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Sino Iron Mine Continuation Proposal

Environmental Review

Prepared for
Citic Pacific Mining
by Strategen

February 2017

Sino Iron Mine Continuation Proposal

Environmental Review

Strategen is a trading name of
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February 2017

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Client: Citic Pacific Mining

Report Version	Revision No.	Purpose	Strategen author/reviewer	Submitted to Client	
				Form	Date
Final Report	0	Final report for legal review	C Courtauld, R Chesney L Ramlee/ H Morgan, M Brook, D Walsh	Electronic	2 February 2017
Revised Final Report	1	Agency submission	C Courtauld, R Chesney L Ramlee/ H Morgan, M Brook, D Walsh	Electronic	14 February 2017

Filename: SIR16097_01 R003 Rev 1 - 14 February 2017

Endorsement:

Chen Zeng, Chief Executive Officer on behalf of: • Sino Iron Pty Ltd ACN: 058 429 708 • Korean Steel Pty Ltd ACN: 058 429 600	Signed: Date: 14th Feb. 2017

Executive Summary

CITIC Limited (formerly named CITIC Pacific Limited) is the ultimate owner of Sino Iron Pty Limited (Sino Iron) and Korean Steel Pty Limited (Korean Steel). Sino Iron and Korean Steel each hold mining rights and subleases authorising the extraction of a combined two billion tonnes (Bt) of magnetite ore, from an orebody known as the George Palmer deposit, located in the West Pilbara region of Western Australia, and contained entirely within Mining Leases M08/123, M08/124 and M08/125.

In 2006, CITIC Limited established CITIC Pacific Mining Management Pty Ltd (CPM) to manage development and ongoing operation of its iron ore mine and export facilities at Cape Preston collectively referred to as the Sino Iron Project. CPM conducts those activities on behalf of Sino Iron and Korean Steel, the proponents for the Sino Iron Project authorised pursuant to Statement 635 (which was granted by the Minister for the Environment under Part IV of the *Environmental Protection Act 1986* (EP Act) in 2003, as amended from time to time).

The existing Sino Iron Project (the existing project) is located at Cape Preston, 80 km south west of Karratha, within the Pilbara region of WA.

The existing project involves the open cut mining, processing and export of magnetite ore and includes:

- mining and crushing of ore and associated groundwater drawdown and waste rock disposal
- ore processing facilities that include pellet and hot briquette plants (yet to be constructed), concentrators, and tailings disposal areas
- infrastructure including power station, desalination plant, workforce accommodation, roads, conveyors, pipelines, bore fields, site drainage structures, flood protection and waste disposal facilities, workshops and administration facilities
- port terminal infrastructure including product stockyards, conveyors, barge loading and transhipment facility, rock causeway and breakwater structure, trestle jetty and dredge berth (yet to be constructed).

The Sino Iron Mine Continuation Proposal (the Proposal) is an expansion of the existing project required to accommodate 2 Bt of mine operations. The Proposal does not seek to alter existing mining, processing and tailings production rates or increase throughput of the desalinisation plant. The Proposal is limited to addressing constraints which are contained within the existing project approvals. The Proposal will ensure continuous operation of the existing project by expanding current facilities including tailings storage facilities (TSF), waste rock landforms, the mine pit (area and depth), product stockyard capacity and other supporting infrastructure. The Proposal will increase discharge of mine dewater into the Fortescue River mouth from two gigalitres per annum (GLpa) to up to 8 GLpa.

In implementing the Proposal, the proponents will use the existing processing and operating infrastructure and administration facilities in accordance with current management practices approved under Statement 635.

Table ES1 provides a summary of the Proposal. Table ES2 provides a description of the location and proposed extent of physical and operational elements of the existing project and the Proposal. Table ES3 provides a summary of potential impacts, proposed mitigation and outcomes for the Proposal.

Table ES1: Summary of the proposal

Proposal title	Sino Iron Mine Continuation Proposal
Proponents name	Sino Iron Pty Ltd and Korean Steel Pty Ltd
Short description	The proposal will expand an existing iron ore mine, processing and export facility at Cape Preston.

Table ES2: Location and proposed extent of physical and operational elements

Element	Location	Approved extent (existing project under Statement 635)	Proposed change (this Proposal)	Proposed extent (revised Proposal)
Physical elements				
Mine and associated infrastructure • Mine pit • WRD • TSF • Port & stockyard • Other • **total**	Mine area	 • 360 ha • 600 ha • 987 ha • 48 ha • 739 ha • **2734 ha**	Increase in disturbance of 7366 ha	No more than 10 100 ha within a Development Envelope of 22 737 ha
Operational elements				
Depth of Pit	Figure 1	Up to 220 m	Additional 180 m	Approximately 400 m
Rate of mining (Ore)		Up to 95 Mtpa	No change	Up to 95 Mtpa
PROCESS PLANT				
Concentrator Rate		Up to 27.6 Mtpa	No change	Up to 27.6 Mtpa
Produced waste to tailings storage		Up to 67.4 Mtpa	No change	Up to 67.4 Mtpa
Pellet production		Up to 13.8 Mtpa	No change	Up to 13.8 Mtpa
Direct reduced/hot briquetted iron	Figure 1	Up to 4.7 Mtpa	No change	Up to 4.7 Mtpa
Infrastructure				
Power Station capacity; gas usage		640MW	No change (Note: only 450 MW constructed to date)	640 MW
Product conveyor/ haul road Mine to Port Service corridor	Figure 1	25 km from mine site to port at Cape Preston – average width 55 m, 81 m at crossing from mainland to Cape Preston Road. Buried slurry pipeline Dewatering plant at the port Additional buried pipelines Power transmission lines	No change	25 km from mine site to port at Cape Preston – average width 55 m, 81 m at crossing from mainland to Cape Preston Road. Buried slurry pipeline Dewatering plant at the port Additional buried pipelines Power transmission lines
Groundwater bore field		Amount to be determined by relevant decision making authority.	No change	Amount to be determined by relevant decision making authority.

Element	Location	Approved extent (existing project under Statement 635)	Proposed change (this Proposal)	Proposed extent (revised Proposal)
Pit dewatering		In accordance with DoW Licence	No change	In accordance with DoW Licence
Dewater discharge	Mouth of the Fortescue River	2 GLpa	Increase in discharge by up to 6 GLpa	Up to 8 GLpa
Desalinated seawater	Figure 1	Up to 44 GL per annum	No change	Up to 44GL per annum
Brine disposal	Figure 1	Up to 57.8 GL per annum	No change	Up to 57.8GL per annum
Accommodation Village	Figure 1	Accommodation village: One permanent village – located on mainland north of the mine, opposite Carey Island (up to 970 people). Village also used as construction camp. Two construction camps located onsite, on ML08/123 and at permanent village sites	No change (Note: only M08/123 construction camp implemented to date)	Accommodation village: One permanent village – located on mainland north of the mine, opposite Carey Island (up to 970 people). Village also used as construction camp. Two construction camps located onsite, on ML08/123 and at permanent village sites.
Port				
Product stockyard capacity		Approximately 1 Mt	Approximately 2 Mt	Approximately 3 Mt
Bridging structures or rock causeway to Preston Island	Figure 1	Approximately 1.1km, bridging structures or rock causeway to island, then trestle jetty.	No change	Approximately 1.1km, bridging structures or rock causeway to island, then trestle jetty.
Dredging		Up to 4.5 million metres cubed (Mm3) disposed offshore.	No change (Note: berth pocket, shipping channel and direct ship loading jetty yet to be constructed)	Up to 4.5 million metres cubed (Mm3) disposed offshore.

Table ES3: Summary of potential impacts, proposed mitigation and outcomes

Element	Description
Hydrological processes	
EPA objective	To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.
Policy and guidance	*Environmental Factor Guideline - Hydrological Processes*
Potential impacts	• groundwater drawdown from dewatering has potential to modify groundwater and surface water flows • discharge of groundwater has potential to modify surface water flows in the Fortescue River • diversion of Edwards Creek will modify surface water flows • construction of physical elements will alter surface water flows.
Mitigation	Avoid:
	• incorporate flood modelling data and surface flow data into the design of the Proposal to avoid impacts to hydrological processes.
	Minimise:

Element	Description
	• discharging groundwater to the Fortescue River on outgoing tides to minimise changes to hydrological processes • a naturally vegetated buffer will be maintained between the bunds around the Proposal elements and floodplain channels to limit increases in flood levels and velocities, and minimise erosion • monitoring will be undertaken to continue to assess potential impacts to nearby creeklines • an Operating Strategy shall detail the monitoring and adaptive management measures for of the groundwater drawdown aspects • realignment of the southern branch of Edwards Creek into two sections to enable the minimisation of the disturbance area of the infrastructure.
Outcomes	Residual Impact:
	• the extent of the 0.5 m, 5.0 m and 10.0 m drawdown contours will decrease relative to the existing project • the recovery of groundwater is expected to result in a pit lake of approximately 250 m deep in the west pit and 20 m deep in the east pit • the regional groundwater levels are not expected to be substantially affected • no permanent pools will be significantly affected • the modelled cumulative impacts of all proposed mining operations at Cape Preston do not substantially affect groundwater levels. Should it be constructed in the future the Balmoral South bore field will increase the extent of the 1.0 m drawdown contour. • during mining the predicted inflows that will need to be dewatered are 8.0 GLpa • the discharge of 8.0 GLpa will not substantially affect flows of the Fortescue River • the development of a WRD adjacent to Du Boulay Creek is not expected to affect the volumes or substantially increase the velocity of flow.
	Offset:
	As the Proposal will meet EPA objective for Hydrological processes no offset is required.
Inland waters environmental quality	
EPA objective	To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values are protected
Policy and guidance	*Environmental Factor Guideline - Inland Waters Environmental Quality*
Potential impacts	• diversion of Edwards Creek has the potential to increase stream velocity, which may affect water quality • physical development of the site and use of infrastructure will generate runoff which has the potential to affect surface water quality • following the formation of a pit lake after closure, evaporation and groundwater flow into the pit has the potential to affect water quality within the pit lake and surrounding environmental values.
Mitigation	Avoid:
	• maintain the same length and natural design (8 – 10 m bed width) for the diversion of Edwards Creek
	Minimise:
	• discharge groundwater on outgoing tides • pass all runoff from disturbed areas through sediment traps prior to discharging downstream (during both construction and operation) • collect seepage from the tailing dam and use it on the mine site for ore-processing, dust control purposes and road-making • remove sediment from sediment basins prior to the wet season to the extent needed to maintain capacity. As required dispose of sediments to bio-remediation facility • monitoring will be undertaken including visual inspection of water quality and quantity in major creeklines and Fortescue River pools.
	Rehabilitate:
	• contain and cleanup any spill in accordance with DR017219 Hydrocarbons - Hazardous Materials Spill Response Procedure - Land.
Outcomes	Residual Impact:

Element	Description
	• diversion of Edwards Creek will not significantly alter either flow or velocity within the creek and therefore is not expected to affect water quality of either Edwards Creek or Fortescue River downstream • collection of surface runoff in sedimentation ponds will prevent surface water contamination • pit lake will act as a terminal sink and likely become hypersaline over time although surrounding groundwater quality will not be adversely affected.
	Offset:
	As the Proposal will meet EPA objective for Inland waters environmental quality no offset is required.
Marine environmental quality	
EPA objective	To maintain the quality of water, sediment and biota so that the environmental values are protected
Policy and guidance	• *Environmental Factor Guideline - Marine Environmental Quality* • *Technical Guidance Protecting the Quality of Western Australia's Marine Environment*
Potential impacts	• discharge of groundwater has the potential to affect the water quality of the Fortescue River estuary.
Mitigation	Avoid:
	• undertake monitoring in accordance with DER discharge licence to ensure the groundwater salt, metal and nutrient concentrations are consistent with discharge licence requirements.
	Minimise:
	• discharging groundwater on outgoing tides to ensure discharge water is rapidly diluted to achieve the target dilution • discharging via a diffuser in accordance with dilution modelling (RPS APASA 2017) • to ensure the integrity of infrastructure any debris or other blockages will be cleared as required. • implement DR017219 Hydrocarbons - Hazardous Materials Spill Response Procedure - Land.
Outcomes	Residual Impact:
	• target dilution for salinity (TDS) is a dilution level of 27 times, which will be achieved throughout the model for both a median and 80^{th} percentile assessment of an 8 GLpa discharge • an 8 GLpa discharge is rapidly diluted on the falling tide and modelling shows no sign of build-up of salinity.
	Offset:
	As the Proposal will meet EPA objective for Marine environmental quality no offset is required.
Flora and vegetation	
EPA objective	To protect flora and vegetation so that biological diversity and ecological integrity are maintained
Policy and guidance	• *Environmental Factor Guideline – Flora and vegetation* • *Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment* Policies and guidelines prior to 13 December 2016: • Guidance Statement No. 51 *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004)* • *Position Statement No. 3 Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002)*
Potential impacts	• clearing of native vegetation has the potential to affect the regional representation of vegetation communities and flora species • clearing has the potential to introduce/spread weeds • groundwater drawdown from dewatering has the potential to affect groundwater dependent ecosystems.
Mitigation	Avoid:
	• inspection of the site for the presence of Mesquite or Parkinsonia prior to any machinery being moved to a site • maintenance of adequate fire breaks across the mine site and around working areas.
	Minimise:

Element	Description
	• restricting clearing to approved areas through the implementation of an internal ground disturbance permit system • restricting all vehicles and equipment to within designated tracks and parking areas • restricting all earthworks and movements of machinery and vehicles to within marked clearing or disturbance boundaries • requirements for all earthmoving machinery to be inspected as clean and free of weed and seed prior to entry and exit from a site • monitoring of GDE vegetation as outlined in the GDVMP (Astron 2015) will be conducted and contingency responses activated when trigger levels are exceeded
	Rehabilitate:
	• Disturbed areas (excluding the mine pit) will be rehabilitated to provide environmentally safe and stable landforms.
Outcomes	Residual Impact:
	• approximately 7366 ha of vegetation will be cleared by the Proposal with the majority of this occurring in habitat of low to moderate conservation significance and well represented in the region • loss of 121.51 ha of vegetation from the Horseflat Land System, a Priority 3iii Ecological Community although this will not result in a significant reduction in the extent of this community with total clearing in the Roebourne Subregion less than 0.5% • no Threatened Flora species listed under either the WC Act or EPBC Act will be affected by the Proposal • no Priority Flora species as listed by Parks and Wildlife will be affected by the Proposal • no change to GDE health is predicted with implementation of the GDE the monitoring plan and related adaptive management actions; and as a result of minimal changes to of groundwater levels (0.5 m) • the Proposal will not conflict with the WC Act as no flora species will significantly affected or have its conservation status affected by the Proposal's implementation.
	Offset:
	As the Proposal will meet EPA objective for Flora and vegetation no offset is required.
Terrestrial fauna	
EPA objective	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained
Policy and guidance	• *Environmental Factor Guideline - Terrestrial Fauna* • *Technical Guidance - Sampling methods for terrestrial vertebrate fauna* • *Technical Guidance - Terrestrial fauna surveys* • *Technical Guidance – Sampling of short range endemic fauna* Policies and guidelines prior to 13 December 2016: • EPA Guidance Statement 20*, Sampling of Short-Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009)* • EPA Guidance Statement 56, *Terrestrial Fauna Surveys for Environmental Impact Assessment in WA (EPA 2004)* • EPA Position Statement 3, *Terrestrial Biological Surveys as an element of Biodiversity Protection (EPA 2002)* • *Technical Guide -Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA and DEC 2010)*
Potential impacts	• the majority of clearing will occur in habitat of low or moderate conservation significance • clearing of approximately 0.12 ha Northern Quoll habitat • clearing for the Development Envelope may disrupt localised fauna linkages for Northern Quoll and other fauna • the process of clearing may result in the deaths of individual terrestrial fauna • vehicle movements during construction and operation could potentially lead to the fatality or injury of individual fauna • interaction of personnel with introduced feral predators has the potential to increase numbers of introduced feral predators which may increase the predation of native animals, particularly small mammals such as the Northern Quoll • light spill, noise emissions, dust and vibration could alter fauna behaviour through avoidance and disruption to behaviour.
Mitigation	Avoid:

Element	Description
	• the Proposal footprint will avoid drainage line habitat alongside Du Boulay creek • maintaining a buffer alongside the Du Boulay Creek to allow potential movement of fauna • preventing unauthorised access to Northern Quoll habitat • record Northern Quoll habitats to ensure baiting exclusion zones to reduce risk of secondary or accidental poisoning.
	Minimise:
	• informing the workforce of the fauna present and preventing direct and inadvertent feeding of feral animals. • implementing and signposting speed limits for both mining equipment and light vehicles in the Development Envelope and on access roads • undertake baiting outside of Northern Quoll breeding season, outside of known habitat and bury baits to prevent non-target species locating the baits.
	Rehabilitate:
	• undertaking feral animal control.
Outcomes	Residual Impact:
	• the majority of the disturbance (approximately 5100 ha of the 7366 ha Proposal) occurs in the Low conservation significance Stony Spinifex plain with or without low shrub and Hilltop/hill slopes/rocky outcrops habitat types • disturbance of habitats of Moderate or High local conservation significance occurs in habitats that have been degraded as a result of historical pastoral activities, such as drainage lines and cracking clay units; disturbance within other habitat types (i.e. dunes, samphire and mangrove) is limited • clearing of Northern Quoll habitat is limited to 0.12 ha and impact on Northern Quoll populations is unlikely as they were not found to utilise the potential habitat within the Proposal footprint during the reconnaissance and targeted surveys • the Proposal will not conflict with the WC Act as no fauna species will be made extinct or have its conservation status affected as the result of the implementation of the Proposal • no species listed as Endangered or Vulnerable under either the WC Act or EPBC Act will be affected by the Proposal.
	Offset:
	As the Proposal will meet EPA objective for Terrestrial fauna no offset is required.
Terrestrial environmental quality	
EPA objective	To maintain the quality of land and soils so that environmental values are protected
Policy and guidance	• *Environmental Factor Guideline – Terrestrial Environmental Quality* • *Management of fibrous minerals in Western Australian mining operations – guideline (DMP 2015).*
Potential impacts	• mining activities have the potential to cause fibrous minerals to become airborne • inappropriate management of potential asbestiform material (including post-closure storage, and mine pit wall exposures) has the potential to cause fibrous minerals to become airborne.
Mitigation	Minimise:
	• mine planning that minimises the interaction with Dales Gorge material • disposing of potentially asbestiform containing material in designated encapsulated cell within WRDs • encapsulation and rehabilitation of TSF areas progressively when and where possible • a rigorous program of preventing or suppressing fibre/dust release (e.g. by water spraying, misting and fogging, application of binders and surfactants, installation of extraction ventilation, etc.). Prevention and/or suppression methods will be used for drilling and blasting, loading, transfer of ore and waste, crusher operations and conveyor transport of ore, processing operations including management of tailings, stockpile management and transfer of concentrate through to transfer onto export vessels • conducting workplace inspections and audits to ensure controls are maintained to a required standard.
	Rehabilitate:
	• Disturbed areas (excluding the mine pit) will be rehabilitated to provide environmentally safe and stable landforms.
Outcomes	Residual Impact:

Element	Description
	• the ongoing implementation of existing management measures (described above) will ensure the Proposal will not result in any significant impact to terrestrial environmental quality
	Offset:
	As the Proposal will meet EPA objective for Terrestrial environmental quality no offset is required.

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1. Introduction

1.1 Purpose and scope

CITIC Limited (formerly named CITIC Pacific Limited) is the ultimate owner of Sino Iron Pty Limited (Sino Iron) and Korean Steel Pty Limited (Korean Steel). Sino Iron and Korean Steel were acquired from Mineralogy Pty Ltd (Mineralogy) and are both parties to the agreement scheduled to the *Iron Ore Processing (Mineralogy Pty. Ltd.) Agreement Act 2002* (as amended) (IOPAA).

Sino Iron and Korean Steel each hold mining rights and subleases authorising the extraction of a combined two billion tonnes (Bt) of magnetite ore, from an orebody known as the George Palmer deposit, located in the West Pilbara region of Western Australia, and contained entirely within Mining Leases M08/123, M08/124 and M08/125.

In 2006, CITIC Limited established CITIC Pacific Mining Management Pty Ltd (CPM) to manage development and ongoing operation of its iron ore mine and export facilities at Cape Preston collectively referred to as the Sino Iron Project. CPM conducts those activities on behalf of Sino Iron and Korean Steel in accordance with requirements within Statement 635 (which was granted by the Minister for the Environment under Part IV of the *Environmental Protection Act 1986* (EP Act) in 2003.

The existing Sino Iron Project (the existing project), is located at Cape Preston 80 km south west of Karratha within the Pilbara Region of WA (Figure 1-1).

The existing project involves the open cut mining, processing and export of magnetite ore and includes the following:

- mining and crushing of ore and associated groundwater drawdown and waste rock disposal
- ore processing facilities that include pellet plants (yet to be constructed), concentrators, and tailings disposal areas
- infrastructure including power station, desalination plant, workforce accommodation, roads, conveyors, pipelines, site drainage structures, flood protection and waste disposal facilities, workshops and administration facilities
- port terminal infrastructure including; product stockyards; conveyors; barge loading and transhipment facility; rock causeway and breakwater structure; trestle jetty and dredge berth (yet to be constructed).

The Sino Iron Mine Continuation Proposal (the Proposal) is an expansion of the existing project required to accommodate 2 Bt of mine operations. The Proposal does not seek to alter existing mining, processing and tailings production rates or increase throughput of the desalinisation plant. The Proposal is limited to addressing constraints which are contained within the existing project approvals. The Proposal will ensure continuous operation of the existing project by expanding current facilities that include tailings storage areas (TSF); waste rock landforms; mine pit area and depth; product stockyard capacity; and other supporting infrastructure. The Proposal will increase discharge of mine dewater discharge into the Fortescue River mouth from 2 gigalitres per annum (GLpa) to up to 8 GLpa.

The Proposal will use the existing processing and operating infrastructure, administration facilities and continue to apply current management practices approved under Statement 635.

1.2 Proponent

The Proponents for the Proposal are Sino Iron Pty Limited and Korean Steel Pty Limited (the proponents for the Sino Iron Project authorised by Statement 635).

Proponent details:

Sino Iron Pty Ltd – ACN 058 429 708
Korean Steel Pty Ltd – ACN 058 429 600
GPO Box 2732
Perth WA 6001

Key contact:

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Manager Sustainability and Environment
CITIC Pacific Mining Management Pty Ltd
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Bruce.watson@citicpacificmining.com

1.3 Environmental impact assessment process

This Environmental Review has been prepared in accordance with Environmental Protection Authority (EPA) *Instructions on how to prepare an Environmental Review Document* (EPA 2016a) to support referral of the Proposal under s 38 of the EP Act.

In accordance with s 2.3.1 of the *Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016*, this Environmental Review aims to provide sufficient information for the EPA to assess the Proposal at the referral stage. Specifically, this Environmental Review has been prepared to a standard consistent with that of similar Environmental Reviews for mines in Western Australia and provides a comprehensive review of environmental factors relevant to the Proposal.

The Proposal will continue to be managed in accordance with the existing project's approved practices. The Proponents have demonstrated a high standard of environmental performance and compliance in the existing project. In addition, the Proponents has undertaken substantial consultation for the Proposal with government agencies (referred to as Decision-Making Authorities (DMAs)). The existing project has in place appropriate licences and secondary approvals and well-established relationships with relevant DMAs. Consultation with DMAs has included describing the Proposal as well as determining steps to progress appropriate licences and secondary approvals to support the Proposal, subsequent to approval under Part IV of the EP Act.

The Proponents has undertaken consultation with the Australian Government Department of Environment and Energy (DEE). The Proposal was referred to the Minister under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 19 January 2017. The referral (2017/7862) was advertised on 27 January 2017 and will available for comment until 10 February 2017. Whether the Proposal is a 'controlled action' under the EPBC Act has not yet been determined.

The Proposal will be submitted to the Minister for State Development for approval in accordance with the IOPAA in due course.

1.4 Other approvals and legislation

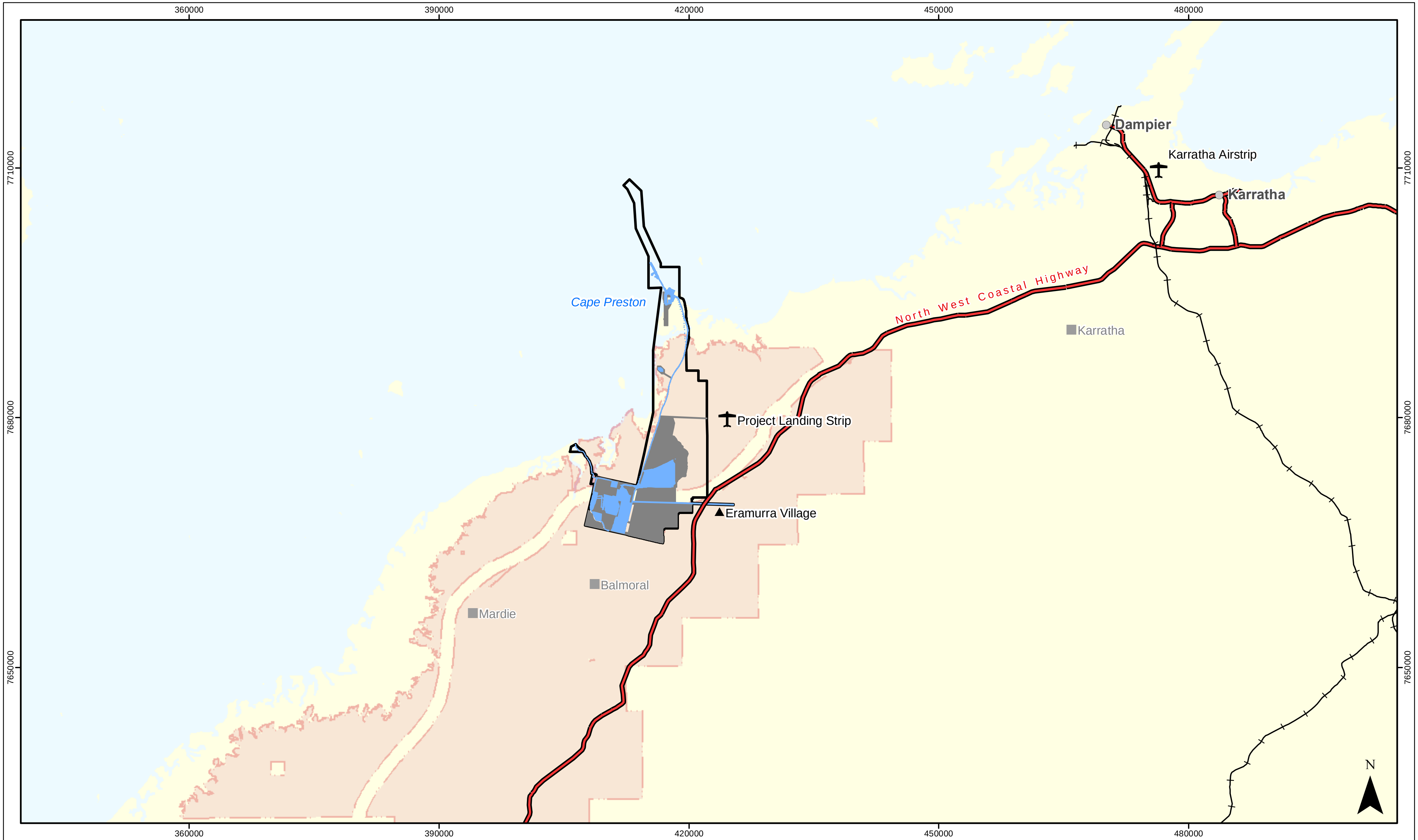
The Proposal is located within the Mardie Station Pastoral Lease (approximately 225 000 ha), which is operated by Pastoral Management Pty Ltd (PMPL) (also a subsidiary company of CITIC Limited) as a cattle station outside the approved mining areas.

With the exception of L08/126 (held by PMPL), the Proposal is located within 'Area A' under the IOPAA (Sino Iron and Korean Steel are parties to the IOPAA and will implement the Proposal in accordance with proposals approved under that State Agreement). Tenements located within 'Area A' are described within Figure 2-6.

The Proponents have appropriate licences and secondary approvals for the existing project as identified in Table 1-1.

Table 1-1: Other approvals and regulation

State and Local Government approvals			
Is rezoning of any land required before the proposal can be implemented? If yes, please provide details.			No
If this proposal has been referred by a decision-making authority, what approval(s) are required from you?			N/A
Proposal activities	**Land tenure/access**	**Type of approval**	**Legislation regulating the activity**
Clearing of native vegetation	IOPAA *Mining Act 1979*	Part IV assessment	EP Act – *Part IV*
Abstraction / Dewatering	IOPAA *Mining Act 1979*	Section 5C Licence to take groundwater Section 26D Licence to construct wells Part IV assessment Part V assessment	*Rights in Water and Irrigation Act 1914* (RiWI Act) EP Act – *Part IV* EP Act – *Part V*
Mining and processing	IOPAA *Mining Act 1979*	Approval of additional Project Proposals Part IV assessment Part V assessment	IOPAA EP Act – *Part IV* EP Act – *Part V*
Disturbance of Aboriginal Heritage sites	IOPAA *Mining Act 1979*	Section 18 consents	*Aboriginal Heritage Act 1972*



CITIC PACIFIC MINING
中信泰富矿业

Mine Continuation Proposal

Figure 1 - 1

Regional location

0 10 20
Kilometres
1:600,000

Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	20/01/2017
Sheet Size:	A4	Status:	Final

Drawn by DS	Requested by MB, Strategen	Internal Reference 4397_01_2017_APP

Legend

- Development Envelope
- Conceptual Footprint
- Statement 635 approval (MS635)
- Populated Place
- Airport
- Eramurra Village
- Homesteads
- Railway
- Principal Road
- Mardie Station

2. The Proposal

2.1 Background

2.1.1 Existing project regulatory history

The existing project was assessed by the EPA under Part IV of the EP Act at a Public Environmental Review (PER) level (referred to in this document as the Austeel PER). This assessment processes also included completion of a Supplementary Environmental Review (SER). Following assessment by the EPA (Bulletin 1056), the existing project was approved by the Minister for the Environment through Statement 635 in October 2003. Subsequent to this approval there have been five s 45c applications to amend the existing project resulting in the following attachments to Statement 635:

- Attachment 1 - Increase in mining rate to approximately 67.4 Mtpa, increase in concentrator rate to approximately 19.6 Mtpa, and increase in production rate of tailings to approximately 47.8 Mtpa (approved 8 September 2004)
- Attachment 2 - Changes in the project layout and increases in infrastructure footprint, including relocation of accommodation village and construction camps, desalination plant, services corridor route, gas pipeline route, waste dumps, TSF, port stockpiles, and expansion of the services corridor and use of a buried slurry pipeline in place of conveyor (approved 13 February 2009)
- Attachment 3 - Relocation of proposed pellet plant from original location near mine site to the project's port at Cape Preston (approved 18 March 2009)
- Attachment 4 - Increases in footprint of mine pit, waste dumps, and tailings storage facility, and increases in mining rate to 95 Mtpa and processing rates (approved 3 July 2009)
- Attachment 5 - Increase to disturbance area (for roads, infrastructure associated with the TSF and for a dewater discharge pipeline from mine to a proposed discharge location near the mouth of the Fortescue River) and discharge of dewatered groundwater from mine site to a location near the mouth of the Fortescue River (approved 31 August 2016).

Statement 822 was issued on 23 December 2009 following a s 46 application to amend the approval conditions in Statement 635. Statement 822 removed Condition 7-1 (5) and Conditions 8-1 to 8-4 of Statement 635 and replaced them with Conditions 8-1 to 8-8. The conditions removed from Statement 635 related to the requirement to conduct further investigations into seawater quality and the location of the marine outfall and replaced them with conditions related to Ecological Protection Areas.

2.1.2 Balmoral South Iron Ore Project – on hold

The Balmoral South Iron Ore Project was proposed by Mineralogy to the south of the existing Sino Iron Project. The Balmoral South Iron Ore Project was assessed by the EPA at the level of PER and recommended for approval with conditions in October 2009 (Report 1340) with Statement 823 issued in December 2009. However, the Balmoral South Project has not progressed in line with condition three of Ministerial Statement 823 (which imposes a 5 year commencement period on the approval) and the Proponents are not aware of any plan by Mineralogy to progress that project.

2.1.3 Mineralogy Expansion Proposal (MEP) – on hold

In 2009 Mineralogy prepared a PER for the Cape Preston Iron Ore Project (the Mineralogy Expansion Proposal (MEP)) (Figure 2-1). The MEP was also referred to as Stages 3-5 of the Mineralogy Cape Preston Iron Ore Project (with the existing Sino Iron Project referred to as Stage 1 and the Balmoral South Iron Ore Project referred to as Stage 2).

Stages 3, 4 and 5 of the MEP were for three different proponents. Stage 3 represented an expansion of the Sino Iron Project, with Stage 4 and 5 comprising development of the proposed Mineralogy Iron Ore Project and the Austeel Steel Project on adjacent tenements. The MEP proposed an increase in the overall disturbance footprint of approximately 20 000 ha in addition to the cumulative 7000 ha already approved for the existing project and the adjacent Balmoral South Project (discussed above).

Stage 3 of the MEP was almost identical to this Proposal and therefore this Environmental Review references information from the MEP for context (Figure 2-2).

The environmental assessment for the MEP was not concluded and has been placed on hold by the EPA. However, prior to being placed on hold the PER for the MEP had been prepared in accordance with EPA approved Environmental Scoping Document and approved for release for a six week public comment period (5 October 2009 to 16 December 2009). During the preparation of the PER and public comment period substantial consultation was undertaken with government agencies and non-government organisations. The consultation involved 26 groups including:

- key government Ministers, agencies and regional branches
- the Shire of Roebourne (Local Government Authority) (now the City of Karratha)
- non-government organisations that represent indigenous interests, conservation and recreation groups and industry bodies
- community groups
- local business groups.

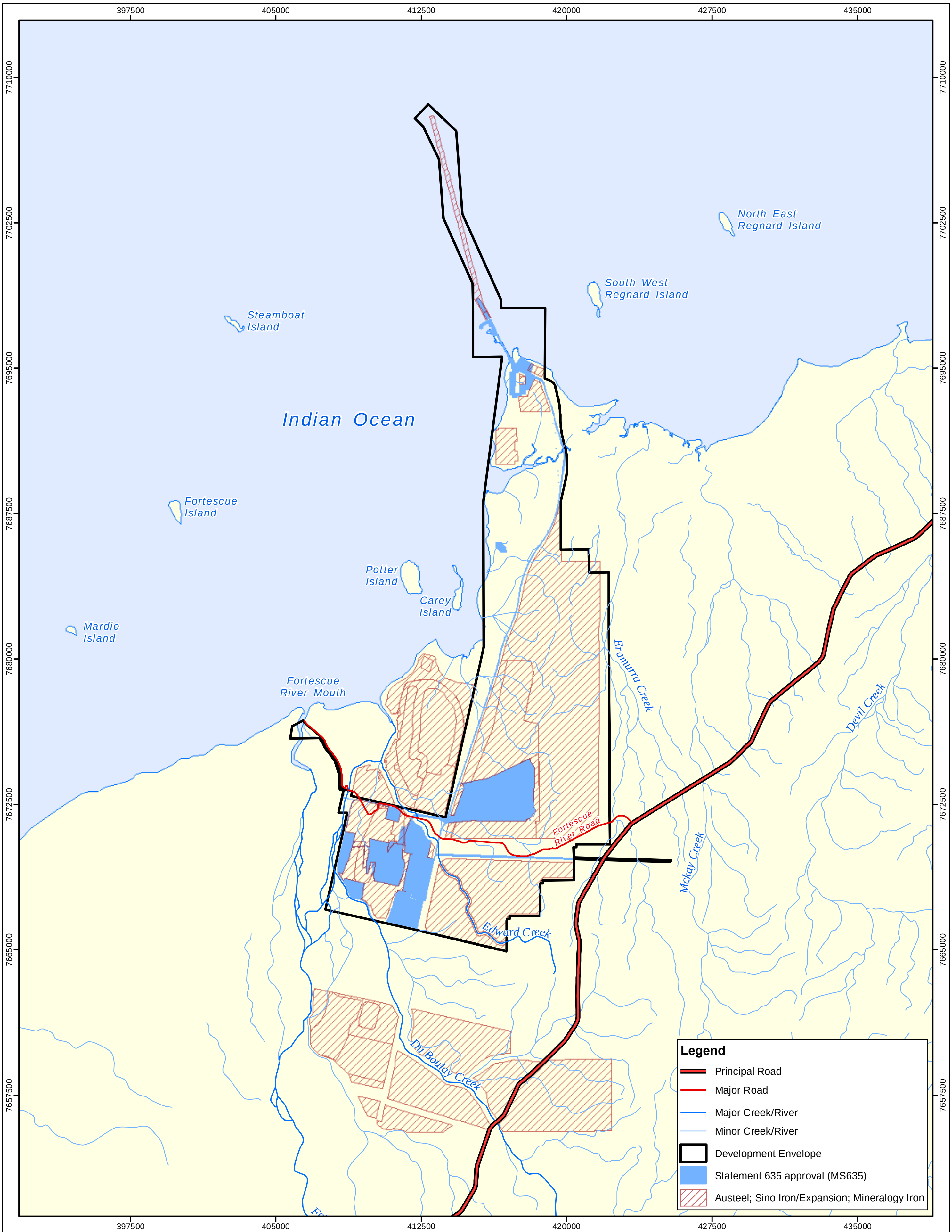
During the preparation of the PER the main issues raised by stakeholders related to:

- effects on vegetation and flora and fauna (including subterranean fauna and short-range endemics and faunal linkages)
- impacts on surface water and groundwater quality and quantity
- effects on the marine environment including water quality and marine fauna
- air emissions (including dust)
- health issues related to water supply and use and wastewater treatment
- Aboriginal heritage.

During the public comment period the submissions received mainly related to requirements for secondary approvals by DMAs. A total of 11 submissions were received including eight from government agencies with two non-government organisation and private submissions. This demonstrates that the MEP received very limited public interest.

The main issues raised by stakeholders were:

- provision of additional technical detail on the design of waste rock dumps (WRD) and TSF to DMP
- provision of information concerning groundwater dewatering operations to DoW
- ongoing consultation regarding Aboriginal heritage values.



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Mine Continuation Proposal

Figure 2 - 1

Mineralogy Expansion Proposal

Department:	ENV	Date:	20/01/2017
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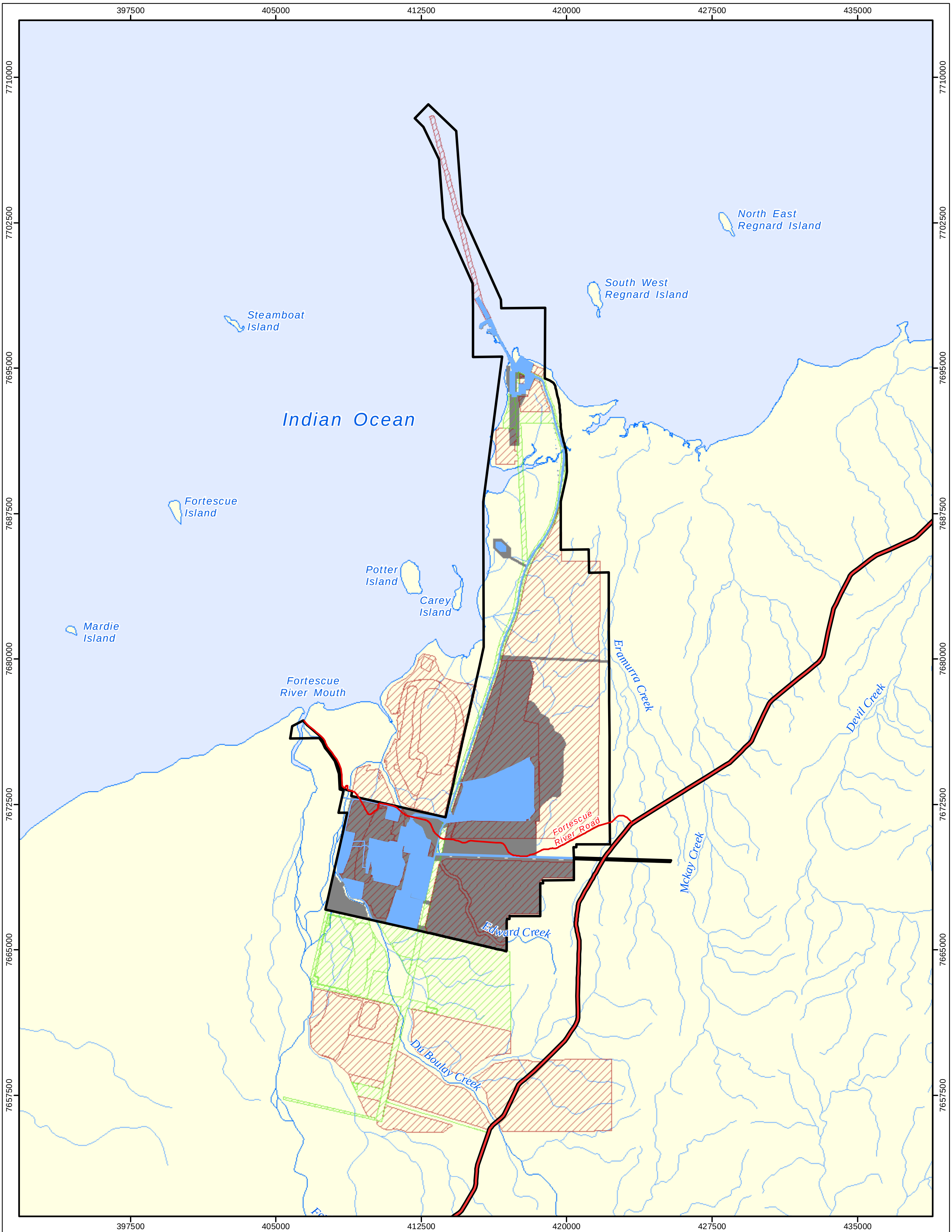

Mine Continuation Proposal Figure 2 - 2 Comparison of Mineralogy Expansion Proposal with Mine Continuation Proposal	0 3 6 Kilometres 1:250,000 Datum: GDA94 Projection: MGA Zone 50	

Department:	ENV	Date:	20/01/2017
Sheet Size:	A4	Status:	Final
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Legend

- Principal Road
- Major Road
- Major Creek/River
- Minor Creek/River
- Conceptual Footprint
- Development Envelope
- Statement 635 approval (MS635)
- Mineralogy Expansion Project Footprint Austeel; Mineralogy Iron; Sino Iron/Expansion;
- Balmoral South Project

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2.2 Justification

The Proponents have commercial agreements in place with Mineralogy authorising the extraction of a combined two billion tonnes of magnetite ore from the George Palmer Orebody. The existing project was designed to allow for construction of infrastructure required for mining and processing for an initial five years of operations in line with the approved Project Proposals under the IOPAA. The Austeel PER identified that the George Palmer Orebody had an estimated reserve of 4 BT and that mining rights to the George Palmer Orebody are held by Mineralogy.

Given that more than five years has now elapsed, to avoid impacts to current operations and to support continuation of the existing project the mine pit and waste rock landforms and the existing TSF capacity need to be extended. An expansion of the port stockyard capacity is also required to provide additional buffering capacity between production inflows and export outflows, to prevent shutdown of upstream operations in the event of prolonged weather delays or unplanned maintenance at the port.

No alternative locations are available within the existing approval footprint for implementation of the Proposal. Similarly in order to maintain continuation of existing operations there are no alternative staging or timing options.

2.3 Description of Proposal

The Proposal includes establishing a Development Envelope to encompass the existing project mine and port areas, which are separated by approximately 10 km (shown in Figure 2-3). The Proposal involves an extension of existing activities at both the mine and port areas (shown in detail in Figure 2-4 and Figure 2-5, respectively). The nature of the extension of activities in each area is described in Section 2.3.1 and 2.3.2.

The Proposal will increase the approved disturbance area by 7366 ha, from 2734 ha to no more than 10 100ha.

2.3.1 Mine

In the mine area the Proposal involves increasing the area of the mine pit, WRD, TSF and associated infrastructure (Figure 2-4). The majority of the increase in the footprint for the Proposal is located in the mine area. The Proposal will not alter approved mining rates; however, the discharge of mine dewater into the Fortescue River mouth will be increased from 2 GLpa to up to 8 GLpa.

Mine pit

The proposed mine pit expansion involves increasing the mine pit depth from approximately 220 m to approximately 400 m and extending the mine pit to the west. The authorised extent of disturbance for the mine pit pursuant to Statement 635 is 360 ha. As part of the Proposal, the mine pit will be extended beyond this limit (this increased disturbance is included in the total proposed additional disturbance area of 7366 ha for the Proposal).

To ensure continuous operations, preparation of the west pit requires earthworks to commence in mid 2017. To coincide with this date approval is required for increased topsoil and subsoil storage capacity within Mining Leases M08/123, M08/124 and M08/125. Approval for removal of overburden from the pit will also be required in mid-2017 to allow commencement of the two year construction period that is required to develop the additional TSF capacity.

In addition to the pit expansion, associated mine infrastructure will be expanded to support continuation of mine operations. This infrastructure may include: temporary workshops; access tracks; flood protection bunds; safety bunds; haulage and light vehicle roads; power lines; water pipelines; mine dewater pumps and pipelines; turkey nests and other water storage facilities; mobile power facilities; environmental monitoring infrastructure, etc.

All disturbances associated with this infrastructure are included in the total proposed additional disturbance area of 7366 ha for the Proposal.

Tailings storage facilities

The authorised extent of the approved TSF pursuant to Statement 635 is 987 ha.

Waste from the concentrator plant is disposed of to the TSF. The approved TSF, which was designed to cater for the first five years of operation, has become severely constrained. The rate for tailings disposal is approximately 46 mtpa of dry tailings, which had been assumed to settle to a bulk density of around 1.45 t/m^3. However, the bulk densities achieved to date have been as low as 1.3 t/m^3. Consequently, a proportionally larger TSF will be required to contain the expected tailings volumes for continued processing operations.

The constructed TSF is located approximately six kilometres north-east of the concentrator plant within Mining Leases M08/264, M08/265 and M08/266. The TSF consists of a conventional paddock type dam, high density thickeners, thickener reagents plant and a sand filtration plant.

The Stage 1 TSF capacity is expected to be fully utilised by early 2017. In alignment with the existing project, the Stage 2 TSF development is being constructed on top of the Stage 1 TSF and is expected to meet the needs for (at most) a further two years of production. The combined Stage 1 and Stage 2 TSF is expected to provide for a total of 147 Mm^3 of storage capacity.

To ensure continuous operations, the TSF will be extended beyond the approved limit of 987 ha as part of this Proposal (this increased disturbance is included in the total proposed additional disturbance area of 7366 ha for the Proposal).

Conceptual designs for the TSFs required to support continued mine operations propose additional locations to the north and south of the approved TSF on G08/53 (to the north) and G08/63 (to the south) respectively. These additional TSFs will require a two year construction period ahead of their operation. To ensure that these additional facilities are available for use when the Stage 2 TSF capacity is exhausted construction is required to commence in mid 2017.

Furthermore, to improve slope rehabilitation and acceptably manage rainwater runoff on the eastern side of the currently approved TSF, the northern TSF is proposed to be built up to the west side of the adjacent ridge located within G08/74.

Waste dumps

The authorised extent of approved waste dumps pursuant to Statement 635 is 600 ha. To ensure continuous operations, the WRDs will be extended beyond the approved limit of 600 ha as part of this Proposal (this increased disturbance is included in the total proposed additional disturbance area of 7366 ha for the Proposal).

The economics of the Proposal's scale of waste rock management demand that overburden and interburden (waste rock) be disposed of as waste rock landforms that are located as close as possible to the mine pit and that avoid significant vertical lifts in order to reduce costs. An exception to this rule would be where waste rock material is identified as being suitable for construction of tailings impoundment retaining walls.

Due to its location at distance from the mine, construction of WRDs and TSF may require installation of a conveyor for the purpose of economically transporting large volumes of mine waste rock required to construct these facilities.

Amongst other considerations, the location of the waste rock landforms has been chosen to minimise encroachment into the 100 year average recurrence interval (ARI) flood levels. The combined capacities of these areas will accommodate the projected waste rock that will be extracted.

The main objectives in determination of the final profile of the waste rock landforms are geotechnical and erosional stability. The final profile including maximum height of each individual waste rock landform will take on a vertical concave design and be sympathetic to the surrounding landscape.

A bund will be constructed around the western and south-western waste rock landforms to provide protection in case of 100 year ARI flood event of the Fortescue River and to control sediment from waste rock landforms and surrounding areas.

Dewatering

The Proposal involves an increase to the rate of groundwater discharge (from mine dewatering) from 2 GLpa. Detailed analysis (RPS APASA 2017) was conducted to determine if an increase in the discharge would be appropriate for the receiving environment. The analysis identified that the receiving environment could receive a discharge of up to 8 GLpa without environmental values being significantly affected. Based on this analysis it is proposed to increase the discharge up to 8 GLpa as part of the Proposal.

The location of the discharge will continue to be into the mouth of the Fortescue River.

Creek diversion

To accommodate infrastructure, the south branch of Edwards Creek will be realigned in two places (Figure 2-4). The two realignments will enable the disturbance area of the infrastructure to be minimised.

Diversion 1 is being proposed to allow expansion of an existing smaller waste dump in M08/123 adjacent to the mine. Diversion 1 involves realigning the southern branch of Edwards Creek along the eastern boundary of M08/123. The alignment requires construction of a 1.4 km channel and will result in the south branch feeding into the middle branch approximately 3 km upstream of the current location. The channel will be designed to be consistent with dimensions of the existing channel.

Diversion 2 is being proposed to accommodate construction of the TSF in mining tenement G08/63. The southern branch of Edwards Creek will be diverted around the TSF. This diversion would run west along the southern boundary of G08/63 and then north to rejoin the creek. The channel will be designed to be consistent with dimensions of the existing channel.

2.3.2 Port

In the port area the Proposal consists of increasing the area of the product stockpile as well as the port infrastructure (Figure 2-5). The increase in footprint at the port is included in the total proposed additional disturbance area of 7366 ha for the Proposal.

The Project differs from other iron ore projects in the Pilbara in that magnetite ore requires significant processing prior to being saleable. After ore is mined it is crushed and ground through a milling process, then mixed with water to form slurry which is passed through a magnetic separator to produce ore concentrate. Once completed the ore concentrate is stored at the port for shipment.

The existing ore concentrate stockpile at the port has a total capacity of approximately one million tonnes, which is equivalent to approximately ten days of shipping capacity (from empty); however, to mitigate operational impacts due to planned or unplanned disruptions to shipping or processing the stockpile must be maintained with a minimum volume of 500,000 tonnes of concentrate. This reduces the available shipping capacity to approximately 500,000 tonnes or the equivalent of only five days shipping capacity.

If there are delays to transport shipping schedules or transhipping associated with weather (e.g. cyclones) the existing approved capacity with the operational constraints is inadequate. Due to the size of the current stockpiles, if there are any prolonged weather delays or unplanned maintenance it will result in a forced suspension of all upstream processing activities.

Expansion of the stockyard (to approximately 3 Mt) at the port is proposed, to provide additional buffering capacity between production inflows and export outflows and thus prevent unplanned shutdowns of upstream operations.

2.3.3 Additional infrastructure corridors

The Proposal includes the construction of two new infrastructure corridors:

- one of which will extend from the north-south road across tenements G08/53 and G08/74 to the airstrip for the purposes of providing transport, power and water supply infrastructure to the airstrip
- the other of which will extend from M08/123 and/or M08/124 across G08/63 (broadly adjacent to L08/20), to connect power and water supplies to mine facilities.

All disturbances associated with these corridors is included in the total proposed additional disturbance area of 7366 ha for the Proposal.

2.3.4 Proposed approval

A key element of the Proposal is modernising the approval for the existing project. This Environmental Review includes:

- revising the key characteristics table and proposing a Development Envelope with a total disturbance footprint within that envelope
- updating the previous Operational Environmental Management Plan (OEMP) (Appendix 3)
- modernisation of the existing Statements (635 and 822) (Appendix 4).

The aim of modernising the approval is to maintain requirements of the existing approved management practices.

This environmental review document assesses impacts of the Proposal in the context of the original approval, although this does not include consideration of impacts from the existing project. Importantly, the Proposal does not introduce any new project elements or impacts that have not been previously assessed.

2.3.5 Key proposal characteristics

The key characteristics provided in Table 2-1 are proposed to replace the key characteristics identified in Statement 635 and 822 and incorporates both the Proposal and the existing project.

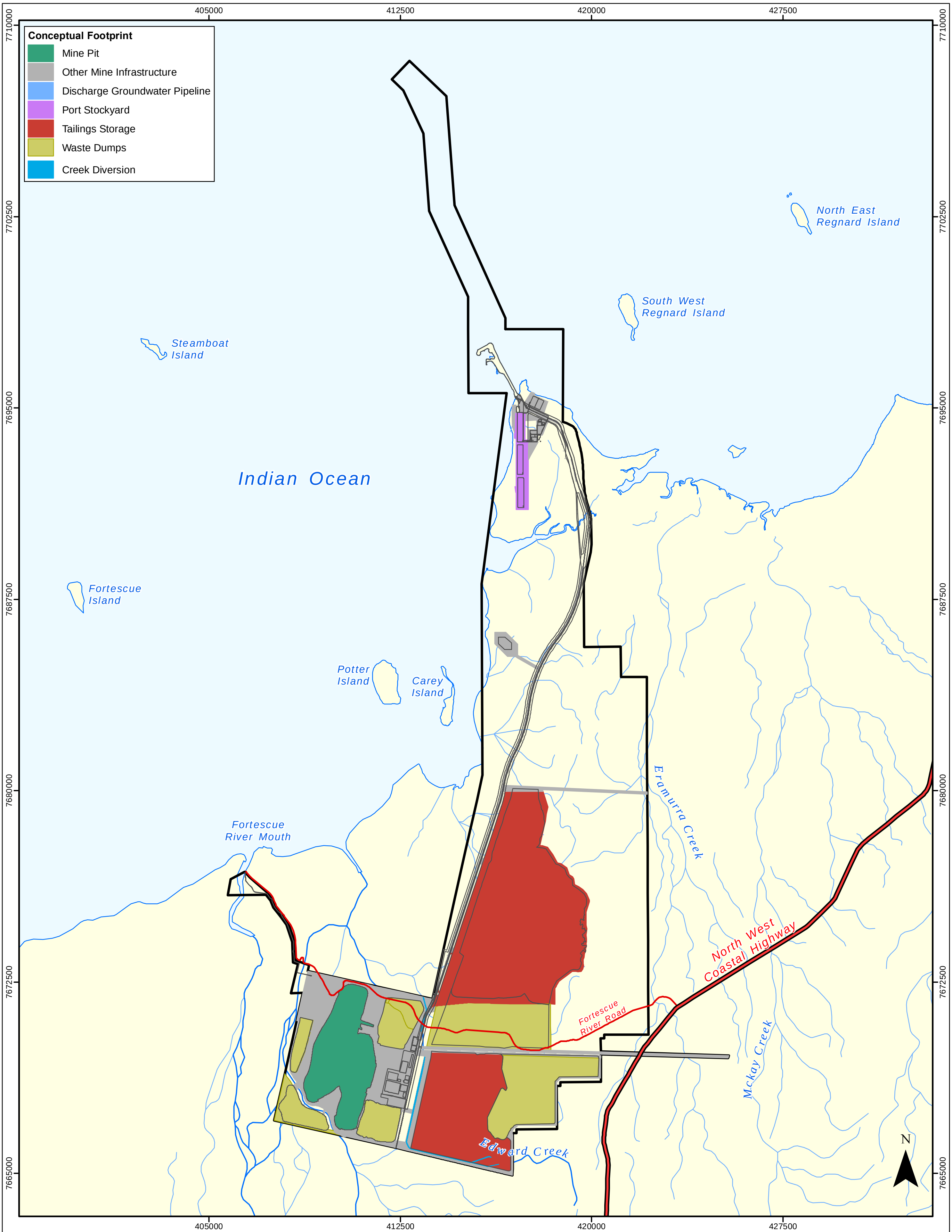
Table 2-1: Key Proposal characteristics

Proposal title	Sino Iron Mine Continuation Proposal
Proponents name	Sino Iron Pty Ltd and Korean Steel Pty Ltd
Short description	The proposal will expand an existing iron ore mine, processing and export facility at Cape Preston.

Element	Location	Approved extent (existing project under Statement 635)	Proposed change (this Proposal)	Proposed extent (revised Proposal)
Physical elements				
Mine and associated infrastructure • Mine pit • WRDs • TSF • Port & stockyard • Other • **total**	Mine area	 • 360 ha • 600 ha • 987 ha • 48 ha • 739 ha • **2734 ha**	Increase in disturbance of 7366 ha	No more than 10 100 ha within a Development Envelope of 22 737 ha

Element	Location	Approved extent (existing project under Statement 635)	Proposed change (this Proposal)	Proposed extent (revised Proposal)
Operational elements				
Depth of Pit	Figure 1	Up to 220 m	Additional 180 m	Approximately 400 m
Rate of mining (Ore)		Up to 95 Mtpa	No change	Up to 95 Mtpa
Process plant				
Concentrator Rate		Up to 27.6 Mtpa	No change	Up to 27.6 Mtpa
Produced waste to tailings storage		Up to 67.4 Mtpa	No change	Up to 67.4 Mtpa
Pellet production		Up to 13.8 Mtpa	No change	Up to 13.8 Mtpa
Direct reduced/hot briquetted iron	Figure 1	Up to 4.7 Mtpa	No change	Up to 4.7 Mtpa
Infrastructure				
Power Station capacity; gas usage		640MW	No change (Note: only 450 MW constructed to date)	640 MW
Product conveyor/ haul road Mine to Port Service corridor	Figure 1	25 km from mine site to port at Cape Preston – average width 55 m, 81 m at crossing from mainland to Cape Preston Road. Buried slurry pipeline replaces conveyor Dewatering plant at the port Additional buried pipelines Power transmission lines	No change	25 km from mine site to port at Cape Preston – average width 55 m, 81 m at crossing from mainland to Cape Preston Road. Buried slurry pipeline replaces conveyor Dewatering plant at the port Additional buried pipelines Power transmission lines
Groundwater bore field		Amount to be determined by relevant decision making authority.	No change	Amount to be determined by relevant decision making authority.
Pit dewatering		In accordance with DoW Licence	No change	In accordance with DoW Licence
Dewater discharge	Mouth of the Fortescue River	2 GLpa	Increase in discharge by up to 6 GLpa	Up to 8 GLpa

Element	Location	Approved extent (existing project under Statement 635)	Proposed change (this Proposal)	Proposed extent (revised Proposal)
Desalinated seawater	Figure 1	Up to 44 GL per annum	No change	Up to 44GL per annum
Brine disposal	Figure 1	Up to 57.8 GL per annum	No change	Up to 57.8GL per annum
Accommodation Village	Figure 1	Accommodation village: One permanent village – located on mainland north of the mine, opposite Carey Island (up to 970 people). Village also used as construction camp. Two construction camps located onsite, on ML08/123 and at permanent village sites	No change (Note: only M08/123 construction camp implemented to date)	Accommodation village: One permanent village – located on mainland north of the mine, opposite Carey Island (up to 970 people). Village also used as construction camp. Two construction camps located onsite, on ML08/123 and at permanent village sites.
Port				
Product stockyard capacity		Approximately 1 Mt	Approximately 2 Mt	Approximately 3 Mt
Bridging structures or rock causeway to Preston Island	Figure 1	Approximately 1.1km, bridging structures or rock causeway to island, then trestle jetty.	No change	Approximately 1.1km, bridging structures or rock causeway to island, then trestle jetty.
Dredging		Up to 4.5 million metres cubed (Mm3) disposed offshore.	No change (Note: berth pocket, shipping channel and direct ship loading jetty yet to be constructed)	Up to 4.5 million metres cubed (Mm3) disposed offshore.



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Mine Continuation Proposal

Figure 2 - 3

Development Envelope and Conceptual Proposal layout

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Kilometres
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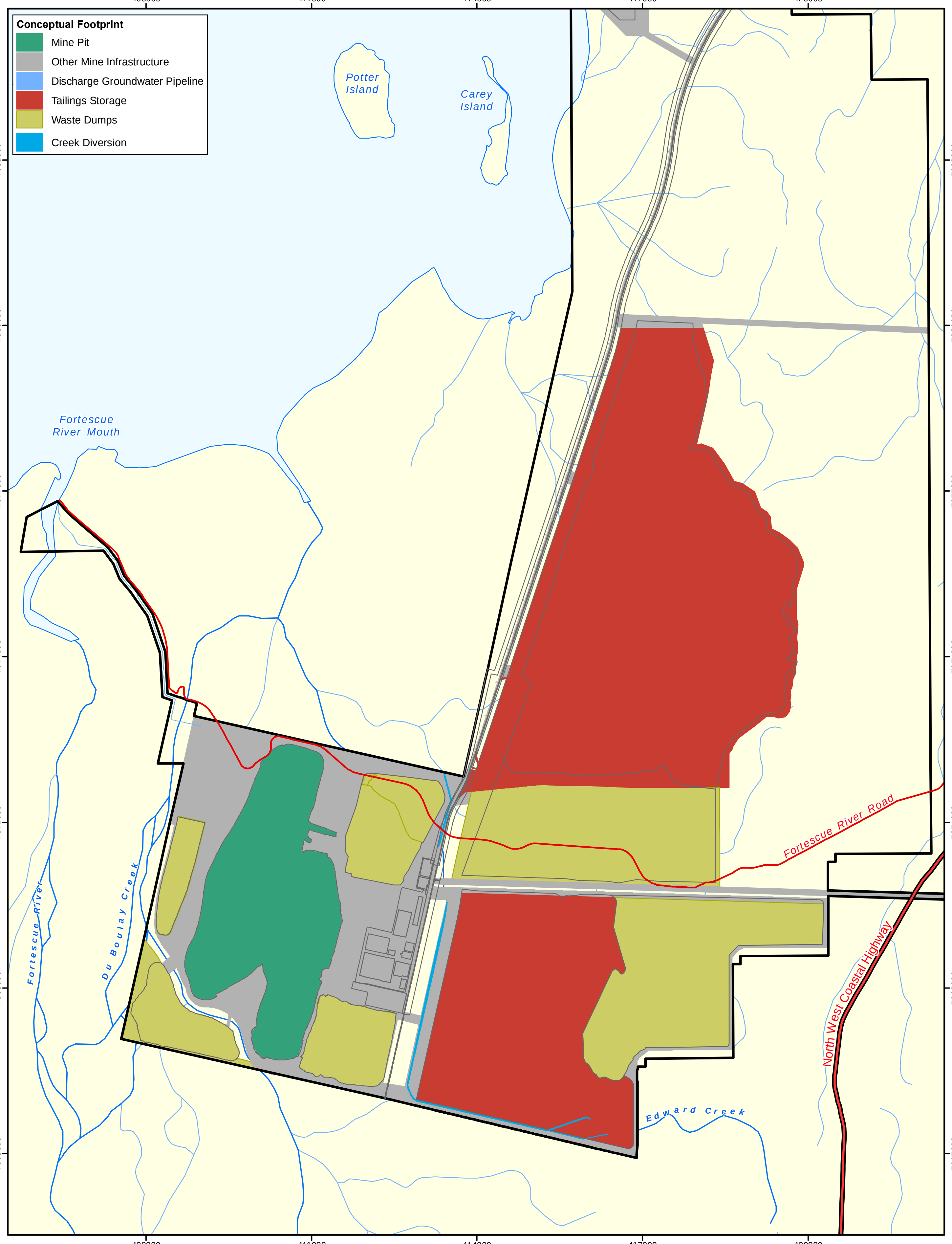
Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	24/01/2017
Sheet Size:	A4	Status:	Final
Drawn by DS	Requested by MB, Strategen	Internal Reference 4400_01_2017_APP	

Legend
- Principal Road
- Major Road
- Major Creek/River
- Minor Creek/River
- Conceptual Layout
- Development Envelope



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Mine Continuation Proposal

Figure 2 - 4

Indicative layout of Mine Area

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Datum: GDA94
Projection: MGA Zone 50

Department: ENV	Date: 20/01/2017
Sheet Size: A4	Status: Final

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- Principal Road
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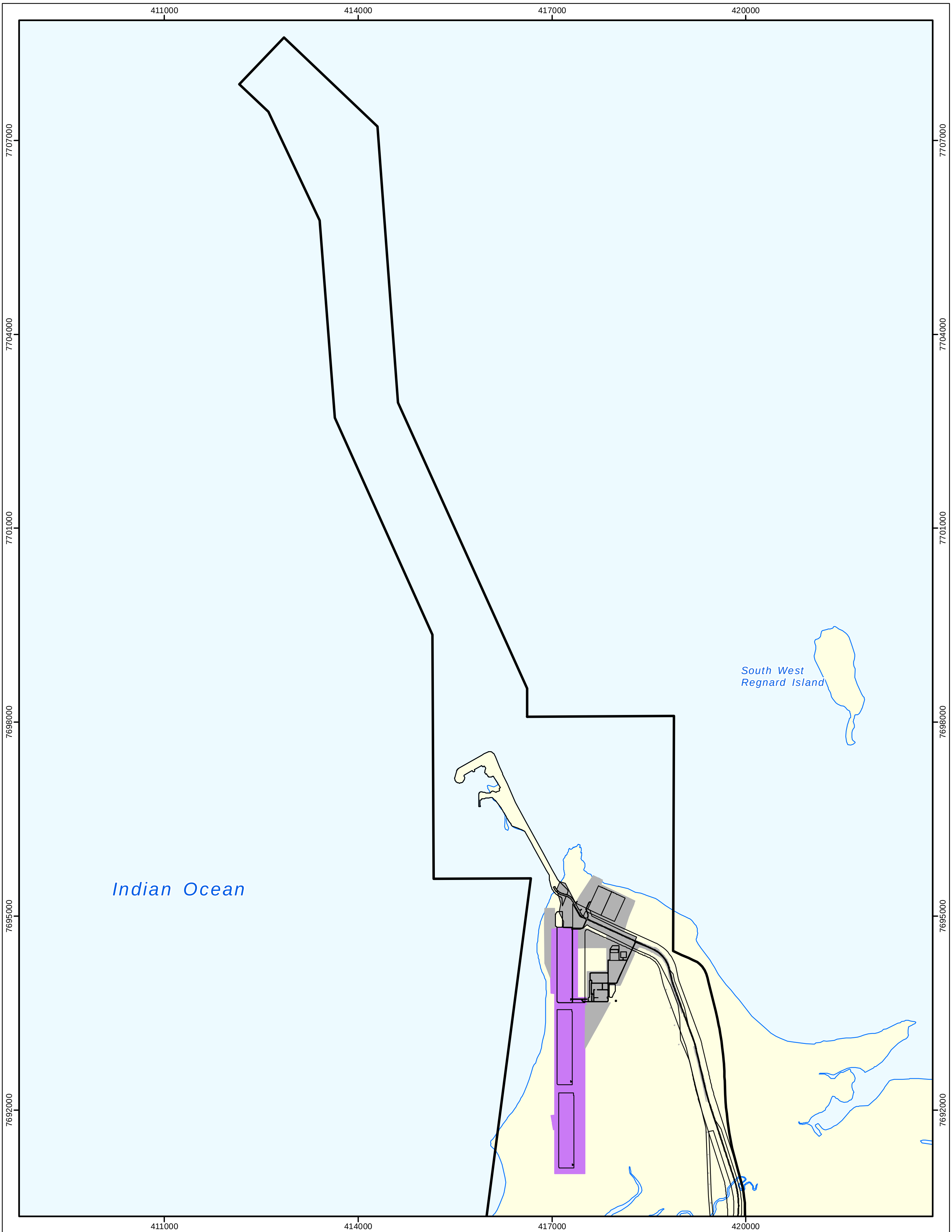
- Conceptual Layout
- Development Envelope



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Mine Continuation Proposal

Figure 2 - 5

Indicative layout of Port Area

0 1.5 3
Kilometres
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Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	20/01/2017
Sheet Size:	A4	Status:	Final
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Legend

- Cenceptual Layout
- Development Envelope

Conceptual Footprint

- Other Mine Infrastructure
- Port Stockyard

2.4 Local and regional context

2.4.1 Physical environment

Cape Preston is 80 km south-west of Karratha in the Pilbara Region of Western Australia which has an arid tropical climate with two distinct seasons: a summer wet season and a winter dry season (Gentilli 1972). The region experiences very low annual rainfall of 250 mm to 300 mm, high evaporation and high daytime temperatures. Rainfall is characterised by frequent, low-intensity events related to localised thunderstorms and tropical upper air disturbances, as well as occasional high-intensity events associated with tropical cyclones, which can lead to large-scale sheet flooding and considerable erosion.

The majority of watercourses in the Pilbara are ephemeral and generally flow after heavy rainfall events (Ruprecht and Ivanescu 2000). The Development Envelope is located adjacent to the lower reaches of the Fortescue River, extending from the coast to about 25 km inland. Edwards Creek and Du Boulay Creek are minor tributaries of the Fortescue River, flowing through the Development Envelope in a north-west direction before discharging into the Fortescue River (Aquaterra 2008a).

During large flood events the channels of the Fortescue River, Edwards Creek and Du Boulay Creek breach and the flood flows extend over the adjacent floodplains (URS 2009). Along the portion of the Fortescue River adjacent to the southern section of the Development Envelope, there is a significant ‘break-out’ area to the west of the main channel, which redirects high level flood flows away from the main channel in a north-westerly direction towards the coast and away from the Development Envelope (URS 2009). For further information on surface hydrology refer to Section 5.3.1.

The hydrogeology of the Development Envelope is mostly influenced by Hamersley Group Lower Proterozoic fractures rock system on the east and the Lower Fortescue Alluvial aquifer on the west. The major aquifers in the region are the gravels of the Fortescue River alluvium and to a lesser extent the Yarraloola Cretaceous Conglomerate and fractures and weathering within the Proterozoic rock (CloudGMS 2017, included in Appendix 1). .

Groundwater flow tends to be in a north-westerly direction towards the coast. The Fortescue River alluvium aquifer and deeper sediments on the main floodplain are mostly recharged by the infiltration of river flow, although there is some minor direct infiltration of rainfall and some throughflow from flanking basement rock aquifers (URS 2009).

The general surface geology of the area is characterised by two series of north-north-easterly trending ridges of outcropping Lower Proterozoic aged rocks of the Mount Bruce Supergroup, which are part of the Hamersley Basin (URS 2009). These rocks dip steeply to the west-north-west and become generally younger from east to west, although there are numerous minor faults in the area that have resulted in some repeats of stratigraphic horizons (URS 2009).

A geological fault line runs in a south to north direction, east of the Development Envelope. West of the fault line, the area is characterised by ridges of Brockman Iron Formation that contains the orebody, Mt. McRale Shale and Mt. Sylvia formation and further west the area is dominated by residual clays, sands, gravel and Fortescue River Alluvium. East and parallel to the fault line, a higher series of ridges are formed by the Kylena and Maddina Volcanics which comprise of basalts and tuffs (URS 2009).

2.4.2 Terrestrial ecology

The Development Envelope is within the Roebourne sub-region of the Pilbara bioregion as per the Interim Biogeographic Regionalisation of Australia. The vegetation found within the Roebourne sub-region is broadly described into four separate categories based on setting (Kendrick and Stanley 2001):

- coastal plains consist of a grass savannah of mixed bunch and hummock grasses, and dwarf shrub steppe of *Acacia stellaticeps* or *A. pyrifolia* and *A. inaequilatera*
- uplands are dominated with Triodia hummock grasslands
- ephemeral drainage lines support *Eucalyptus victrix* or *Corymbia hamersleyana* woodlands
- marine alluvial flats and river deltas support samphire, Sporobolus and mangrove communities.

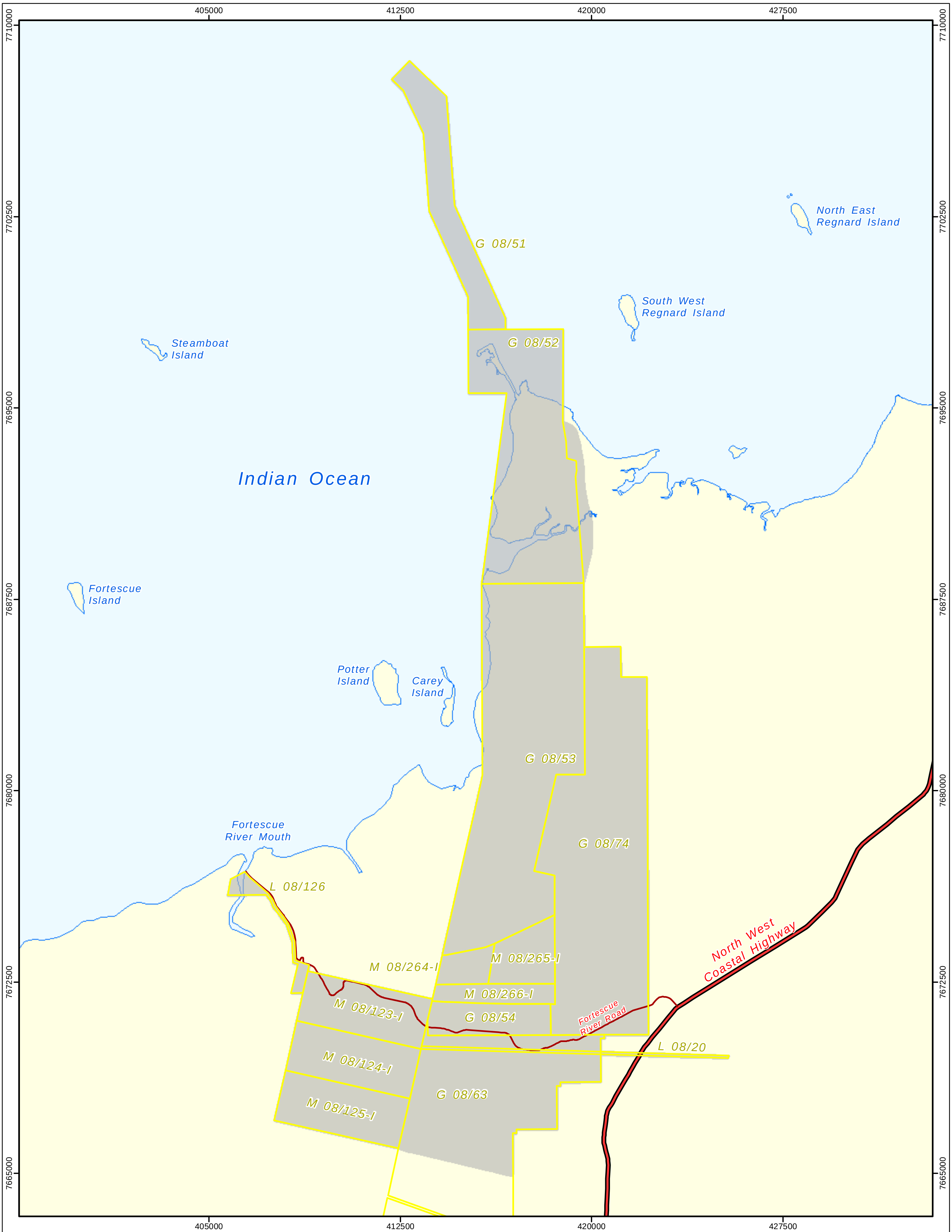
Several vegetation and flora surveys have been undertaken within the Cape Preston region and a total of 639 flora species from 73 families have been recorded. This total includes 614 (96%) native species and 25 (4%) introduced (weed) or non-endemic species. Families with the highest representation were Poaceae (Grass family – 81 native taxa, 5 introduced taxa), Papilionaceae (Pea family – 57 native taxa), and the Malvaceae (Mallow Family – 59 native taxa, 2 introduced taxa). The condition of the vegetation has been largely affected by pastoral grazing, and weeds are present in the area.

No species listed as Declared Rare Flora under State legislation or threatened flora under Federal legislation has been recorded within the project area during site surveys. For further information on flora and vegetation refer to Section 8.

The Cape Preston area contains seven broad terrestrial habitat types (Ecoscape 2016a). The majority of habitat within the Development Envelope is low open shrubland over low spinifex on flat plains, which are of low conservation significance. The highest conservation value terrestrial fauna habitats within the Development Envelope are associated with drainage lines.

Desktop fauna surveys of the project area identified 238 fauna species that could potentially occur or have been previously recorded in the project area. On ground surveys conducted by Phoenix (2009a; 2009b) recorded 132 bird, 84 reptile, 24 native mammal and 3 amphibian species. Of those species recorded, 32 are listed either under *the Wildlife Conservation Act 1950* (WC Act) and/or EPBC Act. The *Biodiversity Conservation Act 2016* (BC Act) was introduced in late 2016; however, the WC Act is still current it has been referred to in the document rather than the BC Act.

Twenty-five potential SRE species were also recorded in the project areas. For further information on fauna species (including potential SRE species) and habitats refer to Section 9.



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Mine Continuation Proposal

Figure 2 - 6

Tenure

0 4 8
Kilometres
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Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	2/02/2017
Sheet Size:	A4	Status:	Final
Drawn by DS	Requested by MB, Strategen	Internal Reference 4403_01_2017_APP	

Legend

- Tenements
- Development Envelope

3. Stakeholder consultation

CPM has an ongoing consultation program with relevant stakeholders. As the Proposal largely overlaps with Stage 3 of the MEP, substantial consultation on the impacts of the Proposal was undertaken with DMAs in 2009 prior to the release of the PER and following the public comment period for the MEP. This consultation involved detailed discussion on the findings of specialist reports and investigations relating to environmental factors.

As operator of the existing project, the Proponents have had an ongoing role in consultation with stakeholders. Additional stakeholder consultation for the Proposal was undertaken from the early planning stages of the Proposal. The focus of the additional consultation has been to inform stakeholders of relevant differences between the previous MEP and the Proposal. Based on the changes (relative to the MEP) the following consultation was undertaken:

State Government agencies:

- Department of Aboriginal Affairs (DAA)
- Department of Environment Regulation (DER)
- Department of Mines and Petroleum (DMP) - Environment Division
- Department of Mines and Petroleum (DMP) - Resource Safety Division
- Department of Water (DoW)
- Department of Parks and Wildlife (Parks and Wildlife)
- Western Australian Office of the Environmental Protection Authority (OEPA)

Australian Government agencies:

- Department of Environment and Energy (DEE)

Other relevant stakeholders:

- Pastoral Management Pty Ltd (PMPL)
- Mineralogy.

Comments and advice received from government agencies and other relevant stakeholders were incorporated into the design of the Proposal. A summary of stakeholder consultation undertaken to date is summarised below in Table 3-1.

Table 3-1: Stakeholder consultation table

Stakeholder	Date	Topic/issue raised	Proponent response/outcome
State Government agencies			
Department of Aboriginal Affairs (DAA)	Briefing 18/01/2017	CPM gave an overview of the Mine Continuation Proposal outlining key characteristics for the proposal and how key issues, including heritage, are to be managed. DAA queries: • Do CPM have indigenous land use agreements (ILUA) in place with traditional land owners who have claims over the area • Have CPM commenced heritage surveys associated with the Proposal.	Agreements are in place, the Yaburara and Mardidhunera People (YM) ILUA is registered with National Native Title Tribunal. YM claim area covers the Proposal, the Kuruma Marthudunera (KM) claim area is only along the south of Mardie Station. Survey on mining tenure (M08/123, M08/124, M08/125) had commenced and a S18 submission to DAA will be made in the coming months. Heritage survey programs for the remaining areas of the Proposal will commence following submission of this s18.

Stakeholder	Date	Topic/issue raised	Proponent response/outcome
Department of Environment Regulation (DER)	Briefing 30/11/2016	DER identified: • Stockpile expansion will necessitate an amendment to L8758/2013/1. • Ambient dust risk assessment and monitoring locations will need to be reviewed to factor in the revised stockpile orientation. • Increased pit dewatering discharge rate to the Fortescue River Mouth will necessitate an amendment to L8308/2008/2. • Future TSF will necessitate an amendment to L8308/2008/2 premise boundary and identify new monitoring bore locations.	CPM has commenced preparing necessary amendments to identified licences. Work to identify additional monitoring points is also being undertaken. A revised monitoring program will accompany CPM's application to amend its existing operating licences
Department of Mines and Petroleum (DMP) (Environment Division)	Briefing 12/10/2016 Briefing 24/11/2016 Site visit 07/12/2016	Updates to TSF and Waste Rock Management Plans DMP provided the following comments/ questions: • Review of 2016 AER noted CPM has almost exhausted the approved disturbance under MS635 • Proposal will necessitate diversion of Edwards Creek. Will this be a permanent diversion? • What are the existing statutory controls re Mesquite Management? • It is considered likely the OEPA will require a revised closure and rehabilitation plan as a component of the Proposal submission.	• This Proposal includes additional area of terrestrial disturbance. • The Proposal includes a permanent diversion of Edwards Creek. External consultant was engaged and surface water modelling completed. Refer to Section 5.5.3 • In accordance with Commitment 5 of Statement 635, CPM is an active member of the Pilbara Mesquite Management Committee. CPM has committed to contributing ~$3,000,000 over 10 years to the control of mesquite on Mardie Station. Refer to Section 8.5.2 • A review of the 2006 OEPA approved preliminary decommissioning and closure plan and the 2011 internal CPM closure plan has been completed and forms a component of this submission. Refer to Appendix 3.
Department of Mines and Petroleum (DMP) - Resource Safety Division (letter and e-mail correspondence associated with meetings)	Correspondence dates: 19/09/2014 27/10/2014 3/12/2014 19/01/2015 24/05/2016	Management of fibrous minerals.	• CPM has provided comprehensive management information and the results of ongoing monitoring and investigation with respect to this matter. Since providing this information DMP has not raised any further concerns. Management of fibrous minerals is addressed within Section 10. The Fibrous Minerals Management Plan submitted to DMP in 2016 is included within Appendix 3. DMP has not raised any further concerns since this Plan was submitted in May 2016.
Department of Water (DoW)	Meeting 17/11/2016	Scope of groundwater model	Groundwater model updated to include cumulative impacts of proposed adjacent mines. Refer to Section 5.5.1 and Appendix 1.
Department of Parks and Wildlife (Parks and Wildlife)	Telephone call 1/12/2016	Description of project and offer of project briefing	Parks and Wildlife advised that OEPA officers are able assess project and no need to consult Parks and Wildlife further.

Stakeholder	Date	Topic/issue raised	Proponent response/outcome
Western Australian Office of the Environmental Protection Authority (OEPA)	Meeting 18/11/2016 Meeting 14/12/2016	Initial high level briefing for OEPA Discussion of marine modelling approach	
Australian Government agencies			
Department of Environment and Energy (DEE)	Briefing 10/01/2017	Briefing on the historical approvals. DEE comments: • Information that addresses how historic survey data was considered and the basis for work to update the previous survey data or reasons for not doing further survey work • Likelihood of the Proposed Action affecting Denning habitat for Northern Quolls.	Terrestrial fauna and Flora and vegetation survey work has been reviewed to consider currency of survey work in terms of guidance and species. Flora and Fauna consultants have confirmed that historic surveys meet required standards and that further survey effort is unlikely to identify further species of conservation significance (Refer Sections 8.3 and 9.3). No Northern Quoll denning habitat likely to be affected by the Proposal (Ecoscape 2016).
Other relevant stakeholders			
Pastoral Management Pty Ltd (PMPL)	Ongoing liaison	PMPL is a subsidiary company of CITIC Limited and manages the cattle station outside the approved mining areas.	No outcomes identified.
Mineralogy	Letter 9/12/2016	Letter from CPM requesting Mineralogy's cooperation in securing approvals.	CPM has ongoing consultation working with Mineralogy as parties to the IOPAA.

4. Assessment of preliminary key environmental factors

4.1 Principles

The EP Act identifies a series of principles for environmental management. The environmental principles are the highest level goals that a proposal or scheme must meet in order to be found environmentally acceptable by the EPA. CPM has considered these principles in relation to the development and implementation of the Proposal. Table 4-1 outlines how the principles relate to the Proposal.

Table 4-1: EP Act principles

Principle	How it will be address by the Proposal
Precautionary principle Where there are threats of serious irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, decisions should be guided by: 1. careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and 2. an assessment of the risk-weighted consequences of various options.	The Proposal has used existing environmental data during design and has supplemented it with additional studies or peer reviews of previous material. CPM has maintained close correspondence with relevant government agencies to minimise any uncertainty surrounding the environmental impact of the Proposal. Detailed design plans, environmental management plans and closure plans will avoid or minimise impacts on identified environmental values.
Intergenerational equity The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	The Proposal can be designed and implemented without significant impacts on the health, diversity or productivity of the environment.
Conservation of biological diversity and ecological integrity Conservation of biological diversity and ecological integration should be a fundamental consideration	Survey work has been used to identify and confirm the range and condition of the environmental factors within and surrounding the Proposal development boundary. The Proposal will not substantially reduce the extent of any vegetation type or habitat within the Cape Preston area. The findings indicate that with appropriate design, management plans and progressive rehabilitation that no likely significant biodiversity or ecological impacts will result from the proposed development at local or regional scales.
Improved valuation, pricing and incentive mechanisms 1. Environmental factors should be included in the valuation of assets and services. 2. The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement. 3. The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste. 4. Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, which benefit and/or minimise costs to develop their own solutions and responses to environmental problems.	Environmental constraint avoidance and management costs have been considered in the design of the Proposal.
Waste minimisation All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment	Waste will be minimised by adopting the hierarchy of waste controls; avoid, minimise, reuse, recycle and safe disposal.

4.2 Preliminary key environmental factors identified

Table 4-2 identifies the relevant preliminary key environmental factors for the Proposal and summarises the associated environmental aspects of the Proposal (e.g. dewatering, clearing) and potential impacts of the environmental aspects. The table also presents the work completed to undertake the environmental assessment. The potential impacts identified for each key environmental factor are assessed in detail within Sections 5 to 10 of this document.

Potential impacts, their mitigation and management, and the proposed regulatory mechanisms for ensuring mitigation are presented using relevant studies to demonstrate the Proposal meets the EPA objective for each preliminary key environmental factor (Table 4-2).

Environmental factors determined not to be key environmental factors are discussed in Section 11.

Table 4-2: Preliminary key environmental factors

Factor	Location	Environmental aspect	Potential impact	Work completed
Hydrological Processes	Mine Edwards and Du Boulay Creeks Fortescue River	• Dewatering and discharge • Construction of infrastructure	1. Groundwater drawdown from dewatering has potential to modify groundwater and surface water flows (Section 5.5.1). 2. Discharge of groundwater has potential to modify surface water flows in the Fortescue River (Section 5.5.2). 3. Diversion of Edwards Creek will modify surface water flows (Section 5.5.3). 4. Construction of physical elements will alter surface water flows (Section 5.5.4).	1. Prepared a peer-reviewed groundwater model to predict changes in groundwater flows. Peer-reviewed groundwater model included: o the cumulative impacts of other mining projects in the area. o prediction of pit lake upon closure 2. Prepared a review to predict the changes in flow volumes for surface water courses as a result of the Proposal.
Inland Waters Environmental Quality	Mine Fortescue River Edwards Creek	• Runoff from mine area • Groundwater discharge • Formation of pit lake post-closure	1. Diversion of Edwards Creek has the potential to increase stream velocity, which may affect water quality (Section 6.5.1). 2. Physical development of the site and use of infrastructure will generate runoff which has potential to affect surface water quality (Section 6.5.2). 3. Following the formation of a pit lake after closure, evaporation and groundwater flow into the pit has the potential to affect water quality within the pit lake and surrounding environmental values (Section 6.5.3).	1. Prepared a review to predict the changes in flow volumes for surface water courses as a result of the Proposal. 2. Identified the location and design parameters of groundwater discharge infrastructure. 3. Peer-reviewed groundwater model includes prediction of the likelihood of the formation of a pit lake after closure as well as a risk assessment of the water quality of the pit lake and likelihood significantly affecting surrounding regional water quality values.
Marine environmental quality	Mine Fortescue River	• Groundwater discharge	1. Discharge of groundwater has potential to affect the water quality of the Fortescue River estuary (Section 7.5.1).	1. Prepared a peer-reviewed hydrodynamic marine model to assess changes to marine water quality as a result of the discharge of groundwater.
Flora and Vegetation	Mine Port	• Clearing • Dewatering	1. Clearing of native vegetation has potential to affect regional representation of vegetation communities and flora species (Section 8.5.1). 2. Clearing has potential to introduce/spread weeds (Section 8.5.2). 3. Groundwater drawdown from dewatering has potential to affect groundwater dependent ecosystems (Section 8.5.3).	1. Prepared a review of completed botanical assessments to summarise and confirm the currency of previous surveys undertaken at Cape Preston. 2. Updated species lists and identified changes in status of conservation significant flora species and vegetation communities.
Terrestrial fauna	Mine Port	• Clearing • Dewatering	1. Clearing has potential to reduce extent of fauna habitat (Section 9.5.1). 2. Clearing has potential to disrupt localised fauna linkages for native fauna (Section 9.5.2). 3. Clearing of Northern Quoll habitat has potential to affect habitat availability for this species (Section 9.5.3). 4. Development has potential to introduce/attract feral animals (Section 9.5.4). 5. Mine operations have potential to reduce habitat quality or result in the death or injury of terrestrial fauna (Section 9.5.5).	1. Prepared a review of completed terrestrial fauna assessments to summarise and confirm the currency of previous surveys undertaken at Cape Preston. 2. For Endangered Northern Quoll undertook an assessment in accordance with the DEE guidelines for surveying, including conducting both a reconnaissance and targeted survey.

Factor	Location	Environmental aspect	Potential impact	Work completed
Terrestrial environmental quality	Mine Port	• Mining and operational activities • Post-closure	1. •Mining activities have the potential to cause fibrous minerals to become airborne 2. Inappropriate management of potential asbestiform material (including post-closure storage, and mine pit wall exposures) has the potential to cause fibrous minerals to become airborne.	1. Summarise the results of fibrous minerals investigations and monitoring as well as the implementation of the existing Fibrous Minerals Management Plan.

5. Hydrological processes

5.1 EPA objective

To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.

5.2 Policy and guidance

The relevant policy for Hydrological processes is:

- *Environmental Factor Guideline - Hydrological Processes* (EPA 2016b).

5.3 Receiving environment

A summary of work completed to describe the receiving environment with respect to Hydrological processes is presented in Table 5-1.

Table 5-1: Summary of environmental studies and survey effort

Author/ date	Survey/ investigations name	Study area, type and timing	Study standard/guidance and limitations
Recently completed work			
Cloud GMS 2017	*Sino Iron Expansion Proposal Groundwater Modelling Study*	Hydrogeological assessments of the effect of the Project during life of mine and post closure.	Peer reviewed model ANZECC/ARMCANZ Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCAZ, 2000) Water Quality Protection Guidelines (No. 1-11) (DoW & DoIR, 2000) State Water Quality Management Strategy (ANZECC and ARMCANZ, 2001) Barnett, B et al. 2012 Australian Groundwater Modelling Guidelines
RPS 2017	*Edwards Creek Diversions and Southwest Waste Dump*	Surface water assessment of engineering designs.	
RPS APASA 2017	*Discharge Modelling Assessment* *Fortescue River Outfall*	Delft3D-FLOW hydrodynamic model.	Peer reviewed model Model adheres to the International Association for Hydro-Environment Engineering and Research guidelines for documenting the validity of computational modelling software, closely replicating an array of analytical, laboratory, schematic and real-world data.
Previously completed work			
Aquaterra 2009a	*Mineralogy Expansion Projects (Stage 3-5) Surface Water Management*	Surface water assessment (including 1 in 100 year ARI flood assessment) of the Fortescue River and Du Boulay Creek floodplain adjacent to the Sino Iron Project for the Stages 3-5 Mineralogy Expansion Proposal conducted in 2009.	ANZECC/ARMCANZ Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCAZ, 2000) Water Quality Protection Guidelines (No. 1-11) (DoW & DoIR, 2000) State Water Quality Management Strategy (ANZECC and ARMCANZ, 2001)

Author/ date	Survey/ investigations name	Study area, type and timing	Study standard/guidance and limitations
Aquaterra 2009b	*Mineralogy Expansion Projects (Stages 3-5) – Hydrogeological assessment*	Hydrogeological assessments (prediction of groundwater inflows and drawdown) of Stages 3-5 Mineralogy Expansion Proposal conducted in 2009.	ANZECC/ARMCANZ Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCAZ, 2000) Water Quality Protection Guidelines (No. 1-11) (DoW & DoIR, 2000) State Water Quality Management Strategy (ANZECC and ARMCANZ, 2001)
Aquaterra 2001	*Austeel Iron Ore Project Prediction of Groundwater Level Drawdown*	Groundwater model of existing Project	

5.3.1 Surface water

The Development Envelope is adjacent to the Fortescue River; the major watercourse in the vicinity of the Proposal with an effective catchment area of 20 000 km^2 (Aquaterra 2009a). The Development Envelope is drained by Edward Creek and Du Boulay Creek, which are minor tributaries to the Fortescue River (Figure 5-1). Near the Development Envelope the Fortescue River is braided and comprises several channels that follow a primary floodplain (approximately 2.5 km wide).

The lower Fortescue River estuary is tidal dominated and experiences strong tidal influence (spring tidal range at approximately 3.6 m) that extends approximately 4 km inland. At the mouth of the Fortescue River, the river channel is in excess of 200 m wide forming an estuarine setting of salt marsh and intertidal flats. Upstream of the estuary the Fortescue River has a well-defined main flow channel, typically 4 m to 6 m deep and about 100 m wide. The combination of a wide well defined channel and high tidal range provides high velocities in the river mouth and the current speed in the Fortescue River frequently exceeds 0.1 m/s (RPS APASA 2017) (Figure 5-2). The strong tidal influence means the estuary has a low sediment trapping efficiency; naturally high turbidity and well mixed waters (RPS APASA 2017).

In addition to the strong tidal flows, the river mouth also experiences a very high rate of flushing from the discharge of water during the wet season. At the DoW Bilanoo gauging station (approximately 35 km upstream) the long-term mean annual discharge of the river is 305 GLpa and on average more than 90% occurs during the wet season from January to April (DoW 2015a). As there are other creeklines that enter the Fortescue River downstream of the gauging station (including Edward and Du Boulay creeks) it is likely that the discharge at the river mouth will be substantially higher. As shown in Figure 5-3, the long-term average monthly streamflow corresponds with rainfall patterns.

An assessment of the permanency of river pools was determined on the basis of an analysis of satellite imagery (CloudGMS 2017). The assessment determined that there are two permanent pools (Mungajee and Tom Bull), five semi-permanent pools (Bilanoo, Stewart, Chuerdoo, Jilan Jilan and one unnamed) and two unnamed intermittent pools.

Tom Bull Pool (the furthest pool downstream) is tidally influenced. The remainder of the pools occur after river flow events, during which groundwater is recharged from the surface water and the watertable rises (CloudGMS 2017).

Edwards and Du Boulay Creeks drain ridges to the east and southeast of the Development Envelope and flow in a north-westerly direction through the Development Envelope into the Fortescue River. The creeks typically have main flow channels with 5 m to 10 m wide gravel beds and trees along the banks.

Floodplains adjacent to the creeks typically comprise open grassed areas with scattered trees. Edwards Creek has three main branches, with a total catchment of about 50 km^2 where the creek enters the Fortescue floodplain. The southern branch comprises approximately 29 km^2 and the middle and northern branch together comprise approximately 21 km^2. Edwards Creek (southern branch) runs northwest diagonally through mining tenement M08/63, from the south east edge of the mining tenement to the north-west corner, where there is a set of large culverts under the North-South Road. The creek then enters mining tenement M08/123.

The catchment area of Du Boulay Creek is about 200 km^2 where it meets the Fortescue River floodplain. The Du Boulay Creek flows at an extremely flat grade on the Fortescue floodplain towards an anabranch of the Fortescue River. Flood flows spread out across the Fortescue floodplain and flood depths are shallow.

Estimates of flood flows for Edwards Creek and Du Boulay Creek were undertaken by RPS (2017). As shown in Table 5-2 the flood estimates of Du Boulay are substantially higher than the south branch of Edwards Creek.

Table 5-2: Flood estimate of Edwards and Du Boulay creeks

ARI flood estimate	Edwards Creek (south branch) (m^3/s)	Du Boulay Creek (m^3/s)
10 year	25	262
20 year	41	426
100 year	97	616

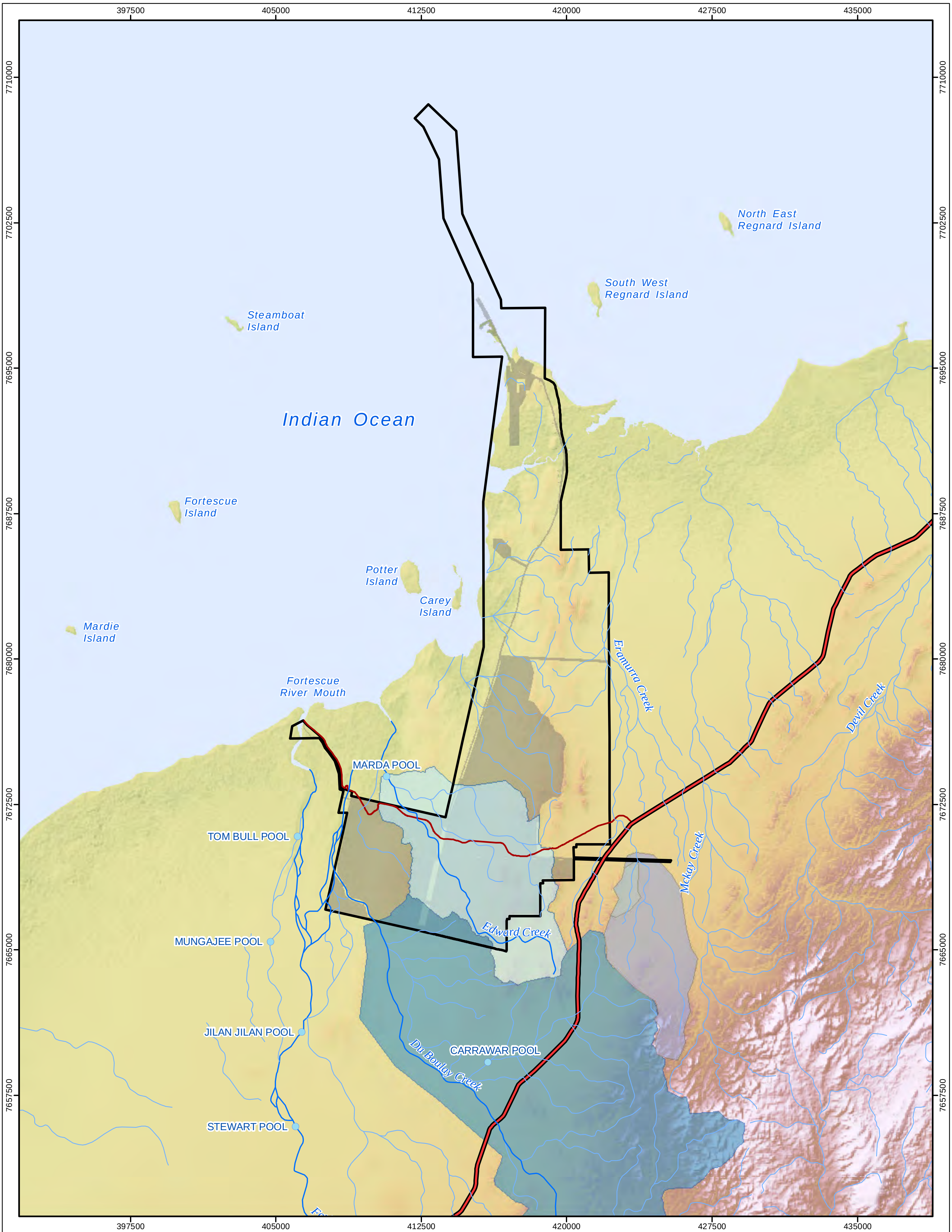

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Figure 5 - 1

Topography and surface hydrology

0 5 10
Kilometres
1:250,000

Datum: GDA94
Projection: MGA Zone 50

Department: ENV	Date: 25/01/2017	
Sheet Size: A4	Status: Final	
Drawn by DS	Requested by MB, Strategen	Internal Reference 4404_01_2017_APP

Legend

- Major Creek/River
- Minor Creek/River
- Development Envelope
- Conceptual Footprint

Catchment Boundaries

- Du Boulay Creek
- Edward Creek
- Eramurra East
- Eramurra West

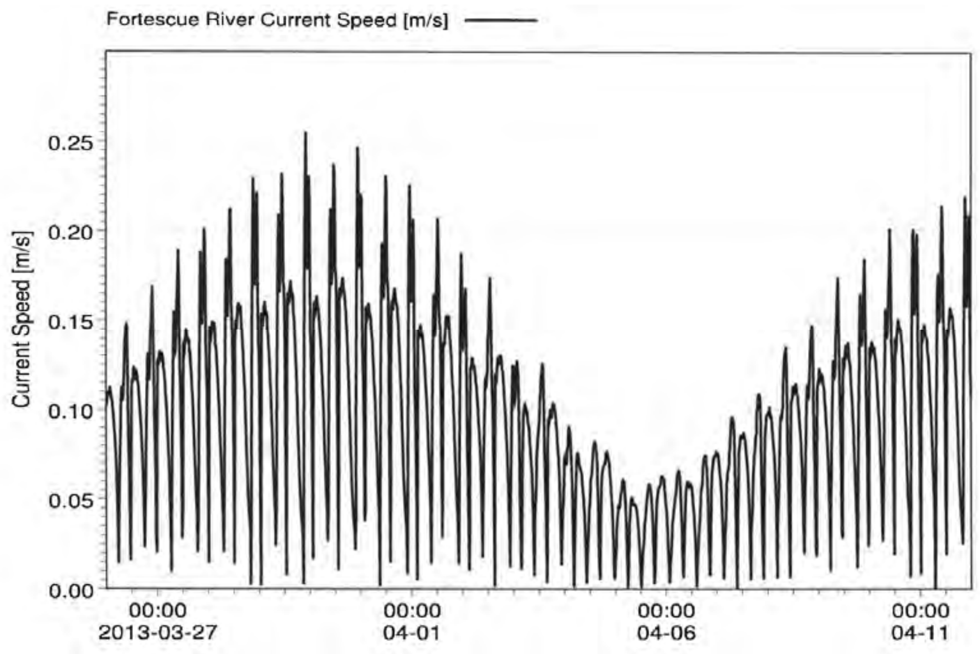


Figure 5-2: Fortescue River current speed

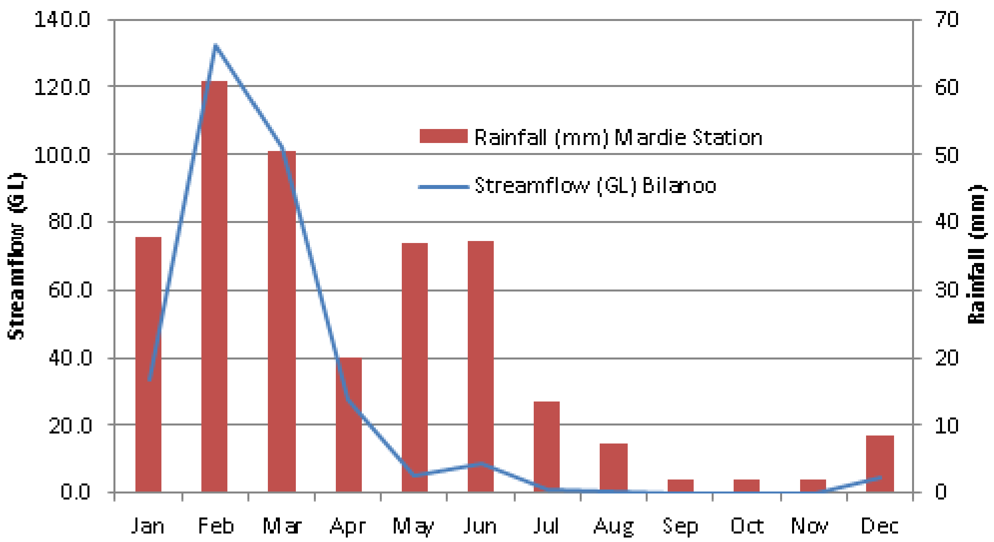


Figure 5-3: Comparison of long-term rainfall (at Mardie Station) and average streamflow of the Fortescue River (at Bilanoo gauging station approximately 35 km upstream)

5.3.2 Groundwater

The George Palmer Orebody is within Proterozoic basement rocks. In order to access the ore the western pit will intersect the edge of the Quaternary Fortescue River floodplain alluvium. The older basement rocks (including the Brockman Iron Formation and the Orebody) lie to the south east of the younger alluvium, which is associated with the historical location of the Fortescue River floodplain. These two geological types have very different hydrogeological properties.

The Fortescue River floodplain alluvium is continuous over an area in excess of 200 km^2 and has a saturated thickness of up to 20 m (Aquaterra 2008c). The Fortescue alluvium is highly permeable and contains a freshwater aquifer. In comparison, there are only minor secondary aquifers in the Proterozoic basement rocks, including the Orebody banded iron formation, generally associated with fracturing.

Groundwater flow in the region is generally to the northwest towards the ocean, with local groundwater flows being influenced by topography, creeklines and underlying geology. The interface between the permeable alluvium and the low permeability basement rocks influences the groundwater levels and flows in the Development Envelope (CloudGMS 2017). The watertable is higher in the basement rocks than the alluvium as the alluvium is permeable which allows water to move through it and discharge (Figure 5-4).

The Proterozoic basement rock aquifers are recharged by infiltration of rainfall and local runoff in areas of outcrop and via leakage from overlying soils and sediments in areas of subcrop. These aquifers discharge to the Fortescue River alluvium and coastal sediments. As such, groundwater flow in the basement rock aquifers is generally from topographic highs towards the Fortescue River and the coast.

The Fortescue River floodplain alluvium is mostly recharged by infiltration of river flow, although there is also direct infiltration of rainfall and some throughflow from flanking basement rock aquifers. These aquifers discharge via base flow to the Fortescue River during periods when the watertable is above the riverbed and river water levels, and by evapotranspiration (CloudGMS 2017).

There are a number of pastoral bores within the Fortescue River floodplain alluvium and the Proterzoic basement rocks associated with the Mardie Station. Mardie Station is owned and operated by PMPL as a cattle station outside the approved mining areas.

Approved extent of groundwater drawdown

The existing project includes dewatering to allow mining to a depth of 220 m. The SER for the existing project included a prediction of groundwater drawdown based on a groundwater model by Aquaterra (2001). The 2001 groundwater model identified that drawdown of 0.5 m would extend 3.5 km to the west, 5 km to the east and 15 km to the north and south of the George Palmer Orebody. Section 3.1 of EPA Bulletin 1056 summarises that the total area covered by the 2001 drawdown zone is about 14 900 ha. The extent is shown in Figure 5-5. As the spatial information for the 2001 groundwater modelling described within Bulletin 1056 was not available, the drawdown contours described in this Bulletin's figures were digitised. Consequently, there is a discrepancy between the area identified in the Bulletin (14 900 ha) and the digitised extents (15 730 ha). Table 5-3 shows the difference between the digitised areas from Bulletin 1056 compared to the more recent CloudGMS (2017) modelling completed for the Proposal. The CloudGMS (2017) model incorporates substantial additional monitoring data since the initial 2001 model was prepared. However, the new model did not re-validate the predicted drawdown from the approved existing project.

The impact of the existing project on the drawdown on groundwater dependent ecosystems (GDEs) is described in Section 8.3.4.

As the existing project does not intersect the Fortescue River floodplain alluvium the extent of drawdown predicted extends in the direction of the mine pit (i.e. northeast to southwest). The predicted extent of the drawdown at 0.5 m, 1.0 m and 5.0 m contours for the existing project (Aquaterra 2009b) is shown in Figure 5-5.

Aquaterra (2001) concluded that water levels would not recover above the base of the final pit. On this basis the existing project was predicted to result in a dry pit void.

Dewatering of groundwater has been conducted to support the existing project and is subject to a licence issued by the DoW under the RiWI Act that specifies the maximum dewatering rate and includes conditions for monitoring. As part of the licensing process an Operating Strategy is required by DoW detailing the volumes that are available for dewatering and the monitoring requirements. The Operating Strategy has been prepared and approved by DoW and regular contact has been maintained with the DoW, including annual reporting of dewatering.

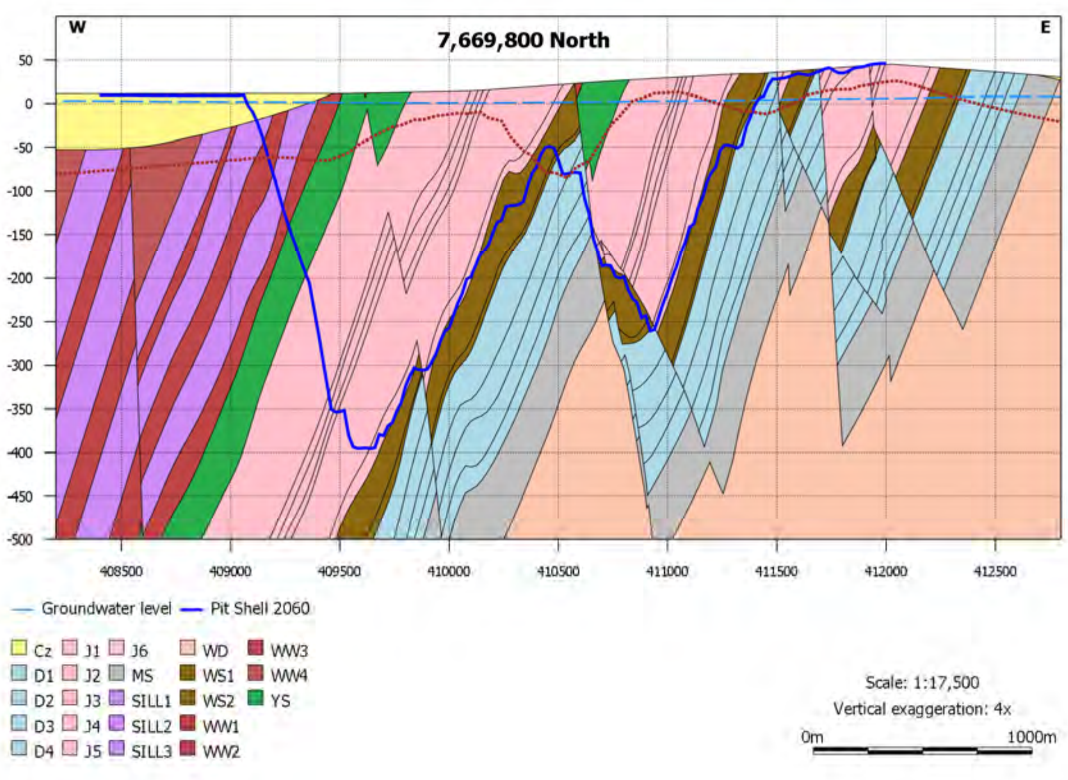
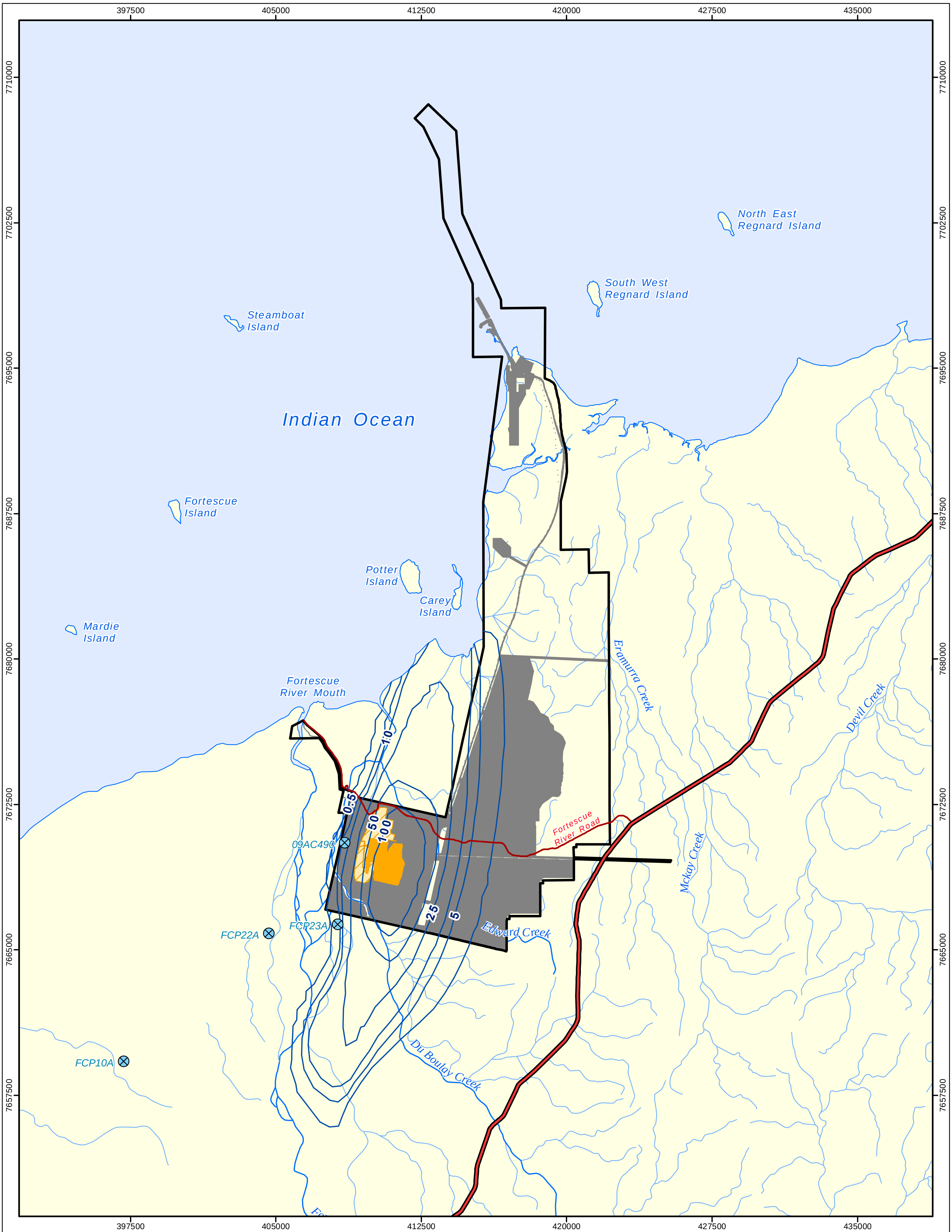


Figure 5-4: Schematic geographic cross section



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Mine Continuation Proposal

Figure 5 - 5

Approved extent of groundwater drawdown

0 5 10
Kilometres
1:250,000

Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	27/01/2017
Sheet Size:	A4	Status:	Final

Drawn by	Requested by	Internal Reference
DS	MB, Strategen	4406_01_2017_APP

- Monitoring bore
- 20 Year Drawdown Approved Extent
- Major Creek/River
- Minor Creek/River
- Conceptual Footprint
- Development Envelope
- Stage 1 - Sino Iron Approved Mine Pit
- Stage 3 - Sino Iron Extension Mine Pit

Mineralogy Expansion Proposal modelling

Modelling of the extent of drawdown from the MEP was conducted by Aquaterra (2009b). The modelling for the MEP occurred after the approval process for the Balmoral South (i.e. Stage 2) commenced. In consideration of the potential Stage 2 mine the MEP modelling included the combined extent of drawdown from Stages 1 to 2 and then Stages 1 to 5 to determine the relative increase from Stages 3 to 5.

Stages 1 and 2 combined had a predicted extent of drawdown of 22 550 ha, which represents 7650 ha above the 14 900 ha predicted from Stage 1 by Aquaterra (2001). With the addition of Stages 3 to 5 the cumulative extent of drawdown (i.e. for Stages 1 to 5) was predicted to be 26 601 ha, representing 4051 ha above the drawdown predicted for Stages 1 and 2. As shown in Figure 5-6, the predicted extent of drawdown from Stages 1 to 5 is approximately 25 km north-south and approximately 15 km east-west, which represents an increase of around 2 km to the east and 2 to 5 km to the north compared to Stages 1 and 2 only (Aquaterra 2009b).

While modelling for Stages 3 to 5 identified that the mine pit would not intersect the Fortescue River alluvium (and therefore limit drawdown within the alluvium) a subsequent review of the geological model identified that it would be unlikely that the mine pit would have been able to avoid intercepting the Fortescue Alluvials. On this basis, it is likely that the extent of drawdown and outflow of water from the alluvium would have been greater than that predicted in modelling for the MEP.

Aquaterra (2009b) predicted the groundwater outflow (i.e. from the alluvium to the pit) to be 172 kL/d to 314 kL/d or approximately 0.1 GLpa from the cumulative effects of Stages 1 to 5 (depending on the stage of development and the modelled recharge conditions). The 2009 model predicted that outflows from the alluvium would be small and may contribute between 4 and 13% of the total dewatering discharge from the mine pit, with the balance contributed from the Proterozoic basement rock aquifer/s.

The groundwater throughflow in the main aquifer (gravels) in the alluvium has been estimated (Commander 1993) at between 2.3 GLpa and 9.2 GLpa, with calculations undertaken by Aquaterra (2009b) give a throughflow estimate of around 5 GLpa under average conditions. Therefore the leakage 0.1 GLpa due to Stages 1 to 5 represents between 1.5 to 2.3% of the total throughflow of the aquifer. Aquaterra (2009b) concluded that although the drawdown within the basement material reaches the eastern edge of the alluvial aquifer in some areas, the magnitude of drawdown in the Fortescue River alluvium would be negligible.

Based on the Aquaterra (2009a) groundwater modeling the MEP PER concluded that the addition of Stages 3 to 5 would result in:

- a relatively minor increase in the extent of drawdown
- a negligible impact on the hydrological regime of the Fortescue River.

During the public comment period DoW recommended that additional work be undertaken to better describe the interactions between dewatering and the alluvium, groundwater dependent vegetation and saline inflows into the pits. These matters are addressed within the next section.

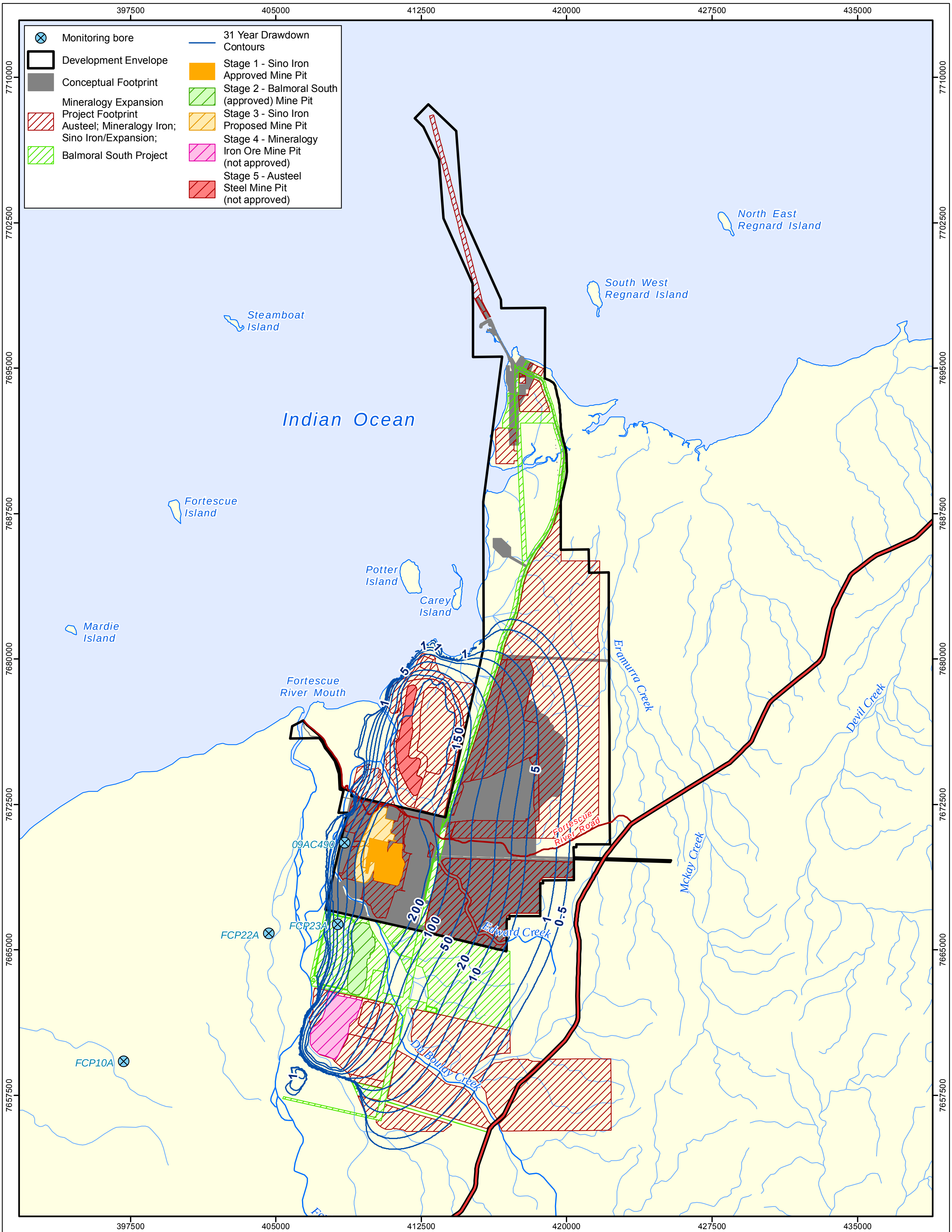

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Figure 5 - 6

Modelled extent of Mineralogy Expansion Proposal Stages 3 – 5 modelling drawdown

Department:	ENV	Date:	27/01/2017
Sheet Size:	A4	Status:	Final
Drawn by CF	Requested by MB, Strategen	Internal Reference 4407_01_2017_APP	

Modelling undertaken for the Proposal

Groundwater modelling for the Proposal was undertaken by CloudGMS (2017) to further refine the modelling undertaken for the existing project as part of DoW groundwater abstraction and dewatering requirements and the MEP in 2009. The scope of the groundwater modelling study was to:

- outline regional and local hydrogeology with reference to recent investigations and present amended cross-sections showing the relationship between alluvial and basement rock aquifers
- predict annual groundwater inflows to the pit
- predict groundwater level drawdowns in response to dewatering
- assess potential impacts of mining/dewatering on groundwater quality and quantity
- predict final pit void water levels, groundwater flows and quality
- assess potential long-term impacts of mining/dewatering on other groundwater users and GDEs.

In the response to the MEP PER the DoW identified several areas of concern relating to the uncertainty of the hydraulic properties of the rocks and hydraulic connection between the alluvial sediments and the pit. Specifically, these responses included:

- representation of the spatial relationship between the alluvial sediments, pit void and basement rocks as depicted in cross-sections of the mine site
- consideration of additional flows via secondary porosity – mining at depth has potential to open up flow paths in fractures and shears in the basement rock, which would change the hydrogeological characteristics of the aquifer
- uncertainty in the hydraulic connection between alluviums associated with the Fortescue River (and Du Boulay Creek) and the pit and the impacts on GDV associated with Du Boulay Creek
- mine closure connection between the Fortescue River alluvium and the pit through secondary porosity / permeability with a worst case scenario of the pit filling to groundwater level of the alluvial aquifer.

The scope of the CloudGMS (2017) groundwater model included addressing DoW comments on previous modelling. To ensure that DoW comments were adequately addressed, the scope of the groundwater modelling was provided to DoW and a meeting held with DoW on 17 November 2016 to discuss the issues. At this meeting DoW also requested that the cumulative impacts of all mines in the Cape Preston (i.e. all mines identified in the MEP) be modelled.

The key difference with the CloudGMS (2017) model and the previous models developed for the mine is the enhanced understanding of the local geology to develop a more accurate conceptual model. Based on the conceptual model the model domain has 15 vertical layers:

- three layers representing the superficial layers
- two layers representing weathered & fractured basement rocks
- 10 layers representing the unweathered basement rocks.

In addition, the Cloud GMS (2017) model has incorporated additional local and regional data, including:

- groundwater level hydrographs from 38 DoW regional observation bores
- groundwater levels from 205 standpipe observation bores (174 of these sites were within the existing model domain and used to inform the model development and calibration)
- monthly average values of pore pressure from 109 sensors deployed across 16 bores (sensors were located at depths between -15 mAHD and -300 mAHD)
- monthly abstraction totals from 17 production bores and in-pit sumps at the existing project
- eight cross-section transects to investigate the extent and thickness of alluvial sediment to be intersected by the west mine pit.

The model extent covers the whole of the Lower Fortescue River catchment downstream of Bilanoo gauging station. The boundary conditions are:

1. Northwest boundary along the Indian Ocean is a constant head boundary and groundwater level is set at the mean seawater level.
2. Eastern boundary approximately aligns with a mapped thrust fault between the Fortescue Group to the east and is assumed as a no-flow boundary given the low conductivity and limited recharge for the weathered Hamersley Group.
3. Southern boundary located along the upstream limit of the alluvial and Yarraloola aquifers is approximately treated as a no-flow boundary as it is perpendicular to groundwater flow and given the low conductivity of the weathered Hamersley Group and only a very small part of the cross-section being alluvial sediments.

5.3.3 Diversion of Edwards Creek

The southern branch of Edwards Creek will be realigned in two sections (Figure 5-7). The two realignments will enable the disturbance area of the infrastructure to be minimised.

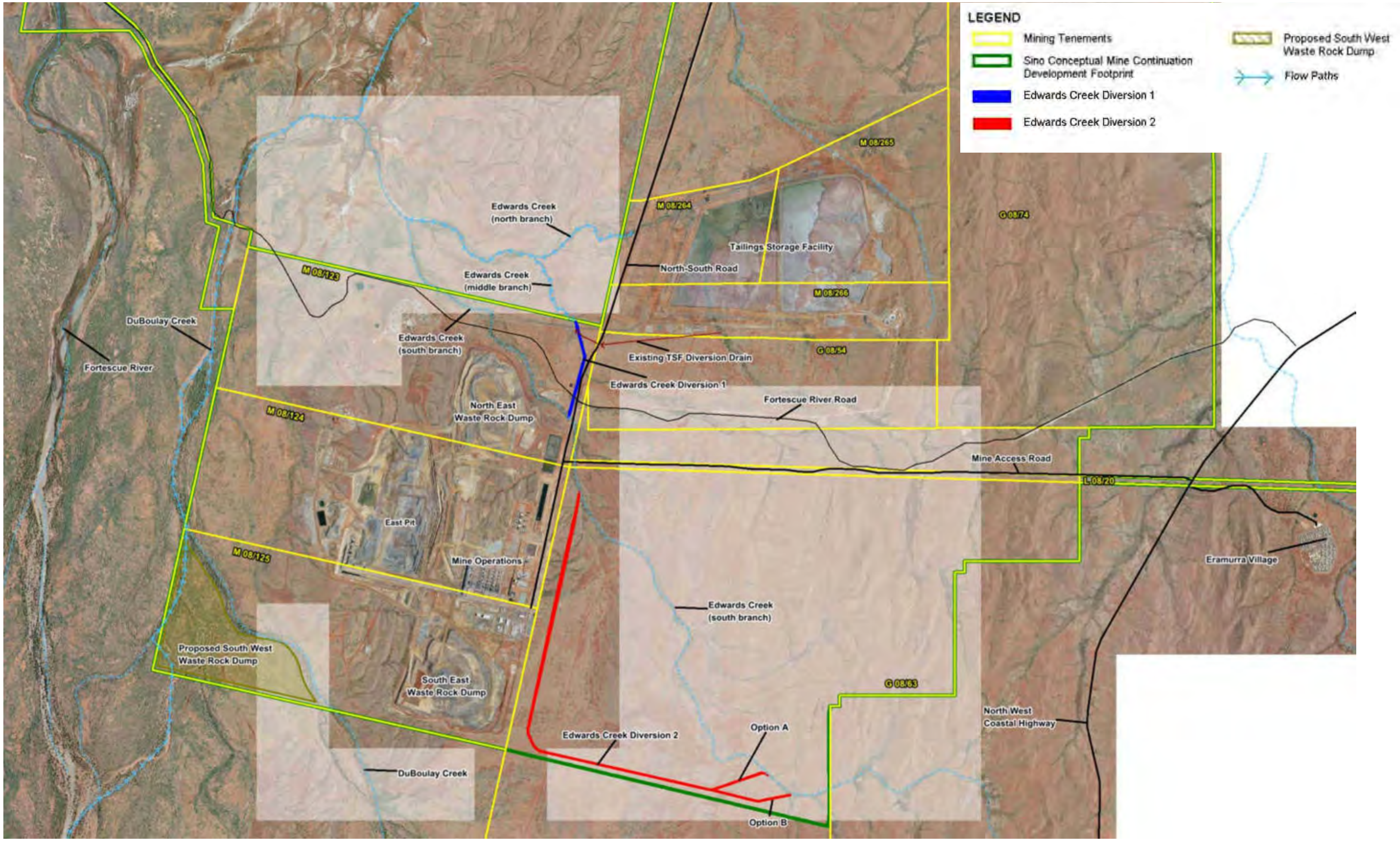
Diversion 1 is proposed to allow expansion of an existing smaller waste dump in Mining Tenement M08/123 adjacent to the mine. Diversion 1 involves realigning the southern branch of Edwards Creek along the eastern boundary of mining tenement M08/123. The alignment requires the construction of a 1.4 km channel and will result in the south branch feeding into the middle branch approximately 3 km upstream of the current location. The channel will be designed to be consistent with the dimensions of the existing channel of Edwards Creek.

Diversion 2 is proposed to accommodate the construction of the TSF in Mining Tenement G08/63 and involves diverting the southern branch of Edwards Creek around the TSF. This diversion will be 7.0 km and run west along the southern boundary of Mining Tenement G08/63 boundary and then north to rejoin the creek. The channel will be designed to be consistent with the dimensions of the existing channel of Edwards Creek.

The drainage design criteria for areas that may acceptably be subject to occasional flooding is typically set at the 1 in 5 to 10 year ARI flood level (RPS 2017). This level of flood protection may be provided by drainage channels that approximate the natural dimensions of the creeks, with a bed width of approximately 8 to 10 m (RPS 2017). Where the consequences of flooding are high (i.e. flooding of a pit) a much greater flood protection (such as a 1 in 100 year ARI) is provided. However, the associated drainage channels required to convey 1 in 100 year ARI flood flows require substantially more clearing and earthworks and are not considered warranted based on consequences.

The two diversions have been designed to accommodate the 1 in 5 to 10 year ARI flood flow. This is equivalent to the level of current flooding risk from the creeks impacting the Development Envelope, and existing drainage provisions (open channels, culverts, etc) in the Development Envelope. Once the design capacity of the open channel is exceeded, such as during cyclonic events, then flooding will occur around the mine site in general, as would occur naturally without the Proposal.

DoW (2015b) advice on future climate projections identifies that global climate change models for the Pilbara are unclear and indicate that both drier or wetter climates are possible. On this basis current rainfall values have been used in the calculation of future ARI flood flows.



Source: RPS 2017

Figure 5-7: Proposed diversion of Edwards Creek

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5.4 Potential impacts

The following potential impacts have been identified:

- groundwater drawdown from dewatering has potential to modify groundwater and surface water flows
- discharge of groundwater has potential to modify surface water flows in the Fortescue River
- diversion of Edwards Creek will modify surface water flows
- construction of physical elements will alter surface water flows.

While Section 5.5.1 predicts the extent of groundwater drawdown, the effects of groundwater drawdown on GDEs are considered in Section 8.5.3. Section 5.5.2 assesses only the effect of the discharge of groundwater on hydrological process, with the effect on the water quality of the Fortescue River estuary described Section 7.5.1.

5.5 Assessment of impacts

5.5.1 Groundwater drawdown

Increase in the extent of the drawdown from the Proposal

The predicted extent of drawdown from the Proposal at the end of mining is shown on Figure 5-8 (CloudGMS 2017). The extent of drawdown at 5 m, 1 m and 0.5 m contours is at approximately 2 km, 5 km and 7 km respectively from the mine pit, although at a smaller drawdown the distance is more variable. The 5.0 m drawdown contour is almost entirely within the Proposal disturbance footprint.

In comparison with the existing project (Figure 5-9) the extent of drawdown is less elongated (i.e. ‘rounder’). While the extent of the 0.1 m drawdown contour for the Proposal will extend an additional 5 km to the west, it extends 5.0 km less to both the north and the south than the existing project. The 5.0 m drawdown for the Proposal is almost entirely within the 5.0 m contour of the existing project. The 10.0 m drawdown contour is entirely within the 10.0 m contour for the existing project.

As shown in shown in Table 5-3 predicted drawdown associated with the Proposal represents an overall decrease in the extent of the 0.5 m, 5.0 m and 10.0 m drawdown contours in comparison to the existing project.

Table 5-3: Comparison of extent of drawdown

Depth of drawdown(m)	Extent of existing project (ha)	Extent of Proposal (ha)	Difference (ha)
0.5	15 730.7	14 399.1	-1331.6
5.0	11 840.5	3192.2	-8648.3
10.0	9940.7	2144.4	-7796.3

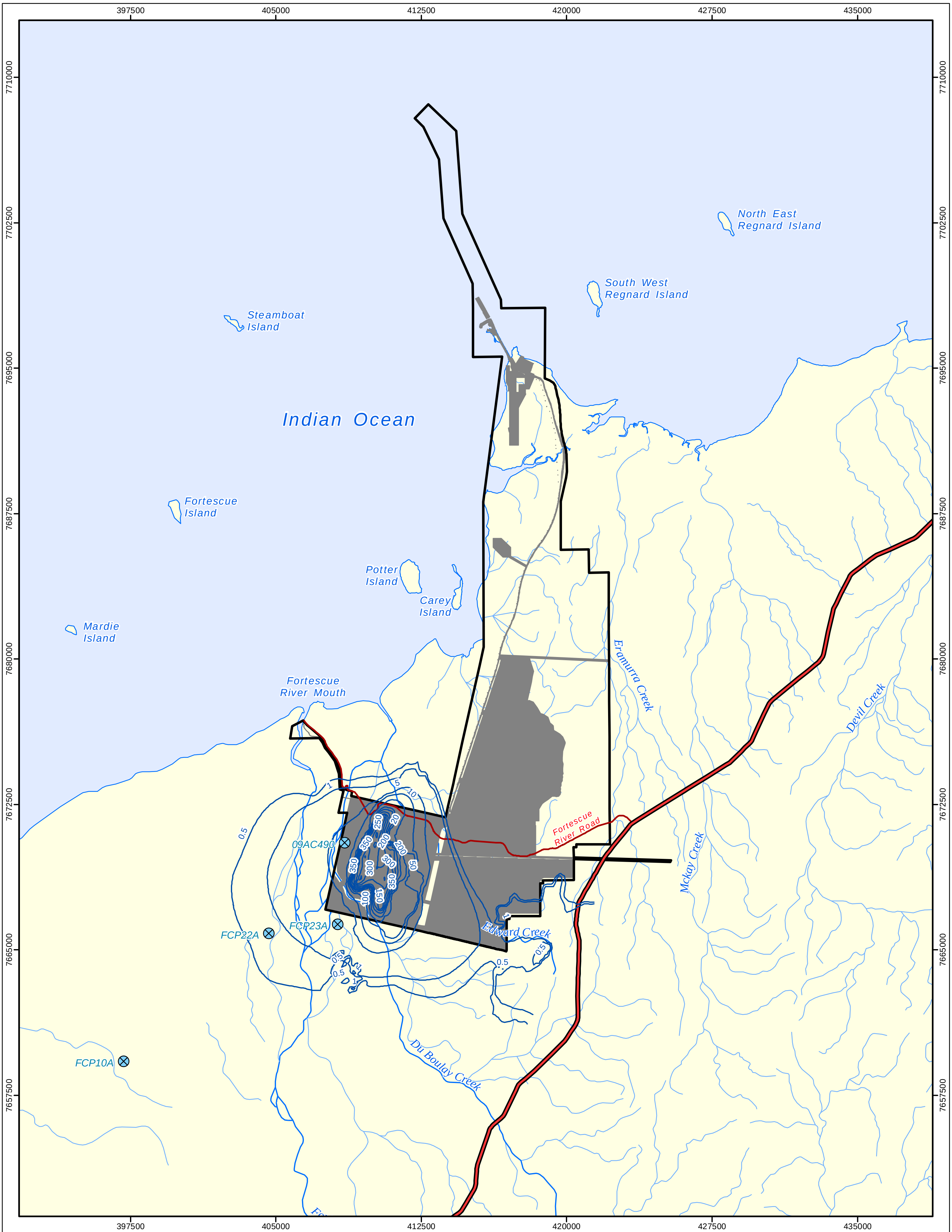

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Figure 5 - 8

Extent of groundwater drawdown

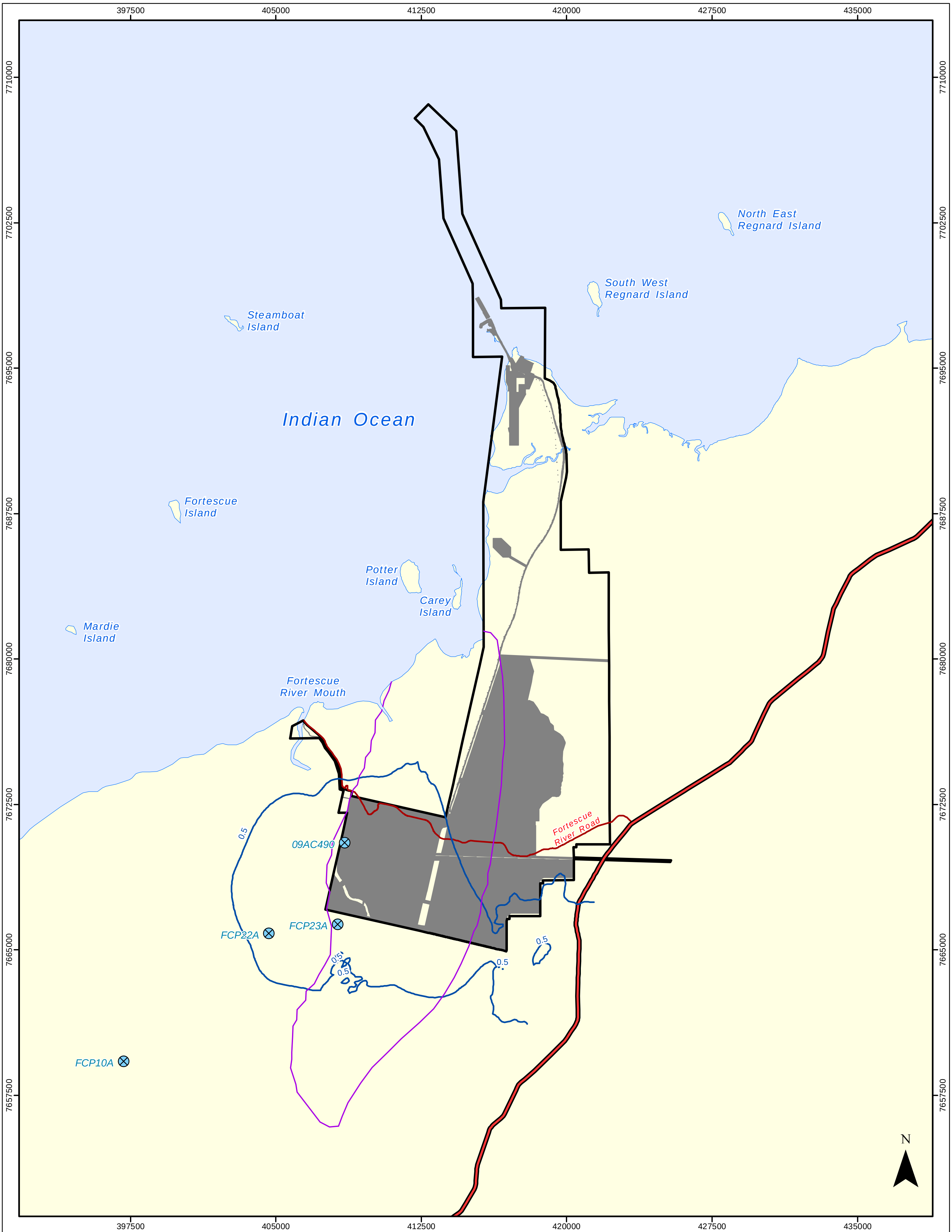
0 5 10
Kilometres
1:250,000

Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	27/01/2017
Sheet Size:	A4	Status:	Final

Drawn by	Requested by	Internal Reference
DS	MB, Strategen	4408_01_2017_APP

Legend
- Monitoring bore
- Groundwater Drawdown Mine Continuation Proposal
- Major Creek/River
- Minor Creek/River
- Development Envelope
- Conceptual Footprint



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Mine Continuation Proposal

Figure 5 - 9A

Comparison of extent of drawdown (0.5m) with approved extent

0 5 10
Kilometres
1:250,000

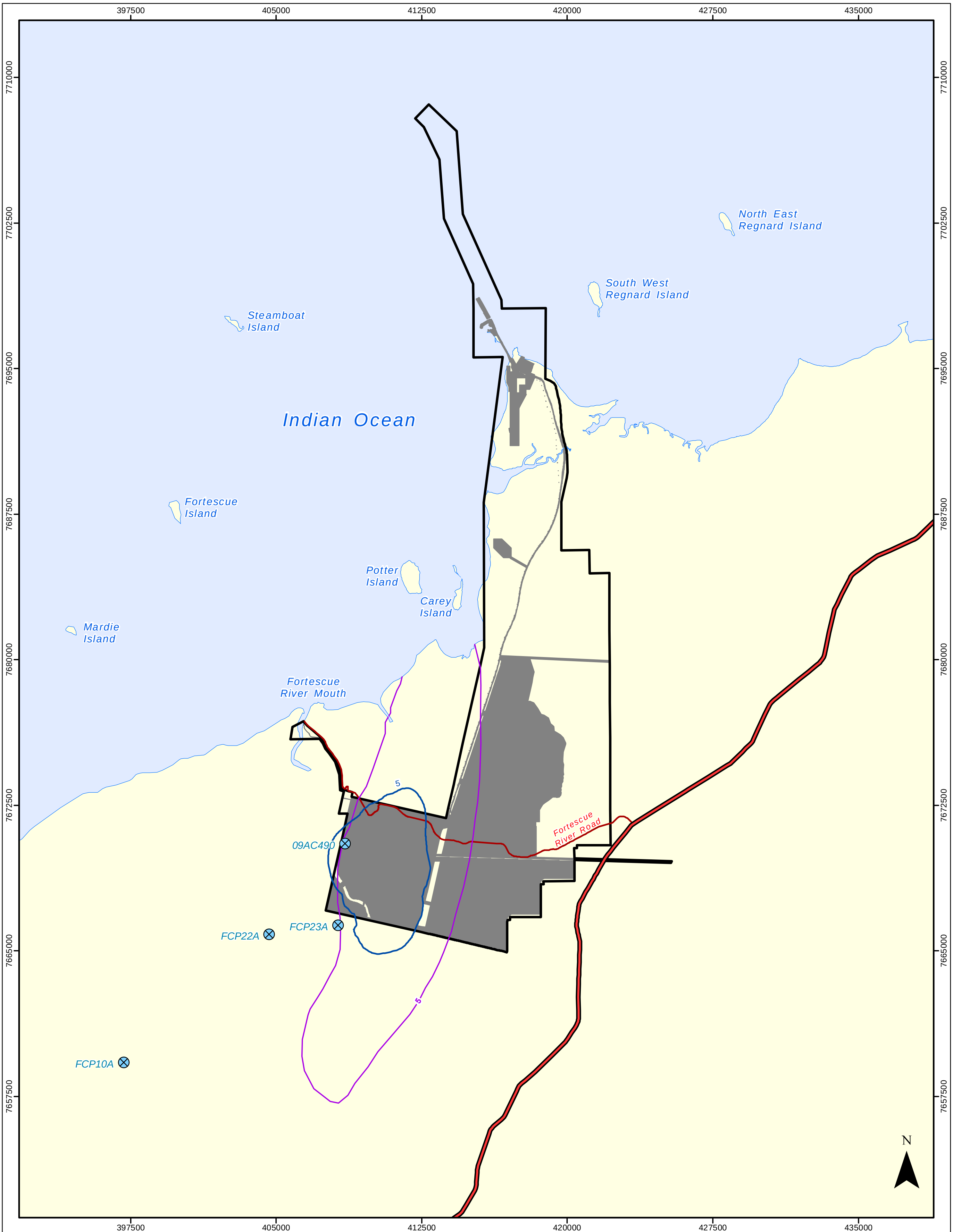
Datum: GDA94
Projection: MGA Zone 50

Department: ENV	Date: 27/01/2017
Sheet Size: A4	Status: Final

Drawn by	Requested by	Internal Reference
DS	MB, Strategen	4409_01_2017_APP

Legend

- Monitoring bore
- Groundwater Drawdown Mine Continuation Proposal
- 20 Year Drawdown Approved Extent
- Development Envelope
- Conceptual Footprint



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Mine Continuation Proposal

Figure 5 - 9B

Comparison of extent of drawdown (5m) with approved extent

0 5 10
Kilometres
1:250,000

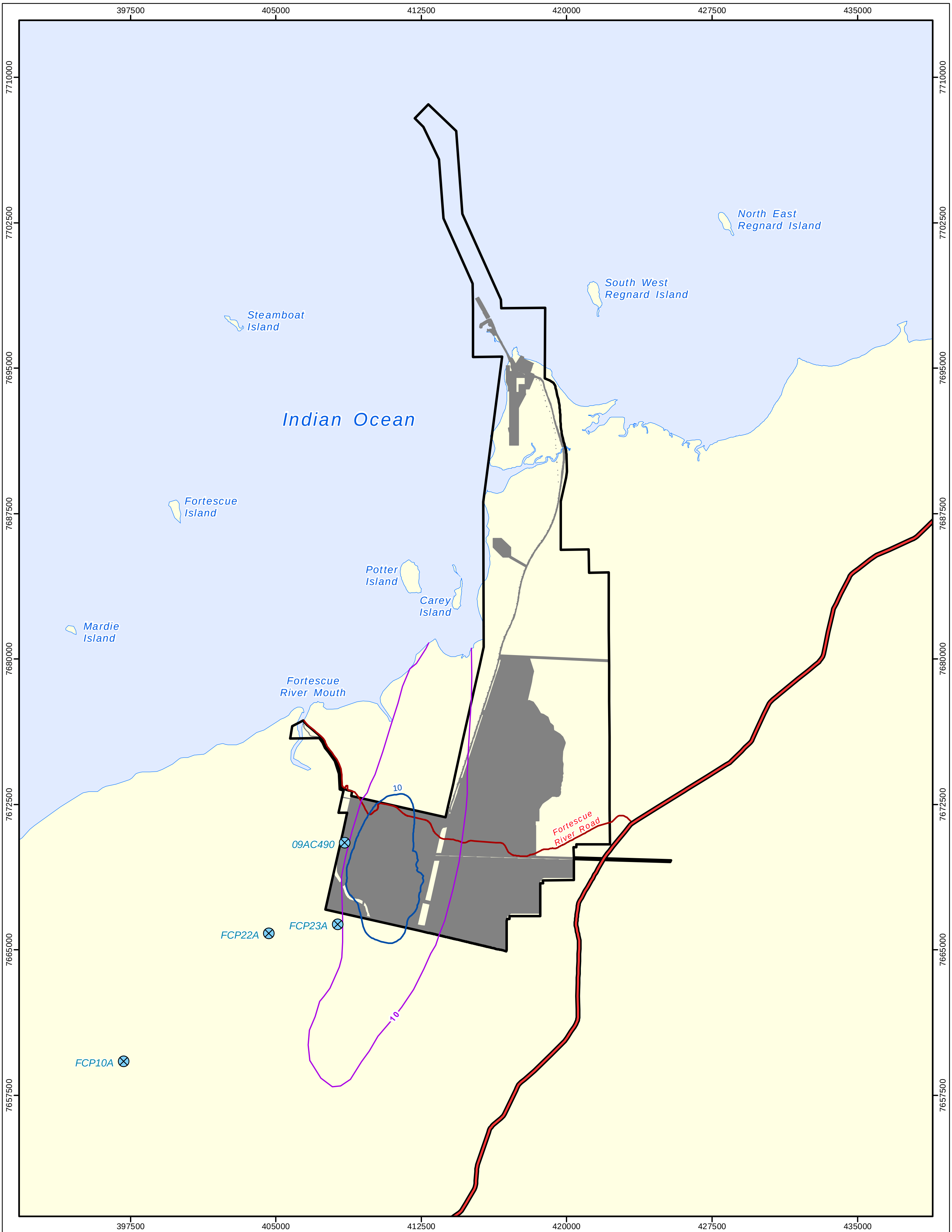
Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	27/01/2017
Sheet Size:	A4	Status:	Final

Drawn by	Requested by	Internal Reference
DS	MB, Strategen	4451_00_2017_APP

Legend

- Groundwater Drawdown Mine Continuation Proposal
- 20 Year Drawdown Approved Extent
- Development Envelope
- Conceptual Footprint



CITIC PACIFIC MINING 中信泰富矿业	Mine Continuation Proposal Figure 5 - 9C Comparison of extent of drawdown (10m) with approved extent	0 5 10 Kilometres 1:250,000 Datum: GDA94 Projection: MGA Zone 50	**Legend** Monitoring bore Groundwater Drawdown Mine Continuation Proposal 20 Year Drawdown Approved Extent Development Envelope Conceptual Footprint

Department:	ENV	Date:	27/01/2017
Sheet Size:	A4	Status:	Final
Drawn by DS	Requested by MB, Strategen	Internal Reference 4452_00_2017_APP	

As shown in Figure 5-10 the potential impacts of a drawdown of less than 1.0 m during the life of mine is expected to be difficult to observe. While the groundwater model is capable of predicting a drawdown of 0.5 m or less, the highly variable groundwater levels within the Fortescue River flood plain is expected to make it difficult to detect a groundwater drawdown of 0.5 m in the field. Modelled groundwater level hydrographs (shown in Figure 5-10) are provided for regional reference monitoring sites to demonstrate the variability and rate of change in groundwater levels within each drawdown contour:

1. FCP10A located approximately 15 km SW of the mine pit is predicted to have a drawdown of less than 0.5 m. This hydrograph shows minimal change in groundwater levels over the 144 year period modelled.
2. FCP22A located at approximately 5 km SW of the mine pit is predicted to have a drawdown of between 0.5 and 1.0 m. The high degree of variability in the hydrograph is a result of the proximity of the bore to the Fortescue River (approximately 1 km) and in response to rainfall and river flows. Groundwater levels will continue to vary seasonally in response to rainfall and river flow by approximately 2.0 m. This hydrograph shows a subtle decline in groundwater levels.
3. FCP23A located approximately 2 km SW of the mine pit is predicted to have a drawdown of between 1.0 and 5.0 m. The groundwater levels at FCP23A shows a gradual decline of approximately 3 to 4 metres during mining and appears to reach dynamic equilibrium at this level soon after the completion of mining.
4. 09AC490 located 1 km West of the mine pit is predicted to have a drawdown of between 5.0 and 10 m. This hydrograph shows a steady decline over the life of mining of approximately 8 m at 40 years (i.e. on average 1 m every five years) and then stabilises at the completion of mining. However, this location is within the Proposal development footprint.

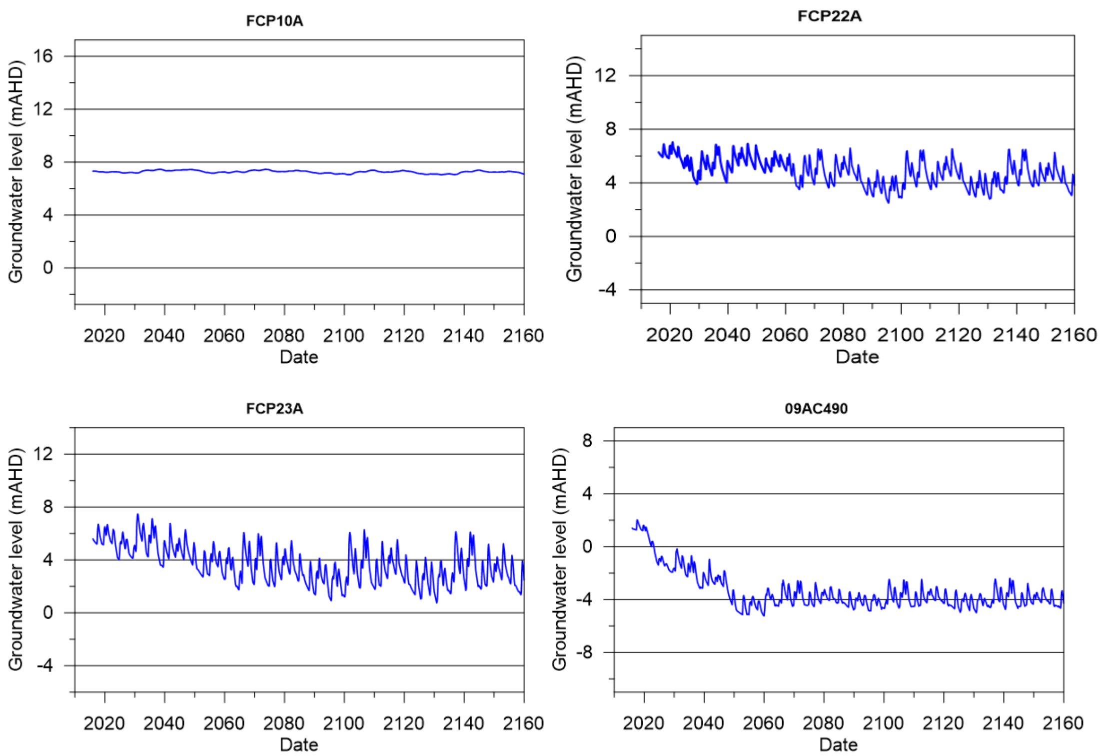


Figure 5-10: Changes to groundwater levels

Effect on surface water pools

As identified in Section 5.3.1, there are two permanent and five temporary groundwater pools on the Fortescue River floodplain. The pools are all river flow fed, although the furthest pool downstream, Tom Bull Pool, is also tidally inundated (CloudGMS 2017). Only Mungajee Pool was identified as a permanent freshwater pool. Mungajee Pool is located at approximately 7 km SW of the mine pit.

As shown in Figure 5-11, groundwater levels at Mungajee Pool are predicted to have a drawdown of less than 1.0 m over more than 100 years. As the groundwater levels vary seasonally by approximately 2.0 m this demonstrates that water in the pool will be present long enough to contribute to the regional groundwater. On this basis, it is unlikely that there will be a significant change in the hydrological values of any surface water pools.

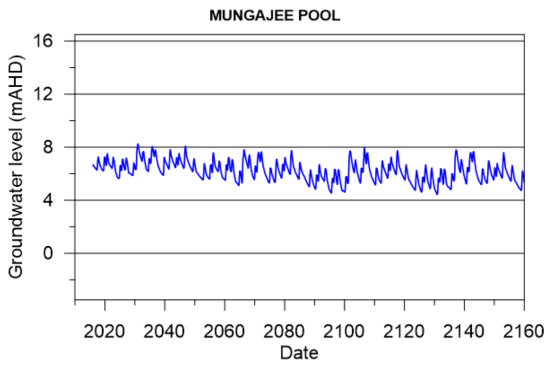


Figure 5-11: Mungajee Pool hydrograph

Recovery of groundwater level after closure

At the completion of mining the vertical profile of the groundwater drawdown will change from a steep-sided deep profile to a shallower profile. While this means that the extent of deeper drawdown levels (i.e. more than 10 m) will contract closer to the mine pit it will result in a minor increase in the extent of the shallower 1.0 m contour. The post closure groundwater levels are shown in Figure 5-12.

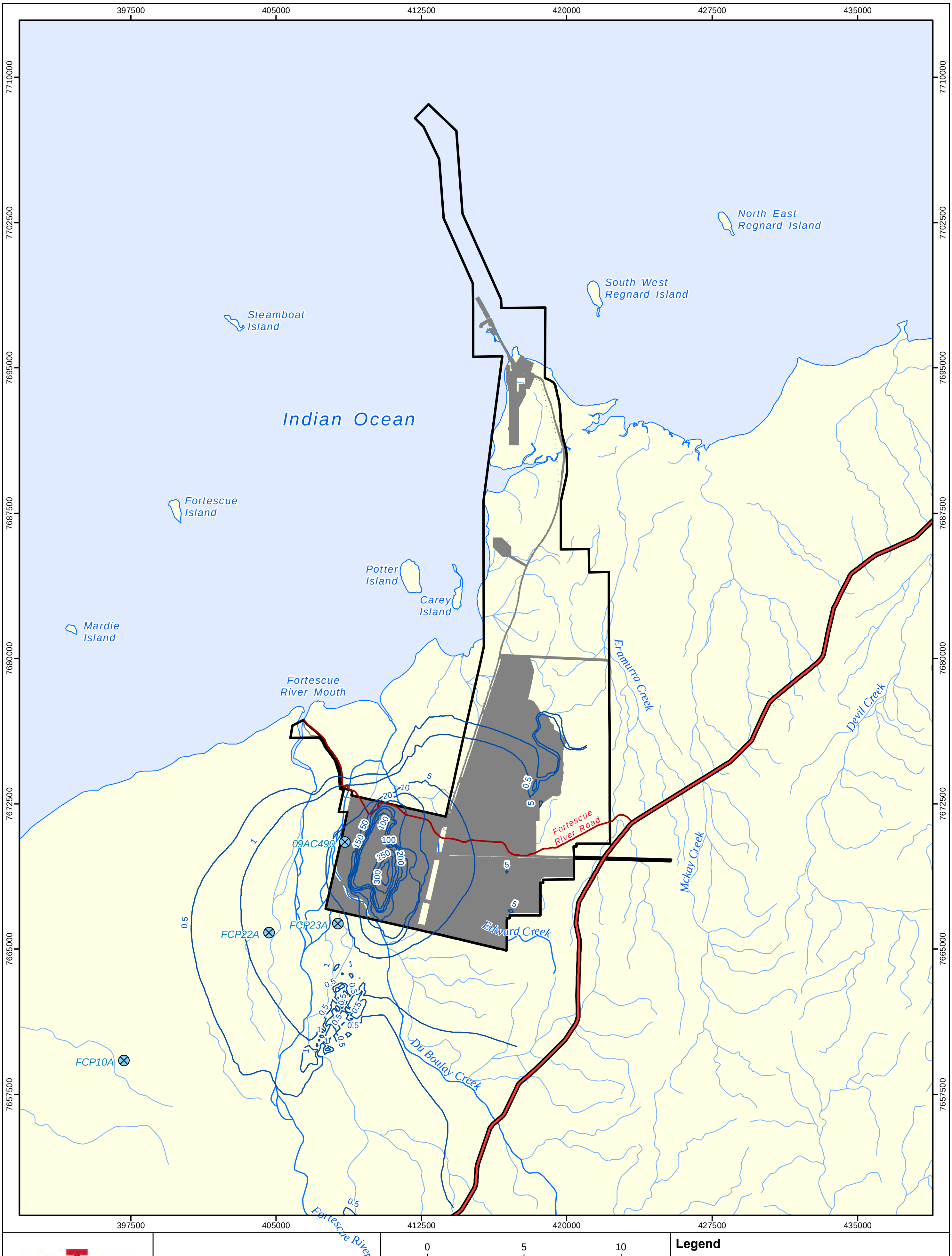
The recovery of groundwater levels will result in the flow of groundwater into the pit. The West Pit is predicted to fill relatively rapidly due to groundwater inflows from the weathered material along the western margin of the pit.

After 100 years the water level in the West Pit is expected to reach a level of approximately -160 to -170 mAHD (i.e. more than 230 m deep) with the East Pit recovering to a water level of approximately -300 to -310 mAHD (i.e. 50 m deep) (Figure 5-13).

Regional context of groundwater changes

In addition to the magnitude of the change in groundwater levels the relative change in groundwater levels is also important. Figure 5-14 to Figure 5-16 show changes to depth to water as a result of the Proposal. As shown in Figure 5-14 currently the depth to the groundwater in proximity to the mine pit is 10 m. The depth to groundwater for the majority of the Fortescue River floodplain is between 20 and 5 m, closer to the coastline the depth to the groundwater decreases. With the exception of the mine pit, at the end of mining the depth to groundwater is not predicted to be substantially different throughout the extent of the model. The dewatering will increase the extent of the area that has a groundwater depth between 10 – 20 m; however, this approximately follows the existing boundaries and distribution of groundwater depths.

At 80 years after the completion of mining (Figure 5-16) the depth to groundwater throughout the modelled area will again be very similar to levels at the start of the modelling period. On this basis, groundwater levels are not expected to substantially change in the regional area.



Mine Continuation Proposal

Figure 5 - 12

Post closure groundwater levels

0 5 10
Kilometres
1:250,000

Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	27/01/2017
Sheet Size:	A4	Status:	Final
Drawn by DS	Requested by MB, Strategen	Internal Reference 4458_01_2017_APP	

Legend

- Monitoring bore
- Post closure groundwater levels
- Major Creek/River
- Minor Creek/River
- Development Envelope
- Conceptual Footprint

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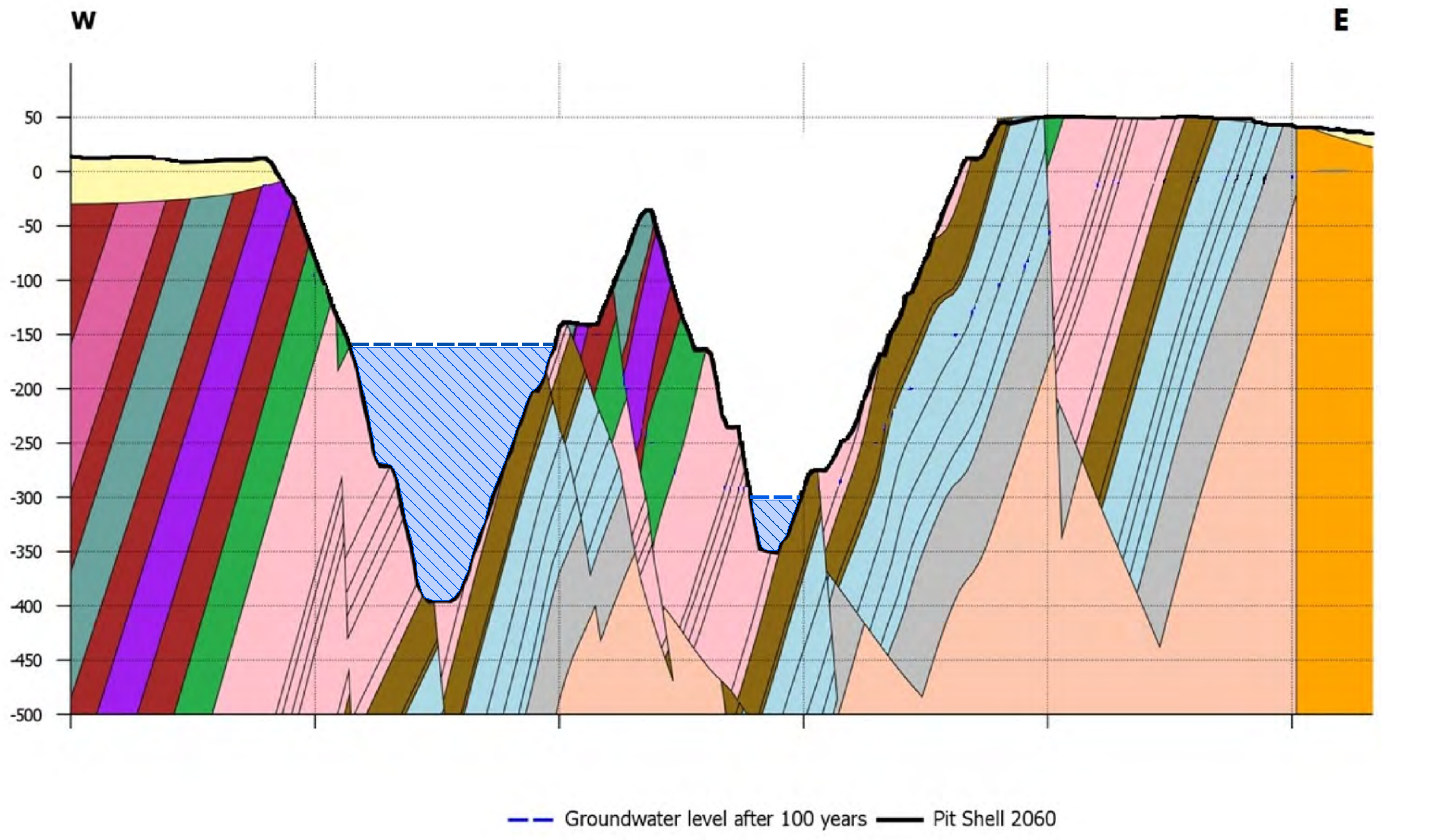

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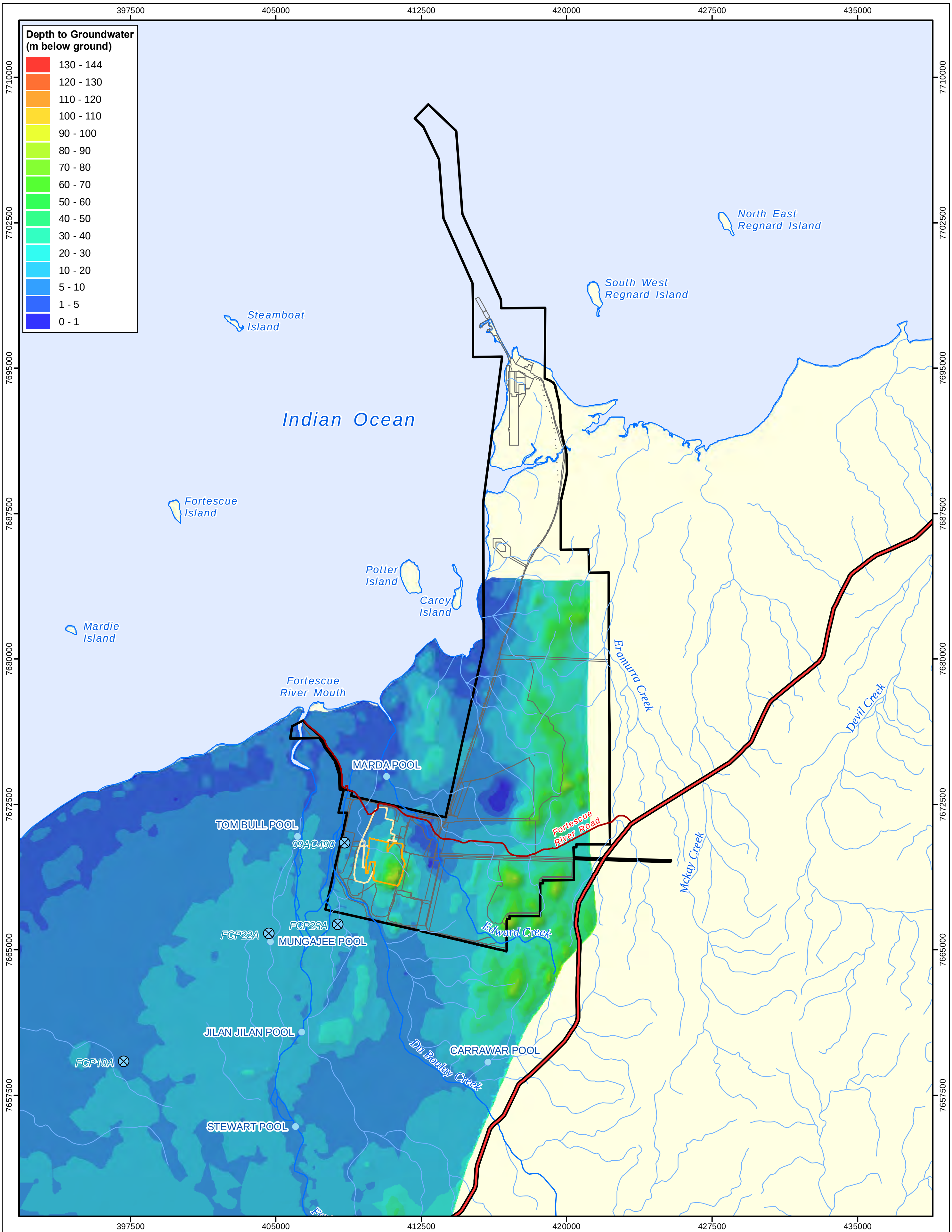
Figure 5-13

Conceptual Mine Pit Closure Section

Department:	ENV	Date:	1/02/2017
Sheet Size:	A4	Status:	Final
Drawn by DS	Requested by MB, Strategen	Internal Reference 4461_00_2017_APP	



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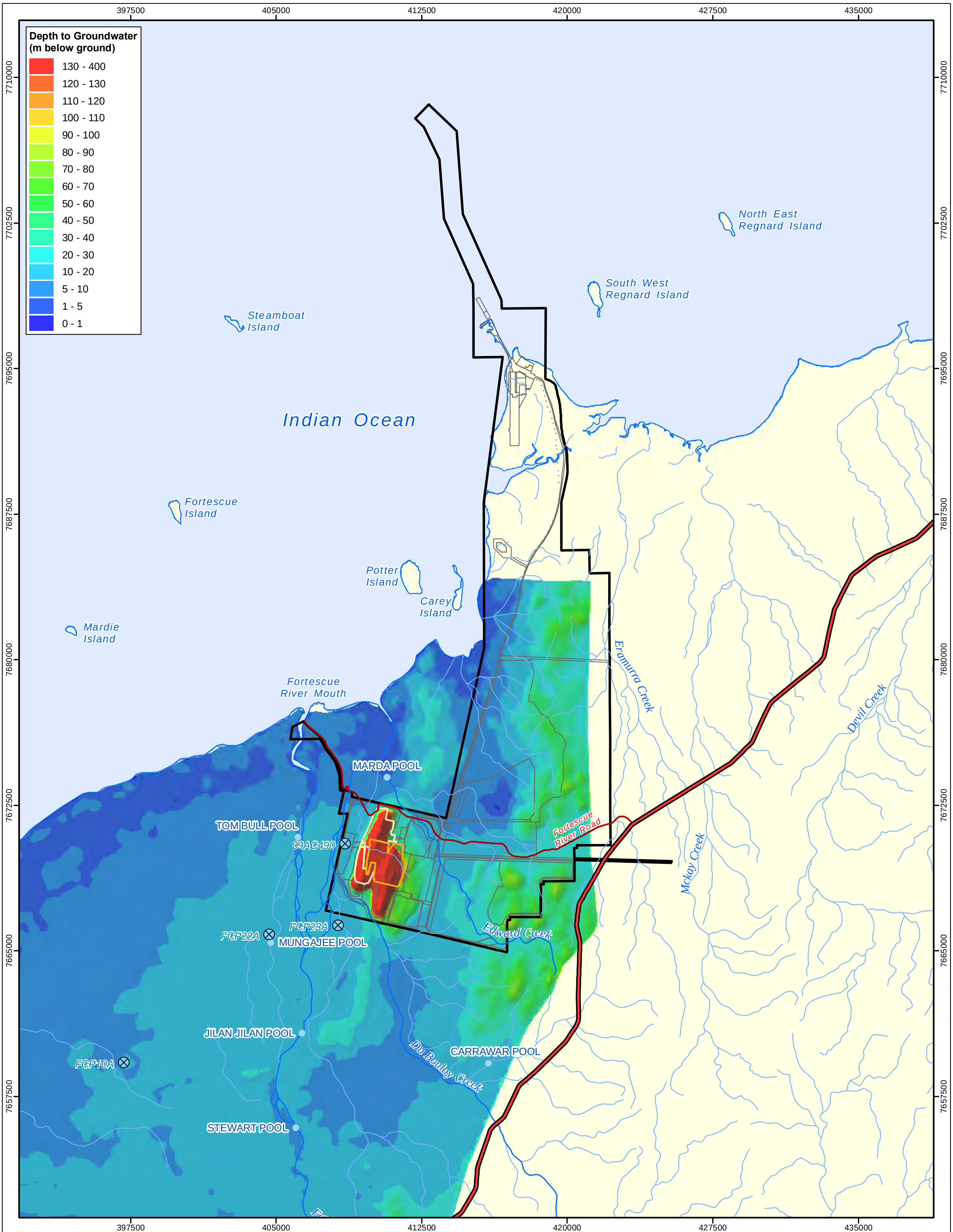
Mine Continuation Proposal

Figure 5 - 14

Current regional dept to groundwater

Department:	ENV	Date:	27/01/2017
Sheet Size:	A4	Status:	Final
Drawn by CF	Requested by MB, Strategen	Internal Reference 4433_00_2017_APP	



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Mine Continuation Proposal

Figure 5 - 15

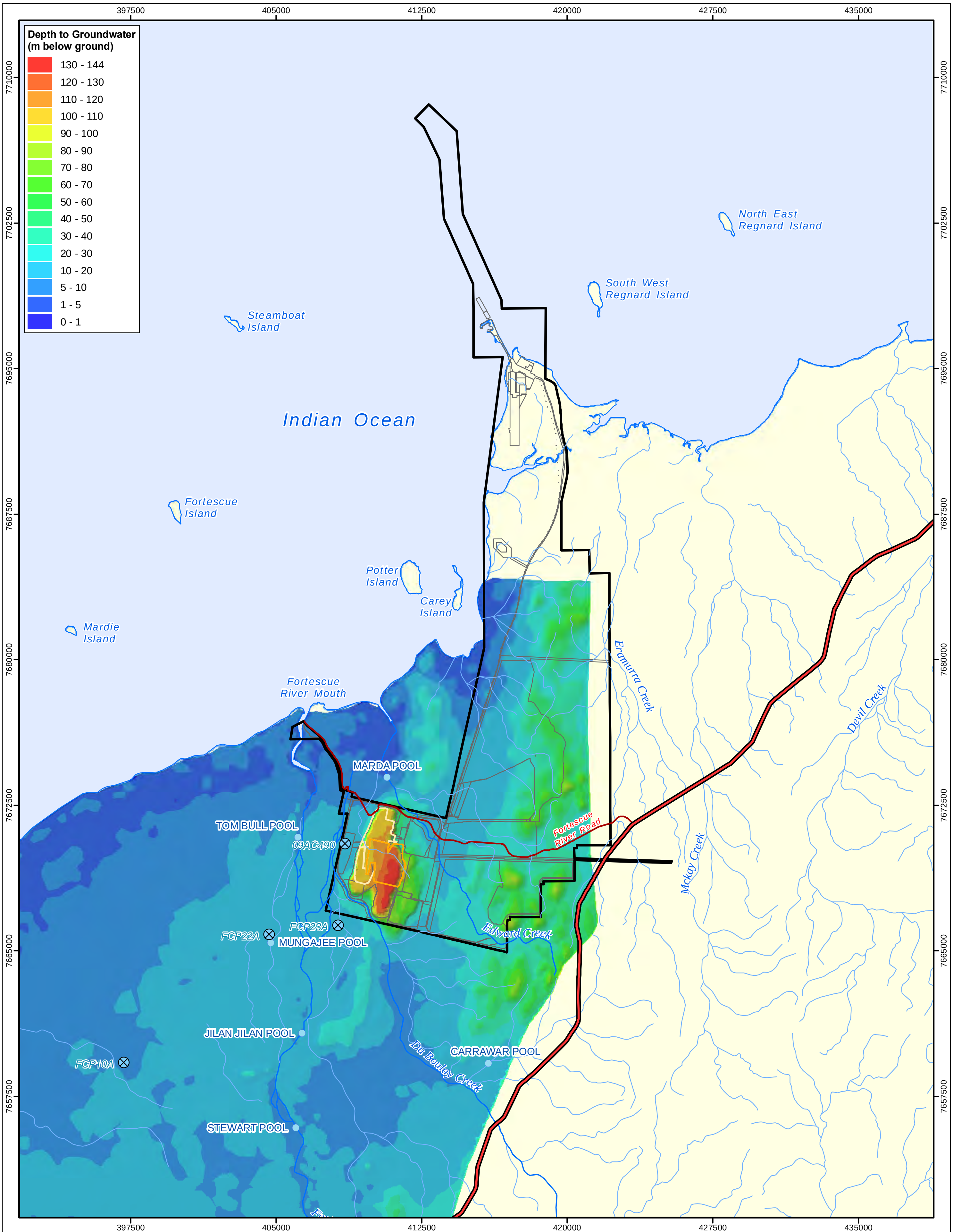
Depth to regional groundwater at end of mining

0 5 10
Kilometres
1:250,000

Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	27/01/2017
Sheet Size:	A4	Status:	Final
Drawn by CF	Requested by MB, Strategen	Internal Reference 4434_00_2017_APP	

Monitoring bore
Pool
Major Creek/River
Minor Creek/River
Conceptual Footprint
Development Envelope
Stage 1 - Sino Iron Approved Mine Pit
Stage 3 - Sino Iron Extension Mine Pit



CITIC PACIFIC MINING 中信泰富矿业	Mine Continuation Proposal Figure 5 - 16 Depth to regional groundwater 80 years after end of mining

0 5 10
Kilometres
1:250,000
Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	27/01/2017
Sheet Size:	A4	Status:	Final
Drawn by CF	Requested by MB, Strategen	Internal Reference 4435_00_2017_APP	

- Monitoring bore
- Pool
- Major Creek/River
- Minor Creek/River
- Conceptual Footprint
- Development Envelope
- Stage 1 - Sino Iron Approved Mine Pit
- Stage 3 - Sino Iron Extension Mine Pit

Consideration of cumulative impacts

In accordance with feedback received from DoW CloudGMS (2017) undertook a model run that included the full development of all mines in the Cape Preston area (as identified in the MEP). The consideration of impacts included an estimate of possible mining and dewatering requirements; however, it has not been possible to verify these assumptions with the other proponents and it is considered unlikely that any of these mines will be developed. Thus these cumulative impacts are highly unlikely to materialise and represent a best estimate ‘worst’ case.

The cumulative impact model assumed that the mines were similar to that proposed in the MEP, which specify similar pit depths to this Proposal for the other mine pits. In addition to the consideration of other mines pits the Balmoral South (i.e. Stage 2) proposal included the establishment of a borefield to produce water for operational requirements. The Balmoral South borefield includes 20 production bores within the Fortescue River floodplain alluvium to the southwest of the Proposal that are designed to generate 6 GLpa (Figure 5-17).

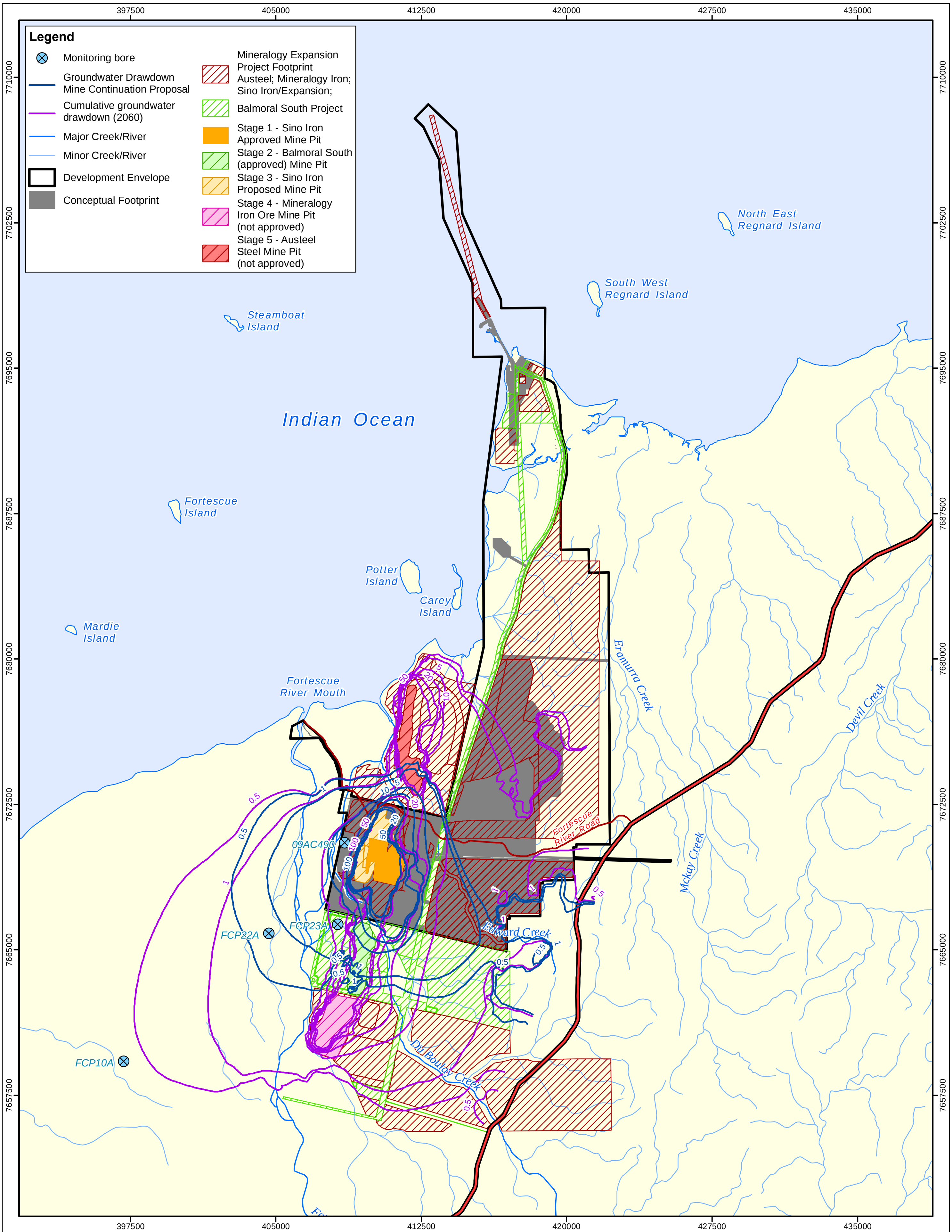
Extent of drawdown from inclusion of additional mine pits generally follows that of the Proposal, i.e. drawdowns of 5 m are generally confined to within 2 km of the mine pits. However, the inclusion of the production bores throughout the superficial aquifer located in the Fortescue River floodplain substantially expand the extent of the 1.0 m and 0.5 m drawdown contours.

As shown in Table 5-4 the extent of the cumulative 0.5 m drawdown contour is substantially larger than either the existing project or the Proposal (approximately twice as large). However, both the 5.0 m and 10.0 m drawdown contours are much smaller than the existing project and not substantially greater than those forecast for the Proposal. This indicates that higher drawdown contours are primarily limited to the immediate vicinity of the mine pits.

Although the development of the other mines pits is considered unlikely by the Proponent, outside the implementation of the production bores, the additional mine pits do not substantially increase the extent of groundwater drawdown.

Table 5-4: Comparison of extent of cumulative drawdown of all mines

Depth of drawdown(m)	Extent of existing project (ha)	Extent of Proposal (ha)	Cumulative drawdown of all Cape Preston mines (ha)
0.5	15 730.7	14 399.1	30 069.6
5.0	11 840.5	3192.2	4972.6
10.0	9940.7	2144.4	2319.0



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Mine Continuation Proposal

Figure 5 - 17

Extent of cumulative groundwater drawdown

1:250,000

Datum: GDA94
Projection: MGA Zone 50

Department: ENV		Date: 27/01/2017	
Sheet Size: A4		Status: Final	
Drawn by DS	Requested by MB, Strategen	Internal Reference 4450_00_2017_APP	

5.5.2 Discharge of groundwater

Figure 5-18 presents the total modelled pit inflows over the life of the mine. The predicted inflows show a steady increase to approximately 5 GLpa in 2025. This steady increase coincides with the mining in the West Pit. The median final pit inflows are approximately 7.5 GLpa at around 2035.

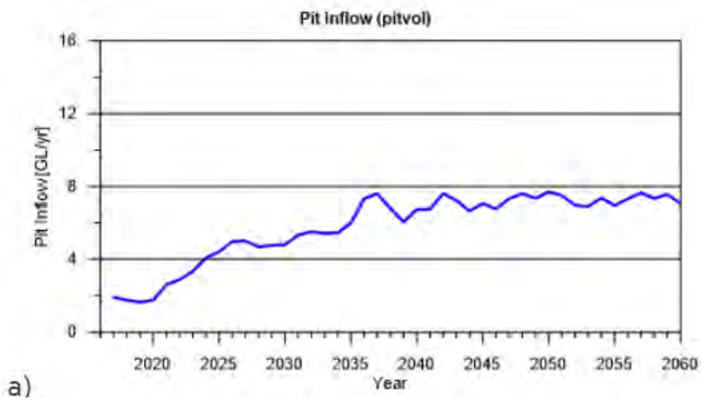


Figure 5-18: Total pit inflows

Based on a median pit inflow of 7.5 GLpa (as identified in Figure 5-18) the Proposal includes increasing the discharge from 2 GLpa to up to 8.0 GLpa. The discharge of 8.0 GLpa will accommodate years where pit inflows are above predicted median inflow. The Proposal will increase the groundwater discharge into the lower Fortescue River estuary. The hydrological regime at the mouth of the Fortescue River is not expected to be significantly affected by the addition of the groundwater as the natural flows are large (Fortescue River discharge is greater than 305 GLpa), highly variable and have a strong tidal influence.

RPS APASA (2017) determined that the peak downstream river flow rates ranged from 40 m^3/s during neap tide to 200 m^3/s during the spring tide. In comparison flow rates from the release of 8 GLpa was 0.24 m^3/s. On this basis, the change to any hydrological processes from the discharge of groundwater would be negligible.

5.5.3 Diversion of Edwards Creek

The southern branch of Edwards Creek will be realigned in two sections (Figure 5-7). As described in Section 5.3.3, the two realignments will enable the disturbance area of the infrastructure to be minimised.

Both diversions have been designed to reflect the existing channel with a bed width of 8 to 10 m and able to accommodate a 5 to 10 year ARI flood event. The intent of the design for the proposed diversions is to perform in a similar manner during runoff events to the existing channel, and be stable in the long term with similar hydraulic and geomorphic characteristics. To achieve the design intent the proposed alignment maintains the length of the original creek so as not to increase the gradient of the creek bed. On this basis, the channel is not expected to significantly alter either the flow or velocity of the creek.

As the velocity of the creek is proposed to be maintained the diversions are unlikely to substantially modify the surface flow properties of Edwards Creek.

5.5.4 Alteration of surface flows

The Proposal will involve placing an additional waste rock stockpile in the south-west corner of tenement M08/125, within the 1 in 100 year ARI flood extent of both the Fortescue River and Du Boulay Creek floodplain. The 1 in 100 year ARI floodplain for Du Boulay Creek is approximately 1400 m wide (on average), while the riparian zone appears to vary from 300 to 600 m and up to 1 km wide.

Encroachment of the waste dump onto the flood plain will restrict flow (in significant flood events), resulting in increased flood height and velocity. During a 1 in 100 year ARI flood the flood height is forecast to rise by 0.75 m with an average increase in velocity of 0.2 m/s (to a total velocity of 2.0 m/s).

The increase in flood height and velocity are not expected to produce a measureable change in the sediment load of the creek during 100 year ARI flood events. The Proposal will maintain vegetation buffer between the Proposal footprint and floodplain channels to limit increases in flood levels and velocities, and minimise erosion. On this basis the Proposal is therefore unlikely to significantly affect stream flow characteristics of any water course.

5.6 Mitigation

The overall objective for the mitigation of impacts to hydrological processes is to ensure that the impacts on hydrological regimes as a result of implementation of the Proposal will be minimised so as to meet the EPA's objective. The Proposal will continue to apply management measures outlined in the DoW operating licence required under the RiWI Act. An application to update the licence will be submitted to DoW that will continue to apply existing measures.

The mitigation measures proposed include:

Avoidance:

- incorporate flood modelling data and surface flow data into the design of the Proposal to avoid significant impacts to hydrological processes.

Minimisation:

- discharging groundwater to the Fortescue River on outgoing tides to minimise changes to hydrological processes
- a naturally vegetated buffer will be maintained between the bunds around the Proposal elements and floodplain channels to limit increases in flood levels and velocities, and minimise erosion
- monitoring will be undertaken to continue to assess potential impacts to nearby creeklines
- an Operating Strategy shall detail the monitoring and adaptive management measures for of the groundwater drawdown aspects
- realignment of the southern branch of Edwards Creek into two sections to enable the minimisation of the disturbance area of the infrastructure.

5.7 Predicted outcome

When the mitigation and management measures have been implemented, it is expected that the Proposal will result in the following outcomes in relation to the Hydrological processes factor:

- the areal extent of the 0.5 m, 5.0 m and 10.0 m drawdown contours will decrease relative to the existing project
- the recovery of groundwater is expected to result in a pit lake of approximately 250 m deep in the west pit and 20 m deep in the east pit
- the regional groundwater levels are not expected to be significantly affected
- no permanent pools will be significantly affected
- the cumulative development of all mines on Cape Preston would not substantially increase the areal extent of groundwater drawdown
- although highly unlikely to occur the inclusion of additional mines to assess cumulative impacts to hydrological processes do not significantly affect groundwater levels; however, Balmoral South borefield will increase the extent of the 1.0 m drawdown contour
- during mining the predicted mine pit inflows that will need to be dewatered are 8.0 GLpa
- the discharge of 8.0 GLpa will not substantially affect flows or values of the Fortescue River
- the development of a Waste Dump adjacent to Du Boulay Creek is not expected to affect volumes or surface water significantly increase flow velocities.

Based on the predicted residual impacts, the objective for Hydrological processes can be met.

6. Inland waters environmental quality

6.1 EPA objective

To maintain the quality of groundwater and surface water so that environmental values are protected.

6.2 Policy and guidance

The relevant policy for Inland waters environmental quality is:

- *Environmental Factor Guideline - Inland Waters Environmental Quality* (EPA 2016c).

6.3 Receiving environment

A summary of work completed to describe the receiving environment regarding Inland waters environmental quality is included in Table 6-1.

Table 6-1: Summary of environmental studies and survey effort

Author/ date	Survey/ investigations name	Study area, type and timing	Study standard/guidance and limitations
Recently completed work			
RPS 2017	*Edwards Creek Diversions and Southwest Waste Dump*	A surface water assessment of engineering designs.	
RPS APASA 2017	*Discharge Modelling Assessment* *Fortescue River Outfall*	Delft3D-FLOW hydrodynamic model.	Peer reviewed model Model adheres to the International Association for Hydro-Environment Engineering and Research guidelines for documenting the validity of computational modelling software, closely replicating an array of analytical, laboratory, schematic and real-world data.
RPS APASA 2016	*Cape Preston Pit Water River Discharge Assessment*	Nearfield dilution assessment for the discharge of 2 GLpa.	
Aquaterra 2009a	*Mineralogy Expansion Projects (Stage 3-5) Surface Water Management*	Surface water assessment (including 1 in 100 year ARI flood assessment) of the Fortescue River and Du Boulay Creek floodplain adjacent to the Sino Iron Project for the Stages 3-5 Mineralogy Expansion Proposal conducted in 2009.	ANZECC/ARMCANZ Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCAZ, 2000) Water Quality Protection Guidelines (No. 1-11) (DoW & DoIR, 2000) State Water Quality Management Strategy (ANZECC and ARMCANZ, 2001)

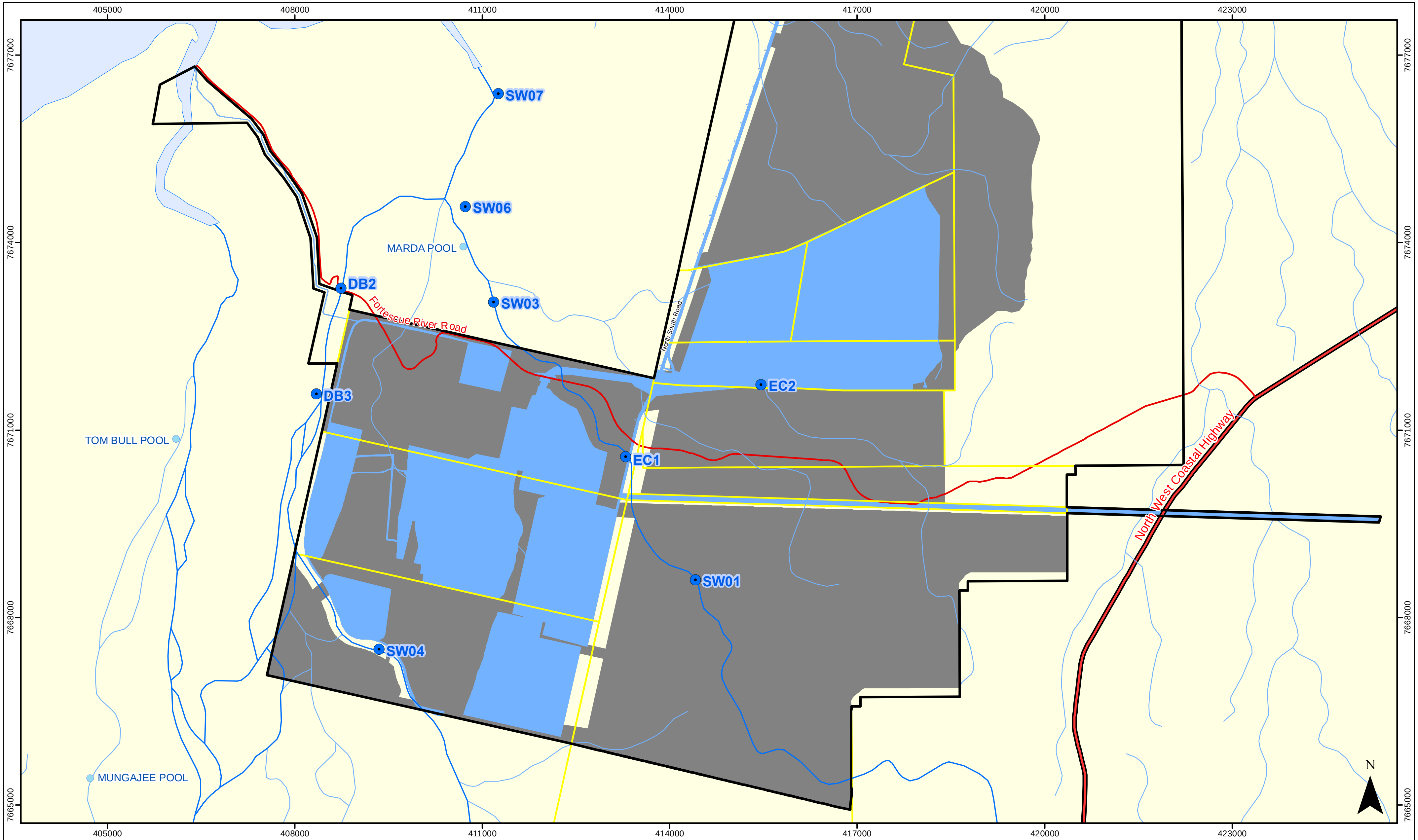
6.3.1 Water quality of the Fortescue River

As described in Section 5.3.1, at the mouth of the Fortescue River, the river channel is in excess of 200 m wide forming an estuarine setting of salt marsh and intertidal flats (Aquaterra 2009a). The combination of a wide well defined channel and high tidal range provides high velocities in the river mouth and the current speed in the Fortescue River frequently exceeds 0.1 m/s (Aquaterra 2009a). The strong tidal influence means the estuary has a low sediment trapping efficiency; naturally high turbidity and well mixed waters. In addition to the strong tidal flows, the river mouth also experiences a very high rate of flushing from the discharge of water during the wet season.

Salinity (TDS) of the lower tidal reaches of the Fortescue River has been recorded between 39 000 to 41 000 mg/L over the dry season, with typical concentrations of 37 000 mg/L which exceeds the typical concentration of seawater salinity (around 35 000 mg/L TDS) due to concentration by evaporation of salts within the river estuary and tidal reaches (RPS APASA 2017). However, the system is expected to be highly dynamic and at periods of high flow (i.e. the wet season) the salinity is expected to be lower, reflecting the greater relative volume of freshwater.

The tidal influence extends approximately 4 km inland.

The Proponents have an ongoing surface water monitoring across the Development Envelope to detect any changes to the water quality in the watercourses (Figure 6-1).



Mine Continuation Proposal

Figure 6 - 1

Location of surface water quality sampling sites

0 1.5 3
Kilometres
1:80,000

Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	20/01/2017
Sheet Size:	A4	Status:	Final
Drawn by DS	Requested by MC, Strategen	Internal Reference 4411_01_2017_APP	

Legend

- Baseline Surface Water Monitoring Site
- Pool
- Major Creek/River
- Minor Creek/River
- Principal Road
- Major Road
- Development Envelope
- Statement 635 approval (MS635)
- Conceptual Footprint

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6.3.2 Design of surface water diversion

The southern branch of Edwards Creek will be realigned in two sections (Figure 5-7). As described in Section 5.3.3, the two diversions will enable the disturbance area of the infrastructure to be minimised.

The two diversions have been designed to accommodate the 5 - 10 year ARI flood flow. This is equivalent to the level of current flooding risk from the creeks impacting the site, and existing drainage provisions (open channels, culverts, etc) on the site. Once the design capacity of the open channel is exceeded, during cyclonic events for example, then flooding will occur around the mine site in general, as would occur naturally without the development.

By maintaining the natural design of the creek the design is not expected to change the hydrological properties of the creek.

6.3.3 Formation of pit lake

As described in Section 5.5.2, during mining the rate of flow into the pit is approximately 8 GLpa. As groundwater levels recover, the numerical model estimates pit inflows to increase to approximately 7.1 GLpa. The rate of evaporative losses from the pit varies depending on the depth of the pit.

After 100 years the water level in the West Pit is expected to reach a level of approximately -160 to -170 mAHD (i.e. more than 230 m deep) with the East Pit recovering to a water level of –approximately -300 to -310 mAHD (i.e. 50 m deep) (Figure 5-13).

The quality of the groundwater flowing into the pit lake has been estimated using a backward streamlines analysis to determine the source of the water. As shown in Figure 6-2, the quality of the groundwater varies with the distance from the coast. The quality of inflows varies and includes both fresh and saline water (CloudGMS 2017).

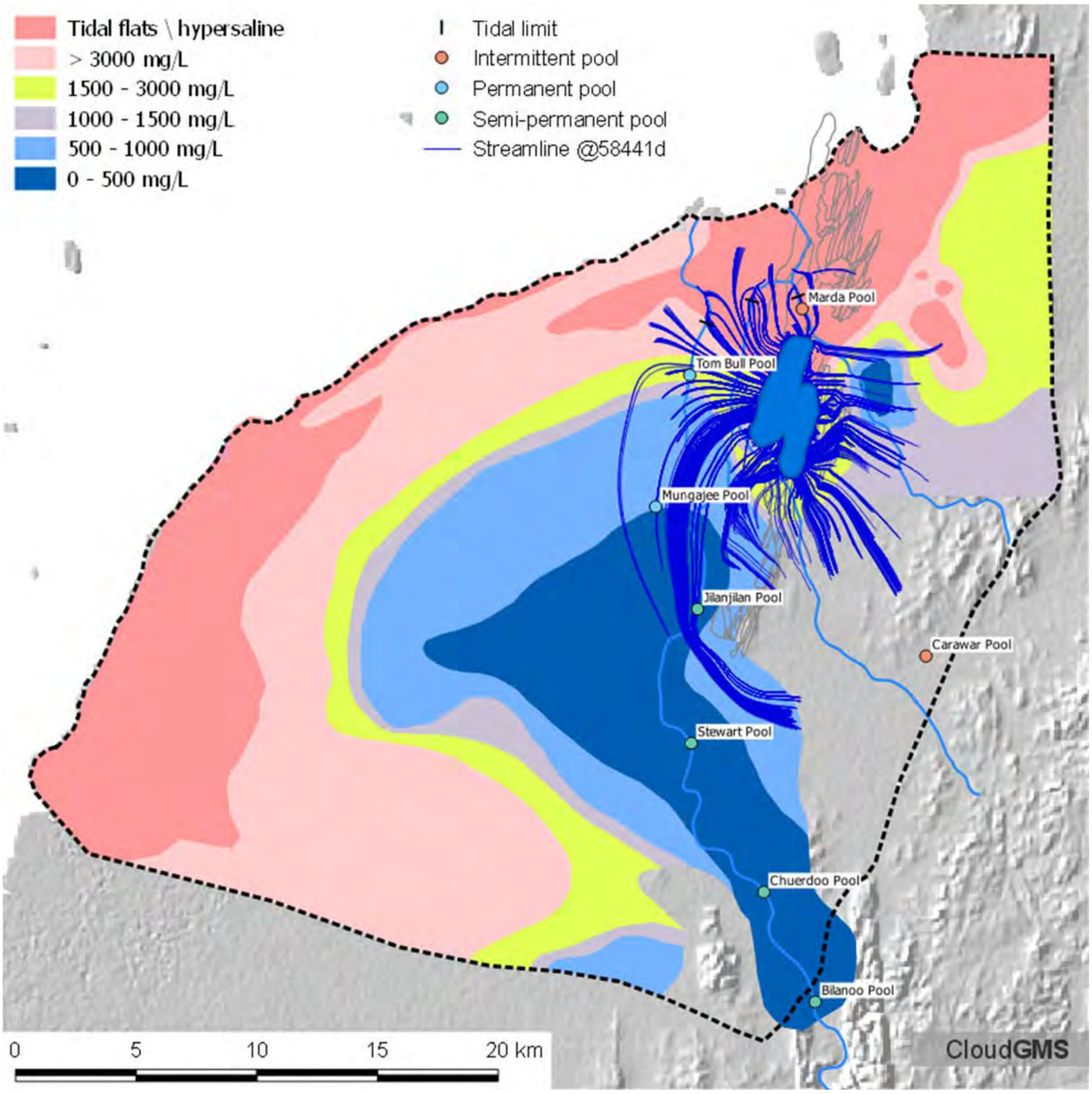

Figure 6-2: Groundwater quality of pit inflows

6.4 Potential impacts

The following potential impacts have been identified:

- diversion of Edwards Creek has the potential to increase stream velocity, which may affect water quality
- physical development of the site and use of infrastructure will generate runoff which has the potential to affect surface water quality
- following the formation of a pit lake after closure, evaporation and groundwater flow into the pit has the potential to affect water quality within the pit lake and surrounding environmental values.

The potential affect on water quality from the discharge of groundwater to the Fortescue River estuary is assessed in Section 7.5.1.

6.5 Assessment of impacts

6.5.1 Diversion of Edwards Creek

As described in Section 5.5.3, by maintaining the same length and natural design (i.e. the 8 – 10 m bed width) the diversions are not expected to substantially alter either the flow or velocity of the creek. The construction of the diversion will result in loose, erodible material within the creek bed to recreate the mobile bed and banks of the existing creeks. The sediment supply is not expected to be substantially affected by the diversion.

By maintaining the flow velocity and volume the creek is not expected to affect the water quality of either Edwards Creek or the Fortescue River downstream.

6.5.2 Alteration of surface flows

Surface water runoff from the Proposal is managed to prevent pollution entering watercourses in the Development Envelope. Proposal elements, such as the WRDs and TSFs that have the potential to generate runoff, are bunded to collect runoff. Collected surface water runoff is directed to sedimentation basins for treatment prior to discharge to the external environment.

The collection system would require a nominal 5 year ARI capacity peak inflow. The sizing (i.e. top surface area of the basin) is based on the rate of inflow, and size and percentage of particles to be removed. Water quality capture and treatment devices are not expected to treat all the flow, but rather focus on smaller, more frequent run-off events.

Collection of surface water runoff ensures that surface water quality is not affected.

At mine closure the WRDs would be rehabilitated, and eventually the dirty water collection bunds and sedimentation basin removed once rehabilitation objectives have been achieved.

6.5.3 Pit lake water quality

The primary influences on the water quality in the pit lake are the initial quality of the groundwater entering the pit and subsequent changes due to evaporation. Ongoing monitoring and testing of waste material encountered during mining has so far not identified material likely to affect pit water quality. This monitoring will be ongoing throughout the life of the mine and will be subject to further analysis as a requirement of the Conceptual Mine Closure Plan (Appendix 3).

As shown in Figure 6-2 the quality of the groundwater inflows will vary, with groundwater from all salinity categories (i.e. fresh to hyper saline) drawn into the final pit-lake (CloudGMS 2017). However, based on the project flow pathways there will be no flow of groundwater from a higher salinity area to a lower salinity area. This will mean that the distribution of groundwater salinities is not expected to be affected in the Fortescue River floodplain as a result of the Proposal.

As described in Section 5.5.1, at the completion of mining groundwater will continue to flow into the pit. Due to evaporation of water the pit will become a terminal pit lake. The flow of groundwater into the pit lake, and then evaporation, will result in an increase in concentration of solutes (i.e. salts and metals) that are in the groundwater (CloudGMS 2017). While the concentration of solutes in the mine pit will increase by operating as a terminal sink the pit lake will prevent any adverse effects to groundwater quality within the surrounding aquifer.

The major aquifer in the region that supports bores and GDEs is in the Fortescue River floodplain alluvium. The base of the mine pit will at approximately -400 mAHD. The base of the aquifer within the Fortescue River floodplain alluvium is approximately -20 mADD. Based on the substantial vertical disconnection from the base of the mine pit and the aquifer, there is no potential for saline plume out of mine pit to affect any sensitive receptors.

It is likely that the quality of the pit lake will evolve to be saline or even hypersaline (i.e. more saline than the seawater).

6.6 Mitigation

The overall objective for the mitigation of impacts to inland water quality is to ensure that the impact on groundwater and surface water quality as a result of implementation of the Proposal will be minimised so as to meet the EPA objective. Implementation of the following measures will assist in mitigating impacts:

<u>Avoidance:</u>

- the design of the Edwards Creek diversion will maintain the same length and natural design (8 – 10 m bed width) as the natural watercourse

<u>Minimisation:</u>

- pass all runoff from disturbed areas through sediment traps prior to discharging downstream (during both construction and operation)
- collect seepage from the tailing dam and use it on the mine site for ore-processing, dust control purposes and road-making
- remove sediment from sediment basins prior to the wet season to the extent needed to maintain capacity. As required dispose of sediments to bio-remediation facility
- monitoring will be undertaken including visual inspection of water quality and quantity in major creeklines and Fortescue River pools in accordance with the OEMP (Appendix 3).

<u>Rehabilitate:</u>

- contain and cleanup any spill in accordance with DR017219 Hydrocarbons - Hazardous Materials Spill Response Procedure - Land.

6.7 Predicted outcome

When mitigation and management measures have been implemented, it is expected that the Proposal will result in the following outcomes in relation to Inland waters environmental quality:

- diversion of Edwards Creek will not significantly alter either flow or velocity within the creek and therefore is not expected to affect water quality of either Edwards Creek or Fortescue River downstream
- collection of surface runoff in sedimentation ponds will prevent surface water contamination
- pit lake will act as a terminal sink and likely become hypersaline over time although surrounding groundwater quality will not be adversely affected.

Based on the predicted residual impacts the Proposal will meet the EPA’s objective for Inland waters environmental quality.

7. Marine environmental quality

7.1 EPA objective

To maintain the quality of water, sediment and biota so that environmental values are protected.

7.2 Policy and guidance

The relevant policies for Marine environmental quality are:

- *Environmental Factor Guideline - Marine Environmental Quality* (EPA 2016d)
- *Technical Guidance Protecting the Quality of Western Australia's Marine Environment* (EPA 2016e).

7.3 Receiving environment

A summary of work completed to describe the receiving environment regarding Marine environmental quality is included in Table 7-1.

Table 7-1: Summary of environmental studies and survey effort

Author	Survey/ investigations name	Study area, type and timing	Study standard/guidance and limitations
Recently completed work			
RPS APASA 2017	*Discharge Modelling Assessment* *Fortescue River Outfall*	Delft3D-FLOW hydrodynamic model	Peer reviewed model. Model adheres to the International Association for Hydro-Environment Engineering and Research guidelines for documenting the validity of computational modelling software, closely replicating an array of analytical, laboratory, schematic and real-world data.
RPS APASA 2016	*Cape Preston Pit Water River Discharge Assessment*	Nearfield dilution assessment for the discharge of 2 GLpa.	

7.3.1 Fortescue River estuary water quality

The lower Fortescue River estuary experiences a strong tidal influence (with a spring tidal range of approximately 3.6 m) that extends approximately 4 km inland (DOW 2010). At the mouth of the Fortescue River, the river channel is in excess of 200 m wide forming an estuarine setting of salt marsh and intertidal flats Aquaterra 2009a). The strong tidal influence of the estuary has a low sediment trapping efficiency, generating naturally high turbidity with well mixed circulation.

The area contains a well developed and structurally complex mangrove system that includes a total mapped area of approximately 35.5 ha of mangal community, with extensive cyanobacterial mats occurring on the tidal flats to the east of the tidal creek.

Salinity (TDS) of the lower tidal reaches of the Fortescue River has been recorded between 39 000 to 41 000 mg/L over the dry season, with typical concentrations of 37 000 mg/L which exceeds the typical concentration of seawater salinity (around 35 000 mg/L TDS) due to concentration by evaporation of salts within the river estuary and tidal reaches (RPS APASA 2017). However, the system is expected to be highly dynamic and at periods of high flow (i.e. the wet season) the salinity is expected to be lower, reflecting the greater relative volume of freshwater.

Background nutrient and chlorophyll-a concentrations in samples collected in 2002 were all found to be slightly above ANZECC & ARMCANZ indicative values for turbid macrotidal areas (DAL 2000, Maunsell 2002). As shown in Table 7-2 the waters around Cape Preston have elevated primary productivity compared to other areas, which may be a result of the occasional large contributions of sediment from Fortescue River and other nearby creek and tidal creek flows.

Table 7-2: Comparison of background water quality values with guideline levels

Parameter	Recorded values	ANZECC/ARMCANZ (2000) guideline values
chlorophyll-a (µg/L)	1.73	0.7-1.4
ortho-phosphorus (µg/L)	3	5
Nitrate + nitrite (µg/L)	38.5	2-8
Ammonium (µg/L)	19	1-10

7.3.2 Current groundwater discharge

In August 2016 the EPA approved the discharge of up to 2 GLpa of saline water from dewatering into the Fortescue River estuary. The groundwater discharge point is located approximately 1.25 km from the river mouth at a part of the river that is approximately 200 m wide (Figure 7-1). The discharge infrastructure consists of a linear diffuser structure placed perpendicular to the river bank extending for approximately 20 m. The diffuser structure is located approximately 10 m from the river bank.

Following approval from the EPA the project was also approved under Part V of the EP Act by DER with a discharge licence. The approved discharge licence requires the release on an outgoing tide to prevent plume migration upstream. The infrastructure has been installed and is currently undergoing commissioning.

The assessment to support the application to discharge groundwater considered the following groundwater quality parameters: salinity (TDS), total suspended solids (TSS), pH, nutrients (ammonia, nitrate and total nitrogen) and metals (boron, copper, nickel and zinc). The quality of groundwater to be discharged was based on sampling from 2013 to 2015 and on sump volume flow weighted averages that were calculated in April 2013 and June 2015.

The discharge stream is hypersaline, potentially also containing elevated levels of nitrate and metals (boron, copper, nickel and zinc) (RPS APASA 2017). To account for the possibility that concentrations of nutrients and metals may change over time CPM have undertaken to the DER to sample nutrients and metals on a monthly basis (during active discharge) at the discharge site and at two additional sites 1 km further upstream and 1 km downstream.

Based on the expected concentrations of potential contaminants in the discharge and the relevant threshold concentrations for each contaminant, the initial water quality variables of most relevance were salinity, temperature and nitrate. The expected ranges for these variables identified that salinity was clearly the discharge contaminant that will require the highest dilution to achieve its concentration target (RPS APASA 2017). The salinity of the discharge stream will increase over the life of the mine due to the changing nature of the mining operations. The discharge stream is expected to eventually reach a maximum salinity concentration of approximately 70 000 mg/L. The regulatory salinity target is for median salinity concentration to be no more than 1200 mg/L above median ambient background at a suitable reference site. Based on the background salinity of 37 000 mg/L, this implies that a 27 times dilution is required.

The nearfield dilution assessment (RPS APASA 2016) for discharge rate of 2 GLpa determined the engineering design of a diffuser that would achieve the target of 27 times dilution for salinity. The assessment determined that this level of dilution would be achieved within 10 to 20 m of the discharge location.

For ammonia and phosphorus the groundwater nutrient concentration was at or below the ANZECC 99% marine protection level for Tropical Australia (ANZECC 2000). While the nitrate levels prior to dilution have the potential to exceed the ANZECC 80% species protection level, downstream of the discharge point the dominant habitat types are mangrove and algal mat zones. Mangrove and algal mat zones have been recognised as a nutrient sink and historically have been used in some locations as a natural filter for wastewater discharge, with algal mats typically comprised of nitrogen fixing blue-green bacteria (bluegreen algae). These organisms are not nitrogen limited, as they are able to fix nitrogen from the air. An increase in nitrogen concentrations in the water is therefore unlikely to significantly impact on their growth. It is noted that there would be no parallel increase in phosphorus concentrations. Thus, while the nitrate concentration at the discharge point is expected to be readily diluted by the combination of tidal and river flows, the impact on mangroves from increased nitrogen loads was considered to be readily manageable and of negligible significance.

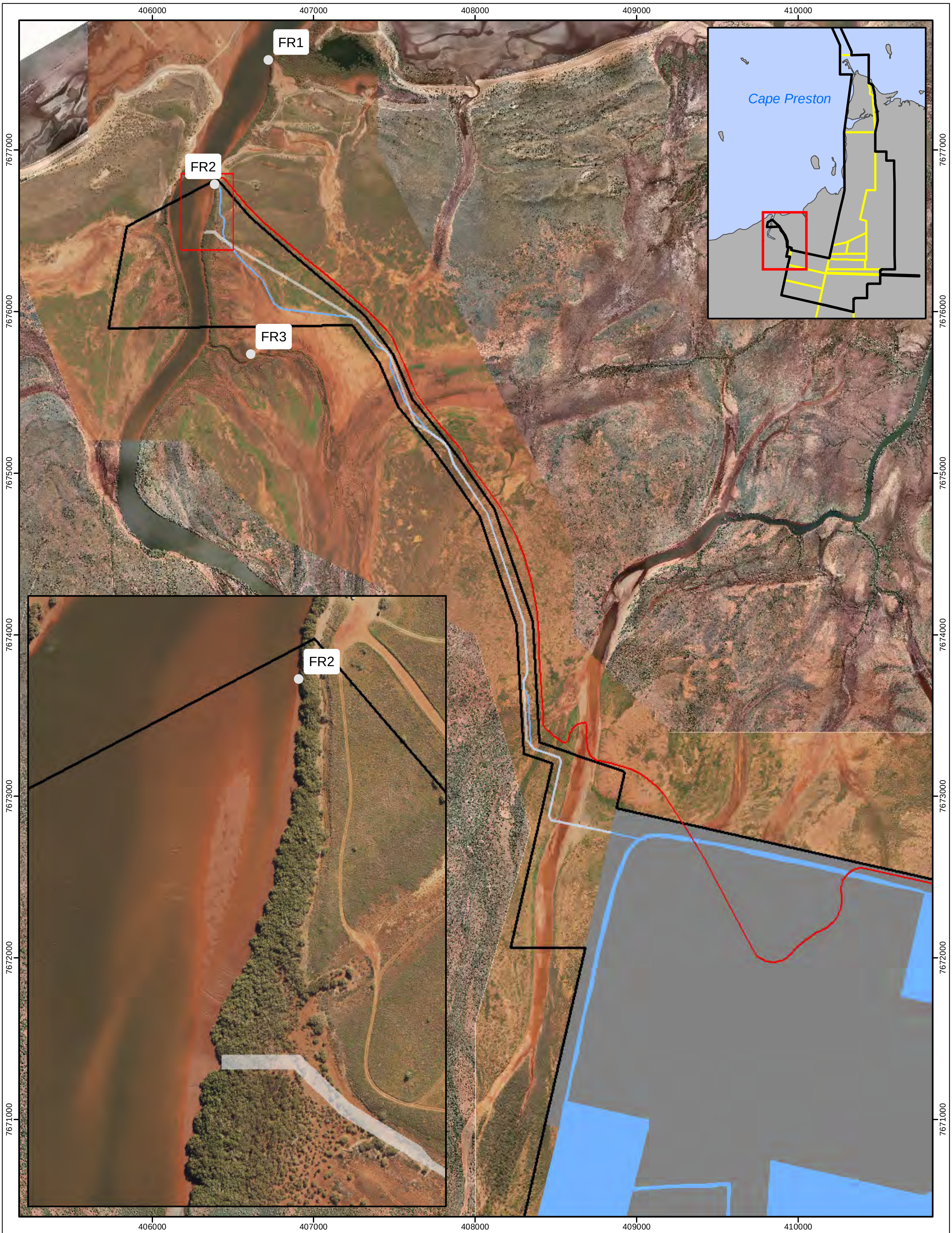

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Figure 7 - 1

Location of mine dewater discharge infrastructure

Department:	ENV	Date:	27/01/2017
Sheet Size:	A4	Status:	Final
Drawn by DS	Requested by MB, Strategen	Internal Reference 4412_01_2017_APP	

7.3.3 Environmental Quality Management Framework

In accordance with EPA (2016e) an Environmental Quality Management Framework (EQMF) has been developed to spatially define, assess and manage potential impacts of the Proposal on marine environmental quality. The EQMF has been used to define Environmental Values (EVs), Environmental Quality Objectives (EQOs) and, for the EQO 'maintenance of ecosystem integrity', Levels of Ecological Protection (LEPs).

Table 7-3 presents the five EVs and eight corresponding EQOs that apply throughout WA coastal waters. The maintenance of ecosystem integrity EQO (that corresponds with the ecosystem health EV) is considered to be a suitable proxy for the maintenance of cultural and spiritual, industrial water and aquaculture EQOs. On this basis, five EQOs were identified for the Proposal as necessary to protect the EVs. The other EVs and EQOs are still relevant to the assessment but are considered to be protected by default through the protection of the ecosystem health values.

Table 7-3: Summary of Environmental Values and Environmental Quality Objectives

Environmental values	Environmental Quality Objective	Relevant for the development of specific EQG
Ecosystem health	Maintenance of ecosystem integrity	Yes
Fishing and aquaculture	Maintenance of aquatic life for human consumption	Yes
	Maintenance of aquaculture	Protection of ecosystem health is an adequate proxy
Recreation and aesthetics	Maintenance of primary contact recreation values	Yes
	Maintenance of secondary recreational values	Yes
	Maintenance of aesthetic values	Yes
Cultural and spiritual	Maintenance of Cultural and spiritual values	Protection of ecosystem health is an adequate proxy
Industrial water supply	Maintenance of Industrial water supply values	Protection of ecosystem health is an adequate proxy

Consistent with EPA (2016e) the relevant LEP (within the maintenance of ecosystem integrity EQO) for the in the vicinity of the Proposal is a High LEP. The objective for a High LEP is to allow for small measurable changes in the quality of water, sediment and biota but not to a level that changes ecosystem processes, biodiversity or abundance and biomass of marine life beyond the limits of natural variation.

A Moderate LEP may be applied to relatively small areas, such as within inner ports, adjacent to heavy industrial premises and waste discharges. In areas assigned a Moderate LEP moderate changes in environmental quality may be acceptable provided there are only small changes in abundance and biomass of marine life and in the rates, but not types, of ecosystem processes. There should be no detectable and persistent changes in biodiversity due to waste discharges or contamination.

EPA (2016e) identifies that EQC should be determined on the basis of the risks to the environmental quality. The development of EQC should also be based on the scientific limits of acceptable change to a measureable environmental quality indicator important for the protection of the associated environmental value and that the EQC should be clear, readily measurable and auditable.

Section 7.3.4 assesses the risk to the environmental quality of the Fortescue River estuary from the discharge based on the comparison of quality of water in the Fortescue River estuary (as described in Section 7.3.1) and quality of groundwater (described in Section 7.3.2) to determine appropriate EQC.

7.3.4 Environmental quality criteria

As described in Section 7.3.3, the EPA (2016e) identify that EQC are developed on the basis of risk to the environmental values. As described in Section 7.3.2, prior to discharge the groundwater to be discharged is equivalent to that of the Fortescue River estuary for TSS, pH and metals (RPS APASA 2017). While the groundwater has naturally elevated nitrogen levels, the receiving environment has nitrogen-fixing algal mats and the low phosphorus levels in the groundwater means that the system is phosphorus limiting and unlikely to generate algal blooms. On this basis, the only key parameter that may affect the marine environmental quality is salinity (TDS).

For all five EQOs determined to be relevant in Section 7.3.3 (i.e. maintenance of ecosystem integrity, aquatic life for human consumption, primary contact recreation values, secondary recreational values and aesthetic values), the EQC for salinity has been adopted. Appendix 1 of EPA (2016e) identifies that salinity is a physico-chemical stressor and provides guideline values for defining High LEP and Moderate LEP as follows:

- High LEP: the 80th percentile of natural background <= predicted median concentration
- Moderate LEP: the 95th percentile of natural background <= predicted median concentration.

However, as described in Section 7.3.2 the regulatory salinity target is for median salinity concentration to be no more than 1200 mg/L (i.e. 1.2 ppt) above median ambient background at a suitable reference site. Based on the background salinity of 37 000 mg/L, this implies that a minimum of 27 times dilution is required (i.e. achieving more than a 27 is better than required). On this basis CPM are applying the same system as the current DER licence. The dilution requirement is considered to be a more conservative than the requirements identified in EPA (2016e).

Within the above context marine modelling (in Section 7.3.5) was therefore undertaken to determine the distribution of dilution levels of the discharge to achieve regulatory levels.

7.3.5 Marine modelling

To assess the dilution RPS APASA (2017) prepared a three-dimensional model with accurate representations of the bathymetry (from high-resolution multi-beam survey data), bottom roughness and spatially-varying wind stress for the region. The Delft3D-FLOW model is ideally suited for representing the hydrodynamics of complex coastal waters, including regions where the tidal range creates large intertidal zones and where buoyancy processes are important.

The new hydrodynamic model was run for a 15 to 30 day simulation period and was to be validated by comparison to 15 days of field measurements from an instrument deployed in the Fortescue River. The model was to be used to assess three potential discharge scenarios:

1. Intermittent discharge with a flow rate of 2 GL/yr. This case represents the flow rate and ebb tide discharge schedule that has been approved by the DER, that is, commencing 30 minutes after the turning of the tide and ceasing 1 hour prior to the next low tide. The outfall consists of one diffuser unit that is 21 m in length.
2. Intermittent discharge with a flow rate of 6 GL/yr. This case uses the same ebb tide discharge schedule. To manage the higher flow rate it is assumed that the outfall diffuser will be extended across the river by two additional 21 m diffuser units installed in serial, giving a total diffuser length of 63 m.
3. Intermittent discharge with a flow rate of 8 GL/yr. This case uses the same ebb tide discharge schedule. To manage the higher flow rate it is assumed that the outfall diffuser will be extended across the river by three additional 21 m diffuser units that will be installed in serial, giving a total diffuser length of 84 m.

The scope of the modelling assessment for each discharge scenario involved preparing salinity dilution maps for each scenario to demonstrate the potential zone of influence within the river, with a focus on the 27 times dilution threshold for salinity. Appendix 2 of EPA (2016e) specifically identifies the requirement to consider potential vertical variation of the potential contaminant plume. Based on the higher density of the more saline plume the model outputs considered at depth 0.5 m above the river bed. This depth was selected because it is consistent with a typical field sampling practices when dense plumes or intrusions are expected.

For all scenarios the median and 80th percentile dilution values were extracted from the model for the analysis depth to allow comparison to the relevant water quality criteria.

7.4 Potential impacts

The following potential impacts have been identified:

- discharge of groundwater has the potential to affect the water quality of the Fortescue River estuary.

Section 7.5 considers the impact to marine environmental quality, refer to Section 5.5.2 for consideration of changes to hydrological processes.

7.5 Assessment of impacts

7.5.1 Discharge of groundwater

The assessment of discharge scenarios is presented in Table 7-4. The assessment considers the modelled extent of dilution level within each cell at both a median and 80th percentile assessment. In addition the assessment provides time series data at the discharge location.

The modelling identifies that the 2 GLpa scenario provides a high level of dilution throughout the model domain. For both the 6 GLpa and 8 GLpa scenarios the dilution results at the discharge point were similar (RPA APASA 2017). For both these scenarios the incidence and duration of the minimum 27 times dilution threshold exceedance at the discharge location was very similar and limited to an hour. On this basis throughout the entire domain no cells were less than the minimum 27 times dilution target for either the median or 80th percentile (as shown in Figure 7-2 for the 80th percentile for the 8 GLpa discharge).

As the 8 GLpa discharge is above the minimum target dilution level for all cells and the time series indicates that this would not be met at the discharge location for only an hour (under certain tides). On this basis the discharge would still meet the requirements of a High LEP. Therefore, an 8 GLpa discharge is not considered to significantly affect any environmental values associated with marine environmental quality.

Table 7-4: Assessment of discharge scenarios

Discharge scenario	Median graphs	80th percentile graph	Time series graphs at discharge location
2 GLpa	The dilution is greater than 50 times dilution everywhere throughout the domain.	The dilution is greater than 50 times throughout most of the domain except for a localised area at the diffuser outlet where dilution was in the range of 40 to 50 times.	Over the 30 day time series the dilutions showed no evidence of any increased tendency to exceed threshold with time. This indicates that there was no significant accumulation of salinity in the model over the 30-day time scale.
6 GLpa	The dilution is greater than 50 times dilution everywhere throughout the domain.	The dilution is greater than the minimum 27 times throughout the entire domain. Dilutions in the range of 30 to 40 times were observed up to around 175 m downstream from the discharge location. Dilutions in the range of 40 to 50 times were observed up to around 350 m downstream from the discharge location.	During neap tide periods there were occasions when the minimum 27 times dilution threshold was either approached or breached before the end of a discharge period, however, these events were insufficient to increase the duration of exceedance, which always remained around approximately 1 hour. The full 30 day time series of dilutions from the simulation period showed no evidence of any increased tendency to exceed threshold with time.
8 GLpa	The dilution is greater than 50 times dilution throughout the domain, except at the discharge location where the dilution was in the range of 40 to 50 times.	The dilution level is greater than the minimum 27 times were met throughout the domain. However, dilutions in the range of 27 to 30 times were observed at the discharge location Dilutions in the range of 30 to 40 times were observed up to around 400 m downstream from the discharge location. Dilutions in the range of 40 to 50 times were consistently observed up to around 550 m downstream from the discharge location and up to around 1 km upstream of the discharge location.	During neap tide periods there were occasions when the minimum 27 times dilution threshold was either approached or breached before the end of a discharge period, however, these events were insufficient to increase the duration of exceedance, which always remained around approximately 1 hour. The full 30 day time series of dilutions from the simulation period showed no evidence of any increased tendency to exceed threshold with time.

Case C: 8 GL/yr
Dilution of Discharge Salinity
80th Percentile
Height: 0.5m Above Bed

Project: Fortescue River Discharge Modelling
Job/Client: MAW0506J.000/Citic Pacific

RPS APASA

Number of Dilutions

- 0 to 10
- 10 to 20
- 20 to 24
- 24 to 27
- 27 to 30
- 30 to 40
- 40 to 50
- >50

Source: RPS APASA 2017

Figure 7-2: Extent of Discharge

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7.6 Mitigation

The overall objective for the mitigation of impacts to marine environmental quality is to ensure that the impact on the quality of water, sediment and biota as a result of the Proposal will be minimised.

The Proposal will continue to apply management measures outlined in the DER discharge licence required under Part V of the EP Act. An application to update the licence will be submitted to DER that will continue to apply existing measures.

The mitigation measures proposed include:

Avoidance:

- undertake monitoring in accordance with DER discharge licence to ensure the groundwater salt, metal and nutrient concentrations are consistent with discharge licence requirements.

Minimisation:

- discharging groundwater on outgoing tides to ensure discharge water is rapidly diluted to achieve the target dilution
- discharging via a diffuser in accordance with dilution modelling (RPS APASA 2017)
- to ensure the integrity of infrastructure any debris or other blockages will be cleared as required.
- implement DR017219 Hydrocarbons - Hazardous Materials Spill Response Procedure - Land.

7.7 Predicted outcome

When the mitigation and management measures have been implemented, it is expected that the Proposal will result in the following outcomes in relation to Marine environmental quality:

- target dilution for salinity (TDS) is a dilution level of 27 times, which will be achieved throughout the model for both a median and 80th percentile assessment of an 8 GLpa discharge
- an 8 GLpa discharge is rapidly diluted on the falling tide and modelling shows no sign of build-up of salinity.

Based on the predicted residual impacts the Proposal will meet the EPA's objective for marine environmental quality.

8. Flora and vegetation

8.1 EPA objective

To protect flora and vegetation so that biological diversity and ecological integrity are maintained.

8.2 Policy and guidance

The relevant policy and guidelines for flora and vegetation are:

- Environmental Factor Guideline – Flora and vegetation (EPA 2016f)
- Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016g)

On 13 December 2016 the EPA released revised guidelines for flora and vegetation. Relevant policies and guidelines prior to date are:

- Guidance Statement No. 51 *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004)
- Position Statement No. 3 *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002).

8.3 Receiving environment

The Cape Preston area has been studied in detail since 2003, including nine flora and vegetation surveys (Table 8-1). Mattiske Consulting conducted a peer review of all surveys completed to date to determine the adequacy of work undertaken in relation to current guidelines, summarise survey results and provide advice on any additional work required to meet current guidelines (Mattiske 2016).

The survey work to date covers detailed Level 1 studies (now known as Reconnaissance Surveys), targeted work on species, targeted work on communities, targeted work on groundwater dependent ecosystems and Level 2 studies (now known as Detailed Surveys) for the majority of the Cape Preston area. Mattiske (2016) determined that the level of work completed to date across the broader area was sufficient to meet the requirements of Guidance Statement 51 (EPA 2004) and Position Statement 3 (EPA 2002), due to work completed by Astron (2009a) and AECOM (2009) which built on and integrated the earlier studies from the region. To enable the work to meet current Level 2 survey standards Mattiske (2016) identified the requirement to:

1. Update and refine the species list
2. Identify local conservation significance of vegetation communities.

Based on the advice from Mattiske, the following tasks were undertaken with regard to Item 1 above:

- verified currency of all individual species names using Florabase (WA Herbarium 1998-)
- cross-checked information provided in Table 3 of the Mattiske (2016) advice
- updated species names in cases where names had been superseded
- removed species that have been excluded by the WA Herbarium, where no alternative name is provided by Florabase
- removed species that are considered out of range by the WA Herbarium, where no alternative name is provided by Florabase
- replaced misapplied species names with a genus only, where a species name has been deemed to have been misapplied against multiple species, e.g. *Mukia maderaspatana* / *Cucumis maderaspatanus* has been deemed to have been misapplied against *Cucumis argenteus*, *C. althaeoides* and *C. variabilis*, therefore has been replaced with *Cucumis* sp.

- combined records where multiple ‘species affinis’ (aff.) were recorded. This notation indicates a very close affinity with the species named, and could potentially be recognised as a separate species. Species recorded in the reports consolidated above that have this notation are not currently recognised as separate species by the WA Herbarium; as such, for the purpose of this document, they have been included with the confirmed species, where present, e.g. *Tephrosia* aff. *supina* is included with *Tephrosia supina*
- combined instances where multiple ‘confer’ (cf.) or ‘?’ notations were recorded. These notations indicate that the species name provided the best possible identification given the available material. For the purpose of this document, species with these notations have been included with the confirmed species, e.g. *Senna ?notabilis* included with *Senna notabilis*, *Rhynchosia* cf. *minima* included with *Rhynchosia minima*
- prepared an updated species list (Appendix 1).

With regard to Item 2 above, the following task was completed:

- reviewed local conservation status of vegetation types in consolidated flora and vegetation reports (Table 8-3).

The results of the additional work undertaken to meet the Level 2 survey requirements are provided in Appendix 1 (updated species list) and Table 8-3 (conservation status of vegetation units).

Table 8-1: Summary of environmental studies and survey effort

Author	Survey/ investigations name	Study area, type and timing	Study standard/guidance and limitations
Recently completed work			
Mattiske 2016	*Review of Flora and Vegetation Reports for the Mineralogy project at Cape Preston*	• Peer Review of previously completed work	NA
Previously completed work			
Maunsell AECOM 2003	*Cape Preston Iron Ore Development. Seasonal Biological Survey – Threatened Flora*	• mine footprint • threatened flora survey • June and July 2003	Seasonal conditions led to some limitations in assessment of flora. Also some areas supported degraded vegetation. In part overcome by July assessment in targeted areas.
Astron Environmental Services 2007a	*General Purpose Leases G08/52 and G08/53 Additional Vegetation Survey and Mapping*	• leases G08/52 and G08/53 • flora and vegetation survey • June 2007	Some limitations on flora coverage due to drier seasonal rainfall conditions prior to the June 2007 assessment.
Mattiske Consulting Pty Ltd 2007a	*Flora and Vegetation Survey of Cape Preston Potential Campsites and Airstrips*	• flora and vegetation survey • February 2007	Some limitations due to seasonal conditions. Coverage of localized areas only (as requested).
Mattiske Consulting Pty Ltd 2007b	*Comparison of Flora and Vegetation Values on Preferred and Original Campsites Cape Preston*	• February 2007	Some limitations due to seasonal conditions. Coverage of localized areas only (as requested).
Maunsell AECOM 2008	*Cape Preston Mining Estate Consolidated Vegetation, Flora and Fauna Assessment*	• consolidation of surveys by HGM (2001), Maunsell (2003), Maunsell AECOM (2006), Mattiske (2007a), Astron (2007a)	Desktop study only
Astron Environmental Services 2008a	*Sino Iron Project – Cape Preston. Mapping and Surveying of Groundwater Dependent Ecosystems*	• leases E08/1414, E08/660, E08/1451, E08/1331, and some adjoining areas to the Northeast on Mardie Station • groundwater-dependent vegetation survey • September – October 2008	Groundwater-dependent vegetation only; limitations due to drier seasonal conditions prior to assessment.

Author	Survey/ investigations name	Study area, type and timing	Study standard/guidance and limitations
AECOM 2009	*Balmoral North and Balmoral South Stage 2. Flora and Vegetation Assessment*	• desktop, reconnaissance and detailed field survey. Flora and vegetation on Balmoral North and South. Some re-assessment of selected 2000 and 2006 quadrats • August – September 2008	Limitations due to timing of assessments in drier months.
Astron Environmental Services 2009a	*Mineralogy Expansion Proposal Desktop Flora and Vegetation Study.*	• desktop extrapolation of unsurveyed areas based on previous surveys of HGM (2001), Maunsell AECOM (2008), AECOM, (2009), Astron (2007a, 2007b, 2007c), Astron, (2008a, 2008b, 2008c)	Some limitations associated with no field studies and difficulty of covering flora and vegetation values without ground-truthing.
Astron Environmental Services 2009b	*Waste Rock Dump and Tailings Expansion Areas Vegetation, Flora and Fauna Survey*	• flora and vegetation survey • WRD expansion area and TSF expansion area • May 2009	• Level 2 survey • some limitations associated with seasonal conditions; although good rains in January and early February 2009 the months leading up to the assessment in May 2009 were drier.

8.3.1 Land Systems

Seven Land Systems are represented within the Development Envelope (Figure 8-1).

Regional extent of clearing for each Land Systems occurring in the Development Envelope is shown for the Pilbara Region and Roebourne Subregion in Table 8-2. Less than 2% of each of these Land Systems has been cleared historically within the Pilbara Subregion, showing negligible loss of vegetation to date at a regional scale. Further, less than 10% of each of Land System has been cleared to date within the Roebourne Subregion.

Table 8-2: Extent and clearing of land systems

Land System	Total area of Land System within the Pilbara Region (ha)	% Cleared within Pilbara Region	Total area of Land System within Roebourne Subregion (ha)	% Cleared within Roebourne Subregion	Cleared from the Proposal (ha)	% cleared within Roebourne Subregion including Proposal
Boolgeeda	826,416.12	0.02	27,085.24	0.49	12.36	0.54
Cheerawara	49,210.84	0.01	48,424.73	0.01	734.68	1.53
Horseflat	328,911.14	0.39	297,358.74	0.43	121.51	0.47
Littoral	248,221.78	0.15	212,125.90	0.18	2.79	0.18
Newman	1,458,027.91	0.03	4,872.65	9.17	346.12	16.27
Paraburdoo	64,135.89	1.52	17,850.10	5.46	1745.11	15.24
River	463,955.92	0.01	125,519.60	0.03	3553.16	2.86
Rocklea	2,428,593.74	0.06	43,182.63	3.36	620.86	4.80
Yamerina	120,270.82	0.49	119,391.09	0.5	12.36	0.51

8.3.2 Vegetation mapping

The extent of vegetation surveys (shown in Figure 8-2) conducted of the Cape Preston area cover an area of over approximately 53 000 ha. A total of 98 vegetation communities have been described and mapped within the Cape Preston area of which 69 occur within the Development Envelope (Figure 8-3). Typical for the Pilbara, the majority of vegetation communities are of low or moderate local conservation significance, with areas of elevated conservation significance generally associated with water courses (AECOM 2009).

The landform and conservation significance of the vegetation communities are identified in Table 8-3.

Table 8-3: Landform, vegetation unit and local conservation significance

Landform	Vegetation community	Local conservation significance
Stoney plains	Bx1, Bd1, Bs1	Moderate to High
Clayey plains	Hp, Hp1, Hpg1, Hpg2, Hpg3, Hps1	Moderate to High
Flowlines	Hc1, Hc2	Moderate to High
Beaches	Lb	Low to Moderate
Intertidal zones	Lm	High
Tidal mudflats	Ls1, Ls2, Ls3a	Moderate
Dunes	Ld1, Ld2, Ld3, Ld4, Ld5	High
Sandy plains	Lp1, Lp2, Lp3, Lp4a, Lp4b, Lp5	Moderate
Hills	Lh1, Lh2	Moderate
Plains	Mp1	Moderate
Outcrops	Mr1,Mr2, Mr3, Mr4, Mr5, Mr6	Moderate
Low Hills and slopes	Nh, Nh1, Nh2, Nh3,Nh4, Nh5	Moderate
Minor flowlines	Nc, Nc1, Nc2, Nc3, Nc4	Moderate to High
Rockpiles	Nr, Nr1, Nr2, Nr3, Nr4	Low to Moderate
Plains	Px1, Px2, Px3, Px4, Px5	Moderate
Plains	Pp1, Pp2. Pp3, Pp4	Moderate
Creeklines and Floodplains	Pc, Pc1, Pc2, Pc3, Pc4, Pf1, Pf2, Pf3	High
Creeklines	Rc1, Rc2, Rc3, Rc4	High
Floodplains	Rf1, Rf2, Rf3	Moderate
Low hills and slopes	Roh1, Roh1a, ROh1b, Roh2, ROh2a, ROh2b, ROh2c, ROh3a	Low to Moderate
Plains	ROpl, ROx1, ROp1 (?)	Low to Moderate
Minor flowlines	ROc1, ROc2, ROc3, ROc4, ROc5	Moderate
Rockpiles	Ror, Ror2, Ror1, Ror3	Low to Moderate
Plains	Yp1	Low to Moderate
Tidal creek	Yc1	Moderate

The number of hectares of each local conservation significance rating is presented in Table 8-4.

Table 8-4: Number of hectares of proposed clearing in each conservation significance rating

Local conservation significance rating	Area (ha)
Low - moderate	2848.1
Moderate	3035.1
Moderate – High	794.7
High	314.9
Unknown	8.5

8.3.3 Conservation significant flora and vegetation

No Threatened Flora species as listed under the WC Act are known from within 15 km of the Development Envelope. Thirteen Priority Flora species listed by Parks and Wildlife have the potential to occur within the broader Cape Preston area, with one, *Goodenia pallida* (P1) having the potential to occur within the Development Envelope (Figure 8-4). No Priority Flora species were recorded by vegetation surveys within the Development Envelope.

Horseflat Landsystem is listed as a Priority 3 iii Ecological Community (PEC) (Parks and Wildlife 2016), which is defined as

> *communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, inappropriate fire regimes, clearing, hydrological change etc.*

As shown in Table 8-2, clearing of the Horseflat Land System, will increase the extent of clearing from 0.43% to 0.47% of the Roebourne Subregion.

A search of the DEE EPBC Act Protected Matters database indicates that there are no Threatened Flora species listed under the EPBC Act known from within 3 km of the Development Envelope.

No Threatened or Priority Ecological Communities (listed under the EPBC Act) occur within the Development Envelope.

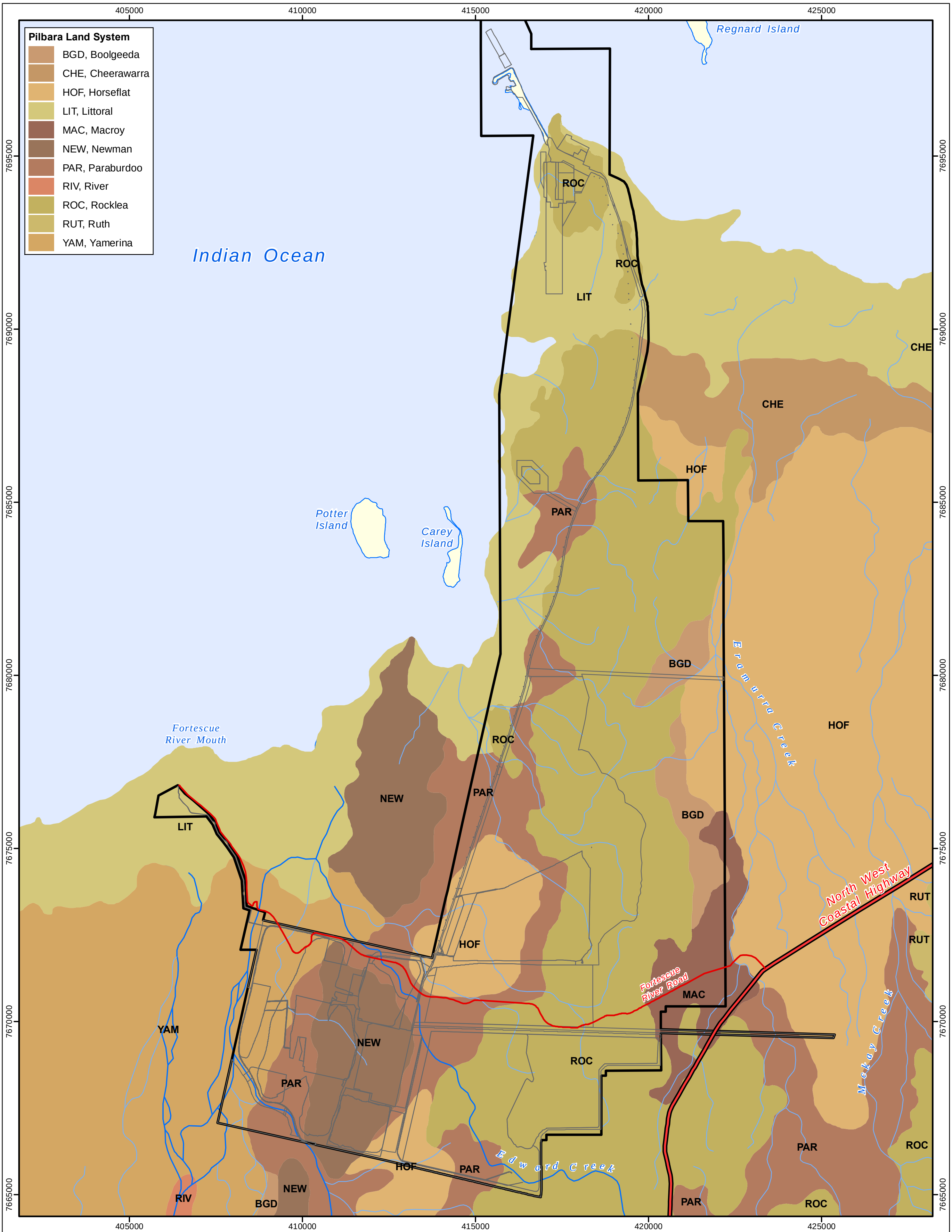

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Figure 8 - 1

Land systems mapped within the Cape Preston area

0 2.5 5
Kilometres
1:140,000

Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	20/01/2017
Sheet Size:	A4	Status:	Final

Drawn by	Requested by	Internal Reference
DS	MC, Strategen	4414_01_2017_APP

Legend

- Principal Road
- Major Road
- Development Envelope
- Conceptual Footprint

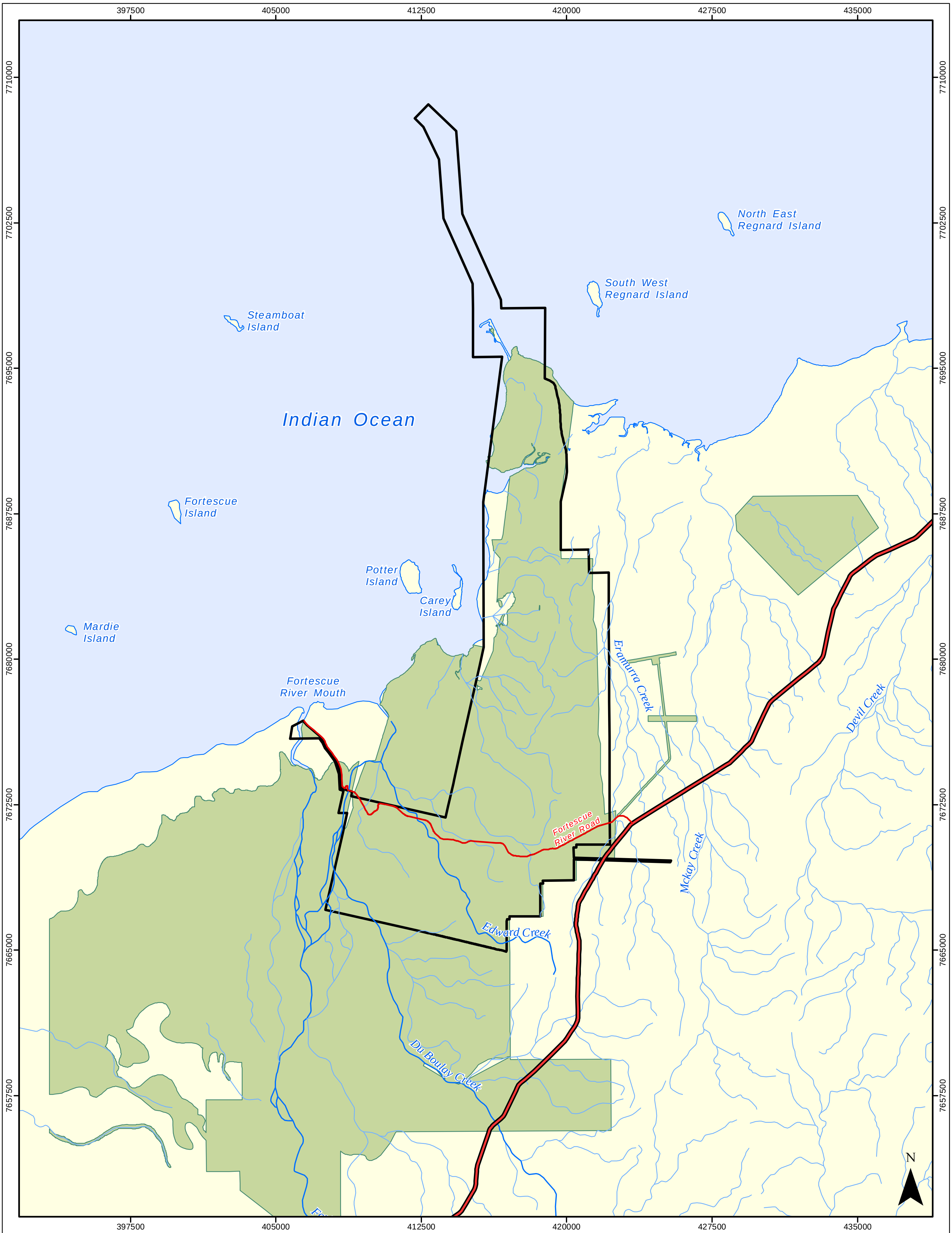

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Figure 8 - 2

Vegetation surveys within the Cape Preston area

0 5 10
Kilometres
1:250,000

Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	20/01/2017
Sheet Size:	A4	Status:	Final

Drawn by	Requested by	Internal Reference
DS	MC, Strategen	4415_01_2017_APP

Legend

- Principal Road
- Major Road
- Major Creek/River
- Minor Creek/River
- Development Envelope
- Vegetation Survey Areas

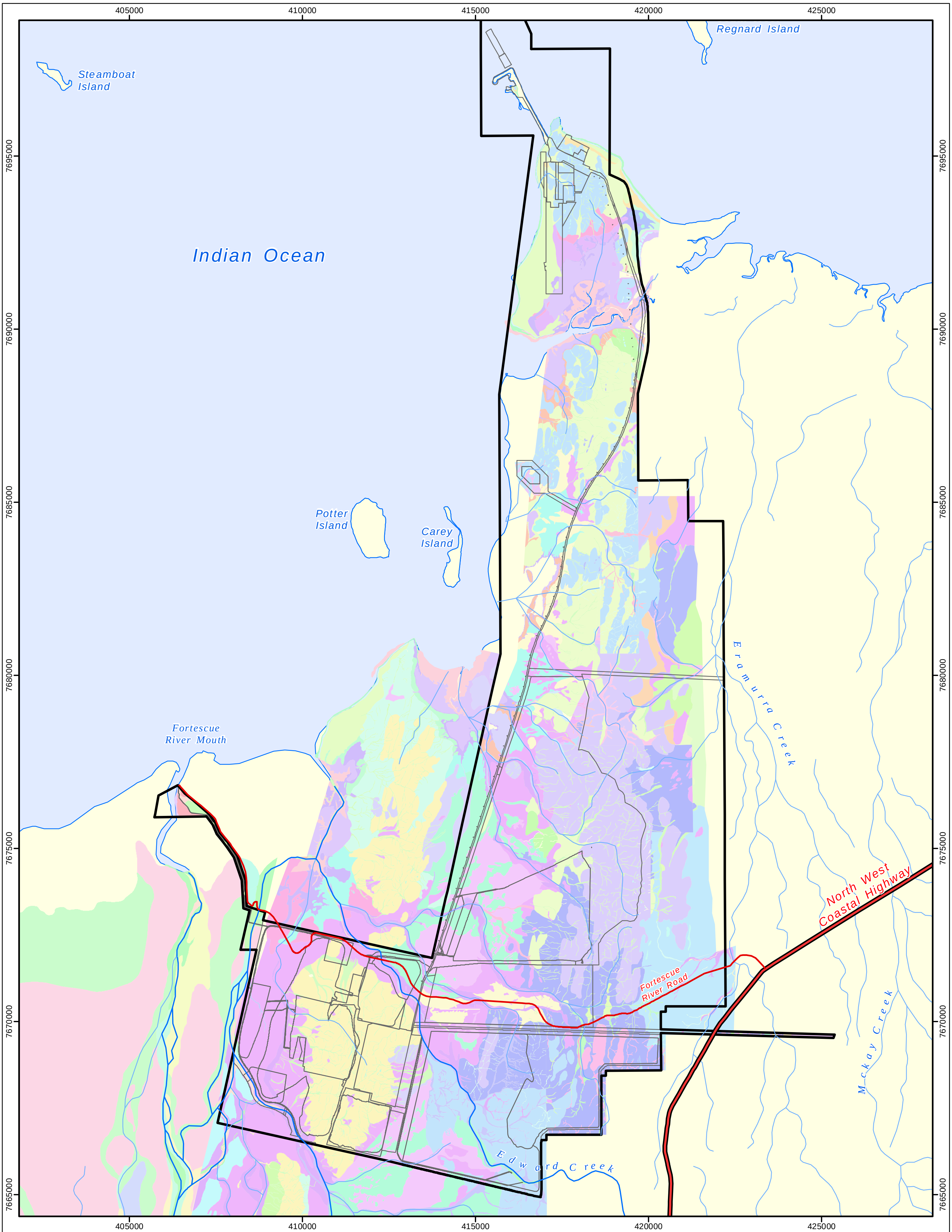

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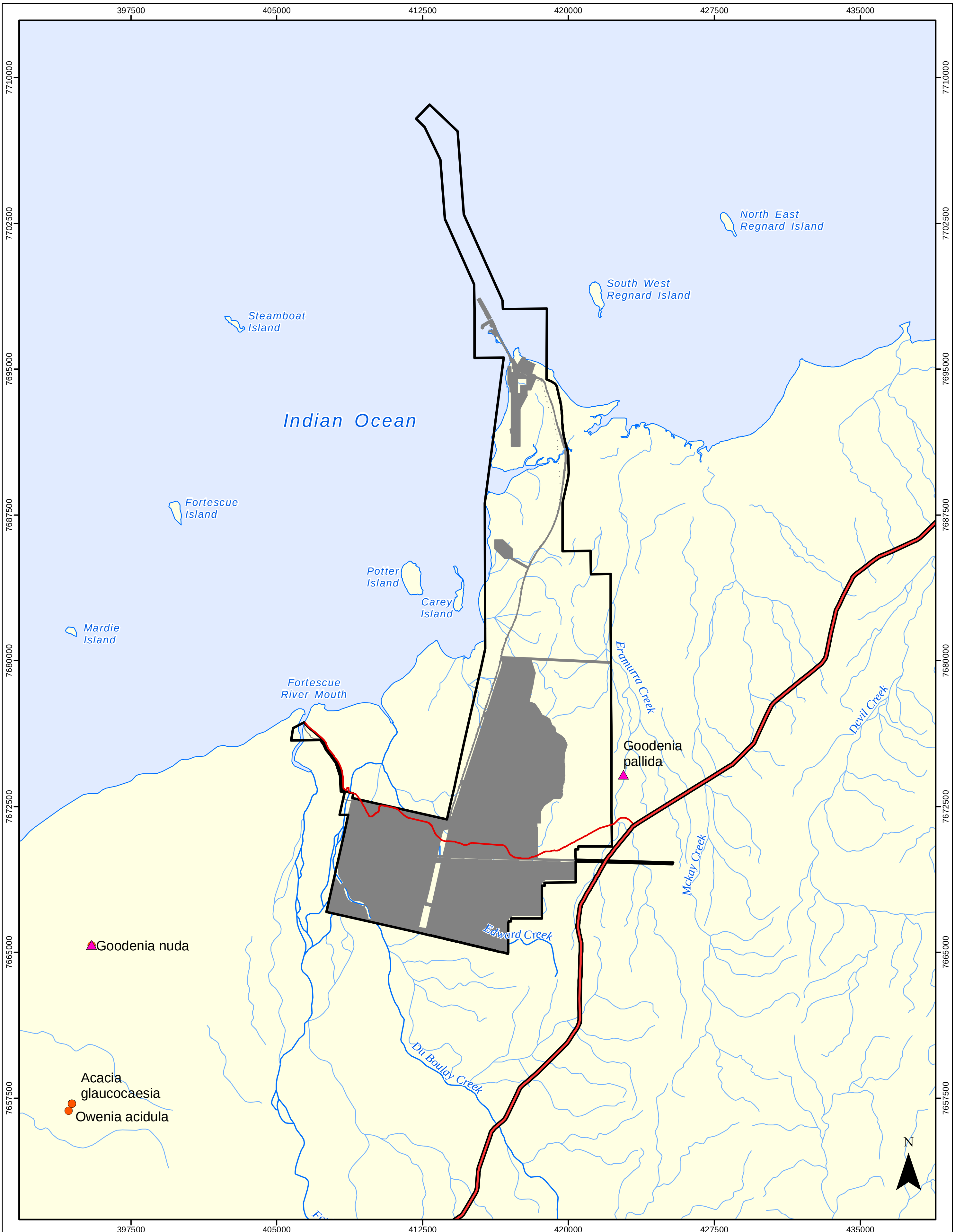
Figure 8 - 3

Vegetation units

Department:	ENV	Date:	20/01/2017
Sheet Size:	A4	Status:	Final

Drawn by DS	Requested by MC, Strategen	Internal Reference 4416_01_2017_APP



CITIC PACIFIC MINING 中信泰富矿业	Mine Continuation Proposal Figure 8 - 4 Location of conservation significant flora species	0 5 10 Kilometres 1:250,000 Datum: GDA94 Projection: MGA Zone 50	**Legend**

Department:	ENV	Date:	1/02/2017		
Sheet Size:	A4	Status:	Final		
Drawn by DS	Requested by MC, Strategen	Internal Reference 4417_01_2017_APP			

Legend:
- Declared Rare Flora
- WA Herbarium
- Principal Road
- Major Road
- Major Creek/River
- Minor Creek/River
- Development Envelope
- Conceptual Footprint

8.3.4 Groundwater Dependent Ecosystems

Much of the area to the west of the Development Envelope is low-lying and has shallow but highly variable groundwater levels. Groundwater levels in bores close to the Fortescue River rise rapidly when river flows and decline soon after the river ceases to flow, and fluctuate as much as 6 m (CloudGMS 2017). Where groundwater is close to the surface it may help support groundwater dependent vegetation that exists predominantly in shallow alluvial aquifers associated with creeklines. Groundwater dependent ecosystems (GDEs) require access to groundwater to meet some or all of their water requirements.

The flora and vegetation that make up GDEs in the Cape Preston area were surveyed and mapped by Astron in September 2008 (Astron 2009b). Vegetation was surveyed to the west of the Development Envelope along major and minor watercourses (Fortescue River and Du Boulay Creek respectively) in an area up to 15 km wide and 35 km long. Thirteen groundwater dependent vegetation communities were mapped, ranging from high to low dependence on groundwater (Astron 2009b) (Figure 8-5). The majority of the vegetation along minor ephemeral flowlines was not considered groundwater dependent (Astron 2009b).

In mapping the vegetation communities as groundwater dependent Astron (2008a) also identified whether the unit was highly dependent (obligate) or moderately dependent (facultative). Obligate GDEs are highly reliant on groundwater for maintenance of some or all of their ecosystem function. *Melaleuca argentea* is one species identified in the Fortescue area as an obligate phreatophyte (Astron 2008a). This species was located along sections of the Fortescue River and Du Boulay Creek. *M. argentea* is highly sensitive to lowering groundwater levels and is likely to show early signs of water stress from significant lowering of the watertable over a short period.

Facultative (or opportunistic) GDEs have a low or moderate reliance on groundwater and only require access to groundwater in some landscapes, but in other landscapes can utilise soil moisture to maintain ecosystem function. Species that were identified within the survey area as being facultative included *Eucalyptus camaldulensis*, *E. victrix* and *Corymbia candida*, which were located along sections of the Fortescue River and Du Boulay Creek.

Facultative GDEs occur across the majority of the floodplain, which is consistent with the environmental setting as the floodplain receives periods of floodwaters from large rainfall events.

8.3.5 Presence of weeds

The Development Envelope is within an active pastoral station that has historically been adversely affected by weed invasion and grazing by stock. The condition of the vegetation within the Cape Preston area ranges from Completely Degraded to Very Good (Maunsell 2008, AECOM 2009, Astron 2009a).

The majority of floodplain in the area is invaded by mesquite (**Prosopis pallida*) and **Parkinsonia aculeata* which are Declared Plants by the Department of Agriculture and Food, pursuant to s 22 of the Biosecurity and Agriculture Management Act 2007 (BAM Act) as well as Weeds of National Significance. Buffel grass (**Cenchrus ciliaris*) is also common throughout the pastoral lease.

Mesquite is one of 20 Weeds of National Significance in Australia, due to its invasiveness and potential for spread across a wide landscape, impacts on the environment, and socioeconomic impacts. Anderson et al. (undated) conducted an aerial survey to determine the extent and density of mesquite infestations throughout the Pilbara. This mapping was used to determine the extent of mesquite infestations throughout the groundwater-dependent vegetation to the west of the Development Envelope, as mapped by Astron (2008a) (Table 8-5, Figure 8-6). Over 80% of the groundwater-dependent vegetation area is infested with mesquite, with over 60% of the area affected by ‘scattered’ to ‘dense’ infestations. Infestation level corresponds closely to availability of water, with the densest infestations found within or directly adjacent to river and creek beds.

A field survey was undertaken at 11 sites within the groundwater-dependent vegetation area to ground-truth mesquite infestation levels. Figure 8-7 illustrates the higher levels of infestation (‘scattered’ to ‘dense’) present within groundwater-dependent vegetation.

Table 8-5: Density of mesquite infestations within groundwater-dependent vegetation

Infestation density	Area of groundwater-dependent vegetation affected (ha)	% of groundwater-dependent vegetation affected
1 plants per ha	1924	3.1
2 to 9 plants per ha	5753.5	9.4
10 to 29 plants per ha	3293	5.4
30 to 70 plants per ha	1165.5	1.9
Scattered	15632.5	25.6
Medium	11636.5	19.0
Mid-dense	8158.5	13.3
Dense	2460.5	4.0
None	11137	18.2
Total	**61161**	**100**

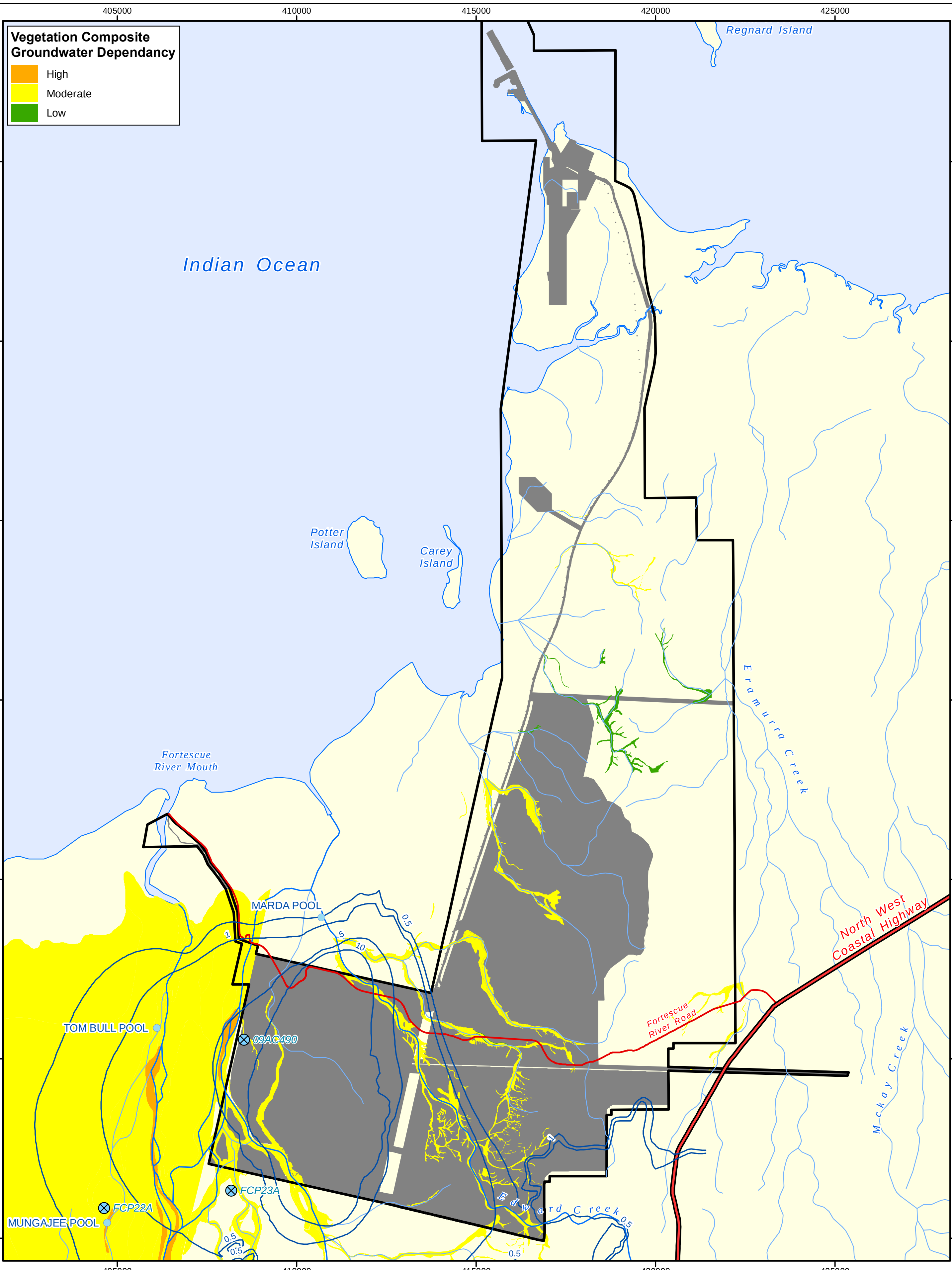


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Figure 8 - 5

Groundwater Dependent Ecosystem mapping

0 2.5 5
Kilometres
1:140,000

Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	27/01/2017
Sheet Size:	A4	Status:	Final
Drawn by DS	Requested by MC, Strategen	Internal Reference 4418_01_2017_APP	

Legend

- Monitoring bore
- Groundwater Drawdown Mine Continuation Proposal
- Principal Road
- Major Road
- Major Creek/River
- Minor Creek/River
- Development Envelope
- Conceptual Footprint

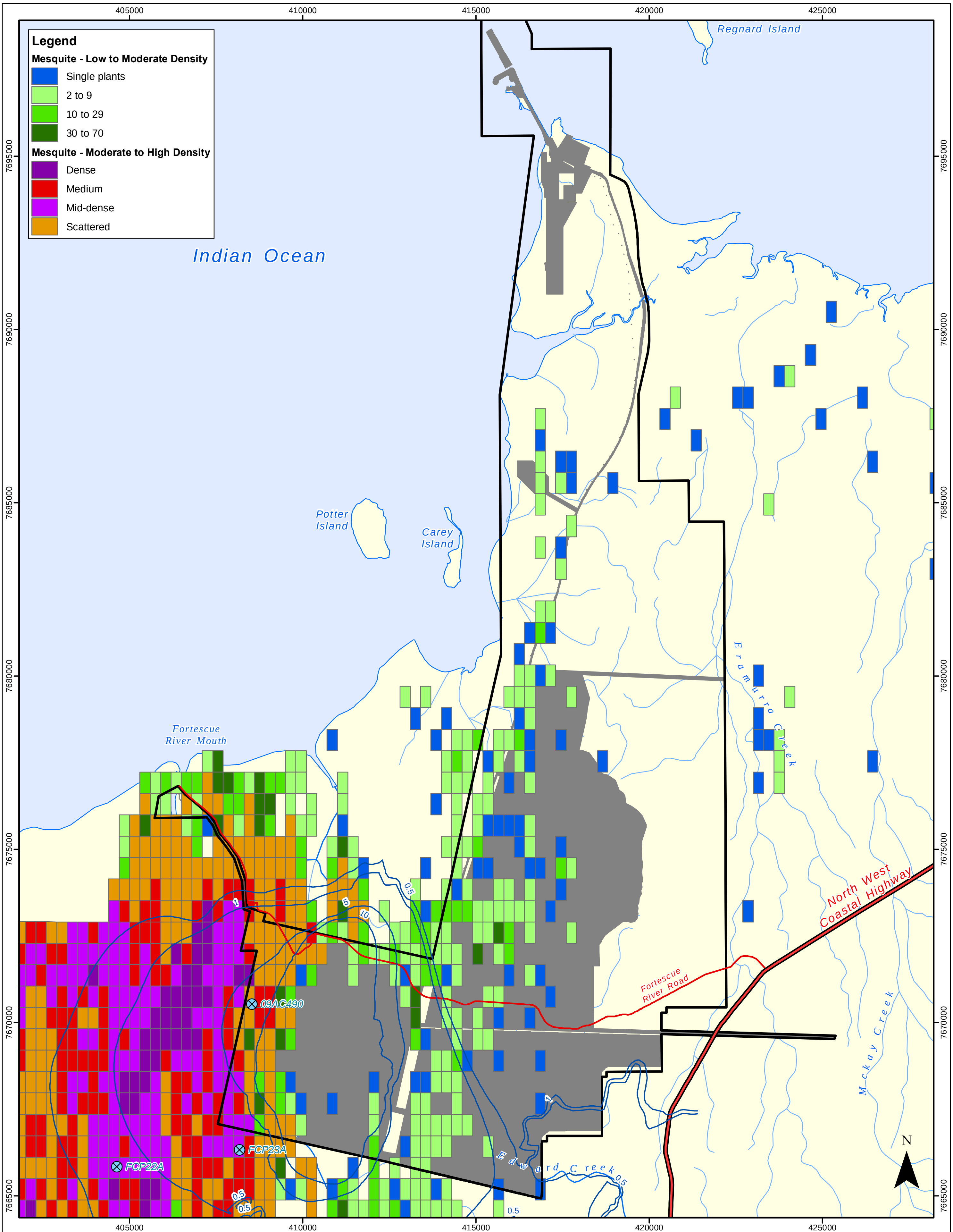

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Figure 8 - 6

Extent of weed mapping

0 2.5 5
Kilometres
1:140,000

Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	27/01/2017
Sheet Size:	A4	Status:	Final

Drawn by	Requested by	Internal Reference
DS	MC, Strategen	4419_01_2017_APP

Legend

- Monitoring bore
- Groundwater Drawdown Mine Continuation Proposal
- Principal Road
- Major Road
- Major Creek/River
- Minor Creek/River
- Development Envelope
- Conceptual Footprint

Figure 8-7: Mesquite infestation levels within groundwater-dependent vegetation

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8.4 Potential impacts

The following potential impacts have been identified:

- clearing of native vegetation has the potential to affect the regional representation of vegetation communities and flora species
- clearing has the potential to introduce/spread weeds
- groundwater drawdown from dewatering has the potential to affect groundwater dependent ecosystems.

This section describes the impacts of groundwater drawdown on groundwater-dependent ecosystems. The extent and impact of groundwater drawdown and discharge on hydrological processes is outlined in Section 5.5.1 while Section 7.5.1 describes the impact of groundwater discharge on marine environmental quality.

8.5 Assessment of impacts

8.5.1 Clearing

Table 8-2 identifies that of the Land Systems present in the Development Envelope less than 2% of each of these has been cleared historically within the Pilbara Subregion, showing negligible loss of vegetation to date at a regional scale. Further, less than 10% of each Land System has been cleared to date within the Roebourne Subregion. This illustrates that the Land Systems present in the Development Envelope are all well represented in the wider region.

While 69 distinct vegetation units have been identified in the Development Envelope, these correspond closely with a limited number of landform elements (i.e. hills, plains and creeks). The landform elements in the Development Envelope are closely linked to the Land Systems. The fact that the Land Systems are well represented in the Roebourne Subregion indicates that the landforms and vegetation units are also likely to also be well represented in the Roebourne Subregion.

The majority of the disturbance (over 5000 ha or more than 70%) occurs within either the Low Hills and Slopes or Plains landforms. These landforms contain vegetation units, which are of low to moderate local conservation significance and are well represented in the local area.

As shown in Table 8-6, (the clearing within 50 of the 69 vegetation units recorded within the Development Envelope (including both the clearing for the existing project and the Proposal) will be less than 60% of their mapped extent. This indicates that for the majority of the vegetation units the additional clearing associated with the Proposal will not be significant.

Of the 17 vegetation units that will have a total clearing of more than 70% clearing, eight of these were already more than 70% cleared as a result of the existing project. The remaining nine units are within landform elements (i.e. plains) that contain other similar vegetation units that are all well-represented.

Within the above context the Proposal will not significantly reduce the extent of vegetation types within any landform and it is considered unlikely that the additional clearing will significantly affect Flora and Vegetation values.

Table 8-6: Area of clearing within Development Envelope and Proposal Footprint

Landform	Vegetation unit	Total	Development Envelope		Existing clearing		Proposal Footprint (including existing clearing)	
		(ha)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Clayey plains	Hp	3838.1	880.4	22.9	281	7.3	792.1	20.6
	Hp1	20.1	20.1	100	19.7	98.2	20.1	100
Beaches	Lb	53.3	31.7	59.5	0.4	0.8	2.4	4.5
Dunes	Ld1	38.5	19.2	49.9	0.6	1.6	0.7	1.8
	Ld2	413.3	312.9	75.7	4.2	1	80.5	19.5
	Ld3	47	23.4	49.8	9.1	19.3	11	23.4
	Ld4	51.6	51.6	100	0	0	2.5	4.8
Hills	Lh2	22.7	2.8	12.3	0	0	0	0
Intertidal zones	Lm	374.2	168.1	44.9	0	0	0.9	0.3
Sandy Plains	Lp1	109	108.9	99.9	0	0	21	19.3
	Lp3	5.9	1.7	28.8	0	0	0.6	10.2
	Lp4a	35.1	18	51.3	0	0	0.9	2.6
	Lp4b	17.5	17.4	99.4	2.8	15.8	2.8	16
	Lp5	14.2	12.5	88	0	0	0.1	0.7
Tidal Mudflats	Ls1	614.4	365.5	59.4	0	0	12.9	2.1
	Ls2	354.9	158	44.5	0.5	0.1	7.8	2.2
	Ls3a	1.5	1.5	100	0	0	0.5	33.3
	Mf1	3.3	2	60.6	0	0	2	60.6
Plains	Mp1	523.4	802.2	153.3	17.2	3.3	24.9	4.8
Minor Flowlines	Nc	968.6	656.1	67.7	172.9	17.9	427.3	44.1
Low Hills and Slopes	Nh	2670.2	1187.4	44.5	808.7	30.3	1179	44.2
	Nh1	173.1	82	47.4	5	2.9	73.9	42.7
	Nh2	861.4	4.4	0.5	0	0	0	0.0

Landform	Vegetation unit	Total	Development Envelope		Existing clearing		Proposal Footprint (including existing clearing)	
		(ha)	(ha)	(%)	(ha)	(%)	(ha)	(%)
	Nh3	345.6	148.9	43.1	22.6	6.5	49.1	14.2
Rockpiles	Nr	4.2	2.2	52.4	2.2	51.9	2.2	52.4
Creeklines and Floodplains	Pc	600.6	184.4	30.7	9.3	1.5	179.2	29.8
	Pc2	732.3	52.3	7.1	1.5	0.2	18.1	2.5
	Pc3	11.5	90.3	785.2	0.2	1.3	9.1	79.1
	Pc4	3.1	3.1	100	0	0	3.1	100.0
	Pf1	1.5	1.5	100	0.1	4.1	1.5	100.0
Plains	Pp1	406.7	406.7	100	15.8	3.9	220.8	54.3
	Pp2	510.8	322	63	9.2	1.8	107.8	21.1
	Px1	2890.6	2120.6	73.4	391.3	13.5	1719.5	59.5
	Px2	3006.2	692.7	23	179.2	6	535.9	17.8
	Px4	4.3	4.3	100	4.3	100	4.3	100.0
	Px5	1.2	1.2	100	1.2	100	1.2	100.0
	Px6	1.6	1.6	100	1.6	99.8	1.6	100.0
Creeklines	Rc1	742	19.7	6	0	0	14.9	2.0
	Rc3	226.9	38.7	17.1	0.1	0	21	9.3
	Rc4	698.9	3.7	0.5	0.2	0	0.9	0.1
Floodplains	Rf1	3589.3	504.4	14.1	90.2	2.5	425.1	11.8
	Rf2	1154	48.8	4.2	0	0	45.7	4.0
	RO3a	1.2	1.2	100	1.2	99.7	1.2	96.7
Minor flowlines	ROc1	38.6	50.5	130.8	0.7	1.9	32.5	84.2
	ROc2	99.8	86.7	86.9	0.7	0.7	23.9	23.9
	ROc3	14.8	14.8	100	0	0	14.8	100.0
	ROc4	54.4	54.1	99.4	1.8	3.3	17	31.3

Landform	Vegetation unit	Total	Development Envelope		Existing clearing		Proposal Footprint (including existing clearing)	
		(ha)	(ha)	(%)	(ha)	(%)	(ha)	(%)
	ROc4/ROh2a	8.3	8.3	100	3.8	45.7	7.3	88.0
	ROc5	3.5	3.5	100	0	0	0.4	11.4
	ROc6	39.7	34.9	87.9	1.7	4.3	30.2	76.1
	ROc7	0.7	0.7	100.0	0.5	71.4	0.7	100.0
	ROc8	1.6	1.6	100	1.6	99.8	1.6	100.0
Low hills and slopes	ROh1	1858.8	2260.8	121.6	117.9	6.3	1117.8	60.1
	ROh1a	116.4	116.4	100	1	0.8	57.5	49.4
	ROh1b	2364.8	1864.9	78.9	117.6	5	897.9	38.0
	ROh2	1384.8	1623.8	117.3	152.6	11	346.3	25.0
	ROh2a	55.6	55.6	100.0	6.3	11.4	43	78.0
	ROh2b	1426.7	1645.5	115.3	245.5	17.2	1130.5	79.2
	ROh3a	2.3	2.3	100	2.3	100	2.3	100.0
Plains	ROp1	217.1	153.5	70.7	2.4	1.1	5.3	2.4
	Ropl	22.3	0.3	1.3	0	0	0	0.0
Rockpiles	ROr	22.4	22.4	100	4.1	20.4	5.1	25.5
	ROr1	5	5	100	0	0	0	0.0
	ROr2	3	3	100	0.4	13.8	0.6	20.0
	ROr3	1.1	0.2	18.2	0	0	0	0.0
Tidal Creek	Yc1	0.9	0.9	100	0	0	0	0.0
	Yf1	11691.6	17.1	0.3	0	0	0.7	0.0
	Yf1d	4113.8	0	0.2	0	0	0.3	0.0
Plains	Yp1	225.6	53.9	23.9	3.1	1.4	53.9	23.9

8.5.2 Spread of weeds

Thirteen species of introduced flora were recorded from the surveyed area. The most problematic is Mesquite (*Prosopis* sp.) which is a Weed of National Significance and a Declared Pest under the *Biosecurity and Agriculture Management Act* 2007 (BAM Act). Its occurrence in this area is part of the largest infestation in Australia, and is often associated with creek lines and floodplains. A number of other introduced species are also present in the area but most are commonplace throughout the rest of the Pilbara. Vehicle or earth movements have the potential to spread existing weed species and to introduce new weed species, particularly if equipment is not adequately inspected and cleaned prior to arrival or departure from site. Activities that disturb native vegetation (such as clearing) can create favourable conditions for weeds to establish. If appropriate management measures are not implemented, weed infestations can outcompete native vegetation and result in alterations to existing ecosystems.

8.5.3 Groundwater drawdown

Groundwater drawdown has the potential to reduce health of phreatophytic species (e.g. *Melaleuca argentea*, *Eucalyptus camaldulensis* and *E. victrix*), which can result in plant deaths and consequently changes in structure of GDEs. Astron 2009b mapped the extent of GDEs and quantified the distribution of highly dependent and moderately dependent ecosystems.

As described in Section 5.3.2, the existing project includes dewatering to allow mining to a depth of 220 m. Aquaterra (2001) identified that drawdown of 0.5 m would extend 3.5 km to the west, 5 km to the east and 15 km to the north and south of the George Palmer Orebody (shown in Figure 5-5). The drawdown zone covers approximately 15 730 ha. Section 5.5.1 identifies that the groundwater modelling for the Proposal predicts that the shape of the drawdown would be less elongated than the previous modelling. The revised modelling for the Proposal shows that the 0.5 m contour will extend approximately 5 km further west and covering a total area of approximately 14 400 ha.

Table 8-7 presents the total areal extent of GDEs within the 0.5 m, 5.0 m and 10.0 m drawdown contours. As summarised in Section 5.5.1, while the extent of the 0.5 m drawdown contour is predicted to be smaller in area than that for the existing project, it will extend further west. By extending further west the 0.5 m drawdown contour increases the area of GDEs potentially affected. In contrast both the 5.0 m and 10.0 m drawdown contour for the Proposal will decrease the extent of GDEs affected.

The key difference between the existing project and the Proposal are:

- extent of GDEs within the 0.5 m drawdown contour will increase
- extent of GDEs within the 5.0 m drawdown contour will decrease
- extent of GDE classed as High Dependence that will experience drawdown will increase.

Table 8-7: Area of groundwater dependent vegetation affected

Drawdown (m)	Existing project area (ha)				Extent of Proposal at 2060 (ha)		
	High Dependence	Moderate Dependence	Low Dependence	**Total**	High Dependence	Moderate Dependence	**Total**
0.5	27.4	1723.9	4.3	**1755.7**	171.1	4984.0	**5155.2**
5.0		1091.2	0.8	**1092.0**	28.3	342.3	**370.61**
10.0		773.5		**773.5**	0.0	164.2	**164.2**

Despite the increase in size of the drawdown zone, vegetation quality is not expected to be significantly affected, for the following reasons:

1. Depth to groundwater in the GDE area is currently relatively deep (5 – 20 m) and thus additional drawdown is unlikely to cause significant additional stress on groundwater-dependent vegetation (Figure 5-14).
2. The majority of GDE within the Proposal Footprint contains species with low to moderate dependence on groundwater, with a small amount of high dependence vegetation within river and creek lines (Figure 8-5).
3. Groundwater levels at monitoring points within the approved drawdown area have been predicted to decrease by 3 – 4 m (monitoring site FCP23a) and 7 – 8 m (monitoring site 09AC490) over a 43 year period (Figure 5-10). Groundwater level decreases outside of the approved drawdown area (i.e. within the GDE area) will be subject to less substantial change at a slower rate, enabling GDEs to adapt.
4. Thirty-six per cent of the GDE area is infested with 'medium' to dense mesquite infestations (Table 8-5, Figure 8-6), and 60% is subject to 'scattered' to dense infestations; as such, this portion of the area already has limited native vegetation value.

Based on the slow rate of change within the 0.5 m drawdown contour, the limited ecosystem value (as a result of the Mesquite infestation), the seasonal surface water availability (as shown in Figure 5-10) and decrease in the extent of GDEs affected by the 5.0 m drawdown contour the Proposal is not expected to significantly affect the Flora and vegetation values as a result of groundwater drawdown.

Consideration of cumulative effects

Section 5.5.1 identified that, with the exception of the Fortescue River floodplain borefield associated with the Balmoral South Proposal, the cumulative effect of the development of all mines in the Cape Preston Area would not substantially increase the extent of groundwater drawdown relative to the Proposal. Table 8-8 shows that the extent of GDEs affected by the cumulative development of all mines. The Fortescue River floodplain borefield, which is a component of the Balmoral South Project (i.e. Stage 2, not progressed), substantially increase the extent of GDEs within the 0.5 m drawdown contour. However, the extent of GDEs within the 5.0 m and 10.0 m drawdown contours is actually less than that of the existing project.

To consider the potential cumulative extent of groundwater drawdown the model has relied only on publically available information that was available for the MEP. Therefore, this assessment approximates the likely result of the inclusion of the mines in this model. The proponents of the other mines would still need to develop their own modelling to take into account their own geological data and mine planning requirements as well as undertaking their own assessment of cumulative impacts to GDEs if they seek approval for their projects.

Table 8-8: Cumulative effect of all mines on GDEs

Drawdown (m)	Cumulative drawdown of all Cape Preston mines (ha)			
	High Dependence	Moderate Dependence	Low Dependence	Total
0.5	171.1	11 247.8	3.1	**11 422.0**
5	34.6	929.9		**964.5**
10.00		393.8		**393.8**

8.6 Mitigation

The overall objective for the mitigation of impacts to flora and vegetation is to ensure that the impact on the quality of flora and vegetation as a result of implementation of the Proposal are minimised.

The following mitigation measures are proposed:

Avoid:

- inspection of the site for the presence of Mesquite or Parkinsonia prior to any machinery being moved to a site
- maintenance of adequate fire breaks across the mine site and around working areas.

Minimise:

- clearing constrained within approved footprint by clearly delineated clearing footprint boundaries
- restricting all vehicles and equipment to within designated tracks and parking areas
- restricting all earthworks and movements of machinery and vehicles to within marked clearing or disturbance boundaries
- weed hygiene measures are implemented to ensure spread of weeds, in particular mesquite, is prevented
- monitoring of GDE vegetation as outlined in the GDVMP (Astron 2015) (Section 8.6.2) will be conducted and contingency responses activated when trigger levels are exceeded.

8.6.1 Weed management

As mesquite is a Declared Pest Plant under the BAM Act, new infestations will be reported to the Pest and Disease Information Service, and management of and control of the species will follow guidelines provided by the Department of Agriculture and Food and the Pilbara Mesquite Management Committee in the *Pilbara Mesquite Management Strategy 2014 to 2017* (Astron 2014). Weed management measures described in the OEMP (Appendix 3) will be implemented.

8.6.2 Groundwater dependent vegetation management

A Groundwater Dependent Vegetation Monitoring Program (GDVMP) comprising biannual monitoring surveys was established in May 2009, when groundwater abstraction commenced (Astron 2015). Monitoring surveys have been conducted in November (towards the end of the dry season) and May (towards the end of the wet season). Monitoring sites have been located along Edwards Creek, Du Boulay Creek and Fortescue River within the predicted drawdown zone (drawdown sites) and outside the predicted drawdown zone (reference sites) (Astron 2015). Comprehensive baseline data has been collected from these sites between 2009 and 2013. Drawdown in the alluvial aquifer has likely only extended beyond the immediate pit area since 2013; as such, monitoring has not continued beyond 2013 (Astron 2015). The only impacts on GDEs attributable to Project activities was a decline in tree health (no deaths observed) detected in May 2014 at Site 6 on Du Boulay Creek to the immediate west of the mining operations. Tree health parameters have varied in response to seasonal and interannual patterns of rainfall (Astron 2015).

The following parameters will be monitored at each site to determine vegetation health in relation to groundwater depth and quality:

- depth to groundwater
- pH and salinity
- leaf water potential
- visual health
- dead/live count
- Projected Foliar Cover
- remotely sensed index of tree condition
- stem diameter
- regeneration
- perennial species presence
- cover by category and species.

Sites will be monitored six-monthly. Two zones have been defined, relating to the extent of groundwater drawdown zone during two time periods, 2015 to 2018 and 2018 to 2025. Monitoring sites in the outer zone are only required to be monitored from the time when the drawdown zone is expected to approach these sites.

8.7 Predicted outcome

When the mitigation and management measures have been implemented, it is expected that the Proposal will result in the following residual impacts and outcomes in relation to flora and vegetation:

- approximately 7366 ha of vegetation will be cleared by the Proposal with the majority of this occurring in habitat of low to moderate conservation significance and well represented in the region
- loss of 121.51 ha of vegetation from the Horseflat Land System, a Priority 3iii Ecological Community although this will not result in a significant reduction in the extent of this community with total clearing in the Roebourne Subregion less than 0.5%
- no Threatened Flora species listed under either the WC Act or EPBC Act will be affected by the Proposal
- no Priority Flora species as listed by Parks and Wildlife will be affected by the Proposal
- no change to GDE health is predicted with implementation of the GDE the monitoring plan and related adaptive management actions; and as a result of minimal changes to of groundwater levels (0.5 m)
- the Proposal will not conflict with the WC Act as no flora species will significantly affected or have its conservation status affected by the Proposal's implementation.

Based on the predicted residual impacts, the Proposal will meet the EPA's objective for the Flora and vegetation factor.

9. Terrestrial fauna

9.1 EPA objective

To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.

9.2 Policy and guidance

The relevant policy and guidelines for Terrestrial fauna are:

- Environmental Factor Guideline - Terrestrial Fauna (EPA 2016h
- Technical Guidance - Sampling methods for terrestrial vertebrate fauna (EPA 2016i) – replaces EPA and DEC 2010
- Technical Guidance - Terrestrial fauna surveys (EPA 2016j) – replaces (EPA 2004)
- Technical Guidance – Sampling of short range endemic fauna (EPA 2016k) – replaces (EPA 2009)

On 13 December 2016 the EPA released revised guidelines for Terrestrial fauna. Relevant policies and guidelines prior to this date are:

- EPA Guidance Statement 20, *Sampling of Short-Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (EPA 2009)
- EPA Guidance Statement 56, *Terrestrial Fauna Surveys for Environmental Impact Assessment in WA* (EPA 2004)
- EPA Position Statement 3, *Terrestrial Biological Surveys as an element of Biodiversity Protection* (EPA 2002)
- *Technical Guide -Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA and DEC 2010)

9.3 Receiving environment

A summary of work completed to describe the receiving environment regarding terrestrial fauna is included in Table 9-1.

The Cape Preston area has been studied in detail since 2000, including ten fauna assessments surveys (Table 9-1). Ecoscape (2016a) conducted a peer review of previously completed fauna surveys to determine the adequacy of work undertaken in relation to current guidelines, summarise survey results and provide advice on any additional work required to meet current guidelines. Ecoscape (2016a) assessed the previous fauna surveys as adequate in relation to current guidelines for vertebrate fauna assessments and that additional work is unlikely to record any species of conservation significance not identified during previous surveys or assessed as potentially occurring. The level of surveying in the area is believed to be sufficient, in particular when considering data made available by Parks and Wildlife, the WA Museum (NatureMap) and the Atlas of Living Australia (ALA).

Table 9-1: Summary of environmental studies and survey effort

Author	Survey/ investigations name	Study area, type and timing	Study standard/guidance and limitations
Recently completed work			
Ecoscape 2016a	Vertebrate fauna desktop review	A review of previously completed vertebrate fauna surveys and assessments within the Development Envelope.	Guidance Statement No. 56 Position Statement No. 3
Ecoscape 2016b	Northern Quoll reconnaissance survey	Northern Quoll reconnaissance survey conducted in 2016 within the Development Envelope.	Guidance Statement No. 56. *Limitations:* Reconnaissance survey only.
Ecoscape 2016c	Targeted Northern Quoll survey	Targeted Northern Quoll survey conducted in 2016 within the Development Envelope.	Guidance Statement No. 56.
Previously completed work			
Pendoley Environmental 2010	Marine turtle survey	Marine turtle survey undertaken in 2010 at Cape Preston.	Guidance Statement No. 56
Pendoley Environmental 2009	Marine turtle survey	Marine turtle survey undertaken in 2009 along the western and eastern side of Cape Preston.	Guidance Statement No. 56
Bennelongia 2008	Shorebird survey	Shorebird survey along the Cape Preston coastline.	Guidance Statement No. 56
Phoenix 2008a	Level 2 fauna survey	Vertebrate fauna assessment within the Development Envelope.	Guidance Statement No. 56
Phoenix 2008b	Level 2 fauna survey	Vertebrate fauna assessment within the entire Cape Preston Iron Ore Mining Precinct.	Guidance Statement No. 56
Phoenix 2008c	Short-range endemic invertebrate fauna survey	Short-range endemic invertebrate fauna survey within the Balmoral area.	Guidance Statement No. 56
Maunsell 2008	Consolidated vegetation, flora and fauna assessment	A review of flora, vegetation and fauna data (2000-2007) and detailed assessments in previously unsurveyed areas, covering all mining leases (M08/118 to M08/130).	Guidance Statement No. 56
Maunsell 2006	Level 2 fauna survey	Vertebrate fauna assessment within the Balmoral area.	Guidance Statement No. 56
Maunsell 2003	Baseline turtle survey	Turtle survey conducted in the 2002/2003 nesting season within the Cape Preston shore surrounding the proposed Mineralogy project site.	EPA condition 2.2 (Bulletin 1056, EPA 2002)
Hassell 2002	Shorebird survey	Shorebird survey at Cape Preston.	Guidance Statement No. 56
HGM *et al*. 2001	Level 2 fauna survey	Vertebrate fauna assessment within the Development Envelope.	Guidance Statement No. 56

9.3.1 Fauna habitat

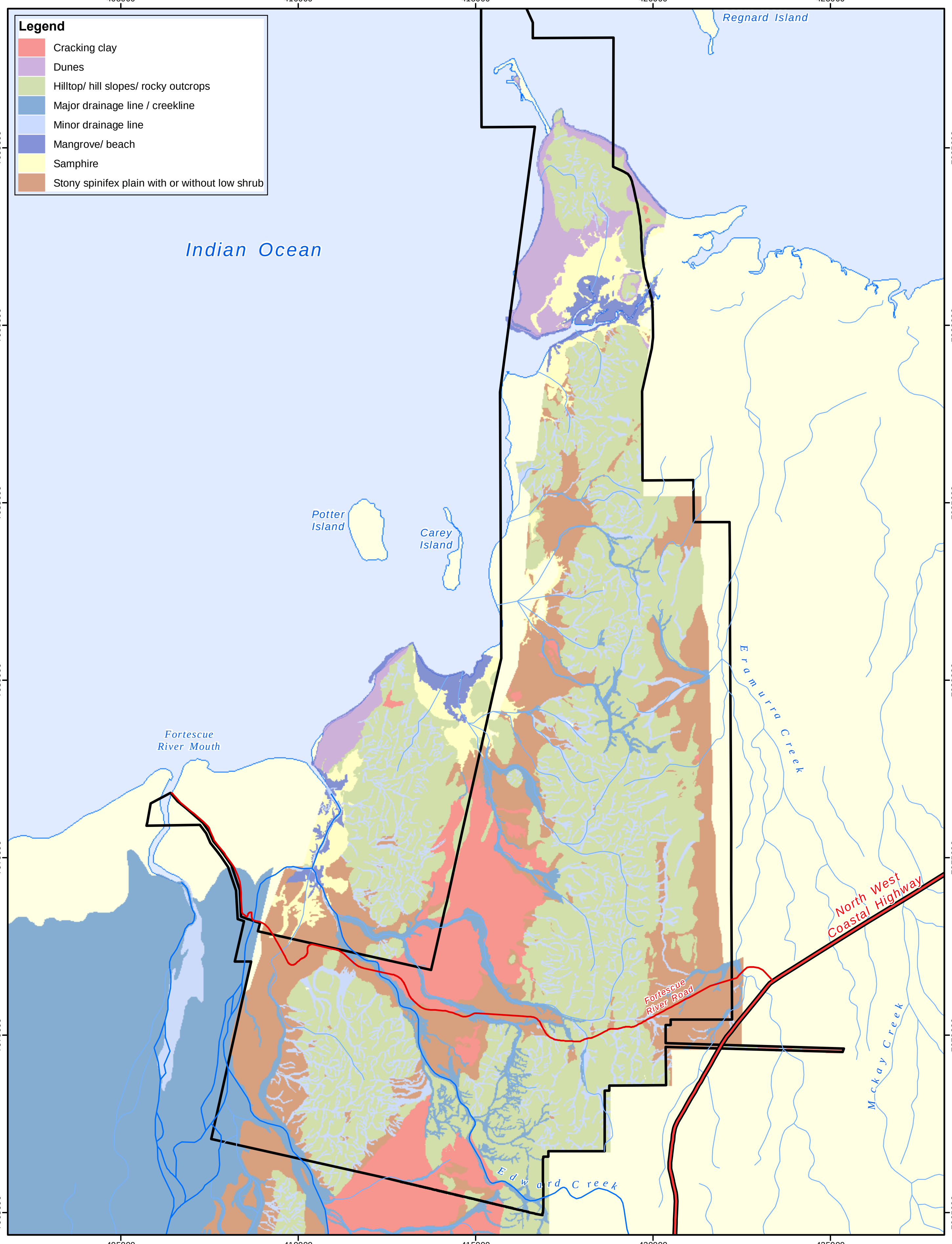
The Cape Preston area contains seven broad terrestrial habitat types (Ecoscape 2016a) (Table 9-2 and Figure 9-1). The majority of habitat within the Development Envelope is low open shrubland over low spinifex on flat plains, which are of low conservation significance. The highest conservation value terrestrial fauna habitats within the Development Envelope are associated with drainage lines.

Table 9-2: Terrestrial fauna habitats

Habitats defined in 2008 survey	Significance of habitat*	Habitats defined in 2001 survey	Land Systems
Cracking clay	**Moderate** – habitat value and significant species	• Cracking clay	Horseflats and Paraburdoo
Drainage line (minor and major)	**Moderate - High** - contains mature trees with hollows that provide roosting sites. May also provide fauna linkages for amphibians and some mammals	• Creeklines	Riverland and Paraburdoo
Dunes	**Moderate** – habitat is restricted in distribution in the Pilbara to the coast	• Coastal dunes • Sandplain	Littoral
Hilltop/ hill slopes/ rocky outcrops	**Low** – habitat is widespread in the Pilbara	• Rocky hills and outcrops • Low stony hills	Newman, Rocklea and Macroy
Mangrove/ beach	**High** - significant species, habitat value and ecological	• Beach • Mangrove (Mangals)	Littoral
Samphire	**Moderate** – habitat is restricted in distribution in the Pilbara to the coast	• Samphire	Littoral
Stony Spinifex plain with or without low shrub	**Low** – habitat is widespread in the Pilbara	• Stony plains	Paraburdoo

*Based on importance as a potential habitat for significant fauna species, habitat value (extent of fauna diversity supported) and ecological function.

Fauna habitat along ridgelines and Edward Creek are corridors of particular habitat types and are considered to be fauna linkages. Whilst no Priority Fauna species are dependent on the area around the creeks for movement or dispersal it is possible that this habitat is important for other species (Phoenix 2009).



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Mine Continuation Proposal

Figure 9 - 1

Fauna habitat

0 2.5 5
Kilometres
1:140,000

Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	20/01/2017
Sheet Size:	A4	Status:	Final

Drawn by	Requested by	Internal Reference
DS	MC, Strategen	4420_01_2017_APP

Legend
- Principal Road
- Major Road
- Major Creek/River
- Minor Creek/River
- Development Envelope

9.3.2 Conservation significant fauna

In addition to the surveys undertaken, Ecoscape (2016a) carried out a database search to determine the fauna species that could potentially occur within the Development Envelope, with an emphasis on species of conservation significance. A total of 57 species of conservation significance (three mammals, 50 birds, and four reptiles) have been recorded during previous surveys at Cape Preston and surrounding areas. An additional 15 species (three mammals, six birds, and six reptiles) have a medium to high likelihood of occurrence based on habitat, database searches and previous records (Table 9-3).

Baseline studies (Hassell 2002, Bennelongia 2008) recorded three Critically Endangered Marine Migratory species (*Calidris ferruginea, Calidris tenuirostris, Numenius madagascariensis*), two Endangered Marine Migratory species (*Charadrius mongolus, Macronectes giganteus*) and one Vulnerable Marine Migratory species (*Charadrius leschenaultii*) listed under the EPBC Act (Figure 9-1). The majority of conservation significant species that were recorded in the area occur over a number of habitat types or occur in habitats that are widespread in the region. None of the habitat types present in the Development Envelope are unique to the locality or regionally significant.

Based on the likely presence in the Development Envelope, Northern Quoll was considered to be potentially affected by the Proposal and subject to a more detailed assessment (Section 9.3.3).

Table 9-3: Conservation significant species likely to occur within the Development Envelope

Species	EPBC Act Status	WA conservation status #	Parks and Wildlife	Likelihood
Mammals				
Dasyurus hallucatus (Northern Quoll)	Endangered	Schedule 2		Recorded
Rhinonicteris aurantia (Pilbara Leaf-nosed Bat)	Vulnerable	Schedule 3		High
Macroderma gigas (Ghost Bat)	Vulnerable	Schedule 3		Medium
Ozimops cobourgianus (Northern Coastal Free-tailed Bat)	-	-	Priority 1	Recorded
*Hydromys chrysogaster (*Water-rat)	-	-	Priority 4	High
*Leggadina lakedownensis (*Lakeland Downs Mouse)	-	-	Priority 4	Recorded
Birds				
Limosa lapponica (Bar-tailed Godwit)	Migratory, Marine	Migratory (S5)	VU	Recorded
Limosa lapponica menzbieri (Bar-tailed Godwit, Northern Siberian)	Critically Endangered		VU	Recorded
Limosa lapponica baueri (Bar-tailed Godwit, Western Alaskan)	Vulnerable		VU	Recorded
Numenius madagascariensis (Eastern Curlew)	Critically Endangered, Migratory, Marine	Schedule 3/ Schedule 5	VU	Recorded
Calidris tenuirostris (Great Knot)	Critically Endangered Migratory, Marine	Schedule 3 /Schedule 5	VU	Recorded
Calidris ferruginea (Curlew Sandpiper)	Critically Endangered, Migratory, Marine	Schedule 3 /Schedule 5	VU	Recorded
Charadrius mongolus (Lesser Sand Plover)	Endangered	Schedule 2 /Schedule 5	EN	Recorded

Species	EPBC Act Status	WA conservation status #	Parks and Wildlife	Likelihood
Charadrius leschenaultii (Greater Sand Plover)	Vulnerable, Migratory, Marine	Vulnerable (S3) Migratory (S5)	VU	Recorded
Sternula nereis nereis (Australian Fairy Tern)	Vulnerable	Schedule 3	VU	High
Pandion haliaetus cristatus (Eastern Osprey)	Migratory, Marine	Migratory (S5)	-	Recorded
Pluvialis fulva (Pacific Golden Plover)	Migratory, Marine	Schedule 5	-	High
Pluvialis squatarola (Grey Plover)	Migratory, Marine	Schedule 5	-	Recorded
Charadrius veredus (Oriental Plover)	Migratory, Marine	Schedule 5	-	Recorded
Numenius phaeopus (Whimbrel)	Migratory, Marine	Schedule 5		Recorded
Tringa stagnatilis (Marsh Sandpiper)	Migratory, Marine	Schedule 5		Recorded
Tringa nebularia (Common Greenshank)	Migratory, Marine	Schedule 5		Recorded
Tringa glareola (Wood Sandpiper)	Migratory, Marine	Schedule 5		Medium
Tringa brevipes (Grey-tailed Tattler)	Migratory, Marine	Schedule 5		Recorded
Tringa cinerea (Terek Sandpiper)	Migratory, Marine	Schedule 5		Recorded
Tringa hypoleucos (Common Sandpiper)	Migratory, Marine	Schedule 5		Recorded
Arenaria interpres (Ruddy Turnstone)	Migratory, Marine	Schedule 5		Recorded
Calidris alba (Sanderling)	Migratory, Marine	Schedule 5		Recorded
Calidris ruficollis (Red-necked Stint)	Migratory, Marine	Schedule 5		Recorded
Glareola maldivarum (Oriental Pratincole)	Migratory, Marine	Schedule 5		Medium
Sterna nilotica (Gull-billed Tern)	Migratory, Marine	Schedule 5		Recorded
Sterna caspia (Caspian Tern)	Migratory, Marine	Schedule 5		Recorded
Sterna anaethetus (Bridled Tern)	Migratory, Marine	Schedule 5		Recorded
Apus pacificus (Fork-tailed Swift)	Migratory, Marine	Schedule 5		Medium
Ardea modesta (Eastern Great Egret)	Marine	Schedule 5		Recorded
Sterna bergii (Crested Tern)	Migratory, Marine			Recorded
Threskiornis spinicollis (Straw-necked Ibis)	Marine			Recorded
Nycticorax caledonicus (Nankeen Night Heron)	Marine			Recorded

Species	EPBC Act Status	WA conservation status #	Parks and Wildlife	Likelihood
Ardea garzetta (Little Egret)	Marine			Recorded
Ardea sacra (Eastern Reef Heron)	Marine			Recorded
Pelecanus conspicillatus (Australian Pelican)	Marine			Recorded
Accipiter fasciatus (Brown Goshawk)	Marine			Recorded
Circus approximans (Swamp Harrier)	Marine			Recorded
Haliastur sphenurus (Whistling Kite)	Marine			Recorded
Haliastur indus (Brahminy Kite)	Marine			Recorded
Haliaeetus leucogaster (White-bellied Sea-Eagle)	Marine			Recorded
Esacus magnirostris (Beach Stone-curlew)	Marine			Recorded
Himantopus himantopus (Black-winged Stilt)	Marine			Medium
Larus novaehollandiae (Silver Gull)	Marine			Recorded
Sterna bengalensis (Lesser Crested Tern)	Marine			Recorded
Chrysococcyx basalis (Horsfield's Bronze Cuckoo)	Marine			Recorded
Chrysococcyx osculans (Black-eared Cuckoo)	Marine			Recorded
Cacomantis pallidus (Pallid Cuckoo)	Marine			Recorded
Ninox boobook boobook (Southern Boobook)	Marine			Recorded
Eurostopodus argus (Spotted Nightjar)	Marine			Recorded
Todiramphus sanctus (Sacred Kingfisher)	Marine			Recorded
Merops ornatus (Rainbow Bee-eater)	Marine			Recorded
Falco cenchroides (Nankeen Kestrel)	Marine			Recorded
Coracina novaehollandiae (Black-faced Cuckoo-shrike)	Marine			Recorded
Grallina cyanoleuca (Magpie-lark)	Marine			Recorded
Hirundo neoxena (Welcome Swallow)	Marine			Recorded
Petrochelidon nigricans (Tree Martin)	Marine			Recorded
Anthus australis (Australian Pipit)	Marine			Recorded

Species	EPBC Act Status	WA conservation status #	Parks and Wildlife	Likelihood
Falco peregrinus (Peregrine Falcon)		Schedule 7		Medium
Falco hypoleucos (Grey Falcon)		Schedule 3		Recorded
Reptiles				
Caretta caretta (Loggerhead Turtle)	Endangered Migratory, Marine	Schedule 2	VU	High
Chelonia mydas (Green Turtle)	Vulnerable Migratory, Marine	Schedule 3	VU	Recorded
Eretmochelys imbricata (Hawksbill Turtle)	Vulnerable Migratory, Marine	Schedule 3	VU	High
Natator depressus (Flatback Turtle)	Vulnerable Migratory, Marine	Schedule 3	VU	High
Ctenotus angusticeps (Airlie Island Ctenotus)	Vulnerable	Schedule 3	VU	Medium
Liasis olivaceus barroni (Pilbara Olive Python)	Vulnerable	Schedule 3	VU	Medium
Aipysurus laevis (Olive Sea Snake)	Marine			High
Ephalophis greyae (North-western Mangrove Sea Snake)	Marine			Recorded
Hydrelaps darwiniensis (Black-ringed Sea Snake)	Marine			Recorded
Notoscincus butleri (Lined Soil-Crevice Skink)	-		Priority 4	Recorded

Schedule 2 – Fauna that is rare or is likely to become extinct as endangered fauna, Schedule 3 – Fauna that is rare or is likely to become extinct as vulnerable fauna, Schedule 5 – Migratory birds protected under an international agreement, Schedule 7 – Other specially protected fauna

9.3.3 Northern Quoll habitat

Northern Quoll reconnaissance survey

Following identification of potential habitat, a Northern Quoll reconnaissance survey was conducted in May 2016 in accordance with the *EPBC Act Referral guideline for the endangered Northern Quoll,* Dasyurus hallucatus (DotE 2016). Scat searches were carried out and 60 motion cameras were installed in a variety of potential Northern Quoll habitat (denning, foraging and dispersal) which included boulder piles in the mine and port areas (Ecoscape 2016b) (shown in Figure 9-2). All motion cameras were baited with non-food reward lures (burley oil soaked cloth ropes) and remained in the field for a minimum of 19 nights.

Motion cameras within the potential habitat recorded Northern Quolls at four locations within the port area within man-made structures (Figure 9-3). All four locations were outside the Proposal footprint. Two recordings were in a water seep and may be associated with denning habitat. The remaining two recordings were along the breakwater, which is located outside the Proposal footprint (Ecoscape 2016b).

The Northern Quoll reconnaissance survey identified a total of 49.75 ha of potential habitat within the Development Envelope, including 49.65 ha within the mine area and 0.12 ha within the port area. Northern Quoll habitat included rugged, rocky areas (boulder piles) and creeklines within the Development Envelope (Ecoscape 2016b). In proximity to mine area there was no evidence of the presence of Northern Quoll and no records from site personnel. The proposed mine area footprint (i.e. as distinct from the port area) was therefore assessed as not containing a population of Northern Quolls. The extent of habitat in the port area is shown in Figure 9-4.

Northern Quoll targeted survey

Based on results from reconnaissance survey, a targeted survey was conducted within the Port area in July 2016 (Ecoscape 2016c).

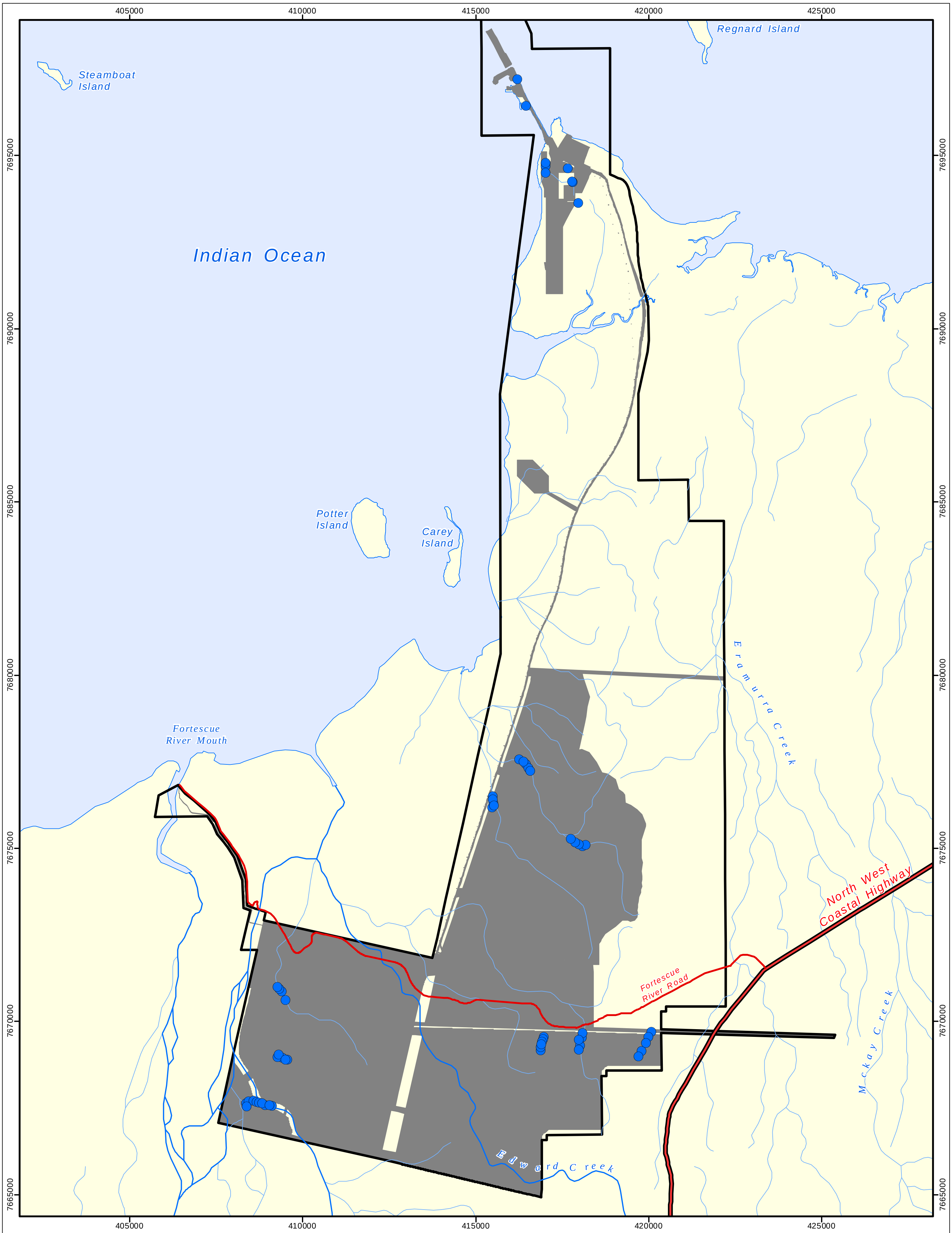
The targeted survey for Northern Quolls was completed with methodology following the EPBC Act Referral guideline for the Northern Quoll, *Dasyurus hallucatus* (DotE 2016). The results of the reconnaissance survey were used to set the design parameters for the targeted survey. The targeted survey was focussed on the Port area including non-impacted areas on Cape Preston.

Trap sites were established at seven locations based on the outcomes from the reconnaissance survey (identification of suitable habitat and recorded Northern Quolls). A total of 80 cage traps and large Elliott box traps were established across seven areas of suitable and critical habitat and left in place for seven consecutive nights (between 18 and 26 July 2016) (Figure 9-5). Each trap was baited using a bolus of rolled oats, peanut butter and sardines (as outlined in the EPBC Act referral guideline) with the bait refreshed every second day. All traps were checked daily within two hours of sunrise and all captured Northern Quoll processed to determine weight, short pes length, caudal width, head length, sex, and reproductive condition. All captured Northern Quoll were also injected with a PIT microchip for identification of recaptures and a small ear notch taken for future DNA analysis by research institutions (Ecoscape 2016b).

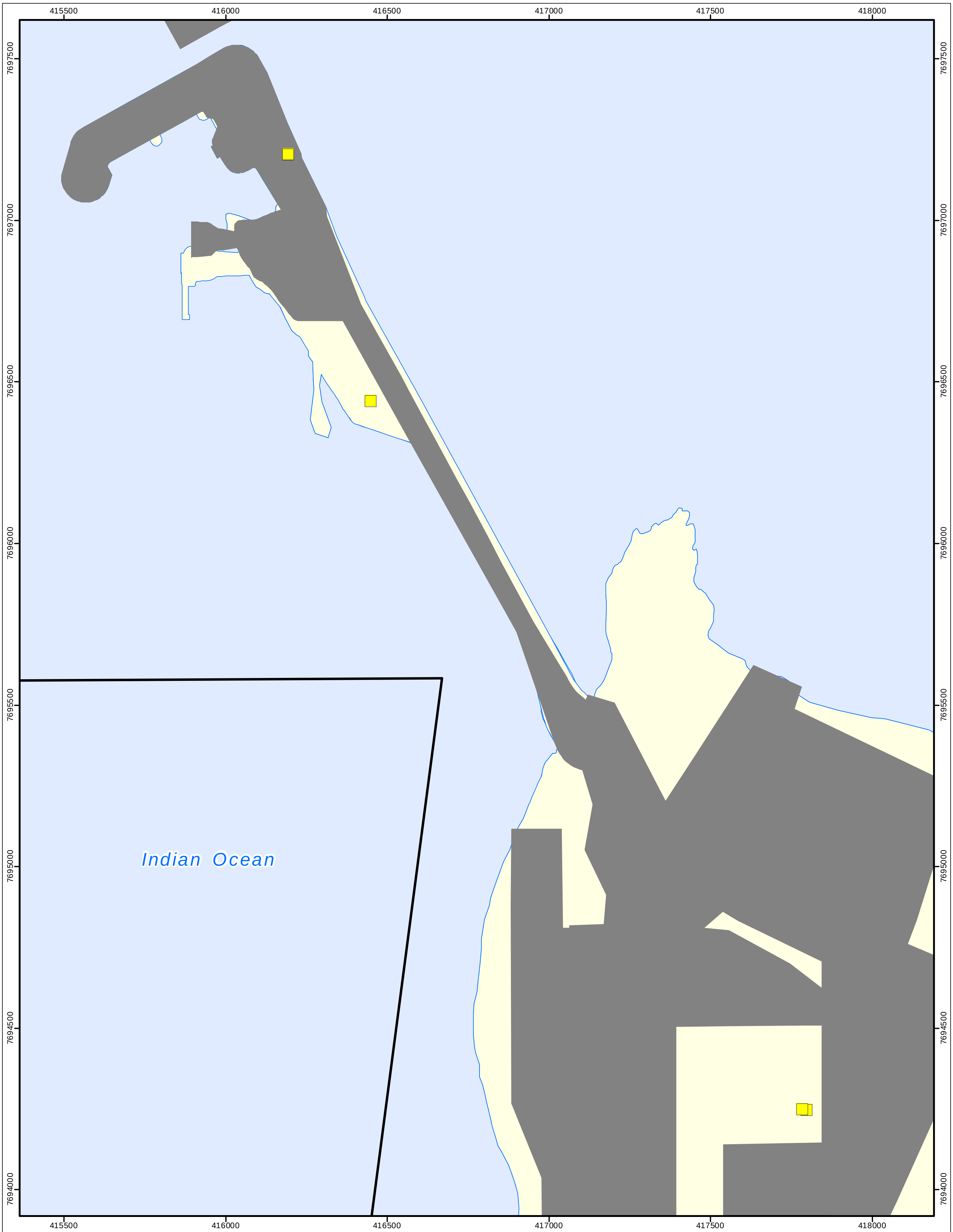
During the targeted survey, three male Northern Quolls were captured on several occasions (Figure 9-6) (Ecoscape 2016c). All captures were located on the northern end of the breakwater (outside the Proposal). Despite the relatively intensive trapping effort, no females were recorded from the site; however, they are likely to reside in close proximity to the existing project. Males are likely to travel to the Port area for foraging and dispersal since males are known to have extensive roaming behaviour. Attributes such as shelter, high humidity, and abundance of food resources (black rats, house mice, crabs etc.) are a likely driving factor for Northern Quolls to utilise this area (Ecoscape 2016c).

Based on habitat mapping and the density and location of records, the northern section of the port infrastructure contains a small amount of critical habitat (both natural and artificial) for the species which is likely to be utilised as foraging ground due to the proximity to the breakwater (Ecoscape 2016c).

In summary, Northern Quolls were not found to utilise the potential habitat within the Proposal footprint during the reconnaissance and targeted surveys.



CITIC PACIFIC MINING 中信泰富矿业	Cape Preston Northern Quoll Reconnaissance Survey Figure 9 - 2 Motion Camera Locations	0 2.5 5 Kilometres 1:140,000 Datum: GDA94 Projection: MGA Zone 50	**Legend** Camera Locations Principal Road Major Road Major Creek/River Minor Creek/River Development Envelope Conceptual Footprint
		Department: ENV	Date: 2/02/2017
		Sheet Size: A4	Status: Draft
		Drawn by CF / Requested by MC, Strategen	Internal Reference 4464_00_2017_APP



CITIC PACIFIC MINING
中信泰富矿业

Cape Preston Northern Quoll Reconnaissance Survey

Figure 9 - 3

Records of Occurrences During Reconnaissance

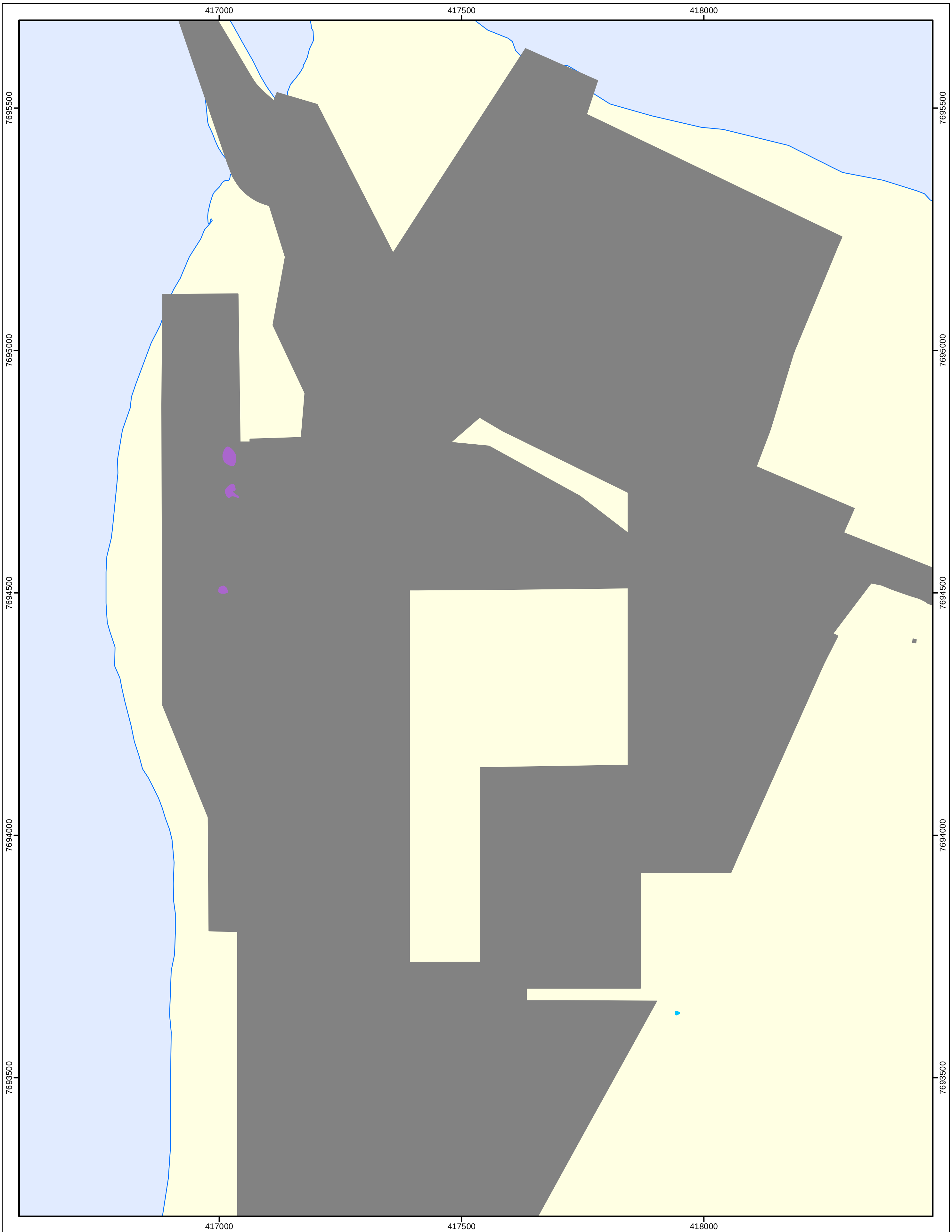
0 0.3 0.6
Kilometres
1:15,000

Datum: GDA94
Projection: MGA Zone 50

Legend

- Northern Quoll
- Development Envelope
- Conceptual Footprint

Department:	ENV	Date:	2/02/2017
Sheet Size:	A4	Status:	Draft
Drawn by CF	Requested by MC, Strategen	Internal Reference 4466_00_2017_APP	



CITIC PACIFIC MINING
中信泰富矿业

Cape Preston Northern Quoll Targeted Survey

Figure 9 - 4

Northern Quoll Habitat

0 150 300
Meters
1:10,000

Datum: GDA94
Projection: MGA Zone 50

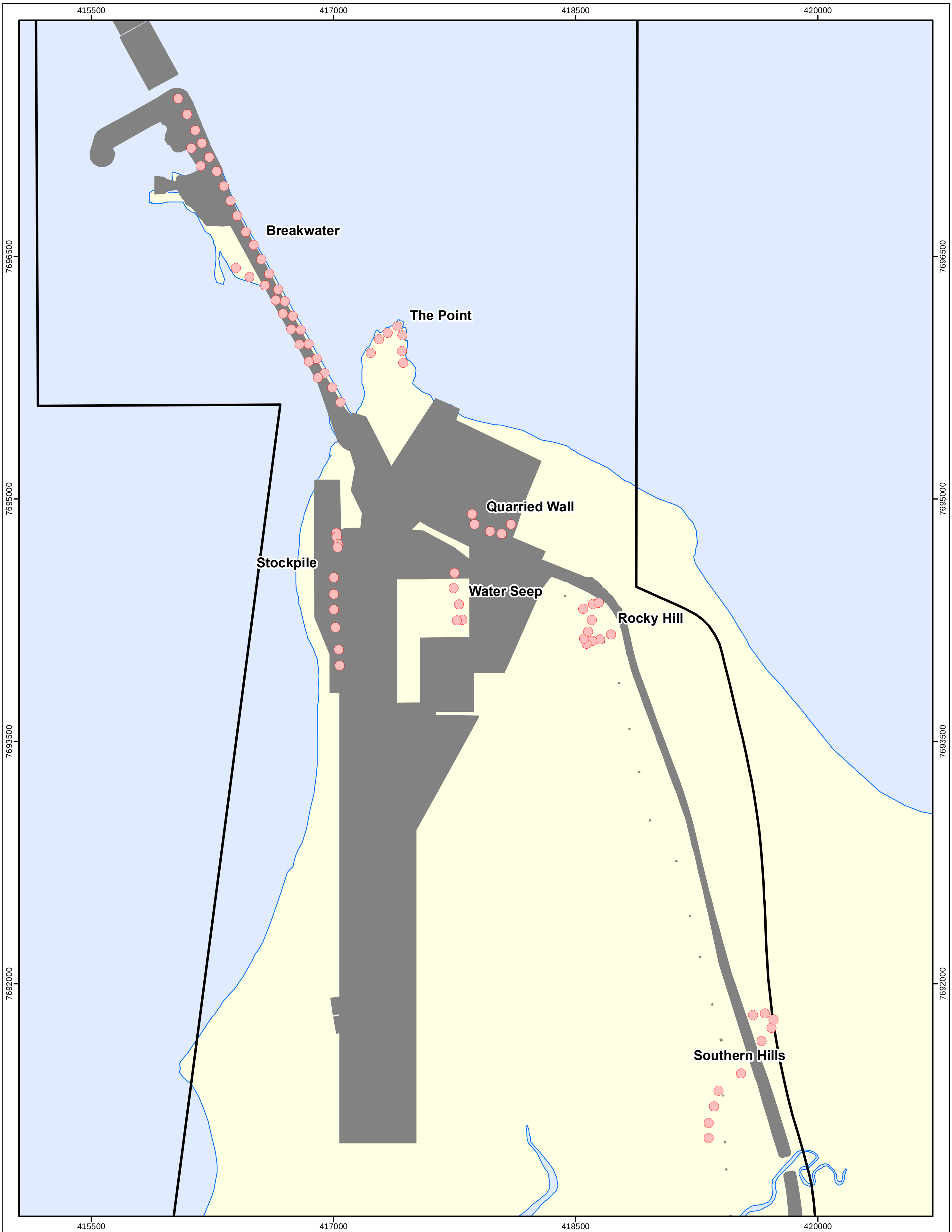
Department:	ENV	Date:	2/02/2017
Sheet Size:	A4	Status:	Final
Drawn by DS	Requested by MC, Strategen	Internal Reference 4468_01_2017_APP	

Legend

- Conceptual Footprint

Moderate Quality

- Potential Foraging Habitat
- Potential Denning Habitat
- Cape Preston Coast



CITIC PACIFIC MINING
中信泰富矿业

Cape Preston Northern Quoll Targeted Survey

Figure 9 - 5

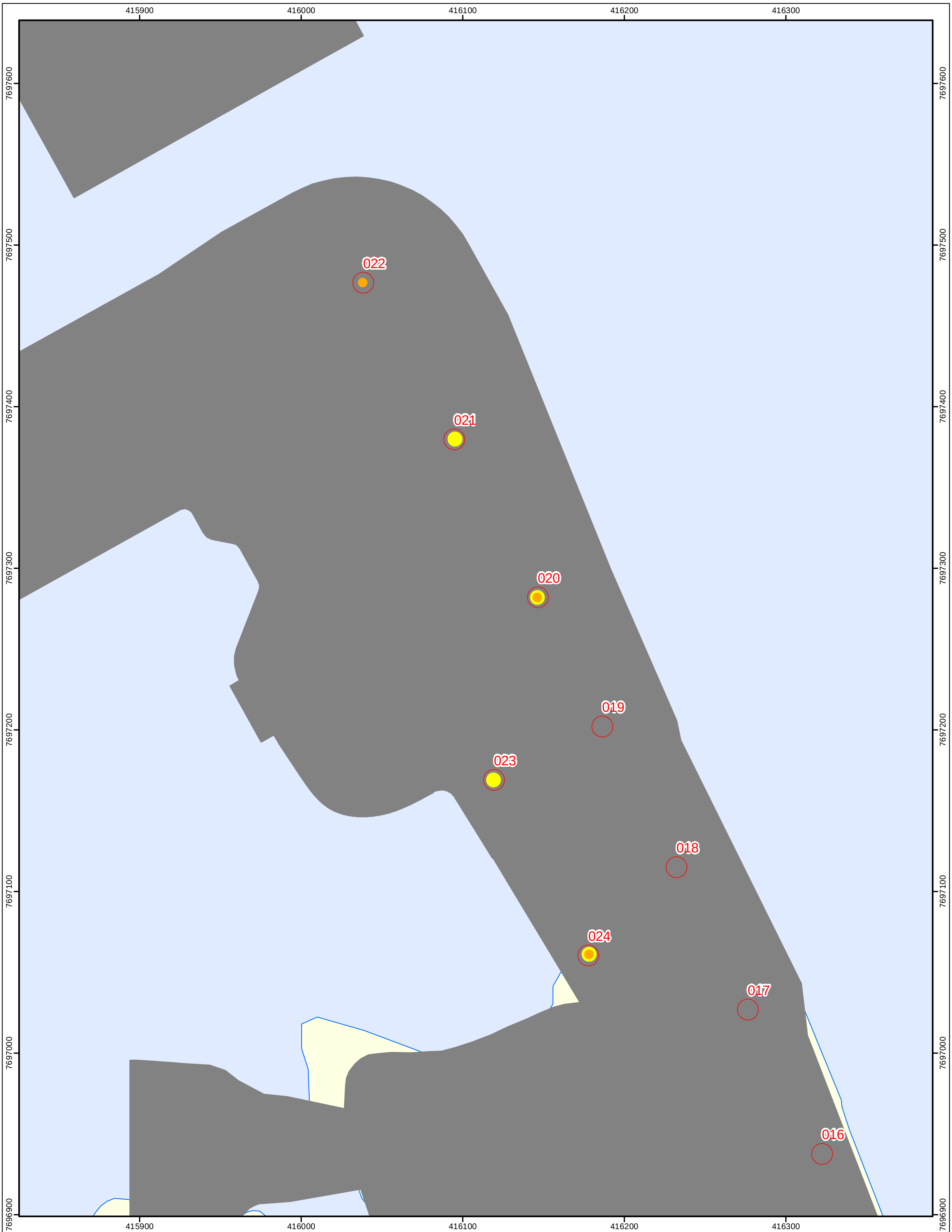
Northern Quoll Trap Locations

0 0.5 1
Kilometers
1:30,000

Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	2/02/2017
Sheet Size:	A4	Status:	Final
Drawn by DS	Requested by MC, Strategen	Internal Reference 4467_00_2017_APP	

Legend
- Trap Location
- Development Envelope
- Conceptual Footprint
- Cape Preston Coast



Cape Preston Northern Quoll Targeted Survey

Figure 9 - 6

Records of Northern Quoll

0 60 120
Meters
1:3,000

Datum: GDA94
Projection: MGA Zone 50

Department:	ENV	Date:	2/02/2017
Sheet Size:	A4	Status:	Final

Drawn by	Requested by	Internal Reference
DS	MC, Strategen	4465_00_2017_APP

Legend

- Captured Quoll
- Recaptured Quoll
- Trap Location
- Conceptual Footprint

CITIC PACIFIC MINING
中信泰富矿业

9.3.4 Invertebrate short-range endemic species

Invertebrate SREs are defined as having a restricted geographic distribution of less than 10,000 km^2 (Harvey 2002). The likelihood of recording SRE invertebrate taxa within the Cape Preston Project Area is considered to be generally low as there are a few landscape and biogeographical features present that would drive short-range endemism (Phoenix 2009).

An SRE invertebrate fauna survey of the Cape Preston area was conducted in 2008 by Phoenix. Sampling methods included wet pitfall trapping, active searches (foraging) and the collection of leaf litter samples.

Wet pitfall trapping was conducted at 50 sites; ten traps were dug in at each site in suitable microhabitats. The traps comprised of one litre plastic containers with a 70 mm diameter that were partly-filled with a solution of ethylene glycol and formaldehyde (2.5% by volume). All traps were left open for a period of 30 days.

Foraging incorporated the systematic inspection of logs, larger plant debris, under the bark of larger trees and the underside and of larger rocks. Methodical searches were also conducted amongst the leaf litter of shade-bearing tall shrubs and trees. Rocks and rock crevices were also inspected, particularly for pseudoscorpions. A temporally and spatially standardised approach was undertaken, whereby each site was sampled for 60 – 90 minutes within a 50 m x 50 m area.

Leaf litter samples were taken from sites where target taxa were not recorded during the foraging component but where they were considered likely to occur. Leaf litter samples were collected from 62 sites.

A total of nine families known to include SRE species were recorded during the survey. These families were represented by 13 genera and 24 species, which included one species of araenomorphae spider, five species of mygalomorphae trapdoor spiders, six species of pseudoscorpions, four species of scorpions, three slaters species and five species of land snails. Of these, three potential SRE species (*Meedo* n. Sp., *Beierolpium* sp. (uncoded) and *Buddelundia* n. sp.1) occurred within or in close proximity to the Development Envelope. Table 9-4 describes the distribution and status of the species.

Table 9-4: Potential SRE species recorded

Species	Distribution within survey area	SRE status
Spiders		
Meedo n. sp.	Recorded from two rocky outcrop sites. Possible rock specialist based on current study and studies of other members of the family Gallieniellidae. Known records on the Newman Land System (iron ore containing Land System / geology).	Likely
Pseudoscorpions		
Beierolpium sp. (uncoded)	Genus suspected of containing SRE species, but taxonomy poorly resolved. A single record from Newman Land System (iron ore containing system). Identity not resolved.	Possibly
Isopods		
Buddelundia n. sp.1	Restricted to three rocky outcrop and rocky slope habitats, including two on the Cape. Likely rock specialist.	Possibly

9.3.5 Introduced fauna

Three introduced fauna species were recorded (Ecoscape 2016c); cat (*Felis catus*), black rat (*Rattus rattus*), House Mouse (*Mus Map musculus*) sheep (*Ovis aries*) and fox (*Vulpes vulpes*).

9.4 Potential impacts

The following potential impacts have been identified:

- clearing has the potential to reduce the extent of fauna habitat
- clearing has the potential to disrupt localised fauna linkages for native fauna
- clearing of Northern Quoll habitat has the potential to affect habitat availability for this species
- development has the potential to introduce/attract feral animals
- mining development has the potential to reduce habitat quality or result in the death or injury of terrestrial fauna.

9.5 Assessment of impacts

9.5.1 Loss of fauna habitat

The clearing of vegetation for mine pits, waste dumps and access roads will result in the direct loss of a substantial loss of fauna habitat.

In total, disturbance for the Proposal will result in the disturbance of approximately 7366 ha. Rehabilitation is expected to return some habitat value to WRD and TSF. The majority of the disturbance (approximately 5100 ha of the 7366 ha Proposal) occurs in the Low conservation significance Stony Spinifex plain with or without low shrub and Hilltop/hill slopes/rocky outcrops habitat types. These two units are widespread in the area (Table 9-5). Habitats with Moderate or High local conservation significance affected included drainage lines and cracking clay units; disturbance within other habitat types (i.e. dunes, samphire and mangrove) is limited.

Table 9-6 assesses the impact of clearing based on the total extent of disturbance (i.e. including both the existing project and the Proposal).

The addition of the Proposal to the existing disturbance increases the proportion of cracking clay to 84.7 of the survey area. The cracking clay habitat may contain habitat for some species of conservation significance, such as *Leggadina lakedownensis* (Short-tailed Mouse) and the *Ardeotis australis* (Australian Bustard). However, the cracking clay habitat is degraded as a result of historical pastoral activities and does not contain substantial or unique habitat values.

The major drainage line / creekline habitat has been identified as having high conservation significance due to the potential mature trees with hollows that provide roosting sites and the potential fauna linkages the habitat could provide. The combined extent of disturbance within this habitat type will be approximately 71%. The mangrove habitat has also been identified as having high conservation significance due to its limited distribution. The combined disturbance to this habitat type is approximately 1.5%

The extent of disturbance to habitats with moderate conservation significance (dunes, minor drainage lines and samphire) is expected to vary from low to moderate significance.

Land clearing activities may directly affect small mammals and reptiles, while some species of fauna may be indirectly affected by not being able to relocate into nearby habitats. Indirect effects may occur within nearby habitats from increased competition, lack of vacant niches and increased densities may cause predation.

The Proposal is unlikely to have a significant impact on conservation significant fauna. The majority of conservation significant species that were recorded either occur in a number of habitat types or occur in habitats that are widespread in the region. Conservation significant species identified during clearing will be translocated where feasible and all native animals encountered on site will be given the opportunity to move on.

Table 9-5: Disturbance of habitats within survey area by the Proposal

Habitat	Extent within survey area (ha)	Extent of disturbance from the existing project		Extent of disturbance from Proposal		Total extent of disturbance	
		ha	%	ha	%	ha	%
Cracking clay	1600	486.9	30.4	868.1	54.3	1355	84.7
Stony Spinifex plain with or without low shrub	4370	439.0	10.0	1707.0	39.1	2146	49.1
Hilltop/hill slopes/rocky outcrops	9356	1500.5	16.0	3410.5	36.5	4911	52.5
Dunes	518	16.4	3.2	99.6	19.2	116	22.4
Major drainage line / creekline	1019	103.0	10.1	621.0	60.9	724	71.1
Minor drainage line	937	183.8	19.6	379.2	40.5	563	60.1
Samphire	525	7.1	1.4	13.9	2.6	21	4
Mangrove	200	3	1.5	0	0.0	3	1.5

The conservation significance of the disturbance from the Proposal is described in Table 9-6. The conservation significance is based on the extent of clearing and the significance of the habitat.

Table 9-6: Significance of habitat disturbance resulting from the Proposal

Habitat	Total disturbance within survey area (including existing project and Proposal) ha (%)	Regional distribution	Significance of habitat	Significance of existing project and Proposal disturbance
Cracking clay	1355 (84.7)	Widespread in the surrounding area	**Moderate** – contains some habitat used by *Leggadina lakedownensis* (Short-tailed Mouse) and the *Ardeotis australis* (Australian Bustard).	**Moderate** – approximately 85% but this habitat is widespread in the surrounding area.
Stony Spinifex plain with or without low shrub	2146 (49.1)	Widespread in the Pilbara region	**Low** – habitat is widespread in the Pilbara.	**Low –**less than 50% of the survey area and this habitat is widespread in the Pilbara.
Hilltop/hill slopes/rocky outcrops	4911 (52.5)	Widespread in the Pilbara region	**Low** – habitat is widespread in the Pilbara	**Low –**less than 70% of the survey area and this habitat is widespread in the Pilbara.
Dunes	116 (22.4)	These are restricted in distribution to the coast but are present along long distances of the coast	**Moderate** – habitat is restricted in distribution in the Pilbara to the coast.	**Low –**less than 50% of the survey area and dunes occur along the coast in the region.
Major drainage line / creekline	724 (71.1)	Widespread throughout region but limited in area	**High** - contain mature trees with hollows that provide roosting sites. May also provide fauna linkages for amphibians and some mammals.	**Moderate –** approximately 71% but this habitat is widespread in the surrounding area

Habitat	Total disturbance within survey area (including existing project and Proposal) ha (%)	Regional distribution	Significance of habitat	Significance of existing project and Proposal disturbance
Minor drainage line	563 (60.1)	Widespread throughout region but limited in local survey area	**Moderate** – may contain some mature trees with hollows that provide roosting sites although unlikely to provide any significant fauna linkages.	**Moderate –**less than 70% of the habitat will be affected by the Expansion Proposal disturbance and this habitat is well represented outside the survey area
Samphire	21 (4)	These are restricted in distribution to the coast	**Moderate** – habitat is restricted in distribution in the Pilbara to the coast.	**Low –** approximately 4% and the habitat is not restricted to the survey area
Mangrove	3 (1.5)	These are restricted in distribution to the coast	**High** - contains some habitat used by *Mormopterus loriae cobourgiana* (Little North-western Mastiff Bat). Habitat is restricted in distribution in the Pilbara to the coast.	**Low –** approximately 1.5% and the habitat is not restricted to the survey area

9.5.2 Disruption to fauna linkages

Disruption of fauna linkages has the potential to restrict fauna movement between or within habitats. Linear habitats, such as the drainage line habitats, are considered the most susceptible to disruption. The drainage lines along Edward and Du Boulay Creeks have the potential to allow fauna movement and are considered to be fauna linkages.

Edward Creek and Du Boulay Creek are minor tributaries of the Fortescue River and run between mining areas and waste rock landforms in the Development Envelope to the Fortescue River. A buffer will be maintained alongside Du Boulay Creek to allow potential movement of fauna. Edwards Creek will be realigned in two sections as discussed in Section 5.5.3.

9.5.3 Northern Quolls

The assessment of Northern Quoll habitat identified 49.65 ha within the mine area and 0.12 ha within the port area potential Northern Quoll habitat (Ecoscape 2016b). Potential Northern Quoll habitat included rugged, rocky areas (boulder piles) and creeklines within the Development Envelope.

The reconnaissance survey identified that Northern Quolls do not occur in the mine area and are limited to the port area. The northern section of the port infrastructure contains a small amount of critical habitat (both natural and artificial) for the species which is likely to be utilised as foraging ground due to the proximity to the breakwater.

On this basis the predicted loss of Northern Quoll habitat as a result of the Proposal is 0.12 ha. However, Northern Quolls were not found to utilise the potential habitat within the Proposal footprint during the reconnaissance and targeted surveys.

9.5.4 Feral animals

An increase in feral animals has the potential to occur from direct and indirect interaction with feral animals. Direct interaction includes feeding the animals and indirect interaction could occur through the increase in food supply from scraps. The potential increase in feral animals such as feral cats could increase predation on native animals, particularly small mammals.

9.5.5 Mining operations

Mining development and operation could potentially affect fauna and alter their behaviour or distribution through light spill, noise and vibration.

Light spill

The impact of light spill is predominantly restricted to turtles and shorebirds; with the potential impacts on turtles listed in Table 9-3. Lighting will be used to ensure the safe operations and security of the mine sites and associated facilities located at the approved port. The effect of lighting is not expected to result in any significant impact to vertebrate fauna. Lighting will be directed at target work areas to ensure impacts to fauna are reduced as far as practicable.

Noise

Construction and operation of the mine site will create noise, which has the potential to affect fauna. Noise may alter fauna behaviour and distribution; however this is not expected to affect the viability of species populations. Bats and shorebirds are likely to be affected; however, this can be minimised by having a setback of 100 m from the mangroves and 50 m from beaches (their respective habitats).

Vehicle movements

Mining development and operations will involve the utilisation of vehicles. The passage of vehicles on haul roads and access tracks has the potential to result in the injury or fatality of native fauna. The implementation of speed limits to prevent the likelihood of fauna road deaths, and avoidance of driving at dusk and dawn will limit the impact of the mining development. It is unlikely that isolated deaths of individuals will affect the conservation status and distribution of any fauna species.

9.6 Mitigation

The overall objective for the mitigation of impacts to fauna is to ensure that the impact on native fauna as a result of implementation of the Proposal is minimised.

The following mitigation measures are proposed:

Avoid:

- the Proposal footprint will avoid drainage line habitat alongside Du Boulay creek
- maintaining a buffer alongside the Du Boulay Creek to allow potential movement of fauna
- preventing unauthorised access to Northern Quoll habitat
- record Northern Quoll habitats to ensure baiting exclusion zones to reduce risk of secondary or accidental poisoning.

Minimise:

- informing the workforce of the fauna present and preventing direct and inadvertent feeding of feral animals.
- implementing and signposting speed limits for both mining equipment and light vehicles in the Development Envelope and on access roads
- undertake baiting outside of Northern Quoll breeding season, outside of known habitat and bury baits to prevent non-target species locating the baits.

9.7 Predicted outcome

When the mitigation and management measures have been implemented, it is expected that the Proposal will result in the following residual impacts and outcomes in relation to terrestrial fauna:

- the majority of the disturbance (approximately 5100 ha of the 7366 ha Proposal) occurs in the Low conservation significance Stony Spinifex plain with or without low shrub and Hilltop/hill slopes/rocky outcrops habitat types
- disturbance of habitats of Moderate or High local conservation significance occurs in habitats that have been degraded as a result of historical pastoral activities, such as drainage lines and cracking clay units; disturbance within other habitat types (i.e. dunes, samphire and mangrove) is limited
- clearing of Northern Quoll habitat is limited to 0.12 ha and impact on Northern Quoll populations is unlikely as they were not found to utilise the potential habitat within the Proposal footprint during the reconnaissance and targeted surveys
- the Proposal will not conflict with the WC Act as no fauna species will be made extinct or have its conservation status affected as the result of the implementation of the Proposal
- no species listed as Endangered or Vulnerable under either the WC Act or EPBC Act will be affected by the Proposal.

Based on the predicted residual impacts the Proposal will meet the EPA's objective for Terrestrial fauna.

10. Terrestrial environmental quality

10.1 EPA objective

To maintain the quality of land and soils so that environmental values are protected.

10.2 Policy and guidance

The relevant guideline for Terrestrial environmental quality is:

- *Environmental Factor Guideline – Terrestrial Environmental Quality* (EPA 2016l)
- *Management of fibrous minerals in Western Australian mining operations – guideline* (DMP 2015).

10.3 Receiving environment

10.3.1 Geology

The Hamersley Group contains one of the largest iron ore deposits in the world, covering more than 600 km from east to west. Numerous large scale operations mine haematite, goethite and limonite deposits found within the Brockman and Marra-Mamba Iron Formations situated within the Hamersley Group (Figure 10-1).

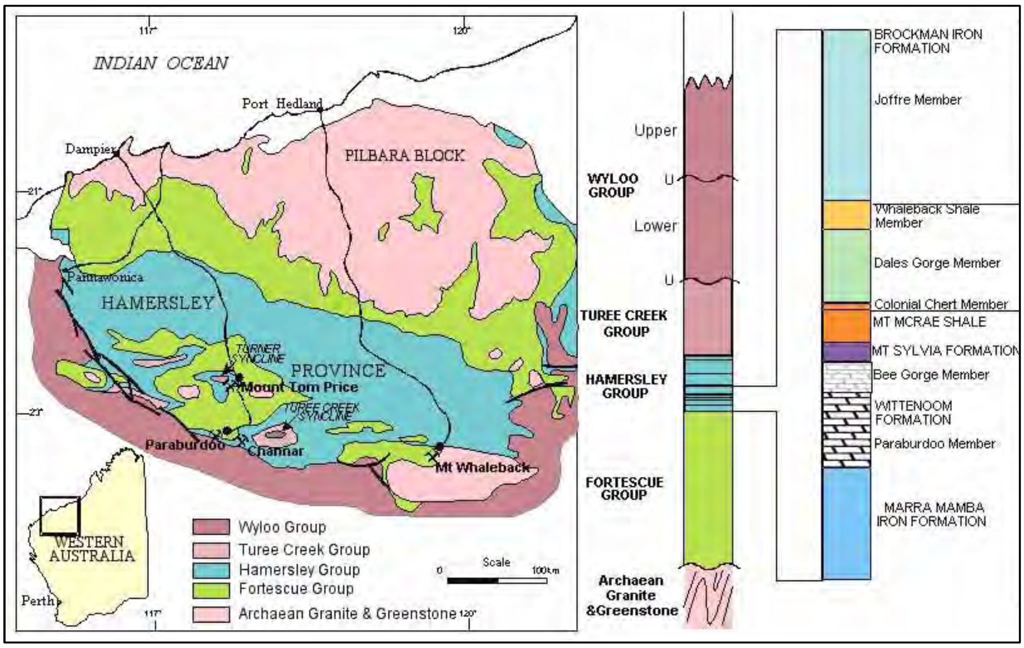


Figure 10-1: Regional geological context

The Joffre and Dales Gorge geological members of the Brockman Iron Formation as well as the Marra Mamba Iron Formation contain banded iron formations that typically consist of alternating sedimentary layers of chert matrix and iron rich bands. These members also contain massive reserves of iron as magnetite.

Fibrous minerals in the Hamersley Iron Group

Fibrous minerals including Actinolite, Tremolite and Riebeckite are ubiquitous throughout the Brockman and Marra-Mamba Iron Formations, each of which may occur in asbestiform and non-asbestiform habits.

While the Dales Gorge Member is known for its occurrence of asbestiform Riebeckite (otherwise known as Crocidolite or "Blue Asbestos") particularly near the centre of the Hamersley Province, the Joffre Member is notable for its absence of crocidolite seams. However, instances of filiform sprays of crocidolite may be encountered in the chert matrix. Asbestiform Actinolite and Tremolite can also be found in the transitional areas around dolerite intrusions.

Fibrous minerals at Sino Iron Ore Operations

The predominant fibrous mineral encountered in the mining operations (of the Joffre Member) is, as would be expected, massive (non-asbestiform) riebeckite. Actinolite and tremolite may occur in trace amounts in transitional areas surrounding dolerite intrusions and, where encountered, are quarantined and transported to encapsulation cells within waste dumps.

The magnetite orebody being mined lies within the Joffre Member of the Brockman Iron Formation which in turns forms part of the Hamersley Group. The orebody overlies the Whaleback Shale and Dales Gorge Members. Dolerite intrusions are present in all geological units as indicated in Figure 10-2.

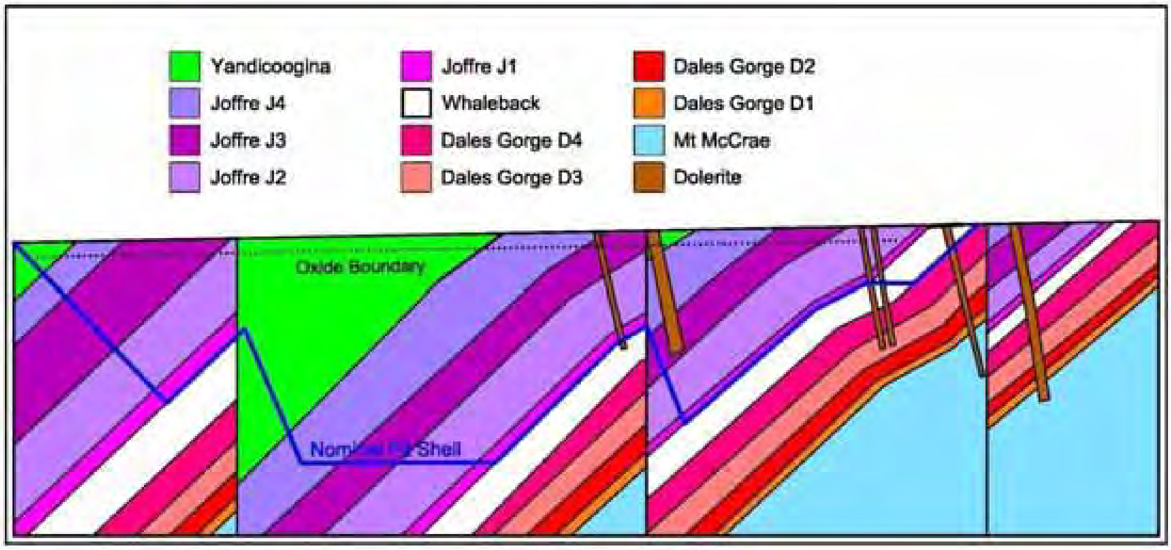


Figure 10-2: Indicative cross sectional view of the geological units within the mine plan.

Although the Dales Gorge does not form part of the target ore body, for economic as well geotechnical stability reasons, planned removal of this material involves quarantine and transport to waste (to be capped).

Massive (non-asbestiform) riebeckite

Massive riebeckite, is commonly encountered in all mining operations extracting ore in and around the Joffre and Dales Gorge Members and consists of densely packed acicular prismatic crystals. Crushing and milling of massive riebeckite can produce atmospheric concentrations of individual acicular crystals which meet the occupational health defined geometric criteria as a countable fibre. While not meeting the formal definition of contaminant asbestos (under MSIA Regulation), based on precautionary principles CPM has chosen to include massive riebeckite in determining atmospheric fibre concentrations.

Fibrous minerals and environmental health

The risks associated with fibrous minerals at the Project are similar to that experienced by other iron ore mining operations mining in and around banded iron formations within the Hamersley Group. The primary concern that arises is the potential effect on human health, both occupational and public.

Atmospheric monitoring for fibrous minerals at the Project indicates that significant dilution occurs within a relatively short distance from point source emissions and are contained within areas that have been designated as being potentially hazardous.

Scanning Electron Microscopy of atmospheric samples reveals that the predominant fibre released into the atmosphere is non-asbestiform, acicular, prismatic fibres of massive riebeckite.

10.3.2 Occupational and public health

The presence of fibrous minerals and the potential hazard to human health has resulted in a significant occupational hygiene monitoring program from which evidence based statements of risk can be made and from which a comprehensive management plan has emerged (see Fibrous Minerals Management Plan (FMMP) in Appendix 3).

Personal exposures to fibrous minerals are well controlled. Atmospheric concentrations of fibrous minerals recorded across the site are generally below the occupational exposure standard. Areas where elevated concentrations may be present (limited to mine pit, processing plant, TSF and parts of port operations) are classified as designated areas where mandatory respiratory protection and decontamination is required.

Public Health

The presence of controls that reduce dust and fibre emissions, coupled with the dilution of emissions ensures that fibrous minerals are contained within designated operational areas. However, the accommodation village should be considered as an area requiring public health standards to be applied to ensure there are no additional exposures to mine workers as well as ensuring the protection of the non-mining workforce. Area and personal monitoring is regularly carried out at the village; all results from 2015-2016 were at or below the limit of detection.

Fibrous minerals management – environmental controls for the protection of health

A FMMP (included in Appendix 3) has been developed by CPM using DMP's guideline: Management of Fibrous Minerals in the Western Australian Mining Industry. Key areas within the FMMP include:

- mine planning that limits mining of Dales Gorge material
- Dales Gorge and transitional areas surrounding dolerite intrusions encountered are quarantined from processing and transported to encapsulation cells within waste dumps
- the delineation of designated areas where respiratory protection and decontamination is mandated
- provision of in-pit dust control and suppression
- crushing and conveyor transport dust suppression systems
- restricting (and recording) access to designated areas to essential personnel
- fitting HEPA systems to heavy plant and buildings
- decontamination facilities for personnel and equipment
- unprecedented respiratory protection program (including fit testing)
- fibrous minerals training and awareness sessions for all personnel
- ongoing occupational hygiene monitoring for fibrous minerals including assessment of similar exposure groups through representative sampling.

10.3.3 Consultation with DMP

As outlined within Section 3 above, CPM has participated in a series of consultations with DMP on the management of this issue and ensuring the provision of a safe work environment is provided. DMP, as regulator for mine safety, has previously requested CPM to provide evidence to demonstrate the risks associated with fibrous material are being managed appropriately. Submissions made by CPM to the DMP has included copies of CPM's FMMP (Appendix 3) and data and information collected from CPM's ongoing monitoring and investigation of this matter. To date, DMP's Resources Safety Division has not raised any further issues since the submission of this material.

10.3.4 Summary

CPM's Sino Iron Ore operations extract and beneficiate magnetite from the banded iron formation of the Joffre Member of the Brockman Iron Formation

The Joffre contains iron rich sedimentary layers as well as bands of chert and massive (non-asbestiform) riebeckite.

Crushing and milling of massive (non-asbestiform) riebeckite (as a small proportion of the ore processed) releases fibres into the atmosphere.

Scanning Electron Microscopy reveals that the predominant fibre released into the atmosphere is non-asbestiform, acicular, prismatic fibres of massive riebeckite

Trace amounts of actinolite are encountered in transitional areas of dolerite intrusions, which is not processed as ore.

Unlike Dales Gorge Member encountered in central regions of the Hamersley Group, overall percentages of crocidolite observed at Cape Preston (at the periphery of the Group) are considerably lower.

The Dales Gorge Member is not mined for ore. However, for economic as well geotechnical stability reasons, any removal involves quarantine and transport to waste (to be capped).

The majority of fibrous minerals are not released into the atmosphere but delivered to the TSF where they are bound in the matrix of the tailings.

CPM has taken a conservative approach to fibrous minerals by assessing all fibres as if they were contaminant asbestos. Accordingly, a comprehensive FMMP has been developed and implemented to reduce fibrous minerals emissions through the application of engineering controls and the protection from personal exposures.

An ongoing program of personal, and area monitoring for fibrous minerals.

Dedicated management plans for the closure and rehabilitation of the TSF and WRD (Appendix 3).

10.4 Potential impacts

The following impacts have been identified:

- mining activities have the potential to cause fibrous mineral to become airborne
- inappropriate management of potential asbestiform material (including post-closure storage, and mine pit wall exposures) has the potential to cause fibrous minerals to become airborne.

Public exposure to fibrous minerals is minimised by:

- the isolation nature in terms of distance from populated areas
- security measures that prevents unauthorised access to the lease areas
- separation (including realignment) of public roads from processing and mining areas.

Public exposure to fibrous minerals outside of the lease area is limited to contact with potentially contaminated vehicles, plant and equipment. CPM mitigate these risks by requiring:

- inspections and, if necessary, decontamination of vehicles, plant and equipment leaving designated areas
- a requirement to inspect and, if necessary, decontaminate vehicles, plant and equipment leaving site
- provision of decontamination facilities for both personnel and plant operating in designated areas
- atmospheric monitoring for fibrous minerals at the project and Eramurra Village and the application of additional controls if required.

10.5 Assessment of impacts

10.5.1 Mining and operational activities

As mentioned above, activities with the greatest risk of releasing fibres are related to mining and processing, and to a lesser extent activities at the port and marine operations. The FMMP has been developed by CPM to address these risks thereby ensuring fibrous minerals are appropriately managed on site.

The key measure in minimising risk of exposure to asbestiform minerals is to avoid known occurrences of asbestiform material where possible. Where asbestiform fibrous material is identified that cannot be avoided (transitional areas surrounding dolerite intrusion and Dales Gorge) this material is transported to designated encapsulation cells within WRDs.

As mentioned above, the existing project has a rigorous ongoing occupational hygiene monitoring program to detect fibrous minerals. To assist in protecting the health of employees on-site CPM has implemented a substantial occupational hygiene monitoring program since the commencement of mining operations.

Regular inspections and audits are conducted across site to ensure effectiveness of fibre controls is maintained.

10.5.2 Post-closure

Asbestiform mineral waste that is excavated from the mine (e.g. dolerite intrusions and any Dales Gorge overburden) is contained within designated encapsulation cell within waste rock landforms. The encapsulation cells are designed to include a minimum of 50 m of material along their sides and a 10 m deep capping layer of clean material on top (as shown in Figure 10-3).

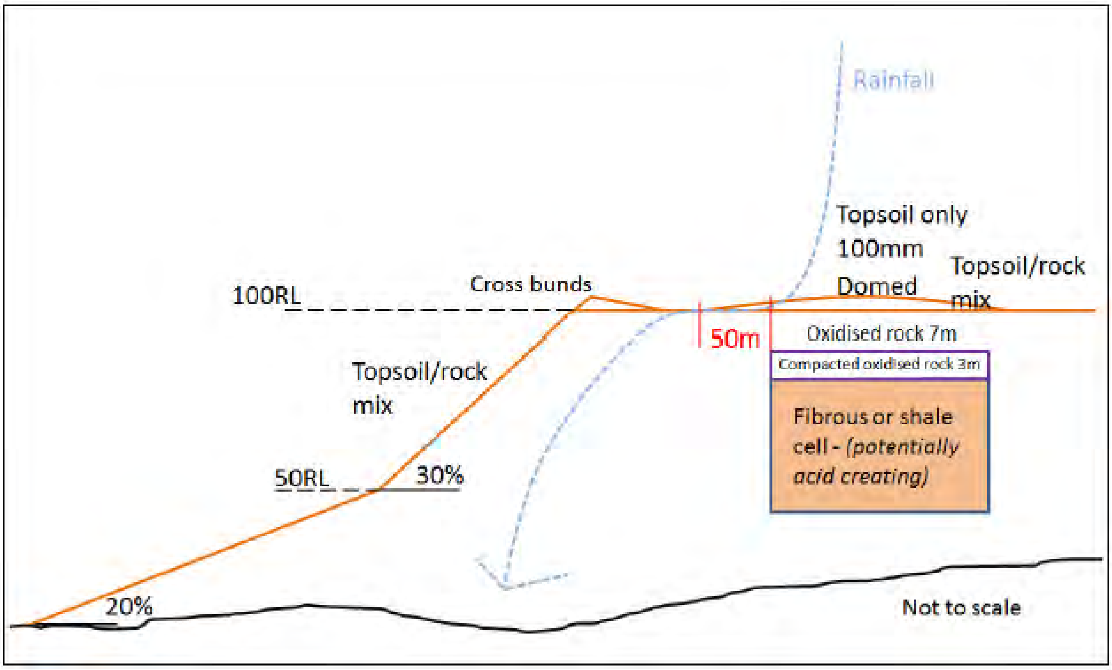


Figure 10-3: Schematic cross-section of encapsulation cell within a waste rock landform

Potential exposure in final pit walls and TSF

The Project's pit design has minimised exposure of Dales Gorge member in the final pit shell. Figure 10-4 presents the areas where the Dales Gorge member will be exposed.

Based on the depth of the pit wall (i.e. ~400 m) it is very unlikely that any asbestiform material would leave the mine pit. The groundwater re-entering the pit void and forming a pit lake is expected to help mitigate the risk of any exposed material becoming airborne. Other management methods such as covering the exposures with clean fill or other material will be assessed to minimise the risk of exposing asbestiform material for long periods. In addition, the TSF will be encapsulated within a layer of clean material. For further information related to closure see the Conceptual Mine Closure Plan at Appendix 3.

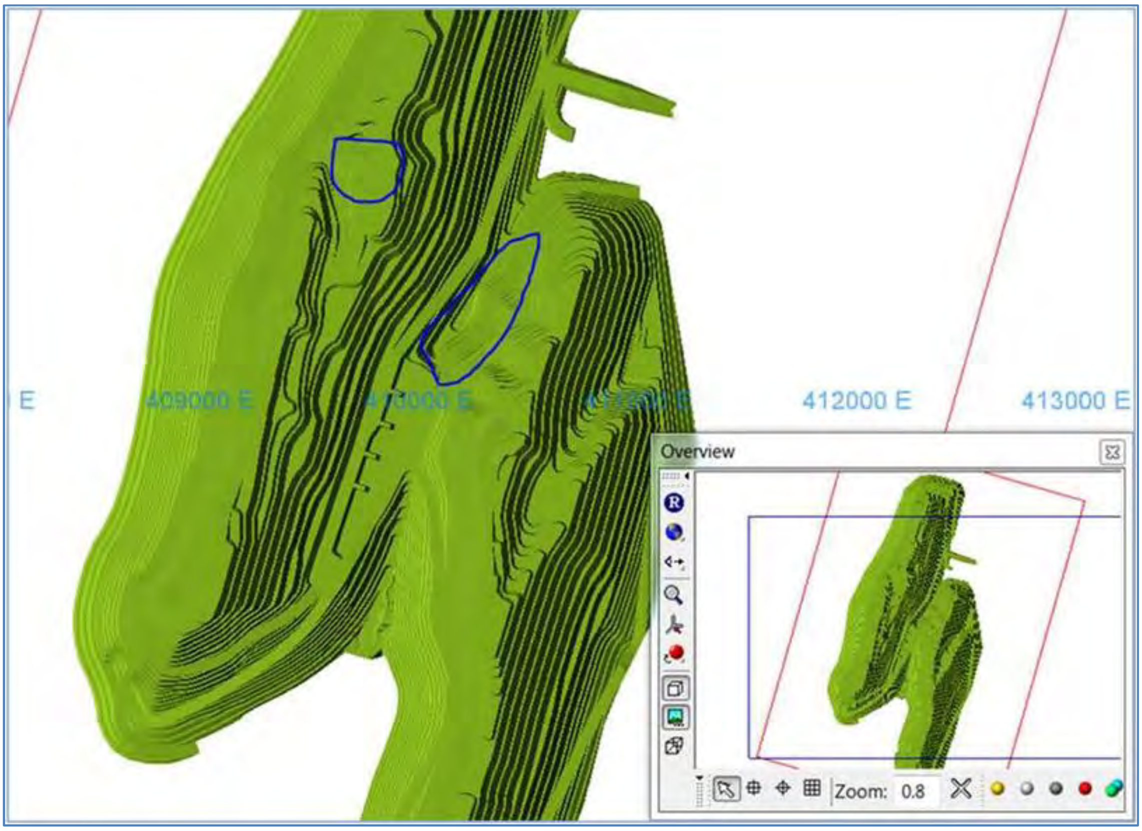


Figure 10-4: Final pit shell and location of potential fibrous material exposure associated with the Dales Gorge member

10.6 Mitigation

CPM's objective for terrestrial environmental quality is to minimise impacts through the implementation of the following:

- mine planning that minimises the interaction with Dales Gorge material
- disposing of potentially asbestiform containing material in designated encapsulated cell within WRDs
- encapsulation and rehabilitation of TSF areas progressively when and where possible
- a rigorous program of preventing or suppressing fibre/dust release (e.g. by water spraying, misting and fogging, application of binders and surfactants, installation of extraction ventilation, etc.). Prevention and/or suppression methods will be used for drilling and blasting, loading, transfer of ore and waste, crusher operations and conveyor transport of ore, processing operations including management of tailings, stockpile management and transfer of concentrate through to transfer onto export vessels
- conducting workplace inspections and audits to ensure controls are maintained to a required standard.

10.7 Predicted outcome

The ongoing implementation of existing management measures (described above) will ensure the Proposal will not result in any significant impact to terrestrial environmental quality.

11. Other environmental factors

The EPA Scoping Guideline identified ‘other’ environmental factors that have the potential to be affected by the proposal. These include:

- Subterranean fauna
- Social surroundings
- Human health.

Due to the low level of impact, application of industry standard controls and other regulatory mechanisms, these factors are not expected to be required to be assessed in detail by the EPA. Table 11-1 provides a summary of the impacts, mitigations and outcomes for these factors.

Table 11-1: Other environmental factors

Element	Description
Subterranean fauna	
EPA objective	*To protect subterranean fauna so that biological diversity and ecological integrity are maintained*
Policy and guidance	Environmental Factor Guideline – Subterranean Fauna (2016m) Technical Guidance – Subterranean Fauna survey (2016n)
Potential impacts	Potential impacts to subterranean fauna through removal of habitat
Mitigation	Avoid:
	The troglofauna community at Cape Preston will be protected through the retention of the majority of the existing troglofauna habitat in the area
	Minimise:
	Dewatering to drain the subterranean environment above the dewatered zone to field capacity, therefore not changing the relative humidity within the soil matrix.
Outcomes	Residual Impact:
	Groundwater drawdown resulting from the Proposal will not significantly affect stygofauna as the amount of habitat lost will be insignificant in relation to each species’ distribution. The troglofauna community at the Development Envelope will be protected through the retention of the majority of the existing troglofauna habitat in the area. The relative humidity in the soil matrix above the watertable is not expected to change as a result of dewatering and, therefore, troglofauna at the Development Envelope appear unlikely to be affected by dewatering.
Social surroundings	
EPA objective	*To protect social surroundings from significant harm*
Policy and guidance	Environmental Factor Guideline – Social surroundings (EPA 2016o)
Potential impacts	Potential impacts to Aboriginal Heritage Sites
Mitigation	Avoid:
	Heritage sites are avoided or salvaged where possible, and consultation with traditional owners is ongoing.
	Minimise:
	Indigenous Land Use Agreements (ILUAs) have been entered into with three Traditional Owner Groups, being the Yaburara & Mardudhunera People (YM), the Kuruma Marthudunera People (KM) and the Wong-Goo-Tt-Oo People (WGTO). Since these ILUAs were agreed: • the native title claim made by WGTO was dismissed by the Federal Court of Australia and removed from the National Native Title Tribunal’s register of Native Title Claims; and • KM amended the boundaries of its native title claim so that its claim no longer overlaps with the area the subject of the Approved Proposals or this Proposal. Pursuant to the current YM ILUA, YM recognises, acknowledges and agrees that the existing and any future mining tenements and titles granted for the purposes of this Proposal are valid, effective and enforceable under the Native Title Act, the IOPAA and otherwise at law. The Proponents will continue to liaise with Traditional Owner Groups regarding interaction with Aboriginal heritage sites.

Element	Description
Outcomes	Residual Impact:
	The Proposal will not significantly affect the values associated with Social surrounds factor and will continue to meet the objective for this factor.
Human health	
EPA objective	*To ensure that human health is not adversely affected*
Policy and guidance	Environmental Factor Guideline – Human Health (2016p)
Potential impacts	Potential impacts of elevated noise levels and potential occurrence of fibrous material on human health.
Mitigation	Avoid:
	Human health will not be affected from noise associated Proposal because of the distance separating sites of public use from the Proposal. Guidance Statement 3 has been considered and no sensitive receptors identified.
	Minimise:
	The potential occurrence of fibrous material is managed in accordance with a FMMP, which has been submitted to DMP.
Outcomes	Residual Impact:
	The Proposal will not significantly affect the values associated with Human health factor and will continue to meet the objective for this factor.

12. Holistic impact assessment

Avoidance has been a key approach for CPM in managing the potential environmental impacts associated with the Proposal. Numerous studies within Cape Preston have been utilised in understanding the potential impacts of the Proposal and mitigation measures have been formulated to prevent potentially significant impacts. The Proposal activities within the port area have been designed to avoid the critical Northern Quoll habitat adjacent to the Proposal footprint.

For significant flora species, vegetation or habitat that is unable to be completely avoided, disturbance will be minimised through the implementation of management measures. These are outlined in the Draft OEMP and include restriction of access and retention of vegetation along creek lines (Appendix 3).

CPM has undertaken stakeholder consultation throughout planning for the Proposal (see Section 3). Consultation will continue to develop as the Proposal progresses into the detailed design, construction and operational phases of the project.

'Key' and 'other' environmental factors have been considered against EPA objectives and relevant guidelines. The key environmental factors, impacts of the Proposal and mitigation actions to address potential residual impacts are summarised in Table 12-1. Based on the mitigation measures proposed and the continuation of existing management measures, the Proposal is considered to meet the EPAs objective for each environmental factor.

The proposed Approval Statement is included in Appendix 4.

Table 12-1: Assessment of preliminary key environmental factors

Description and potential impacts	Environmental aspect	Mitigation actions to address residual impacts	Proposed regulatory mechanisms for ensuring mitigation	Outcome to demonstrate that Proposal meets EPA objective
Hydrological processes - *To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.*				
<u>Context</u> The hydrological regime at the mouth of the Fortescue River includes: • high variability in natural flow volumes • strong tidal flows and high tidal range • high velocities and rate of flushing and well mixed circulation. <u>Key survey findings</u> Modelling of the extent of groundwater drawdown was conducted for the Proposal. Modelling indicated that at the completion of mining the vertical profile of the groundwater drawdown will change from a steep-sided deep profile to a shallower profile. The extent of deeper drawdown contours (more than 10 m) will contract closer to the mine pit but it will result in a minor increase in the extent of the shallower 1.0 m contour. At the end of mining, the depth to groundwater will not be substantially different throughout the extent of the model with the exception of the mine pit. The recovery of groundwater is expected to result in a pit lake of 250 m in the west pit and 20 m in the east pit. The regional groundwater levels are not expected to be substantially affected. During mining the predicted inflows that will need to be dewatered are 7.5 GLpa. The Proposal includes the discharge of up to 8.0 GLpa and will not substantially affect flows of the Fortescue River as the natural flows are large, highly variable and have a strong tidal influence. The development of a Waste Dump adjacent to Du Boulay Creek is not expected to increase the velocity of flow. <u>Potential impacts:</u> • groundwater drawdown from dewatering has potential to modify groundwater and surface water flows • discharge of groundwater has potential to modify surface water flows in the Fortescue River • diversion of Edwards Creek will modify surface water flows • construction of physical elements will alter surface water flows.	Mine construction Groundwater drawdown	<u>Avoidance:</u> • incorporate flood modelling data and surface flow data into the design of the Proposal to avoid impacts to hydrological processes. <u>Minimisation:</u> • discharging groundwater to the Fortescue River on outgoing tides to minimise changes to hydrological processes • a naturally vegetated buffer will be maintained between the bunds around the Proposal elements and floodplain channels to limit increases in flood levels and velocities, and minimise erosion • monitoring will be undertaken to continue to assess potential impacts to nearby creeklines • an Operating Strategy shall detail the monitoring and adaptive management measures for of the groundwater drawdown aspects • realignment of the southern branch of Edwards Creek into two sections to enable the minimisation of the disturbance area of the infrastructure.	A requirement to maintain an approved Environmental Management Plan (EMP). This EMP will specify the methods, procedures and management to avoid and minimise the impacts on hydrological processes. Groundwater abstraction and discharge licence (RIWI Act).	<u>Outcomes</u>: • the areal extent of the 0.5 m, 5.0 m and 10.0 m drawdown contours will decrease relative to the existing project • the recovery of groundwater is expected to result in a pit lake of approximately 250 m deep in the west pit and 20 m deep in the east pit • the regional groundwater levels are not expected to be significantly affected • no permanent pools will be significantly affected • the cumulative development of all mines on Cape Preston would not substantially increase the areal extent of groundwater drawdown • although highly unlikely to occur the inclusion of additional mines to assess cumulative impacts to hydrological processes do not significantly affect groundwater levels; however, Balmoral South borefield will increase the extent of the 1.0 m drawdown contour • during mining the predicted mine pit inflows that will need to be dewatered are 8.0 GLpa • the discharge of 8.0 GLpa will not substantially affect flows or values of the Fortescue River • the development of a Waste Dump adjacent to Du Boulay Creek is not expected to affect

Description and potential impacts	Environmental aspect	Mitigation actions to address residual impacts	Proposed regulatory mechanisms for ensuring mitigation	Outcome to demonstrate that Proposal meets EPA objective
				volumes or surface water significantly increase flow velocities. Assessment against EPA objective The Proposal has been designed and would be managed to avoid or minimise impacts on hydrological processes. The Proposal can be managed to meet the EPA's objective for Hydrological processes subject to existing licences. The abstraction of groundwater is licensed under s 5C of *the Rights in Water and Irrigation Act 1914* (GWL167151, GWL167891, GWL171149, GWL167324 and GWL168819). Given the hydrological regime and contribution of water at the mouth of the Fortescue River, the Proposal is unlikely to affect the stream flow characteristics of any water course.
Inland waters environmental quality - *To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values are protected.*				
Context The Fortescue River system is highly dynamic. Salinity at the mouth of the Fortescue River fluctuates depending on season and the tide and river conditions. Key survey findings The southern branch of Edwards Creek will be realigned in two sections, enabling the disturbance area of the infrastructure to be minimised. The two diversions have been designed to accommodate the 5 – 10 year ARI flood flow, which maintains the natural design of the creek therefore the hydrological properties of the creek is not expected to change. During mining the rate of flow into the pit is approximately 8 GLpa. As groundwater levels recover, the numerical model estimates pit inflows to increase to approximately 14 GLpa. The quality of groundwater flowing into the pit lake has been estimated to vary with the distance from the coast. Potential impacts	Discharge of groundwater from groundwater drawdown	Avoidance: • maintain the same length and natural design (8 – 10 m bed width) for the diversion of Edwards Creek Minimisation: • pass all runoff from disturbed areas through sediment traps prior to discharging downstream (during both construction and operation) • collect seepage from the tailing dam and use it on the mine site for ore-processing, dust control purposes and road-making • remove sediment from sediment basins prior to the wet season to the extent needed to maintain capacity. As required dispose of sediments to bio-remediation facility • monitoring will be undertaken including visual inspection of water quality and quantity in major creeklines and Fortescue River pools.	A requirement to maintain an approved Environmental Management Plan (EMP). This EMP will specify the methods, procedures and management to avoid and minimise the impacts on inland waters environmental quality.	Outcomes: • diversion of Edwards Creek will not significantly alter either flow or velocity within the creek and therefore is not expected to affect water quality of either Edwards Creek or Fortescue River downstream • collection of surface runoff in sedimentation ponds will prevent surface water contamination • pit lake will act as a terminal sink and likely become hypersaline over time although surrounding groundwater quality will not be adversely

Description and potential impacts	Environmental aspect	Mitigation actions to address residual impacts	Proposed regulatory mechanisms for ensuring mitigation	Outcome to demonstrate that Proposal meets EPA objective
• diversion of Edwards Creek has the potential to increase stream velocity, which may affect water quality • physical development of the site and use of infrastructure will generate runoff which has the potential to affect surface water quality • following the formation of a pit lake after closure, evaporation and groundwater flow into the pit has the potential to affect water quality within the pit lake and surrounding environmental values.		Rehabilitate: • contain and cleanup any spill in accordance with DR017219 Hydrocarbons - Hazardous Materials Spill Response Procedure - Land.	Groundwater abstraction licence (RIWI Act).	affected. Assessment against EPA objective The Proposal has been designed and would be managed to avoid or minimise impacts on inland waters environmental quality. The Proposal can be managed to meet the EPA's objective for Hydrological processes subject to existing licences. The abstraction of groundwater is licensed under s 5C of *the Rights in Water and Irrigation Act 1914* (GWL167151, GWL167891, GWL171149, GWL167324 and GWL168819). The diversions of the creek are not expected to alter either the flow or velocity of the creek. By maintaining the flow velocity and volume of the creek, it is not expected that the water quality of either Edwards Creek or the Fortescue River downstream will be affected.
Marine environmental quality - *To maintain the quality of water, sediment and biota so that the environmental values are protected.*				
Context The lower Fortescue River estuary is a delta which experiences strong tidal influence, with low sediment trapping efficiency, generating naturally high turbidity with well mixed waters. The area contains a well-developed and structurally complex mangrove system that fringes the major tidal creek with extensive cyanobacterial mats occurring on the tidal flats. Key survey findings Prior to discharge, the groundwater to be discharged is equivalent to that of the Fortescue River estuary for TSS, pH and metals. The groundwater has elevated nitrogen levels, but the receiving environment has nitrogen-fixing algal mats and the low phosphorus levels in the groundwater means that the system is phosphorus limiting and unlikely to generate algal blooms. On this basis the only key parameter that may affect the marine environmental quality is the salinity (TDS).	Discharge of groundwater from groundwater drawdown	Avoidance: • undertake monitoring in accordance with DER discharge licence to ensure the groundwater salt, metal and nutrient concentrations are consistent with discharge licence requirements. Minimisation: • discharging groundwater on outgoing tides to ensure discharge water is rapidly diluted to achieve the target dilution • discharging via a diffuser in accordance with dilution modelling (RPS APASA 2017) • to ensure the integrity of infrastructure any debris or other blockages will be cleared as required. • implement DR017219 Hydrocarbons - Hazardous Materials Spill Response Procedure - Land.	A condition requiring the preparation of an approved Environmental Management Plan (EMP). This EMP will specify the methods, procedures and management to avoid and minimise the impacts on marine environmental quality.	Outcomes: • target dilution for salinity (TDS) is a dilution level of 27 times, which will be achieved throughout the model for both a median and 80th percentile assessment of an 8 GLpa discharge • an 8 GLpa discharge is rapidly diluted on the falling tide and modelling shows no sign of build-up of salinity. Assessment against EPA objective The Proposal has been designed and would be managed to avoid

Description and potential impacts	Environmental aspect	Mitigation actions to address residual impacts	Proposed regulatory mechanisms for ensuring mitigation	Outcome to demonstrate that Proposal meets EPA objective
The groundwater quality to be dewatered ranges from brackish within the south of the deposit to saline and hypersaline at the north, which associated with the naturally occurring saline seawater wedge. Potential impacts • discharge of groundwater has the potential to affect the water quality of the Fortescue River estuary.				or minimise impacts on marine environmental quality. The Proposal can be managed to meet the EPA's objective for Marine environmental quality subject to: implementation of the EMP The Proposal is not expected to result in significant changes to marine environmental quality and is expected to meet the EPA objective for this factor.
Flora and vegetation - *To protect flora and vegetation so that biological diversity and ecological integrity are maintained.*				
Context The Development Envelope is within an active pastoral station that has historically been adversely affected by weed invasion and grazing by stock. The condition of the vegetation within the Cape Preston area ranges from Completely Degraded to Very Good. The majority of the Development Envelope contains vegetation communities of moderate local conservation significance (3035 ha) within the well-represented Newman, Paraburdoo, Rocklea and Horseflats land systems. Key Survey Findings Extensive flora and vegetation surveys of the Cape Preston area have been conducted over approximately 53 000 ha. No Threatened Flora species as listed under the WC Act are known from within 15 km of the Development Envelope. Thirteen Priority Flora species listed by Parks and Wildlife have the potential to occur within the broader Cape Preston area, with one, *Goodenia pallida* (P1) having the potential to occur within the Development Envelope. No Priority Flora species were recorded by vegetation surveys within the Development Envelope Thirteen groundwater dependent vegetation communities have been mapped to the west of the Development Envelope, ranging from high to low dependence on groundwater. Potential impacts • clearing of native vegetation has potential to affect regional representation of vegetation communities and flora species • clearing has potential to introduce/spread weeds	Clearing of native vegetation Introduced weeds Groundwater drawdown	Avoidance: • inspection of the site for the presence of Mesquite or Parkinsonia prior to any machinery being moved to a site • maintenance of adequate fire breaks across the mine site and around working areas. Minimisation: • restricting clearing to approved areas through the implementation of an internal ground disturbance permit system • restricting all vehicles and equipment to within designated tracks and parking areas • restricting all earthworks and movements of machinery and vehicles to within marked clearing or disturbance boundaries • requirements for all earthmoving machinery to be inspected as clean and free of weed and seed prior to entry and exit from a site • monitoring of GDE vegetation as outlined in the GDVMP (Astron 2015) will be conducted and contingency responses activated when trigger levels are exceeded Rehabilitate: • progressive rehabilitation of any disturbed areas not required for other future mining activities, sourcing topsoil for rehabilitation from areas of lowest weed	A requirement to maintain an approved Environmental Management Plan (EMP). This EMP will specify the methods, procedures and management to avoid and minimise the impacts on vegetation and flora.	Outcomes: • approximately 7366 ha of vegetation will be cleared by the Proposal with the majority of this occurring in habitat of low to moderate conservation significance and well represented in the region • loss of 121.51 ha of vegetation from the Horseflat Land System, a Priority 3iii Ecological Community although this will not result in a significant reduction in the extent of this community with total clearing in the Roebourne Subregion less than 0.5% • no Threatened Flora species listed under either the WC Act or EPBC Act will be affected by the Proposal • no Priority Flora species as listed by Parks and Wildlife will be affected by the Proposal • no change to GDE health is predicted with implementation of the GDE the monitoring plan and related adaptive

Description and potential impacts	Environmental aspect	Mitigation actions to address residual impacts	Proposed regulatory mechanisms for ensuring mitigation	Outcome to demonstrate that Proposal meets EPA objective
• groundwater drawdown from dewatering has potential to affect groundwater dependent ecosystems.		infestation where possible.		management actions; and as a result of minimal changes to of groundwater levels (0.5 m) • the Proposal will not conflict with the WC Act as no flora species will significantly affected or have its conservation status affected by the Proposal's implementation. <u>Assessment against EPA objective:</u> The Proposal has been designed and would be managed to avoid or minimise impacts on vegetation and flora. The Proposal can be managed to meet the EPA's objective for Vegetation and Flora subject to: implementation of the EMP Given the mitigation measures together with the widespread vegetation types, low percentage of vegetation types affected and lack of conservation significant species identified within the Development Envelope, it is considered likely that the residual impacts of the Proposal will meet the EPA objective for this factor.
Terrestrial fauna - *To protect terrestrial fauna so that biological diversity and ecological integrity are maintained*				
<u>Context</u> The Cape Preston area contains broad terrestrial habitat types including cracking clays, dunes, hilltop/hill slopes/rocky outcrops, mangrove/beach, samphire, stony spinifex plain with or without low shrub and woodland drainage areas. The majority of habitat within the Development Envelope is of moderate conservation significance consisting of cracking clay and major drainage line / creekline habitats. <u>Key survey findings</u> Potential habitat for Northern Quolls (*Dasyurus hallucatus*) listed as Endangered (EPBC Act, WC Act) identified within the Development		<u>Avoidance:</u> • the Proposal footprint will avoid drainage line habitat alongside Edward and Du Boulay creeks • maintaining a buffer alongside the Edward and Du Boulay creeks to allow potential movement of fauna • preventing unauthorised access to Northern Quoll habitat • record Northern Quoll habitats to ensure baiting exclusion zones to reduce risk of secondary or	A requirement to maintain an approved Environmental Management Plan (EMP). This EMP will specify the methods, procedures and management to avoid and minimise	<u>Outcomes</u>: • the majority of the disturbance (approximately 5100 ha of the 7366 ha Proposal) occurs in the Low conservation significance Stony Spinifex plain with or without low shrub and Hilltop/hill slopes/rocky outcrops habitat types • disturbance of habitats of Moderate or High local

Description and potential impacts	Environmental aspect	Mitigation actions to address residual impacts	Proposed regulatory mechanisms for ensuring mitigation	Outcome to demonstrate that Proposal meets EPA objective
Envelope No Northern Quolls were recorded within the Proposal footprint One short range endemic (SRE) species (*Bdelloidea* sp.) has been recorded in the Development Envelope. This species is at low regional risk. Potential impacts • clearing has the potential to reduce the extent of fauna habitat • clearing has the potential to disrupt localised fauna linkages for native fauna • clearing of Northern Quoll habitat has the potential to affect habitat availability for this species • development has the potential to introduce/attract feral animals • mining development has the potential to reduce habitat quality or result in the death or injury of terrestrial fauna.	Clearing of native vegetation	accidental poisoning. Minimisation: • informing the workforce of the fauna present and preventing direct and inadvertent feeding of feral animals. • implementing and signposting speed limits for both mining equipment and light vehicles in the Development Envelope and on access roads • undertake baiting outside of Northern Quoll breeding season, outside of known habitat and bury baits to prevent non-target species locating the baits. Rehabilitate: • undertaking feral animal control.	the impacts on fauna.	conservation significance occurs in habitats that have been degraded as a result of historical pastoral activities, such as drainage lines and cracking clay units; disturbance within other habitat types (i.e. dunes, samphire and mangrove) is limited • clearing of Northern Quoll habitat is limited to 0.12 ha and impact on Northern Quoll populations is unlikely as they were not found to utilise the potential habitat within the Proposal footprint during the reconnaissance and targeted surveys • the Proposal will not conflict with the WC Act as no fauna species will be made extinct or have its conservation status affected as the result of the implementation of the Proposal • no species listed as Endangered or Vulnerable under either the WC Act or EPBC Act will be affected by the Proposal. Assessment against EPA objective The Proposal has been designed and would be managed to avoid or minimise impacts on fauna. The Proposal can be managed to meet the EPA's objective for Fauna subject to: implementation of the EMP Given the low to moderate significance of the fauna habitat affected and the lack of critical

Description and potential impacts	Environmental aspect	Mitigation actions to address residual impacts	Proposed regulatory mechanisms for ensuring mitigation	Outcome to demonstrate that Proposal meets EPA objective
				population of conservation significant species within the Development Envelope, the residual impacts of the Proposal are expected to meet the EPA objective for this factor.
Terrestrial environmental quality - *To maintain the quality of land and soils so that environmental values are protected*				
<u>Context</u> CPM's Sino Iron Ore operations extract and beneficiate magnetite from the banded iron formation of the Joffre Member of the Brockman Iron Formation The Joffre contains iron rich sedimentary layers as well as bands of chert and massive (non-asbestiform) riebeckite. Crushing and milling of massive (non-asbestiform) riebeckite (as a small proportion of the ore processed) releases fibres into the atmosphere. Scanning Electron Microscopy reveals that the predominant fibre released into the atmosphere is non-asbestiform, acicular, prismatic fibres of massive riebeckite Trace amounts of actinolite are encountered in transitional areas of dolerite intrusions, which is not processed as ore. Unlike Dales Gorge Member encountered in central regions of the Hamersley Group, overall percentages of crocidolite observed at Cape Preston (at the periphery of the Group) are considerably less. The Dales Gorge Member is not mined for ore. However, for economic as well geotechnical stability reasons, any removal involves quarantine and transport to waste (to be capped). The majority of fibrous minerals are not released into the atmosphere but delivered to the TSF where they are bound in the matrix of the tailings. CPM has taken a conservative approach to fibrous minerals by assessing all fibres as if they were contaminant asbestos. Accordingly, a comprehensive fibrous minerals management plan has been developed and implemented to reduce fibrous minerals emissions through the application of engineering controls and the protection of personal exposures. An ongoing program of personal, and area monitoring for fibrous minerals. Dedicated management plans for the closure and rehabilitation of the TSF and WRD (Appendix 3). <u>Potential impacts</u>	Mining and operational activities Post-closure	<u>Minimisation:</u> • mine planning that minimises the interaction with Dales Gorge material • disposing of potentially asbestiform containing material in designated encapsulated cell within WRDs • encapsulation and rehabilitation of TSF areas progressively when and where possible • a rigorous program of preventing or suppressing fibre/dust release (e.g. by water spraying, misting and fogging, application of binders and surfactants, installation of extraction ventilation, etc.). Prevention and/or suppression methods will be used for drilling and blasting, loading, transfer of ore and waste, crusher operations and conveyor transport of ore, processing operations including management of tailings, stockpile management and transfer of concentrate through to transfer onto export vessels • conducting workplace inspections and audits to ensure controls are maintained to a required standard.	A requirement to maintain an approved Fibrous Minerals Management Plan (FMMP). This FMMP will specify the methods, procedures and management to prevent and control the presence of fibrous minerals.	<u>Outcomes</u>: The ongoing implementation of existing management measures (described above) will ensure the Proposal will not result in any significant impact to terrestrial environmental quality <u>Assessment against the EPA objective</u> The Proposal has been designed and would be managed to prevent and control the presence of fibrous minerals The Proposal can be managed to meet the EPA's objective for Terrestrial environmental quality subject to: • implementation of the FMMP Given the mitigation measures, it is considered likely that the residual impacts of the Proposal will meet the EPA objective for this factor.

Description and potential impacts	Environmental aspect	Mitigation actions to address residual impacts	Proposed regulatory mechanisms for ensuring mitigation	Outcome to demonstrate that Proposal meets EPA objective
• mining activities have the potential to cause fibrous minerals to become airborne • inappropriate management of potential asbestiform material (including post-closure storage, and mine pit wall exposures) has the potential to cause fibrous minerals to become airborne.				

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Our Ref 59917086/L001

Contact P.D. Treloar

6 February 2017

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RPS Australia West Pty Ltd
Level 2, 27-31 Troode Street
WEST PERTH WA 6872

Attention: Ryan Alexander
Cc: Murray Burling

Dear Sir,

CITIC PACIFIC RIVER DISCHARGE MODELLING PEER REVIERW

Acting upon your instructions I have reviewed the RPS APASA Report 'Discharge Modelling Assessment, Fortescue River Outfall' Rev 0 and Rev 1 versions dated 24 and 31 January 2017, respectively. I have also considered the responses to my comments set down in RPS APASA's Memo dated 31 January 2017.

I am satisfied that the report addresses the relevant requirements and that the required minimum median dilution of 27 will be generally achieved with the diffuser configuration and proposed ebb tide discharge management plan. I note that this report advises that detailed delivery pipeline, outfall and diffuser design are required, including river bed survey.

Yours faithfully,

P.D. Treloar
Senior Principal
for **Cardno (NSW/ACT) Pty Ltd**

RPS APASA

Date:	31/01/2017
To:	Doug Treloar
From:	Ryan Alexander
Reference:	MAW0506J - CPM Fortescue River Discharge Modelling - Rev 0
Subject:	Responses to Review

Dear Doug,

Regarding your review of the Fortescue River Discharge Modelling report (Rev 0), as you are aware, I have received your completed review in the form of an annotated report and we have discussed your annotated comments in detail over the phone (31/1/17). In the text that follows I have provided a list of my responses to your comments. In most cases I have responded to your comment by making amendments in the next revision of the report (Rev 1). Note that the page and paragraph numbers references below refer to the Rev 0 version of the report.

Yours sincerely
Ryan Alexander
Environmental Engineer
RPS APASA

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Perth | Gold Coast

RPS APASA

1) Page 1; Para 2: DT: "A performance criterion has been established that seeks to maintain median salinity values within 1.2 ppt above background within 10-20 m of the diffuser" – For all discharges or 95%?

APASA: It is not strictly the role of APASA to interpret the DER licensing conditions, but interpretation of the existing DER license (agreed with the client) is that the median salinity values within 1.2 ppt above background within 10-20 m of the diffuser, with the median being calculated over 24 hours (i.e. not just during the discharge). Another consultant (Strategen) provided the client with the initial advice on relevant environmental standards (this is not APASA's area of expertise).

2) Page 1; Para 3: DT: "Any dispersion coefficient calibration data?"

APASA: Although no site specific field data was available for calibrating a dispersion coefficient, we have used coefficients that we believe are appropriate for the model grid scales based on previous experience and based on other studies where dye trace experiments have been carried out.

3) Page 1; Para 4: DT: Does the following dot point apply to near field or far field

- "The median 27 times dilution target for salinity was predicted to be achieved at all locations, including the discharge site.

APASA: We have edited for clarity:

- The median 27 times dilution target for salinity was predicted to be achieved at all near field and far field locations, including the discharge site.

4) Page 1; Para 4: DT: Approaching slack water?

APASA: This suggested wording has been added

5) Page 2; DT: Summary comments for 6GL and 8GL were as for 2GL flow?

APASA: Summary comments were very similar for all three cases as the results for the median in all three cases were the same (i.e. all below threshold). As the median criteria is the key criteria being evaluated for regulatory approval, it was important to state this explicitly for each case. The results did differ with respect to the 80th percentile and these differences were included in the summary to emphasise that the higher flow cases did have consequences for the dilution – just not enough to exceed the specified threshold.

6) Page 3; Para 1; DT: is there an outfall that is already built?

APASA: No, no diffuser has been built at this date.

7) Page 3; Para 3; DT: Does the following sentence apply in all tidal regimes? Is the dilution mentioned an average or maximum?

The predicted performance of the diffuser under the designed discharge regime indicated that the targeted dilution level would be achieved within a horizontal scale of approximately less than 10 m.

APASA: No, this result from the near field modelling was based on quiescent flow conditions and this has now been added to the sentence. Because the near field result was derived from the no river flow case then near field results don't have any variation, the diffuser design was configured to achieve the result.

8) Page 3; Para 3; DT: What is the port diameter? IS the port outlet a duckbill?

APASA: Information about the port dimeter (0.1m) has been added). Regarding the detailed design of the diffuser, APASA was engaged to provide a conceptual design and recommended that this design be implemented and finalised with input from a specialist manufacturer such as Tideflex. The following sentence has been added to the paragraph to make this clearer.

"It was recommended that a specialist design engineering firm should complete the detailed aspects of the diffuser design including assessment of the required pumping levels, delivery pipe sizes and materials."

9) Page 3; Para 4; DT: will the pipe be buried?

APASA: We are unsure if the pipe is to be buried and this relates to the detailed aspects of the design, rather than the conceptual design APASA provided.

10) Page 3; Para 6; DT: how will the discharge regime be managed?

APASA: We are uncertain on the details of how the discharge will be managed as that aspect is being managed by CPM. We think it will be a manual controlled system rather than automated. We understand that the start/stop times for each discharge must be logged by CPM.

11) Page 3; Para 7; DT: Comments regarding clarifications of sampling locations, times and depths for monitoring of diffuser performance.

APASA: the sampling locations are as described later, at the discharge location, 1km upstream of discharge location and 1km downstream of discharge location. The exact time of sampling is not specified by the DER, except that it is occur during "active discharge". The depth of sampling is not specified by DER but CPM intention is to sample 0.5m above the river bed.

12) Page 4; Para 1; DT: dilution is precisely equal to 27.5

APASA: Yes, agreed. The 27 number has been rounded. This is considered appropriate as it would be perhaps overselling the near field modelling results to be more precise.

13) Page 4; Para 1; DT: How is discharged to be managed

APASA: addressed in response to comment 10.

14) Page 6; Para 3; DT: Case C diffuser length? Should be 84m?

APASA: Yes agreed, this was a mistake made during document editing – now corrected.

15) Page 6; Para 4; DT: Have you checked the results for salinity as well as dilution?

APASA: We haven't processed the results for salinity, simply due to time constraints. We agree with the point that 27 times dilution is not exactly the same as the salinity difference of 1.2ppt above background but it is very close, and we believe it provides a suitable level of accuracy for its purpose. In particular, as results show subsequently, median results were well above the 27 times dilution.

16) Page 7; Para 4; DT: Total height is height of ports above seabed plus rise heights?

APASA: Yes, modified the following sentence to clarify:

"The terminal rise height of the plume was expected to be approximately 2.3 m above the diffuser port outlets."

17) Page 8; Para 2; DT: Is there data to support the salinity of 37 ppt?

APASA: The value of 37 ppt was selected as a 'representative' value. However, it is within the range of previous values measured by CPM and this has now been added to the text.

18) Page 8; Para 2; DT: But plume would sink more quickly in fresher water?

APASA: Agreed, but we have assumed the turbulent effects would dominate. However, we have now added a sentence to raise this point explicitly.

19) Page 9; Table 3-1; DT: Comments relating to diffuser configuration

APASA: The mistake in the number of ports and diffuser length for case C has been corrected. We agree with the comments annotated below the table, which mostly relate to detailed to what we would describe as 'detailed design' issues. Most of these were covered in our recommendations (i.e. conclusion section). We have suggested that the depth of the river be surveyed at the diffuser location. We had considered the issue of head loss across the diffuser and recommended it be considered as part of detailed design work. We had not considered the potential for blocking of ports by mud but this point has now been added to our recommendations.

20) Page 10; Section 4.1; para 3; DT: Confusing comment about importance of wind forcing?

APASA: original first sentence wasn't well worded and has now been edited.

21) Page 12; para 1; DT: Grid size 16.33m

APASA: The quoted grid size of 16m was a rounded number. This has now been clarified as follows "A horizontal resolution of approximately 16 m was used for the region around the discharge point"

22) Page 16; para 3; DT: Courant Number for finest grid

APASA: The Courant Number for the Fortescue River grid was a max of around 10, which is considered acceptable according the Deltares user manual

23) Page 16; para 4; DT: Was there a basis for model parameter choices?

APASA: Modified a sentence in the text to say that the model parameters came from within the range of those recommended in the user manual.

24) Page 17; para 2; DT: What period was chosen?

APASA: With selecting the period we considered that the most important aspect was to capture a spring and neap tide. We would argue that the seasonal variation is less significant than the tidal variation at this site.

25) Page 18; para 4; DT: Four grid points doesn't match with Table 3.1 for 8GL/yr

APASA: This paragraph is referring to the 6GL/yr case. Because of the grid configuration the 6GL case had to use one extra cell for discharge, otherwise there would have been a 'gap' in the model of the diffuser.

26) Page 18; para 6; DT: That is, the input was the sum of the ports for each diffuser. Does this provide the correct load of contaminant with mass conserved

APASA: Yes mass of fluid and salt were conserved appropriately, and the discharge was not pre-diluted in the far field model. Paragraph 6 had been re-written to make this clearer.

27) Page 19; Fig 4-4; DT: Legend is confusing

APASA: Fixed an error in the legend of upstream/downstream. Added text to the caption to help with interpretation of the figure. Basically, the legend only shows the colour of the grid points used for each case, not how many grid points were used.

28) Page 20; Para 1; DT: Were CFSR wind available for this period

APASA: Yes, not all variants of CFSR were available but one variant was (i.e. Re-analysis 1)

29) Page 20; Para 5; DT: Ebb tide not fully in-sync, show part of the time series on a bigger scale

APASA: Added a new figure (Fig 4.6) to show a more zoomed in view of the spring tide period. The figure shows that the water level is reasonably in-sync. The wording in the text has been now been softened to acknowledge it was not a perfect sync.

30) Page 20; Para 7; DT: Any eddies affecting this

APASA: An animation of the model velocity field was inspected. It did not show any clear evidence of eddies in the discharge area .

31) Page 23; Para 3; DT: Check length of Case C diffuser?

APASA: As mentioned previously a mistake in the reported diffuser length for case C has been corrected to 84m as suggested.

32) Page 23; Para 4; DT: Summer only?

APASA: The summer only simulation period was considered appropriate because tidal forcing is dominant in this lower part of the river. If the footprint of effect reached the ocean it may have been necessary to consider differences due to seasonal winds, but this wasn't the case. A sentence was added to the end of the paragraph; “Although the analysis period only covered the summer season, the flow in the lower section of the river is expected to be dominated by tide in all months.”

33) Page 23; Para 6; DT: Cross section is not particularly near to discharge?

APASA: made small modification to the text to address this.

34) Page 23; Para 7; DT: Did you then consider the percentage ratio for the river flow estimates

APASA: No, we did not calculate the percentage of recycled water. The purpose of this section was just to provide some basic flow numbers for the river as this was requested by the client.

35) Page 26; Para 5; DT: Isn't this inconsistent? (also applies for other cases)

APASA: A mistake in the time series figures for the 6 and 8 GL cases has been corrected and description text was updated as a consequece. The description of the results have been edited to be clearer, but basically there is no inconsistency in the result. While the 27 times dilution threshold was exceeded on some occasions along the time series, the median of the time series was well above 27. Text has been made clearer to distinguish between the time series results and the median of the time series.

37) Page 27; Para 1; DT: How does the salinity migrate upstream

APASA: Added the following explanation “The upstream migration of the salinity signal occurs because a small proportion of the salt from the discharge that remains in the river at the end of the ebb tide is transported upstream on the incoming tide. However, because the magnitude of this effect was relatively small the 27 times dilution target was still met.”

38) Page 40; Para 1; DT: General comments about the detailed design of the diffuser

APASA: The final paragraph of the conclusions has been modified to include discussion of some of the practical issues regarding the diffuser installation.

Sino Iron Expansion Proposal Groundwater Modelling Study

version 0.3

PREPARED FOR CITIC PACIFIC MINING BY

CLOUDGMS

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Executive Summary

Background

CITIC Pacific Mining Management Pty Ltd (CPM) is developing the Sino Iron Project which consists of an iron ore mining, processing and export facility near Cape Preston approximately 80 km south-west of Karratha.

The project is the first stage of the Mineralogy Expansion Project, which includes the following projects:

Stage 1 - Sino Iron Project (Balmoral Central Block);

Stage 2 - Balmoral South Iron Ore Project (northern Balmoral South Block);

Stage 3 - Sino Iron Continuation Project (Balmoral Central Block);

Stage 4 - Mineralogy Project (southern Balmoral South Block); and

Stage 5 - Austeel Project (Balmoral North Block).

The Sino Iron Project is currently the only project that is approved and operational. The Sino Iron and Sino Iron Continuation Projects are the subject of this groundwater modelling study, although the cumulative impacts of the other projects are also considered.

Modelling objectives

The objective of this study is to present an assessment of the effect of the Sino Iron Continuation Project during life of mine and post-closure on groundwater resources in the area and thus determine the potential impacts that the Sino Iron Project will have on local and regional groundwater resources and any consequent additional impacts on other local users and identified areas with groundwater dependent vegetation (GDV).

The following activities will be undertaken and form the scope of the groundwater modelling study:

- Outline the regional and local hydrogeology with reference to recent (post 2009) investigations and present amended cross-sections showing the relationship between the alluvial aquifers and basement rocks;
- Identify other groundwater users and areas of groundwater dependent vegetation for use in the impact assessment;
- Assessment of the range of site specific hydrogeological properties for the Sino Iron Project life of mine proposal and where available, the hydraulic properties for the regional groundwater systems;
- Design, construct and calibrate a transient groundwater model capable of examining the following impacts:
    - Prediction of annual groundwater inflows to the Sino Iron Expansion pit over a 44 year period from 2016 to 2060;
    - Prediction of groundwater level drawdowns in response to dewatering from the Sino Iron Expansion;
    - Assessment of potential impacts of mining/dewatering on groundwater quality and quantity;
    - Assessment of potential impacts of mining/dewatering on other groundwater users and identified GDV (ie Du Boulay Creek and Edward Creek).
    - Prediction of final pit void water levels and assessment of the potential impacts on groundwater flow and quality, with consideration of hydraulic connection between pit(s) and the Fortescue alluvial sediments through secondary porosity / permeability;

  - Assessment of potential long-term impacts of mining/dewatering on other groundwater users and GDV;
  - Consideration of potential impacts to nearby Du Boulay Creek; and
  - Assessment of the cumulative impacts assuming all stages of the Mineralogy Expansion Project proceed; and
- Review of the groundwater trigger levels for further action and impact management measures.

Consistency with the Groundwater Modelling Guidelines

The modelling study and accompanying report is consistent with the Groundwater Modelling Guidelines (Barnett, et al. 2012) and Western Australian water in mining guideline (DoW, 2013) and will be designed to address specific issues raised by the Department of Water during the 2009 Mineralogy PER process.

Confidence classification

Based on the available data the regional pit-dewatering model is at a Class 2 confidence level classification. A Class 2 model is suitable for "providing estimates of dewatering requirements for mines and excavations and the associated impacts" (Barnett, et al., 2012).

Hydrogeological conceptualisation

The hydrogeology of the project area is essentially comprised of two groundwater systems:

a) younger, superficial aquifer system comprising sands, silts/clays and gravels; and

b) older, deep, low permeability, low storage aquifer system comprising cherty banded iron formation and mafic volcanics.

The Fortescue River is the major surface water feature within the project area, with the riverbed being located within the alluvial sediments. The Fortescue River is a major source of recharge to the superficial aquifer system.

Direct infiltration from precipitation also recharge to the groundwater system. A significant part of this water discharges back into creeks and as evapotranspiration. The deep groundwater system also receives recharge from the shallow groundwater system due to the differences in hydraulic head and the existence of a vertical downward gradient.

During mining conditions the major sources of inflow to the proposed pits would be: groundwater storage of the weathered rocks of the deep groundwater system (during initial stages of pit excavation); (b) groundwater storage of the deep groundwater system (during late stages of pit excavation); (c) direct inflow from precipitation; and (d) through the alluvial sediments where the pit intersects appreciable thicknesses and as leakage to the weathered basement groundwater system through overlying sediments.

Both pits will be excavated from the ground surface through the Brockman Iron Formation unit to a depth of ~ 400 m. The dewatering well system was simulated as a total of 22 pumping centres on the perimeter of the east pit, pumping water from the shallow and deep groundwater systems.

Based on the climatic, hydrological, geological and hydrogeological conditions, a conceptual model for the development of a groundwater numerical model is summarised below:

Model design

The model has been designed to meet the following criteria:

- Designed with effective simplicity to run as quickly as possible to undertake uncertainty analysis.
- Refined in the areas of interest: the pit and river features.

- Designed to incorporate features that may be impacted by the mine pit.

The FEFLOW (Finite Element subsurface FLOW and transport system v 7.009) modelling code developed by DHI-WASY GmbH (Diersch, 2015). This code is an industry standard groundwater modelling tool used by many jurisdictions to study groundwater level behaviour within groundwater systems.

FEFLOW handles a broad variety of physical processes for subsurface flow and transport modelling and simulates groundwater level behaviour indirectly by means of a governing equation that represents the Darcy groundwater flow processes that occur in a groundwater system.

The model covers the lower Fortescue River catchment, with the Indian Ocean as the northwest boundary and low permeability formations (Fortescue Group) as south and east boundaries.

The model extends from the natural ground surface (essentially the groundwater table) to beyond the maximum mining depth of ~400 mBGL to ~600 mBGL.

Geologic formations considered in the model are:

- The superficial aquifer system comprising separate layers for the Quaternary alluvial aquifer, Trealla Limestone aquitard and Yarraloola Conglomerate aquifer;
- Weathered basement rocks (Hamersley Group, Fortescue Group),
- Fresh basement rocks (Hamersley Group, Fortescue Group).

Based on the conceptual model the model domain is discretized vertically into 15 layers. A single numerical layer was used to represent each of the upper three superficial formations where it existed and the weathered basement rocks where the superficial sediments were absent.

The layer geometry of the numerical model was generated using the Leapfrog Hydro v2.6 geological modelling platform. The stratigraphy of the superficial sediments (alluvial gravels, Trealla Limestone and Yarraloola Conglomerate) were generated using the available geological logs (Commander, 1989; Global Groundwater Pty Ltd, 2010). In the areas where geological information was not available the surfaces presented by MWH (2010) were used.

The following boundary conditions were employed in the groundwater flow model:

Summary of nodal boundary conditions employed in the groundwater model.

Feature	Boundary condition	Value	Constraint	Value
Coast and tidal sections of the rivers	Dirchlet (specified head)	0.5 mAHD	-	-
Mining activities	Dirchlet (seepage face)	Pit shell elevation	Minimum flow	0 m^3/d
Post mining pit void lake	Evaporation	0 mm/d 0.65 pan to 0.85 pan	-	-
River	Cauchy	Ground elevation	Maximum flow Minimum flow	Timeseries 0 m^3/d
Dewatering bore	Well	Variable m^3/d	-	Timeseries

Calibration and sensitivity

The calibrated model provides reasonable matches to the available observation data, however, the majority of the available data only provides information relating to the weathered material in the vicinity of the pit, and often within the footprint of the final 2060 pit shell.

The limited sensitivity of observation groups to changes in the hydraulic parameters of the weathered rocks of the Hamersley Group for the area along the western margin of the West Pit suggests that the available information is insufficient to constrain the parameters in this area.

It should be noted that although a number of parameters deviated significantly from their preferred value during calibration, particularly underlying NE Waste Dump, the impact of these parameters is unlikely to have a bearing on the impacts to the groundwater resources within the superficial sediment aquifers to the west.

The variation in groundwater levels in the superficial sediments, which comprise the aquifers sustaining the GDV and the pools identified as being permanent in the region, generally reflect the natural stresses (ie recharge and discharge processes). The hydraulic parameters such as specific yield have been constrained by the groundwater level response and the estimated recharge to the superficial aquifer system, therefore, the derived hydraulic parameters are biased by the assumptions used to estimate these values.

To overcome the limited information available from the current datasets uncertainty analysis has been undertaken for the LoM forecast and the cumulative impact LoM scenarios. The uncertainty analysis has been conducted with emphasis on the hydraulic properties of the weathered rocks of the Hamersley Group along the western margin of the West Pit to examine the impacts of assuming similar hydraulic parameters determined through calibration in the current pit area.

To reduce the uncertainty in the material properties along the western margin of the West Pit, CPM are currently designing a hydrogeological drill program to address points raised by the DoW in response to the Mineralogy Expansion Proposal 2009. The drill program comprise approximately 40 investigation / monitoring wells and 6 test production wells scheduled for mid 2017. The program objectives include: refining the alluvial aquifer geometry in relation to the proposed west pit; locating test production wells to assess likely alluvial dewatering rates, hydraulic connection between the weathered bedrock and major structural faults to the alluvial system; and to refine and validate site specific hydraulic parameters used for modelling.

Sino Iron LoM and post closure forecast scenarios

The LoM impacts of the Sino Iron Continuation Project mine have been modelled using the calibrated model as a basis with two scenarios considered.

- Life of mine impacts for the period of mining from 2016 – 2060; and
- Post closure mine impacts scenario assuming all sources associated with mining activities cease after 2060.

The results for the LoM and pit lake models are presented as timeseries groundwater levels and as final groundwater level contours. Streamline analysis (section 6.5) has also been conducted using the final timestep of each model to investigate the possible long term impacts to the groundwater quality in the vicinity of the Sino Iron pit.

Sino Iron LoM and post closure forecast impacts

The inflows to the Sino Iron pits during the calibrated LoM model parameters is estimated at approximately 7.5 GL/yr and the post closure flux from the final pit lake surface is also expected to be approximately 7.5 GL/yr, this is approximately 20% of the overall water budget a significant component of the overall recharge to groundwater systems in the study area. Examination of the results from the uncertainty analysis indicates a median final pit inflows determined from the uncertainty analysis are approximately 8 GL/yr (22000 kL/d) with 50% of realisations (ie pit inflows between p25 and p75) showing a variation of ±1.5 GL/yr or 18%.

The groundwater level at the permanent pools Tom Bull Pool show declines of between 1 – 5 metres and Mungajee Pool shows less than 1 metre drawdown. The majority of groundwater dependent vegetation (GDV) monitoring bores close to the Sino Iron pits show groundwater drawdowns of between 5 – 10 metres. However, the rate of groundwater level decline is less than 0.2 metres per year and GDV may be able to adapt to this rate of change in groundwater regime.

Final pit lake levels after 100 years in the Sino Iron pits are estimated to be:

- -160 to -170 mAHD in the West Pit; and
- -300 to -310 mAHD in the East Pit.

The disparity in the final water levels in the West Pit and East Pit is a result of the increased inflows related to the superficial sediments and the weathered Hamersley Group along the western margin of the West Pit.

The estimated pit-lake levels using a surface area vs evaporative flux analytical relationship and the final inflows to the pit from the groundwater system indicate that the evaporative flues and the pit water level have not reached a state of equilibrium after 100 years. Further investigations into aquifer properties to the west of the pits is required in order to reduce crucial uncertainties before further hypothesis testing would be warranted.

Water quality impacts have been estimated using streamline analysis with reference to current regional groundwater salinity mapping. It was found that the streamlines completely surround the Sino Iron pits, this indicates that the pits are a regional sink at the end of mining and following development of the pit lake. It also appears that the poorer quality groundwater will not be drawn into areas of better groundwater quality. It is expected that the resulting water quality residing in the Sino Iron pit-lake will evolve to eventually become hypersaline through evapoconcentration processes. However, to understand the evolution of the water quality in the pit-lake, a study similar to that completed for the Mount Goldsworthy pit-lake would be required.

The majority of existing stock wells in the study area show drawdowns of less than 1 metre. Marda Well and Fortescue Bore show drawdowns of between 1 – 5 metres, with Fortescue Bore expecting closer to 5 metres drawdown.

Cumulative impact LoM and post closure forecast scenarios

The possible impacts of the development of the Sino Iron mine and the additional 3 proposed mines comprising the Mineralogy Expansion Project were investigated using a cumulative impacts scenario. The scenario considered includes:

- parameters determined for the calibrated Sino Iron mine model;
- initial heads determined from the calibrated model at 42370d (01/01/2016);
- the 4 pits developed as per the schedules detailed below; and
- inclusion of the Balmoral South borefield.

The Mineralogy and Balmoral South pits are projected to commence in 2022 and the Austeel pit in 2024. It has been assumed that the three additional pits cease mining at the same time in 2038.

The Balmoral South borefield operates for the 24 year life of the mine and is located in the superficial sediments to the southwest of the Sino Iron project. The pumping rate for each bore was set at 822 kL/d assuming a 6 GL/yr (16438 kL/d) allocation limit and 20 production bores.

The cumulative impact scenario is consistent with the Sino Iron LoM assessment commencing at 01/07/2016 (42370d) and uses the final calibrated heads as the initial conditions.

Cumulative impact LoM and post closure forecast impacts

The average annual pit inflows to the individual mines during the LoM are listed below:

- Austeel pit average 5.1 GL/yr;
- Sino Iron pit average 6.4 GL/yr;
- Balmoral South pit average 1.7 GL/yr; and
- Mineralogy pit average 1.7 GL/yr.

The groundwater level at the permanent pools Tom Bull Pool show declines of between 1 – 5 metres and Mungajee Pool shows less than 1 metre drawdown. The majority of groundwater dependent vegetation (GDV) monitoring bores show groundwater drawdowns of between 5 – 10 metres.

Estimated pit lake levels after 100 years of recovery for the 4 mines are:

- Sino Iron pits
  - -170 to -180 mAHD in the Sino West Pit;
  - -320 to -330 mAHD in the Sino East Pit;
- -180 to -190 mAHD in the Austeel pit;
- -240 to -250 mAHD in the Balmoral South pit; and
- -240 to -250 mAHD in the Mineralogy pit.

The estimated pit-lake levels using a surface area vs evaporative flux analytical relationship and the final inflows to the pit from the groundwater system indicate that the evaporative flues and the pit water level have not reached a state of equilibrium after 100 years. Further investigations into aquifer properties to the west of the pits is required in order to reduce crucial uncertainties before further hypothesis testing would be warranted.

Streamline analysis conducted for the cumulative impact scenario indicate that the streamlines completely surround the pits, indicating that the final pit voids will become terminal sinks following development of the pit lakes. It also appears that the poorer quality groundwater will not be drawn into areas of better groundwater quality.

The extent of the drawdown impacts are appreciably greater than the Sino Iron scenario. Jillan Jillan Well can expect drawdowns of greater than 1 metre. Drawdowns of approximately 5 metres are evident at Marda Well, and Fortescue Bore. Balmoral Well at the Balmoral Homestead and Tarquin Well show drawdowns of greater than 5 metres. All other wells in the study area are expected to show drawdowns of less than 1 metre. Depending on the construction of the wells, it is possible that drawdowns of greater than 5 metres may have a significant impact on the available drawdown and therefore the yield of the affected bores. The streamline analysis discussed previously indicates that water quality changes are unlikely to occur at the existing bores and wells.

Predictive uncertainty

Uncertainty analysis builds upon, but is distinct from, sensitivity analysis. Whereas sensitivity simply evaluates how model outputs change in response to changes in model input, uncertainty analysis is a more encompassing assessment of the quality of model predictions.

To the importance of the connection between the superficial sediments and the pit, a suite of 100 random parameter sets were used in the model. Each parameter was centred on its calibrated value and the allowable range determined by a user supplied value for the standard deviation of the log transformed parameter value. The standard deviation value was chosen to provide a reasonable range in each parameter and generally providing values that spanned 2 orders of magnitude.

The focus of the uncertainty analysis was to investigate the possible impacts of the pit on the water resources of the superficial sediment aquifer and as such the model was simplified by removing the leakage features such as the TSF.

The uncertainty analysis has only been completed for the LoM phase of each scenario as the uncertainty analysis of the post closure mining has been found to be inappropriate at this time. The reason for this is that the unconstrained variation of hydraulic parameters (particularly hydraulic conductivity) has been observed to result in an unstable model at the interface between the low permeability host rock and the higher hydraulic conductivity used to simulate the pit-lake void.

Reduction of the range in hydraulic parameters along the western margin of the West Pit through drilling and hydraulic testing and investigation is required to devise strategies to provide a robust model to enable examination of parameter uncertainty on the post closure impacts. Despite this limitation it is felt that the uncertainty analysis conducted on the LoM phase is sufficient at this stage.

Although the uncertainty analysis is not exhaustive, it does provide insights to the areas where further work could reduce the uncertainty regarding the possible impacts on the groundwater resource within the superficial sediments of the Fortescue River floodplain.

1 Introduction

1.1 Mineralogy Expansion Project

CITIC Pacific Mining Management Pty Ltd (CPM) is developing the Sino Iron and Sino Iron Continuation Projects, which consists of an iron ore mining, processing and export facility near Cape Preston approximately 80 km south-west of Karratha.

Life of mine expansion approval requirements are being pursued for the mining of two billion tonnes of magnetite ore for Sino Iron & Korean Steel (each with an allocation of one billion tonnes) under the Iron Ore Processing (Mineralogy Pty Ltd) Agreement Act 2002 (IOPAA). The IOPAA still requires environmental & heritage approvals to be obtained prior to this part of the project progressing. Environmental approvals require a submission to the Environmental Protection Authority under part iv of the Environmental Protection Act.

This dewatering model study is an important requirement in the environmental assessment process.

The project is the first stage of the Mineralogy Expansion Project, which includes the following projects:

Stage 1 - Sino Iron Project (Balmoral Central Block);

Stage 2 - Balmoral South Iron Ore Project (northern Balmoral South Block);

Stage 3 - Sino Iron Continuation Project (Balmoral Central Block);

Stage 4 - Mineralogy Project (southern Balmoral South Block); and

Stage 5 - Austeel Project (Balmoral North Block).

The Sino Iron Project is currently the only project that is approved and operational. The Sino Iron and Sino Iron Continuation Projects are the subject of this groundwater modelling study, although the cumulative impacts of the other projects are also considered.

At its maximum extent the Sino Iron Project open pit is expected to be 2.5 km wide and up to 6 km long with 15 m benches to a depth of approximately 410 m below natural surface, with a final depth of -400mAHD.

Mining of the Cape Preston iron ore deposits is by open cut methods using conventional blast and haul methods and waste rock will be deposited external to the pit in allocated waste dump areas. The proposed pits will be developed in several stages to a maximum depth of approximately 420m below ground surface, or around 410m below the local water table, resulting in variable groundwater inflows.

The locations of the four projects considered in this study are presented below in Figure 1-1.

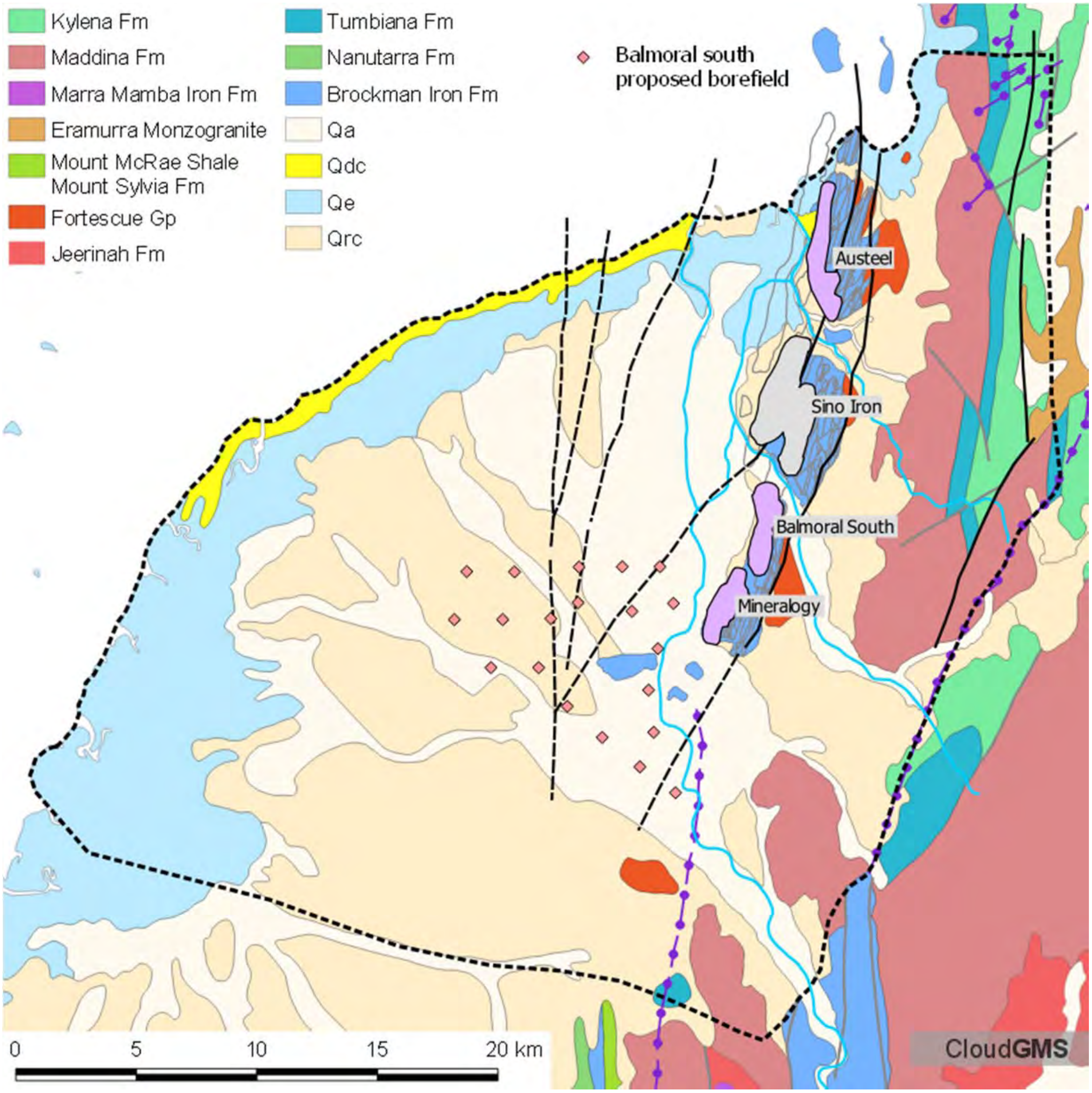

Figure 1-1 Location of projects mining the Balmoral iron ore deposits.

1.2 Previous Life of Mine groundwater modelling assessments

Numerical modelling has been conducted previously to assess groundwater inflows to the proposed pits as they develop, and to evaluate the potential cumulative impacts of mine dewatering on groundwater levels in the region.

In 2009 Mineralogy Pty Ltd commissioned Aquaterra to undertake a life of mine (LoM) groundwater assessment, which included a groundwater modelling study, as input to the Mineralogy Expansion Project, Cape Preston Public Environmental Review (PER) process.

The objective of the study was to present an assessment of the cumulative effect of the proposed projects on groundwater in the area and thus determine the potential overall impacts on local and regional groundwater resources and any consequent additional impacts on other local users and groundwater dependent ecosystems (Aquaterra, 2009).

Subsequent to the completion of the regional modelling several groundwater modelling studies have been conducted focused primarily on the Sino Iron pit and examining the pit de-watering requirements and the insights gained from these works will be incorporated into the proposed LoM study.

1.3 Department of Water 2009 PER response

In the response to the Mineralogy Expansion Project PER the DoW identified several areas where the groundwater assessment was seen as deficient. The areas of concern were related to the uncertainty of the hydraulic properties of the rocks and the hydraulic connection between the alluvial sediments and the pit specifically:

- The representation of the spatial relationship between the alluvial sediments, the pit void and the basement rocks as depicted in cross-sections of the mine site;
- Consideration of additional flows via secondary porosity – mining at depth has the potential to open up flow paths in fractures and shears in the basement rock, which would change the hydrogeological characteristics of the aquifer;
- Uncertainty in the hydraulic connection between alluvials associated with the Fortescue River (and Du Boulay Creek) and the pit and the impacts on groundwater dependent vegetation (GDV) associated with Du Boulay Creek;
- Mine closure connection between the Fortescue River alluvial sediments and the pit through secondary porosity / permeability with a worst case scenario of the pit filling to groundwater level of the alluvial aquifer.

The DoW considered the uncertainty of the hydraulic connection between the alluvium and the pit as '*…a significant issue and requires additional work to further understand the local hydrogeology of this system.*'

There were also issues raised relating to the monitoring of groundwater levels and quality:

- trigger level of 20% above predicted drawdown levels, which were considered by the DoW to be '*…too large for a first stage response.*' The DoW suggested that a preferred mechanism was to have a two level trigger system based on responses predicted in the hydrogeological assessment, involving a stage one trigger, normally about +10%, where the management response is to review and investigate, and a stage two trigger, normally about +20%, in which the response would be to make operational changes to reduce or remove the observed impact. It was also suggested that this approach should also apply to groundwater quality monitoring.
- potential inland migration of the saltwater interface, with '*…further assessment and mapping is required*' and '*…monitoring wells around the pit* [are considered] *a critical management tool to identify and monitor the inland migration of the saltwater interface*.'

Since the completion of the Aquaterra (2009) work, additional groundwater investigations and groundwater modelling studies have been conducted to inform some of the issues raised by the DoW associated with the development of the Sino Iron Project expansion.

It is proposed to address these groundwater-related uncertainties through the collation and presentation of the relevant works completed to date and the development of a suitable groundwater model.

1.4 Objectives and Scope

The objective of this study is to present an assessment of the effect of the Sino Iron Project during life of mine and post-closure on groundwater in the area and thus determine the potential impacts that the Sino Iron Project will have on local and regional groundwater resources and any consequent additional impacts on other local users and identified areas with groundwater dependent vegetation (GDV).

The following activities will be undertaken and form the scope of the groundwater modelling study:

- Outline the regional and local hydrogeology with reference to recent (post 2009) investigations and present updated cross-sections showing the relationship between the alluvial aquifers and basement rocks;
- Identify other groundwater users and areas of groundwater dependent vegetation for use in the impact assessment;
- Assessment of the range of site specific hydrogeological properties for the Sino Iron Project life of mine proposal and where available, the hydraulic properties for the regional groundwater systems;
- Design, construct and calibrate a transient groundwater model capable of examining the following impacts:
    - Prediction of annual groundwater inflows to the Sino Iron Expansion pit over a 44 year period from 2016 to 2060;
    - Prediction of groundwater level drawdowns in response to dewatering from the Sino Iron Expansion;
    - Assessment of potential impacts of mining/dewatering on groundwater quality and quantity;
    - Assessment of potential impacts of mining/dewatering on other groundwater users and identified GDV (ie Du Boulay Creek and Edward Creek).
    - Prediction of final pit void water levels and assessment of the potential impacts on groundwater flow and quality, with consideration of hydraulic connection between pit(s) and the Fortescue alluvial sediments through secondary porosity / permeability;
    - Assessment of potential long-term impacts of mining/dewatering on other groundwater users and GDV; and
    - Assess the cumulative impacts assuming all stages of the Mineralogy Expansion Project proceed.
- Review of the groundwater management trigger levels used for further action and impact management measures.

1.5 Consistency with available guidelines

The modelling study and accompanying report is consistent with the Groundwater Modelling Guidelines (Barnett, et al. 2012) and Western Australian water in mining guideline (DoW, 2013) and will be designed to address specific issues raised by the Department of Water during the 2009 PER process.

1.6 Model confidence level classification

Based on the available data the regional pit-dewatering model is at a Class 2 confidence level classification. A Class 2 model is suitable for "providing estimates of dewatering requirements for mines and excavations and the associated impacts" (Barnett, et al., 2012).

This study will also undertake an uncertainty analysis consistent with chapter 7 of the modelling guideline (Barnet et al, 2012), to quantify the degree of confidence in model predictions and explore areas where further data could help reduce uncertainties.

1.7 Limitations

The calibration dataset spans a period of 8 years, which typically would be the period that predictions could be made, however, the model has been utilised to forecast approximately 140 years.

Unsaturated conditions have not been considered, therefore, a formal assessment of the persistence of groundwater in the alluvial sediments to the north and south of the Sino Iron pit cannot be determined. To undertake this type of analysis would require a model capable of incorporating unsaturated processes, detailed knowledge of the unsaturated properties and geometry of the alluvial and weathered basement materials.

1.8 Reports and supporting documentation

The following reports relating directly to the previous modelling study were provided:

Schlumberger Water Services (2013a), Pit Dewatering Model Report;

Schlumberger Water Services (2013b), Pit Dewatering Model Report (Dewatering Bore Addendum).

Auxiliary reports provided as background:

Aquaterra (2008a), Balmoral South Iron Ore Project - Fortescue River Borefield Investigation, prepared for Australasian Resources Ltd;

Aquaterra (2008b), Memo - Predicted Impacts on Groundwater Levels of Revised Mining Plan;

Aquaterra (2009), Mineralogy Expansion Model Report prepared for Mineralogy Pty Ltd;

CITIC Pacific Mining Management (2013), SINO Iron Project Annual Groundwater Monitoring Summary GWL167151(2);

CITIC Pacific Mining Management (2014) Weathering Profile around the Sino Iron Pit – Drilling photo analysis;

CITIC Pacific Mining Management (2015), SINO Iron Project Annual Groundwater Monitoring Summary GWL167151(5) Mine Operations;

Global Groundwater (2010) Sino Iron Project – Cape Preston Western Superficial Deposits 2009 Investigation, Drilling and Testing Report;

MWH (2010a), Numerical Groundwater Model for the Lower Fortescue River Catchment prepared for Department of Water, WA;

MWH (2010b), Sino Iron Project Mine Dewatering Model prepared for CITIC Pacific Mining;

Schlumberger Water Services (2013c), Draft Sino Pit Water Balance Model;

Schlumberger Water Services (2013d), Final Sino Pit Water Balance Model – Text only;

Additional emails and memos documenting on-site water related issues.

2 Available data

Development of the regional model will involve collating and processing the available data and requires the following datasets:

- Additional climatic data (either daily rainfall observations between 1987 and 2015 at the Mardie gauging station (#005008) or SILO data drill);
- Daily flow discharge at Bilanoo Pool gauging station (505046);
- Groundwater dependent vegetation mapping;
- Locations of dewatering bores and pumping rates;
- Pit geometry and pit elevation data for the Sino Iron pits from 2010 to 2060;
- Monthly abstraction rates from 7 in-pit sumps (between 2009 and 2015);
- Estimated pit geometry and elevation data for the pits for the adjacent projects;
- Production bore locations and pumping rates for the Balmoral South borefield.

2.1 Climate

The climate is hot in summer and mild in winter. The average monthly maximum temperature is nearly 40°C in summer and about 26°C in winter (refer Figure 2-1). Temperatures over 45°C are common in summer. Rainfall is virtually restricted to the summer months, although it is unreliable.

Average annual rainfall based on the SILO data for the period 1900-2016 is 276 mm. Average potential evaporation for the same period is 3244 mm.

The average rainfall for the period 1983 – 2016 which was selected as the period for calibration is 0.81 mm/d and the average pan evaporation rate for the same period is 8.74 mm/d.

Potential evaporation exceeds rainfall by a factor of 4 times in the summer months and more than a factor of 10 times during the months September through November (when there is very little rainfall). The episodic nature of the rainfall means that river flows in the study area are ephemeral.

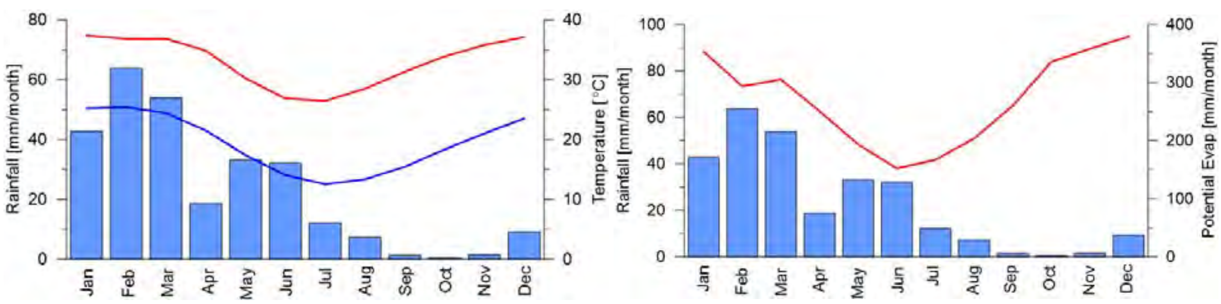

Figure 2-1 Average monthly rainfall compared to average max and min temperatures and average monthly rainfall compared to monthly potential evaporation for the period 1900-2016 (SILO Data Drill).

2.2 Topography

The Shuttle Radar Topography Mission (SRTM) digital terrain model (Farr et al., 2007) is available for the entire state of Western Australia (in fact the entire globe). The digital terrain model data is presented below in Figure 2-2 overlaid with the location of the project area for reference.

Unfortunately, in areas where there is considerable vegetation cover (eg riparian zones along rivers) the SRTM data reflects the height of the vegetation and depending on the type of vegetation can produce elevations up to 15 metres above the actual ground level. It is assumed that the majority of the project area has limited vegetation cover and errors in elevation due to vegetation are expected to be minimal.

Topography varies from 100 mAHD in the east of the study area to 0 mAHD along the coast. Two sets of north-northeast south-southwest trending topographic highs or ridges relating to outcropping Proterozoic basement rocks are the most obvious areas of elevated ground surface, with much of the study area represented by the relatively flat floodplain of the lower Fortescue River.

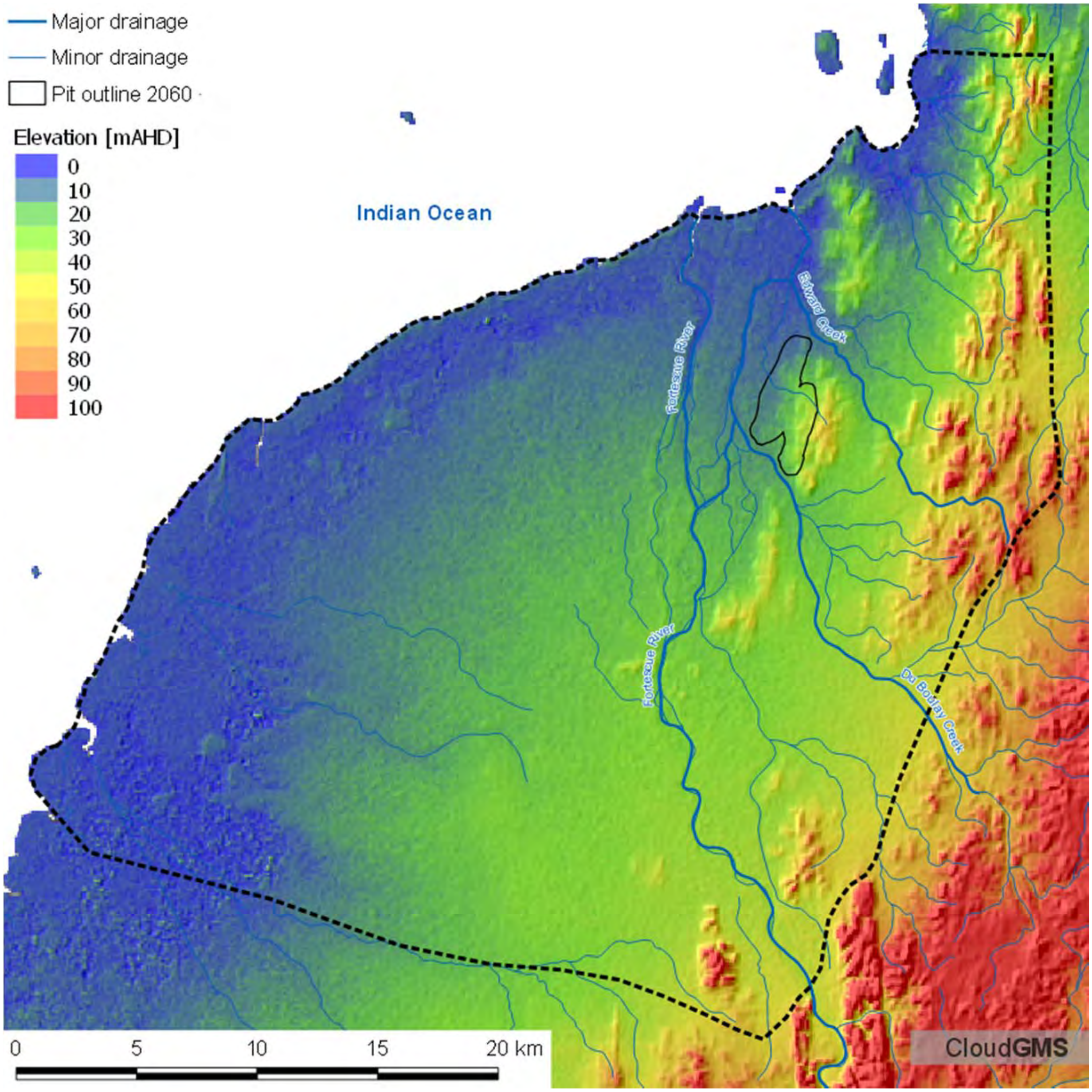

Figure 2-2 SRTM topography of the project area. Topographic highs are associated with outcropping Proterozoic rocks.

2.3 Groundwater users

2.3.1 Existing users

Groundwater abstraction currently occurs in the area for pastoral purposes and for activities being undertaken at other mining projects. However, the currently approved and proposed future mine operations are likely to draw additional groundwater supplies for construction and mine dewatering.

The published 1:50,000 scale topographic map series for the area indicates 13 pastoral wells in the vicinity of the project area; these wells are shown on Figure 2-3. The majority of these wells are assumed to be equipped with windmill driven pumps with at least one (Du Boulay Well) indicated as being equipped with a solar powered electric pump.

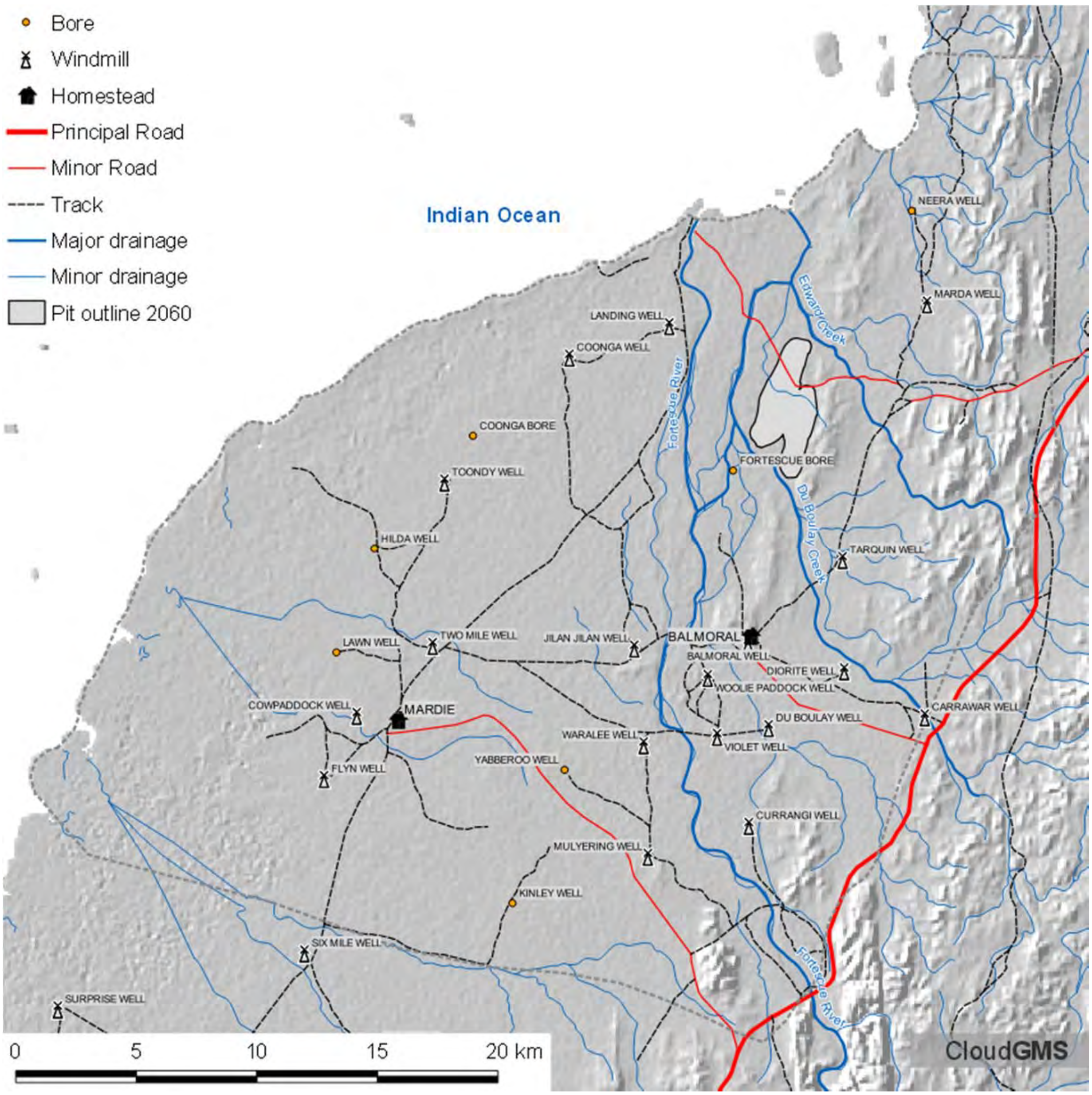

Figure 2-3 Location of existing wells and bores in the project area (source GEODATA v3)

2.3.2 Future users

It is recognised that additional groundwater users may occur in the future and that mining operations will continue to impact on local groundwater long after mining has ceased. Possible long- term impacts of the pit void are discussed in section 6.6 and section 8.6.

2.3.3 Allocation limit and water availability

The Department of Water used a risk-based approach to determine the lower Fortescue alluvial aquifer allocation limit. This approach is adopted in cases where knowledge about the groundwater resource is limited and competing demands for the water are limited, allowing for the development of allocation limits and licensing rules within a shorter timeframe and in a consistent manner.

This approach has four steps:

1. Identify and define the groundwater resource (including estimation of aquifer recharge).
2. Describe aquifer properties, environmental, cultural and social groundwater- dependent values and assess the risks to those properties/values from abstraction; describe the consumptive uses of water from the aquifer and assess the development risks of not abstracting water for consumptive use.
3. Assess whether any risks identified above can be managed through licensing rules.
4. Following the above assessment process, set allocation limits (the amount of water available for consumptive use) and licensing rules.

Using the process outlined above, the Department of Water has set an allocation limit for the lower Fortescue alluvial aquifer of 6.6 GL/year. This has been determined using the average annual recharge estimate of 11 GL/year and the selected yield proportion of 60 per cent. As at December 2010, there is no further water available for licences due to pending requested allocations (Department of Water, 2011).

2.4 Hydrology

2.4.1 River flows

The Fortescue River in the West Pilbara has a catchment area of 20,000km^2 and is a major drainage system of the region. The surface water flows in the lower Fortescue River provide the major source of recharge to the alluvial aquifer (refer to section 3.7.1), therefore, characterising the hydrology of the river is important for determining the recharge to the groundwater system in the project area. The lower reach of the Fortescue River flows through the modelling area from south to north-northeast, and discharges over tidal flats and into the Indian Ocean. The river has a well-defined main flow channel, which is 4 to 6 metres deep and about 100 m wide, up to a point some 5 km from the mouth of the river (MWH, 2010a). Closer to the river mouth the channel becomes less defined allowing floods to extend over the adjacent floodplains. The lower-most portion of the Fortescue River, prior to discharging into the Indian Ocean, becomes braided and deltaic in nature. The lower-most part of the river system is influenced by tidal movement (refer below section 2.4.3).

The Fortescue River has two major tributaries in the modelling area; Edwards and Du Boulay Creeks (MWH, 2010a). These creeks have small catchment areas compared to the Fortescue River catchment, and the combination of lower flow volume/duration and smaller stream width means they are unlikely to contribute significantly to groundwater recharge in the project area.

Flow in the lower Fortescue River is seasonal and generated primarily by rainfall runoff from the river catchment, with the highest flows occurring in December, January, February and March (Figure 2-4 a). Low or no flow is typically experienced from July through to November.

Flow exceedance statistics indicate that the river ceases to flow for at least 15% of the time, and this could be increased to 40% of the time if it is assumed that cease to flow actually occurs at around 40 – 50ML/d (ie assuming that the rating curve for 16510 overestimated the low flows).

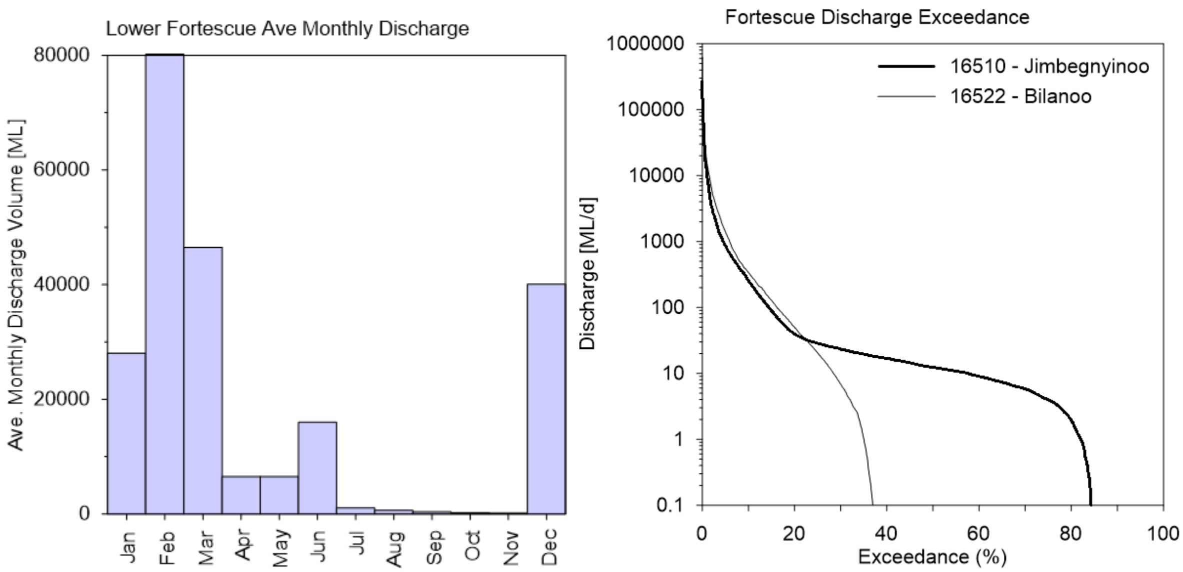

Figure 2-4 Lower Fortescue River a) average monthly discharge volume (ML) and b) daily discharge exceedances for 16510 and 16522.

Four (4) Department of Water river flow gauging stations are located within the study area and have been installed and operated for various periods of time upstream of the North West Coastal Highway – Koolumba Pool (AWRC No. 708226), Jimbegnyinoo Pool (AWRC No. 708003) and the Bilanoo (AWRC No. 708015). The locations of gauging stations, which are in the SE corner of the study area, are presented below in Figure 2-5. Summary details of the gauging stations along the Fortescue River are presented below in Table 1. Archived stage height and flows are available from the DoW Water INformation (WIN) database.

Stage height, derived discharge and site details for the two gauge stations were obtained from the Western Australian Water Information Reporting website: http://wir.water.wa.gov.au/Pages/Water-Information-Reporting.aspx

The Jimbegnyinoo Pool gauging station is about 4.6 km upstream of the Bilanoo gauging station. The Jimbegnyinoo Pool gauging station started operation on 10 November, 1968 and ceased on 2 July, 2002.

The Koolumba Pool gauging station lies midway between Jimbegnyinoo Pool and Bilanoo stream gauging stations. The station operated between 1 December, 1966 and 3 July, 1974.

The Bilanoo gauging station started on 11 November, 1975 and is still in operation. In the period from 1983 to 2007, recorded mean annual flow at the Bilanoo gauging station was 335 GL with very large annual variations. The largest flow (1414 GL) occurred in 2004. Minimal flow was recorded in 1986, 2002, 2003 and 2007.

Table 1 Summary of gauging stations in the project area (source DoW WRI online database).

SITE	NAME	EASTING	NORTHI	CATCH	OWNER	START	END

			NG	AREA			
14864	N-W COASTAL HWY	411103	7645599	N/A	No Current Owner	15/01/1973	04/03/1984
16510	JIMBEGNYINOO POOL	412438	7640755	18370	Water And Rivers Commission	01/11/1968	02/07/2002
16522	BILANOO	411238	7645255	18400	Department of Water	11/12/1975	present
16525	KOOLUMBA POOL	412038	7642155	18380	No Current Owner	01/12/1966	03/07/1974

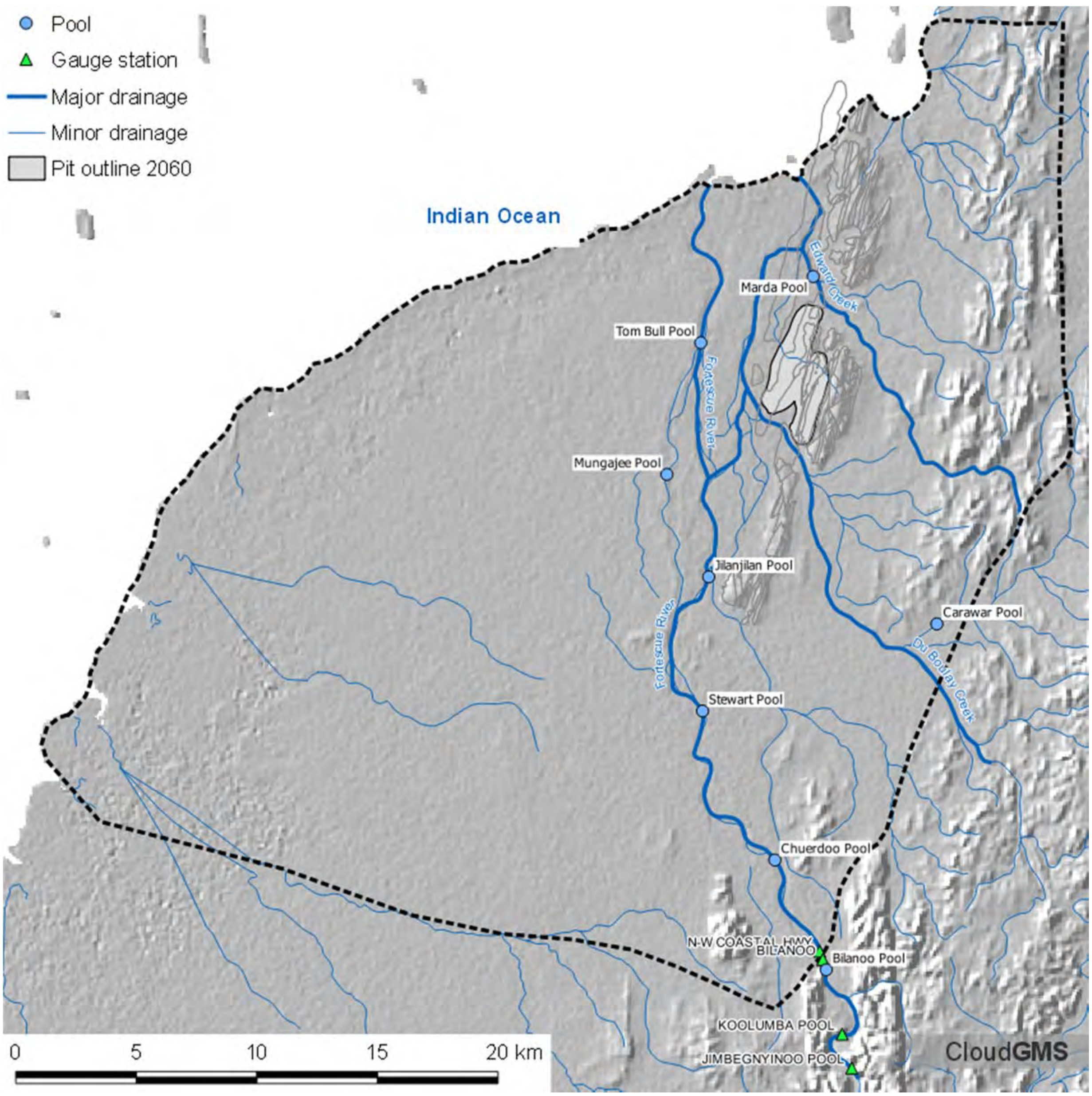

Figure 2-5 Locations of drainage, pools and gauging stations in the project area.

The gauging stations at 16510 (Jimbegnyinoo Pool) and 16522 (Bilanoo Pool) provide an almost continuous record of discharge for the period 1968 to present. As indicated above the period of flow record for Bilanoo available from the WIN database is from 1987 to present and to provide a suitable record of river flows to generate recharge events, the two flow records (16510 & 16522) have been merged to provide continuous flow for the period of available groundwater level observations.

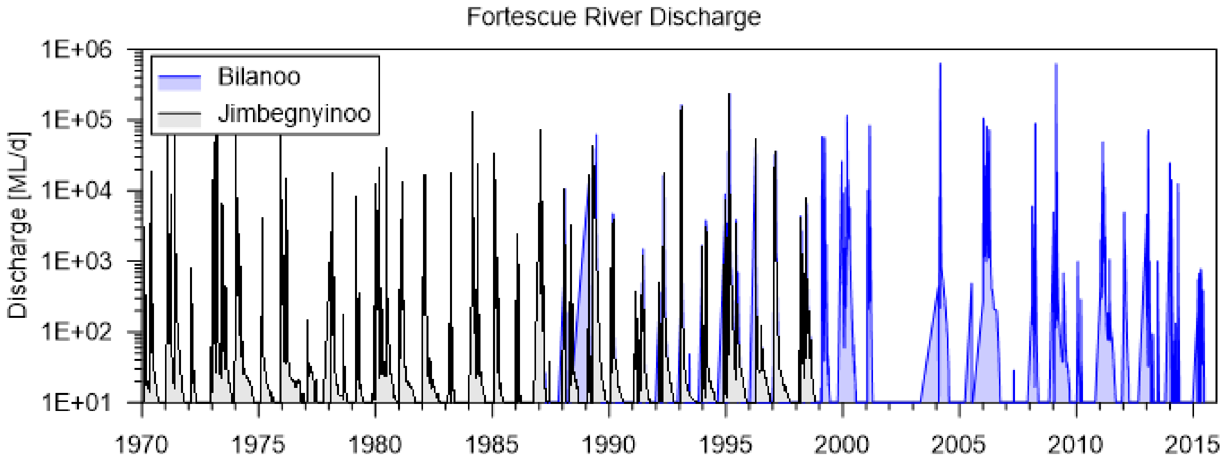

Figure 2-6 Fortescue River discharge for the period 1970 - 2016 using records from gauging stations 16510 (@Jimbegnyinoo Pool) and 16522 (@Bilanoo Pool).

2.4.2 Permanent and semi-permanent pools

In the lower Fortescue River area, sub-regionally significant wetlands are associated with permanent and semi-permanent pools (Figure 2-5) such as Jilan Jilan Pool, Tom Bull Pool, Marda Pool, Chuerdoo Pool, and Bilanoo Pool.

Some pools (Jilan Jilan Pool and Tom Bull Pool) are on the lower Fortescue River and directly overly the alluvials. Drawdowns in the alluvial aquifer may affect these pools. However, no observed data are available on pool water levels. It is not likely that these pools are a significant sink for groundwater in the area when compared with other groundwater discharges (ie evapotranspiration and discharge into the ocean).

The Jilan Jilan Pool is located on the Fortescue River, approximately 2 km from the Balmoral Homestead site. This pool may be affected by any development of the alluvial aquifer; thus a review of the potential impacts is recommended.

Tom Bull Pool is located on the western channel of the Lower Fortescue River, 10 km downstream of the Balmoral Homestead and directly downstream of the area mapped by Commander (1994a) as having salinity of less than 1000 mg/L. Effects of development closer to the old homestead site should be assessed.

Marda Pool is located 11 km west of the lower Fortescue River where the flood plain meets the salt flats. Impacts from development along the Fortescue River would be unlikely.

Chuerdoo Pool is located on the Fortescue River, but is about 2 km upstream of the alluvial aquifer. This pool is unlikely to be affected.

Other pools such as Bilanoo Pool, Jimbegnyinoo Pool and Bullinnarwa Pool are upstream of the alluvial aquifer system and any development would have minimal to no impact.

The conceptualisation of the connection between the groundwater and the pools is discussed further in section 2.11.1. The impact of the mine on groundwater levels at these sites are assessed during the LoM predictive scenarios.

2.4.3 Tides

The Indian Ocean is the northern boundary of the modelling domain, with water level in the Fortescue River observed to be influenced by tidal action up to a location near to the junction of Edwards Creek with the Fortescue River. Observed maximum spring high and low tidal elevations at Karratha (King Bay) are +4.91 and +0.29m AHD (October 2008), respectively. The range of tidal oscillation varies from 1.5m to 4.7m. Data loggers in groundwater monitoring bores in the Fortescue River alluvial sequences (07RC155 & 07RC141), located up to 8 kms from the Indian Ocean, show groundwater level responses and correlation to tidal movement (MWH, 2010a). The influence of the tide as a driver on groundwater levels is relatively small compared to the impacts from the dewatering of the pit (~1-2 metres cf ~400 metres) and tidal fluctuations will not be considered in this study. However, given that the tides extend between upto 8 km inland and these tidally influenced sections are expected to form constant head boundaries.

2.5 Standpipe groundwater levels and VWP levels.

2.5.1 Groundwater levels (Department of Water)

Groundwater level hydrographs are available from 38 regional observation bores installed by the Department of Water (Commander, 1989), the locations of which are shown on Figure 2-7. The bores are listed in Appendix A along with the available period of record. Groundwater levels and bore details were obtained from the Western Australian Water Information Reporting website:
http://wir.water.wa.gov.au/Pages/Water-Information-Reporting.aspx

The watertable in this area is relatively shallow, generally between 5 mbgl and 12 mbgl. The watertable is subject to significant short term fluctuations especially near river beds as a result of recharge by fresh surface flow in the Fortescue River, fluctuations of up to 6m have been recorded in some bores located close to the Fortescue River (Commander, 1993).

2.5.2 Groundwater levels (CITIC Pacific Mining)

Groundwater levels in the vicinity of the Sino pit were provided for 205 standpipe observation bores, 174 of these sites were within the existing model domain and used to inform the model development and calibration. The locations of the observation bores are presented below in Figure 2-7 and summary details are presented in Appendix A.

The groundwater monitoring network consists of standpipe piezometers and VWP arrays. The VWP arrays are generally located within 400 metres of the current extent of the East pit and have recorded drawdown in pressures of around 10-40 metres due to passive seepage of groundwater into the pit. Standpipe piezometers within 1100 metres along strike of the pit have also recorded drawdown in groundwater levels of up to 5 metres and in abstraction bores of up to 100 metres. Many of the monitoring bores to the west of the current pit extent (approximately 500-600m distant) show no impacts from mine dewatering. Drawdowns in bores are highly variable and recovery in pressures and levels has also been observed in response to reduced abstraction.

The analysis of the response at standpipe piezometers, particularly constructed in the alluvial sediments approximately 750 metres to the west of the pit, is complicated somewhat by the short and long term responses to rainfall that mask the relatively small influence of mining effects (at most of these bores there is no discernable drawdown from mining related activities).

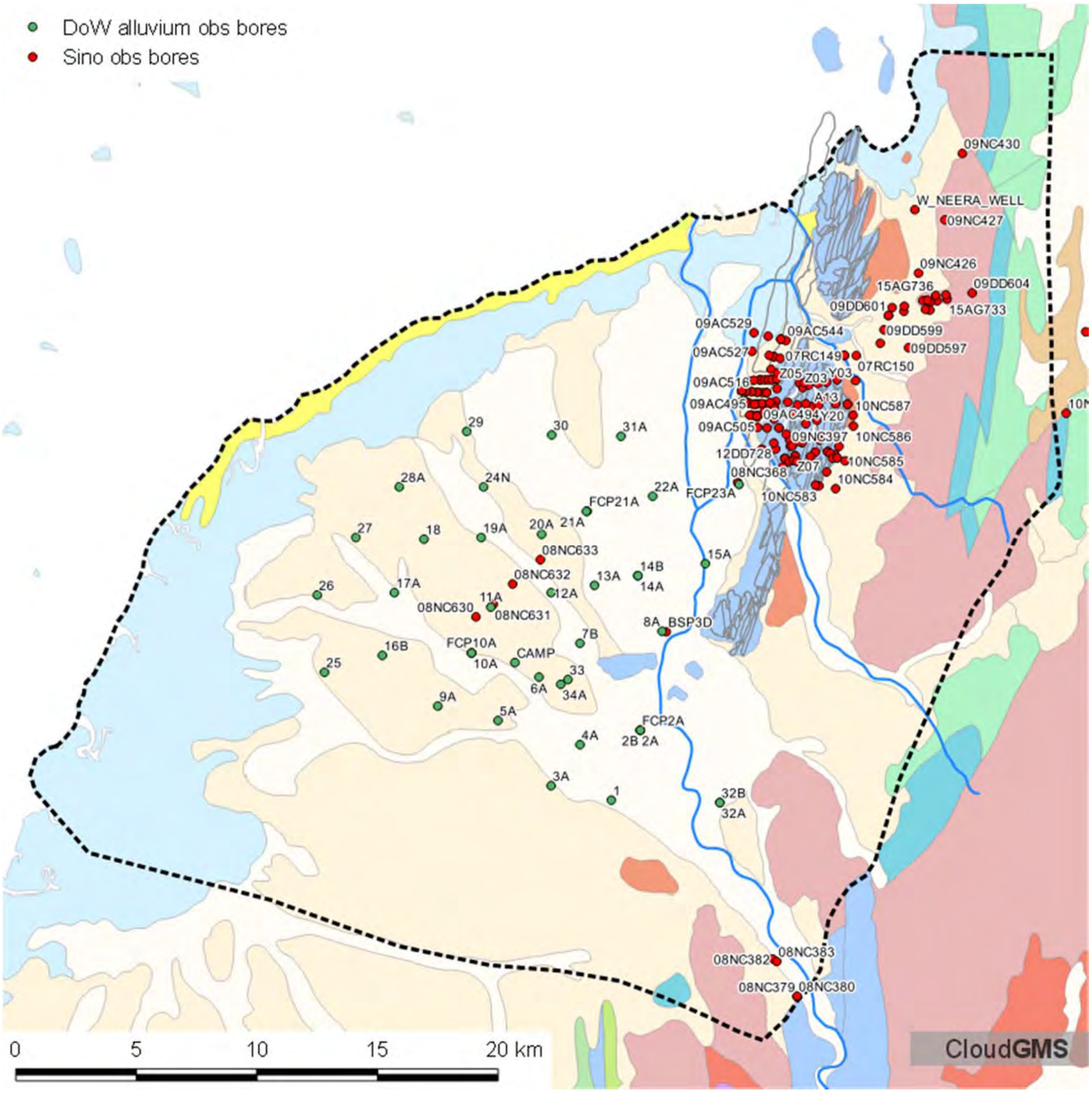

Figure 2-7 Regional distribution of Department of Water and CPM observation bores in the project area.

A detailed plan of the observation bores in the vicinity of the pit is presented below in Figure 2-8. Many of the observation bores target the alluvial sediments to the west of the pit. Groundwater levels in these bores show responses to river recharge events.

2.5.3 Vibrating Wire Piezometers (VWP)

Monthly average values of pore pressure were also supplied for 109 sensors deployed across 16 bores. The sensors are located at depths between -15 mAHD and -300 mAHD. The horizontal locations of the VWP sensors are presented below in Figure 2-8.

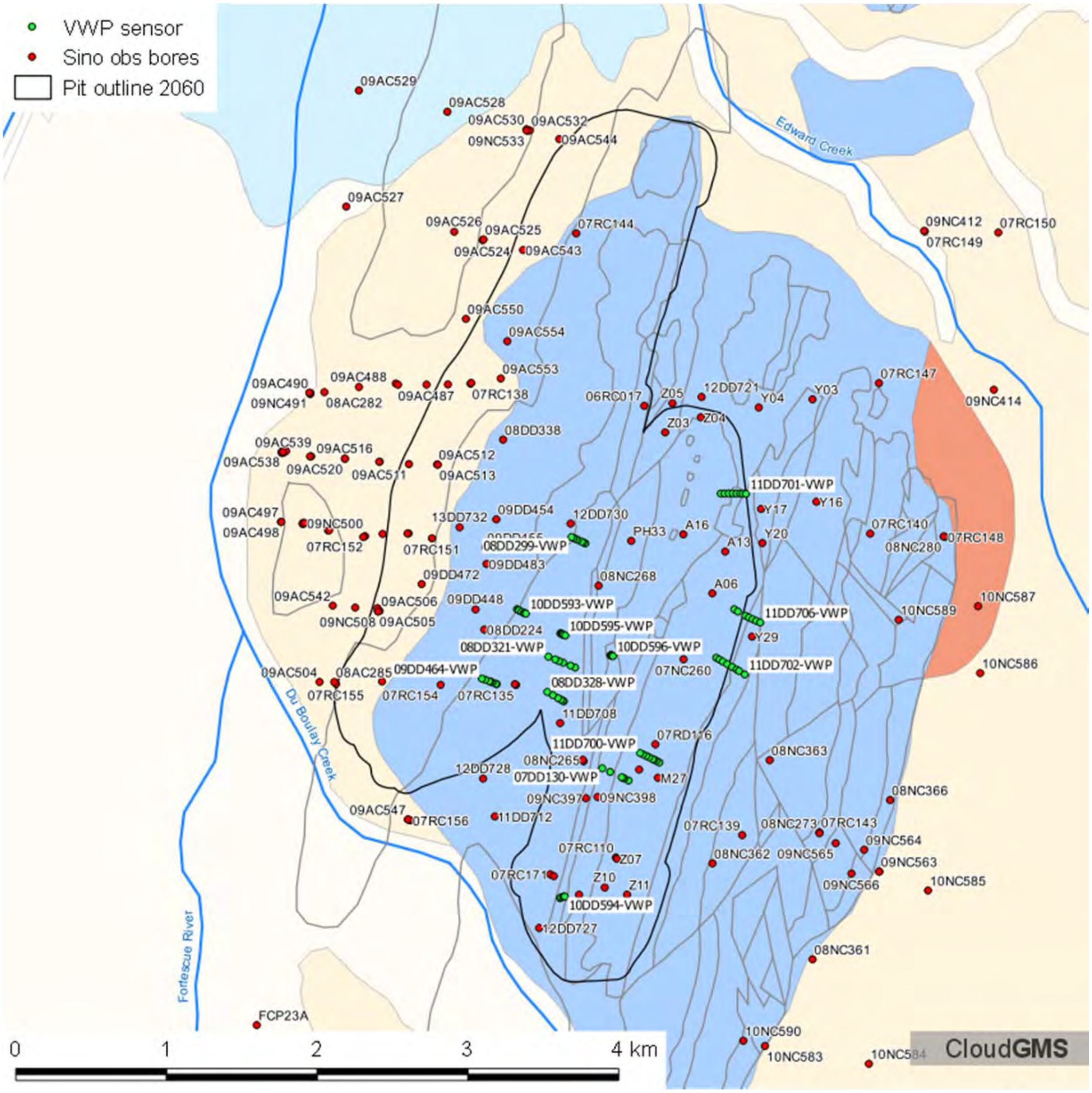

Figure 2-8 Locations of standpipe observation bores and VWP sensors relative to the 2060 pit extents.

2.6 Leakage features

Water management practices have resulted in areas where groundwater recirculation is occurring within the pit. Although it is expected that future management practices will remove these features, the areas where pit water has been applied has resulted in elevated groundwater levels beneath these features, therefore to adequately reproduce the observed historic groundwater trends during calibration, these features have been incorporated into the model to represent the following features.

- North heave
- NE waste dump
- SE waste dump
- Raw water pond
- Coarse ore stockpile
- Tailing storage facility

The locations of these features are presented below in Figure 2-9.

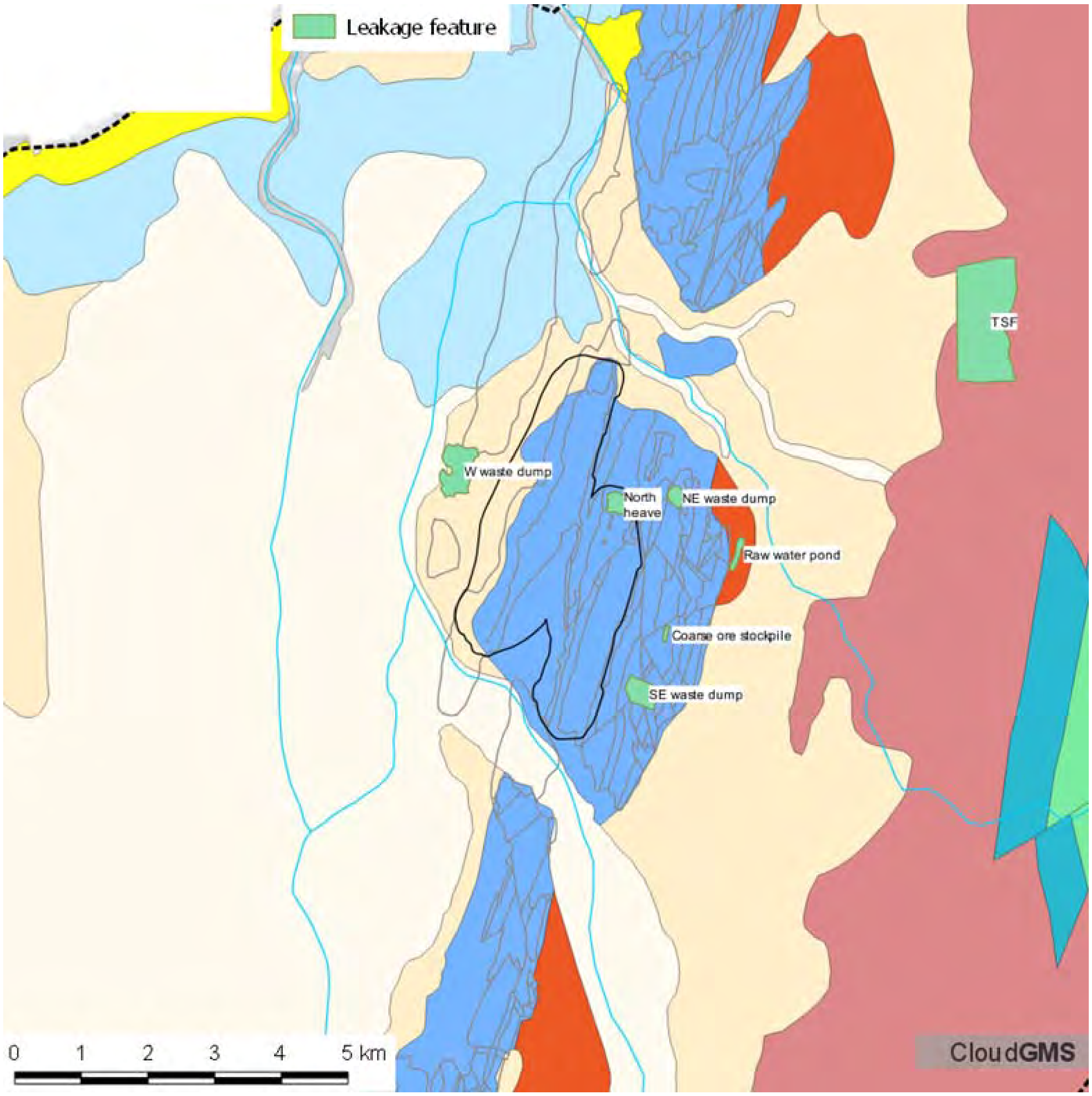

Figure 2-9 Leakage features identified around the mine site.

2.6.1 NE waste dump

The NE waste dump is an ex-pit dust suppression discharge point approximately 500 metres to the NE of the northern end of the pit. Discharge to the NE waste dump commenced in August 2013 and was being used for disposal of inflows from sump 07 & 08 up until Q1 2016.

The identified area of application is relatively small; (J. Baroni pers comm 06/11/2015). Using a representative area, the NE waste dump discharge volumes pumped from Sump 07 & 08 were converted to an application rate in m/d for input into the model.

2.6.2 SE waste dump

The SE waste dump is an ex-pit discharge point covering a relatively small area; J. Baroni pers comm 06/11/2015). Discharge to the SE waste dump is from sump 01 / 04 and sump 02. The combined discharge from sump 01 / 04 occurred from June 2009 to December 2012 and March 2013 to May 2013 (SWS, 2013c). Although the recent information indicates abstraction from sump 01 / 04 is no longer discharged to the SE waste dump and is being diverted to the turkey nest for use as dust suppression.

The discharge to the SE waste dump was represented in a similar manner to the NE waste dump, using a nominal area of approx. 6240 m^2 and converting pump rates for Sump 01 / 04 & 02 to an application rate in m/d.

2.6.3 North heave

The north heave in-pit discharge point was used over the period from August 2011 to April 2013. It is described as an unlined facility, comprising blasted material with enhanced permeability (~12 m deep blast holes). The north heave accepted inflows from sump 05 from August 2011 to April 2013 and averaging ~30 L/s and sump 06 from January 2013 to February 2013 (SWS, 2013).

2.6.4 Raw water pond

The raw water pond is a lined storage facility, however, the rapid rises in groundwater levels in the observation bores adjacent to the pond (07RC140, 07RC148 & 08NC280) suggest considerable leakage has been occurring since early to mid 2014. Currently no estimate is available of flow rates to the pond or leakage rates from the pond to the groundwater are available (J. Baroni pers comm 06/11/2015).

The area of the raw water pond is approx. 42710 m^2 based on satellite imagery and a leakage rate was determined using trial and error.

2.6.5 Coarse ore stockpile

The discharge as a result of excessive dust suppression to the coarse ore stockpile was represented in a similar manner to the raw water pond; that is a representative leakage area of approx. 9350 m^2 was estimated and an application rate was determined using trial and error.

2.6.6 Camp 123 and western waste dump

These areas are utilised for dust suppression. The western waste dump is not currently connected to the pit reticulation system (L. Dunn pers comm 19/01/2016).

These features are located further from the pit and local monitoring bores have not shown a pit water recirculation response as such this feature has not been included in the model. The majority of these bores have a prefix 09AC and their hydrographs are presented in Appendix E.

2.6.7 Tailing Storage Facility

The tailing storage facility is located to the north east of the Sino Iron pits. The area of the current footprint of the TSF was used to estimate the flux applied at the ground surface by matching the elevation in groundwater levels observed in the monitoring bores adjacent to the facility.

2.7 Dewatering infrastructure

23 abstraction bores have been constructed around the current pit to provide construction water and to dewater the formations prior to mining commencing. Appendix B presents summary information for the dewatering bores in the vicinity of the pit.

Nine (9) passive dewatering sumps have been excavated during the life of the mine.

The locations of the dewatering bores and the pit dewatering sumps are presented below in Figure 2-10.

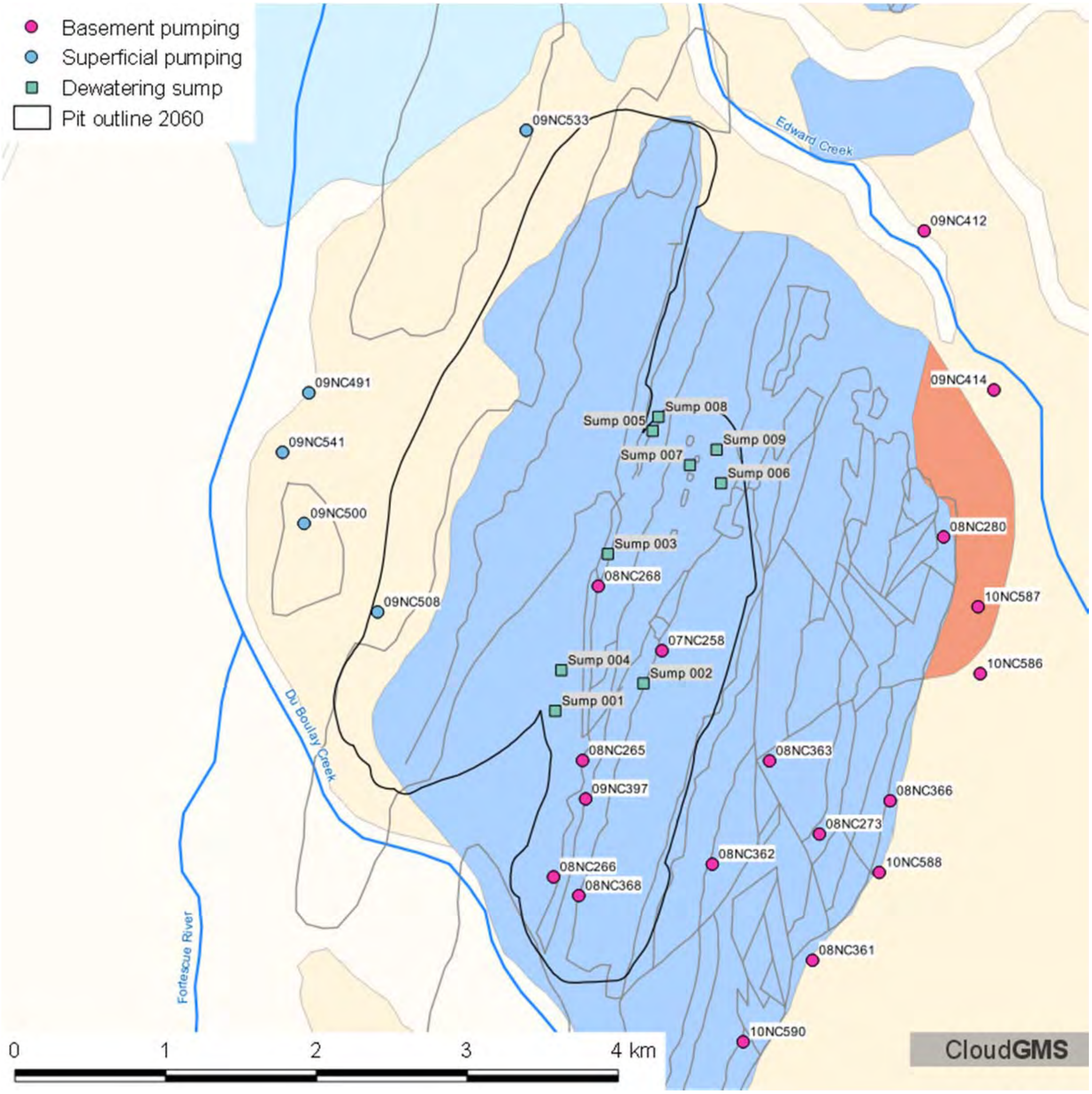

Figure 2-10 Location of historic and current pit dewatering sites.

2.7.1 Dewatering production bore pumped volumes

Monthly abstraction totals are available for 37 bores operated as part of the Sino operations. 22 of these bores are located in the vicinity of the pit. 17 of these bores are installed in the basement formations and 5 were constructed as part of the Global Groundwater (2010) investigations targeting the alluvial sediments (2) and Yarraloola Conglomerate (3). The locations of the production bores are shown above in Figure 2-10. A summary of completion details for these production bores is provided in Appendix B.

Since January 2008 approximately 5 GL of groundwater has been abstracted from the dewatering bores in the basement and conglomerate. The majority of dewatering bores in the vicinity of the pit are no longer being pumped, however, some bores were pumped post December 2013 with 10NC590 being pumped up until at least July 2015. A summary of the total abstraction from the basement dewatering bores and alluvium bores are presented below in Figure 2-11 and Figure 2-12.

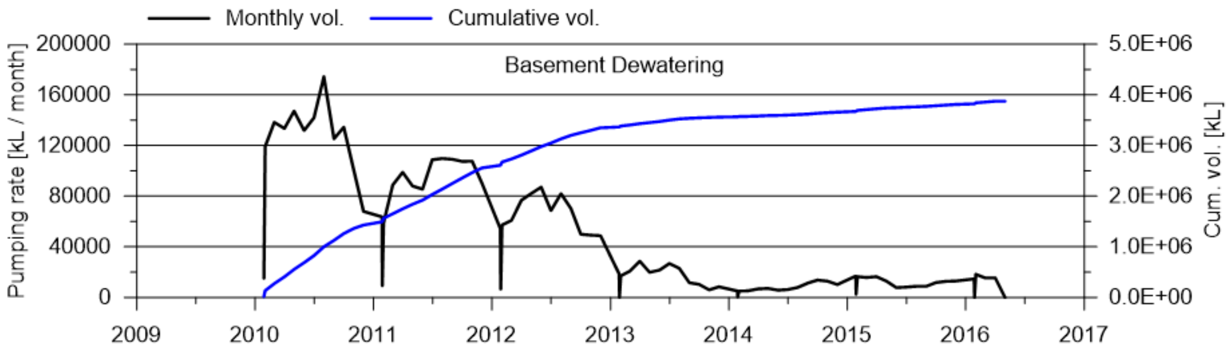

Figure 2-11 Monthly abstraction and cumulative extraction from bores constructed in the basement rocks in the vicinity of the pit for dewatering purposes.

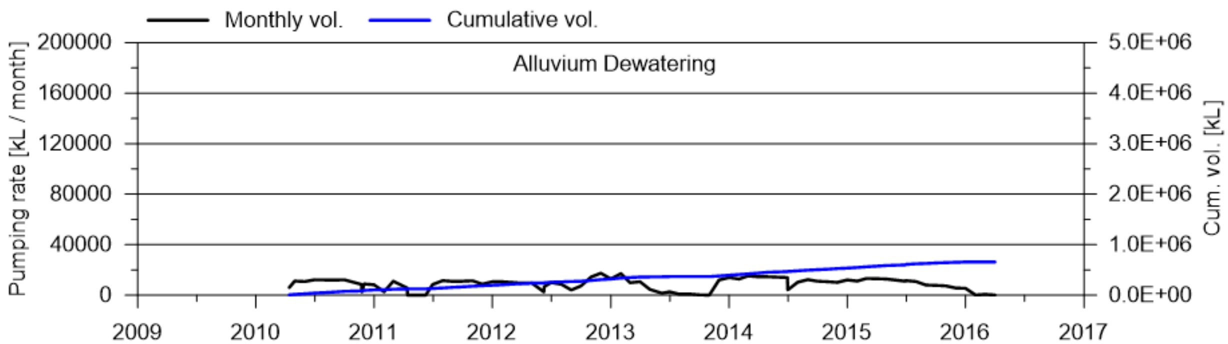

Figure 2-12 Monthly abstraction and cumulative extraction from bores constructed in the alluvial sediments and Yarraloola Conglomerate.

2.7.2 Current pit sump pumped volumes

Monthly sump abstraction volumes were provided for the period June 2012 to June 2015 for sumps 01 (which includes 04), 02, 03, 05, 06, 07, 08 and 09. Historic sump extraction data have been summarised for the southern and northern pit domains and are presented below in Figure 2-13 and Figure 2-14 respectively. The total volume pumped from the sumps in the southern pit domain to date is approximately 4 GL. This is about half the volume pumped from the sumps in the northern pit domain, which to date has been about 9 GL.

It should be noted that the total volume pumped to date is about 72% of the predicted volume for the life of mine in previous studies (13 GL cf 18 GL).

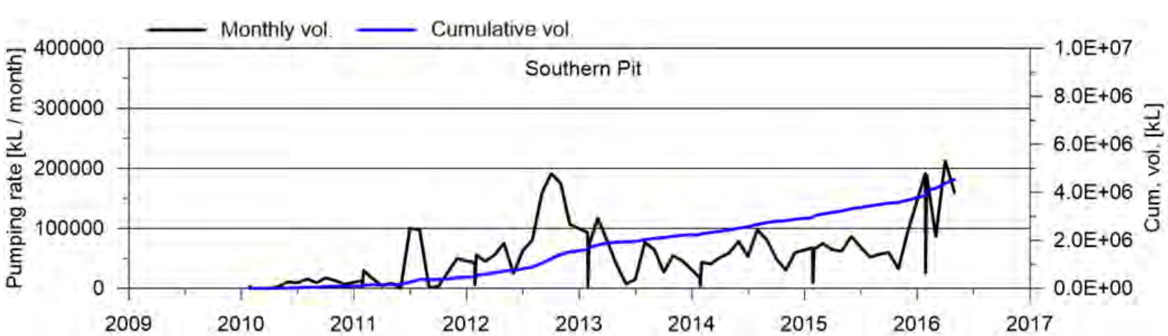

Figure 2-13 Southern pit extraction history (Sump 01, Sump 02, Sump 03 & Sump 04).

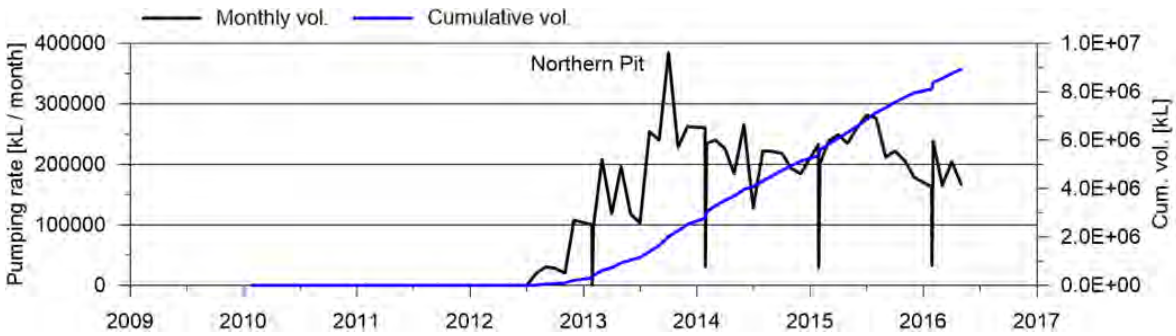

Figure 2-14 Northern pit extraction history (Sump 05, Sump 06, Sump 07, Sump 08 & Sump 09).

Monthly sump abstraction volumes were provided for the period June 2012 to June 2015 for sumps 01 (which includes 04), 02, 03, 05, 06, 07, 08 and 09.

2.8 Pit shell elevation data

2.8.1 Overview

The impacts of the Sino Iron Project are the main objective of this groundwater modelling study, however, to examine the cumulative impacts to the environment it is necessary to include the other three proposed projects in the Balmoral deposit. The pit elevation data used during the cumulative impact prediction scenarios are presented below.

2.8.2 Sino Iron Pit

Pit shell elevations are available in 3D dxf format for the East Pit from June 2010 to Dec 2016. Planned pit shell elevations are available from 2017 to 2060. The designed pit shell elevations for the period from 2016 to the end 2020 are available at yearly intervals and at 5 yearly intervals from 2020 to the projected end of mining in 2060.

Each dxf file was interpolated to a 20 x 20 grid using Surfer. The grid elevations for each of the pit shells were extracted to the locations of the nodes assigned as seepage face boundary conditions used to represent the development of the pit. A time series of specified levels was then developed for each seepage face boundary condition within the pit area (i.e. to set the pit shell elevations in the model and allow it to calculate the inflows).

The pit shell elevation contours for years 2016 and 2060 as used in this assessment are presented below in Figure 2-15.

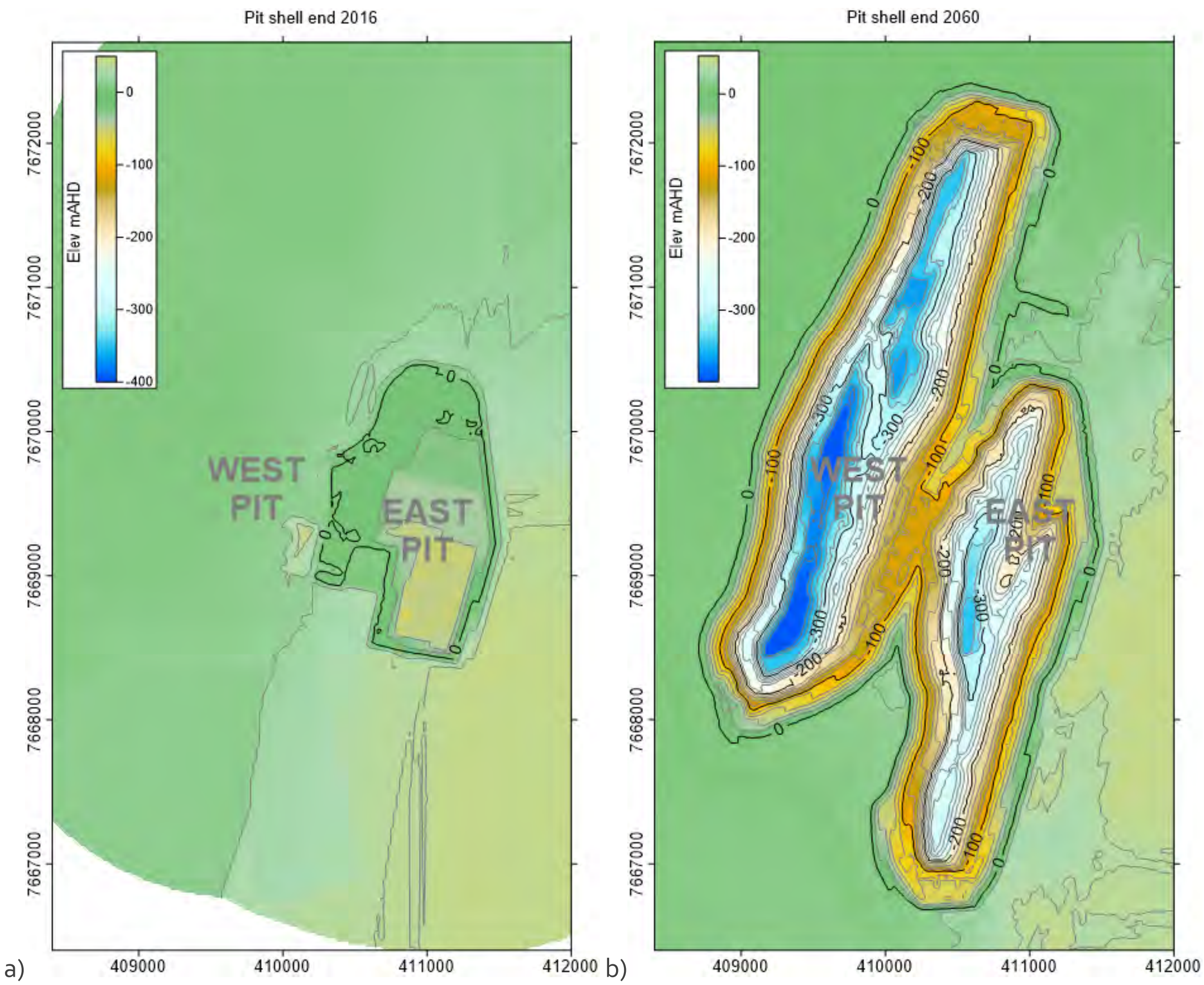

Figure 2-15 Sino pit shell elevations for a) end of year 2016 and b) end of year 2060 (contour intervals are 20 m).

2.8.3 Balmoral South, Mineralogy & Austeel pit elevation data

The final pit shell elevations for the Austeel, Balmoral South and Mineralogy projects are presented below in Figure 2-16. Due to the lack of details regarding the staged development of each of the additional projects considered as part of the cumulative impact assessment the pit shells are applied to the model using the final pit shell as a basis and assigning the base of the pit to the value indicated in the schedule for each pit detailed below in section 8.1. This results in a pit that covers the entire footprint of the final mine, that develops downwards to the final pit shell in 2 yearly time steps.

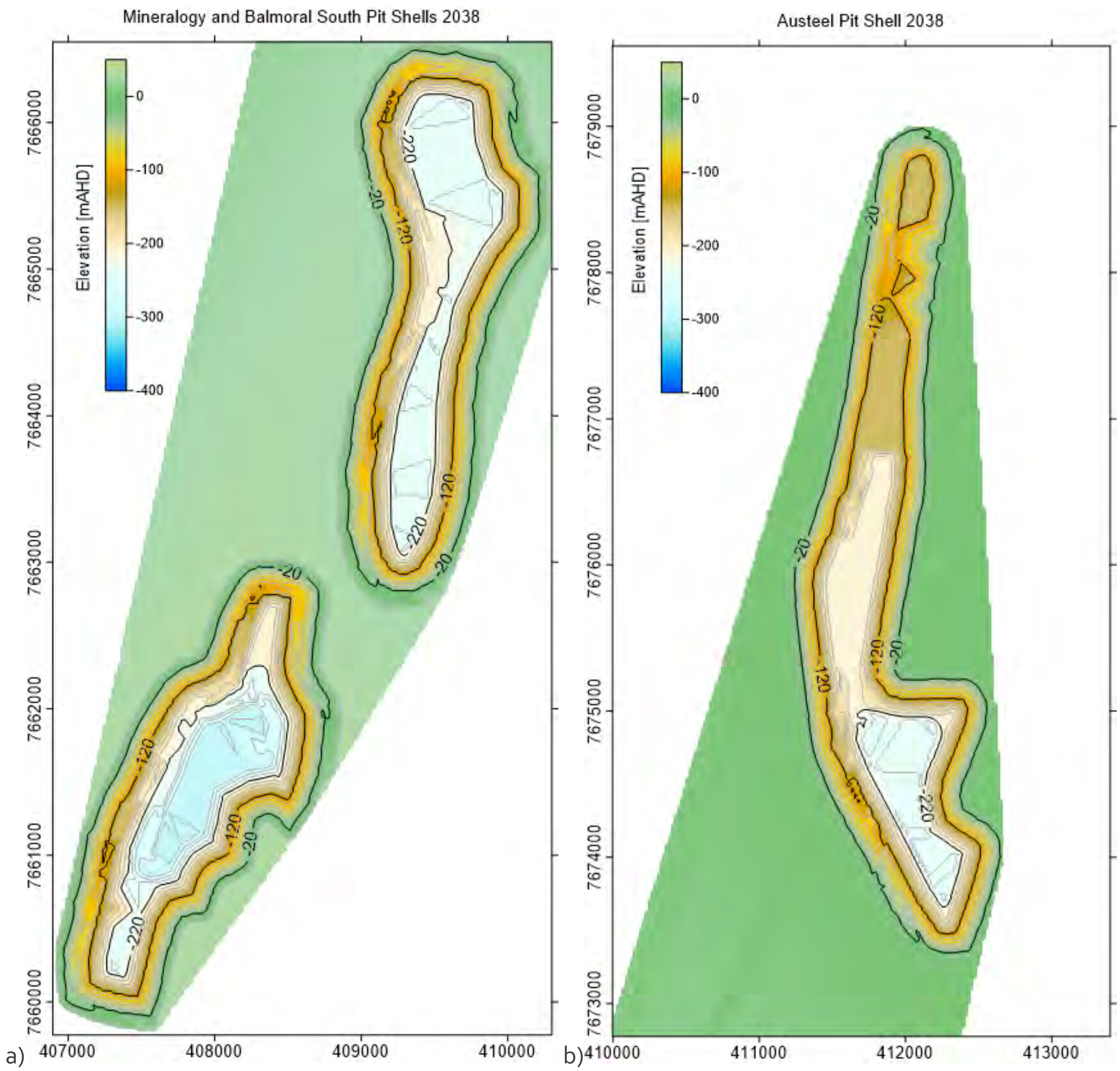

Figure 2-16 Final pit shell elevations used in the cumulative impacts assessment for a) the Mineralogy and Balmoral South pits and b) the Austeel pit.

2.9 Geological inputs

2.9.1 Superficial sediment mapping

Drilling investigations into the distribution and properties of the Cenozoic aged sediments along the western margin of the Central Balmoral deposit were conducted in 2007, 2008 and 2010 by Global Groundwater. The 2010 works included drill site selection, investigation and production bore drilling, test pumping, water analyses and evaluation.

Seven cross-section lines (A, B, C, D, E, G & H) were selected on alignments perpendicular to the Du Boulay Creek and extending from within the planned pit in the east to the mine lease boundary in the west Figure 2-17.

Bores 09NC491 (A-A’), 09NC500 (C-C’) & test production bores were sited were selected to test the Cretaceous sequence where it is confined at depth. Bore 09NC533 (D-D’) was selected to test the unconfined Cretaceous sequence where it is very close to the surface. Two bores 09NC508 and 09NC541 located on lines H-H’ and G-G’ respectively were selected to test the shallow Cainozoic alluvial sequence.

The locations of the sections and the interpreted extent of the alluvial sediments (Qrc) relative to the outcropping Brockman Iron Fm and the pit extents for year 2060 are presented below in Figure 2-17. The cross-sections developed by Global Groundwater are presented in Appendix C.

The alluvial sediments typically appear to be 20 – 30 metres thick along the western edge of the outcropping Brockman Iron Formation of the Central Balmoral deposit with a saturated thickness of between 10 – 20 metres. It can be seen that the proposed footprint of the west pit intersects the alluvial sediments. The relationship between the superficial sediments, the basement rocks and the extent of the 2060 pit is also presented as a west – east cross-section (7669800 mN) presented below in Figure 2-20.