.0[1]**	14	0.089	0.065	0.150	0.030
Cadmium (mg/L)	**0.0002[1]**	14	0.0001	0.0001	0.0001	0.0001
Chromium (mg/L)	**0.001[1]**	14	0.001	0.001	0.001	0.001
Cobalt (mg/L)	**1.0[3]**	14	0.001	0.001	0.001	0.001
Copper (mg/L)	**0.0014[1]**	14	0.003	0.001	0.002	0.001
Lead (mg/L)	**0.0034[1]**	14	0.001	0.001	0.001	0.001
Manganese (mg/L)	**1.9[1]**	14	0.159	0.128	0.366	0.035
Molybdenum (mg/L)	**0.010[6]**	14	0.001	0.001	0.001	0.001
Nickel (mg/L)	**0.011[1]**	14	0.001	0.001	0.002	0.001
Selenium (mg/L)	**0.005[1]**	14	0.010	0.010	0.010	0.010
Silver (mg/L)	**0.00005[1]**	14	0.001	0.001	0.001	0.001
Uranium (mg/L)	**0.01[6]**	14	0.001	0.001	0.001	0.001
Vanadium (mg/L)	**0.1[6]**	14	0.010	0.010	0.010	0.010
Zinc (mg/L)	**0.008[1]**	14	0.007	0.005	0.005	0.005
Iron (mg/L)	**0.2[6]**	14	0.056	0.050	0.070	0.050
Mercury (mg/L)	**0.0006[1]**	14	0.0001	0.0001	0.0001	0.0001

Source: 1 – ANZECC; 2 – EPP (Water) 'Aquatic Ecosystem'; 3 – EPP (Water) 'Stock Water'; 4 – EPP (Water) 'Human Consumer'; 5 – EPP (Water) 'Primary Recreation'; 6 – EPP (Water) 'Irrigation'. 7 – the WQO for dissolved oxygen is based on a conversion from the % saturation to mg/L assuming temperature at 25oC and altitude of 300 mAHD. The dissolved oxygen WQO was a percentage of saturation is 85% to 110%.

9.5.5 Proposed Contaminant Trigger Levels and Release Criteria

To protect from environmental harm, release contaminant triggers and investigation levels have been established based on a range of default or model criteria including;

- Model water conditions for coal mines in the Fitzroy basin (version 3) (EHP 2013); and
- Environmental Protection (Water) Policy 2009 - Styx River, Shoalwater Creek and Water Park Creek Basins Environmental Values and Water Quality Objectives (2014a).

The potential contaminants and release trigger investigation levels are presented in Table 9-27. These trigger values may be revised in the future based on further assessment of site specific data, with the quality characteristic either disregarded if below trigger levels, or included as priority contaminants if above trigger levels. For metals and metalloids, trigger levels apply if dissolved results exceed trigger levels. However, total (unfiltered) results for metals and metalloids can be used to disregard a parameter.

Table 9-27 Release contaminant trigger investigation levels, potential contaminants

Quality Characteristic[3]	Trigger level (µg/L)	Basis	Comment on trigger level
Aluminium	55	Model Conditions[1]	For aquatic ecosystem protection, based on SMD guideline
Arsenic	13	Model Conditions[1]	For aquatic ecosystem protection, based on SMD guideline
Cadmium	0.2	Model Conditions[1]	For aquatic ecosystem protection, based on SMD guideline
Chromium	1	Model Conditions[1]	For aquatic ecosystem protection, based on SMD guideline
Copper	2	Model Conditions[1]	For aquatic ecosystem protection, based on LOR for ICPMS
Iron	300	Model Conditions[1]	For aquatic ecosystem protection, based on low reliability guideline
Lead	4	Model Conditions[1]	For aquatic ecosystem protection, based on SMD guideline
Mercury	0.2	Model Conditions[1]	For aquatic ecosystem protection, based on LOR for CV FIMS
Nickel	11	Model Conditions[1]	For aquatic ecosystem protection, based on SMD guideline
Zinc	8	Model Conditions[1]	For aquatic ecosystem protection, based on SMD guideline
Boron	370	Model Conditions[1]	For aquatic ecosystem protection, based on SMD guideline
Cobalt	90	Model Conditions[1]	For aquatic ecosystem protection, based on low reliability guideline
Manganese	1,900	Model Conditions[1]	For aquatic ecosystem protection, based on SMD guideline
Molybdenum	34	Model Conditions[1]	For aquatic ecosystem protection, based on low reliability guideline
Selenium	10	Model Conditions[1]	For aquatic ecosystem protection, based on LOR for ICPMS
Silver	1	Model Conditions[1]	For aquatic ecosystem protection, based on LOR for ICPMS
Uranium	1	Model Conditions[1]	For aquatic ecosystem protection, based on LOR for ICPMS
Vanadium	10	Model Conditions[1]	For aquatic ecosystem protection, based on LOR for ICPMS
Ammonia	900	Model Conditions[1]	For aquatic ecosystem protection, based on SMD guideline
Nitrate	1,100	Model Conditions[1]	For aquatic ecosystem protection, based on ambient Qld WQ Guidelines (2006) for TN
Petroleum hydrocarbons (C6-C9)	20	Model Conditions[1]	-

Quality Characteristic[3]	Trigger level (µg/L)	Basis	Comment on trigger level
Petroleum hydrocarbons (C10-C36)	100	Model Conditions[1]	-
Fluoride (total)	2,000	Model Conditions[1]	Protection of livestock and short-term irrigation guideline
Sodium (mg/L)	180	EPP Water[2]	Fitzroy Basin Association, drinking water guideline adopted

1 - Model water conditions for coal mines in the Fitzroy basin (version 3) (EHP 2013).
2 - Environmental Protection (Water) Policy 2009 - Styx River, Shoalwater Creek and Water Park Creek Basins Environmental Values and Water Quality Objectives (2014a).
3 - The quality characteristics required to be monitored as per Table 9-12 - Release contaminant trigger investigation levels, potential contaminants will be reviewed once the results of two years monitoring data is available, or if sufficient data is available to adequately demonstrate negligible environmental risk. It may be determined that a reduced monitoring frequency is appropriate or that certain quality characteristics can be removed from the monitoring program.
4 - SMD is slightly moderately disturbed level of protection, guideline refers ANZECC and ARMCANZ (2000).
5. - LOR is typical reporting for method stated. ICPMS/CV FIMS – analytical method required to achieve LOR.

Mine affected water release points represent a potential source of water contaminated by mining activity. This does not include release points for runoff contaminated only by sediment where they are associated with erosion and sediment control structures installed in accordance with the standards and requirements of an Erosion and Sediment Control Plan.

The proposed release limits for pH and Turbidity are presented at Table 9-28. As part of the release strategy for the pit dewater dam it was determined that there is insufficient data to propose end-of-pipe release limits for electrical conductivity (EC). The end of pipe discharges and target in-stream dilution values for EC will be determined post establishment of site specific WQOs.

Table 9-28 Proposed mine affected water release limits

Parameter	Flow level[1]	Proposed criteria	Monitoring Frequency	Comment on criteria level
pH	Low Medium High Very High Flood Extreme Flood	6.5 (minimum) – 9.0 (maximum)	Daily during release (the first sample must be taken within two hours of commencement of release)	ANZECC guidelines – Protection of aquatic ecosystem environmental values.
Turbidity (NTU)	Low Medium High Very High Flood Extreme Flood	50	Daily during release (the first sample must be taken within two hours of commencement of release)	Due to the very ephemeral nature of the area, limited turbidity data is available and as such the proposed criteria will need to be determined once additional data from the proposed ongoing monitoring program becomes available.

9.6 Flooding and Stormwater Drainage Assessment

This section details the flood assessment conducted for Tooloombah Creek, Deep Creek and the Styx River with the aim of:

- Demonstrating the flood immunity of critical mine infrastructure and haul roads; and
- Assessing impacts on flood behaviour due to mine construction.

Also documented in this section is the conceptualisation and hydraulic performance of the stormwater management system, including diversion drains, culverts, floodways and sediment basins.

The hydrologic and hydraulic modelling has been conducted in terms of Annual Exceedance Probability (AEP) as is recommended by industry with the recent implementation of Australia Runoff and Rainfall 2016 (Ball et al. 2016). The change in terminology comes from a common misinterpretation of Average Recurrence Interval (ARI) terminology, in which it is erroneously assumed that a 1 in 10 year ARI, for example, will only occur exactly once in every ten years.

The AEP better handles this by describing the probability of a magnitude flood event being exceeded in any given year as a percentage probability. However, there are some guidelines and analyses that have not adopted the AEP definition, which ultimately means that the design standard for environmental dams, diversion drains and culverts are still established in terms of Annual Recurrence Interval (ARI). The relationship between AEP and ARI is as follows: 9.5% AEP (10 year ARI), 4.9% AEP (20 year ARI), 2% AEP (50 year ARI), 1% AEP (100 year ARI) and 0.1% AEP (1,000 year ARI).

9.6.1 Hydrologic Assessment

The aim of the hydrologic assessment detailed herein is to produce flood hydrographs for input to hydraulic model simulations that predict flood characteristics such as inundation depth, flood extent, and flow velocities.

9.6.1.1 Baseline Model Build

A rainfall-runoff model was constructed using XP-RAFTS, which is a general non-linear rainfall/runoff and streamflow routing program, used to estimate peak flows, flood hydrographs and other channel inputs using actual storm events or design rainfall data. The program calculates flood discharges over time (hydrographs) by simulating rainfall over a catchment also with time, removing losses to calculate the rainfall excess runoff, and routing this runoff through the catchment model.

The sub-catchment delineation and river reach network is shown in Figure 9-6. The temporal distribution of rainfall was defined using the North Coast East zone, Australian Rainfall and Runoff (AR&R16) areal patterns for durations above 12 hours, while point temporal patterns were applied for durations below 12 hours.

To simulate the variability of storm events, ten temporal patterns, referred to as “an ensemble” were tested for each storm duration. Point temporal patterns were based on the frequency of the AEP event, whilst areal patterns were based on catchment area. Design rainfall intensities were determined from the BoM website using the 2016 Intensity-Frequency-Duration (IFD) chart. Point rainfall intensities at the site, for selected storm durations are shown in Table 9-29.

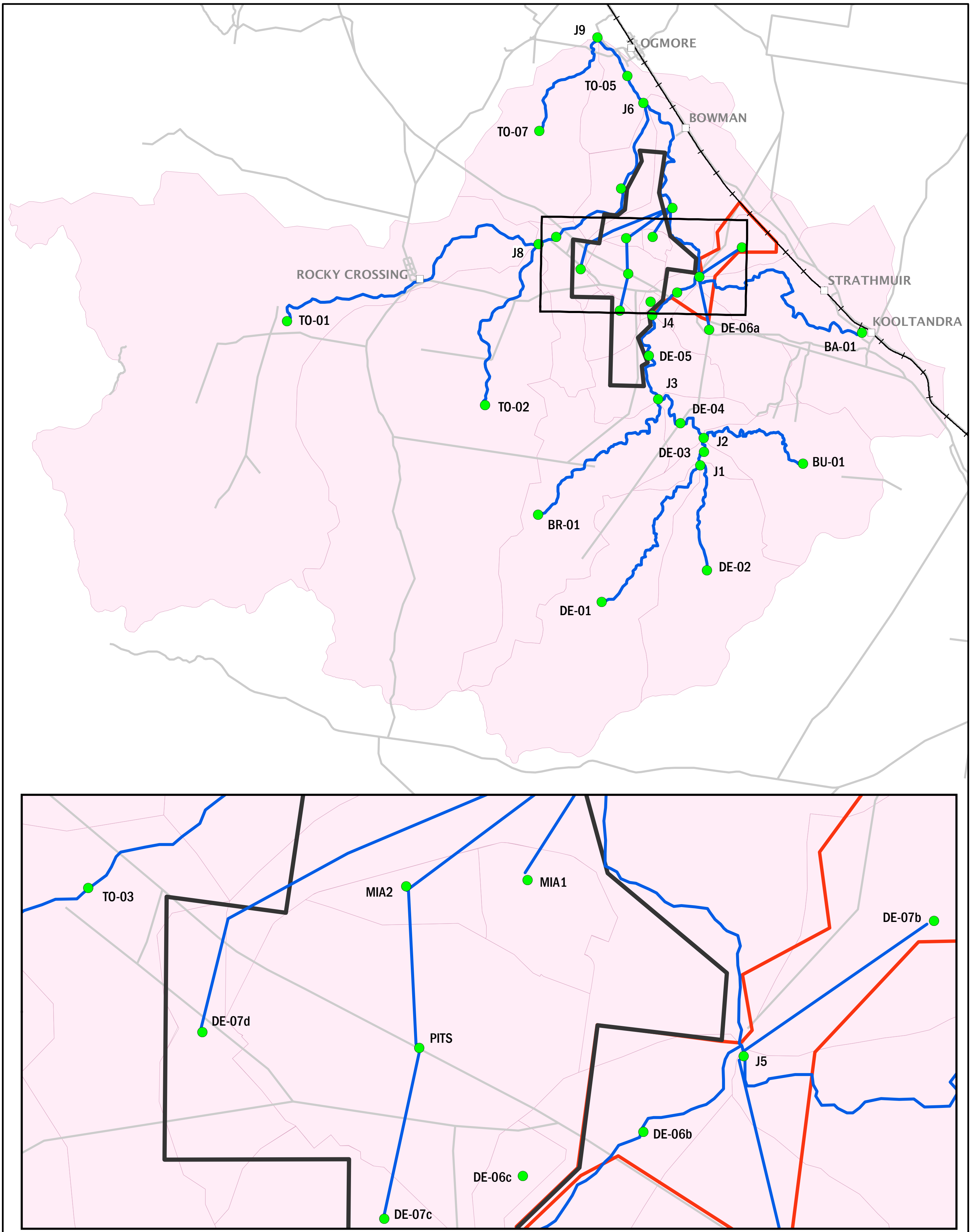
Table 9-29 Design point rainfall intensities (mm/hr)

Event Duration (hr)	9.5% AEP (10 Yr ARI)	4.9% AEP (20 Yr ARI)	2% AEP (50 Yr ARI)	1% AEP (100 Yr ARI)	0.1% AEP (1,000 Yr ARI)
9	15.81	18.37	22.26	25.40	-
12	13.34	15.62	19.13	22.00	-
18	10.24	12.12	15.07	17.53	-
24	8.69	10.37	13.04	15.29	24.08
36	6.64	8.02	10.21	12.07	20.19

Initial simulations were run for standard AEP events (1:10, 4.9%, 2%, 1% and 0.1%) and durations (9 hours to 36 hour). For each of these cases, the ensemble of ten temporal pattern was interrogated, with the median case peak flow value, as calculated at the MLA boundary (see Figure 9-6) presented in Table 9-30.

Table 9-30 Peak flow (median temporal pattern) at MLA boundary (J6) (m^3/s)

Event Duration (hr)	9.5% AEP (10 Yr ARI)	4.9% AEP (20 Yr ARI)	2% AEP (50 Yr ARI)	1% AEP (100 Yr ARI)	0.1% AEP (1,000 Yr ARI)
9	1,130	1,432	1,862	2,269	-
12	1,279	1,636	2,198	2,698	-
18	1,393	1,804	2,448	3,045	-
24	1,423	1,838	2,472	3,055	5,368
36	1,383	1,767	2,380	2,896	5,316



N

0 2 4 km

Scale @ A4 1:210,000
Date: 17/07/17
Drawn: Daniela S.

Legend

- Nodes
- Reaches
- XP-RAFTS Catchments
- ML 80187
- ML 700022
- North Coast Rail Line
- Main road

Figure 9-6
XP-RAFTS catchment delineation – Base Case

CDM Smith

9.6.1.2 Model Verification

In the absence of historical gauged data against which to calibrate, a comparison between XP-RAFTS median peak flows and the Regional Flood Frequency Estimation method for peak flows was carried out to test whether the two methods produced results that were reasonably consistent with each other. This comparison is presented in Figure 9-7.

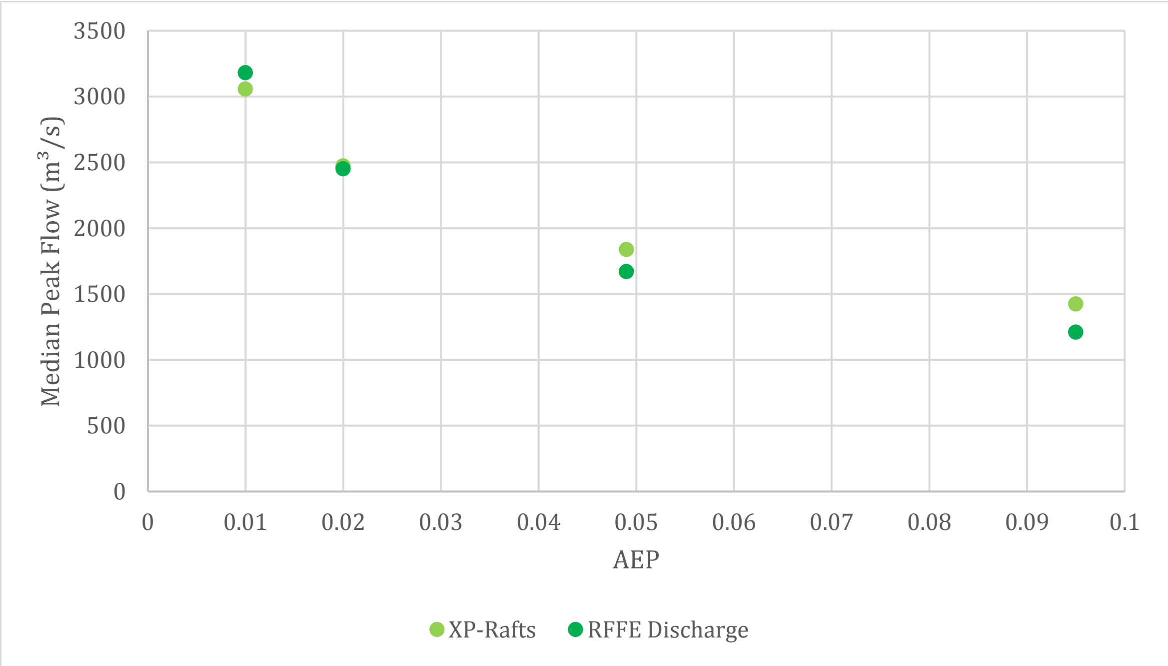


Figure 9-7 Comparison of peak flows of XP-RAFTS and RFFE

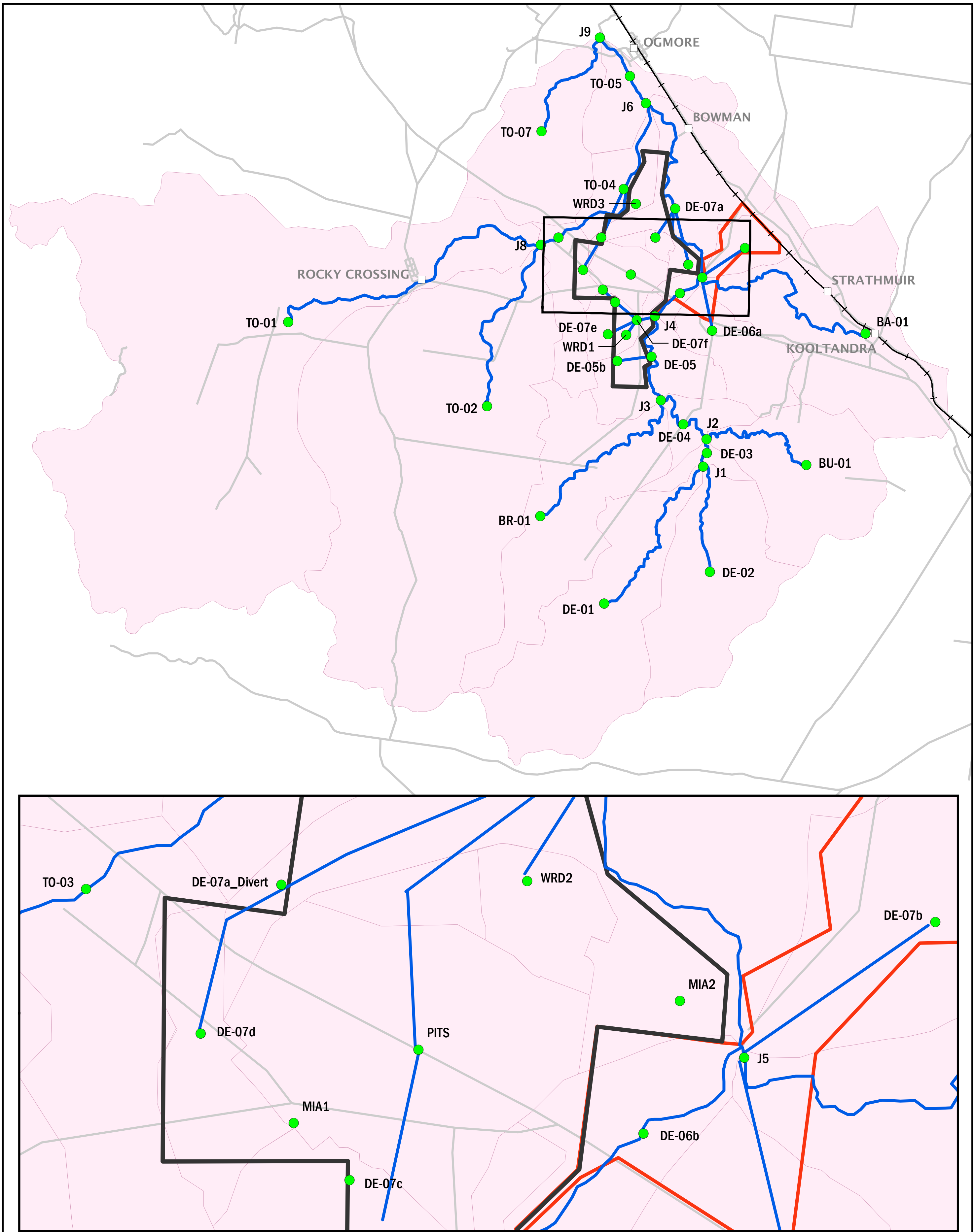
It can be seen from Figure 9-7 that results from the two methods are closely correlated, particularly for the smaller AEP events. This correlation provides some confidence that the XP-RAFTS modelling is generally representative of the expected hydrological processes occurring in the catchment.

9.6.1.3 Developed Case Model Build

The developed case model build involved applying the same temporal patterns and design rainfall intensities as the existing case model. Key changes in the developed case model compared to the existing case model include:

- Removing the open pit mine areas from the contributing catchments;
- Applying a higher impervious value to the MIA to stimulate the likely increases in the catchment response time caused by topographic changes;
- Diverting the two catchments upstream of the south open pit around the mine;
- Diverting the catchment upstream of Waste Area 1 around and into Deep Creek;
- Diverting the catchment to the south west of the south open pit around Open Cut 4 and into Tooloombah Creek, and
- Applying a lower impervious value to the waste area to stimulate the likely decrease in the catchment response time caused by topographic changes.

The updated sub-catchment delineation is shown in Figure 9-8 .



Legend

- Nodes - Developed
- Reaches - Developed
- XP-RAFTS Catchments
- ML 80187
- ML 700022
- North Coast Rail Line
- Main road

Scale @ A4 1:210,000
Date: 17/07/17
Drawn: Daniela S.

Figure 9-8
XP-RAFTS catchment delineation – Developed Case

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-5 R2 Styx Coal Project_Dev - XP-Rafts_A.mxd 7/17/2017

9.6.1.4 Baseline Case Results

The base case critical duration storm event peak flows, produced at the confluence of Tooloombah Creek and Deep Creek, and for the 1:10, 4.9%, 2%, 1% and 0.1% AEP events, are presented in Table 9-31.

Table 9-31 Peak flows at the Project area boundary (J6) – existing case

Item	9.5% AEP (10 Yr ARI)	4.9% AEP (20 Yr ARI)	2% AEP (50 Yr ARI)	1% AEP (100 Yr ARI)	0.1% AEP (1,000 Yr ARI)
Median Peak Flows (m^3/s) – Existing Case	1,423	1,838	2,472	3,055	5,368
Duration (hr)	24	24	24	24	24

The corresponding runoff hydrographs are shown in Figure 9-9. The temporal rainfall pattern that generated the median peak flow for the 9.5%, 4.9%, 2%, 1% and 0.1% AEP events has a symmetrical rainfall pattern as evident by the curve shape. Time to peak was in the order of 22 hours.

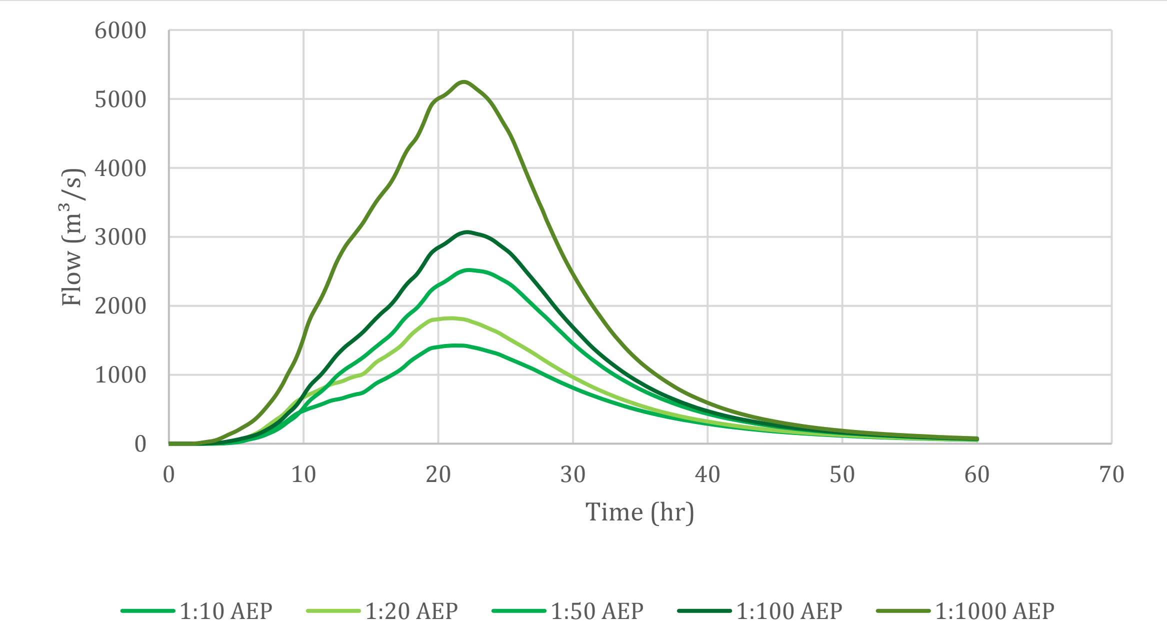


Figure 9-9 Critical storm duration hydrographs – existing case

9.6.1.5 Developed Case Results

The developed case hydrologic model assumes that the mine is operating at its ultimate configuration; that is, intermediate development cases, or staging, were not considered in this analysis. Thus, the developed case assumed that both the north and south pits were fully mined and no longer contributing catchments within the hydrologic model.

Critical duration peak flows from this model, produced at the confluence of Tooloombah Creek and Deep Creek, are presented in Table 9-32.

Table 9-32 Peak flows at the Project area boundary (J6) – developed case

Item	9.5% AEP (10 Yr ARI)	4.9% AEP (20 Yr ARI)	2% AEP (50 Yr ARI)	1% AEP (100 Yr ARI)	0.1% AEP (1,000 Yr ARI)
Median Peak Flows (m^3/s) – Existing Case	1,408	1,801	2,431	3,045	5,136
Duration (hr)	24	24	24	24	24

Both the existing case and the developed case have the same critical storm duration of 24 hrs. The developed case peak flows are lower than existing case peak flows by approximately 1-4% due to the reduction in contributing catchment caused by creating open pit voids – a negligible reduction in the context of the broader catchment.

Developed case runoff hydrographs are presented in Figure 9-10. In general, the time to peak runoff was observed to quicken slightly with respect to the existing model. The developed peak median hydrographs demonstrate a small two peak graph, with a faster initial response before a second main peak.

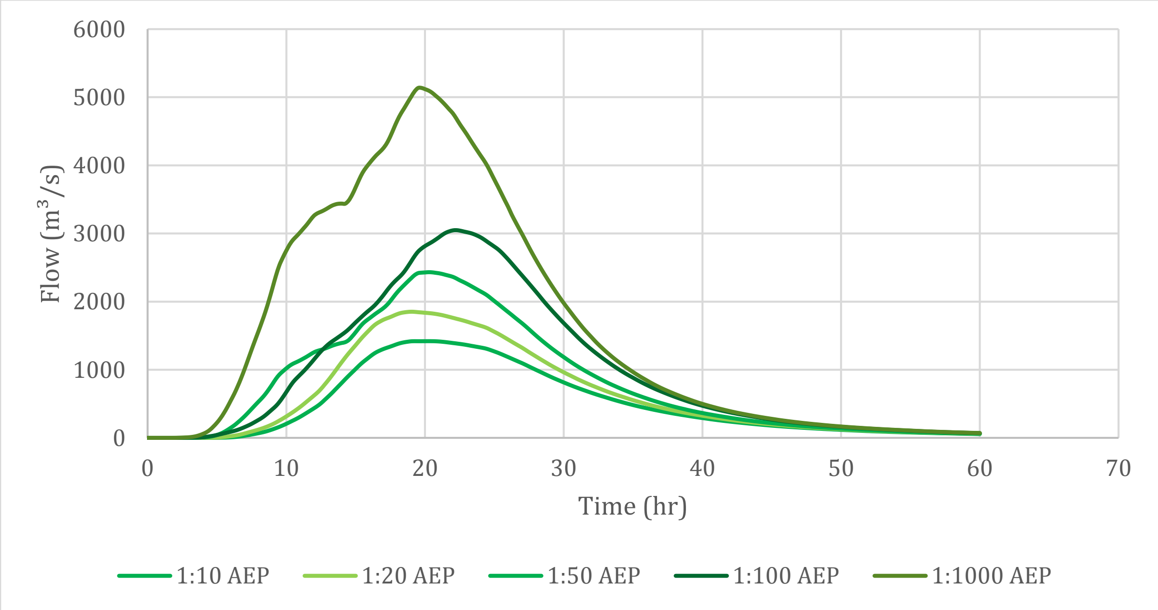


Figure 9-10 Critical storm duration – developed case

It needs to be noted that as the peak flows from hydrologic model are the median of an ensemble of 10 temporal rainfall patterns, the storm hydrograph that corresponds to the existing peak case median flow may not be the same storm pattern that corresponds to the peak developed case median flow.

The biggest impact with regards to flowrate magnitude is at the Deep Creek Bridge location (refer J4) where several catchments are diverted into Deep Creek compared to the existing case. These diversions are unlikely to impact the hydraulic performance of the bridge structure as the peak of the diverted flow is calculated to arrive prior to the main flood peak. This occurs due to the small size of the diverted catchments in comparison to the relatively large catchment upstream of the bridge.

9.6.2 Hydraulic Assessment

The aim of the hydraulic assessment is to characterise the Project's impact on localised flood characteristics such as flood depth, extent and velocity, as well as to quantify the immunity of critical infrastructure and the mine pits. Hydrodynamic modelling was used to create thematic maps showing flood extents, water depths and velocities, through input of the flood hydrographs developed by the hydrologic assessment (see Section 9.6.1).

9.6.2.1 Baseline Case Model Build

Hydraulic modelling was conducted using the MIKE21 software package. The program models free surface flows based on two-dimensional implementation of the St. Venant equations for both sub-critical and super-critical flows.

Hydrographs produced by the XP-RAFTS model (see Section 9.6.1.4) were adopted as inputs to hydraulic model simulations.

Light Detection and Ranging (LiDAR) survey data captured by Vekta on behalf of Yeats Consulting Engineers (date flown 17/06/2011) formed the topographic basis for the flood model.

The 1m-resolution LiDAR dataset was down-sampled to a 10m grid. This grid size ensured numerical stability, provided appropriate definition of the major topographic features (e.g. river channel definition, and resulted in manageable simulation times. Both Tooloombah Creek and Deep Creek were modelled in a single 2D grid. Model dimensions are listed in Table 9-33.

Table 9-33 MIKE21 model dimensions

Item	Description
Grid Cell Size	10 m
Grid Orientation/Rotation	North up (i.e. zero degrees rotation)
Model extent (width x height)	1100 cells x 1520 cells
Model extent (km x km)	11 km x 15.2 km
Model Origin (Lower Left Corner)	769005 m East; 7481505 m North
Map Projection	MGA, Zone 55

The downstream model boundary sits inside the tidally-influenced reach of the Styx River; however, the available tidal plane data were limited, and unable to be reduced to the Australian Height Datum. For this reason, a normal-depth rating curve was developed from the LiDAR and applied at the downstream boundary.

The rating curve sensitivity to changes in parameter values was assessed to determine the accuracy of the rating curve. The LiDAR derived channel section and slope were derived from LiDAR with average data accuracies of ±0.08 m. The cross-section and slope were therefore not included in the sensitivity analysis. The manning's n value required judgement of the channel conditions and interpretation of literature and were therefore included in the sensitivity analysis. The Manning's 'n' values was altered by ±0.005 to represent the range of values that could reasonably be applied for the channel conditions encountered. The channel roughness sensitivity analysis results for Boundary 1 shows small impact on the results with a maximum water depth difference of approximately 0.25 m relative to the adopted curve for in-channel flows. For Boundary 2 in-channel flows, the water depth difference is within 0.1 m of the adopted curve.

The existing Bruce Highway culverts and bridge infrastructure were modelled in the baseline MIKE21 model (see flooding figures - Figure 9-11 to Figure 9-40). Limited information is available regarding culvert and bridge geometry; as such, Google Earth, Google Streetview and LiDAR elevation values were used to approximate the size of infrastructure. The Deep Creek Bridge was modelled using a pier resistance routine, which allows for the turbulent losses induced by the bridge piers to be modelled at a sub grid scale level. The culvert was represented in the 2D model by lowering the topography to allow water to pass through the embankment. Head losses through the structure were simulated by implementing a locally higher zone of Manning's roughness.

A spatially-distributed roughness map was developed to reflect the variance in resistance to surface flow based on topographic features and vegetation. Land use areas were identified from the high-resolution aerial imagery and ground-truthed during field investigations. The Manning's n values chosen for the model are consistent with literature by Chow 1959, and are summarised in Table 9-34.

Table 9-34 Adopted existing Manning's n roughness values

Land Use	Value
Pasture	0.035
Channel	0.03
Light Brush	0.06
Heavy Brush	0.1

9.6.2.2 Baseline Case Results

The MIKE21 models were observed to be stable at a 1.5 second time step. Each model was run for a 32 hours of simulation time, which captured the bulk of the flood wave and peak water levels and velocities throughout the model domain. Results were processed to create maps showing depth and velocity maxima; these maps are shown in Figure 9-11 to Figure 9-22.

Tooloombah Creek is incised and was not predicted to break out of its banks under any of the modelled scenarios.

Deep Creek is less incised. When the bank-full capacity is reached, flow breaks out into defined anabranches before spreading into the broader floodplain. The modelling predicted that the bank-full capacity was in the order of the 2% AEP event. For floods of larger magnitude, water breaks out over the floodplain at low depths and velocities. Breakout flow depths were predicted to be of the order of approximately 0.25 m for the 1% AEP event and approximately 0.75 m in the 0.1% AEP event.

The catchments upstream of proposed Open Cut 1 contribute to widespread flooding at low flow depths due to the site being generally flat and due to the existence of contour bunds which capture and store runoff under current conditions. Flooding across the south pit area has depths below 0.25 m and velocities below 0.25 m/s for all the events below the 1% AEP. Both types of flooding behaviour are commonly observed in small coastal creeks in Queensland.

Flood depth and velocity maps show that the proposed pit locations are at risk of flooding under base case conditions due to Open Cut 1 and Open Cut 2 both being located on existing natural drainage features. The presence of several culverts beneath the Bruce Highway between the boundary of Open Cut 1 and Open Cut 2, demonstrates the existence of a minor flow path through the Project site. These culverts were overtopped during events larger than the 9.5% AEP. Deep Creek bridge was overtopped during the 0.1% AEP event, causing widespread breakout flow to pass through the eastern portion of the Project area.

Flood depth and velocities in Deep Creek and Tooloombah Creek for the 9.5% AEP to 1% AEP can generally be summarised as:

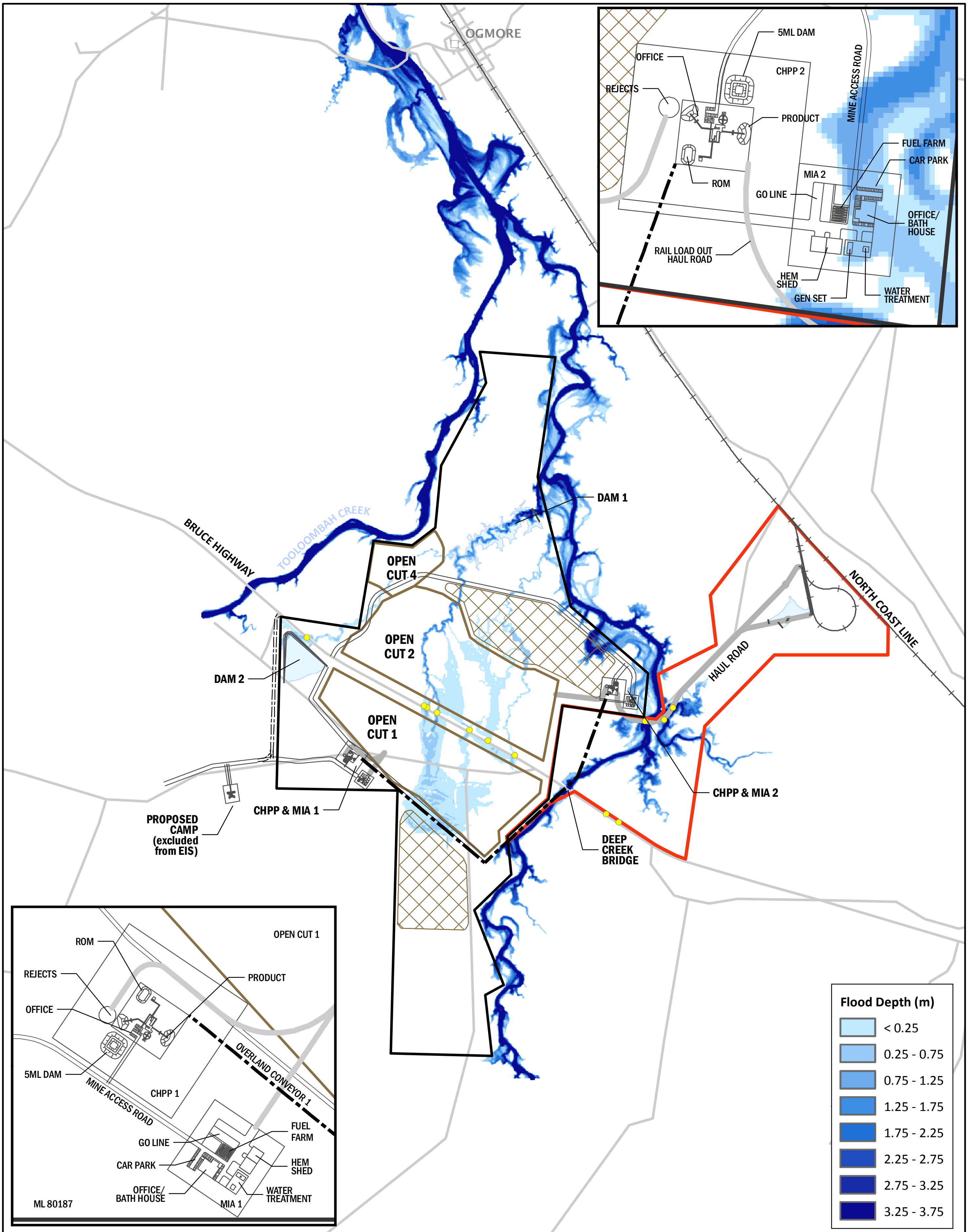
- Deep Creek:
  - In-channel flood depths between 6.5 m and 8.5 m;
  - In-channel flood velocities between 1.5 m/s and 2.0m/s.
- Tooloombah Creek:
  - In-channel flood depths between 6.6 m and 11.7 m;
  - In-channel flood velocities between 1.5 m/s and 2.6 m/s.

Flood depths and velocities in the minor tributary drainage features that traverse the site for the 9.5% -1% AEP events can generally be summarised as:

- 1st order minor tributary:
  - Flood depths between 0.15 m and 0.30 m;
  - Flood velocities between 0.3 m/s and 0.5 m/s.
- 2nd order minor tributary (main drainage feature in Project area):
  - Flood depths between 1.5 m and 2.4 m;
  - Flood velocities between 0.2 m/s and 0.6 m/s.

Flood depths and velocities in Deep Creek, Tooloombah Creek and the minor tributary drainage features that traverse the site for the 0.1% - Probable Maximum Flood (PMF) AEP events can generally be summarised as:

- Deep Creek:
  - In-channel flood depths between 9.0 m and 12.5 m;
  - In-channel flood velocities between 2.5 m/s and 3.5 m/s.
- Tooloombah Creek:
  - In-channel flood depths between 12 m and 14 m;
  - In-channel flood velocities between 3.0 m/s and 4.5m/s.
- 1st order minor tributary:
  - Flood depths between 0.35 m and 1.2 m;
  - Flood velocities between 0.5 m/s and 1.0 m/s.
- 2nd order minor tributary (main drainage feature in Project area):
  - Flood depths between 2.6 m and 3.0 m;
  - Flood velocities between 0.8 m/s and1.3 m/s.



N

0 1 2 km

Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

Legend

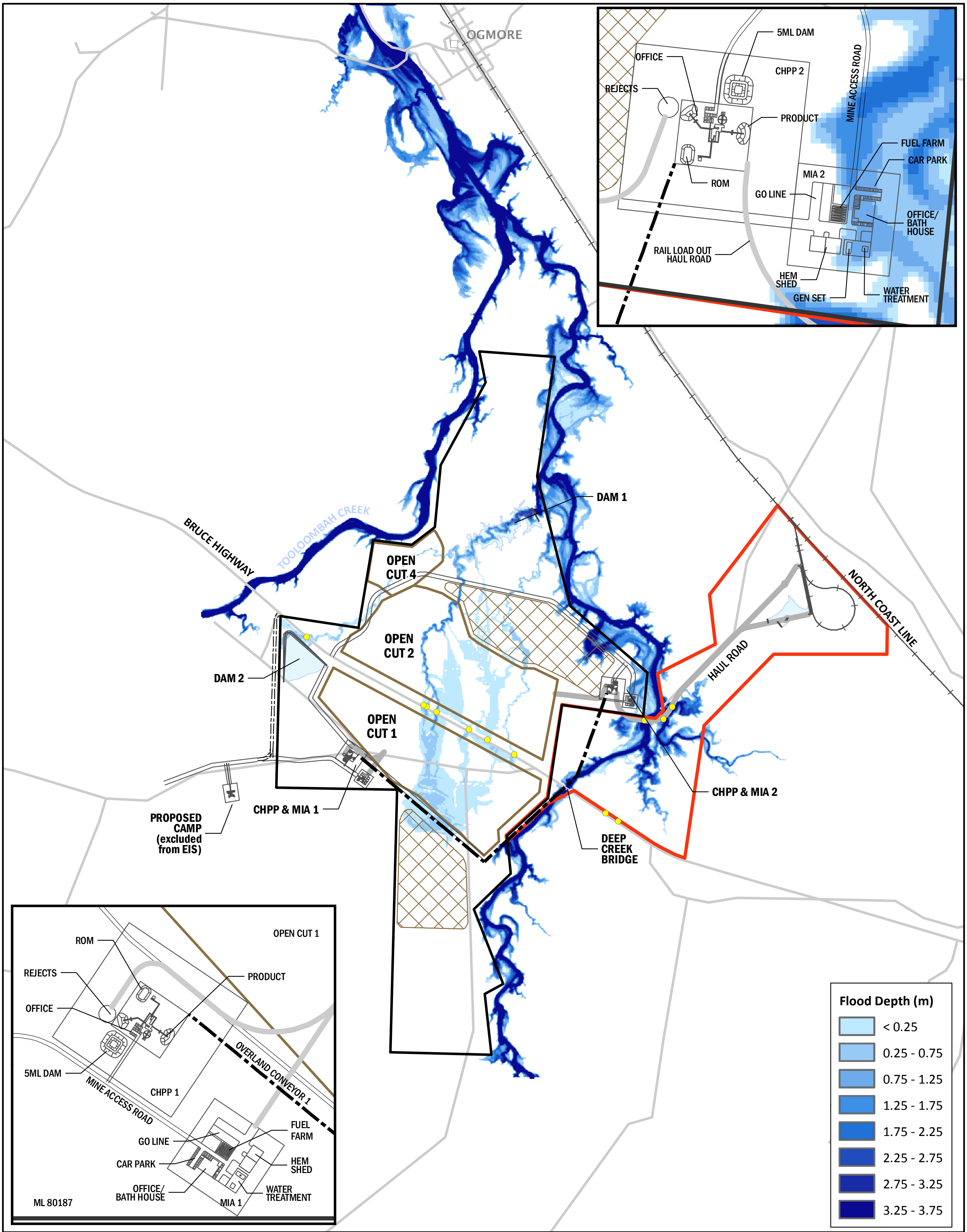
- Culverts
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Dam Catchment
- Waste Dump Area
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

Figure 9-11
9.5% AEP peak flood depth – existing scenario

DATA SOURCE
QLD Open Source Data, 2017

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-11 R2 Styx Coal Project_Ex - 9p5 AEP Flood_Depth_A.mxd 7/17/2017



N

0 1 2 km

Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

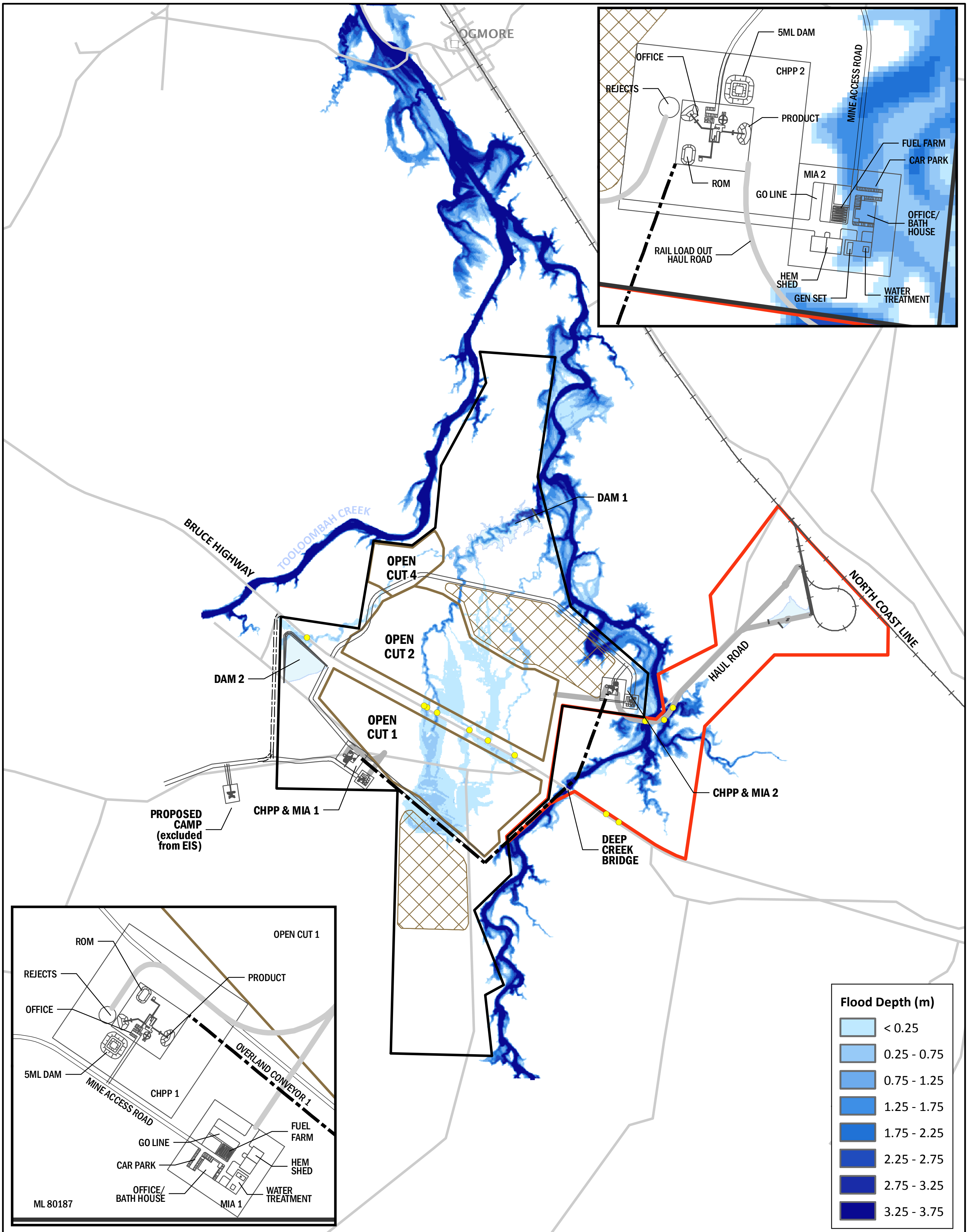
Legend

- Culverts
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Dam Catchment
- Waste Dump Area
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

DATA SOURCE
QLD Open Source Data, 2017

Figure 9-12
4.9% AEP peak flood depth – existing scenario

CDM Smith



N

0 1 2 km

Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

Legend

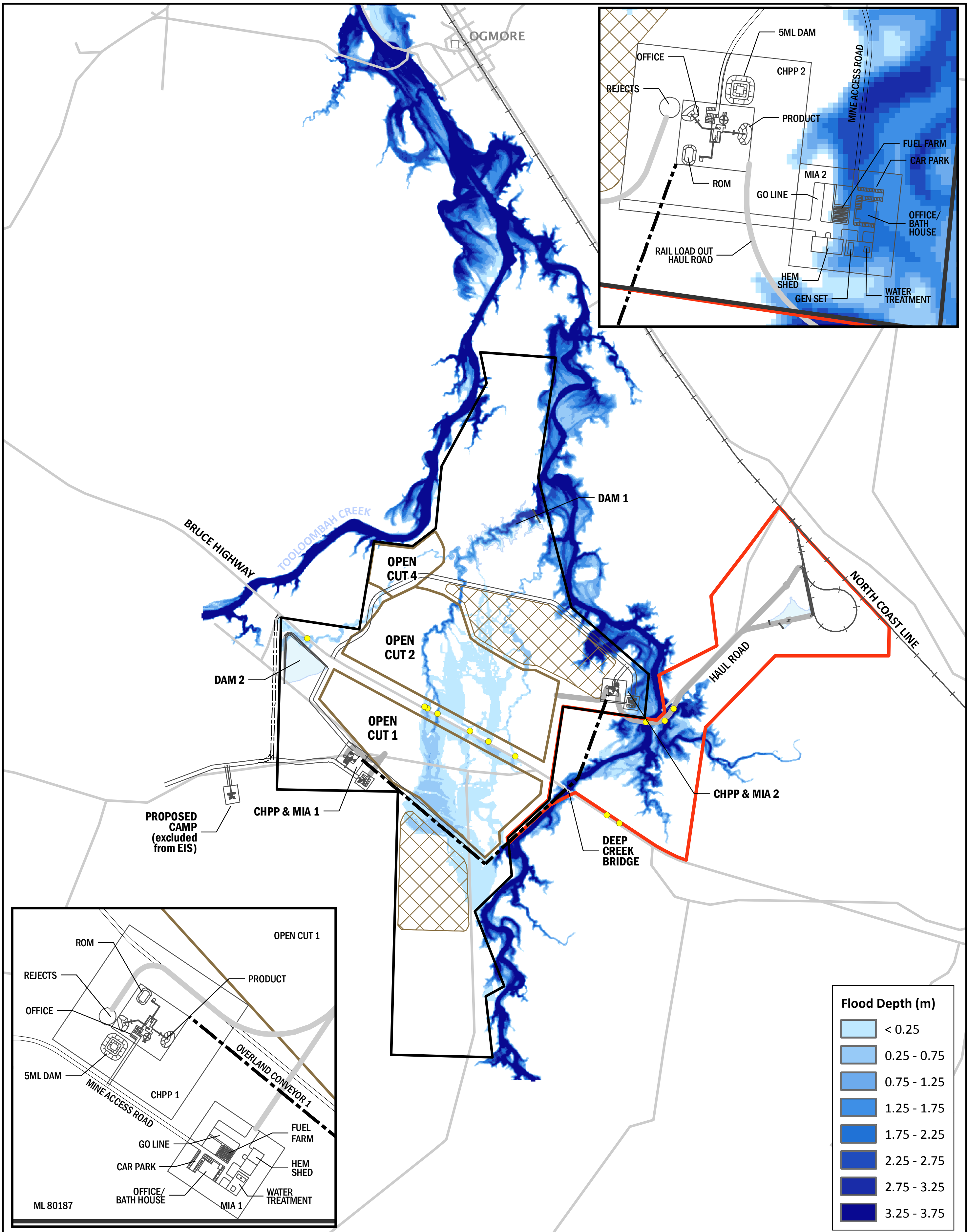
- Culverts
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Dam Catchment
- Waste Dump Area
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

Figure 9-13
2% AEP peak flood depth – existing scenario

DATA SOURCE
QLD Open Source Data, 2017

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-13 R2 Styx Coal Project_Ex - 2 AEP Flood_Depth_A.mxd 7/17/2017



Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

Legend

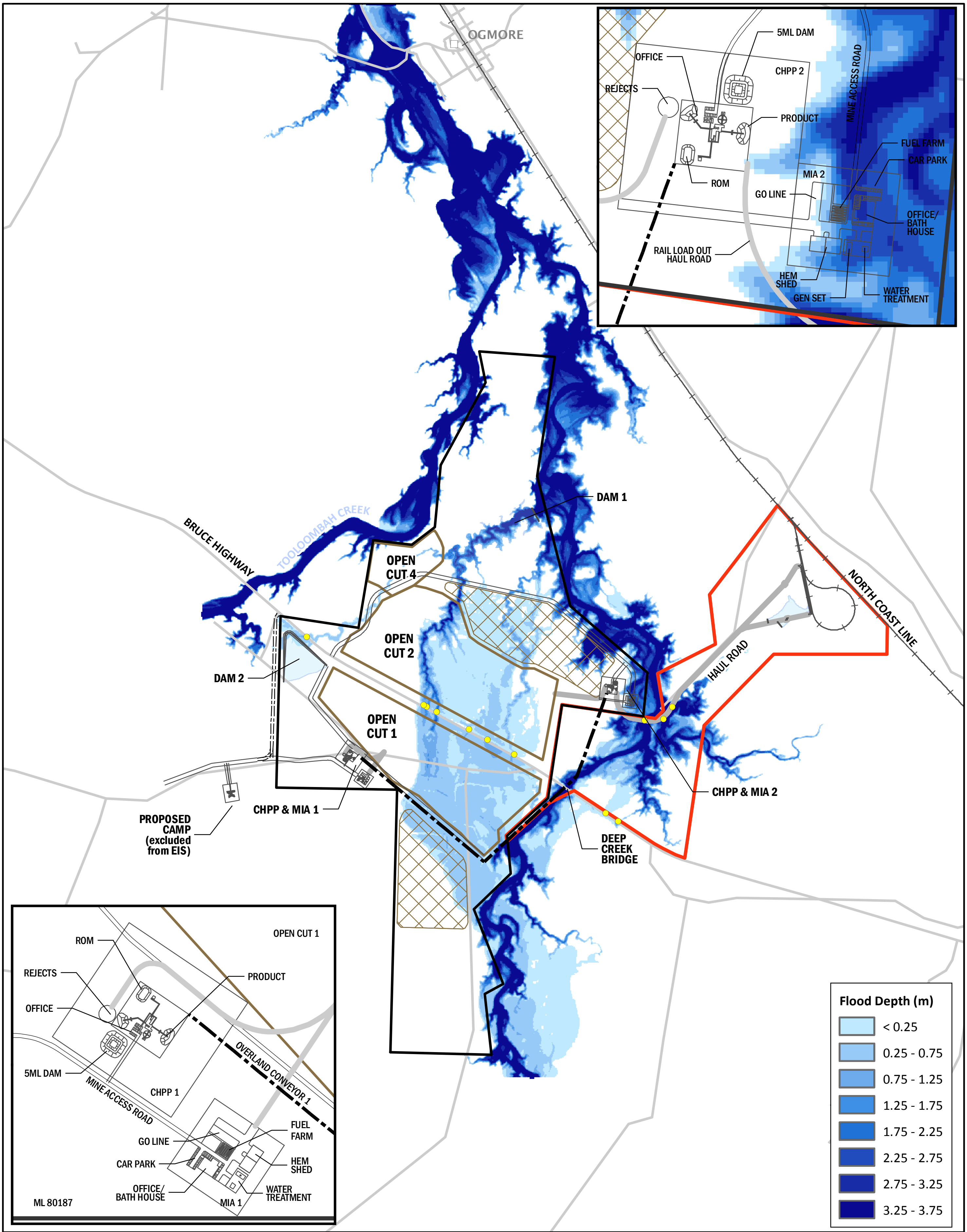
- Culverts
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Dam Catchment
- Waste Dump Area
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

DATA SOURCE
QLD Open Source Data, 2017

Figure 9-14
1% AEP peak flood depth – existing scenario

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-14 R2 Styx Coal Project_Ex - 1 AEP Flood_Depth_A.mxd 7/17/2017



N

0 1 2 km

Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

Legend

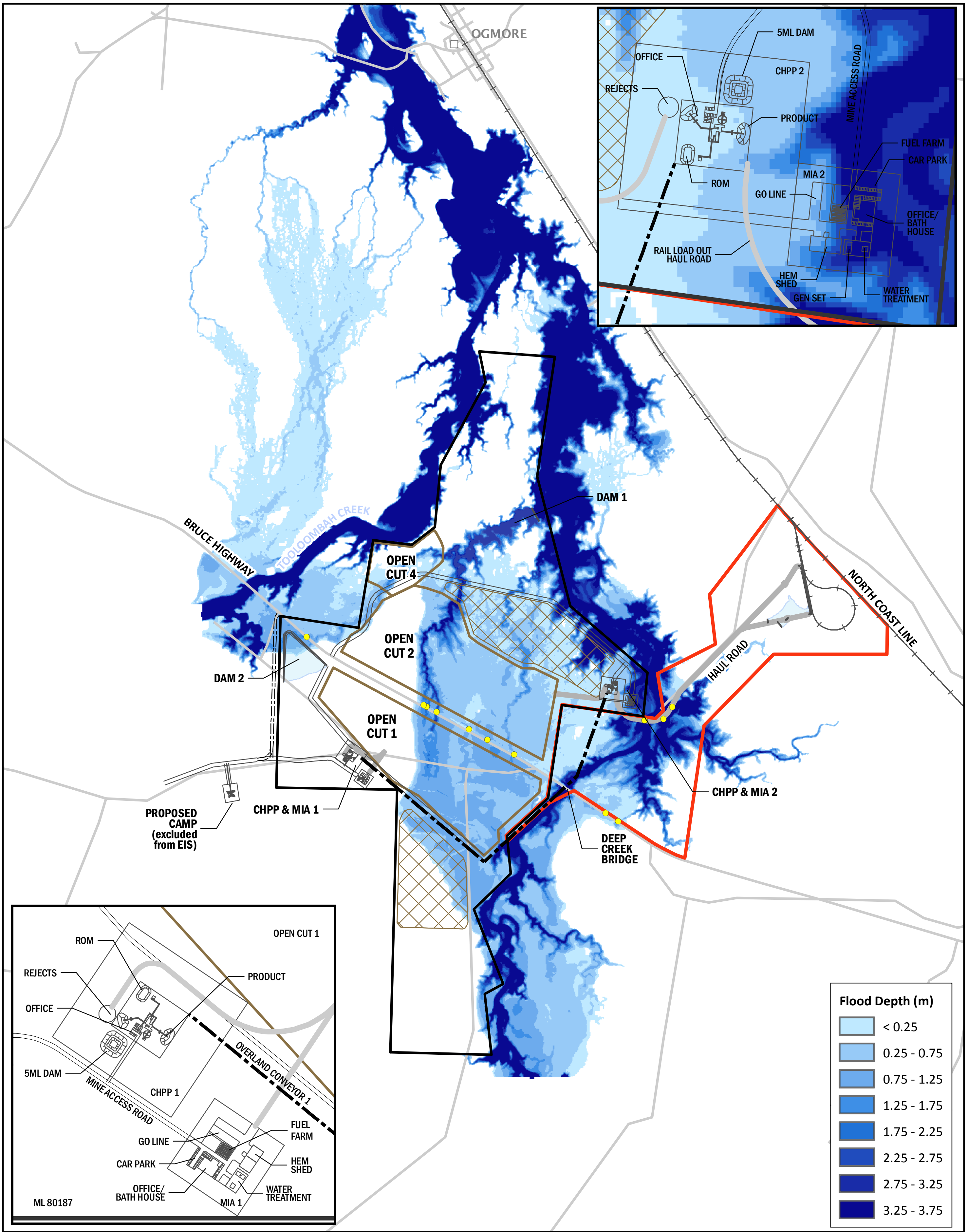
- Culverts
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Dam Catchment
- Waste Dump Area
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

DATA SOURCE
QLD Open Source Data, 2017

Figure 9-15
0.1% AEP peak flood depth – existing scenario

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-15 R2 Styx Coal Project_Ex - 0p1 AEP Flood_Depth_A.mxd 7/17/2017



N

0 1 2 km

Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

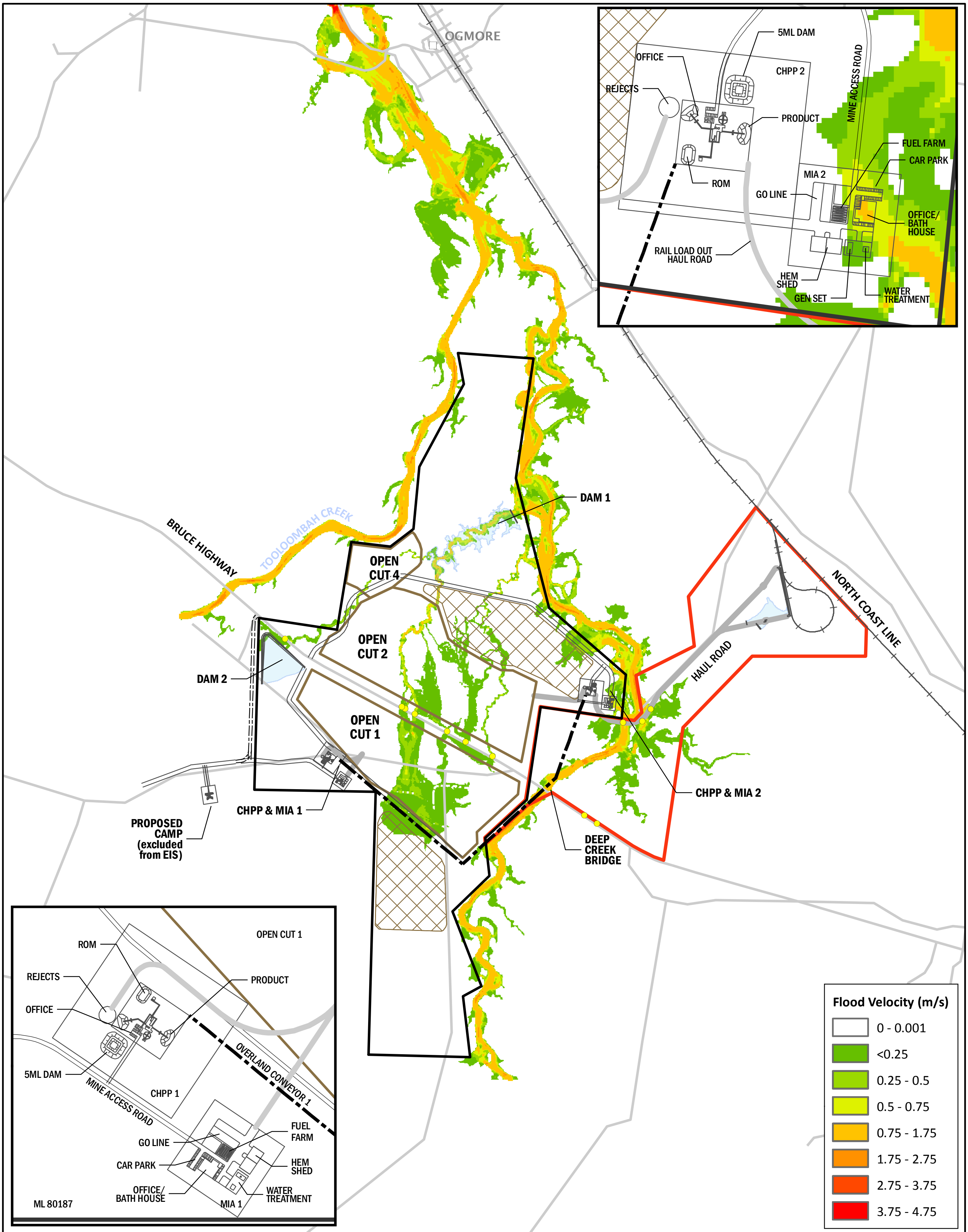
Legend

- Culverts
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Dam Catchment
- Waste Dump Area
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

DATA SOURCE
QLD Open Source Data, 2017

Figure 9-16
PMF peak flood depth – existing scenario

CDM Smith



0 1 2 km

Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

Legend

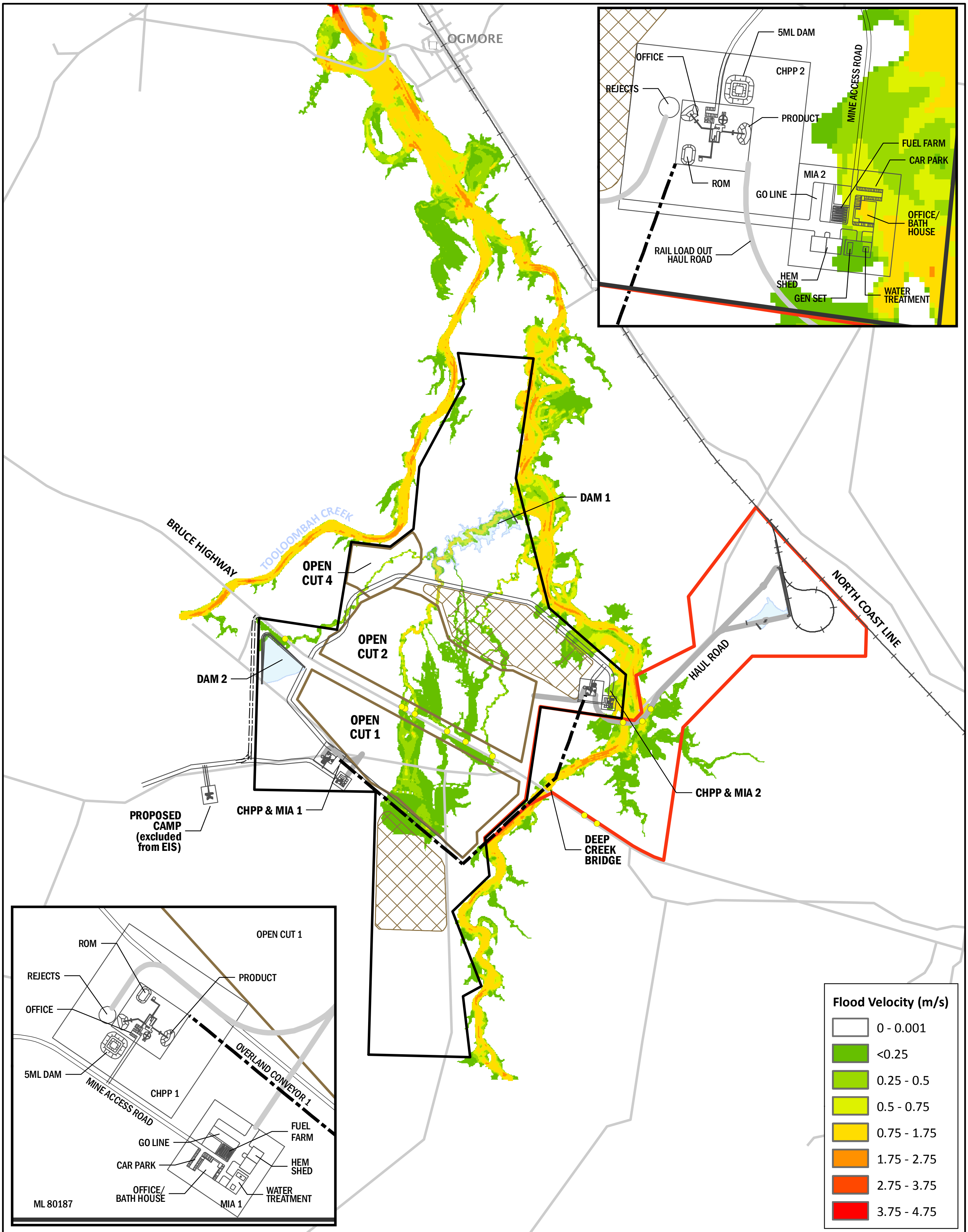
- Culverts
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Dam Catchment
- Waste Dump Area
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

DATA SOURCE
QLD Open Source Data, 2017

Figure 9-17
9.5% AEP peak flood velocity – existing scenario

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-17 R2 Styx Coal Project_Ex - 9p5 Flood_Velocity_A.mxd 7/17/2017



N

0 1 2 km

Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

Legend

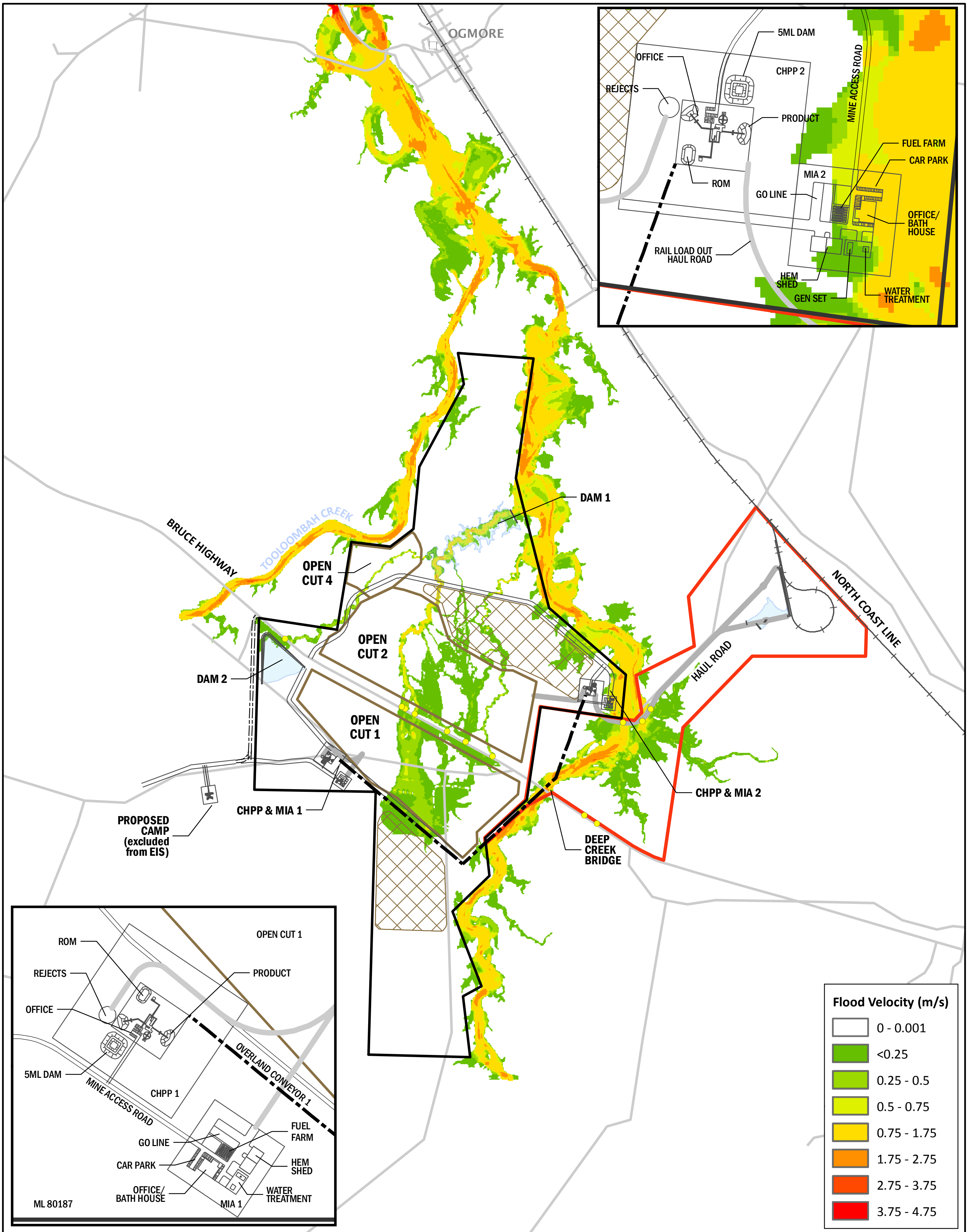
- Culverts
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Dam Catchment
- Waste Dump Area
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

Figure 9-18
4.9% AEP peak flood velocity – existing scenario

DATA SOURCE
QLD Open Source Data, 2017

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-18 R2 Styx Coal Project_Ex - 4p9 Flood_Velocity_A.mxd 7/17/2017



N

0 1 2 km

Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

Legend

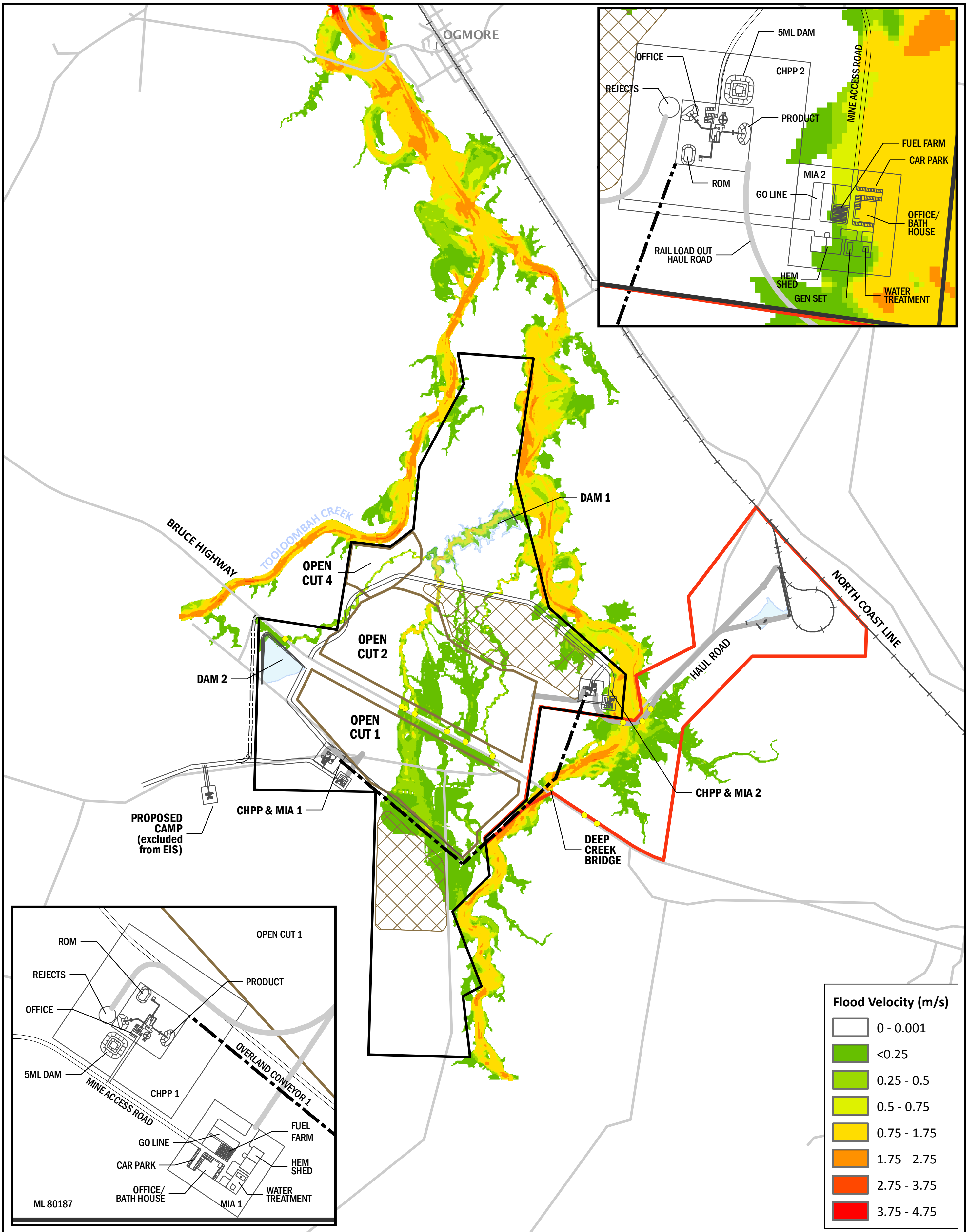
- Culverts
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Dam Catchment
- Waste Dump Area
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

Figure 9-19
2% AEP peak flood velocity – existing scenario

DATA SOURCE
QLD Open Source Data, 2017

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-19 R2 Styx Coal Project_Ex - 2 AEP Flood_Velocity_A.mxd 7/17/2017



N

0 1 2 km

Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

Legend

- Culverts
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Dam Catchment
- Waste Dump Area
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

DATA SOURCE
QLD Open Source Data, 2017

Figure 9-20
1% AEP peak flood velocity – existing scenario

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-20 R2 Styx Coal Project_Ex - 1 AEP Flood_Velocity_A.mxd 7/17/2017

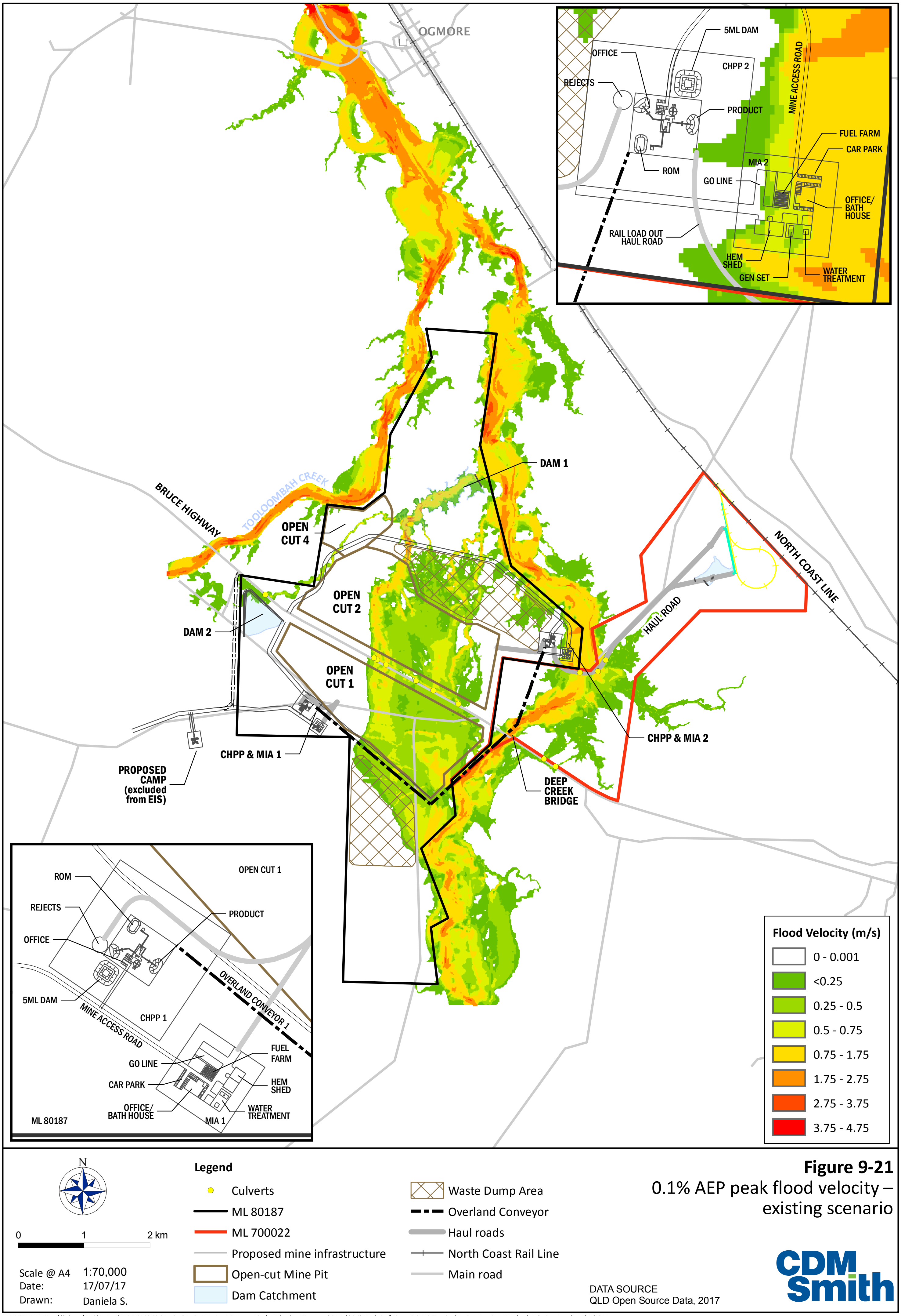
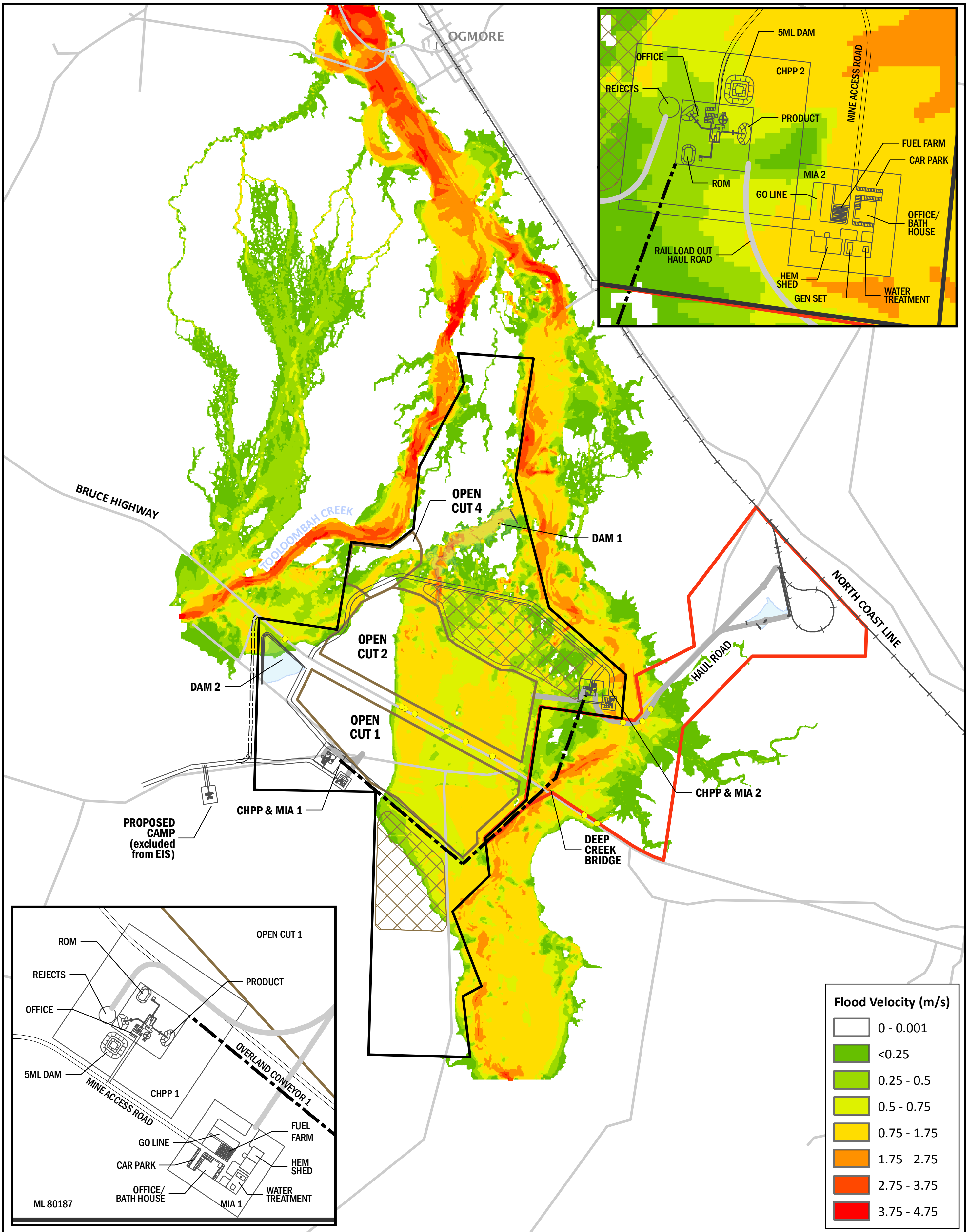


Figure 9-21
0.1% AEP peak flood velocity – existing scenario

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-21 R2 Styx Coal Project_Ex - 0p1 AEP Flood_Velocity_A.mxd 7/17/2017



N

0 1 2 km

Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

Legend

- Culverts
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Dam Catchment
- Waste Dump Area
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

DATA SOURCE
QLD Open Source Data, 2017

Figure 9-22
PMF peak flood velocity – existing scenario

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-22 R2 Styx Coal Project_Ex - PMF Flood_Velocity_A.mxd 7/17/2017

9.6.2.3 Developed Case Model Build

The developed case model was built by applying the hydrographs (see section 9.6.1.5) from the developed case hydrologic model and by making changes to the topographic grid to reflect the final expected land form. Key changes (see flooding figures Figure 9-23 to Figure 9-33) in the developed case model topography, compared to the existing case included:

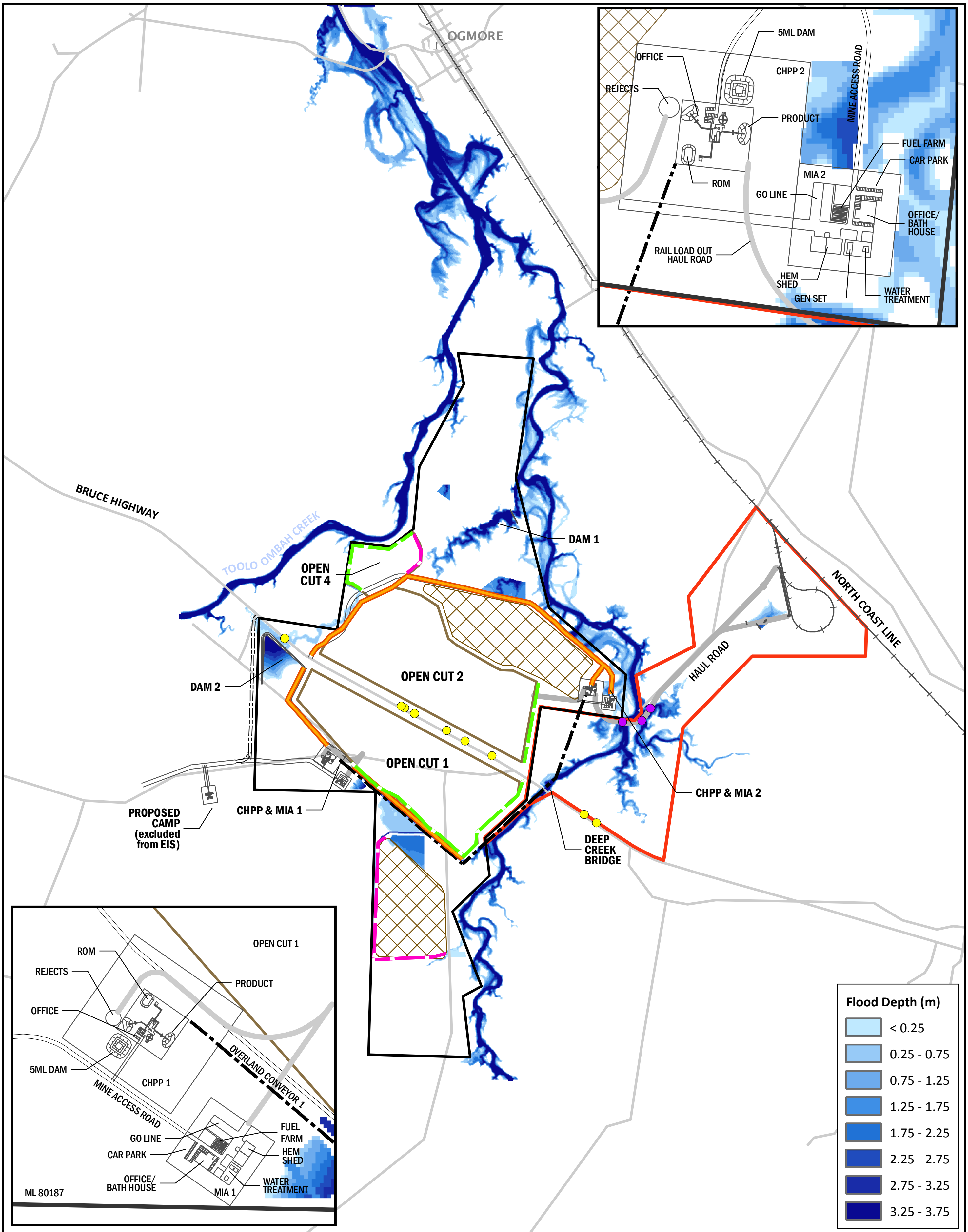
- The addition of a levee along the Open Cut 1 boundary, along the east boundary of Open Cut 2, and along the Tooloombah Creek boundary of Open Cut 4 to stop breakout flow from passing into the open pit areas;
- The addition of a diversion drain to Open Cut 1 boundary to divert water way from the levee and into Deep Creek;
- The addition of a diversion drain around the west of the Waste Area 1 to direct the water within the upstream catchment into the diversion near the levee;
- The addition of a bund to Waste Area 1 along the east and south boundary to prevent the upstream catchment from entering the overburden;
- The addition of the waste area and MIA environment dams;
- An increase in elevation of 2 m along the access road alignment to prevent backflow from entering Waste Area 2; and
- The addition of a low-level, three cellbox culvert crossing of Deep Creek and its two tributaries to allow for access to the TLF.

A key assumption in the developed case model is that Open Cut 1, 2 and 4 are fully mined and that the Bruce Highway culverts located between Open Cut 1 and Open Cut 2 have insignificant contributing catchments. The TLF culvert crossing was constructed as a 1D Mike model which was coupled to the MIKE21 model using MIKEFLOOD. This allowed a better representation of the culverts as the large size of this structure precluded its implementation in the 2D domain.

9.6.2.4 Developed Case Results

Results were processed to create maps showing depth and velocity maxima; these maps are shown in Figure 9-23 to Figure 9-33.

Afflux is defined as the change in water levels caused by a change (usually as a result of filling, excavation, or construction of a structure within the floodplain). It can be either positive (higher levels as a result of a change) or negative (lower levels as a results of a change). Afllux maps illustrating the expected changes to peak water levels as a result of the project, for the six flood events, are shown in Figure 9-35 to Figure 9-40.



N

0 1 2 km

Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

Legend

- Existing Culverts
- Haul Road Culverts
- Modelled Access Road
- Levee
- Bund
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Waste Dump Area
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

Figure 9-23
9.5% AEP peak flood depth – developed scenario

DATA SOURCE
QLD Open Source Data, 2017

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-23 R2 Styx Coal Project_Dev - 9p5 AEP Flood_Depth_A.mxd 7/17/2017

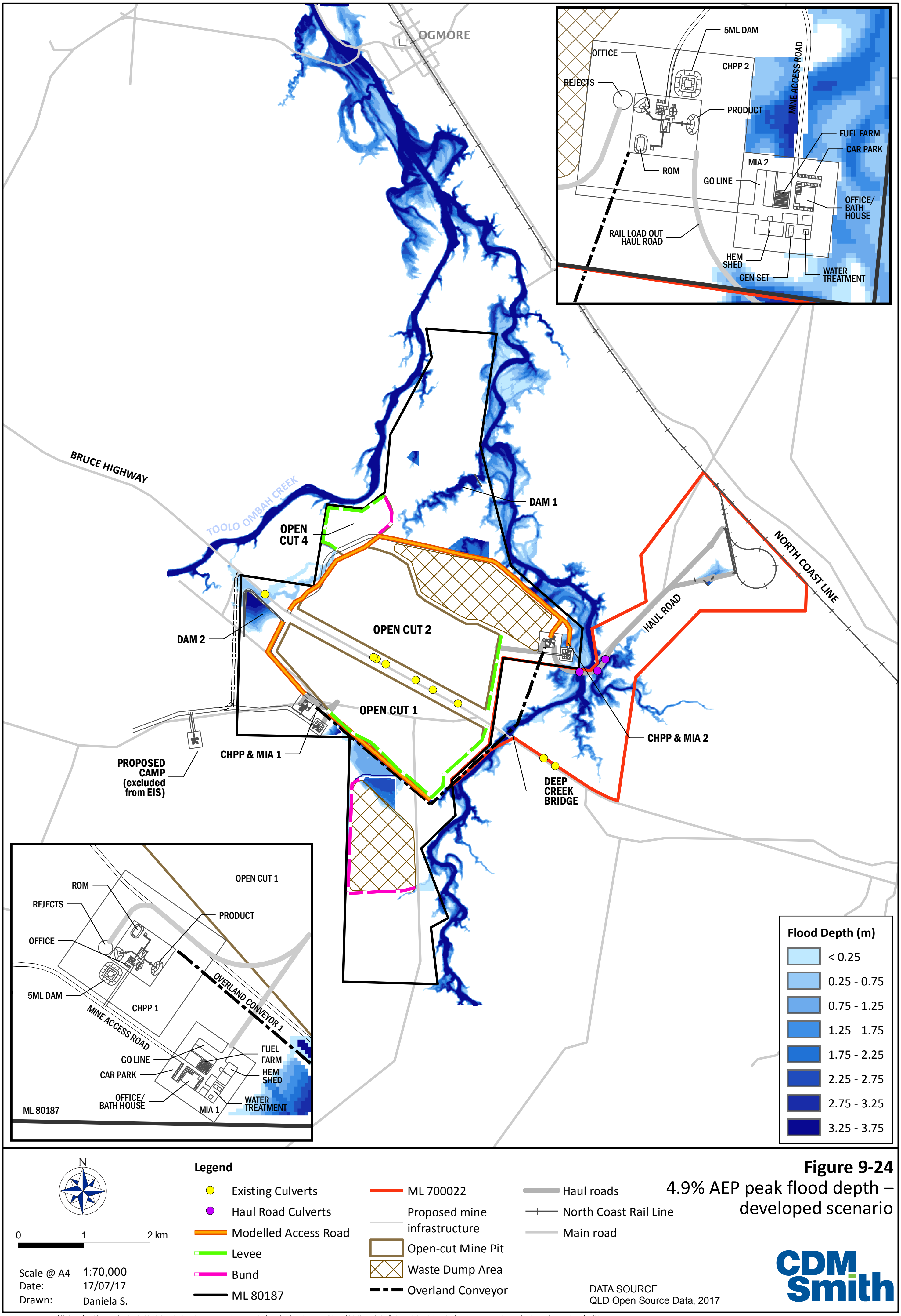
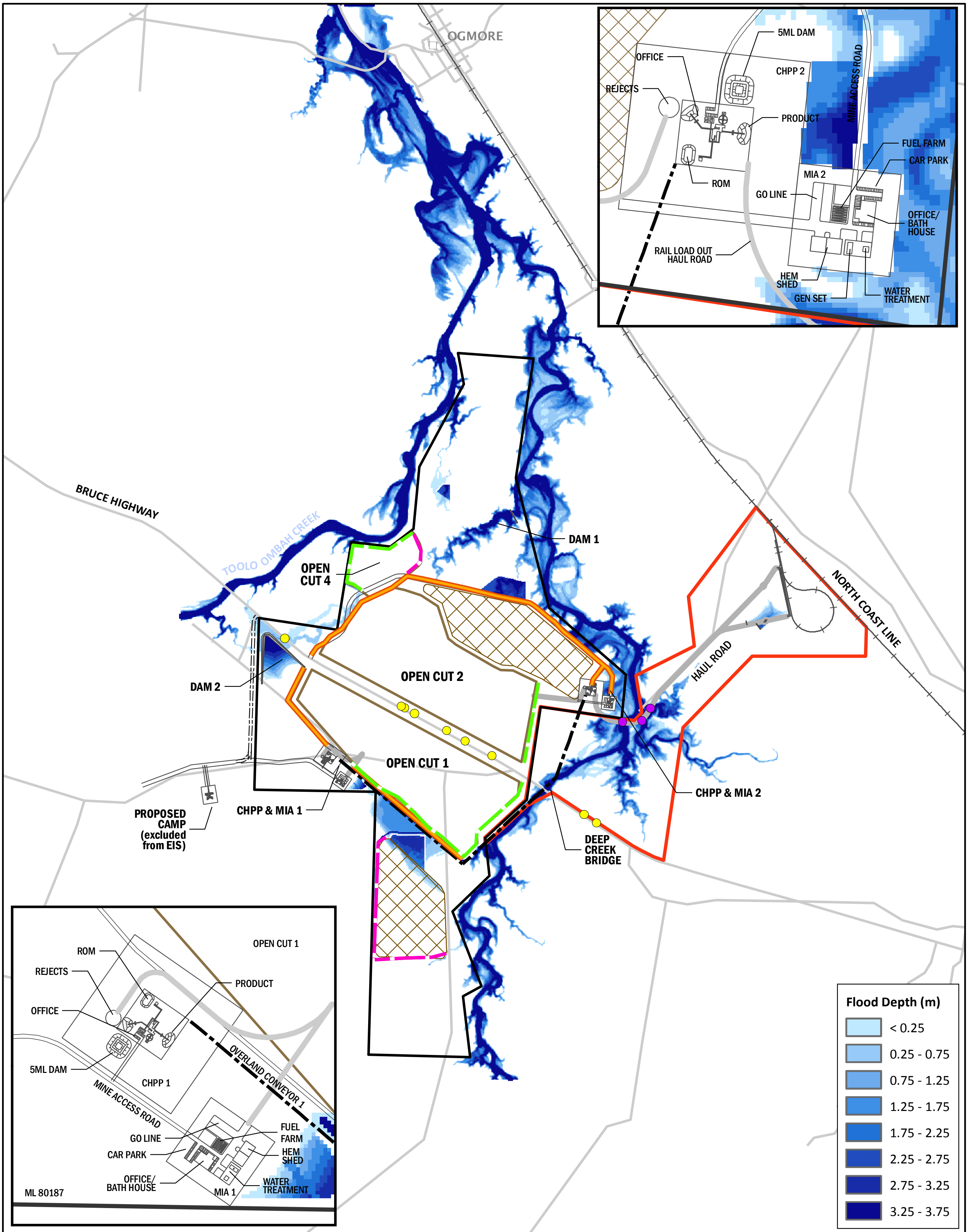


Figure 9-24
4.9% AEP peak flood depth – developed scenario

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-24 R2 Styx Coal Project_Dev - 4p9 AEP Flood_Depth_A.mxd 7/17/2017



N

0 1 2 km

Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

Legend

- Existing Culverts
- Haul Road Culverts
- Modelled Access Road
- Levee
- Bund
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Waste Dump Area
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

Figure 9-25
2% AEP peak flood depth – developed scenario

DATA SOURCE
QLD Open Source Data, 2017

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-25 R2 Styx Coal Project_Dev - 2 AEP Flood_Depth_A.mxd 7/17/2017

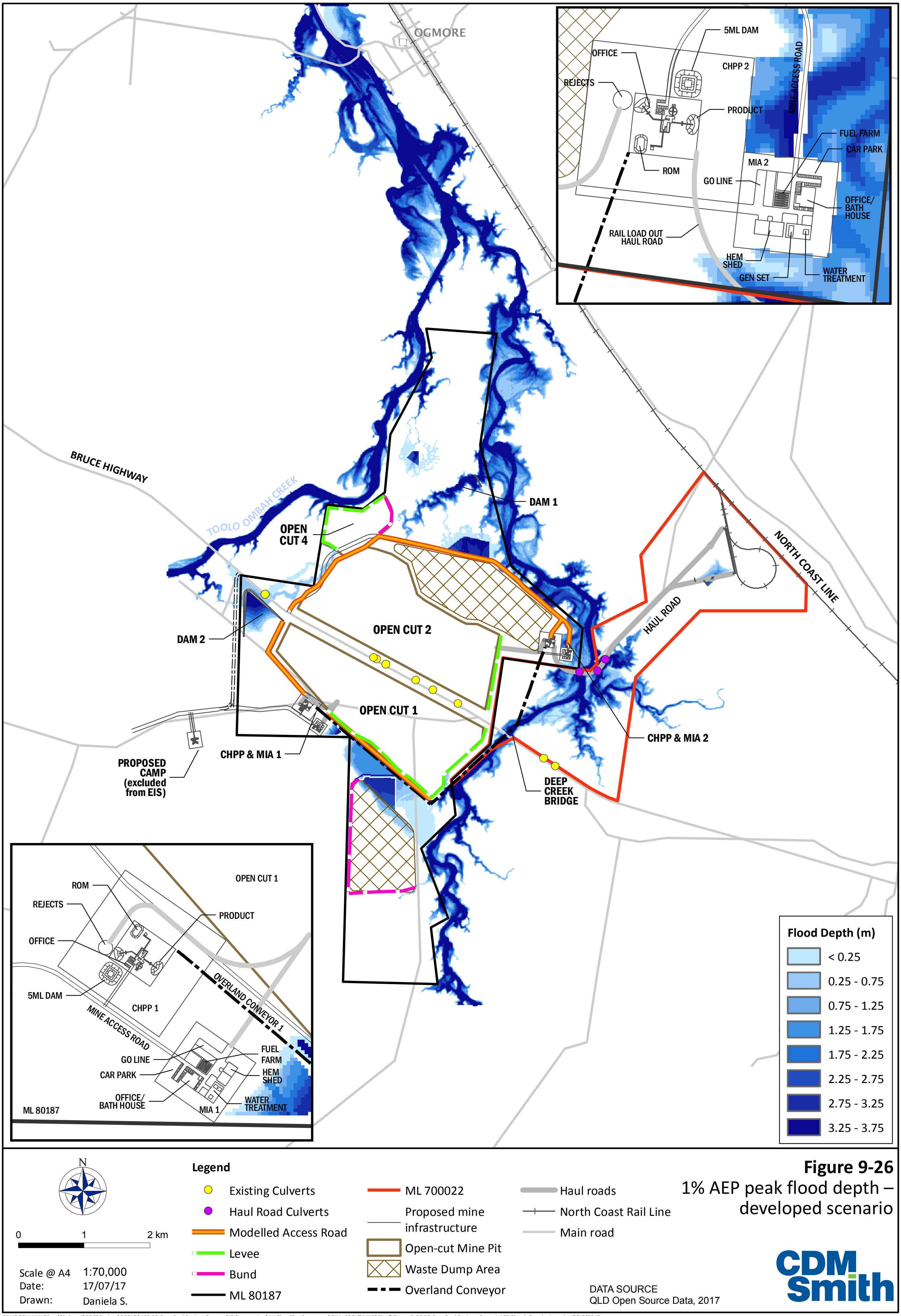
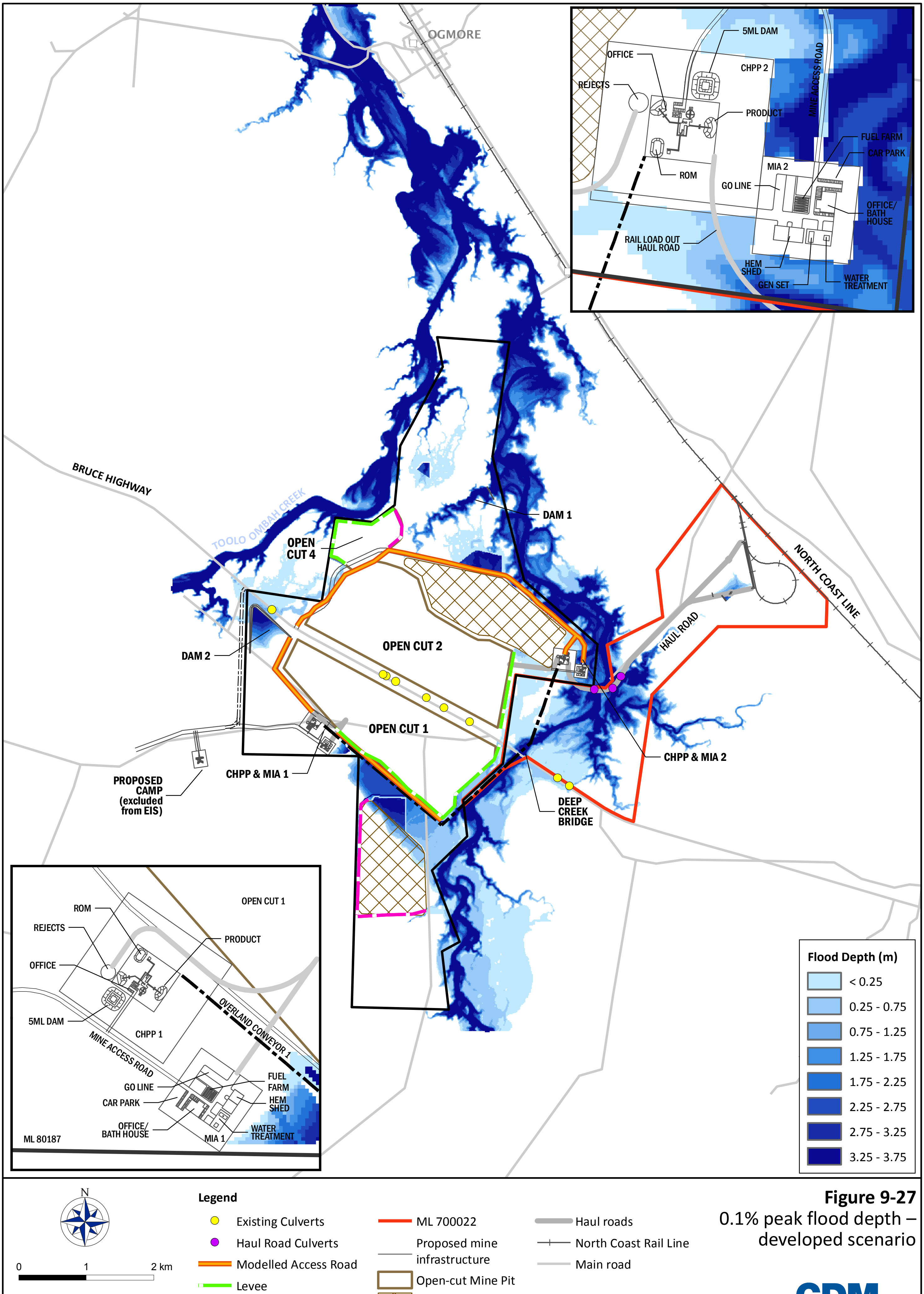


Figure 9-26
1% AEP peak flood depth – developed scenario

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-26 R2 Styx Coal Project_Dev - 1 AEP Flood_Depth_A.mxd 7/17/2017



Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

DATA SOURCE
QLD Open Source Data, 2017

Figure 9-27
0.1% peak flood depth – developed scenario

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-27 R2 Styx Coal Project_Dev - 0p1 AEP Flood_Depth_A.mxd 7/17/2017

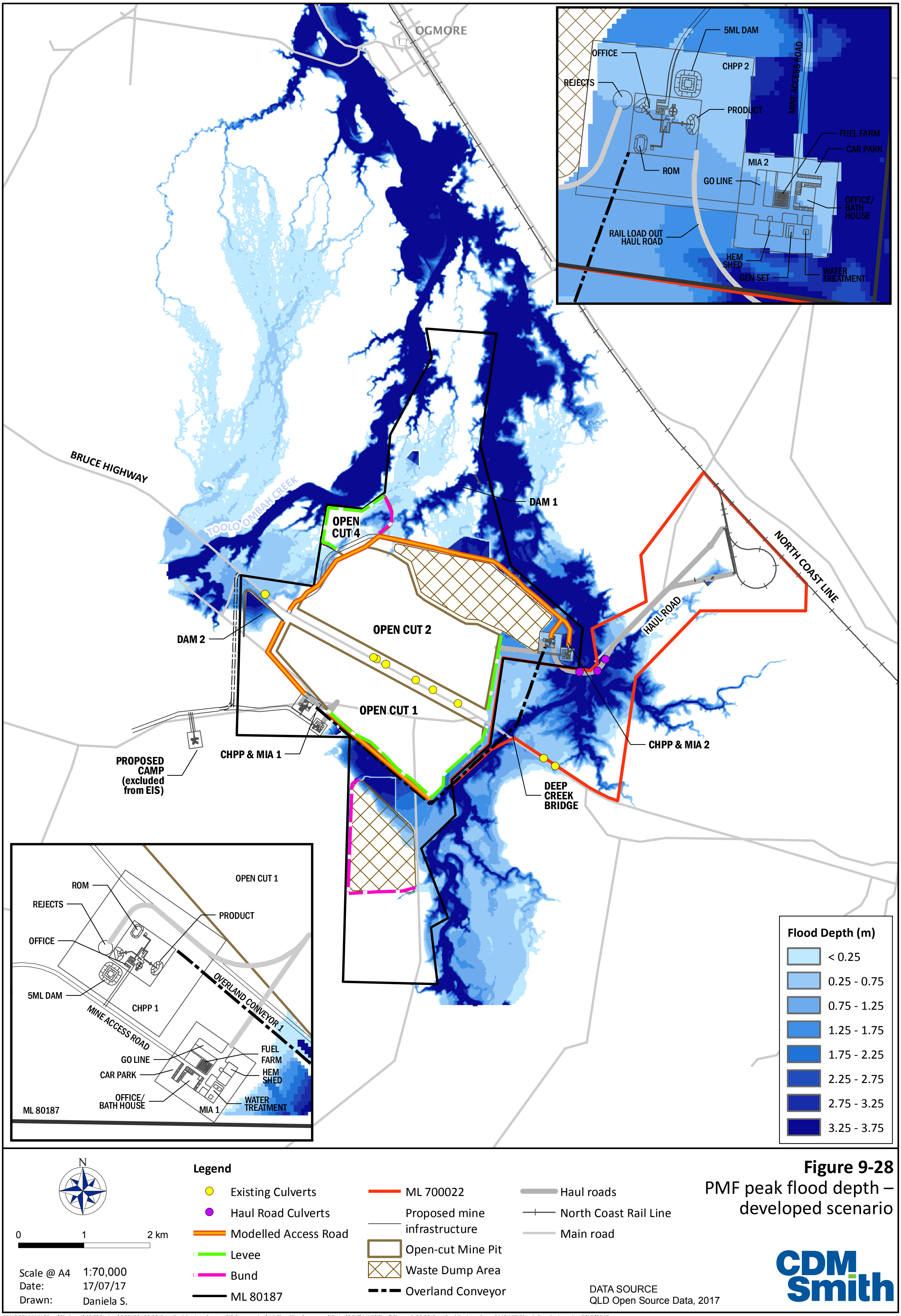
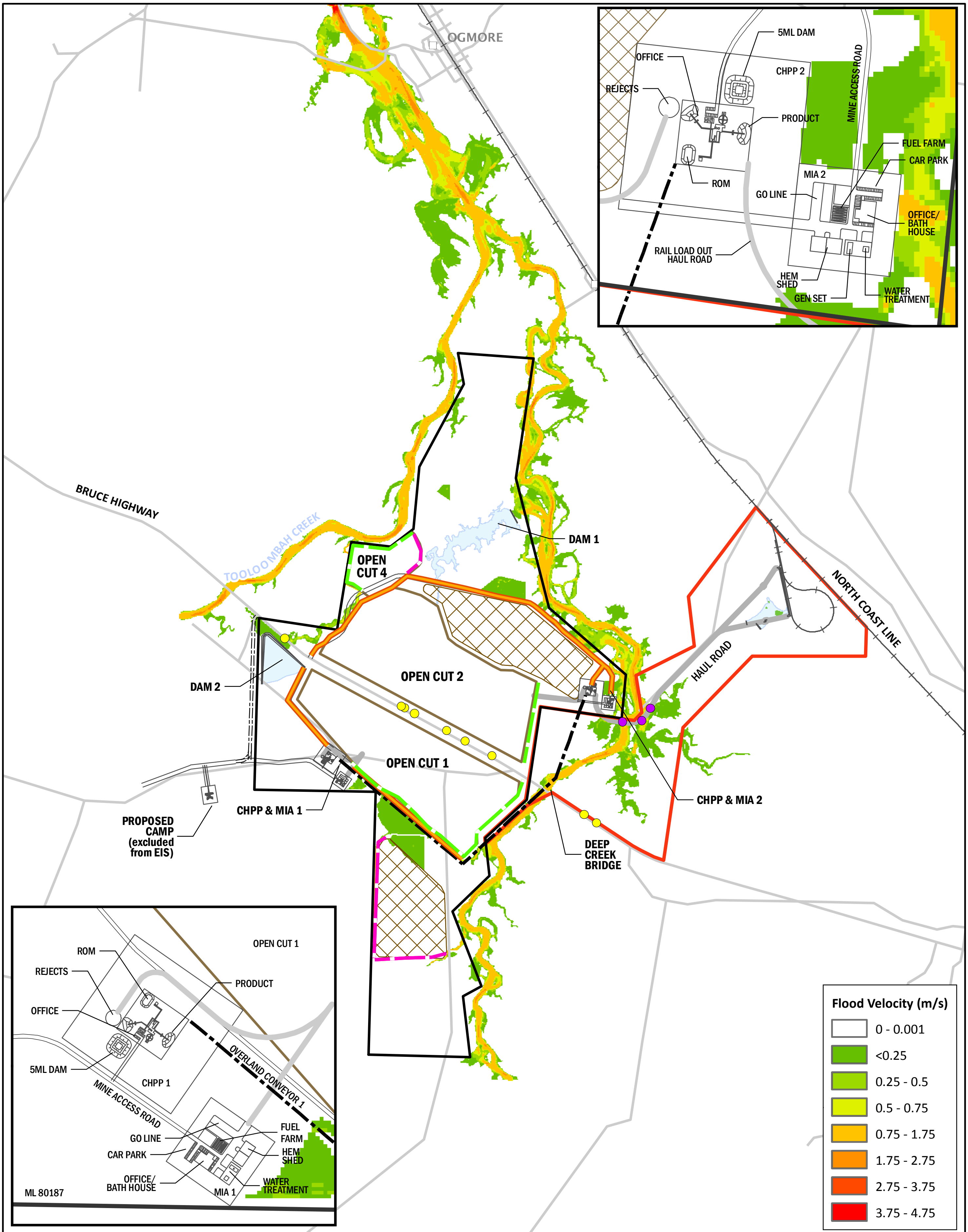


Figure 9-28
PMF peak flood depth – developed scenario

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-28 R2 Styx Coal Project_Dev - PMF AEP Flood_Depth_A.mxd 7/17/2017



N

0 1 2 km

Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

Legend

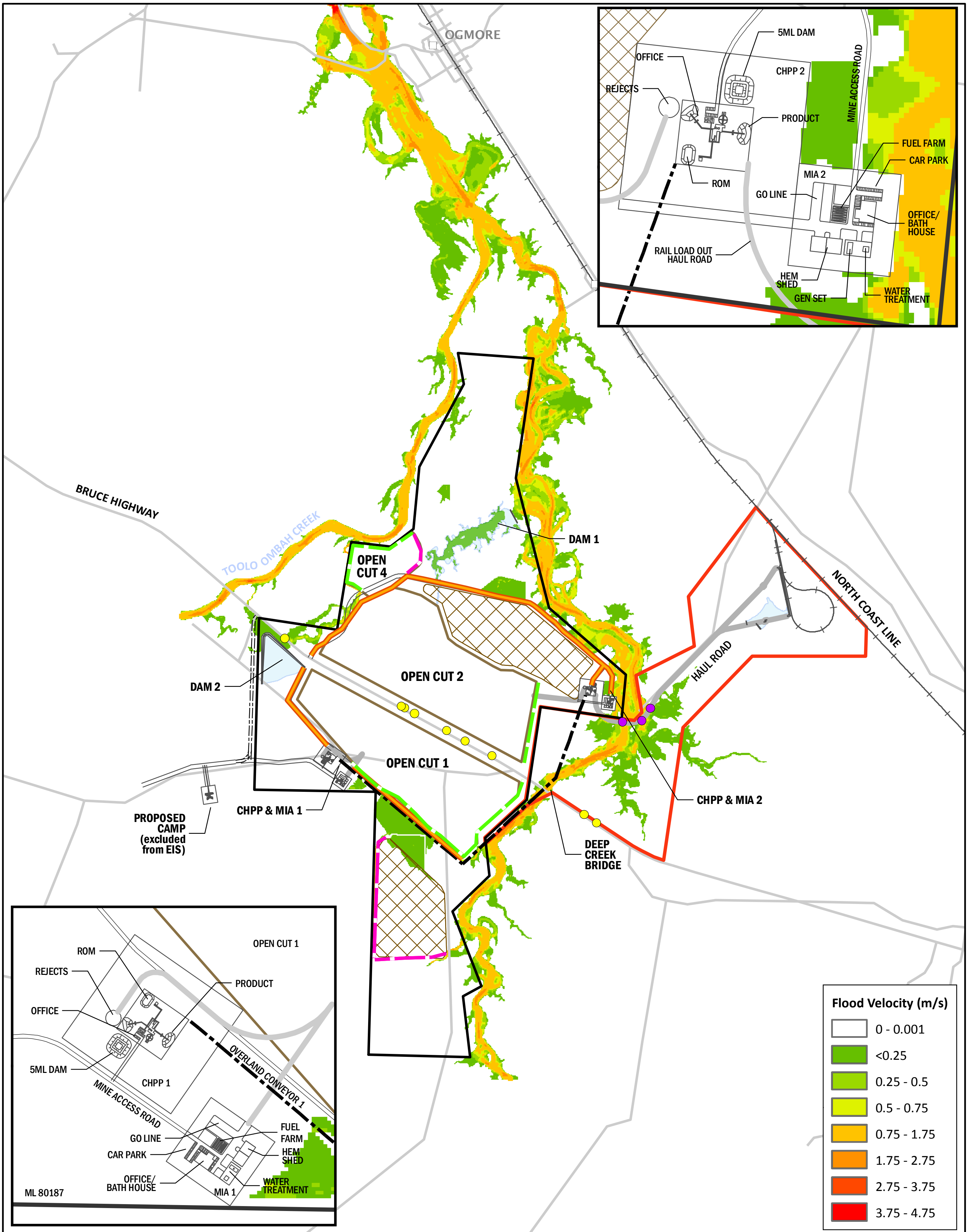
- Existing Culverts
- Haul Road Culverts
- Modelled Access Road
- Levee
- Bund
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Waste Dump Area
- Dam Catchment
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

DATA SOURCE
QLD Open Source Data, 2017

Figure 9-29
9.5% AEP peak flood velocity – developed scenario

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-29 R2 Styx Coal Project_Dev - 9p5 AEP Flood_Velocity_A.mxd 7/17/2017



N

0 1 2 km

Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

Legend

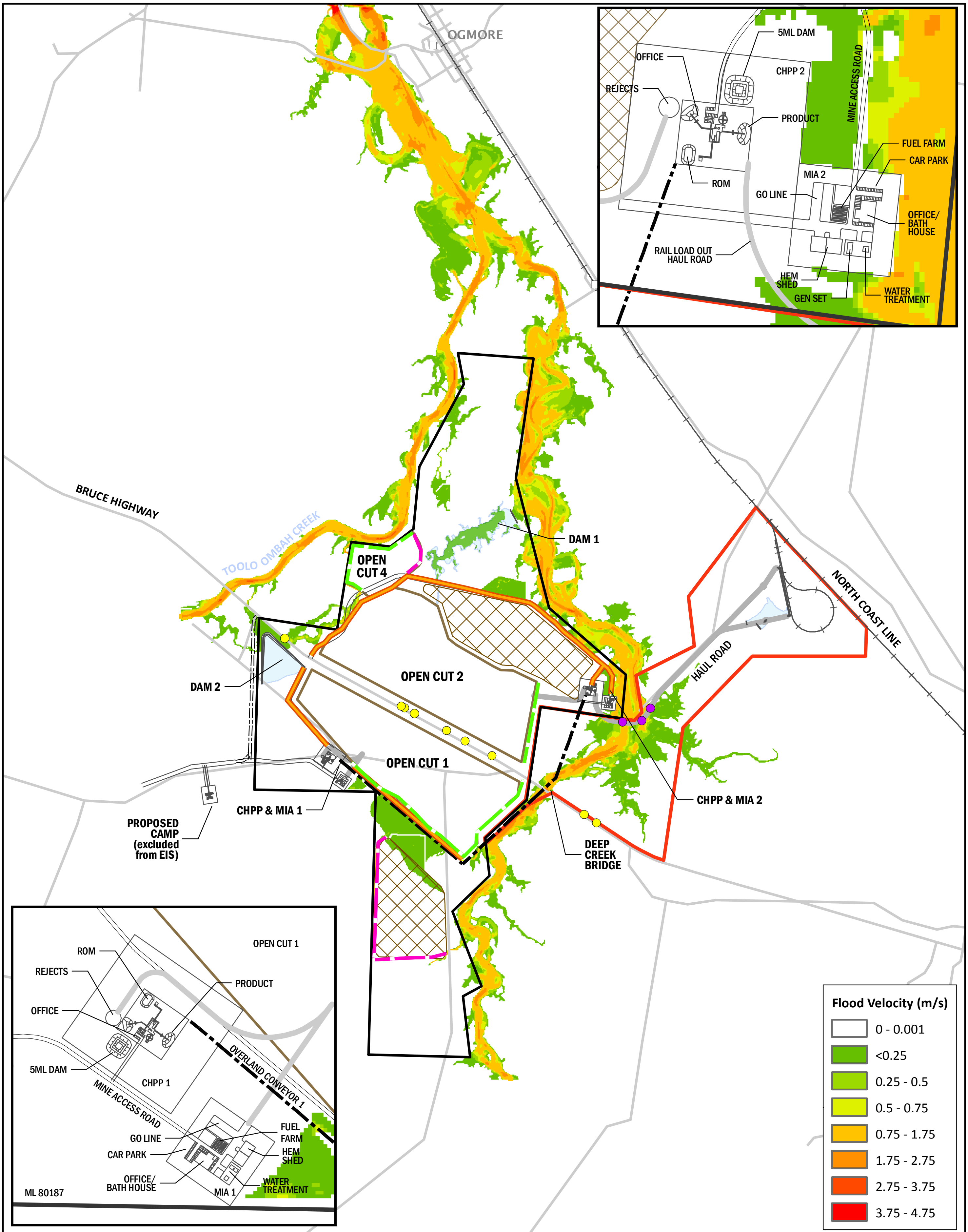
- Existing Culverts
- Haul Road Culverts
- Modelled Access Road
- Levee
- Bund
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Waste Dump Area
- Dam Catchment
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

DATA SOURCE
QLD Open Source Data, 2017

Figure 9-30
4.9% AEP peak flood velocity – developed scenario

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-30 R2 Styx Coal Project_Dev - 4p9 AEP Flood_Velocity_A.mxd 7/17/2017



N

0 1 2 km

Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

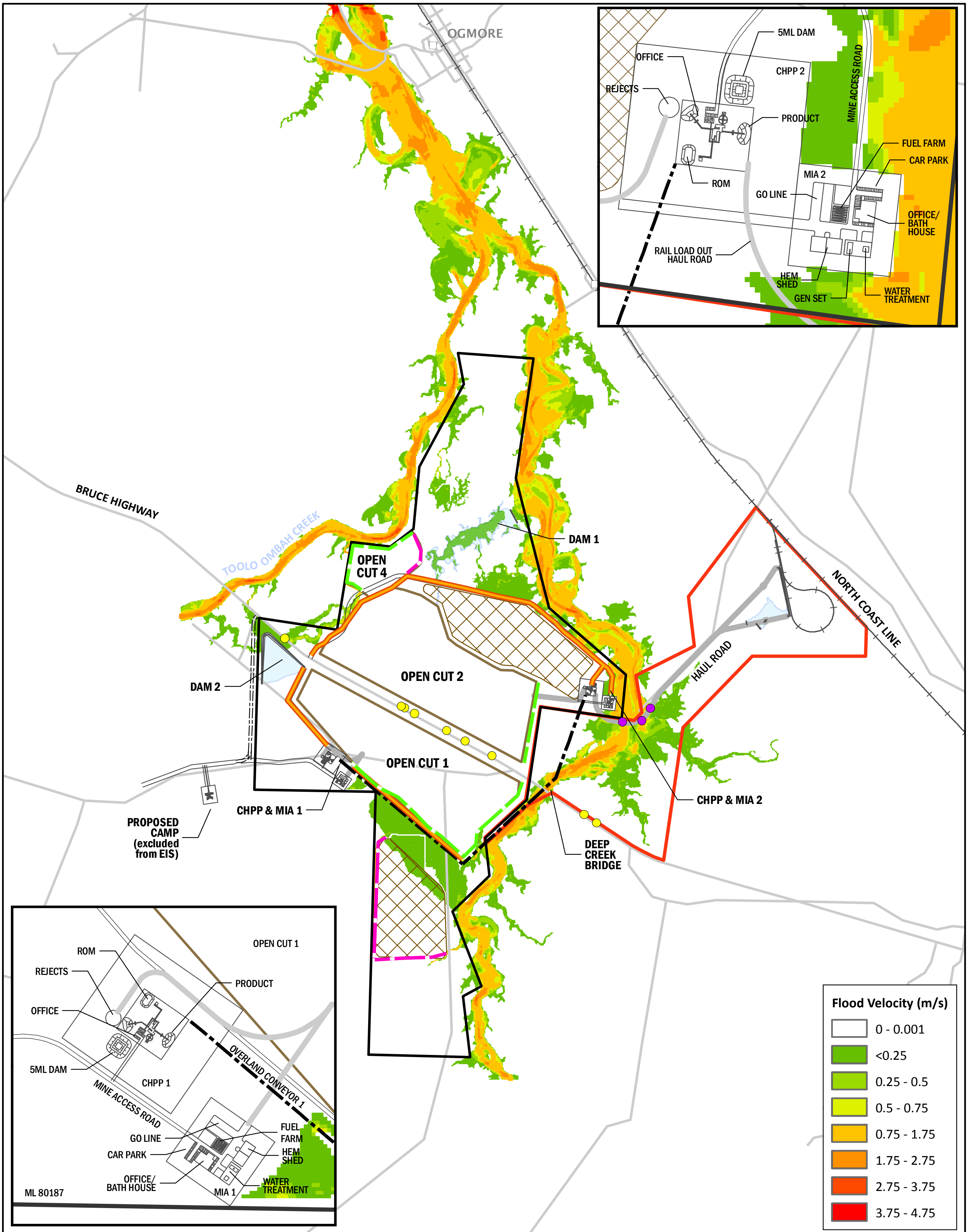
Legend

- Existing Culverts
- Haul Road Culverts
- Modelled Access Road
- Levee
- Bund
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Waste Dump Area
- Dam Catchment
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

DATA SOURCE
QLD Open Source Data, 2017

Figure 9-31
2% AEP peak flood velocity – developed scenario

CDM Smith



Legend

- Existing Culverts
- Haul Road Culverts
- Modelled Access Road
- Levee
- Bund
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Waste Dump Area
- Dam Catchment
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

N

0 1 2 km

Scale @ A4 1:70,000
Date: 17/07/17
Drawn: Daniela S.

DATA SOURCE
QLD Open Source Data, 2017

Figure 9-32
1% AEP peak flood velocity – developed scenario

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-32 R2 Styx Coal Project_Dev - 1 AEP Flood_Velocity_A.mxd 7/17/2017

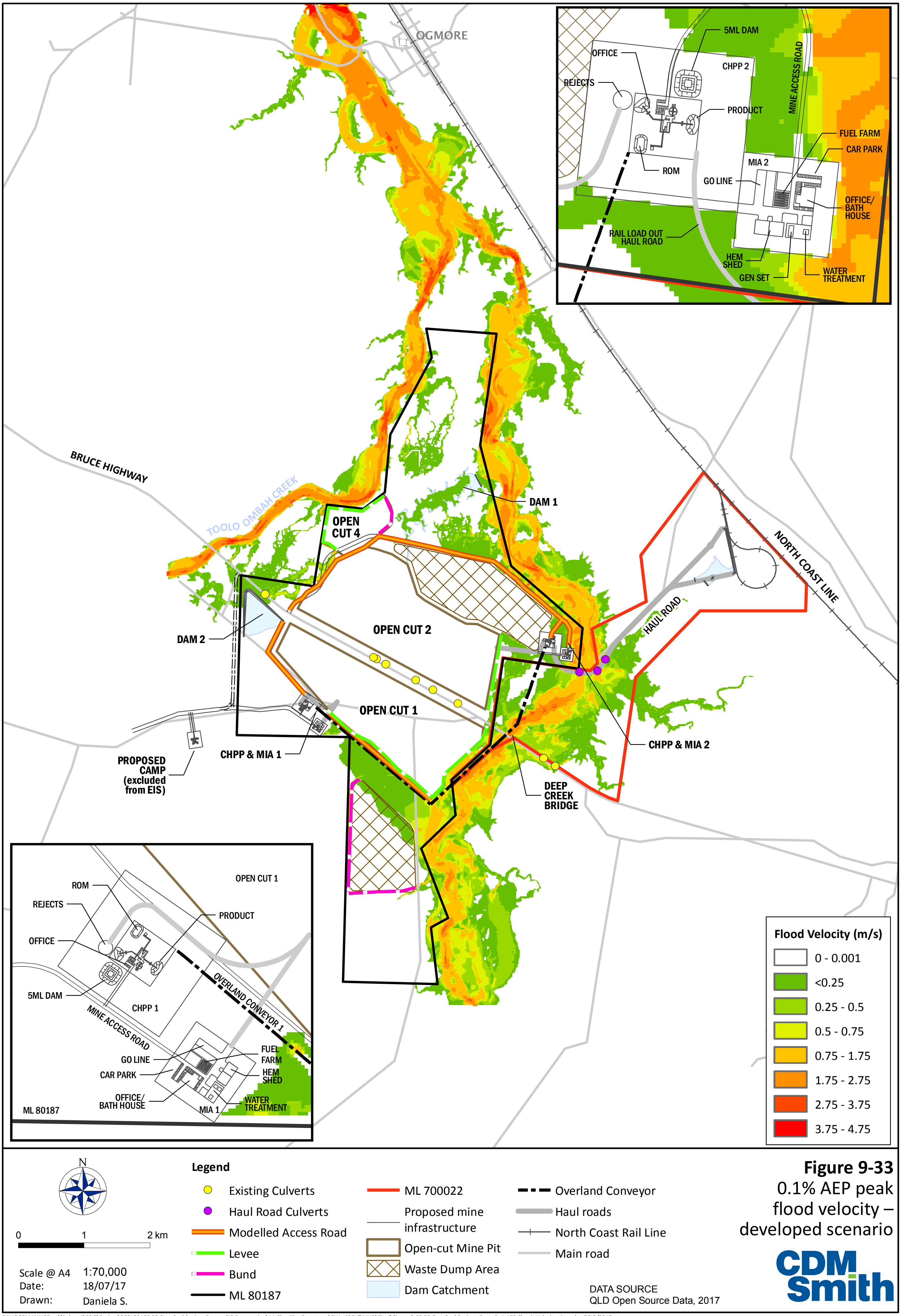
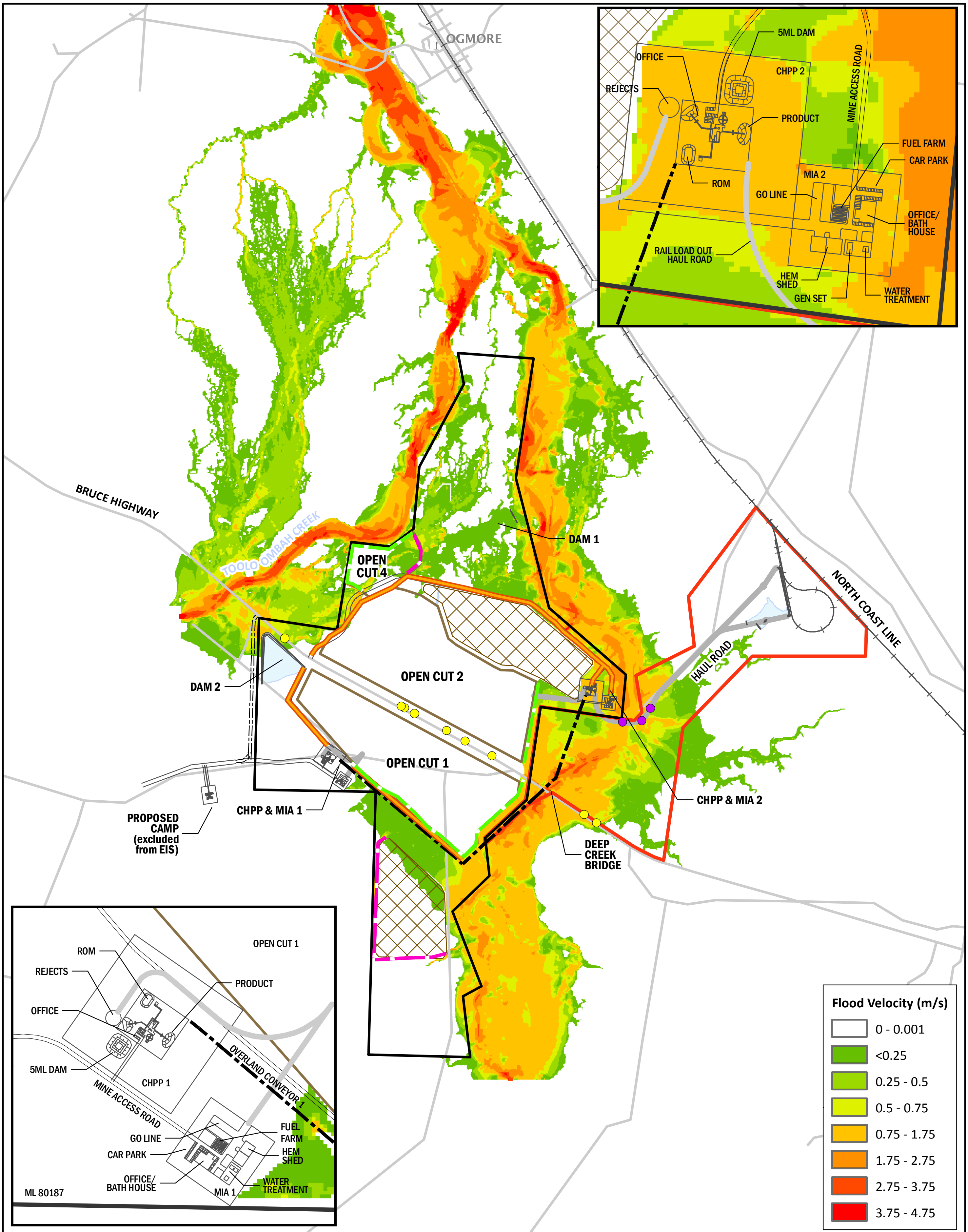


Figure 9-33
0.1% AEP peak flood velocity – developed scenario

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-33 R2 Styx Coal Project_Dev - 0p1 AEP Flood_Velocity_A.mxd 7/18/2017



N

0 1 2 km

Scale @ A4 1:70,000
Date: 18/07/17
Drawn: Daniela S.

Legend

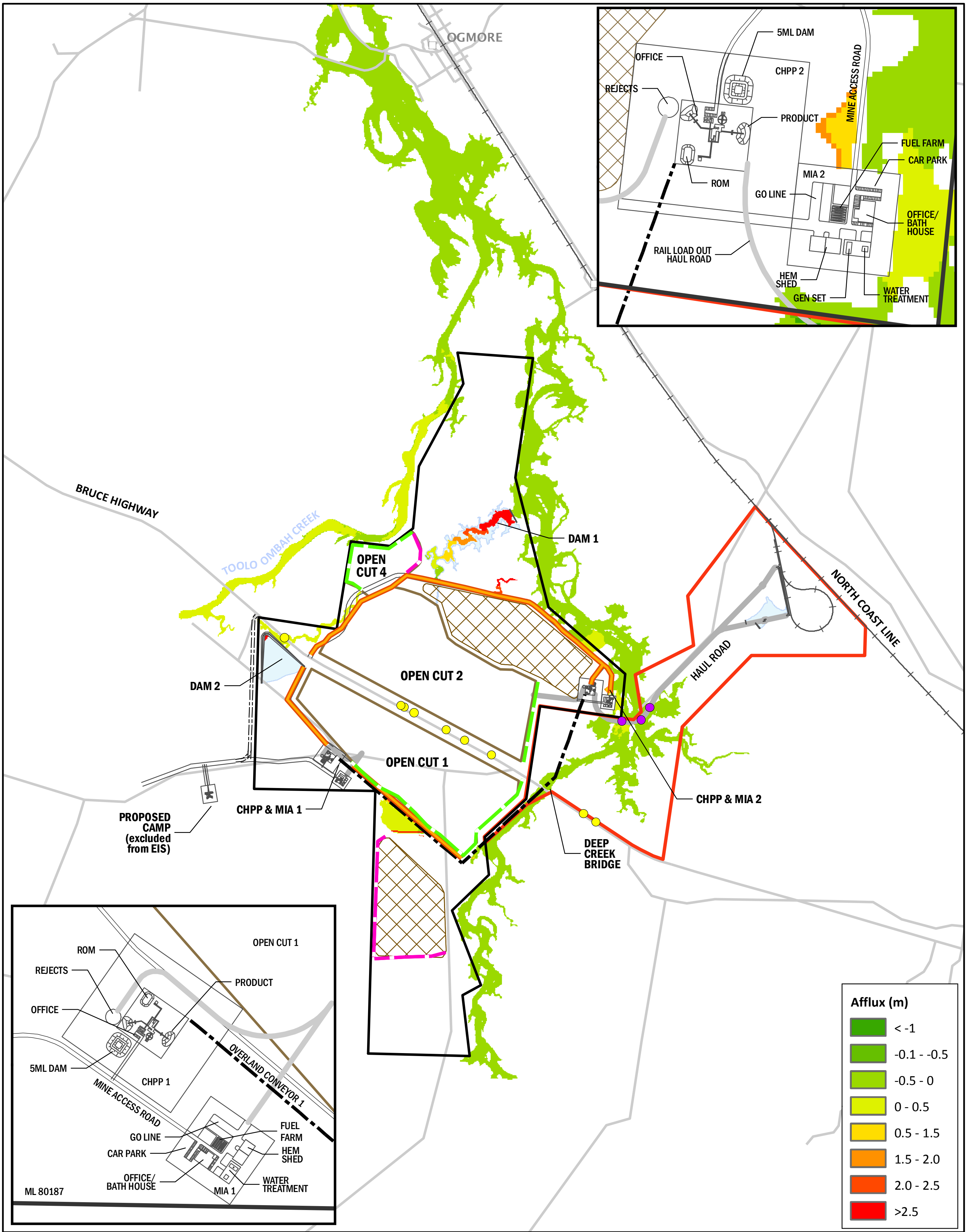
- Existing Culverts
- Haul Road Culverts
- Modelled Access Road
- Levee
- Bund
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Waste Dump Area
- Dam Catchment
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

DATA SOURCE
QLD Open Source Data, 2017

Figure 9-34
PMF peak flood velocity – developed scenario

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-34 R2 Styx Coal Project_Dev - PMF Flood_Velocity_A.mxd 7/18/2017



N

0 1 2 km

Scale @ A4 1:70,000
Date: 18/07/17
Drawn: Daniela S.

Legend

- Existing Culverts
- Haul Road Culverts
- Modelled Access Road
- Levee
- Bund
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Waste Dump Area
- Dam Catchment
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

DATA SOURCE
QLD Open Source Data, 2017

Figure 9-35
9.5% AEP Afflux

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-35 R2 Styx Coal Project_Afflux - 9p5_A.mxd 7/18/2017

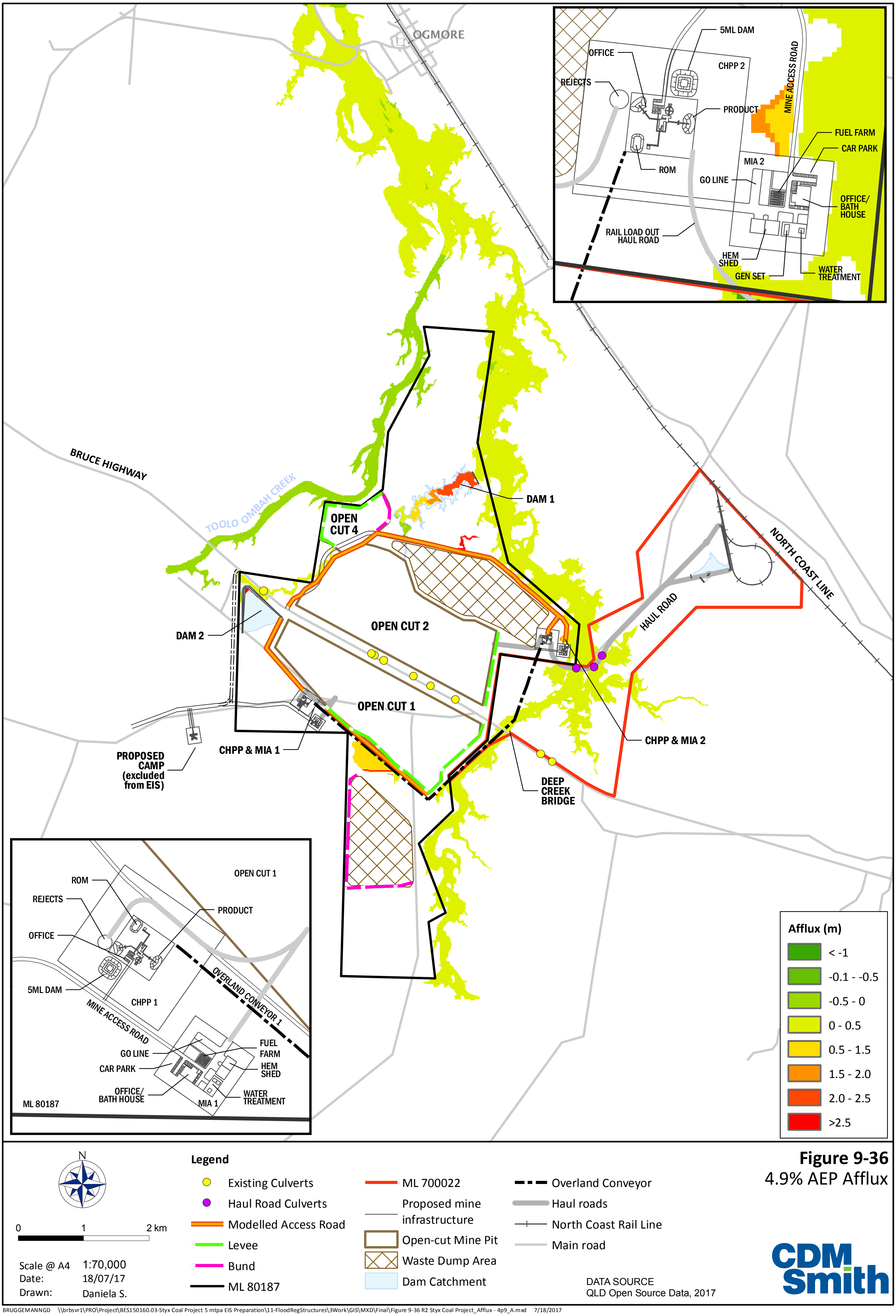
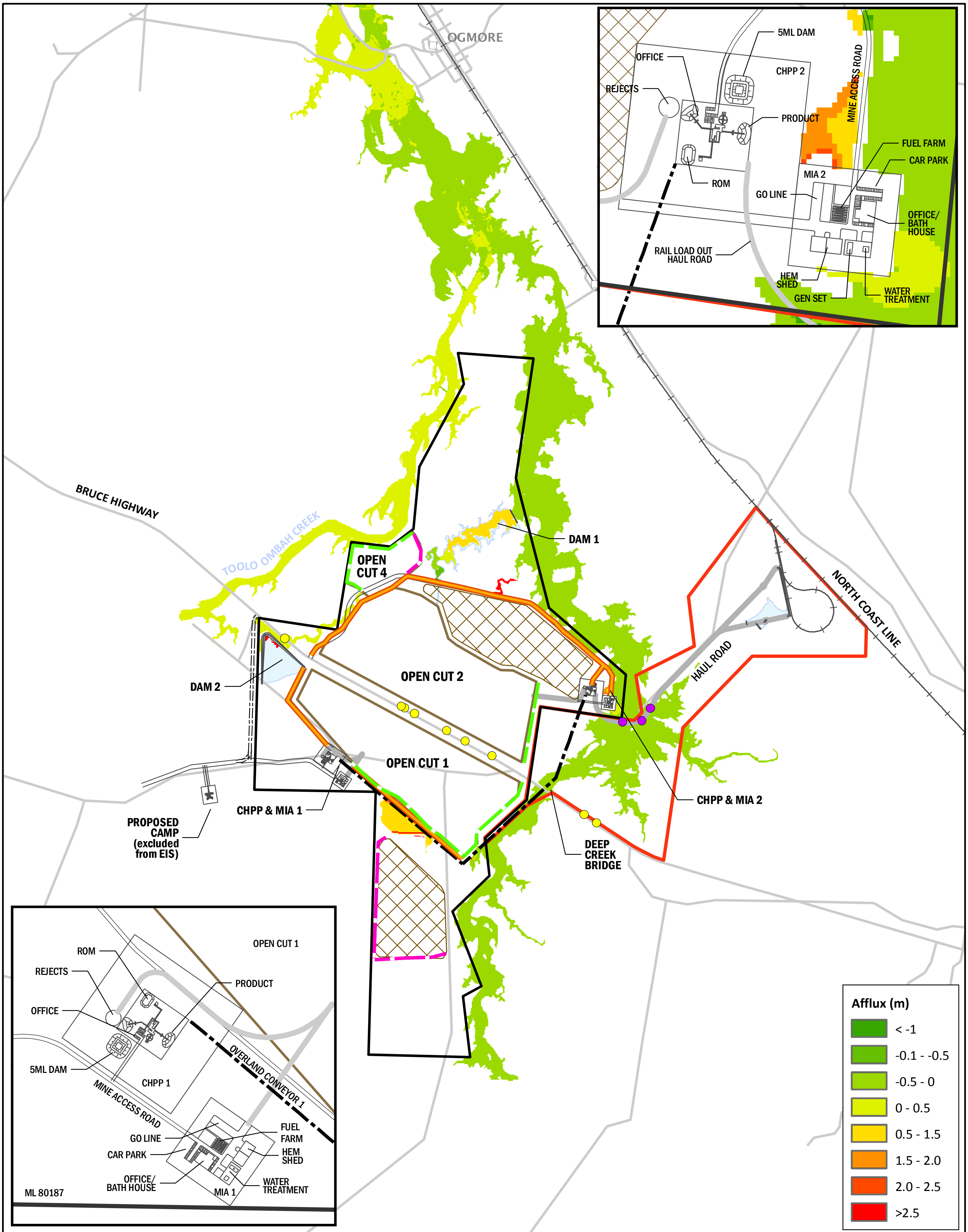


Figure 9-36
4.9% AEP Afflux



N

0 1 2 km

Scale @ A4 1:70,000
Date: 18/07/17
Drawn: Daniela S.

Legend

- Existing Culverts
- Haul Road Culverts
- Modelled Access Road
- Levee
- Bund
- ML 80187
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- Proposed mine infrastructure
- Open-cut Mine Pit
- Waste Dump Area
- Dam Catchment
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

DATA SOURCE
QLD Open Source Data, 2017

Figure 9-37
2% AEP Afflux

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-37 R2 Styx Coal Project_Afflux - 2_A.mxd 7/18/2017

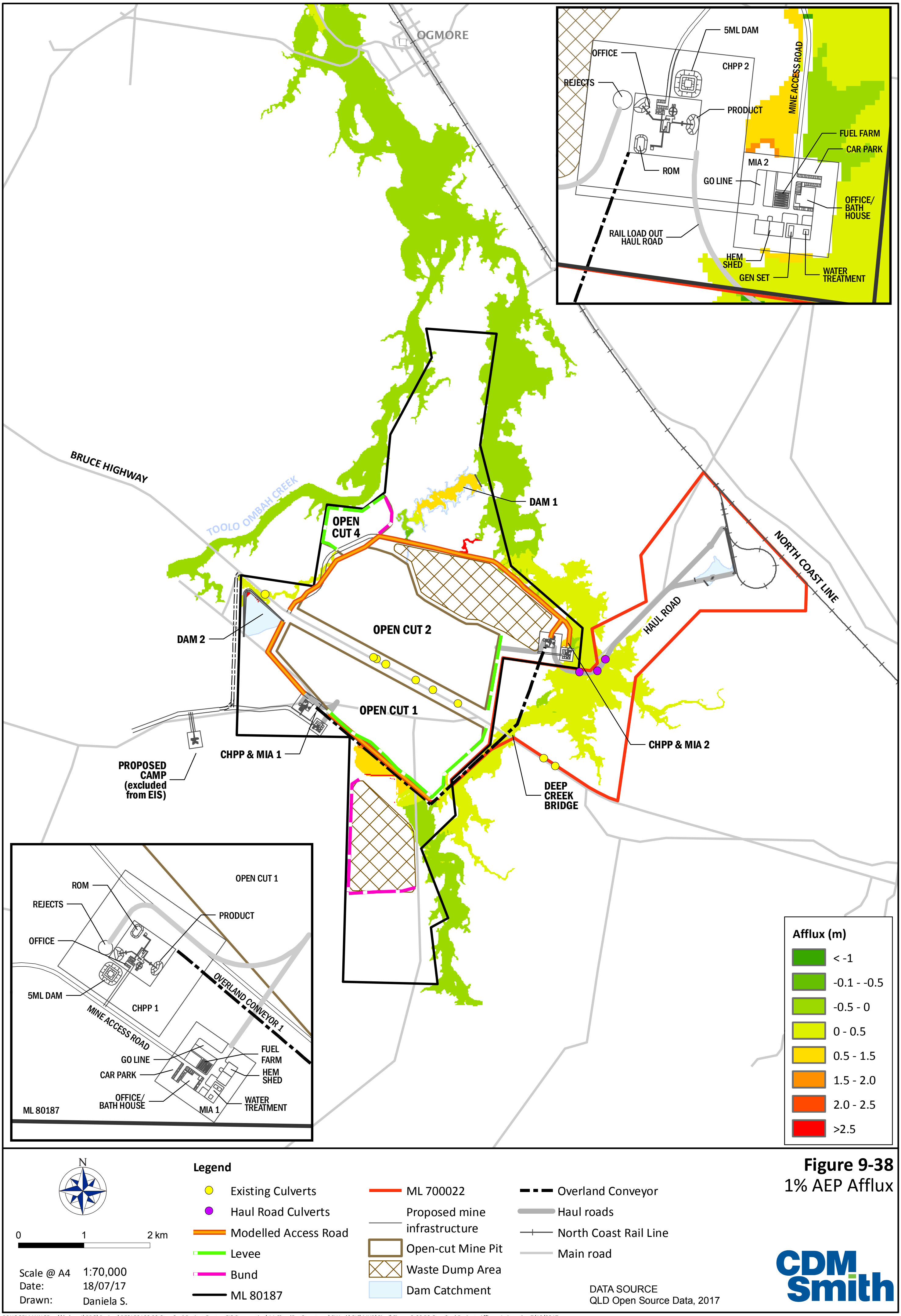


Figure 9-38
1% AEP Afflux

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-38 R2 Styx Coal Project_Afflux - 1_A.mxd 7/18/2017

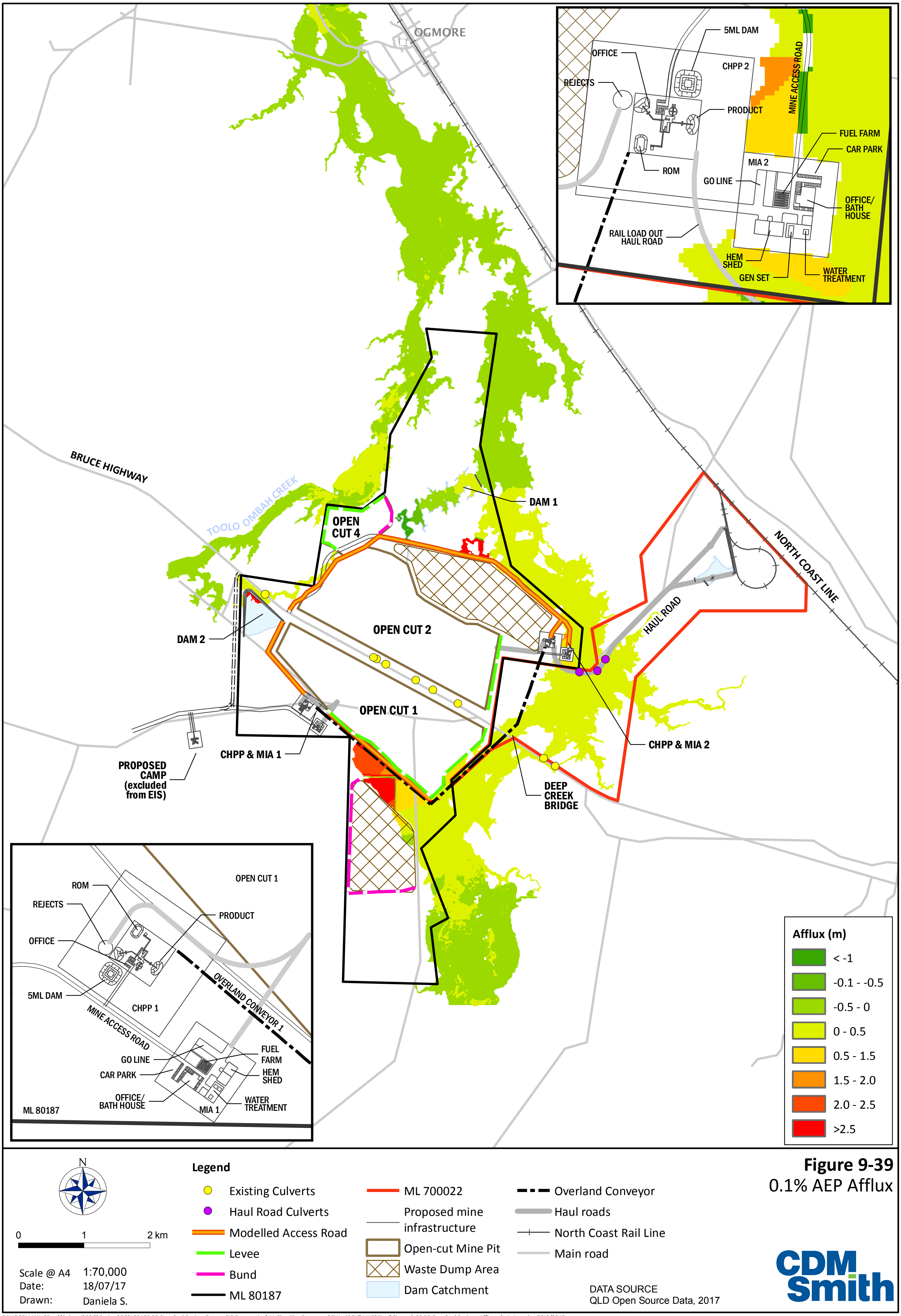


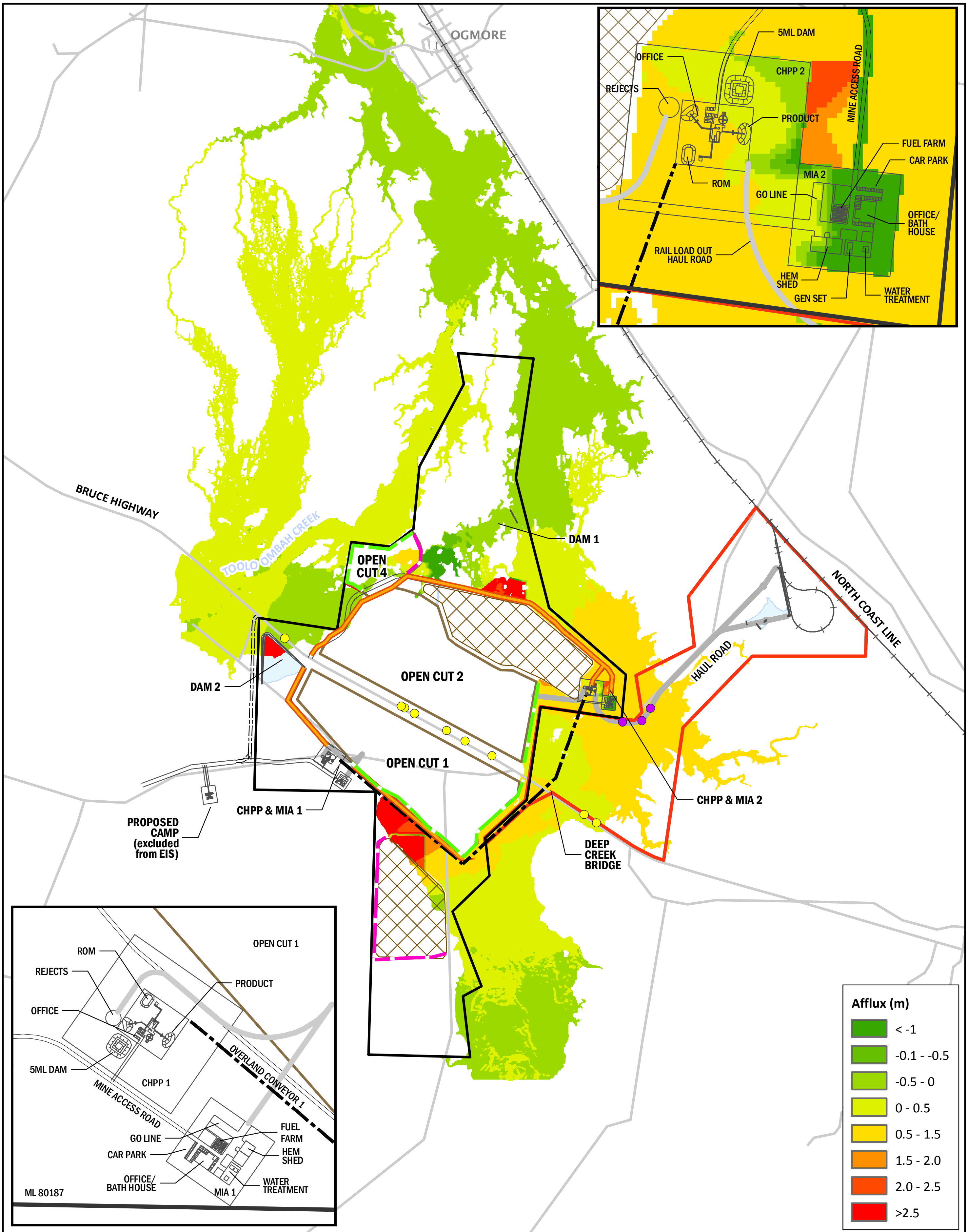
Figure 9-39
0.1% AEP Afflux

Scale @ A4 1:70,000
Date: 18/07/17
Drawn: Daniela S.

DATA SOURCE
QLD Open Source Data, 2017

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-39 R2 Styx Coal Project_Afflux - 0p1_A.mxd 7/18/2017



N

0 1 2 km

Scale @ A4 1:70,000
Date: 18/07/17
Drawn: Daniela S.

Legend

- Existing Culverts
- Haul Road Culverts
- Modelled Access Road
- Levee
- Bund
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Open-cut Mine Pit
- Waste Dump Area
- Dam Catchment
- Overland Conveyor
- Haul roads
- North Coast Rail Line
- Main road

DATA SOURCE
QLD Open Source Data, 2017

Figure 9-40
PMF AEP Afflux

CDM Smith

BRUGGEMANNGD \\brbsvr1\PRO\Project\BES150160.03-Styx Coal Project 5 mtpa EIS Preparation\11-FloodRegStructures\3Work\GIS\MXD\Final\Figure 9-40 R2 Styx Coal Project_Afflux - PMF_A.mxd 7/18/2017

9.6.2.5 Discussion of Results

Comparison of Flood Impacts

The existing case and developed case peak water depths and velocities were extracted from the model at 11 key locations for comparison. These results are shown in Table 9-35. Afflux maps for the six flood events are shown in Figure 9-35 to Figure 9-40.

Table 9-35 Selected key locations

Design storm event	Location	Coordinates		Peak water depth (m)		Peak water velocity (m/s)		Afflux (m)
		Easting	Northing	Existing Case	Developed Case	Existing Case	Developed Case	
9.5% AEP 24 hr duration	1 - Conveyor	774655	7485635	0	0	0	0	0
	2-Haul Road Culvert 1	775975	7486725	6.29	6.44	0.78	0.96	0.15
	3-Haul Road Culvert 2	773175	7488455	4.97	5.73	0.67	0.84	0.76
	4- Haul Road Culvert 3	773175	7488325	3.98	4.48	0.3	0.33	0.5
	5-Downstream Waste Area 2 Environment Dam	774305	7488835	0.57	0	0.61	0	-0.57
	6-1st order Deep Creek tributary	774695	7485605	0.2	0.34	0.31	0.51	0.14
	7- Deep Creek Bridge	773725	7484815	6.34	6.44	1.34	1.42	0.1
	8- P1DD-1 outlet	772745	7485315	2.47	2.62	0.1	0.59	0.15
	9- P3DD outlet	773655	7493845	0	0.14	0	0	0.14
	10- South Levee	774565	7502375	0.19	0	0.12	0	-0.19
	11-Styx River	775475	7510905	9.93	9.86	1.53	1.5	-0.07
4.9% AEP 24 hr duration	1 - Conveyor	774655	7485635	0.28	0.45	0.36	0.53	0.17
	2-Haul Road Culvert 1	775975	7486725	6.59	6.94	0.87	0.93	0.35
	3-Haul Road Culvert 2	773175	7488455	5.3	6.28	0.71	0.84	0.98
	4- Haul Road Culvert 3	773175	7488325	4.31	5.05	0.35	0.44	0.74
	5-Downstream Waste Area 2 Environment Dam	774305	7488835	0.61	0	0.66	0	-0.61
	6-1st order Deep Creek tributary	774695	7485605	0.21	0.43	0.34	0.63	0.22
	7- Deep Creek Bridge	773725	7484815	6.87	7.07	1.5	1.69	0.2
	8- P1DD-1 outlet	772745	7485315	3.13	3.33	0.25	0.78	0.2
	9- P3DD outlet	773655	7493845	0	0.19	0	2.74	0.19
	10- South Levee	774565	7502375	0.22	0	0.14	0	-0.22
	11-Styx River	775475	7510905	10.34	10.36	1.76	1.76	0.02
2% AEP 24 hr duration	1 - Conveyor	774655	7485635	0.79	0.99	0.9	1.22	0.2
	2-Haul Road Culvert 1	775975	7486725	7.1	7.21	0.9	0.98	0.11
	3-Haul Road Culvert 2	773175	7488455	5.87	6.6	0.79	0.89	0.73
	4- Haul Road Culvert 3	773175	7488325	4.89	5.34	0.41	0.5	0.45
	5-Downstream Waste Area 2 Environment Dam	774305	7488835	0.91	0.68	0.75	0.3	-0.23
	6-1st order Deep Creek tributary	774695	7485605	0.27	0.42	0.4	0.62	0.15
	7- Deep Creek Bridge	773725	7484815	7.43	7.64	1.83	1.85	0.21
	8- P1DD-1 outlet	772745	7485315	3.76	4.03	0.39	0.9	0.27
	9- P3DD outlet	773655	7493845	0.12	0.28	0.01	2.57	0.16
	10- South Levee	774565	7502375	0.29	0	0.18	0	-0.29
	11-Styx River	775475	7510905	10.84	10.84	2.03	2	0
1% AEP 24 hr duration	1 - Conveyor	774655	7485635	1.07	1.12	1.32	1.25	0.05
	2-Haul Road Culvert 1	775975	7486725	7.22	7.48	0.91	0.98	0.26
	3-Haul Road Culvert 2	773175	7488455	6.02	6.91	0.77	0.81	0.89
	4- Haul Road Culvert 3	773175	7488325	5.03	5.66	0.42	0.55	0.63

Design storm event	Location	Coordinates		Peak water depth (m)		Peak water velocity (m/s)		Afflux (m)
		Easting	Northing	Existing Case	Developed Case	Existing Case	Developed Case	
	5-Downstream Waste Area 2 Environment Dam	774305	7488835	1.08	1.03	0.75	0.57	-0.05
	6-1st order Deep Creek tributary	774695	7485605	0.25	0.44	0.38	0.65	0.19
	7- Deep Creek Bridge	773725	7484815	7.74	7.78	1.91	2.03	0.04
	8- P1DD-1 outlet	772745	7485315	4.14	4.17	0.27	0.83	0.03
	9- P3DD outlet	773655	7493845	1.15	1.11	0.01	2.76	-0.04
	10- South Levee	774565	7502375	0.27	2.05	0.16	0.05	1.78
	11-Styx River	775475	7510905	11.14	11.13	2.14	2.1	-0.01
0.1% AEP 24 hr duration	1 - Conveyor	774655	7485635	1.71	2.07	1.89	2.11	0.36
	2-Haul Road Culvert 1	775975	7486725	7.82	8.43	0.93	1.01	0.61
	3-Haul Road Culvert 2	773175	7488455	6.71	7.93	0.84	0.84	1.22
	4- Haul Road Culvert 3	773175	7488325	5.73	6.7	0.44	0.61	0.97
	5-Downstream Waste Area 2 Environment Dam	774305	7488835	2.09	2.21	1.05	0.31	0.12
	6-1st order Deep Creek tributary	774695	7485605	0.32	0.51	0.45	0.76	0.19
	7- Deep Creek Bridge	773725	7484815	8.43	8.81	2.23	2.43	0.38
	8- P1DD-1 outlet	772745	7485315	4.86	5.14	0.2	0.83	0.28
	9- P3DD outlet	773655	7493845	3.18	3.19	0.12	3.23	0.01
	10- South Levee	774565	7502375	0.59	3.1	0.34	0.06	2.51
	11-Styx River	775475	7510905	12.16	12.14	2.17	2.14	-0.02
PMF 24 hr duration	1 - Conveyor	774655	7485635	2.26	2.83	2.27	2.47	0.57
	2-Haul Road Culvert 1	775975	7486725	8.56	9.33	0.86	0.94	0.77
	3-Haul Road Culvert 2	773175	7488455	7.47	8.87	0.82	0.94	1.4
	4- Haul Road Culvert 3	773175	7488325	6.50	7.63	0.49	0.64	1.13
	5-Downstream Waste Area 2 Environment Dam	774305	7488835	3.50	3.64	1.22	0.18	0.14
	6-1st order Deep Creek tributary	774695	7485605	1.34	1.03	1.21	1.26	-0.31
	7- Deep Creek Bridge	773725	7484815	9.00	9.54	2.37	2.67	0.54
	8- P1DD-1 outlet	772745	7485315	5.47	6.00	0.50	1.35	0.53
	9- P3DD outlet	773655	7493845	5.43	5.53	0.98	2.81	0.1
	10- South Levee	774565	7502375	1.01	3.84	0.50	0.11	2.83
	11-Styx River	775475	7510905	14.08	13.99	2.24	2.21	-0.09

Flooding of Pits and Subsequent Levee Heights

The developed case flood maps demonstrate no flooding of the open pit areas (see Figure 9-23 to Figure 9-33) for up to including the 0.1% AEP event, due to the inclusion of levees and the raising of the access road (refer to developed flood figures). Open Cut 1, Open Cut 2 and Open Cut 4 all have Probable Maximum Flood (PMF) immunity with the inclusion of levees.

The levees and localised raising of road embankments are situated in areas where breakout flows and backwater effects were predicted to occur during extreme flood events (i.e. above 1% AEP). The levee along the Open Cut 1 boundary is not overtopped during any scenario. To achieve this, the levee is required to vary in height from 1 m to 3 m above natural ground level, with an estimated total fill quantity of 20,000 m^3 to achieve 0.1% AEP immunity.

To achieve PMF immunity for Open Cut 1 a levee height of 2.6 m to 4.0 m above natural ground level would be required, with an estimated total fill quantity of 45,000 m^3. A levee of height 0.8 m will be required along the eastern boundary of Open Cut 2 to prevent the breakout flow from Deep Creek inundating the pit area. Open Cut 4 will require a levee that has a height of between approximately 2.0 and 7.0 m above the natural ground level, for an estimated fill quantity of 16,000 m^3.

The isolation of the open pits from the available floodplain has an impact on the peak flood depths within Tooloombah and Deep Creek. As the developed case assumes a fully developed mining scenario - flow within the tributaries located within Open Cut 1 and Open Cut 2 are completely cut-off in the model. This leads to lower depths and velocities within tributaries located downstream of the pits. The downstream end of the 2^{nd} order minor tributary that runs through Open Pit 1 and Open Cut 2 now reports to the Raw Water Dam bunding water below 36.4 m AHD into the local contours of the area. As the upstream catchments of the tributary have been removed in the developed case, water is stored in the dam from pumping water out of Tooloombah Creek during high flow scenarios.

This results in a decrease in the peak depths within Deep Creek and Tooloombah Creek by 0.07 m and 0.03 m, respectively. The decrease is considered minor and will unlikely affect the aquatic ecology EVs.

Flooding of Access Roads

The access road wraps around the Project Area connecting CHPP 1 with CHPP 2 located near Deep Creek. To prevent backwater inundation from Deep Creek, modelling found that the access road alignment would need to be raised by up to 2.0 m. A corresponding fill volume of approximately 250 m^3 would be required. Filling in these backwater locations results in an afflux of 1.8 m during the 9.5% AEP event along the road alignment near Waste Area 2.

The hydraulic model also predicted that the access road near Open Cut 1 would need to be raised by between 1.0 and 2.0 metres to avoid inundation and provide a 10% AEP flood immunity.

Diversion Drains

The two diversion drains cause localised higher depths and velocities within Tooloombah and Deep Creek. The 1^{st} order minor tributary no longer reports to Deep Creek and is diverted around Open Cut 4 into Tooloombah Creek. This causes localised increases in peak flood depths at the diversion drain outlet.

The diversion of Open Cut 1 upstream catchment to Deep Creek results in an increase in peak depths and velocities. Measured at Deep Creek Bridge, an increase in depth of 0.38 m was predicted for the 0.1% AEP event.

Overall, the impact of the two diversion drains is considered minor. Although they cause localised increases in flood depths and velocities, changes are limited to the immediate area and do not propagate any great distance upstream or downstream.

Flooding to Critical Infrastructure

MIA and CHPP 2 are located within the floodplain of Deep Creek and have been represented in the model by a raised area corresponding to the fill pad upon which this infrastructure will sit. The pad elevation of 31.5 m AHD was selected to ensure that infrastructure is not inundated under any scenarios up to the 0.1% AEP event. The pad would be inundated under the PMF event, as indicated in Figure 9-28. In general, the addition of a fill pad to the flood plain was found to cause a water level afflux of up to 0.6 m in the immediate area, and a decrease in peak flood velocity of approximately 0.67 m/s.

The location of MIA and CHPP 1 is not affected by flooding, as it is located at the top of a ridge, and the nearby CHPP environmental dam drains away from this infrastructure, with the result that even if the dam is overtopped, the infrastructure areas remain unaffected.

Flooding to Hazardous Dams

At the time of modelling an environmental dam, located north of Open Cut 4, was included for a waste area which was since removed from the design. The inclusion of this dam does not affect the modelling results.

Flood modelling confirms that all environment dams can contain the surface runoff generated by the 9.5% AEP event without overtopping.

Flood Impact of Deep Creek Conveyor Option

The option to transport ROM coal between Open Cut 1 and the MIA and CHPP 2 via a conveyor located underneath Deep Creek Bridge, was assessed in the flood model. This option is illustrated in Figure 9-41.

The option has not been explicitly modelled, as it is beyond the capabilities of the software; however, the option has been assessed by investigating the AEP at which the conveyor would be inundated and the corresponding velocities that the infrastructure would need to withstand.

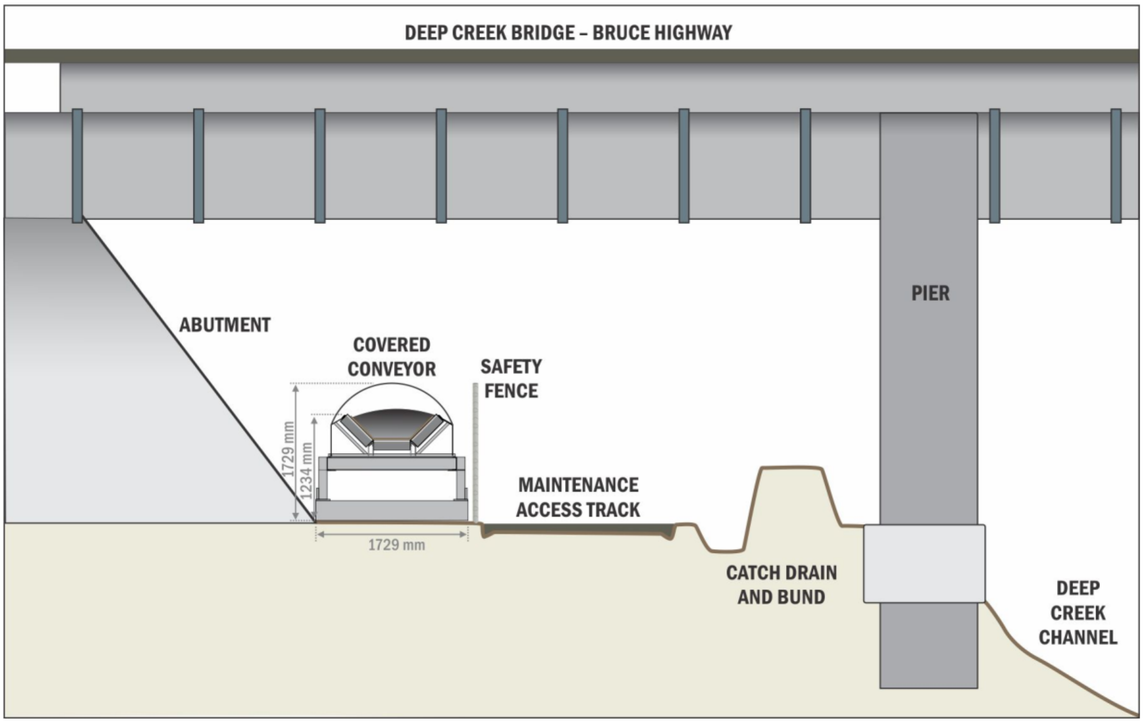


Figure 9-41: Conveyor crossing under Deep Creek road bridge

In the developed case, the conveyor is subjected to higher peak flood depths and velocities than in the baseline case. These changes result in:

- A peak depth afflux of between 0.03 m and 0.36 m; and
- A peak velocity afflux of 0.07-0.32 m/s.

The out-of-channel area is inundated for events between 9.5% and 0.1% AEP. The following flood depths are expected at the conveyor location:

- 0.45 m during the 4.9% AEP event; and
- greater than 0.99 m within the 2% AEP or larger events.

The likely velocities that the conveyor will need to withstand is in the range of 1.21 m/s to 2.47 m/s. There will be minimal effective flow area reductions below the bottom of the conveyor belt as water is still capable of passing beneath the belt due to the portal frame structure. Above this level the conveyor structure will significantly affect the effective flow area and would result in the inundated of product.

The conveyor is unlikely to cause any impacts on the flood inundation extent or height of flooding within the area. This assumes that the conveyor structure is a portal frame which will allow water to pass below it until a certain height and the fact that the infrastructure would be dismantled and relocated from under the bridge prior to the commencement of large flood events.

Flood Impact of Deep Creek Culverts

Culverts are required at three locations to enable watercourses to drain freely beneath the haul road.

Installation of the culverts, and the embankment in which they sit, is predicted to cause increases to peak water levels on the upstream side.

The following changes to the peak flood depths and velocities were predicted:

- Culvert location 1:
  - Flood depth increase of between 0.15 m and 0.61 m; and
  - Flood velocity increase of between 0.08 m/s and 0.18 m/s.
- Culvert location 2:
  - Flood depth increase of between 0.76 m and 1.22 m; and
  - Flood velocity increase of between 0.17 m/s and 0.95 m/s.
- Culvert location 3:
  - Flood depth increase of between 0.5 m and 0.97 m; and
  - Flood velocity increase by between 0.03 m/s and 0.17 m/s.

Changes to flood depths are considered minor and have no impact on the flooding experienced in the Project area. The increase in velocities is caused by flow contraction through the culverts. This will be addressed by the provision of scour protection (such as concrete aprons, rip-rap or rock mattresses) at culvert outlets.

9.6.3 Mine Site Drainage Assessment

The Project's impact on riverine flooding in Tooloombah Creek and Deep Creek, as well as the change in flood hydraulics in the minor drainage gullies that transect the MLA are discussed in Section 9.6.1 and 9.6.2. The method for assessing these impacts is not as appropriate for the design of the mine site stormwater drainage for the following reasons:

- The rainfall runoff hydrologic model detailed in Section 9.6.1 has been developed for critical storm durations of Tooloombah Creek and Deep Creek catchments. Local catchments that contribute to mine stormwater culverts and drains are much smaller and hence have a much-reduced critical storm duration. In all cases, stormwater systems are designed to the critical storm duration at the location of the stormwater drain or structure;
- The hydrologic model outputting hydrographs, when only peak flows are required to size the stormwater system;
- The hydraulic model detailed in Section 9.6.2 being simulated on a 10 m grid, which is insufficient to capture the detail of small scale drains and culvert structures, which would in any case be modelled in 1D within the two-dimensional model domain; and
- Empirical formulae representing a more practicable approach to sizing the stormwater system for the nominated AEP design event.

The mine site drainage assessment detailed herein therefore utilises empirical methods to size the following stormwater elements:

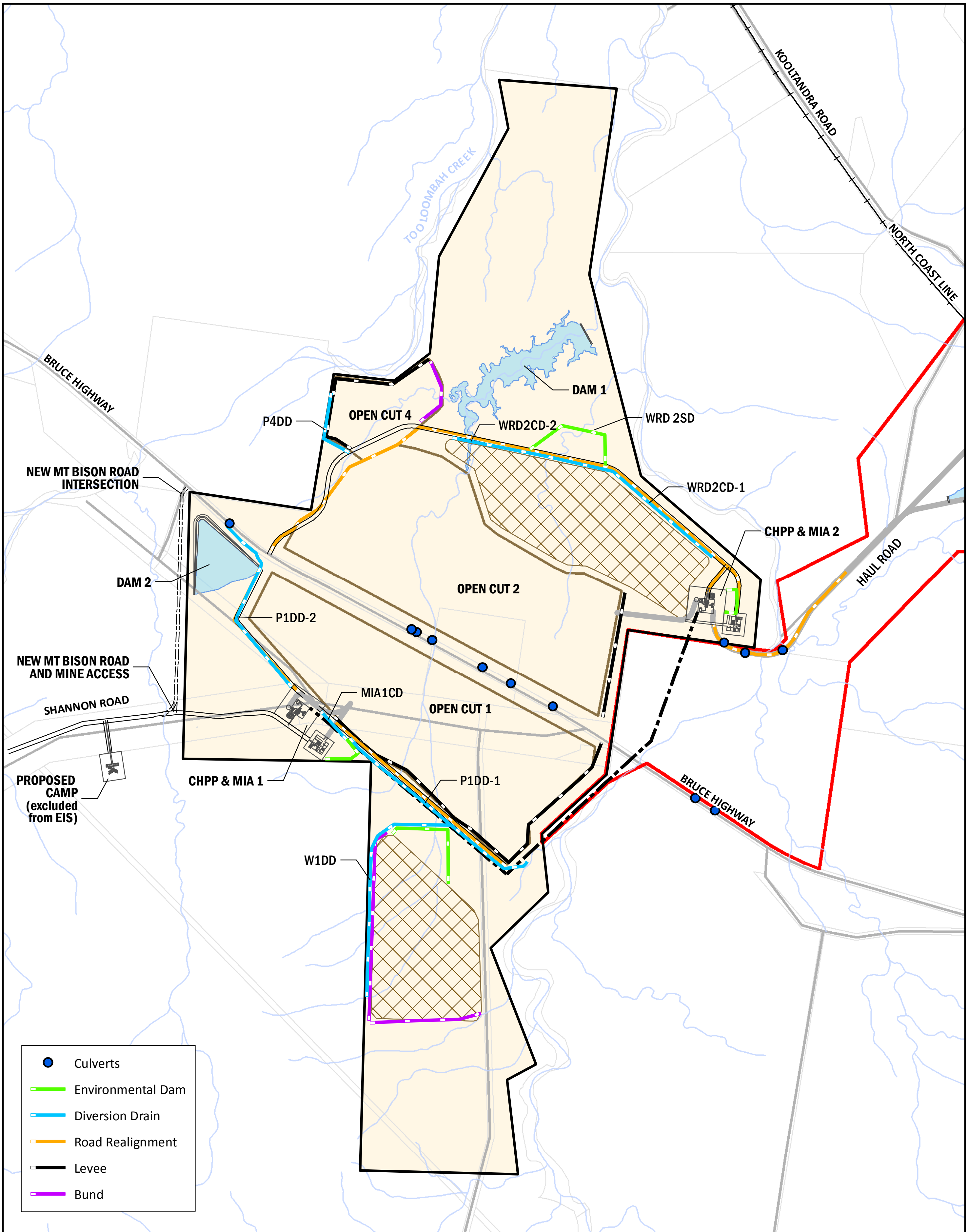
- Haul road culvert crossings;
- Dirty water diversion drains;
- Clean water diversion drains; and
- Clean water diversion bunds.

9.6.3.1 Stormwater Management Overview

Stormwater runoff containment devices, namely environment dams and drainage sumps, function to capture dirty water runoff generated from disturbed areas such as stockpiles and workshops. Environment dams are sized based on the 10 year ARI, 24 hour rainfall event in keeping with the EHP *Stormwater Guideline* (EHP 2014b). Environment dams will have a low flow perforated riser-pipe outlet to discharge treated water to the receiving environment. Environment dams are located at the MIA, overburden stockpiles and TLF. MIA drainage sumps and proprietary oil removal devices are proposed to capture runoff from truck wash and workshop areas for treatment and reuse or disposal.

Runoff intercepted by or generated from haul roads will be captured in table drains and conveyed longitudinally towards culvert structures. In areas of steeper grade, sediment transport can be effectively managed using check-dam structures within the drain. Where haul roads cross drainage gullies or the Deep Creek watercourse, an appropriately sized culvert will be provided, allowing for fish passage where relevant.

Clean water runoff from local catchments will be diverted around open pit mining areas for events up to and including the 0.1% AEP (1,000 year ARI) flood. The volume of stormwater entering open mine pits and becoming mine affected water is therefore effectively limited to that rain which falls directly on the open pit area. Precipitation received in the open pits will be dewatered to an ex-pit storage (pit dewater dam) for reuse, or discharged to receiving waters as controlled discharges under conditions licensed be the Environmental Authority.



N

0 0.5 1 km

Scale @ A4 1:45,000
Date: 24/07/17
Drawn: Gayle B.

Legend

ML 80187
ML 700022
Open-cut Mine Pit
Dam Catchment
Waste Dump Area
Overland Conveyor
Haul roads
Proposed mine infrastructure
Watercourse
Cadastral boundary
North Coast Rail Line
Main road

Figure 9-42
Mine site drainage

DATA SOURCE
QLD Open Source Data, 2017

CDM Smith

BRUGGEMANNGD B:\BES150160 Styx Coal\GIS\DATA\MXD\FINAL\.03 EIS Preparation\BES150160.03-046 R3 Mine Site Drainage.mxd 7/24/2017

9.6.3.2 Clean Water Diversions

Diversion drains and bunds are proposed to divert clean water runoff around the mine affected areas, including the open pits and waste areas (see Figure 9-42) This reduces the potential volume of mine-affected water that is created, subsequently minimising the need for storage and release management.

The two diversion drains around Open Cut 1, namely diversion drain P1DD-1 and P1DD-2, have been sized to pass the 0.1% AEP event. P1DD-1 discharges to Deep Creek south of the Deep Creek bridge on the Bruce Highway, whereas P1DD-2 discharges to the 1st order drainage feature that forms a tributary of Deep Creek.

In the developed case, the 1st order drainage feature is diverted downstream at Open Cut 4 into Tooloombah Creek via P4DD. A drainage bund is proposed on the open pit side of the diversion drain to increase the pit immunity to a 0.1%AEP event. The drains will be cut into the existing ground and the cut material used to construct a bund on the downgradient side (see Figure 9-43).

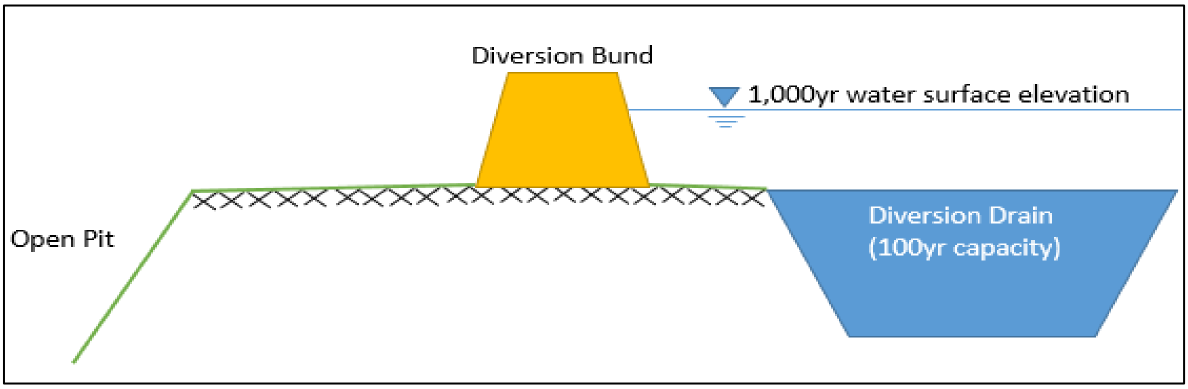


Figure 9-43 Diversion drain and bund concept

A diversion drain is also specified to capture clean water from the catchment upstream of Waste Area 1 and diverts it through WRD1DD into the P1DD-1. This diversion drain has been sized for the 1% AEP event.

9.6.3.3 Dirty Water Drains

Dirty water drains collect runoff from stockpiles, waste areas and processing facilities within the vicinity of the CHPP, ROM and MIA, and discharge to the CHPP Environment dams and waste area environmental dams. These dirty water drains have been sized to capture runoff generated from a 9.5% AEP event, which represents the design capacity of the environment dam for which they discharge to. BCSCD-1, BCSCD-2 and MIACD divert dirty water from catch drains into the CHPP Environment Dam. Similarly, the waste areas have a series of perimeter catch drains, with a design capacity of 9.5% AEP, that discharge to the Waste Area 1 Environment Dam.

There will be bunds that run on either side of the Bruce Highway that separates Open Cut 1 and Open Cut 2. In addition to preventing runoff from entering the pits, the bunds will act as a barrier to minimise visual impacts from the road, and to reduce driver distraction. On either side of the bund will be a sediment collection drain and a diversion drain that redirects the flow to the main culvert along the Bruce Highway (see Figure 9-44). This concept is shown in Figure 9-44. Both the collection drain and diversion drain will have a minimal catchment and have been sized based on 9.5% AEP event. Check dams will be installed in the sediment catchment drain to drop out sediment prior to entering the existing tributary and Bruce Highway culvert crossings. The drains will require periodic cleaning of sediment to maintain their efficacy.

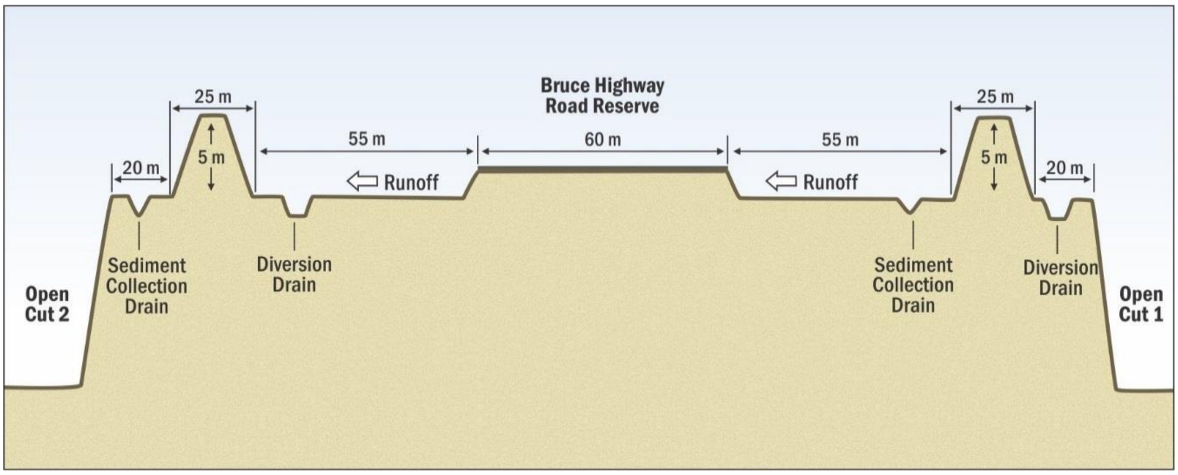


Figure 9-44 Bruce Highway catch drain arrangement

9.6.3.4 Culvert Crossings

The proposed haul road connecting the MIA and CHPP 2 with the TLF crosses several drainage gullies, therefore requiring cross-drainage culvert infrastructure. The location of these structures is shown in Figure 9-42. The crossings are conceptualised as box culvert crossings with capacity to pass a minimum 9.5% AEP design discharge. Discharges above the design event will pass over the box culvert as a floodway-type arrangement. The floodway arrangement efficiently passes flows over the road, therefore reducing impacts on localised flood depths and velocities, as well as impacts associated with rising headwaters upstream of the culvert crossing. The use of box culverts removes the need to place cover fill material and hence reduces the migration of sediments where potential scour velocities develop around the culvert structure. The box culvert and floodway concept is illustrated in Figure 9-45. The figure also shows the approach to using circular low flow culverts on overbank regions, if required, including the implementation of a rock armoured floodway.

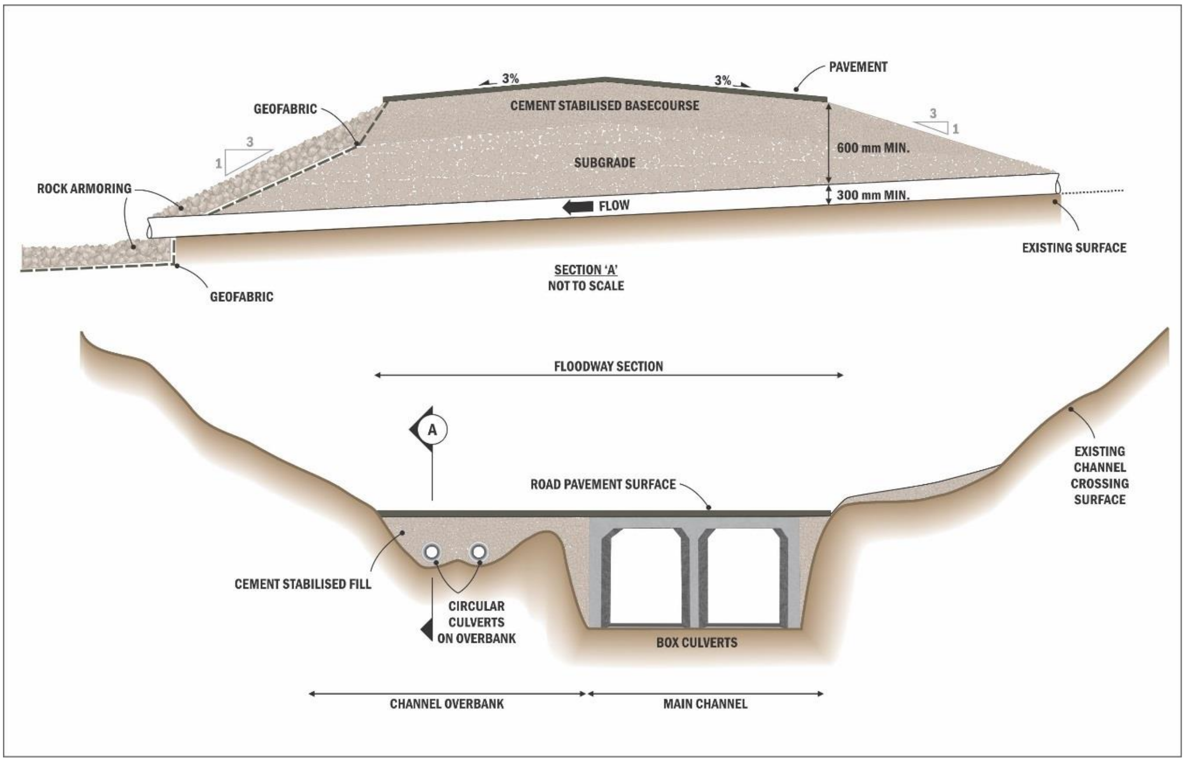


Figure 9-45 Box culvert and circular culvert and floodway arrangement

Fish Passage Design Considerations

Consideration has been given to the requirements of Section 5.2 of State Development Assessment Provisions (DILGP 2013), "Constructing or raising waterway barrier works in fish habitats state code".

The code contains a number of provisions that should be addressed. Key items, and their applicability to the Project, are discussed below:

- Access for fish along waters and into key fish habitats is maintained and restored:
    - The MLA is not considered a key fish habitat due to the Project infrastructure location intercepting 1st and 2nd order streams of low to moderate impact (see Figure 9-46)
    - Deep Creek is defined watercourse with a high impact rating (see Figure 9-46). A box culvert arrangement provides clear access for fish along this watercourse
- The ability for fish to move through the waterway network and access alternative habitats is maintained and restored (longitudinal connectivity):
    - Longitudinal connectivity is maintained through addition of culverts
- Connectivity between main waterway channels and other aquatic habitats (for example, inundated floodplains) is maintained and restored (lateral connectivity):
    - There is no floodplain connectivity in the MLA region
- The haul road culvert crossings comply with the acceptable outcomes for Performance Outcome 23 by installing culverts only where the site conditions do not allow for a bridge:
    - Due to the small and ephemeral nature of the haul road crossings within the MLA, bridge structures are not considered feasible
    - A bridge could be constructed on Deep Creek; however, this does not represent a cost-effective solution where suitable box culvert structures can be installed
- The combined width of the culvert cell apertures is equal to 100 per cent of the main channel width:
    - The crossings are designed to provide low flow passage through the width of main channel and then overtop for out of bank flood flows
- The culvert crossing and associated erosion protection structures are installed at no steeper gradient than the waterway bed gradient:
    - This is standard design practice and will be applied to this Project
- For the life of the culvert crossing, relative levels of the culvert invert, apron and scour protection and the stream bed are kept so that there are no drops in elevation at their respective joins:
    - The profile between scour aprons and culvert inverts will be flush and with no steps that will impede fish passage
- The base of the culvert is:

  - Buried a minimum of 300 millimetres to allow bed material to deposit and reform the natural bed on top of the culvert base or
    - This is required for the use of circular culverts or box culverts with a base slab
    - The base of the culvert is the stream bed or
    - This is only permissible for box culverts with footings instead of a base slab. The use of footings must be confirmed through geotechnical analysis during the detailed design phase
  - The base of the culvert cell is roughened throughout the culvert floor to approximately simulate natural bed conditions:
    - This outcome is not proposed as it reduces the cover to reinforcement and would likely breach manufacturer's standards and the culverts structural integrity
- The outermost culvert cells incorporate roughening elements such as baffles on their bankside sidewalls:
  - This condition will be considered for the Deep Creek crossing only
- Roughening elements are installed on the upstream wingwalls:
  - This condition will be considered for the Deep Creek crossing only
- Roughening elements provide a contiguous lower velocity zone (no greater than 0.3 metres/second) for at least 100 millimetres width from the wall through the length of the culvert and wingwalls:
  - This condition may not be appropriate given high velocity flow already present in the natural stream channel. Furthermore, no design event is listed for this velocity condition to be met in practice
- In-stream scour protection structures are roughened throughout to approximately simulate natural bed conditions:
  - Rock aprons are typically used and are appropriate
- Culvert alignment to the stream flow minimises water turbulence:
  - Culverts are aligned in the direction of flow
- There is sufficient light at the entrance to and through the culvert so that fish are not discouraged by a sudden descent into darkness:
  - The culvert length is a function of haul road width. The minimum width that allows safe crossing of the haul road vehicles will be applied
- The depth of cover above the culvert is as low as structurally possible, except where culverts have an average recurrence interval (ARI) greater than 50 years:
  - A 9.5% AEP design has been adopted. A box culvert solution will allow for minimal to no depth of cover
- For culvert crossings designed with a flood immunity >ARI 50, fish passage is provided up to culvert capacity:

  - Not applicable

- Adequate design (for example, culvert aperture) and maintenance measures are in place for the life of the crossing to keep crossings clear of blockages through a regular inspection program to retain fish passage through the crossing; and

- Crossings within the bed and banks do not incorporate culverts.

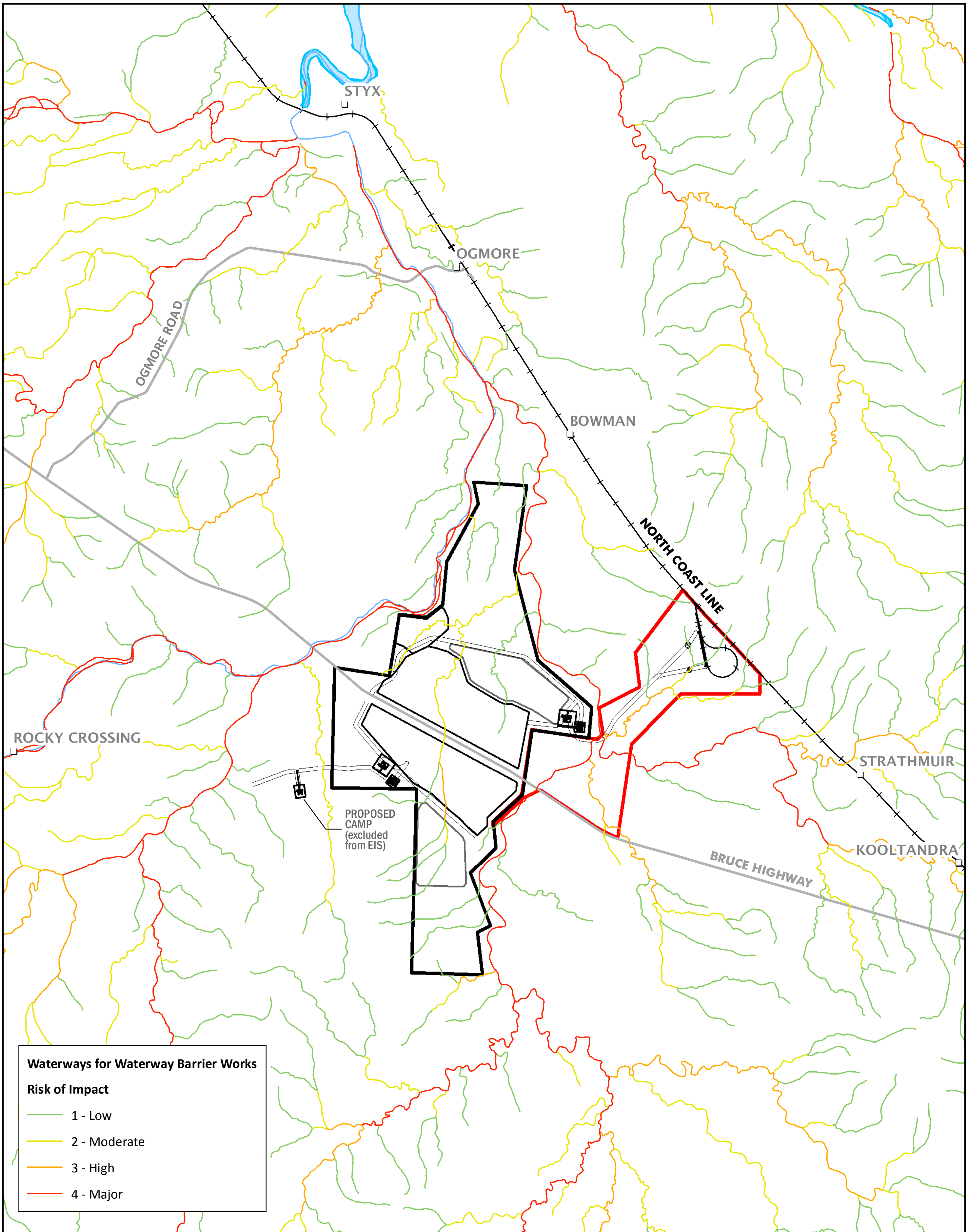


Figure 9-46

Fish habitat area and risk of impact

Legend

- ML 80187
- ML 700022
- MSES – Declared Fish Habitat Area
- Proposed mine infrastructure
- North Coast Rail Line
- Main road

0 1 2 km

Scale @ A4 1:100,000
Date: 17/07/17
Drawn: Gayle B.

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017

CDM Smith

BRUGGEMANNGD B:\BES150160 Styx Coal\GIS\DATA\MXD\Chapter 9\BES150160.03 R3 fish habitat and watercourses.mxd 7/17/2017

9.6.3.5 Stormwater Culvert and Drain Peak Design Flow Estimates

To establish the sizing of stormwater infrastructure, the local catchments reporting structures and drains was determined and the likely peak flow was estimated for a nominated design AEP event. The peak flows were initially determined using the Regional Flood Frequency Estimation (RFFE) (ARR16). However, the RFFE formulae were derived from catchments much larger than those associated with the Project stormwater system and produced peak flow estimates that were extremely high and unrepresentative of the Project catchments. It was therefore determined that the rational method would be used in the sizing of these drainage infrastructures.

The probabilistic Rational Method provides an estimate of peak discharge for a given design storm frequency, and is represented as follows:

$$Q_y = (C_y * I_y * A)/360$$

Where:

Q_y = Peak discharge (m^3/s);

C = Coefficient of Runoff;

I = Design Rainfall Intensity (mm/h);

A = Catchment Area (ha); and,

The subscript ‘y’ denotes the particular AEP under consideration.

Catchment analysis was undertaken in ArcGIS to delineate the various local catchments reporting to the diversion drains and haul road culvert crossings. The corresponding catchments to each crossing, diversion drain and catch drain are shown in Table 9-36.

The diversion drains and haul road crossings are assumed to be constructed in Year 1 of the mine life and therefore representative of conditions where the greatest peak flow will report to the structures throughout the mine life. As mining develops, the contributing catchments to some structures and drains is reduced and the structures and drains will essentially be oversized from that point forward. The locations of the stormwater elements are shown in Table 9-36.

Table 9-36 Local catchment areas

Catchment name	Area (ha)
P1DD-1	505
P1DD-2	189
W1DD	207
P4DD	252
W2CD-1	90
W2CD-2	90
W3CD-1	15
W3CD-2	16
MIA1CD	21

The Coefficient of Runoff ‘C’ and rainfall intensity ‘I’ were calculated following the guidance provided in the *Queensland Urban Drainage Manual* (DEWS 2013). The Coefficient of Runoff is a dimensionless factor designed to account for the various natural processes that intercept or otherwise prevent precipitation from turning into runoff. It considers the degree of pervious surfaces in the catchment, the type of ground cover, and an estimate of the soil porosity. It varies in accordance with storm frequency per the equation below:

$$(C_y = F_y * C_{10})$$

Where:

C = Coefficient of Runoff;

F = Frequency Adjustment Factor;

C10 = Coefficient of Runoff, 10 yr ARI design rainfall event; and

The subscript 'y' denotes the ARI under consideration.

Coefficients of Runoff adopted for this analysis are presented in Table 9-37. The result peak flow predictions for each catchment, for a range of standard ARI events, is presented in Table 9-38 and Table 9-39, for diversion drains and haul road culverts, respectively.

The diversion drains estimated peak flows in Table 9-38 are the peak flows at Year 1 when the contributing catchment areas to the diversion drains are at their largest. The haul road crossing peak flows presented in Table 9-39 are calculated in accordance with catchment areas as of mining Year 1. As the mining progresses, the contributing catchments to the diversion drains and haul road crossings will decrease, therefore decreasing the estimated peak flow and increasing the design immunity of the system.

Table 9-37 Coefficients of runoff

ARI	F_y	C_{10}	C_y
10 year	1.00	0.70	0.70
20 year	1.05	0.70	0.74
50 year	1.15	0.70	0.81
100 year	1.20	0.70	0.84

Table 9-38 Rational method peak flow – diversion drains

Diversion name	Peak flow at outlet (m^3/s)			
	10% AEP	5% AEP	2 % AEP	1% AEP
P1DD-1	60.3	71.5	89.9	103.0
P1DD-2	18.1	21.5	27.2	31.3
W1DD	41.3	48.6	60.9	69.5
P4DD	37.3	41.8	42.1	48.2

Table 9-39 Rational method peak flow – haul road culverts

Haul road crossing	Peak flow at outlet (m^3/s)			
	10% AEP	5% AEP	2 % AEP	1% AEP
Haul Road Crossing 1 (based on hydraulic modelling)	2,779	3,025	3,135	3,678
Haul Road Crossing 2 (based on hydraulic modelling)	767	816	840	965
Haul Road Crossing 3 (based on hydraulic modelling)	134	147	150	178

9.6.3.7 Stormwater Culvert and Drain Sizing

The culvert arrangement has been conceptualised to pass the 9.5% AEP peak flows (see Section 9.6.3.5) through the culvert, with greater flows passing over a floodway arrangement. The culvert locations are illustrated in Figure 9-42. The low flow culvert and floodway arrangement reduces filling within the drainage gullies and reduces flood afflux for rare and extreme flood events by more efficiently passing flows over the floodway. A greater flood immunity may be adopted, however due to the small critical times of concentration of the contributing catchments, road overtopping events are not likely to significantly hinder mine operations or access for extended periods.

The culvert sizing results are summarised in Table 9-40. The sizing is based on reinforced concrete box culverts. The use of box culverts allows for fish passage at low and high flows and reduces the velocity through the structure. Furthermore, open bottom box culverts are preferred for fish passage over the use base slabs, however box culverts along the haul road will likely require at least a concrete footing. Deep Creek and tributary crossing was sized in the hydraulic assessment by constructing a 1D culvert within the 2D model domain. Further information regarding the sizing of the culvert is discussed in Section 9.6.2.2.

Table 9-40 Culvert sizing

Crossing	Headwater depth (m)	Peak flow (m^3/s)	Number of Units	Span x Height (mm)	Type
Haul Road Crossing 1 (based on hydraulic modelling)	6.47	2780	5	3600x3600	RCBC
Haul Road Crossing 2 (based on hydraulic modelling)	5.72	767	5	3600x3600	RCBC
Haul Road Crossing 3 (based on hydraulic modelling)	4.39	134	5	3600x3600	RCBC

Note: RCBC= reinforced concrete box culvert, size in mm diameter

Diversion drain dimensions are summarised in Table 9-41 for the specified design events and corresponding peak flow estimates. The drains were sized using Manning's Equation, as follows:

$$Q = 1/n * A * R^{2/3} * Se^{1/2}$$

Where:

Q = Design flow (m^3/s);

n = Manning's roughness coefficient;

A = Flow area (m^2)

R = Hydraulic Radius (m)

Se = Channel slope (m/m)

Table 9-41 Rational method peak flow – diversion drains

Diversion drain	Design event (ARI)	Design flow (m^3/s)	Design velocity (m/s)	Base width (m)	Channel slope (%)	Depth (m)	Side slope (1V:XH)
P1DD-1	100	103.0	1.50	6.0	1.1	1.9	3
P1DD-2	100	31.3	2.25	6.0	0.5	1.2	3
W1DD	100	69.5	2.00	3.0	1.3	1.6	3
P4DD	100	48.2	3.65	3.0	1.0	1.6	3

The diversion drains around the south pits will incorporate a diversion bund on the pit side of the drain to provide a combined 0.1% AEP flood immunity from runoff generated by local upstream catchments. This concept is shown in Figure 9-43 and is tested hydraulically in flood modelling covered under Section 9.6.2.

Catch drains that report to the overburden environment dams cater for smaller catchments compared to those of the diversion drains. The peak discharge in catch drains will also likely be attenuated by storage and attenuation within the overburden pore space. Notwithstanding, the catch drains have been conceptualised to be consistent with the sizing of the diversion drains and are therefore likely conservative in their capacity. To further ensure adequate capacity, material removed from the catch drain can be formed into a diversion bund downgradient of the overburden stockpiles and in a similar arrangement to that shown in Figure 9-43 . Optimisation of the catch drain design will occur during detailed design of the water management system. The size of the catch drains is outlined in Table 9-42.

Table 9-42 Rational method peak flow – catch drains

Diversion drain	Design event (ARI)	Design flow (m^3/s)	Design velocity (m/s)	Base width (m)	Channel slope (%)	Depth (m)	Side slope (1V:XH)
W2CD-1	10	15.2	1.4	3.0	0.003	1.5	3
W2CD-2	10	15.2	1.8	3.0	0.003	1.2	3
W3CD-1	10	2.5	0.9	3.0	0.002	0.6	3
W3CD-2	10	2.7	1.0	3.0	0.002	0.6	3
MIA1CD	10	4.2	1.3	3.0	0.003	0.7	3

9.7 Water Resource Management

A schematic of the proposed water management network for the Project is shown in Figure 9-47. The breakdown of the mine water demands which must be satisfied by the water supply system is summarised in Table 9-43. The maximum total annual demand is calculated at 1,373 Megalitres (ML).

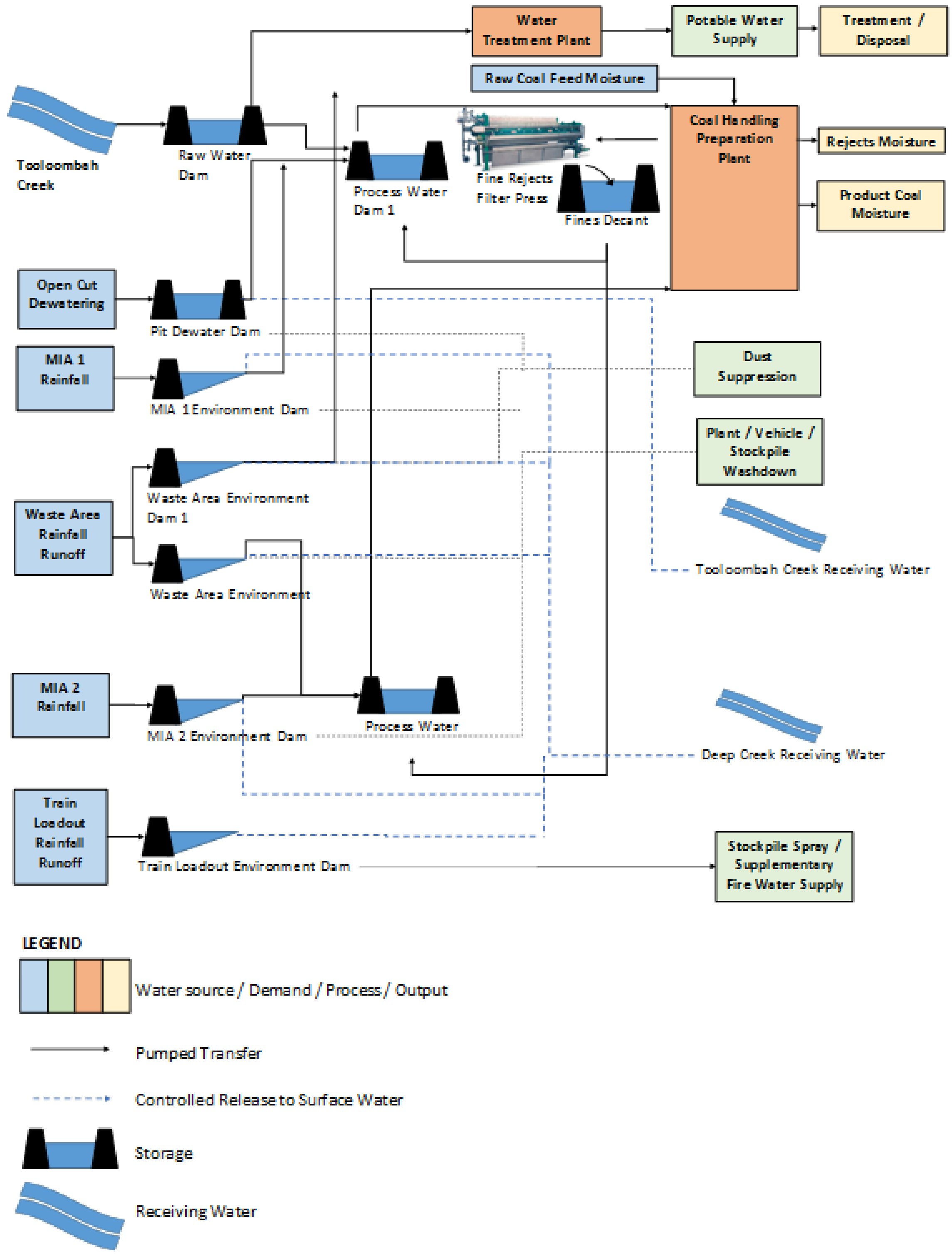


Figure 9-47 Proposed water management network

Table 9-43 Mine water demands

Water Use	Annual Water Use Per Year of Mine Life (ML)							
	1	2	3	4	5	6	7	8
Potable	3.1	3.8	4.0	4.2	4.5	5.0	5.4	5.6
Sewage	2.8	3.4	3.6	4.0	4.2	4.4	4.6	4.8
CHPP	-	-	100	100	200	200	300	300
Dust suppression	15	30	45	60	75	90	105	120
Washdown	10	10	12	12	15	20	22	25
Totals	**28.1**	**43.8**	**161**	**176.2**	**294.5**	**315**	**432.4**	**450.6**
Water Use	**Annual Water Use Per Year of Mine Life (ML)**							
	9	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Potable	5.8	6.0	6.3	6.3	6.0	5.8	5.4	5.0
Sewage	5.0	5.3	5.6	5.6	5.3	5.0	4.8	4.6
CHPP	400	400	500	500	400	300	200	100
Dust suppression	135	140	150	150	135	120	105	90
Washdown	28	30	36	36	30	28	25	22
Totals	**568.8**	**576**	**692.3**	**692.3**	**571**	**453.8**	**335.4**	**217**

The water demand for rehabilitation years (years 17-20) will likely be significantly lower than the demands during the operations of the mine. Water demands during rehabilitation stages is assumed to be 20 ML and will be finalised during detailed design.

A 350 ML raw water dam (RWD) is proposed to provide a secure water supply for both construction and operational phases and involves impounding a tributary drainage feature of Deep Creek and flood harvesting from Tooloombah Creek to provide a reliable water supply over the life of the mine. The proposed raw water flood harvest pipeline will be approximately 1 km in length and will draw water from Tooloombah Creek according to the specified licence conditions. For this assessment, an environmental pass flow of 172.8 ML/d (2 m^3/s) and a maximum extraction rate of 86.4 ML/d (1 m^3/s) is assumed.

The RWD will supply water for potable use (after first undergoing treatment), plant washdown, dust suppression and makeup water for the CHPP. The makeup water demand on the RWD is determined by the balance between incoming and outgoing coal and rejects moisture content, water required for coal washing, and decant water return from the CHPP decant ponds. The wet fines from coal washing will pass a filter press with an estimated 60% moisture recovery rate.

In general, reuse of water captured on site in environment dams and mine dewater dams will take preference over raw water use. Suitable applications for reuse water include CHPP makeup water, dust suppression and stockpile sprays, and vehicle washdown. The water will be sourced from the dam location and/or transferred to the Process Water Dams (PWD) for coal washing use within the CHPP.

Environment dams are proposed to capture rainfall runoff from the CHPPs, TLF and waste dump areas. The primary function of the environment dams is to capture sediment laden runoff for sediment removal. A perforated riser pipe outlet is proposed to allow gravity draining of the environment dam within 48 hours of filling. A gated outlet is proposed for potentially storing water for use (overburden and CHPP environment dams) or for stockpile spray and supplementary fire supply (TLF environment dam). Oil / water separators are proposed for vehicle wash and workshop areas to treat hydrocarbon contaminated runoff prior to release or containment in environment dams.

A potable water demand of approximately 6.3 ML/annum is estimated for the MIA. The potable supply will comply with standards outlined in the *Australian Drinking Water Standard Guidelines* (NHMRC and NRMMC 2011). The likely treatment of raw water from the RWD required to meet the standards would include sand filtration and chlorine dosing. A polyethylene potable use water tank will be required at the MIA for the storage of treated water. A sewage treatment plant is proposed to be located near the MIA. Effluent and sludge waste streams will be appropriately treated and discharged to surface or used as mulching media, respectively.

Fire water supply provisions are incorporated into the RWD storage capacity. A total of 5 ML has provisionally been included in the RWD for this water resources assessment. It is anticipated that these stores be replenished post use and that the total volume is available for firefighting activities during operations. Additional fire water supply will be provided at the TLF in closed storage tanks primarily designated for dust suppression supply.

9.7.1 Mine Water Balance

A water balance of the water management network described in Section 9.7 was simulated in GoldSim. The primary objectives of the water balance were to determine the net balance of water to be held in storages, the water reuse potential and raw water requirements. The main elements of the model are summarised in Table 9-44. The CHPP water balance, including decant water return and coal moisture input and rejects moisture outputs, was not simulated in the model; however, the overall CHPP make-up water demand from reuse water and raw water sources was included to obtain the net water balance. At the time of modelling a waste area to the north of Open Cut 4 was included, however this dam is no longer required due to a subsequent change in the mine plan. This dam is likely to have little impact on the model results due to the location and small size of the storage.

Table 9-44 Water balance model elements

Model element	Inputs	Outputs	Comments/assumptions
Process Water Dam	- Direct rainfall - Pump transfer from pit dewater dam and RWD	- Evaporation - CHPP demand	The process water dam is a turkey's nest storage located at each of the MIA locations and supplies water to the CHPP. The PWD holds a 14-day CHPP demand volume to buffer against water supply maintenance and breakdown. The PWD is kept full from transfers from the pit dewater dam (priority 1), transfers from environmental dams (priority 2) and the RWD (priority 3). The PWD does not discharge to the environment and has a design storage allowance to ensure overtopping does not occur.
Open cut mine pits	- Direct Rainfall; - Groundwater inflow - In-pit Runoff	- Evaporation - Pump transfer to ex-pit dams	Open cut pits contain a sump (nominally 5 ML) from which groundwater inflow and rainfall runoff volumes is stored. Water is transferred from the pit sump to an ex-pit mine dewater dam at a rate of 200 l/s.

Model element	Inputs	Outputs	Comments/assumptions
Pit dewater dam (Dam 2)	- Direct Rainfall - Groundwater inflow - Runoff - Pump transfer from in-pit sump	- Evaporation - Pump transfer PWD for CHPP use - Dust Suppression - Washdown - Licenced discharges	The pit dewater dam accepts water pumped from the open cut pit sumps to ensure dewatering of pits and continued access to the coal resource. The pit dewater stored volume is preferences for dust suppression, washdown and transfer to the PWD for CHPP use.
Raw Water Dam (Dam 1)	- Direct Rainfall - Catchment runoff - Flood harvest from Tooloombah Creek	- Evaporation - Potable use - Pump transfer PWD for CHPP use, - Dust Suppression - Washdown	The raw water dam is located near Open Cut 2, which forms the raw water demand source. Demand for raw water depends on the available and suitability of mine affected water for use in the CHPP, for dust suppression and for washdown use. The Raw water dam is the only source for potable water supply.
Environmental Dams	- Direct Rainfall - Catchment runoff	- Evaporation - Pump transfer PWD for CHPP use, Dust Suppression and Washdown - License discharge	There are six environmental dams around the project that transfers water to the PWD to minimise the project's reliance on the RWD. Each of the CHPP and MIA's, waste areas and TLF (Dam 3) have an environmental dam. The dams have been sized using a 10 yr 24hr storm. The environment dams that are closest to the PWD have priority over dams that are further away. Each of the dams have an established licence condition

9.7.2 Climate Data

A total of 127 years (1889 to 2017) of SILO historical climate data (DSITI 2017) was used to simulate climate variability within the water balance model (see Section 9.4.1.1 for a climate data and variability discussion). By running multiple simulations of the 16-year operational mine plan and by stepping through the full 127 years of available historical climate data, the net water balance in the driest and wettest years were analysed.

During the driest years, there is more reliance on raw water supply, whereas during the wettest years there is more opportunity for water reuse. Moreover, during the wetter years there is a greater net storage requirement to contain open pit mine dewater volumes as well as catchment runoff volumes and direct rainfall falling on the storage areas. Morton's Lake evaporation was used to simulate evaporation from storages; whereas Morton's Wet evapotranspiration rates were used to estimate evaporation from soil moisture stores.

9.7.3 Groundwater Inflow and Licenced Discharges

The water demands and sources for the Central Queensland mine is presented in Table 9-43, Section 9.7.1. It should be noted that groundwater inflows also represent a water source that is collected in open cut pit sumps and transferred to the pit dewater dam. Groundwater inflow volumes predicted for the Project are estimated in Chapter 10 - Groundwater and summarised in Table 9-45 and Figure 9-48.

Table 9-45 Predicted groundwater inflow rates and volumes

Mining year	Average inflow rate (ML/day)	Period inflow volume (ML)	Cumulative Volume (ML)
	Open cut	Open cut	Open cut
1	2.5	902.0	902.0
2	2.5	894.9	1796.9
3	1.7	623.4	2420.3
4	1.6	598.6	3018.9
5	1.6	597.2	3616.1
6	0.9	344.0	3960.1
7	0.9	314.0	4274.1
8	0.7	253.1	4527.2
9	0.7	241.4	4768.6
10	1.8	657.4	5426.0
11	1.2	448.0	5873.9
12	1.3	491.5	6365.4
13	0.8	629.5	6655.5
14	0.3	705.3	6770.5
15	0.3	767.7	6886.7
16	0.3	856.0	6990.7

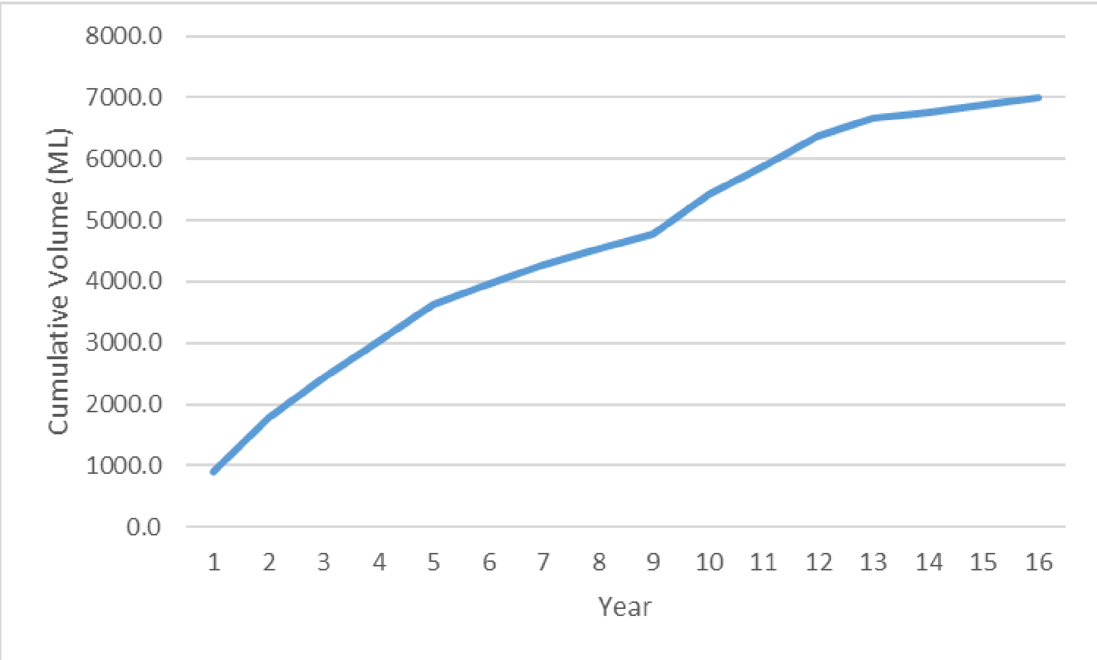


Figure 9-48 Cumulative runoff pit inflow volume

Licenced discharges will also be permitted under Environmental Authority conditions, allowing for better quality water to be released from the pit dewater dam during natural flow events in the receiving waters. The release limits proposed for the Project are presented in Section 9.5.5 and based on WQOs for the Styx Basin and an adopted instream dilution rate for electrical conductivity. For the water balance assessment, and in the absence of licence conditions to simulate, the pit dewater dam and WRD3 environmental dam were assumed to discharge to Tooloombah Creek at a rate of 1 m^3/s when discharge within Tooloombah Creek exceeded 2 m^3/s. The other environmental dams were assumed to discharge to Deep Creek at a rate of 1 m^3/s when discharge within Deep Creek exceeded 2 m^3/s.

9.7.4 Tooloombah and Deep Creek Flow Characteristics

No gauge data exists for Tooloombah or Deep Creek from which to estimate how frequently and to what magnitude licenced discharges and flood harvest activities could operate. A rainfall-runoff model was therefore established for the Tooloombah and Deep Creek catchments through implementation of Boughton's Australian Water Balance Model, which is a catchment water balance model that relates daily rainfall and evapotranspiration to runoff. The Australian Water Balance Model (AWBM) schematic is illustrated in Figure 9-49.

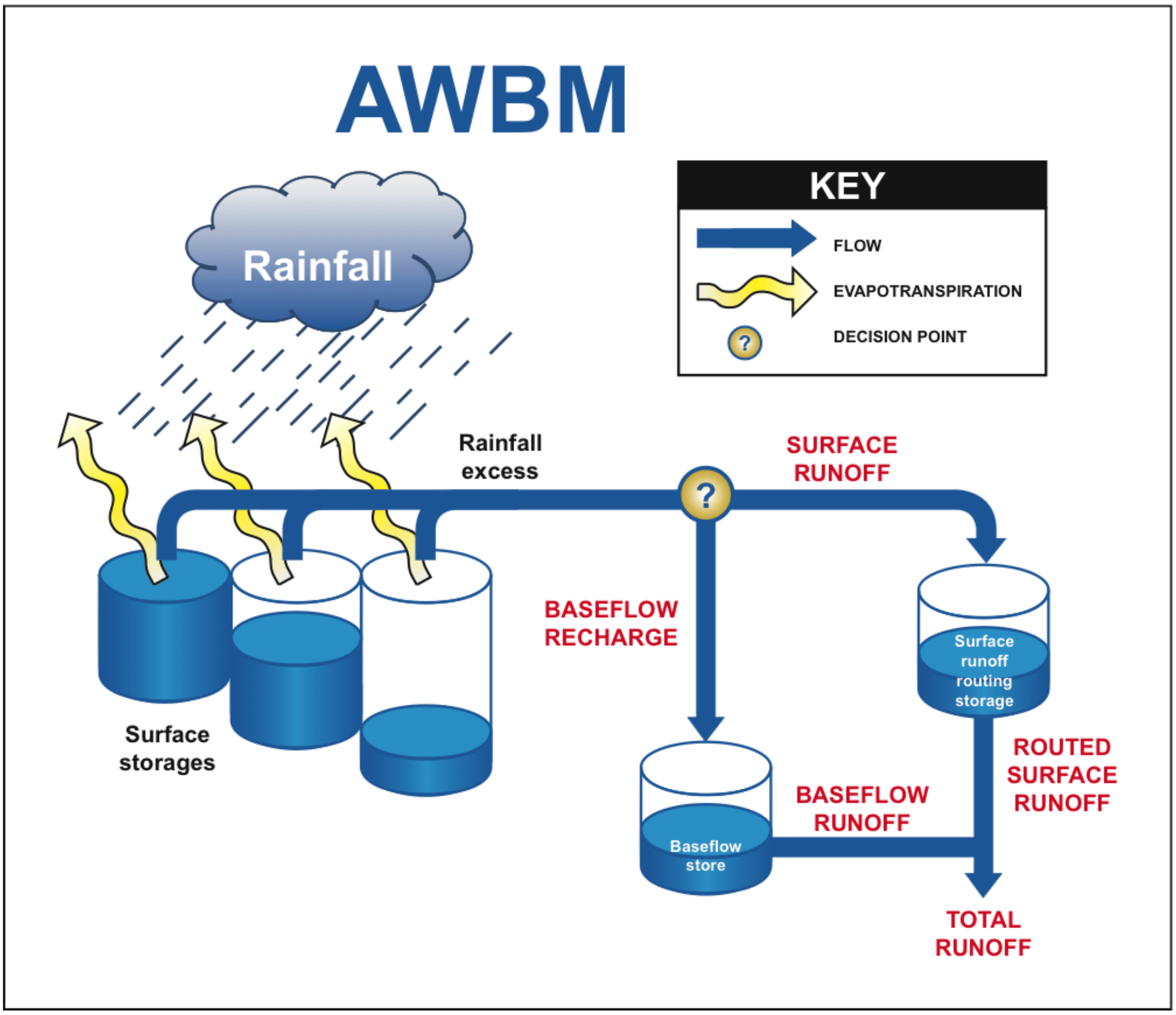


Figure 9-49 Australian Water Balance Model schematic

The adopted AWBM parameters are presented in Table 9-46, and are described as follows:

- BFI - The baseflow index, or ratio of baseflow to total flow;
- KBase - The baseflow recession constant where (1-KBase) multiplied by the baseflow store gives the rate of depletion from the store contributing to total runoff;
- KSurf- The surface recession constant, where (1-KSurf) multiplied by the surface store gives the rate of depletion from the store contributing to total runoff;
- C1-C3 - Surface storage capacities; and
- A1-A3 - Partial areas of the C1-C3 storage capacities.

Table 9-46 Australian water balance model parameters – adopted values

AWBM Parameter	Adopted Value	Default Value
Baseflow Index, BFI	0.17	0.35
Baseflow recession constant, Kb	0.95	0.95
Surface flow recession constant, Ks	0.10	0.35
Surface store capacity, C1	20mm	7mm
Surface store capacity, C2	50mm	70mm
Surface store capacity, C3	120mm	150mm
Partial Area, A1	0.134	0.134
Partial Area, A2	0.433	0.433
Partial Area, A3	0.433	0.433

Note: These parameter values are average values for Queensland catchments (Boughton W. 2009)

In the absence of data to calibrate the AWBM model, representative values from literature were used. These literature values were based on a study (Boughton, 2009) which investigated 70 catchments within Queensland in varying size from 51 km^2 to 1870 km^2. The rainfall over these catchments varied in quantity between 583-2289 mm/yr. By comparison, the catchments are for Tooloombah and Deep Creek are 370 ha and 298 ha respectively, with an average annual rainfall of 711 mm.

Since Tooloombah and Deep Creek have catchments sizes within the study range it is considered acceptable to use the parameter values established by Boughton's (2009) study for this water balance.

9.7.5 Water Balance Results

The primary objective of the water balance model was to determine the net water balance and the required storage sizes for the pit dewater dam, the PWDs, and the RWD. The maximum storage requirements are presented in Table 9-47. The pit dewater dam was sized based on having no non-compliant discharges, considering reuse and licenced controlled discharges. The RWD capacity was maximised to the extent of topographical constraints to provide reliable supply to the MIAs and CHPPs. The PWD was sized to have a maximum 10 days CHPP demand storage capacity to account for maintenance and down-time of the water management network.

Table 9-47 Maximum storage requirement

Storage	Design capacity (ML)
Raw Water Dam - RWD	350
Pit Dewater Dam - PDWD	220
Process Water Dams - PWD	5

Water reuse potential is high for the Mine due to the large predicted groundwater inflow volumes and runoff volumes collected in open pits, relative to mine water demands. The following figures show the 5th percentile, mean and 95th percentile storage results for the PWD 1, PWD 2 and the PDWD (Dam 2). The statistics are derived by assessing the climate variability over the historical rainfall and evaporation data record (1889 through 2017). The dates shown on the x-axis are not significant. They signify the arbitrary start date of the simulation, which is set to 1889 as this is the first year of historical climate data.

The following conclusions can be made from the results:

- For PWD 1, the maximum storage capacity reached is 5ML, for each of the 5th percentile, mean and 95th percentile scenario. This dam is continuously filled by transfers from all other environmental dams in close proximity. Note, transfer only occur to maintain this level;

- For PWD 2, the maximum storage capacities reached for the 5th percentile, mean and 95th percentile scenarios are 1.6 ML, 2.2 ML, and 3.3 ML respectively. This dam receives less transfers from environmental dams and the majority of its transfers are used to meet the water demand; and
- For the PDWD, the maximum storage capacities reached for the 5th percentile, mean and 95th percentile scenarios are 140 ML, 185 ML, and 210 ML respectively.

It is important to note the results contained herein are greatly influenced by the predicted groundwater inflow volumes, assumptions surrounding reuse (see Table 9-44) and the eventual release conditions imposed for mine affected water (see 9.9.2 for proposed strategy). On commencement of mine construction, detailed water balance models should be constructed, continually updated with new data and validated to reflect the conditions encountered.

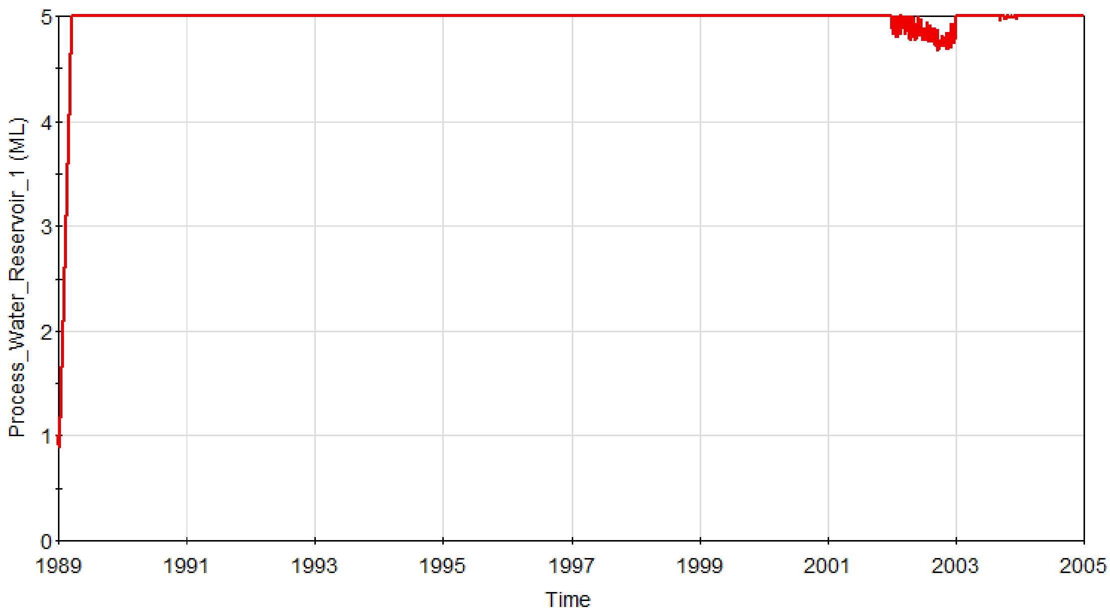


Figure 9-50 Process Water Dam 1 - 5th percentile storage history

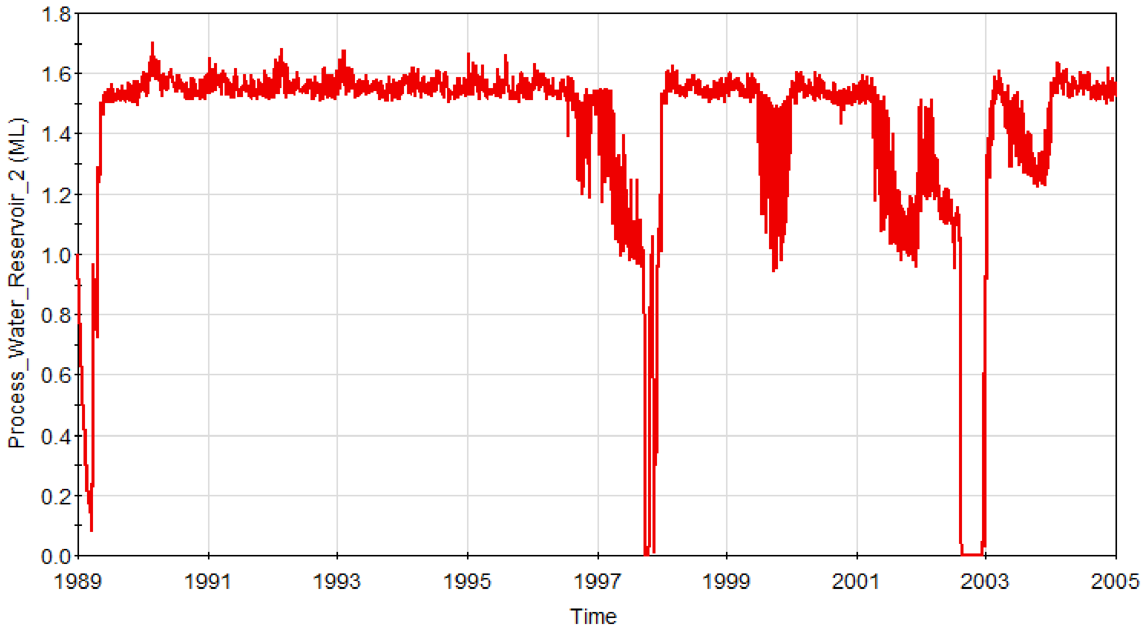


Figure 9-51 Process Water Dam 2 - 5th percentile storage history

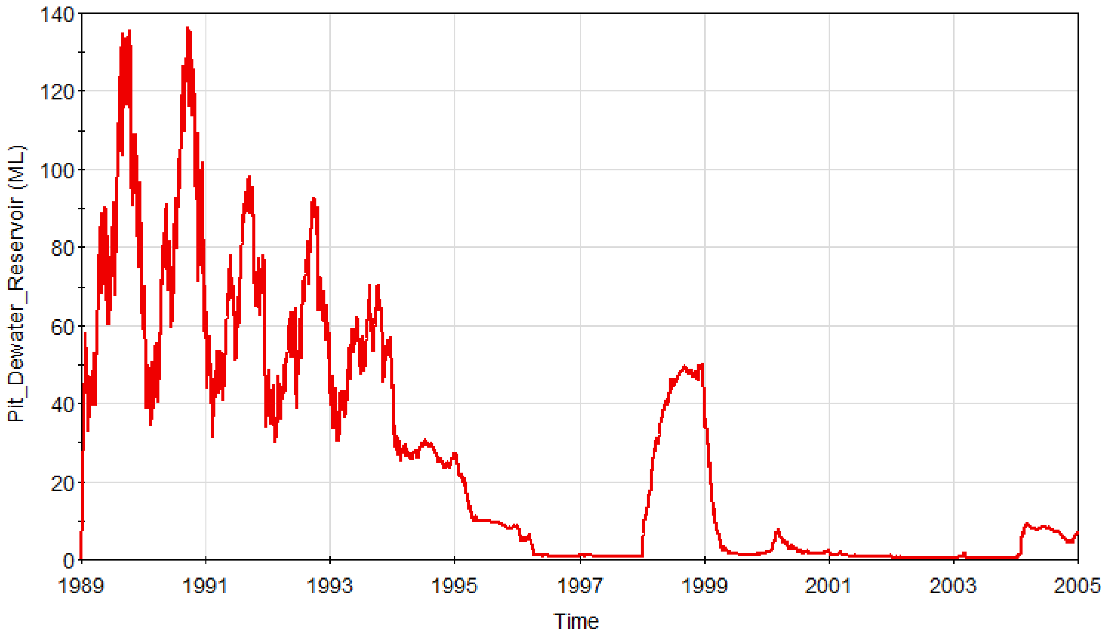


Figure 9-52 PDWD - 5th percentile storage history

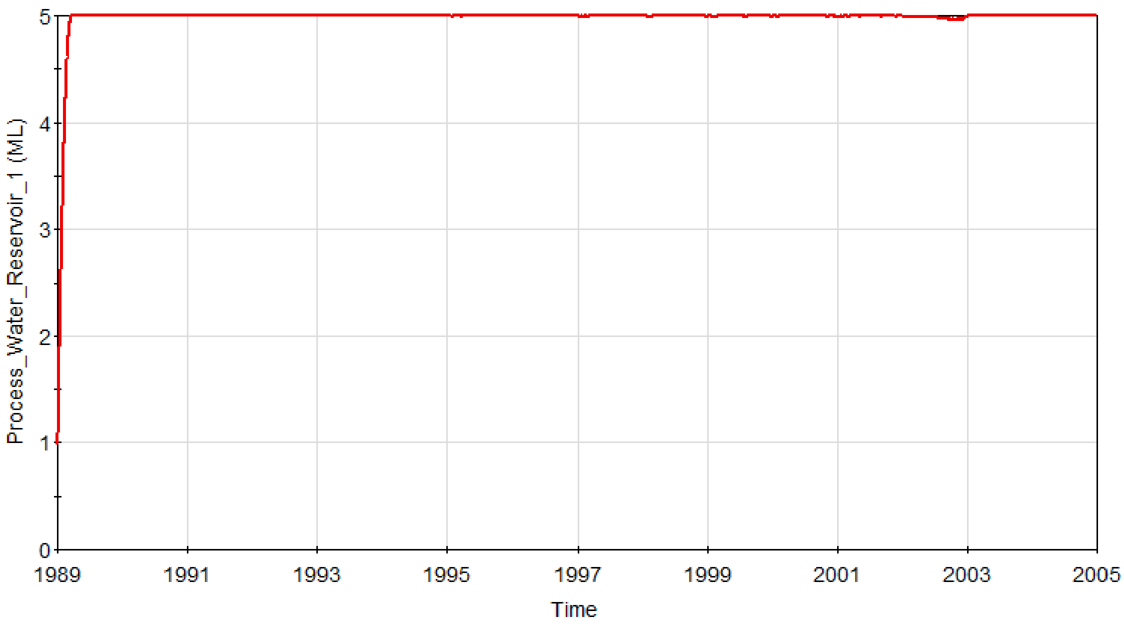


Figure 9-53 Process Water Dam 1 - mean storage history

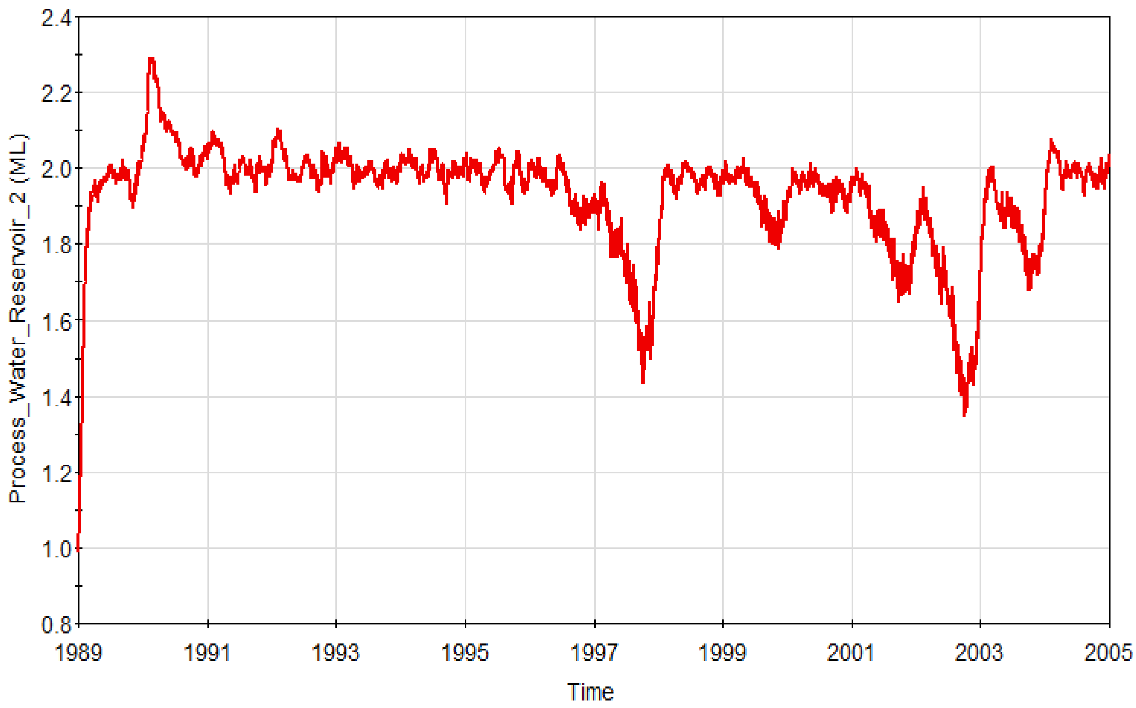


Figure 9-54 Process Water Dam 2 - mean storage history

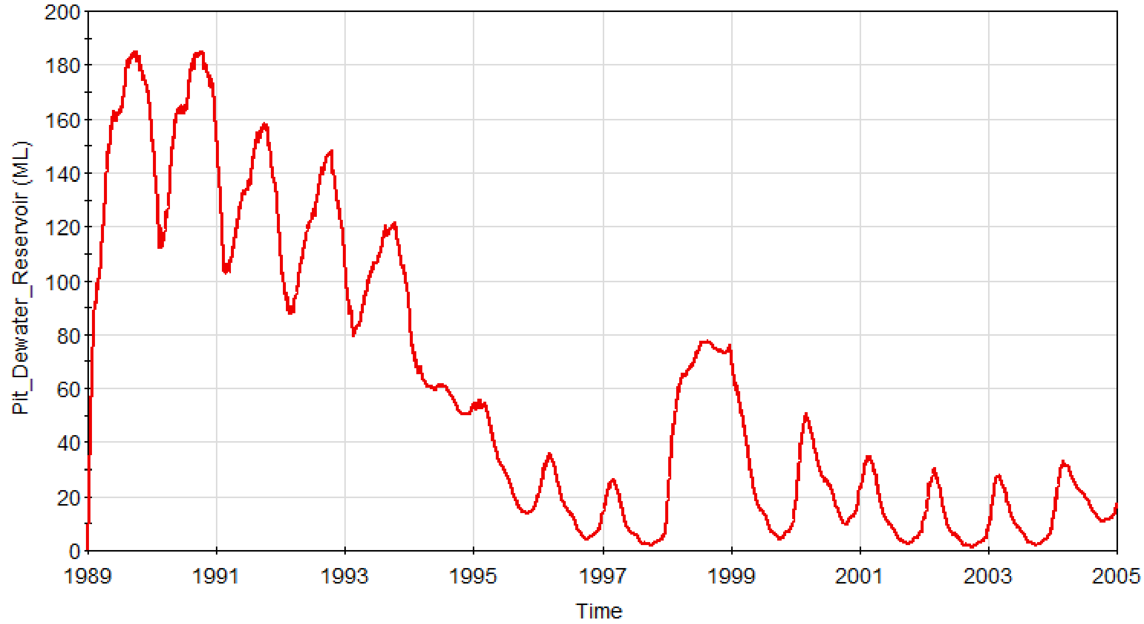


Figure 9-55 PDWD - mean percentile storage history

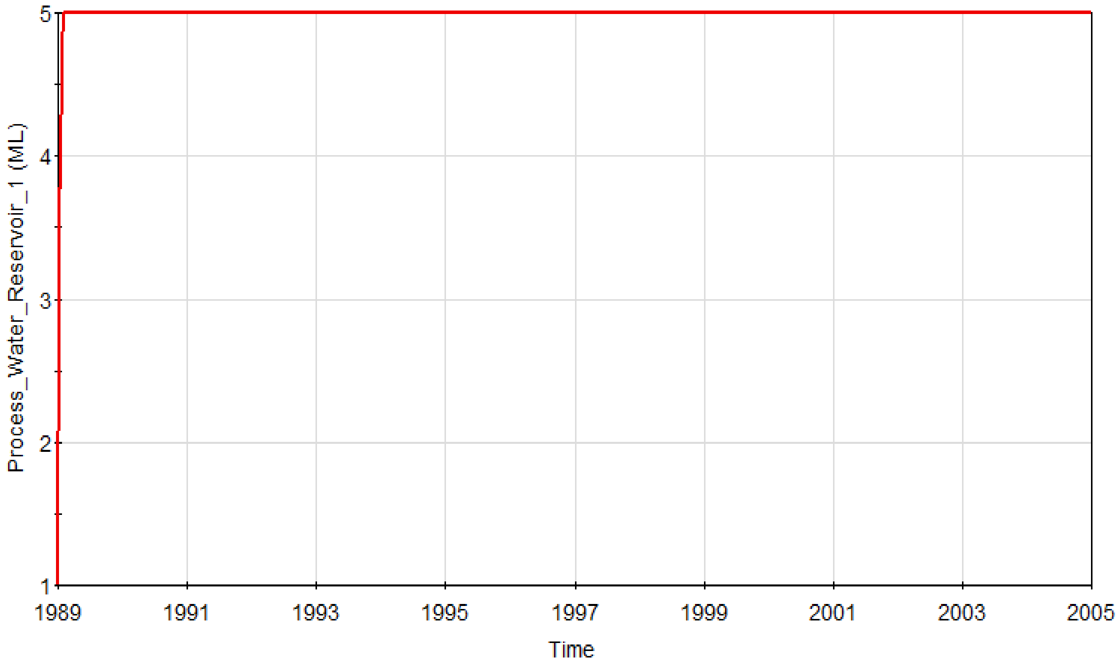


Figure 9-56 Process Water Dam 1 - 95th percentile storage history

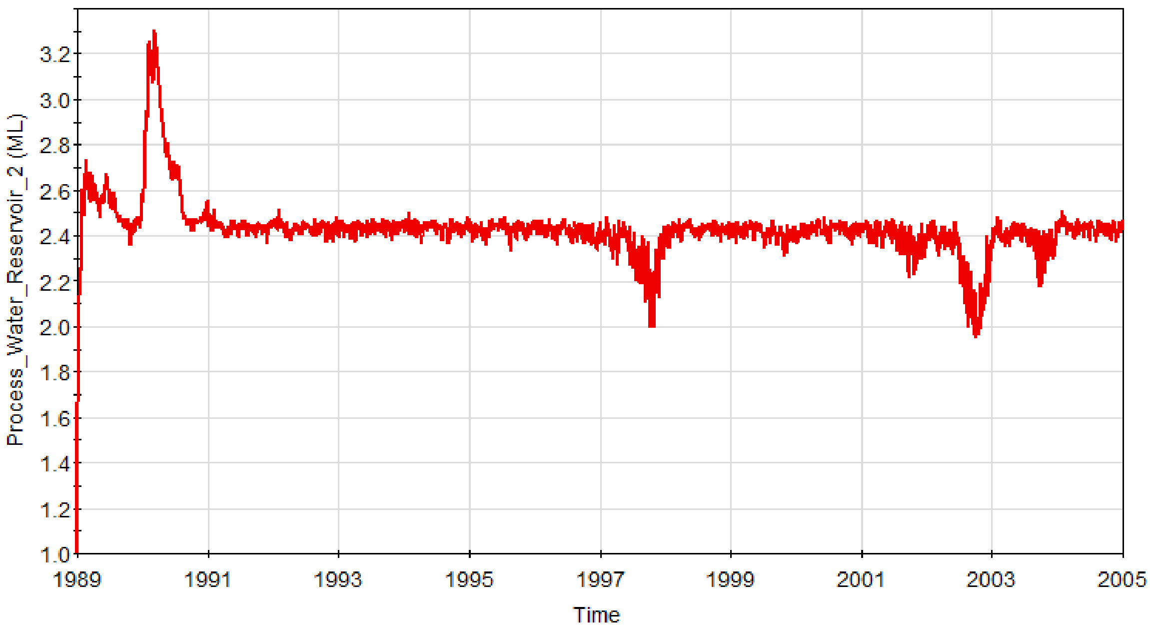


Figure 9-57 Process Water Dam 2 - 95th percentile storage history

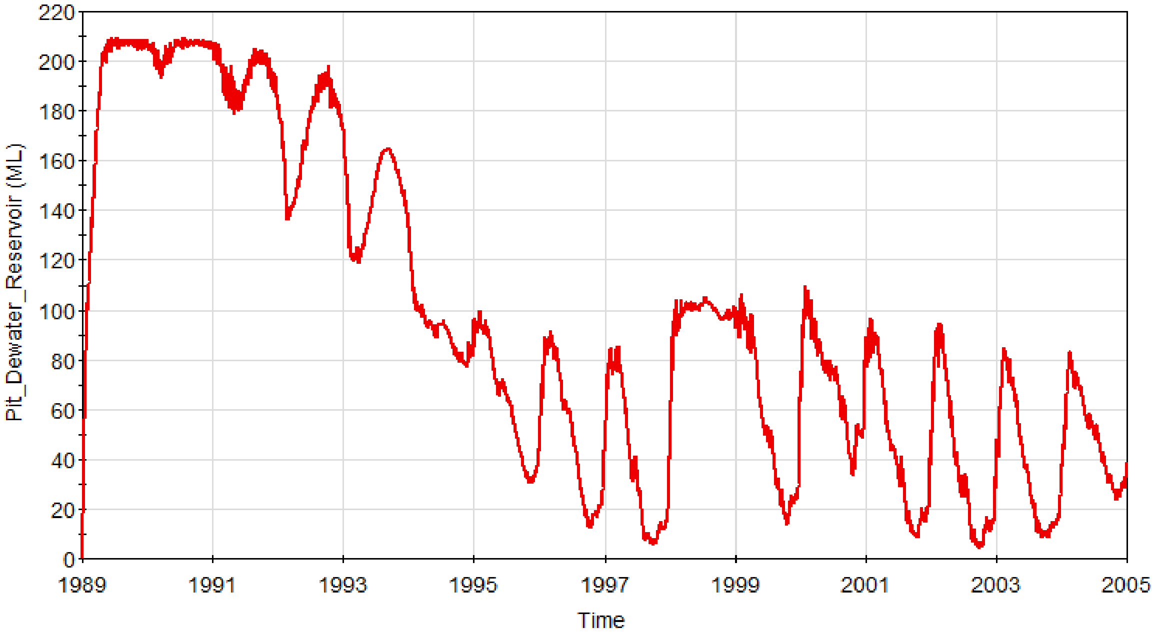


Figure 9-58 PDWD – 95th percentile storage history

The water deficit over the 16 years of mining operations is predicted to be minimal, with any deficit most likely to occur during peak production years. Figure 9-59 demonstrates the demand over the 16-year mining simulation; instances and volumes of deficits are indicated by the location and size of the pink bars. Five possible deficits were observed, with the first at Year 9 and the last at Year 16. Despite these occurrences, the predicted reliability of supply is greater than 99%. Although PWD2 does dry out on occasion it is still able to provide a reliability of 99%.

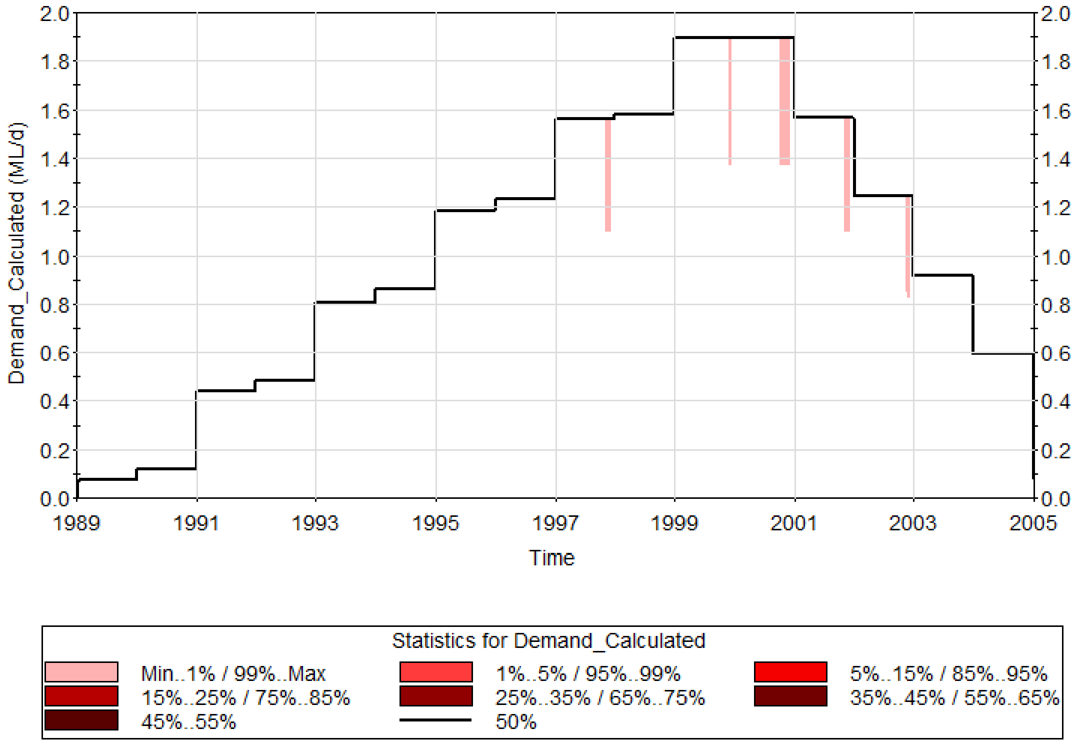


Figure 9-59 Whole mine water demand

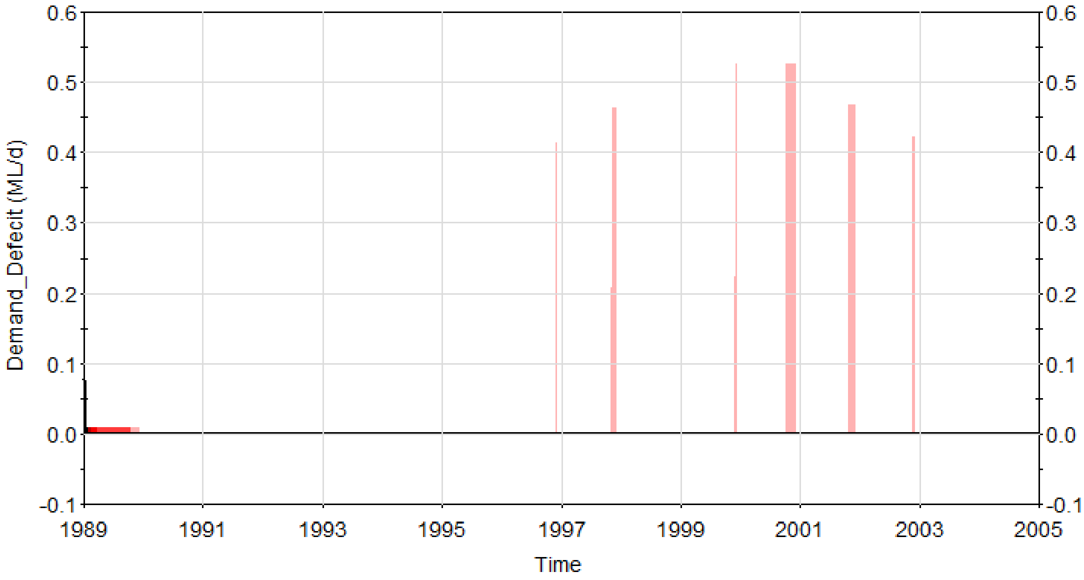


Figure 9-60 Daily demand deficit

9.8 Regulated Structures Assessment

All proposed storages and levees have undergone preliminarily assessment under the EHP *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* to determine the minimum hydraulic performance requirements. A summary of the consequence assessment is shown in Table 9-48. The PDWD, PWD and CHPP fines dewatering ponds were classified under the "significant" consequence category for the "failure to contain-overtopping" and "dam break" scenarios. Levees were determined to be regulated structures and hence must have a crest elevation higher than the peak 0.1% AEP flood level.

The "failure to contain – seepage" scenario has a minimum classification of "significant" in the EHP consequence manual. Leak detection and monitoring may be imposed through EA conditions for regulated dams containing contaminants, such as the PWD, CHPP dewatering ponds and the pit dewater dam. Design provisions for these dams include the use of, where practicable, low permeability clay as the dam foundation or liner to prevent the migration of contaminants.

Table 9-48 Consequence assessment summary

Storage	Scenario	Consequence Category	Overall Consequence Category	Comments
Raw Water Dam	Failure to Contain	Low	Low	Clean water with negligible environmental harm expected from overtopping discharge.
	Dam Break	Low		The 350 ML storage capacity is not considered a likely risk to populations and infrastructure downstream.
Pit Dewater Dam	Failure to Contain	Significant	Significant	Possible harm to the receiving environment of moderate or significant values, however the harm is unlikely to meet the thresholds for the "High" consequence category.
	Dam Break	Significant		Possible harm to the receiving environment of moderate or significant values due to contaminant release. Volume is too small to be considered a risk to populations and infrastructure downstream. The PDD has a small containment volume of ~220 ML and is unlikely to create a downstream population at risk.
Process Water Dam	Failure to Contain	Significant	Significant	Possible harm to the receiving environment of moderate or significant values, however the harm is unlikely to meet the thresholds for the "High" consequence category.
	Dam Break	Significant		Possible harm to the receiving environment of moderate or significant values due to contaminant release. Volume is too small to be considered a risk to populations and infrastructure downstream. The PWD has a small containment volume of ~5 ML and is unlikely to create a downstream population at risk.
Environment Dams	Failure to Contain	Low	Low	Sediment laden, but otherwise clean water with negligible environmental harm expected from overtopping discharge.
	Dam Break	Low		Volume is too small to be considered a risk to populations and infrastructure downstream.
Levee	Dam Break	Regulated Structure	Regulated Structure	Levees are designed to prevent ingress of clean flood water into an operational area or containment system.

Only dams with an embankment height of greater than 10 m may possibly be categorised as ”referrable”, thus requiring a Failure Impact Assessment (FIA). The FIA will be conducted in accordance with the Queensland Government Department of Energy and Water Supply - *Guidelines for Failure Impact Assessment of Water Dams.* The RWD could possibly fall within this category, pending the outcomes of further assessment and design. The dam FIA, if required, will be undertaken as outlined in the *Guidelines for Failure Impact Assessment of Water Dams* (DEWS 2012). The population at risk (PAR) determined by the FIA will inform the failure impact category that applies to the dam and subsequently the minimum design requirements outlined in applicable Australian National Committee on Large Dams guidelines. The chief executive will then impose dam safety conditions, which are likely to include the following:

- The provision of design and construction reports;
- The preparation of an Emergency Response Plan as prescribed by the DEWS framework for referable dams;
- The production of Operation and Maintenance Manual procedures in accordance with DNRM guidelines; and
- Development of standard operating procedures.

It is not anticipated that any of the dams conceptualised herein will create a PAR due to the sparse population density and small containment volume of the dams. Furthermore, except for environmental dams, no other storages have external contributing catchments, and therefore can only overtop if the pumps that feed water to the storages fail to shut off at full supply level, or in the unlikely case of extremely intense rain falling directly on to the storage. The spillways will therefore be designed to pass the maximum pump rate that supplies each storage to mitigate against dam break due to overtopping failures.

9.8.1 Storage Assessment

Based on the consequence assessment summarised in Table 9-48 and discussed at Section 9.7, the following Design Storage Allowance, Extreme Storm Storage and spillway capacities have been selected in accordance with the EHP consequence manual:

- Spillway capacity of 1:1,000 AEP with freeboard allowance for wave run-up from a 1:10 AEP wind;
- Design Storage Allowance for a 1:20 AEP wet season;
- Water balance modelling informed the 1:20 AEP wet season storage through Monte Carlo simulation of 127 years of historic climate data and by adding a 50% contingency to the increase in storage volume from 1 November; and
- Extreme Storm Storage for a 1:10 AEP, 72 hr duration rainfall event. The corresponding 1:10 AEP, 72 hr design rainfall depth is 300 mm, per the BoM’s Intensity Frequency Duration curves for the Project location.[1]

The mine dewater dam, RWD, dewatering ponds and the PWD are designed as turkey’s nest storages with no external contributing catchment. Contributing catchments to environment dams are

[1] IFD curves sourced from: http://www.bom.gov.au/hydro/has/cdirswebx/cdirswebx.shtm for coordinates 21.69 m S and 149.66 m E

restricted to the area of disturbance generating dirty water runoff i.e. clean water runoff is kept separate and diverted around areas of disturbance. The required storage size for the dams was informed by simulating the mine water balance as discussed in Section 9.7.1 and / or by applying the following performance criteria:

- Raw Water Dam –Provide 99% reliable water supply for the life of the Project;
- Environment Dams – Sized to capture the 9.5% year ARI, 24 hr duration storm event in accordance with The Department of Environment and Heritage Protection *Stormwater Guideline* (EHP 2014b);
- Pit Dewater Dam – Sized to have no non-compliant discharges for the maximum rainfall and assuming licenced discharges, dust suppression and washdown demands, and transfer to the PWD for use within the CHPP; and
- CHPP Dewatering Ponds and PWDs – Sized to have no non-compliant discharges for the maximum rainfall and assuming return of decant to the PWD.

A summary of the storage sizing assessment is at Table 9-49 and the locations are shown at Figure 9-61.

Table 9-49 Storage sizing assessment summary

ID	Storage	Design Capacity (ML)	Regulated Structure (Y/N)	Indicative Footprint (ha)	Design Storage Allowance	Extreme Storm Storage (ESS)	Spillway Capacity
1	Raw Water Dam	350	N	32.12	N/A	N/A	0.1% AEP rainfall or pump supply rate, whichever is greater.
2	Pit Dewater Dam	177	Y	19	150 ML based on 4.9% AEP wet season volume increase plus 50%	56.3 ML based on a storage surface area of 19 ha and 300 mm rainfall depth	0.1% AEP rainfall or pump supply rate, whichever is greater.
3	Process Water Dam 1	5	Y	0.1	0.5 ML based on 4.9% AEP wet season volume increase plus 50%	0.2 ML based on a storage surface area of 0.1 ha and 300 mm rainfall depth	0.1% AEP rainfall or pump supply rate, whichever is greater.
4	Process Water Dam 2	5	Y	0.1	0.5 ML based on 4.9% AEP wet season volume increase plus 50%	0.2 ML based on a storage surface area of 0.1 ha and 300 mm rainfall depth	0.1% AEP rainfall or pump supply rate, whichever is greater.
5	CHPP Dewatering Ponds	8.3	Y	0.5	4.2 ML based on 4.9% AEP 3-month rainfall depth of 849 mm	1.5 ML based on a storage surface area of 0.5 ha and 300 mm rainfall depth	0.1% AEP rainfall or pump supply rate, whichever is greater.

ID	Storage	Design Capacity (ML)	Regulated Structure (Y/N)	Indicative Footprint (ha)	Design Storage Allowance	Extreme Storm Storage (ESS)	Spillway Capacity
6	CHPP Dewatering Ponds	8.3	Y	0.5	4.2 ML based on 4.9% AEP 3-month rainfall depth of 849 mm	1.5 ML based on a storage surface area of 0.5 ha and 300 mm rainfall depth	0.1% AEP rainfall or pump supply rate, whichever is greater.
7	CHPP Environment Dam 1	58	N	1.9*	N/A	N/A	1% AEP rainfall#
8	CHPP Environment Dam 2	32	N	1.1*	N/A	N/A	1% AEP rainfall#
9	Waste Environment Dam 1	275	N	9.2*	N/A	N/A	1% AEP rainfall#
10	Waste Environment Dam 2	340	N	11.3*	N/A	N/A	1% AEP rainfall#
11	TLF Environment Dam	52	N	1.7*	N/A	N/A	1% AEP rainfall#

#1% AEP spillway capacity proposed for environment dams that are not regulated structures
*Dam areas calculated on an assumed average depth of 3m

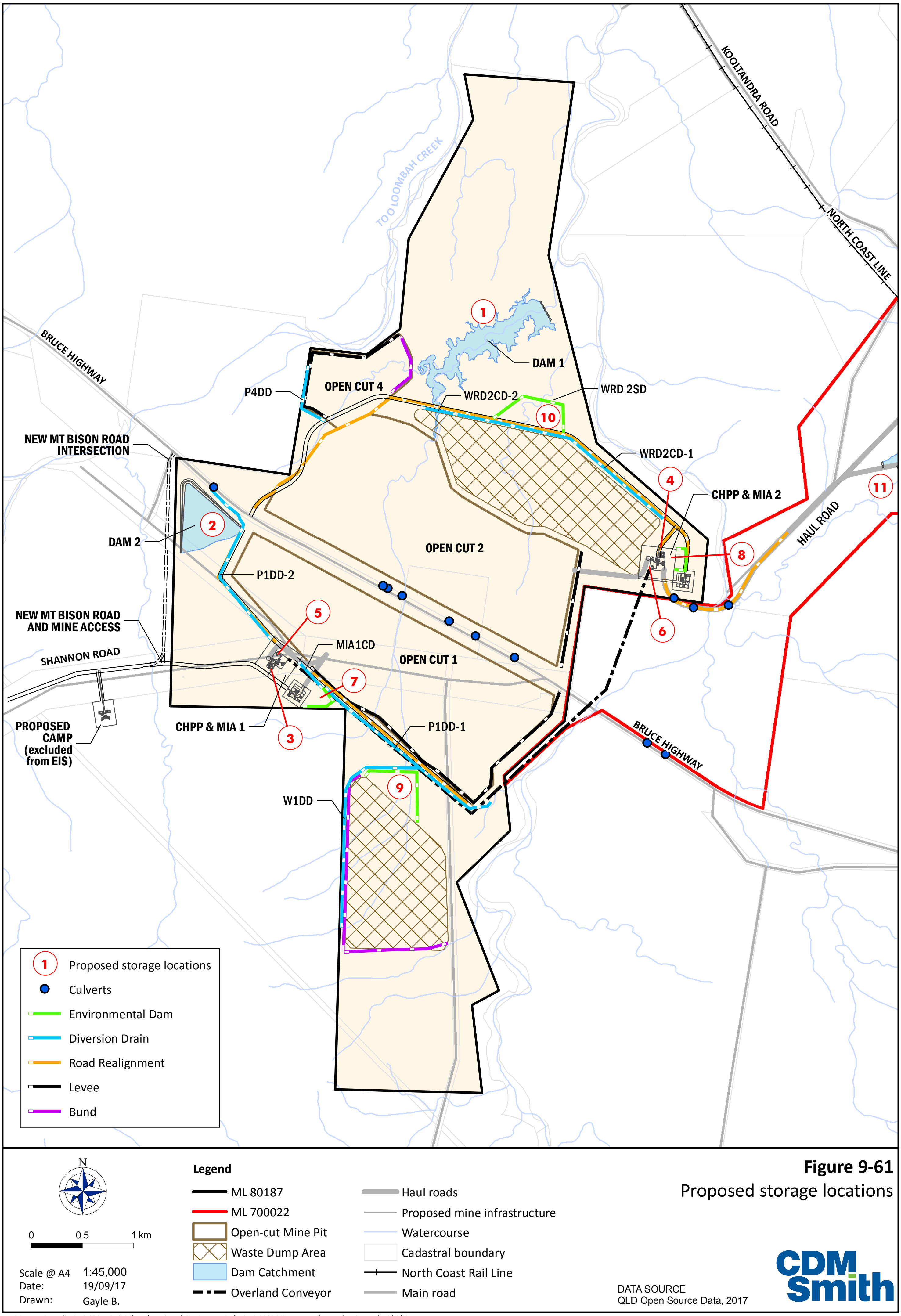


Figure 9-61
Proposed storage locations

Scale @ A4 1:45,000
Date: 19/09/17
Drawn: Gayle B.

DATA SOURCE
QLD Open Source Data, 2017

CDM Smith

BRUGGEMANNGD B:\BES150160 Styx Coal\GIS\DATA\MXD\FINAL\.03 EIS Preparation\BES150160.03-099 R1 Proposed storage locations.mxd 9/19/2017

9.9 Mine Affected Water Release Strategy

This section details a water release strategy for mine affected water. The release of mine affected water is proposed as a contingency measure after water reuse within mine operations. Notwithstanding this, it is considered prudent to have a release strategy to minimise the risk of non-compliant discharges through effective balance of the mine water inventory and by discharging better quality water when possible instead of allowing contaminants to concentrate in storages. Releases of mine affected water may occur as "controlled" release through a piped transfer to Tooloombah or Deep Creek in accordance with EA conditions or as an "uncontrolled" release via flow over a designated spillway during extreme wet weather events. Controlled and uncontrolled releases may occur at the same time, for example, during emergency situations.

9.9.1 Release Points

Release points (RPs) have been designated for storages containing pit dewater volumes, overburden stockpile runoff and mine process water (see Table 9-50). Mine affected water dams have piped outlets that transfer water to RPs within Tooloombah Creek, where instream dilution is possible. Environment dams located within the Deep Creek catchment have piped transfers to RPs within Deep Creek. The mine affected water RPs, sources and receiving waters are summarised in Table 9-50 and shown at Figure 9-62. RPs will also be located at erosion and sediment control structures at the MIA, TLF overburden stockpile areas.

Table 9-50 Mine affected water release points, sources and receiving waters

Release point	Latitude (Decimal Degrees,)	Longitude (Decimal Degrees,)	Mine affected water source and location	Monitoring point	Receiving water description
Mine water dam release points					
RP 1	-22.695	149.635	Pit dewater dam spillway overflow and piped transfer to Tooloombah	Dam spillway and sampling tap on outlet pipe	Tooloombah Creek
RP 2	-22.712	149.643	Process Water Dam 1 spillway overflow (no control releases planned)	Dam spillway and sampling tap on outlet pipe	Tooloombah Creek
RP 3	-22.710	149.644	CHPP 1 Decant ponds overflow	Dam spillway and sampling tap on outlet pipe	Tooloombah Creek
RP 4	-22.701	149.681	Process Water Dam 2 spillway overflow (no control releases planned)	Dam spillway and sampling tap on outlet pipe	Deep Creek
RP 5	-22.702	149.680	CHPP 2 Decant ponds overflow	Dam spillway and sampling tap on outlet pipe	Deep Creek
Environment dam release points					
RP 6	-22.715	149.649	CHPP 1 environment dam riser pipe outlet	Sampling tap on riser pipe outlet	Tooloombah Creek
RP 7	-22.701	149.683	CHPP 2 environment dam riser pipe outlet	Sampling tap on riser pipe outlet	Deep Creek

Release point	Latitude (Decimal Degrees,)	Longitude (Decimal Degrees,)	Mine affected water source and location	Monitoring point	Receiving water description
RP 8	-22.721	149.658	Waste area south environment dam 1 and piped transfer to diversion drain to Deep Creek	Sampling tap on riser pipe outlet	Deep Creek
RP 9	-22.688	149.669	Waste Area 2 north environment dam and piped to tributary of Deep Creek	Sampling tap on riser pipe outlet	Discharge to existing drainage path towards Deep Creek

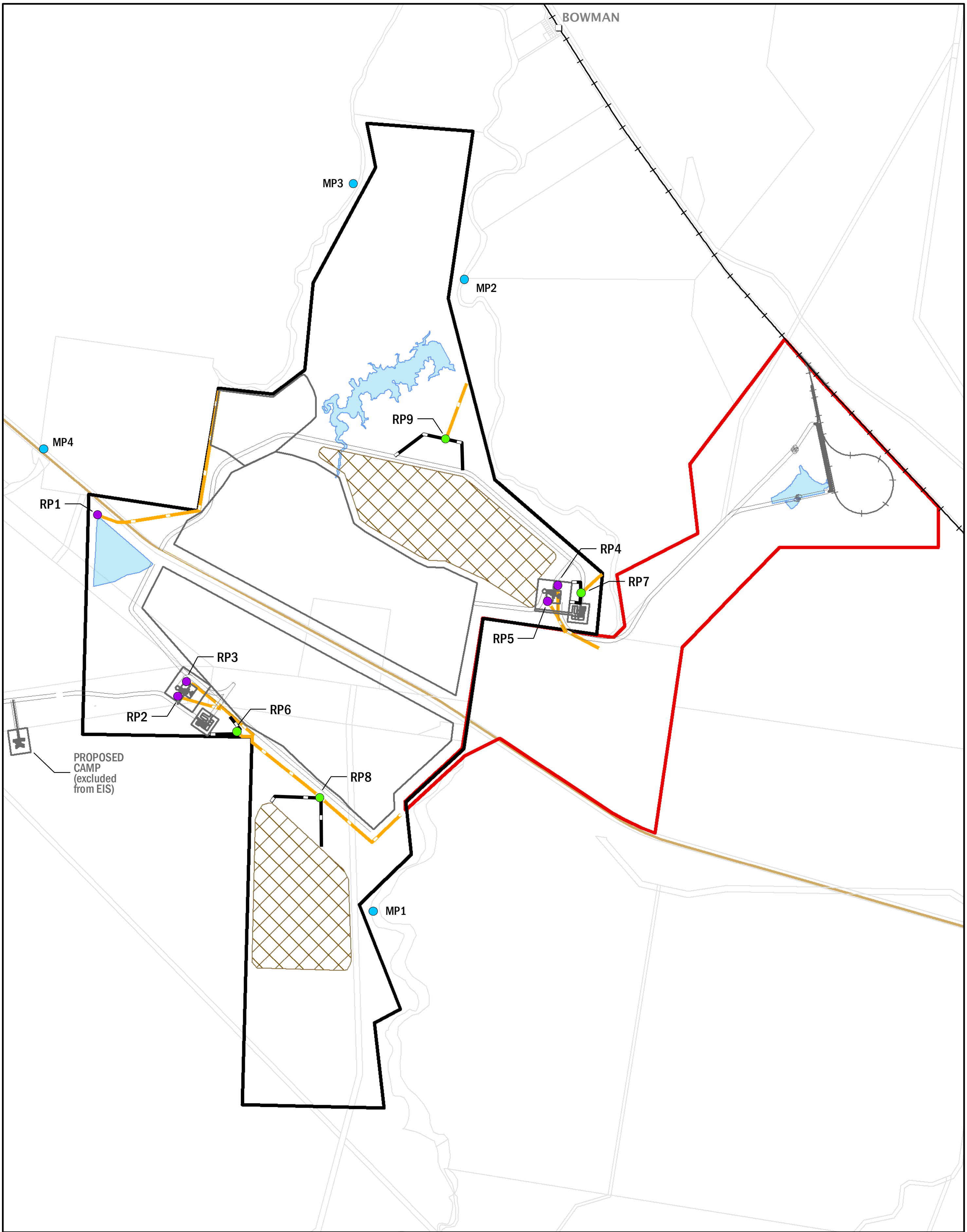
9.9.2 Release Strategy

The proposed release conditions presented herein have been developed based on EHP's *Model Water Conditions for Coal Mines in the Fitzroy Basin* (EHP 2013). The proposed releases reside within the adjoining Styx Basin; however, the EHP guidelines for the Fitzroy Basin form current regulatory expectations for mine water management and thus have been adopted as the basis of the release strategy.

Water quality release limits for mine affected water include electrical conductivity (µS/cm), pH, suspended solids (mg/L) and sulphate (mg/L). In addition to the release limits, release contaminant trigger investigation levels also apply. Should the contaminant trigger level be exceeded, further investigation of background levels would be required. Should the release contaminant levels be shown to exceed the background monitoring level, Central Queensland Coal is required to investigate the potential environmental harm and provide reporting to the administering authority outlining the actions taken to prevent environmental harm.

9.9.2.1 Monitoring of Mine Affected Water Release

Water monitoring will be undertaken at the discharge locations of the environmental dams and mine-affected water dams, and at reference locations both upstream and downstream of the Project area. If water quality levels exceed the WQOs set out in Central Queensland Coal's EA, upstream (control) values will be compared to the water quality within and downstream of the Project area to determine if the exceedance is site-specific, and thus likely to be a result of Project activities, or if it is likely to be natural (similar to water quality levels upstream). The proposed upstream and downstream monitoring points are shown in Figure 9-62 and listed in Table 9-51.



Legend

- Monitoring points

Release Point

- Mine water dam release points
- Environmental dam release points
- Pipeline Transfer
- Environmental Dam
- ML 80187
- ML 700022
- Proposed mine infrastructure
- Waste Dump Area
- Dam Catchment
- North Coast Rail Line
- Main road
- Cadastral boundary

Scale @ A4 1:50,000
Date: 19/09/17
Drawn: Gayle B.

DATA SOURCE
QLD Spatial Catalogue (QSpatial), 2017

Figure 9-62
Proposed release and monitoring points

CDM Smith

BRUGGEMANNGD B:\BES150160 Styx Coal\GIS\DATA\MXD\FINAL\.03 EIS Preparation\BES150160.03-045 R4 mine affected water release-mon pt.mxd 9/19/2017

Table 9-51 Proposed monitoring points and receiving waters

Monitoring points	Receiving waters location description	Latitude (Decimal Degrees, GDA94)	Longitude (Decimal Degrees, GDA94)
Upstream background monitoring points			
Monitoring Point 1 (MP1)	Deep Creek, located outside the proposed mine lease boundary, upstream of mine releases.	-22.731	149.663
Monitoring Point 4 (MP4)	Tooloombah Creek located outside the proposed mine lease boundary, upstream of mine releases.	-22.689	149.630
Downstream monitoring points			
Monitoring Point 2 (MP2)	Deep Creek located outside the proposed mine lease boundary downstream of mine releases.	-22.673	149.671
Monitoring Point 3 (MP3)	Tooloombah Creek located outside the proposed mine lease boundary, downstream of mine releases.	-22.665	149.66

9.9.2.2 Flow Triggers and Electrical Conductivity Quality Criteria

There are no flow gauges within the Styx Basin by which to define the hydrologic regime and determine appropriate flow triggers for release of mine affected water. A catchment hydrology model (see Section 9.7.4) was constructed to estimate the historical daily runoff volumes in Tooloombah Creek at the proposed monitoring location (with a catchment area of approximately 369.68 km^2). A simulation was run across the 128 years of historical rainfall and evaporation data to produce the daily flow statistics presented in Table 9-52. To derive the flow statistics, values of runoff lower than 0.01 m^3/s (1 ML/d) were filtered from the data and a percentiles function applied to determine the percentage exceedance probability for stormwater flow events. For example, when a flow event occurs, there is a greater than 80% chance that the flow will exceed 68 ML/d.

Table 9-52 Tooloombah Creek monitoring point - flow statistics for stormwater runoff events

Percentage exceedance probability (%)	Daily flow volume (ML/d)*	Flow rate (m^3/s)*
95	8	0.1
80	68	0.8
50	366	4.2
20	2,219	25.7
10	6,456	74.7
5	15,198	175.9
1	86,832	1005.0

*Simulations were run on a daily timestep. Flow volume (ML/d) represents the average recorded flow rate (in m^3/s) applied across the entire duration for any given day.

The following figure (Figure 9-63) presents a flow duration curve for Tooloombah Creek derived from AWBM runoff estimates. Unlike in Table 9-52 there has been no filtering of the data (i.e. days of zero and low flow are included). The flow duration curve shows that there is greater than approximately 100 m^3/s flow in the Tooloombah Creek at the monitoring location on 10% of days and flows above 0.01 m^3/s on 90% of days.

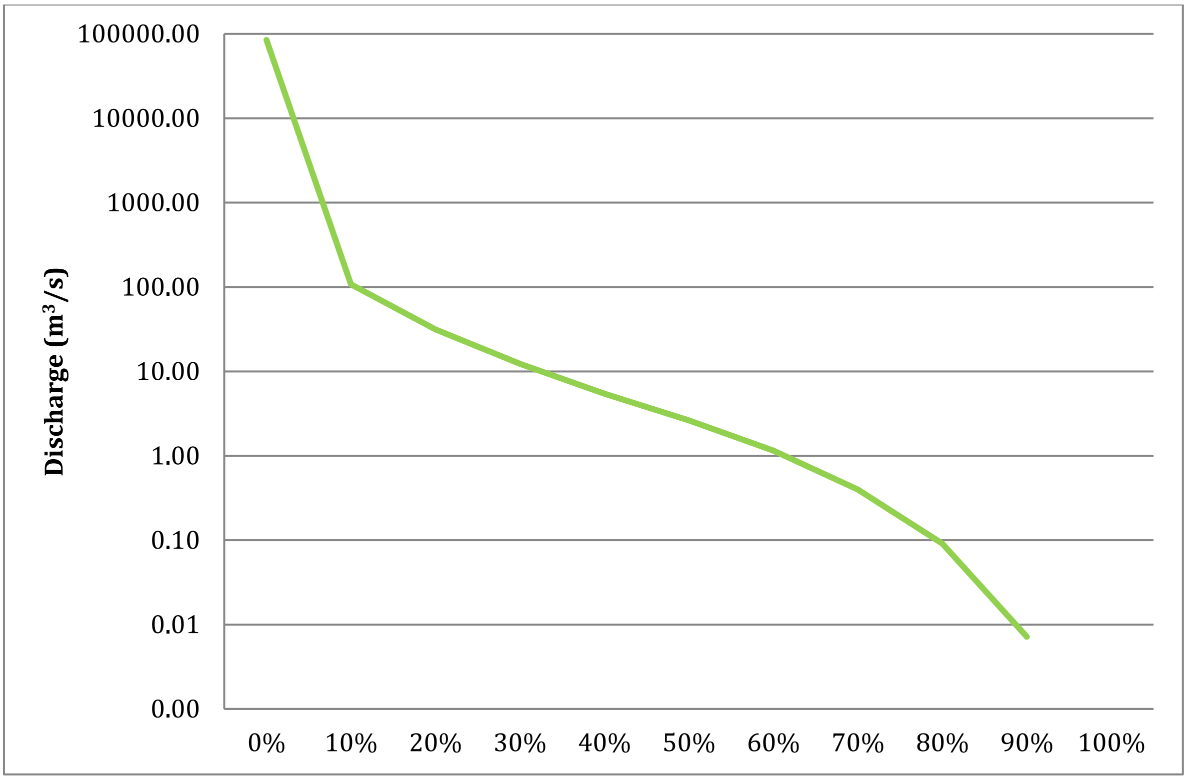


Figure 9-63 Tooloombah Creek monitoring point flow duration curve

Flow triggers for release of mine affected water are separated into the following conditions and general principals. Flow and EC release conditions for the below conditions are summarised in Table 9-53 and Table 9-54. It is proposed that the release conditions be updated once sufficient water quality data has been collected to derive site specific WQOs and background 75th/80th percentile EC results.

- No / low flow stream conditions (low EC mine affected water):
  - End-of-pipe water quality water that meets or exceeds water quality objectives
  - Discharge four weeks after flow event ceases for ephemeral systems where duration of release is limited
  - Low flow trigger determined by the 20th percentile probability of exceedance, occurring on ~22.1% of days
  - Mine discharge rate set to equal the trigger flow
- Moderate flow stream conditions (medium quality mine affected water):
  - Requires the use of a flow trigger above which release can occur
  - End-of-pipe EC <3,500 µS/cm or <2,500 µS/cm, with corresponding volumetric limits imposed on each contaminant release limit
  - Discharge rate based on the instream diluted EC limit defined by site specific WQOs (TBC)
  - Medium flow trigger determined by the 20th percentile probability of exceedance, occurring on ~22.1% of days

- High flow stream conditions (poorer quality water):
  - Requires the use of a flow trigger above which release can occur
  - End-of-pipe EC <4,500 µS/cm or 3,500 µS/cm, with corresponding volumetric limits imposed on each contaminant release limit
  - Discharge rate based on the instream diluted EC limit defined by site specific WQOs (TBC)
  - High flow trigger determined by the 10^{th} percentile probability of exceedance, occurring on ~12.4% of days
- Very high flow event stream conditions (poor quality water):
  - Requires the use of a flow trigger above which release can occur
  - End-of-pipe EC <5,500 µS/cm or 4,500 µS/cm, with corresponding volumetric limits imposed on each contaminant release limit
  - Discharge rate based on the instream diluted EC limit defined by site specific WQOs (TBC)
  - Very high flow trigger determined by the 5^{th} percentile probability of exceedance, occurring on ~7.4% of days
- Flood event stream conditions (poor quality water and uncontrolled spill prevention):
  - Requires the use of a flow trigger above which release can occur
  - End-of-pipe EC <6,500 µS/cm or 5,500 µS/cm, with corresponding volumetric limits imposed on each contaminant release limit
  - Discharge rate based on the instream diluted EC limit defined by site specific WQOs (TBC)
  - Flood flow trigger determine by the 1 percentile probability of exceedance, occurring on ~2.2% of days.

Table 9-53 Tooloombah Creek release conditions

Flow condition	Receiving water flow trigger (m^3/s)	Maximum combined mine discharge (m^3/s)	End-of-pipe EC limit (µS/cm)	Tooloombah Creek EC at monitoring point (µS/cm)
No/Low Flow	>68*	TBC^	TBC^	TBC^
Medium Flow	26-75	TBC^	TBC^	
	26-75	TBC^	TBC^	
High Flow	75-176	TBC^	TBC^	
	75-176	TBC^	TBC^	
Very High Flow	176-1005	TBC^	TBC^	
	176-1005	TBC^	TBC^	
Flood	>1005	TBC^	TBC^	
	>1005	TBC^	TBC^	

*Following a flow event exceeding 68 ML/d, release of high quality water is permitted for a period of up to 28 days after flow recedes below 68 ML/d

^The end-of-pipe discharge and instream dilution criteria will be determined once site specific WQOs have been established.

Table 9-54 Deep Creek release conditions

Flow condition	Receiving water flow trigger (m³/s)	Maximum combined mine discharge (m³/s)	End-of-pipe EC limit (µS/cm)	Deep Creek EC at monitoring point (µS/cm)
No/Low Flow	>68*	TBC^	TBC^	TBC^
Medium Flow	26-75	TBC^	TBC^	
	26-75	TBC^	TBC^	
High Flow	75-176	TBC^	TBC^	
	75-176	TBC^	TBC^	
Very High Flow	176-1005	TBC^	TBC^	
	176-1005	TBC^	TBC^	
Flood	>1005	TBC^	TBC^	
	>1005	TBC^	TBC^	

*Following a flow event exceeding 68 ML/d, release of high quality water is permitted for a period of up to 28 days after flow recedes below 68 ML/d

^The end-of-pipe discharge and instream dilution criteria will be determined once site specific WQOs have been established.

9.10 Potential Impacts on Environmental Values

Mining activities and proposed works that have the potential to impact on surface water conditions and EVs are outlined below for the different Project phases. Potential impacts area discussed and management measures aimed at mitigating those impacts are provided.

The main construction activities that could impact on surface water EVs are:

- Excavations and earthmoving including topsoil removal and stockpiling for the construction of the mine infrastructure including site access roads, bunds, dams, CHPP and MIA. This may potentially lead to erosion and sedimentation, deterioration of water quality, and changes to water flows; and
- The use of fuels and chemicals for vehicles and construction equipment, potentially resulting in water contamination because of spills, leaks, or other uncontrolled releases.

Operational impacts are in relation to:

- Altered catchment conditions on the hydrology of waterways and drainage lines due to excavations, buildings and infrastructure, water harvesting dams, sediment dams and waste dump areas;
- Altered flooding response due to the reduction in available floodplain due to bunds, levee, sediment dams and mine infrastructure; and
- Stormwater runoff, erosion and contamination from either CHPP or MIA areas.

9.10.1 Increased Sedimentation of Waterways and Sediment Runoff

During construction and operation, sediment can be mobilised and transported by surface water during rainfall events, ultimately discharging into Deep Creek drainage lines. This may result in negative impacts on water quality and aquatic habitats. Specifically, increased quantities of suspended sediments can reduce light penetration, decreasing the photosynthesis of aquatic flora and lowering dissolved oxygen concentrations. Due to the ephemeral nature of the drainage features and watercourses, this is unlikely to be an impact in the immediate area but would more likely cause impacts downstream and in the Styx River where more permanent refugial pools exist. Suspended sediments from runoff will likely contain elevated nitrogen and phosphorus levels due to the agricultural activities on the Mamelon property. Increased nutrients can promote algal growth and in extreme cases result in blooms and surface water deoxygenation within low flow situations. Due to proximity to the MIA, Deep Creek is considered the watercourse most at risk from increased sedimentation.

Erosion and sedimentation during the operation phases is most likely to occur from stormwater runoff from the coal stockpile, MIA and from ongoing minor earthworks associated with the maintenance of roads and dams. If stormwater runoff is not adequately contained, there is a potential for increased sedimentation and contamination to adversely impact surface water receiving environments, particularly Deep Creek. Surface water observations taken during the no flow period in February 2017 recorded naturally high turbidity levels in Deep Creek sites (refer Table 9-23).

Impacts to Tooloombah Creek are unlikely, as most of the Project area drains towards Deep Creek with only 15% draining towards Tooloombah Creek. The catchment is relatively isolated from most of the Project infrastructure components. However, the dewatering dam (Dam 2 – see Figure 9-42) has potential to mobilise sediments entering the creek during rainfall periods in the construction period. The diversion of clean stormwater run-off from upstream of Open Cut 1 western section may mobilise sediments during the operational period.

Baseline water quality monitoring results indicated that existing waterways generally have low to moderate turbidity and suspended sediment loads during flow periods (such as sampled in June 2011 and May 2017). During dry periods (as sampled in February 2017) when the waterways are reduced to isolated pools, high levels of turbidity and suspended sediment loads were recorded in the lower Deep Creek sites (De3 and De4), although the remaining sites maintained the low levels recorded at other times.

The potential impacts of erosion and sedimentation from surface runoff, if not adequately mitigated, could produce moderate impacts on local downstream water quality, and on aquatic ecosystems EVs, including the marine environment (and associated recreational fishing values).

9.10.2 Direct Disturbance of Waterways

The Project MIA, open cut pit and stockpiles will be located to the east of Deep Creek and are unlikely to directly disturb the watercourses. However, the abovementioned Project components and infrastructure will cut-off the two drainage features that traverse the open pit locations. This will result in lower flows in the reaches downstream of the open pits.

The access road will traverse several minor drainage features as the access road loops around the open pit locations. Most the waterway disturbance will occur at the haul road crossings of Deep Creek, Barrack Creek and an unnamed tributary of Deep Creek. Both Deep Creek and Barrack Creek are incised with channel depths in the range of 6.5 m to 7.8 m. The unnamed tributary of Deep Creek is significantly shallower with a channel depth of around 3.5 m.

At these crossings, impacts may include: riparian vegetation clearing, direct deformation of the bed and banks, and alteration of hydrological flows. Consequential impacts may include: decreased habitat, increased potential for erosion and an increase in runoff velocity due to effective increase in bed slope that can result from the construction of cross-drainage structures.

Potential impacts of direct watercourse disturbance, if not adequately mitigated, could produce moderate impacts on local and downstream water quality, aquatic ecosystem, stock water and irrigation EVs.

9.10.3 Accidental Release of Pollutants

Accidental release of pollutants is most likely to impact Deep Creek as the Project Area majority lies within the Deep Creek catchment. There is a less likely impact on Tooloombah Creek as the Mine Dewater dam is the only infrastructure to discharge into the creek. Potential sources of pollutants include MIA and the CHPP areas, which are located approximately 250 m and 500 m from Deep Creek respectively. Waste Area 1 is located approximately 250 m west of Deep Creek representing another potential source of contaminants (see Figure 9-42).

Several items of infrastructure have the potential to accidentally release contaminants to the creek, owing to their proximity. These include:

- Mine dewatering dam will be in the Tooloombah Creek catchment to the east of Open Cut1. This dam has the potential to release contaminated run-off in the creek;
- The northern waste area located to the south of Open Cut 1 and thereby has potential to release contaminated run-off in the creek;
- Waste area located to the north of the access road that loops around the open pits which has the potential of releasing contaminated run-off into the creek network; and
- The RWD is located onstream, which during the construction of the dam wall has the potential to release fuels and chemicals into the creek.

Without mitigation, potential exists for aqueous waste streams to potentially enter waterways. This includes such things as:

- Oily waste water (from heavy equipment cleaning);
- Contaminated runoff from chemical storage areas;
- Contaminated drainage from fuel oil storage areas; and
- General washdown water.

The accidental release of pollutants can result in acute fatality of flora and fauna (i.e. through coating) or may manifest itself as chronic illness and mortality, via slow and long term release of contaminants.

The EVs for the receiving waters include irrigation, stock watering and human consumption. Accidental release of pollutants and contaminants may adversely impact downstream agricultural operations and prevent use of the water for human consumption.

Potential impacts of accidental pollutant and contaminant releases, if not adequately mitigated, could produce moderate impacts on local and downstream water quality, aquatic ecology, irrigation, farm supply, stock water and cultural/spiritual EVs. It is unlikely to impact human consumer and drinking water EVs due to the distance between the Project area and downstream extraction points.

9.10.4 Hydrology and Water Flows

The major changes in catchment hydrology relates to the addition of drains to divert the catchments upstream of the open pits. This will result in increased volumes of runoff presenting at the Deep Creek Bridge. All catchments to the west of MIA 1 will be diverted around Open Cut 4 into Tooloombah Creek, where the additional contributing catchment may also result in increased runoff volumes with respect to the current situation.

The addition of hardstand areas such as the MIA, haul roads and access roads will also change hydrologic characteristics, as these surfaces are relatively impervious and transform a higher proportion of rainfall into run-off, increasing peak runoff rates. Waste areas; however, are generally comprised of loose spoil and have a high capacity to absorb rainfall. Incident precipitation slowly percolates through the spoil before discharging to the environmental dam. This process has the effect of reducing peak runoff.

Hydraulic modelling indicates that a general reduction in peak flows is likely downstream of the site boundary, because of the reduction in contributing catchment area caused by the construction of the open pits

The overall impact is relatively minor – for example, under the 1,000 year ARI design flood event a reduction peak flood level of approximately 0.02 m in is predicted at the Styx River confluence of Deep Creek and Tooloombah Creek. In Deep Creek, a decrease in peak levels of about 0.07 m is predicted. Tooloombah Creek levels are predicted to decrease by about 0.03 m. As would be expected, peak velocities are predicted to decrease commensurately. Changes to peak flows, levels, and velocities, are likely to have only have a minor impact on aquatic ecology EVs.

9.11 Mitigation and Management Measures

To manage the potential impacts listed in Section 9.10, the following mitigation and management measures are proposed.

9.11.1 Control of Erosion and Sediment

The Project is located on the Mamelon property. Mamelon encompasses a total area of 6,478 ha of which the Project footprint covers approximately 1,070 ha. CQC have proposed destocking the majority of the property and restricting cattle access to already cleared habitat in the south-west and south of the property. This area encompasses approximately 1,000 ha. The remaining area, including the creek lines which lie adjacent to the mine area, will be managed and allowed to regenerate. In the longer term this measure will contribute to localised water quality improvements, and contribute to improving the water quality entering Broad Sound and the GBRWHA through the following:

- The long-term restoration of this habitat, and in particular allowing vegetation to regrow along the riparian zones along Deep Creek and Tooloombah Creek (which are presently mostly cleared), will capture / entrain sediment and nutrient run-off from the property;
- The restoration of cleared areas will also reduce soil erosion on cleared areas of the property, thereby reducing the entrainment of sediments entering creek lines during bouts of heavy rainfall; and
- The removal of cattle from much of the property will also remove a source of long-term nutrient input into creek lines following rainfall.

Prior to the commencement of construction activities, an ESCP will be developed for the Project, detailing control measures to be implemented, construction details, dimensions, materials specifications, expected outcomes and the proposed staging of erosion and sediment controls once construction is complete. The ESCP will be certified by a suitably qualified person and will be approved by the appropriate authority prior to the commencement of works. The ESCP will include as a minimum the following control measures:

- Installation of sediment fences on the downslope side of any disturbed areas;

- Diversion of clean water around disturbed areas;
- Policies to avoid and minimise the use earthmoving activities during intense rainfall events,
- Installation of erosion control devices diversion drains; and
- A construction plan that minimises the area required to be disturbed for operations.

Dust suppression measures outlined in Chapter 12 – Air Quality, including watering of roads and stockpiles, will be implemented where required to avoid wind dispersion of sediments into surface water bodies. Sedimentation in channels will be monitored as a part of the Project Receiving Environment Monitoring Program.

Several environmental dams (see Section 10.8.3) are planned to be constructed during the early site works. The early construction of these storages will allow for runoff from disturbed areas to be captured and thus provide one of the most effective mitigation measures to minimise potential erosion and sedimentation impacts in relation to the MIA. As previously outlined, all site dams, including environmental dams have been and will continue to be designed in accordance with the 'Manual for Assessing Hazard Categories and Hydraulic Performance of Structures' (EHP 2016).

9.11.2 Mine Affected Water Release Impact Mitigating

The mine water release strategy presented in Section 9.9 sets the basic criteria to minimising the effect of mine affected water releases on the receiving environment. In addition, the following mitigating measures are proposed:

- Maintain a site-specific mine water balance to:
  - Assess the net mine water inventory
  - Determine the likely mine water release volumes for oncoming wet seasons
  - Forecast the likelihood of non-compliant discharges
  - Adjust the mine water release strategy based on the above
- Release better quality water as soon as possible to avoid the accumulation of salts and other contaminants; and
- Incorporate suitable monitoring and water infrastructure such as:
  - Automated real-time flow and EC monitoring at point discharge and background monitoring locations to determine the appropriate quality and quantity of mine affected water releases
  - Sufficient mine dewater dam capacity to reduce non-compliant discharges from overtopping
  - Automated release gates to allow release of mine affected water during wet weather conditions where access is limited
  - Continually assess the release strategy and its impact on the receiving environment.

9.11.3 Control of Pollutants and Contaminants

All contaminated water on-site will be collected using site environmental dams, preventing the water from entering local waterways. The Project will include six environmental dams. These dams will collect water from the MIA, CHPP, waste rock storage, coal stockpile and the TLF and store contaminated rainfall runoff across the site. This water will be used to supplement the demands for stockpile dust suppression, washdown and CHPP demand.

In addition to the installation of environmental dams, the following management measures will be implemented to minimise the risk of pollutants and contaminants entering local water ways:

- Appropriate spill control materials including booms and absorbent materials will be onsite at refuelling facilities at all times. These will be used for mitigating and managing events where a substance is spilled into the surrounding waters;
- All refuelling facilities and the storage and handling of oil and chemicals will comply with relevant Australian Standards (management and mitigation measures for wastewater is discussed in Chapter 7 - Waste Management);
- Procedures will be established at the mine for safe and effective fuel, oil and chemical storage and handling. This includes storing these materials within roofed, bunded areas with a storage capacity of 100% of the largest vessel and 10% of the second largest vessel. The bunding will have floors and walls that are lined with an impermeable material to prevent leaching and spills; and
- Wash-down areas for plant and equipment will be clearly marked to prevent contaminated water from leaching into soils or flowing into nearby watercourses.

9.11.4 Ongoing Water Quality Management and Monitoring

9.11.4.1 Water Release Points and Monitoring

The Project has 11 proposed mine affected water release points (Table 9-55). Water monitoring will be undertaken at the environmental dams, mine-affected water dams, discharge locations and locations both upstream and downstream of the Project area (Figure 9-62). In addition, ongoing monitoring will be undertaken at the sample locations identified in Table 9-55 to assess water quality impacts on waterway flows. This will enable Central Queensland Coal to continually monitor water quality within the waterways (upstream of the Project area at the control sites) and the potentially impacted watercourses (within the Project area and downstream of the Project area at the impact and monitoring sites).

Table 9-55 Mine affected water release points, sources and receiving waters

Release point	Latitude (Decimal Degrees,)	Longitude (Decimal Degrees,)	Mine affected water source and location	Monitoring point	Receiving water description
Mine water dam release points					
RP 1	-22.695	149.635	Pit dewater dam spillway overflow and piped transfer to Tooloombah	Dam spillway and sampling tap on outlet pipe	Tooloombah Creek
RP 2	-22.712	149.643	Process Water Dam 1 spillway overflow (no control releases planned)	Dam spillway and sampling tap on outlet pipe	Tooloombah Creek
RP 3	-22.710	149.644	CHPP 1 Decant ponds overflow	Dam spillway and sampling tap on outlet pipe	Tooloombah Creek
RP 4	-22.701	149.681	Process Water Dam 2 spillway overflow (no control releases planned)	Dam spillway and sampling tap on outlet pipe	Deep Creek

Release point	Latitude (Decimal Degrees,)	Longitude (Decimal Degrees,)	Mine affected water source and location	Monitoring point	Receiving water description
RP 5	-22.702	149.680	CHPP 2 Decant ponds overflow	Dam spillway and sampling tap on outlet pipe	Deep Creek
Environment dam release points					
RP 6	-22.715	149.649	CHPP 1 environment dam riser pipe outlet	Sampling tap on riser pipe outlet	Tooloombah Creek
RP 7	-22.701	149.683	CHPP 2 environment dam riser pipe outlet	Sampling tap on riser pipe outlet	Deep Creek
RP 8	-22.721	149.658	Waste area south environment dam 1 and piped transfer to diversion drain to Deep Creek	Sampling tap on riser pipe outlet	Deep Creek
RP 9	-22.688	149.669	Waste Area 2 north environment dam and piped to tributary of Deep Creek	Sampling tap on riser pipe outlet	Discharge to existing drainage path towards Deep Creek
RP 10	-22.676	149.660	Waste Area 3 north environment dam and piped to tributary of Deep Creek	Sampling tap on riser pipe outlet	Tooloombah Creek

Table 9-56 Proposed monitoring points and receiving waters

Monitoring points	Receiving waters location description	Latitude (decimal degree, GDA94)	Longitude (decimal degree, GDA94)
Upstream background monitoring points			
Monitoring Point 1 (MP1)	Deep Creek, located outside the proposed mine lease boundary, upstream of mine releases.	-22.731	149.663
Monitoring Point 4 (MP4)	Tooloombah Creek located outside the proposed mine lease boundary, upstream of mine releases.	-22.689	149.630
Downstream monitoring points			
Monitoring Point 2 (MP2)	Deep Creek located outside the proposed mine lease boundary downstream of mine releases.	-22.673	149.671
Monitoring Point 3 (MP3)	Tooloombah Creek located outside the proposed mine lease boundary, downstream of mine releases.	-22.665	149.66

9.11.4.2 Receiving Environment Monitoring Program

Monitoring will complement the water management strategy to confirm that any potential uncontrolled discharges (overflows from the environmental dams) or controlled discharges do not adversely impact on downstream water quality. Monitoring will also serve as a continual improvement mechanism for the ongoing management of stormwater including operational calibration of the water balance model.

A Project Receiving Environment Monitoring Program (REMP) will be developed in accordance with EHP Guidelines, including the technical guideline - Wastewater Release to Queensland Waters (EHP 2016a), and will be periodically updated as required throughout the life of the Project. The REMP will incorporate the following elements:

- Development of Final WQOs, with trigger values set at the 20th and 80th percentiles and in accordance with the Styx River, Shoalwater Creek and Water Park Creek Basins Environmental Values and Water Quality Objectives. Percentiles will be identified through ongoing baseline investigations undertaken prior to construction (responses to trigger values are explained below). Baseline water quality monitoring to determine locally derived WQOs for the Project. If EHP deems that insufficient data has been collected prior to construction to determine baseline trigger values, interim WQO trigger values will be applied as per Styx River, Shoalwater Creek and Water Park Creek Basins Environmental Values and Water Quality Objectives;

- An ongoing baseline assessment and interpretation of water quality data, undertaken in accordance with relevant guidelines, including the EHP's Monitoring and Sampling Manual 2009 (EHP 2009a), QWQG (EHP 2009), and ANZECC guidelines. The monitoring program will outline, as a minimum:

  - Measures to further derive local WQOs from data collected from reference sites, chosen in accordance with the QWQG (EHP 2009)

  - Frequency and locations for sampling

  - Relevant water quality parameters, including physico-chemical and estimation of local stream flow

  - Water quality sampling methods

- The recording of all data used to determine locally-derived WQOs. Data shall be recorded in an electronic format for review by the administering authority if requested;

- Monitoring that includes inspections of construction areas and surrounding waters for visual changes to water quality. Specifically, the programme will include:

  - Event based monitoring throughout the life of the Project, carried out at a minimum of six sampling locations (one location upstream and one location downstream of release points, for each for Deep Creek, Tooloombah Creek and tributary of Deep Creek)

  - Ongoing quarterly monitoring of water quality, to be carried out on the mine affected water dams, when standing water is present

- Physical and chemical water quality monitoring, both up and down stream of work sites, and in all Project affected water dams and defined watercourses within the Project area;

- A plan that includes the actions required if a trigger level is exceeded. Specific actions will include:
  - A comparison of upstream and downstream results to determine if the pollutant source is likely to have come from the Project
  - A review of construction methods to determine ways of improving works to minimise the risk of further contamination
  - The identification of corrective actions to prevent any future exceedances.

The incident reporting processes to EHP will be completed as per the EA conditions.

9.12 Cumulative Impacts

The Project is wholly contained within the Styx River Basin, and the two catchments for the Project area are Tooloombah and Deep Creek. Tooloombah Creek catchment comprises approximately 36,000 ha and Deep Creek comprises a further 29,000 ha. Only 15% of the Project area drains towards Tooloombah Creek with the majority of surface water draining into Deep Creek. Both Deep Creek and Tooloombah Creek meet at a confluence downstream of the Project area to form the Styx River.

For this cumulative assessment, we have chosen to restrict the assessment to the overall Styx River, as it is unlikely that the project will impact area beyond this extent. The Styx River is dominated by cattle grazing with most of the catchment rural with minimal developments.

There are however three surface water entitlements in Tooloombah and Deep Creek which could be adversely impacted by proposed extraction from Tooloombah Creek to meet the onsite potable water demand. The existing water entitlements are small with extraction requirements of 18 ML and 8 ha. The combined existing and new water extraction is unlikely to impact the water flow within Tooloombah Creek as the Project Area will only extract water under 80% flow conditions; therefore, these will likely occur during flood events.

The Project resides within the middle region of Styx Basin in which there are numerous proposed mines and developments. Many the exploration permits within the basin are dominated by mineral and coal exploration permits The Styx River is currently undeveloped which effectively minimises surface water cumulative impacts associated with the project as there are no developments which are likely to increase the impacts of the Central Queensland Coal mine.

9.13 Qualitative Risk Assessment

Potential impacts on ecological values have been assessed utilising the risk assessment framework outlined in Chapter 1 - Introduction.

For the purposes of risk associated with aquatic EVs, risk levels are defined as follows:

- Extreme – Works must not proceed until suitable mitigation measures have been adopted to minimise the risk;
- High – Works should not proceed until suitable mitigation measures have been adopted to minimise the risk;
- Medium – Acceptable with formal review. Documented action plan to manage risk is required; and
- Low - Acceptable with review.

A qualitative risk assessment is outlined in Table 9-42. It outlines: the potential impacts, the initial risk, proposed control measures (as detailed in the previous section), and the residual risk following the implementation of those measures.

Table 9-57 Qualitative risk assessment

Issue	Potential impacts	Potential risk	Mitigation measures	Residual risk
Increased Sedimentation of Waterways and Sediment Runoff	▪ Degradation of instream habitat / water quality including downstream HEV estuarine habitat in the Styx River ▪ Changes flood extent as less storage available for rainfall events	High	▪ Design and implement Project Erosion and Sediment Control Plan ▪ Surface waters managed and monitored under Project Receiving Environment Monitoring Program ▪ Minimise unnecessary disturbance to vegetated lands ▪ Progressive rehabilitation of disturbed areas will be undertaken ▪ Appropriately designed water management system including environmental dams	Low
Direct Disturbance of Waterways	▪ Changes to flow characteristics ▪ Changes in sediment loads ▪ Decrease habitat ▪ Increased erosion and increase in runoff velocity due to the construction of culverts ▪ Causes localised surface water ponded areas	High	▪ Construction of culverts and watercourse / drainage feature crossings during no-flow/low-flow conditions; ▪ Implementation of requirements set out in the Erosion and Sediment Control Plan (ESCP); ▪ Vegetation will be preserved with only the minimum amount of land required to operate the Project cleared at any one time; and ▪ Monitor the crossings and Erosion and Sediment Control (ESC) devices to ensure ongoing effectiveness and implement corrective actions should a fault in the crossings or ESC devices be identified.	Low
Accidental release of pollutants	▪ Degradation of instream habitat/water quality including downstream HEV estuarine habitat in the Styx River ▪ Fish mortality events ▪ Decreases in water quality i.e. lower DO levels, higher turbidity	High	▪ Design and implement Project Receiving Environment Monitoring Program and Water Management Plan ▪ Controlled release of better quality water in accordance with licensed EA conditions ▪ Maintenance of Design Storage Allowance on the onset of the wet season to minimise the likelihood of uncontrolled discharges ▪ Pipeline connectivity between storages to allow water transfer to where there is available capacity ▪ Establish measures to minimise/control Project-associated chemical spills ▪ Project design will locate infrastructure to minimise stormwater run-off ▪ All waters discharged into adjacent waterways will be treated in retention basins and similar in quality to receiving waters	Medium
Hydrology and water flows	▪ Reduction of inflows to watercourses and drainage features	High	▪ Design and implement Project Receiving Environment Monitoring Program ▪ Project design to ensure surface water flows into creeks maintained as close to natural conditions as practical	Low

Note: R=Rare, UL= Unlikely, P=Possible, L=Likely, AC=Almost Certain

9.14 Conclusion

This chapter described the EVs of surface water resources that may be affected by the Project, and identified historical and current surface water conditions upstream, downstream and within the Project area. The ephemeral watercourses and wetlands (including farm dams) within the Project area and surrounding region are classified as moderately disturbed, with the background water quality reflecting that the land is largely given over to grazing.

Intermittent flooding is a natural feature of the landscape, reflected in the predominance of ephemeral watercourses. Flood modelling identified that the CHPP and MIA 1 will be outside of the area of flood risk and, with the use of sediment control devices, no impact is anticipated to watercourses within and surrounding the Project site during construction. CHPP and MIA 2 are within the flood risk for events greater than 0.1%, with water ponding on the pad surface. During the PMF AEP event a maximum water depth of 0.99 m was recorded on the pad; this is with the existing surface elevation raised by between 1.0-2.5 m.

A Project Receiving Environment Monitoring Program will be developed that specifies the threshold and trigger levels for management actions, and identifies the mitigating or reparative actions required to reduce the risk or effect of impacts. A Water Management Plan will be developed prior to construction, to monitor the effects on the waterways which will receive the highest level of disturbance. Although some level of impacts is unavoidable, the assessment has identified that mitigation and management measures can be employed to significantly reduce the potential for adverse impacts on the area's surface water EVs.

9.15 Commitments

In relation to surface water, Central Queensland Coal's commitments are provided in Table 9-58.

Table 9-58 Commitments – surface water

Commitment
Should the release contaminant levels be shown to exceed the background monitoring level, Central Queensland Coal will investigate the potential environmental harm and provide reporting to the administering authority outlining the actions taken to prevent environmental harm.
Undertake water monitoring at the discharge locations of the environmental dams and mine-affected water dams, and at reference locations both upstream and downstream of the Project area.
Use monitoring as a continual improvement mechanism for the ongoing management of stormwater including operational calibration of the water balance model.
Design and implement a Project Erosion and Sediment Control Plan to be certified by a suitably qualified person, prior to construction.
Develop and implement a Receiving Environment Monitoring Program in accordance with EHP Guidelines and periodically update as required throughout the life of the Project.
Prepare and implement a Water Management Plan that outlines the monitoring and management measures for surface water and groundwater.
Minimise unnecessary disturbance to vegetated lands.
Undertake progressive rehabilitation of disturbed areas.
Prepare and implement a water management network to manage impact to water resources.
Reuse water captured in environment dams (onsite) and mine dewater dams before using raw water, where practicable.

9.16 ToR Cross-reference Table

Table 9-59 ToR Cross Reference Table

Terms of Reference	Section of the EIS
8.3 Water Quality	
The assessment of water quality is considered a critical matter given the proximity of the Great Barrier Reef World Heritage Area, the presence of a wetland of national significance within the protect area, and usage of water resources for grazing purposes in the area. Conduct impact assessment in accordance with the EHP's *EIS information guideline—Water*.	Noted
With reference to the Environmental Protection (Water) Policy 2009 and section 9 the EP Act, identify the environmental values of surface waters within the project area, downstream and upstream that may be affected by the project, including any human uses of the water and any cultural values.	Section 9.4
Define and/or establish the relevant water quality objectives applicable to the environmental values, and demonstrate how these will be met by the project during construction, operation and decommissioning.	Sections 9.5, 9.7 and 9.11
Quantify sediment and contaminant load increases in streams and to the reef as a result of mining operations.	Section 9.10
Detail the chemical, physical and biological characteristics of surface waters and groundwater within the area that may be affected by the project and at suitable reference locations using sufficient data to define background conditions and natural variation in accordance with appropriate national and state guidelines and policies.	Section 9.5
Describe the quantity, quality, location, duration and timing[2] of all potential and/or proposed releases of contaminants addressing applicable standards from any relevant regional water quality management plans, strategies, or guidelines relating to water quality. Releases may include controlled water discharges to surface water streams, uncontrolled discharges when the design capacity of storages is exceeded, spills of products during loading or transportation, spills of product from the conveyor, contaminated run-off from operational areas of the site (including seepage from waste rock dumps), or run-off from disturbed acid sulphate soils.	Section 9.9
Assess the likely impacts of any releases from point or diffuse sources on all relevant environmental values of the receiving environment, including environmentally sensitive areas; such as the Great Barrier Reef World Heritage Area and Broad Sound Directory of Important Wetlands in Australia (DIWA) nationally important wetland as well as near-field and mid-field locations. The assessment should consider the quality and hydrology of receiving waters and the assimilative capacity of the receiving environment.	Section 9.10
Describe how impacts on water quality objectives and environmental values would be avoided or minimised through the implementation of management strategies that comply with the management hierarchy and management intent of the Environmental Protection (Water) Policy 2009. Appropriate management strategies may include the use of erosion and sediment control practices, and the separation of clean storm water run-off from the run-off from disturbed and operational areas of the site.	Section 9.11

[2] Duration and timing are important aspects of the risk characteristics that affect the impacts of mine and CSG water releases; e.g. for how long will water be released in total and when will it occur with respect to existing 'natural' flows

Terms of Reference	Section of the EIS
Describe how monitoring would be used to demonstrate that objectives were being assessed, audited and met. For example, provide measureable criteria, standards and/or indicators that will be used to assess the condition of the ecological values and health of surface water environments. Propose corrective actions to be used if objectives are not being met.	Section 9.11.4
8.4 Water Resources	
The assessment of surface water and groundwater resources is considered a critical matter given the usage of water resources for grazing purposes in the area. Conduct impact assessment in accordance with the EHP's *EIS Information guidelines – Water*.	Noted
The assessment of surface water and groundwater resources is considered a critical matter given the usage of water resources for grazing purposes in the area. Conduct impact assessment in accordance with the EHP's *EIS information guidelines—Water*. Describe present and potential users and uses of water in areas potentially affected by the project, including municipal, agricultural[3], industrial, recreational and environmental uses of water.	Section 9.4.6
Provide details of any proposed changes to, or use of, surface water or groundwater	Sections 9.4.3 and 9.6.3
Identify any approval or allocation that would be needed under the *Water Act 2000*.	Section 9.2.4
Include maps of suitable scale showing the location of diversions and other water-related infrastructure in relation to mining infrastructure.	Sections 9.6 and 9.7
Detail any significant diversion or interception of overland flow.	Section 9.6
Assess the potential impacts of any new water infrastructure (including diversions, pits, dams, etc.) and any proposed changes to water supply or take, on ground and surface water hydrology, quality and hydrological processes.	Section 9.10
Describe the options for supplying water to the project and assess any potential consequential impacts in relation to the objectives of any water resource plan and resource operations plan that may apply.	Chapter 3 – Project Description
Describe the proposed supply of potable water for the project, including temporary demands during the construction period.	Chapter 3 – Project Description
Also describe on-site storage and treatment requirements for waste water from accommodation and/or offices and workshops.	Section 9.8 and Chapter 3 Project Description
Describe the practices and procedures that would be used to avoid or minimise impacts on water resources.	Section 9.11 and Chapter 3 - Project Description
8.5 Flooding	
The assessment of surface water and groundwater resources is considered a critical matter given the use of the area for cattle grazing and the need to protect the environmental values of water resources.	Noted
Describe current flood risk for a range of annual exceedance probabilities (AEPs) up to the PMF for the project site.	Section 9.6

[3] https://publications.qld.gov.au/dataset/daff-environmental-impact-assessment-companion-guide/resource/7b1825c4-5e42-4cf8-aa2d-7fa55c2f5e4c

Terms of Reference	Section of the EIS
Use flood modelling to assess how the project may potentially change flooding and run-off characteristics on-site and upstream and downstream of the site.	Section 9.6
Maps and plans showing inundated and flooded areas for the full range of AEPs up to the PMF flood should be presented for the site, for the case before construction of the project, and also after mine closure. The assessment should consider all infrastructure associated with the project including levees, roads, and linear infrastructure, and all proposed measures to avoid or minimise impacts.	Section 9.6
Evidence should be provided that the securing of storage containers of hazardous contaminants during flood events meets the requirements of Schedule 5, table 2 of the EP Regulation.	Section 9.11.3
Describe and illustrate where any residual voids and mining features e.g. waste rock dumps would lie in relation to the extent of the PMF. Demonstrate that these features will not impact on the ecological functioning and physical processes of the floodplain and GBR in the longer-term.	Section 9.6.2
Assess the project's vulnerabilities to climate change (e.g. changing patterns of rainfall, hydrology, temperature and extreme weather events).	Chapter 4 – Climate
Describe possible adaptation strategies (preferred and alternative) based on climate change projections for the project.	Chapter 4 – Climate
8.6 Regulated Structures	
Conduct impact assessments on regulated structures in accordance with the EHP's *EIS information guideline—Regulated structures*, EHP's *Guideline on structures which are dams of levees constructed as part of environmentally relevant activities*[4], and EHP's *Manual for assessing hazard categories and hydraulic performance of structures*[5].	Noted
Describe the purpose of all dams or levees proposed on the project site.	Section 9.7.1 and Chapter 3 – Project Description
Show their locations on appropriately scaled maps, and provide plans and cross-sections, illustrating such features as embankment heights, spillways, discharge points, design storage allowances, and maximum volumes.	Section 9.8
Describe how storage structures and other infrastructure would be sited to avoid or minimise risks from flooding.	Section 9.6
Where project infrastructure comprises dams or other structures for storing potentially hazardous materials, undertake a consequence category assessment for each dam or levee, according to the criteria outlined in EHP's *Manual for assessing consequence categories and hydraulic performance of structures*. The assessment must be undertaken for the three different failure event scenarios described in EHP's manual, i.e. for seepage, overtopping and dam break. Regulated structures must comply with the *Manual for assessing consequence categories and hydraulic performance of structures* in accordance with Schedule 5, table 2 of the EP Regulation.	Section 9.8

[4] http://www.ehp.qld.gov.au/assets/documents/regulation/era-gl-structures-dams-levees-eras.pdf

[5] https://www.ehp.qld.gov.au/assets/documents/regulation/era-mn-assessing-consequence-hydraulic-performance.pdf

Terms of Reference	Section of the EIS
Following the consequence category assessment, determine the consequence category (‘low, significant, or high’) according to table 1 of EHP’s *Manual for assessing hazard categories and hydraulic performance of structures* and provide certified copies of these the consequence category determination for each of the proposed dams or levees.	Section 9.8. Note; however, the proponent is seeking to have this requirement to provide certified copies of drawings as an EA Condition as this will enable the outcomes of the EIS process to be considered in final design of each dam.
Describe how risks associated with dam or storage failure, seepage through the floor, embankments of the dams, and/or with overtopping of the structures will be avoided, minimised or mitigated to protect people, property and the environment.	Section 6.8