Adani Mining Pty Ltd

Adani Mining Pty Ltd

Report for Carmichael Coal Mine and Rail Project: Technical Report

Mine Hydrology Report 25215-D-RP-0027

14 November 2012

Revision 0

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Abbreviations and Glossary

Project Specific Terminology

Abbreviation	Term
the EIS	Carmichael Coal Mine and Rail Project Environmental Impact Statement
the Proponent	Adani Mining Pty Ltd
the Project	Carmichael Coal Mine and Rail Project

Generic Terminology

Abbreviation	Term
ADWG	Australian Drinking Water Guidelines
ANZECC	Australian and New Zealand Environment and Conservation Council
ARI	Average Recurrence Interval
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BOM	Bureau of Meteorology
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CEMP	Construction Environmental Management Plan
CSG	Coal Seam Gas
DEHP	Department of Environment and Heritage Protection (Qld) (previously DERM)
DERM	Department of Environment and Resource Management (Qld)
DO	Dissolved Oxygen
DRN	Drain boundary
EC	Electrical Conductivity
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EPC	Exploration Permit for Coal
EPP (Water)	Queensland Environmental Protection (Water) Policy 2009
EVs	Environmental Values
FWL	Fracture well
GAB	Great Artesian Basin
GABCC	Great Artesian Basin Consultative Council
GDE	Groundwater Dependent Ecosystem
GHB	General head boundary

Generic Terminology	
Abbreviation	**Term**
GMA	Groundwater Management Area
GMU	Groundwater Management Unit
GWMP	Groundwater Management Plan
IFD	Intensity Frequency Duration
LIDAR	Light Detection and Ranging
LTV	Long-term trigger value
LoR	Limit of Reporting
mAHD	Metres Australian Height Datum
MAW	Mine affected water
mBGL	Metres below ground level
MLA	Mine lease area
Mtpa	Million tonnes per annum
PAHs	Polycyclic Aromatic Hydrocarbons
PWB	Preliminary Water Balance
ROP	Resource Operations Plan
RSF	Recharge-seepage face
SPA	Sustainable Planning Act 2009
STV	Short-term trigger value
SWMP	Surface Water Management Plan
TDS	Total dissolved solids
TOC	Total organic carbon
ToR	Terms of reference
TPH	Total Petroleum Hydrocarbon
QWQG	Queensland Water Quality Guidelines
WERD	Water Entitlements Registered Database
WQGs	Water Quality Guidelines
WQOs	Water Quality Objectives
WRP	Water Resource Plan

1. Introduction

1.1 Background

Adani Mining Pty Ltd (Adani) is proposing to develop a 60 million tonne (product) per annum (Mtpa) thermal coal mine in the north Galilee Basin approximately 160 kilometres (km) north-west of the town of Clermont, Central Queensland. All coal will be railed via a privately owned rail line connecting to the existing QR National rail infrastructure to coal terminal facilities at the Port of Abbot Point and/or the Port of Hay Point (Dudgeon Point expansion), where it will be loaded onto export vessels. The Carmichael Coal Mine and Rail Project (the Project) will have an operating life of approximately 90 years.

The Project comprises of two major components:

- The Project (Mine): a greenfield coal mine over EPC1690 and the eastern portion of EPC1080, which includes both open cut and underground mining, on mine infrastructure and associated mine processing facilities (the Mine) and the Mine (offsite) infrastructure including:
  - A workers accommodation village and associated facilities
  - A permanent airport site
  - Water supply infrastructure
- The Project (Rail): a greenfield rail line connecting the Mine to the existing Goonyella and Newlands rail systems to provide for the export of coal via the Port of Hay Point (Dudgeon Point expansion) and the Port of Abbot Point, respectively; including:
  - Rail (west): a 120 km dual gauge portion from the Mine site running west to east to Diamond Creek
  - Rail (east): a 69 km narrow gauge portion running east from Diamond Creek connecting to the Goonyella rail system south of Moranbah

The Project has been declared a ‘significant project’ under the *State Development and Public Works Organisation Act 1971* (SDPWO Act) for which an Environmental Impact Statement (EIS) is required. The Project is also a ‘controlled action’ and requires assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Project EIS has been developed with the objective of avoiding or mitigating all potential adverse impacts to environmental, social and economic values and enhancing positive impacts. Detailed descriptions of the Project are provided in Volume 2 Section 2 Project Description (Mine) and Volume 3 Section 2 Project Description (Rail). Figure 1-1 shows the Project location.

1.2 Objectives of Report

The objective of this report is to address the relevant parts of Section 3.4 Water Resources within the EIS Terms of Reference (ToR). In particular, the report documents the environmental impact assessment (EIA) process applied during the design of the Project (Mine) with respect to the management of water resources.

Studies providing an assessment of the Project (Mine) on existing surface water hydrology, water quality and groundwater resources are provided in separate reports, namely:

- Carmichael Coal Mine and Rail Project, Mine Surface Water Quality (GHD, 2011)
- Carmichael Coal Mine, Preliminary Flood Mitigation and Creek Diversion Design (GHD, 2012a)
- Carmichael Coal Project – Mine Site, Mine Hydrogeology Report (GHD, 2012b)

LEGEND

- Town
- Major Port
- Other Rail Network
- Goonyella System
- Newlands System
- State Road
- Local Road
- Watercourse
- Local Government Area
- Project (Rail)
  - Rail (West)
  - Rail (East)
- Project (Mine)
- Mine (Offsite)

1:2,000,000 (at A4)

0 10 20 30 40 50

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number	41-25215
Revision	L
Date	28-08-2012

Project Location

Figure: 1-1

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: © Commonwealth of Australia (Geoscience Australia): Town, Railways, Watercourses (2007); DERM: LGA, (2011), Hillshade (2009); DMR: State Roads (2008); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011); Adani: Alignment Opt9 Rev3 (2012). Created by: BW, JVC

1.3 Report Scope

The ToR sets out the scope of the EIS. With respect to water resources, the ToR requires the following scope of works for surface water flows and water levels:

- A description of existing surface water in terms of its physical characteristics;
- A description of existing surface drainage patterns, history of flooding (i.e. extent, levels and frequency) and present water uses;
- An assessment of the potential impacts of the Project on these characteristics; and
- The identification of measures to protect and enhance water resources, and how these measures will be implemented, monitored, managed and audited.

A summary of the methodology applied to meet this scope is provided in Section 2.

Table 1-1 provides a summary and cross reference to the ToR. A full cross reference to the TOR is included as Appendix A of this Report.

Table 1-1 Summary - Terms of Reference

Terms of Reference Requirement / Section Number	Section of this Report
3.4. Water Resources	
3.4.1 Description of Environmental Values	
Describe the existing water resources that may be affected by the project in the context of environmental values as defined in such documents as the EP Act, *Environmental Protection (Water) Policy 2009* (EPP (Water)), *Australia and New Zealand Guidelines for Fresh and Marine Water Quality* and the *Queensland Water Quality Guidelines.*	Section 4
Describe present and potential users and uses of water in areas potentially affected by the project.	Section 4.5
Describe the environmental values of the surface waterways of the affected area in terms of existing and other potential surface and groundwater users.	Section 4.5
Provide a detailed description of the quality and quantity of surface and groundwater resources in the area potentially affected by the project.	Section 4.2 Volume 4 Appendix Q
Describe the groundwater quality considering seasonal variations in depth and flow and all times of natural flow in ephemeral streams.	Volume 4 Appendix R
Investigate the relationship between groundwater and surface water to assess the nature of any interaction between the two resources.	Volume 4 Appendix R, Volume 4 Appendix Q
Describe the environmental values of the surface waterways and groundwater of the affected area : ◗ values identified in the EPP ◗ Physical integrity, fluvial processes and morphology ◗ Any impoundments ◗ Hydrology of waterways and groundwater	Section 4, 4.3, 4.4, 5, 6, Volume 4 Appendix R, Volume 4 Appendix O

Terms of Reference Requirement / Section Number	Section of this Report
3.4. Water Resources	
◗ Sustainability (quality and quantity) ◗ Dependent ecosystems ◗ Existing and other potential surface and groundwater users ◗ Details of any proposed buffer widths between project activities and waterways ◗ Any water resource plans relevant to the affected catchments	
If the project is likely to use or affect local sources of groundwater, describe the groundwater resources in the area.	Volume 4 Appendix R
3.4.2 Potential Impacts and Mitigation Measures	
Assess potential impacts, including long-term indirect impacts of the project on water resource environmental values identified in the previous section.	Section 8
Chemical and physical properties of any wastewater including stormwater at the point of discharge into natural surface waters, including the toxicity of effluent to flora and fauna.	Section 8.5, Volume 4 Appendix Q
Environmental monitoring to check the effectiveness of mitigation measures.	Section 8.6.4
Potential impacts on other downstream receiving environments, considering the available assimilative capacity of the receiving waters, if it is proposed to discharge water to a riverine system.	Section 8.4
The potential to contaminate surface and groundwater resources and measures to prevent, mitigate and remediate such contamination.	Section 8.4.2, Volume 4 Appendix Q
Describe and address the impacts of subsidence.	Volume 2 Section 4
Assess any potential surface water and groundwater interaction as a result of subsidence of a watercourse.	Section 4.5, 8.4.4 Volume 4 Appendix Q
Assess the potential impacts of subsidence.	Volume 2 Section 4
Outline impacts on all surface water resources by describing existing and altered overland flow.	Section 5, Section 8.3
Describe the option for supplying water to the project, and assess the consequential impacts.	Volume 2 Section 2
Reference the properties of the land disturbed and processing liquid wastes, the technology for settling suspended clays from contaminated water, and the techniques to be employed to ensure contaminated water is contained and successfully treated on site.	PWB, Appendix XX
Describe the proposed stormwater drainage system and proposed disposal arrangements. (Illustrate with figures and contours).	Section 6.2, 6.3, Appendix D
The EIS should outline all of the approvals required under the Water Act 2000, Water Regulation 2002 and subordinate legislation to complete the project, including construction and operational stages.	Section 3

Terms of Reference Requirement / Section Number	Section of this Report
3.4. Water Resources	
Describe management strategies in adequate detail to demonstrate best practice management and environmental values of receiving waters will be maintained to nominated water quality objectives.	Section 6, Section 8.5 Volume 4 Appendix Q
Address where there will be a requirement for a Quarry Material Allocation and an associated Development Approval under the Sustainable Planning Act.	N/A

2. Methodology

2.1 Overview

Baseline information and data on existing water resources were obtained from a combination of a desktop review and a series of targeted field investigations. Preliminary design of surface water-related infrastructure and a preliminary water balance (PWB) were undertaken in order to inform the Project (Mine) surface water management and therefore the assessment of impacts and mitigation options. The steps undertaken therefore to perform the hydrology assessment for the EIS are as follows:

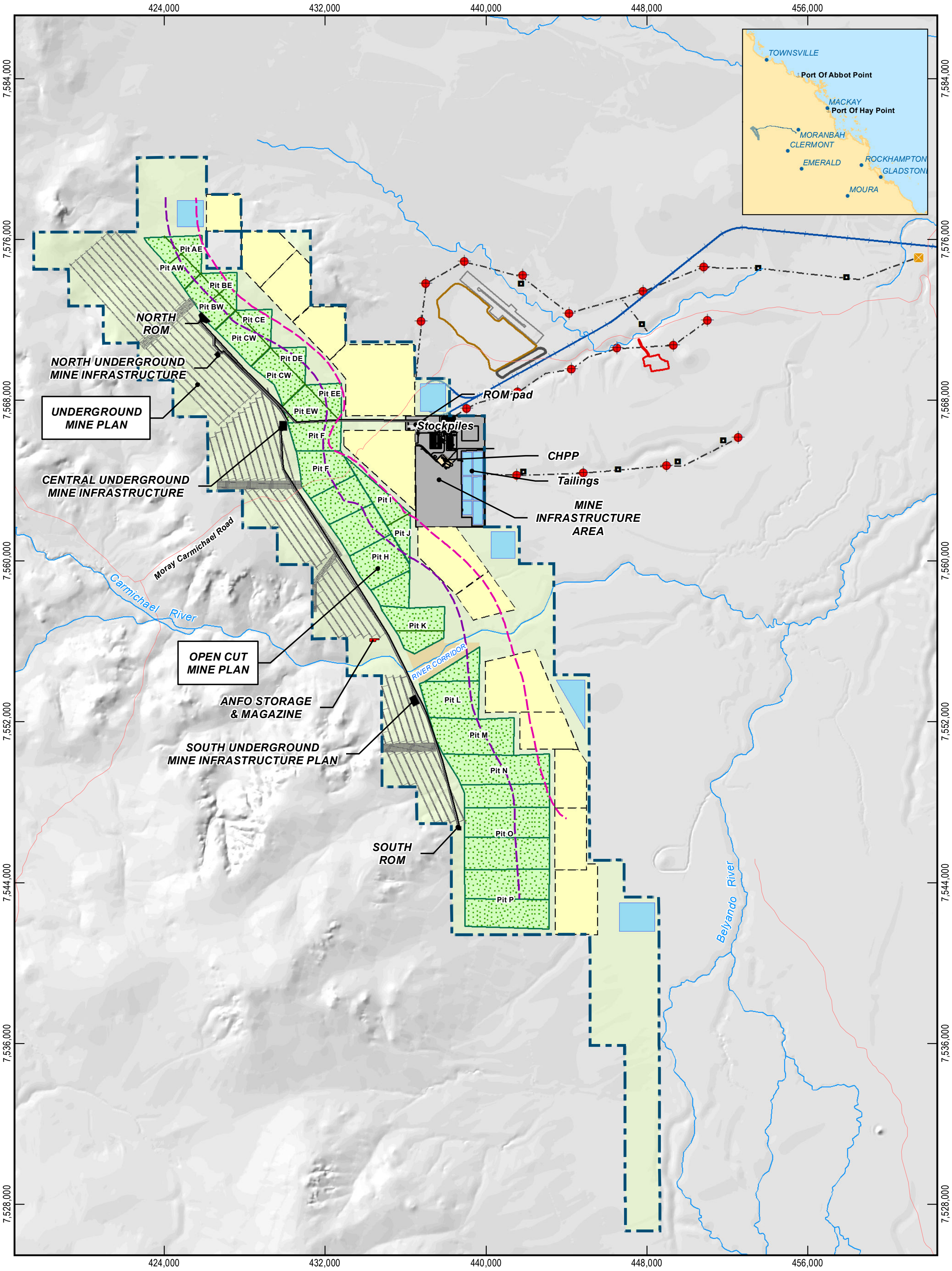
- Collate existing baseline data for the Belyando Basin in the region of the Carmichael River and mine site
- Describe the baseline hydrological conditions
- Undertake baseline flood study
- Assess likely flooding impacts to the mine
- Undertake preliminary flood protection infrastructure design
- Perform a water supply analysis
- Assess likely water deficits and surpluses
- Re-assess the likely flooding impacts to the mine with the proposed infrastructure in place
- Assess the hydrological and hydraulic impact of the mine site with the proposed infrastructure in place
- Recommend management and mitigation options for the residual impacts

The results of this exercise were used to identify and characterise the existing hydrological conditions within the Study Area (as defined below). This information was then used to inform the Project (Mine) design as well as the impact assessment.

2.2 Study Area

The Study Area for this assessment comprises the area within exploration permit for coal (EPC) 1690 and the eastern parts of EPC 1080 (Figure 2-1), as well as the area immediately upstream and downstream where the Carmichael River crosses EPC 1690. This encompasses approximately 45,400 hectares (ha) of predominantly grazing land.

The field investigations were undertaken based on the initial Study Area boundary, being EPC 1690. Subsequent to the field studies, the eastern portion of EPC 1080 was included in the Study Area.



LEGEND

Local Road	Rail (West)	Mine (Offsite)	Airport Location
River / Watercourse	Mine (Onsite)	Borehole	Rail Siding
AB1 Cropline	Open Cut Blocks	Storage Site (Instream)	Industrial Area
D1 Cropline	Out of Pit Waste Dumps	Storage Facility (Offstream)	Workers Accommodation Village
Overland Conveyors	Water Management Dams	Pipeline Network	

1:270,000 (at A4)

0 2 4 6 8

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision A
Date 05-09-2012

Study Area

Figure 2-1

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: GA: Road, River / Watercourse (2007); DME:EPC1690 (2010), EPC1080 (2011); Adani: Mine Layout / Infrastructure (2012); Gassman Hyder: Mine (Offsite) (2012);. Created by: CA

2.3 Modelling

2.3.1 Flooding

Hydrologic and hydraulic modelling informed the assessment of baseline hydrological conditions, flood protection infrastructure requirements and identification of residual impacts. The modelling was undertaken according to the following methodology:

1. *Develop a hydrologic (rainfall-runoff) model of the existing conditions in the Carmichael River catchment*– This model estimates critical storm durations and resulting design flow rates for the 1 in 10 year, 1 in 50 year, 1 in 100 year and 1 in 1000 year average recurrence interval (ARI) events. These events were selected to describe a range of flood conditions including the design flood immunity desired by the Proponent.
2. *Develop a hydrologic model of the developed condition in the Carmichael River catchment* – This model estimates critical storm durations and resulting design flow rates for the 1 in 10 year, 50 year, 100 year and 1000 year ARI events within the Carmichael River and within the diversion drains. It demonstrates the hydrologic impact of the proposed development on contributing catchment areas and peak flows. This model uses the existing conditions model, which was modified to include the development changes due to the works.
3. *Develop a two-dimensional (2D) hydraulic model of the Carmichael River and floodplain in the vicinity of the mine site under existing conditions* – This model defines existing hydraulic conditions and peak flood levels and extents for the 10 year, 50 year, 100 year and 1000 year ARI critical storm duration events.
4. *Develop a one-dimensional (1D) hydraulic model of the minor watercourses within the MLA that are not draining to the Carmichael River, for the existing condition* – This model allowed estimation of critical storm durations and resulting design flow rates for 10 year, 50 year, 100 year and 1000 year ARI event flooding at the northern and southern extents of the Carmichael River. The model output also provides the volume of flow entering the ephemeral creeks outside of the mine lease area during flood conditions.
5. *Plan a conceptual Project (Mine) flood protection and creek diversion plan that progresses throughout the Project (Mine) life* – This provides a concept and alignment upon which to base the preliminary sizing of flood protection infrastructure and diversion drains. These primary drainage requirements are based on the mine progress plots provided by Runge (Runge, 2011).
6. *Undertake preliminary design of a haul road & conveyor crossing at the Carmichael River* – Hydraulic analysis of the crossing and an associated bridge was undertaken to design a bridge that provided the required flood immunity to the bridge structure. Modelling was also used to determine the likely flooding of the bridge during storm events greater than the design event.
7. *Undertake preliminary design of a flood protection levee containing the Carmichael River* – The levee bank alignments and heights were established based on providing 1 in 1000 year ARI flood immunity to the internal mine areas as required by the Proponent. The alignment was chosen to minimise hydraulic impact on the Carmichael River and the effluent Cabbage Tree Creek.
8. *Undertake a case study design of a proposed creek diversion drain* – One diversion drain proposed within the conceptual staged drainage plan (Step 5) was used as a preliminary design case study. This was performed as an example for the design of subsequent proposed drains.

The horizontal and vertical alignments of this case study drain were optimised to take flow through the mine site within allowable velocity constraints and to re-join existing natural channels. The preliminary design also takes into account potential subsidence on the surface above the underground mining region.

9. *Develop a 2D hydraulic model to show flooding under developed conditions* – This model demonstrates the impact of the development and preliminary designs for flood protection infrastructure to mitigate flooding from the Carmichael River. It also demonstrates the flood immunity to the mine footprint provided by the proposed levee and haul road crossing infrastructure.

2.3.2 Water supply

A yield assessment of the local water supply sources was completed by Hyder[1] to understand the potential for providing a secure water supply to the mine. The assessment involved two water balance models:

1. *Integrated Quantity Quality Model (IQQM)* – The legislated water resource plan and resource operation plan (as described in Section 3.6 and Section 0) were implemented in an IQQM River model that was adjusted to include the two proposed surface water extractions to supply the mine site. The extractions were developed and optimized to ensure all environmental flow objectives (EFOs) were met and impacts on downstream users were minimized; and
2. *GOLDsim* – An off-site water balance of the mine's proposed main water supply storage was developed using GOLDsim software. This was created to aid in understanding what extractions (from the river/boreholes), what storage capacity and mine operation considerations were required to meet the projected water demands.

2.4 Data Collection

2.4.1 Desktop Review

Data collated through the desktop review included:

- *Digital Elevation Model (DEM)* – A 10 m digital elevation model (DEM) was created based on LiDAR data (Vekta, 2011). The DEM extends just outside of the mine lease area;
- *Regional Elevation Model* – 10 m contour of Queensland;
- *Mine Site Layout* – Rough geospatial files of the mine site layout for all mine stages were provided by Runge (Runge 2011);
- *Aerial Photograph* – Aerial photography of mine site location and extending approximately just outside the boundary of the mine lease from the Proponent;
- *Intensity-Frequency-Duration (IFD) Rainfall Data* – Obtained from the Bureau of Meteorology (BOM IFD 2011) for the location of the mine site. FORGE (CRC-FORGE, 2000) data was also generated for rare rainfall events;

[1] Hyder, October 2012, Adani Carmichael Coal Mine Water Demands Report.

- *Stream Gauge Data* – Daily stream flow data was provided by DEHP for nearby stream gauges (DERM, 2011);
- *Watercourse Locations* – Watercourse locations in the vicinity of the mine lease area were provided by DEHP as geospatial files;
- *Historical Climate Data* –6-minute pluviograph rainfall and evapotranspiration data was obtained from the Bureau of Meteorology (2011) for the gauges as listed within the Report;
- *Evaporation data* – This was obtained from the Queensland Government's SILO Data Drill program. This data is recorded data in-filled with modelled data where required;
- *Water licence information for the Belyando River (DEHP 2011);*
- *Extents of Flooding due to Cyclone Helen for the Belyando Region (17 January 2008); and*
- *Preliminary water balance data* from the Proponent.

2.4.2 Field Investigations

Field investigations were carried out by GHD and Hyder[2] within the Study Area, as part of the Project (Mine), to inform the Project preliminary design and EIS. This information was used to supplement the data gathered through the desktop review.

Two surface water monitoring stations were established as part of the Project (Mine) engineering and EIS studies within EPC 1690 on the Carmichael River at two locations: one close to the upstream boundary of the lease (Station No. 333301) and one close to the downstream boundary (Station No. 333302) (Figure 2-2). These monitoring stations recorded water levels and flows at approximately the upstream and downstream boundaries of the Study Area. Monitoring commenced in July 2011.

2.5 Limitations and Assumptions

It is noted that twelve months of monitoring data had been collected at the time of writing and hence provides a relatively limited data set on water levels and flow. In addition, no data has been collected from the network of smaller creeks that discharge from the proposed Project (Mine). However, given the level of consistency in data records, both in time and spatially across the Study Area, and the similarity in landscape and soil characteristics within the Study Area to those across the wider catchment, it is considered that the information gathered to date is sufficient to:

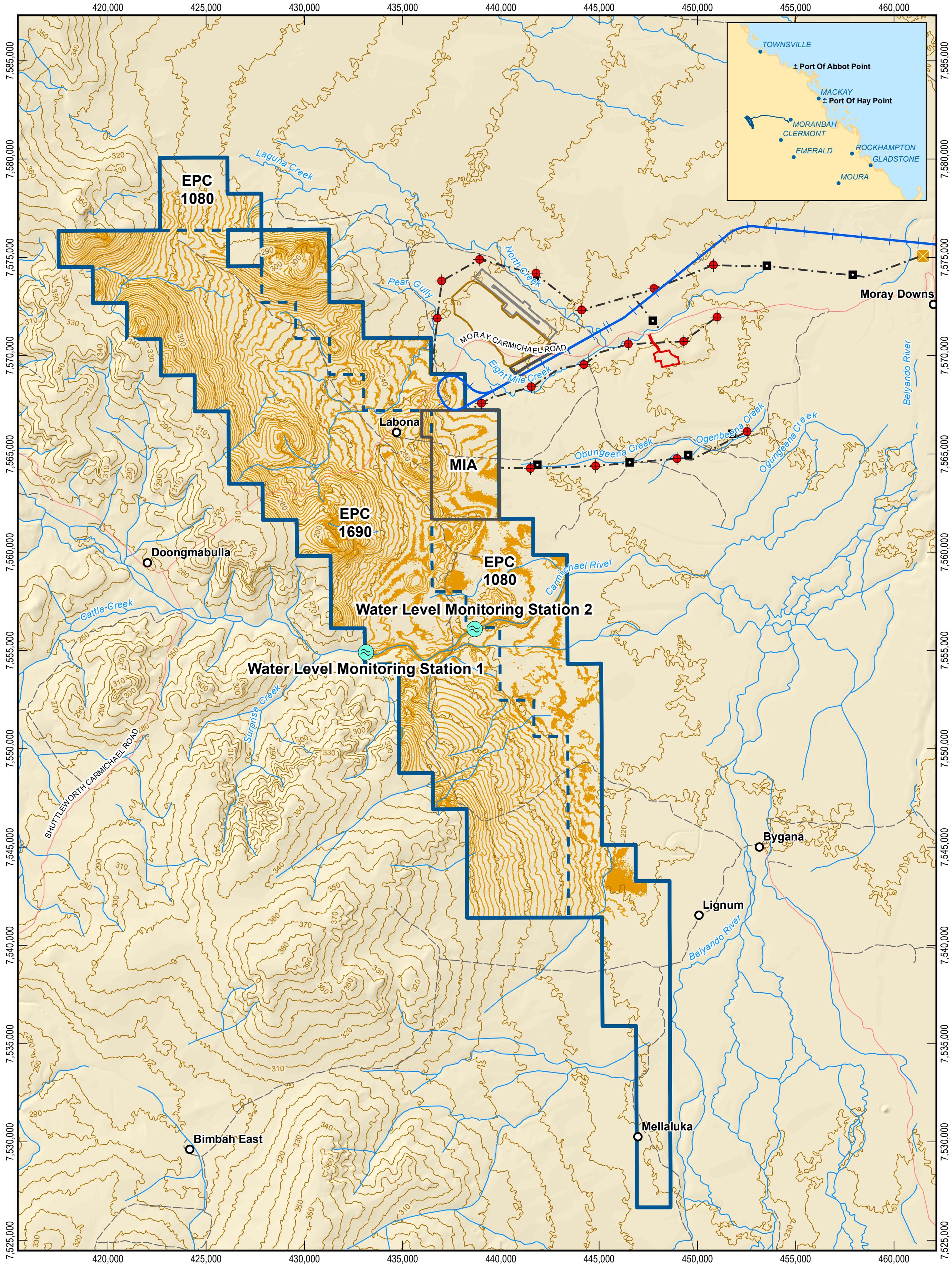
- Establish a satisfactory understanding of the hydrology within the Study Area
- Assess the likely environmental impacts of the Project (Mine) based on conceptual design studies undertaken to date.

Ongoing monitoring by the Proponent will continue to inform the Project as the assessment and design process progresses.

Flood modelling results from the Preliminary Flood Mitigation and Diversion Drain study are also subject to limitations. This report presents an analysis of risk in terms of the so-called "return period" (or Average Recurrence Interval ARI) adopted within the various design criteria. The return period is the "average" number of years between successive events of the same or greater magnitude.

[2] Hyder, October 2012, Adani Carmichael Coal Mine Water Demands Report.

Effective risk management acknowledges that there is always some level of residual risk when developing within or adjacent to a floodplain or drainage corridor, and that flood events larger than the agreed design events could occur at any time over the life of the Project. In accordance with the DERM Manual for Assessing Hazard Categories and hydraulic Performances of Dams all levees have been considered ‘regulated structures’ with a minimal extreme design event of 1 in 1,000 year ARI, as assessed in Volume 2 Section 12 Hazard and Risk.



LEGEND

- Surface Water Quality Monitoring Station
- Homestead
- Watercourse
- Local Road
- Track
- Contour - 10m
- Contour - 2m
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area
- Mine (Offsite)
- Borehole
- Storage Site (Instream)
- Storage Facility (Offstream)
- Pipeline Network
- Airport Location
- Rail Siding
- Industrial Area
- Workers Accommodation Village

Based on or contains data provided by the State of QLD (DERM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Job Number	41-25215
Revision	C
Date	05-09-2012

Flow Monitoring Stations

Figure 2-2

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DME: EPC 1690 (2010), EPC 1080 (2011); DERM: 10m Contours (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road, Watercourse (2007); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012); GHD: Monitoring Stations (2011), 2m Contours (2012). Created by: BW, CA

3. Relevant Legislation

3.1 Queensland Environmental Protection Act 1994

The *Environment Protection Act 1994* (EP Act) provides a regulatory framework for the protection and management of the Queensland environment. The objective of the EP Act is to protect Queensland's environment whilst allowing for development that is ecologically sustainable. This is achieve through various mechanisms including the management of environmentally relevant activities (ERAs) and the identification and protection of environmental values (EVs) under the subordinate *Environmental Protection (Water) Policy 2009* (Section 3.2). A Water Management Plan (WMP) may be mandated within the conditions of the EA or in order to comply with the Environmental Protection (Water) Policy 2009 whereby environmental values must be identified and protected by achieving associated water quality objectives (WQOs). The WMP then forms part of the Environmental Management Plan (EMP) for the project and should be designed in according to the DEHP (2012) guidelines 'Preparation of Water Management Plans for Mining Activities'.

3.2 Environmental Protection (Water) Policy 2009

The *Environmental Protection (Water) Policy 2009* (EPP (Water)) applies to all waters including tidal, non-tidal, lakes, wetlands and groundwater. It seeks to protect Queensland's waters while allowing for development that is ecologically sustainable, the objective identified by the *Environmental Protection Act 1994*.

This purpose is achieved within a framework that includes identifying EVs such as aquatic ecosystems, water for drinking, water supply, water for agriculture, industry and recreational use for Queensland waters and stating corresponding water quality guidelines (WQGs) and water quality objectives (WQOs) to enhance or protect the environmental values.

The EVs considered applicable to the Project (Mine) to be particularly enhanced or protected under the EPP (Water) are the following:

- Biological integrity of an aquatic ecosystem;
- Suitability for agricultural use; and
- The cultural and spiritual values of the water.

3.3 Sustainable Planning Act 2009

The *Sustainable Planning Act 2009* (SP Act) manages the process of development and the effects of development on the environment. Under SPA, construction works to take water (i.e. extraction of groundwater or dewatering) require a Development Permit and will be applicable if water is to be taken for any purpose for the Project other than water monitoring.

3.4 Water Act 2000

This is the primary act for administration of water in Australia. The *Water Act 2000* provides a framework for management and allocation of water resources and licences, based on development of catchment-based Water Resource Plans (WRPs). The WRPs are then activated through related Resource Operations Plans (ROPs) which provide detail on how the water resources will be managed to implement the strategies and objectives as set out in the WRP.

Water resources within the central and southern parts of EPC 1690 and within EPC 1080 are managed under the *Water Resource (Burdekin Basin) Plan 2007* and the *Burdekin Basin Resource Operations Plan 2009*.

The Project (Mine) will require approvals and licences in accordance with the provisions of the *Water Act 2000*, for activities including:

- Interfering with watercourses traversing the Project Area where not included under the guideline 'Activities in a watercourse, lake or spring associated with a resource activity or mining operation' (DNRM 2012); and
- Sourcing of water from nearby watercourses or overland flow.

3.5 Water Regulation (2002)

The *Water Regulation 2002* is subordinate to the *Water Act 2000* and defines the purpose of use (such as stock / domestic use) that do not require authorisation to take water and, by omission, those purposes that do require authorisation.

3.6 Water Resource (Burdekin Basin) Plan 2007

The *Water Resource (Burdekin Basin) Plan 2007* (the WRP) was created under the catchment-based water resource planning process instigated by the *Water Act 2000* and is the relevant WRP for the Project (Mine). It provides a framework to allocate and sustainably manage water resources, reverse degradation in natural ecosystems, and to identify priorities and mechanisms for dealing with future water requirements. In addition, it defines the availability of water and regulates the taking of overland flow or groundwater.

The Project (Mine) lies within sub-catchment E of the applicable plan area (see Schedule 2 of the ROP) thus waterway diversions and stormwater collection systems required for the Project will come under Section 147 of the WRP which establishes need for monitoring of various parameters by the operators of infrastructure for interfering with water (including overland flows). The ROP also informs the granting of a licence for the interference with water under Section 206 of the *Water Act 2000*, which will apply to the Project as described in Section 3.2 of this report.

3.7 Burdekin Basin Resource Operations Plan (2009)

The *Burdekin Basin Resource Operations Plan* (2009) (the ROP) implements the *Water Resource (Burdekin Basin) Plan 2007* by ‘protecting the biological diversity and health of natural ecosystems and contributing to the protection and, where possible, reversal of degradation of water resources by-detailing arrangements for the collection and assessment of data by the chief executive relating to the RWP general and specific ecological outcomes’. The ROP achieves this by setting conditions, monitoring and reporting on water taking or water storage within the Burdekin Basin. The ROP applies to water in a watercourse or lake, water in springs or overland flow water. It is therefore applicable to overland flow and watercourses on the Project (Mine) site.

3.8 National Land and Water Resource Audit 2000-2002

The National Land and Water Resources Audit) provides a framework for natural resource management decision making by:

- Providing a clear understanding of the status of, and changes in, the nation’s land, vegetation and water resources and implications for their sustainable use.
- Providing an interpretation of the costs and benefits (economic, environmental and social) of land and water resource change and any remedial actions.
- Developing a national information system of compatible and readily accessible land and water data.

4. Environmental Values

4.1 Overview

The Study Area is located within the upper reaches of the Burdekin River Basin. Key features of this catchment are the Burdekin River Gorge and falls, and the Burdekin Falls dam which lie downstream of the Study Area. The main basins within the catchment include the Upper Burdekin, Cape Campaspe, Belyando, Suttor, Bowen Broken Bogie and Lower Burdekin (Dight, 2009). The gorge falls and dam have influenced the ecology of the catchment by restricting movement from the eastern coastal area to the upper catchment areas.

The Study Area is located within the Belyando basin of the Burdekin River catchment which is dominated by grazing on natural and introduced pastures. Widespread clearing has resulted in a decline in riparian habitat condition and occurrence over the past 30 years. Unlike the more undulating and wetter northern part of the Burdekin catchment, the Belyando basin is characterised by generally low relief floodplains drained by braided channels and surrounded by wide alluvial plains. The basin is predominantly under Kandosol soils, a fine sandy soil with moderate water holding capacity. Little is known of the ecology and condition of aquatic habitats in this sub-catchment, including records of permanent waterholes (Dight, 2009).

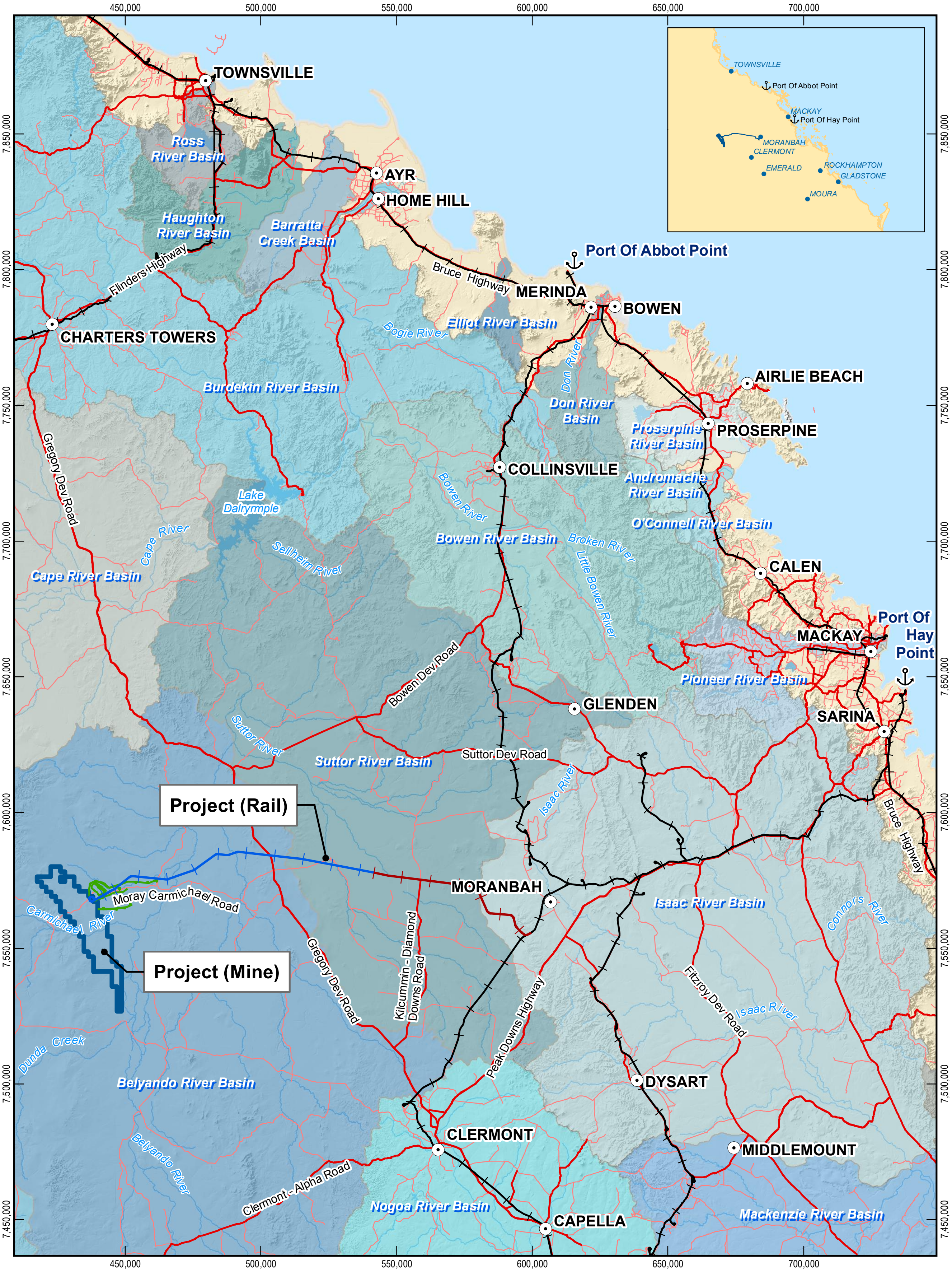
As shown in Figure 4-1, the main riverine feature of the Study Area is the Carmichael River, which flows through EPC 1690 and EPC 1080 and joins the Belyando River almost 20 km downstream of the eastern boundary of the EPCs. The Belyando River converges with the Suttor River and the waterway eventually drains into the Burdekin River. As a result of the upstream location in the catchment and seasonality in rainfall, flows are expected to be restricted to the wetter months, November to March, with many streams and drainage channels drying entirely and larger rivers sustaining only pools or low flows by the winter months (June/July).

4.2 Carmichael River Catchment

The Study Area is located within the Carmichael River catchment which is a sub-catchment of the Burdekin River Basin. Tributaries within the Carmichael River catchment include:

- Cattle Creek
- Dylingo Creek
- Surprise Creek
- Carmichael Creek;
- Dingo Creek
- Dooyne Creek

Cattle Creek, Dylingo Creek and Surprise Creek converge into the Carmichael River just upstream of the Study Area boundary. The river also receives discharge from the Doongmabulla Spring complex eight kilometres to the west of the Study Area. Topography across the Study Area typically slopes towards the east and north-east from a north-west to south-east trending ridge line, west of the lease boundary and running parallel to it (Figure 4-2).



LEGEND

Town	State Road	Project (Rail)	Mine (Onsite)
Major Port	Local Road	Rail (West)	Mine (Offsite)
Other Railway	Watercourse	Rail (East)	

Based on or contains data provided by the State of QLD (DERM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

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Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision A
Date 31-08-2012

Catchment Locations

Figure 4-1

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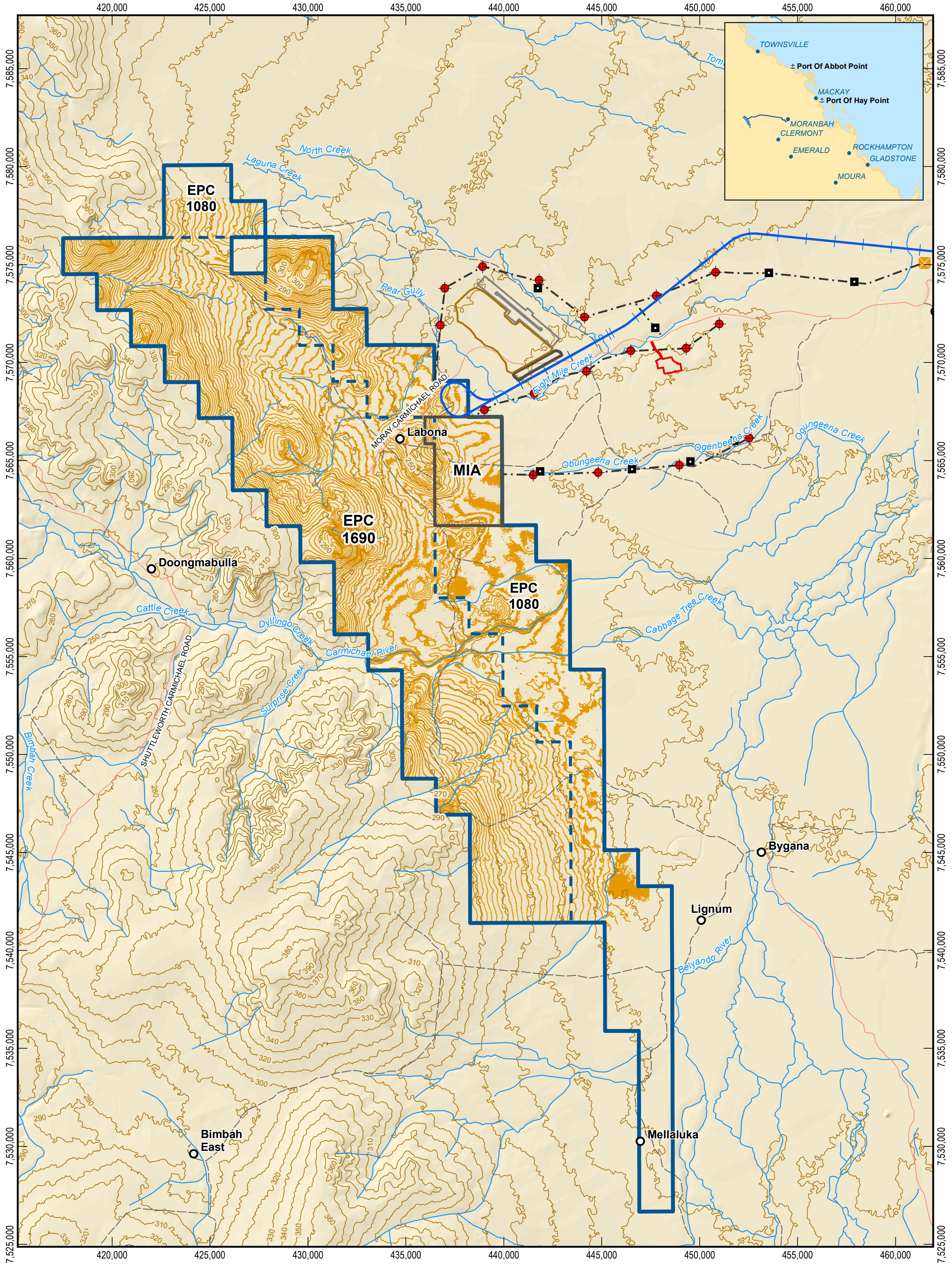
Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: © Commonwealth of Australia (Geoscience Australia): Town, Railways, Roads, Watercourses (2007); DERM: LGA, River Basins (2011); DMR: State Roads (2008); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011); Adani: Alignment Opt9 Rev3 (2012). Created by: BW, JVC, CA



LEGEND

Homestead	Watercourse	Rail (West)	Mine (Offsite)	Airport Location
Local Road	Contour - 10m	Mine (Onsite)	Borehole	Rail Siding
Track	Contour - 2m	Mine Infrastructure Area	Storage Site (Instream)	Industrial Area
			Storage Facility (Offstream)	Workers Accommodation Village
			Pipeline Network	

Based on or contains data provided by the State of QLD (DERM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

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Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision B
Date 04-09-2012

Topography of the Study Area

Figure 4-2

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\41-25215_537_rev_b.mxd Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DME: EPC 1690 (2010), EPC 1080 (2011); DERM: 10m Contours (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road, Watercourse (2007); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012); GHD: 2m Contours (2012). Created by: BW, CA

The topographic gradient flattens out in the vicinity of the Carmichael River and in the eastern parts of the Study Area. The ridgeline is bisected by the Carmichael River, which flows west to east through the southern half of the Study Area. Plate 4-1 shows the Carmichael River near the eastern boundary of EPC 1690. Figure 4-3 and Figure 4-4 illustrate cross-sections of the Carmichael River taken at the two stream gauge monitoring sites. The Study Area is bisected by the Carmichael River but only a moderate proportion of the large site contributes runoff to the river. The Carmichael River has an effluent flow path south to Cabbage Tree Creek during flood events. Cabbage Tree Creek is therefore an ephemeral distributary creek of the Carmichael River. Within the Study Area, Cabbage Tree Creek is designated as a first order stream (DERM, 2010) (refer Plate 4-2). The majority of the Study Area drains not into the Carmichael River but east into a series of ephemeral creeks including Pear Gully and Eight Mile Creek. These are not tributaries of the Carmichael River but flow east, becoming undefined before reaching the Belyando River. Eight Mile Creek is located at the north of the Study Area. Within the Study Area this ephemeral creek is designated as a first and second order stream (DERM, 2010) (refer Plate 4-3). There are also a number of ill-defined watercourses to the north and the south of the Carmichael River within the Study Area that drain generally in an easterly direction toward the Belyando River. A detailed assessment of surface water quality for the study area is provided in Volume 4 Appendix Q Mine Water Quality Report.

Plate 4-1 Carmichael River Downstream of Flow Gauge (August 2010)

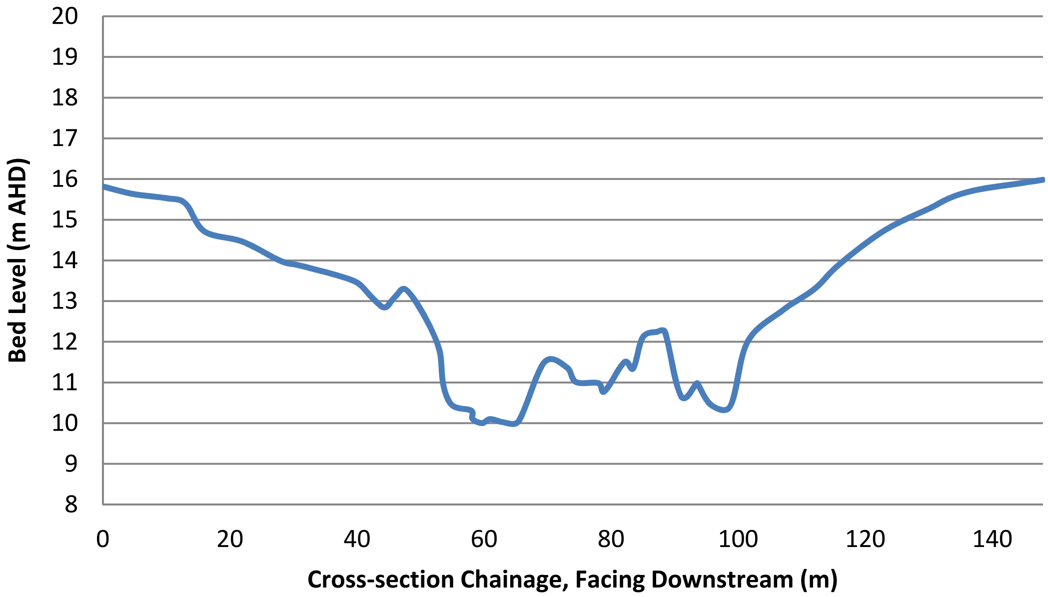


Figure 4-3 Carmichael River Cross Section (Logger location 333301)

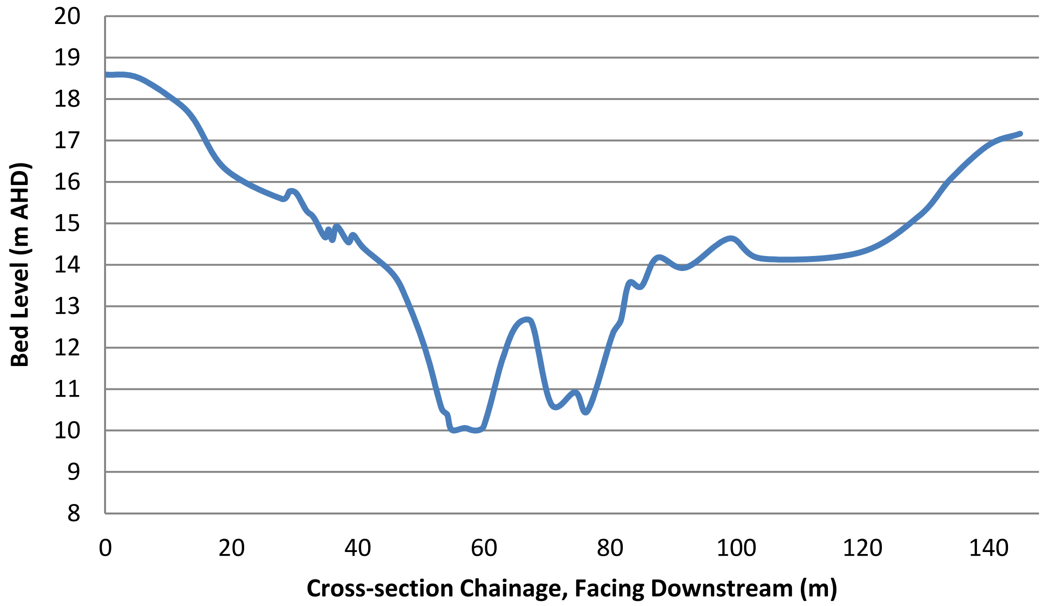


Figure 4-4 Carmichael River Cross Section (Logger location 333302)

Plate 4-2 Cabbage Tree Creek West

Plate 4-3 Eight Mile Creek (Upstream South Branch)

4.3 Flows

4.3.1 Desktop Review

No historical stream gauge data exist within the Carmichael River. However, three Bureau of Meteorology (BOM) flow depth and gauging sites were identified within the Belyando River during the desktop review. The water level gauging sites are as follows.

- Belyando River at the Gregory Development Road Crossing, Gauge number 120301B. This is the closest water level recording to Study Area. It is approximately 70 km to the northeast of the Study Area
- Mistake Creek at Twin Hills, gauge number 120309A. This gauge records water levels and corresponding flow depths. The gauge is located 60 km to the east of the Study Area
- Native Companion Creek at Alpha, gauge number 120305A. It is located in the middle of the creek downstream of the Alpha Clermont Road. It is approximately 150 km to the southeast of the Study Area

Figure 4-5 summarises the daily flow record for the Belyando River at the Gregory Development Road gauge 120301B. It shows that despite being located near the downstream end of the Belyando catchment, the recorded base flow (minimum) is low to zero throughout the year, especially during the winter (i.e. the predominantly dry months June to December). Although the length of dry periods is unpredictable, they occur frequently. Typically, the flow regime is dominated by the wet season (January to May). It is during this period that flood events of short duration generally occur, although records show that flooding may begin as early as November. These flood events tend to mask the seasonality of flows.

In addition to the highly seasonal fluctuation, the annual variability can be large. For example, a series of above average (high flow) years can be followed by a series of below average (low flow) years (Refer Figure 4-6).

Figure 4-5 Daily Flows – Belyando River at Gregory Development Road Bridge Gauge 120301B (1949 – 2007)

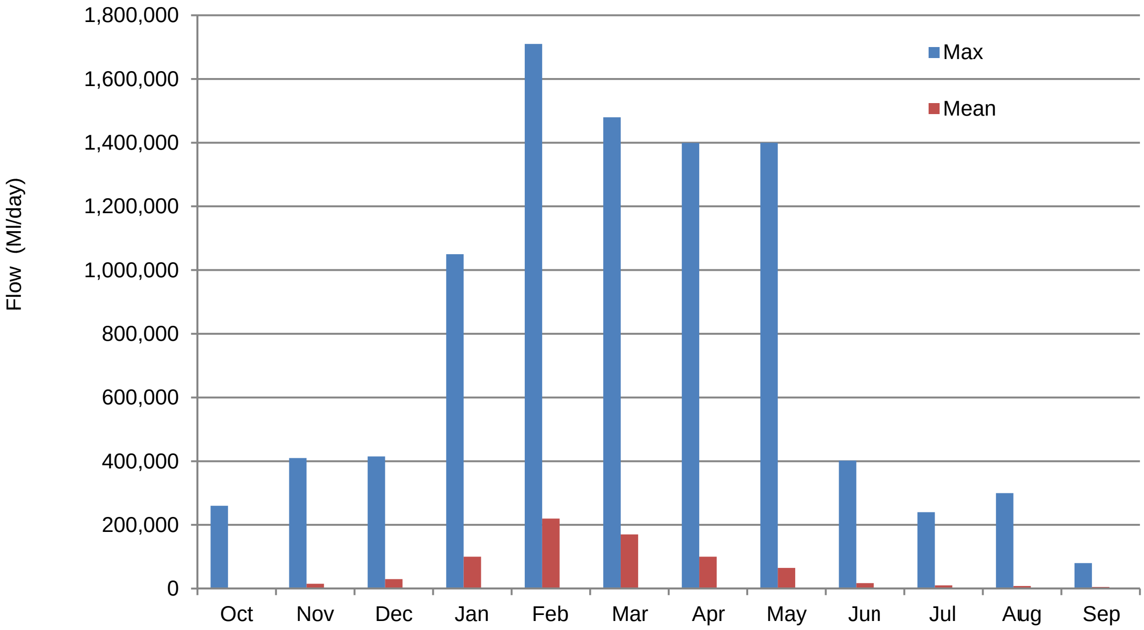


Figure 4-6 Annual Discharge – Belyando River at Gregory Development Road Bridge Gauge 120301B (1976 – 2009)

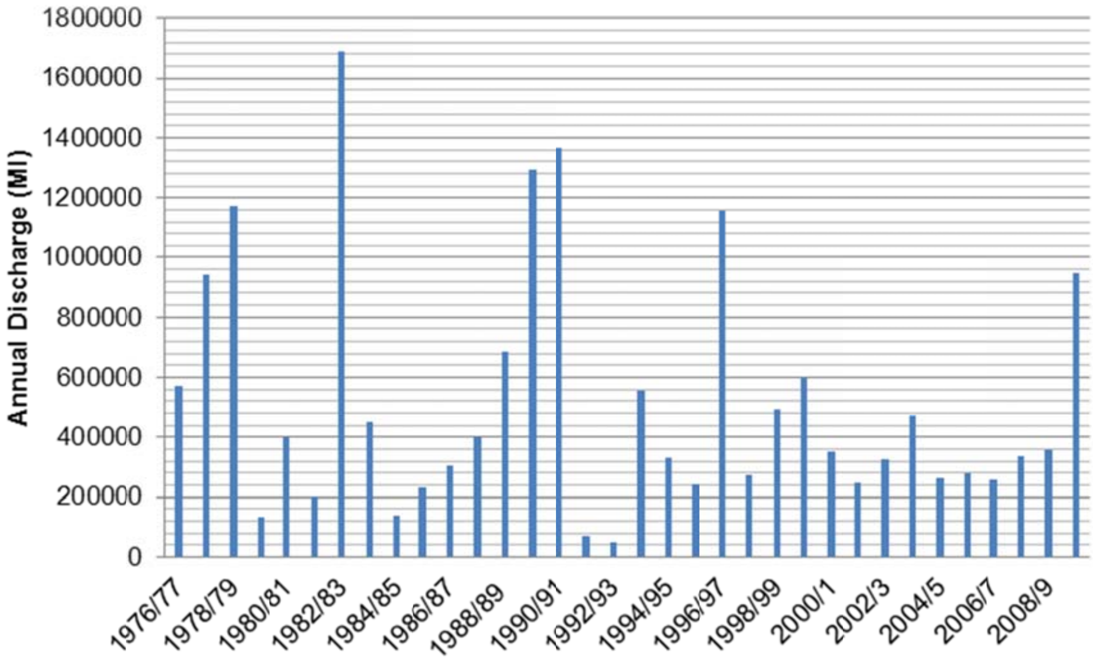


Table 4-1 provides an indication of the contribution of the sub-catchments to the Burdekin. In relative terms (based on catchment area), the Belyando River and the adjoining Suttor River catchment contribute less flow than do other tributary sub-catchments to the discharge of the Burdekin River at Clare (flow gauge 120006 S19°46' E147°18' and 40 km west of the mouth of the Burdekin River to the Coral Sea).

Under normal conditions, the Carmichael River generally maintains a low base flow in the dry season. Modelling indicates that once storm flows reach the river, it rapidly fills and overflows the channel banks and flows into the surrounding, relatively flat floodplain.

Table 4-1 Average Sub-catchment Contributions to the Burdekin River at Clare

Sub-catchment	Area (km²)	% area of Burdekin Basin above Clare	Sub-catchment annual contribution (ML/a)	% contribution to total flow
Upper Burdekin	36,181	28	4,067,000	52
Belyando/Suttor	73,828	57	2,554,500	33
Bowen/Broken	9,413	7	1,021,760	13
Lower Burdekin	10,028	8	132,700	2
Total at Clare	129,450	100	7,775,960	100

Source: Burrows, 1999

4.3.2 Field Investigations

Figure 4-7 shows a hydrograph of the flow data on the Carmichael River collected from late July to November 2011 at the upstream 333301 and downstream 333302 gauges. Figure 4-8 shows flow data collected from November 2011 to August 2012 for the downstream gauge only. Equipment failure resulted in no further records from the upstream gauge 333301 since December 2011. Field inspection of the downstream gauge from August 2012 indicated incorrect logging of water level and flow and hence observed data should be considered indicative only at this stage.

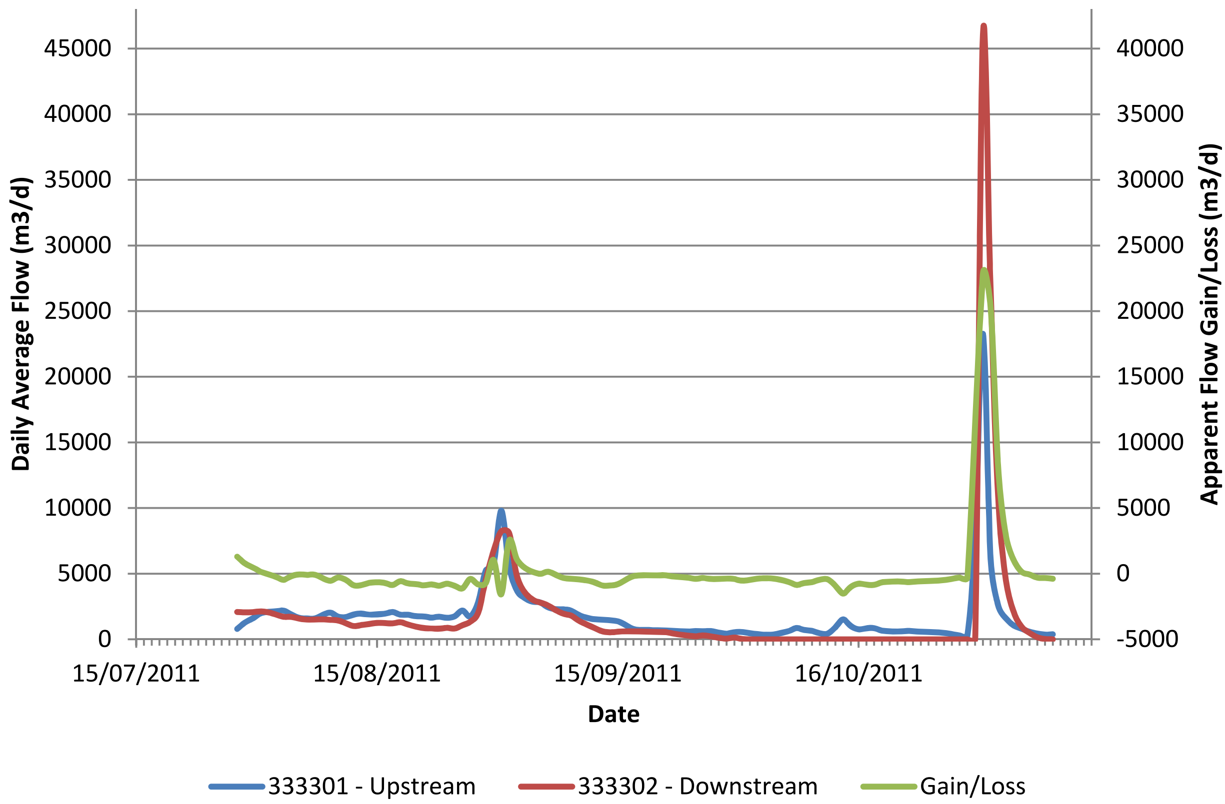
It should be noted that the data in Figure 4-7 are not actual flow measurements but rather flow estimates derived by comparing the measured water level to a stage-discharge relationship. Presently this stage-discharge relationship has been derived from a single flow gauging event, not a range of flow events as typically required for accurate flow estimation. Gauging over a range of flow events is typically required for accurate flow estimation. As such, observed flow data for these gauges should be considered indicative only at this stage. The limited available flow data for this period are considered to suggest the following with regard to baseline conditions.

- Continuous flow has been observed at the upstream gauge despite rainfall being limited to two events in late August and early November. This suggests that groundwater discharge to the Carmichael River upstream of the EPC 1690 lease area is occurring and is consistent with the upward gradient observed by GHD during groundwater monitoring in the bore at site C027 close to the western margin of the lease. For mapping of the groundwater monitoring bore sites please see Volume 4 Appendix R Mine Hydrogeology Report.

- Apparent flow losses between the upstream and downstream gauges during dry periods. This is consistent with the downward gradient observed from riverbed to groundwater at sites C025 to C029 close to the eastern margin of the lease

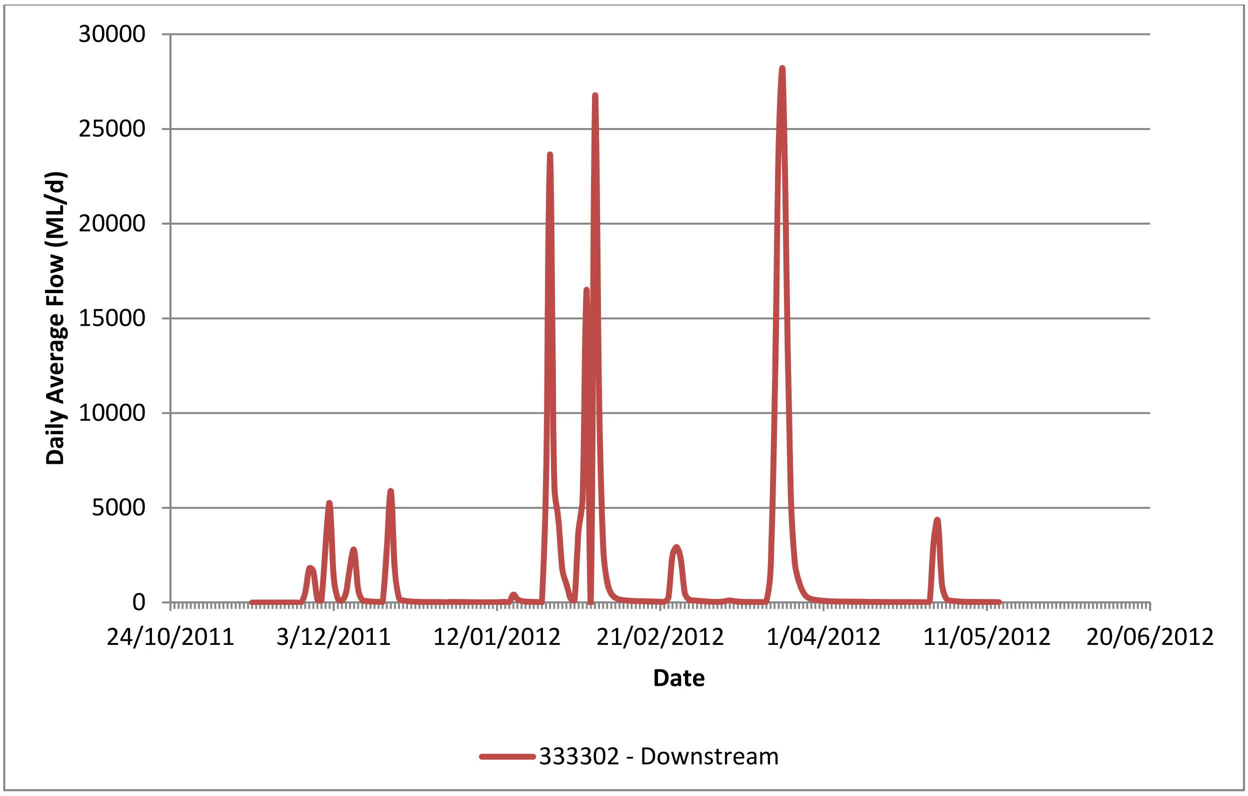
It is possible from these observations that dry season flows in the Carmichael River are supplemented primarily by discharges from the Doongmabulla Springs, and that direct groundwater discharge to the river itself is negligible. Further monitoring of flows and water quality discharging from the springs will continue to develop a better understanding of the connectivity and flow interfaces.

Figure 4-7 Hydrograph of Flow Data Collected at the Study Area – Dry Season



The wet season peak flows (Figure 4-8) show a significant increase when compared to base flows recorded during the dry season (refer Figure 4-7). The downstream gauge station 333302 was affected by flood flows during the wet season, resulting in loss of data recording. This was particularly an issue during the peak flow event in February. Excluding the data gap from 3rd to 5th February, 2012, water level monitoring captured a peak level of 18.53 m in the Carmichael River, which indicates very high flows during this period.

Figure 4-8 Hydrograph of Flow Data Collected at the Study Area – Wet Season



4.4 Rainfall and Evapotranspiration

Rainfall gauges located within 180 km of the Study Area and with significant lengths of record are presented below for the Belyando and Isaac River catchments.

- Belyando catchment:
  - Moray Downs Station (36071, S21°56.99' E146°37.799')
  - Bygana Station (36089, S22°11.999' E146°32.717')
  - Alpha Post office (35000, S23°39.015' E146°39.009')
- Isaac River catchment:
  - Moranbah Water Treatment Plant (34038, S21°59.754' E148°01.832')

Annual averages for the four stations are:

- Moray Downs: 521 mm
- Bygana Station: 550 mm
- Alpha Post Office: 588 mm
- Moranbah Water Treatment Plant: 559 mm

The BOM regional average is 550 mm. The monthly distribution of the annual average rainfall at these stations is shown in Figure 4-9 through Figure 4-12. The source data for these figures was provided by BOM 2011.

Figure 4-9 Monthly Rainfall – Moray Downs Station, 36071 1914 – 2010[3]

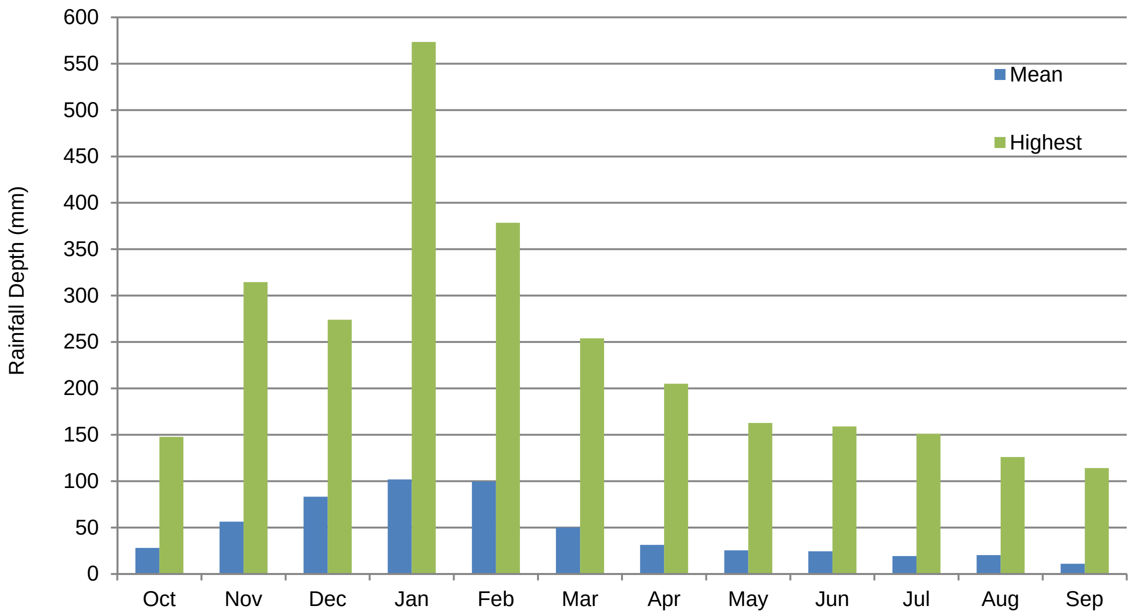
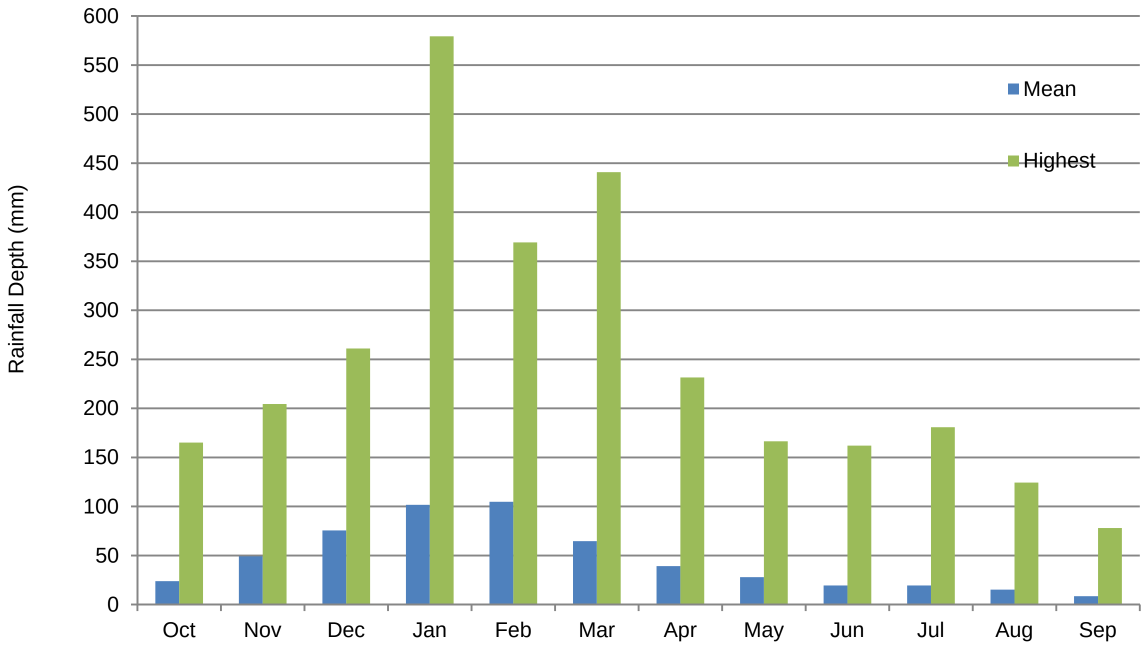


Figure 4-10 Rainfall – Bygana Station 36089, 1946 – 2010



[3] Minimum rainfall values are negligible and so have been excluded at this scale for all charts.

Figure 4-11 Rainfall – Alpha Post Office Station 35000, 1886 - 2010

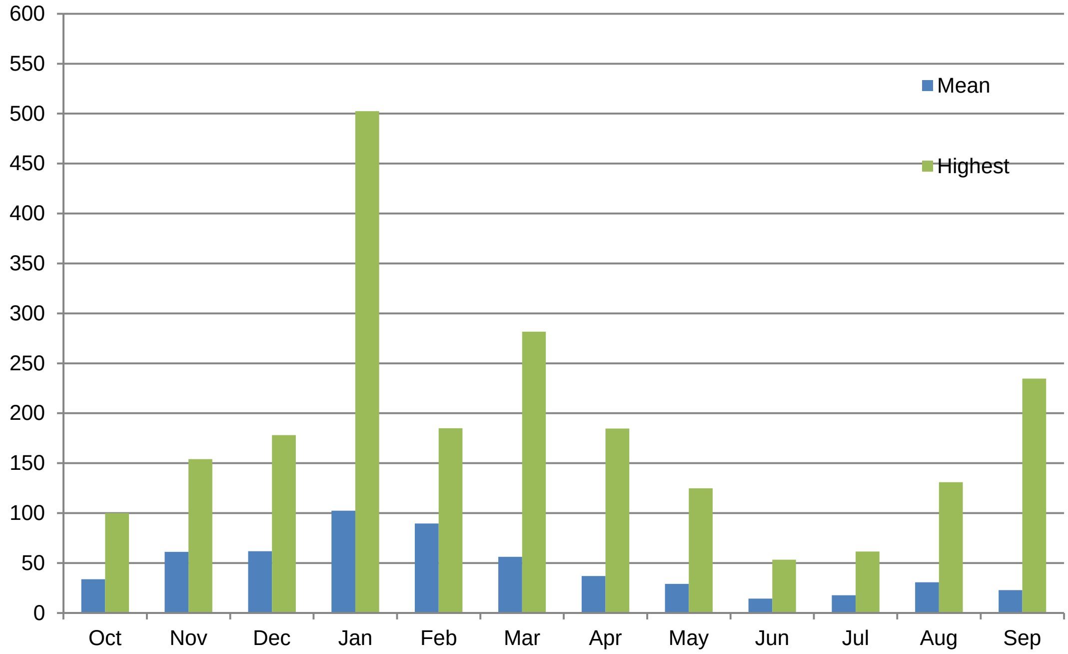


Figure 4-12 Rainfall – Moranbah Station 340381 1972 – 2010

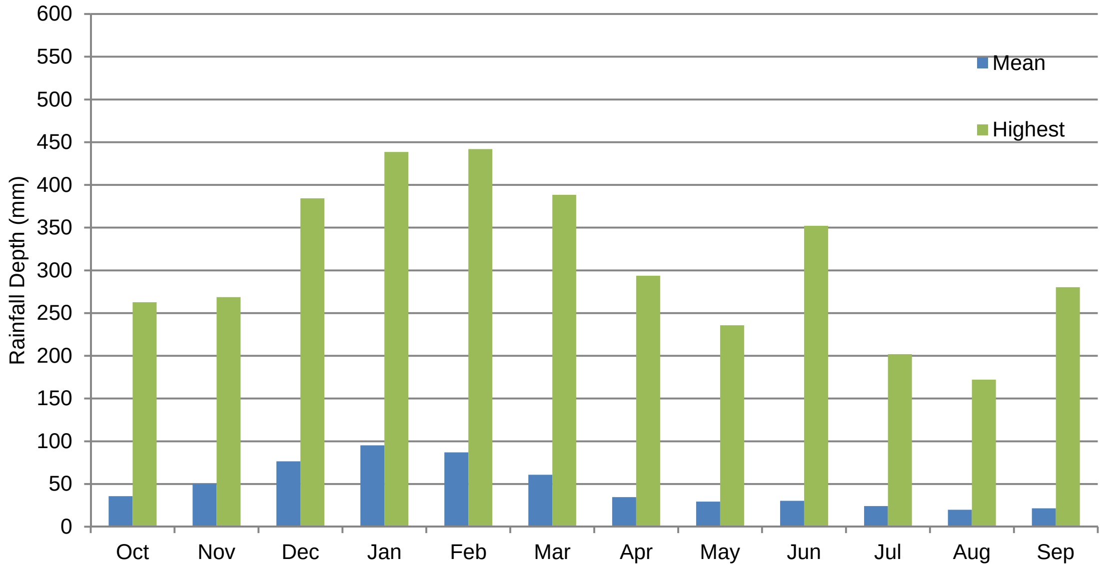


Figure 4-9 through Figure 4-12 show that:

- Temporal patterns are similar for all the stations and are highly seasonal with high rainfall in summer and low rainfall in winter
- While minimums are not shown in the figures, in any given month of the year there can be no rainfall at all

The monthly patterns are consistent with the Belyando River flows presented in Figure 4-5.

Summer maxima rainfall normally occur from prolonged periods of rain arising from eastward travelling monsoon depressions and intense short term contributions from predominantly westward travelling tropical cyclones. Australian tropical cyclones commonly originate either in the Gulf of Carpentaria or in the Coral Sea between 9 and 19 degrees south (Sturman and Tapper, 2006).

An average of ten tropical cyclones per year develop over Australian waters, of which six cross the coast, mostly over northwest Western Australia and northeast Queensland. Since 1959, when accurate radar based records commenced, 33 tropical cyclones have passed through, or within 400 km of the centre of the Belyando River catchment, which has been arbitrarily taken as Bygana Station at S22°11.999' E146°32.717'.

According to Watkins (2011), the frequency of cyclones in Eastern Queensland is significantly correlated to the fluctuations in the El Niño-Southern Oscillation, or ENSO, which is driven by variability on sea surface temperatures in the Pacific Ocean. A strong La Niña phase of the ENSO (cooler sea surface temperatures off eastern Australia) saw four tropical cyclones crossing Queensland over the 2010/11 summer, including the Category 5 Cyclone Yasi on 2 February 2011.

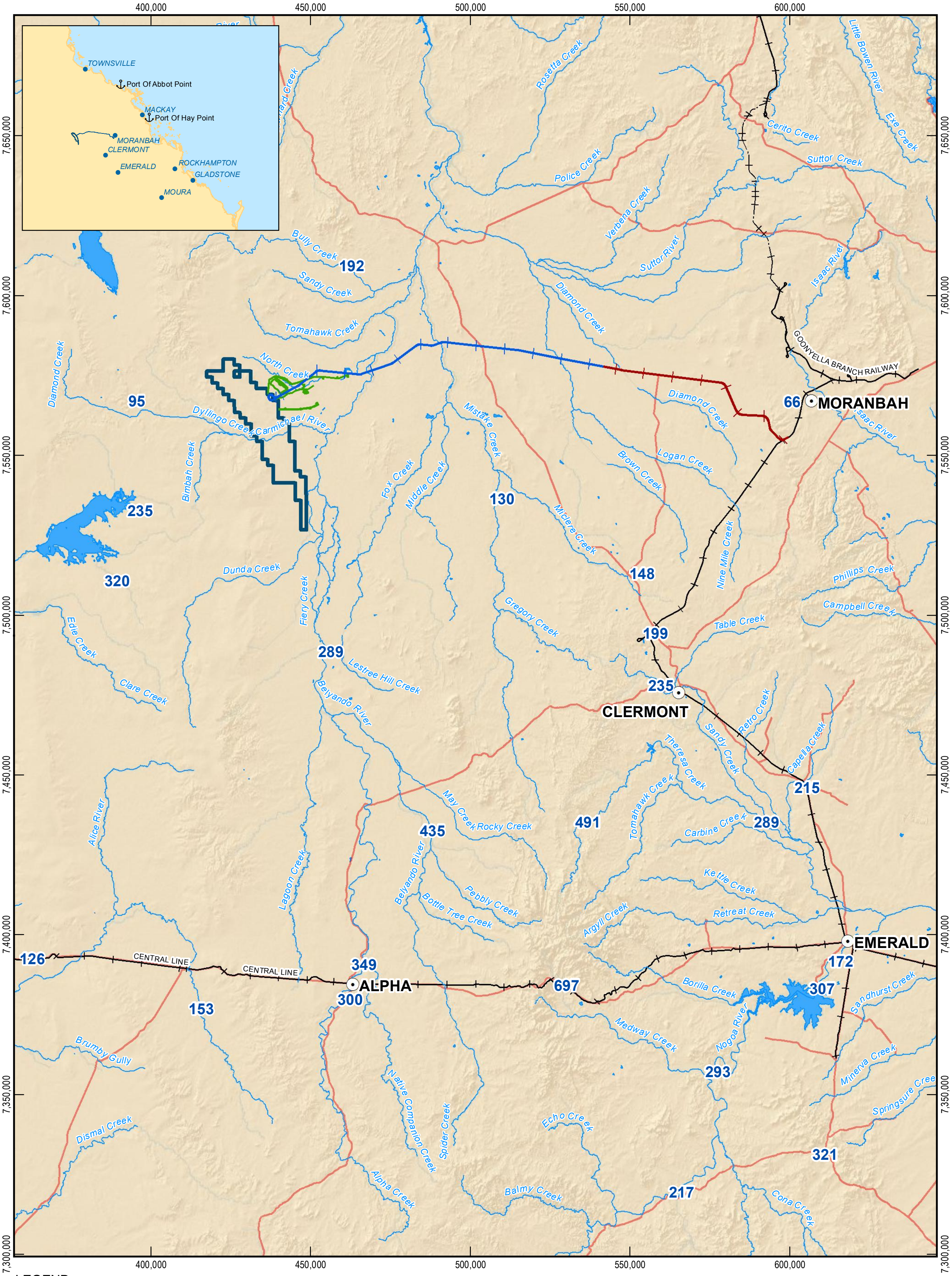
Rainfall associated with monsoons and tropical cyclones in North Queensland is often of extreme intensity and while as much as 1,000 mm can fall in a few days at the coast, rain events of 200 mm to 300 mm are more common inland as shown in Figure 4-13 by the rain depths associated with Cyclone Helen, which occurred from 8 to 19 January 2008. Although the Belyando River catchment did not experience rainfalls of comparable depth over the summer of 2010/11, relatively high totals were still recorded including 92 mm at Moranbah and 196 mm at Barcaldine (approximately the 10 year ARI event for 120 hours) over the period 22 to 27 December 2010 (BOM, 2011).

The winter rainfall minima coincide with the stalling of large stable anticyclones over Central Australia that cause cool dry west to southwesterly airflow to predominate over Queensland (Sturman and Tapper, 2006). Rainfall in this season is associated with short southerly fronts originating in the southern oceans that affect the southern and eastern coasts of Australia. Table 4-2 contains the Intensity Frequency Duration (IFD) rainfall data for the Study Area as modelled by the industry standard CRC FORGE software.

Rainfall depths resulting from Cyclone Helen (five day total) are presented in Figure 4-13. The highest total of 697 mm (at a point midway between Emerald and Alpha) was well in excess of the five day 100 year ARI design total of 370 mm. The rainfall total surrounding the mine site, i.e. 95 mm, 192 mm, 130 mm and 235 mm are all less than the 100 year ARI 48 hour value of 281 mm.

Table 4-2 Intensity Frequency Duration of Rainfall – Study Area (10 Mile Bore)

	Total Rainfall (mm)				
	5 years	10 years	20 years	50 years	100 years
5 mins	12.8	14.7	17.2	20.4	23.0
6 mins	14.3	16.4	19.2	22.9	25.7
10 mins	19.8	22.7	26.5	31.5	35.5
20 mins	30.1	34.3	40.0	47.7	53.3
30 mins	37.5	42.7	49.7	59.0	66.0
1 hr	50.6	57.7	67.0	79.4	88.9
2 hr	63.0	71.6	83.2	98.4	110.2
3 hr	69.6	79.2	91.8	108.6	121.5
6 hr	81.0	92.4	106.8	126.6	141.6
12 hr	97.4	110.9	128.4	152.4	170.4
24 hr	123.6	140.9	163.4	193.4	216.5
48 hr	158.9	181.9	211.2	250.1	280.8
72 hr	175.0	199.4	232.6	275.0	308.9
96 hr	182.3	207.2	239.8	282.8	318.7
120 hr	190.4	216.4	250.4	295.4	369.8



LEGEND

- Town
- 123 5 Day Rainfall (mm)
- State Road
- Other Rail Network
- Northern Missing Link
- Watercourse
- Waterbody
- Mine (Onsite)
- Mine (Offsite)
- Rail (West)
- Rail (East)

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Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision D
Date 11-10-2012

Cyclone Helen - Recorded Flood Depths in and near the Belyando River Catchment

Figure 4-13

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: BOM: Cyclone Helen 5 Day Rainfall (2008); DERM: State Road (2010); DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Locality, Rail, Watercourse (2007); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012); GHD: Northern Missing Link (2011); Created by: BW, CA

Drought has also frequently occurred during the period of record. Annual rainfall depth information has been acquired from the following four weather stations:

- Moray Downs (Figure 4-14)
- Bygana Station (Figure 4-15)
- Alpha Post Office (Figure 4-16)
- Moranbah Water Treatment Station (Figure 4-17)

The periods of above and below average rainfall reflected at all the weather stations also correlates with the annual discharges of the Belyando River (Refer Figure 4-6) over the equivalent years. It is considered that the cycle of wet and dry years is highly variable.

Figure 4-14 Annual Total Rainfall Depth – Moray Downs Station 3607, 1968 – 1997

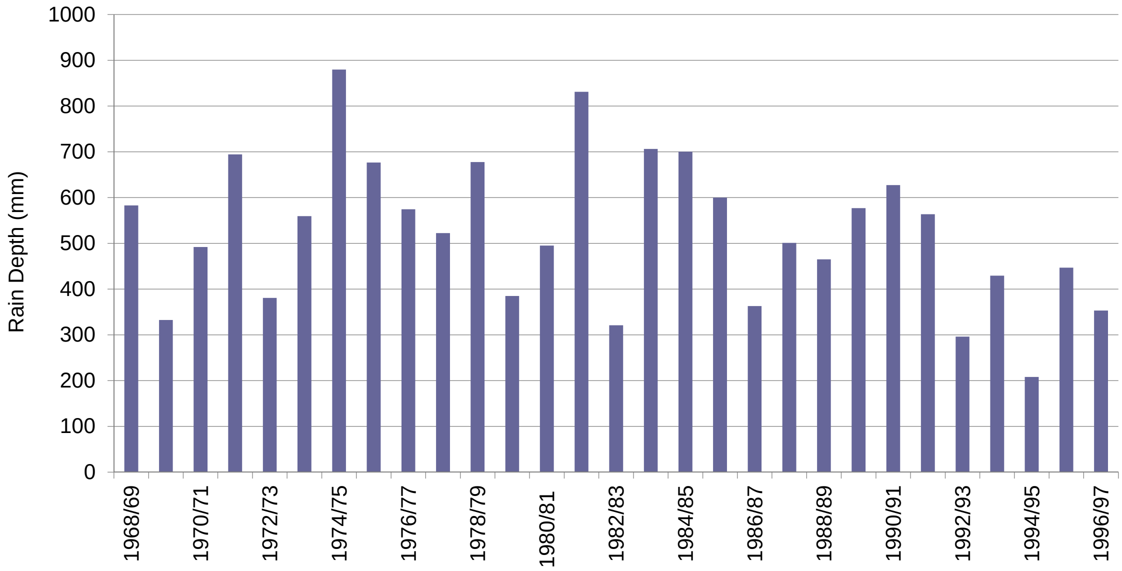


Figure 4-15 Annual Total Rainfall Depth – Bygana Station 36089, 1976 – 2006

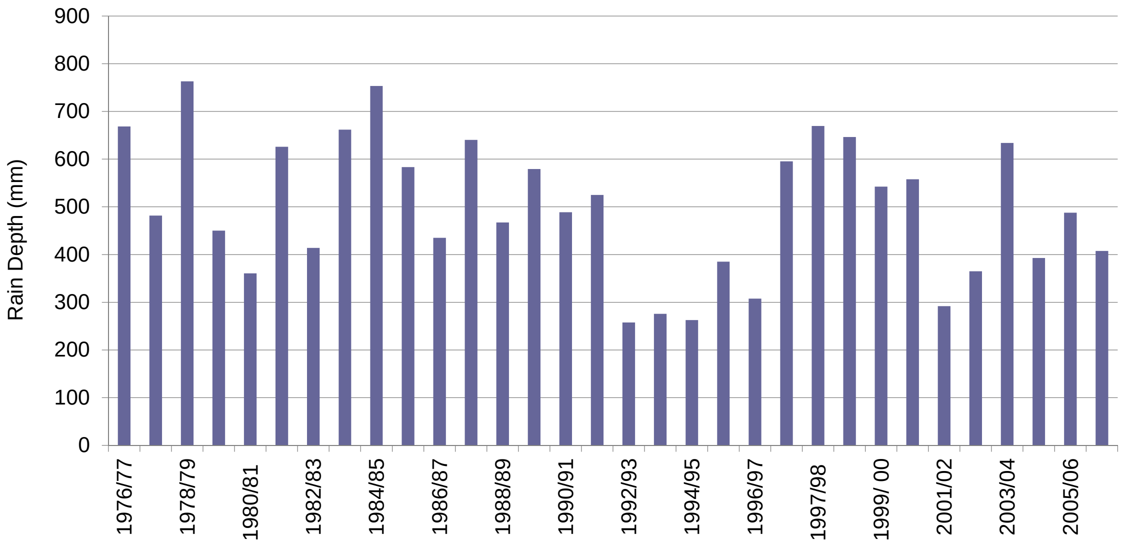


Figure 4-16 Annual Total Rainfall Depth – Alpha Post Office Station 35000, 1967 – 2007

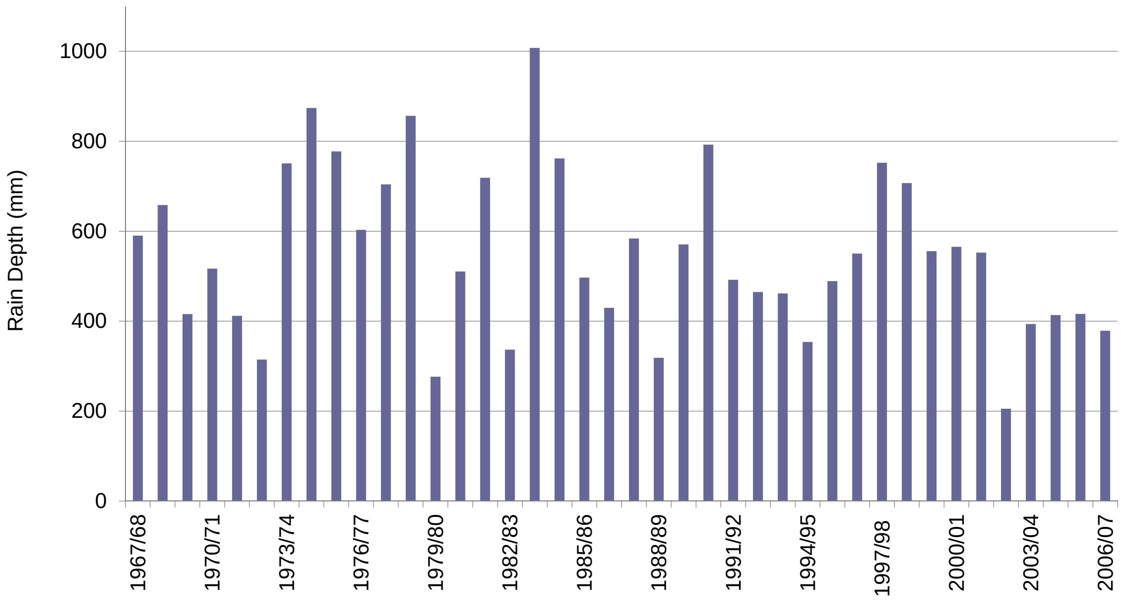
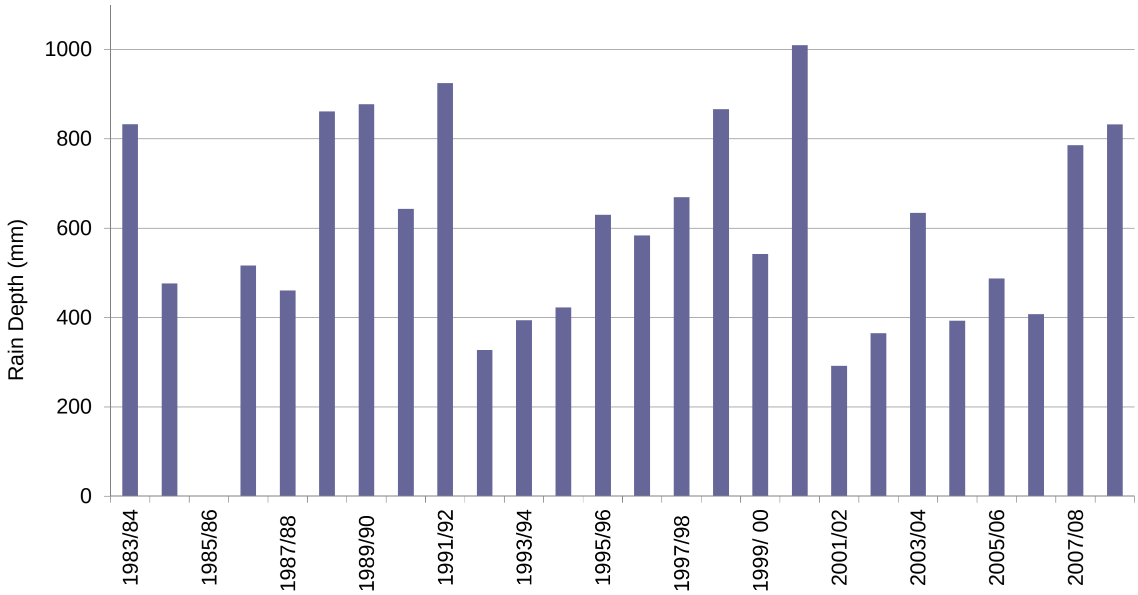


Figure 4-17 Annual Total Rainfall Depth – Moranbah Water Treatment Station 34038, 1983 – 2008



(Note: There are no 1985/6 data for Moranbah)

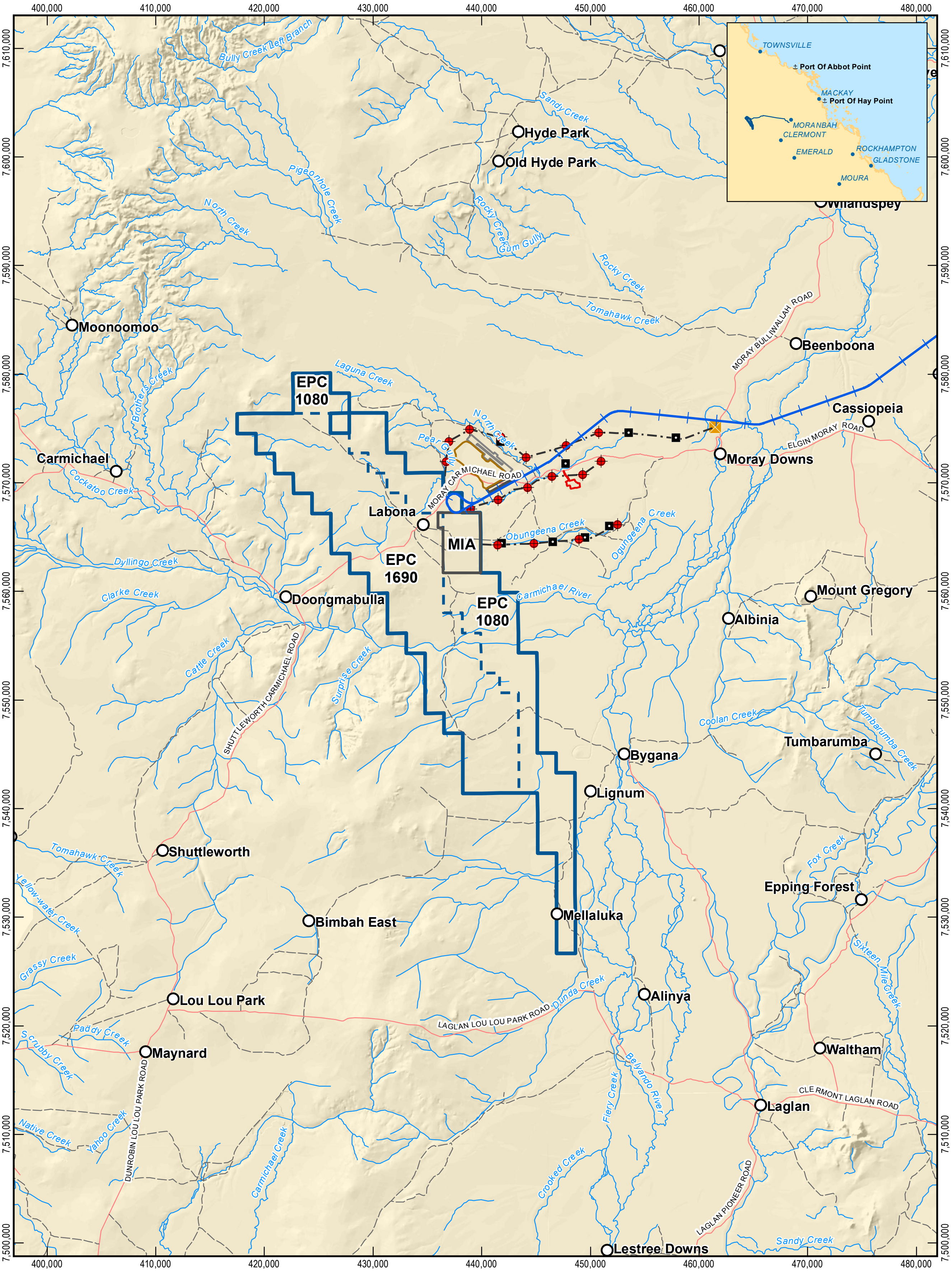
4.5 Other Factors Affecting Flows and Water Levels

4.5.1 Land Use

More than 90 per cent of the Study Area is under grazing for beef cattle production. Surface water resources are utilised for stock watering, either directly from the channels of the Carmichael and Belyando Rivers during the wet season, or from impounded water in dams.

4.5.2 Existing Usage

There is no existing major public water infrastructure in the Belyando River catchment. However, a number of unregulated private weirs, pumps and inline/off-stream storages (farm dams) exist for water-harvesting and irrigation on its tributaries (see homesteads in the area in Figure 4-18). Most of this infrastructure has been constructed by local farmers to take advantage of the wet season flows and base flow.



LEGEND

Homestead	Rail (West)	Mine (Offsite)	Airport Location
Local Road	Mine (Onsite)	Borehole	Rail Siding
Track	Mine Infrastructure Area	Storage Site (Instream)	Industrial Area
Watercourse		Storage Facility (Offstream)	Workers Accommodation Village
		Pipeline Network	

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Location of Homesteads
in the Vicinity of the Study Area

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Revision B
Date 04-09-2012

Figure 4-18

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\41-25215_530_rev_b.mxd

Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DME: EPC 1690 (2010), EPC 1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road, Watercourse (2007);
Adani: Alignment Opt9 Rev3, Mine Infrastructure Area (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: BW, CA

Recorded Homestead Stations taking stock water from waterways in the vicinity of the Project (Mine) site are as follows (DNRM, 2011):

- Bygana (4.9 km away);
- Moray Downs (22.5 km away);
- Mount Gregory (25.7 km away);
- Albina (17.9 km away);
- Mellaluka (on Mine boundary); and
- Lignum (1.4 km away).

A list of the licences for Belyando River diversions and water takes obtained from DNRM (2011) is contained in Table 4-3. In the Belyando River catchment there are nine licences for water harvest and impoundment; three for irrigation; two for stock watering; and one each for channel diversion, construction (the Proponent's take from Dylingo Creek) and domestic supply. The licenced water takes are in the reaches of the Belyando River that are potentially affected by the development and operation of the Project (Mine).

Although the licence information shows only 650 ha under irrigation, it is estimated in the Burdekin Dry Tropics Natural Resources Management Plan (BDTNRMP; 2005) that approximately 6,400 ha of cotton and grain crops are irrigated in the Belyando River Catchment, with about half of this water taken from Mistake Creek. The reason for the 10 fold discrepancy in area is not known. Irrigated land tends to be concentrated in areas with suitable alluvial plains adjacent to the main channel of the river and its larger tributaries. Most licences are for stream pumps with or without off-stream storages.

Figure 4-19 summarises water use in the wider Belyando/Suttor catchment. Urban and Urban/industrial use is not specifically defined in BDTNRMP (2005), but is likely to cover potable supplies for small communities like Alpha at the head of the Belyando River and demand from mines in the Suttor River catchment for coal washing and dust suppression.

Table 4-3 Licensed Water Takes from Belyando River (DNRM, 2011)

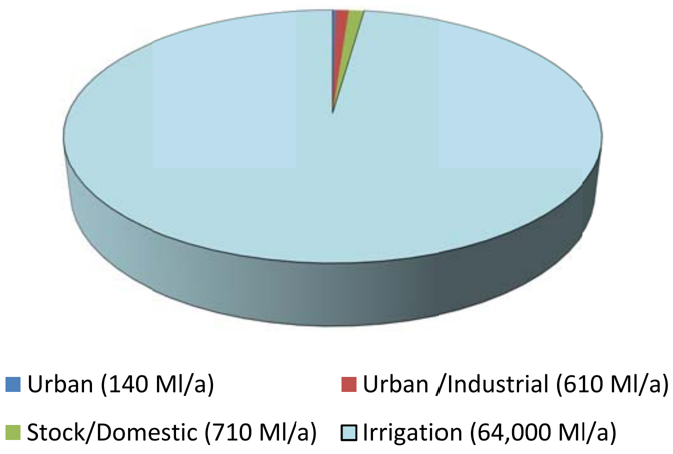
Water code	Water course	Authorisation Ref	Authorisation Type	Purpose
120.01.06.26.16.03	Alpha Creek	103511	Licence to take water	Water harvesting
120.01.06.26	Belyando River	00933F	Licence to interfere by impounding-Embankment or Wall	Impound water
120.01.06.26	Belyando River	48434F	Licence to take water	Domestic Supply
120.01.06.26	Belyando River	52623F	Licence to take water	Water harvesting

Water code	Water course	Authorisation Ref	Authorisation Type	Purpose
120.01.06.26.07.00+	Belyando River (Anabranch)	37407F	Licence to interfere by impounding- Embankment or Wall	Impound water
120.01.06.26z	Belyando River (Longreach Channel)	37488F	Licence to interfere by impounding- Embankment or Wall	Impound water
120.01.06.26.08.05	Dyllingo Creek	604941	Licence to take water	Construction
120.01.06.26.02.02	Fox Creek	28340F	Licence to interfere by impounding- Embankment or Wall	Impound water
120.01.06.26.02.02	Fox Creek	41328F	Licence to take water	Stock
120.01.06.26.02	Mistake Creek	0426439F	Licence to take water	Water harvesting
120.01.06.26.02	Mistake Creek	057819F	Licence to take water	Water harvesting
120.01.06.26.02	Mistake Creek	41234F	Licence to take water	Irrigation
120.01.06.26.02	Mistake Creek	41235F	Licence to take water	Water harvesting
120.01.06.26.02	Mistake Creek	46204F	Licence to take water	Irrigation, Water harvesting
120.01.06.26.02	Mistake Creek	52670F	Licence to interfere by diversion channel	Divert the course of flow
120.01.06.26.02	Mistake Creek	57717WF	Licence to interfere by impounding- Embankment or Wall	Impound water
120.01.06.26.02	Mistake Creek	57718WF	Licence to interfere by impounding- Embankment or Wall	Impound water

Water code	Water course	Authorisation Ref	Authorisation Type	Purpose
120.01.06.26.02	Mistake Creek	57746WF	Licence to interfere by impounding-Embankment or Wall	Impound water
120.01.06.26.02	Mistake Creek	57847F	Licence to take water	Water harvesting
120.01.06.26.02	Mistake Creek	57882F	Licence to take water	Water harvesting
120.01.06.26.02	Mistake Creek	57883F	Licence to take water	Water harvesting
120.01.06.26.02	Mistake Creek	57884F	Licence to take water	Water harvesting
120.01.06.26.02.01	Pelican Lagoon	0426441F	Licence to take water	Irrigation
120.01.06.26.02.01	Pelican Lagoon	174169	Licence to interfere by impounding-Embankment or Wall	Impound water
120.01.06.26.02.01	Pelican Lagoon	52622F	Licence to interfere by impounding-Embankment or Wall	Impound water
120.01.06.26.00+	UT Belyando River	37295F	Licence to take water	Stock

Figure 4-19 presents the distribution of four categories of water use within the Belyando River catchment. The only water use category in the vicinity of the proposed mine is cattle grazing. Financial constraints within the farming industry may inhibit the more effective use of available water and land resources in the wider catchment. Further land suitability, agro-economic assessments and water resource assessments will be necessary to define the true agricultural potential of the region (BDTNRMP 2005). According to ANRA 2005, no sustainable yield studies have been conducted on the Belyando Suttor Surface Water Management Area. Detailed analysis of the agricultural land suitability within the Project (Mine) site is described in Volume 4 Appendix L Soils Assessment.

Figure 4-19 Water Allocation in the Belyando/Suttor Catchment

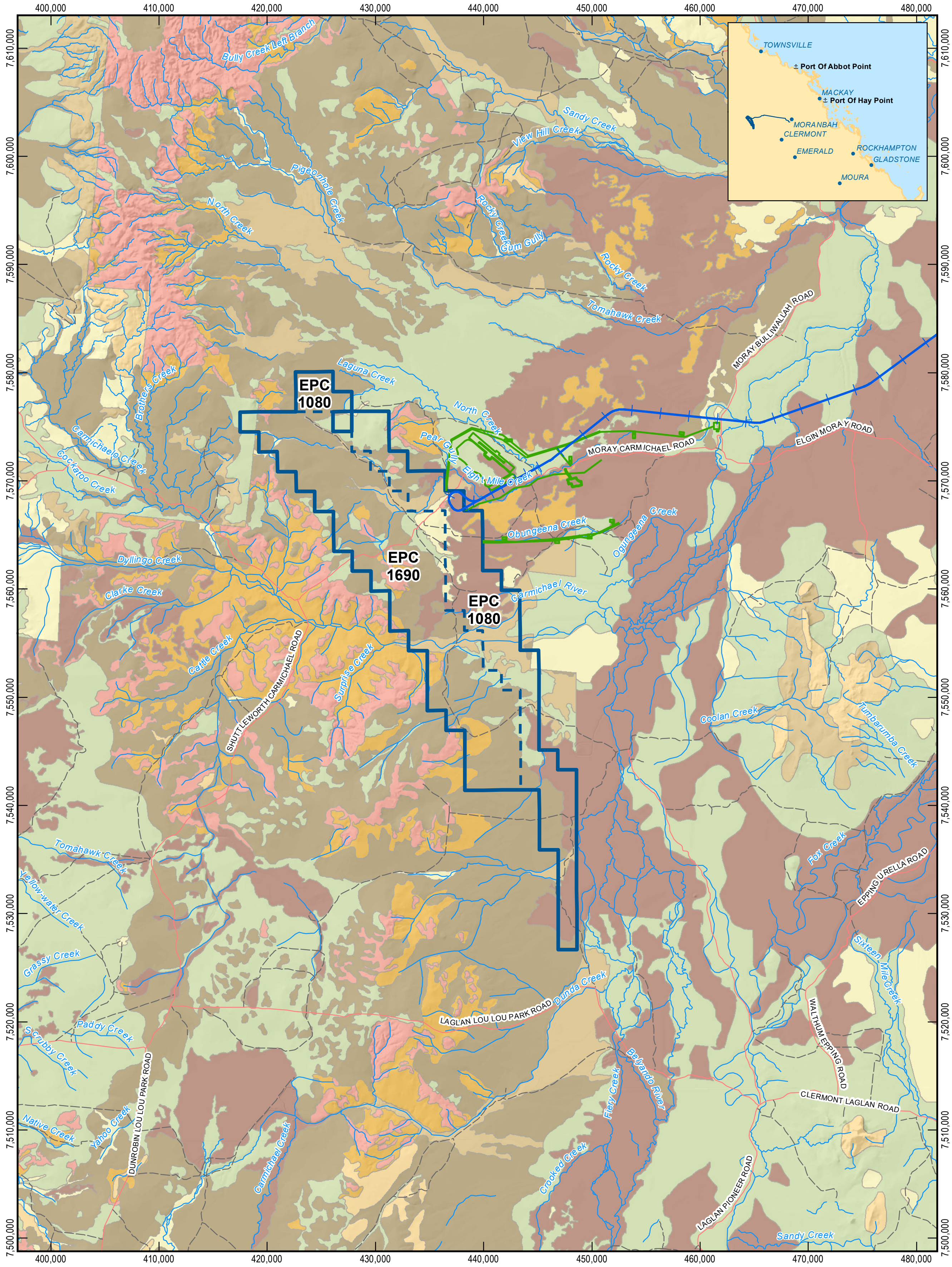


Source: BDTNRMP, 2005

4.5.3 Soils

Sandy vertosol (cracking clay) is the dominant local soil in the Belyando River catchment. This clay soil is highly dispersive, has high shrink-swell properties and exhibits strong cracking when dry. At depth slickensides and/or lenticular structural aggregates occur. During June to December, this sandy vertosol soil shrinks and deep cracks open up to as much as a metre beneath the surface. When disturbed, such as at vehicle tracks, this highly dispersive soil can become a very fine dust. With the onset of wetter weather during January to May, the soil swells, closing the cracks, water collects on the surface in the characteristic gilgai pattern and saturated infiltration rates decline to near zero. In the dry season, substantial rainfall can be absorbed and ponded before runoff and stream flow commences (McKenzie et al., 2004).

A regional scale soil map of the area is presented in Figure 4-20 and is derived from Mackenzie and Hook (1992). The figure indicates that kandosols are the dominant soil in the vicinity of the Project (Mine). Kandosol soils are fine sandy soils which have low to moderate agricultural potential with moderate chemical fertility and water-holding capacity. These soils are found in poorly drained sites with rainfall between 300 mm and 1,400 mm and in well-drained sites with rainfall between 250 mm and 1,400 mm. Some small areas of vertosols occur within the Carmichael River floodplain, near the Study Area. Detailed analysis of the soils within the Mine site is described in Volume 4 Appendix L Soils Assessment.



LEGEND

Local Road	Rail (West)	Qld Combined Soils (2m)	Kandasols	Sodosols
Track	Mine (Onsite)	Chromosols	Kurosols	Tenosols
Watercourse	Mine (Offsite)	Dermosols	Rudosols	Vertosols

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1:500,000 (at A4)

0 2.5 5 7.5 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Carmichael Coal Mine and Rail Project

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Revision	B
Date	04-09-2012

Soil Types in the Study Area

Figure 4-20

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Data Source: DME: EPC 1690 (2010), EPC 1080 (2011); DERM: QLD Combined Soils (2010); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Roads, Watercourses (2007);
Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: BW, CA

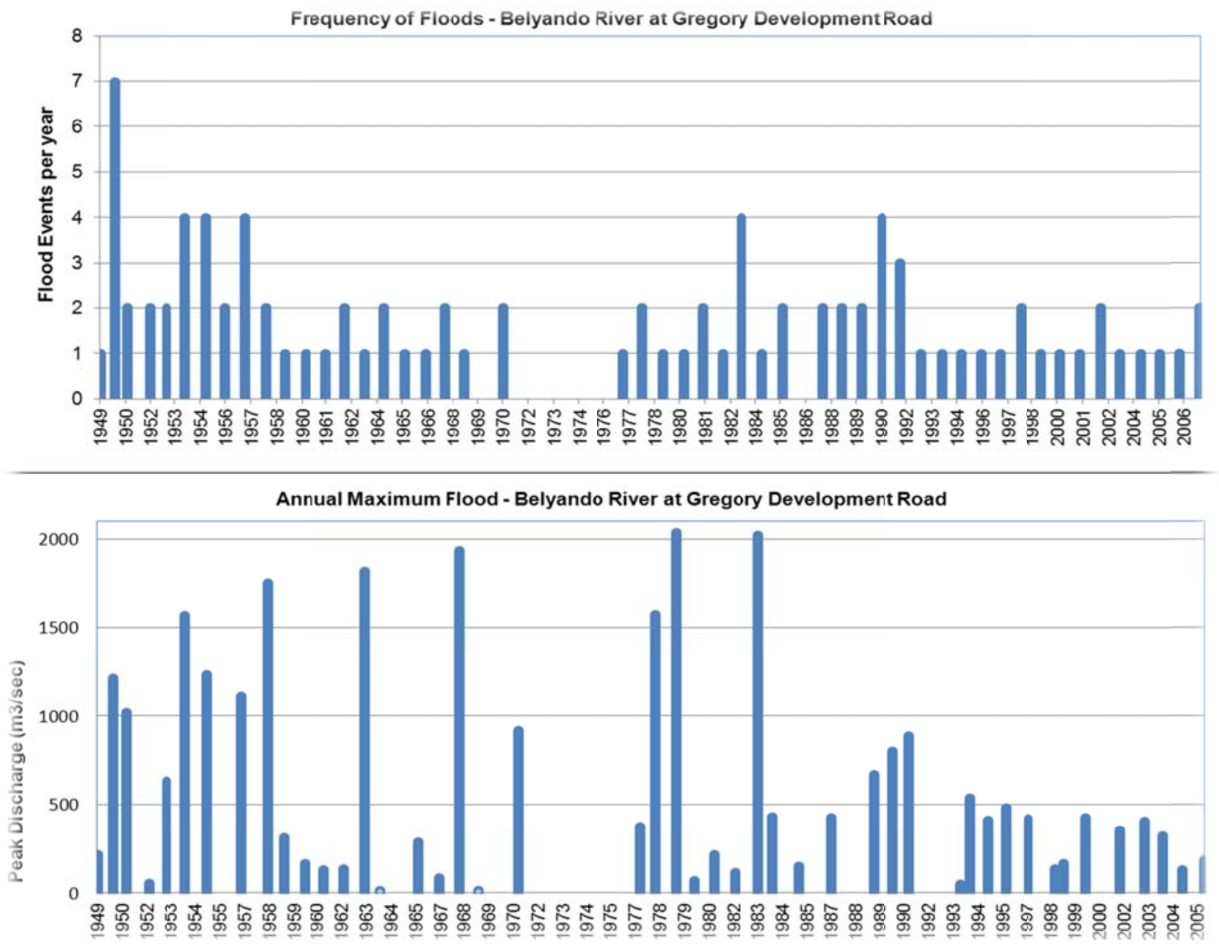
4.5.4 Vegetation

Much of the landscape surrounding the Study Area has experienced broad-scale vegetation clearing, and as such, remnant vegetation coverage is fragmented. Connectivity of remnant vegetation at a landscape level is maintained by tracts of vegetation including mature river red gum (*Eucalyptus camaldulensis*) and Paper Bark (*Melaleuca leucadendra*) associated with major watercourses including the Carmichael and Belyando Rivers. Further information regarding the vegetation in the study area is provided in Appendix N1 Mine Terrestrial Ecology Report.

Flows in the major watercourses including the Carmichael and Belyando River are understood to be relatively persistent and this is supported by flow data for the site. Even during extended dry periods these systems are thought to maintain a series of semi-permanent to permanent waterholes. This suggests that the major watercourses and the associated remnant riparian vegetation are groundwater-dependent to a degree in the regions upstream of the Project (Mine). Watercourses within and downstream of the Study Area are more likely to be losing to groundwater according to Appendix R Mine Hydrogeology Report Flood History

For the reach of the Belyando River at the Gregory Development Road, the flow record extends from 1949 to 2007. However there are gaps in data for the periods 1972 to 1976 and 2006 to 2010. Figure 4-21 presents flood data obtained from BOM in terms of the number of floods occurring per year, defined as an event where water flows over the road embankment. The years in which numerous floods have occurred correlate with the frequency of summer monsoonal and cyclonic rain events, as expected. The severity of each flood event is likely to be influenced by the amount of rainfall and catchment conditions and saturation at the time, for example, the degree of soil cracking.

Figure 4-21 BOM flood data for Belyando River at Gregory Developmental Road (1949-2006)



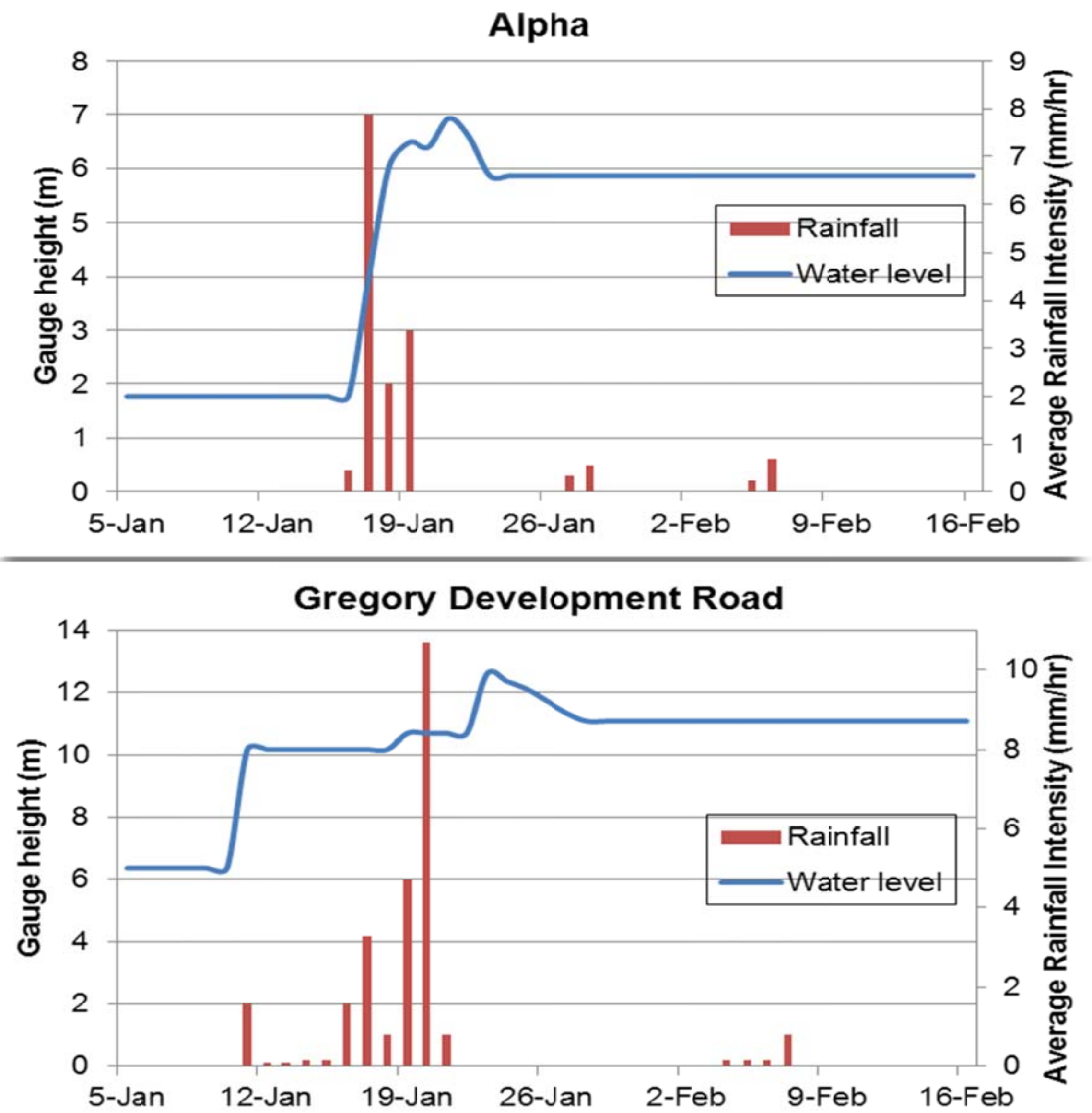
4.6 Cyclones

4.6.1 Cyclone Helen

During Cyclone Helen, 162 mm of rain was recorded at the Alpha rain gauge on 17 January 2008. This value is the highest 24 hour total recorded at this gauge and occurred within a six-day total of 225 mm. The rainfall and recorded flood levels from the Alpha and Gregory Development Road gauges are presented in Figure 4-22. It is noted that the flood levels rise, fall modestly and then reach a plateau for more than two weeks. It is not known if this pattern represents a persistence of flooding or a malfunction of the gauges, such as a stuck recorder.

Flood frequency analysis for the flood record at Gregory Developmental Road (refer to Appendix B of this report) shows that the 9.9 m recorded during cyclone Helen equates to approximately a 1 in 100 year ARI event.

Figure 4-22 Cyclone Helen – Water level and Rainfall Intensity in the Belyando River Catchment, January 2008



Source: BOM 2008

The lateral extent of the Cyclone Helen flooding is shown in Figure 4-23, with peak flood heights presented in Table 4-4. During this event, 380,000 ha and 59 properties were inundated. At Bygana Station, on the Belyando River, 10 km along the Belyando up river from the Carmichael River confluence and approximately 5 km to the southeast of the lower end of the Project (Mine), 50 per cent of the property remained under water for 32 days after the rain ceased. There are no flood records of significant flooding in the Carmichael River resulting from this event. This may reflect the rainfall received and/or the hydraulics of the steeper channel, which would lead to a more rapid passage of the flood waters.

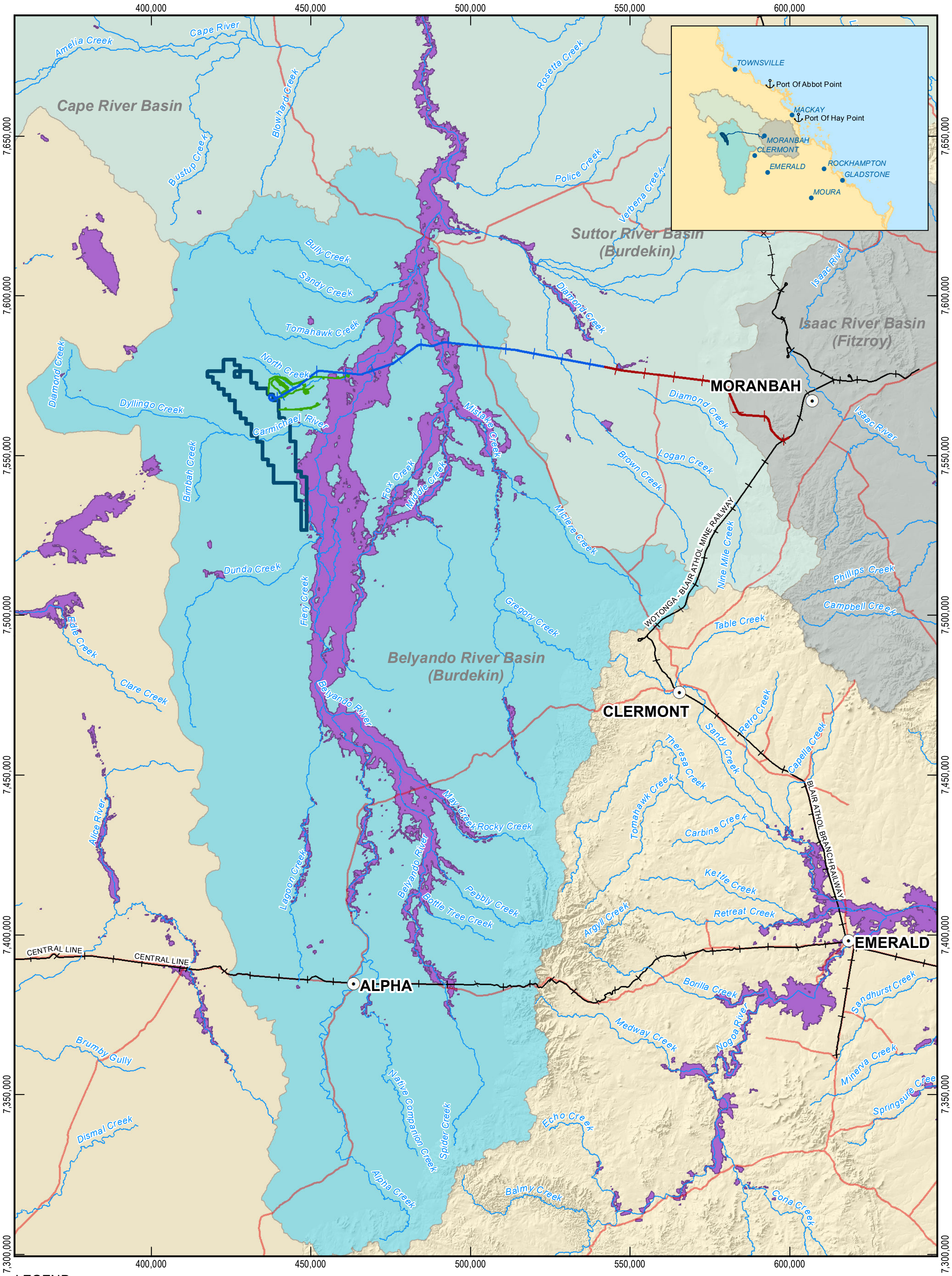
Table 4-4 Cyclone Helen – January 2008 - Peak Flood Heights for the Belyando River Alpha and Gregory Developmental Road Gauges

Station No.	Station Name	Date	Height (metres)	Flood Class
35229	Alpha	18/01/2008 22:00	7.3	Minor
35229	Alpha	20/01/2008 04:00	7.7	Moderate
536007	Gregory Developmental Road	23/01/2008 07:30	9.1	Moderate
536007	Gregory Developmental Road	23/01/2008 16:00	9.9	Major

Source: BOM (2011)

4.6.2 Cyclone Yasi

The bulk of rainfall during Cyclone Yasi fell to the north of the Belyando River Catchment. The vicinity of the Study Area was affected by the wet weather in December 2010 and the Belyando River level reached a peak of 3.2 m on 27 Dec 2010 at the Gregory Developmental Road gauge. Concurrent flood heights recorded at the BOM Alpha gauge (Bureau station number: 035229), which is 70 km to the south of the Project (Mine) and 140 km to the east of Barcaldine, were the third highest heights on record and only 1 m lower than the record peak of April 1990.



LEGEND

- Town
- State Road
- Watercourse
- Other Rail Network
- Northern Missing Link
- Cyclone Helen Flood Extent (2008)
- River Basins
  - Belyando River
  - Suttor River
  - Isaac River
- Mine (Onsite)
- Mine (Offsite)
- Rail (West)
- Rail (East)

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1:1,700,000 (at A4)

0 10 20 30 40 50

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Revision B
Date 04-09-2012

Extent of Flooding in the Belyando River - Cyclone Helen 8-19 January 2008

Figure 4-23

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: BOM: Cyclone Helen Flood Extent (2008); DERM: River Basin (2009), State Road (2010); DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Locality, Rail, Watercourse (2007); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012); GHD: Northern Missing Link (2011); Created by: BW, CA

5. Baseline Design Flood Modelling

5.1 Overview

Multiple models were developed to demonstrate the baseline flooding conditions within the MLA. The modelling has been undertaken in accordance with the methodology summarised in Section 5.2.1, including development of hydrologic models to provide design peak flows estimates and then hydraulic models to determine the extent and magnitude of flooding.

5.2 Peak Flow Estimation

5.2.1 Methodology

Hydrologic modelling of the Carmichael River regional catchment was undertaken to provide input to the baseline flooding model of the Carmichael River corridor within the MLA. It was also used to generate design flood flows for use in the design of the diversion drains and Carmichael River levees. The 10 year, 50 year, 100 year and 1,000 year ARI design floods were determined. Two models were created, one for existing catchment conditions and one for post-development catchment conditions. A comparison of the two models was required to quantify the change in flood flows in the Carmichael River due to the Project (Mine). The Carmichael River design flows were used in the hydraulic models of the Carmichael River corridor.

CatchmentSIM software was used to define the regional contributing catchment, delineate sub-catchments and stream networks. XP-RAFTS (XP-RAFTS, 2012) software was used to route the runoff from the contributing catchments into the Carmichael River and produce the resulting peak flows hydrographs.

5.2.2 Design Rainfall Intensity

Rainfall intensity coefficients as sourced from BOM for the Carmichael Mine site are summarised in Table 5-1. These coefficients were fitted to a Log-Pearson Type III distribution as recommended by Book 6, Volume 1 (EA 1998) to generate design rainfall intensities up to 100 year ARI. The resulting rainfall intensities are presented in Appendix B of this report.

For the rainfall intensities of greater than 100 year ARI, the FORGE method was used. FORGE method results are presented in Appendix B.

Table 5-1 Rainfall Intensity Variables for Carmichael Mine

	Duration (hr)		
2 Year ARI	1	Intensity (mm/hr)	38.83
	12		6.21
	72		1.86
50 Year ARI	1		80.66
	12		12.42
	72		3.75
G (skewness) coefficient			0.050
F2 (2 Year ARI) coefficient			3.98
F50 (50 Year ARI) coefficient			16.40

Source: BOM IFD 2011

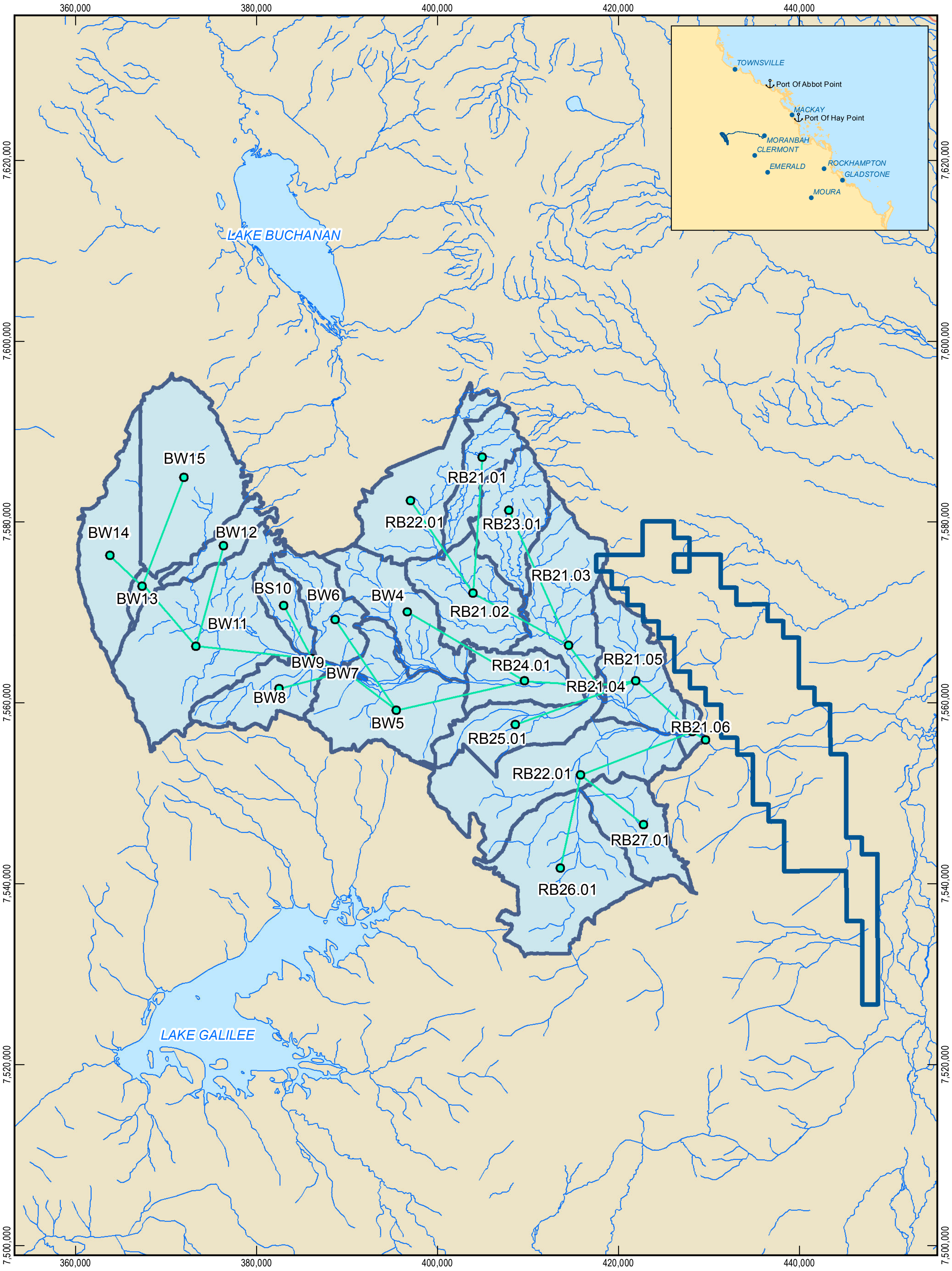
5.2.3 Design Model Parameters

The following model parameters were adopted for this study:

- Design Rainfall Losses – 25 mm initial loss and 2.5 mm continuing loss were adopted as recommended in Volume 1 Australia Rainfall and Runoff (ARR)1998
- Design Temporal Patterns – Design temporal patterns for Zone 3 from ARR 1998 were adopted for up to the 100 year ARI event. For the 1,000 year event the GSDM and GSTMR temporal patterns were applied (BOM, 2003; BOM, 2005)
- Manning's 'n' – A coefficient of 0.045 for sparse vegetation was adopted for the floodplain (DERM, 2007)
- Imperviousness – An imperviousness of 2 per cent was chosen as an estimate for 'grazing' rural surfaces
- Lag Times – Lag times were calculated by CatchmentSIM (Catchment Simulation Solutions, 2009) using the Bransby-Williams equation on the generated sub-catchments and corresponding longest flow paths

5.2.4 Sub-catchments Contributing to Peak Flow in Study Area – Existing Conditions

Sub-catchment areas contributing to the flow of the Carmichael River within the study area were identified using CatchmentSIM software. These sub-catchments and the corresponding XP-RAFTS hydrologic model network layout can be seen in Figure 5-1. Sub-catchment properties are included in Appendix B of this report**.** According to the DEHP watercourse map, seven minor watercourses are shown to intersect the western boundary of the Study Area. A combination of CatchmentSIM and ridge analysis was used to delineate sub-catchments contributing runoff to the seven minor watercourses. These sub-catchment areas formed the basis of the XP-RAFTS hydrologic model of the existing conditions within the Study Area as shown in Figure 5-2, not including the Carmichael River corridor.



LEGEND

- XP-RAFTS Model Node
- XP-RAFTS Model Link
- Watercourse
- State Road
- Mine (Onsite)
- Carmichael Regional Subcatchments
- Waterbody

1:600,000 (at A4)

0 5 10 15 20

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Revision | A
Date | 04-09-2012

Carmichael River Regional Subcatchments and XP-RAFTS Model Network

Figure 5-1

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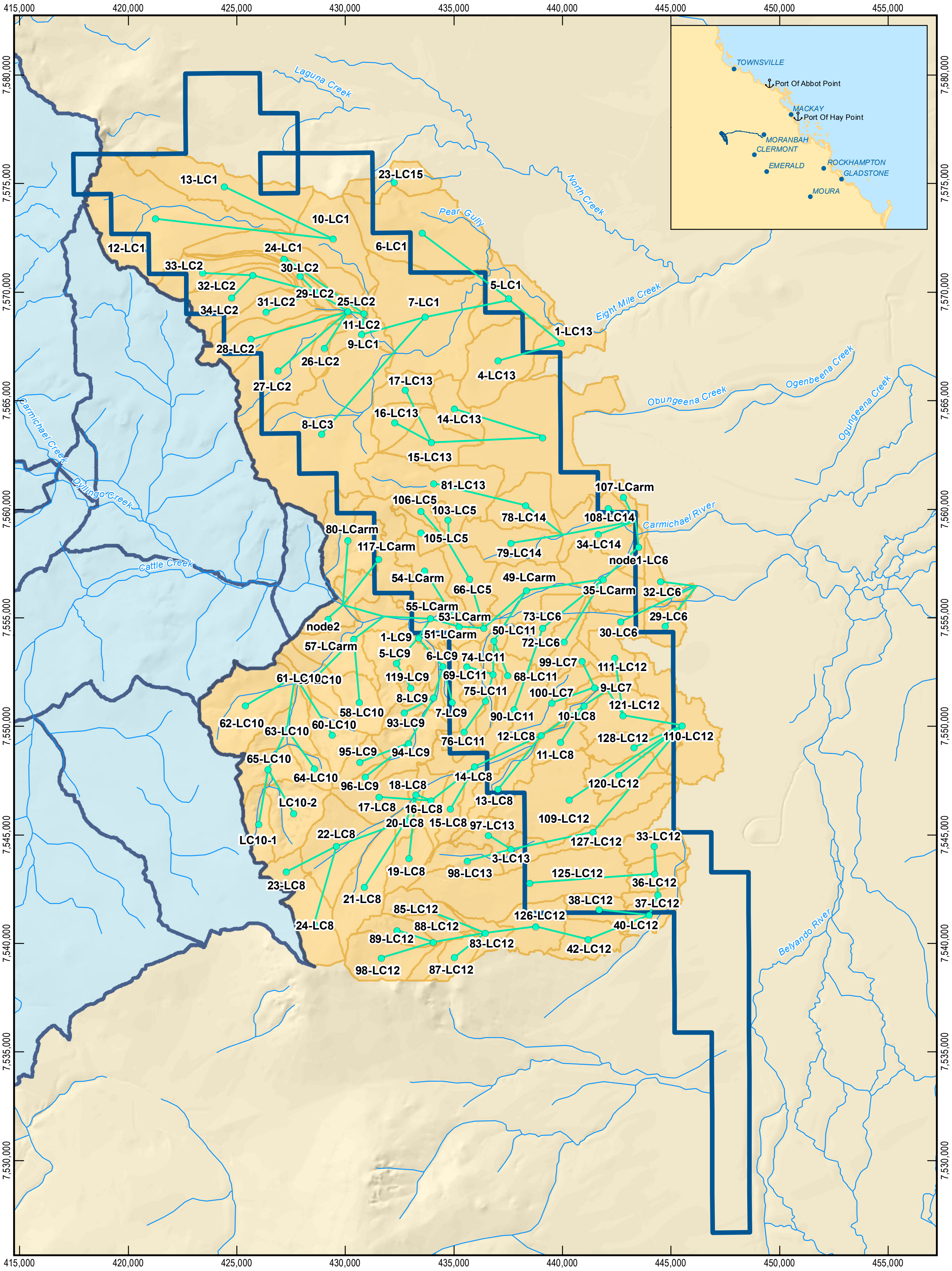
Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Locality, Watercourse, Waterbody (2007); Adani: Alignment Opt9 Rev3 (2012); GHD: Subcatchment Boundaries, XP-RAFTS Model Data (2011); Created by: BW, CA



LEGEND

- XP-RAFTS Nodes
- XP-RAFTS Links
- Watercourse
- Mine (Onsite)
- Carmichael Regional Subcatchments
- Mine Local Subcatchment

1:250,000 (at A4)

0 1 2 3 4 5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Mine Catchment
XP-RAFTS Model Layout

Job Number	41-25215
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Figure 5-2

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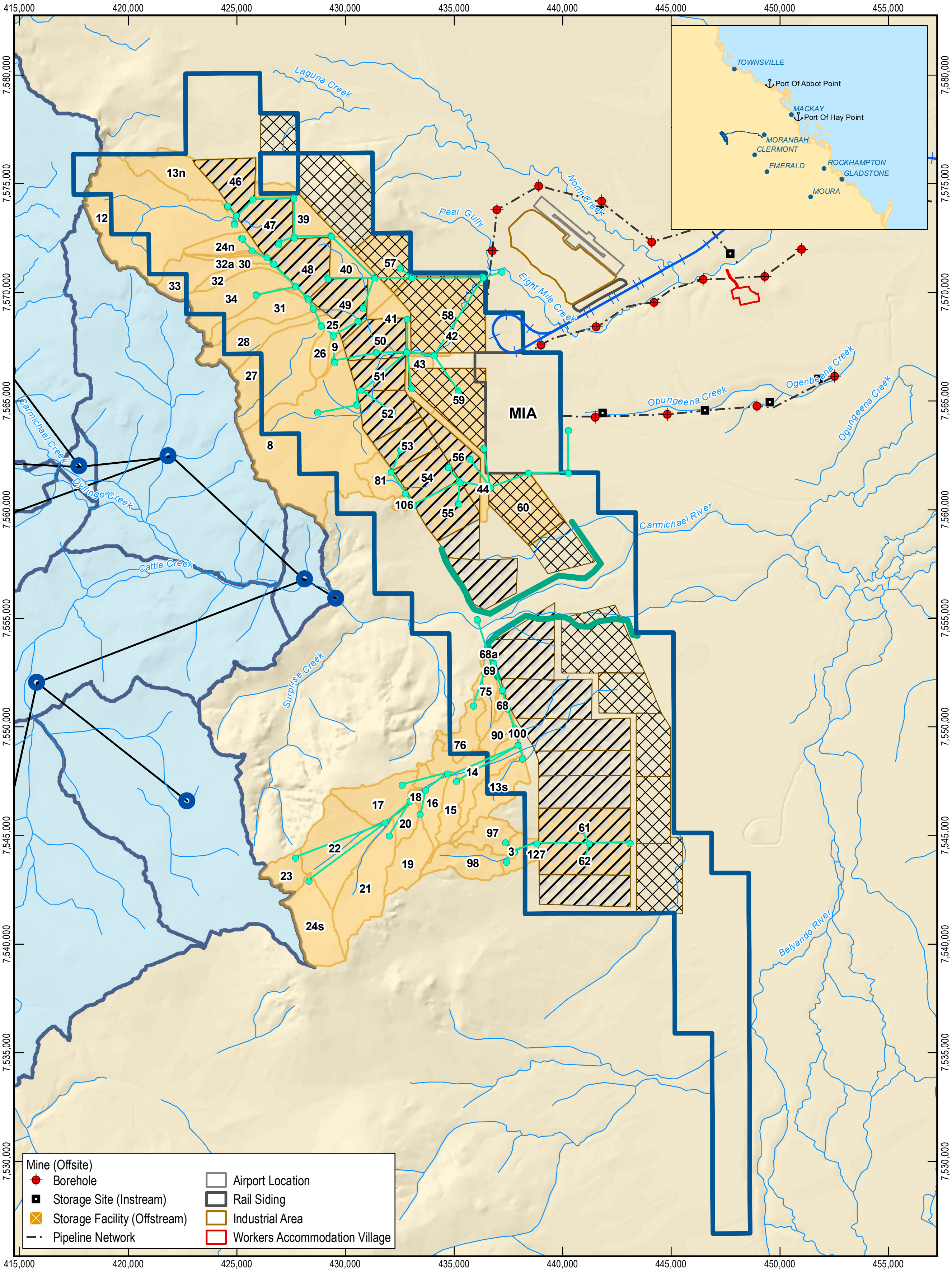
Data Source: DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Locality, Watercourse (2007); GHD: Subcatchment Boundaries, Model Data (2012); Created by: BW, CA

5.2.5 Sub-catchments Contributing to Peak Flow in Study Area – Post-development Conditions

Flows in the Carmichael River upstream of the Study Area, will be unaffected by the development of the Project (Mine). However, within the Study Area the Carmichael River will receive small additional flood flows from the diversion of a section of local drainage along the western boundary of the open cut pit areas as described in Section 6.3 and the mine drainage plan stages as shown in Appendix D of this report. In order to protect the internal mine area from receiving the runoff from sub-catchments outside of the Study Area, watercourses that currently intersect or traverse the mine area will need to be diverted as the mine plan progresses through the mine life.

The post-development condition mine local catchment can be seen in Figure 5-3; diverted sub-catchments are summarised in Appendix B. ArcGIS was used to determine the post-development hydrologic conditions, by establishing waterway intersections with the proposed mine layout within the existing sub-catchment areas. This allowed the change in sub-catchment area to be calculated, taking into account the change in terrain and diverted or collected runoff areas. Subsided areas will likely drain into these diversions, with local minor drainage channels constructed from subsided areas to the diversions as required.

For the purposes of this study, the change in sub-catchment area was assumed to not impact the equal area sub-catchment slope.



LEGEND

Carmichael Catchment Node
Local XP-RAFTS Node
Local XP-RAFTS Link
Carmichael Catchment Link
Watercourse
Rail (West)
Proposed Carmichael River Levees
Mine (Onsite)
Mine Infrastructure Area
Waste Rock Dump Area
Open Cut Mining Area
Carmichael Regional Subcatchments
Local Diverted Subcatchment

1:250,000 (at A4)
0 1 2 3 4 5
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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GHD adani

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Mine Catchment
Post Development

Job Number	41-25215
Revision	A
Date	04-09-2012

Figure 5-3

Data Source: DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Locality, Rail, Watercourse(2007); Adani: Alignment Opt9 Rev3, Open Cut Areas, Waste Areas (2012); GHD: Subcatchment Boundaries, XP-RAFTS Model Data, Levees (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: BW, CA

5.2.6 Peak Flow Estimates

Storms of durations ranging from 1 hour to 72 hours were modelled in the XP-RAFTS hydrologic model. The resulting peak flow rates were analysed to determine the critical storm duration and hence the peak flow for each ARI event.

For the Carmichael River, peak flows at the location of the proposed haul road and conveyor crossing for the existing conditions are summarised in Table 5-2.

Table 5-2 Peak Flows in the Carmichael River at the Location of the Proposed Haul Road & Conveyor Crossing – Existing Conditions

ARI	Critical Duration	Peak Flow (m^3/s)
10 year	30 hr	1187.25
50 year	18 hr	2140.5
100 year	18 hr	2604.0
1000 year	6 hr	4897.8

Existing peak flows were also modelled for the minor waterways local to the Study Area as shown in Figure 5-2 (excluding the Carmichael River). Flow results for these small sub-catchments are included in Appendix B of this report and show critical durations between two and six hours.

5.3 Verification of Peak Flows

Historical flood data was not available for the Carmichael River and as such it was not possible to calibrate the XP-RAFTS flood model. However, records from nearby stream gauges, empirical data and existing flow estimates were used to verify peak design flow estimates produced by the XP-RAFTS hydrologic model.

5.3.1 Comparison with 1 per cent Annual Exceedance Probability Flood Peaks for Queensland

A comparison of the 1 per cent Annual Exceedance Probability (AEP) (100 year ARI) design flow estimate predicted by the hydrologic model against the *Plot of 1 per cent AEP Flood Peaks* for Queensland chart (refer to GHD [2012a]) shows that the 1 per cent AEP design flow estimate of 2,600 m^3/s, as derived using the XP-Rafts model lies in the lower range of the typical flows per area for Queensland rivers. Typical flows indicated by the chart lay between 2,000-5,000 m^3/s for an equivalent catchment size of 2,000 km^2 i.e. the catchment area of the Carmichael River at the Study Area boundary. Factors such as the relatively flat terrain and low rainfall are consistent with the flow estimate falling at the lower end of the typical range.

5.3.2 Flood Frequency Analysis on Nearby Stream Gauges

There are three stream gauge data stations in the vicinity of the Project (Mine), being Mistake Creek, 120309A; Belyando, 120301B; and Cornish Creek, 003204A. Records from two additional gauges (Cape River at Pentlands, 120307 and Cape River at Taemas, 120302) were acquired. Although located further away from the Study Area, the data from the additional gauges was used for comparative purposes. No historical stream gauges exist on the Carmichael River.

Flow frequency analysis was undertaken on the data from the five DEHP stream gauges and scaled to calculate a predicted 100 year ARI design flow estimate for the Carmichael catchment according to *Hydrologic Recipes* (Grayson, 1963). The analysis of each data set indicated 100 year ARI flows much lower than generally found for the contributing catchment size (excepting the gauge Cape at Pentlands, 120307). The Carmichael River 100 year ARI peak flow calculated by the hydrologic model is comparatively high. However, these gauges have low quality data according to the DEHP quality codes, with, on average, only 56 per cent of the analysed data being considered ‘normal’ or ‘good’. In addition, the period of data collection is relatively short (the longest record commenced in 1976). The majority of data has been captured within a relatively dry hydrologic period, therefore making it difficult to extrapolate for a more rare flood event estimation. The much higher flows predicted by hydrologic model undertaken for this study were maintained as a conservative estimate of design flows in the Carmichael River for this reason.

Two stream gauges have been recently installed within the Study Area as described in Section 4.3.2. To date these have not yet produced sufficient data to validate the model peak design flow predictions.

5.3.3 Comparison to Golders Railway Hydrology

The *Carmichael Coal Mine Project: Preliminary Railway Hydrological Investigation* (Golder Associates, 2011) created a regression model based on twenty-five stream gauge results for similar catchments near to the Belyando River and within 300 km of the Project (Rail) (Golder Associates, 2011). The regression curve was then fit to the Carmichael River catchment as a function of catchment area and annual rainfall. It estimated a 100 year ARI design flow of 1,200 m^3/s for the Carmichael sub-catchment at the Project site. This is approximately half of the magnitude of the 100 year ARI design flow determined herein based on hydrologic model (see Section 5).

The design flood estimates presented in this report are based upon a rainfall runoff model of the catchment. The design rainfall intensities are based upon longer record lengths due to the greater availability of rainfall data compared to stream gauge data. At this stage of the Project (Mine) it is considered reasonable to adopt a more conservative approach, i.e. to base the designs on a higher rather than lower value.

5.4 Hydraulic Modelling

5.4.1 Overview

Hydraulic modelling to determine water levels resulting from flood flows has been undertaken for the existing (pre-development) and post-development condition using one-dimensional (HEC-RAS) hydraulic modelling software to simulate minor waterways and two-dimensional (TUFLOW) hydraulic modelling software to model the more complex Carmichael River floodplain. Both of these packages are recognised as industry standard within Australia and are appropriate for modelling flood extents for this study.

Hydraulic modelling was undertaken for the 10, 50, 100 and 1,000 year ARI design events with a model time step of five seconds. All the inflow hydrographs were sourced from the hydrologic models described in Section 5.

5.4.2 Existing Conditions Digital Elevation Model

In order to represent the Carmichael River floodplain in the vicinity of the Project site, a 10 m grid digital elevation model was developed over an area of approximately 17,700 ha using aerial survey data.

A cell size of 10 m x 10 m was adopted to adequately represent the bathymetry and topography of the study area whilst limiting model run times to an acceptable length. The extent of the digital elevation model (which forms the basis of the 2D hydraulic model) was selected to:

- Accommodate the post-development flood flows and levels as well as existing conditions
- Cover likely upstream and downstream development impacts, noting that flood extent is only know after the modelling has been done
- Include key hydraulic controls, including significant existing upstream and downstream road and railway alignments
- Allow for modelling of complex flow interactions
- Enable appropriate boundary conditions to be applied
- Reduce boundary condition effects in areas of the model where results are more important

5.4.3 Model Boundaries

A major inflow boundary condition was applied at the western (upstream) boundary of the hydraulic model. This boundary simulates the in-channel flow of the Carmichael River that arises from its natural catchment at that point. Additional ‘source point’ inflows representing runoff from the minor local sub-catchments internal to the model area were also applied.

A ‘free outfall’ method was adopted for the tailwater conditions around the boundary of the model. The water surface profile was analysed and showed that boundary effects were localised to approximately 200 m from the edge of the model boundary and therefore the flooding within the MLA was not significantly affected.

The existing conditions 2D hydraulic model was tested for sensitivity to varying tailwater conditions by simulating the 1000 year ARI flood event with a range (+/- 1 m) of the adopted tailwater levels. The effects of these changes were limited to the proximity of the model boundary and did not significantly alter modelled flood conditions within the MLA.

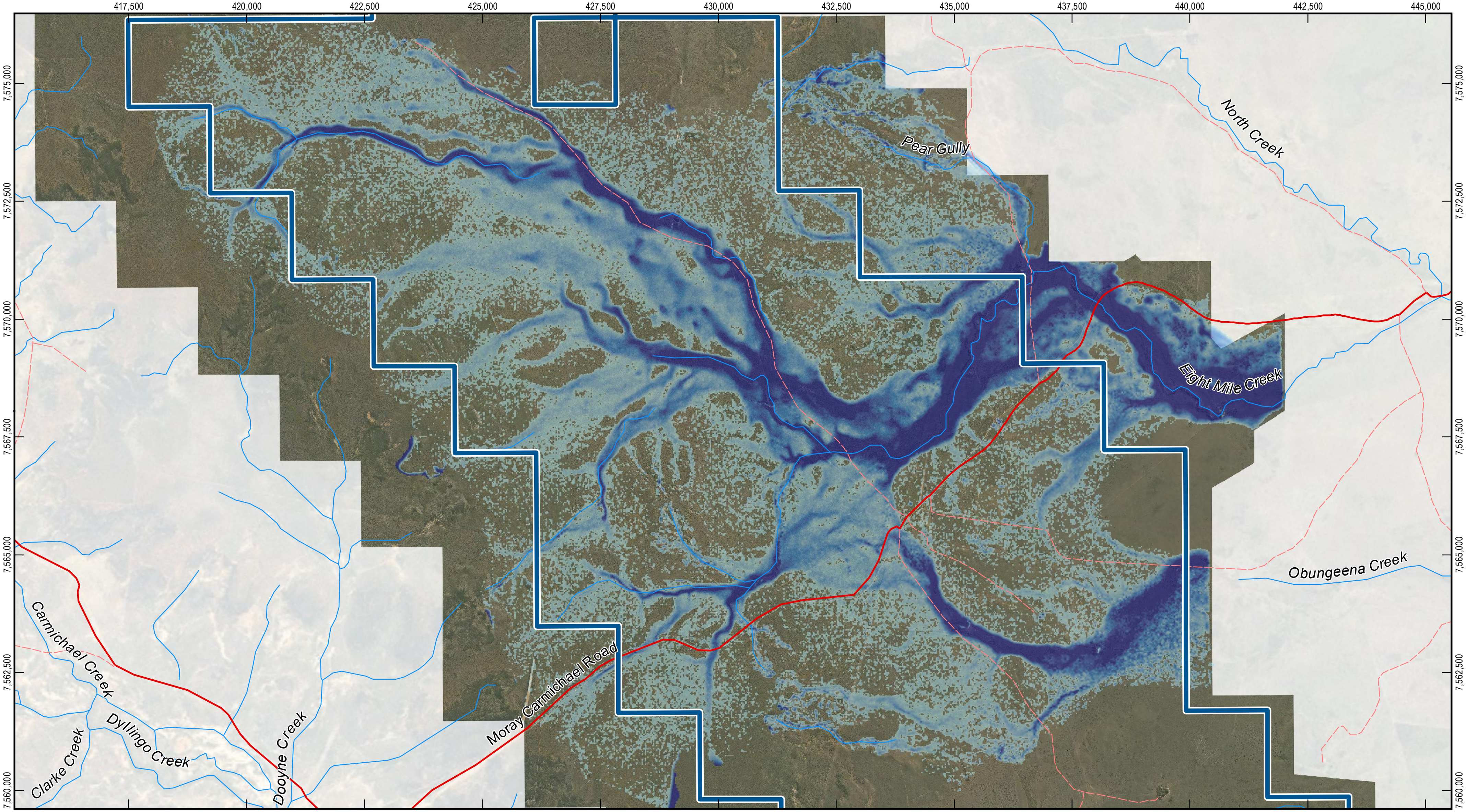
5.4.4 Hydraulic Roughness

Manning's roughness coefficients were adopted based on a field inspection of the floodplain, recent aerial photographs were used for further assessment and comparison of the adopted roughness values and engineering judgement. There are no sets of recorded flood levels for a gauged flood flow, so verification and or calibration of the hydraulic model was not possible at the time of preparing the model. The adopted roughness coefficient for the floodplain surface was 0.045, as recommended for 'sparse vegetation' (DERM 2007).

5.4.5 Model of Minor Waterways

Some regions within the MLA have a flat topography with undefined drainage paths. To ascertain the flow paths within the Study Area, an initial 2D hydraulic model was created aid in defining the likely drainage flow patterns. The model was run with 'test' rainfall data applied directly to each grid cell across the catchment (Figure 5-4).

Results from this exercise informed the HEC RAS modelling and the development of the conceptual diversion drain design as proposed in Section 6.3.3.



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Watercourse
- Track
- Minor Road
- Mine (Onsite)

Indicative Topographic and Hydraulic Analysis
- More Water
- Less Water

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Indicative Topographic Drainage Analysis - North Region of Study Area

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Figure 5-4

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Data source: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Watercourse, Tracks, Roads (2007);
GHD: Drainage Modelling (2012); Created by: BW, CA

5.4.6 Baseline Design Flood Extents

Flood inundation maps indicating the extent and depth of flooding for the 10, 50, 100 and 1,000 year ARI design events under existing site conditions, as discussed in this section, are provided in Appendix C of this report.

10 Year ARI Storm Event

For all recurrence intervals modelled the flood flow path follows an existing route that ultimately discharges into Cabbage Tree Creek to the south-east of the Carmichael River. 10 year ARI model results indicate that flows are largely contained within the river channel with some localised overbank flooding at the major inflow gullies. The results show that a breakout is likely to occur in a southerly direction from Cabbage Tree Creek which causes substantial localised flooding along the eastern boundary of the area proposed for Pits M and L. These flood flows contribute to overland flow which is approximately 0.5 m deep in the eastern region of the Study Area.

To the north, the local flood model indicates extensive flooding across approximately half of proposed Pit N area, with a natural flow path toward the intersection of Pits O and P. Flooding is shown to occur along the western boundary opposite proposed Pits M and L. Runoff from the north of the Project (Mine) site concentrates and flows in the natural gullies on the western side of the site. The topography becomes flatter across the area identified for open-cut pits. The change in existing landform causes the runoff to flood more extensively across all proposed pit areas. Runoff from the north of the mine site eventually discharges to Eight Mile Creek.

50 Year ARI Storm Event

The model results for the 50 year ARI event indicate a potential flood extent width of approximately 1.5 km-wide bordering the river channel within the Study Area. Flood water overbank depths range between 0.3 to 1.5 m. To the east of the Study Area boundary, the flood water flows into Cabbage Tree Creek, this has the effect of substantially increasing the floodplain extent substantially to an inundated area approximately 2.5 km wide. Overland flow depths in this region are approximately 0.5 m at the edge of the model boundary.

The flooding characteristics within the minor waterways to the north and south of the Study Area do not change significantly from the 10 year ARI event. However the flow widths along the defined runoff paths typically increase by 6 m and up to 45 m in the larger flat area to the east.

100 Year ARI Storm Event

During the major storm event, wide-spread flooding is evident to the north of the Carmichael River. Extensive flooding also occurs in the region adjoining and to the south of Cabbage Tree Creek. Flood water depths overbank of the Carmichael River range between 0.3 to 1.7 m. Resulting water depths of approximately 0.3 to 1.3 m are shown surrounding Cabbage Tree Creek and along the south-eastern Study Area boundary.

Flooding within the minor waterways to the north and south of the Study Area does not change significantly from the 10 and 50 year ARI events. However the flood extents along the defined runoff paths typically increase by 7 to 20 m either side and up to 60 m either side in the larger flat inundated area to the east compared to the lower flood events.

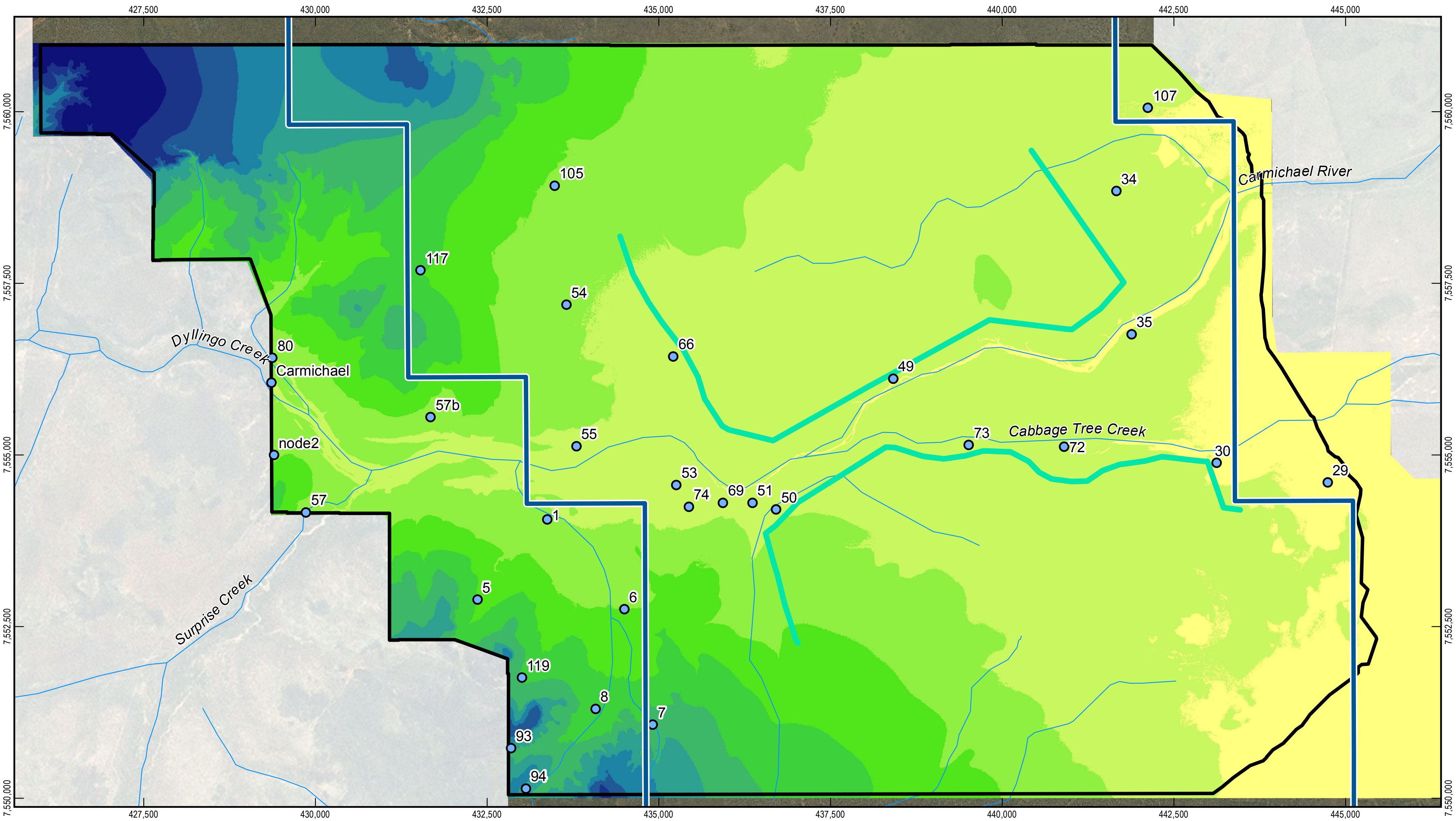
1000 Year ARI Storm Event

The combined effect of incoming overland runoff over a flat plain and Carmichael River breakout flow creates flooding a distance of 3 km across proposed Pit K to the north of the main channel, much of it between 0.5 to 1.0 m deep.

To the east of the Study Area, almost the entire 2D model extent is inundated to a depth of 0.5 m or more, with almost half of the proposed Pit L area experiencing flood depths of approximately 1.2 m. The local flooding model indicates substantial flooding across the Project. Flooding extents along the minor waterways and defined runoff paths typically increase from 25 m up to 250 m in the larger flat inundated area to the east.

Sensitivity Analysis

A sensitivity analysis was undertaken on the 1000 year ARI existing condition event by raising and lowering the applied tailwater condition. Results indicate that changing the tailwater level by this plus or minus 1 m did not have a significant impact on flood levels in the vicinity of the mine site, with a maximum difference of 7 mm over the predicted flood level. Therefore it was concluded that the flood extents are relatively insensitive to the adopted tailwater conditions.



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Inflow Source Point
- Watercourse
- Proposed Carmichael River Levees
- 2D Model Extent
- Mine (Onsite)

m (AHD)

210 - 220	240 - 250	280 - 290
220 - 230	250 - 260	290 - 300
230 - 240	260 - 270	300 - 310
	270 - 280	310 - 320

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Date | 04-09-2012

2D Carmichael River Hydraulic Model Post-development DEM & Setup

Figure 5-5

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Data source: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Watercourse (2007); GHD: Inflow Source Points, Levees, Model Extent, DEM (2012); Created by: BW, CA

6. Preliminary Surface Water Assessment of the Mine Plan

Planning for expected surface water management components has occurred within a preliminary water balance study and a drainage infrastructure design study. These were performed for ten of the proposed mine stages as shown in Table 6-1. (Note the dates align with the Runge Macro Conceptual Plan (Runge, 2011), thus 2013 corresponds to Year 1 of mining.)

Table 6-1 Mine stages for Preliminary Water Balance

Stages	I	II	III	IV	V	VI	VII	VIII	IX	X
Years	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103

During the operational stage of the Project (Mine), activities will include the construction of the following structures to provide an appropriate level of flood mitigation for mining operations and also to minimise the amount of mine affected water requiring treatment:

- Levees;
- Bunds;
- Diversion drains; and
- Haul road and conveyor crossing over the Carmichael River.

These measures will form part of the Project (Mine) flood management system. This system has been developed using the model outcomes described in Section 5. Preliminary designs for the flood protection infrastructure components are included in Section 6.2 to Section 6.4.

There are a number of major items of infrastructure required for the proposed mine, each of which will influence the management of water on the site. The various elements of infrastructure shown in Figure 2-1 in Section 2.2 of this report and include the following:

- Open cut pit areas;
- Underground working areas;
- Out of pit spoil areas;
- Haul roads;
- Mine affected water (MAW) storages;
- Industrial working area including the mine industrial area (MIA), the run of mine (ROM) coal area, coal handling and production plant (CHPP) and train load out (TLO) facility;
- Creek diversion channel(s);
- Flood protection infrastructure; and
- Pumps and pipes.

The major infrastructure components will be connected to create the mine water management network.

Figures showing the different mine stages and associated creek diversions and levees are included in Appendix D. This conceptual drainage scheme has been designed to protect the active mine areas from flooding while retaining natural channels wherever practical. To achieve this, minor and major levees, diversion drains, culverts and waterway crossings are recommended as described in Section 6.2, Section 6.3 and Section 6.4.

6.1 Water Supply

The availability of water for the Project (Mine) can be assessed against the yield assessment performed by Hyder[4] for the off-site infrastructure. The assessment takes into account the upper reaches of the Belyando River, Native Companion and Mistake Creek which form sub-catchment E of the WRP Section 3.6 is managed by the Resource Operations Plan as described in and Section 0.

The legislated ROP IQQM model developed by the Queensland Government was used to assess potential river extraction rates for the yield assessment. The river model includes the entire Burdekin Basin which is made up of recorded stream-flow data in-filled with flows from calibrated Sacramento rainfall runoff models for each gauged catchment. The gauge has recorded data from 1967 to date. The station has generally high quality readings as various sized floods have been recorded (flow vs heights) to develop an accurate rating table (flow vs height relationship) to produce flows from recorded heights. Previous to 1967, the flows are in-filled with a calibrated Sacramento model of the area which uses recorded rainfall back to 1889. The model runs from 1889-2004, with the Project extractions situated within Sub-Catchment E of the IQQM model, which is based on the flows from the Gregory Development Road Gauging station (120301B).

Several small local creeks (North and Obangeena) within the site, which form part of the larger Belyando River system, were used to assess the potential surface water extractions via several in-stream storages. These systems are ephemeral, running for less than 20 km and usually ending with a natural breakout which results in significant transmission losses (80 per cent) before joining the Belyando River via several ephemeral drainage lines. The main water extraction point will be at the main channel of the Belyando River as it crosses the main access road to the Project (Offsite) Moray Downs site. The associated catchment area for this area is approximately 70 per cent of the total 35,400 km^2 Belyando River sub-catchment. The area suffers significant losses due to natural breakouts and long periods of no flow, which is reflected in the yield assessment.

The modeling performed was able to incorporate the water extraction conditions under the ROP with the environmental flow objectives identified within the WRP as described in Section 6.1.1 and existing user extraction (Section 6.1.2) to predict the potential availability or shortage of water extraction supply possible for the project.

[4] Hyder, October 2012, Adani Carmichael Coal Mine Water Demands Report..

6.1.1 Water Resource Planning

The relevant WRP (Section 3.6) has defined specific environmental values within the connected surface water system that makes up the Burdekin Basin. These values are associated with the hydrologic characteristics (including low, high and medium flows, velocities and flood extents) of the waterways within the system which have an impact on both terrestrial and aquatic flora and fauna. These values have been quantified by the Burdekin Basin's Technical Advisory Panel (TAP) within a set of environmental flow objectives (EFOs).

Within the WRP these objectives are set as benchmarks for water extractions, and can be applied across various critical nodes (points along the different river systems) along the entire Burdekin Basin. These also drive the WRP project performance indicators and targets for the environmental flow and water allocation security objectives. Key EFOs evaluated include:

- Flows;
- Mean annual flows;
- Median annual flows;
- Low flow objectives;
  - Total number of days where 50 per cent of non-zero daily flow is equalled or exceeded be at least 32 per cent of total
  - Total number of days where 8 per cent non-zero daily flow is equalled or exceeded be at least 52 per cent of total
- Medium to high flow objective;
  - 1.5 year daily flow volume in the simulation period, expressed as a percentage of the 1.5 year daily flow volume for the pre-development flow pattern, to be at least 94 per cent;
  - 5 year daily flow volume in the simulation period, expressed as a percentage of the 1.5 year daily flow volume for the pre-development flow pattern, to be at least 96 per cent; and
  - 20 year daily flow volume in the simulation period, expressed as a percentage of the 1.5 year daily flow volume for the pre-development flow pattern, to be at least 98 per cent.

6.1.2 Existing Users

The Burdekin Basin WRP lists all owners of water allocations within the boundaries of the Burdekin basin. This includes all existing, future (approved but not developed) and sleeper (in the ground but not active) users within the system. The ROP IQQM model reflects the scenario of all users, including the strategic and state reserve, being active and taking their full entitlement.

Due to the location of the mine, very few users are within the area are likely to be affected by the mines activities when compared to the total number of users in the system. Based on the ROP, the users situated on the main Belyando or Suttor River downstream of the Study Area that may be impacted by the Projects proposed extractions are identified and listed in Table 6-2.

Table 6-2 Existing users downstream of mine water extractions

ROP IQQM Node	Licence Type	Mean Annual Demand ML/yr
233	Stock And Domestic	15.4
246	Stock And Domestic	30.2
279	Stock And Domestic	5.7
232	Water Harvester	950
291	Irrigator	560
292	Water Harvester	5570
293	Water Harvester	2750
300	Water Harvester	3888
302	Water Harvester	1150

6.2 Proposed Levees and Bunds

6.2.1 Overview

Levee banks are proposed in various locations to reduce the risk of flood waters entering pits and to assist with the separation of mine affected areas. These controls will reduce the amount of mine affected water (MAW). The proposed levees include:

- Levees located either side of the Carmichael River and extending to wrap around active open cut pits and out-of-pit waste rock dump areas (see Figure 6-1 for locations) to reduce the risk of Carmichael River flood waters from entering the pits. These levees are referred to as the Carmichael River levees and are required from approximately Year 2047 for the southern levee and from Year 2067 for the northern levee;
- Bunds around pit areas to prevent flooding due to runoff from local mine runoff within the Study Area in all years;

- Minor levees either side of Eight Mile Creek inflow at the eastern edge of the MLA so as to safely pass the existing waterway between out-of-pit waste rock dump areas without flooding these areas (refer Year 2015 onwards as seen in Appendix D);
- Minor levees around active pit areas to protect from flooding of local minor waterways (refer Year 2013, 2027 and 2067); and
- Levees or other measures to protect underground mine access areas from either local or regional flooding (to be designed when the locations of these access areas are confirmed).

Levees protecting the open cut pits are expected to remain once the mining activities have ceased. A final void balance will need to be developed to show if the pits will fill up with water or not. Regardless of this, it is expected that local stormwater runoff and flood water from the Carmichael River will not enter the open cut pits and create environmental hazard.

6.2.2 Carmichael River Levee Design Criteria

The following criteria were adopted for the Carmichael River levees at this stage of the design:

- The alignment of the flood protection levees along the northern and southern sides of the Carmichael River corridor has been based on the available corridor provided in the conceptual mine design (Runge, 2011);
- The flood protection levees along the northern and southern sides of the Carmichael River corridor, and the levees along the northern and southern external diversion drains, have been designed with crest levels set at the 1,000 year ARI flood level, with an additional 600 mm of freeboard;
- For the purposes of this design stage, the batter slopes on the levees have been set at 1 vertical to 5 horizontal, and a 6 m top width of levee. Further assessment and consideration of the geotechnical engineering issues and design refinement will be required at a later stage; and
- The alignment should not block the runoff flow path from the Carmichael River to Cabbage Tree Creek.

Levees will be a regulated structure and will be designed with reference to the Queensland Government *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams (EM635)* (DERM 2012) and associated guidelines, or other equivalent guidelines that are in place at the time that the levees are required to be constructed.

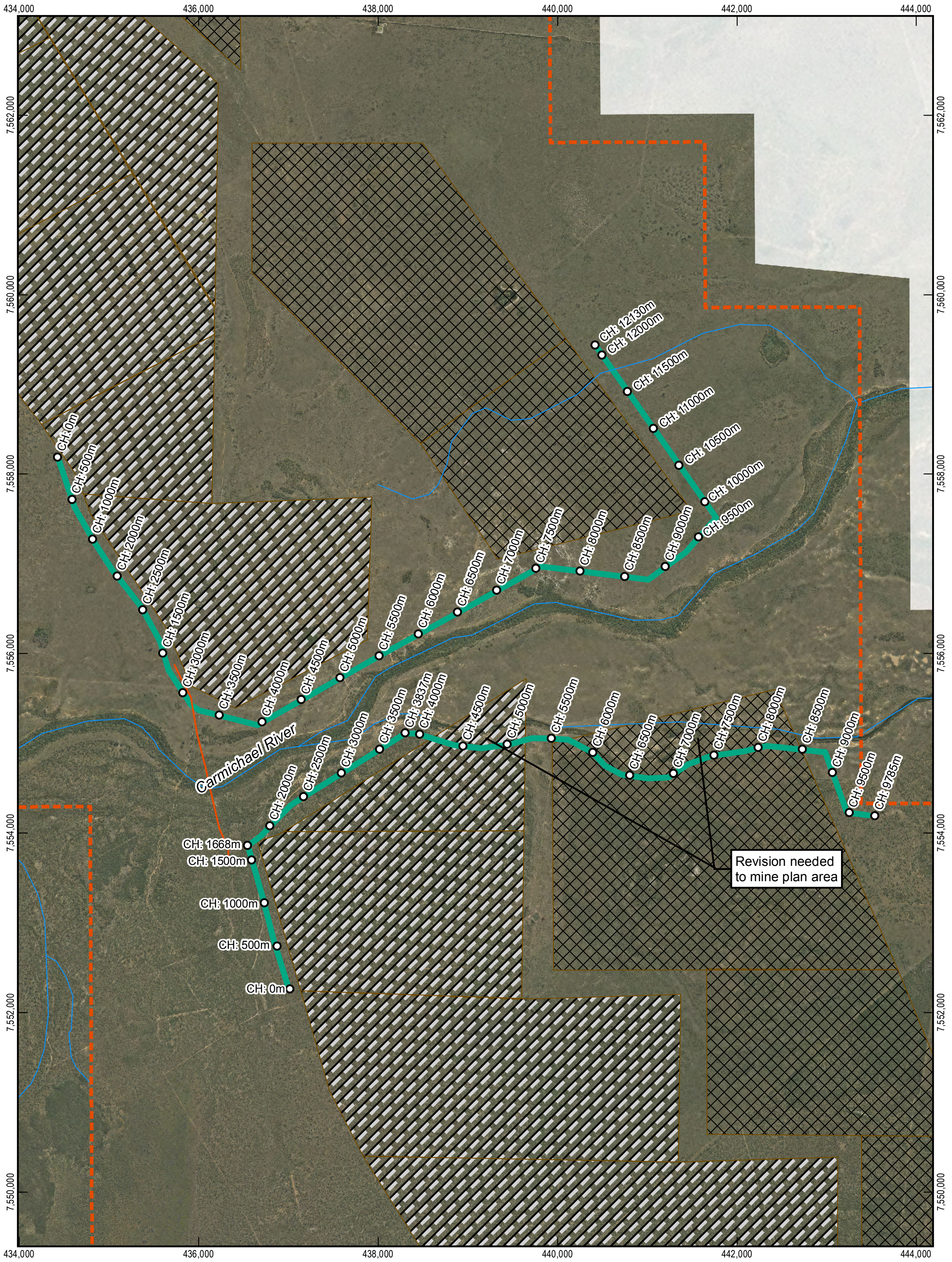
6.2.3 Description of the Levee Design

Under existing conditions, the 100 year ARI flood extents of the Carmichael River within the Study Area are mostly contained within a 1.5 km wide corridor approximately centred upon the river channel. The design criteria require the levee to provide 1000 year ARI flood immunity to the open cut pits, and a minimum of 100 year ARI immunity to the waste dump areas. The alignment geometry was chosen to curve around the open cut pits and waste dump areas to provide protection from local overland flow as well as flooding from the Carmichael River. The alignment was also designed to allow for the effluent flow path from the Carmichael River into Cabbage Tree Creek.

The alignment of the flood protection levees is presented on Figure 6-1. The height of the levee above natural ground level averages at approximately two metres with a maximum height of 6.1 m.

The maximum height occurs in a localised area where the levee crosses a natural depression or gully.

Levees to protect Eight Mile Creek from the out-of-pit waste rock dumps were assessed during the sizing of the case study diversion drain (refer Section 6.3.3). Preliminary hydraulic modelling indicated that a minimum waterway corridor width of 75 m is required through the waste dump at the downstream end of the drain to manage afflux (reference Figure 6-2). Levees to protect the waste dumps should be located outside of this 75 m corridor, and should be constructed to a height equal to or exceeding the 100-year ARI flood level plus 600 mm.



LEGEND

- Existing Watercourse
- Haul Rd & Conveyor Crossing
- Proposed Carmichael River Levees
- Mine Lease Area
- Waste Rock Dump Area
- Open Cut Mining Area

Based on or contains data provided by the State of QLD (DERM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

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Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Carmichael Coal Mine and Rail Project

Carmichael River
Proposed Infrastructure

Job Number	41-25215
Revision	A
Date	04-09-2012

Figure 6-1

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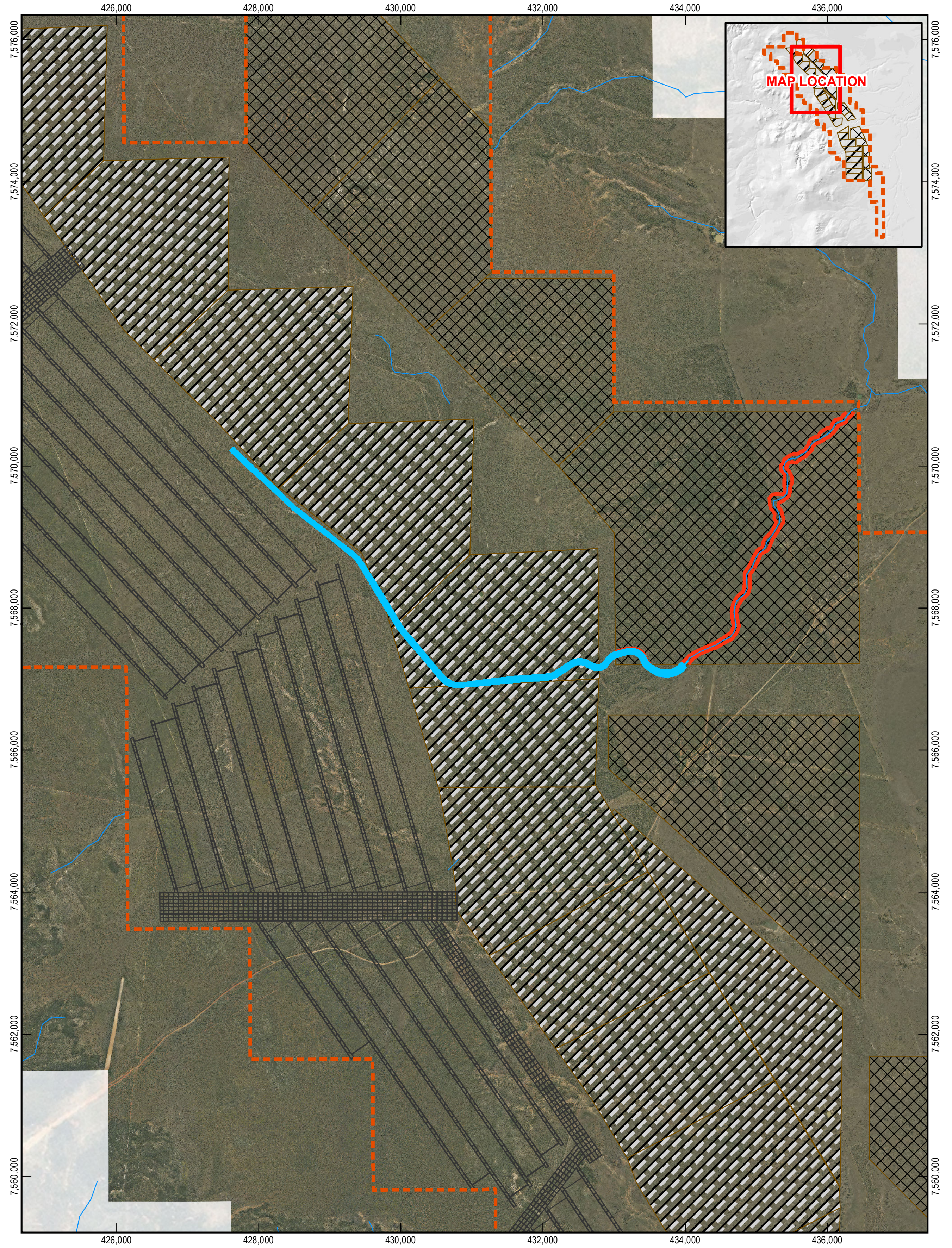
Data Source: DERM: Watercourse (2010); DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Locality, Rail, Watercourse(2007); Adani: Waste Dump, Open Cut Pits (2012); GHD: Proposed Haul Road, Levees (2012); Created by: BW, CA



LEGEND

- Existing Watercourse
- Diversion Drain
- Levee
- Underground Mine Plan
- Mine Lease Area
- Waste Rock Dump Area
- Open Cut Mining Area

1:75,000 (at A4)

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Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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GHD adani

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Carmichael Coal Mine and Rail Project

Waste Rock Dump Levees and Case Study Diversion Drain

Job Number	41-25215
Revision	A
Date	05-09-2012

Figure 6-2

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Data Source: DERM: Watercourse (2010); DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Locality, Rail, Watercourse(2007); Adani: Underground Mine Plan Waste Dump, Open Cut Pits (2012); GHD: Diversion Drain, Levees (2012); Created by: BW, CA

6.3 Diversion Drains

Design criteria have been established for diversion drains required to redirect surface water away from mine affected areas. The purpose of these diversion drains is to both provide flood immunity to the site and to minimise the volume of mine-affected water requiring treatment before discharge. For the purposes of conceptual design, diversion drains are categorised as follows:

- External diversions drains - These are located outside of the mine affected area (but within the MLA) and are constructed in phases depending upon mining activity and to last for the life of the mining activity in that area. They will also be maintained and integrated into the rehabilitation plan for the mine site. As noted in Section 0, a case study design for one of these external diversion drains is described here in order to demonstrate indicative sizing. Sizing of the remainder of the proposed external diversion drains will be required in further stages of design; and
- Internal diversion drains and bunds - These are located within the MLA and are constructed as required to provide required flood mitigation. These will require relocation or replacement as the mine plan advances to allow for the progression of the open cut mining footprint and to ultimately ensure alignment and compliance with final landform and drainage requirements. The diversion drains are expected to remain after the mine operations have ceased. Due to the open cut pits and waste rock stockpiles the natural waterways cannot be restored. It is also expected that the diversion drains will develop their own environmental values during the many years they will be required that would be destroyed by reinstating the previous natural waterway.

Refer to Appendix D for mine progress plots of the creek diversion scheme.

6.3.1 External Diversion Drain Design Criteria

The external diversion drains are to be designed in accordance with the following drainage design criteria:

- The design must accommodate the 100 year ARI flow with an additional 600 mm freeboard; no allowance for climate change (higher rainfall intensities) as derived using the hydrologic models described in Section 5;
- The design should consider expected subsidence up to seven metres (SCT, 2011);
- The maximum flow velocity in the diversion drains to be no greater than 2.5 m/s velocity for the 50 year ARI event (DERM, 2011);
- No greater than 80 N/m^2 shear stress for the 50 year ARI event (DERM, 2011);
- No greater than 220 watt/ m^2 stream power for the 50 year ARI event (DERM, 2011); and
- Drain banks to have 1:5 slope; and
- Where the mine pits are potentially at risk of inundation from the diversion drains, diversion bunds will be constructed along the eastern side of the drain to provide for 1,000 year ARI flood immunity for the pit from flood waters originating from the diversions drains. These are sized according to the 1,000 year ARI peak flood level, plus 600 mm freeboard.

6.3.2 Diversion Drain Alignment

Diversion drains that cater for external catchment flows have been proposed at various locations as shown in the conceptual drainage plan for each stage in Appendix D of this report. The designs have been based on the current mine plan and have taken account of the existing topography and where possible follow existing grades with the aim of reducing the amount of excavation.

The drains have been located between staged open cut pit areas based on the current indicative mine plan. As mine planning progresses, the locations of diversion drains may need to be reviewed. Diversion drain alignments have been chosen with due consideration of conceptual infrastructure such as haul roads and conveyors where such information is known. The final alignments may need to be reviewed in the detail design phase once infrastructure locations are confirmed.

The existing watercourses have been maintained where possible. Drain discharge points have also been designed to closely mimic existing drainage paths and maintain inflows to waterways to the east of the MLA. This approach was also adopted to reduce the potential for erosion in the floodplain. The proposed alignment for the diversion drains at each of the selected mine stages can be found in Appendix D.

A case study preliminary design was undertaken to demonstrate the intent for these diversion drains and provide indicative sizing. The case study diversion drain was aligned to collect runoff from part of the subsidence area over the underground mining area as well as some external catchment runoff. The diversion drain outlet re-joins the existing natural watercourse within the MLA, where it will be bounded on either side by the proposed waste rock stockpile areas. The preliminary design of the case study drain includes a recommendation for the minimum waterway corridor width through the spoil heap, with protection levees to be constructed outside this corridor as described in Section 6.2. Design of detailed alignments for the other proposed diversion drains are required during further design stages.

6.3.3 Case Study Diversion Drain Design Summary

Longitudinal and cross sectional profiles of the case study diversion drain are provided in Drawings SK004 and SK005 in Appendix E.

Table 6-3 indicates selected drain characteristics and flow results at key locations for the 50 year ARI flood for comparison against the DEHP design guideline velocity limits (DERM, 2011). The drain has also been designed with a conveyance capacity equivalent to a 1 in 100 year ARI event and a minimum 600 mm freeboard. Results for this event are shown in

Table 6-4.

The diversion drain details provide typical deep-cut cross sections, a typical shallow-cut cross section with fill required for the channel embankments. Two additional cross-sections through the waste dump waterway corridor are also provided on drawing SK005 in Appendix E. The drain varies in depth from four to seven metres; and in top of channel width between approximately 50-70 m.

Table 6-3 Characteristics of case study diversion drain for 50 year ARI flows

HECRAS station	Diversion Drain Chainage (m)	Channel Base Width (m)	Q50 (m3/s)	Slope	Flow Depth (m)	Channel Velocity (m/s)
22641	0	1	93	1:450	2.89	1.98
20844	1800	1	113	1:450	3.15	2.01
20244	2400	1	145	1:450	3.40	2.22
19644	3000	1	152	1:460	3.45	2.26
19133	3490	1	152	1:460	3.10	2.72
19044	3600	3.6	155	1:460	2.98	2.67
18844	3790	8	155	1:460	2.94	2.22
17044	5600	8	155	1:460	2.71	2.57
16444	6200	24	155	1:460	2.33	1.96
15644	7000	24	265	1:460	3.02	2.30
14525	8120	24	270	1:810	2.98	2.02

Table 6-4 Characteristics of case study diversion drain for 100 year ARI flows

HECRAS station	Diversion Drain Chainage (m)	Channel Base Width (m)	Q100 (m3/s)	Water Level (m AHD)	Flow Depth (m)	Freeboard (m)
22641	0	1	114	252.48	3.11	3.02
20844	1800	1	138	248.79	3.41	0.79
20244	2400	1	179	247.73	3.68	2.50
19644	3000	1	188	246.45	3.73	3.62
19133	3490	1	188	244.96	3.35	3.72
19044	3600	3.6	191	244.66	3.25	3.78
18844	3790	8	191	244.20	3.22	3.68
17044	5600	8	191	240.00	2.95	1.05
16444	6200	24	191	238.34	2.60	1.41

HECRAS station	Diversion Drain Chainage (m)	Channel Base Width (m)	Q100 (m3/s)	Water Level (m AHD)	Flow Depth (m)	Freeboard (m)
15644	7000	24	320	237.27	3.27	0.73
14525	8120	24	326	235.69	3.24	0.76

The extent of excavation required for the drain is primarily due to two factors:

- The alignment of the drain. The open cut pits are located on low-lying land intercepting the natural watercourses, meaning that drains along the edges of these pits must cut through higher ground; and
- The allowance for up to 7 m of subsidence at the upstream end of the drain.

Due consideration will be required at the detail design phase to mitigate impacts on local drainage and other inflows where the diversion drain requires fill embankments to contain the 100 year ARI design flows.

The hydraulic design was based on limiting the 50 year ARI flow velocities to 2.5 m/s. It can be seen in the above table that in isolated locations the current design does not satisfy this design criterion. It is expected that incorporation of energy dissipation and erosion control measures at these locations will address these minor non-compliances.

A check was also undertaken for the 1000 year ARI design flows to assess the general requirements for open cut pit protection levees, where required adjacent to the case study drain. The 1000 year ARI water levels were on average 1.2 to 1.8 m higher than the 100 year ARI levels. Thus, to meet the design criteria of 600 mm freeboard in the 1000-year event, the height of the pit protection levees will need to be up to 1.8 m adjacent to the diversion drain. Further design of these levees will occur as the design of other nearby infrastructure, such as haul roads and overland conveyors progresses. This case study external diversion drain design required the provision of a levee because of its alignment however levees are not required for all of the proposed diversions (although provision of minor bunds will be). Appendix D indicates the likely location of any levees.

The preliminary channel grading shown on Drawing SK004 does not account for any subsidence at this stage. As subsidence occurs across the underground mining areas it will be necessary for the inlet of the diversion to be lowered to allow for collection of drainage from subsided areas. At this preliminary stage it is proposed that the typical profile be initially constructed with a deeper re-grading of the drain as subsidence occurs. Further refinement of this design would be undertaken during the detail design phase.

6.4 Haul Road and Conveyor Crossing

The Project (Mine) design includes provision for a haul road and conveyor crossing of the Carmichael River. This crossing links the southern parts of the mine to the mine infrastructure in the northern area. Given that the crossing of the Carmichael River has the potential to have a large impact on the existing flood regime, particularly flood levels, a preliminary design of the crossing was undertaken using a hydraulic model to inform the design and demonstrate that potential hydraulic impacts could be addressed through design.

The conceptual mine plan (Runge, 2011) indicates that the crossing would take the form of a causeway, thus having a low flood immunity standard and would be overtopped by large floods. Preliminary analysis of a causeway, suggests a large number of culverts would be required to provide 50 year ARI flood immunity and that providing a bridge instead may prove to be an appropriate alternative.

This section describes the crossing of the Carmichael River, based on the inclusion of a bridge and two sets of culverts.

6.4.1 River Crossing Design Criteria

The haul road and conveyor crossing has been designed in accordance with the following design criteria:

- 50 year ARI flood immunity for the haul road and conveyor crossing, with 600 mm freeboard for the haul road;
- Haul road width of 40 m;
- Conveyor to be located on the same structure as the haul road crossing therefore not requiring separate hydraulic analysis;
- Velocity of flows under bridge less than 5 m/s;
- Allowance for passage of flow through natural minor channels on the flood plain, where possible; and
- Assumptions adopted for the preliminary design including:
  - Piers to support the bridge have a pile cap base of 2 m diameter and are 1 m in diameter above the pile cap
  - The soffit level of the bridge will be approximately 0.5 m above the 50 year ARI flood to allow for debris passage
  - In the absence of a defined limit to afflux, it has been assumed that 600 mm at the upstream side of the crossing is acceptable.

6.4.2 Description of the Haul Road and Conveyor Crossing Design

A preliminary drawing of the proposed haul road and conveyor crossing of the Carmichael River is shown on drawing SK009 in Appendix E.

Key features of the concept design of the crossing are as follows.

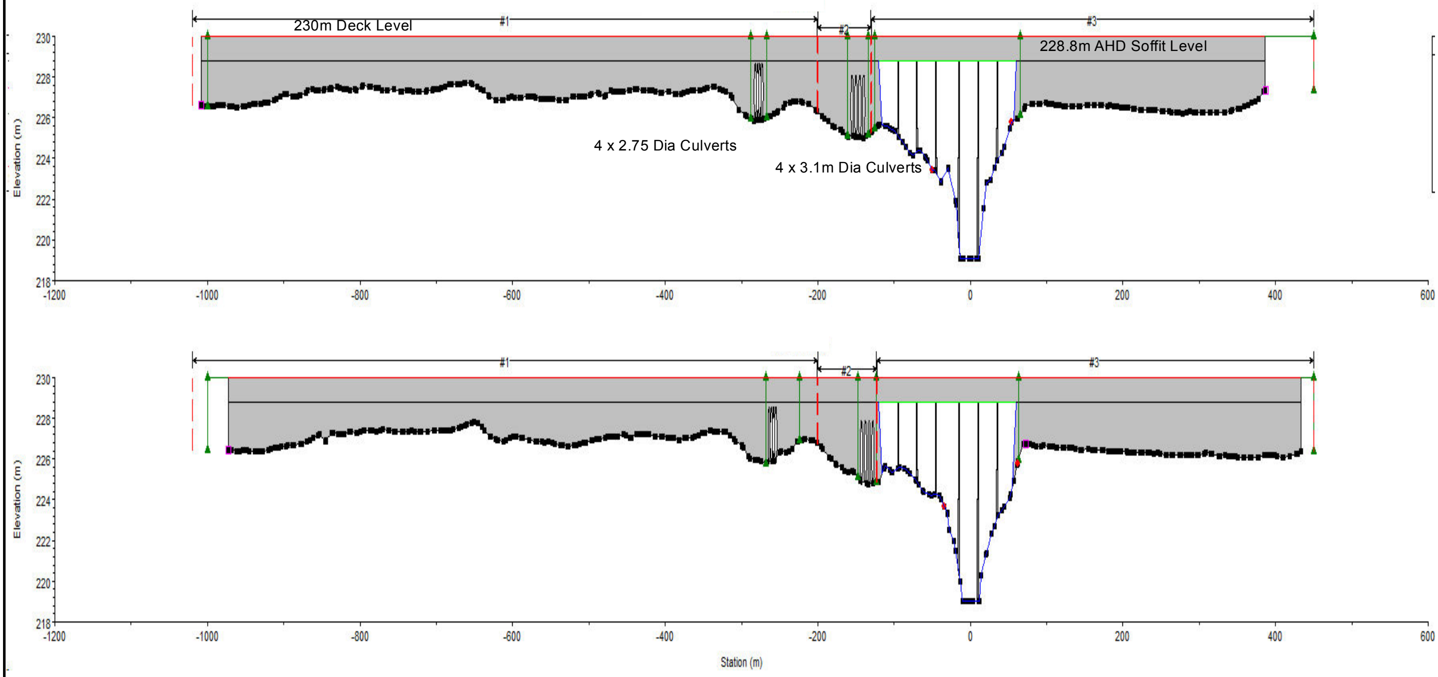
- A 180 m bridge comprising 7 x 25 m bridge spans located over the river channel
- Six cylindrical piers of 1 m diameter aligned in the direction of flow for each bridge support
- Bridge deck level of 230 m AHD
- The bridge soffit level of 228.8 m AHD (i.e. a 1.2 m deep bridge deck structure). At this stage the soffit level is 0.7 m above the 50 year ARI flood level to allow for debris passage
- Four culverts of 3.1 m diameter located approximately at a low point in the floodplain approximately 250 m from the centreline of the Carmichael River (refer to drawing SK009 in Appendix E);

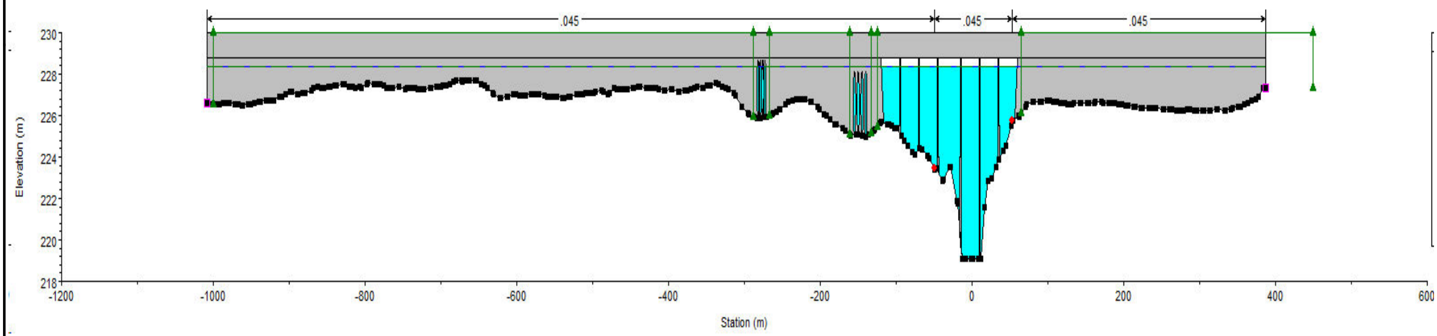
- Four culverts of 2.75 m diameter located at approximately 175 m from the centreline of the Carmichael River;
- Riprap placement at and just downstream of the bridge to minimise scour potential and protect the abutments and piers due to high velocities through the bridge;
- Haul road has a maximum longitudinal gradient of 10 per cent;
- The culverts are included to provide additional flow capacity, and therefore limit afflux, and to provide waterway capacity at naturally occurring floodplain channels in order to minimise impact to the ecology of the area. Circular pipe culverts have been used in the hydraulic model, but box culverts of equivalent cross-sectional area could be used instead; and
- 1D (HEC-RAS) analysis of the proposed design (refer Figure 6-3) shows that it meets the design immunity criteria, in scope to refine the design if required. The velocity design constraint is met and summarised here in Table 6-5; these results are taken from the post-development 2D model.

Table 6-5 Summary Hydraulic Analysis of Proposed Design (from 2D Results)

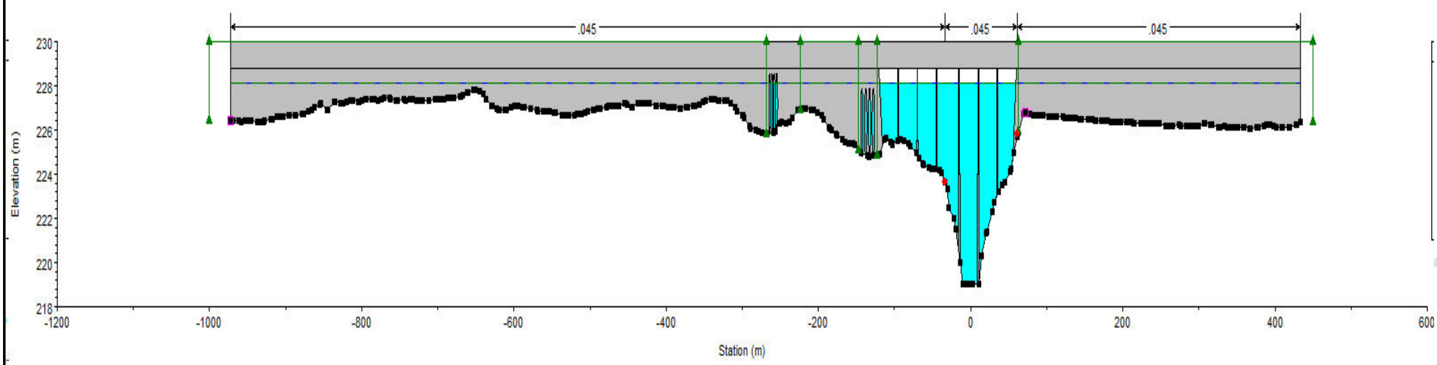
ARI (Yrs)	Q (m3/s)	U/S WL (m AHD)	Headwater Afflux (m)	Tailwater Afflux (m)	Velocity Through Bridge (m/s)
10	1230	227.20	0.13	0.03	2.39
50	2204	228.24	0.52	0.17	3.18
100	2684	228.66	0.72	0.24	3.57
1,000	5553	230.33	1.63	0.64	4.08

Proposed Bridge Design - 170m span, approximately 7 x 25m spans
40m wide Haul Road





Proposed Bridge In 50 Year ARI Flood Conditions
Q = 2204m3/s, U/S WSL = 228.24m, Headwater Afflux = 0.52m



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Carmichael Coal Mine and Rail Project

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1D Hydraulic Model Results of Proposed Haul Road & Conveyor Crossing

Figure 6-3

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Data source: GHD, Proposed Haul Road And Conveyor Crossing Conceptual Design (2012), Haul Road Crossing 1D HEC-RAS Results (2012).

7. Potential Impacts and Mitigation Measures – Construction Phase

7.1 Overview

Initial construction will progressively occur over a period of several years and provide for the following Project (Mine) infrastructure components:

- Mine infrastructure area;
- Water and waste management facilities;
- Mine airport;
- Workers accommodation village; and
- Upgrade of Moray Carmichael Road.

Key construction activities associated with this work include the use of construction vehicles and machinery, storage of materials, bulk earthworks and works within or next to existing watercourses.

7.2 Potential Impacts of Construction Activities

The potential effects of construction activities on surface water hydrology and hydraulics include:

- Temporary increased surface runoff as a result of vegetation clearance, topsoil removal and soil compaction on land adjacent to watercourses. This is not likely to be significant;
- Changed flow velocities, increased erosion and subsequent changes in bed and bank stability as a result of works within or adjacent to watercourses; and
- Change in local flood levels (higher in some regions, lower in others) as a result of watercourse diversions or temporarily restricted flows during construction. This would be a localised effect and not expected to impact outside of the construction area.

The watercourses located adjacent to the proposed construction works are ephemeral and relatively small in size. Effects of any change to surface water flows within these creeks are therefore likely to be confined to the local vicinity. Furthermore, given the relatively small area of catchments to be disturbed during construction, it is unlikely that any loss of catchment area will substantially change runoff flow volumes. Notwithstanding this, mitigation measures to avoid and minimise potential impacts on surface water flows are recommended in the following sections.

7.3 Management, Mitigation and Monitoring Activities – Construction Phase

The key mitigation measure in relation to construction impacts on surface water hydrology and hydraulics is to design all diversions and structures within flood plains to minimise impacts on hydrology.

Construction activities should be designed to minimise the disturbance in and immediately adjacent to watercourses. Temporary fencing off of areas should be implemented to help achieve this and stormwater management infrastructure such as temporary sediment screens and basins should be implemented before works near these areas commence.

Where practicable, preference should be given to completing works within watercourses or floodplains quickly and reinstating disturbed areas outside of the wet season (January – May inclusive) and whilst ephemeral creek beds are typically dry (i.e. June – December inclusive). In areas where works cannot be completed before the wet season, then work should be planned ahead so that it can be completed as quickly as possible and all disturbed areas within or adjacent to watercourses should be stabilised and robust controls installed to minimise the effects of erosion i.e. sediment weirs and sediment basins.

The design of sedimentation ponds will be in accordance with requirements for retaining water for a suitable time to enable settling of sediments before discharge. Water monitoring will be undertaken as described in Volume 4 Appendix Q Mine Water Quality Report.

In addition, an erosion and sediment control plan should be prepared to minimise the risk of erosion and loss of bed and bank stability. The plan should follow IECA's (2008) *Best Practice Erosion and Sediment Control* as recommended and described in Volume 4 Appendix Q Mine Water Quality Report.

Assuming the above mitigation measures are included as part of the Project proposal, no significant impacts are expected to occur on surface water flows during construction.

8. Potential Impacts and Mitigation Measures – Operational Phase

8.1 Overview

Potential operational impacts in relation to surface water hydrology and hydraulics include:

- Exacerbation of flooding due to the presence of structures in the flood plain or channel of rivers and creeks. This in turn may affect the extent and duration of inundation of upstream lands in flood events. Changes in flow characteristics may also occur which may result in localised or more extensive scouring of channels.
- Reduced or increased flows downstream of the mine due to diversions, inter-catchment transfer, water extraction and changes in surface runoff characteristics.
- Stream and surface water flows across mining and infrastructure areas may collect contaminants and convey these to downstream waters. While this results in impacts on water quality, this issue is also discussed in this report as the key mitigation involves hydraulic separation of clean and dirty water and capture of potentially contaminated water.
- Stream and overland flows may flow into open cut and underground mine working areas, resulting in excessive water inventory within the mine.

8.2 Mine Water Management

Mine Water Management is described in the Volume 4 Appendix P2 Preliminary Water Balance (PWB). The PWB provides estimates of expected water volumes on site in order to:

- Develop an understanding of possible water shortages or surpluses
- Estimate required water storage volumes
- Determine the requirement for controlled discharges of water from the Project site to the environment

General Mine Water Management principles have been established as part of the PWB, with the following principles proposed for the Project:

- Raw water will be delivered and temporarily stored in a raw water dam;
- MAW is to be retained on site and stored in facilities that are designed and managed in accordance with relevant guidelines. Controlled discharges will occur when the mine water inventory reaches a threshold to be determined and will be matched to high flow events in the receiving environment;
- All water entering or derived from an open cut pit or underground working areas is considered MAW;
- Runoff from disturbed catchments areas has to be treated to a sufficient level before being released into the natural environment through controlled discharges;
- Clean water runoff from undisturbed catchments areas is diverted around any mine workings or disturbed areas;

- Uncontrolled discharges are to be minimised and relate only to events larger than the design event for the DSA Discharges;
- Stored water available in sediment basins could potentially be used for dust suppression after sufficient settlement time;
- Controlled discharges are in accordance with Environmental Authorities;
- In case of acid mine drainage (AMD), water needs to be treated through neutralization. The nature of exact treatment will depend upon the water quality;
- Water running off from spoil areas and other disturbed areas will be captured in sediment basins designed to retain flows in up to the 20 year AEP event. More information on sedimentation basin sizing is provided in Volume 4 Appendix P2 Mine Preliminary Water Balance; and
- Mine workings are protected from local stormwater runoff and regional flooding from Carmichael River and other water ways up to the 1000 year ARI event.

8.3 Impacts on Environmental Flow Objectives

Additional water extractions for the Project (Mine) within the Burdekin Basin have the potential to impact on other users and will be required to meet all of the EFOs set out in the WRP.

To limit the impact, the extraction operating rules have been developed such that they will not impact on the flows (low) which are critical to EFO requirements. Using an iterative approach with the IQQM model a set of operating rules were developed, that provided the required volume of extraction needed by the Project and meet all EFOs, and had limited or no impact on downstream users.

Impacts (EFO benchmarks) on the environmental flows were checked using the environmental nodes specified in the WRP. Within Belyando River, node 347 within the IQQM ROP model described in Hyder[5] has been identified as the Environmental Flow Indicator. Modelling showed that all required WRP EFOs were met under conditions including extractions for the Project (Mine), therefore creating a minimal impact.

The Project site (in-stream extractions) sees a very low percentage of the overall flows, and is situated high up in the catchment where large breakouts and losses occur before reaching other users. The water harvesting is based on start to pump level of 430 ML/d reducing the impact on the initial wetting of the catchment, low flows, and small freshes (critical small events required for fish spawning below the selected pump trigger) which are seen as critical for protection of environmental values and EFOs.

It is proposed that the following operational requirements be put in place to further reduce impact on environmental values:

- As the in-stream storages form one end of a natural waterhole, complete emptying of the storages will not occur;
- During initial filling, low flow releases will be allowed from the storage to ensure low flow conditions are met downstream;

[5] Hyder, October 2012, Adani Carmichael Coal Mine Water Demands Report.

- The first small flood of the wet season in the main Belyando River should be left for fish spawning and flora regeneration (up to a specified peak flood volume e.g. 700 ML/d).

8.4 Flood Impact Modelling Results

8.4.1 Overview of Post-development Model Creation

In order to determine the impact of the Project (Mine), hydrologic and hydraulic modelling was undertaken for post-development conditions which includes proposed mine infrastructure. These models were based on the baseline condition models with adjustment for proposed mine plan infrastructure.

8.4.2 Creation of the Local Waterways Case Study Diversion Drain Hydraulic Model

In order to present a potential diversion drain design and resulting post-development conditions, a hydraulic model of the first and largest diversion drain was created as a case study (as described in Section 6.3.3). This forms an example case for the modelling and design of subsequent external diversion drains to be undertaken in further design stages. Model inflows were sourced from the post-development hydrologic model and the following changes were made relative to the existing conditions 1D hydraulic model:

- The model geometry was altered to represent the case study diversion drain as designed in Section 6.3 This will intercept a section of local flow originating outside of the Study Area that previously followed natural gullies across the mine internal area;
- Manning's n value was reduced to 0.025 for an excavated clay channel lined with gravel; and
- Cross-section locations for the 1D diversion drain model were established approximately every 100 m.

8.4.3 Modification of the Carmichael River Corridor Hydraulic Model

In order to represent post-development conditions as shown (Figure 5-5) the following changes were made to the existing conditions 2D hydraulic model:

- The terrain was raised to represent the proposed levees adjacent to the Carmichael River, in accordance with the preliminary levee design (refer Section 6.2);
- Terrain modification and a layered 2D flow bridge structure were incorporated to represented the proposed haul road and conveyor crossing of the Carmichael River, in accordance with the preliminary design (refer Section 6.4); and
- Model inflows were sourced from the post-development hydrologic model (i.e. with the external diversion drains in place).

8.4.4 Change in Hydrology

Modelling of the mine site hydrology under post-development conditions predicted changes to the flow in the Carmichael River due to the levee removing previous areas of local runoff contribution. These changes are summarised in Table 8-1.

Table 8-1 Peak Flows in the Carmichael River at the Location of the Proposed Haul Road & Conveyor Crossing – Post-Development Conditions

ARI	Critical Duration	Peak Flow (m3/s)	Change Compared to Existing (%)
10 year	30 hr	1190.8	0.3
50 year	18 hr	2157.2	0.7
100 year	18 hr	2622.9	0.7
1000 year	30 hr	4965.0	1.7

Results indicate that the contribution of the diversion drains only creates a minor increase in peak flow at the haul road crossing. This is because the time of the peak flow from the relatively small diverted catchment does not coincide with the corresponding peak flow of the larger Carmichael River. Therefore, the addition of the diversion hydrograph does not change the duration of storm event producing the Carmichael River peak flow.

The reduction in catchment area due to the open cut pits and the diversion of flows in the proposed drains as described in Section 6.3 cause changes in the hydrology of the mine site. The proposed drainage scheme takes into account an intention to retain flows to the east of the MLA as close to existing hydrology as possible. While this is achieved for the most part, hydrologic modelling of the MLA showed that flows at given locations in the catchment are increased or reduced due to the impacts of development, as summarised in Table 8-2.

Table 8-2 Existing and developed conditions peak flows in local waterways

Ext Flow Node	Dev Flow Node	10 year ARI (m3/s)		50 year ARI (m3/s)		100 year ARI (m3/s)		1000 year ARI (m3/s)		Average change (%)
		Exst	Dev	Exst	Dev	Exst	Dev	Exst	Dev	
10-LC1	40	60	87	99	159	106	192	251	462	68
5-LC1	node 6	242	259	386	466	419	563	905	1373	28
7-LC1	node 5	217	148	348	265	380	320	831	808	-19
25-LC2	26	100	86	173	152	192	188	446	486	-5
78-LC14 / 79-LC14	44	43	63	71	113	87	136	162	347	69
12-LC8	14	128	131	223	234	252	284	532	696	13
50-LC11	68a	30	147	56	259	65	314	147	758	388
127-LC12	15	21	10	35	18	44	22	85	59	-45
121-LC12 (2-LC8)	0	146	0	253	0	305	0	493	0	-100

8.4.5 Impacts on Flooding of the Carmichael River within the Mine Lease Area

Flood inundation maps indicating the depth of flooding and the predicted change in flood level (afflux) for the 10, 50, 100 and 1,000 year ARI design events under post-development site conditions are provided in Figure 8-1 to Figure 8-4. With the establishment of the Mine site and accompanying flood mitigation infrastructure, the Carmichael River is now confined to the corridor between the flood levees with no runoff being received from the area internal to the Study Area. The contraction of the floodplain causes an insignificant increase in flood extent upstream of the MLA for any of the simulated flood events. This outcome reflects the relative distance of the contraction from the western MLA boundary.

The proposed levees successfully prevent flooding of either the underground mining area or the open cut pit areas. The Carmichael River (haul road) bridge is immune to the 10 year or 50 year ARI events, but is overtopped by the 100 year and 1,000 year events. As discussed elsewhere the velocity through the bridge is high, leading to a potentially substantial risk of scour in floods larger than the 50 year ARI event.

Figure 8-5 presents the afflux values for the ARI events considered as part of the Project (Mine) modelling and are as summarised below in Table 8-3 and following paragraphs.

Table 8-3 Projected Afflux From Proposed Development at Selected Locations

Mapped Location	Description	Afflux (mm)			
		10 year ARI	50 year ARI	100 year ARI	1,000 year ARI
4	Upstream of Haul Road Crossing	0.13	0.52	0.72	1.63
5	Downstream of Haul Road Crossing	0.03	0.17	0.24	0.64
8	Western Study Area Boundary	0.02	0.02	0.03	0.20
3	Eastern Study Area Boundary	0.01	0.13	0.19	0.51
1	Carmichael River Model Inflow Boundary	0.00	0.00	0.00	0.01
2	2 km Downstream of Carmichael River Model Inflow	0.00	0.00	0.01	0.04
7	2 km Upstream of Carmichael River Model Tailwater	0.00	0.00	0.01	0.07
6	Upstream Cabbage Tree Creek	0.04	0.19	0.25	0.63
9	Downstream Cabbage Tree Creek	0.01	0.07	0.09	0.15

8.4.5.1 10 Year ARI

The 10 year ARI flood does not reach along the length of the levee and causes only marginal increases in flood levels immediately upstream of the haul road. Afflux is negligible at the western

boundary of the MLA, and nil at the eastern boundary. Through the corridor bounded by the levees, there are no significant increases in flood levels.

8.4.5.2 50 Year ARI

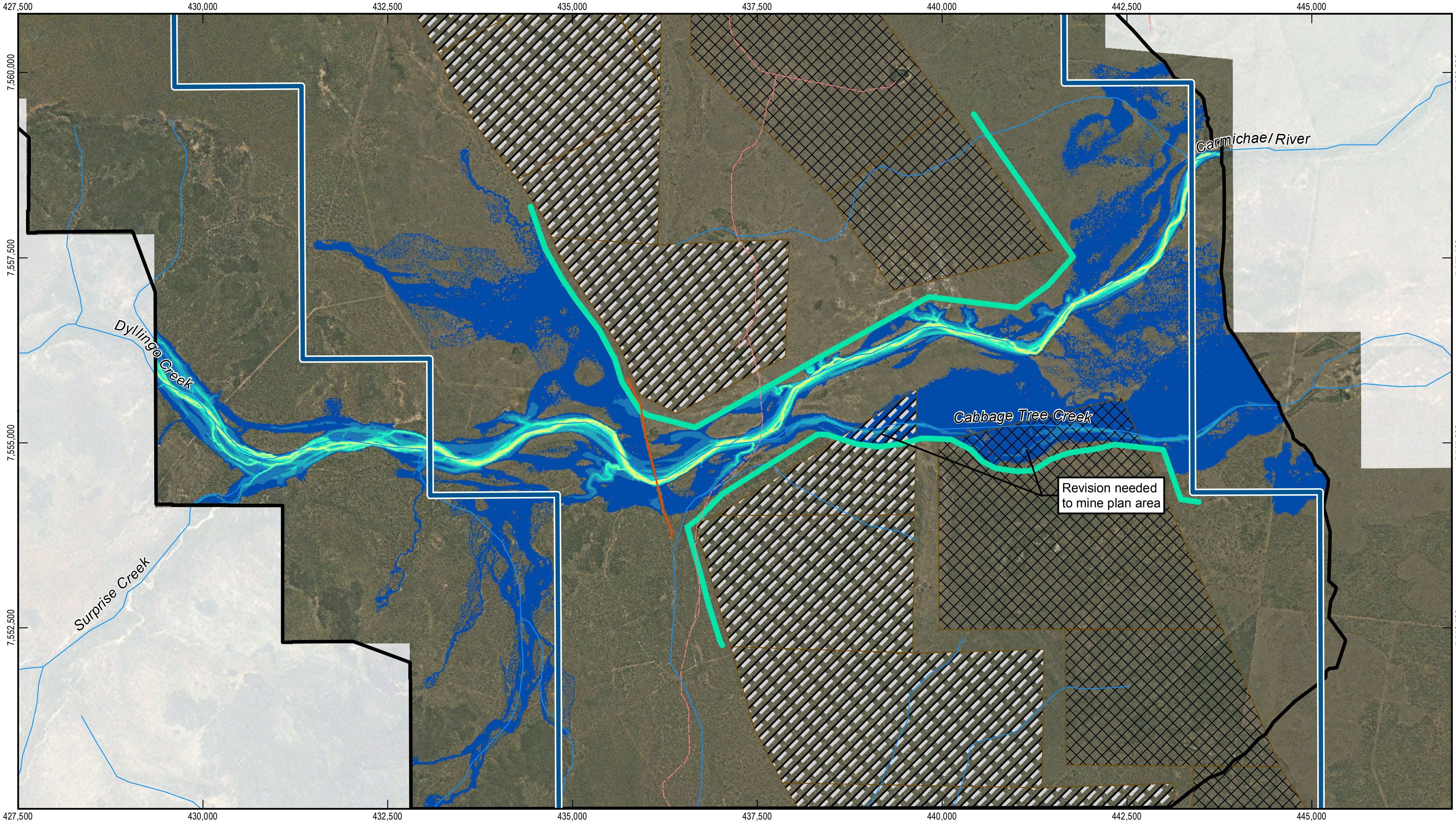
While increases of more than 0.5 m in flood levels are predicted immediately upstream of the haul road the impacts at the western MLA boundary are expected to be negligible. Through the levee corridor, moderate increases in flood level of 0.1 – 0.2 m are expected, dropping away to nil at the eastern boundary in the Carmichael River. Flood levels in Cabbage Tree Creek at the eastern MLA boundary are increased by approximately 0.07 m because the levee redirects some water that would have otherwise left the creek as overland flow to the south.

8.4.5.3 100 Year ARI

As expected, the impacts predicted for the 50-year ARI event are marginally worsened in the 100-year ARI event. The haul road causes localised afflux of more than 0.7 m. A minor 0.03 m increase in flood level is predicted at the western MLA boundary, which drops to nil 2 kilometres further upstream. Increases in the range of 0.2 – 0.3 m are indicated through the levee corridor. Moving further downstream, there is no significant increase in flood level in the Carmichael River at the eastern MLA boundary, although Cabbage Tree Creek levels are increased by approximately 0.1 m.

8.4.5.4 1,000 Year ARI

More significant impacts are indicated for the 1000-year ARI event as the haul road is overtopped. Afflux of 1.5 – 2.0 m is expected at this location, decreasing to 0.2 m at the western MLA boundary, and then to 0.03 m by 2 km upstream of the boundary. A negligible 0.01 m increase is predicted at the upstream model boundary, which is approximately 4 km upstream of the MLA. Through the levee corridor, flood levels are increased by 0.5 to 0.7 m on average. At the eastern MLA boundary, Carmichael River and Cabbage Tree creek levels are increased by 0.07 and 0.2 m respectively.



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Watercourse
- Track
- Minor Road
- Proposed Carmichael River Levees
- 2D Model Extent
- Mine (Onsite)
- Waste Rock Dump Area
- Open Cut Mining Area

Depth (m)

- 0.08 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- 6.0 - 7.0
- 7.0 - 8.0
- 8.0 - 9.0
- 9.0 - 10.0
- 10.0 - 11.0

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Carmichael Coal Mine and Rail Project

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10 Year ARI Flood Event (Post Development)

Figure 8-1

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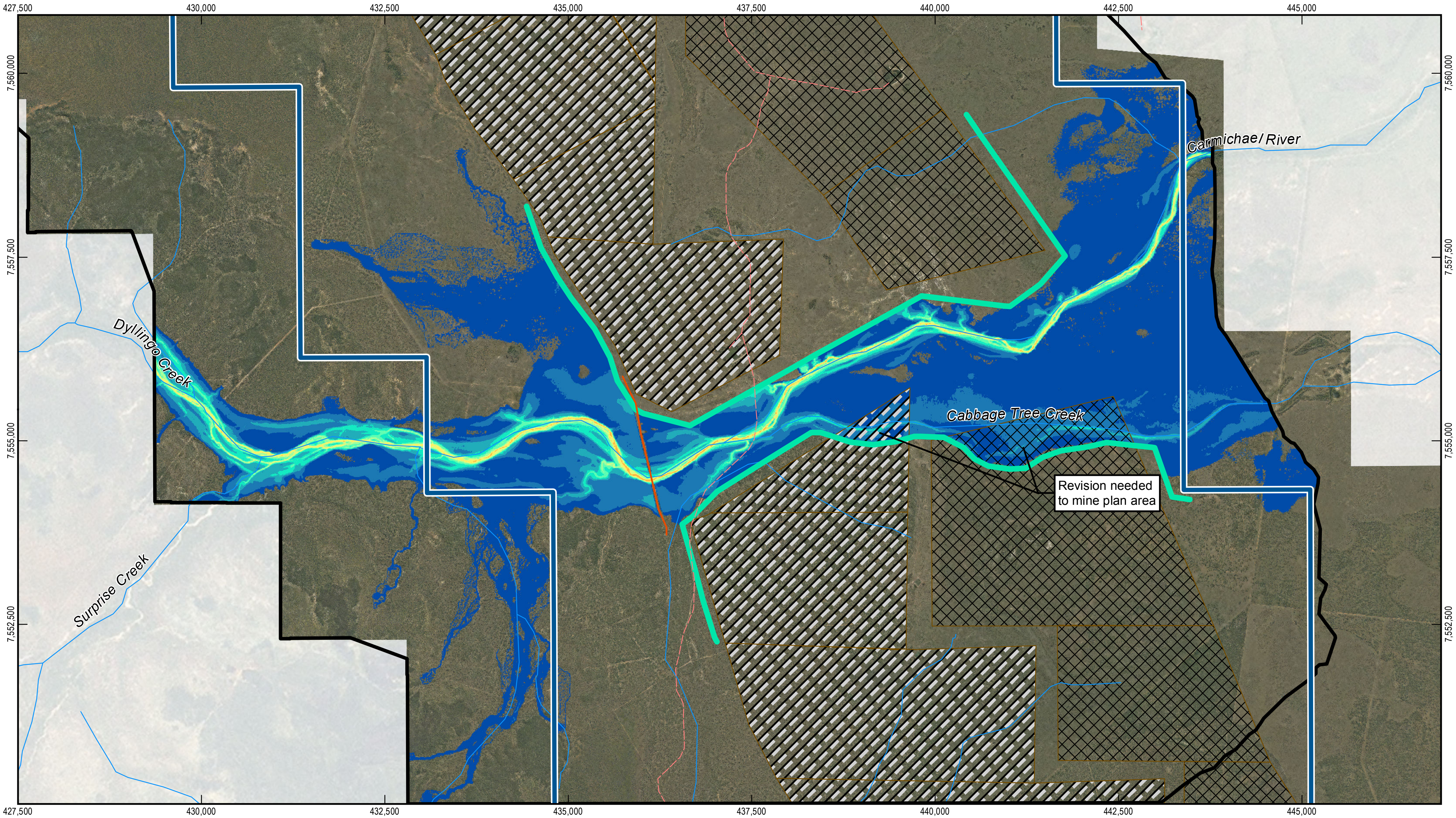
Data source: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Tracks, Roads, Watercourse (2007); Adani Pty Ltd: Waste Dump Areas, Open Cut Areas (2012)
GHD: Flood Modelling, Levees (2012); Created by: BW, CA



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

Watercourse	2D Model Extent	Depth (m)
Track	Mine (Onsite)	
Minor Road	Waste Rock Dump Area	
Proposed Carmichael River Levees	Open Cut Mining Area	

Depth (m): 0.08 - 1.0; 1.0 - 2.0; 2.0 - 3.0; 3.0 - 4.0; 4.0 - 5.0; 5.0 - 6.0; 6.0 - 7.0; 7.0 - 8.0; 8.0 - 9.0; 9.0 - 10.0; 10.0 - 11.0

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

50 Year ARI Flood Event
(Post Development)

Job Number 41-25215
Revision B
Date 04-09-2012

Figure 8-2

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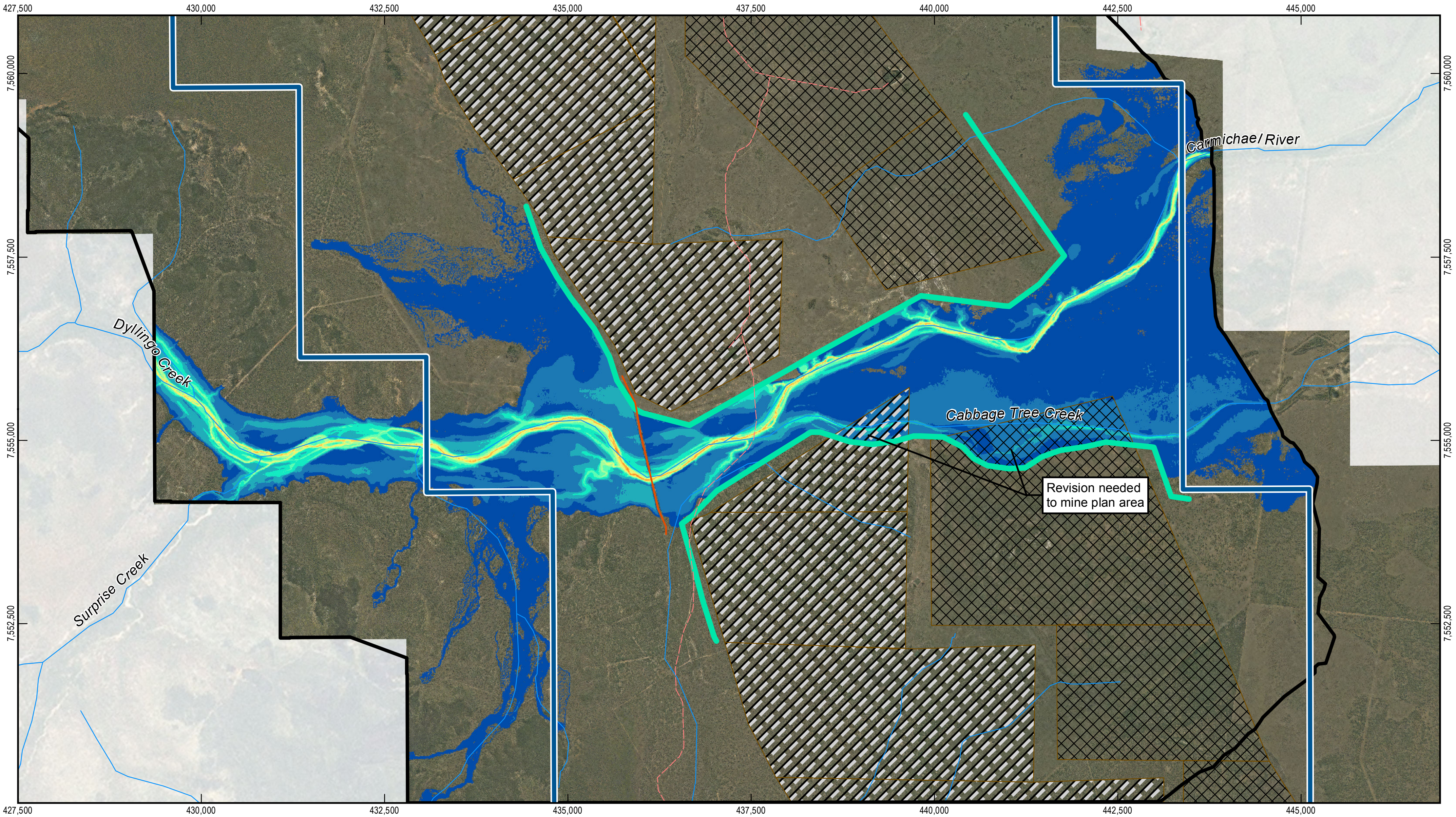
Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Tracks, Roads, Watercourse (2007); Adani Pty Ltd: Waste Dump Areas, Open Cut Areas (2012)
GHD: Flood Modelling, Levees (2012); Created by: BW, CA



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Watercourse
- Track
- Minor Road
- Proposed Carmichael River Levees
- 2D Model Extent
- Mine (Onsite)
- Waste Rock Dump Area
- Open Cut Mining Area

Depth (m)

0.08 - 1.0	3.0 - 4.0	7.0 - 8.0
1.0 - 2.0	4.0 - 5.0	8.0 - 9.0
2.0 - 3.0	5.0 - 6.0	9.0 - 10.0
	6.0 - 7.0	10.0 - 11.0

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision B
Date 04-09-2012

100 Year ARI Flood Event
(Post Development)

Figure 8-3

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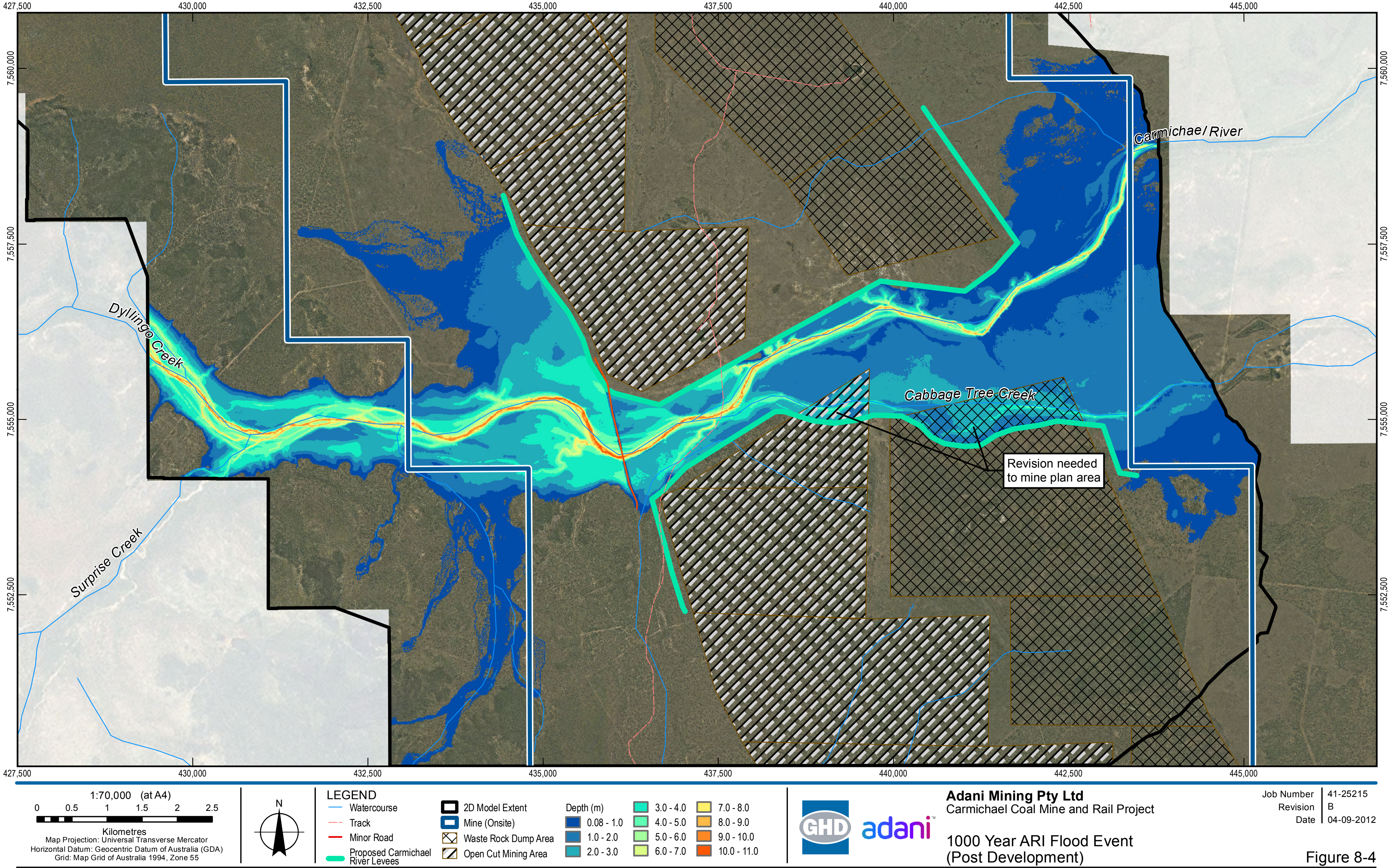
Data source: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Tracks, Roads, Watercourse (2007); Adani Pty Ltd: Waste Dump Areas, Open Cut Areas (2012)
GHD: Flood Modelling, Levees (2012); Created by: BW, CA



Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

1000 Year ARI Flood Event
(Post Development)

Job Number	41-25215
Revision	B
Date	04-09-2012

Figure 8-4

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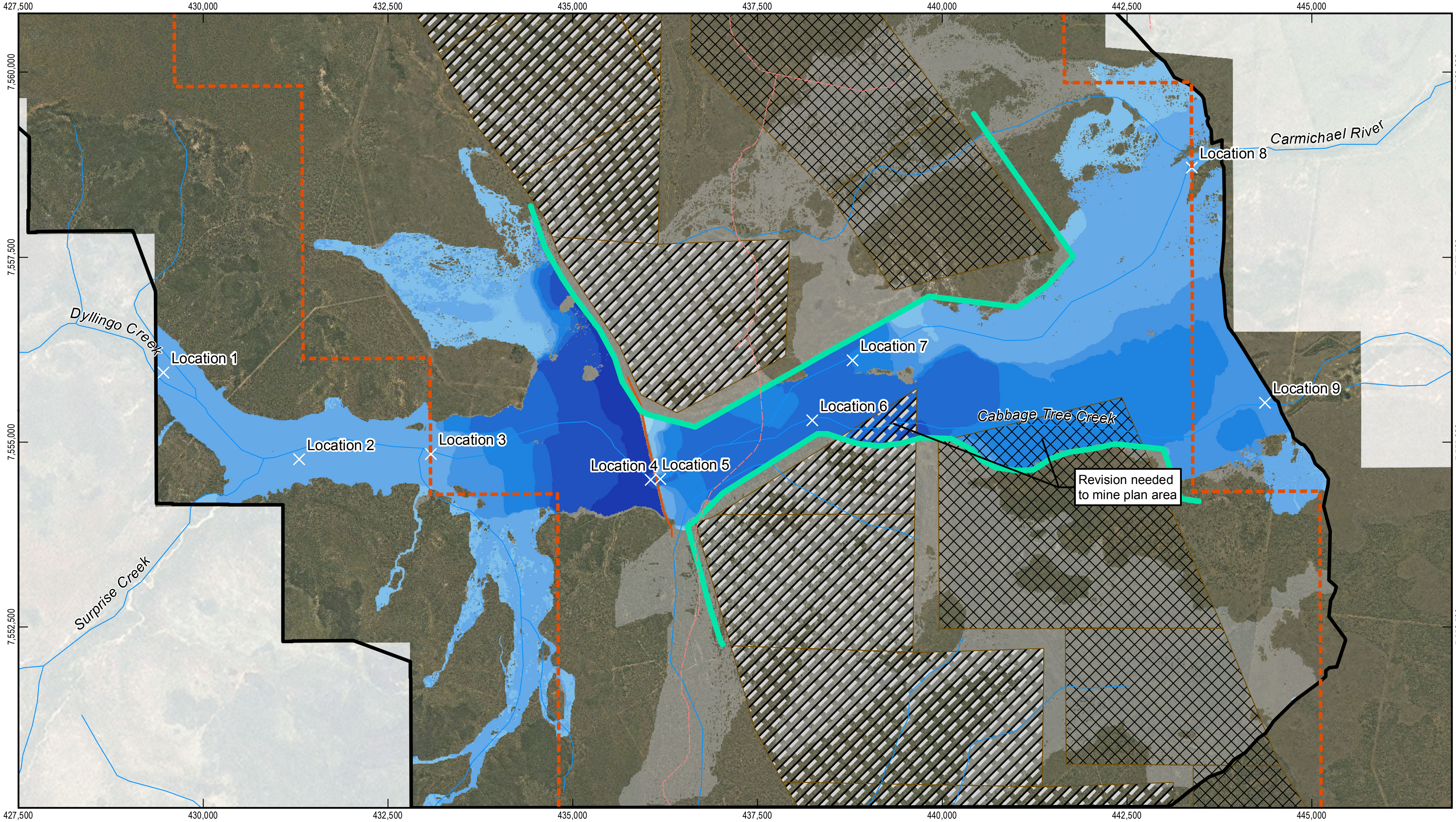
Data source: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Tracks, Roads, Watercourse (2007); Adani Pty Ltd: Waste Dump Areas, Open Cut Areas (2012)
GHD: Flood Modelling, Levees (2012); Created by: BW, CA



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Watercourse
- Track
- Minor Road
- Proposed Carmichael River Levees
- 2D Model Extent
- Mine Lease Area
- Waste Rock Dump Area
- Open Cut Mining Area
- Flood Extent Change

Afflux (m)

- -37.3 - -0.4
- -0.4 - -0.2
- -0.2 - 0.0
- 0.0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4
- 0.4 - 0.8
- 0.8 - 1.6
- 1.6 - 3.2
- 3.2 - 6.2

Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Job Number | 41-25215
Revision | A
Date | 04-09-2012

Afflux with Points of Interest
100 Year ARI Event

Figure 8-5

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Data source: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Roads, Watercourse (2007); Adani Pty Ltd: Waste Dump Area, Open Cut Area (2012)
GHD: Modelling, Levees (2012); Created by: BW, CA

8.5 Potential Impacts of Operational Activities

8.5.1 Impacts on Surrounding Land Users

The available licence information does not include references to daily, monthly or annual volumetric allowances or maximum diversion (or extraction) rates, making it difficult to make more than generalised assessments of the adverse effects of the disruption of the natural catchments by the Project (Mine) and the discharge of mine process water and runoff on local water users who include the local cattle stations, namely Bygana and Moray Downs. The drainage diversion strategy ensures minimum change in the direction of water runoff so sub-catchments experience minimum reduction in flow. In this way it is not expected that surrounding users will be significantly impacted by changes to in-stream flows. Surrounding users are also far enough away from the Project (Mine) site to not experience significant change from the reduction in runoff area.

The impact of proposed water extractions for the Project (Mine) from the Belyando River system was assessed by Hyder[6]. This is in line with the requirement of the WRP to limit impacts to existing users on a system. Table 8-4 lists the downstream users with the potential to be impacted.

Table 8-4 - Summary of Impacts of Water Extractions on Downstream users

Node	Licence Type	ROP IQQM Case (GL/year)		
		Mean Annual Demand (ML/yr)	Monthly Reliability	Annual Reliability
233	Stock And Domestic	15.4	99.9	99.1
246	Stock And Domestic	30.2	100	100
279	Stock And Domestic	5.7	100	100
232	Water Harvester	828	N/A	N/a
291	Water Harvester	550	N/A	N/a
292	Water Harvester	4803	N/A	N/A
293	Water Harvester	2675	N/A	N/A
300	Water Harvester	3454	N/A	N/A
302	Water Harvester	1113	N/A	N/A

[6] Hyder, October 2012, Adani Carmichael Coal Mine Water Demands Report.

Modelling shows that a limited to no impact will occur to nearby users occurs due to the Project extractions. Nodes 233 through to 292 in the IQQM model are relatively close to the extraction with minimal impact. Some positive impacts are shown further downstream due to the reduction in the reserve. This minimal impact can also be attributed to the small percentage of flows seen by the Project when compared to the total flow in the Belyando system.

Based on the results of the hydraulic modelling carried out as part of the Project (Mine), the increase in flows at the Carmichael River levee is less than 1 per cent of peak flows for 10, 50 and 100 year ARI events. The change in the 1,000 year ARI event is predicted to be a 1.4 per cent flow increase. The increase in flow is greatest through the levees due to the flow constriction, reduction in floodplain size and addition of diverted water from surrounding watercourses through the Project (Mine) site. Based on the limited change predicted for this location, it can be assumed that any change in peak flows downstream of the Project (Mine) will be less than these values and therefore insignificant in terms of impacts on any existing land uses.

The proposed diversion drains maintain the connectivity of most of the existing watercourses traversing the mine site from west to east. Whilst most of the redirected water will return to flows within the Carmichael River and other watercourses to the east of the site, the interception of surface water within the mine workings and for water management will result in some losses in flows. This in turn could potentially result in slight reduction in flows available to land users and aquatic ecosystems downstream of the Project (Mine).

The impact of runoff interception is apparent at the eastern boundary of the Project (Mine) as creeks flow through the site from west to east. It is therefore here that the relative reduction in flows would be higher.

As the Study Area is relatively remote and undeveloped there are a limited number of roads or other infrastructure routes nearby which could be impacted by afflux. No significant change in existing flood extent or duration is predicted at any existing infrastructure corridors including the Moray-Carmichael Road or Shuttleworth Carmichael Road. The extent of afflux is local to the vicinity of the levees and unlikely to affect existing land use activities within the Study Area, including cattle grazing or homesteads.

8.5.2 Impacts on Downstream Flows in Minor Streams

Potential change in environmental flows as result of the Project (Mine) has not been modelled within the context of naturally occurring seasonal and annual variations. Rather, only peak flows have been assessed for the purposes of the preliminary Project (Mine) design. Although it is unlikely that flows will change significantly downstream of the Project (Mine) within the context of environmental flows, further studies are recommended to be carried out as part of the Project to confirm the magnitude and extent of any potential changes.

8.5.3 Effects of Climate Change on Flooding

The preliminary Carmichael River levees were designed to prevent flooding from the Carmichael River into the active mining area. Current climate change estimates over the life of the mine, would see rainfall likely to increase or decrease in the order of 20 per cent by the end of the design life of the Carmichael Mine according to the Queensland Government Scientific Advisory Group (SAG) guidelines (DERM 2010).

For flood estimation purposes this is interpreted as a 20 per cent increase in rainfall intensity. By inputting these increased intensities to the hydrologic model it is possible to estimate potential peak flow rates under climate change conditions. The 20 per cent increase in rainfall intensity produces an average of 35 per cent increase in runoff for the 1,000 year ARI event.

Hydraulic modelling of the proposed levees under climate change-affected hydrology for the 1,000 year ARI event showed that the southern levee will overtop upstream of the haul road and conveyor crossing but not downstream, thereby keeping the open cut pit areas dry. On the northern side, overtopping occurs along the first two-thirds (from the east) of the levee alignment. Overtopping ceases downstream of the natural hill in the topography at approximately eight kilometres chainage.

While the above estimated flows shown an average increase of 35 per cent by the end of the mine lifespan due to climate change impacts, it is an estimate only. Other climate change scenarios are possible which may differ from those presented in this report. The risk of climate change over the period of the mine infrastructure and operations should be considered during future mine planning and design and provision should be made to raise levees if necessary. Potential increases in peak flow rates and the resultant impact they may have on the operation of the flood protection infrastructure present a particular risk.

8.6 Management, Mitigation and Monitoring Activities – Operational Phase

8.6.1 Recommendations for Future Design Refinement

8.6.1.1 Levees

- Consider adjustment to the boundary of the planned open cut pit and out-of-pit waste rock dump areas near the Carmichael River corridor to accommodate the recommended levee alignment and retain effluent flows to Cabbage Tree Creek. Figure 8-1 and Figure 8-2 should be used as a reference;
- Review climate change impacts and adjust design accordingly; and
- Review side slope stability: The adopted one vertical to five horizontal side slopes on the proposed levees will require design refinement based upon knowledge of the geological data and the available construction material when it is available.

8.6.1.2 Diversion Drains

It is suggested the following areas require attention in the next stage of the design of the drains.

- *Importance of drainage issues to mine safety* - The reliance on constructed drainage measures to manage surface water and local flooding within the mine site will necessitate careful consideration of drainage design, construction, monitoring and maintenance issues throughout the life of the mine;
- *Interfaces with other infrastructure* – Further design of the diversion drains and other infrastructure needs to consider how these elements interface;
- *Design of inlets into the diversion drains* – The management of drainage, scour and erosion at the inlets to the diversion drains requires on-going attention as the mine design progresses;

- *Design of waterway crossings and culverts* – The design of all waterway crossings and culverts will require on-going revision as the mine design progresses;
- *Calculation of appropriate channel side slope* – As yet no geotechnical data has been provided for the region underlying the proposed diversion drains. The assumed channel side slopes of 1 vertical to 5 horizontal are for conceptual modelling purposes only and a geotechnical analysis of a stable slope angle both with respect to slumping and scour protection placement capability is required to confirm appropriate channel cross sections;
- *Benching of Large Cuts*- The proposed design is based on an assumed channel side slope of 1 vertical to 5 horizontal with no benches. Where deeper cuts are required for diversion drains, benching may be required. The need for benching would be determined on the basis of analysis of geotechnical data and horizontal and vertical profile requirements;
- *Potential Erosion at Outlet Gully* – Detailed consideration of the flow velocities at the outlets into the existing natural minor waterway is required, including the need for any erosion protection measures;
- *Lining of the Drain* – At this stage the nature of the lining of the drain has not been considered. This aspect will require further attention in the next stage of the design;
- *Energy Dissipation Structures* – Based on the case study diversion drain, energy dissipation is likely to be required on a number of diversion drains in order to reduce the 50 year ARI in-channel velocity to the acceptable maximum of 2.5 m/s. Methods of energy dissipation in these areas could include rip-rap lining or rock chutes;
- Design in Accordance with *Watercourse Diversions Guidelines – Central Queensland Mining Industry (DERM, 2011)* – these guidelines include further design criteria which include:
  - Incorporation of features that mimic the natural stream characteristics to create ‘dynamic equilibrium’
  - Providing a corridor of suitable width to accommodate potential channel meanders
  - Consideration of channel vegetation implementation to stabilise channel banks, terraces and floodplain drainage paths
  - Consideration of the need for fish movement within the channel, or a fish movement exemption notice application; and
- Consideration of final landform and rehabilitation and closure requirements.

8.6.1.3 Haul Road and Conveyor Crossing

Modelling indicates that there is a substantial head drop across the haul road and conveyor crossing structure which may cause scour of the haul road bank, particularly in combination with the relatively high velocities through the structure. Detailed design of the bridge needs to recognise that these can be overtopped in the floods marginally bigger than the 100 year ARI flood.

Further consideration should also be given to the waterway openings presented in the design, and to whether there are benefits in increasing the size of these openings to reduce the risk of scour damage in a flood.

8.6.1.4 Sediment Basins

Further modelling is required during detailed design to determine the sizing requirements for sediment basins based on catchment inflows and required retention times to achieve suspended sediment reduction objectives. Design criteria in relation to the frequency of overflow of these dams should also be refined based on downstream water quality objectives and likely contaminants and contaminant levels arising from catchment flows.

A hazard assessment is required for sediment basins that treat water throughout the operational period of the mine and into the initial periods of rehabilitation. This should be performed in accordance with the *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams* (DERM, 2012).

8.6.2 Mitigation During Construction of Diversions

The following measures should be included in the environmental management plan in relation to construction of the diversion drains and levees:

- Construction works should be undertaken in low flow periods and preferably in the dry season wherever possible.
- Weather conditions should be monitored and if significant rain events are forecast, any in-stream works should cease and disturbed streams stabilised.
- Requirements of the guideline *activities in a watercourse, lake or spring associated with a resource activity or mining operations* (WAM/2008/3435) should be adhered to, or if these cannot be met, conditions of a riverine protection permit should be complied with.

An operational erosion and sediment control plan should be prepared to minimise the risk of erosion and bed and bank stability. The plan should follow the IECA's (2008*)* erosion and sediment control guideline.

8.6.3 Mine Water Containment

It is important to develop a better understanding of mine affected water volumes during the mine life. This necessitates a better understanding of groundwater inflows is required as are details about the intermediate mine years in between the current mine stages that are included in the PWB. The following recommendations are made.

- The PWB should be updated with more accurate estimates of the volume of groundwater inflows in the open cut pits and underground working areas;
- Improve the groundwater model using information from additional field data to gain a better understanding of seepage losses from MAW storage;
- An external water supply of sufficient reliability needs to be established for the mine operations, to ensure operations during a dry period;
- Due to the planned long period of mine operations potential impacts of climate change on the mine operations should be assessed;
- When groundwater quality data and geotechnical data becomes available it should be used to develop an understanding of expected water quality in the MAW storages over time and how this may affect discharge to the environment;

- As part of the future design stages a comprehensive water management plan will need to be developed in accordance with DEHP guidelines;
- For a more rigorous definition of risk than the percentiles provided, the frequency of excess mine water should be fitted to an appropriate statistical distribution and values expressed in terms of an annual exceedance probability;
- The PWB does not address the impacts of the mine operations starting at the beginning of a dry or wet period. It also does not address the consequences of a dry period on the flows in the Belyando and therefore on the external water supply. The potentially significant risks of this kind should be addressed in future water balance analyses; and
- A detailed water balance, incorporating a stochastic rainfall model, should be developed to create a robust assessment of available water volumes over time and possible effects of variations in rainfall on these volumes. As this model will depend on the level of detail of the mine plan it is recommended to set up the model for the first 10 years of the mine operations for which the best level of mine plan detail will be available. This model will allow for a more robust understanding of the water management regarding aspects like: staged construction of the MAW storages, required pump capacities and locations over time, lengths of pipelines etc.

MAW in storages can be better calculated having gained a better understanding of the affected water volumes. In order to minimise the size of the infrastructure required to house this water there are various options to minimise the build-up of MAW volume . These options include the following.

- Maximising evaporation by either extending the storage areas, or spread water over as many storages as possible
- Increasing volumes used for dust suppression by either increasing the area or by increasing the volume used per ha
- Discharges into the Carmichael River or other local waterways whenever water quality (of MAW) and volumes in the receiving waterways allow for discharges
- An alternate solution may be to build a pipeline to the Belyando River for discharge purposes as the Belyando is expected to allow for larger discharge volumes. This type of excess MAW management is being considered by other miners, however the acceptability to regulating authorities is largely untested at this stage

8.6.4 Monitoring

A comprehensive monitoring program will be developed as part of the site water management plan. The site water management plan will include the following monitoring measures as outlined in Volume 2 Section 13 Environmental Management Plan for the Mine:

- Surface flows will be monitored on an ongoing basis prior to construction, during operation and post operation upstream, downstream and within the Study Area to measure changes;
- All regulated water management infrastructures (dams, levees, diversion dams) will be annually inspected at a minimum by a suitably qualified and experienced person. A report will be produced with any recommendations required to ensure the structural integrity, as recommended in the DEHP (2012) guidelines *Structures which are dams or levees constructed as part of environmentally relevant activities (EM634);*

- Dam capacity must be reviewed on 1 November annually to ensure that sufficient capacity exists to meet the design storage allowance as determined by the *Manual for assessing hazard categories and hydraulic performance of dams (EM635); and*
- Diversion drains, floodplains and discharge points to downstream waterways will be inspected regularly during the wet season and after any flow event to identify any scouring, instability or erosion. Corrective action will be taken promptly.

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9. References

EA 1998 Australian Rainfall and Runoff: A Guide to Flood Estimation (AR&R), Institution of Engineers, Australia

BDTNRMP 2005 Burdekin Dry Tropics Natural Resources Management Plan (2005-2010), May 2005

BOM 2003 *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method*, Hydrometerological Advisory Service

BOM 2005 *The Estimation of Probable Maximum Precipitation in Australia: Generalised Tropical Storm – Revised Method*, Hydrometerological Advisory Service

BOM 2011 Intensity frequency duration data http://www.bom.gov.au/hydro/has/cdirswebx/cdirswebx.shtml

Burrows, D. W. 1999 *An Environmental Assessment of Water Infrastructure Options in the Burdekin Catchment Report 99/29 to Department of Natural Resources.* Regional Infrastructure Development Programme, North Region Australian Centre for Tropical Freshwater Research. James Cook University.

Catchment Simulation Solutions 2009 *CatchmentSIM Version 2 User Manual*

CRC-FORGE 2000 Software from the Cooperative Research Centre for Catchment Hydrology http://www.catchment.crc.org.au/support_programs/index.html

DERM 2007 *Queensland Urban Drainage Manual, Volume 1, Second Edition*

DERM 2010 *Increasing Queensland's resilience to inland flooding in a changing climate: Final report on the Inland Flooding Study*

DERM 2011 *Watercourse Diversions – Central Queensland Mining Industry version 5.0*

GHD 2011 *Report for Carmichael Coal Mine and Rail Project – Mine Surface Water Quality*

GHD 2012a *Carmichael Coal Mine Project – Report for Preliminary Flood Infrastructure and Diversion Drain Design*

GHD 2012b *Carmichael Coal Project – Mine Site, Mine Hydrogeology Report*

GHD 2012c *Carmichael Coal Mine – Preliminary Water Balance EPC 1690 & EPC 1080*

Golder Associates 2011 *Carmichael Coal Mine Project: Preliminary Railway Hydrological Investigation*

Grayson 1963 *Hydrological Recipes: Estimation Techniques in Australian Hydrology,* Cooperative Research Centre for Catchment Hydrology

McKenzie, N. and Hook, J. 1992 *Interpretation of the Atlas of Australian Soils*. CSIRO Technical Report 94/1992

McKenzie, N. Jacquier, D. Isbell R. Brown, K. 2004 *Australian Soils and Landscapes – an illustrated compendium*. CSIRO ISBN 0 643 06958 5

Runge 2011 Carmichael Macro-Conceptual Mining Study. Report No .ADV-BR-10370a / May, 2011. Runge Limited

SCT 2011 *Preliminary Estimates of Subsidence associated with Longwall Extraction of AB and D Seams at the Carmichael Project*, Memorandum, 30 November

Strahler, A. N. 1976 *Elements of Physical Geography*. John Wiley, New York.

Sturman, A and Tapper, N. 2006 *The Weather and Climate of Australia and New Zealand*. 2 Edition. Oxford University Press.

Watkins A 2011 *Chalk, cheese, cats and dogs - what can we say about La Niña in 2011*?

http://reg.bom.gov.au/social/2011/09/chalk-cheese-cats-and-dogs/

Appendix A

Terms of Reference Cross Reference

Terms of Reference Requirement/Section Number	Section of this Report
3.4. Water Resources	
3.4.1 Description of Environmental Values	
Describe the existing water resources that may be affected by the project in the context of environmental values as defined in such documents as the EP Act, Environmental Protection (Water) Policy 2009 (EPP (Water)), Australia and New Zealand Guidelines for Fresh and Marine Water Quality and the Queensland Water Quality Guidelines.	Section 4
Describe present and potential users and uses of water in areas potentially affected by the project, including municipal, agricultural, industrial and recreational uses of water, and reference to any licences held by users.	Section 4.4.2
Describe the environmental values of the surface waterways of the affected area in terms of existing and other potential surface and groundwater users	Section 4
Provide a detailed description of the quality and quantity of surface and groundwater resources in the area potentially affected by the project.	Section 4.2 Volume 4 Appendix Q
Describe the groundwater quality considering seasonal variations in depth and flow and all times of natural flow in ephemeral streams. Parameters should include a broad range of water quality indicators including, but not necessarily limited to:	Volume 4 Appendix R
• Electrical conductivity	Volume 4 Appendix R
• Major cations and anions	Volume 4 Appendix R
• Dissolved metals (including Al, Ag, As, B, Br, Ca, Co, Cr, Cu, Fe, Hg, Mo, Mn, Ni, Pb, Se, U, V, Zn)	Volume 4 Appendix R
• Minor ions (such as ammonia, nitrite, nitrate, fluoride)	Volume 4 Appendix R
• Hydrocarbons	Volume 4 Appendix R
• Any other potential toxic or harmful substances	Volume 4 Appendix R
• Turbidity	Volume 4 Appendix R
• Suspended sediments	Volume 4 Appendix R
• pH.	Volume 4 Appendix R
All sampling should be performed in accordance with the Monitoring and Sampling Manual 2009 or the most current edition. The description of water quality should include medians, ranges and percentiles appropriate for comparison with appropriate trigger levels and guidelines for the protection of aquatic ecosystems and downstream users.	Volume 4 Appendix Q

Terms of Reference Requirement/Section Number	Section of this Report
3.4. Water Resources	
Investigate the relationship between groundwater and surface water to assess the nature of any interaction between the two resources and any implications of the proposed mine that would affect the interaction. If the project is likely to use or affect local sources of groundwater, describe the groundwater resources in the area in terms of interaction with surface water	Volume 4 Appendix R, Volume 4 Appendix Q
Describe the environmental values of the surface waterways and groundwater of the affected area in terms of:	
• values identified in the EPP	Section 4
• Physical integrity, fluvial processes and morphology	Section 4
• Any impoundments	Section 4
• Hydrology of waterways and groundwater	Section 5
• Sustainability (quality and quantity)	Section 4.3, 4.4
• Dependent ecosystems	Volume 4 Appendix O
• Existing and other potential surface and groundwater users	Section 4.4
• Details of any proposed buffer widths between project activities and waterways	Section 8.1
• Any water resource plans relevant to the affected catchments	Section 4
If the project is likely to use or affect local sources of groundwater, describe the groundwater resources in the area in terms of:	Volume 4 Appendix R
• A comprehensive hydrogeological description covering: the coal seams and surrounding aquifers, both artesian and sub-artesian; inter-aquifer connectivity; flow of water; recharge and discharge mechanisms; and hydrogeological processes at work	Volume 4 Appendix R
• Current extraction regime	Volume 4 Appendix R
• Geology/stratigraphy	Volume 4 Appendix R
• Aquifer type	Volume 4 Appendix R
• Depth to and thickness of aquifers	Volume 4 Appendix R
• Depth to water level and seasonal changes in levels	Volume 4 Appendix R
• Groundwater flow directions	Volume 4 Appendix R
• Interaction with surface water	Volume 4 Appendix R

Terms of Reference Requirement/Section Number	Section of this Report
3.4. Water Resources	
• Possible sources of recharge	Volume 4 Appendix R
• Potential exposure to pollution	Volume 4 Appendix R
• Current access to groundwater resources (bores, springs, ponds, etc.)	Volume 4 Appendix R
The groundwater assessment should also be consistent with relevant guidelines for the assessment of acid sulphate soils, including spatial and temporal monitoring, to accurately characterise baseline groundwater characteristics.	Volume 4 Appendix R
For the taking of groundwater, the EIS should review the significance of groundwater in the project area, together with groundwater use in neighbouring areas. Specific reference should be made to relevant legislation or water resource plans for the region. The review should also assess the potential take of water from the aquifer and how current users and the aquifer itself and any connected aquifers will be affected.	Volume 4 Appendix R
The review should include a survey of existing groundwater supply facilities (bores, wells, or excavations) to the extent of any environmental harm. Information gathered for analysis should include:	Volume 4 Appendix R
• location, type and status of existing water entitlements and associated infrastructure (bores, wells or excavations)	Volume 4 Appendix R
• pumping parameters	Volume 4 Appendix R
• draw down and recharge at normal pumping rates	Volume 4 Appendix R
• seasonal variations (if records exist) of groundwater levels	Volume 4 Appendix R
Develop a network of observation points that would satisfactorily monitor groundwater resources both before and after commencement of operations.	Volume 4 Appendix R
The data obtained from the groundwater survey should be sufficient to enable specification of the major ionic species present in the groundwater, pH, electrical conductivity and total dissolved solids.	Volume 4 Appendix R

Terms of Reference Requirement/Section Number	Section of this Report
3.4. Water Resources	
3.4.2 Potential Impacts and Mitigation Measures	
Assess potential impacts, including long-term indirect impacts of the project on water resource environmental values identified in the previous section. Define and describe the objectives and practical measures for protecting or enhancing water resource environmental values, to describe how nominated quantitative standards and indicators may be achieved, and how the achievement of the objectives will be monitored, audited and managed. Address and describe the following matters, including provision of maps:	
• Potential impacts on the flow and the quality of surface and groundwater from all phases of the project, with reference to their suitability for the current and potential downstream uses and discharge licences	Section 8.1, 8.4
• All likely impacts on groundwater depletion or recharge regimes	Volume 4 Appendix R
• The likely volume of groundwater to be dewatered during the operations, and its likely quality characteristics, including salinity	Volume 4 Appendix R
• The impacts on groundwater resources in each aquifer of any take of groundwater or dewatering as a result of the mine's operation, including any potential migration and risks associated with the inter-basin transfer of water	Volume 4 Appendix R
• How extracted groundwater will be managed in the surface water management system to minimise the likelihood of discharging highly saline water	Volume 4 Appendix R
• Measures to prevent, mitigate and remediate any impacts on existing users or groundwater-dependent ecosystems	Volume 4 Appendix R
• The potential environmental impact caused by the project (and its associated project components) to local groundwater resources, including the potential for groundwater-induced salinity	Volume 4 Appendix R
• Response of the groundwater resource to the progression and cessation of the proposal	Volume 4 Appendix R
• Impact on the local groundwater regime caused by the altered porosity and permeability of any land disturbance	Volume 4 Appendix R
• Any potential for the project to impact on groundwater-dependent vegetation, including avoidance and mitigation measures	Volume 4 Appendix R

Terms of Reference Requirement/Section Number	Section of this Report
3.4. Water Resources	
• Potential impacts of surface water flow on existing infrastructure, with reference to the EPP (Water) and the Water Act 2000	Section 4
• Chemical and physical properties of any wastewater including stormwater at the point of discharge into natural surface waters, including the toxicity of effluent to flora and fauna	Section 8.4
• How contaminants and wastes are avoided, minimised, treated and managed in accordance with section 13 of EPP (Water)	Section 8.4, Volume 2 Section 10
• Environmental monitoring to check the effectiveness of mitigation measures	Section 8.7
• Potential impacts on other downstream receiving environments, considering the available assimilative capacity of the receiving waters, if it is proposed to discharge water to a riverine system	Section 8.4
• If it is proposed to discharge water to a riverine system, mitigation measures for water treatment	Volume 4 Appendix P
• The results of a risk assessment for uncontrolled releases to water due to system or catastrophic failure, implications of such emissions for human health and natural ecosystems, and strategies to prevent, minimise and contain impacts	Volume 2 Section 12
• The potential to contaminate surface and groundwater resources and measures to prevent, mitigate and remediate such contamination.	Section 8.4.2
Describe and address the impacts of subsidence.	Volume 2 Section 4
Assess any potential surface water and groundwater interaction as a result of subsidence of a watercourse. Also assess the potential impacts on the groundwater regime in alluvial and deeper aquifers due to altered porosity, permeability and interconnectivity from any land disturbance, including subsidence.	Section 5.7, 7.2.6, 8.2.4
Assess the potential impacts of subsidence on the sediment load within watercourses. Identify any existing Quarry Material Allocation Notice (QMAN) holders in, or downstream of, subsidence areas; and if there are any QMAN holders, assess whether there would be potential impacts on their resource or entitlement. Provide mitigation measures for any impacts on any QMAN holders.	Volume 2 Section 4
Assess the impacts of subsidence on the ecological condition of the bed and banks, including fish passage	Volume 2 Section 4

Terms of Reference Requirement/Section Number	Section of this Report
3.4. Water Resources	
Assess the impacts of subsidence effects on terrestrial ecosystems	Volume 2 Section 4
Detail measures that would mitigate the impacts of subsidence	Volume 2 Section 4
Outline impacts on all surface water resources by describing:	
• Local overland flow catchment characteristics and estimated change to mean and median (50th percentile) annual run off from local overland flow catchments	Section 5
• Change to flows including mean and median (50th percentile) annual flow, in watercourses immediately downstream of the site	Section 5.7
Describe the option for supplying water to the project, and assess the consequential impacts.	Volume 2 Section 2
Reference the properties of the land disturbed and processing liquid wastes, the technology for settling suspended clays from contaminated water, and the techniques to be employed to ensure contaminated water is contained and successfully treated on site.	Section 4.4
Describe the proposed stormwater drainage system and proposed disposal arrangements. (Illustrate with figures and contours).	Section 8, Figure 8-1
The EIS should outline all of the approvals required under the Water Act 2000, Water Regulation 2002 and subordinate legislation to complete the project, including construction and operational stages	Section 3
Describe management strategies in adequate detail to demonstrate best practice management and environmental values of receiving waters will be maintained to nominated water quality objectives.	Section 7.3, 8.4
Address where there will be a requirement for a Quarry Material Allocation and an associated Development Approval under the Sustainable Planning Act.	N/A

Appendix B

Hydrologic Data

Hydrologic Sub-catchment Data

Carmichael Catchment Design Rainfall Intensity Data

Local subcatchment parameters - existing conditions

Sub-catchment Label	Total Area (km^2)	Catchment Slope (%)
RB21.06	9.55	0.47
RB28.02	184.89	0.10
RB21.05	98.24	0.16
RB27.01	83.26	0.15
RB21.04	3.14	0.22
RB24.03	68.86	0.13
RB21.03	127.55	0.20
RB23.01	87.92	0.27
RB21.02	102.87	0.17
RB29.01	76.31	0.35
RB28.01	182.14	0.20
RB21.01	61.68	0.40
RB22.01	120.86	0.31
CC1.10	0.00	0.00
BW5	155.80	0.17
BW6	67.87	0.23
BW7	1.46	0.13
BW8	70.49	0.28
BW9	1.95	0.11
BW10	36.17	0.40
BW11	243.19	0.33
BW12	34.44	0.26
BW13	13.29	0.34
BW14	115.96	0.33
BW15	185.04	0.25
57-2DSP-LCarm	4.64	0.32
12-LC8	0.38	0.61
12-LC8	0.38	0.61
94-LC9	6.35	1.26
93-LC9	1.50	1.55

Sub-catchment Label	Total Area (km^2)	Catchment Slope (%)
80-LCarm	8.61	0.75
Node2-Lcarm	2.46	0.32
5-LC9	7.14	0.28
6-LC9	1.37	0.63
8-LC9	1.05	0.94
7-LC9	2.28	0.98
50-LC11	1.15	0.97
119-LC9	1.17	0.28
75-LC11	2.24	1.02
90-LC11	4.12	0.99
68-LC11	2.73	0.28
69-C11	0.67	0.70
76-LC11	2.95	0.75
74-LC11	2.58	0.45
100-LC7	5.60	0.36
10-LC8	1.45	0.32
9-LC7	1.44	0.13
110-LC12	10.57	0.30
121-LC12	6.47	0.30
72-LC6	2.98	0.24
29-LC6	2.89	0.06
30-LC6	4.11	0.06
99-LC7	1.59	0.14
111-LC12	3.47	0.30
73-LC6	6.03	0.21
49-LCarm	8.22	0.17
35-LCarm	7.59	0.68
79-LC14	7.08	0.14
103-LC5	1.56	0.28

Sub-catchment Label	Total Area (km^2)	Catchment Slope (%)
78-LC14	6.03	0.13
Node1-LC6	1.81	0.10
34-LC14	6.34	0.15
107-LCarm	1.15	0.10
54-LCarm	4.97	0.45
51-LCarm	1.04	0.55
106-LC5	2.03	0.58
105-LC5	1.95	0.48
117-LCarm	8.94	0.75
53-LCarm	1.59	0.56
55-LCarm	3.70	0.39
57b-LCarm	4.64	0.32
1-LC9	0.64	0.49

Peak flows in minor waterway subcatchments to the north of the Carmichael River - Existing

	ARI	10 yr	50 yr	100 yr	1000 yr
	Critical Duration	6 hr	3 hr	2 hr	2 hr
Subcatchment Label	12-LC1	29.543	47.612	50.456	121.358
	13-LC1	18.1	28.809	30.964	74.262
	10-LC1	60.244	98.796	105.798	251.217
	9-LC1	164.851	266.08	293.816	637.857
	7-LC1	216.67	347.717	380.34	830.877
	5-LC1	241.581	385.77	419.011	905.102
	4-LC13	13.011	20.805	22.182	52.529
	1-LC10	252.654	401.043	434.074	930.161
	27-LC2	19.731	31.857	34.276	81.656
	32-LC2	35.877	64.671	71.384	167.924
	29-LC2	49.176	87.813	98.157	228.824
	30-LC2	4.151	7.863	8.748	20.939
	25-LC2	100.267	173.237	191.882	445.91
	11-LC2	112.868	193.881	214.024	497.65
	8-LC3	35.351	55.687	59.592	143.739
	6-LC1	23.508	37.915	40.808	96.055

Peak flows in minor waterway subcatchments to the south of the Carmichael River - Existing

	ARI	10 yr	50 yr	100 yr	1000 yr
	Critical Duration	6 hr	3 hr	2 hr	2 hr
Subcatchment Label	15-LC8	8.813	17.349	21.588	48.529
	16-LC8	99.639	177.523	199.624	433.521
	14-LC8	117.371	207.463	234.489	499.05
	12-LC8	127.635	223.051	251.824	532.175
	13-LC8	12.79	23.76	26.495	62.258
	11-LC8	3.525	5.757	6.178	14.834
	10-LC8	133.124	231.601	160.975	551.369
	100-LC	9.372	15.455	16.535	40.433
	94-LC9	30.965	61.128	74.206	165.814
	8-LC9	39.265	77.157	94.502	208.342
	6-LC9	50.363	97.847	117.839	256.686
	1-LC9	64.01	122.368	144.475	317.543
	7-LC9	7.198	14.254	17.268	39.856
	75-LC11	14.798	28.314	32.914	74.558
	69-LC11	22.551	42.817	49.51	112.886
	50-LC11	29.96	56.06	65.07	147.13
	98-LC13	13.608	26.968	32.266	74.148
	97-LC13	8.888	17.465	20.936	47.975
	3-LC13	22.756	44.959	53.96	123.765

Local subcatchment parameters - post-development conditions

Subcatchment Number	Total Area (ha)	Catchment Slope (%)	Peak Total Flow (m3/s)			
			10 year ARI	50 year ARI	100 year ARI	1000 year ARI
3	9.0	1.2	24.7	45.1	54.5	124.1
8	2637.3	0.4	34.5	61.6	76.0	145.9
9	67.2	0.3	87.6	154.9	191.3	401.2
12	2283.0	0.4	30.5	55.5	68.6	129.5
14	577.9	0.7	131.0	234.1	283.5	577.4
15	260.7	1.2	9.7	17.6	21.7	48.9
16	323.7	1.1	101.2	181.9	220.4	453.6
17	530.4	0.9	14.2	26.4	32.2	70.3
18	34.8	0.9	79.1	142.4	172.7	353.9
19	420.0	1.3	14.4	26.1	31.5	72.5
20	150.4	1.3	67.3	118.8	145.8	301.8
21	820.5	1.0	21.3	39.7	48.1	103.6
22	1002.9	0.7	44.1	77.1	95.4	200.9
23	249.9	0.6	6.4	11.9	14.6	31.3
25	1.8	0.4	0.1	0.2	0.2	0.5
26	172.3	0.5	86.0	152.1	187.8	394.0
27	1211.9	0.5	81.8	144.6	178.5	374.2
28	535.7	0.6	62.5	112.8	138.5	292.9
30	24.8	0.5	6.0	11.0	13.5	29.3
31	438.2	0.6	51.0	92.6	113.9	241.7
32	181.4	0.4	40.7	74.1	91.2	194.1
33	469.5	0.7	18.9	35.1	42.8	92.2
34	713.0	0.8	17.5	32.0	39.8	83.5
39	382.1	0.4	63.1	115.8	140.9	277.3
40	408.2	0.2	87.3	158.7	192.3	378.8
41	168.7	0.5	4.4	8.3	10.1	22.1
43	152.6	0.2	2.8	5.2	6.3	12.5
44	185.4	0.5	63.1	112.6	136.0	284.1
46	454.0	0.5	47.2	88.4	107.9	208.4
47	501.6	0.5	10.3	18.6	22.4	46.6

48	515.1	0.5	10.5	19.1	22.9	47.4
49	483.9	0.5	10.0	18.1	21.9	45.6
50	467.3	0.5	96.9	170.9	210.0	439.4
51	356.6	0.5	8.0	14.2	17.7	37.2
52	467.2	0.5	9.8	17.5	21.4	44.6
53	402.0	0.5	8.7	15.5	19.3	40.6
54	425.2	0.5	9.1	16.2	20.2	42.0
55	477.1	0.5	9.9	17.9	21.7	45.2
56	422.9	0.5	9.1	16.2	20.1	41.9
57	466.4	0.5	9.7	17.5	21.4	44.6
58	1284.1	0.2	258.8	466.2	563.0	1122.3
59	839.8	0.5	15.2	27.9	33.8	66.5
60	724.0	0.5	76.6	137.2	165.7	340.6
61	673.5	0.5	12.9	23.5	28.3	56.4
62	619.9	0.5	12.1	22.1	26.6	53.4
68	52.2	0.3	136.1	242.2	293.5	596.4
69	57.8	0.7	147.2	259.0	314.0	631.2
75	224.1	1.0	16.0	29.1	35.3	79.7
76	294.5	0.8	8.3	15.6	19.0	42.2
81	279.1	0.4	14.5	25.9	31.8	66.7
90	175.5	0.4	135.0	240.6	291.4	592.6
97	293.2	1.0	9.5	17.5	21.2	48.3
98	444.7	1.2	14.9	27.1	32.7	74.8
100	18.1	0.4	131.4	234.6	284.2	578.6
106	50.1	0.6	15.8	28.1	34.8	74.2
127	188.5	0.3	28.2	52.1	63.1	142.6
13n	544.8	0.4	9.7	18.0	21.8	43.1
13s	439.2	0.8	11.8	22.3	26.9	58.5
24n	243.0	0.4	5.3	9.5	11.8	24.8
24s	651.9	0.9	16.5	30.3	37.5	79.7
32a	46.1	0.4	7.4	13.7	16.7	36.8
68a	6.4	0.3	147.2	259.1	314.1	631.4
node1	0.0	0.0	47.2	88.4	107.9	208.4

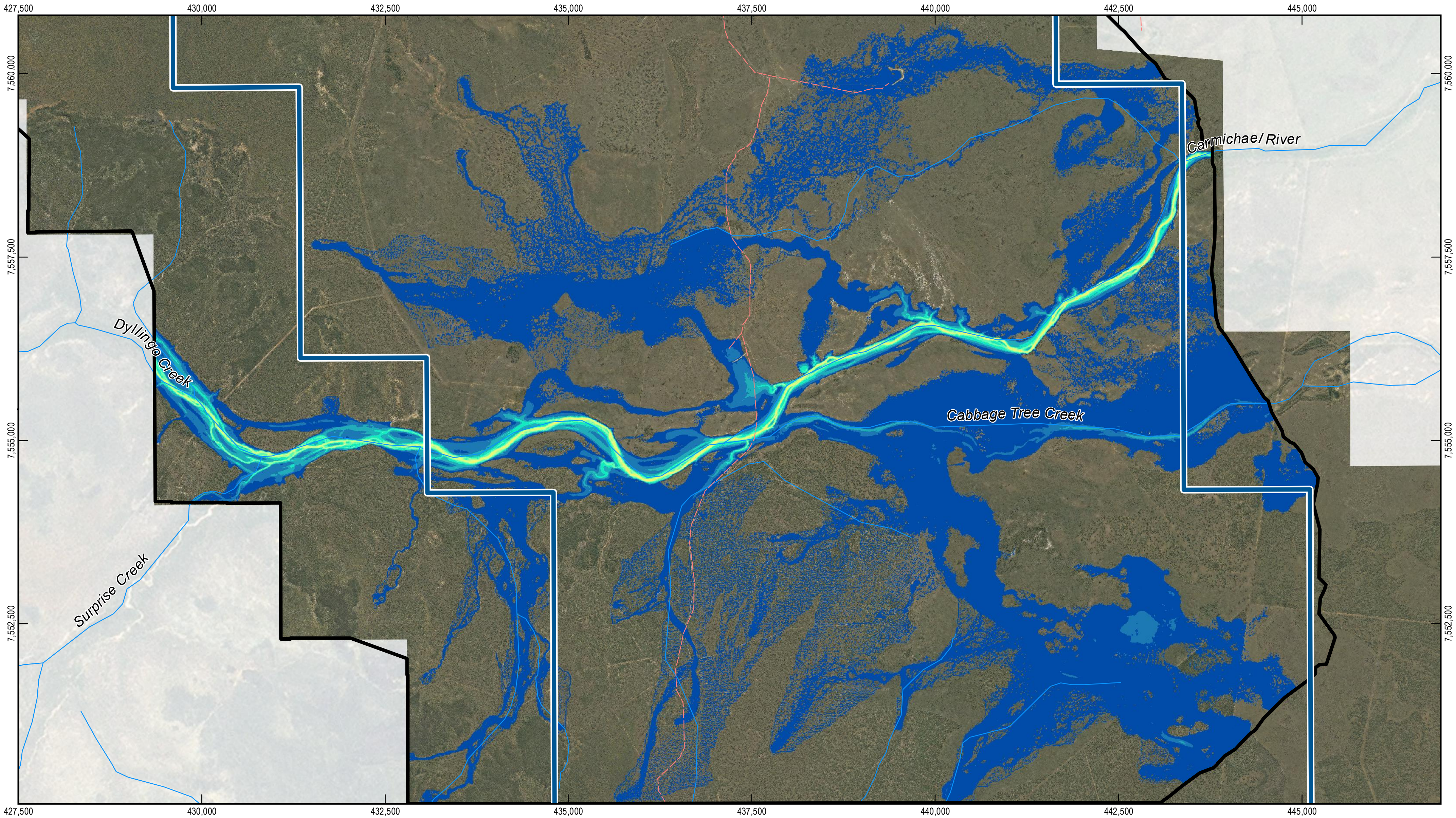
node10	0.0	0.0	95.5	172.6	208.3	409.4
node11	0.0	0.0	76.6	137.2	165.7	340.6
node12	0.0	0.0	41.9	77.1	94.1	179.9
node13	0.0	0.0	147.2	259.1	314.1	631.4
node14	0.0	0.0	8.7	15.5	19.3	40.6
node15	0.0	0.0	51.3	94.9	115.6	250.9
node16	0.0	0.0	51.3	94.9	115.6	250.9
node17	0.0	0.0	34.7	61.5	74.8	158.2
node19	0.0	0.0	51.3	94.9	115.6	250.9
node2	0.0	0.0	150.9	269.9	325.8	668.6
node3	0.0	0.0	519.0	916.8	1102.6	2209.9
node4	0.0	0.0	76.6	137.2	165.7	340.6
node5	0.0	0.0	148.1	264.9	319.8	657.3
node6	0.0	0.0	258.8	466.2	563.0	1122.3
node7	0.0	0.0	34.5	61.6	76.0	145.9
node8	0.0	0.0	38.9	73.1	89.7	169.7
node9	0.0	0.0	56.5	104.0	126.7	247.6

Return Period (yrs)	Duration (hrs)	Rainfall (mm)	Areal Rainfall (mm)	Intensity (mm/hr)
		IFD Rainfall Data		
10	0.25	28.900	28.900	**115.6**
10	0.5	41.900	41.900	**83.8**
10	0.75	51.225	51.225	**68.3**
10	1	58.700	58.700	**58.7**
10	1.5	65.549	65.549	**43.7**
10	2	70.601	70.601	**35.3**
10	3	78.000	78.000	**26**
10	6	92.401	92.401	**15.4**
10	12	110.399	110.399	**9.2**
10	18	127.804	127.804	**7.1**
10	24	141.603	141.603	**5.9**
50	0.25	40.434	40.434	**161.735**
50	0.5	58.489	58.489	**116.978**
50	0.75	71.304	71.304	**95.072**
50	1	81.557	81.557	**81.557**
50	1.5	90.863	90.863	**60.576**
50	2	97.677	97.677	**48.838**
50	3	107.784	107.784	**35.928**
50	6	127.261	127.261	**21.21**
50	12	150.623	150.623	**12.552**
50	18	175.163	175.163	**9.731**
50	24	194.5	194.5	**8.104**
100	0.25	45.577	45.577	**182.31**
100	0.5	65.856	65.856	**131.712**
100	0.75	80.229	80.229	**106.972**
100	1	91.717	91.717	**91.717**
100	1.5	102.098	102.098	**68.066**
100	2	109.688	109.688	**54.844**
100	3	120.934	120.934	**40.311**
100	6	142.579	142.579	**23.763**
100	12	168.507	168.507	**14.042**
100	18	196.006	196.006	**10.889**
100	24	217.681	217.681	**9.07**
		FORGE Rainfall*		
1000	1	142.5878474		**142.5878474**
1000	1.5	183.7570964		**122.5047309**
1000	2	204.8432289		**102.4216145**
1000	3	186.7661445		**62.25538151**
1000	4.5	222.3447189		**49.40993754**
1000	6	219.318574		**36.55309566**
1000	9	261.2742787		**29.03047541**
1000	12	258.094262		**21.50785516**
1000	18	300.5628726		**16.69793737**
1000	24	334.004339		**13.91684746**

*Note that the ARF (0.877) that is incorporated into the FORGE results (based on the Carmichael River catchment area) has been removed for the local catchment hydrology.

Appendix C

Carmichael River Design Flood Maps – Existing Conditions



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0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Watercourse
- Track
- Minor Road
- 2D Model Extent
- Mine (Onsite)

Depth (m)

- 0.08 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- 6.0 - 7.0
- 7.0 - 8.0
- 8.0 - 9.0
- 9.0 - 10.0
- 10.0 - 10.44

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

10 Year ARI Flood Event
(Existing)

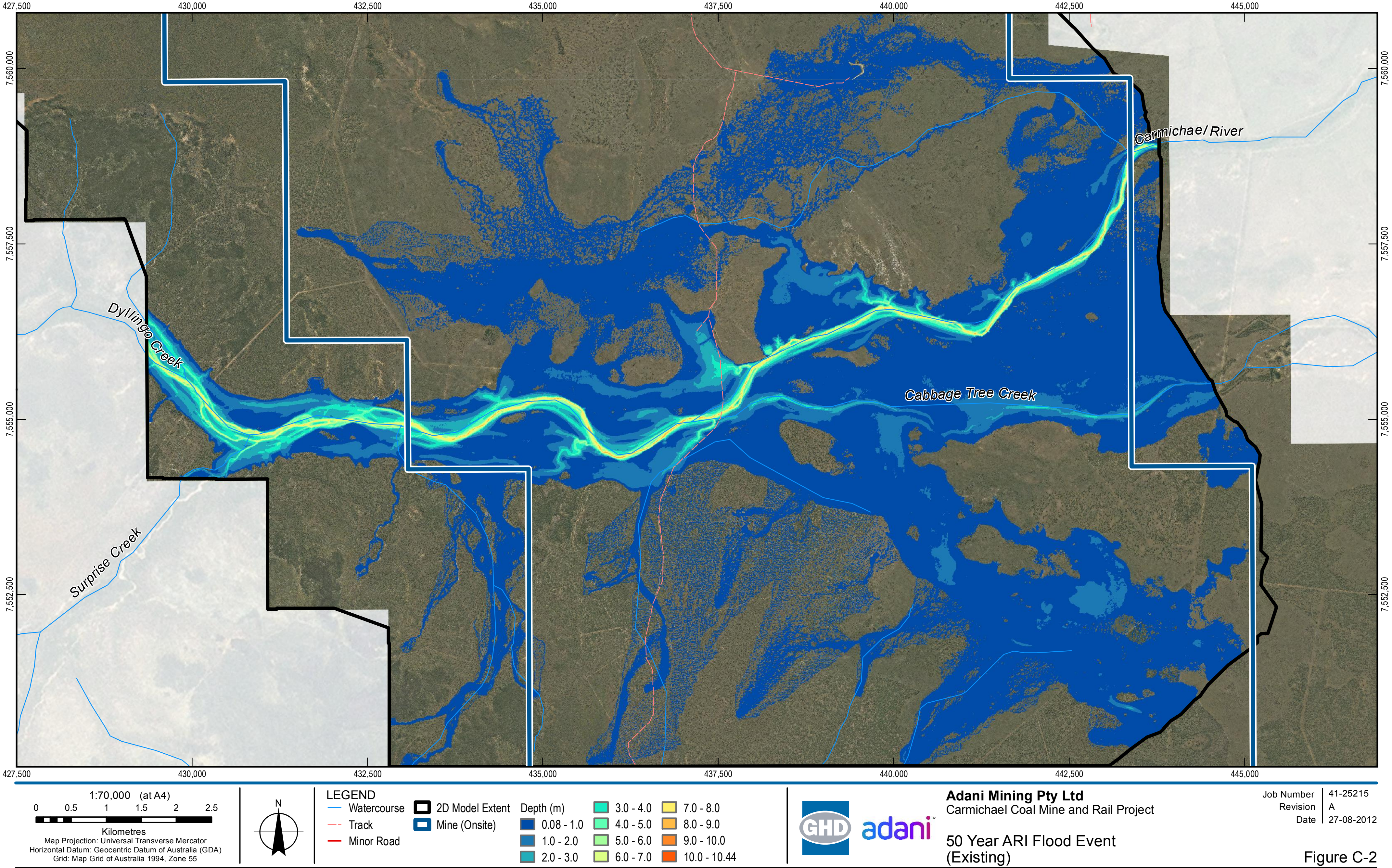
Job Number	41-25215
Revision	A
Date	27-08-2012

Figure C-1

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\41-25215_571-01_rev_a.mxd

Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Watercourse, Trails, Tracks (2007);
GHD: Flood Modelling (2012); Created by: BW, CA



Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision A
Date 27-08-2012

50 Year ARI Flood Event
(Existing)

Figure C-2

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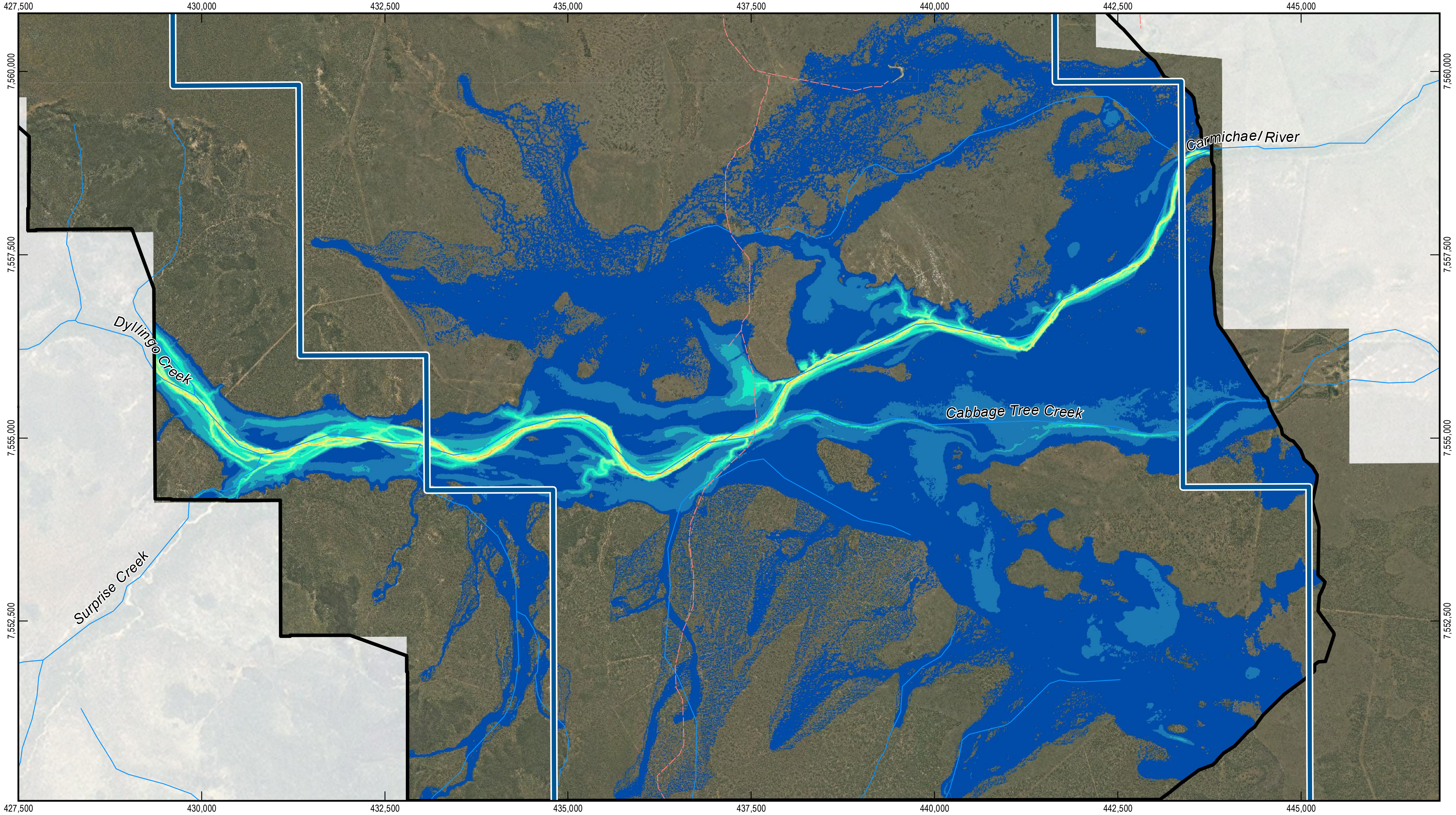
Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Watercourse, Trails, Tracks (2007);
GHD: Flood Modelling (2012); Created by: BW, CA



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Watercourse
- Track
- Minor Road
- 2D Model Extent
- Mine (Onsite)

Depth (m)

- 0.08 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- 6.0 - 7.0
- 7.0 - 8.0
- 8.0 - 9.0
- 9.0 - 10.0
- 10.0 - 10.44

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number	41-25215
Revision	A
Date	27-08-2012

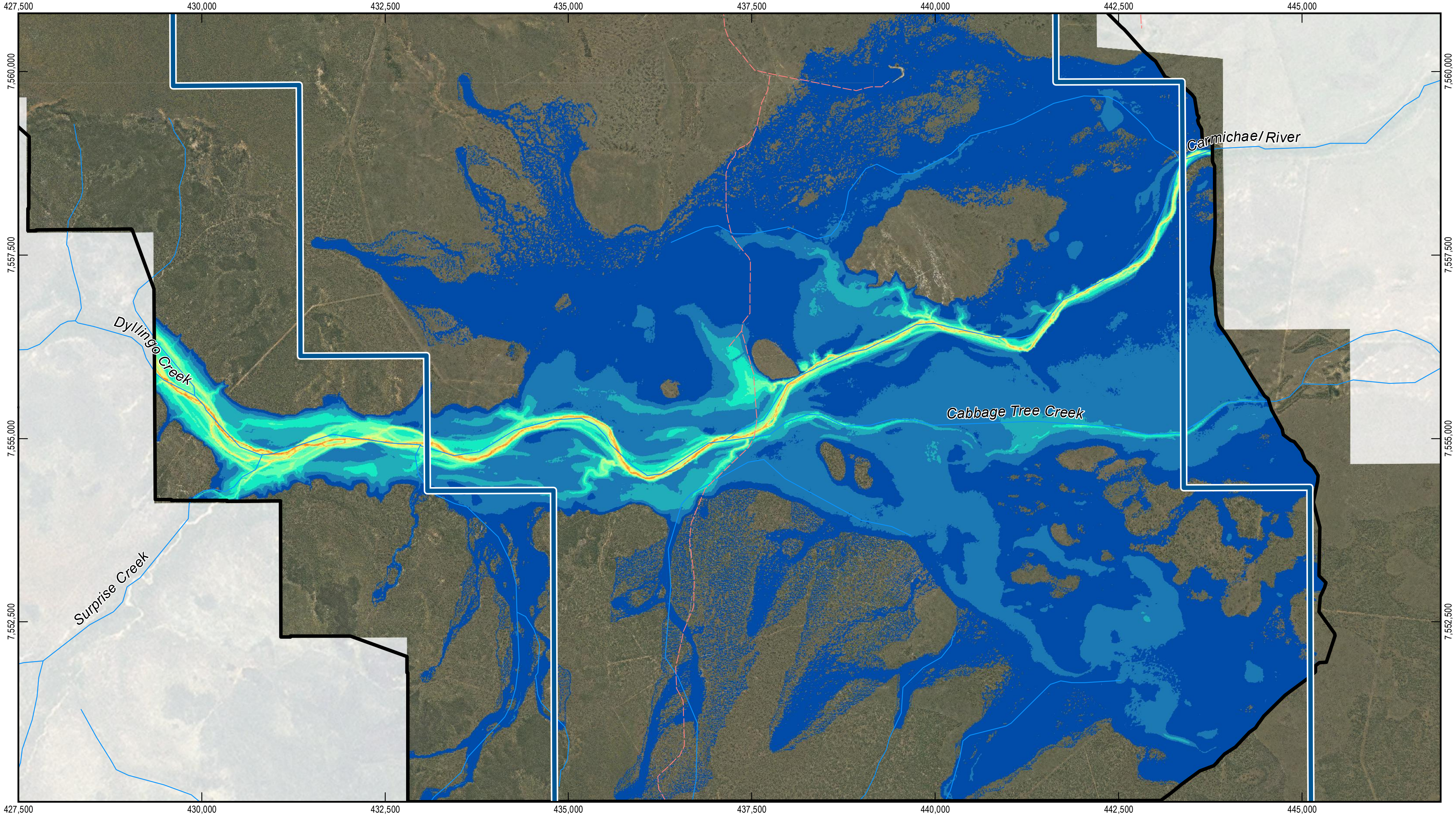
100 Year ARI Flood Event
(Existing)

Figure C-3

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\41-25215_571-03_rev_a.mxd

Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Watercourse, Trails, Tracks (2007);
GHD: Flood Modelling (2012); Created by: BW, CA



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Watercourse
- Track
- Minor Road
- 2D Model Extent
- Mine (Onsite)

Depth (m)

- 0.08 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- 6.0 - 7.0
- 7.0 - 8.0
- 8.0 - 9.0
- 9.0 - 10.0
- 10.0 - 10.44

GHD adani

Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Job Number	41-25215
Revision	A
Date	27-08-2012

1000 Year ARI Flood Event
(Existing)

Figure C-4

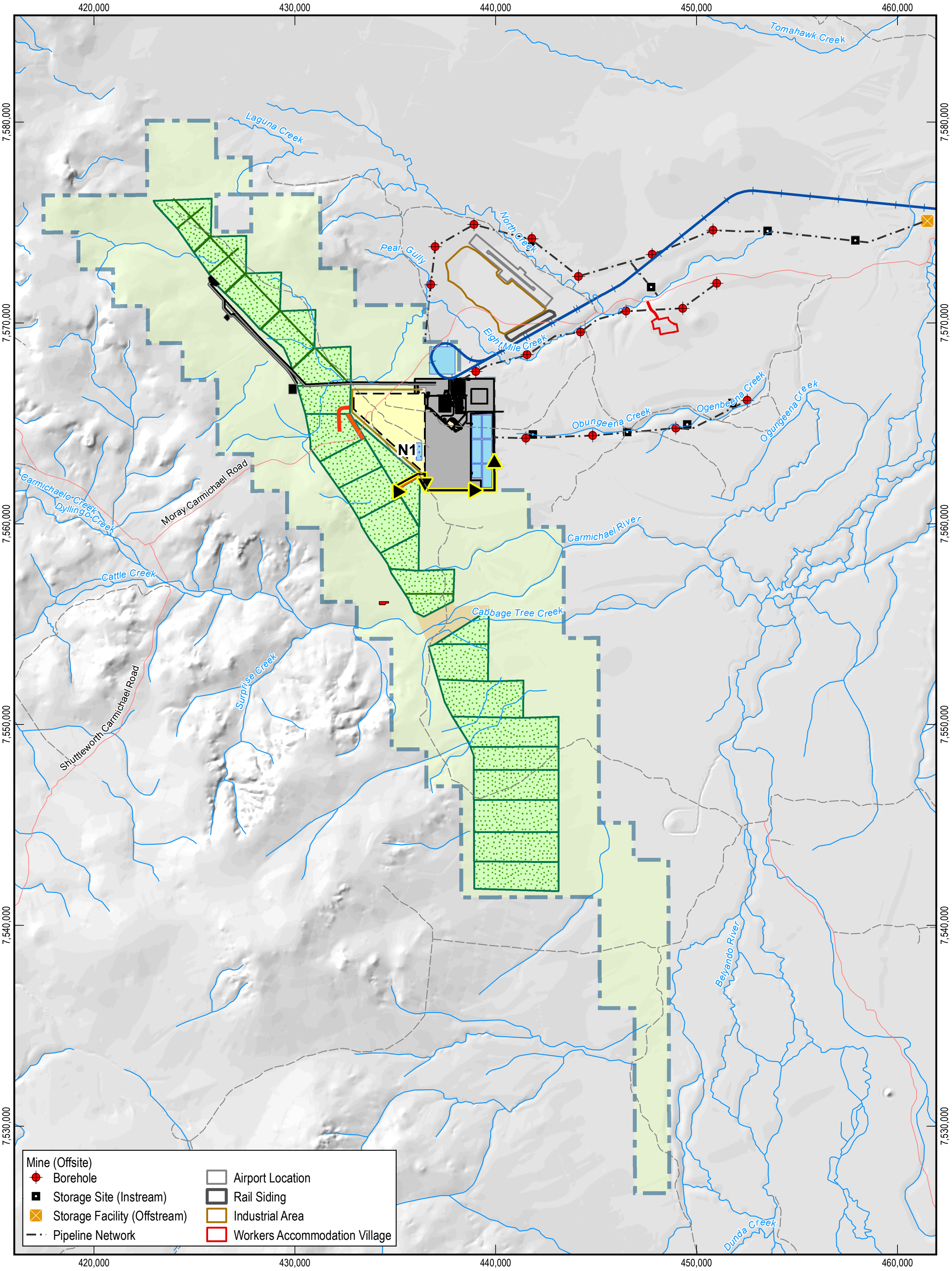
G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\41-25215_571-04_rev_a.mxd

Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Watercourse, Trails, Tracks (2007);
GHD: Flood Modelling (2012); Created by: BW, CA

Appendix D

Mine Drainage Plan Progress Plots



LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Levee
- Rail (West)
- Proposed Diversion
- Active Mining Area
- Out of Pit Waste Dumps
- Water Management Dams
- Sediment Basins
- Open Cut Blocks
- Mine (Onsite)

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1:270,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number: 41-25215
Revision: A
Date: 03-09-2012

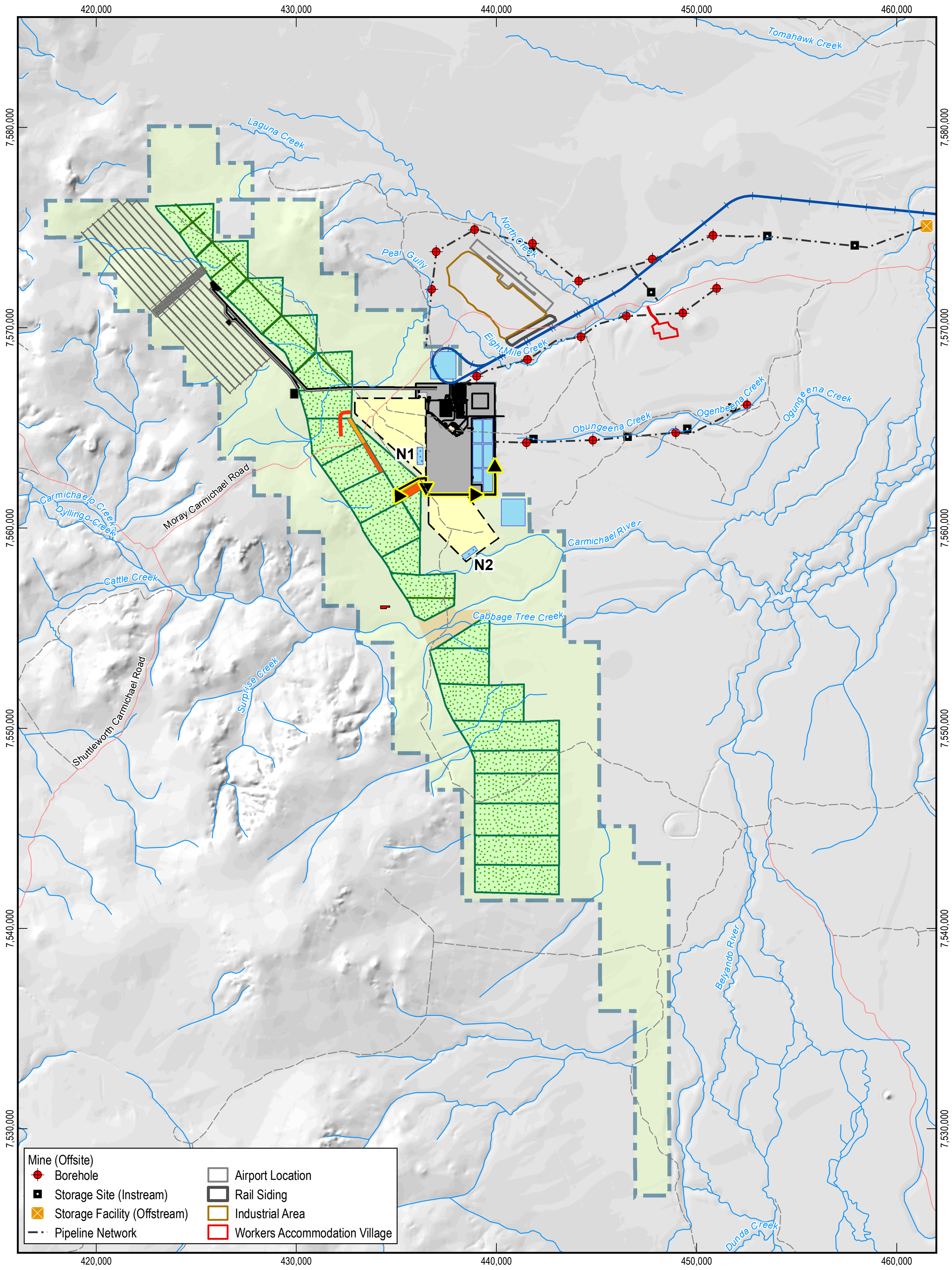
Mine Drainage Progress
Plot - Year 2013

Figure D-1

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\41-25215_572-01_rev_a.mxd

Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: © Copyright Commonwealth of Australia - Geoscience Australia: Roads, Watercourse (2007); GHD: Creek Crossings, Levees, Sediment Basins, Diversions (2012);
Adani: Alignment Opt9 Rev3 (2012), Mine Layout/Infrastructure (2012); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH, CA



LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Levee
- Proposed Diversion
- Rail (West)
- Active Mining Area
- Disturbed Mining Area
- Out of Pit Waste Dumps
- Open Cut Blocks
- Water Management Dams
- Sediment Basins
- Mine (Onsite)

1:270,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Mine Drainage Progress
Plot - Year 2014

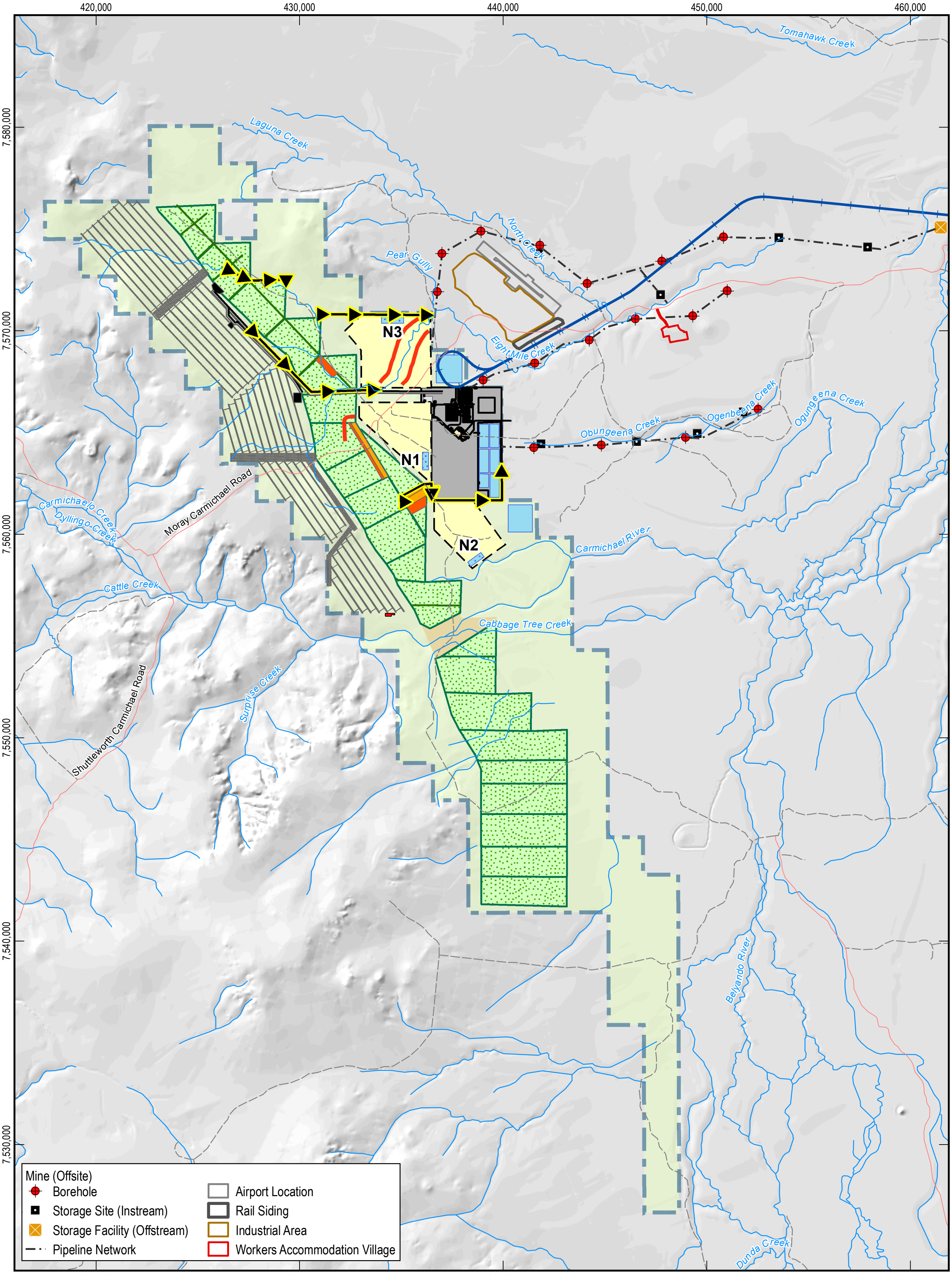
Job Number	41-25215
Revision	A
Date	03-09-2012

Figure D-2

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\41-25215_572-02_rev_a.mxd

Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: © Copyright Commonwealth of Australia - Geoscience Australia: Roads, Watercourse (2007); GHD: Creek Crossings, Levees, Sediment Basins, Diversions (2012);
Adani: Alignment Opt9 Rev3 (2012), Mine Layout/Infrastructure (2012); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH, CA



LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Levee
- Proposed Diversion
- Rail (West)
- Active Mining Area
- Disturbed Mining Area
- Out of Pit Waste Dumps
- Open Cut Blocks
- Water Management Dams
- Sediment Basins
- Mine (Onsite)

1:270,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

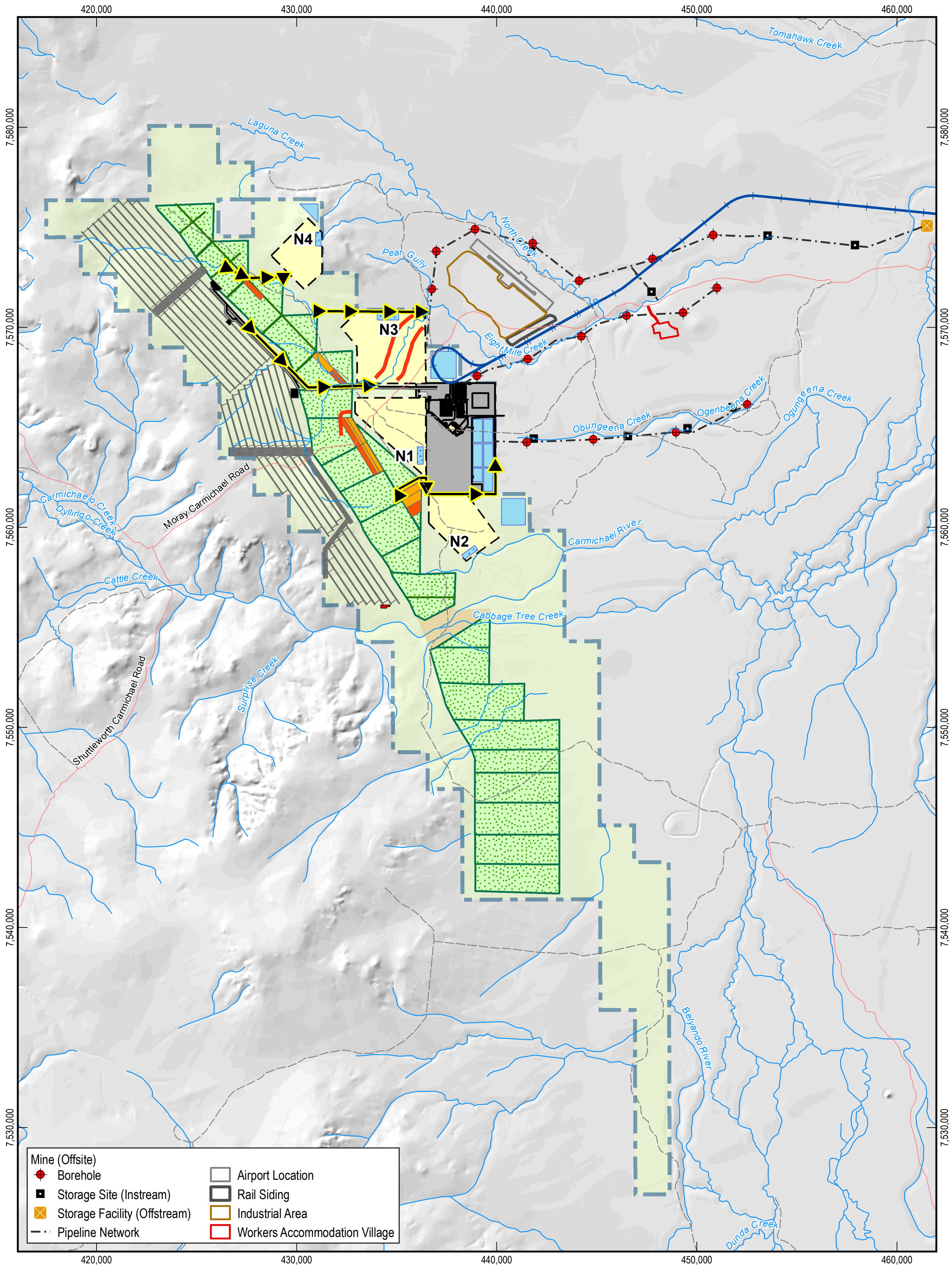
Mine Drainage Progress
Plot - Year 2015

Job Number	41-25215
Revision	A
Date	03-09-2012

Figure D-3

Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: © Copyright Commonwealth of Australia - Geoscience Australia: Roads, Watercourse (2007); GHD: Creek Crossings, Levees, Sediment Basins, Diversions (2012);
Adani: Alignment Opt9 Rev3 (2012), Mine Layout/Infrastructure (2012); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH, CA



LEGEND

Local Road	Levee	Active Mining Area	Water Management Dams
Track	Proposed Diversion	Disturbed Mining Area	Sediment Basins
Watercourse	Rail (West)	Out of Pit Waste Dumps	Mine (Onsite)
Overland Conveyors		Open Cut Blocks	

1:270,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

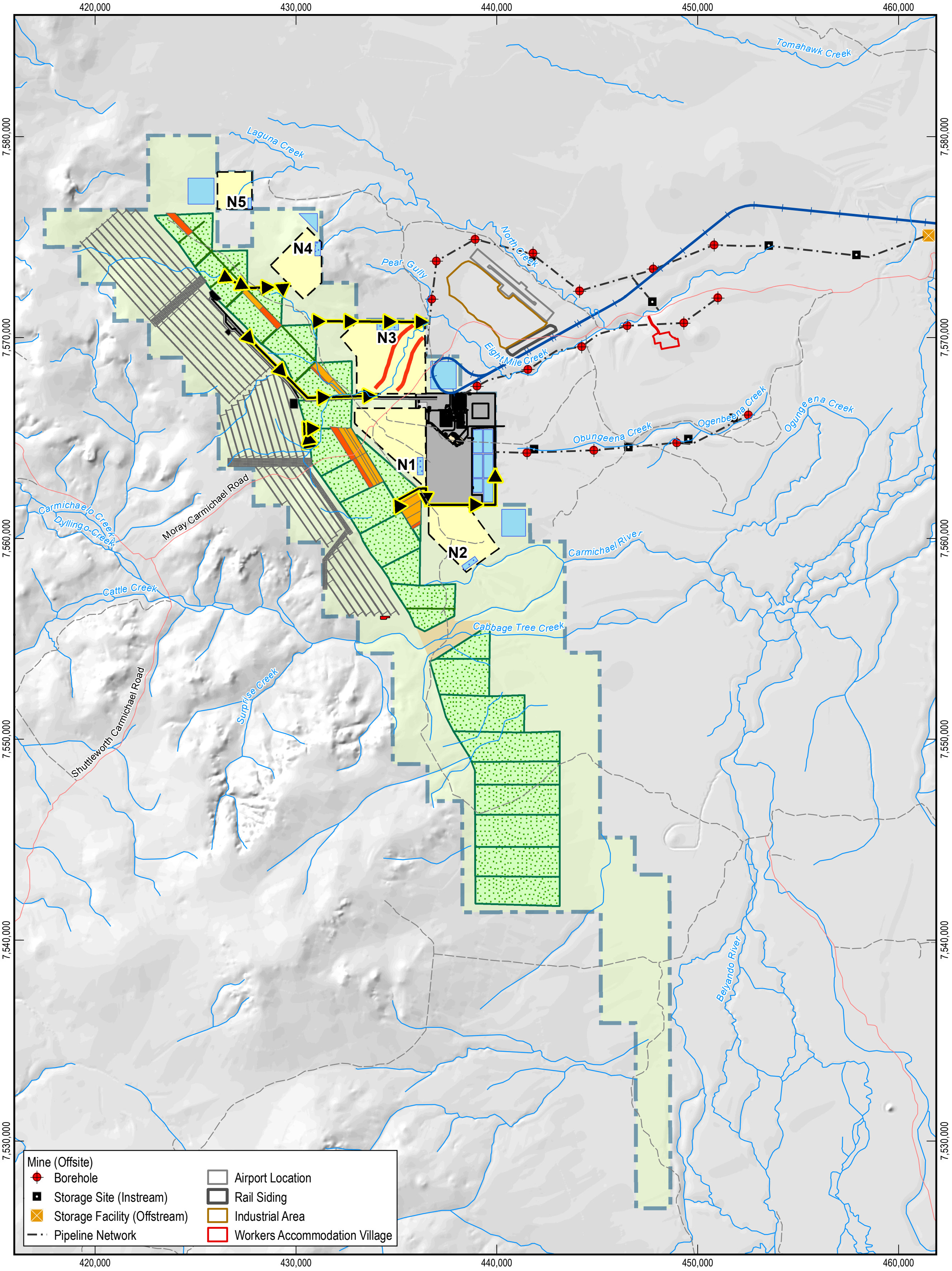
Job Number 41-25215
Revision A
Date 03-09-2012

Mine Drainage Progress
Plot - Year 2016

Figure D-4

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\41-25215_572-04_rev_a.mxd Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: © Copyright Commonwealth of Australia - Geoscience Australia: Roads, Watercourse (2007); GHD: Creek Crossings, Levees, Sediment Basins, Diversions (2012);
Adani: Alignment Opt9 Rev3 (2012), Mine Layout/Infrastructure (2012); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH, CA



LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Levee
- Proposed Diversion
- Rail (West)
- Active Mining Area
- Disturbed Mining Area
- Out of Pit Waste Dumps
- Open Cut Blocks
- Water Management Dams
- Sediment Basins
- Mine (Onsite)

1:270,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Mine Drainage Progress
Plot - Year 2017

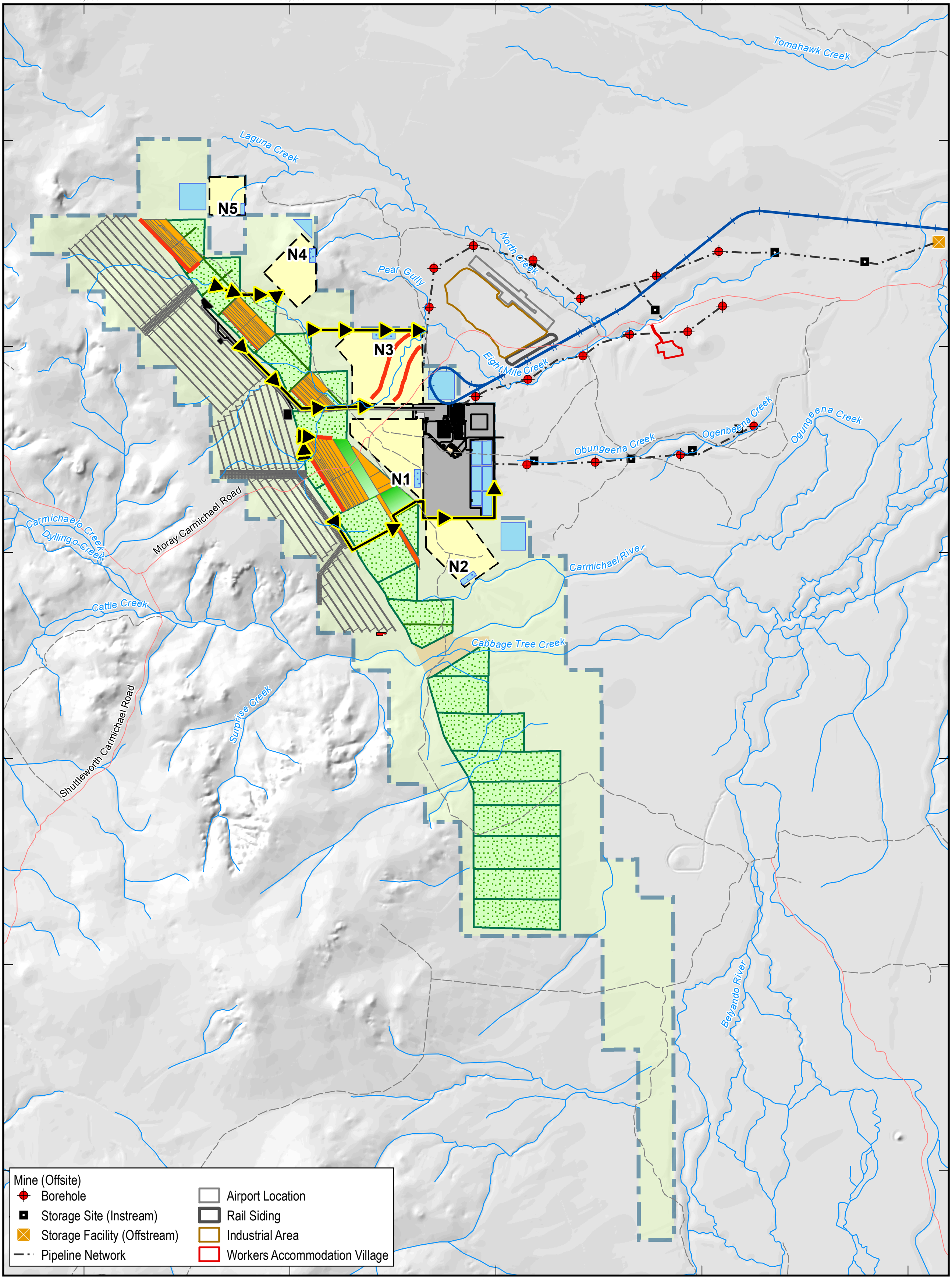
Job Number	41-25215
Revision	A
Date	03-09-2012

Figure D-5

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\41-25215_572-05_rev_a.mxd

Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: © Copyright Commonwealth of Australia - Geoscience Australia: Roads, Watercourse (2007); GHD: Creek Crossings, Levees, Sediment Basins, Diversions (2012);
Adani: Alignment Opt9 Rev3 (2012), Mine Layout/Infrastructure (2012); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH, CA



LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Levee
- Proposed Diversion
- Rail (West)
- Active Mining Area
- Disturbed Mining Area
- Area Under Rehabilitation
- Out of Pit Waste Dumps
- Open Cut Blocks
- Water Management Dams
- Sediment Basins
- Mine (Onsite)

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1:270,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Mine Drainage Progress Plot - Year 2027

Job Number	41-25215
Revision	A
Date	03-09-2012

Figure D-6

Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

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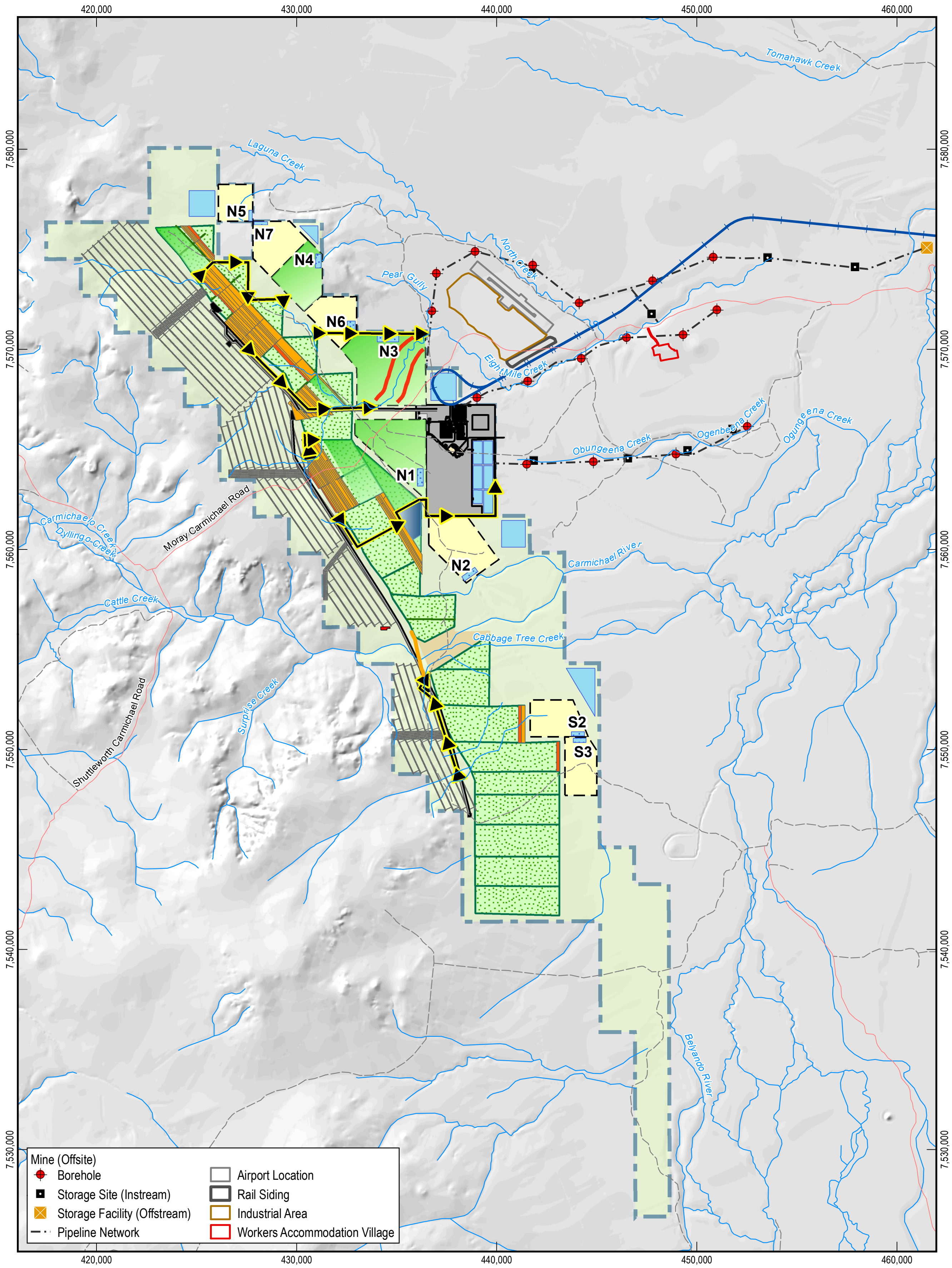


LEGEND

Local Road	Haul Rd & Conveyor Crossing	Active Mining Area	Open Cut Blocks
Track	Levee	Disturbed Mining Area	Water Management Dams
Watercourse	Proposed Diversion	Area Under Rehabilitation	Sediment Basins
Overland Conveyors	Rail (West)	Out of Pit Waste Dumps	Mine (Onsite)

1:270,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

GHD adani

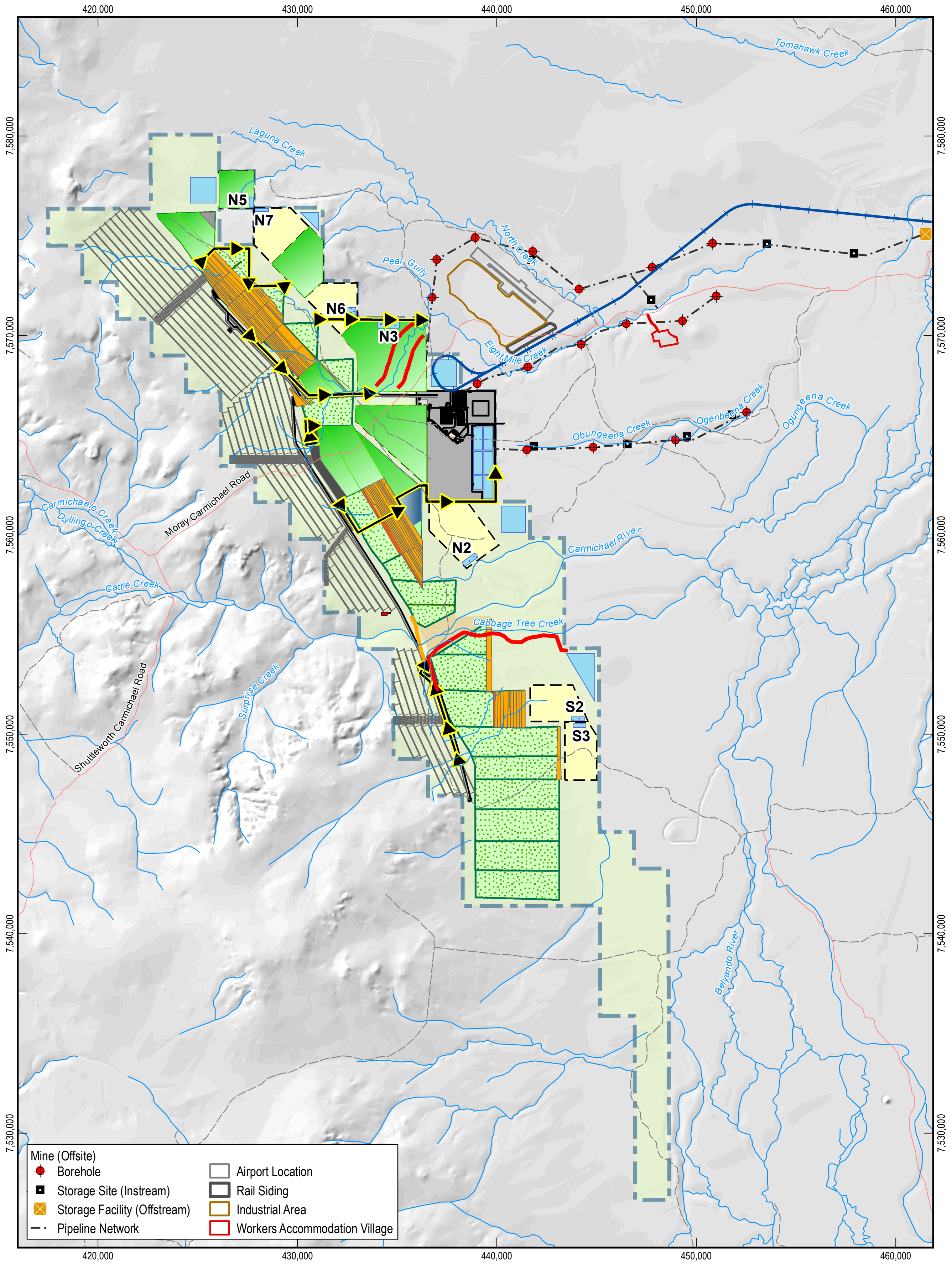
Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision A
Date 03-09-2012

Mine Drainage Progress Plot - Year 2037

Figure D-7

Data Source: © Copyright Commonwealth of Australia - Geoscience Australia: Roads, Watercourse (2007); GHD: Creek Crossings, Levees, Sediment Basins, Diversions (2012); Adani: Alignment Opt9 Rev3 (2012), Mine Layout/Infrastructure (2012); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH, CA



LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Haul Rd & Conveyor Crossing
- Levee
- Proposed Diversion
- Rail (West)
- Active Mining Area
- Disturbed Mining Area
- Area Under Rehabilitation
- Out of Pit Waste Dumps
- Open Cut Blocks
- Water Management Dams
- Sediment Basins
- Mine (Onsite)
- Remediated Void
- Void

1:270,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Mine Drainage Progress
Plot - Year 2047

Job Number	41-25215
Revision	A
Date	03-09-2012

Figure D-8

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\41-25215_572-08_rev_a.mxd Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

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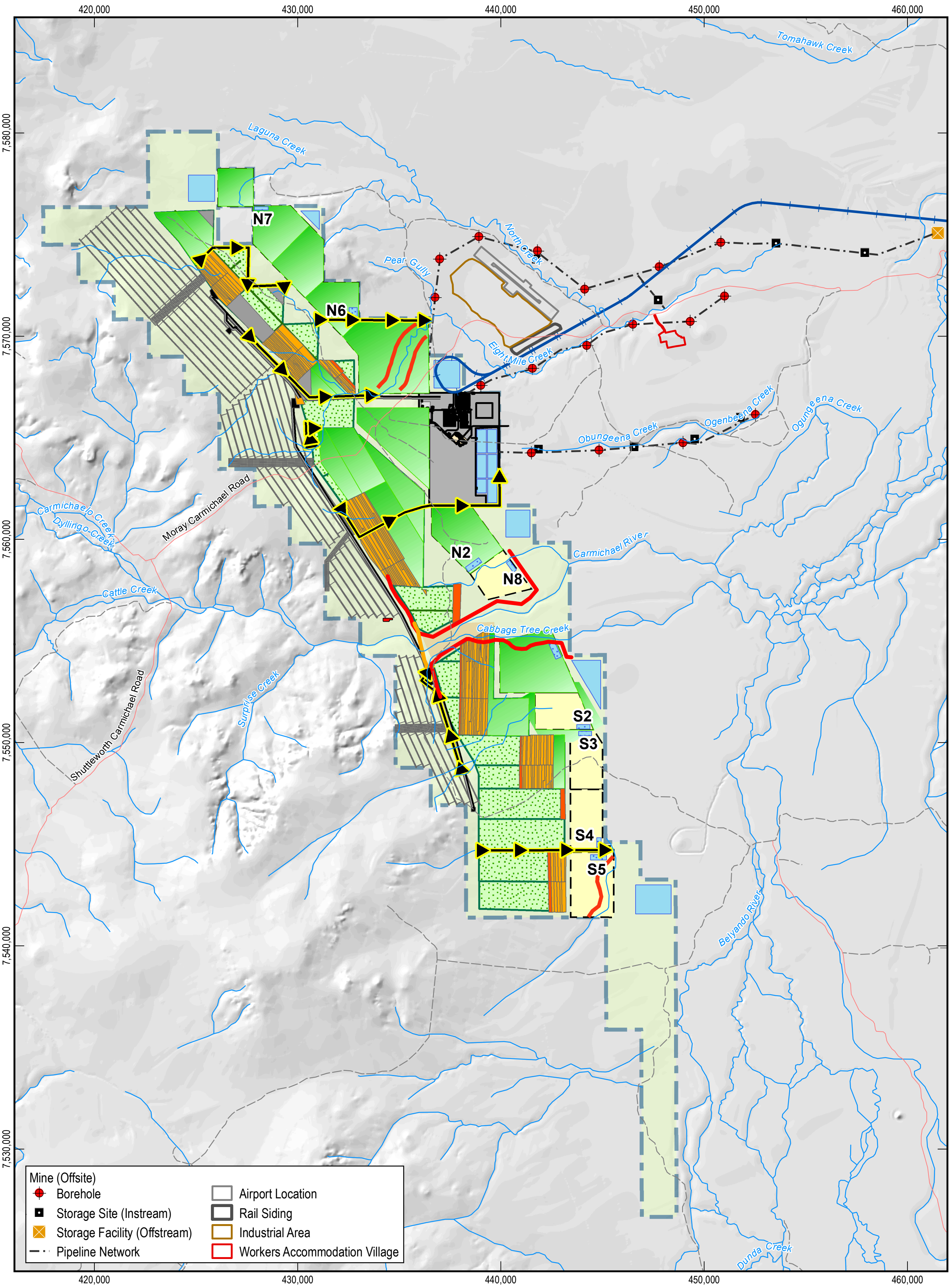
Adani: Alignment Opt9 Rev3 (2012), Mine Layout/Infrastructure (2012); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH, CA



LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Haul Rd & Conveyor Crossing
- Levee
- Proposed Diversion
- Rail (West)
- Active Mining Area
- Disturbed Mining Area
- Area Under Rehabilitation
- Out of Pit Waste Dumps
- Open Cut Blocks
- Water Management Dams
- Sediment Basins
- Mine (Onsite)
- Remediated Void

1:270,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

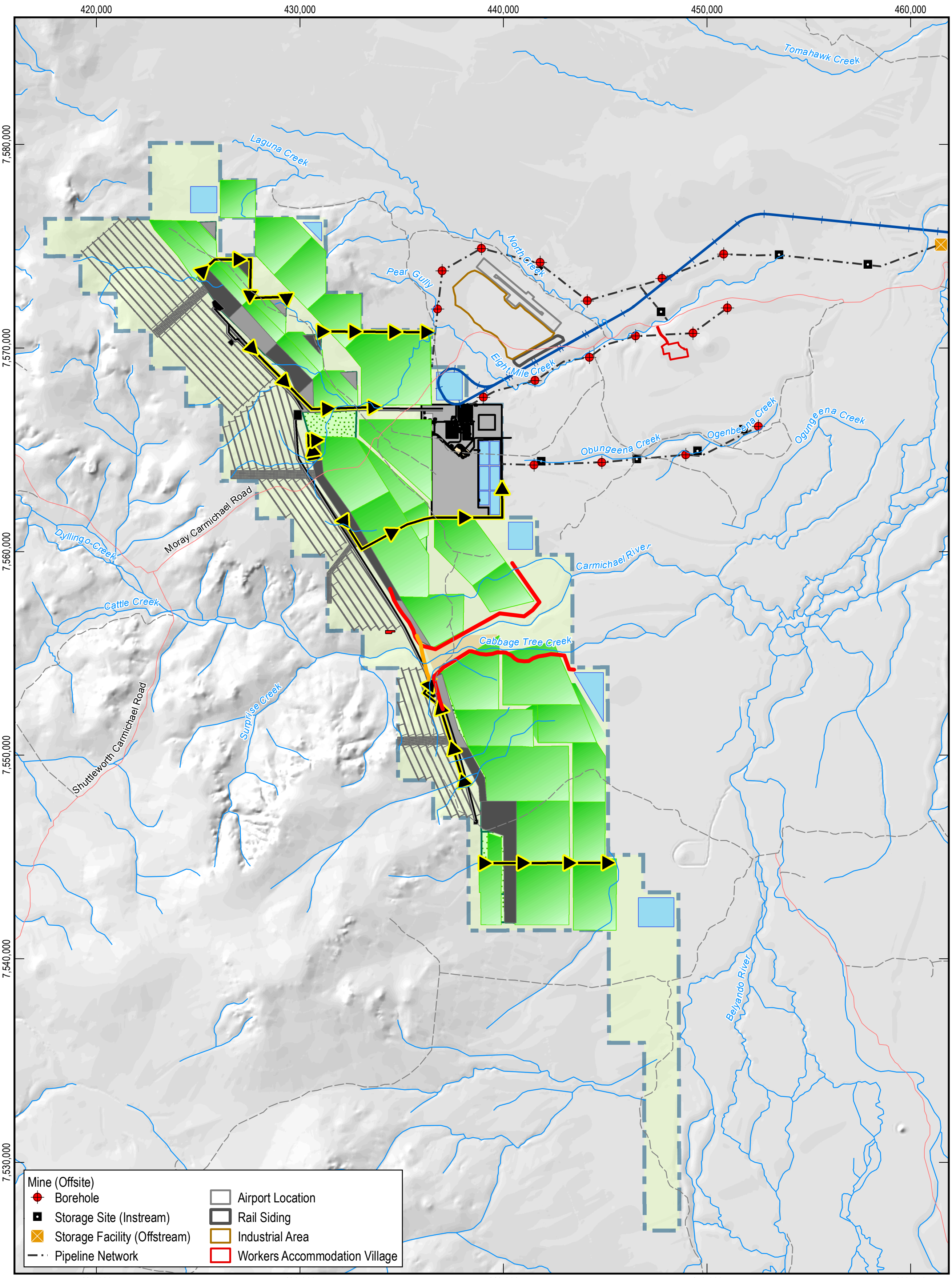
Job Number	41-25215
Revision	A
Date	03-09-2012

Mine Drainage Progress Plot - Year 2067

Figure D-9

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\41-25215_572-09_rev_a.mxd Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: © Copyright Commonwealth of Australia - Geoscience Australia: Roads, Watercourse (2007); GHD: Creek Crossings, Levees, Sediment Basins, Diversions (2012); Adani: Alignment Opt9 Rev3 (2012), Mine Layout/Infrastructure (2012); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH, CA



LEGEND

Local Road	Haul Rd & Conveyor Crossing	Void	Open Cut Blocks
Track	Levee	Remediated Void	Mine (Onsite)
Watercourse	Proposed Diversion	Area Under Rehabilitation	
Overland Conveyors	Rail (West)	Water Management Dams	

1:270,000 (at A4)
0 2 4 6 8 10
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision A
Date 03-09-2012

Mine Drainage Progress
Plot - Year 2103

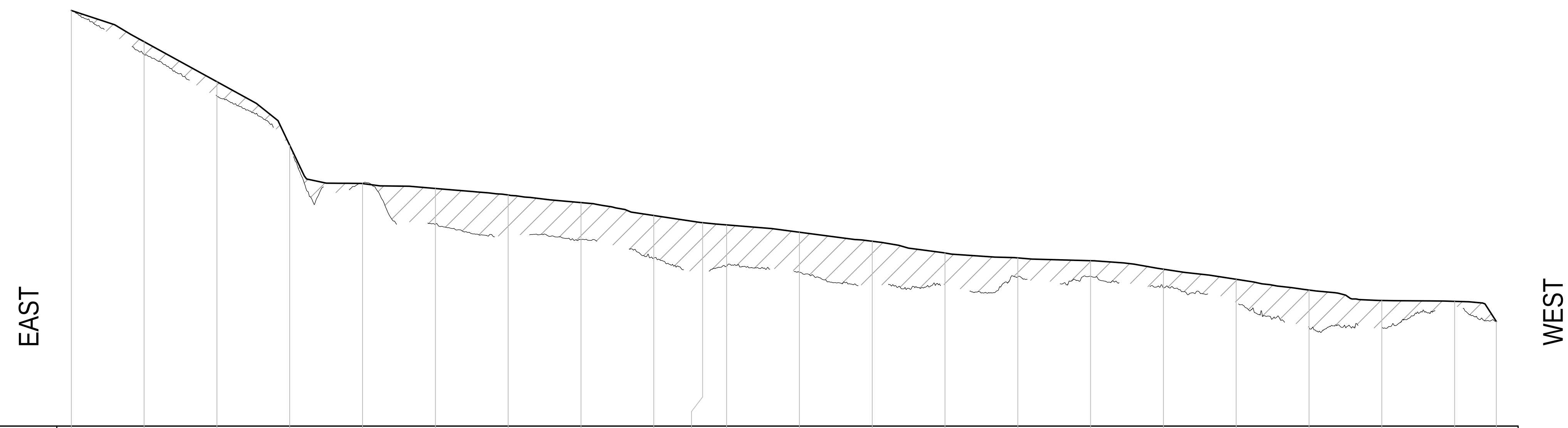
Figure D-10

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\41-25215_572-10_rev_a.mxd Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: © Copyright Commonwealth of Australia - Geoscience Australia: Roads, Watercourse (2007); GHD: Creek Crossings, Levees, Sediment Basins, Diversions (2012);
Adani: Alignment Opt9 Rev3 (2012), Mine Layout/Infrastructure (2012); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH, CA

Appendix E

Preliminary Design Drawings



DATUM RL. 213.00

LEVEL DIFFERENCE CUT - / FILL +	-0.01	0.89	1.01	0.18	-0.01	2.46	2.70	2.56	2.92	3.40	2.84	2.75	3.00	2.24	1.28	1.07	1.29	1.58	2.56	1.88	0.31	-0.00
DESIGN SURFACE LEVEL	241.584	239.443	236.691	232.319	229.687	229.350	228.905	228.375	227.484	226.970	226.839	226.337	225.719	224.910	224.569	224.378	223.798	223.098	222.358	221.645	221.579	220.198
EXISTING SURFACE LEVEL	241.59	238.56	235.68	232.14	229.70	226.89	226.21	225.82	224.57	223.57	224.00	223.59	222.72	222.67	223.29	223.30	222.51	221.52	219.79	219.77	221.27	220.20
CHAINAGE	0.00	500.00	1000.00	1500.00	2000.00	2500.00	3000.00	3500.00	4000.00	4335.32	4500.00	5000.00	5500.00	6000.00	6500.00	7000.00	7500.00	8000.00	8500.00	9000.00	9500.00	9785.88

LONGITUDINAL SECTION - SOUTH CARMICHAEL LEVEE

HORZ 1:40000 VERT 1:400

PRELIMINARY

rev	description	app'd	date
A	INITIAL ISSUE		

ADANI MINING PTY LTD

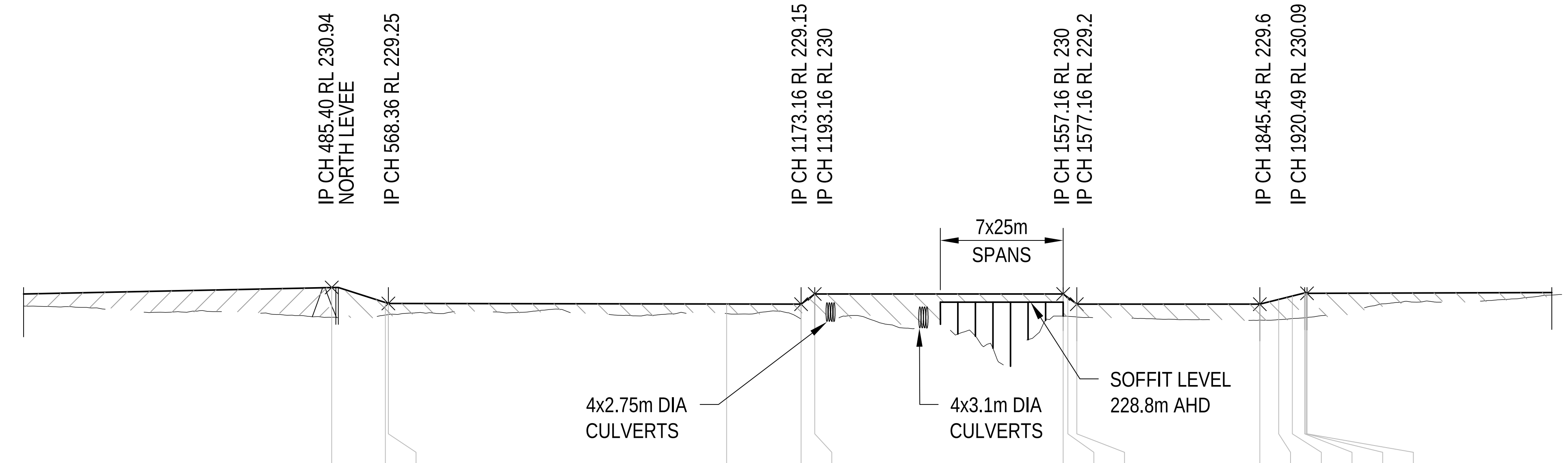
CARMICHAEL COAL MINE SURFACE WATER STUDY

SOUTH CARMICHAEL LEVEE
LONG SECTION

Level 4, 201 Charlotte St Brisbane QLD 4000 Australia
GPO Box 668 Brisbane QLD 4001
T 61 7 3316 3000 **F** 61 7 3316 3333
E bnemail@ghd.com **W** www.ghd.com

scale - for A3 job no. 41-24415
date JAN 2012 rev no. A

approved (PD) SK010



DATUM RL. 205.00

VERTICAL ALIGNMENT: L=451.54m G=0.21% | L=73.4m G=-3.19% | L=604.8m G=-0.02% | L=20m G=7.5% | L=364m G=0% | L=20m G=-7.5% | L=268.29m G=0% | L=3.31m G=-1.48% | L=358.81m G=0.03%

CHAINAGE	LEVEL DIFFERENCE CUT - / FILL +	DESIGN SURFACE LEVEL	EXISTING SURFACE LEVEL
0.00			228.51
485.40	4.38	230.944	226.57
564.00	1.83	228.745	226.91
568.36	2.28	229.250	226.97
1064.00	1.38	228.519	227.13
1173.16	2.82	229.15	226.33
1193.16	4.07	230.000	225.93
1557.16	3.25	230.000	226.75
1564.00	2.77	229.487	226.72
1577.16	2.57	229.20	226.63
1845.45	3.43	229.60	226.17
1873.10	2.95	229.190	226.24
1893.08	3.30	229.688	226.39
1911.19	3.64	230.140	226.50
1913.06	3.59	230.113	226.52
1920.49	3.55	230.090	226.54
2280.00			229.92

LONGITUDINAL SECTION - HAUL ROAD CROSSING

HORZ 1:9000 VERT 1:900

PRELIMINARY

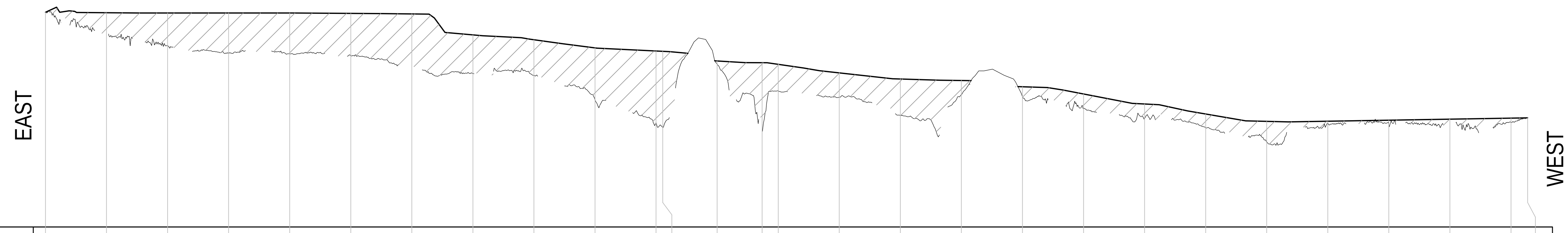
rev	description	app'd	date
A	INITIAL ISSUE		

ADANI MINING PTY LTD
CARMICHAEL COAL MINE SURFACE WATER STUDY
HAUL ROAD CROSSING
LONG SECTION

GHD
Level 4, 201 Charlotte St Brisbane QLD 4000 Australia
GPO Box 668 Brisbane QLD 4001
T 61 7 3316 3000 **F** 61 7 3316 3333
E bnemail@ghd.com **W** www.ghd.com

scale - for A3 job no. 41-24415
date JAN 2012 rev no. A

approved (PD) SK009



DATUM RL. 214.00

CHAINAGE	EXISTING SURFACE LEVEL	DESIGN SURFACE LEVEL	LEVEL DIFFERENCE CUT - / FILL +
0.00	231.58	231.579	0.00
500.00	229.51	231.538	2.03
1000.00	228.83	231.519	2.69
1500.00	228.20	231.517	3.31
2000.00	228.16	231.513	3.35
2500.00	228.01	231.484	3.47
3000.00	227.11	231.438	4.33
3500.00	226.57	229.721	3.15
4000.00	226.40	229.325	2.92
4500.00	224.41	228.662	4.26
5000.00	222.53	228.407	5.88
5054.48	222.15	228.224	6.07
5500.00	227.33	227.587	0.26
5868.08	221.88	227.422	5.55
6000.00	225.14	227.316	2.17
6500.00	224.62	226.610	1.99
7000.00	223.13	226.113	2.98
7500.00	224.83	225.993	1.16
8000.00	224.67	225.476	0.80
8500.00	223.69	224.889	1.20
9000.00	222.90	224.063	1.16
9500.00	222.12	223.249	1.12
10000.00	220.96	222.644	1.69
10500.00	222.48	222.653	0.17
11000.00	222.38	222.739	0.36
11500.00	222.47	222.824	0.35
12000.00	222.57	222.910	0.34
12136.78	222.93	222.933	-0.00

LONGITUDINAL SECTION - NORTH CARMICHAEL LEVEE

HORZ 1:35000 VERT 1:350

PRELIMINARY

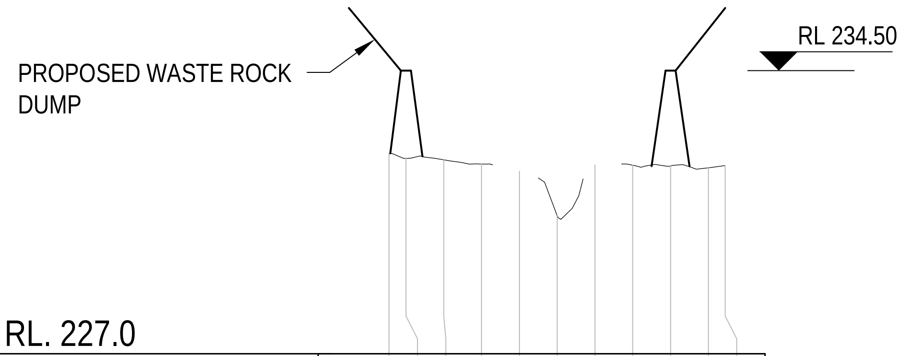
rev	description	app'd	date
A	INITIAL ISSUE		

ADANI MINING PTY LTD
CARMICHAEL COAL MINE SURFACE WATER STUDY
NORTH CARMICHAEL LEVEE LONG SECTION

Level 4, 201 Charlotte St Brisbane QLD 4000 Australia
GPO Box 668 Brisbane QLD 4001
T 61 7 3316 3000 **F** 61 7 3316 3333
E bnemail@ghd.com **W** www.ghd.com

scale - for A3 job no. 41-24415
date month 2011 rev no. A
approved (PD) DEC 2011 SK008

Plot Date: 21 August 2012 - 1:55 PM Plotted by: Shayne Johnson Cad File No: G:\41\24415\CADD\Drawings\41-24415-SK008.dwg

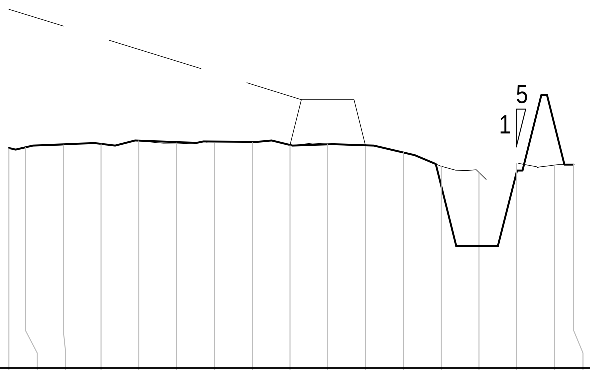


DATUM RL. 227.0

EXISTING SURFACE LEVEL	232.314	232.174	232.137	232.029	231.835	230.663	232.004	231.996	231.979	231.927	231.983
CHAINAGE	-88.93	-80	-60	-40	-20	0	20	40	60	80	88.93

CROSS SECTION OF NATURAL CHANNEL THROUGH WASTE ROCK DUMP HECRAS 13069

HORIZONTAL SCALE 1:4000
VERTICAL SCALE 1:200



DATUM RL. 230.0

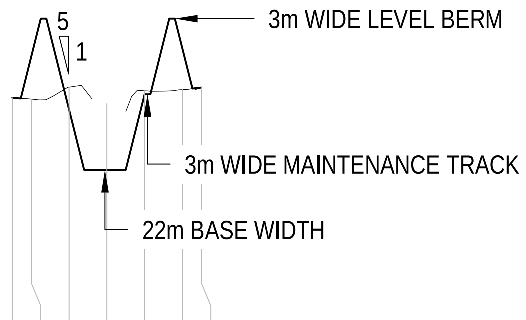
DESIGN LEVEL	235.82	235.84	235.919	235.931	236.016	235.976	235.991	235.981	235.9	235.919	235.893	235.701	234.825	233.225	235.192	236.425	235.381
EXISTING SURFACE LEVEL	235.82	235.84	235.902	235.93	236.01	235.953	235.95	235.966	235.895	235.927	235.879	235.702	235.339	235.171	235.41	235.371	235.381
CHAINAGE	-248.737	-240	-220	-200	-180	-160	-140	-120	-100	-80	-60	-40	-20	0	20	40	50

CROSS SECTION CH 7500 HECRAS STATION 15156

HORIZONTAL SCALE 1:4000
VERTICAL SCALE 1:200

NOTE:

PLEASE SEE THE PRELIMINARY FLOOD MITIGATION & CREEK DIVERSION DESIGN REPORT, SECTION 9.3, FOR DETAIL OF CASE STUDY DIVERSION DRAIN

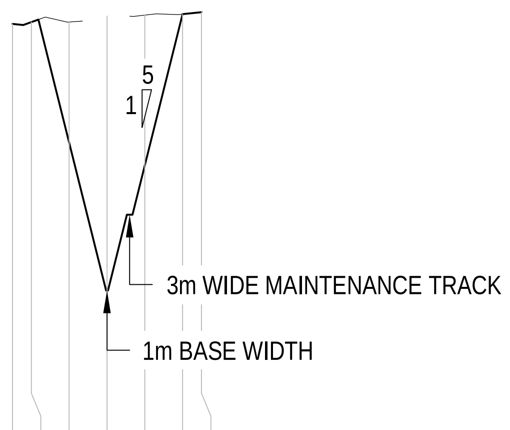


DATUM RL. 230.0

DESIGN LEVEL	235.903	236.998	235.598	233.998	235.998	237.198	236.175
EXISTING SURFACE LEVEL	235.903	235.869	236.184	235.751	236.09	236.119	236.175
CHAINAGE	-50	-40	-20	0	20	40	50

CROSS SECTION CH 7000 HECRAS STATION 15644

HORIZONTAL SCALE 1:4000
VERTICAL SCALE 1:200



DATUM RL. 239.0

DESIGN LEVEL	249.764	249.811	246.619	242.719	246.019	250.019	250.071
EXISTING SURFACE LEVEL	249.764	249.811	249.813	249.968	249.994	250.019	250.071
CHAINAGE	-50	-40	-20	0	20	40	50

CROSS SECTION CH 3000 HECRAS STATION 19644

HORIZONTAL SCALE 1:4000
VERTICAL SCALE 1:200

PRELIMINARY

rev	description	app'd	date
A	INITIAL ISSUE		

ADANI MINING PTY LTD
CARMICHAEL COAL MINE SURFACE WATER STUDY
CASE STUDY DIVERSION DRAIN
CROSS SECTIONS

GHD

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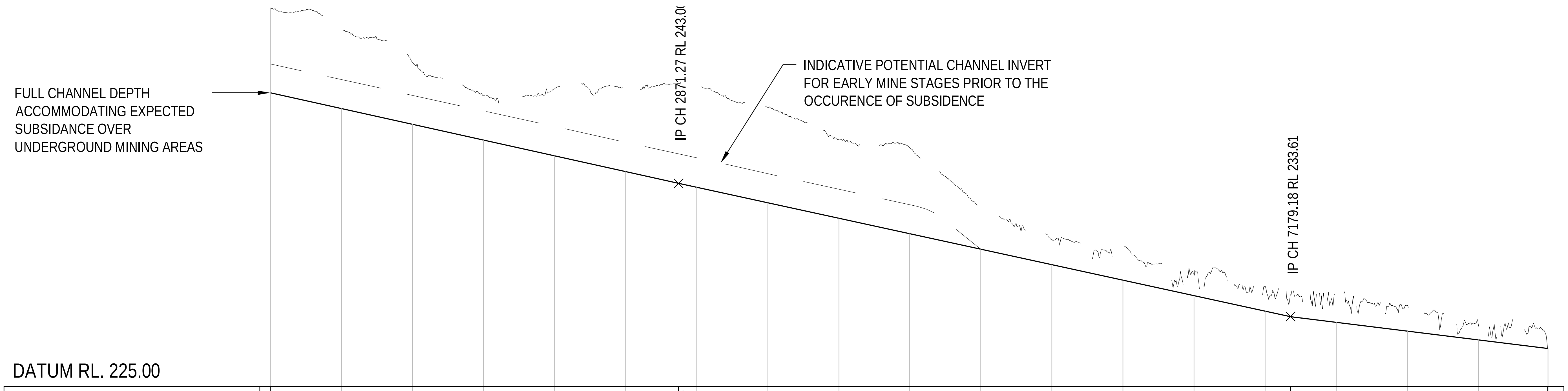
scale - for A3 job no. 41-24415
date DEC 2011 rev no. A

approved (PD) SK005



VERTICAL ALIGNMENT	L=2871.27m G=-0.22%						L=4307.91m G=-0.22%									L=1809.96m G=-0.12%			
LEVEL DIFFERENCE CUT - / FILL +	-5.97	-5.55	-4.37	-3.16	-4.72	-5.75	-7.25	-6.72	-5.56	-6.06	-2.88	-1.75	-2.38	-1.48	-1.75	-2.18	-1.80	-1.10	0.03
DESIGN SURFACE LEVEL	249.381	248.270	247.159	246.048	244.936	243.825	242.719	241.629	240.539	239.449	238.359	237.268	236.178	235.088	233.998	233.211	232.593	231.976	231.374
EXISTING SURFACE LEVEL	255.35	253.82	251.52	249.21	249.66	249.58	249.97	248.35	246.10	245.50	241.24	239.02	238.56	236.57	235.75	235.39	234.39	233.08	231.35
CHAINAGE	0.00	500.00	1000.00	1500.00	2000.00	2500.00	3000.00	3500.00	4000.00	4500.00	5000.00	5500.00	6000.00	6500.00	7000.00	7500.00	8000.00	8500.00	8990.01

CASE STUDY DIVERSION DRAIN
LONG SECTION

SCALE 1:30000 HORIZONTAL
SCALE 1:300 VERTICAL

NOTE:

1. DURING DETAILED DESIGN, ENERGY DISSIPATION MEASURES INCLUDING RIP RAP SHOULD BE IMPLEMENTED WHERE REQUIRED.
   SEE SECTION 9.3 OF THE REPORT FOR DETAILS OF DIVERSION DRAIN VELOCITY AND WIDTH.

PRELIMINARY

rev	description	app'd	date
A	INITIAL ISSUE		

ADANI MINING PTY LTD
CARMICHAEL COAL MINE SURFACE WATER STUDY
CASE STUDY DIVERSION DRAIN
LONG SECTION

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	G Mallory P Jones	G Mallory	On File	J Keane	On file	20/02/2012
B	L Macadam	J Postlethwaite	On file	J Keane	On file	05/09/2012
0	L Macadam	J Postlethwaite	On file	J Keane	On file	14/11/2012